DARBHANGA COLLEGE OF ENGINEERING

COURSE FILE

OF

CONSTRUCTION PLANNING AND MANAGEMENT (011827)

Faculty Name:

AHSAN RABBANI

Assistant Professor, DEPARTMENT OF CIVIL ENGINEERING

विज्ञान एवं प्रावैधिकी विभाग

Department of Science and Technology

Government of Bihar

CONTENTS

DEPARTMENT OF CIVIL ENGINEERING
DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

Vision of Department

To bring forth competent engineers to serve national & multi-national industries and society and, encouraging them towards higher studies

Mission of Department

M1. To nurture graduates into competent and technologically capable professionals through motivated teaching-learning ambience and by collaborating with relevant industries.

M2. To encourage graduates towards research and innovation in the field of civil engineering.

M3. To inculcate humanitarian ethical values in graduates through various social-cultural activities.

Program Educational Objectives (PEOs)

PEO1. The graduates will be able to demonstrate knowledge and skills of civil engineering to solve engineering problems related to structural design.

PEO2. The graduates will be able to function in the evolving research and development as design consultant in the relevant industry using modern software tools.

PEO3. The graduates will be able to showcase professional skills encompassing societal and ethical values.

Program Specific Outcomes (PSO):

PSO1: Students will be able to use advanced modern methods and tools like GIS, Auto CAD, Staad Pro, Total station to function as design consultants.

PSO2: Graduates will able to develop knowledge in some specific technical areas of civil engineering like Structural, Geotechnical, Transportation, Earthquake, Geomatics and Environmental Engineering.

CIVIL ENGINEERING PROGRAM EDUCATIONAL OBJECTIVES

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1	To prepare our graduates to have successful careers in design and analysis of various Civil Engineering structures and also motivate them to pursue higher studies and research in the relevant fields.
PEO2	To prepare our graduates as a good cognizance of Societal, Environmental and Ethical issues and have effective communication skills.
PEO3	To develop awareness of contemporary professionals issues and encourage them to support the Engineering profession through contribution in professional's societies and/or Educational Institutions.

PROGRAM SPECIFIC OUTCOMES (PSOs)

The PSOs of Civil engineering programme supported by the curriculum are given below.

PSO1	To function as design consultants in the relevant industry for the design of civil engineering structures using modern software tool.
PSO2	To develop knowledge in some specific technical areas of civil engineering; Structural, Geotechnical, Transportation, Earthquake and Environmental engineering.

PROGRAMME OUTCOMES (PO)

PO1	**Engineering knowledge**: An ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to get the solution of the engineering problems.
PO2	**Problem analysis:** Ability to Identify, formulates, review research literature, and analyze complex engineering problems.
PO3	**Design/development of solutions:** Ability to design solutions for complex engineering problems by considering social, economical and environmental aspects.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge to design, conduct analyse experiments to get valid conclusion.
PO5	**Modern tool usage:** ability to create, select, and apply appropriate techniques, and to model complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Ability to apply knowledge by considering social health, safety, legal and cultural issues.
PO7	**Environment and sustainability:** Understanding of the impact of the adopted engineering solutions in social and environmental contexts.
PO8	**Ethics**: Understanding of the ethical issues of the civil engineering and applying ethical principles in engineering practices.
PO9	**Individual and teamwork:** Ability to work effectively as an individual or in team, as a member or as a leader.
PO10	**Communication:** An ability to communicate clearly and effectively through different modes of communication.
PO11	**Project management and finance:** Ability to handle project and to manage finance related issue
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning.

Institute/college Name	Darbhanga College of Engineering, Darbhanga
Corse/Branch	B.Tech./Civil Engineering
Year/Semester	IV/VIII
Course Code/Choice	011827 / Core
Course credits	3
Course Name	Construction Planning and Management
Lecture/ Sessional (per week)	3/0
Course Teacher name	Mr. Ahsan Rabbani
Deptt./Designation	Civil Engineering/Assistant Professor

Course Description

This course is designed to review the management and finance aspects of civil engineering project. It comprises of equipment and their safety and usage, Economics of a project which include money, man-power and machinery resources, CPM & PERT techniques of project management, brief overview of management tools such as MS Project, Primavera etc. Basically, CPM (Critical Path Method) and PERT (Programme Evaluation Review Technique) are project management techniques, which have been created out of the need of Western industrial and military establishments to plan, schedule and control complex projects. PERT/CPM provided a focus around which managers could brain-storm and put their ideas together. It proved to be a great communication medium by which thinkers and planners at one level could communicate their ideas, their doubts and fears to another level. Most important, it became a useful tool for evaluating the performance of individuals and teams and overs topics like safety in construction, general management, material management, and engineering economy amongst others. The course also covers about pre fabrication techniques used in the construction industry and introduction about the project management software.

The course also deals project planning and management with essential components in management principles, overview of government regulations, project planning and control techniques, financial management, time-cost trade off, cost estimating, scheduling and resources management and risk analysis. The Construction Planning and Management curriculum is designed to prepare interested students for future careers in Project management, Tendering and contracts (marketing) etc.

Course Objectives

- To get the knowledge about various types of pre-fabrication techniques along with its advantages and disadvantages.
- To understand network analysis and its solution using CPM & PERT method.
- To Learn about Resource Utilization under Resource Smoothening and Resource Levelling.
- To provide basic understanding about planning, value analysis and management processes for execution of construction projects.

Course Outcome (5)

At the end of the course, the student will be able to

CO1: Understand Pre-fabrication, its Pros and limits, knowledge of construction equipment's and suitability

CO2: Learn various techniques of feasibility analysis and resources monitoring

CO3: Learn project planning and monitoring by CPM & PERT techniques and resource management by levelling & smoothening.

CO4: Understand of project management softwares such as MS Project, primavera etc being used in the industry.

CO-PO MAPPING

Sl No.	Course Outcome	PO
1	CO.1 Understand Pre-fabrication, its Pros and limits, knowledge of construction equipments and suitability	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO11, PO12. PSO1, PSO2
2	CO.2 Learn various techniques of feasibility analysis and resources monitoring	PO1, PO2, PO3, PO4, PO6, PO7, PO11, PO12, PSO1, PSO2
3	CO.3 Learn project planning and monitoring by CPM & PERT techniques and resource management by levelling & smoothening.	PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO11, PO12, PSO1, PSO2
4	CO.4 Understand of project management softwares such as MS Project, primavera etc being used in the industry.	PO1, PO2, PO3, PO4, PO5, PO6, P07, PO8, PO9, PO11, PO12, PSO1, PSO2

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1 Understand of Pre-fabrication, its Pros and limits, knowledge of construction equipments and suitability	1	2	1	1	2	2	1	2	1	-	2	3	2	2
CO.2 Learn various techniques of feasibility analysis and resources monitoring	3	3	2	1	-	1	1	-	-	-	1	3	2	2
CO.3 Learn project planning and monitoring by CPM & PERT techniques and resource management by levelling & smoothening.	3	3	2	1	1	1	-	-	2	-	1	3	3	3
CO.4 Understand of project management softwares such as MS Project, primavera etc being used in the industry.	3	3	3	2	3	2	2	1	2	-	2	3	2	3

Correlation Level: 1- Slight (Low) 2- moderate (Medium) 3 – Substantial (High)

011827	Construction Planning and Management	3L:0T:0P	3 credits

Construction and fabrication methods: Pre-fabrication techniques; choice of equipment safety features and Regulations. **Lecture: 8**

Value Analysis: Feasibility studies; Economics of project evaluation: Finance, material and manpower development. **Lecture: 8**

Network analysis: PERT, Leveling of Resources. **Lecture: 8**

Site organization: layout, work study, Decision making processes, CPM and L. P. Project monitoring. **Lecture: 10**

Maintenance management: Case studies **Lecture: 6**

Introduction to Project Management Software **Lecture: 5**

Total: 45 lecture

Text Book:
TB1: 'Construction Planning and Management' by U.K. Srivastav, Galgotia Publications Pvt. Limited
TB2: 'PERT & CPM' by B.C. Punmia, Laxmi Publications Private Limited

References:
RB1: 'Construction Project Management: Theory and Practices' by Kumar Neeraj Jha, Pearson Education India.
RB2: 'Construction Planning and Management' by PS Gahlot, New age publishing House

Gate Syllabus:

Construction Materials and Management: Construction Materials: Structural steel – composition, material properties and behaviour; Concrete – constituents, mix design, short-term and long-term properties; Bricks and mortar; Timber; Bitumen. Construction Management: Types of construction projects; Tendering and construction contracts; Rate analysis and standard specifications; Cost estimation; Project planning and network analysis – PERT and CPM.

Evaluation Details:

<table>
<tr><td colspan="4">Total Marks =100</td></tr>
<tr><td colspan="3">Internal Marks = 30</td><td>External Marks =70</td></tr>
<tr><td>Mid-Term = 20</td><td>Attendance =5</td><td>Class Test/ Assignment = 5</td><td>End Semester Exam = 70</td></tr>
</table>

Time Table: 8th Semester

Darbhanga College of Engineering, Darbhanga WEF:13/01/2020

8th Semester

DAY	Dept.	09:00-10:00 (1)	10:00-11:00 (2)	11:00-12:00 (3)	12:00-1:00 (4)	01:00-02:00	2:00-3:00 (5)	3:00-4:00 (6)	4:00-5:00 (7)
MONDAY	EE (S12)	DEC	MCT	PSD	PMIR		PSD/Project		
	CSE (S4)	PMIR [NA]	DM [SK]	W.Comm.	IS [PP]		PROJECT SEMINAR		
	ME (S10)	Remedial	IP	MSD	MIS		MSD LAB		
	CE (S11)	PROJECT		APM			PROJECT		
TUESDAY	EE (S12)	MCT	DEC	PMIR	PSD		Project/PSD		
	CSE (S4)	PMIR [NA]	DM [SK]	W.Comm.	IS [PP]		PROJECT SEMINAR		
	ME (S10)		IP	SD	MSD		PROJECT (MK/PK)		
	CE (S11)	PROJECT		PCS	IRRIGATIO	L	TPS	PROJECT	
WEDNESDAY	EE (S12)	PMIR	MCT	DEC	PSD		Seminar/Project		
	CSE (S4)	PMIR [NA]	DM [SK]	W.Comm.	IS [PP]		I&I	PROJECT SEMINAR	
	ME (S10)	Remedial	SD	IP	MIS	U	PROJECT		
	CE (S11)		PCS	IRRIGATIO	CPM		E & C LAB		
THRUSDAY	EE (S12)	PSD	PMIR	MCT	Remedial		Project/Seminar		
	CSE (S4)	PROJECT SEMINAR			E- Commerce		I&I	PROJECT SEMINAR	
	ME (S10)	Remedial	MSD	SD	IP (T)	N	PROJECT (CPS/MR)		
	CE (S11)	TPS		CPM	PCS		APM	PROJECT	
FRIDAY	EE (S12)	PSD	MCT	DEC	Remedial		Project/Seminar		
	CSE (S4)	PROJECT SEMINAR			E- Commerce		I&I	PROJECT SEMINAR	
	ME (S10)	MIS	SD (T)	Remedial	IP (T)	C	PROJECT (PS/NP)		
	CE (S11)	E & C LAB			CPM		IRRIGATION	PROJECT	
SATURDAY	EE (S12)	Project					Project		
	CSE (S4)	PROJECT SEMINAR			E- Commerce	H	DM LAB		
	ME (S10)	Remedial	SD (T)	MSD (AM)	Remedial		PROJECT (PS/NP)		
	CE (S11)	PROJECT					PROJECT		

Sl.No.	Electrical and Electronics Enginering	
1	DEC	Mr. Deepak Singh
2	MCT	Mr. Sanjay Kumar
3	PMIR	Mr. Akhil Md KK
4	PSD	Mr. Tabish Shanu
5	Seminar	Mr. Tabish Shanu/ Dr. R. Ranjan
6	Project	Mr. Ravi Kumar/All faculty

Sl.No.	Computer Science and Engineering	
1	DM	Mr. Sunil Kumar Sahu
2	E-Commerce	Mr. Dhirendra Kumar
3	IS	Mrs. Punam Prabha
4	W.Comm.	Dr. Ravi Ranjan
5	PMIR	NA
6	I&I	Mr. Akhlesh Kumar
7	Project	All Faculties

Sl.No.	Mechanical Enginering	
1	IP	Mr. Mukesh Kumar
2	SD	Mr. Vishnu Singh
3	MSD	Dr. Md. Asjad Mokhtar
4	MIS	Mr. Ajeet Kumar Gupta
5	Project	All Faculties

Sl.No.	Civil Engineering	
1	IE	Mr. Loknath kumar
2	TPS	Mr. Prashant Kumar
3	CS&E	Mr. Akash
4	CPM	Mr. Ahsan Rabbani
5	PSC	Mr. Ravi Ranjan Kumar
6	APM	Mr. Prashant Kumar
7	Project	All Faculties

10/01/2020 HOD EEE 10/01/20 10/01/20 10/01/2020

10/01/2020
Co-Ordinator
(Mr. Ravi Kumar)

Time Table Incharge
(Dr. A K Choudhary)

10/01/2020
PRINCIPAL
(Dr. Achintya)

List of Student: B Tech Civil Engineering (8th Semester)			
Sl. No.	**Registration No.**	**Roll No.**	**Name**
1	16101111001	16-C-68	KANHAIYA KUMAR YADOV
2	16101111002	16-C-52	VISHAL RAJ
3	16101111003	16-C-12	VINEET KUMAR
4	16101111004	16-C-66	RISHI KUMAR
5	16101111005	16-C-03	KIRTHI
6	16101111006	16-C-24	MITESH KUMAR MITESH
7	16101111007	16-C-37	ANKESH KUMAR
8	16101111008	16-C-16	SHUDHANSHU SHEKHAR JHA
9	16101111009	16-C-05	SHIKHA
10	16101111010	16-C-56	KUMARI PRIYANSHU
11	16101111011	16-C-41	MOTI LAL MANJHI
12	16101111012	16-C-43	KESHAV KUMAR
13	16101111013	16-C-64	CHANDAN KUMAR
14	16101111014	16-C-50	PREMRANJAN KUMAR
15	16101111015	16-C-54	RAJNISH KUMAR
16	16101111016	16-C-10	AMAR KUMAR
17	16101111017	16-C-28	SAURAV KUMAR SHANU
18	16101111018	16-C-27	RAHUL KUMAR
19	16101111019	16-C-33	ABHISHEK KUMAR SHUKLA
20	16101111020	16-C-58	NARENDRA KUMAR
21	16101111021	16-C-31	RUPAK RAJ
22	16101111022	16-C-63	RAHUL RAVI
23	16101111023	16-C-36	SANTOSH KUMAR
24	16101111024	16-C-12	PRINCE KUMAR
25	16101111025	16-C-32	NEERAJ KUMAR
26	16101111026	16-C-47	PRABHAT RANJAN
27	16101111027	16-C-51	MD ZAKI AHMAD
28	16101111028	16-C-30	HEMANT KUMAR
29	16101111029	16-C-11	AMIT RAJ
30	16101111030	16-C-15	RAKESH KUMAR
31	16101111031	16-C-62	MUSAFIR KUMAR
32	16101111032	16-C-09	AJAZ AHMAD
33	16101111033	16-C-04	POOJA KUMARI
34	16101111034	16-C-48	SHIVAMVEER KUMAR
35	16101111035	16-C-26	SUNIL KUMAR
36	16101111036	16-C-65	ATISH DEEPANKAR
37	16101111037	16-C-20	VIKRAM BHARTI

38	16101111038	16-C-46	DIPESH KUMAR
39	16101111039	16-C-34	CHANDRAMANI KUMAR
40	16101111040	16-C-40	AMIT KUMAR
41	16101111041	16-C-19	RAJEEV RANJAN
42	16101111042	16-C-07	SOPHIA KHATOON
43	16101111043	16-C-01	ADITI
44	16101111044	16-C-69	PRIYADARSHI KUMAR
45	16101111045	16-C-22	RAJVANSHI KUMAR SINGH
46	16101111046	16-C-57	BHUDEV BHASKAR
47	16101111047	16-C-44	SUDHIR KUMAR
48	16101111048	16-C-67	CHANDRESH KUMAR
49	16101111049	16-C-18	DILIP KUMAR
50	16101111050	16-C-21	RAMESH KUMAR SAH
51	16101111051	16-C-29	UMANG BHARDWAJ
52	16101111053	16-C-49	MD SALIK ANWAR
53	16101111054	16-C-61	RAUSHAN KUMAR
54	16101111055	16-C-02	SAIMA FIRDAUS
55	16101111056	16-C-60	DURGESH KUMAR
56	16101111058	16-C-38	RAM RATAN KUMAR
57	16101111059	16-C-59	SHANKAR RAM
58	17101111901	17-LE-C-05	PANKAJ KUMAR SAH
59	17101111902	17-LE-C-04	RAHUL KUMAR
60	17101111903	17-LE-C-06	ANKESH KUMAR
61	17101111904	17-LE-C-01	ADARSH ANAND
62	17101111905	17-LE-C-12	PRATEEK KUMAR
63	17101111906	17-LE-C-03	SANATAN KUMAR JHA
64	17101111907	17-LE-C-02	SACHIN KUMAR
65	17101111908	17-LE-C-08	MRITYUNJAY KUMAR
66	17101111909	17-LE-C-07	BIBEKANAND KUMAR
67	17101111910	17-LE-C-11	KUMAR SUMAN SAURABH
68	17101111911	17-LE-C-10	PINKEE KUMARI
69	17101111912	17-LE-C-09	JAI KUMAR

Lecture Plan:

Lecture on topic	Lecture Number	Proposed Date of Lecture
Module 1		
Construction and Prefabrication methods	1	
Need of prefabrication, Classification of prefabrication	2	
Scope of prefabrication, Advantages and disadvantages of prefabrication	3	
Design principles of prefabricated system	4	
Introduction of safety in construction,	5	
Need of Accident prevention program, Causes of accidents,	6	
Classification of construction accidents, Measurements of accidents,	7	
Salient features of “A” safety program, Protective equipments	8	
Module 2		
Introduction: Project evaluation, Project feasibility	9	
Defining the objectives and scope of projects, Identifying and selecting suitable options	10	
Carrying out project analyses • Economic analysis • Environmental analysis • Social analysis • Budget analysis	11	
Selecting the preferred option	12	
Business case: A generic outline for business cases	13	
Executive summary: Project background, Objectives and scope of project	14	
Project options, Project analysis, Preferred option	15	
Recommendations	16	
Module 3		
Introduction: CPM and PERT	17	
Benefits, Application and Limitations of CPM/PERT	18	
Basic steps in CPM/PERT	19	
Framework for PERT and CPM, Network diagram representation	20	
Rules for drawing network diagram, Common errors in drawing network	21	
Critical path in network analysis	22	
Worked example in CPM	23	
Worked example in PERT	24	
Module 4		
Introduction: Concepts and Formulas of Construction Site Layout Planning Elements	25	
Significance of Site Layout Planning	26	
Site Investigation (SI): Safety, Site Accessibility, Information Signs, Security, Accommodation	27	
Wok Procedure for SI, Steps of Soil Exploration	28	
Decision Criteria and Site Facilities Adopted in Site Layout Planning	29	
Examples of Site Layout Planning	30	
CRITERIA FOR DECISION MAKING	31	
CAUSES OF PROJECT SUCCESS OR FAILURE	32	
Use of Network Analysis for project monitoring	33	
Application of Decision CPM to dynamic monitoring and control of projects	34	

Department of Civil Engineering, Darbhanga College of Engineering, Darbhanga

ASSIGNMENT III

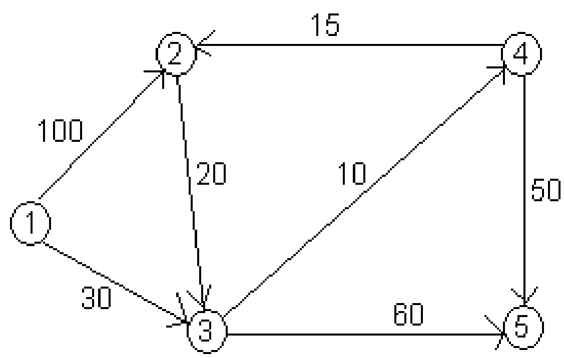
B Tech 8th Semester

Submit it on or before 20th April 2020

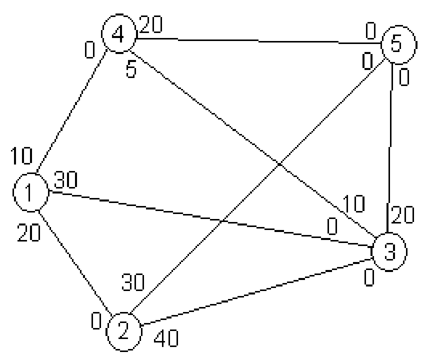
01. Construct a network for each of the activities and their precedence relationships are given below:

Activities	A	B	C	D	E	F	G	H	I	J	K
Predecessor	-	-	A	A	I,J,K	B,D	B,D	F	A	G,H	F

02. Find the shortest routes between city 1 to city 2 by Dijkstra's algorithm.



03. Find the maximum flow in the network



04. Draw a network diagram for the following project & find critical path and critical activities and project duration.

Activity	**Predecessor**	**Duration (days)**
A	---	6
B	A	4
C	B	7
D	A	2
E	D	4
F	E	10
G	---	2

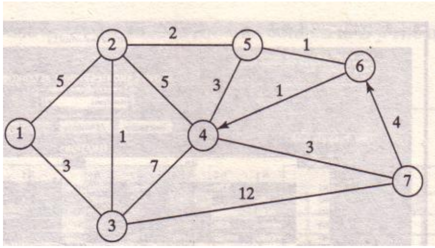
H	G	10
I	J,H	6
J	---	13
K	A	9
L	C,K	3
M	I,L	5

05. A project consists of 8 activities named A to H. Construct a network so as to satisfy the scheduling requirements shown in the table below.

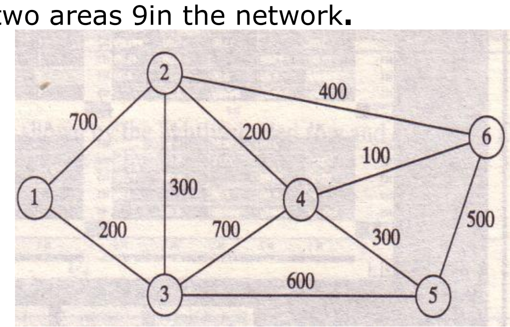
Activity	Completion time (days)	immediate predecessor activities
A	3	-
B	6	A
C	7	A
D	5	A
E	13	B,C
F	8	C,D
G	11	D,F
H	6	G,E

Find the least time required to complete the whole project and identify the critical activities. How is the project completion time affected if?

1. activity F is delayed by 3 days
2. activity E is delayed by 7 days
3. Activity G is finished 7 days early.



6. The Reliance Mobile Phone Company services six graphical areas. The satellite distances (in miles) among the six areas in following figure. All needs to determine the most efficient message routes that should be established between each two areas 9in the network**.**



DARBHANGA COLLEGE OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

Subject Code: 011827 Subject Name: Construction Planning and Management

Subject teacher: Ahsan Rabbani

Unit 1: Construction and fabrication methods

1. **Modular co-ordination of construction means proper**
A. planning
B. designing
C. execution
D. all the above.

Answer: D

2**. The first stage of a construction, is**
A. preparation of estimate
B. survey of the site
C. initiation of proposal
D. preparation of tender
E. allotment of funds.

Answer: C

3. **Define construction and construction management.**

Answer:

Construction management is the process of planning, coordinating and providing monitoring and controlling of a construction project. This style of project management is designed for the, as the name implies, construction industry. There are few types of construction that use construction management, they are industrial, civil, commercial, environmental and residential. Each category has its own way of running projects, but all will follow the construction management methodology.

Construction management is the overall planning, coordination, and control of a construction process from the start to the end. The objectives of project management are to produce a project that meets client requirements on budget and schedule, and at acceptable risk, quality, and safety.

Construction management has five stages, where project management has five phases. The stages are design, pre-construction, procurement, build, and owner occupancy.

- Design Stage: The design stage is where the project begins. This stage has to look at more than the planning stage in project management. It will look at concepts, schematics, contracts, design and regulatory and industry codes.

- Preconstruction Stage: During the preconstruction stage the owner has given permission to begin the project. The construction team is assembled and documents are reviewed. The team will analyze all requirements and will need to perform a walkdown of the construction site. This walkdown will detail actual conditions and help identify any areas that were not identified in the design stage. The earlier issues are identified with the site, the easier they are to get corrected.

- Procurement stage: During this stage, items are purchased and sub-vendors are selected and retained. Many companies can and will perform all needed job functions, but some will sub-contract items like electrical or plumbing. A construction manager has to properly vet a sub-contractor and ensure they are properly licensed and insured. Many construction managers selected cheap sub-contractors, only to find out that the work is subpar. For example, Joe is the construction manager for a new mall in New Jersey. Joe's company can handle everything except asphalt paving. Joe contacts a few asphalt companies in the area and arranges for a bid meeting. During the bid meeting, Joe discusses the project and hands out a project information packet. A week later bids are due and Joe selects the best value.

4. **Describe financial aspects related to construction equipments.**

Answer:

Construction financial managers sometimes wonder how their duties, responsibilities and relations with others within the organization compare to other construction financial managers. Similarly, construction company owners sometimes wonder what skills are needed and what expectations should be held of their construction financial manager. This information will help provide the answers to such questions. We will review how a construction financial manager works with the senior management team to accomplish financial goals while helping other managers accomplish their goals, how financial managers administer the finance department, their responsibilities to the company’s owners and creditors, their administrative responsibilities and the related ethical considerations.

In today’s environment, the role of the financial manager in a construction organization is essential to organizational success, and more importantly, is vital to avoiding failure. That may sound extreme, but in many circumstances, competition is so fierce and margins are so thin, reliable financial information and analysis certainly can make the difference between success and failure.

The construction financial manager’s role may vary from company to company, partly because different financial managers have different skills and personalities. The role also varies depending on the size of the company. A construction financial manager’s background often indicates the areas in which the manager will concentrate. For example, a construction financial manager whose background is in construction operations (estimating and project management) initially will concentrate on the proper recording of job costs. A construction financial manager whose background is in public accounting probably will initially emphasize financial reporting and income tax planning. The financial manager should recognize these influencing factors and make efforts to compensate for any deficiencies.

The skills and personalities of the other members of the management team also affect the role of the construction financial manager. The majority of a company’s administrative work can be performed in any department and will be allocated among departments partly based on the skills and personalities of the respective department managers. For example, most construction financial managers feel that cash management is their responsibility. If the other management team members share this feeling, responsibility for cash management probably will be assigned to the finance department. However, if another management team member feels that responsibility for cash management should be shared, some compromise will be made. To a great extent, sharing of responsibilities depends on the skills and personalities of the management team members. Successful financial managers respect the need for compromise in sharing responsibilities.

As already mentioned, the size of the company frequently affects the role of the financial manager, because roles and responsibilities are more specialized in larger companies than in smaller companies. In small companies, responsibilities are assigned to a smaller group of managers and, accordingly, each manager must handle a wider range of responsibilities. For example, the financial manager in a small company with three senior managers (owner, operations manager and finance manager) will typically be responsible for all administrative and financial tasks. The other two senior managers will typically concentrate on marketing, estimating and project management. In larger companies, with responsibilities assigned to a larger group of managers, each manager will be assigned more specialized responsibilities. For example, the financial manager of a large company with several senior managers often has limited responsibility for administrative tasks involving contact with customers and subcontractors. The department with primary responsibility for customer and subcontractor relations (usually the construction operations department) will prefer to be the primary contact in order to minimize the possibility of misunderstandings between the parties. Because there is no one standard set of construction financial manager responsibilities, each financial manager should be alert for areas of responsibility that are not clearly defined in the organization. The financial manager should take the initiative in assuring that all significant responsibilities are assigned.

5. **State advantages and disadvantages of hiring construction equipments**.

Answer:

<u>Advantages</u>

Low risk, increased safety

By ‘sub-contracting’ out the provision of equipment to a rental company, the responsibility of the equipment being compliant and ready to use is placed with them – lowering the risk for the contractor or customer. Therefore, the rental company is more likely to keep the equipment fleet up-to-date and regularly serviced. (Eg. recently inspected to LOLER or PUWER standards.)

More cost effective

Renting construction equipment is a better financial decision as it requires minimal upfront investment. This is particularly important if you are completing a specific task or project and you’re not likely to use a specific piece of equipment again.

Low / no maintenance

By hiring directly from an equipment supplier, the cost of asset management and equipment maintenance is with them. Not only does this mean you don’t need to invest in equipment to clean, repair and repaint the equipment it also means you do not need space for storage or suitable lifting equipment to move it around a storage facility.

Equipment disposal

If you hire equipment you are obviously do not have to worry about selling or disposing of the equipment when it is no longer useful to you. The hassle that is associated with this process, using auction sites or similar, often results in a low return on investment and not realising the true value of the equipment.

Disadvantages

- You are responsible for transporting, maintaining, repairing, and storing the equipment. You will also be responsible for disposing of it at the end of its working life.
- If you have to make a large down payment or high monthly payments, it can put a strain on your company's bank account.
- Buying turns liquid assets into fixed assets. Liquidity is used to determine your ability to pay obligations.
- If the equipment sees a lot of hard use, the trade-in value will shrink.
- It is possible the machinery will become obsolete during your ownership, making it nearly impossible to trade-in or sell.
- If you are already writing off a lot of depreciation, more may cause you to pay Alternative Minimum Tax penalties.
- You are stuck with it whether there is growth or retraction of the construction industry or its customers.

6. **Describe some common causes of accidents in construction site.**

Answer:

The Occupational Safety & Health Administration (OSHA) reports that there were 3,945 worker fatalities in private industry in 2012. Of that number, 775 or 19.6% were in construction. There are many causes of an accident on a construction site. The top causes of construction worker deaths on the job were falls, followed by struck by object, electrocution, and caught-in/between. These "Fatal Four" were responsible for nearly three out of five of the construction worker deaths.

Many accidents may be attributed to some type of negligence and may involve unsafe work site conditions, improper use of tools and-or equipment, and lack of protective safeguards.

Some examples of construction site accidents are more common than others. Below is a list of the more common ones starting with the Fatal Four.

1. Falls. Falls accounted for 278 out of 775 (36%) total deaths in construction in 2012, according to OSHA. An injury of this type may occur when a worker near an open-sided floor steps backwards or sideways without looking. Falling hazards also commonly occur on stairwells with no guardrails. Since high elevations often play a role in these falls, the results can be catastrophic to workers who sustain serious injuries. The main cause of death in construction occurs where inadequate or no fall protection is provided.
2. Struck by object. Seventy-eight construction workers died as a result of being struck by an object in 2012. A number of these deaths may have been prevented if the workers

had undergone proper training and used equipment and machinery properly. Employees must remember to use parking brakes on nonmoving vehicles, reverse vehicle alarms, tool guards, personal protection equipment, debris nets, catch platforms and more.

3. Electrocutions. In 2012, 66 workers (9%) were seriously injured or killed by electrocution. Electrocution is when a person, tool or piece of equipment comes into contact with power lines or exposed electrical sources. Sometimes, these types of accident occur because workers are simply unaware of all energized power sources, from overhead and underground power lines to damaged receptacles and connectors. As an example, a construction worker carrying a metal ladder may strike an overhead power line.
4. Caught-in/between. Although it seems obvious to never stand between a piece of heavy equipment and an immovable object, sometimes workers concentrating on their jobs find themselves in unexpected danger. Caught in/between accidents are when a worker's body part is caught, crushed, squeezed, compressed or pinched between two or more objects. Examples include cave-ins or collapsing materials, body parts caught in the moving parts of an unguarded piece of machinery, equipment rollovers and getting pinned between fixed objects, like a wall, and piece of heavy equipment.
5. Slip and falls. These are among the most common accidents on a construction site. These accidents may be linked to unsafe conditions conditions including uncovered holes or trenches and exposed stakes.
6. Ladder accidents. This is one of the leading causes of injury and long-term disability. Most ladder accidents, including falls, happen because workers use the wrong type of ladder for their job or they set up the ladder improperly, perhaps on a slippery or unstable surface, and the ladder unexpectedly shifts or slips. Workers also may experience a foot slip, or they may lose their balance, or overreach. Ladders may also be defective or improperly maintained.
7. Scaffolding accidents. Despite strict regulations, scaffolding accidents occur. In a Bureau of Labor and Statistics (BLS) study, 72% of workers injured in scaffold accidents attributed the accident either to the planking or support giving way, or to the employee slipping or being struck by a falling object. In a general sense, most scaffolding accidents are caused by improper construction or negligent maintenance.
8. Power tool and machinery accidents. Power tool and machinery injuries may occur for reasons that include mechanical defects, electrical failure, inadequate training and failure or lack of proper safety equipment. A significant number of injuries are caused by the use of power tools and large equipment.
9. Musculoskeletal disorders. A leading cause of injuries, disability claims and medical costs in construction are sprains and strains of the muscles. Construction work can also cause injuries to the joints, bones, and nerves. These injuries often stem from job demands that constantly wear and tear on the body.
10. Vehicle Accidents. Dangerous construction site vehicles include forklifts, graders, backhoes and dump trucks. A common forklift accident occurs when the vehicle is turned or maneuvered with the load raised. Large trucks all too often back up and hit a pedestrian. Another hazard on construction sites is falling from a vehicle.

While construction sites may appear to be dangerous, many of these accidents can be avoided through common sense and protective measures. Prevention begins with adequate awareness and a properly maintained working environment that is safe and secure.

7. **Classify the equipments required in construction industry.**

Answer:

There are several equipment that is been used in the Construction Industry. These are used for both large and small scale purposes. Various types of Equipment are been used for Building & structural Construction, Road construction, underwater and other marine

construction work Power projects etc. There are various operations that are involved in construction projects, whether it’s a large scale or a small scale; Excavation and digging of large quantities of earth, Placement of construction materials (eg:-Bricks, concrete) Compacting and leveling, Dozing, Grading, Hauling etc…
Construction equipment can be categorized in to 4 main sections based on purpose and use, they are:

1. Earth Moving equipment
2. Construction vehicle
3. Material Handling Equipment
4. Construction Equipment

NOTE:- There can be several types of classification base on techniques, purpose, types, brands etc…

EARTH MOVING EQUIPMENT

- Excavators
- Graders
- Loaders
- Skid loader
- Crawler loaders
- Backhoe
- Bulldozers
- Trenchers
- Scrapers
- Wheeled loading shovels

CONSTRUCTION VEHICLE

- Tippers
- Dumbers
- Trailers
- Tankers

MATERIAL HANDLING EQUIPMENT

- Crane
- Conveyors
- Hoists
- Fork Lifts

CONSTRUCTION EQUIPMENT

- Concrete Mixture
- Compactors
- Pavers
- Road Rollers

TUNNELING EQUIPMENT

- Road Headers
- Tunnel Boring Machines (TBM)

OTHER CONSTRUCTION EQUIPMENT

8. **Discuss various costs parameters that are considered and analyzed in order to formulate equipment replacement policy.**

Answer:

Organizations use equipment in production and testing which must be maintained or replaced on planned basis. Manufacturing industries are facing fierce competition therefore companies invest in highly automated production system with good quality equipment. It is necessary to utilize equipment in best way to stay in the global market, and maintain the production operation thus leading to the economical sustainability as well as increase company profit. When an unplanned interruption occurs due to machines or equipment failure, this disturbs the production operation.

- Equipment Replacement

The replacement of productive equipment is important strategic decisions faced by both manufacturing and service firms because purchasing a new piece of equipment often involves more cost and can affect the productivity and effectiveness of the firm. Currently, this issue is highlighted in fast changing technologies and good equipment purchase can soon become obsolete. Under these situations, the driving motivation to take replacement decisions is likely to be technological outmodedness instead of physical deterioration, of the existing equipment. This situation is typical of microcomputers, computerized numerically controlled machines, and other electronics technologies.

Bulk of management studies have been done in equipment replacement. The customary approach to the equipment replacement problem emphasizes the physical deterioration of the existing equipment. The main concept is to replace the equipment when the cost of operating and maintaining it become sufficiently high, in net expected present value terms, to substantiate a replacement. In most conventional models, technology is supposed to remain constant over time (Derman, and Hatoyama, 1984). The approach of Derman, and Hatoyama would lead to inappropriate decisions if technology does change. Currently, researchers started to model the equipment replacement problem due to technological change under vagueness. Goldstein, Ladany and Mehrez introduce uncertainty using stationary forecasts. Hopp and Nair developed a model using non-stationary technology forecasts but where the revenue generated by various technologies is different but constant over time (1991).

The replacement problems are associated with the issues that develops when the performance of an item decreases, failure or breakdown occurs. The decline in performance or breakdown may be gradual or sometimes sudden. There is a need for replacement of items when;

1. The existing item or system has become inefficient or require more maintenance.
2. The existing equipment has failed due to accident or otherwise and does not work at all.
3. The existing equipment is expected to fail shortly.
4. The existing equipment has become obsolete due to the availability of equipment with latest technology and better design. The solution to replacement problem is to device best policy that determines the time at which the replacement is most economical instead of continuing at an increased maintenance cost.

The Main objective of replacement policy is to guide the organization in many situations so that it can take correct decision such in a situations when waiting for complete failure of item or to replace earlier at the expense of higher cost of the item, whether to replace the underperforming equipment with the similar kind of item or by different kind of item. The problem of replacement occurs in the case of both men and machines.

There are numerous reasons for equipment replacement. The first reason is the equipment is depleted of function. Second reason for replacing equipment is if the equipment becomes obsolete. For example, older computers are much slower and have fewer features than their modern counterparts. In addition, older computers are harder to maintain because replacement parts and qualified technicians are much harder to find. Another reason for replacement is deterioration due to aging. Equipment is inadequate and does not meet needs, increased demand. Then it is replaced with a larger asset.

There are many types of failure in equipment:

1. Gradual Failure: In this, the failure mechanism is progressive. As an equipment becomes old, its performance deteriorates. This results in increased operating cost, decreased productivity of the item and decrease in resale value of item.
2. Sudden Failure: This type of failure occurs in equipment that do not deteriorate gradually with age but which fail suddenly after some period of service. The time period between installations and failure will not be constant for any particular equipment. However the failure pattern will follow certain frequency distribution that may be progressive, retrogressive or random in nature.
3. Progressive failure: progressive failure occurs when probability of failure increases with the age of an item.
4. Retrogressive failure: Certain items will have more probability of failure in the early years of their life and with the increase in the life of an item the chances of failure become less. That is, the ability of the item to survive in the initial years of life increases its expected life.
5. Random failure: Random failure occurs when continuous probability of failure is related with equipment that fails because of random causes such as physical shocks that are independent of age. In the case of random failure, virtually all items fail before aging has any effect.

The replacement situations are categorized into the following four types:

1. Replacement of capital equipment whose performance decreases with time.
2. Group replacement items that fail completely: Some system usually composed of a large number of low cost items that are prone to failure with age such as failure of a resistor in television, radio, computer etc. In some cases the failure of a component may cause the complete failure of the system. In such cases, the cost of overall failure will be quite higher than the cost of component itself. In such situations, two types of replacement procedures must be considered. First is Individual replacement. In this policy, an item is replaced immediately after its failure. Secondly, Group replacement in which, decision is about the age when all the items should be replaced, irrespective of whether the items have failed or not. In this policy, the items that fail before the optimal time, will be replaced individually.
3. Problem of mortality and staffing.
4. Miscellaneous problems.

Replacement Planning Process:

1. Assess clinical needs
2. Use multidisciplinary approach
3. Assess technical/maintenance/safety/regulatory needs/indicators

4. Review equipment database
5. Review maintenance criteria and calculations
6. Assess budget

9. **Explain different type of construction equipments being used in India along with safety features associated with it.**

Answer:

Different types of construction equipment commonly used in the construction area in India are as follows:

1. Excavators
2. Backhoe
3. Dragline Excavator
4. Bulldozers
5. Graders
6. Wheel Tractor Scraper
7. Trenchers
8. Loaders
9. Tower Cranes
10. Pavers
11. Compactors
12. Telehandlers
13. Feller Bunchers
14. Dump Trucks
15. Pile Boring Machine
16. Pile Driving Machine

1. Excavators

Excavators are important and widely used equipment in construction industry. Their general purpose is to excavation but other than that they are also used for many purposes like heavy lifting, demolition, river dredging, cutting of trees etc.

Excavators contains a long arm and a cabinet. At the end of long arm digging bucket is provided and cabinet is the place provided for machine operator. This whole cabin arrangement can be rotatable up to 360^{o} which eases the operation. Excavators are available in both wheeled and tracked forms of vehicles.

2. Backhoe

Backhoe is another widely used equipment which is suitable for multiple purposes. The name itself telling that the hoe arrangement is provided on the back side of vehicle while loading bucket is provided in the front.

This is well useful for excavating trenches below the machine level and using front bucket loading, unloading and lifting of materials can be done.

3. Dragline Excavator
Dragline excavator is another heavy equipment used in construction which is generally used for larger depth excavations. It consists a long length boom and digging bucket is suspended from the top of the boom using cable.
For the construction of ports, for excavations under water, sediment removal in water bodies etc. can be done by dragline excavator.

4. Bulldozers
Bulldozers are another type of soil excavating equipment which are used to remove the topsoil layer up to particular depth. The removal of soil is done by the sharp edged wide metal plate provided at its front. This plate can be lowered and raised using hydraulic pistons.
These are widely used for the removal of weak soil or rock strata, lifting of soil etc.

5. Graders
Graders also called as motor graders are another type of equipment used in construction especially for the construction of roads. It is mainly used to level the soil surface. It contains a horizontal blade in between front and rear wheels and this blade is lowered in to the ground while working. Operating cabin is provided on the top of rear axle arrangement.
Motor Graders are also used to remove snow or dirt from the roads, to flatten the surface of soil before laying asphalt layer, to remove unnecessary soil layer from the ground etc.

6. Wheel Tractor Scrapers
Wheel Tractor Scrapers are earth moving equipment used to provide flatten soil surface through scrapping. Front part contains wheeled tractor vehicle and rear part contain a scrapping arrangement such as horizontal front blade, conveyor belt and soil collecting hopper.
When the front blade is lowered onto the ground and vehicle is moved, the blade starts digging the soil above the blade level and the soil excavated is collected in hopper through conveyor belt. When the hopper is full, the rear part is raised from the ground and hopper is unloaded at soil dump yard.

10. **Explain and analyse different safety regulations for the construction projects.**

Answer:

Working on a construction site is one a dangerous occupation. According to recent findings from the Bureau of Labor Statistics, construction-related fatalities accounted for around 21.4% of all worker fatalities in 2015. With nearly, 6.5 million people working at over 250, 000 construction sites across the US on any given day, it's easy to see why enforcing preventative construction site safety procedures is critical.
Some of the potential hazards that construction workers face every day include:

- Falls from heights
- Scaffold collapse
- Electrocution and arc blast/flash
- Trench collapse
- Repetitive motion injuries
- Failure to use the required PPE (Personal Protective Equipment)

Every employer is required by law to ensure the safety and health of their workers, regardless of the industry or their occupation. Construction workers are particularly exposed to high-risk environments that pose dangers which need to be addressed. If you're a construction site manager or project manager, it's your responsibility to take the right safety measures to safeguard the work site from unnecessary dangers or hazards.

Here are the top construction site safety procedures you should have in place for construction sites:

Do a Thorough Worksite Evaluation

Analyze Your Worksite or Worksites

Regularly analyze your work site to identify any potential hazards and come up with an effective way or plan to eliminate them. Be aware of the main potential hazards in construction sites:

- Electrocution
- Falls
- Caught-between or caught-in
- Struck-by

If workers are carrying out their work without the proper protective equipment, identify the problem and let them know. If workers are struggling to complete certain tasks safely, prioritize on the specific issue in your training program.

Before any work commences, you should always check construction equipment, tools and machines in the construction site to ensure they're safe for use. For instance, conducting proper planning and staging before starting the day ensures that employees have the right tools and equipment they need for their work.

Use Clear Signage

It's important to use clear signage so that all construction site safety procedures are known, including a 24-hour emergency number and clear directions to the site office. Visible signage helps workers remember and understand safety protocols that need to be followed at all times. There should be clear signage for site amenities as well as first aid and emergency fire equipment.

Site Security

Ensure proper construction site security. Restricted site access is not just about preventing equipment theft or damage. You should have security measures in place that restrict access to the work site outside of working hours to protect workers or any other person from potential construction hazards. Strict safety and security protocols must always be followed.

Entry and Exit Points

Construction sites must also have separate entry and exit points for vehicle access and heavy machinery to ensure safety at high-traffic areas in the construction site.

Provide Proper Training

Training is a key part of ensuring workplace safety in all industries. Many project managers assume that all workers are aware of the construction site safety procedures of a working site. Failing to provide training to workers, whether working only for a few days or months to come, is one of the contributing factors to rising cases of injuries and fatalities in construction sites.

Develop a Simple but Effective Training Plan

Based on worksite analysis, develop a simple training plan for your workers. It’s advisable to have more than one category. E.g.

- Safety training on new equipment
- Safety training for new workers
- Safety training refresher courses for existing workers
- Safety training updates for all employees

Your training plan should prioritize on the most common mistakes, safety risks and incidents that you’ve noted in a specific area. The training program should be simple but effective.
Provide Training in an Easy Format

It’s one thing to offer training and another to offer it in an easy-to-understand format. Workers will be more engaged if they can understand the training you’re offering. Whether you’re offering training to address certain violations or on construction site safety procedures for a new construction project, you should deliver training in an accessible and flexible model.
You can use a learning management system to deliver short and precise courses that can be accessed online on any device so that workers can access them anywhere and at any time.

Tailor Your Training for Your Workers
It’s common to find construction workers speaking multiple languages in construction sites across the United States. Even though all your workers may speak some English, you should tailor your training program to fit all your workers. That’s why adopting a learning management system that you can develop and modify courses to fit your workers’ needs is recommended.

For one, you can create training courses in different languages, or you can have specific courses for specific workers like those using heavy machinery or working at height.

Train Workers on First Aid
In the construction industry, you’re required to have at least one qualified first aid officer per 25 workers. On top of that, it’s best to train your workers on basic first aid in case of an emergency. First aid kits and equipment must also be provided and placed in easily accessible areas in the construction site.

Supply Workers with Personal Protective Equipment (PPE)
As part of construction site safety procedures, all construction workers should be provided with the proper personal protective equipment and clothing. If you’re a worker and don’t have the right protective clothing or gear, you have the right to demand them from the people in charge or your employer. Here are some of the PPE requirements for construction sites.
Minimum PPE requirements for Construction Sites

- A helmet has to be supplied and worn at all times at the construction site
- Safety glasses must be provided to protect workers against debris in the air
- Safety/high-visibility vests must be provided and worn to keep workers visible
- Protective gloves should be supplied and worn to protect against cuts
- Proper clothing is a must for worker protection both indoors and outdoors
- Anti-slip footwear is also necessary

Additional PPE Requirements

- Hearing protection must be worn near any tool, machine or equipment that produces loud noises
- Respiratory protection is needed to protect against dust and other air contaminants
- Face shields are a must for welding operations and other debris/spark producing operations
- Safety harnesses must be used as a safety procedure to prevent falls

Quality, well-fitting and comfortable personal protective equipment and gear must be provided to construction workers. The gear and equipment should be stored properly after use and be inspected and maintained on a regular basis.

Promote and Enforce Good Practices

In every working environment, promoting and enforcing good practices and construction site safety procedures plays a huge role in ensuring safety for everyone. Ensure that the top management, site supervisors, and even workers are enforcing rules, observing working protocols and encouraging positive behavior.

Empower Workers to be Part of the Safety Program

You should also encourage your workers to be part of the construction site safety program. They can contribute by offering ideas on improving their own safety. Encourage workers to report safety concerns and risks to supervisors and project managers. The management is expected to take immediate action on any reported hazards. Most incidents can be easily avoided if someone speaks up, so remind workers to be open when they see something.

Don't Become Complacent

Construction sites present new safety challenges every other day. You must be vigilant in maintaining safety at all times. For instance, good site housekeeping practices like cleaning up working areas after a day's work can help avoid trips and falls that could cause injuries. If there is a damaged or broken fence, have it fixed to protect workers.

Environmental Conditions

Let your workers know the right time to work and when to stop working due to environmental conditions. Extreme weather conditions can easily cause safety hazards in construction sites. You should have in place clear construction site safety procedures for workers to follow in the event of an emergency.

Minimize and Manage Risk

Due to the nature of working at construction sites, it's hard to eliminate all safety risks. While enforcing good practices in construction sites may help prevent safety issues, it's always best to minimize and manage risks in construction sites. This can be done by regularly conducting safety audits and having in place protocols to report, evaluate and address potential hazards.

Ensure Proper Material Handling and Storage

All personnel working at a construction site should be aware of the proper material handling and storage procedures. For manual material handling, the expected lifting techniques should be made clear to avoid injuries. For handling of mechanical materials, operators need

to be aware of the weight lifting capacity of equipment like cranes and forklifts to avoid potential accidents.
All construction materials and equipment should be stored properly when not in use to prevent materials damage, accidents or injuries. Ensure safe loading limits for materials stored inside a building. All passageways should be kept clear for workers.

11. **List down the factors which affect the selection of construction equipment.**

Most of the construction projects involve laborious work which is to be handled by men and the equipment designed for doing the work undersigned.

It is difficult for workers to accomplish all things in a project and so there comes the need for machines particularly the construction equipment (machinery) that is widely used nowadays almost everywhere in the world.

For speedy and economic construction of a project, proper choice of equipment is of preliminary importance for civil engineers. The versatile range of equipment available commercially involves the decision of people. There are few basic things that are considered in selection of suitable equipment. They are as follows:

Use of Available Construction Equipment:
Where the full utilization of new equipment for its entire working life is not foreseen, or its utilization on further projects is uncertain, it may be desirable to use existing old equipment even if its operation is somewhat more expensive. The depreciation cost of the new machine is likely to be high, and this would raise the owning cost of the equipment and thus the unit cost of work.

Suitability for Job Conditions:
The equipment chosen should suit the conditions of the job, soil, valley, working conditions and climate of the region.

Uniformity in Type:
A minimum number of types should be acquired so that there is uniformity in the type of equipment on a job. A common type of engine should be selected for the different types machines such as excavators, dump trucks, tractors and scrapers that are on the project.

Size of Construction Equipment:
Larger equipment gives higher output on full load, but its cost of production on part load is usually greater than that of smaller units working on full load. Larger equipment needs correspondingly larger size of matching units, and shutting down of one primary unit may render several other large units idle.

Transportation to works is generally difficult and costly. Servicing, maintenance and repair facilities have to be greater for larger units. However, larger machines are usually more sturdy and suitable for tough working conditions.

It is desirable to have equipment of same size on the project. With standbys, the cost of larger size standby equipment is more than that of smaller size.

Use of Standard Construction Equipment:
Standard equipment is commonly manufactured and is available. Such equipment is manufactured in large numbers and so readily available and moderately priced. Spare parts of standard equipment are easily available and are less costly. After the work is over, disposing off standard equipment and its spare parts is generally easier than disposing off non-standard or specialized equipment.

Unit Cost of Production:
The economics of equipment is one of the most important considerations in the selection of equipment.

When calculating owning cost, all items of expenses, like freight, packing and forwarding, insurance, erection, commissioning, etc. should be included with the price paid to the supplier.

Country of Origin:
For imported equipment, it is preferable to import from a soft currency rather from a hard currency area, to save foreign currency reserves.

Availability of Spare Parts:
The availability of spare parts at reasonable costs during the entire working life of the equipment should be ensured while selecting a particular type or make of equipment, especially of imported equipment. Downtime due to shortage of spare parts commonly accounts for long idle periods during the working life of equipment. If specialists are needed, their availability should also kept in mind.

Versatility:
The machine selected should, if possible, be able to do more than one function and should be inter-convertible wherever possible.

Selection of Manufacturer:
It is good to have equipment of the same manufacturer on a project as far as possible and to have minimum number of different makes of equipment. The quality and commitment of local dealers is important. They should be sincere and capable of extending prompt after sales service.

Suitability of Local Labour:
The locally available operators and technicians should be able to handle the equipment selected. A special equipment may have excellent performance but it may be difficult to handle it through available know-how.

Adaptability for Future Use:
If the machine is required to work for only a part of its useful life then possibility on of disposing it off or its employment some other job should be considered. Obsolescence of the machine should not be overlooked.

12. **What is prefabrication? What is the scope of prefabricated system of building construction in India?**

Answer:
Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. The term is used to distinguish this process from the more conventional construction practice of transporting the basic materials to the construction site where all assembly is carried out.

The term prefabrication also applies to the manufacturing of things other than structures at a fixed site. It is frequently used when fabrication of a section of a machine or any movable structure is shifted from the main manufacturing site to another location, and the section is supplied assembled and ready to fit. It is not generally used to refer to electrical or electronic components of a machine, or mechanical parts such as pumps, gearboxes and compressors which are usually supplied as separate items, but to sections of the body of the machine which in the past were fabricated with the whole machine. Prefabricated parts of the body of the machine may be called 'sub-assemblies' to distinguish them from the other components.

“Prefabrication will be a key enabler in mission “Digital India” and play a vital role in all infrastructural development.” ‘Building it brick by brick’ to ‘build it before you build it’, transformative technologies being led primarily by Prefabrication are now beginning to blur lines between the construction and manufacturing sectors in India. Slated to have the world’s third largest construction industry by 2025, India is witnessing a high uptake of modular techniques with its construction sector slowly transforming and behaving more like the business of manufacturing.

The last two decades are testament to the fact that from Supercomputing to Space and Pharma to Biotech, India has always taken the lead to brace innovation and tech adoption be it any sector or industry. Today, the way things are being made is causing widescale disruption across industries including construction of buildings and infrastructure – Future of Manufacturing Things (FoMT). Riding the prefabrication wave and clocking a CAGR of 7-8 per cent, the Indian construction sector today stands at the threshold of a huge opportunity to leapfrog into FoMT and prefabrication or modular construction remain at the heart of it.

Process of Manufacturing Buildings
As a manufacturing process, Prefabrication is a method of construction that includes assembling components of a structure at a separate production site and then transporting complete or partial assemblies to the actual site where the structure is being constructed. It is basically a combination of superior design with modern high-performance components and quality-controlled manufacturing procedures. Therefore, prefabrication not just ensures faster completion of a project but also brings down its overall cost. From residential high rises in New York to low cost hotels in Europe, Prefabrication allows engineers to blur lines between design and manufacturing process and create products for the future. Over the next few years, India would feature amongst the fastest-growing countries in terms of construction output, making technology intervention a key component of this.

Barriers & Challenges in Adoption of Prefab

Globally, prefabrication has already seen significant adoption by the construction sector – Burj Khalifa in Dubai and the Sydney Opera House being two of the finest examples. According to a report published by Technavio, a global technology research and advisory firm, the global prefabricated construction market is expected to grow at a CAGR of 6-7 per cent until 2020. However, in India the uptake of modular technologies continues to remain slow and prefabricated buildings comprise only 1 per cent of India's $100 Billion Real Estate Market. The main reason for this being that Prefabrication as a technology is still battling a mindset blockade in India, with most developers averse to investing in modular methods of construction and hesitant to incorporate prefabrication in their new and ongoing projects.

The Indian construction marketplace today stands plagued by constricted space, overcrowding, delay in completion and clearance snarls. In addition to this the sector continues to be labour intensive and heavily reliant on traditional construction practices. While, upfront the cost of switching over to prefab is a lot higher but in the long term it is prefabrication that can give developers the benefit of time, safety and quality, enabling them to churn out buildings faster and capture the demand.

Rise of BIM, Green Buildings and Lean Construction

The surge of prefab and modular as a 'trend' is significantly tied to the rise of advanced technology platforms such as Building Information Modelling – BIM. The application of BIM in prefabricated construction has multiple benefits – while it helps to ease the design flow it also provides data-centric information based on design, specification and construction issues. Additionally, BIM can also enable developers to track time, errors, and cost. Also, the industry recognizes contribution of modular technologies in meeting green goals. Apart from waste reduction benefits, working off-site reduces habitat and site disturbance; protects raw materials from rain and extreme weather contributing to the development of a more adaptive building. Similarly, lean construction, the new buzzword these days mainly focusses on eliminating waste, leading to significant savings in both schedules and budgets.

Confluence of Manufacturing and Construction

The uptake of transformative technologies was slow in the initial years as majority of tech innovation was focused on manufacturing construction equipment but over the last few years it is the process of construction and design that has become the focal point. It is now officially the age of manufactured buildings where constructing 3 floors a day or 57 floors in 19 days as built by China's Broad Sustainable Building (BSB) company is no longer an aspirational feat but a target easily achievable.

Most of the delay in construction happens at Stage – 1 due to faulty design. 3D Printing and designing everything on the cloud takes care of that problem with most of the iteration happening on the cloud itself. Big data and cloud computing are expected to have an immense impact on the design and management of construction projects. More frequent use of 3D printing technology, increased applications coupled with various kinds of materials and project types could completely change the process of physical delivery in coming years.

The next decade belongs to prefabrication with the Indian construction sector expected to expand to a size of $1 trillion and contribute over 15 per cent to the overall GDP. The government's ambitious project of building 20 million affordable houses and 98 smart cities by 2022 will see the construction and manufacturing industries confluence further to create an ecosystem for increased innovation and technology adoption. Thus, prefabrication will be a key enabler in mission “Digital India” and play a vital role in all infrastructural development.

13. **Explain the design principles of the prefabricated system of building construction.**

Answer:

The Main reasons to choose Precast Construction method over conventional in method:

- Economy in large scale project with high degree of repetition in work construction.
- Special requirement in finishing.
- Consistency in structural quality control.
- Fast speed of construction.
- Constraints in availability of site resources (e.g. materials & Laborites)
- Other space & environmental constraints.
- Overall assessment of some or all of the above factors which points to the superiority of adopting precast construction over convention method.

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5. Constraints in availability of site resources ce.g.materials & labour etc..
6. Other space & environmental constraints.
7. Overall assessment of some or all of the above factors which points to the superiority of adopting precast construction over conventional method

The following details gives the cost implications of precast construction & conventional in situ method.

Prefabrication Elements :

1. Flooring / Roofing system.
2. Priciest Beams
3. Precast Columns
4. Precast walk panels.
5. recast Stabs.

Classification: The Prefabrication is classified as follow from the view of degree of Precast construction.

1. Small prefabrication
2. Medium Prefabrication
3. Large Prefabrication

4. Cast in Site Prefabrication
5. Off-Site (or) factory Prefabrication
6. Open system of prefabrication
7. Closed system of prefabrication
8. Partial prefabrication
9. Total prefabrication

Small Prefabrication: The first 3 types are mainly classified according to their degree of precast elements using in that construction for eg.: brick is a small unit precast and used in building. This is called as small prefabrication. That the degree of precast element is very low.

Medium Prefabrication: Suppose the roofing systems and horizontal members are provided with pretested elements those construction are known as medium prefabricated construction here th degree of precast elements are moderate.

Large Prefabrication: In large prefabrication most of the members like wall panels, roofing / flooring Systems, beams and columns are prefabricated. Here degree of precast elements are high.

Cast - in - site prefabrication : OFF - site (factory) prefabrication : One of the main factor which affect the factory prefabrication is transport. The width of mad walls, mode of transport, vehicles are the factors which prefabrication is to be done on site on factory.

Suppose the factory situated at a long distance from the construction site and the vehicle have to cross a congested traffic with heavy weighed elements the cost in side prefabrication is preferred even though the same condition are the cast in site prefabrication is preferred only when number of houses and more for small elements the conveyance is easier with normal type of lorry and trailers. Therefore we can adopt factory (or) OFF site prefabrication for this type of construction.

Open system of prefabrication: In the total prefabrication systems, the space framers are casted as a single unit and erected at the site. The wall fitting and other fixing are done on site. This type of construction is known as open system of prefabrication.

Closed system of prefabrication: In this system the whole things are casted with fixings and erected on their position.

Partial prefabrication: In this method of construction the building element (mostly horizontal) required are precast and then erected. Since the costing of horizontal elements (roof / floor) often take there time due to erection of from work the completion of the building is delayed and hence this method is restored. In most of the building sites this method is popular more.

This method is efficient when the elements are readily available when the building reached the roof level. The delay caused due to erection of formwork, delay due to removal eliminated completely in this method of construction Suitable for any type of building provided lifting and erection equipments are available.

Total Prefabrication: Very high speed can be achieved by using this method of construction. The method can be employed for frame type of construction or for panel type of or the total prefabrication can be on site or off-site. The choice of these two methods depend on the situations when the factory produced elements are transported and erected site we call if off-site prefabrication. If this method is to be adopted then we have a very good transportation of the products to site. If the elements are cast near the building site and erected, the transportation of elements can be eliminated, but we have consider the space availability for establish such facilities though it is temporary. The choice of the method of construction also depends on the following;

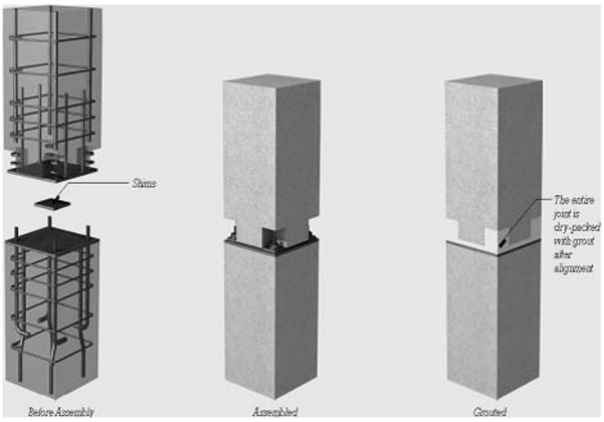
1. Type of equipment available for erection and transport.
2. Type of structural scheme (linear elements or panel)
3. Type of connections between elements.
4. Special equipment devised for special method construction.

14. **Discuss the various prefabricated elements with sketch.**

Answer:

Prefab Building Components

Some of the prefabricated components are as explained below



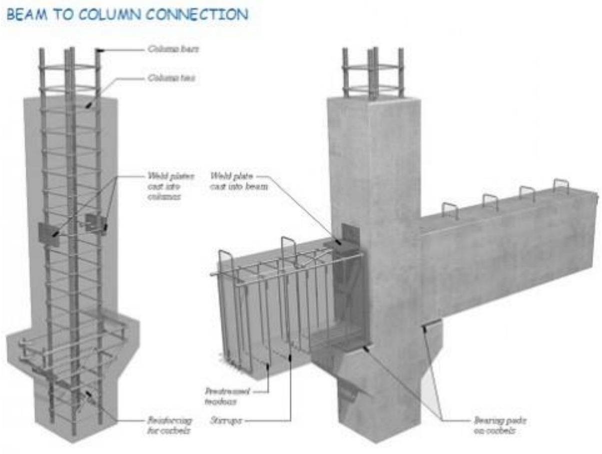
Prefab Column to Column Connection

Columns: – A column is a vertical member carrying the beam and floor loadings to the foundation. It is a compression member and therefore the column connection is required to be proper. The main principle involved in making column connections is to ensure continuity and this can be achieved by a variety of methods.

Beams: – Beams can vary in their complexity of design and reinforcement from the very simple beam formed over an isolated opening to the more common encountered in frames where the beams transfer their loadings to the column. Methods of connecting beams and columns are

- A precasting concrete haunch is cast on to the column with a locating dowel or stud bolt to fix the beam.
- A projecting metal corbel is fixed to the column and the beam is bolted to the corbel.
- Column and beam reinforcement, generally in the form of hooks, are left exposed. The two members are hooked together and covered with insitu concrete to complete the joint. This is as shown in the figure.

Waffle unit for flooring / roofing: – These are suitable for roofs / floors spanning in two directions. They are laid in a grid pattern. These units are cast in moulds. The saving achieved is not much. Also Shuttering are complicated and costly. Time consumption for construction is less



Prefab Column to Beam Connection

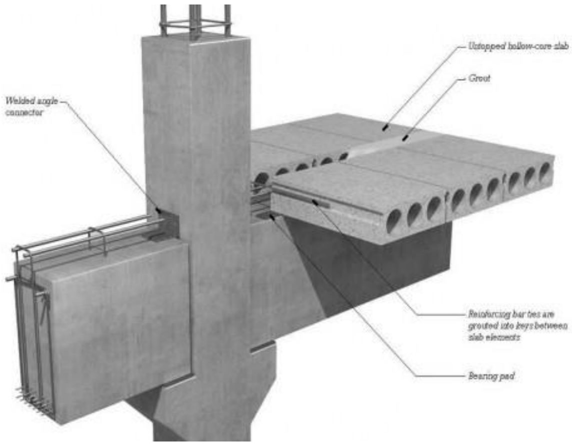
Advantages and Disadvantages

Advantages:

1. Saving in cost, material, time & manpower.
2. Shuttering and scaffolding is not necessary.
3. Installation of building services and finishes can be done immediately.
4. Independent of weather condition.
5. Components produced at close supervision .so quality is good
6. Clean and dry work at site.
7. Possibility of alterations and reuse
8. Correct shape and dimensions and sharp edges are maintained.
9. Very thin sections can be entirely precast with precision.

Disadvantages:

- Handling and transportation may cause breakages of members during the transit and extra provision is to be made.
- Difficulty in connecting precast units so as to produce same effect as monolithic. This leads to non-monolithic construction.
- They are to be exactly placed in position, otherwise the loads coming on them are likely to get changed and the member may be affected.
- Disadvantages:
- High transport cost
- Need of erection equipment
- Skilled labour and supervision is required.



Prefabricated Slab To Beam Connection

The prefab components and prefab structures eliminate space and time over conventional constructions. Although prefabrication is employed to a large extent in a wide variety of countries, in India, construction industry, in spite of its expansion continues to adopt same conventional methods. The root of the economic problem is the fact that the majority of the households do not have the confidence needed to construct prefab houses. These structures are easy to erect as it is light material. This type of prefab buildings were constructed in earthquake prone areas of Lature and Gujarat.

15. What are the disadvantage and advantage of Prefabrication technique?

Answer:
Advantages of Pre-Fabricated Buildings

Prefabricated homes can be ordered and transported straight to your block. You can organize the stumping and plumbing and electrical connections or have it pre-ordered into the overall package.

Prefabricated homes cause less damage to the environment than conventional brick homes. They can be mass-produced or fabricated to your design and are quick to build so it will save you rent as brick homes tend to be dragged out with different contractors' being involved.

They will cost a lot less, than a double brick home by far. They can be insulated to reduce the cost of heating and cooling. Not only that they are environmentally friendly.

The real beauty of one of these is if you have a really bad neighbor you can up and take your home and chattels to another town without any problems.

- As it saves time
- It saves money and labor
- Enables money and standardization.
- It enhances aesthetic appeal.
- It is lightweight and easy to transport.
- Easy to installing and maintaining: i.e. rust, fire, and pest retardant and insulated.
- It is re-locatable and eco-friendly.

The disadvantages of prefabricated homes

The cost of your prefabricated home will depend on the size your home will be put on. Site costs will vary from block to block. If you are doing the stumping etc yourself then that is not a problem. If they need to factor that into the price they will need to make varying changes to prices due to the level and position of the block where the prefabricated home will be built.

Your choice of prefab metal buildings Canada home will be affected by your particular budget. Low-cost designs may suit those on a tight budget. Then if you can afford the better styles, then the price may not affect your decision.

The better high-quality designs are made for the higher-income families and could be out of your price range.

Prefabricated homes are improving like other forms of buildings and the main advantage of a prefabricated home is the potential to reduce the harmful impact on our environment. This is one of the world's biggest concerns these days.

17. What is the role of standardization in prefabrication?

Answer:

Standardization may be defined as adoption (selection) of generally accepted procedures, dimensions, materials, parts, principles, workplace arrangements for designing a product or facility. Standardization helps in reducing the varieties in size of similar components to facilitate assembly at the site to make the components interchangeable between different manufacturers. In prefabrication plant, standardization mainly focuses on making standards in manufacturing processes, materials, fits and tolerance. Standardization makes it is possible to manufacture interchangeable parts.

The established standards are recorded for the future reference in the form of formulae, descriptions, details, drawings and models. Standardization helps for easy communication between the supplier and customer of prefabrication parts and also it reduces the conflict between supplier and customer.

In the prefabrication industry, some of the standardized components are doors, stairs, windows, walls, floors, roof trusses, columns, beams and even entire building. Co-operation required from designers, suppliers and builders is essential for standardizing the prefabricated components. Prefabricated parts are suitable only for large volume required prefabricated components with a minimum number of standard sizes. Standardization is nothing but making the use of guidelines for the production of interchangeable parts. It helps to sell the products in global marketing. Standardization not only helps the manufacturer but also benefited by customers in terms of choice, availability and interchangeability. It establishes the limits within which the products or components must fall. Then only the parts will be useful, if the parts fall outside the limit, then the parts are said to be not standard/interchangeable.

Quality control and testing are used to measure the achievement of standards. Standardization promotes clear communication within and among the organization, it can also lower the cost of the product, labour and repair. National and international organizations play an important role for establishing the standardization. Standardization promotes the chances for globalization of business.

Standard implies the component or part fit for any particular use. It helps the organization to focus on their attention on delivering excellence to customer and compete globally. Components are standardized based on size, weight, function, shape, material.

Levels of standardization:

Compatibility (Designed to work with another system without modification), inter changeability (Capability of the part replacing the other without the need for attention and adjustments), commonality (Degree of similarity between parts or system that allows inter changeability), reference (A source of information is used for future reference).

Advantages of standardization:

1. Able to reduce the number of verities of components, need to maintain large inventories.
2. Lowering the installation and starting cost, down time, maintenance cost.
3. Enabling the interchangeability of parts.
4. Improving the design with less effort, communication.
5. Provides opportunity to use specialized machines.
6. Reducing the erection and assembly time, additional alterations.
7. Increase the chances for global marketing, productivity.

Unit 2: Value Analysis

18. Define following terms
    a. Indirect cost
    b. Direct cost

Indirect costs:

It represents the expenditure on those items which are shared by more than one activity and cannot be directly allocated to individual activity of a project.

Indirect costs of a project are those expenditures which cannot be apportioned or clearly allocated to the individual activity. These include the expenditure related to the administration and establishment charges, overhead, supervision, loss of revenue etc.

Indirect cost rises with increased duration. Relationship between indirect cost and project duration is shown in Fig. 29.1. This relationship would be represented by a straight line, with a slope equal to daily overhead.

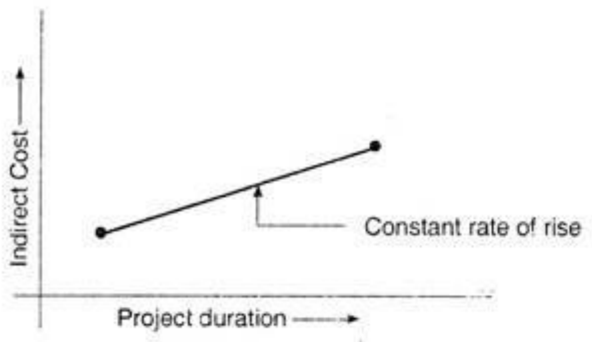


Fig. 29.1. Relationship between indirect cost and project duration.

When there is a loss of profits due to inability to meet the demand or some penalty due to delay, a corresponding cost increase (known as outage loss), must be added to the cost of overheads.

<u>Direct cost:</u>
It represents the expenditure which can be allocated to different activities in a project, like manpower, material etc.

19. For a network shown in Fig. 29.6, Normal time, Crash time, Normal cost and Crash costs are given in the table. Contract the network by crashing it to optimum value and calculate the optimum project cost. Indirect cost is given as Rs. 100 per day.

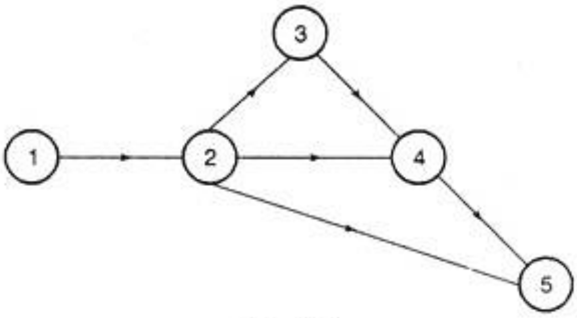


Fig. 29.6.

Solution:
By drawing the network with normal duration, we see (from following figure) that critical path is 1-2-3-4-5.

The project duration is, therefore, equal to 18 days. On this path, Crash time = 13 days (from given data on critical path).

Activity	Normal		Crash	
	Time in days	*Cost in Rs.*	*Time in days*	*Cost in Rs.*
1-2	3	300	2	400
2-3	6	480	4	520
2-4	7	2100	5	2500
2-5	8	400	6	600
3-4	4	320	3	360
4-5	5	500	4	520

Normal cost and crash cost can now be calculated by adding values of all the activities, given in the table.

Normal cost = Rs. 4100 and Crash cost = Rs. 4900.

To construct the network, in first stage we should identify those activities on critical paths, which have cost-slopes less than the indirect cost. For this purpose cost slopes are calculated hereunder

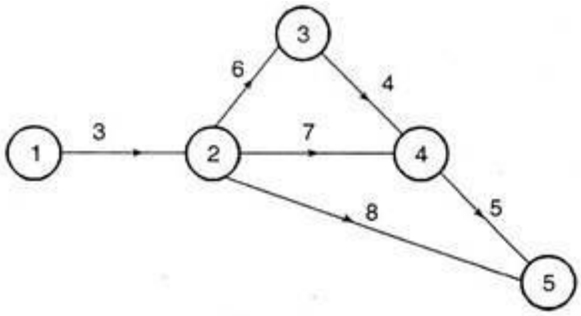


Fig. 29.7.

Activity	Normal		Crash		Cost-slope		
	Time in days	*Cost in Rs*	*Time in days*	*Cost in Rs.*	ΔC	ΔT	$\frac{\Delta C}{\Delta T}$
1-2	3	300	2	400	100	1	100
2-3	6	480	4	520	40	2	20
2-4	7	2100	5	2500	400	2	200
2-5	8	400	6	600	200	2	100
3-4	4	320	3	360	40	1	40
4-5	5	500	4	520	20	1	20

Critical path activities 2-3 and 4-5 have least cost slopes. Therefore, these activities are first crashed and network is again drawn (Refer Fig. 29.8).

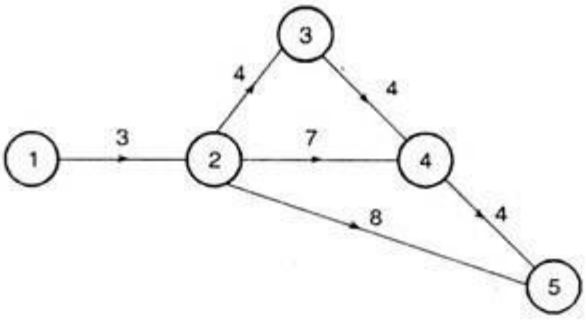


Fig. 29.8.

This network shows that, after crashing activities 2-3 by 2 days and 4-5 by 1 day, the critical path is same, i.e. 1-2-3-4-5 and have 15 days duration.

Now in second stage, the least cost slope in remaining activities is for activity 3-4 on the critical path.

By crashing this activity, we see that two paths become critical path, 1-2-3-4-5 and 1-2-4-5 as shown in Fig. 29.9 below:

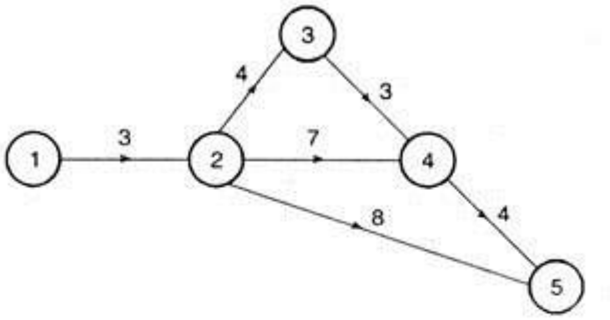


Fig. 29.9.

Now we see that after crashing activities 2-3, 4-5 and 3-4, there is no other activity on both the critical paths which have cost slopes less than indirect cost. This shows that this is the optimum network and hence optimum project duration is 14 days.

Total direct project cost for this optimum duration

= Direct cost for all activities on the network

= Cost on activities 1-2; – 2-3; 2-4; 2-5; 3-4; 4-5

= 300 + 520 + 2100 + 400 + 360 + 520 = Rs. 4200.

And indirect cost for 14 days @ Rs. 100 per day = Rs. 1400

Total project cost after crashing = 4200 + 1400 = 5600.

Whereas total cost with all normal activities was (i.e. without crashing)

= Normal cost + Indirect for 18 days = 4100 + 1800

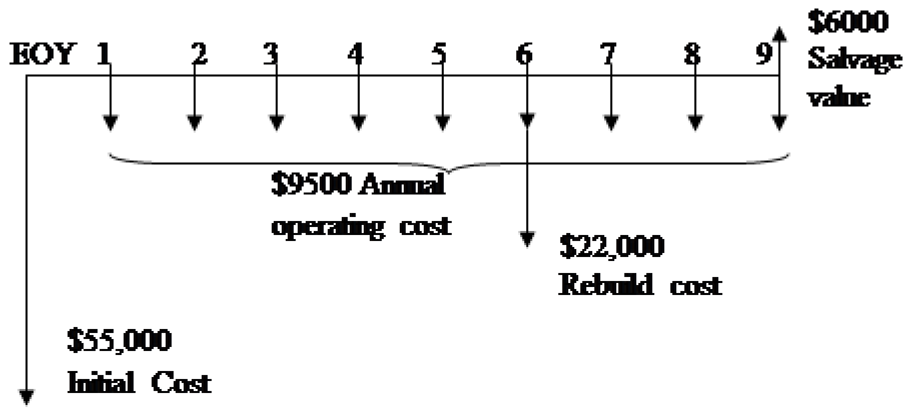
= Rs. 5900.

Thus the optimum cost of the project is Rs. 5600. By crashing to optimum value, we could save Rs. 300. If we further crash the project beyond optimum value, the project shall become costlier.

20. Explain cash flow diagram and its importance with simple example.

Cash flow diagrams visually represent income and expenses over some time interval. The diagram consists of a horizontal line with markers at a series of time intervals. At appropriate times, expenses and costs are shown.
Note that it is customary to take cash flows during a year at the end of the year, or EOY (end-of-year). There are certain cash flows for which this is not appropriate and must be handled differently. The most common would be rent, which is normally taken at the

beginning of a cash period. There are other pre-paid flows which are handled similarly. For example, consider a truck that is going to be purchased for $55,000. It will cost $9,500 each year to operate including fuel and maintenance. It will need to have its engine rebuilt in 6 years for a cost of $22,000 and it will be sold at year 9 for $6,000. Here is the cash flow diagram:



Note that the initial cost, the purchase price, is recorded at the beginning of Year 1, sometimes referred to as end-of-year 0, or EOY 0. Also, operating and maintenance costs actually will occur during a year, but they are recorded at EOY, and so forth.

21- 24. **Common data to question (21) to (24):-**
The initial cost of a piece of construction equipment is Rs.30,00,000 having a useful life of 10 years. The estimated salvage value of the equipment at the end of the useful life is Rs.450,000.

21. The book value of the construction equipment at the end of 5th year using Straight -line method is

Solution:
Given: Original cost of equipment (V) = Rs. 30, 00,000
Salvage value of equipment (Vs) = Rs. 4, 50,000
Useful life (n) = 10 years
Calculate:
Annual depreciation and book value of the construction equipment at the end of 5thyear i.e. d5 and BV5 respectively.

Using straight line method-
As in this method annual depreciation d1= d2 =d3=…=d.
Therefore,
Annual depreciation (d) =d5= (Original value of equipment (V)-Salvage value of equipment (Vs))/service life (n)
d=**d5**= (3000000-450000)/10 = **Rs.2,55,000**
Book Value (V5) after 5 years =V-d*a = 3000000-255000*5 = **Rs.1,72,5000**

22. The book value of the construction equipment at the end of 5th year (BV5) and depreciation (d5) for 5th year using Double-declining balance method are:

Solution:
Given: Original cost of equipment (V) = Rs. 30, 00,000
Salvage value of equipment (Vs) = Rs. 4, 50,000

Useful life (n) = 10 years
Calculate:
Annual depreciation and book value of the construction equipment at the end of 5thyear i.e. d5 and BV5 respectively.

Using Double-declining balance method
Amount to be depreciated = (V-Vs) = 3000000-450000= Rs.2550000
Using straight line depreciation method
Annual depreciation = 2550000/10= Rs.255000 per year
Annual depreciation (in terms of fraction of original cost) = 255000/3000000 =0.085
Thus for double decline method annual depreciation will be =2*0.085 =0.17
Thus for 1st year depreciation amount will be = 3000000*0.17= Rs. 510000
Book value at the end of 1st year (V1) = (3000000-510000) = Rs. 2490000
For 2nd year depreciation amount will be= Recent Book value*0.17 =2490000*0.17 = Rs.423300
Book value at the end of 2nd year (V2) = (2490000-423300) = Rs. 2066700
For 3rd year depreciation amount will be= Recent Book value*0.17 =2066700*0.17= Rs.351339
Book value at the end of 3rd year (V3) = (2066700-351339) = Rs. 1715361
For 4th year depreciation amount will be= Recent Book value*0.17 =1715361*0.17= Rs.291611.37
Book value at the end of 4th year (V4) = (1715361-291611.37) = Rs. 1423749.63
For 5th year depreciation amount will be= Recent Book value*0.17 =1423749.63*0.17= **Rs.242037.44**
Book value at the end of 5th year (V5) = (1423749.63-242037.44) =**Rs. 1181712.19**

23. Determine the book value (BV5) of the construction equipment at the end of 5th year and depreciation (d5) for 5th year using Sum-of-the-years-digits method?

Solution:
Given: Original cost of equipment (V) = Rs. 30, 00,000
Salvage value of equipment (Vs) = Rs. 4, 50,000
Useful life (n) = 10 years
Calculate:
Annual depreciation and book value of the construction equipment at the end of 5thyear i.e. d5 and BV5 respectively.

Using Sum of years digits method
Depreciable cost = Rs.3000000-Rs.450000=Rs.2550000
Sum of the years' digits for n years = 1 + 2 + 3 + ... + (n-1) + n
= (n+1) x (n / 2) = (10+1)*10/2= 55
or Sum of the years' digits = 1+2+3+…+10 = 55
Depreciation for 1st year = (2550000) x 10/55 = 10*46363.63636=Rs.463636.36
Book value at the end of 1st year= (3000000-463636.36) = Rs. 2536363.64 Depreciation for 2nd
year= (2550000) x 9/55 =9*46363.63636=Rs.417272.73
Book value at the end of 2nd year= (2536363.64-417272.73) = Rs. 2119090.91
Depreciation for 3rd year = (2550000) x 8/55 = 8*46363.63636=Rs. 370909.09
Book value at the end of 1st year= (2119090.91-370909.09) = Rs. 1748181.82
Depreciation for 4th year= (2550000) x 7/55 = 7*46363.63636=Rs. 324545.45
Book value at the end of 1st year= (1748181.82-324545.45) = Rs. 1423636.37
Depreciation for 5th year = (2550000) x 6/55 = 6*46363.63636=**Rs. 278181.82**
Book value at the end of 5th year= (1423636.37-278181.82) = **Rs. 1145454.54**

24. Determine accumulated depreciation at the end of 5th year using Sinking fund method, if interest rate is 8.2 % per year?

Solution:
Given: Original cost of equipment (V) = Rs. 30, 00,000
Salvage value of equipment (Vs) = Rs. 4, 50,000
Useful life (n) = 10 years
Calculate:
Annual depreciation and book value of the construction equipment at the end of 5thyear i.e. d5 and BV5 respectively.

Interest rate (i) = 8.2 % per year =0.082
V-Vs= 2550000, is the depreciable cost which should be accumulated at the end of 10th year or it can be called the future value at the end of 10th year which needs to be generated through constant equal installments (R). R is the annual equal amount of depreciation.

$$R = (V - V_s) * [\frac{i}{(1+i)^n - 1}]$$

Annual depreciation=R = 2550000*0.0684 = Rs. 174420
Book value at the end of 1st year = (3000000-174420) = Rs. 2825580
Interest earned at the end of 2nd year = 174420*0.082= Rs.14302.44
Increased in fund value for 2nd year= (174420+14302.44) = Rs. 188722.44
Accumulated depreciation at the end of 2nd year = (174420+188722.44)
= Rs. 363142.44
Book value at the end of 2nd year = (2825580-188722.44) = Rs. 2636857.56
Interest earned at the end of 3rd year =363142.44*.082 =Rs. 29777.68

Increased in fund value for 3rd year= (174420+29777.68) = Rs. 204197.68
Accumulated depreciation at the end of 3rd year = (363142.44+204197.68)
= Rs. 567340.12
Book value at the end of 3rd year = (2636857.56-204197.68) = Rs. 2432659.88
Interest earned at the end of 4th year = 567340.12*.082 = Rs. 46521.89
Increased in fund value for 4th year= (174420+46521.89) = Rs. 220941.89
Accumulated depreciation at the end of 4th year = (567340.12+220941.89)
= Rs. 788282.01
Book value at the end of 4th year = (2432659.88-220941.89) = Rs. 2211717.99
Interest earned at the end of 5th year = 788282.01*.082 = Rs.64639.12
Increased in fund value for 5th year= (174420+64639.12) = Rs. 239059.12
Accumulated depreciation at the end of 5th year = (788282.01+239059.12)
= **Rs. 1027341.13**
Book value at the end of 5th year = (2211717.09-239059.12) = **Rs. 1972657.96**

25. **The original cost of a heat exchanger is Rs.1, 00,000. It has a useful life of 10 years. The estimated salvage value of the heat exchanger at the end of useful life is zero. Calculate the book value at the end of 3rd year, using repair provision method, if the repairs and maintenance charges together were estimated to be Rs. 18,000 during the lifetime of the equipment. And also determine the annual depreciation to be provided?**

Solution:

Given:
Original cost of heat exchanger (V) = Rs. 1,00,000
Salvage value of equipment (V_s) = 0
Useful life (n) = 10 years
Estimated total cost of repair= Rs.18000
Calculate:
Annual depreciation and book value of the heat exchanger at the end of 3rd year
Solution:
Annual amount to be provided for depreciation (d):
= [(original cost-salvage value) +Estimated total cost of repair]/expected useful life
= [(100000-0) +18000]/10 = **Rs.11800**
Book value at the end of 3rd year = V-a*d = 100000-3*11800 = **Rs. 64600**

26. There are two plans for a new godown construction for storage. We can either go in for a new concrete building (Plan-1) or have an extension to the existing building (Plan-2). The new concrete building is estimated to cost Rs. 60,000 with a permanent life. Its annual maintenance, insurance and tax cost is expected to be Rs. 500.The extended building will cost Rs. 20,000 and annual maintenance, insurance, and tax cost being Rs. 800. Both plans have life spans of 20 year. Assuming 10% as an attractive return, and using the annual cost method, choose the correct statement-

Solution:

Given:

	Plan-1	**Plan-2**
Capital investment(Rs.)	60000	20000
maintenance, insurance, and tax cost per year(Rs.)	500	800
Useful life (years),n	20	20
Rate of return (%), i	10	10

Annual cost of the capital recovery is the annuity based on time value of money that one has to pay throughout the useful life, which will be equal to the capital investment at the start of the 1^{st} year.

Annual cost of capital recovery = Capital investment*i / [1-(1+i)$^{-n}$]

For Plan-1

Annual cost of Capital recovery =60000*0.1/[1-(1+0.1)$^{-20}$] = Rs.7047.58

For Plan-2

Annual cost of Capital recovery =20000*0.1/[1-(1+0.1)$^{-20}$] = Rs.2349.19

	Plan-1	**Plan-2**
Capital investment	Rs.60,000	Rs.20,000
Estimated useful life	20	20
Maintenance, insurance, and tax cost per year	Rs.500	Rs.800
Rate of return	10%	10%
Solution given below		
Annual cost of capital recovery	Rs.7047.58	Rs.2349.19
Total annual cost(annual cost of capital recovery + annual operating cost)	**Rs.7547.58**	**Rs.3149.19**

Decision: We should go in for Plan-2 in comparison to Plan-1 as its total annual cost is low.

27. A restaurant buys a wood-burning stove for Rs. 20,000. The stove has a lifetime of 4 years and a salvage value of Rs. 1500.What is the accumulated depreciation (D3) and book value (BV3) at the end of 3rd year by Sinking fund method, if annual interest rate is 9%?

Solution:

Given: Original cost of wood burning stove (V) = Rs. 20000

Salvage value of equipment (Vs) = Rs. 1500

Useful life (n) = 4 years

Calculate:

Accumulated Depreciation for 3rd year and asset value of the wood burning stove at the end of 3rd year

Interest rate (i) = 9 % per year =0.09

V-Vs=Rs. 18500, is the depreciable cost which should be accumulated at the end of 4th year or it can be called the future value at the end of 4th year which needs to be generated yearly investment of Rs. R. R is the annual equal amount of depreciation.

$$R = (V - V_s) * [\frac{i}{(1+i)^n - 1}]$$

Annual depreciation=R = 18500*0.2187 = Rs. 4045.37

Book value at the end of 1st year = (20000-4045.37) = Rs. 15954.63

Interest earned at the end of 2nd year = 4045.37*0.09= Rs.364.08

Increased in fund value for 2nd year= (4045.37+364.08) = Rs. 4409.45

Accumulated depreciation at the end of 2nd year = (4045.37+4409.45)

= Rs. 8454.82

Book value at the end of 2nd year = (15954.63-4409.45) = Rs. 11545.18
Interest earned at the end of 3rd year =8454.82*.09 =Rs. 760.93
Increased in fund value for 3rd year = Rs. 4806.30
Accumulated depreciation at the end of 3rd year = (8454.82+4806.3)
= **Rs. 13261.12**
Book value at the end of 3rd year = (11545.18-4806.30) = **Rs.6738.88**

Year	Annual Dep. Computed(Rs.)	Interest earned (Rs.)	Increase in fund value (Rs.)	Accumulated Depreciation (Rs.)	Book Value (Rs.)
0					20000
1	4045.37	-	4045.37	4045.37	15954.63
2	4045.37	364.08	4409.45	8454.82	11545.18
3	4045.37	760.93	4806.30	**13261.12**	**6738.88**
4	4045.37	1193.51	5238.88	18499.99	1500.00

28. Explain meaning of cash flow analysis. Discuss purpose of cash flow analysis. Also differentiate between cash flow for contractor and cash flow for owner.

Answer:

Definition: The amount of cash or cash-equivalent which the company receives or gives out by the way of payment(s) to creditors is known as cash flow. Cash flow analysis is often used to analyse the liquidity position of the company. It gives a snapshot of the amount of cash coming into the business, from where, and amount flowing out.

Description: As discussed cash flows can either be positive or negative. It is calculated by subtracting the cash balance at the beginning of a period which is also known as opening balance, form the cash balance at the end of the period (could be a month, quarter or a year) or the closing balance.

If the difference is positive, it means you have more cash at the end of a given period. If the difference is negative it means that you have less amount of cash at the end of a given period when compared with the opening balance at the starting of a period.

To analyse where the cash is coming from and going out, cash flow statements are prepared. It has three main categories – operating cash flow which includes day-to-day transactions, investing cash flow which includes transactions which are done for expansion purpose, and financing cash flow which include transactions relating to the amount of dividend paid out to stockholders.

However, the level of cash flow is not an ideal metric to analyse a company when making an investment decision. A Company's balance sheet as well as income statements should be studied carefully to come to a conclusion.

Cash level might be increasing for a company because it might have sold some of its assets, but that doesn't mean the liquidity is improving. If the company has sold off some of its assets to pay off debt then this is a negative sign and should be investigated further for more clarification.

If the company is not reinvesting cash then this is also a negative sign because in that case it is not using the opportunity to diversify or build business for expansion.

29. A machine was purchased two years ago at a cost of Rs. 2,00,000 to be useful for eight years with salvage value at the end of its life as Rs. 25,000. The annual maintenance cost is Rs. 25,000. The market value of the present machine is Rs. 1,20,000. Now, a new machine to cater to the need of the present machine is available at Rs. 1,50,000 to be useful for six years. Its annual maintenance cost is Rs. 14,000. The salvage value of the new machine at the end of its life is estimated to be Rs. 20,000. Using an interest rate of 12%, the decision regarding whether to continue services of existing equipment or replace it.

Solution:

Defender: P = 120000, F = 25000, n = 6, MC = 25000, i = 12%
CR(i) = (120000 – 25000) (A/P,12,6) + (25000x0.2) + 25000 = 51104
Challenger: P = 150000, F = 20000, n = 6, MC = 14000, i = 12%
CR(i) = (150000 – 20000) (A/P,12,6) + (20000x0.2) + 14000 = 48016
Since, CR(i) of challenger is lower than defender hence, existing machine should be replaced.

30. Discuss network crashing.

For any given activity a point will reach beyond which no further reduction in time will be possible irrespective of the resources spent on this activity. The time for the activity at which minimum cost is called normal time and the minimum time for the activity is called crash time. The cost associated with these times are called normal cost and crash cost respectively.

The total direct cost of the project can be determined by adding the direct costs of each individual activities. Initially, for all activities, normal time estimates are assumed and the total project duration is computed using the computational procedure.

If the project duration has to be reduced, then time of one or more activities has to be reduced. The activities selected should be such that the total project duration is reduced at the least cost. This process can be repeated till no further reduction in the project duration can be achieved.

The reduction in the project duration can be achieved by reducing the time requirement of few selected activities from their normal time, the maximum reduction in time possible for any activity being upto its crash time. This process of reducing the total project duration by reducing activity timing is known as crashing project network.

Crashing Procedure:

Crashing of a network can be done in following steps:

1. Critical path:

Find the normal critical path and identify the critical activity.

2. Cost slope:

Calculate the cost slope for the different activities by using the formula.

Cost slope = Crash cost-Normal cost/Crash time-Normal time

The cost slope indicates the extra cost required to expedite an activity per unit time.

3. Ranking:

Rank the activities in the ascending order of cost slope . The activity having the minimum cost slope have to be crashed first, crash the selected activity to its minimum duration.

4. Crashing:

Crash the activities in the critical path as per the ranking i.e., activity having lower cost slope would be crashed first to the maximum extent possible. Calculate the new direct cost by cumulative adding the cost or crashing to the normal cost.

5. Parallel crashing:

As the critical path duration is reduced by the crashing in step 3, other paths also become critical, i.e., we get parallel critical path. This means that project duration can be reduced duly by simultaneous crashing or activity on the parallel critical path.

6. Total cost:

Crashing as per steps 3 and 4, one reaches a point when further crashing is either not possible or does not result in the reduction or crashing or project duration. For the different project durations total cost is found up to total cost is got by adding corresponding fixed cost to the direct cost, and the direct cost is got by adding the expediting crashing cost commutative to the normal cost.

31. Define capitalized cost and salvage value.

Answer:

<u>Capitalized cost:</u>

Capitalized cost represents the present worth of an alternative for a project that is going to serve for a longer period of time i.e. for an infinite period of time. As the name indicates, it refers to the present worth of mainly cost or expenditures (cash outflows) of the alternative over infinite period of time. Capitalized worth refers to present worth of expenditures and revenues of an alternative over infinite period of time. The capitalized cost method is used for comparison of mutually exclusive alternatives which have perpetual service life (assumed to serve forever). The examples of this kind of projects are bridges, dams, irrigation projects, water supply systems for cities, pipeline projects etc. This method an also be used for finding out the capitalized cost of permanent fellowship/scholarship endowment in educational institutes and other organizations. As already stated, capitalized cost/worth is the present worth of an alternative that has a perpetual or permanent cash flow series.

The capitalized cost of a single amount occurring at regular intervals in future period of time is calculated by first finding out the equivalent uniform annual worth ‘A’ of the uniform series and then dividing by the interest rate ‘I’.

Salvage value:

It is the estimated amount that a company will receive at the end of a plant asset's useful life. It is the amount of an asset's cost that will not be part of the depreciation expense during the years that the asset is used in the business.

Salvage value is also referred to as *disposal value*, *residual value*, or *scrap value*.

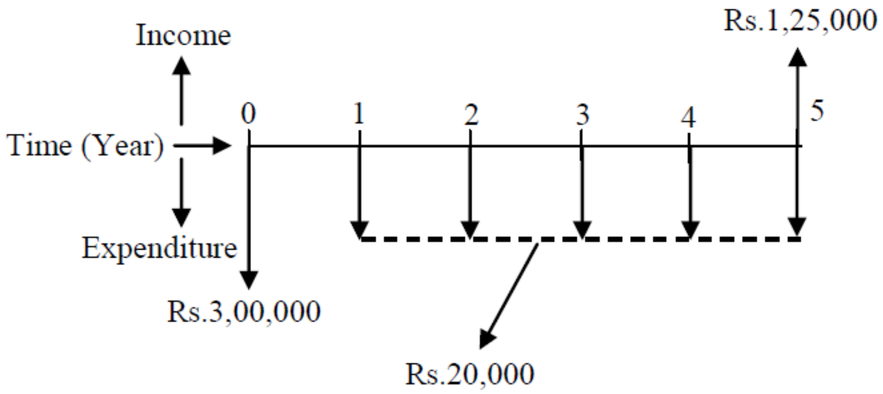
Example of Asset Salvage Value

Perhaps the most common calculation of an asset's salvage value is to assume there will be no salvage value. As a result, the entire cost of the asset used in the business will be charged to depreciation expense during the years of the asset's expected useful life.

A salvage value of zero is reasonable since it is assumed that the asset will no longer be useful at the point when the depreciation expense ends. Even if the company receives a small amount, it may be offset by costs of removing and disposing of the asset.

32. **There are two alternatives for purchasing a concrete mixer. Both the alternatives have same useful life. The cash flow details of alternatives are as follows; Alternative-1: Initial purchase cost = Rs.3,00,000, Annual operating and maintenance cost = Rs.20,000, Expected salvage value = Rs.1,25,000, Useful life = 5 years. Alternative-2: Initial purchase cost = Rs.2,00,000, Annual operating and maintenance cost = Rs.35,000, Expected salvage value = Rs.70,000, Useful life = 5 years. Using present worth method, find out which alternative should be selected, if the rate of interest is 10% per year.**

Solution: Since both alternatives have the same life span i.e. 5years, the present worth of the alternatives will be compared over a period of 5 years. The cash flow diagram of Alternative-1 is shown in Fig. 2.1. As already mentioned Module-1, the cash outflows i.e. costs or expenditures are represented by vertically downward arrows whereas the cash inflows i.e. revenue or income are represented by vertically upward arrows. The same convention is adopted here.



The equivalent present worth of Alternative-1 i.e. PW_1 is calculated as follows;
The initial cost, P = Rs.3,00,000 (cash outflow),
Annual operating and maintenance cost, A = Rs.20,000 (cash outflow),
Salvage value, F = Rs.1,25,000 (cash inflow).
PW_1 = - 3,00,000 – 20,000(*P/A, i, n*) + 1,25,000(*P/F, i, n*)
PW_1 = - 3,00,000 – 20,000(*P/A, 10%, 5*) + 1,25,000(*P/F, 10%, 5*)
Now putting the mathematical expressions of different compound interest factors (as mentioned in Module-1) in the above expression for PW_1 (in Rs.) results in the following;

$$PW_1 = -3{,}00{,}000 - 20{,}000 \times \frac{(1+i)^n - 1}{i(1+i)^n} + 1{,}25{,}000 \times \frac{1}{(1+i)^n}$$

$$PW_1 = -3{,}00{,}000 - 20{,}000 \times \frac{(1+0.1)^5 - 1}{0.1(1+0.1)^5} + 1{,}25{,}000 \times \frac{1}{(1+0.1)^5}$$

$$PW_1 = -3{,}00{,}000 - 20{,}000 \times 3.7908 + 1{,}25{,}000 \times 0.6209$$

$$PW_1 = -\ 3{,}00{,}000 - 75{,}816 + 77{,}613$$

$$\boldsymbol{PW_1 = -\ \text{Rs.}2{,}98{,}203}$$

33- 34 The following should be used for both the questions 33 and 34

A project manager is relegated to a venture ahead of schedule in the venture lifecycle. Something that must be done is to do a justification for the project. Since very little information is known about the project, the estimates are considered to be rough estimates. The accompanying table is the project manager's gauge of the income that will occur throughout the following five years:

End of Year	Cash Flow In	Cash Flow Out
1	0	500,000
2	300,000	90,000
3	400,000	100,000
4	100,000	175,000
5	50,000	35,000

33. What is the payback period for this project?

Explanation:

End of Year	Cash Flow In	Cash Flow Out	Net (Yearly)	Net (overall)
1	0	500,000	(500,000)	(500,000)
2	300,000	90,000	210,000	(290,000)
3	400,000	100,000	300,000	10,000
4	100,000	175,000	(75,000)	(65,000)
5	50,000	35,000	15,000	(50,000)

Payback period for this project is three years.

34. If the net present value for each of the cash flows were calculated at a 10% interest rate, the net present value cash flow at the end of five years would be:

Explanation:

$$NPV = \left(-\frac{500{,}000}{(1+0.1)^0}\right) + \left(-\frac{290{,}000}{(1+0.1)^1}\right) + \left(\frac{10{,}000}{(1+0.1)^2}\right) + \left(\frac{-65{,}000}{(1+0.1)^3}\right) + \left(\frac{-50{,}000}{(1+0.1)^4}\right)$$
$$= -838{,}358$$

$$Cash\ flow\ without\ NPV = -500{,}000 - 290{,}000 + 10{,}000 - 65{,}000 - 50{,}000 = -895{,}000$$

35. A project manager is dealing with a venture. The first extension standard of the venture was planned at $100,000. Since work on the venture began there have been seventeen approved and affirmed changes to the venture. The progressions have an estimation of $17,000 and the cost of exploring them before their endorsement was $2,500. What is the present spending plan for the venture?

Solution:
Initial Cost: $100,000
Progressions: $17,000
Cost of Exploring: $2500
Total = $119,500

36. Explain Work breakdown structure.

Answer:

Dividing complex projects to simpler and manageable tasks is the process identified as Work Breakdown Structure (WBS). Usually, the project managers use this method for simplifying the project execution. In WBS, much larger tasks are broken down to manageable chunks of work. These chunks can be easily supervised and estimated. WBS is not restricted to a specific field when it comes to application. This methodology can be used for any type of project management.

Following are a few reasons for creating a WBS in a project:

- Accurate and readable project organization.
- Accurate assignment of responsibilities to the project team.
- Indicates the project milestones and control points.
- Helps to estimate the cost, time and risk.
- Illustrate the project scope, so the stakeholders can have a better understanding of the same.

Construction of a WBS

Identifying the main deliverables of a project is the starting point for deriving a work breakdown structure.

This important step is usually done by the project managers and the subject matter experts (SMEs) involved in the project. Once this step is completed, the subject matter experts start breaking down the high-level tasks into smaller chunks of work.

In the process of breaking down the tasks, one can break them down into different levels of detail. One can detail a high-level task into ten sub-tasks while another can detail the same high-level task into 20 sub-tasks.

Therefore, there is no hard and fast rule on how you should breakdown a task in WBS. Rather, the level of breakdown is a matter of the project type and the management style followed for the project.

In general, there are a few "rules" used for determining the smallest task chunk. In "two weeks" rule, nothing is broken down smaller than two weeks worth of work.

This means, the smallest task of the WBS is at least two-week long. 8/80 is another rule used when creating a WBS. This rule implies that no task should be smaller than 8 hours of work and should not be larger than 80 hours of work.

One can use many forms to display their WBS. Some use tree structure to illustrate the WBS, while others use lists and tables. Outlining is one of the easiest ways of representing a WBS.

Following example is an outlined WBS:

Project Name			
	Task 1		
		Subtask 1.1	
			Work Package 1.1.1
			Work Package 1.1.2
		Subtask 1.2	
			Workpackage 1.2.1
			Workpackage 1.2.2
	Task 2		
		Subtask 2.1	
			Workpackage 2.1.1
			Workpackage 2.1.2

There are many design goals for WBS. Some important goals are as follows:

- Giving visibility to important work efforts.
- Giving visibility to risky work efforts.
- Illustrate the correlation between the activities and deliverables.
- Show clear ownership by task leaders.

WBS Diagram

In a WBS diagram, the project scope is graphically expressed. Usually the diagram starts with a graphic object or a box at the top, which represents the entire project. Then, there are sub-components under the box.

These boxes represent the deliverables of the project. Under each deliverable, there are sub-elements listed. These sub-elements are the activities that should be performed in order to achieve the deliverables.

Although most of the WBS diagrams are designed based on the deliveries, some WBS are created based on the project phases. Usually, information technology projects are perfectly fit into WBS model.

Therefore, almost all information technology projects make use of WBS. In addition to the general use of WBS, there is specific objective for deriving a WBS as well. WBS is the input for Gantt charts, a tool that is used for project management purpose.

Gantt chart is used for tracking the progression of the tasks derived by WBS.

Following is a sample WBS diagram:

Unit 3: Network Analysis

37. Select the correct equation for calculating total float for an activity.

a. Total Float = LFT – EST
b. Total Float = EFT – EST
c. Total Float = LFT – EFT
d. Total Float = LST – EFT

Answer: C

38. What is the term for an activity that cannot be deferred without affecting the project completion date or another activity's start date?

a. Standard float
b. Intermediate float
c. Free float
d. Zero float

Answer: C

39. PERT stands for:

a. Programme evaluation and review technique
b. Project estimation and review technique
c. Programme estimation and renew technology
d. None of these

Answer: A

40. Activities which have zero float are called:

a. Critical Activities
b. Dummy activities
c. Non-critical activities
d. None of these

Answer: B

41. The time by which activity completion time can be delayed without affecting the start of succeeding activities, is known as

a. duration
b. total flat
c. free float
d. interfering float

Answer: C

42. The artificial activity which indicates that an activity following it, cannot be started unless the preceding activity is complete, is known as

a. event
b. free float
c. dummy
d. constant

Answer: C

43. The estimated time required to perform an activity, is known as

a. Event
b. Dummy
c. Duration
d. Float

Answer: C

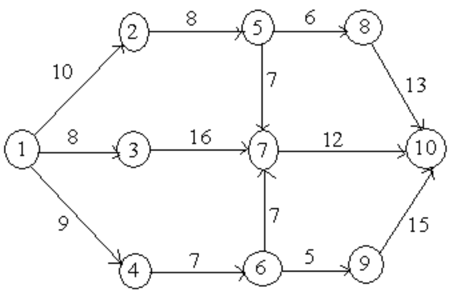
44. Explain various differences between PERT and CPM.

Answer:

Key Differences Between PERT and CPM:

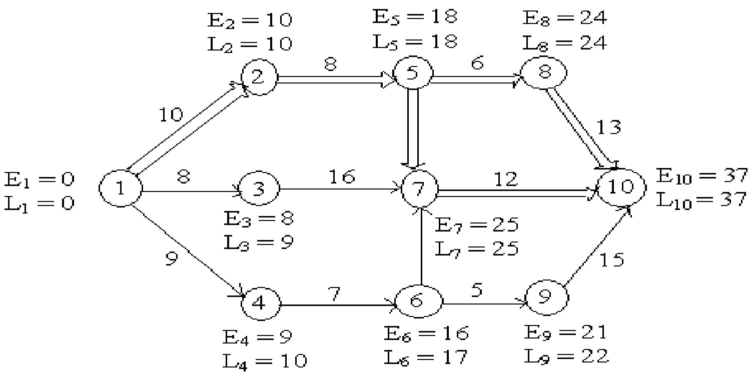
1. PERT is a project management technique, whereby planning, scheduling, organising, coordinating and controlling uncertain activities are done. CPM is a statistical technique of project management in which planning, scheduling, organising, coordination and control of well-defined activities take place.
2. PERT is a technique of planning and control of time. Unlike CPM, which is a method to control costs and time.
3. While PERT is evolved as a research and development project, CPM evolved as a construction project.
4. PERT is set according to events while CPM is aligned towards activities.
5. A deterministic model is used in CPM. Conversely, PERT uses a probabilistic model.
6. There are three times estimates in PERT, i.e. optimistic time (to), most likely time ™, pessimistic time (tp). On the other hand, there is only one estimate in CPM.
7. PERT technique is best suited for a high precision time estimate, whereas CPM is appropriate for a reasonable time estimate.
8. PERT deals with unpredictable activities, but CPM deals with predictable activities.
9. PERT is used where the nature of the job is non-repetitive. In contrast to, CPM involves the job of repetitive nature.
10. There is a demarcation between critical and non-critical activities in CPM, which is not in the case of PERT.
11. PERT is best for research and development projects, but CPM is for non-research projects like construction projects.
12. Crashing is a compression technique applied to CPM, to shorten the project duration, along with the least additional cost. The crashing concept is not applicable to PERT.

45. Determine the early start and late start in respect of all node points and identify critical path for the following network.



Solution:

Calculation of E and L for each node is shown in the network



Activity(i, j)	Normal Time (D_{ij})	Earliest Time		Latest Time		Float Time $(L_i - D_{ij}) - E_i$
		Start (E_i)	Finish ($E_i + D_{ij}$)	Start ($L_i - D_{ij}$)	Finish (L_i)	
(1, 2)	10	0	10	0	10	0
(1, 3)	8	0	8	1	9	1
(1, 4)	9	0	9	1	10	1
(2, 5)	8	10	18	10	18	0
(4, 6)	7	9	16	10	17	1
(3, 7)	16	8	24	9	25	1
(5, 7)	7	18	25	18	25	0
(6, 7)	7	16	23	18	25	2
(5, 8)	6	18	24	18	24	0
(6, 9)	5	16	21	17	22	1
(7, 10)	12	25	37	25	37	0
(8, 10)	13	24	37	24	37	0
(9, 10)	15	21	36	22	37	1

Network Analysis Table

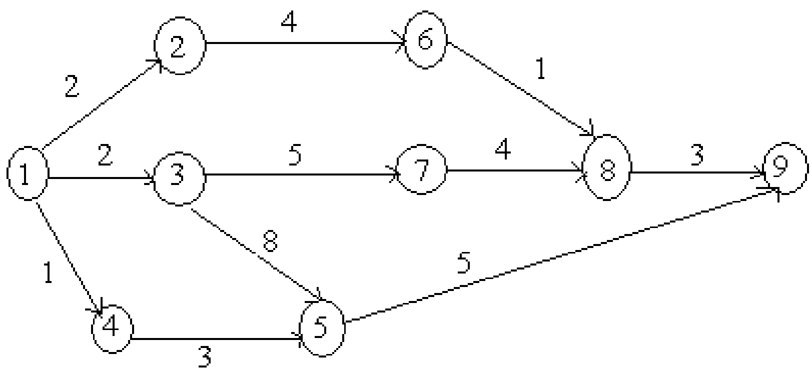
From the table, the critical nodes are (1, 2), (2, 5), (5, 7), (5, 8), (7, 10) and (8, 10)

From the table, there are two possible critical paths

i. $1 \rightarrow 2 \rightarrow 5 \rightarrow 8 \rightarrow 10$

ii. $1 \rightarrow 2 \rightarrow 5 \rightarrow 7 \rightarrow 10$

46. Find the critical path and calculate the slack time for the following network

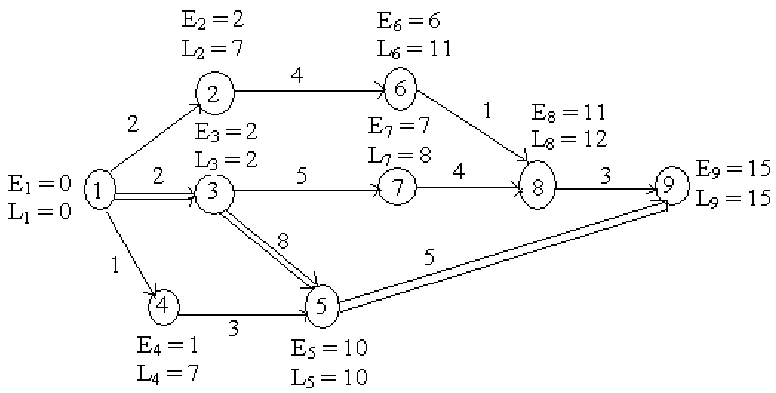


Solution

The earliest time and the latest time are obtained below

Activity(i, j)	Normal Time (D_{ij})	Earliest Time Start (E_i)	Earliest Time Finish ($E_i + D_{ij}$)	Latest Time Start ($L_i - D_{ij}$)	Latest Time Finish (L_i)	Float Time ($L_i - D_{ij}$) - E_i
(1, 2)	2	0	2	5	7	5
(1, 3)	2	0	2	0	2	0
(1, 4)	1	0	1	6	7	6
(2, 6)	4	2	6	7	11	5
(3, 7)	5	2	7	3	8	1
(3, 5)	8	2	10	2	10	0
(4, 5)	3	1	4	7	10	6
(5, 9)	5	10	15	10	15	0
(6, 8)	1	6	7	11	12	5
(7, 8)	4	7	11	8	12	1
(8, 9)	3	11	14	12	15	1

From the above table, the critical nodes are the activities (1, 3), (3, 5) and (5, 9)



The critical path is 1 → 3 → 5 → 9

47. A project has the following times schedule

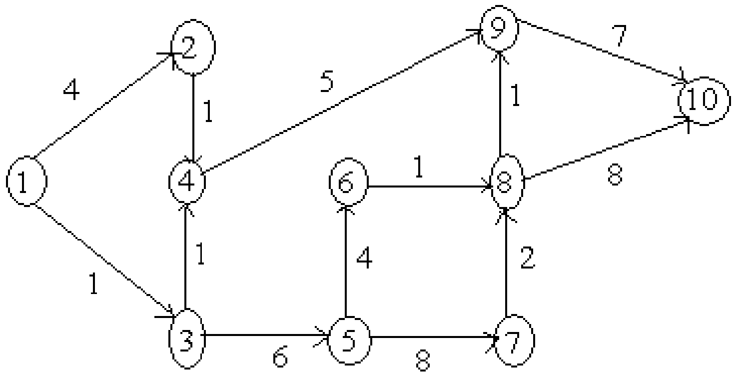
Activity	Time (weeks)	Activity	Time (weeks)	Activity	Time (weeks)
(1 – 2)	4	(4 – 9)	5	(8 – 9)	1
(1 – 3)	1	(5 – 6)	4	(8 – 10)	8
(2 – 4)	1	(5 – 7)	8	(9 – 10)	7
(3 – 4)	1	(6 – 8)	1		

Construct the network and compute

1. T_E and T_L for each event
2. Float for each activity
3. Critical path and its duration

Solution:

The network is

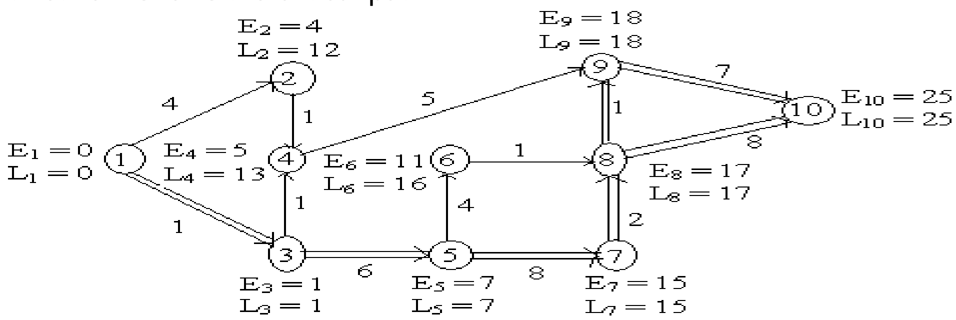


Event No.:	1	2	3	4	5	6	7	8	9	10
T_E:	0	4	1	5	7	11	15	17	18	25
T_L:	0	12	1	13	7	16	15	17	18	25

Float = T_L (Head event) – T_E (Tail event) – Duration

Activity	Duration	T_E (Tail event)	T_L (Head event)	Float
(1 – 2)	4	0	12	8
(1 – 3)	1	0	1	0
(2 – 4)	1	4	13	8
(3 – 4)	1	1	13	11
(3 – 5)	6	1	7	0
(4 – 9)	5	5	18	8
(5 – 6)	4	7	16	5
(5 – 7)	8	7	15	0
(6 – 8)	1	11	17	5
(7 – 8)	2	15	17	0
(8 – 9)	1	17	18	0
(8 – 10)	8	17	25	0
(9 – 10)	7	18	25	0

The resultant network shows the critical path

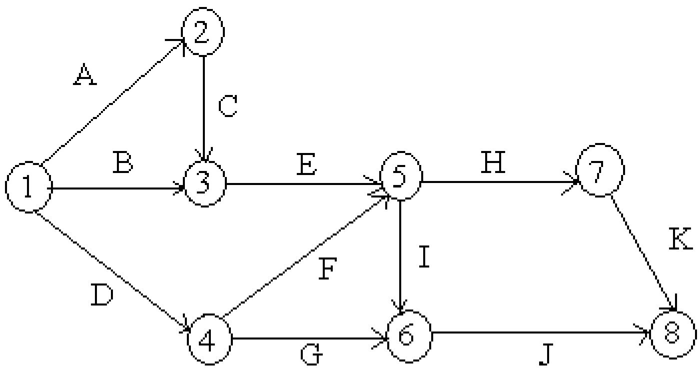


The two critical paths are

i. 1 → 3 → 5 →7 → 8 → 9 →10

ii. 1 → 3 → 5 → 7 → 8 →10

48. For the project



Task:	A	B	C	D	E	F	G	H	I	J	K
Least time:	4	5	8	2	4	6	8	5	3	5	6
Greatest time:	8	10	12	7	10	15	16	9	7	11	13
Most likely time:	5	7	11	3	7	9	12	6	5	8	9

Find the earliest and latest expected time to each event and also critical path in the network.

Solution

Task	**Least time (t_0)**	**Greatest time (t_p)**	**Most likely time (t_m)**	**Expected time ($(to + t_p + 4t_m)/6$)**
A	4	8	5	5.33
B	5	10	7	7.17
C	8	12	11	10.67
D	2	7	3	3.5
E	4	10	7	7

F	6	15	9	9.5
G	8	16	12	12
H	5	9	6	6.33
I	3	7	5	5
J	5	11	8	8
K	6	13	9	9.17

`

Task	Expected time (t_e)	Start		Finish		Total float
		Earliest	Latest	Earliest	Latest	
A	5.33	0	0	5.33	5.33	0
B	7.17	0	8.83	7.17	16	8.83
C	10.67	5.33	5.33	16	16	0
D	3.5	0	10	3.5	13.5	10
E	7	16	16	23	23	0
F	9.5	3.5	13.5	13	23	10
G	12	3.5	18.5	15.5	30.5	15
H	6.33	23	23	29.33	29.33	0
I	5	23	25.5	28	30.5	2.5
J	8	28	30.5	36	38.5	2.5
K	9.17	29.33	29.33	31.5	38.5	0

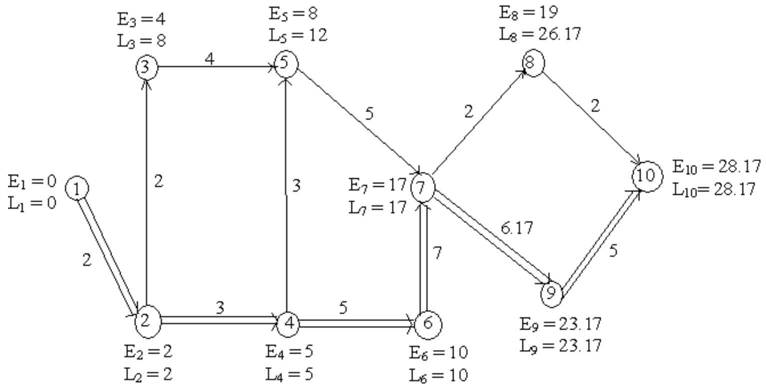
The network is

The critical path is A →C →E → H → K

49. **A project has the following characteristics**

Activity	**Most optimistic time (a)**	**Most pessimistic time (b)**	**Most likely time (m)**
(1 – 2)	**1**	**5**	**1.5**
(2 – 3)	**1**	**3**	**2**
(2 – 4)	**1**	**5**	**3**
(3 – 5)	**3**	**5**	**4**
(4 – 5)	**2**	**4**	**3**
(4 – 6)	**3**	**7**	**5**
(5 – 7)	**4**	**6**	**5**
(6 – 7)	**6**	**8**	**7**
(7 – 8)	**2**	**6**	**4**
(7 – 9)	**5**	**8**	**6**

(8 – 10) **(9 – 10)**	**1** **3**	**3** **7**	**2** **5**



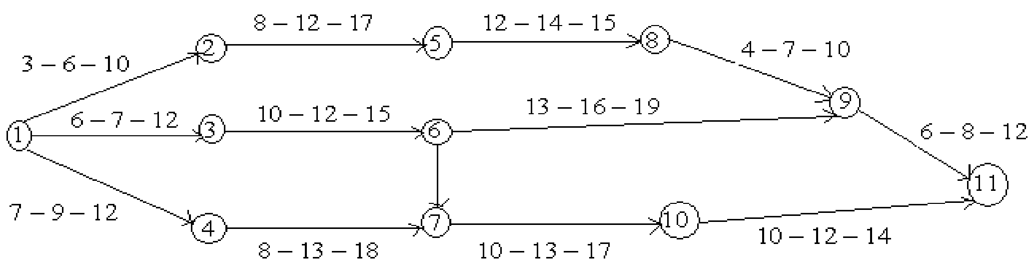
Construct a PERT network. Find the critical path and variance for each event.
Solution:

Activity	(a)	(b)	(m)	(4m)	t_e (a + b + 4m)/6	V $[(b - a) / 6]^2$
(1 – 2)	1	5	1.5	6	2	4/9
(2 – 3)	1	3	2	8	2	1/9
(2 – 4)	1	5	3	12	3	4/9
(3 – 5)	3	5	4	16	4	1/9
(4 – 5)	2	4	3	12	3	1/9
(4 – 6)	3	7	5	20	5	4/9
(5 – 7)	4	6	5	20	5	1/9
(6 – 7)	6	8	7	28	7	1/9
(7 – 8)	2	6	4	16	4	4/9
(7 – 9)	5	8	6	24	6.17	1/4
(8 – 10)	1	3	2	8	2	1/9
(9 – 10)	3	7	5	20	5	4/9

The network is constructed as shown below

The critical path = 1 → 2 → 4 → 6 → 7 →9 →10

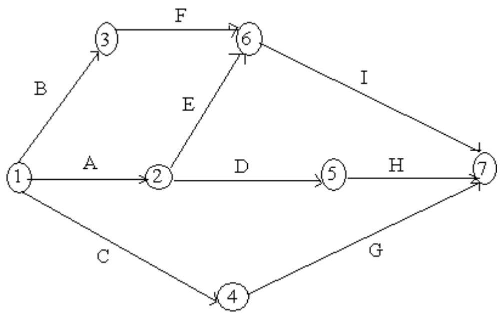
50. Calculate the variance and the expected time for each activity



Solution:

Activity	(t_o)	(t_m)	(t_p)	$t_e =$ $(t_o + t_p + 4t_m)/6$	$V =$ $[(t_p - t_o) / 6]^2$
(1 – 2)	3	6	10	6.2	1.36
(1 – 3)	6	7	12	7.7	1.00
(1 – 4)	7	9	12	9.2	0.69
(2 – 3)	0	0	0	0.0	0.00
(2 – 5)	8	12	17	12.2	2.25
(3 – 6)	10	12	15	12.2	0.69
(4 – 7)	8	13	19	13.2	3.36
(5 – 8)	12	14	15	13.9	0.25
(6 – 7)	8	9	10	9.0	0.11
(6 – 9)	13	16	19	16.0	1.00
(8 – 9)	4	7	10	7.0	1.00
(7 – 10)	10	13	17	13.2	1.36
(9 – 11)	6	8	12	8.4	1.00
(10 – 11)	10	12	14	12.0	0.66

51. A project is represented by the network as shown below and has the following data



Task:	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Least time:	5	18	26	16	15	6	7	7	3
Greatest time:	10	22	40	20	25	12	12	9	5
Most likely time:	15	20	33	18	20	9	10	8	4

Determine the following

a. Expected task time and their variance

b. Earliest and latest time

Solution

a.

Activity	Least time (t_0)	Greatest time (t_p)	Most likely time (t_m)	Expected time ($to + t_p + 4t_m$)/6	Variance (σ^2)
(1-2)	5	10	8	7.8	0.69
(1-3)	18	22	20	20.0	0.44
(1-4)	26	40	33	33.0	5.43
(2-5)	16	20	18	18.0	0.44
(2-6)	15	25	20	20.0	2.78
(3-6)	6	12	9	9.0	1.00
(4-7)	7	12	10	9.8	0.69
(5-7)	7	9	8	8.0	0.11
(6-7)	3	5	4	4.0	0.11

b.

Earliest time

$E_1 = 0$

$E_2 = 0 + 7.8 = 7.8$

$E_3 = 0 + 20 = 20$

$E_4 = 0 + 33 = 33$

$E_5 = 7.8 + 18 = 25.8$

$E_6 = \max [7.8 + 20, 20 + 9] = 29$

$E_7 = \max [33 + 9.8, 25.8 + 8, 29 + 4] = 42.8$

Latest time

$L_7 = 42.8$

$L_6 = 42.8 – 4 = 38.8$

$L_5 = 42.8 – 8 = 34.3$

$L_4 = 42.8 – 9.8 = 33$

$L_3 = 38.8 – 9 = 29.8$

$L_2 = \min [34.8 – 18, 38.8 – 20] = 16.8$

$L_1 = \min [16.8 – 7.8, 29.8 – 20, 33 - 33] = 0$

52. Which of the following has no effect on replacement decision?

a. Defender’s sunk cost
b. Defender’s salvage value
c. Defender’s operating cost
d. Challenger’s first cost

Answer: a

53. A sunk cost is the difference between

a. First cost and salvage value
b. Present market value and salvage value
c. First cost and present market value
d. Book value and present market value

Answer: c

54. When asset's annual operating and maintenance are always increasing while salvage values remain constant (over the life of asset), the economic life of the asset is

a. Shortest possible life
b. Longest possible life
c. Zero
d. Can't be said

Answer: a

55. The unused capital cost of an investment alternative at some point in time prior to the end of its expected life is known as

a. Salvage value
b. Implied salvage value
c. Book value
d. Depreciation charges

Answer: b

56. After two years of service rendered, the capacity of a bulldozer to move soil has reduced. If the bulldozer is considered for replacement, the reason will be

a. Physical deterioration
b. Obsolescence
c. Lack of technological upgradation
d. None of the above

Answer: a

57. The value of the defender in study of replacement is

a. What it cost when originally purchased
b. The sunk cost
c. The salvage value at the end of its life
d. Its worth at present time

Answer: d

Unit 4: Site Organization

58. Discuss objectives of construction management and Explain Planning, Scheduling and Controlling as a Function of Construction Management.

Answer:

Objectives of Construction Management: If one is going to practice management within an industry, it is a good idea to define the arena in which the management techniques will be applied. We really need to know just what business we are in to evaluate our present goals, find out where we have been, and where we hope to go from here.

- Prepare and negotiate cost estimates, budgets, and work timetables
- Select appropriate construction methods and strategies
- Interpret and explain contracts and technical information to workers and other professionals
- Report on work progress and budget matters to clients
- Collaborate with architects, engineers, and other construction and building specialists
- Instruct and supervise construction personnel and activities onsite
- Respond to work delays and other problems and emergencies
- Select, hire, and instruct laborers and subcontractors
- Comply with legal requirements, building and safety codes, and other regulations

Planning

Planning in the context of a project involves providing a roadmap for the proper execution of the project. The planning process involves defining the project, including the proposed outcome of the project. The planning process also involves clearly defining the goals and objectives of the project, the specifications of the quality, the budget and time estimates and control parameters. In short, the planning stage is a stage to review and reaffirm the project objectives and guidelines and resolve any undermining issues. Contingency approaches are also designed during the planning process to avoid pitfalls. Ideally, the planning process should involve all the team members.

Scheduling

Scheduling projects involves breaking down the project to clearly defined simpler tasks. This is also known as the “work breakdown structure”. This structure allows the team members to understand a complex project in terms of simple achievable tasks. Scheduling also involves assigning these tasks to the relevant personnel and establishing the time, money and other resource constraints for each task. For example, if the project is to organize a convention, then the work breakdown structure would involve tasks such as booking a hall or printing brochures. Specific people are assigned to each task with time, money and quality constraints.

Control

Execution of the project involves dealing with unexpected events. While establishing a clear plan and scheduling process minimizes ambiguities, careful control has to be exercised by the project manager in order to maintain the time, quality and budget requirements. Two elements of project control involve establishing and achieving clearly defined project milestones and maintaining clear lines of communication. Milestones help in monitoring progress, and communication helps in oversight and improving team effort.

59. Explain the concept of time value of money.

Answer:

The time value of money (TVM) is the concept that money you have now is worth more than the identical sum in the future due to its potential earning capacity. This core principle of finance holds that provided money can earn interest, any amount of money is worth more the sooner it is received. TVM is also sometimes referred to as present discounted value.

KEY TAKEAWAYS

- Time value of money is based on the idea that people would rather have money today than in the future.
- Given that money can earn compound interest, it is more valuable in the present rather than the future.
- The formula for computing time value of money considers the payment now, the future value, the interest rate, and the time frame.
- The number of compounding periods during each time frame is an important determinant in the time value of money formula as well.

60. Explain the importance of organization in construction projects. Discuss the superiority of line and staff organisation over the other systems.

Answer:

Organizations are systems created to achieve common goals through people-to-people and people-to-work relationships. They are essentially social entities that are goal-directed, deliberately structured for coordinated activity systems, and is linked to the external environment. Organizations are made up of people and their relationships with one another. Managers deliberately structure and coordinate organizational resources to achieve the organization's purpose. Each organization has its own external and internal environments that define the nature of the relationships according to its specific needs. Organizing is the function that managers undertake to design, structure, and arrange the components of an organization's internal environment to facilitate attainment of organizational goals. Organizing creates the framework needed to reach a company's objectives and goals. Organizing is the process of defining and grouping activities, and establishing authority relationships among them to attain organizational objectives.

Importance of Organizing

A comprehensive approach to organizing helps the management in many ways. Organizing aligns the various resources towards a common mission.

Efficient Administration

It brings together various departments by grouping similar and related jobs under a single specialization. This establishes coordination between different departments, which leads to unification of effort and harmony in work.

It governs the working of the various departments by defining activities and their authority relationships in the organizational structure. It creates the mechanism for management to direct and control the various activities in the enterprise.

Resource Optimization

Organizing ensures effective role-job-fit for every employee in the organization. It helps in avoiding confusion and delays, as well as duplication of work and overlapping of effort.

Benefits Specialization

It is the process of organizing groups and sub-divide the various activities and jobs based on the concept of division of labor. This helps in the completion of maximum work in minimum time ensuring the benefit of specialization.

Promotes Effective Communication

Organizing is an important means of creating coordination and communication among the various departments of the organization. Different jobs and positions are interrelated by structural relationship. It specifies the channel and mode of communication among different members.

Creates Transparency

The jobs and activities performed by the employees are clearly defined on the written document called job description which details out what exactly has to be done in every job. Organizing fixes the authority-responsibility among employees. This brings in clarity and transparency in the organization.

Expansion and Growth

When resources are optimally utilized and there exists a proper division of work among departments and employees, management can multiply its strength and undertake more activities. Organizations can easily meet the challenges and can expand their activities in a planned manner.

Advantages of Line and Staff Organisation over other:

1. Specialization:

Line and staff organisation introduces specialization in a systematic manner. Persons with specialized knowledge are appointed to help line officers. The planning part is generally undertaken by staff personnel and line officers are able to devote much time for execution.

2. Better Discipline:

The unity of command is maintained in this type of organisation. The staff personnel do not interfere with the executive work of line officers. The workers get command from line personnel and are accountable directly to them for their performance. This creates better understanding and discipline among employees.

3. Balanced and Prompt Decisions:

The functional managers have the advantage of expert advice when taking important decisions. The staff can also be used to investigate and advise on inter-departmental relationships. The line officers can take balanced and quick decisions.

4. Growth and Expansion:

The line and staff organisation is quite suitable for growth and expansion. The burden of line staff is eased by the appointment of specialists. Line officers will be able to devote much time for future planning. The present staff will enable the expansion and growth of unit. Some assistants can be appointed to cope with the work if needed.

5. Development of Employees:

This organisation provides scope for advancement of career to able and dedicated employees. There are more openings for those who have capabilities of going up. The separation of functions of ‘planning’ and ‘doing’ also helps in creating more and more job opportunities. Promotional chances increase for deserving persons.

6. Lesser Burden on Line Officers:

With the appointment of staff officers the burden of the officers is greatly reduced. The specialists help line officers in deciding things regarding their lines of specialization. The line officers are left with routine administrative work. They will be able to devote their time in supervising the implementation of various plans and policies.

61. Discuss resource scheduling and resource smoothening.

Answer:

Resource Leveling

You use resource leveling when you have limited resources and you may extend the schedule.

Resource leveling is used when:

- A critical resource may not be available for a certain duration;
- A critical resource may not be available at a certain point of time;
- You have to share a resource with another project;
- The demand for a resource exceeds the supply.

You also use this technique when you must keep some resource usage at a constant level.

In resource leveling, you are asked to optimize the limited resources given to you. Here the schedule is not fixed.

Resource leveling answers the question of when you will be able to complete the project with the given resources.

Resource leveling is sometimes called resource constrained scheduling (RCS). If resources are not available, the project duration may change.

Resource Smoothing

You use resource smoothing when you have to optimize the resources and you cannot extend the schedule.

Since you cannot extend the schedule, the project completion date and the critical path will stay the same. Here the activities cannot be delayed more than their total and free float.

Using float in this technique will cause you to lose some flexibility from your path; however, the schedule will be optimized, efficient and cost effective.

In resource smoothing, you must be careful to avoid any delay in activity as it may affect your critical path.

Time is the main constraint here. You have a fixed schedule and are asked to optimize resources.

Resource smoothing is also known as time constrained scheduling (TCS). The project end date cannot be changed, and you have to optimize resources within the float.

Difference Between Resource Leveling and Resource Smoothing

The following are a few differences between resource leveling and resource smoothing:

- In resource leveling the project end date may change while in smoothing it does not change.
- In resource leveling the critical path changes (generally increases) while in resource smoothing it does not, and activities can be delayed within their float.
- Generally resource smoothing is usually performed after the resource leveling.
- In resource leveling resources are the main constraint while in resource smoothing project end date is a constraint.
- Resource leveling is used when resources are under or over allocated. Resource smoothing is used when resources are unevenly allocated.
- Resource leveling can be applied to activities on the critical path while in resource smoothing you do not touch activities on the critical path.

Similarities Between Resource Leveling and Resource Smoothing

The following are a few similarities between these two techniques:

- They both help you optimize resource utilization
- They both help you in scheduling network analysis

Resource leveling and resource smoothing are different techniques and they are used under different situations. It is not always necessary to use both techniques; in this blog post I mentioned that resource smoothing usually happens after resource leveling.

62. Describe decision making under uncertainity.

Answer:

A decision problem, where a decision-maker is aware of various possible states of nature but has insufficient information to assign any probabilities of occurrence to them, is termed as decision-making under uncertainty. A decision under uncertainty is when there are many unknowns and no possibility of knowing what could occur in the future to alter the outcome of a decision.

We feel uncertainty about a situation when we can't predict with complete confidence what the outcomes of our actions will be. We experience uncertainty about a specific question when we can't give a single answer with complete confidence.

Launching a new product, a major change in marketing strategy or opening your first branch could be influenced by such factors as the reaction of competitors, new competitors, technological changes, changes in customer demand, economic shifts, government legislation and a host of conditions beyond your control. These are the type of decisions facing the senior executives of large corporations who must commit huge resources.

The small business manager faces, relatively, the same type of conditions which could cause decisions that result in a disaster from which he or she may not be able to recover. A situation of uncertainty arises when there can be more than one possible consequences of selecting any course of action. In terms of the payoff matrix, if the decision-maker selects A_1, his payoff can be X_{11}, X_{12}, X_{13}, etc., depending upon which state of nature S_1, S_2, S_3, etc., is going to occur.

63. Related to construction injuries, define frequency rate, severity rate and incidence rate.

Answer:

Frequency Rate- The frequency rate shall be calculated both for lost time injury and reportable lost time injury as follows:

$$F_A = \frac{\text{Number of lost time injury} \times 1\ 000\ 000}{\text{Man-hours worked}}$$

$$F_B = \frac{\text{Number of reportable lost time injury} \times 1\ 000\ 000}{\text{Man-hours worked}}$$

Severity Rate – The severity rate shall be calculated from man days lost both of lost time injury and reportable lost time injury as follows:

$$S_A = \frac{\text{Man-days lost due to lost time injury} \times 1\ 000\ 000}{\text{Man-hours worked}}$$

$$S_B = \frac{\text{Man-days lost due to reportable lost time injury} \times 1\ 000\ 000}{\text{Man-hours worked}}$$

Incidence Rates – Ratio of the number of injuries to the number of persons during the period under review. It is expressed as the number of injuries per 1 000 persons employed.

$$\text{Lost-time injury incidence rate} = \frac{\text{Number of lost-time injuries} \times 1\ 000}{\text{Average number of persons employed}}$$

$$\text{Reportable lost-time injury incidence rate} = \frac{\text{Number of reportable lost-time injuries} \times 1\ 000}{\text{Average number of persons employed}}$$

64. What is the importance of a job lay-out and sketch a typical job layout for RCC framed building construction?

The sequence of work to be followed in the construction of a building is the at most important procedures of construction. The major sequences of construction are marking, excavation, concreting, brick masonry, roof laying, flooring and finishing.

1. Paper Work

Construction of residential building required paper work before the start of actual construction. The paper works are preparation of drawings, estimation of material cost, labor cost & contingencies, approval of drawings from City Development Authority.

2. Marking of Layout

The approved plan boundaries are marked in the ground first and the ground inside and outside the layout is cleaned. Later the complete layout is marked on the ground with accurate dimension and orientation.

Fig : Marking of Layout

3. Excavation

Generally excavation is carried out for the construction of wall foundations. Excavation should be carried out as per the drawings defined lengths & widths. Suitable machines are used to excavate the the earth for the making of foundation.

4. Foundation Work

Foundation work consists of many sub works which are as follows,

1. Compacting the ground

The excavation pits are trimmed and dressed as per the requirement and the bottom is compacted using hand compactors.

2. PCC

To form a solid bases on which the reinforcement can be tied and footing can be placed. Plain cement concrete of the mix 1:4:8 or 1:3:6 is laid on the compacted soil in varying depth as required.

3. Footing Reinforcement

Reinforcement steel bars are tied together and placed on the PCC to form a skeleton in which the concrete is poured and the column rods are taken from them.

4. Shuttering

To achieve proper shaped concrete, shuttering is done as per the dimensions mentioned in the drawing. It is also done so that the concrete doesn't come in contact with the soil .

5. Footing Concrete

It is very necessary to check the levels of foundation before concrete work. There are patches where excavated depth slightly exceeds and vice versa. Concrete is poured as per drawing specs.

Depth of foundation varies from 9" to 18" and normally for most of the cases it is considered as 12'' depth. The foundation width is kept equals to its depth.

5. Column Casting

Casting of columns is made by fixing the shuttering framework and concrete is poured in the formwork. The shuttering is usually removed after 24hr of casting and curing is done.

6. Construction of Walls

Walls are constructed using many materials such as brick, wooden, precast concrete and many other. Before starting the wall construction the base of wall is constructed first using concrete or size stone masonry. The height of the walls depends upon the floor height. Necessary opening are to given for doors, windows and ventilators.

7. Lintel

Masonry work of buildings is carried out in one go till roof. Openings for windows & doors are left during masonry works. Reinforced cement concrete beams are laid down on the top of openings. So, those loads of structure above openings not directly come on to the door frames.

8. Roofing

Roof slab of building is poured after completion of masonry works. Now a days, roofing is of reinforced cement concrete slab. Slab thickness & reinforcement details should be according to approved drawings.

9. Plastering Work

Form work is removed after 14 days of slab pouring. Now plaster work begins. Mortar for plaster work is generally of 1:3 or 1:4 is used. Thickness of plaster layer should not be more than 0.75inch. Cure the surface about 7 days. So that, plaster gain proper strength.

Generally, internal walls of buildings are covered with plastered layer and external walls with pointing. It is better plaster the external walls rather than pointing.

10. Fixing of Doors and Windows

Traditionally, doors and windows of woods are used. But, steel & aluminum is also not a bad choice. In case of wooden doors & windows, frames are fixed in walls during masonry work. Panels are then fixed with hinges after plaster work. Steel and aluminum doors are fixed after completion of paint works.

11. Fixing of Electrical and Plumbing Works

The necessary electrical and plumbing works are carried out before the final finishing works such as painting and tiles laying is done so as to reduce the damage.

12. Tiles Laying

Majorly tiles are laid in the bathrooms and kitchen area. First the wall tiles are fixed after which the floor tiles are fixed. For flooring works, granite, marble, tiles , epoxy are also used.

13. Painting

Painting consists of different sequences depending upon the type of finished required. 1 coat of primer and 2 coat of water based paint is also done or 2 coat of putty and 2 coats of painting is done for the smooth finish. It defers for outside and inside works.

14. Miscellaneous Works

Other than all these above mentioned works, there are other works that are carried as per the requirement of the consumer and design engineer.

- Terrace water proofing
- landscaping works
- False Ceiling
- Installation of Furniture

65. What criteria would you suggest for evaluating the effectiveness of a management team?

Answer:

To assist in this process, the Harvard Business Review has published five components of emotional intelligence that can be extremely helpful when estimating how good potential management candidates might be. Similarly, these criteria can help you to effectively judge your management's potential at any step along the way.

The five criteria are:

1) Self-Awareness – Your managers' ability to recognize their own moods

2) Self-Regulation – Their ability to separate personal mood from job performance

3) Motivation – The level of passion for the job that goes beyond salary

4) Empathy – Their ability to actually "connect" with employees, clients and customers

5) Social Skills – Their ability to "gel" with employees and other managers, as well as the ability to clearly communicate ideas and concepts

66. Discuss the methods of project monitoring.

Answer:

Project monitoring methods are the different methods and means by which the ongoing success of a project is measured. Regular project monitoring is essential, because it allows the project team and the Project Manager to evaluate whether:

- the project is proceeding as planned (within cost budgets and according to the schedule)

- the team is working effectively, with resources being efficiently used
- the project is staying within the expected project boundaries.

Regular monitoring allows managers to identify anything not ‘going to plan’ early. They can then take remedial action quickly, before the problem (and any consequent time, cost or scope blow-outs) develops further. Lack of monitoring has the converse effect: problems can build and accelerate so that they become very difficult to control or to reverse without adverse consequences for the project.

Project stakeholders may also use various project monitoring methods to stay informed about current project progress. This external project monitoring, however, is normally agreed in advance.

Qualitative and quantitative methods
In general, monitoring is either quantitative or qualitative:

- Quantitative methods use numerical data to evaluate the project. These methods may include financial auditing, auditing of resources and analysis of person-hours spent on the project.
- Qualitative methods monitor non-numerical aspects of the project. Methods may include holding certain meetings, providing certain reports, interviewing team members and analysing project documentation.

The type(s) of project monitoring methods chosen may depend on what phase the project is currently in, or what particular information is sought.
Project monitoring methods are usually decided upon during the project planning phase, so that team members know when the monitoring will take place and what format it will take.

67. Outline and explain the factors to be considered for site layout development.

Answer:

A proper site selection is one of the most important steps before beginning construction works. The contractor or civil engineer should consider key factors affecting when selecting a site. Site selection of a building should be done based upon some surveys of various aspects of the site such as the development of the site, cost, the stability of the proposed structure, and type of construction project, for example industrial, commercial or residential building.

Three main categories of factors provide influence to the site selection and layout process.

1. Natural Factors
2. Man-made Factors or Cultural Factors
3. Aesthetic Factors

Following general factors must be taken account while selecting a site for any type of building construction.

1. Purpose of Building
2. Government Laws

3. Shape & Size
4. Terrain Condition
5. Type of Ground Soil
6. Natural Light & Air
7. Environmental Condition
8. Legal & Financial Aspects

Unit 5: Maintenance Management

68. Discuss the importance of safety in construction project management.

Answer:

Health and safety is one of the most important considerations you should take before any construction project gets underway. You should always make sure that all aspects of health and safety have been considered before you step foot on the construction site. Health and safety in construction are particularly important because the industry is prone to hazardous situations and can be dangerous at times. Statistics show that 3% of all construction workers in the UK sustain a work related injury and around 4% are suffering from work related illness. This can lead to a huge loss in working hours and also mean that workers are unhappy within their job roles. There are some major reasons why health and safety is important in the workplace.

Injuries in Construction

Over the last year, there were 43 workers fatally injured in the construction sector, which is still an alarmingly large number. A large portion of accidents on the construction site were caused by slips, trips and falls, as reported by employers in 2015/16. But many people were also injured during lifting and handling or falling from a height on the construction site. This emphasises the magnitude of safety in construction and there are 2 ways that you can help to prevent these accidents from happening.

- Training – many accidents occur on the construction site because workers have not had the proper training before starting on a project. Effective training will make sure your employees are aware of the risks on the construction site.
- Tools – the right safety tools can also make a huge difference in the workplace and help to avoid any unnecessary accidents. Safety products such as fall arrest harnesses and safety clothing can help to reduce the risk in the workplace.

Businesses are Responsible

If you don’t have the correct health and safety procedures in place then you will most likely be breaking the law. This means that your business could be fined, sued or even banned from operating depending on the level of risk. If the HSE find that the construction site has not met health and safety regulations, they have the power to take action against your business. If an employee feels they have not received the proper health and safety training, they can inform the HSE who will investigate the issues. You may also face the problem of compensation if a worker is seriously injured on the construction site, and the project might even need to be halted for investigation.

Your Business Can Benefit

Not only is health and safety important to avoid injury, there are also plenty of other long term benefits that your business stands to gain. By implementing the right health and safety procedures, your employees are much more likely to be happier in their roles. If your workers have the right knowledge and tools, it can boost morale on the construction site and lead to better productivity. With less illness and injury you can also gain more productive working hours, which can lead to better profitability. In the long term you can also build a good reputation for your business and it will help to retain staff.

If you are looking for health and safety equipment then take a look at our range of products online. We provide a comprehensive range of health and safety products to make sure that you have the correct equipment and our team can advise you on the most suitable products and specifications for your business. We offer same day emergency delivery in London and next day delivery on our products nationwide.

69. Discuss different elements of Risk cost management.

Answer:

The key elements of a risk management program include:

a. Process
b. Integration
c. Culture
d. Infrastructure.

These elements of a risk management program are flexible. They have to be, because strategies, organizational structures, operating philosophies and risk profiles vary in complexity across industries and firms.

Step One: Identify Risk

An enterprise risk assessment process identifies and prioritizes a company's risks, providing quality inputs to decision makers to help them formulate effective risk responses, including information about the current state of capabilities around managing the priority risks.

Risk assessment spans the entire organization, including critical business units and functional areas. Effectively applied using business strategy as a context, risk assessment considers attributes such as:

1. Impact
2. Likelihood
3. Velocity
4. Persistence

Step Two: Source Risk

Once priority risks are identified, they are traced to their root causes. If management understands the drivers of risk, it is easier to design risk metrics and proactive risk responses at the source. Will this step present challenges? Almost certainly. Overcoming them is key to success.

Step Three: Measure Risk

There is an old adage that says, "If you can't measure something, you can't manage it." Because not all risks are quantifiable, increasing transparency by developing quantitative and qualitative risk measures is common practice.
Measurement methodologies may be simple and basic. Here are some examples of how to measure risk:

1. Risk rating or scoring
2. Claims exposure and cost analysis
3. Sensitivity analysis

4. Stress testing
5. Tracking key variables relating to an identified exposure

More complex methodologies for companies with more advanced capabilities could differ — and might be more complicated. But remember: ignoring risk won't make it go away. Other risk management methodologies might include analyzing these complex factors:

1. Earnings at risk
2. Rigorous analytics that are proprietary to the company
3. Risk-adjusted performance measurement
4. Examining value at risk

Step 4: Evaluate Risk

Based on the priority risks identified, their drivers or root causes and their susceptibility to measurement, the next step requires that management choose the appropriate risk response.

There are four categories of risk responses:

1. Avoid
2. Accept
3. Reduce
4. Share

These responses can be applied to groups of related risks consisting of natural families of risks that share fundamental characteristics (like common drivers, positive or negative correlations, etc.) consistent with a portfolio view.

The organization first decides whether to accept or reject a risk based on an assessment of whether the risk is desirable or undesirable. A desirable risk is one that is inherent in the entity's business model or normal future operations and that the company believes it can monitor and manage effectively. An undesirable risk is one that is off-strategy, offers unattractive rewards or cannot be monitored or managed effectively.

If an entity chooses to accept a risk, it can accept it at its present level, reduce its severity and/or its likelihood of occurrence (typically through internal controls), or share it with a financially capable, independent party (typically through insurance or a hedging arrangement).

Step 5: Mitigate Risk

Depending on the risk response selected, management identifies any gaps in risk management capabilities and improves those capabilities as necessary to implement the risk response. Over time, the effectiveness of risk mitigation activities should be monitored.

Step 6: Monitor Risk

Models, risk analytics and web-enabled technologies make it possible to aggregate information about risks using common data elements to support the creation of a risk management dashboard or scorecard for use by risk owners, unit managers and executive management.

Dashboard and scorecard reporting should be flexible enough to enable the design of reports to address specific needs, including reporting to the board of directors. Examples of

dashboard reporting, which often features "heat maps" or "traffic light" indicators, are provided in the Application Techniques of the COSO Enterprise Risk Management Integrated Framework. Monitoring also includes activities of an internal audit function.
The purpose of the risk management process varies from company to company, e.g., reduce risk or performance variability to an acceptable level, prevent unwanted surprises, facilitate taking more risk in the pursuit of value creation opportunities, etc. Regardless of purpose, the good news is that a large body of knowledge on the risk management process is readily available so that companies can adopt a process view that best fits their circumstances.

70. Discuss the important aspects of project planning.

The important aspect is to deal with it. The project manager needs to strike a balance between the three constraints so that quality of the project will not be compromised.
To overcome the constraints, the project managers have several methods to keep the project going. Some of these will be based on preventing stakeholders from changing the scope and maintaining limits on both financial and human resources.
A project manager's role is evolved around responsibility. A project manager needs to supervise and control the project from the beginning to the closure.
The following factors will outline a project manager's role:

- The project manager needs to define the project and split the tasks amongst team members. The project manager also needs to obtain key resources and build teamwork.
- The project manager needs to set the objectives required for the project and work towards meeting these objectives.
- The most important activity of a project manager is to keep stakeholders informed on the progress of the project.
- The project manager needs to asses and carefully monitor risks of the project.

Skills Required for a Project Manager
In order to overcome the challenges related to project triangle and meet the project objectives, the project manager needs to have a range of skills, which includes:

- Leadership
- Managing people
- Negotiation
- Time management
- Effective communication
- Planning
- Controlling
- Conflict resolution
- Problem solving

Therefore, software project management is essential to incorporate user requirements along with budget and time constraints.

71. Explain the role of decision in Project Management.

Answer:

A project manager is a person who has the overall responsibility for the successful initiation, planning, design, execution, monitoring, controlling and closure of a project. Construction, petrochemical, architecture, information technology and many different industries that produce products and services use this job title.

The project manager must have a combination of skills including an ability to ask penetrating questions, detect unstated assumptions and resolve conflicts, as well as more general management skills.

Key among a project manager's duties is the recognition that risk directly impacts the likelihood of success and that this risk must be both formally and informally measured throughout the lifetime of a project.

Risks arise from uncertainty, and the successful project manager is the one who focuses on this as their primary concern. Most of the issues that impact a project result in one way or another from risk. A good project manager can lessen risk significantly, often by adhering to a policy of open communication, ensuring every significant participant has an opportunity to express opinions and concerns.

A project manager is a person who is responsible for making decisions, both large and small. The project manager should make sure they control risk and minimise uncertainty. Every decision the project manager makes must directly benefit their project.

Project managers use project management software, such as Microsoft Project, to organise their tasks and workforce. These software packages allow project managers to produce reports and charts in a few minutes, compared with the several hours it can take if they do it by hand.

Roles and Responsibilities

The role of the project manager encompasses many activities including:

- Planning and Defining Scope
- Activity Planning and Sequencing
- Resource Planning
- Developing Schedules
- Time Estimating
- Cost Estimating
- Developing a Budget
- Documentation
- Creating Charts and Schedules
- Risk Analysis
- Managing Risks and Issues

- Monitoring and Reporting Progress
- Team Leadership
- Strategic Influencing
- Business Partnering
- Working with Vendors
- Scalability, Interoperability and Portability Analysis
- Controlling Quality
- Benefits Realisation

Finally, senior management must give a project manager support and authority if he or she is going to be successful.

72. Whar is a Gantt Bar chart? Explain, with the help of a suitable example, the method of preparing a bar chart.

Answer:

A Gantt chart is a graphical depiction of a project schedule. It's is a type of bar chart that shows the start and finish dates of several elements of a project that include resources, milestones, tasks, and dependencies. Henry Gantt, an American mechanical engineer, designed the Gantt chart.

The Gantt chart is the most widely used chart in project management. These charts are useful in planning a project and defining the sequence of tasks that require completion. In most instances, the chart is displayed as a horizontal bar chart.

Horizontal bars of different lengths represent the project timeline, which can include task sequences, duration, and the start and end dates for each task. The horizontal bar also shows how much of a task requires completion.

A Gantt chart is constructed with a horizontal axis representing the total time span of the project, broken down into increments (for example, days, weeks, or months) and a vertical axis representing the tasks that make up the project (for example, if the project is outfitting your computer with new software, the major tasks involved might be: conduct research, choose software, install software). Horizontal bars of varying lengths represent the sequences, timing, and time span for each task. Using the same example, you would put "conduct research" at the top of the verticle axis and draw a bar on the graph that represents the amount of time you expect to spend on the research, and then enter the other tasks below the first one and representative bars at the points in time when you expect to undertake them. The bar spans may overlap, as, for example, you may conduct research and choose software during the same time span. As the project progresses, secondary bars, arrowheads, or darkened bars may be added to indicate completed tasks, or the portions of tasks that have been completed. A vertical line is used to represent the report date.

Gantt charts give a clear illustration of project status, but one problem with them is that they don't indicate task dependencies - you cannot tell how one task falling behind schedule affects other tasks. The PERT chart, another popular project management charting method, is designed to do this. Automated Gantt charts store more information about tasks, such as the individuals assigned to specific tasks, and notes about the procedures. They also offer the benefit of being easy to change, which is helpful. Charts may be adjusted frequently to reflect the actual status of project tasks as, almost inevitably, they diverge from the original plan.

Example of a Gantt Chart
If the project is about installing new software on a server, the project tasks that require completion are conducting research, selecting a software product, testing the software and installing it. A milestone is selecting the software. These tasks appear as vertical lines on the chart. The project duration is 40 days.

Each task takes 10 days to complete, and each task is dependent on the previous task. A critical activity is testing the software in the development and test environments. The task start and end dates, duration, and milestones appear as horizontal bars. The percentage of work completed for each task also is displayed on the horizontal bars.

73. Describe common defects in buildings and their remedial measures.

Webster word reference characterizes building absconds as an inadequacy; an insufficiency intends to be needing, ailing in some quality important for fulfillment. (California jury, 2001) likewise characterizes building deserts as a disappointment of building or any segment to be raised in a sensibly workmanlike way or to play out the way planned by the producer or sensibly expected by the purchaser which roughly makes harm the structure. (Akinsola, 2010 pp. 58) characterizes a building imperfection as any blame in the parts or entire of a building which sterns the execution of the building part in which its happens. A building or development imperfection is a deformity or lack in the outline, development, or materials on a development extend. Extensively, incorporating deserts fall with two (2) classifications: surrenders that influence the execution of the structure, and deformities that influence the presence of the structure. From the lawful point of view, a building imperfection is characterized in fairly extraordinary terms. Lawfully, a building imperfection is an infringement of the relevant construction law, an infringement of the standard of care in the group in which the venture is found, or an infringement of the producer's proposals (Mann, 2007) Defect is the dissention of a part with a standard or determined trademark. Imperfection is utilized some of the time as an equivalent word for "disappointment", yet the favored significance is to demonstrate just a deviation from a few (saw) standard that may, however won't really, result in disappointment (David, 1997)

Causes of Building defects
Building surrenders emerges through improper or poor plan, detail and development and in addition lacking consideration given to building support. It can certainly be said that no building is free from deformities, not even another one, close supervision on quality procedures will diminishes the quantity of imperfections and great review will uncover any undeniable deformity. A deformity alludes to the unmistakable proof of an undesirable condition in progress influencing serviceability, basic condition or appearance. Damaged building development not just adds to the last cost of the item additionally to the cost of support which can be generous. Deficient development incorporates exercises, for example, compaction not done to detail prompting ground subsidence and in the end early crumbling of each segment of the building, this may prompt finish disappointment of a structure with high cost of support on the long run. Deserts bringing about off base development can be maintained a strategic distance from by guaranteeing that appropriate examination instruments are set up. (Adeyeye, 2009) expressed in this respects most nearby working in Nigeria experiences avoidable deformities. As per the National Building Agency (1985), deserts happen either in light of poor plan, or low quality workmanship, or on the grounds that the building was not built by the outline, or on the grounds that it has been liable to elements not took into consideration in the plan. These essential drivers may work separately or in blend and result in imperfections demonstrated by changes in organization

of materials; in the development itself; in the size, shape or weight of materials; or basically in appearances

Category of Building Defects

The defect can be divided into two categories, which are:
a) Structural defect

Basic imperfection implies any deformity in an auxiliary component of a building that is owing to blemished plan, inadequate or flawed workmanship or deficient material and once in a while any blend of these. Building structure incorporates earth holding dividers, sections, bars and level sections. (Northern Territory Consolidated Regulation) According to the Engineering Encyclopedia, basic imperfection can be classified as splits in establishments (Substructure), breaks in floor or pieces (superstructure), and breaks in dividers (superstructure). These imperfections can be caused by shameful soil investigation, improper site determination, and the utilization of deficient materials. The greater part of the auxiliary issue can be stayed away from by inferring the correct and detail of the outline and arranging. Auxiliary deformities in a building can happen after some time because of crumbling, wear and tear, over-burdening, and poor support. They should be repaired to keep up the building's structure and to keep any further disappointments. Consistent investigation is the way to securing the "wellbeing" of a building's structure. Basic deformity that dependably happens are steel consumption, splits, and redirection.

b) Non-structural defect

As per Northern Territory Consolidated Regulation, a non-basic deformity in a private building is depicted as an imperfection in a non-basic component of the working subsequently of blemished private building work. As per the Engineering Encyclopedia, non-auxiliary deformity incorporates imperfection in block work, moistness in old structures, and imperfections in mortar works.

74. What is crashing?

a. Using more time to complete activities not on the critical path
b. Using more resources to complete activities on the critical path
c. Using fewer activities to shorten the overall project duration
d. Using fewer resources to complete activities on the critical path

Answer: B

75. The technique for establishing and maintaining priorities among the various jobs of a project, is known

a. Event flow scheduling technique
b. Critical ratio scheduling
c. Slotting technique for scheduling
d. Short interval scheduling.

Answer: B

76. Frederick W. Taylor introduced a system of working known as

a. line organization
b. line and staff organization
c. functional organization

d. effective organization

Answer: C

77. A Milestone chart

a. shows the interdependencies of various jobs
b. depicts the delay of jobs, if any
c. points outgoing ahead of schedule of jobs, if any
d. none of these

Answer: D

78. Bar charts are suitable for

a. minor works
b. major works
c. large projects
d. all the Above

Answer: C

79. Arrange the phases of project management in correct order

1. Controlling, 2. Scheduling, 3. Planning

a. 1-2-3
b. 2-1-3
c. 3-1-2
d. 3-2-1

Answer: D

80. One of the main disadvantages of the Bar charts in project analysis is that

a. Progress of the work cannot be monitored
b. They do not show the interdependencies of the activities
c. The time schedule is not shown properly
d. The financial aspect is not show

Answer: D

81. For a given activity, the optimistic time, pessimistic time and the most probable estimates are 5, 17 and 8 days respectively. The expected time is

a. 8 days
b. 9 days
c. 10 days
d. 15 days

Answer: B

82. The probability distribution taken to represent the completion time in PERT analysis is

a. Gamma distribution
b. Normal distribution
c. Beta distribution
d. Log normal distribution

Answer: B

83. The area under the Beta-distribution curve is divided into two equal halves by vertical ordinate through

a. Expected time
b. Most likely time
c. Optimistic time
d. Pessimistic time

Answer: A

84. State the important points to be observed during inspection of the RCC, Masonry, sanitary and water supply services, electrical services.

Answer:

Every operation is connected with the quality of the product. In the case of construction the quality of construction is to be maintained as per project specifications. It is important that quality requirements be satisfied and production schedules are met. The satisfaction of the owner of the project is mainly derived by the quality of the work.
Stiff competition in the national and international level of construction sector demands a high quality oriented attitude of engineers. However, the management is required to achieve the satisfaction of the owner by completing the project within the cost constraints for the project. Both of these things are dependent on properly integrating quality development, quality maintenance and quality improvement in construction. The integration of all these three aspects can be achieved through a sound quality control system.

Inspection means the checking of material or product at various stages of manufacture or construction of an object. It is done with respect to some pre-defined parameters and it tries to detect the faulty nature of the object. When we inspect something, we try to see the past history of construction and try to learn from our past experiences. Faulty objects are sorted out and are rejected. For example, those structural members, whose construction has been faulty, may be dismantled and reconstructed. There may be different aspects which may be followed. For example, the quality of a beam specimen may be faulty because the concrete in that beam may not be of the chosen grade. It may be considered faulty if the detailing of reinforcement (i.e. how the reinforcement is to be placed in the beam) also is faulty. Such beam members would be discarded, dismantled and reconstructed.
Inspection should not be confused with quality control. Inspection is a way or method of maintaining the quality of the object being constructed or produced. Controlling the quality is what is termed as quality control. Quality control is a wide term which involves inspections at various stages of construction. Basically, when we consider the quality control of some object, we always have some future object in mind and we try to find out the ways as to how to control the quality of that object, to be produced in future. This is why, the quality control people are provided with instructions prior to the production or construction of some object or some building.
Inspections give us needed inputs to control quality. If the quality of an object is found to be not as per expectations, we have to take remedial steps. Inspections check the quality of past constructions and quality control norms or specifications are provided for the future constructions. Inspection is an act of checking the objects or items, sorting out and finding out the faulty item. Quality control is a broad term which includes inspection as an activity out of a number of activities carried out for the purpose.
Inspections are carried out using precise equipment and instruments. These devices or tools are used to measure those characteristics which define the quality of an object. Using such devices, we can ascertain the quality of past constructions and judge if those objects, which were constructed, were as per accepted norms and specifications. Inspection is mainly carried out by people who are responsible for it. They must know the norms and specifications, characteristics to be measured and should know how to use different devices

and tools to examine the quality of a construction.
For inspecting the quality of construction, non-destructive test procedures have been established. In such procedures, which are termed as NDT procedures, we can test the quality of construction without deforming a structural element.

To understand the aspect of quality control in construction, it has to appreciate that construction industry is somewhat different from other manufacturing industries. The objects created or constructed in this sector are most of the times unique in the sense that the structures are never the same or the exact replica of one another. Two buildings, two bridges, two roads may be chosen at random and in each case we would find that there are differences or variations.
There are certain considerations which should be kept in mind when we consider quality control in civil engineering construction.
Quality of construction is dependent, to a great extent, on
• The quality of materials which are used in construction
• The expertise of workers
• The technology adopted in construction
• Number, type and quality of inspections
• Quality consciousness of people
• Funds available for construction and quality control
• Time available for quality control procedures
• Existence of norms and guidelines for assessing quality of construction of a particular type
• Experience and expertise of inspectors
• Quality of design
• Nature of the construction project

Unit 6: Introduction to Project Management Software

85. Explain various elements of Project management.

Projects come in all shapes and sizes from small, simple ones to larger and more complex projects. Whatever the size or type of project, there are 5 essential elements that you must get right in order to achieve a successful outcome. Whether your project is about improving an existing product or service, managing change or implementing a new system, the same basic considerations are required when managing projects.
In order to ensure that all your projects reach the required level of success, here are the 5 essential elements that need to be included:

Strategic Planning

The first stage of any project is to understand the need for the project and what it is trying to achieve. SMART (Specific, Measurable, Attainable, Relevant, Timely,) objectives need to be established along with measures of success and key milestones where progress can be reviewed. Working as an internal project manager will require close liaison with key internal stakeholders and departments to establish their specific requirements and set commonly agreed objectives.

Product Development

The variety of activities that are deemed to be projects are wide-ranging and varied, and can include new products, processes and services. The development of any of these needs to be closely linked to meeting defined business objectives and adding value to the organisation. The benefits of a project should be well articulated at the beginning so there is a clear link to the success of the project and the impact on overall business aims.

Communication
It is vital to sell the benefits of any project to those who will be affected during the project or by the project's final outcome. Implementing a new process requires that end users understand why the project is beneficial and potential buyers need to be convinced by the advantages of new products and services. In essence, communicating the message of why new or different is good will help counteract the typical human reluctance to change.

Resources
It is vital to ensure that adequate resources in terms of people, time, finances and equipment are in place. Internally, this could involve the IT department providing the appropriate hardware/software, Human Resources recruiting the necessary people or the Facilities department providing offices or other relevant support. There also needs to be allocated budgets and finance as well as appropriate timelines for project completion.

People
No project manager works in isolation. There are many stakeholders involved in a project who all have a specific role to play and who all have a vested interest in the project's success. The key stakeholders who drive projects and help make them a success include:

- Sponsor: The project sponsor is the person who defines the business objectives that drive the project. The sponsor can be a member of the senior management team or someone from outside of the organisation.
- Project Manager: A professional project manager creates the project plan and ensures that it meets the budget, schedule and scope determined by the sponsors. The project manager is also responsible for risk assessment and management.
- Project Team Members: These can include subject area experts, members of departments, external professionals and new recruits. Anyone who can offer a positive contribution to the project in terms of their knowledge and capabilities makes a good team member.

Including these elements in a project will ensure that the final outcome is a successful one.

86. Define Project Management Information System (PMIS).

Answer:

Project Management Information System (PMIS) are system tools and techniques used in project management to deliver information. Project managers use the techniques and tools to collect, combine and distribute information through electronic and manual means. Project Management Information System (PMIS) is used by upper and lower management to communicate with each other.

Project Management Information System (PMIS) help plan, execute and close project management goals. During the planning process, project managers use PMIS for budget framework such as estimating costs. The Project Management Information System is also used to create a specific schedule and define the scope baseline. At the execution of the project management goals, the project management team collects information into one database. The PMIS is used to compare the baseline with the actual accomplishment of each activity, manage materials, collect financial data, and keep a record for reporting purposes. During the close of the project, the Project Management Information System is used to review the goals to check if the tasks were accomplished. Then, it is used to create a final report of the project close.

To conclude, the project management information system (PMIS) is used to plan schedules, budget and execute work to be accomplished in project management.

87. Name some of the popular project management software. Discuss their utility.

Anser:

Popular project management software
Scoro
It is a comprehensive solution that combines all the features you might need in project management software: projects & tasks, contact management, quotes, team collaboration, billing, and reporting.

Top features:

- Projects with sub-tasks and deadlines
- Real-time KPI dashboard
- Shared team calendar & meeting scheduling
- Contact management
- Time tracking and billing for work
- Detailed reports on project progress and finances
- Quoting and invoicing with pre-set templates

Proofhub

It offers a replacement for conventional emailing and a bunch of other tools, integrating multiple project management features under one roof.

Top features:

- Assigned user roles
- Online team discussions and chats
- Task delegating and assignments
- Reporting and tracking project history
- Secure file storage

Basecamp

It is the preferred tool for thousands of project management teams, who enjoy its modern social media-like interface and carefree team collaboration features.

Top features:

- Projects to manage multiple users' work
- Message boards for discussing new projects or ideas
- In-app collaboration with team
- Reporting on project performance
- Separate dashboard for showing to clients
- Email and desktop notifications

Asana

It combines elements of project management, file storage, and collaboration and helps to manage projects across a team without email.

Top features:

- Break your work down into tasks, and assign it to team members
- Organize your tasks into projects for roadmaps and timelines
- Review milestones, and check on your team's progress
- Get notified about projects updates
- Use project dashboards to get a quick overview

Podio

It is a flexible and highly customizable online hub for work and team communication.

Top features:

- Assign tasks, attach files and discuss details within the solution
- Share encrypted & large files
- Automate the sales pipelines, project budget tracking, and more
- Get an overview of the company with visual dashboards
- Automate your workflows

88. Effective software project management focuses on the four P's. What are those four P's?

A) People, performance, payment, product
B) People, product, process, project
C) People, product, performance, project
D) All of the above.

Answer: B

89. You are working in a company as a project manager. Company wants to develop a project. You are also involved in planning team. What will be your first step in project planning

A) Establish the objectives and scope of the product.
B) Determine the project constraints.
C) Select the team.
D) None of the above.

Answer: A

90. Which of these software characteristics are used to determine the scope of a software project?

A) Only performance.
B) Only context.
C) Information objectives, function, performance
D) None of the above.

Answer: C

91. Boehm suggests an approach that addresses project objectives, milestones and schedules, responsibilities, management and technical approaches, and required resources. This principle is called as:

A) W3HH principle
B) WHO principle
C) W5HH principle
D) None of the above.

Answer: C

92. Which of the following is/are considered stakeholder in the software process?

A) Customers
B) End-users
C) Project managers
D) All of the above.

Answer: D

93. You are working in a company as a project manager. What you will do to minimize the risk of software failure?

A) Request a large budget
B) You will increase the team size
C) Track progress
D) None of the above.

Answer: C

94. What are the signs that a software project is in trouble?

A) The product scope is poorly defined.
B) Deadlines are unrealistic.
C) Changes are managed poorly.
D) All of the above.

Answer: D

95. Completion of an activity on CPM network diagram, is generally known

A) Event
B) Node
C) Connector
D) All the above.

Answer: D

96. For completion of a project, the critical path of the network represents

A) Minimum time
B) Maximum time
C) Maximum cost
D) Minimum cost

Answer: A

97. Pick up the correct network for the activities of pouring concrete, erection of form work, removal of form work and curing of concrete from the following :

A) 1. Pouring of Concrete, 2. Erection of form work, 3. Curing of concrete, 4. Removal of form work
B) 1. Erection of form work, 2. Pouring of concrete 3. Curing of concrete, 4. Removal of form work
C) 1. Removal of form work 2. Erection of form work 3. Pouring of concrete, 4. Curing of concrete
D) 1. Pouring of concrete2. Curing of concrete 3. Erection of form work 4. Removal of form work.

Answer: B

98. In a certain project an activity C can only be started when activities A and B have been completed, which have no bearing on each other and can be started independently. The correct network for the activities, is

A) Activities A and B can be started independently
B) Activity C can be started only on completion of activity A
C) Activity D can be started only on completion of activity
D) D. all the above

Answer: D

99. Pick up the incorrect statement from the following :

A. The activity is the time consuming part of a project
B. The beginning and end of a job, are called events
C. The activity which consumes maximum time, is called a node
D. Logically and sequentially connected activities and events form a network

Answer: C

100. Pick up the correct statement from the following:

A) CPM analysis is activity oriented
B) PERT analysis is event oriented
C) CPM does not make any allowance for the uncertainties in the duration of time
D) All the above

Answer: D

DARBHANGA COLLEGE OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

Subject Code: 011827 Subject Name: Construction Planning and Management

Subject teacher: Ahsan Rabbani

Unit 1: Construction and fabrication methods

1. Modular co-ordination of construction means proper
A. planning
B. designing
C. execution
D. all the above.

2. The first stage of a construction, is
A. preparation of estimate
B. survey of the site
C. initiation of proposal
D. preparation of tender
E. allotment of funds.

3. Define construction and construction management.

4. Describe financial aspects related to construction equipments.

5. State advantages and disadvantages of hiring construction equipments.

6. Describe some common causes of accidents.

7. Classify the equipments required in construction industry.

8. Discuss various costs parameters that are considered and analyzed in order to formulate equipment replacement policy.

9. Explain different type of construction equipments being used in India along with safety features associated with it.

10. Explain and analyse different safety regulations for the construction projects.

11. List down the factors which affect the selection of construction equipment.

12. List down the factors which affect the economic life of equipment. Discuss each factor in details by assuming some data.

13. What is the prefabrication? What is the scope of prefabricated system of building construction in India?

14. Explain the design principles of the prefabricated system of building construction.

15. Discuss the various prefabricated elements with sketch.

16. What are the disadvantage and advantage of Prefabrication technique?

17. What is the role of standardization in prefabrication?

Unit 2: Value Analysis

1. Define following terms
   a. Crash cost
   b. Crash duration
   c. Indirect cost
   d. Direct cost

2. For the network having following details determine optimum duration and corresponding minimum cost

Activity	Normal cost Ra	Normal Duration	Crash cost	Ccrash duration
1-2	4500	4	6500	2
1-3	7000	6	10000	4
1-4	5000	5	7000	4
4-5	8000	8	9500	5
2-5	7000	5	7800	3
3-5	4000	4	5000	2

Indirect cost = Rs. 2500 / week

3. Explain cash flow diagram and its importance with simple example.

4. Estimate book value of equipment at the end of each year of ownership Data:
   Initial book value of equipment = Rs. 25,00,000/-
   Period of ownership = five years.
   Salvage value = Rs. 2,00,000/-
   method of depreciation = sinking fund method take i =5%

5. Explain meaning of cash flow analysis. Discuss purpose of cash flow analysis. Also differentiate between cash flow for contractor and cash flow for owner.

6. An equipment that was purchased at a cost of Rs 20 lakhs, six years age is considered for replacement. The existing equipment can be sold at a price of Rs. 5 lakhs and if kept for another six years will have salvage value of Rs. 1 lakh. The challenger has annual operating cost of Rs. 50000/- and its salvage value is rs. 5 lakhs at the end of 12 years. Rate of interest is 10%. Decide whether to continue services of existing equipment or replace it.

7. Discuss network crashing.

8. Define cash flow diagram, capitalized cost and salvage value.

9. A construction company purchases certain materials for five years. The present cost of these materials is Rs50 lakh. The cost increases annually in geometrical pattern with

rate of increase/ decrease being (i) -5%, (ii) 0% and (iii) 5%. Calculate the present worth of material purchase for the five year period for all the three cases. The rate of interest is 8% compounding annually.

10. Maintenance costs for new bridge with an expcted 50 year life was estimated to be Rs 10,000 each year for the first five years followed by aRs 100,000 expenditure in the 15th year and Rs 100,000 expenditure in 30th year. If I = 10% per year, what is the equivalent uniform annual cost over the entire 50 year period?

11. A building has been rented on an annual rent of Rs 4800. The life of the building in the present position is expected to be 12 years. If the major repairs to the building are done now, its life shall be increased by another 15 years. The major repairs will cost Rs 25,000. Determine whether it would be economical to do the major repair of the building or not, i = 6%.

12. The fixed cost or the year is Rs. 30,000. The extimated sales for the period are valued at Rs. 1,00,000. The variable cost per unit or the single product made is Rs 3. If each unit sells arRs 10, construct the breakeven chart and determine; a)The breakeven point, b) above how many units the company should produce in order to seek profit.

13. When his son was born a man deposited a sum of money in a saving bank at 10% interest compounded quarterly. On his twentieth birthday the son received Rs. 1,00,000 that had accumulated. How?

14. Explain Work breakdown structure.

Unit 3: Network Analysis

1. Select the correct equation for calculating total float for an activity.
   a. Total Float = LFT – EST
   b. Total Float = EFT – EST
   c. Total Float = LFT – EFT
   d. Total Float = LST – EFT

2. What is the term for an activity that cannot be deferred without affecting the project completion date or another activity's start date?
   a. Standard float
   b. Intermediate float
   c. Free float
   d. Zero float

3. PERT stands for:
   a. Programme evaluation and review technique
   b. Project estimation and review technique
   c. Programme estimation and renew technology
   d. None of these

4. Activities which have zero float are called:
   a. Critical Activities
   b. Dummy activities

c. Non-critical activities
d. None of these

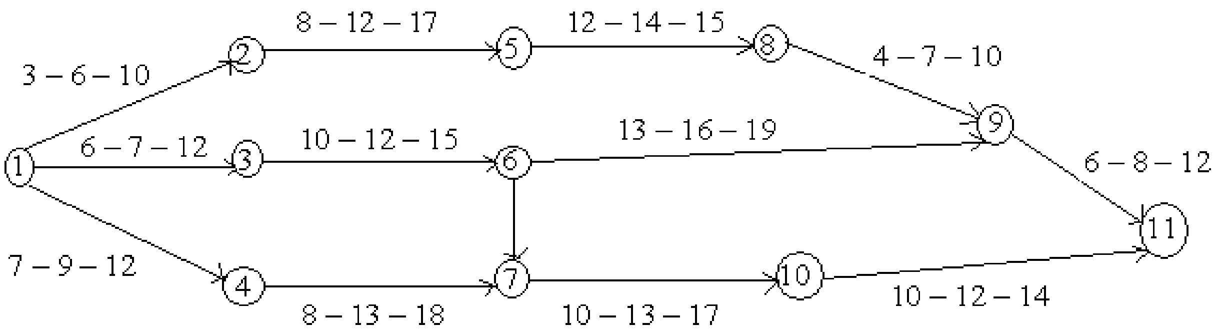
5. The time by which activity completion time can be delayed without affecting the start of succeeding activities, is known as
a. duration
b. total flat
c. free float
d. interfering float

5. The artificial activity which indicates that an activity following it, cannot be started unless the preceding activity is complete, is known as
a. event
b. free float
c. dummy
d. constant

6. The estimated time required to perform an activity, is known as
a. Event
b. Dummy
c. Duration
d. Float

7. Explain various differences between CPM and PERT.

8. Calculate the variance and the expected time for each activity



9. A project has the following times schedule

Activity	Time (weeks)	Activity	Time (weeks)	Activity	Time (weeks)
(1 – 2)	4	(4 – 9)	5	(8 – 9)	1
(1 – 3)	1	(5 – 6)	4	(8 – 10)	8
(2 – 4)	1	(5 – 7)	8	(9 – 10)	7
(3 – 4)	1	(6 – 8)	1		

Construct the network and compute

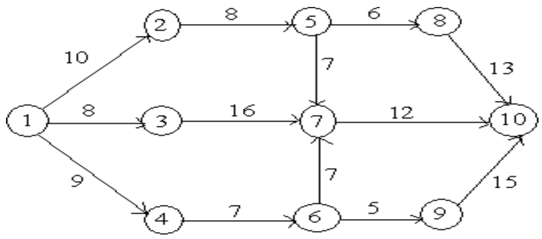
1. T_E and T_L for each event

2. Float for each activity

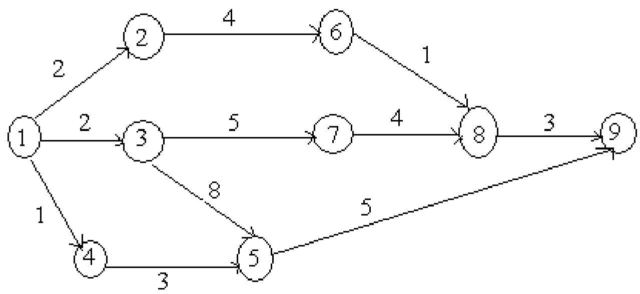
Critical path and its duration

10. Determine the early start and late start in respect of all node points and identify critical

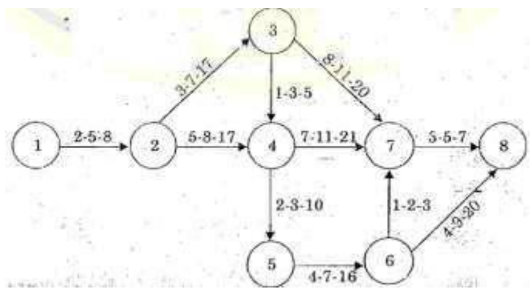
path for the following network.



11. Find the critical path and calculate the slack time for the following network



12. The time estimates in days for optimistic, most likely, and pessimistic times of various activities of a project are shown below in the network diagram. Obtain the expected time and the latest allowable time for each event. Draw the critical path and estimate the approximate value of standard deviation for the network.

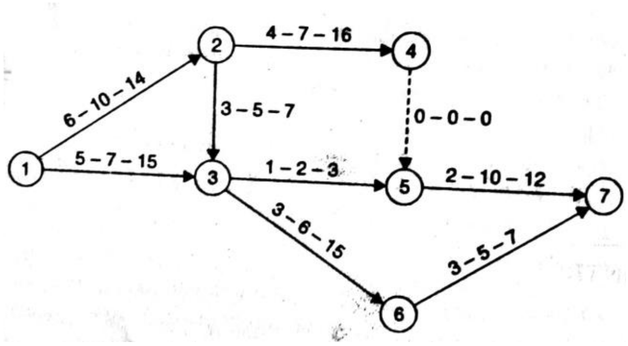


13. PERT calculation yields the project length of 50 weeks with the variance of 16 within how many weeks would you expect that project to be complete with probability of 75%. Also compute the probability of completion of this project in 35 weeks.
14. A construction project consists of 8 major activities. Their interdependency is given below. Draw the network and determine the time for completion of the project. Also mention duration for each path.
    a. Activities A, B and E can start concurrently. (Starting of the project)
    b. Activities C and D are concurrent and depend on the completion of A and B.
    c. Activities F and G are concurrent and can start after completion of C.
    d. Activity H depends on the completion of C, E and F.
    e. Project ends with the completion of G and H.
    Time needed for each activity is A - 4 weeks, B - 3 weeks, C - 5 weeks, D - 2 weeks, E - 4 weeks, F - 3 weeks, G- 4 Weeks and H- 2 Weeks

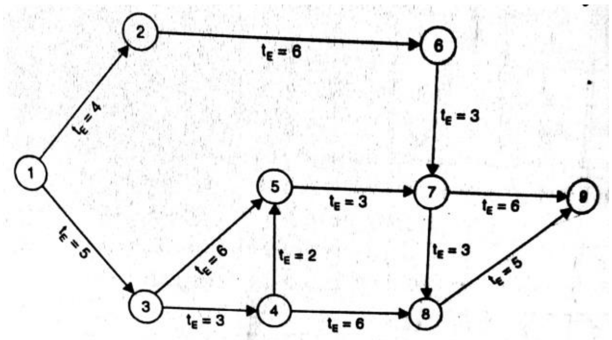
15. A project has fourteen activities A through M. The relationships which obtain amongst these activities are given below:
    a. A is the first operation
    b. B and C can be performed in parallel and are immediate successor to A
    c. D, E and F follow B
    d. G follows E

e. H follows D, but cannot start until E is complete
f. I and J succeed G
g. F and J precede K
h. H and I precede L
i. M succeeds L and K
j. The last operation succeeds M and C
Construct the network diagram.

16. The network for ascertain project is shown in figure below. Determine the expected time for each path. Which path is critical?



17. The expected time of completion (in days) for each activity of a network is shown in figure below. Determine the critical path. It is given that the scheduled completion time in 21 days.



18. The activities and their excepted time of project are shown in table .From the table draw the net work and determine the activity times and floats. Also determine the critical path and its duration.

Activity	1-2	1-3	1-4	2-7	3-4	4-5	4-7	5-6	5-7	5-8	6-8	7-8
Duration in days	9	11	6	7	4	8	0	5	4	7	6	6

19. The three time estimates optimistic, most likely , and pessimistic times of each activity of a project are given below

Activity	optimistic time t_0	most likely time t_L	pessimistic times t_p
1-2	2	5	14
1-3	3	12	21
2-4	5	14	17
3-4	2	5	8
3-5	6	15	30
4-5	1	4	7

i. Draw the network.
ii. Find the expected time and variance of each activity
iii. Calculate the early and late occurrence time for each event.
iv. Determine the expected duration of the project.
v. Calculate the total float for each activity.
vi. Find the variance and standard deviation of the entire project.

20. Four activities to be under taken in series for the completion of a project are as follows:

Activity	optimistic time t_0 in days	most likely time t_L in days	pessimistic times t_p in days
P	8	14	22
Q	7	21	32
R	8	19	28
S	28	40	52

Estimate the time required at 95%.Probablity, 55 % and 5% probability to complete the work. Which of the above four activities has the most reliable time estimate?

21. A work project consists of 12 activities, labeled as A to L. When the work manager was asked to specify the order in which jobs had to be done, he answered as follows: Job A comes first and precedes B, C and D. Both B and C must be done before E starts, and C and D must precede F, but G and H can start as soon as D is completed. Job I succeeds D, E, F and G, and jobs J and K can start when G, H, and I are all completed. Job L comes after J and K.

22. A father notes that his teenage daughter uses the telephone. She takes no less than 5 minutes for a call and sometimes as much as hour. Fifteen minutes calls are more frequent than calls of any other duration. If daughter's call were an activity in PERT project.
a) What would be the phone calls expected duration?
b) What estimate would you give for its variance?
c) In scheduling the project, how much time would you allocate for the phone call?

23. A project is expected to take 15 months along the critical path, having a standard deviation of 3 months. What is the probability of completing the project within 15 months, 21 months and 12 months.
The probability percentage for different values of probability factor is: 15.87% for -1; 50.00% for 0; 97.72% for +2.

Unit 4: Site Organization

1. Discuss objectives of construction management and Explain Planning, Scheduling and Controlling as a Function of Construction Management.

2. Explain the importance of equipments in construction industry and Discuss aspects of construction equipments that are required to be studied and mastered in order to accomplish cost effective and timely completion of construction projects.

3. Explain the concept of time value of money.

4. Explain the importance of organization in construction projects. Discuss the superiority of

line and staff organisation over the other systems.

5. Discuss the important aspects of project planning.
6. Discuss resource scheduling and resource smoothening.
7. Describe decision making under uncertainity.
8. Related to construction injuries, define frequency rate, severity rate and incidence rate.
9. What is the importance of a job lay-out and sketch a typical job layout for RCC framed building construction?
10. How to construct various construction schedules. Show how they facilate the work of construction planning.
11. What criteria would you suggest for evaluating the effectiveness of a management team?
12. Discuss the methods of project monitoring.
13. Outline and explain the factors to be considered for site layout development.

Unit 5: Maintenance Management

1. Discuss the importance of safety in construction project management.
2. Discuss different elements of Risk cost management.
3. Discuss the important aspects of project planning.
4. Explain the importance of organization in construction projects. Discuss the superiority of line and staff organisation over the other systems.
5. Explain the role of decision in Project Management.
6. Whar is a Gantt Bar chart? Explain, with the help of a suitable example, the method of preparing a bar chart.
7. How does CPM network facilitate the work of construction management of a project?
8. Why is an accident prevention programe essential in a construction project/industrial enterprise?
9. Describe common defects in buildings and their remedial measures.
10. A contractor who employs an average of 200men working 48hrs per week for 45 weeks has 8 disabling injuries and a total of 24 days lost from work. Calculate injury frequency rate, injury severity rate and injury index.

11. What is crashing?

    a. Using more time to complete activities not on the critical path
    b. Using more resources to complete activities on the critical path
    c. Using fewer activities to shorten the overall project duration
    d. Using fewer resources to complete activities on the critical path Answer: B

12. The technique for establishing and maintaining priorities among the various jobs of a project, is known
    a. Event flow scheduling technique
    b. Critical ratio scheduling
    c. Slotting technique for scheduling
    d. Short interval scheduling.

13. Frederick W. Taylor introduced a system of working known as
    a. line organization
    b. line and staff organization
    c. functional organization
    d. effective organization

14. A Milestone chart
    a. shows the interdependencies of various jobs
    b. depicts the delay of jobs, if any
    c. points outgoing ahead of schedule of jobs, if any
    d. none of these

15. Bar charts are suitable for
    a. minor works
    b. major works
    c. large projects
    d. all the Above

16. Arrange the phases of project management in correct order
    1. Controlling, 2. Scheduling, 3. Planning
    a. 1-2-3
    b. 2-1-3
    c. 3-1-2
    d. 3-2-1

17. One of the main disadvantages of the Bar charts in project analysis is that
    a. Progress of the work cannot be monitored
    b. They do not show the interdependencies of the activities
    c. The time schedule is not shown properly
    d. The financial aspect is not show

18. For a given activity, the optimistic time, pessimistic time and the most probable estimates are 5, 17 and 8 days respectively. The expected time is
    a. 8 days
    b. 9 days
    c. 10 days
    d. 15 days

19. The probability distribution taken to represent the completion time in PERT analysis is
    a. Gamma distribution
    b. Normal distribution

c. Beta distribution
d. Log normal distribution

20. The area under the Beta-distribution curve is divided into two equal halves by vertical ordinate through
    a. Expected time
    b. Most likely time
    c. Optimistic time
    d. Pessimistic time

21 Explain maintenance management? Write a note on case study regarding maintenance management of any one construction project?

22 State the important points to be observed during inspection of the RCC, Masonry, sanitary and water supply services, electrical services.

Unit 6: Introduction to Project Management Software

1. Explain various elements of Project management.

2. Define Project Management Information System (PMIS).

3. Name some of the popular project management software. Discuss their utility.

4. List different project management software. Write the detailed steps for management of construction project through Primavera?

5. **Effective software project management focuses on the four P's. What are those four P's?**

   A) People, performance, payment, product
   B) People, product, process, project
   C) People, product, performance, project
   D) All of the above.

6. **You are working in a company as a project manager. Company wants to develop a project. You are also involved in planning team. What will be your first step in project planning**

   A) Establish the objectives and scope of the product.
   B) Determine the project constraints.
   C) Select the team.
   D) None of the above.

7. **Which of these software characteristics are used to determine the scope of a software project?**

   A) Only performance.
   B) Only context.
   C) Information objectives, function, performance
   D) None of the above.

8. **Boehm suggests an approach that addresses project objectives, milestones and schedules, responsibilities, management and technical approaches, and required resources. This principle is called as:**

   A) W3HH principle
   B) WHO principle
   C) W5HH principle
   D) None of the above.

9. **Which of the following is/are considered stakeholder in the software process?**

   A) Customers
   B) End-users
   C) Project managers
   D) All of the above.

10. **You are working in a company as a project manager. What you will do to minimize the risk of software failure?**

    A) Request a large budget
    B) You will increase the team size
    C) Track progress
    D) None of the above.

11. **What are the signs that a software project is in trouble?**

    A) The product scope is poorly defined.
    B) Deadlines are unrealistic.
    C) Changes are managed poorly.
    D) All of the above.

Darbhanga College of Engineering, Darbhanga

Department of Civil Engineering

B.Tech [VIIIth Semester (CE)]

Mid. Sem Exam

(Session: 2020-21)

Course Code–011827

Time: 2 Hours **Construction Planning and Management** **Max. Marks: 20**

Note: Attempt all questions. CO–Course Outcomes, BL–Bloom Level

S. No.	Question	Marks	CO	BL
1.	What are the advantages and disadvantages of prefabrication? or What are the factors must be taken into account before selection of construction equipment?	5	CO1	L1
2.	Compare and contrast CPM and PERT. Under what circumstances would you use PERT as opposed to CPM in project management? or Define and explain pessimistic time and optimistic time.	5	CO3	L1
3.	Discuss the methods of project monitoring. or What are the various objective of site layout planning?	5	CO4	L2
4.	Describe common defects in building and their remedial measures. or A building has been rented on an annual rent of Rs. 4800. The life of the building in the present position is expected to be 12 years. If the major repairs to the building are done now, its life shall be increased by another 15 years. The major repairs will cost Rs. 25,000. Determine whether it would be economical to do the major repair of the building or not. Take interest rate = 6%.	5	CO5	L4

Modular co-ordination of construction means proper
planning
designing
execution
all the above

Answer: D

The initial cost of a piece of construction equipment is Rs.3000000 having a useful life of 10 years. The estimated salvage value of the equipment at the end of the useful life is Rs. 450000. The book value of the construction equipment at the end of 5th year using Straight - line method is

Rs.1145454
Rs.1181712
Rs.1725000
Rs.1763521

Answer: Rs.1725000

What will be the accumulated depreciation at the end of 5th year using Sinking fund method, if interest rate is 8.2 % per year?

Rs.1970157
Rs.1970657
Rs.1971657
Rs.1972657

Answer: Rs. 1972657

A project manager is dealing with a venture. The first extension standard of the venture was planned at Rs. 10000000. Since work on the venture began there have been seventeen approved and affirmed changes to the venture. The progressions have an estimation of Rs. 1700000 and the cost of exploring them before their endorsement was Rs. 250000. What is the present spending plan for the venture?

Rs.11950000
Rs.11700000
Rs.10000000
Rs.80500000

Answer: Rs. 11950000

Select the correct equation for calculating total float for an activity.
Total Float = LFT – EST
Total Float = EFT – EST
Total Float = LFT – EFT
Total Float = LST – EFT

Answer: C

What is the term for an activity that cannot be deferred without affecting the project completion date or another activity’s start date?

Standard float
Intermediate float
Free float
Zero float

Answer: C

PERT stands for:
Programme evaluation and review technique
Project estimation and review technique
Programme estimation and renew technique
Project evaluation and renew technique

Answer: A

Activities which have zero float are called:
Critical Activities
Dummy activities
Non-critical activities
Non-dummy activities

Answer: B

The time by which activity completion time can be delayed without affecting the start of succeeding activities, is known as
duration
total flat
free float
interfering float

Answer: C

After two years of service rendered, the capacity of a bulldozer to move soil has reduced. If the bulldozer is considered for replacement, the reason will be

Physical deterioration
Obsolescence
Lack of technological upgradation
Chemical disintegration

Answer: a

The value of the defender in study of replacement is

What it cost when originally purchased
The sunk cost
The salvage value at the end of its life
Its worth at present time

Answer: d

What is crashing?
Using more time to complete activities not on the critical path
Using more resources to complete activities on the critical path
Using fewer activities to shorten the overall project duration
Using fewer resources to complete activities on the critical path

Answer: B

Frederick W. Taylor introduced a system of working known as
Line organization
Line and staff organization
Functional organization
Effective organization

Answer: C

Bar charts are suitable for
Minor works
Major works
Large projects
All the Above

Answer: C

Arrange the phases of project management in correct order 1. Controlling, 2. Scheduling, 3. Planning

1-2-3
2-1-3
3-1-2
3-2-1

Answer: D

For a given activity, the optimistic time, pessimistic time and the most probable estimates are 5, 17 and 8 days respectively. The expected time is

8 days
9 days
10 days
15 days

Answer: B

The probability distribution taken to represent the completion time in PERT analysis is

Gamma distribution
Normal distribution
Beta distribution
Log normal distribution

Answer: B

Effective software project management focuses on the four P's. What are those four P's?

People, performance, payment, product
People, product, process, project
People, product, performance, project
People, performance, process, product

Answer: B

For completion of a project, the critical path of the network represents

Minimum time
Maximum time
Maximum cost

Minimum cost

Answer: A

Pick up the correct network for the activities of pouring concrete (1), erection of form work (2), removal of form work (3) and curing of concrete (4) from the following:

1-2-4-3
2-1-4-3
3-2-1-4
1-4-2-3

Answer: B

Code : 011827

B.Tech 8th Semester Exam., 2020

CONSTRUCTION PLANNING AND MANAGEMENT

Time : 3 hours

Full Marks : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are **NINE** questions in this paper.*

(iii) *Attempt **FIVE** questions in all.*

(iv) *Question No. **1** is compulsory.*

1. Choose the correct answer of the following (any *seven*) : 2×7=14

(a) The time by which activity completion time can be delayed without affecting the start of succeeding activities, is known as

(i) duration

(ii) total flat

(iii) free float ✓

(iv) interfering float

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(b) Henry Gantt developed bar charts for planning and scheduling of projects in

(i) 1880

(ii) 1900

(iii) 1920

(iv) 1940

(c) Critical path lies along the activities having total float

(i) positive

(ii) negative

(iii) zero

(iv) same

(d) The estimated time required to perform an activity, is known as

(i) event

(ii) dummy

(iii) duration ✓

(iv) float

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(e) Works costing less than ₹ 20,000 are treated as

(i) projects

(ii) major projects

(iii) minor projects

(iv) All of the above

(f) Bar charts are suitable for

(i) minor works ✓

(ii) major works

(iii) large projects

(iv) All of the above

(g) If TL is the latest allowable event occurrence time, total activity slack(s) is/are equal to

(i) LST-EST

(ii) LFT-EFT

(iii) TL-EFT

(iv) All of the above ✓

(h) If t is the duration of an activity, t_1 is the latest finish possible moment of its preceding activity and t_2 is the earliest start possible moment, the independent float of the activity is

(i) $(t_1 - t_2) - t$ ✓

(ii) $t - (t_1 - t_2)$

(iii) $(t_1 + t_2) - t$

(iv) $t + (t_1 - t_2)$

(i) For the supply of materials for concrete, formwork reinforcing and placing of concrete, removal of formwork and curing of concrete, number of bars required on bar chart, is

(i) 1

(ii) 2

(iii) 3

(iv) 4

(j) PERT analysis is based on

(i) optimistic time

(ii) pessimistic time

(iii) most likely time

(iv) All of the above

(Turn Over)

2. *(a)* Explain the meaning and significance of the following terms used in the network analysis : 7

   (i) Dummy activity

   (ii) Total float

   (iii) Construction obligation period

   (b) With the help of the suitable diagrams, compare and contrast 'activity on arrow' and 'activity on node' network. 7

3. *(a)* Write the algorithm for the analysis of a network by PERT. 7

   (b) What is beta distribution? How is it used in PERT? 7

4. Explain the following : 14

   (a) AOA diagram

   (b) Standard deviation

   (c) Most likely time estimate

   (d) Latest allowable occurrence time

5. Use the simplex method to find the maximum value of $Z = 2x_1 - x_2 + 2x_3$ subject to the constraints

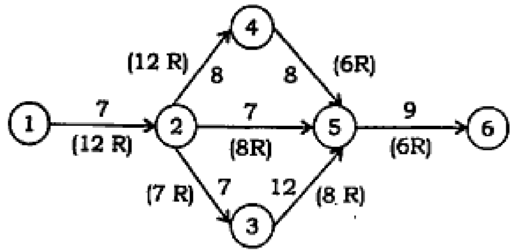
$$2x_1 + x_2 \le 10$$
$$x_1 + 2x_2 - 2x_3 \le 20$$
$$x_2 + 2x_3 \le 5$$

where $x_1 \ge 0, x_2 \ge 0, x_3 \ge 0$. 14

6. *(a)* Discuss the resource allocation problem. What are the methods of solving the problem? 7

   (b) Explain the line of balance technique. 7

7. *(a)* Consider the network shown in the figure below and do the resource allocation EST scheduling and LST scheduling : 7



   (b) Draw a typical cost duration curve and show optimal duration and minimum project cost on it. 7

8. *(a)* Describe the common equipment safety measures. 7

   (b) Discuss the various organizational forms for managing construction project. 7

9. The project has nine activities and the expected time of each activity is given below :

Activity	1–2	1–3	1–4	2–5	3–5	3–6	4–6	5–7	6–7
Expected time in day(s)	1	3	4	3	4	5	6	5	2

(a) Draw the network diagram.

(b) Identify the critical path.

(c) Draw the table showing EST, LST, EFT and float. 14

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Code : 011827

B.Tech 8th Semester Exam., 2019

CONSTRUCTION PLANNING AND MANAGEMENT

Time : 3 hours | *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct answer of the following (any *seven*) : 2×7=14

   (a) Which of the following does not represent an activity?

   (i) Site located

   (ii) Foundation is being dug

   (iii) The office area is being cleaned

   (iv) The invitations are being sent

   (b) Sensitivity analysis is a study of

   (i) comparison of profit and loss

   (ii) comparison of assets and liabilities

   (iii) change in output due to change in input

   (iv) estimates of cost and benefits of the project

   (c) Preliminary project report for a road project must contain

   (i) the detailed estimated cost based on detailed design

   (ii) the several alternatives of the project that have been considered

   (iii) the soil survey, traffic survey, concept design and approximate cost

   (iv) the contract documents for inviting tenders

   (d) Updating may result in

   (i) change of critical path

   (ii) decrease of project completion time

   (iii) increase of project completion time

   (iv) All of the above

(e) Critical path method

(i) is an improvement upon bar chart method

(ii) provides a realistic approach to daily problems

(iii) avoids delays which are very common in bar charts

(iv) All of the above

(f) In the time-cost optimization, using CPM method for network analysis, the crashing of the activities along the critical path is done starting with the activity having

(i) longest duration

(ii) highest cost slope

(iii) least cost slope

(iv) shortest duration

(g) Interfering float is the difference between

(i) total float and free float

(ii) total float and independent float

(iii) free float and independent float

(iv) None of the above

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(h) PERT technique of network analysis is mainly useful for

(i) small projects

(ii) large and complex projects

(iii) research and development projects

(iv) deterministic activities

(i) For completion of a project, the critical path of the network represents

(i) minimum time

(ii) maximum time

(iii) maximum cost

(iv) minimum cost

(j) Which one of the following represents an event?

(i) Concrete cured

(ii) Fixing of door

(iii) Plastering of walls

(iv) Selecting sites

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2\. (a) What are the types of pre-fabricates based on (i) plan area and (ii) weight? 7

(b) What is the need of pre-fabricates structures? 7

3\. (a) Compare and contrast CPM and PERT. Under what circumstances would you use PERT as opposed to CPM in project management? 7

(b) Discuss the objectives of network analysis. 7

4\. The following table gives the data for the duration and costs of each activity of the project network. The indirect cost of the project is ₹ 11·5 lakh per week. Determine the optimum duration and minimum the optimum duration and minimum duration of project and corresponding cost. Draw the time-scaled version of the crashed network : 14

Activity Crash Cost	*Normal Duration (weeks)*	*Normal Cost (lakh)*	*Crash Duration (weeks)*	*Crash Cost (lakh)*
1–2	6	40	3	70
1–3	5	30	3	52
2–4	2	60	1	84
3–4	10	70	6	98
2–5	3	45	2	63
4–5	4	26	2	50

5\. A company manufactures two products X_1 and X_2 on three machines A, B and C. X_1 requires 1 hour on machine A and 1 hour on machine B and yields a revenue of ₹ 3. Product X_2 requires 2 hours on machine A and 1 hour on machine B and 1 hour on machine C and yields revenue of ₹ 5. In the coming planning period, the available time of three machines A, B and C are 2000 hours, 1500 hours and 600 hours respectively. Find the optimal product mix using linear programming. 14

6\. (a) List the various safety measures you suggest for a multi-storeyed construction work. 7

(b) What do you understand by 'work breakdown structure' in construction planning? Draw the work breakdown structure for construction of two-storeyed hostel building. 7

7\. (a) Derive graphically relationship between optimum duration time and optimum cost. 7

(b) What do you mean by updating? How and when is it done? 7

8. *(a)* Discuss the methods of project monitoring. 7

(b) What are the objectives of resource allocation? Explain what you mean by resource levelling. Explain step-by-step process for resource levelling. 7

9. *(a)* Explain the concept of value and define value analysis. Write in detail the steps in value analysis. 7

(b) Define and explain the following : 7

(i) Pessimistic time

(ii) Optimistic time

(iii) Most probable time

* * *

Code : 011827

B.Tech. 8th Semester Exam., 2017

Construction Planning and Design

Time : 3 hours *Full Marks : 70*

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are NINE questions in this paper.*

(iii) *Attempt FIVE questions in all.*

(iv) *Questions No. 1 is compulsory.*

1. Answer any seven questions from the following multiple choice type questions: 2×7=14

(i) CPM and PERT network is

(a) activity oriented

(b) activity and event oriented

(c) event oriented

(d) resources oriented

(ii) Gantt chart is drawn for

(a) time versus activity

(b) activity versus time

(c) resources versus progress

(d) progress versus time

P.T.O.

(iii) Negative slack occurs

(a) When latest allowable time is greater than earliest expected time

(b) when events stick to their schedule

(c) when deficiency of resource exist

(d) none of these

(iv) If an activity has its optimistic, most likely and pessimistic times as 2, 3 and 7 respectively, then its expected time and variance respectively are

(a) 3.5 and 25/36

(b) 3.5 and 5/6

(c) 5 and 25/36

(d) 4 and 5/6

(v) A tractor shovel has as purchase price of Rs. 4.7 lacs and could save the organisation an amount of rupee one lac per year on operating costs. The salvage value after the amortization period is 10% of the purchase price. The Capital recovery period will be

(a) 3.7 years

(b) 5 years

(c) 7.87

(d) 4.23 years

(vi) In resource levelling

(a) total duration of project is reduced

(b) total duration of project is increased

(c) uniform demand of resources is achieved

(d) cost of project is controlled

(vii) Cost-benefit studies are essential to

(a) assess the total cost of the work

(b) ascertain the relevant escalation in price

(c) monitor the expenditure

(d) evaluate the viability and worth whileness of taking up the project

(viii) Site order book is used for recording

(a) instructions of the executive engineer

(b) construction managements

(c) requirement of plants and equipment

(d) indents for materials to be ordered

(ix) A 75 m^3 scraper working on a 150 m haul is expected to give an output of approximately

(a) 1 m^3/hr

(b) 5 m^3/hr

(c) 10 m^3/hr

(d) 100 m^3/hr

P.T.O.

(x) The size of the power shovel is indicated by the size of

(a) boom

(b) dipper

(c) hoist line

(d) cab

2. A building project consists of 12 activities. The normal duration required to perform various activities and the relationship among the activities are given below:

Activity	A	B	C	D	E	F	G	H	I	J	K	L
Predecessor	—	—	A	A	B	B	C	C	D,E	F	G	H,I,J
Duration week	7	5	10	5	8	6	5	4	10	5	8	9

Compute (i) the project completion time (ii) the critical path and (iii) the total float and free float each activity. 14

3. The three time estimates of each activities of a project are given below:

Activity	1-2	1-3	2-4	3-4	4-5	3-5
t_o(days)	2	3	5	2	1	6
t_m(days)	5	12	14	5	4	15
t_p(days)	14	21	17	8	7	30

(i) Draw the network diagram (ii) Find the expected duration and variance of each activity (iii) Calculate the

Code : 011827

early and late occurrence times for each event (iv) Determine the expected duration (v) Calculate the total float for each activity. 14

(a) Distinguish clearly between the following: 7

(i) Large block construction and Medium panel construction

(ii) Large panel construction and Box unit construction

(b) Fly ash bricks are precast cost-effective building materials and are sufficient to replace the burnt bricks. Give reasons.

5. (a) Define the following terms: 6

(i) Injury-frequency rate

(ii) Injury-severity rate

(iii) Injury Index

(b) What are the safety measures that can be adopted in demolition of buildings? 8

6. (a) State and explain Limit of economical haul or economical overhaul distance. 5

(b) For the given value of data of the section of highways, draw the mass-haul curve and calculate (i) total volume of cut and total volume of fill (ii) the chainage at which the total excavated volume has been used in filling (iii) volume of fill material

required from borrow pit to complete the earthwork and the chainage for the purpose. 9

Chainage(m)	Volume(m^3)	
	Cutting volume	Filling volume
0		
50	500	
100	1500	
150	2000	
200	1800	
250	1000	
300	200	
350		600
400		900
450		2000
500		2500
550		1800
600		1200

7. (a) What are the functions of Break Even Chart? 6

(b) A building has been rented on an annual rent of Rs.4800. The life of the building in the present position is expected to be 12 years. If the major repairs to the building are done now, its life shall be increased by another 15 years. The major repairs will cost Rs.25,000. Determine whether it would be economical to do the major repair of the building or not. Take interest rate=6%. 8

8. (a) Discuss the characteristics of construction management. 7

(b) What are the factors must be taken into account before selection of construction equipment. 7

9. (a) Calculate the output per day of a concrete mixer of 200 liters. Assume all data reasonably for the purpose. 6

(b) How many litters of fresh water will be pumped per minute by a double acting duplex pump having size 15 cm×30 cm driven by a crank shaft making 60 rpm. If the total head is 50 meter and the efficiency of the pump is 70%, what is the minimum horse power required to operate the pump? 8

***

(e) Difference between total float and free float is

(f) The probability that the load on a scaffolding will exceed 2t is 0·15 and the probability that the strength of scaffolding will be more than 2t is 0·8. The probability of failure of the scaffolding is ___

(g) In time-cost analysis, cost slope is defined as

(h) The optimum duration, total cost of the project is ___

(i) ___ is a deterministic network technique.

(j) Sinking fund method is useful in estimating

2. (a) What are the advantages and disadvantages of prefabrication? 7

(b) Explain in brief the design principle of prefabricated system. 7

3. (a) Related to construction injuries, define frequency rate, severity rate and incidence rate. 2+2+2=6

(b) Name some of the popular project management software. Discuss their utility. 8

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B.Tech 8th Semester Exam., 2015

CONSTRUCTION PLANNING AND MANAGEMENT

Time : 3 hours *Full Marks* : 70

Instructions :

(i) *The marks are indicated in the right-hand margin.*

(ii) *There are* **NINE** *questions in this paper.*

(iii) *Attempt* **FIVE** *questions in all.*

(iv) *Question No.* **1** *is compulsory.*

1. Fill in the blanks of any *seven* of the following : 2×7=14

(a) In resource levelling, total duration of the project normally ___

(b) If the original cost of an equipment is ₹ 10,000 and its salvage value after 5 years is ₹ 1,000, its book value after 2 years is ___

(c) For a given activity, the optimistic, the pessimistic and the most probable times are 5, 17 and 8 days respectively, the expected time of the activity is ___.

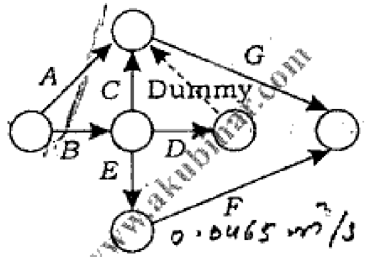
(d) The probability distribution representing the completion time in PERT analysis is

6. (a) Discuss network crashing. 6

(b) Discuss resource scheduling and resource smoothening. 4+4=8

7. Describe common defects in buildings and their remedial measures. 14

8. For the following network and data, determine the project duration which will result in minimum total project cost. Indirect cost is ₹ 400/day ; 14



	Normal		Crash	
	Time (weeks)	Cost (₹ '000)	Time (weeks)	Cost (₹ '000)
A	10	20	7	30
B	8	15	6	20
C	5	8	4	14
D	6	11	4	15
E	8	9	5	15
F	5	5	4	8
G	12	3	8	4

4. (a) Define cash flow diagram, capitalized cost and salvage value. 2+2+2=6

(b) A construction company purchases certain materials for five years. The present cost of these materials is ₹ 50 lakh. The cost increases annually in geometrical pattern with rate of increase/decrease being *(i)* –5%, *(ii)* 0% and *(iii)* 5%. Calculate the present worth of material purchase for the five-year period for all the three cases. The rate of interest is 8% compounding annually. 8

5. A project consists of 11 activities as detailed below :

Job/ activity	*Immediate predecessors*	*Activity duration*
A		5
C	A	7
D	B	5
E	B	5
F	C	3
H	D	10
I	E, F	9
J	G	5
K	I, J, H	0

Draw an arrow diagram of the project. Also find EST, EFT, LST, LFT, project duration and total float. 2+(2×6)=14

9. *(a)* Describe decision-making under uncertainty. 6

(b) A firm manufactures three types of products. The fixed and variable costs are as follows :

	Fixed cost (₹)	*Variable cost per unit* (₹)
Product A	25,000	12
Product B	25,000	12
Product C	25,000	12

The likely demands (units) of the products are as :

Poor demand = 3000
Moderate demand = 7000
High demand = 11000

If the sale price of each type of product is ₹ 25, then prepare the payoff (profit) matrix.

DEPARTMENT OF CIVIL ENGINEERING

B TECH 8th SEMESTER

01 1827 CONSTRUCTION PLANNING AND MANAGEMENT

L-T-P : 3-0-0 Credit : 3

Module 2: Value Analysis, Feasibility studies; Economics of project evaluation: Finance, material and manpower development.

Total number of Lecture: 8

Introduction: The competencies required for developing business cases comprise a range of skills, including those for:

- facilitation and negotiation
- demand management
- risk management
- value management
- economic, social, environmental and budget analyses, and
- strategic planning.

Project evaluation

Evaluation of building project proposals is a key element of a department's financial and service delivery planning and in the formulation of capital works programs. Building projects are initiated where strategies selected through strategic planning involve building requirements. Planning for assets at this strategic level involves establishing what assets are required to support service and output strategies identified in a department's corporate plan and service delivery strategies. These are compared to existing available assets. Strategies are developed for acquisition of new building assets and reconfiguration, use, refurbishment and disposal of existing assets. This process includes consideration of recurrent cost implications of capital investment.

Asset strategies developed through this process and incorporated in a department's capital investment strategic plan form the basis from which options are further developed and evaluated and capital investment programs formulated. These activities are undertaken as part of the project development, which includes the project evaluation and program formulation phases in the capital works management process.

Asset strategic planning, project evaluation and the State Budget process are key elements in determining building requirements and those building proposals that provide the best value for money and that can and should progress to funding approval in the program formulation phase.

The project evaluation phase incorporates the project feasibility and business case stages and provides a structured approach for undertaking project feasibility studies to establish preferred options and, where required, develop a business case that supports service delivery through asset strategies. When asset strategies include building elements, the business case should establish: a preferred building solution that meets service delivery needs; the basis for funding application and inclusion in capital works programs; and the basis for building performance review in the project review phase of the capital works management process.

Project feasibility

Project feasibility involves:

- defining the objectives and scope of individual projects;
- identifying and selecting suitable options;
- carrying out project analyses; and
- selecting preferred options.

Project feasibility involves the comparative evaluation of ‘build' and ‘non-build' scenarios relating to the project and should be undertaken in accordance with the process. It revisits the asset strategic planning process with input to a department's capital investment strategic plan, but at a project level.

Defining the objectives and scope of projects

The purpose of the project must be defined in terms of the benefits the project will provide. These can be expressed as ‘outcomes' (e.g. increased provision of government services to the region) and as an ‘output' (e.g. build a new facility). These outcomes and outputs should be drawn from the department's corporate and capital investment strategic planning processes, which establish linkages with government priorities and regional strategies. Any project proposal should include specific information on the functional requirements and how it will contribute to the department's service delivery strategy.

Identifying and selecting suitable options

Departments should pursue innovative solutions when formulating options for building projects and should consider option strategies, such as joint ventures, non-building solutions, outsourcing and private sector involvement. Options should include suitable options identified through the asset strategic planning process (e.g. gap analysis may identify potential to meet building requirements through refurbishment or upgrading of existing buildings). They should always include the option to take no action.

Building project options may include:

- new building construction;

- extensions to existing buildings;
- major refurbishment (or upgrading) of buildings;
- reconfiguration of existing buildings;
- acquisition of buildings;
- leasing of building space; or
- site acquisition for building purposes.

Project options should, where appropriate, take into account the disposal of existing buildings and the decommissioning of leased premises. When a number of location and site options are available, it will be necessary to include these in project analyses.

Carrying out project analyses

Following identification and preliminary assessments of all reasonable building, non-building, location and site options, the most suitable options should be short listed for detailed analysis. The purpose of detailed project analysis is to ensure best value for money through economic, environmental, social and budget analyses of all short listed options. The degree of analysis undertaken should be tailored to appropriately manage risks associated with individual projects. In undertaking the analysis, departments should give consideration to departmental priorities, government policies and legislation.

Economic analysis

Techniques used for economic analysis such as Cost/Benefit Analysis and Cost/Effectiveness Analysis. For building projects, the net economic benefits of each option are assessed by calculating the Net Present Value (NPV) using the Cost/Benefit Analysis technique. Cost/Effectiveness Analysis is appropriate for projects with strong community or social welfare objectives that may be difficult to value and should only be used when the project and the benefits are of reasonable significance. NPV is today's value of all future cash inflows and outflows of a project option. The NPV is the difference between the streams of costs and benefits of an option, both discounted to a present value by the application of a discount rate. Discounting takes into account the time value of money so that options with different cash flows can be compared.

Analysis of the cost of service delivery associated with an option should consider total asset management and service delivery costs. This will involve analyses of life cycle costs including capital, recurrent and disposal costs. In some cases, such as the delivery of health services, the recurrent costs associated with projects can exceed the capital investment after a relatively short period of use. The NPV is a key decision criterion used to rank project options. All other considerations being equal, the project option with the highest NPV represents the option with the greatest economic benefit. In these cases, social benefits and other qualitative issues may be important considerations. As there will always be some degree of uncertainty surrounding the outcome of an evaluation, the projected outcomes should be tested under different scenarios. This may be undertaken by determining realistic ranges (i.e. worst to best) for all key variables. NPV calculations are performed using different combinations of worst and best case scenarios. These analyses can identify minimum sets of changes in key assumptions that would alter the ranking of project options.

Techniques include sensitivity analysis, risk analysis and scenario planning. *Sensitivity analysis* is used to determine the sensitivity of the NPV to changes in key project variables. This process enables the identification of variables that are critical to the robustness of the estimated values. Sensitivity analyses should be undertaken to establish:

- sensitivity of the options' NPVs to changes in the discount rate; and
- sensitivity of the options' NPVs to changes in at least one key project variable.

Risk analysis can be used where there are a limited number of key variables. Major assumptions made in the analysis will assist in identifying risks associated with the options. For capital building projects, risks may be associated with the following areas:

- benefits - the areas of exposure or major assumptions associated with the estimated benefits;
- time, cost and quality - the major factors in selecting either a traditional or a non-traditional form of project delivery to manage the project specific risks. Risks may be associated with reliability of cost estimates (including potential cost exposures) or with management of particularly large projects, and
- social and environmental impacts - assumptions made in estimating the social and environmental impact of options. Risks may be associated, for example, with particular local requirements for disaster mitigation strategies, including preventative measures to safeguard or minimize impact on or of all new building projects.

  Scenario planning may also be used to assess risk associated with project options if there is a number of assumptions and variables used in the analysis. Clear statements of assumptions made in analyses and the reasons for making such assumptions must be given so that decision-makers are fully informed. For example, if analysis of an option for construction of office accommodation is undertaken on the assumption that office rents will increase at more than the rate of inflation, the assumption could be justified by evidence of market trends including the projected returns and demand for office space in the particular area. Where necessary, independent expert assessments should be obtained in order to develop and justify the costs and demand estimates.

Environmental analysis

As well as its general benefits and its financial and economic performance, a project should also be assessed as to whether it might have any negative impact on the environment.

The negative environmental impact of a project normally relates to the development of the market site itself. If this not undertaken properly and in conformity with an agreed master plan the development could: increase traffic congestion in the vicinity of the market site, particularly if the site entry is poorly located;

- cause flooding to adjacent land, because of increased surface water run-off, a restricted site outlet or lack of on-site storage; and
- produce glare and noise impact on adjacent land uses if insulation, screening and planting proposals are not carefully integrated into the development programme.

Social analysis

Budget analysis
This analysis should identify outlays and revenues over the forward estimates period for all resource strategies (i.e. human resource, information technology and asset strategies) and include capital and recurrent outlays, revenues and the funding source for each project option. The effects each option has on the State Budget should also be identified, and include consideration of the impact on the department's capital and recurrent budgets. The impact on other organisations (such as the impact of any inter-departmental charges) should also be included.

Selecting the preferred option
The short-listed options should be ranked according to the NPV when the Cost/Benefit Analysis technique has been used. For Cost/Effectiveness Analysis, the NPV of costs should be used to determine the lowest cost option. Where the impacts of environmental, social and budget analysis have not been factored into the economic evaluation, the ranking of options established by the economic analysis should be adjusted based on a synthesis of these analyses. This may be undertaken by assessing costs associated with the major environmental, social and budget impacts to adjust the NPVs to reflect departmental and Government priorities.
The preferred option, which is the outcome of the project feasibility stage, contributes to the formulation of capital investment plans and capital works programs.

Business case

The business case stage involves documentation of the analyses undertaken in the project feasibility stage. Where required for building projects, documentation of a business case is undertaken when the project analysis has arrived at a preferred option that incorporates building elements.
In these cases, the functional requirements justified by the project feasibility and documented in the business case will form the basis of project delivery and assist in keeping building projects focused on service delivery outcomes.

A generic outline for business cases
The following generic table of contents has been developed to provide guidance on the content and requirements for business cases. Departments may choose to adopt this structure for documentation of business cases.

Table of contents
Executive summary
1 Project background
2 Objectives and scope of project
3 Project options
4 Project analysis
5 Preferred option
6 Recommendations
Attachments

Executive summary
An executive summary should provide an outline of the capital investment proposal and, consistent with the requirements for project evaluation reports and it should state:

- whether the project advances government priorities and contributes to outcomes established through the department's strategic plan;
- if the project forms part of an interdepartmental strategy (such as for co-location of facilities);
- the impact the project will have on service delivery and departmental outcomes;
- how the project contributes to outputs and increased productivity;
- what budgetary impact and economic return the project will produce;
- whether options other than the government as owner and operator have been considered; and
- how the project is to be funded.

Project background
The project background should document:

- earlier planning for service delivery through corporate planning and development of service delivery and resource strategies, and in particular, identified needs for capital building elements incorporated in asset strategies;
- any earlier activities relating to project development; and
- an explanation of the process and analyses undertaken in developing the business case.

The emphasis, here, should be on the major benefits of the project, including the impact it will have on service delivery outcomes.

Objectives and scope of project

Based on the results of the project feasibility stage of project development, the purpose of the project must be defined in terms of the benefits the project will provide. The main issues to be documented relate to:

- current and projected demand for services;
- identification of functional requirements of the building project proposal; and
- the functional relationship with other infrastructure segments.

Project options

Project options identified and selected in the project feasibility stage should be documented. The concept of each option including details of joint ventures, outsourcing and private sector involvement as well as details of the take no action scenario and both building and nonbuilding solutions should be outlined. Particular information to be included should relate to:

- meeting functional and service delivery requirements, such as location and details of space and floor area provisions;
- capital costs including land acquisition, design and construction costs, furniture and equipment costs, fees and charges, relocation and commissioning costs and allowances for contingencies;
- recurrent costs including operating costs (for the asset, human resources and information technology) and maintenance costs;
- associated financial strategies including funding of capital and recurrent costs; and
- site and other project implications.

Project analysis

This section should summarise the analysis of the building and non-building options undertaken in the project feasibility stage. It should present findings of analyses undertaken in the project feasibility stage, including:

- the economic analysis presenting a comparison of the net benefits of each option and the associated sensitivity and risk analyses;

- the environmental analysis outlining all environmental consequences and the short-term and long-term environmental effects and mitigation strategies relating to each option;
- the social analysis outlining significant social issues, impacts, costs or opportunities associated with each option as well as their impact and proposed strategies;
- the budget analysis outlining the outlays and revenues for each option over the forward estimates period and documenting the impact of each option on the State Budget and other organisations; and
- the synthesis of the above analyses including results of application of performance criteria reflecting departmental and government priorities.

Preferred option

A summary of the preferred option should be presented along with a statement outlining the reasons for selecting this option. Where the preferred option includes a building solution, the summary should describe the concept including details of any joint ventures, outsourcing and private sector involvement.

Particular information to be summarised should relate to:

- location and details of the building concept, including space and floor area provisions;
- capital costs including land acquisition, design and construction costs, furniture and equipment costs, fees and charges, relocation and commissioning costs, and allowances for contingencies;
- recurrent costs including operating costs (for the asset, human resources and information technology) and maintenance costs;
- associated financial strategies including funding of capital and recurrent costs as well as cash flows for each financial year over the three year forward estimates period (and subsequent years as appropriate);
- site and other project implications; and
- a procurement strategy including delivery and programming aspects.

Recommendations

The recommendations should be introduced by referring to the preferred option, the reasons for selecting this option and the impact should the project not proceed. This section should then provide specific recommendations relating to adoption of the preferred option and make further recommendations as appropriate to progress the project. Particular recommendations may relate to:

- any site designation or approval processes;
- further considerations required by government committees, such as the Cabinet Budget Review Committee; and
- Cabinet submissions required such as when the proposal provides for private sector participation.

Attachments

The extent of information required to support the project will depend on the level of analysis undertaken and, where appropriate, may be attached to the business case.

DEPARTMENT OF CIVIL ENGINEERING

B TECH 8th SEMESTER

01 1827 CONSTRUCTION PLANNING AND MANAGEMENT

L-T-P : 3-0-0 Credit : 3

Module 2: Value Analysis, Feasibility studies; Economics of project evaluation: Finance, material and manpower development.

Total number of Lecture: 8

Introduction: The competencies required for developing business cases comprise a range of skills, including those for:

- facilitation and negotiation
- demand management
- risk management
- value management
- economic, social, environmental and budget analyses, and
- strategic planning.

Project evaluation

Evaluation of building project proposals is a key element of a department's financial and service delivery planning and in the formulation of capital works programs. Building projects are initiated where strategies selected through strategic planning involve building requirements. Planning for assets at this strategic level involves establishing what assets are required to support service and output strategies identified in a department's corporate plan and service delivery strategies. These are compared to existing available assets. Strategies are developed for acquisition of new building assets and reconfiguration, use, refurbishment and disposal of existing assets. This process includes consideration of recurrent cost implications of capital investment.

Asset strategies developed through this process and incorporated in a department's capital investment strategic plan form the basis from which options are further developed and evaluated and capital investment programs formulated. These activities are undertaken as part of the project development, which includes the project evaluation and program formulation phases in the capital works management process.

Asset strategic planning, project evaluation and the State Budget process are key elements in determining building requirements and those building proposals that provide the best value for money and that can and should progress to funding approval in the program formulation phase.

The project evaluation phase incorporates the project feasibility and business case stages and provides a structured approach for undertaking project feasibility studies to establish preferred options and, where required, develop a business case that supports service delivery through asset strategies. When asset strategies include building elements, the business case should establish: a preferred building solution that meets service delivery needs; the basis for funding application and inclusion in capital works programs; and the basis for building performance review in the project review phase of the capital works management process.

Project feasibility

Project feasibility involves:

- defining the objectives and scope of individual projects;
- identifying and selecting suitable options;
- carrying out project analyses; and
- selecting preferred options.

Project feasibility involves the comparative evaluation of ‘build' and ‘non-build' scenarios relating to the project and should be undertaken in accordance with the process. It revisits the asset strategic planning process with input to a department's capital investment strategic plan, but at a project level.

Defining the objectives and scope of projects

The purpose of the project must be defined in terms of the benefits the project will provide. These can be expressed as ‘outcomes' (e.g. increased provision of government services to the region) and as an ‘output' (e.g. build a new facility). These outcomes and outputs should be drawn from the department's corporate and capital investment strategic planning processes, which establish linkages with government priorities and regional strategies. Any project proposal should include specific information on the functional requirements and how it will contribute to the department's service delivery strategy.

Identifying and selecting suitable options

Departments should pursue innovative solutions when formulating options for building projects and should consider option strategies, such as joint ventures, non-building solutions, outsourcing and private sector involvement. Options should include suitable options identified through the asset strategic planning process (e.g. gap analysis may identify potential to meet building requirements through refurbishment or upgrading of existing buildings). They should always include the option to take no action.

Building project options may include:

- new building construction;

- extensions to existing buildings;
- major refurbishment (or upgrading) of buildings;
- reconfiguration of existing buildings;
- acquisition of buildings;
- leasing of building space; or
- site acquisition for building purposes.

Project options should, where appropriate, take into account the disposal of existing buildings and the decommissioning of leased premises. When a number of location and site options are available, it will be necessary to include these in project analyses.

Carrying out project analyses

Following identification and preliminary assessments of all reasonable building, non-building, location and site options, the most suitable options should be short listed for detailed analysis. The purpose of detailed project analysis is to ensure best value for money through economic, environmental, social and budget analyses of all short listed options. The degree of analysis undertaken should be tailored to appropriately manage risks associated with individual projects. In undertaking the analysis, departments should give consideration to departmental priorities, government policies and legislation.

Economic analysis

Techniques used for economic analysis such as Cost/Benefit Analysis and Cost/Effectiveness Analysis. For building projects, the net economic benefits of each option are assessed by calculating the Net Present Value (NPV) using the Cost/Benefit Analysis technique. Cost/Effectiveness Analysis is appropriate for projects with strong community or social welfare objectives that may be difficult to value and should only be used when the project and the benefits are of reasonable significance. NPV is today's value of all future cash inflows and outflows of a project option. The NPV is the difference between the streams of costs and benefits of an option, both discounted to a present value by the application of a discount rate. Discounting takes into account the time value of money so that options with different cash flows can be compared.

Analysis of the cost of service delivery associated with an option should consider total asset management and service delivery costs. This will involve analyses of life cycle costs including capital, recurrent and disposal costs. In some cases, such as the delivery of health services, the recurrent costs associated with projects can exceed the capital investment after a relatively short period of use. The NPV is a key decision criterion used to rank project options. All other considerations being equal, the project option with the highest NPV represents the option with the greatest economic benefit. In these cases, social benefits and other qualitative issues may be important considerations. As there will always be some degree of uncertainty surrounding the outcome of an evaluation, the projected outcomes should be tested under different scenarios. This may be undertaken by determining realistic ranges (i.e. worst to best) for all key variables. NPV calculations are performed using different combinations of worst and best case scenarios. These analyses can identify minimum sets of changes in key assumptions that would alter the ranking of project options.

Techniques include sensitivity analysis, risk analysis and scenario planning. *Sensitivity analysis* is used to determine the sensitivity of the NPV to changes in key project variables. This process enables the identification of variables that are critical to the robustness of the estimated values. Sensitivity analyses should be undertaken to establish:

- sensitivity of the options' NPVs to changes in the discount rate; and
- sensitivity of the options' NPVs to changes in at least one key project variable.

Risk analysis can be used where there are a limited number of key variables. Major assumptions made in the analysis will assist in identifying risks associated with the options. For capital building projects, risks may be associated with the following areas:

- benefits - the areas of exposure or major assumptions associated with the estimated benefits;
- time, cost and quality - the major factors in selecting either a traditional or a non-traditional form of project delivery to manage the project specific risks. Risks may be associated with reliability of cost estimates (including potential cost exposures) or with management of particularly large projects, and
- social and environmental impacts - assumptions made in estimating the social and environmental impact of options. Risks may be associated, for example, with particular local requirements for disaster mitigation strategies, including preventative measures to safeguard or minimize impact on or of all new building projects.

  Scenario planning may also be used to assess risk associated with project options if there is a number of assumptions and variables used in the analysis. Clear statements of assumptions made in analyses and the reasons for making such assumptions must be given so that decision-makers are fully informed. For example, if analysis of an option for construction of office accommodation is undertaken on the assumption that office rents will increase at more than the rate of inflation, the assumption could be justified by evidence of market trends including the projected returns and demand for office space in the particular area. Where necessary, independent expert assessments should be obtained in order to develop and justify the costs and demand estimates.

Environmental analysis

As well as its general benefits and its financial and economic performance, a project should also be assessed as to whether it might have any negative impact on the environment.

The negative environmental impact of a project normally relates to the development of the market site itself. If this not undertaken properly and in conformity with an agreed master plan the development could: increase traffic congestion in the vicinity of the market site, particularly if the site entry is poorly located;

- cause flooding to adjacent land, because of increased surface water run-off, a restricted site outlet or lack of on-site storage; and
- produce glare and noise impact on adjacent land uses if insulation, screening and planting proposals are not carefully integrated into the development programme.

Social analysis

Budget analysis
This analysis should identify outlays and revenues over the forward estimates period for all resource strategies (i.e. human resource, information technology and asset strategies) and include capital and recurrent outlays, revenues and the funding source for each project option. The effects each option has on the State Budget should also be identified, and include consideration of the impact on the department's capital and recurrent budgets. The impact on other organisations (such as the impact of any inter-departmental charges) should also be included.

Selecting the preferred option
The short-listed options should be ranked according to the NPV when the Cost/Benefit Analysis technique has been used. For Cost/Effectiveness Analysis, the NPV of costs should be used to determine the lowest cost option. Where the impacts of environmental, social and budget analysis have not been factored into the economic evaluation, the ranking of options established by the economic analysis should be adjusted based on a synthesis of these analyses. This may be undertaken by assessing costs associated with the major environmental, social and budget impacts to adjust the NPVs to reflect departmental and Government priorities.
The preferred option, which is the outcome of the project feasibility stage, contributes to the formulation of capital investment plans and capital works programs.

Business case

The business case stage involves documentation of the analyses undertaken in the project feasibility stage. Where required for building projects, documentation of a business case is undertaken when the project analysis has arrived at a preferred option that incorporates building elements.
In these cases, the functional requirements justified by the project feasibility and documented in the business case will form the basis of project delivery and assist in keeping building projects focused on service delivery outcomes.

A generic outline for business cases
The following generic table of contents has been developed to provide guidance on the content and requirements for business cases. Departments may choose to adopt this structure for documentation of business cases.

Table of contents
Executive summary
1 Project background
2 Objectives and scope of project
3 Project options
4 Project analysis
5 Preferred option
6 Recommendations
Attachments

Executive summary
An executive summary should provide an outline of the capital investment proposal and, consistent with the requirements for project evaluation reports and it should state:

- whether the project advances government priorities and contributes to outcomes established through the department's strategic plan;
- if the project forms part of an interdepartmental strategy (such as for co-location of facilities);
- the impact the project will have on service delivery and departmental outcomes;
- how the project contributes to outputs and increased productivity;
- what budgetary impact and economic return the project will produce;
- whether options other than the government as owner and operator have been considered; and
- how the project is to be funded.

Project background
The project background should document:

- earlier planning for service delivery through corporate planning and development of service delivery and resource strategies, and in particular, identified needs for capital building elements incorporated in asset strategies;
- any earlier activities relating to project development; and
- an explanation of the process and analyses undertaken in developing the business case.

The emphasis, here, should be on the major benefits of the project, including the impact it will have on service delivery outcomes.

Objectives and scope of project

Based on the results of the project feasibility stage of project development, the purpose of the project must be defined in terms of the benefits the project will provide. The main issues to be documented relate to:

- current and projected demand for services;
- identification of functional requirements of the building project proposal; and
- the functional relationship with other infrastructure segments.

Project options

Project options identified and selected in the project feasibility stage should be documented. The concept of each option including details of joint ventures, outsourcing and private sector involvement as well as details of the take no action scenario and both building and nonbuilding solutions should be outlined. Particular information to be included should relate to:

- meeting functional and service delivery requirements, such as location and details of space and floor area provisions;
- capital costs including land acquisition, design and construction costs, furniture and equipment costs, fees and charges, relocation and commissioning costs and allowances for contingencies;
- recurrent costs including operating costs (for the asset, human resources and information technology) and maintenance costs;
- associated financial strategies including funding of capital and recurrent costs; and
- site and other project implications.

Project analysis

This section should summarise the analysis of the building and non-building options undertaken in the project feasibility stage. It should present findings of analyses undertaken in the project feasibility stage, including:

- the economic analysis presenting a comparison of the net benefits of each option and the associated sensitivity and risk analyses;

- the environmental analysis outlining all environmental consequences and the short-term and long-term environmental effects and mitigation strategies relating to each option;
- the social analysis outlining significant social issues, impacts, costs or opportunities associated with each option as well as their impact and proposed strategies;
- the budget analysis outlining the outlays and revenues for each option over the forward estimates period and documenting the impact of each option on the State Budget and other organisations; and
- the synthesis of the above analyses including results of application of performance criteria reflecting departmental and government priorities.

Preferred option

A summary of the preferred option should be presented along with a statement outlining the reasons for selecting this option. Where the preferred option includes a building solution, the summary should describe the concept including details of any joint ventures, outsourcing and private sector involvement.

Particular information to be summarised should relate to:

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Attachments

The extent of information required to support the project will depend on the level of analysis undertaken and, where appropriate, may be attached to the business case.

Introduction

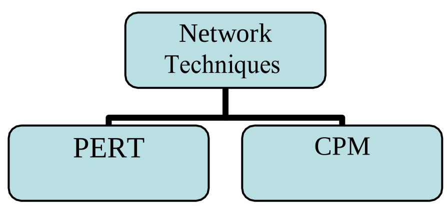
Network is a technique used for planning and scheduling of large projects in the fields of construction, maintenance, fabrication, purchasing, computer system instantiation, research and development planning etc. There is multitude of operations research situations that can be modeled and solved as network. Some recent surveys reports that as much as 70% of the real-world mathematical programming problems can be represented by network related models. Network analysis is known by many names _PERT (Programme Evaluation and Review Technique), CPM (Critical Path Method), PEP (Programme Evaluation Procedure), LCES (Least Cost Estimating and Scheduling), SCANS (Scheduling and Control by Automated Network System), etc
This chapter will present three of algorithms.

1. PERT & CPM
2. Shortest- route algorithms
3. Maximum-flow algorithms

The Basic Terminology

Network

It is a graphical representation of logical and sequentially connected activities and events of a project. Network is also called **arrow diagram***.* PERT (Programme Evolution Review Technique) and (Critical Path Method) are the two most widely applied techniques.



Project

A project is defined as a combination of interrelated activities which must be executed in a certain order in for its completion.

Project Management Process

Network analysis is the general name given to certain specific techniques which can be used for the planning, management and control of projects

Activity

Any individual operation, which utilizes resources and has an end and a beginning, is called activity.

- A task or a certain amount of work required in the project
- Requires time to complete
- Represented by an arrow

These are usually classified into four categories:

- Predecessor activity
- Successor activity

- Concurrent activity
- Dummy activity

Dummy Activity
It Indicates only precedence relationships and does not require any time of effort

PERT(Program Evaluation and Review Technique) is a method to analyze the involved tasks in completing a given project, especially the time needed to complete each task, and identifying the minimum time needed to complete the total project.

PERT is based on the assumption that an activity's duration follows a probability distribution instead of being a single value
Three time estimates are required to compute the parameters of an activity's duration distribution:

1. **Pessimistic time** (t_p) - the time the activity would take if things did not go well
2. **Most likely time** (t_m) - the consensus best estimate of the activity's duration
3. **Optimistic time** (t_o) - the time the activity would take if things did go well.

Mean (expected time) = $\dfrac{(t_p - 4t_m + t_o)}{6}$

Variance (σ^2) = $\left(\dfrac{t_p - t_o}{6}\right)^2$

Probability computation: Determine probability that project is completed within specified time $Z = \dfrac{X-\mu}{\sigma}$

Where μ = project mean time
σ = project standard mean time
x = (proposed) specified time

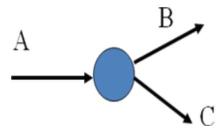
Float:
Float of an activity represents the excess of available time over its duration.

Total Float (F_t)
The amount of time by which the completion of an activity could be delay beyond the earliest expected completion time without affecting the overall project duration.
i.e. Tf= (Latest start-Earliest start) for activity(i-j), or,$(Tf)_{ij}=(LS)_{jj}-(ES)_{ij}$

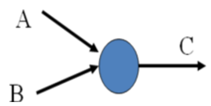
Free Float (F_f)
The time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent (succeeding) activities.

Situations in network diagram

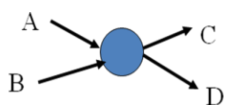
1. A must finish before either B or C can start



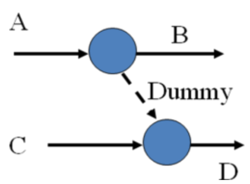
2. Both A and B must finish before C can start



3. Both A and C must finish before either of B or D can start



4. A must finish before B can start both A and C must finish before D can start



Benefits of CPM/PERT

1) Useful at many stages of project management
2) Mathematically simple
3) Give critical path and slack time
4) Provide project documentation
5) Useful in monitoring costs

Distinguish Between PERT and CPM?

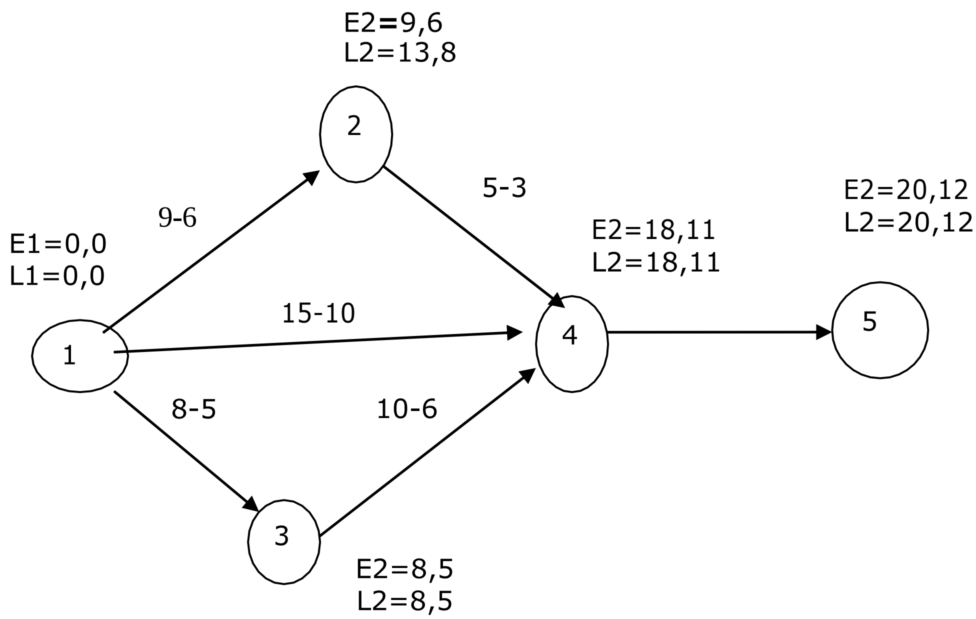
PERT (Programme Evaluation Review Technique)	**CPM** (Critical Path Method)
1. PERT is event oriented. 2. PERT is probabilistic. 3. PERT is primarily concerned with time only. 4. PERT is generally used for projects where time required to complete the activities is not known a priori. Thus PERT is used for large, R&D type of projects. 5. Three time estimates are possible for activities linking up two events.	1. CPM is activity oriented. 2. CPM is deterministic. 3. CPM places dual emphasis on project time as well cost. 4. CPM is used for projects which are repetitive in nature and comparatively small in size. 5.One time estimate is possible for activities (No allowance is made for uncertainty)

Example: 02. The following table gives the activities of a construction project and other relevant information.

Activities (i-j)	Normal duration (days)	Crash duration (days)	Crashing cost (Rs. per day)
1-2	9	6	20
1-3	8	5	25
1-4	15	10	30
2-4	5	3	10
3-5	10	6	15
4-5	2	1	40

A. What is the normal project length and minimum project length?
B. Determine the minimum crashing costs of schedule ranging from length down to and the minimum length schedule.
C. What is the optimal length schedule duration of each job for your solution?
Given that over head cost total Rs. 60 per day.

Solution:



A. The Critical path is 1 →3 →4 →5 with normal duration 20 days and minimum project length is 12 days.

Normal Project length(days)	Crashing Cost (day/Rs.)	Overhead cost @ Rs. 60/day	Total Cost(Rs.)
20	------	20×60=1200	1200
19	1×15=15	19×60=1140	1155
18	15+1×15=30	18×60=1080	1110
17	30+1×13=45	17×60=1020	1065
16	45+1×40=85	16×60=960	1045
15	85+1×40+1×30=145	15×60=900	1030
14	145+1×30+1×10+1×25=195	14×60=840	1035

B. Total cost increasing for 14 days duration, the minimum total cost Rs. 1030 occurs 15 days duration.

C. Optimum duration of each job is as follows:

D.

Job:	(1,2)	(1,3)	(1,4)	(2,4)	(3,4)	(4,5)
Optimum duration days:	9	8	14	4	6	1

Example-3: The time estimates (in hours) for the activities of a PERT network are given below:

Activity	t_0	t_m	t_p
1-2	1	1	7
1-3	1	4	7
1-4	2	2	8
2-5	1	1	1

3-5	2	5	14
4-6	2	5	8
5-6	3	6	15

Where t_0 is the optimistic time t_p is the pessimistic time and t_m is most likely time

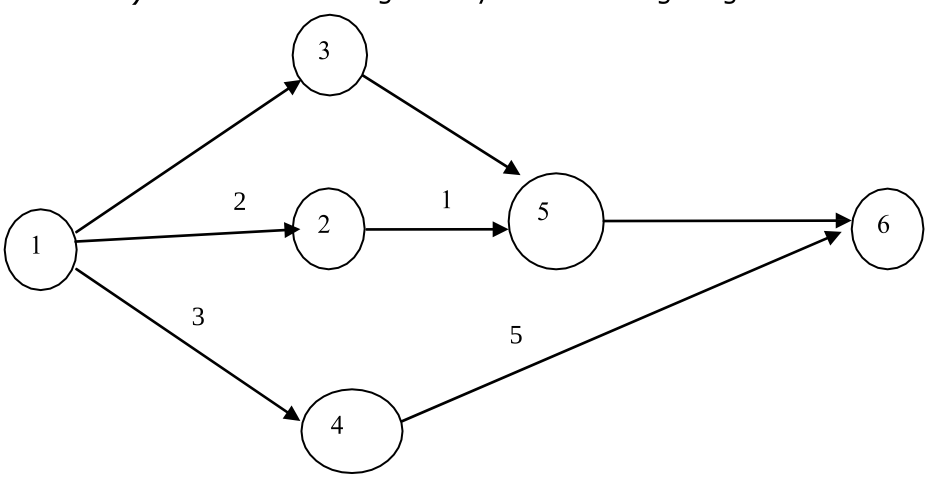
(a) Draw the project network
(b) Identify all paths through it and write critical path.
(c) Determine the expected project length
(d) Calculate standard deviation and variance of the project length
(e) What is the percentage of confidence that the project will complete

I. at least 4 weeks earlier then expected time
II. not more than 4 weeks than the expected time

(f) What should be the scheduled complication times for the probability of complication are 90% confidence and 100% confidence?

Given data $P(Z \le 1.33) = 0.9082, P(Z \le 1.28) = 0.9, P(Z \le 5) = 0.99999.$

Solution: i) The Network is given by the following diagram



The expected time and variance of each activity is shown below

Activity	t_0	t_m	t_p	$t_e = \frac{t_0 - t_m t - {}_p}{6}$	$\sigma^2 = \left(\frac{t_p - t_0}{6}\right)^2$
1-2	1	1	7	2	1
1-3	1	4	7	4	1
1-4	2	2	8	3	1
2-5	1	1	1	1	0
3-5	2	5	14	6	4
4-6	2	5	8	5	1
5-6	3	6	15	7	4

b) Determination of project paths

Length of the path 1→ 2→5→6 = 2+1+7=10

Length of the path 1→ 3→5→6 = 4+6+7=17

Length of the path 1→ 4→6 = 5+3= 8

Since 1→ 3→5→6 has largest duration. Therefore the critical path is1→ 3→5→6.

c) The expected project length duration is = 17 weeks

d) Standard deviation of project length (σ^2)=sum of the standard deviations of the activities on the critical paths=1+4+4 =9

e) I) the probability of completing the project with in 4 weeks earlier than expected is given by $P(Z \le D),\ where\ D = \frac{T_S - T_E}{\sigma}$

$D = \frac{13-17}{3} = -1.33$. Given that $P(Z \le 1.33) = 0.9082$. Therefore

$$\begin{aligned} P(Z \le -1.33) &= 0.5 - \varphi(1.33) \\ &= 0.5 - 0.4082 \\ &= 0.0918 = 9.18\% \end{aligned}$$

ii) The probability of completing the project not more than 4 weeks than the expected time is given by $P(Z \le D),\ where\ D = \frac{T_S - T_E}{\sigma}$

$D = \frac{21-17}{3} = 1.33$. Given that $P(Z \le 1.33) = 0.9082$. Therefore

$$\begin{aligned} P(Z \le 1.33) &= 0.5 - \varphi(1.33) \\ &= 0.5 + 0.4082 \\ &= 0.9082 = 90.82\% \end{aligned}$$

f) Value of Z for p=90% i.e. $\frac{T_S - 17}{3} = 1.28$, Therefore T_S=1.28×3+17=20.84 weeks

DEPARTMENT OF CIVIL ENGINEERING
B TECH 8th SEMESTER
01 1827 CONSTRUCTION PLANNING AND MANAGEMENT

L-T-P: 3-0-0 Credit: 3

Network analysis, PERT: Leveling of Resources

Total number of Lecture: 8

Introduction

CPM/PERT or Network Analysis as the technique is sometimes called, developed along two parallel streams, one industrial and the other military.

CPM (Critical Path Method) was the discovery of M.R.Walker of E.I.Du Pont de Nemours & Co. and J.E.Kelly of Remington Rand, circa 1957. The computation was designed for the UNIVAC-I computer. The first test was made in 1958, when CPM was applied to the construction of a new chemical plant. In March 1959, the method was applied to maintenance shut-down at the Du Pont works in Louisville, Kentucky. Unproductive time was reduced from 125 to 93 hours.

PERT (Project Evaluation and Review Technique) was devised in 1958 for the POLARIS missile program by the Program Evaluation Branch of the Special Projects office of the U.S.Navy, helped by the Lockheed Missile Systems division and the Consultant firm of Booz-Allen & Hamilton. The calculations were so arranged so that they could be carried out on the IBM Naval Ordinance Research Computer (NORC) at Dahlgren, Virginia.

The methods are essentially **network-oriented techniques** using the same principle. PERT and CPM are basically time-oriented methods in the sense that they both lead to determination of a time schedule for the project. The significant difference between two approaches is that the time estimates for the different activities in CPM were assumed to be **deterministic** while in PERT these are described **probabilistically**. These techniques are referred as **project scheduling** techniques.

In **CPM** activities are shown as a network of precedence relationships using activity-on- node network construction

- Single estimate of activity time
- Deterministic activity times

USED IN: Production management - for the jobs of repetitive in nature where the activity time estimates can be predicted with considerable certainty due to the existence of past experience.
In **PERT** activities are shown as a network of precedence relationships using activity-on- arrow network construction

- Multiple time estimates
- Probabilistic activity times

USED IN: Project management - for non-repetitive jobs (research and development work), where the time and cost estimates tend to be quite uncertain. This technique uses probabilistic time estimates.

Benefits of PERT/CPM

- Useful at many stages of project management
- Mathematically simple
- Give critical path and slack time
- Provide project documentation
- Useful in monitoring costs

Limitations of PERT/CPM

- Clearly defined, independent and stable activities
- Specified precedence relationships
- Over emphasis on critical paths

Applications of CPM / PERT

These methods have been applied to a wide variety of problems in industries and have found acceptance even in government organizations. These include

- Construction of a dam or a canal system in a region
- Construction of a building or highway
- Maintenance or overhaul of airplanes or oil refinery
- Space flight
- Cost control of a project using PERT / COST
- Designing a prototype of a machine

- Development of supersonic planes

Basic Steps in PERT / CPM

Project scheduling by PERT / CPM consists of four main steps

1. **Planning**

- The planning phase is started by splitting the total project in to small projects. These smaller projects in turn are divided into activities and are analyzed by the department or section.
- The relationship of each activity with respect to other activities are defined and established and the corresponding responsibilities and the authority are also stated.
- Thus the possibility of overlooking any task necessary for the completion of the project is reduced substantially.

2. **Scheduling**

- The ultimate objective of the scheduling phase is to prepare a time chart showing the start and finish times for each activity as well as its relationship to other activities of the project.
- Moreover the schedule must pinpoint the critical path activities which require special attention if the project is to be completed in time.
- For non-critical activities, the schedule must show the amount of slack or float times which can be used advantageously when such activities are delayed or when limited resources are to be utilized effectively.

3. **Allocation of resources**

- Allocation of resources is performed to achieve the desired objective. A resource is a physical variable such as labour, finance, equipment and space which will impose a limitation on time for the project.
- When resources are limited and conflicting, demands are made for the same type of resources a systematic method for allocation of resources become essential.
- Resource allocation usually incurs a compromise and the choice of this compromise depends on the judgment of managers.

4. **Controlling**

- The final phase in project management is controlling. Critical path methods facilitate the application of the principle of management by expectation to identify areas that are critical to the completion of the project.
- By having progress reports from time to time and updating the network continuously, a better financial as well as technical control over the project is exercised.
- Arrow diagrams and time charts are used for making periodic progress reports. If required, a new course of action is determined for the remaining portion of the project.

The Framework for PERT and CPM

Essentially, there are six steps which are common to both the techniques. The procedure is listed below:

I. Define the Project and all of its significant activities or tasks. The Project (made up of several tasks) should have only a single start activity and a single finish activity.
II. Develop the relationships among the activities. Decide which activities must precede and which must follow others.
III. Draw the "Network" connecting all the activities. Each Activity should have unique event numbers. Dummy arrows are used where required to avoid giving the same numbering to two activities.
IV. Assign time and/or cost estimates to each activity
V. Compute the longest time path through the network. This is called the critical path.
VI. Use the Network to help plan, schedule, and monitor and control the project.

The Key Concept used by CPM/PERT is that a small set of activities, which make up the longest path through the activity network control the entire project. If these "critical" activities could be identified and assigned to responsible persons, management resources could be optimally used by concentrating on the few activities which determine the fate of the entire project.

Non-critical activities can be replanned, rescheduled and resources for them can be reallocated flexibly, without affecting the whole project. Five useful questions to ask when preparing an activity network are:

- Is this a Start Activity?

- Is this a Finish Activity?
- What Activity Precedes this?
- What Activity Follows this?
    - What Activity is Concurrent with this?

Network Diagram Representation

In a network representation of a project certain definitions are used

1. Activity

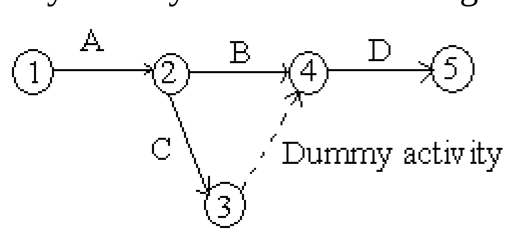
Any individual operation which utilizes resources and has an end and a beginning is called activity. An arrow is commonly used to represent an activity with its head indicating the direction of progress in the project. These are classified into four categories

1. **Predecessor activity** – Activities that must be completed immediately prior to the start of another activity are called predecessor activities.
2. **Successor activity** – Activities that cannot be started until one or more of other activities are completed but immediately succeed them are called successor activities.
3. **Concurrent activity** – Activities which can be accomplished concurrently are known as concurrent activities. It may be noted that an activity can be a predecessor or a successor to an event or it may be concurrent with one or more of other activities.
4. **Dummy activity** – An activity which does not consume any kind of resource but merely depicts the technological dependence is called a dummy activity.

The dummy activity is inserted in the network to clarify the activity pattern in the following two situations

- To make activities with common starting and finishing points distinguishable
- To identify and maintain the proper precedence relationship between activities that is not connected by events.

For example, consider a situation where A and B are concurrent activities. C is dependent on A and D is dependent on A and B both. Such a situation can be handled by using a dummy activity as shown in the figure.

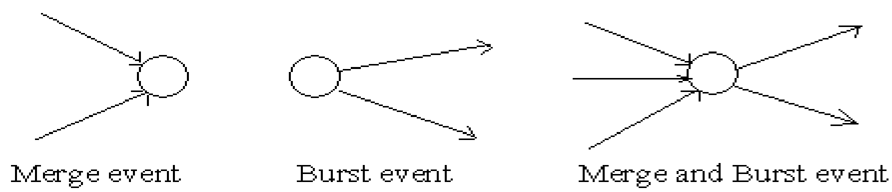


2. Event

An event represents a point in time signifying the completion of some activities and the beginning of new ones. This is usually represented by a circle in a network which is also called a node or connector.

The events are classified in to three categories

1. **Merge event** – When more than one activity comes and joins an event such an event is known as merge event.
2. **Burst event** – When more than one activity leaves an event such an event is known as burst event.
3. **Merge and Burst event** – An activity may be merge and burst event at the same time as with respect to some activities it can be a merge event and with respect to some other activities it may be a burst event.



3. Sequencing

The first prerequisite in the development of network is to maintain the precedence relationships. In order to make a network, the following points should be taken into considerations

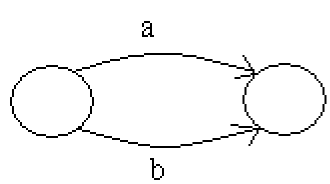
- What job or jobs precede it?
- What job or jobs could run concurrently?
- What job or jobs follow it?
- What controls the start and finish of a job?

Since all further calculations are based on the network, it is necessary that a network be drawn with full care.

<u>Rules for Drawing Network Diagram</u>

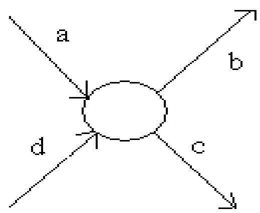
Rule 1

Each activity is represented by one and only one arrow in the network



Rule 2

No two activities can be identified by the same end events



Rule 3

In order to ensure the correct precedence relationship in the arrow diagram, following questions must be checked whenever any activity is added to the network

- What activity must be completed immediately before this activity can start?
- What activities must follow this activity?
- What activities must occur simultaneously with this activity?

In case of large network, it is essential that certain good habits be practiced to draw an easy to follow network

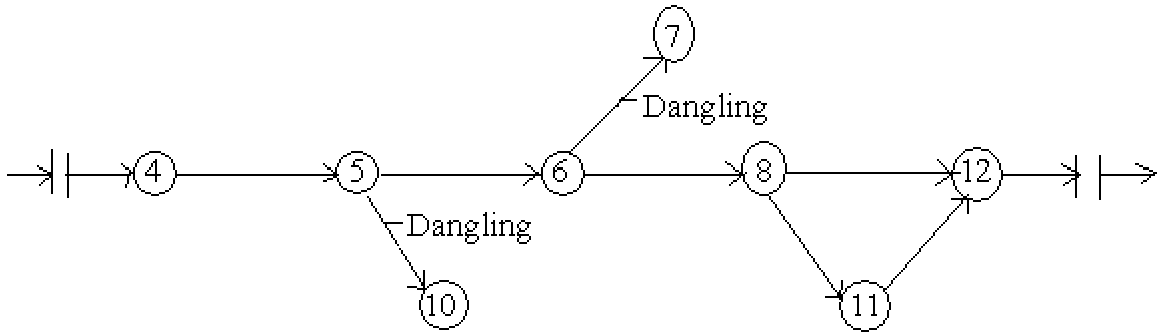
- Try to avoid arrows which cross each other
- Use straight arrows
- Do not attempt to represent duration of activity by its arrow length
- Use arrows from left to right. Avoid mixing two directions, vertical and standing arrows may be used if necessary.
- Use dummies freely in rough draft but final network should not have any redundant dummies.
- The network has only one entry point called start event and one point of emergence called the end event.

<u>Common Errors in Drawing Networks</u>

The three types of errors are most commonly observed in drawing network diagrams

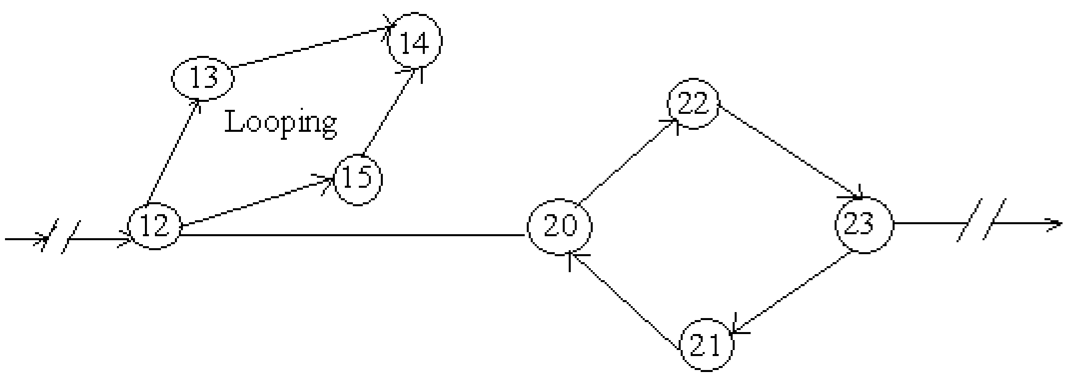
1. Dangling

To disconnect an activity before the completion of all activities in a network diagram is known as dangling. As shown in the figure activities (5 – 10) and (6 – 7) are not the last activities in the network. So the diagram is wrong and indicates the error of dangling



2. Looping or Cycling

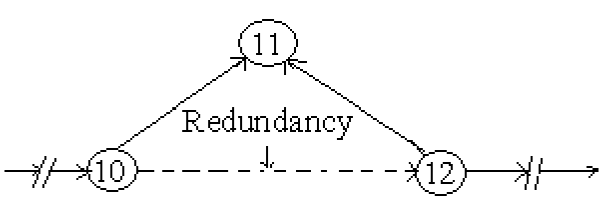
Looping error is also known as cycling error in a network diagram. Drawing an endless loop in a network is known as error of looping as shown in the



following figure.

3. Redundancy

Unnecessarily inserting the dummy activity in network logic is known as the error of redundancy as shown in the following diagram



Advantages and Disadvantages

PERT/CPM has the following advantages

- A PERT/CPM chart explicitly defines and makes visible dependencies (precedence relationships) between the elements,

- PERT/CPM facilitates identification of the critical path and makes this visible,
- PERT/CPM facilitates identification of early start, late start, and slack for each activity,
- PERT/CPM provides for potentially reduced project duration due to better understanding of dependencies leading to improved overlapping of activities and tasks where feasible.

PERT/CPM has the following disadvantages:

- There can be potentially hundreds or thousands of activities and individual dependency relationships,
- The network charts tend to be large and unwieldy requiring several pages to print and requiring special size paper,
- The lack of a timeframe on most PERT/CPM charts makes it harder to show status although colours can help (e.g., specific colour for completed nodes),
- When the PERT/CPM charts become unwieldy, they are no longer used to manage the project.

Critical Path in Network Analysis

Basic Scheduling Computations

The notations used are

(i, j) = Activity with tail event i and head event j

Ei = Earliest occurrence time of event i

Lj = Latest allowable occurrence time of event j

Dij = Estimated completion time of activity (i, j)

(Es)ij = Earliest starting time of activity (i, j)

(Ef)ij = Earliest finishing time of activity (i, j)

(Ls)ij = Latest starting time of activity (i, j)

(Lf)ij = Latest finishing time of activity (i, j)

The procedure is as follows

1. **Determination of Earliest time (E_j): Forward Pass computation**

- **Step 1**

The computation begins from the start node and move towards the end node. For easiness, the forward pass computation starts by assuming the earliest occurrence time of zero for the initial project event.

- **Step 2**

i. Earliest starting time of activity (i, j) is the earliest event time of the tail end event i.e. $(Es)_{ij} = E_i$

ii. Earliest finish time of activity (i, j) is the earliest starting time + the activity time i.e $(E_f)_{ij} = (Es)_{ij} + D_{ij}$ or $(E_f)_{ij} = E_i + D_{ij}$

iii. Earliest event time for event j is the maximum of the earliest finish times of all activities ending in to that event i.e. $E_j = \max [(E_f)_{ij}$ for all immediate predecessor of (i, j)] or $E_j = \max [E_i + D_{ij}]$

2. Backward Pass computation (for latest allowable time)

- **Step 1**

For ending event assume E = L. Remember that all E's have been computed by forward pass computations.

- **Step 2**

Latest finish time for activity (i, j) is equal to the latest event time of event j i.e. $(L_f)_{ij} = L_j$

- **Step 3**

Latest starting time of activity (i, j) = the latest completion time of (i, j) – the activity time or $(Ls)_{ij} = (Lf)_{ij} - D_{ij}$ or $(Ls)_{ij} = L_j - D_{ij}$

- **Step 4**

Latest event time for event 'i' is the minimum of the latest start time of all activities originating from that event i.e. $L_i = \min [(Ls)_{ij}$ for all immediate successor of (i, j)] $= \min [(Lf)_{ij} - D_{ij}] = \min [L_j - D_{ij}]$

3. Determination of floats and slack times

There are three kinds of floats

- **Total float** – The amount of time by which the completion of an activity could be delayed beyond the earliest expected completion time without affecting the overall project duration time.

Mathematically

$(T_f)_{ij}$ = (Latest start – Earliest start) for activity (i – j)

$(Tf)_{ij} = (Ls)_{ij} - (Es)_{ij}$ or $(Tf)_{ij} = (L_j - D_{ij}) - E_i$

- **Free float –** The time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity.

Mathematically

$(F_f)_{ij}$ = (Earliest time for event j – Earliest time for event i) – Activity time for (i,j)

$(F_f)_{ij} = (E_j - E_i) - D_{ij}$

- **Independent float** – The amount of time by which the start of an activity can be delayed without effecting the earliest start time of any immediately following activities, assuming that the preceding activity has finished at its latest finish time.

Mathematically

$(I_f)_{ij} = (E_j - L_i) - D_{ij}$

The negative independent float is always taken as zero.

- **Event slack** - It is defined as the difference between the latest event and earliest event times.

Mathematically

Head event slack = $L_j – E_j$, Tail event slack = $L_i - E_i$

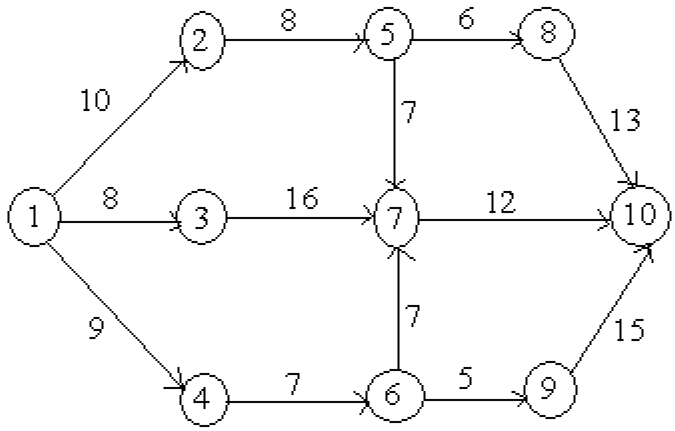
4. **Determination of critical path**

- **Critical event** – The events with zero slack times are called critical events. In other words the event i is said to be critical if $E_i = L_i$
- **Critical activity** – The activities with zero total float are known as critical activities. In other words an activity is said to be critical if a delay in its start will cause a further delay in the completion date of the entire project.
- **Critical path** – The sequence of critical activities in a network is called critical path. The critical path is the longest path in the network from the starting event to ending event and defines the minimum time required to complete the project.

<u>Worked Examples on CPM</u>

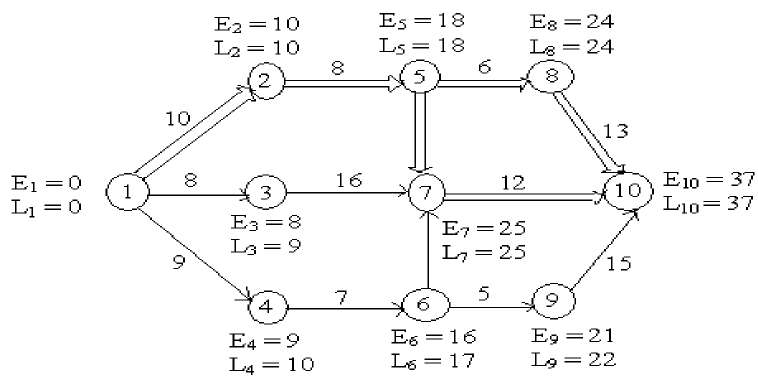
Example 1

Determine the early start and late start in respect of all node points and identify critical path for the following network.



Solution

Calculation of E and L for each node is shown in the network



Activity (i, j)	Normal Time (D_{ij})	Earliest Time		Latest Time		Float Time (L_i - D_{ij}) - E_i
		Start (E_i)	Finish (E_i + D_{ij})	Start (L_i - D_{ij})	Finish (L_i)	
(1, 2)	10	0	10	0	10	0
(1, 3)	8	0	8	1	9	1
(1, 4)	9	0	9	1	10	1
(2, 5)	8	10	18	10	18	0
(4, 6)	7	9	16	10	17	1
(3, 7)	16	8	24	9	25	1
(5, 7)	7	18	25	18	25	0
(6, 7)	7	16	23	18	25	2

(5, 8)	6	18	24	18	24	0
(6, 9)	5	16	21	17	22	1
(7, 10)	12	25	37	25	37	0
(8, 10)	13	24	37	24	37	0
(9, 10)	15	21	36	22	37	1

Network Analysis Table

From the table, the critical nodes are (1, 2), (2, 5), (5, 7), (5, 8), (7, 10) and (8, 10)

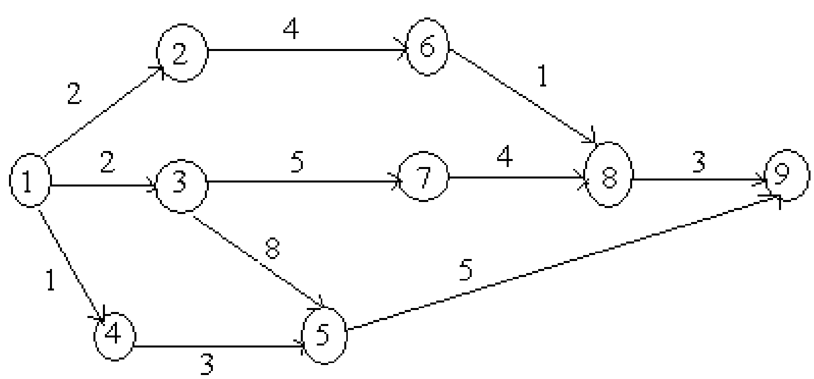
From the table, there are two possible critical paths

i. $1 \rightarrow 2 \rightarrow 5 \rightarrow 8 \rightarrow 10$

ii. $1 \rightarrow 2 \rightarrow 5 \rightarrow 7 \rightarrow 10$

Example 2

Find the critical path and calculate the slack time for the following network



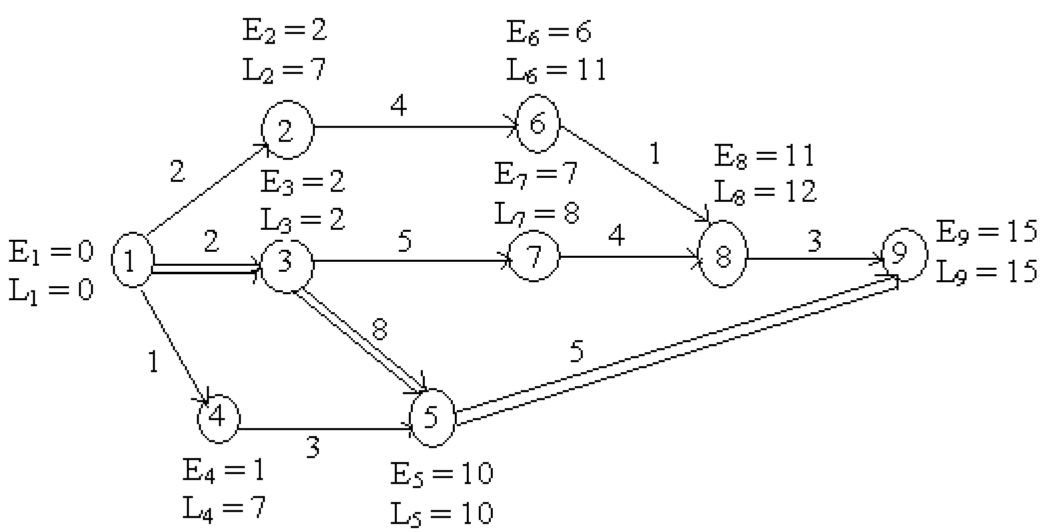
Solution

The earliest time and the latest time are obtained below

Activity (i, j)	Normal Time (D_{ij})	Earliest Time Start (E_i)	Earliest Time Finish ($E_i + D_{ij}$)	Latest Time Start ($L_i - D_{ij}$)	Latest Time Finish (L_i)	Float Time ($L_i - D_{ij}$) - E_i
(1, 2)	2	0	2	5	7	5
(1, 3)	2	0	2	0	2	0
(1, 4)	1	0	1	6	7	6

(2, 6)	4	2	6	7	11	5
(3, 7)	5	2	7	3	8	1
(3, 5)	8	2	10	2	10	0
(4, 5)	3	1	4	7	10	6
(5, 9)	5	10	15	10	15	0
(6, 8)	1	6	7	11	12	5
(7, 8)	4	7	11	8	12	1
(8, 9)	3	11	14	12	15	1

From the above table, the critical nodes are the activities (1, 3), (3, 5) and (5, 9)



The critical path is $1 \rightarrow 3 \rightarrow 5 \rightarrow 9$

Example 3

A project has the following times schedule

Activity	Time (weeks)	Activity	Time (weeks)	Activity	Time (weeks)
(1 – 2)	4	(4 – 9)	5	(8 – 9)	1
(1 – 3)	1	(5 – 6)	4	(8 – 10)	8
(2 – 4)	1	(5 – 7)	8	(9 – 10)	7
(3 – 4)	1	(6 – 8)	1		

Construct the network and compute

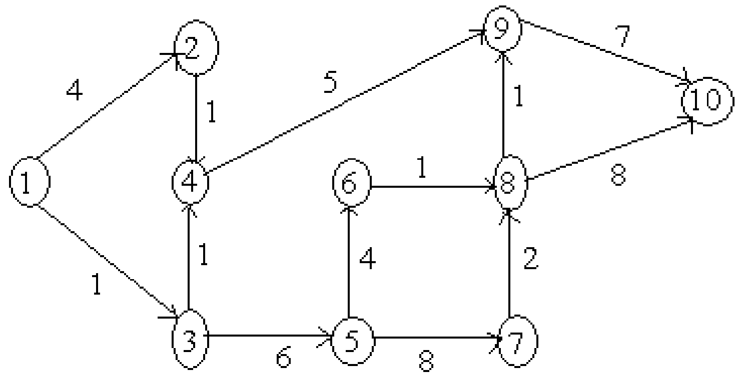
1. T_E and T_L for each event

2. Float for each activity

3. Critical path and its duration

Solution

The network is



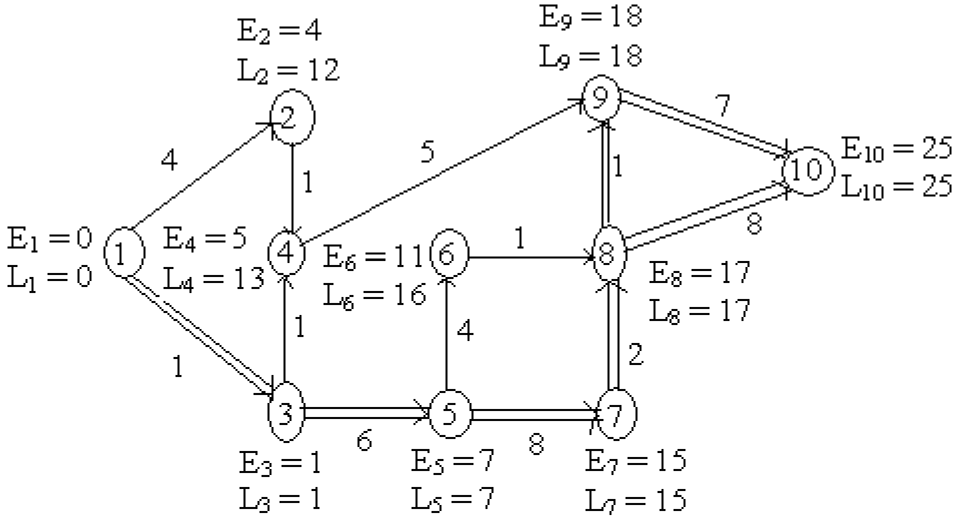
Event No.:	1	2	3	4	5	6	7	8	9	10
T_E:	0	4	1	5	7	11	15	17	18	25
T_L:	0	12	1	13	7	16	15	17	18	25

Float = T_L (Head event) – T_E (Tail event) – Duration

Activity	**Duration**	**T_E (Tail event)**	**T_L (Head event)**	**Float**
(1 – 2)	4	0	12	8
(1 – 3)	1	0	1	0
(2 – 4)	1	4	13	8
(3 – 4)	1	1	13	11
(3 – 5)	6	1	7	0
(4 – 9)	5	5	18	8
(5 – 6)	4	7	16	5
(5 – 7)	8	7	15	0
(6 – 8)	1	11	17	5
(7 – 8)	2	15	17	0

(8 – 9)	1	17	**18**	**0**
(8 – 10)	8	17	**25**	**0**
(9 – 10)	7	18	**25**	**0**

The resultant network shows the critical path



The two critical paths are

i. $1 \rightarrow 3 \rightarrow 5 \rightarrow 7 \rightarrow 8 \rightarrow 9 \rightarrow 10$

ii. $1 \rightarrow 3 \rightarrow 5 \rightarrow 7 \rightarrow 8 \rightarrow 10$

Project Evaluation and Review Technique (PERT)

The main objective in the analysis through PERT is to find out the completion for a particular event within specified date. The PERT approach takes into account the uncertainties. The three time values are associated with each activity

Optimistic time – It is the shortest possible time in which the activity can be finished. It assumes that every thing goes very well. This is denoted by t_0.

Most likely time – It is the estimate of the normal time the activity would take. This assumes normal delays. If a graph is plotted in the time of completion and the frequency of completion in that time period, then most likely time will represent the highest frequency of occurrence. This is denoted by t_m.

Pessimistic time – It represents the longest time the activity could take if everything goes wrong. As in optimistic estimate, this value may be such that only one in hundred or one in twenty will take time longer than this value.

This is denoted by t_p.
In PERT calculation, all values are used to obtain the percent expected value.

1. **Expected time** – It is the average time an activity will take if it were to be repeated on large number of times and is based on the assumption that the activity time follows Beta distribution, this is given by

$$t_e = (t_0 + 4\ t_m + t_p) / 6$$

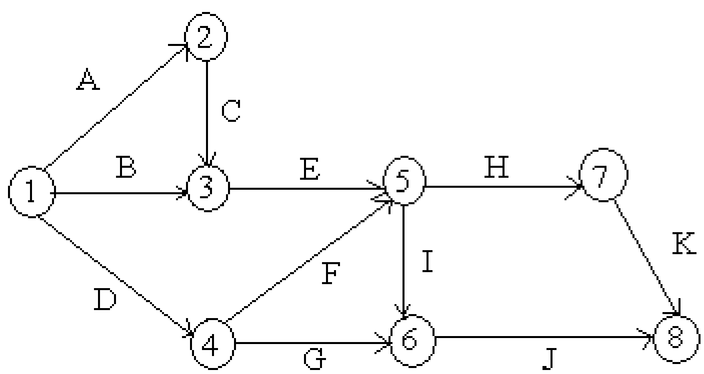
2. The **variance** for the activity is given by

$$\sigma^2 = [(t_p – t_o) / 6]^2$$

Worked Examples

Example 1

For the project



Task:	A	B	C	D	E	F	G	H	I	J	K
Least time:	4	5	8	2	4	6	8	5	3	5	6
Greatest time:	8	10	12	7	10	15	16	9	7	11	13
Most likely time:	5	7	11	3	7	9	12	6	5	8	9

Find the earliest and latest expected time to each event and also critical path in the network.

Solution

Task	Least time (t_0)	Greatest time (t_p)	Most likely time (t_m)	Expected time (to + t_p + $4t_m$)/6
A	4	8	5	5.33
B	5	10	7	7.17
C	8	12	11	10.67
D	2	7	3	3.5
E	4	10	7	7
F	6	15	9	9.5
G	8	16	12	12
H	5	9	6	6.33
I	3	7	5	5
J	5	11	8	8
K	6	13	9	9.17

`

Task	Expected time (t_e)	Start		Finish		Total float
		Earliest	Latest	Earliest	Latest	
A	5.33	0	0	5.33	5.33	0
B	7.17	0	8.83	7.17	16	8.83
C	10.67	5.33	5.33	16	16	0
D	3.5	0	10	3.5	13.5	10
E	7	16	16	23	23	0
F	9.5	3.5	13.5	13	23	10
G	12	3.5	18.5	15.5	30.5	15
H	6.33	23	23	29.33	29.33	0
I	5	23	25.5	28	30.5	2.5
J	8	28	30.5	36	38.5	2.5
K	9.17	29.33	29.33	31.5	38.5	0

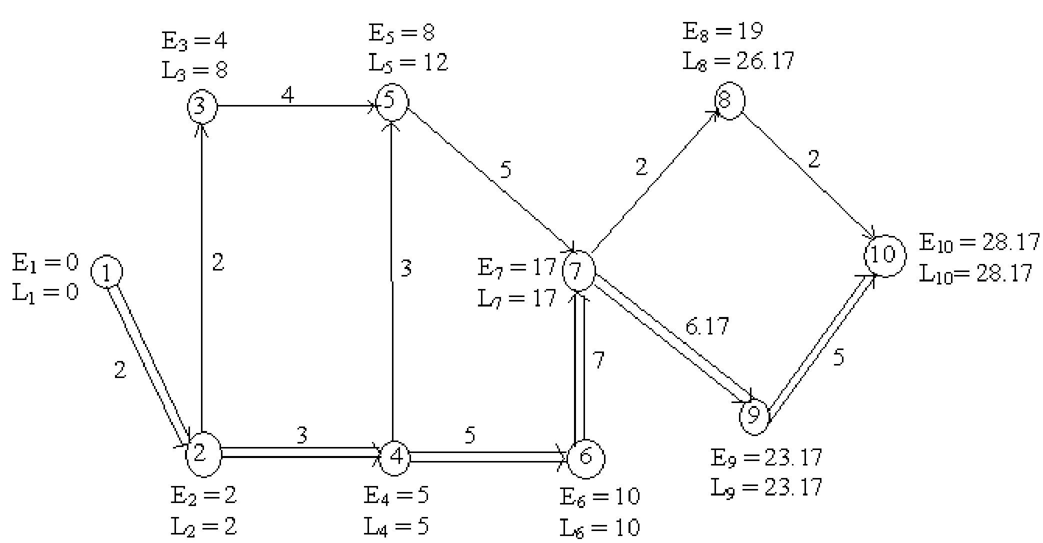
The network is

The critical path is A →C →E → H → K

Example 2

A project has the following characteristics

Activity	Most optimistic time (a)	Most pessimistic time (b)	Most likely time (m)
(1 – 2)	1	5	1.5
(2 – 3)	1	3	2
(2 – 4)	1	5	3
(3 – 5)	3	5	4
(4 – 5)	2	4	3
(4 – 6)	3	7	5
(5 – 7)	4	6	5
(6 – 7)	6	8	7
(7 – 8)	2	6	4
(7 – 9)	5	8	6
(8 – 10)	1	3	2
(9 – 10)	3	7	5



Construct a PERT network. Find the critical path and variance for each event.

Solution

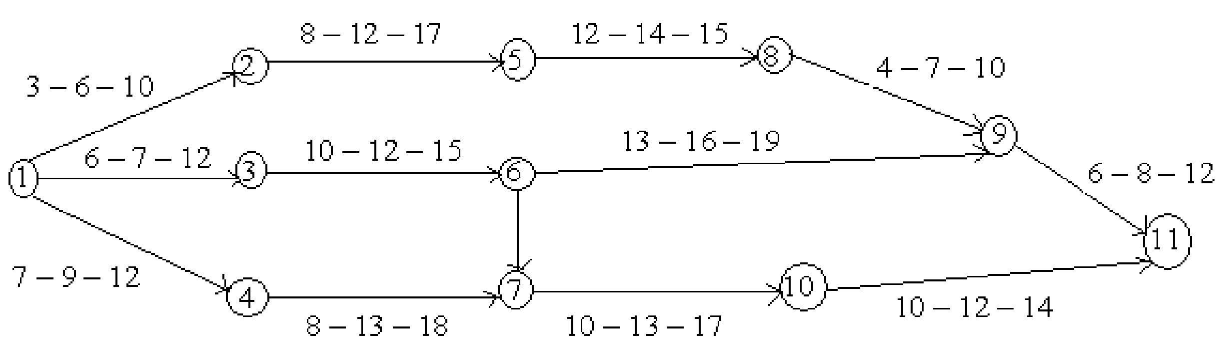
Activity	(a)	(b)	(m)	(4m)	t_e (a + b + 4m)/6	V $[(b – a) / 6]^2$
(1 – 2)	1	5	1.5	6	2	4/9
(2 – 3)	1	3	2	8	2	1/9
(2 – 4)	1	5	3	12	3	4/9
(3 – 5)	3	5	4	16	4	1/9
(4 – 5)	2	4	3	12	3	1/9
(4 – 6)	3	7	5	20	5	4/9
(5 – 7)	4	6	5	20	5	1/9
(6 – 7)	6	8	7	28	7	1/9
(7 – 8)	2	6	4	16	4	4/9
(7 – 9)	5	8	6	24	6.17	1/4
(8 – 10)	1	3	2	8	2	1/9
(9 – 10)	3	7	5	20	5	4/9

The network is constructed as shown below

The critical path = 1 → 2 → 4 → 6 → 7 →9 →10

Example 3

Calculate the variance and the expected time for each activity

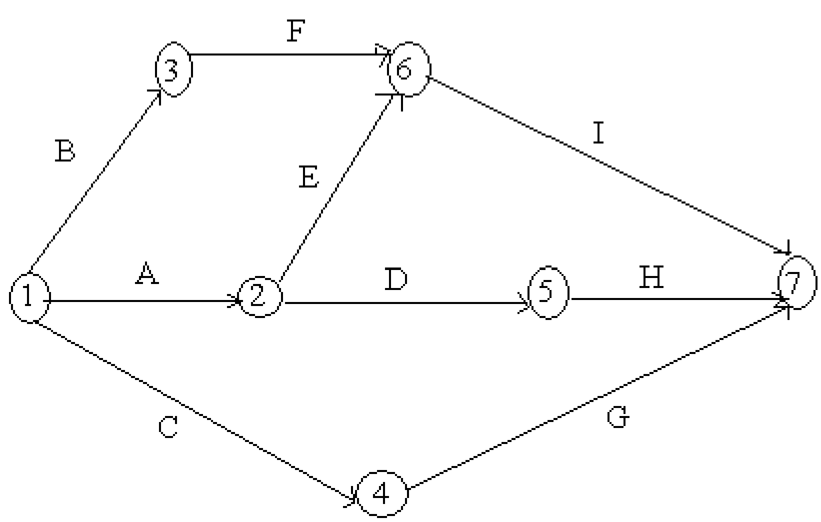


Solution

Activity	(t_o)	(t_m)	(t_p)	t_e $(t_o + t_p + 4t_m)/6$	v $[(t_p – t_o) / 6]^2$
(1 – 2)	3	6	10	6.2	1.36
(1 – 3)	6	7	12	7.7	1.00
(1 – 4)	7	9	12	9.2	0.69
(2 – 3)	0	0	0	0.0	0.00
(2 – 5)	8	12	17	12.2	2.25
(3 – 6)	10	12	15	12.2	0.69
(4 – 7)	8	13	19	13.2	3.36
(5 – 8)	12	14	15	13.9	0.25
(6 – 7)	8	9	10	9.0	0.11
(6 – 9)	13	16	19	16.0	1.00
(8 – 9)	4	7	10	7.0	1.00
(7 – 10)	10	13	17	13.2	1.36
(9 – 11)	6	8	12	8.4	1.00
(10 – 11)	10	12	14	12.0	0.66

Example 4

A project is represented by the network as shown below and has the following data



Task:	A	B	C	D	E	F	G	H	I
Least time:	5	18	26	16	15	6	7	7	3
Greatest time:	10	22	40	20	25	12	12	9	5
Most likely time:	15	20	33	18	20	9	10	8	4

Determine the following

a. Expected task time and their variance

b. Earliest and latest time

Solution

a.

Activity	Least time (t_0)	Greatest time (t_p)	Most likely time (t_m)	Expected time $(to + t_p + 4t_m)/6$	Variance (σ^2)
(1-2)	5	10	8	7.8	0.69
(1-3)	18	22	20	20.0	0.44
(1-4)	26	40	33	33.0	5.43
(2-5)	16	20	18	18.0	0.44
(2-6)	15	25	20	20.0	2.78
(3-6)	6	12	9	9.0	1.00
(4-7)	7	12	10	9.8	0.69
(5-7)	7	9	8	8.0	0.11
(6-7)	3	5	4	4.0	0.11

b.

Earliest time

$E_1 = 0$

$E_2 = 0 + 7.8 = 7.8$

$E_3 = 0 + 20 = 20$

$E_4 = 0 + 33 = 33$

$E_5 = 7.8 + 18 = 25.8$

E_6 = max [7.8 + 20, 20 + 9] = 29
E_7 = max [33 + 9.8, 25.8 + 8, 29 + 4] = 42.8

Latest time

L_7 = 42.8
L_6 = 42.8 – 4 = 38.8
L_5 = 42.8 – 8 = 34.3
L_4 = 42.8 – 9.8 = 33
L_3 = 38.8 – 9 = 29.8
L_2 = min [34.8 – 18, 38.8 – 20] = 16.8
L_1 = min [16.8 – 7.8, 29.8 – 20, 33 - 33] = 0

Exercise

1. What is PERT?
2. For the following data, draw network. Find the critical path, slack time after calculating the earliest expected time and the latest allowable time

Activity	Duration	Activity	Duration
(1 – 2)	5	(5 – 9)	3
(1 – 3)	8	(6 – 10)	5
(2 – 4)	6	(7 – 10)	4
(2 – 5)	4	(8 – 11)	9
(2 – 6)	4	(9 – 12)	2
(3– 7)	5	(10 – 12)	4
(3 – 8)	3	(11 – 13)	1
(4 – 9)	1	(12 – 13)	7

[Ans. Critical path: 1 → 3 → 7 → 10 → 12 →13]

3. A project schedule has the following characteristics

Activity	Most optimistic time	Most likely time	Most pessimistic time
(1 – 2)	1	2	3
(2 – 3)	1	2	3
(2 – 4)	1	3	5
(3 – 5)	3	4	5
(4 – 5)	2	5	4
(4 – 6)	3	5	7
(5 – 7)	4	5	6
(6 – 7)	6	7	8
(7 – 8)	2	4	6
(7 – 9)	4	6	8
(8 – 10)	1	2	3
(9 – 10)	3	5	7

Construct a PERT network and find out

a. The earliest possible time

b. Latest allowable time

c. Slack values

d. Critical path

4. Explain the following terms

a. optimistic time

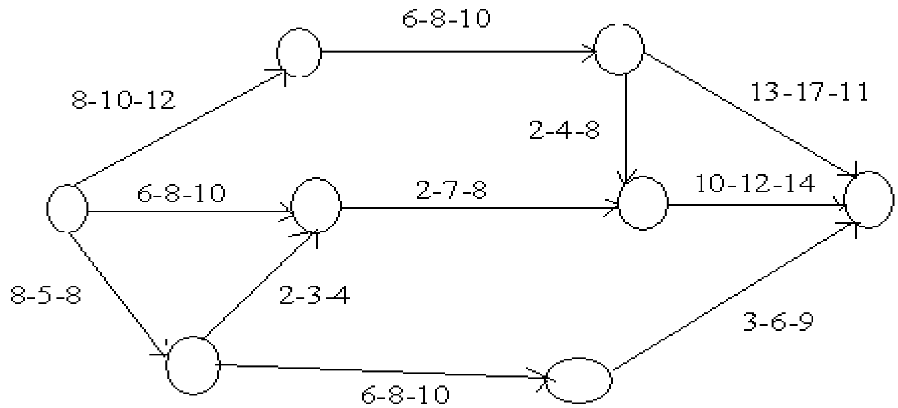
b. Most likely time

c. Pessimistic time

d. Expected time

e. Variance

5. Calculate the variance and the expected time for each activity



Exercise

1. What is PERT and CPM?
2. What are the advantages of using PERT/CPM?
3. Mention the applications of PERT/CPM
4. Explain the following terms
   a. Earliest time
   b. Latest time
   c. Total activity slack
   d. Event slack
   e. Critical path
5. Explain the CPM in network analysis.
6. What are the rules for drawing network diagram? Also mention the common errors that occur in drawing networks.
7. What is the difference between PERT and CPM/
8. What are the uses of PERT and CPM?
9. Explain the basic steps in PERT/CPM techniques.
10. Write the framework of PERT/CPM.

PROJECT MANAGEMENT

NETWORK ANALYSIS (CPM & PERT)

What is a Project?

- A project is an interrelated **set** of **activities** that has **definite starting** and **ending** points and that result in a **unique product** or service
- Cuts across organizational lines - they need varied skills of different profession
- Uncertainties like new technology & external environment can change the character of the project
- Personnel, materials, facilities etc. are temporarily assembled to accomplish a goal within a specified time frame and then disbanded
- Upon finish, a project releases lot of resources which were engaged in execution of the project

Examples of Project

- Hosting a College Annual Function
- Plan a Space Shuttle to Mars
- Construct a Plant to Manufacture Ball Bearings
- Plan for Wedding
- Designing and Implement a Computer System
- Designing a ABS System
- Executing Environmental Clean-up Of a Contaminated Site
- Erect a New Lab in the Dept. of Mechanical Engineering

Definition of Project

- A project is a one shot, time limited, goal directed, major undertaking, requiring the commitment of varied skills & resources.
- It also describes project as a combination of human and non human resources pooled together in a temporary organization to achieve specific purpose

Project Attributes

A project:

- Has a unique purpose.
- Is temporary.
- Is developed using **progressive** elaboration.
- Requires resources, often from various areas.
- Should have a primary customer or sponsor.
  - The **project sponsor** usually provides the direction and funding for the project.
- Involves **uncertainty**.

Project and Program Managers

Project managers work with project sponsors, project teams, and other people involved in projects to meet project goals.

Program: "A group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually."

Program managers oversee programs and often act as bosses for project managers.

Project management is "the application of knowledge, skills, tools and techniques to project activities to meet project requirements."

Project Management Tools and Techniques

Project management tools and techniques assist project managers and their teams in various aspects of project management.

Specific tools and techniques include:

Project charters, scope statements, and WBS (scope).

Gantt charts, **network diagrams, critical path analyses, critical chain scheduling (time).**

Cost estimates and earned value management (cost).

NETWORK ANALYSIS

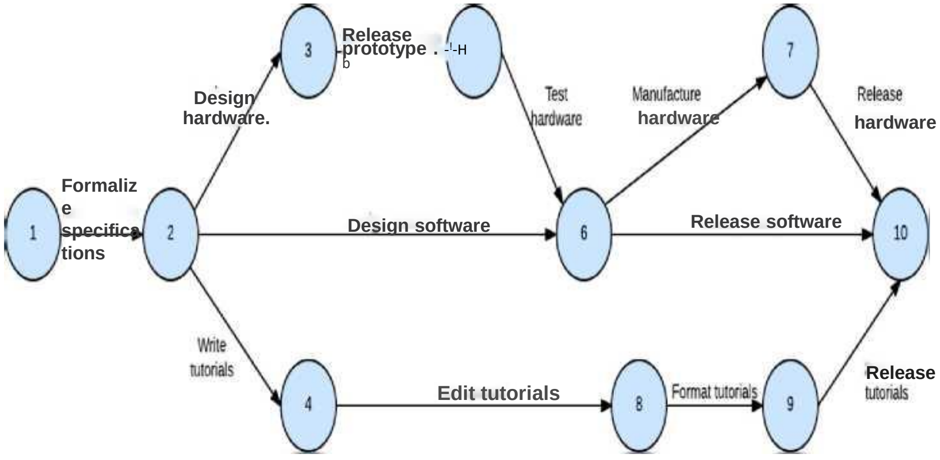
Network Analysis refers to a number of techniques for the planning and control of complex projects.

The two most frequently used forms of network planning are:

1. Programme Evaluation and Review Technique (PERT)
2. Critical Path Method (CPM)

WHAT IS A NETWORK?

A network is a graphical diagram consisting of certain configuration of “Arrows” (O) and “Nodes” (O) for showing the logical sequence of various tasks to be performed to achieve the project objective.



PERT / CPM Techniques

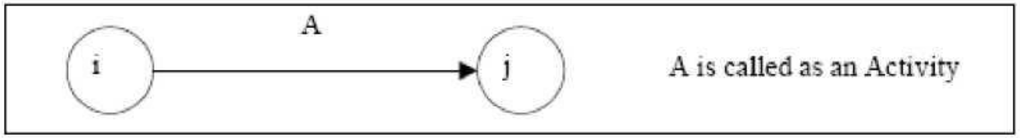
The initial step in PERT/CPM project scheduling process is the determination of all specific activities that comprise the project and their relationships.

EXAMPLE

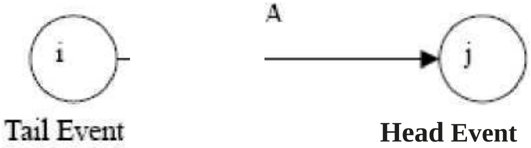
Activity	Description	Duration (in weeks)	Immediate predecessor
A	Obtain the budget approval	2	-
B	Obtain the machine	5	A
C	Hire the operator	1	A
D	Install the machine	1	B
E	Train the operator	6	C
F	Produce the goods	1	D,E

TERMS USED IN A NETWORK

Activity: *An activity represents an action and consumption of resources (time, money,* energy) required to complete a portion of a project. Activity is represented by an arrow, .



Event: *An event (or node) will always occur at the beginning and end of an activity. The* event has no resources and is represented by a circle. The ith event and jth event are the tail event and head event respectively.

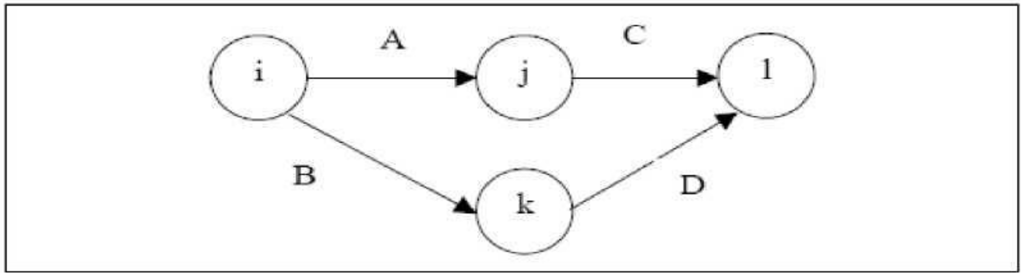


Merge and Burst Events

One or more activities can start and end simultaneously at an event.

Preceding and Succeeding Activities

Activities performed before given events are known as *preceding activities*, and activities performed after a given event are known as *succeeding activities*.



Activities A and B precede activities C and D respectively.

RULES OF NETWORK CONSTRUCTION

1. Each defined activity is represented by one and **only one arrow** in the network.

2. **Before** an **activity** can be undertaken, all activities **preceding** it must be **completed**.

3. The **arrows** depicting various **activities** are indicative of **logical procedure** only. The length and bearing of the arrows are of no significance.

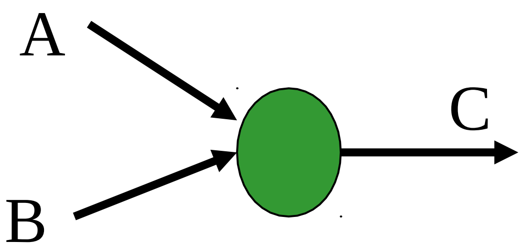
4. The **arrow direction** indicates the general **progression** in time. Head events and Tail events.

5. When a number of activities terminate at one event, it indicates that no activity emanating from that event may start unless all activities terminating there have been completed.

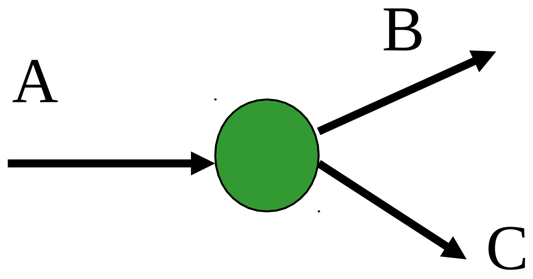
6. Events are identified by **numbers**.

7. The activities are identified by the numbers of their starting and ending events or by alphabets.

1. A network should have only one initial and terminal node.



Merge Event



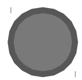
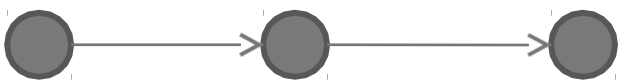
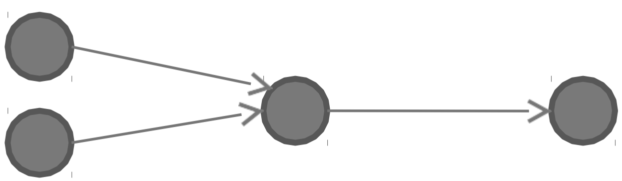
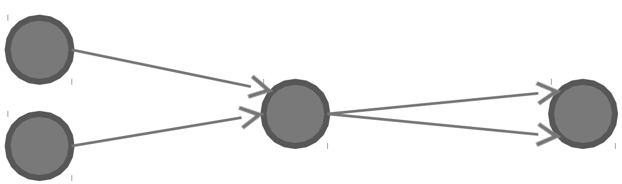
Burst Event

10. **Parallel activities** between two events, without intervening events, are **prohibited**. When two or more parallel activities in a project have the same head and tail events, dummy activities are needed in constructing the network.

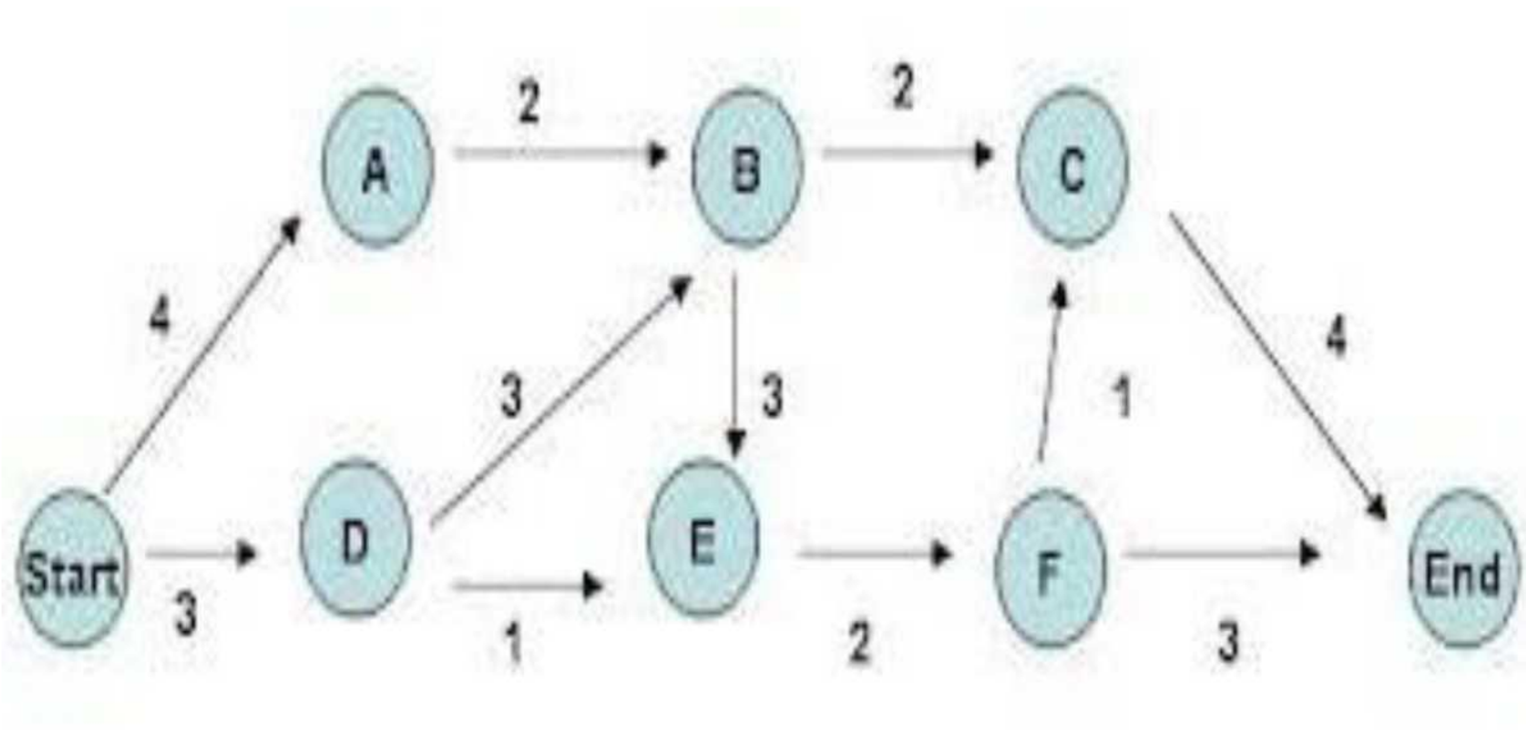
Dummy activities do not consume time or resources. An efficient network contains a minimum number of dummy activities required to portray the correct precedence relationships.

11. Looping is not permitted in a network.

NETWORK SYMBOLS

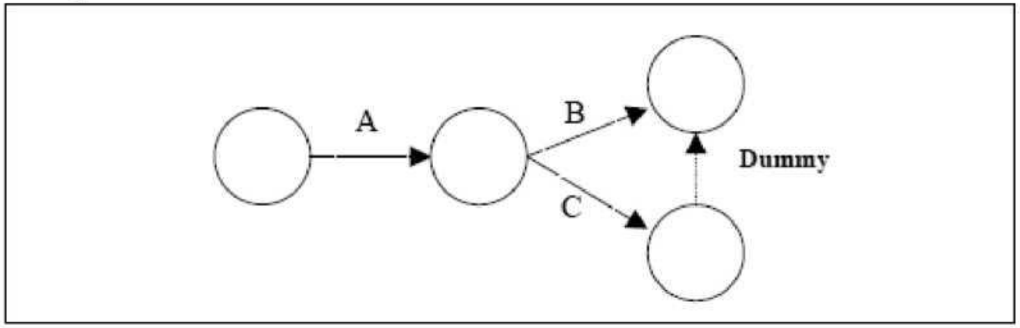
SYMBOL	MEANING
	Activity
	Event
	Activity A must be completed before Activity B completed
	Activities A & B can occur concurrently, but both must be completed before activity C can begin
	Activities A & B must be completed before activities C & D can begin, but C can begin independently of D & vice versa

SAMPLE NETWORK



DUMMY ACTIVITY

An imaginary activity which does not consume any resource and time is called a ***dummy activity. Dummy activities are simply used to represent a connection between events in*** order to maintain a logic in the network. It is represented by a dotted line in a network.



CRITICAL PATH METHOD

CPM aims at the determination of the time to complete a project and the important activities on which a manager shall focus attention.

PROCEDURE

- Consider all the paths in a project, beginning with the start event and stopping at the end event.

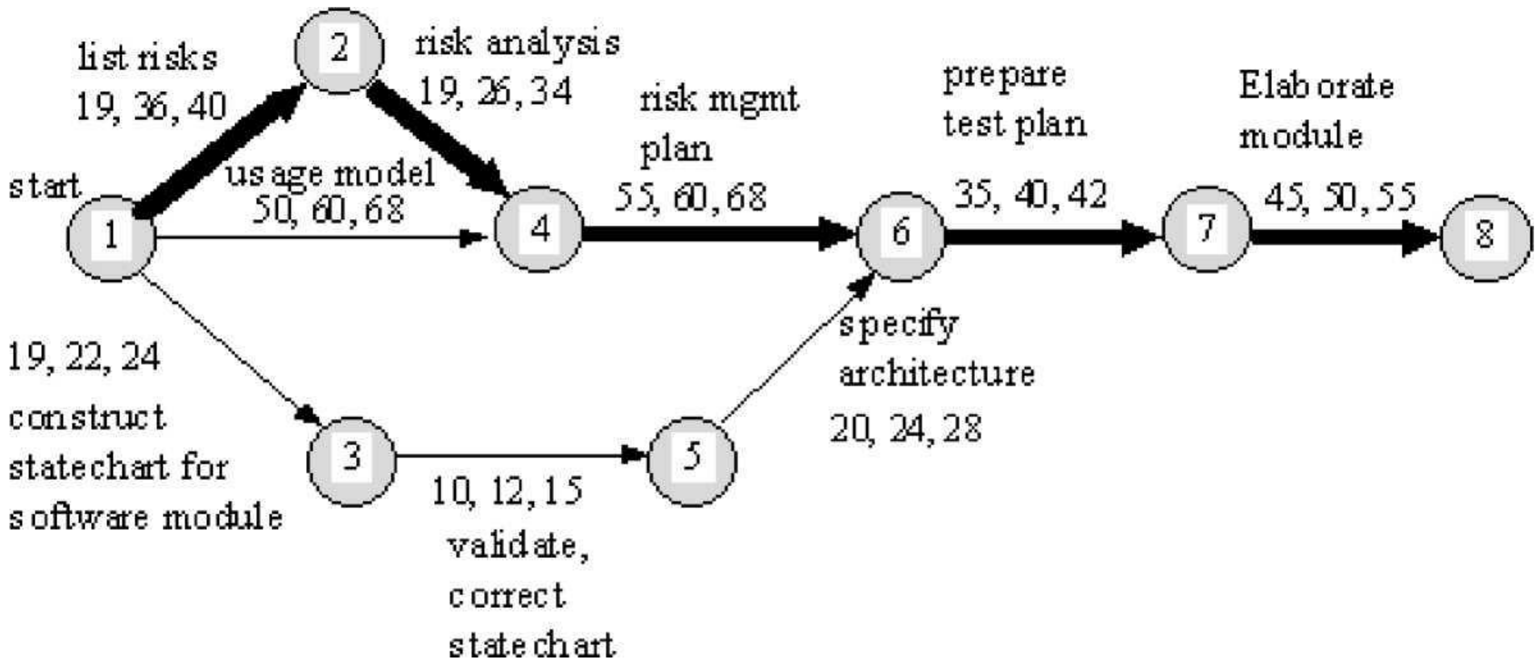
- For each path, calculate the time of execution.

- The path with the largest time is called the critical path and the activities along this path are called critical activities or bottleneck activities.

1. You are required to prepare a network diagram for constructing a 5 floor apartmei

The major activities of the project are given as follows:

Activity	Description	Immediate Predecessor
A	Selection of site	-
B	Preparation of drawings	-
C	Arranging the for finance	A
D	Selection of contractor	A
E	Getting approval from Govt	A
F	Laying the foundation	E
G	Start construction	D.F
H	Advertise in newspaper	B.C
I	Allocation of tenants	G.H



PERT

(Project or Program Evaluation and Review Techniques)

PROJECT EVALUATION REVIEW TECHNIQUE

In the critical path method, the time estimates are assumed to be known with certainty. In certain projects like research and development, new product introductions, it is difficult to estimate the time of various activities.

Hence PERT is used in such projects with a probabilistic method using three time estimates for an activity, rather than a single estimate, as shown in Figure

Optimistic time tO:

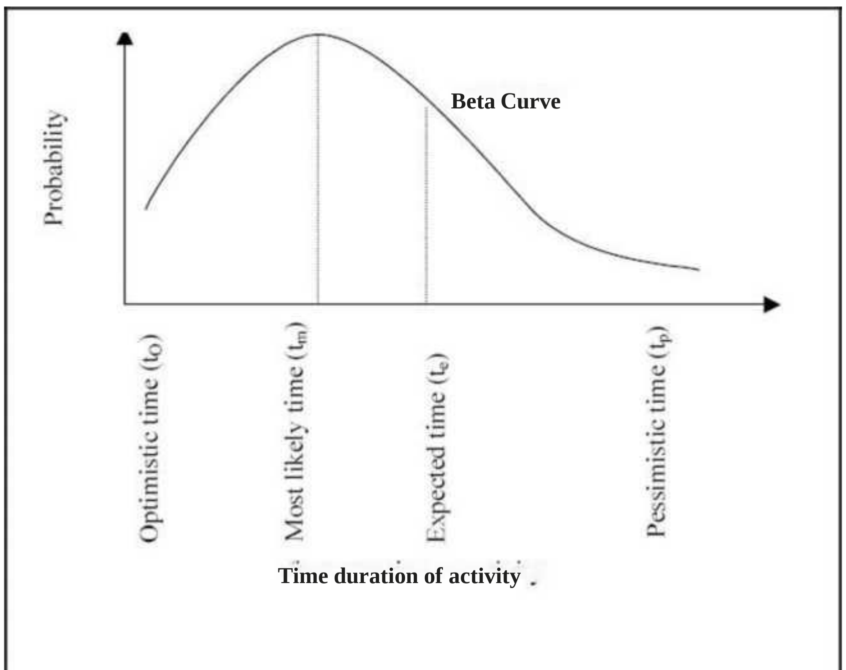


Figure 8.22: PERT L sing Probabilistic Method with 3 Time Estimates

It is the shortest time taken to complete the activity. It means that if everything goes well then there is more chance of completing the activity within this time.

Most likely time t_m:

It is the normal time taken to complete an activity, if the activity were frequently repeated under the same conditions.

Pessimistic time tp:

It is the longest time that an activity would take to complete. It is the worst time estimate that an activity would take if unexpected problems are faced.

Taking all these time estimates into consideration, the expected time of an activity is arrived at.

The average or mean (ta) value of the activity duration is given by,

$$T_a = \frac{t_0 + 4t_m + t_p}{6} \quad \text{.....................}(5)$$

The variance of the activity time is calculated using the formula,

$$\sigma_i^2 = \left(\frac{t_p - t_0}{6}\right)^2$$

Probability for Project Duration

The probability of completingthe project within the scheduled time (Ts) or contracted time may be obtained by using the standard normal deviate where Te is the expected time of project completion.

$$Z_0 = \frac{T_s - T_e}{\sqrt{\Sigma\sigma^2 \text{ in critical path}}}$$

Probability of completing the project within the scheduled time is,

$$P(T \leq T_s) = P(Z \leq Z_0) \quad \text{(from normal tables)}$$

Example Problem of PERT

An R & D project has a list of tasks to be performed whose time estimates are given in the Table 8.11, as follows.

Table 8.11: Time Estimates for R & D Project

Activity i j	Activity Name	T_0	t_m (in days)	t_p
1-2	A	4	6	8
1-3	B	2	3	10
1-4	C	6	8	16
2-4	D	1	2	3
3-4	E	6	7	8
3-5	F	6	7	14
4-6	G	3	5	7
4-7	H	4	11	12
5-7	I	2	4	6
6-7	J	2	9	10

a. Draw the project network.

b. Find the critical path.

c. Find the probability that the project is completed in 19 days. If the probability is less than 20%, find the probability of completing it in 24 days.

Time expected for each activity is calculated using the formula (5): Similarly, the expected time is calculated for all the activities.

$$T_a = \frac{t_0 + 4tm + tp}{6}$$

$$= \frac{4+4(6)+8}{6} = \frac{36}{6} = 6 \text{ days for activity A}$$

The variance of activity time is calculated using the formula (6). Similarly, variances of all the activities are calculated.

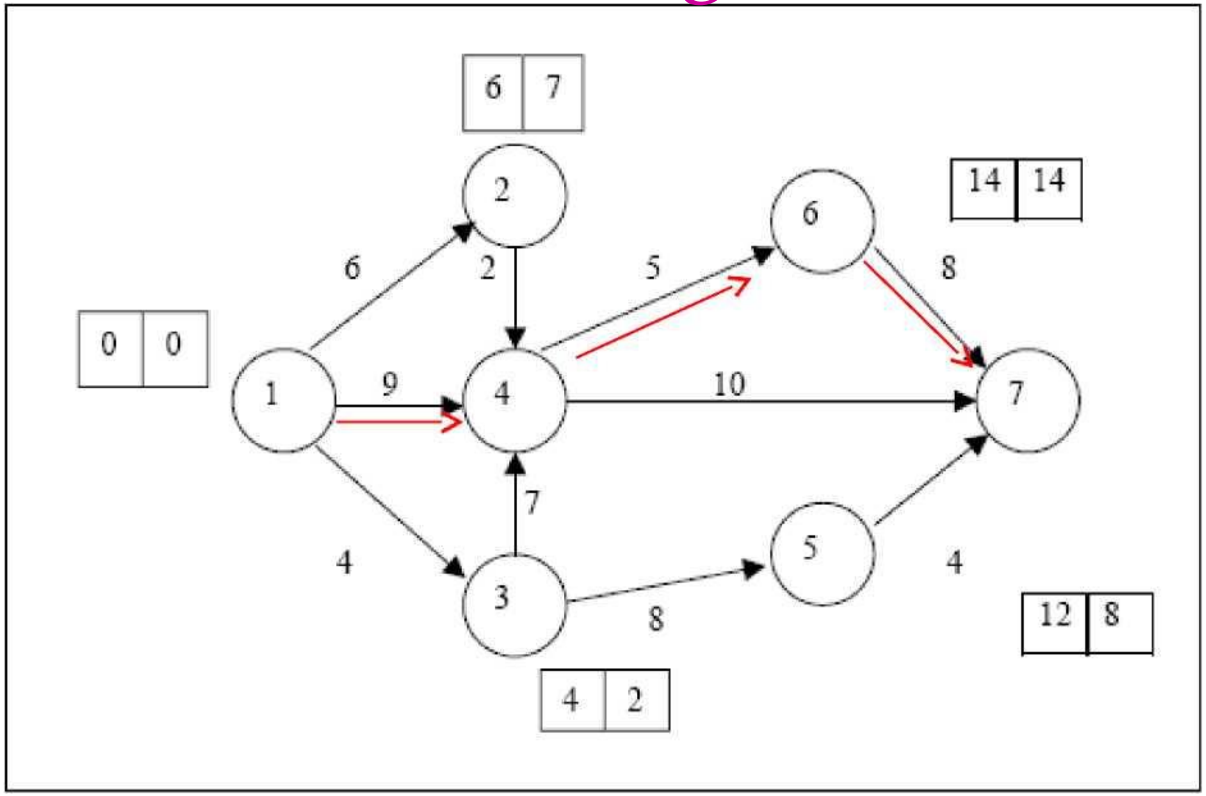
$$\sigma_i^2 = \left(\frac{t_p - t_0}{6}\right)^2$$

$$= \left(\frac{8-4}{6}\right)^2 = 0.444$$

Table 8.12: T_e & s^2 Calculated

Activity	T_o	T_m	T_p	T_a	σ^2
1-2	4	6	8	6	0.444
1-3	2	3	10	4	1.777
1-4	6	8	16	9	2.777
2-4	1	2	3	2	0.111
3-4	6	7	8	7	0.111
3-5	6	7	14	8	1.777
4-6	3	5	7	5	0.444
4-7	4	11	12	10	1.777
5-7	2	4	6	4	0.444
6-7	2	9	10	8	1.777

A) Construct a network diagram:



calculate the time earliest (TE) and time Latest (TL) for all the activities.

From the network diagram Figure 8.24, the critical path is identified as 1-4, 4-6, 6-7, with a project duration of 22 days.

C) The probability of completing the project within 19 days is given by, P (Z< Zo)

To find Zo ,

$$Z_0 = \left(\frac{T_s - T_e}{\sqrt{\Sigma\sigma \text{ in critical path}}} \right)$$

$$= \left(\frac{19 - 22}{\sqrt{2.777 + 0.444 + 1.777}} \right) \qquad = \left(\frac{-3}{\sqrt{5}} \right) = -1.3416$$

we know, P (Z <Z Network Model 0) = 0.5 - z (1.3416) (from normal tables, z (1.3416) = 0.4099)

= 0.5 - 0.4099

= 0.0901

= 9.01%

Thus, the probability of completing the R & D project in 19 days is 9.01%.

Since the probability of completing the project in 19 days is less than 20% As in question, we find the probability of completing it in 24 days.

$$Z_0 = \frac{T_s - T_e}{\sqrt{\Sigma\sigma \text{ in critical path}}}$$

$$= \left(\frac{24-22}{\sqrt{5}}\right) = \left(\frac{2}{\sqrt{5}}\right) = 0.8944 \text{ days}$$

$$P(Z \leq Z_0) = 0.5 - Y\ (0.8944) \qquad \text{(from normal tables, } Y\ (0.8944) = 0.3133)$$

$$= 0.5 + 0.3133$$

$$= 0.8133$$

$$= 81.33\%$$

COST ANALYSIS

The two important components of any activity are the cost and time. Cost is directly proportional to time and vice versa.

For example, in constructing a shopping complex, the expected time of completion can be calculated using the time estimates of various activities. But if the construction has to be finished earlier, it requires additional cost to complete the project. We need to arrive at a time/cost trade-off between total cost of project and total time required to complete it.

Normal time:
Normal time is the time required to complete the activity at normal conditions and cost.

Crash time:
Crash time is the shortest possible activity time; crashing more than the normal time will increase the direct cost.

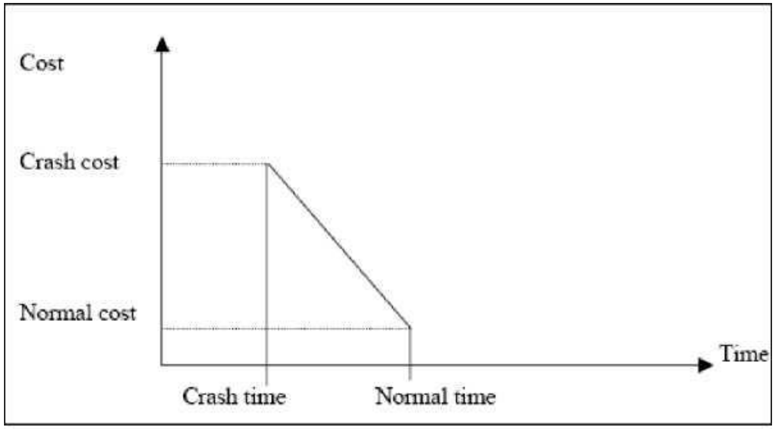


Figure 8.27: Linear Cost Curve

Cost Slope
Cost slope is the increase in cost per unit of time saved by crashing. A linear cost curve is shown in Figure.

$$\text{Cost slope} = \frac{\text{Crash cost } C_c - \text{Normal cost } N_c}{\text{Normal time } N_t - \text{Crash time } C_t}$$

$$= \frac{C_c - N_c}{N_t - C_t} \qquad \text{..........................(9)}$$

Example

An activity takes 4 days to complete at a normal cost of Rs. 500.00. If it is possible to complete the activity in 2 days with an additional cost of Rs. 700.00, what is the incremental cost of the activity?

Incremental Cost or Cost Slope $= \frac{C_c - N_c}{N_t - C_t} = \frac{700-500}{4-2} = \text{Rs. } 100.00$

It means, if one day is reduced we have to spend Rs. 100/- extra per day.

Project Crashing

Procedure for crashing

Step1: ***Draw the network diagram and mark the Normal time and Crash time.***

Step2: ***Calculate TE and TL for all the activities.***

Step3: ***Find the critical path and other paths.***

Step 4: ***Find the slope for all activities and rank them in ascending order.***

Step 5: ***Establish a tabular column with required field.***

Step 6: *Select the lowest ranked activity; check whether it is a critical activity. If so,* crash the activity, else go to the next highest ranked activity.

Note: The critical path must remain critical while crashing.

Step 7: ***Calculate the total cost of project for each crashing*** **Step 8:** ***Repeat Step 6 until all the activities in the critical path are fully crashed.***

Example

The following Table 8.13 gives the activities of a construction project and other data.

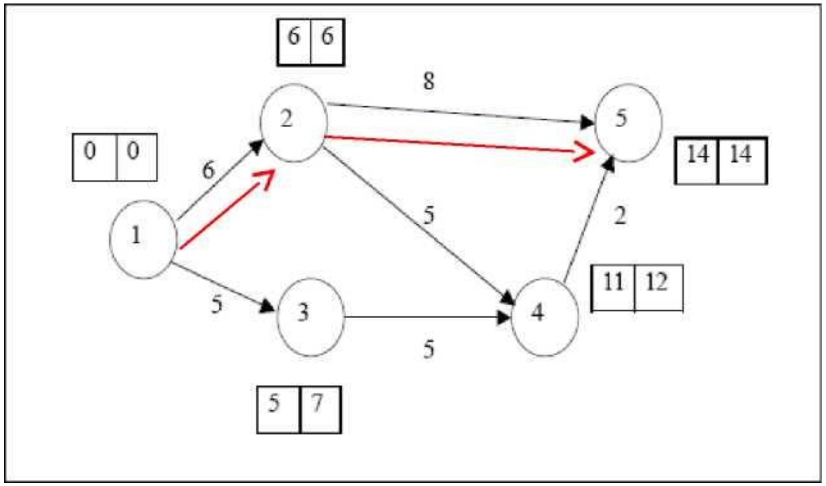
Table 8.13: Construction Project Data

Activity	Normal		Crash	
	Time (days)	Cost (Rs)	Time (days)	Cost (Rs)
1-2	6	50	4	80
1-3	5	80	3	150
2-4	5	60	2	90
2-5	8	100	6	300
3-4	5	140	2	200
4-5	2	60	1	80

If the indirect cost is Rs. 20 per day, crash the activities to find the minimum duration of the project and the project cost associated.

Solution

From the data provided in the table, draw the network diagram (Figure 8.28) and find the critical path.



From the diagram, we observe that the critical path is 1-2-5 with project duration of 14 days

The cost slope for all activities and their rank is calculated as shown in Table 8.14

$$\text{Cost slope} = \frac{\text{Crash cost } C_c - \text{Normal cost } N_c}{\text{Normal time } N_t - \text{Crash time } C_t}$$

$$\text{Cost Slope for activity } 1\text{–}2 = \frac{80-50}{6-4} = \frac{30}{2} = 15$$

Table 8.14: Cost Slope and Rank Calculated

Activity	Cost Slope	Rank
1-2	15	2
1-3	35	4
2-4	10	1
2-5	100	5
3-4	20	3
4-5	20	3

The available paths of the network are listed down in Table 8.15 indicating the sequence of crashing (see Figure 8.29).

Table 8.15: Sequence of Crashing

Path	Number of days crashed
1-2-5	~~14~~ ~~12~~ ~~11~~ 10
1-2-4-5	~~13~~ ~~11~~ 10
1-3-4-5	~~12~~ ~~11~~ 10

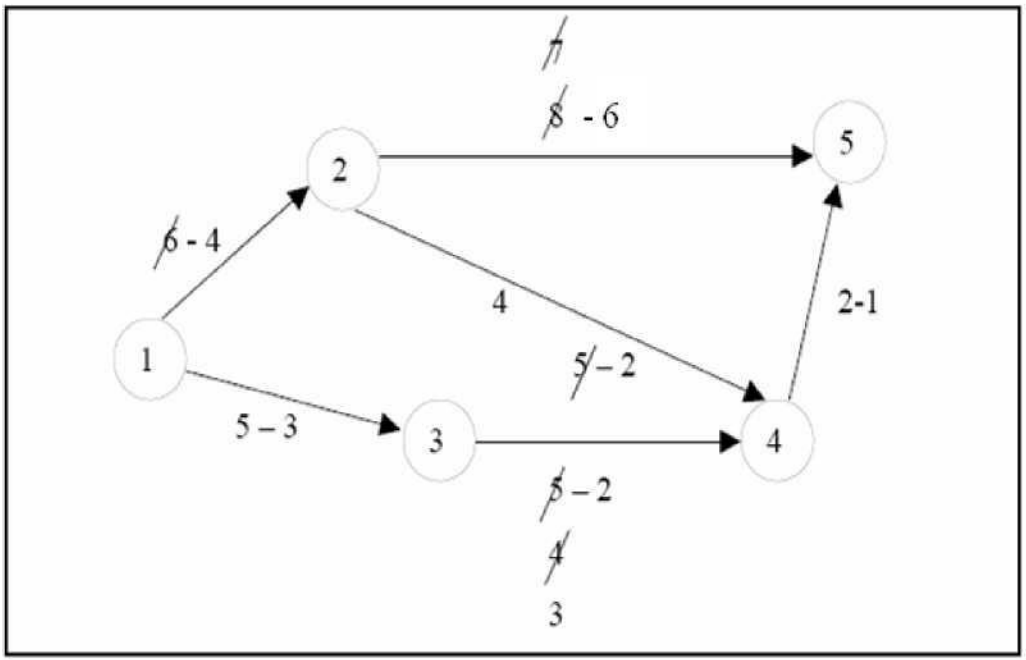


Figure 8.29: Network Diagram Indicating Sequence of Crashing

The sequence of crashing and the total cost involved is given in Table 8.16 Initial direct cost = sum of all normal costs given = Rs. 490.00

Activity Crashed	Project Duration	Critical Path	Direct Cost in (Rs.)	Indirect Cost in (Rs.)	Total Cost in (Rs.)
-	14	1-2-5	490	14 x 20 = 280	770
1 - 2(2) 2 - 5(2) 2 - 4(1) 3 - 4(2)	10	1 - 2 - 5 1 - 3 - 4 - 5 1 - 2 - 4 - 5	490 + (2 x 15) + (2 x 100) + (1 x 10) + (2 x 20) = 770	10 x 20 = 200	970

It is not possible to crash more than 10 days, as all the activities in the critical path are fully crashed. Hence the minimum project duration is 10 days with the total cost of Rs. 970.00.

THANK YOU

B Tech 8th Semester

YouTube link Network Analysis Module III, CPM

https://www.youtube.com/watch?v=H58TPQNr2kM

https://www.youtube.com/watch?v=RQNZWCl6eXI&list=PLBd76GK9sWTwVXm9FlVHOTXXbGY2vZR8z

https://www.youtube.com/watch?v=2AOhCWhwOKo

https://www.youtube.com/watch?v=pwv1Nu3TO4A&list=PL3MO67NH2XxLUV6O3z1C0Cd6j5-uT7fRC

DEPARTMENT OF CIVIL ENGINEERING
B TECH 8th SEMESTER
01 1827 CONSTRUCTION PLANNING AND MANAGEMENT

L-T-P: 3-0-0 Credit: 3

Site organization: layout: work study: Decision making processes: CPM and L. P. Project monitoring.

Total number of Lecture: 10

Lecture No. 25-30

Introduction:

Most construction sites that run into trouble do so for reasons related to managerial factors rather than because of technical problems. The site-based management can make significant improvements in the cost and time savings during the construction process without involving a mass of additional work. The role of site managers is to control and maintain work performance and then taking actions to rectify situations where performance is unsatisfactory.

Concepts and Formulas of Construction Site Layout Planning Elements:

A well-planned site including all temporary facilities and utilities lead to: 1) increasing productivity and safety, 2) reducing area(s) needed for temporary construction, and 3) maximizing utilization. The following points should be considered in good site layout

Site layout planning can affect productivity and is crucial to project success. However, as construction is heterogeneous in the nature of its organizations, project designs, time constraints, environmental effects, etc., site layout planning for each project becomes unique. Affected by many uncertainties variables! And variations, site layout planning is a typical multi objective problem.

Problem solving requires representing the problem in a language that problem solvers can understand. However, solutions of most construction problems rely on empirical Knowledge about the site layout that can be as a site space allocation for material storage, working areas, units of accommodation, plant positions, general circulation areas, and also access and egress for deliveries and emergency services. Furthermore, conflicting objectives and the uniqueness of construction projects like bad site layout make the problems difficult to conceptualize and define.

Significance of Site Layout Planning

Site layout shows the relationship of the proposed site with its surroundings with respect to communication, approaches, and existing facilities. Good site layout planning assists in minimizing the traveling time and movement costs of plant, labor, and materials, activity interference during construction work, and site accidents, and ensures that work on buildings and other construction positions is not impeded by the thoughtless storage of materials on these locations. So site layout can thus either enhance or adversely affect construction productivity and progress. It is important to acquire the knowledge of the project site before setting out the site layout. The knowledge about the project site can be obtained from:

Site Investigation (SI):

Site investigation is a process of site exploration consisting of boring, sampling and testing so as to obtain geotechnical information for a safe, practical and economical geotechnical evaluation and design. Generally it is an exploration or discovery of the ground conditions especially on untouched site.

In other words the main purpose of site investigation is to determine within practical limits, the depth, thickness, extent and compositions of each subsoil stratum, the depth and type of rock, the depth and composition of groundwater, the strength, compressibility and hydraulic characteristics of soil strata required by geotechnical engineers. Sometimes it is also known as geotechnical investigation.

A site layout plan shows a detailed layout of the whole site and the relationship of the proposed works with the boundary of the property, nearby roads and neighbouring buildings.

Most applications should include an existing site layout plan and a proposed site layout plan. For simple applications the existing and proposed site can be combined and shown on one plan so long as what is existing, what is proposed and what is to be demolished is highlighted and annotated clearly.

Safety:

- Fire prevention: Fire is a major cause of damage on construction sites. So that, fire extinguishers are basic requirements on a construction project.
- Medical services: On construction project a first aid kit is a must. In remote projects a well-equipped medical room with a doctor and nurse is important.
- Construction safety clothing: Basic safety supplies like safety shoes, hard hats, gloves, and goggles must be used by workers.

Site Accessibility:

Easy accessibility will keep the morale of the equipment and vehicle drivers high, minimize the chance of accidents, and save time in maneuvering to arrive at and leave the project. In case of large projects, proper planning is required to layout the roads leading from the nearest highway. Internal roads are necessary for easy flow of work. Also, Parking Lots are provided for the owner, office, and craft personnel, but this facility must be planned where space does exist.

Information Signs:

- Site map: It should locate details of the project, and displayed in the office of the site superintendent or project manager and posted at the entrance gate.
- Traffic regulatory signs: For large projects, traffic regulatory signs help in guiding the traffic on the site and avoid accidents to a considerable extent.
- Display of labor relations' policy and safety rules: This will help in eliminating disputes between labor and management.
- Emergency routes and underground services: It is important to display the emergency escape routes on every floor as the building progresses. Locations of underground services should be marked to prevent its damage.

Security:

- Entrance: It is necessary to have a proper guard entrance to the site provided by a booth. Also, it is necessary to keep track of all visitors to the project.
- Lighting: It is necessary to have a standby generator to maintain site lighting.
- Fencing: The boundary should be fenced off from a security point of view.

Accommodation:

On large construction projects, it is necessary to provide camp accommodation for all type of staff involved in the project.

Offices:

The offices should be close together, close to the site, and in a safe area. Also, provide the offices with proper office equipment. The offices at the site may include job office, general contractor office, and sub-contractors and consultants Offices.

Water Supply and Sanitation:

It is necessary to have water and toilet facilities in convenient locations to accommodate the work force.

Material Handling:

One third or more of all construction operations can be classified as material handling. The use of proper equipment for material handling and advance planning for minimizing multiple handling will result in direct cost and time savings.

Storage and site cleaning:

It is necessary to plan and reserve storage areas for materials so that multiple movement of material is avoided.

- Laydown areas: Areas reserved for storage of large materials and equipment and it can be short-term or long-term.
- Warehouses: They are sheltered storage facilities where materials are stored until they have disbursed to the job.
- Material staging areas: They used when materials are stored near the work on a short-term basis. They are generally as close to work as possible.
- Site cleaning: It is necessary at a work place and especially where the extent of debris produced is high. Regular disposal of debris is necessary.

Craft Change-Houses:

Craft change-houses provide sheltered space for craft personnel to change and store clothes, wash, and rest during waiting periods.

Batch plant and Fabrication Shops:

Batch plants are provided on projects where it is more economical to produce concrete on site than to buy a ready mix. Aggregate storage piles, cement silos, and admixture tanks will accompany an on-site batch plant. Shops are used where materials and equipment are fabricated on site. This includes electrical, mechanical, carpentry, and paint shops. Also, testing shops used to house the necessary testing equipment and personnel for the project.

Wok Procedure for SI:

Steps of work involved in site investigation:

1. Desk study to collect all the relevant data and information,

2. Reconnaissance of site works,

3. Planning program after reviewing the above,

4. Ground or soil exploration includes boring, sampling and testing,

5. Laboratory testing (also field if necessary),

6. Preparation and documentation of SI report,

7. Engineering design stages,

8. Review during construction and monitoring.

Steps of Soil Exploration

Soil exploration consists of:

Boring: Refers to drilling or advancing a hole in the ground. The test would include hand auger, motorized hand boring (wash boring), deep boring (rotary drilling), and/or trial pits.

Sampling: Refers to removing soil from the hole. The samples can be classified as disturbed or undisturbed sampling. Disturbed samples are usually used for soil grain-size analysis, determination of liquid limit, specific gravity of soil as well as compaction test and California bearing ratio (CBR). The undisturbed samples are collected at least every 1.5 m and if changes occur within 1.5 m intervals, an additional sample should be taken.

Testing: Refers to determining the properties from the soil. The test can be performing either at laboratory or at field. Laboratory testing would normally be moisture content, sieve analysis, liquid limit, compaction test, CBR and so forth. Field test would include Standard Penetration Test (SPT), Cone Penetration Test (CPT) and Vane test.

Record of Soil Exploration:

It is important to keep complete and accurate records of all data collected. Boring, sampling and testing are often costly. A good map giving specific locations of all boring should be available. All boring should be identified and its location documented by measurement to permanent features. And all pertinent data should be recorded in the field on a boring log sheet. Soil data obtained from a series of test boring can best be presented by preparing a geologic profile:

Arrangement of various layers of soil,

Ground water table,

Existing / proposed structures,

Soil properties data (e.g., Standard Penetration Test values).

The profile was prepared with data obtained from the boring, sampling and testing of each borehole from selected points.

Decision Criteria and Site Facilities Adopted in Site Layout Planning:

Although each site layout is unique, site layout planning can be resolved into a repetitive selection-evaluation process. Several analysis techniques can be used for the selection process for example, the dominant factor analysis and Parker s judgment technique, which can be used to screen out available decisions in choosing facilities, and identify key decision factors and locations for each particular facility.

All space-planning problems consist of a set of activities to be located and a space in which to locate them. Site layout planning consists of identifying the facilities needed to support construction operations, determining their size and shape, and positioning them within the boundaries of the site. So, the most temporary facilities are classified into six important categories.

Temporary facilities

Description

Access road and exit

Needs vary with the type of project and the stage of the job. It will normally be linked with the plan of construction and in some cases may actually control the progress of construction. Ideally, short direct routes and one-way traffic are encouraged.

Location of plant and equipment

Choice of the major items of the plant is of real consequence on most sites. Correctly chosen and well operated and maintained equipment enables a construction project to be completed efficiently and economically.

Material storage and handling area

Areas must be set aside for the storage and handling of material. The objective here is to minimize waste and losses arising from careless handling, bad storage, or theft, and to reduce costs by obviating double handling or unnecessary movement.

Site accommodations and welfare facilities

Consideration should always be given to the possibility of ensuring that the site accommodations are kept at a suitable distance from the construction work and are in such a position to enable the site staff to conduct their duties (welfare facilities also)

Temporary services

This includes water supply, electricity supply, gas, telephones, and drainage the requirements of which may vary between different projects.

Workshop position

Position should be indicated to enable the site supervisor to arrange for the erection of the following types of workshops: 1) fitter s shops and work area; 2) joinery shop and machinery area;

3) Reinforcement and bar bending areas; and

4) Concrete mixing.

Bad site layout planning

Bad site layout is usually a multi criteria problem involving in construction site without any or less temporary facilities regarding to the type of project.

Examples of Site Layout Planning

Example 1
Figure 1 illustrates the layout of building materials and access roads for the purposes of servicing two hoists for the erection of a low-rise building. Comment on and criticize the present layout in relation to the positioning of both the materials and hoists.

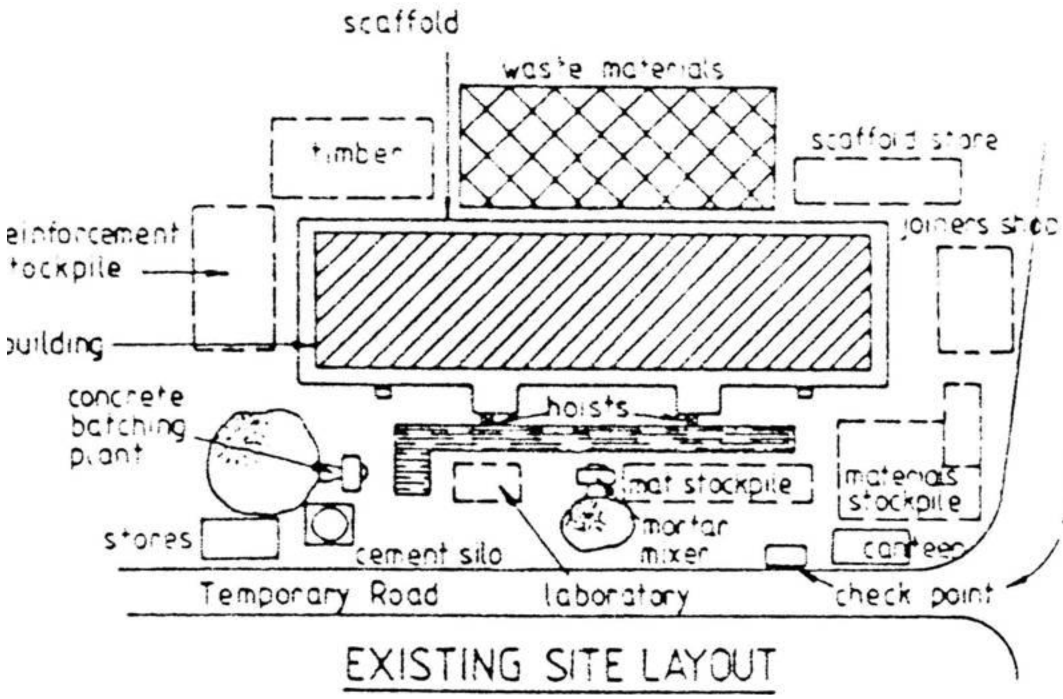


Fig.1: Existing site layout

Criticism of existing site layout:

- Both hoists have separate scaffold staging, causing increased costs.
- Materials are not stockpiled near hoists.
- Entrance to the site is too narrow for truck to pass.

Stores are located behind the batching plant so obscuring storeman's view and check point is separated from the stores.

- Concrete and mortar mixers are located too far from the hoists.
- Stockpiles are dispersed and hinder unloading.
- Temporary roads are long and narrow.
- Some stores are difficult to reach.

Example 2:

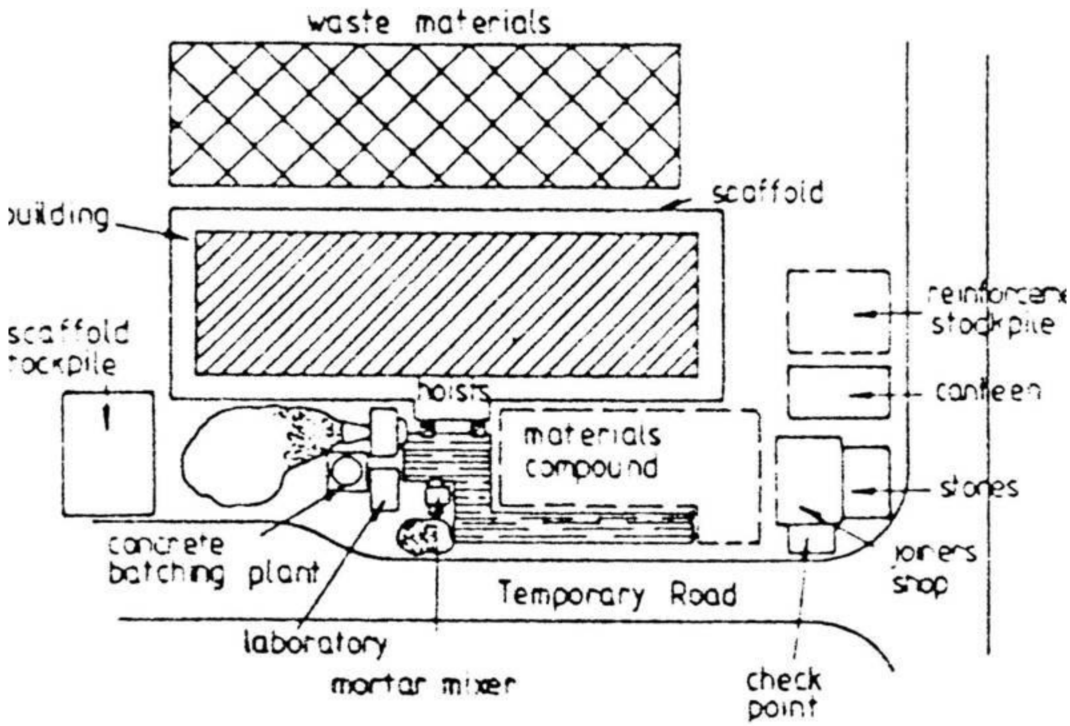


Fig. 2: Improved site layout

Suggested improved layout:

- Both hoists are housed in a common scaffold.
- Batching plants have direct discharge into dumpers.
- The access has been widened near the site entrance.
- The stores are located to give a good view of all materials stockpiles, and are sited near the temporary road.
- Concrete and mortar mixers are located near the hoists.
- The temporary road is shorter and wider.
- A compound is provided to police non-bulk materials.

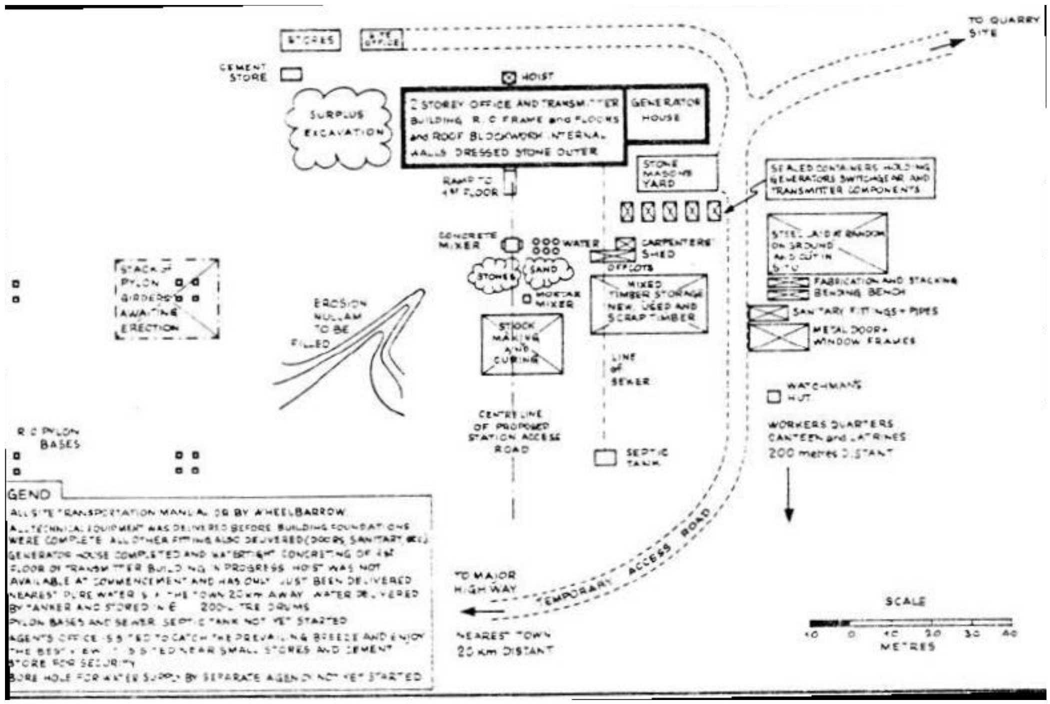


Fig. 3: Existing site layout

Criticism of existing site layout

- In general, the working area is too spread out, making control more difficult and increasing travelling time about the site which will lead to reducing productivity.
- Site latrines and canteen are too far away, causing loss of time due to unnecessary travelling. There is no apparent supply of drinking water on site.
- No security fencing is shown.
- Temporary access road should follow the line of the proposed station access road to avoid duplication of work.
- Surplus excavation should have been led directly to the erosion site to avoid double handling.
- Pylon girders have been stacked over foundation bases, necessitating double handling.
- Site office is wrongly located. As the building rises the view of the site will be blocked.
- Cement store is too far from the mixer.
- Hoist is on the wrong the side of the building, too far from the work areas.
- Mortar-mixing and block-making areas are too far from the building.
- Temporary buildings and storage areas are sited over the line of the sewer. The sewer should be constructed early to free the ground.
- Steel is laid on the ground and not stacked in an orderly manner. Bending and fabrication benches are wrongly placed.
- Timber storage area is unorganized.
- Sanitary fittings, pipes, and frames are stacked too near to the access road violating safety.

Suggested improved layout:

Fig. 4 shows the suggested improved site layout planning to offset the drawbacks recorded from the previous site plan given in Fig. 3.

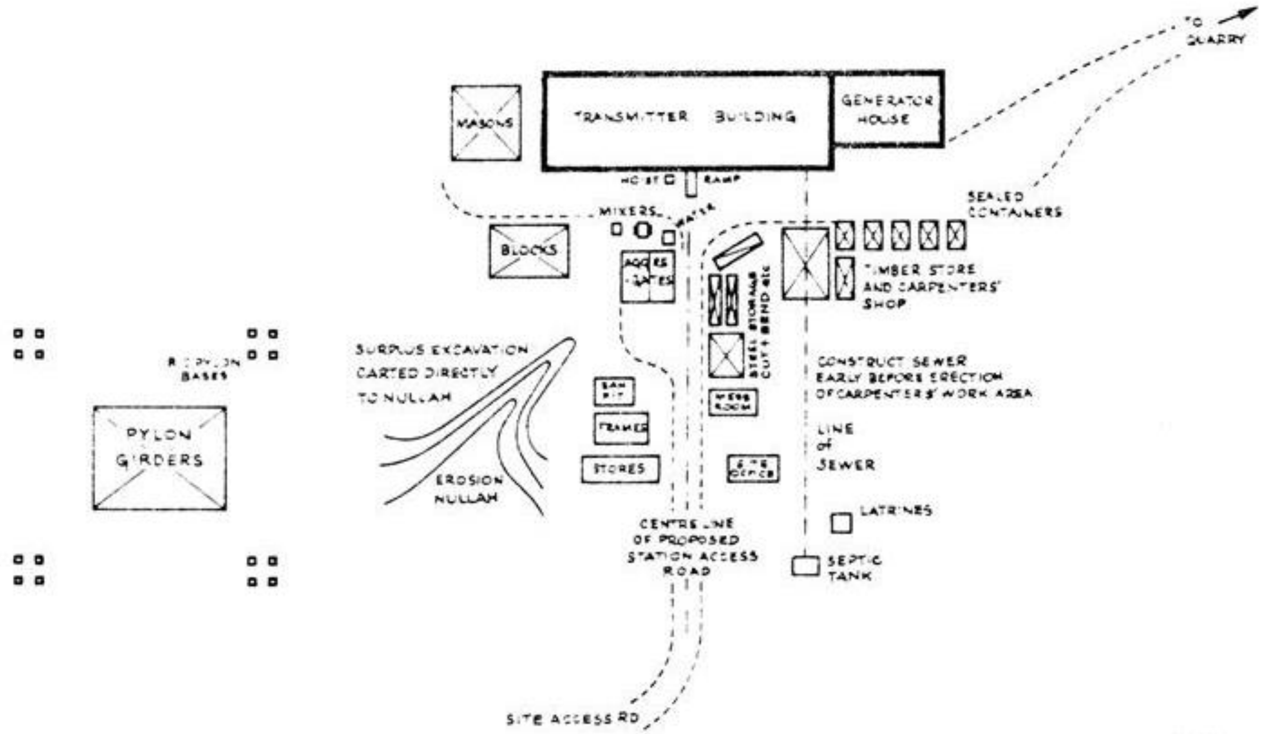


Fig. 4: Improved site layout

Summarizing:

Site investigation product plane such as space allocations and material transportations need a lot of experience and knowledge. The planning of a site layout in practice will depend upon a number of factors such as the time and money. The need for careful site layout and site organization planning becomes more relevant as the size and complexity of the construction operation increases, and especially where spare site space is very limited.

Scope of site investigation works when planned by different engineers tend to be varied because there are an infinite number of conditions to be met and the process of planning also leaves many areas where individual judgment and experiences must be applied. It is also impossible to attempt to provide an exhaustive step by step guideline applicable to all possible cases. It should be realized that there is a possibility that any site investigation may leave some area unexplored or overlooked. The main risk in foundation design is the uncertainty involving in predicting soil conditions which may change with environment. The more site investigation the more it will reduce the margin of uncertainty but the time and cost requirement will be exorbitant. Therefore the extent and the cost of Site Investigation should be such that risk is at an established acceptable level to the designer and also comply to the accepted code of practice.

Decision making processes: CPM and L. P. Project monitoring.

Lecture No. 31-34

Critical path analysis is commonly considered to be a technique for planning and scheduling of projects. The planning phase is usually identified with the construction of the method of performing jobs as well as their technical ordering. At the same time standard times are assigned to these jobs. At the completion of the planning stage it is possible, using the conventional CPM calculations, to schedule the starting time of each job in the project. Unless several different planes are evaluated in this way, or unless the technique of job crashing is used, there is no interaction between the planning and the scheduling phase of the usual CPM analysis. Thus if there are a number of competing methods of performing some of the jobs, each method having a different cost, a different time duration, and different technological dependencies, we shall include all these in the project graph rather than making the decisions in advance. Then in the scheduling phase we shall consider the effect of all alternate methods of performing a task on the total cost of completing the project, and choose those alternatives that minimize the cost. We may apply the same method to the control of projects being carried out. Thus decisions previously considered to be optimal, may be changed after partial completion of the project because of the delay in completion of certain jobs. The complete problem is called Decision CPM (DCPM), and it can be set up as a formal mathematical problem to solve using various techniques.

A project graph is defined as that containing information of all jobs to be completed in the projects, alternative methods of performing some of the jobs, and precedence relations between the jobs. Integer programming and heuristic techniques can be used for solving such graph for the set of jobs that are to be performed and the criticality of these jobs. The technique can be applied to dynamic monitoring and control of projects during their execution.

CRITERIA FOR DECISION MAKING

Some of the important criteria for decision-making are as under:

• Time overrun/ under-run i.e., whether the ‘activities’ are on course, delayed or advanced, particularly the critical ones; whether criticality of ‘activities’ has changed or likely to change.
• Cost overrun/ under-run. i.e. whether actual cost is more than/ less than the value of work done.

• Resources availability; matching availability of manpower, construction equipment, funds, etc. with the schedule.

CAUSES OF PROJECT SUCCESS OR FAILURE

It seen that many mega projects of water supply, STP, roads etc., get delayed due to improper project manager/team and unclear project authority and powers not defined. Experience and research studies in India indicate that rarely the critical elements of a project, viz.-

• Correct choice of project,

• Proper choice of site,

• Timely execution of the project,

• Keeping check on the capital cost,

• Proper Project Manager are found to combine, resulting in exorbitant delays, capital costs and operating costs far exceeding estimates, and making the project a nonstarter. A study of a few years ago gives alarming information on project overruns in India, which becomes a serious economic problem for the country.

Some constraints and causes have been mentioned under 'PROJECT PLANNING'. The crux of good project management is correct identification of causes of delay to help the project team to try and eliminate the same. Broadly, the reasons for delay may lie in-

• Planning

• Organizing

• Monitoring

Hence the need to plan the resources adequately, right choice of project manager and his team, project oriented organization (based on Work Breakdown Structure), proper and adequate delegation of authority commensurate with responsibility would go a long way to reduce the overruns. Proper MIS and effective coordination with all concerned (with the organization and outside agencies, statutory bodies etc.) would ensure timely project completion. Some of the important factors to be borne in mind and taken care are:

• Detailed planning and implementation schedule.

• Sound monitoring

• Resource planning based on time schedule and anticipated progress.

• Ensuring safety measures while preparing contracts.

• Rewards/ incentive schemes for project staff.

• Selection of appropriate, feasible technology.

• Decentralized decision making for fast implementation.

• Continuity of project manager and key project personnel till completion of the project

• Adequate training of workers and supervisors involves.

• Anticipating omissions and mistakes, and preparing contingency plan.

• Communication follow-up with vendors, subcontractors, financing agencies, statutory authorities

• Adequate MIS

• Encourage innovative attitude and skill of the project team,

• Clarity of scopes on project objectives.

• Clarity of responsibilities and authority to the team members.

• Lucid financial cost estimates.

• Mile stone charts, project audit reports, etc.

Project Monitoring

Project monitoring is basically keeping track of progress of a project by comparing its performance against targets, looking for causes of deviation, and attempting to check adverse variances. Time and cost are two critical parameters for monitoring and control of a project, and criteria for decision making in project management. Resources management is another very important area in this respect.

A project may succeed or fail, based on a number of factors like choice of project, choice of site, and its timely execution without any cost over-run. Examples of failed projects are innumerable, evidenced by enormous project delays, cost overruns and persistent accumulation of losses due to, inter-alia, inefficient and/ or ineffective monitoring and control. The project manager monitors the overall project. The phase project manager reports to the overall project manager of any risks.

Monitoring has the following tasks and the concerned officer/manager does it with utmost care;

• Identify Risks, Potential Project Problems, As Early As Possible

• Identify When Goals May Not Be Met

• Identify When Constraints May Be Violated

• Ensure That Contingency Plans Occur Before Unrecoverable Problems Occur

• Provide and receive project status for the phases and total project.

When there is a significant chance that the goals of the project will not be met, this risk should be reported to upper management. The project manager after identifying the likely problems, risks and constraints would discuss the same with team and the higher management for resolving the issues without hurdles. What however is not often realized is that project control involves all the stages of a project cycle. It is not the implementation alone which calls for close supervision and control. (The expressions ‘supervision’ and ‘control’ should not mislead people into believing that these will be day to day intervention and interference). It has to be systematic, well conceived and built into different stages of project cycle. This supervision and control mechanism has to be set up well in advance, at the time of inception.

WHAT IS PROJECT MONITORING?

As soon as the project is launched, monitoring and control becomes the prime concern of project management. In fact, planning and control becomes clearly intertwined in an integrated management process. Project monitoring and control involves a regular comparison of performance against targets, a search for the causes of deviation, and an attempt to check adverse variances. This serves two major purposes:

(i) It keeps everyone concerned with the project, informed regarding the status of the project. We can tell whether we are on time or delayed, reasons for delay, if any, potential delays, if any, and reasons thereof; whether we are within the budget or have exceeded it, reasons for exceeding the budget, if any, and so on. (ii) It motivates the project personnel to strive for achieving project objectives.

Effective monitoring and control is critical for realization of project objectives. Yet more often than not, control of project in practice tends to be ineffective. This is mainly due to the following reasons:

a. Characteristics of the project- Large and complex projects, involving thousands of activities, many organization and personnel, make the task of monitoring and controlling them difficult. Keeping track of physical performance and expenditure on so many activities going on simultaneously, which are mostly non-routine, is a stupendous task. Future, coordination and communication problem multiplies with the complexity of organization involved in the project.

b. People problem- Most managers, used to the steady rhythm of normal operations and routine work, find themselves thoroughly inadequate to monitor a wide range of disparate factors, to sense the symptoms indicative of potential problems, and to comprehend the combined effect of multiple forces interacting in a large project. This may be due to lack of experience, training, competence and commitment to control projects.

c. Poor control and information system- Some of the weaknesses in control and information system could be-

• Delay in reporting performance, which prevents effective monitoring and initiation of timely action to check adverse developments.

• Inappropriate level of detail, i.e. information, irrespective of the level of detail employed, for project planning and budgeting, is not useful for identifying problems and planning corrective action.

• Unreliable information, i.e. inaccurate date & information. There is a tendency to report, “Everything is OK”, when, in fact, they are not OK.

The purpose for any cost and control system is to establish policies, procedures and techniques that can be used in management and control of projects. The planning and control system must, therefore, provide information that gives a picture of true work progress and relates cost and schedule performance. It should also identify potential problems with respect to their sources and be able to demonstrate that the milestones are valid, timely and auditable. The planning and control system, in addition to being a tool by which objectives can be defined also exists as a tool to develop planning, measure progress and control change.

Procurement Procedures

Having identified the material and equipment required for the project, the next step is to identify the various vendors, provide specifications, invite quotations, and carryout discussions with select vendors. For medium to high value items, tendering process can be adopted. Tenders have to be evaluated for technical and financial aspects. (See chapter on tendering and contract procedure)

PARAMETERS & TOOLS OF CONTROL

Use of Network Analysis for project monitoring

Network forms the basis for monitoring. The critical activities, with zero float/ very little float are closely watched. As activities get completed progressively, the network is updated to take note of fresh interdependencies that might come to light while updating the network. The network technique is a versatile one, as it is action-oriented and continually revalidates and revises the inter-relationship between the activities. Let us assume the following example, which gives the position of the project at the planning and scheduling stage before actual start of the activities.

Problem Statement

Managing a large-scale project requires coordinating many activities of varying duration and involving numerous dependencies. PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) are two closely-related operations research techniques that use networks to coordinate activities, develop schedules, and monitor progress of projects. PERT and CPM were developed independently in the 1950s. While the original versions differed in some important ways, the two techniques had much in common. Over time, the techniques have merged and, for the most part, the names are used interchangeably or combined in a single acronym, PERT/CPM.

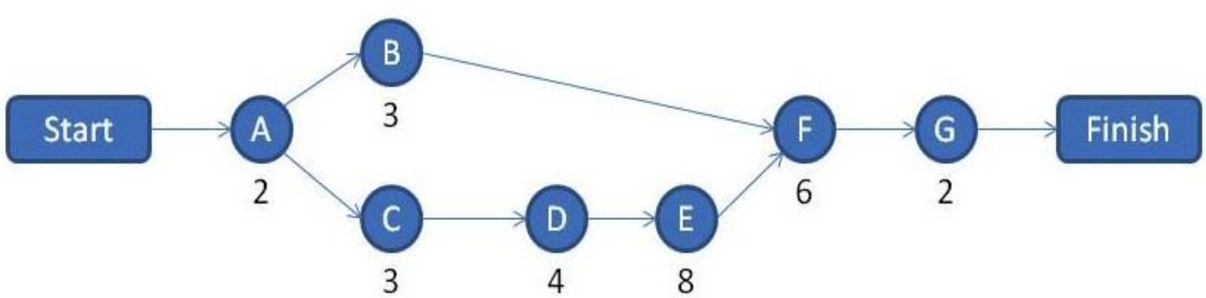
We introduce a small example that will be used to illustrate various aspects of CPM. Suppose we are constructing a new building; the required construction activities are shown in the table below along with the estimated duration of each activity and any immediate predecessors. An immediate predecessor of an activity *y*y is an activity *x*x that must be completed no later than the starting time of activity *yy*. When an activity has more than one immediate predecessor, all of them must be completed before the activity can begin.

Activity	Duration (weeks)	Predecessor(s)
A	2	None
B	3	A
C	3	A
D	4	C
E	8	D
F	6	B, E
G	2	F

There are many questions to be answered when scheduling a complex project but two of the important questions are:

1. What is the total time required to complete the project if no delays occur?
2. What are the critical bottleneck activities?

A project network is used to represent a project and to show the relationships between the activities. In an *activity-on-node* (AON) network, each activity is represented by a node. Each predecessor relationship is represented by an arc; there is an arc from node i to node j if the activity at node *i*i is an immediate predecessor to the activity at node j. The duration of the activity at node i is recorded next to node i. The figure below shows a network representation of the project information from the table above.



1. What is the total time required to complete the project?

If we add up the times required for all of the activities, we get 28 weeks. However, this is not the best answer to the question, since some of the activities can be performed at the same time. Instead, to determine the total time required, we want to consider the length of each path through the network. A **path** through the network is a route made up of nodes and arcs that traverses the network from the start node to the finish node. The **length** of a path is the sum of the durations of the activities on the nodes along the path. In this simple example, there are two paths through the network:

- start -> A -> B -> F -> G -> finish, with a length of 13
- start -> A -> C -> D -> E -> F -> G -> finish, with a length of 25

The project duration will be no longer than the longest path through the network. Therefore, the total time required to complete the project equals the length of the longest path through the network -- and this longest path is called the **critical path**. In the example, the total time to complete the project should be 25 weeks if no delays occur.

2. What are the critical bottleneck activities?

The critical bottleneck activities are the activities that are "critical" to completing the project on time; a delay in a critical bottleneck activity will delay the project completion time. Therefore, the activities on the critical path are the critical bottleneck activities. In our example, the critical bottleneck activities are A, C, D, E, F, and G; the project should be managed to avoid delays in any of these activities. There is also a positive aspect to knowing the critical bottleneck activities; a reduction in the duration of a critical bottleneck activity *may* reduce the time required to complete the project.

Mathematical Formulation

For small projects, it is possible to enumerate all of the paths and identify the critical path. For larger, more complex projects with many dependencies, a more efficient procedure is required. One approach is to formulate the project scheduling problem as a linear programming problem; due to the underlying network structure, even large problems can be solved efficiently. Thus, given a list of activities required to complete a project along with the duration of each activity and the dependencies between activities, the objective of the Critical Path Method (CPM) is to determine the sequence of activities that minimizes the latest completion time.

Sets

A = set of activities,

e.g., $P=\{A,B,C,D,E,F,G\}$P={A,B,C,D,E,F,G}

P = set of predecessor pairs, e.g., element (i,j) means that activity i is an immediate predecessor of activity j

Parameters

di = duration of activity i, $\forall i \in A$

Decision Variables

T = total time required to complete the project
si = start time of activity i, ∀i∈A

Objective Function

minimize T

Constraints

The total time to complete the project must be greater than or equal to the start time plus the duration of all of the activities.

si+di≤T,∀i∈A

For each predecessor pair (i,j), the start time of activity j, must be greater than or equal to the start time of activity i plus the duration of activity i.

$s_i + d_i \leq s_j, \forall (i,j) \in P$

$s_i \geq 0$

To solve this linear programming problem, we can use one of the NEOS Server solvers in the Linear Programming (LP) category. Each LP solver has one or more input formats that it accepts.

Application of Decision CPM to dynamic monitoring and control of projects

Decision CPM has been presented as a technique to solve combined planning and scheduling problems for construction type projects, as originally stated. However it is clear that such things as project crashing can be handled by the technique if the assumption is made that there are several discrete levels of performance possible, rather than a continuous linear relation between job cost and job time. The assumption of discreteness is particularly fitting in construction projects where there is a choice such as one or two shift operation and the use of regular or quick drying cement, etc. Furthermore the potential of the technique for project design arid job crashing has important implications for the dynamic monitoring control of the project as we carry out the plan. Suppose that daily information is collected concerning the status of jobs in a project being worked on. At any given time some jobs would have been finished on time or early and others will have been delayed. Given this information it is possible to solve again for a new optimum in the decision project graph of the remaining problem. It is true that some earlier decision may be unchangeable; perhaps because of the purchase of material, but some decision sets and many possibilities for crashing of jobs will usually remain. Given the actual status of the project, new decisions may now be better than those previously accepted.

In summary, the dynamic design and control processes will operate as follows.

(1) Collect information on

(a) Tasks to be performed and alternative methods of performing them (jobs),

(b) Technological relations between jobs,

(c) Interdependences among decisions,

(d) Job times,

(e) Job costs,

(f) Job crashing methods and costs,

(g) Project due date, penalty, and premium.

(2) Solve problems using Decision CPM for original plan.

(3) Begin project.

(4) At regular intervals collect information on project progress.

(5) Update job cost and job time data.

(6) Replace decision nodes by single jobs as decisions become irrevocable over time.

(7) At regular intervals resolve the remaining decision project graph to see if savings are possible by the implementation of a new plan. Go to 4

(8) Halt when project is complete.

DEPARTMENT OF CIVIL ENGINEERING

B TECH 8th SEMESTER

01 1827 CONSTRUCTION PLANNING AND MANAGEMENT

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Introduction to Project Management Software

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INTRODUCTION

Project management is one of the high-responsibility tasks in modern organizations. Project management is used in many types of projects ranging from software development to developing the next generation fighter aircrafts.

In order to execute a project successfully, the project manager or the project management team should be supported by a set of tools. These tools can be specifically designed tools or regular productivity tools that can be adopted for project management work. The use of such tools usually makes the project managers work easy as well as it standardizes the work and the routine of a project manager.

A project is well-defined task, which is a collection of several operations done in order to achieve a goal (for example, software development and delivery). A Project can be characterized as:

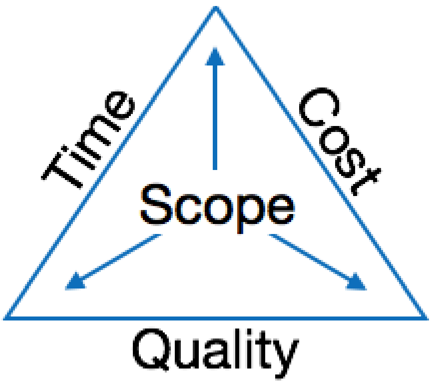
- Every project may has a unique and distinct goal.
- Project is not routine activity or day-to-day operations.
- Project comes with a start time and end time.
- Project ends when its goal is achieved hence it is a temporary phase in the lifetime of an organization.
- Project needs adequate resources in terms of time, manpower, finance, material and knowledge-bank.

SOFTWARE PROJECT

A Software Project is the complete procedure of software development from requirement gathering to testing and maintenance, carried out according to the execution methodologies, in a specified period of time to achieve intended software product.

Need of software project management

Software is said to be an intangible product. Software development is a kind of all new stream in world business and there's very little experience in building software products. Most software products are tailor made to fit client's requirements. The most important is that the underlying technology changes and advances so frequently and rapidly that experience of one product may not be applied to the other one. All such business and environmental constraints bring risk in software development hence it is essential to manage software projects efficiently.



The image above shows triple constraints for software projects. It is an essential part of software organization to deliver quality product, keeping the cost within client's budget constrain and deliver the project as per scheduled. There are several factors, both internal and external, which may impact this triple constrain triangle. Any of three factor can severely impact the other two.

The project management triangle is used by managers to analyze or understand the difficulties that may arise due to implementing and executing a project. All projects irrespective of their size will have many constraints.

Although there are many such project constraints, these should not be barriers for successful project execution and for the effective decision making.

There are three main interdependent constraints for every project; time, cost and scope. This is also known as Project Management Triangle.

Let's try to understand each of the element of project triangle and then how to face challenges related to each.

The Three Constraints

The three constraints in a project management triangle are time, cost and scope.

1 - Time

A project's activities can either take shorter or longer amount of time to complete. Completion of tasks depends on a number of factors such as the number of people working on the project, experience, skills, etc.

Time is a crucial factor which is uncontrollable. On the other hand, failure to meet the deadlines in a project can create adverse effects. Most often, the main reason for organizations to fail in terms of time is due to lack of resources.

2 - Cost

It's imperative for both the project manager and the organization to have an estimated cost when undertaking a project. Budgets will ensure that project is developed or implemented below a certain cost.

Sometimes, project managers have to allocate additional resources in order to meet the deadlines with a penalty of additional project costs.

3 - Scope

Scope looks at the outcome of the project undertaken. This consists of a list of deliverables, which need to be addressed by the project team.

A successful project manager will know to manage both the scope of the project and any change in scope which impacts time and cost.

Quality

Quality is not a part of the project management triangle, but it is the ultimate objective of every delivery. Hence, the project management triangle represents implies quality.

Many project managers are under the notion that 'high quality comes with high cost', which to some extent is true. By using low quality resources to accomplish project deadlines does not ensure success of the overall project.

Like with the scope, quality will also be an important deliverable for the project.

Six stages of Project Management

A project undergoes six stages during its life cycles and they are noted below:

- **Project Definition -** This refers to defining the objectives and the factors to be considered to make the project successful.
- **Project Initiation -** This refers to the resources as well as the planning before the project starts.
- **Project Planning -** Outlines the plan as to how the project should be executed. This is where project management triangle is essential. It looks at the time, cost and scope of the project.
- **Project Execution -** Undertaking work to deliver the outcome of the project.
- **Project Monitoring & Control -** Taking necessary measures, so that the operation of the project runs smoothly.
- **Project Closure -** Acceptance of the deliverables and discontinuing resources that were required to run the project.

Overcoming Challenges to Project Constraints

It is always a requirement to overcome the challenges related to the project triangle during the project execution period. Project managers need to understand that the three constraints outlined in the project management triangle can be adjusted.

The important aspect is to deal with it. The project manager needs to strike a balance between the three constraints so that quality of the project will not be compromised.

To overcome the constraints, the project managers have several methods to keep the project going. Some of these will be based on preventing stakeholders from changing the scope and maintaining limits on both financial and human resources.

A project manager's role is evolved around responsibility. A project manager needs to supervise and control the project from the beginning to the closure.

The following factors will outline a project manager's role:

- The project manager needs to define the project and split the tasks amongst team members. The project manager also needs to obtain key resources and build teamwork.
- The project manager needs to set the objectives required for the project and work towards meeting these objectives.
- The most important activity of a project manager is to keep stakeholders informed on the progress of the project.
- The project manager needs to asses and carefully monitor risks of the project.

Skills Required for a Project Manager

In order to overcome the challenges related to project triangle and meet the project objectives, the project manager needs to have a range of skills, which includes:

- Leadership
- Managing people
- Negotiation
- Time management
- Effective communication

- Planning
- Controlling
- Conflict resolution
- Problem solving

Therefore, software project management is essential to incorporate user requirements along with budget and time constraints.

Software Project Manager

A software project manager is a person who undertakes the responsibility of executing the software project. Software project manager is thoroughly aware of all the phases of SDLC that the software would go through. Project manager may never directly involve in producing the end product but he controls and manages the activities involved in production.

A project manager closely monitors the development process, prepares and executes various plans, arranges necessary and adequate resources, maintains communication among all team members in order to address issues of cost, budget, resources, time, quality and customer satisfaction.

Let us see few responsibilities that a project manager shoulders -

Managing People

- Act as project leader
- Liaison with stakeholders
- Managing human resources
- Setting up reporting hierarchy etc.

Managing Project

- Defining and setting up project scope
- Managing project management activities
- Monitoring progress and performance
- Risk analysis at every phase

- Take necessary step to avoid or come out of problems
- Act as project spokesperson

Software Management Activities

Software project management comprises of a number of activities, which contains planning of project, deciding scope of software product, estimation of cost in various terms, scheduling of tasks and events, and resource management. Project management activities may include:

- **Project Planning**
- **Scope Management**
- **Project Estimation**

Project Planning

Software project planning is task, which is performed before the production of software actually starts. It is there for the software production but involves no concrete activity that has any direction connection with software production; rather it is a set of multiple processes, which facilitates software production. Project planning may include the following:

Scope Management

It defines the scope of project; this includes all the activities, process need to be done in order to make a deliverable software product. Scope management is essential because it creates boundaries of the project by clearly defining what would be done in the project and what would not be done. This makes project to contain limited and quantifiable tasks, which can easily be documented and in turn avoids cost and time overrun.

During Project Scope management, it is necessary to -

- Define the scope
- Decide its verification and control
- Divide the project into various smaller parts for ease of management.
- Verify the scope
- Control the scope by incorporating changes to the scope

Project Estimation

For an effective management accurate estimation of various measures is a must. With correct estimation managers can manage and control the project more efficiently and effectively.

Project estimation may involve the following:

- **Software size estimation**

  Software size may be estimated either in terms of KLOC (Kilo Line of Code) or by calculating number of function points in the software. Lines of code depend upon coding practices and Function points vary according to the user or software requirement.

- **Effort estimation**

  The managers estimate efforts in terms of personnel requirement and man-hour required to produce the software. For effort estimation software size should be known. This can either be derived by managers' experience, organization's historical data or software size can be converted into efforts by using some standard formulae.

- **Time estimation**

  Once size and efforts are estimated, the time required to produce the software can be estimated. Efforts required is segregated into sub categories as per the requirement specifications and interdependency of various components of software. Software tasks are divided into smaller tasks, activities or events by Work Breakthrough Structure (WBS). The tasks are scheduled on day-to-day basis or in calendar months.

  The sum of time required to complete all tasks in hours or days is the total time invested to complete the project.

- **Cost estimation**

  This might be considered as the most difficult of all because it depends on more elements than any of the previous ones. For estimating project cost, it is required to consider -

- Size of software
- Software quality
- Hardware
- Additional software or tools, licenses etc.
- Skilled personnel with task-specific skills
- Travel involved
- Communication
- Training and support

Project Estimation Techniques

We discussed various parameters involving project estimation such as size, effort, time and cost.

Project manager can estimate the listed factors using two broadly recognized techniques –

Decomposition Technique

This technique assumes the software as a product of various compositions.

There are two main models -

- **Line of Code** Estimation is done on behalf of number of line of codes in the software product.
- **Function Points** Estimation is done on behalf of number of function points in the software product.

Empirical Estimation Technique

This technique uses empirically derived formulae to make estimation. These formulae are based on LOC or FPs.

- **Putnam Model**

This model is made by Lawrence H. Putnam, which is based on Norden's frequency distribution (Rayleigh curve). Putnam model maps time and efforts required with software size.

- **COCOMO**

  COCOMO stands for Constructive Cost Model, developed by Barry W. Boehm. It divides the software product into three categories of software: organic, semi-detached and embedded.

Project Scheduling

Project Scheduling in a project refers to roadmap of all activities to be done with specified order and within time slot allotted to each activity. Project managers tend to define various tasks and project milestones and arrange them keeping various factors in mind. They look for tasks lie in critical path in the schedule, which are necessary to complete in specific manner (because of task interdependency) and strictly within the time allocated. Arrangement of task which lies out of critical path is less likely to impact over all schedule of the project.

For scheduling a project, it is necessary to -

- Break down the project tasks into smaller, manageable form
- Find out various tasks and correlate them
- Estimate time frame required for each task
- Divide time into work-units
- Assign adequate number of work-units for each task
- Calculate total time required for the project from start to finish

Resource management

All elements used to develop a software product may be assumed as resource for that project. This may include human resource, productive tools and software libraries.

The resources are available in limited quantity and stay in the organization as a pool of assets. The shortage of resources hampers the development of project and it can lag behind the schedule. Allocating extra resources increases development cost in the end. It is therefore necessary to estimate and allocate adequate resources for the project.

Resource management includes -

- Defining proper organization project by creating a project team and allocating responsibilities to each team member
- Determining resources required at a particular stage and their availability
- Manage Resources by generating resource request when they are required and de-allocating them when they are no more needed.

Project Risk Management

Risk management involves all activities pertaining to identification, analyzing and making provision for predictable and non-predictable risks in the project. Risk may include the following:

- Experienced staff leaving the project and new staff coming in.
- Change in organizational management.
- Requirement change or misinterpreting requirement.
- Under-estimation of required time and resources.
- Technological changes, environmental changes, business competition.

Risk Management Process

There are following activities involved in risk management process:

- **Identification -** Make note of all possible risks, which may occur in the project.
- **Categorize -** Categorize known risks into high, medium and low risk intensity as per their possible impact on the project.
- **Manage -** Analyze the probability of occurrence of risks at various phases. Make plan to avoid or face risks. Attempt to minimize their side-effects.
- **Monitor -** Closely monitor the potential risks and their early symptoms. Also monitor the effects of steps taken to mitigate or avoid them.

Project Execution & Monitoring

In this phase, the tasks described in project plans are executed according to their schedules.

Execution needs monitoring in order to check whether everything is going according to the plan. Monitoring is observing to check the probability of risk and taking measures to address the risk or report the status of various tasks.

These measures include -

- **Activity Monitoring -** All activities scheduled within some task can be monitored on day-to-day basis. When all activities in a task are completed, it is considered as complete.
- **Status Reports -** The reports contain status of activities and tasks completed within a given time frame, generally a week. Status can be marked as finished, pending or work-in-progress etc.
- **Milestones Checklist -** Every project is divided into multiple phases where major tasks are performed (milestones) based on the phases of SDLC. This milestone checklist is prepared once every few weeks and reports the status of milestones.

Project Communication Management

Effective communication plays vital role in the success of a project. It bridges gaps between client and the organization, among the team members as well as other stake holders in the project such as hardware suppliers.

Communication can be oral or written. Communication management process may have the following steps:

- **Planning** - This step includes the identifications of all the stakeholders in the project and the mode of communication among them. It also considers if any additional communication facilities are required.
- **Sharing** - After determining various aspects of planning, manager focuses on sharing correct information with the correct person on correct time. This keeps every one involved the project up to date with project progress and its status.

- **Feedback** - Project managers use various measures and feedback mechanism and create status and performance reports. This mechanism ensures that input from various stakeholders is coming to the project manager as their feedback.
- **Closure** - At the end of each major event, end of a phase of SDLC or end of the project itself, administrative closure is formally announced to update every stakeholder by sending email, by distributing a hardcopy of document or by other mean of effective communication.

After closure, the team moves to next phase or project.

Configuration Management

Configuration management is a process of tracking and controlling the changes in software in terms of the requirements, design, functions and development of the product.

IEEE defines it as "the process of identifying and defining the items in the system, controlling the change of these items throughout their life cycle, recording and reporting the status of items and change requests, and verifying the completeness and correctness of items".

Generally, once the SRS is finalized there is less chance of requirement of changes from user. If they occur, the changes are addressed only with prior approval of higher management, as there is a possibility of cost and time overrun.

Baseline

A phase of SDLC is assumed over if it base-lined, i.e. baseline is a measurement that defines completeness of a phase. A phase is base-lined when all activities pertaining to it are finished and well documented. If it was not the final phase, its output would be used in next immediate phase.

Configuration management is a discipline of organization administration, which takes care of occurrence of any change (process, requirement, technological, strategical etc.) after a phase, is base-lined. CM keeps check on any changes done in software.

Change Control

Change control is function of configuration management, which ensures that all changes made to software system are consistent and made as per organizational rules and regulations.

A change in the configuration of product goes through following steps -

- **Identification** - A change request arrives from either internal or external source. When change request is identified formally, it is properly documented.
- **Validation** - Validity of the change request is checked and its handling procedure is confirmed.
- **Analysis** - The impact of change request is analyzed in terms of schedule, cost and required efforts. Overall impact of the prospective change on system is analyzed.
- **Control** - If the prospective change either impacts too many entities in the system or it is unavoidable, it is mandatory to take approval of high authorities before change is incorporated into the system. It is decided if the change is worth incorporation or not. If it is not, change request is refused formally.
- **Execution** - If the previous phase determines to execute the change request, this phase take appropriate actions to execute the change, does a thorough revision if necessary.
- **Close request** - The change is verified for correct implementation and merging with the rest of the system. This newly incorporated change in the software is documented properly and the request is formally is closed.

Project Management Tools

The risk and uncertainty rises multifold with respect to the size of the project, even when the project is developed according to set methodologies.

There are tools available, which aid for effective project management. A few are described -

- Project Plan

All the projects that should be managed by a project manager should have a project plan. The project plan details many aspects of the project to be executed. First of all, it details out the project scope. Then, it describes the approach or strategy used for addressing the project scope and project objectives. The strategy is the core of the project plan. The strategy could vary depending on the project purpose and specific project requirements.

The resource allocation and delivery schedule are other two main components of the project plan. These detail each activity involved in the project as well as the information such as who executes them and when.

This is important information for the project manager as well as all the other stakeholders of the project.

- Milestone Checklist

This is one of the best tools the project manager can use to determine whether he or she is on track in terms of the project progress. The project manager does not have to use expensive software to track this. The project manager can use a simple Excel template to do this job. The milestone checklist should be a live document that should be updated once or twice a week.

- Project Management Softwares

With the introduction of computer technology, there has been a number of software tools specifically developed for project management purpose. MS Project is one such tool that has won the hearts of project managers all over the world. MS Project can be used as a standalone tool for tracking project progress or it can be used for tracking complex projects distributed in many geographical areas and managed by a number of project managers. There are many other software packages for project management in addition to MS Project. Most of these new additions are online portals for project management activities where the project members have access to project details and progress from anywhere.

- Project Reviews

A comprehensive project review mechanism is a great tool for project management. More mature companies tend to have more strict and comprehensive project reviews as opposed to basic ones done by smaller organizations. In project reviews, the project progress and the adherence to the process standards are mainly considered. Usually, project reviews are accompanied by project audits by a 3rd party (internal or external).

The non-compliances and action items are then tracked in order to complete them.

- Delivery Reviews

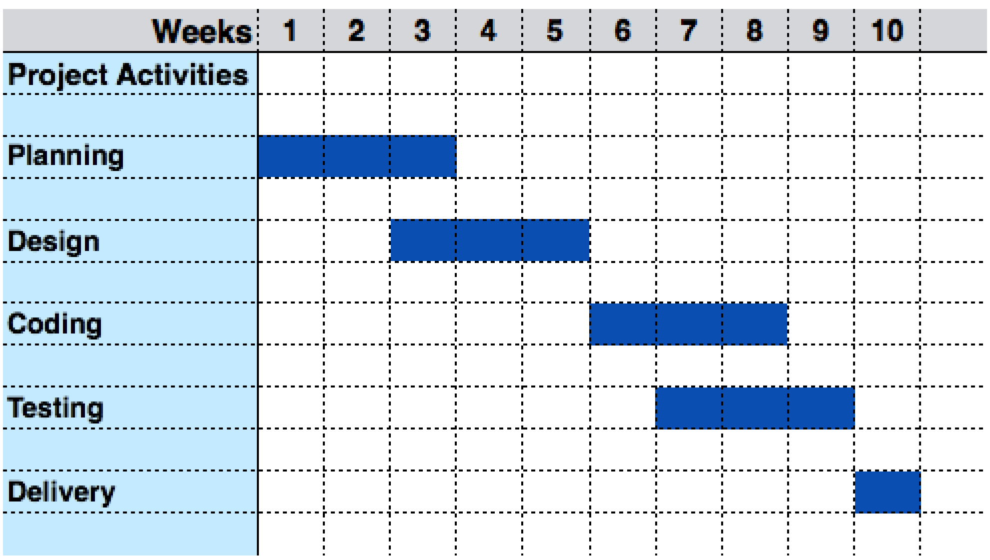
Delivery reviews make sure that the deliveries made by the project team meet the customer requirements and adhere to the general guidelines of quality. Usually, a 3rd party team or supervisors (internal) conduct the delivery review and the main stakeholders of the project delivery do participate for this event. The delivery review may decide to reject the delivery due to the quality standards and non-compliances.

- Score Cards

When it comes to performance of the project team, a scorecard is the way of tracking it. Every project manager is responsible of accessing the performance of the team members and reporting it to the upper management and HR. This information is then used for promotion purposes as well as human resource development. A comprehensive score card and performance assessment can place the team member in the correct position.

- **Gantt chart**

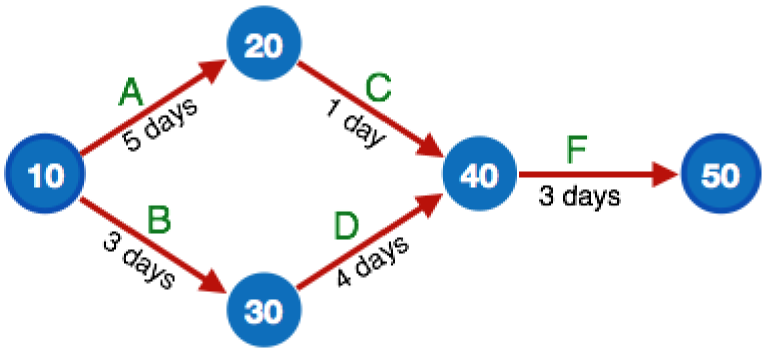
A Gantt chart was devised by Henry Gantt (1917). It represents project schedule with respect to time periods. It is a horizontal bar chart with bars representing activities and time scheduled for the project activities.



Gantt chart illustrates the project schedule and shows the project manager the interdependencies of each activity. Gantt charts are universally used for any type of project from construction to software development. Although deriving a Gantt chart looks quite easy, it is one of the most complex tasks when the project is involved in hundreds of activities. There are many ways you can create a Gantt chart. If the project is small and simple in nature, you can create your own Gantt chart in Excel or download an Excel template from the Internet. If the project has a high financial value or high-risk exposure, then the project manager can use software tools such as MS Project.

- **PERT Chart**

PERT (Program Evaluation & Review Technique) chart is a tool that depicts project as network diagram. It is capable of graphically representing main events of project in both parallel and consecutive way. Events, which occur one after another, show dependency of the later event over the previous one.

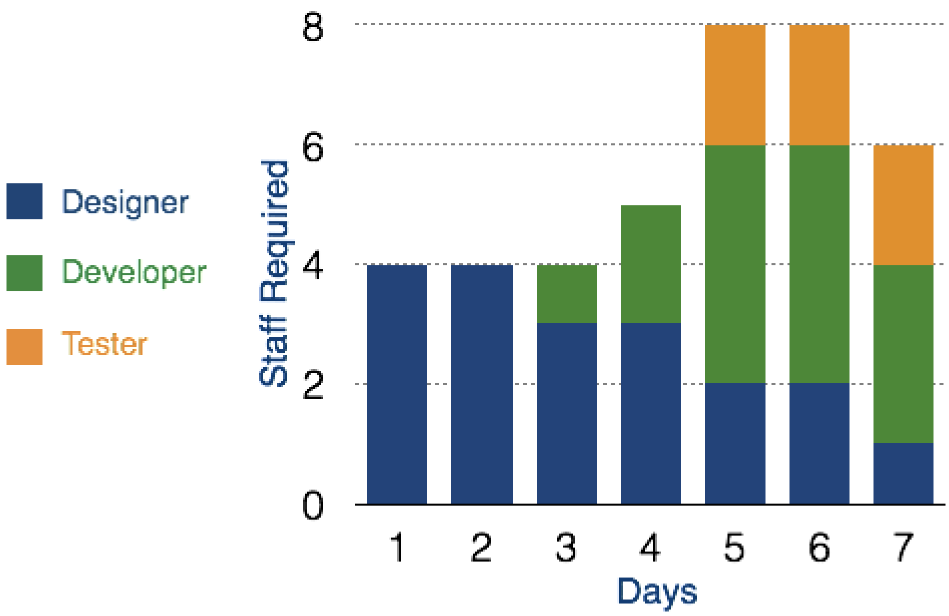


Events are shown as numbered nodes. They are connected by labeled arrows depicting sequence of tasks in the project.

Resource Histogram

This is a graphical tool that contains bar or chart representing number of resources (usually skilled staff) required over time for a project event (or phase). Resource Histogram is an effective tool for staff planning and coordination.

Staff	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Designer	4	4	3	3	2	2	1
Developer	0	0	1	2	4	4	3
Tester	0	0	0	0	2	2	2
Total	4	4	4	5	8	8	6



- Critical Path Analysis

This tool is useful in recognizing interdependent tasks in the project. It also helps to find out the shortest path or critical path to complete the project successfully. Like PERT diagram, each event is allotted a specific time frame. This tool shows dependency of event assuming an event can proceed to next only if the previous one is completed.

The events are arranged according to their earliest possible start time. Path between start and end node is critical path which cannot be further reduced and all events require to be executed in same order.

The software requirements are description of features and functionalities of the target system. Requirements convey the expectations of users from the software product. The requirements can be obvious or hidden, known or unknown, expected or unexpected from client’s point of view.

Requirement Engineering

The process to gather the software requirements from client, analyze and document them is known as requirement engineering.

The goal of requirement engineering is to develop and maintain sophisticated and descriptive 'System Requirements Specification' document.

Requirement Engineering Process

It is a four step process, which includes –

- Feasibility Study
- Requirement Gathering
- Software Requirement Specification
- Software Requirement Validation

Let us see the process briefly -

Feasibility study

When the client approaches the organization for getting the desired product developed, it comes up with rough idea about what all functions the software must perform and which all features are expected from the software.

Referencing to this information, the analysts does a detailed study about whether the desired system and its functionality are feasible to develop.

This feasibility study is focused towards goal of the organization. This study analyzes whether the software product can be practically materialized in terms of implementation, contribution of project to organization, cost constraints and as per values and objectives of the organization. It explores technical aspects of the project and product such as usability, maintainability, and productivity and integration ability.

The output of this phase should be a feasibility study report that should contain adequate comments and recommendations for management about whether or not the project should be undertaken.

Requirement Gathering

If the feasibility report is positive towards undertaking the project, next phase starts with gathering requirements from the user. Analysts and engineers communicate with the client and end-users to know their ideas on what the software should provide and which features they want the software to include.

Software Requirement Specification

SRS is a document created by system analyst after the requirements are collected from various stakeholders.

SRS defines how the intended software will interact with hardware, external interfaces, speed of operation, response time of system, portability of software across various platforms, maintainability, speed of recovery after crashing, Security, Quality, Limitations etc.

The requirements received from client are written in natural language. It is the responsibility of system analyst to document the requirements in technical language so that they can be comprehended and useful by the software development team.

SRS should come up with following features:

- User Requirements are expressed in natural language.
- Technical requirements are expressed in structured language, which is used inside the organization.
- Design description should be written in Pseudo code.
- Format of Forms and GUI screen prints.
- Conditional and mathematical notations for DFDs etc.

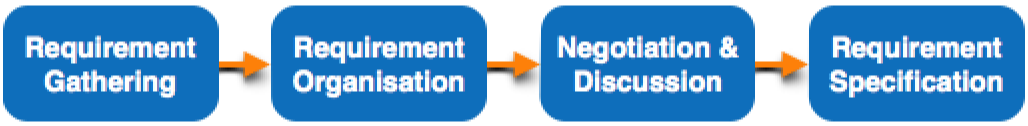
Software Requirement Validation

After requirement specifications are developed, the requirements mentioned in this document are validated. User might ask for illegal, impractical solution or experts may interpret the requirements incorrectly. This results in huge increase in cost if not nipped in the bud. Requirements can be checked against following conditions -

- If they can be practically implemented
- If they are valid and as per functionality and domain of software
- If there are any ambiguities
- If they are complete
- If they can be demonstrated

Requirement Elicitation Process

Requirement elicitation process can be depicted using the following diagram:



- **Requirements gathering -** The developers discuss with the client and end users and know their expectations from the software.
- **Organizing Requirements -** The developers prioritize and arrange the requirements in order of importance, urgency and convenience.
- **Negotiation & discussion -** If requirements are ambiguous or there are some conflicts in requirements of various stakeholders, if they are, it is then negotiated and discussed with stakeholders. Requirements may then be prioritized and reasonably compromised.

  The requirements come from various stakeholders. To remove the ambiguity and conflicts, they are discussed for clarity and correctness. Unrealistic requirements are compromised reasonably.

- **Documentation -** All formal & informal, functional and non-functional requirements are documented and made available for next phase processing.

Requirement Elicitation Techniques

Requirements Elicitation is the process to find out the requirements for an intended software system by communicating with client, end users, system users and others who have a stake in the software system development.

There are various ways to discover requirements

Interviews

Interviews are strong medium to collect requirements. Organization may conduct several types of interviews such as:

- Structured (closed) interviews, where every single information to gather is decided in advance, they follow pattern and matter of discussion firmly.
- Non-structured (open) interviews, where information to gather is not decided in advance, more flexible and less biased.
- Oral interviews
- Written interviews
- One-to-one interviews which are held between two persons across the table.
- Group interviews which are held between groups of participants. They help to uncover any missing requirement as numerous people are involved.

Surveys

Organization may conduct surveys among various stakeholders by querying about their expectation and requirements from the upcoming system.

Questionnaires

A document with pre-defined set of objective questions and respective options is handed over to all stakeholders to answer, which are collected and compiled.

A shortcoming of this technique is, if an option for some issue is not mentioned in the questionnaire, the issue might be left unattended.

Task analysis

Team of engineers and developers may analyze the operation for which the new system is required. If the client already has some software to perform certain operation, it is studied and requirements of proposed system are collected.

Domain Analysis

Every software falls into some domain category. The expert people in the domain can be a great help to analyze general and specific requirements.

Brainstorming

An informal debate is held among various stakeholders and all their inputs are recorded for further requirements analysis.

Prototyping

Prototyping is building user interface without adding detail functionality for user to interpret the features of intended software product. It helps giving better idea of requirements. If there is no software installed at client's end for developer's reference and the client is not aware of its own requirements, the developer creates a prototype based on initially mentioned requirements. The prototype is shown to the client and the feedback is noted. The client feedback serves as an input for requirement gathering.

Observation

Team of experts visit the client's organization or workplace. They observe the actual working of the existing installed systems. They observe the workflow at client's end and how execution problems are dealt. The team itself draws some conclusions which aid to form requirements expected from the software.

Software Requirements Characteristics

Gathering software requirements is the foundation of the entire software development project. Hence they must be clear, correct and well-defined.

A complete Software Requirement Specifications must be:

- Clear
- Correct
- Consistent
- Coherent
- Comprehensible
- Modifiable
- Verifiable
- Prioritized
- Unambiguous
- Traceable
- Credible source

Software Requirements

We should try to understand what sort of requirements may arise in the requirement elicitation phase and what kinds of requirements are expected from the software system.

Broadly software requirements should be categorized in two categories:

Functional Requirements

Requirements, which are related to functional aspect of software fall into this category.

They define functions and functionality within and from the software system.

Examples -

- Search option given to user to search from various invoices.
- User should be able to mail any report to management.
- Users can be divided into groups and groups can be given separate rights.

- Should comply business rules and administrative functions.
- Software is developed keeping downward compatibility intact.

Non-Functional Requirements

Requirements, which are not related to functional aspect of software, fall into this category. They are implicit or expected characteristics of software, which users make assumption of.

Non-functional requirements include -

- Security
- Logging
- Storage
- Configuration
- Performance
- Cost
- Interoperability
- Flexibility
- Disaster recovery
- Accessibility

Requirements are categorized logically as

- **Must Have** : Software cannot be said operational without them.
- **Should have** : Enhancing the functionality of software.
- **Could have** : Software can still properly function with these requirements.
- **Wish list** : These requirements do not map to any objectives of software.

While developing software, 'Must have' must be implemented, 'Should have' is a matter of debate with stakeholders and negation, whereas 'could have' and 'wish list' can be kept for software updates.

User Interface requirements

UI is an important part of any software or hardware or hybrid system. A software is widely accepted if it is -

- easy to operate
- quick in response
- effectively handling operational errors
- providing simple yet consistent user interface

User acceptance majorly depends upon how user can use the software. UI is the only way for users to perceive the system. A well performing software system must also be equipped with attractive, clear, consistent and responsive user interface. Otherwise the functionalities of software system can not be used in convenient way. A system is said be good if it provides means to use it efficiently. User interface requirements are briefly mentioned below -

- Content presentation
- Easy Navigation
- Simple interface
- Responsive
- Consistent UI elements
- Feedback mechanism
- Default settings
- Purposeful layout
- Strategical use of color and texture.
- Provide help information
- User centric approach
- Group based view settings.

Software System Analyst

System analyst in an IT organization is a person, who analyzes the requirement of proposed system and ensures that requirements are conceived and documented properly & correctly. Role of an analyst starts during Software Analysis Phase of SDLC. It is the responsibility of analyst to make sure that the developed software meets the requirements of the client.

System Analysts have the following responsibilities:

- Analyzing and understanding requirements of intended software
- Understanding how the project will contribute in the organization objectives
- Identify sources of requirement
- Validation of requirement
- Develop and implement requirement management plan
- Documentation of business, technical, process and product requirements
- Coordination with clients to prioritize requirements and remove and ambiguity
- Finalizing acceptance criteria with client and other stakeholders

Software Metrics and Measures

Software Measures can be understood as a process of quantifying and symbolizing various attributes and aspects of software.

Software Metrics provide measures for various aspects of software process and software product.

Software measures are fundamental requirement of software engineering. They not only help to control the software development process but also aid to keep quality of ultimate product excellent.

According to Tom DeMarco, a (Software Engineer), "You cannot control what you cannot measure." By his saying, it is very clear how important software measures are.

Let us see some software metrics:

- **Size Metrics -** LOC (Lines of Code), mostly calculated in thousands of delivered source code lines, denoted as KLOC.

  Function Point Count is measure of the functionality provided by the software. Function Point count defines the size of functional aspect of software.

- **Complexity Metrics -** McCabe's Cyclomatic complexity quantifies the upper bound of the number of independent paths in a program, which is perceived as complexity of the program or its modules. It is represented in terms of graph theory concepts by using control flow graph.

- **Quality Metrics -** Defects, their types and causes, consequence, intensity of severity and their implications define the quality of product.

  The number of defects found in development process and number of defects reported by the client after the product is installed or delivered at client-end, define quality of product.

- **Process Metrics -** In various phases of SDLC, the methods and tools used, the company standards and the performance of development are software process metrics.
- **Resource Metrics -** Effort, time and various resources used, represents metrics for resource measurement.

Conclusion

Project management is very often represented on a triangle. A successful project manager needs to keep a balance between the triple constraints so that the quality of the project or outcome is not compromised.

There are many tools and techniques that are available in order to face the challenges related to the three constraints. A good project manager will use appropriate tools in order to execute the project successfully.

A project manager cannot execute his/her job without a proper set of tools. These tools do not have to be renowned software or something, but it can pretty well be simple and proven techniques to manage project work.

Having a solid set of project management tools always makes project managers' work pleasurable and productive.

Format for On-line lectures (Subject Wise)

Name of Institution: Darbhanga College of Engineering

Branch: Civil Engineering

Semester: 8th

Name of subject: Construction Planning and Management

Period allotted as per syllabus: L:T:P- 3:0:3

Name of Teacher: Ahsan Rabbani

Status of availability of syllabus: Yes
(College website/Students WhatsApp Group/University website)

Number of units as per syllabus: 06

Name the website or Online link information Shared with student's group /College website:
https://www.dce-darbhanga.org/faculty/mr-ahsan-rabbani/

Date of up Load-ing	Title of the Unit and Unit number	No. of Period allotted per unit as per time table	Material type (PPT, Class note, NPTEL Link, you Tube, Video If other link-Name)	Assignment/Numerical question/ Quiz uploaded (y/N)	Evaluation pattern (Uploading of answer/ on line evaluation)	Uploading of material on College website/ students WhatsApp group	Mode of on-line classes/ Doubt clearing classes if any (mention the link)
30-03-2020	Construction and fabrication methods (Unit-01)	08	Class Note, https://northgateindustries.com/five-methods-of-prefabricated-construction/ http://www.constructionworld.org/7-benefits-prefabricated-construction/ https://www.slideshare.net/SofiaRajesh/an-introduction-to-prefabricated-structures https://blog.plangrid.com/2019/11/everything-need-know-prefabrication/	Y	Uploading of answers	Y	Through whatsapp group

			https://www.sciencedirect.com/topics/engineering/prefabricated-construction				

Lesson 1

MEANING, NATURE AND IMPORTANCE OF PROJECT

STRUCTURE

1.0 OBJECTIVE

After reading this lesson, you should be able to

a) Define the project and explain the nature and classification of project.

b) Understand the concepts of idea generation, project life cycle and project management.

1.1 INTRODUCTION

Projects have a major role to play in the economic development of a country. Since the introduction of planning in our economy, we have been investing large amount of money in projects related to industry, minerals, power, transportation, irrigation, education etc. with a view to improve the socio-economic conditions of the people. These projects are designed with the aim of efficient management, earning adequate return to provide for future development with their own resources. But experience shows that there are several shortcomings in the ultimate success of achieving the objectives of the proposed project.

1.2 CONCEPT OF PROJECT AND PROJECT MANAGEMENT

The term project has a wider meaning. A project is accomplished by performing a set of activities. For example, construction of a house is a project. The construction of a house consists of many activities like digging of foundation pits, construction of foundation, construction of walls, construction of roof, fixing of doors and windows, fixing of sanitary fitting, wiring etc. Another aspect of project is the non-routine nature of activities. Each project is unique in the sense that the activities of a project are unique and non routine. A project consumes resources. The resources required for completing a project are men, material, money and time. Thus, we can define a project as an organized programme of pre determined group of activities that are non-routine in nature and that must be completed using the available resources within the given time limit.

Let us now consider some definitions of 'project'. Newman et. al define that "a project typically has a distinct mission that it is designed to achieve and a clear termination point the achievement of the mission".

Gillinger defines "project" as the whole complex of activities involved in using resources to gain benefits. Project management institute, USA defined project as "a system involving the co-ordination of a number of separate department entities throughout organization, in a way it must be completed with prescribed schedules and time constraints".

According to the encyclopedia of management, "project is an organized unit dedicated to the attainment of goal, the successful completion of a development project on time, within budget, in conformance with predetermined programme specification."

Though project management is in the process of getting evolved as a separate branch of study, projects are not new to the earth. One of the seven wonders of the world, the pyramids date back to 2650 B.C. which stand as the hall mark of Egyptian civilization. The period of construction of the Taj Mahal, another wonder of the world is reported to be during 1626-1648 A.D. It is reported that about 20,000 persons worked for nearly 22 years to complete this spectacular structure, which stands today as mankind's proudest creation. One can imagine the extent of resources and expertise that would have been put forth for the completion of such magnificent projects.

Project management is an organised venture for managing projects, involves scientific application of modern tools and techniques in planning, financing, implementing, monitoring, controlling and coordinating unique activities or task produce desirable outputs in accordance with the determined objectives with in the constraints of time and cost.

1.3 CHARACTERISTICS OF PROJECT

(1) **Objectives** : A project has a set of objectives or a mission. Once the objectives are achieved the project is treated as completed.

(2) **Life cycle** : A project has a life cycle. The life cycle consists of five stages i.e. conception stage, definition stage, planning & organising stage, implementation stage and commissioning stage.

(3) **Uniqueness** : Every project is unique and no two projects are similar. Setting up a cement plant and construction of a highway are two different projects having unique features.

(4) **Team Work** : Project is a team work and it normally consists of diverse areas. There will be personnel specialized in their respective areas and co-ordination among the diverse areas calls for team work.

(5) **Complexity** : A project is a complex set of activities relating to diverse areas.

(6) **Risk and uncertainty** : Risk and uncertainty go hand in hand with project. A risk-free, it only means that the element is not apparently visible on the surface and it will be hidden underneath.

(7) **Customer specific nature** : A project is always customer specific. It is the customer who decides upon the product to be produced or services to be offered and hence it is the responsibility of any organization to go for projects/services that are suited to customer needs.

(8) **Change** : Changes occur through out the life span of a project as a natural outcome of many environmental factors. The changes may very from minor changes, which may have very little impact on the project, to major changes which may have a big impact or even may change the very nature of the project.

(9) **Optimality** : A project is always aimed at optimum utilization of resources for the overall development of the economy.

(10) **Sub-contracting** : A high level of work in a project is done through contractors. The more the complexity of the project, the more will be the extent of contracting.

(11) **Unity in diversity** : A project is a complex set of thousands of varieties. The varieties are in terms of technology, equipment and materials, machinery and people, work, culture and others.

1.4 PROJECT FAMILY TREE

A project normally originates from a plan, national plan or corporate plan. In normal scheme of things, the family tree for a project would be as given below

Plan = National/Corporate plan with target for growth.

↓

Programme = health programme, educational programme, R&D programme.

↓

Project = Power plant, hospital, housing project etc.

↓

Work Package = Water supply, power supply and distribution package.

↓

Task = Award of water supply contract, construction & foundation.

↓

Activity = Excavation, laying of cable, preparation of drawing.

Fig. 1.1 Project Family Tree

1.5 CLASSIFICATION OF PROJECTS

The location, type, technology, size, scope and speed are normally the factors which determine the effort needed in executing a project. Project can be classified under different heads, some of which are shown in figure 1.2.

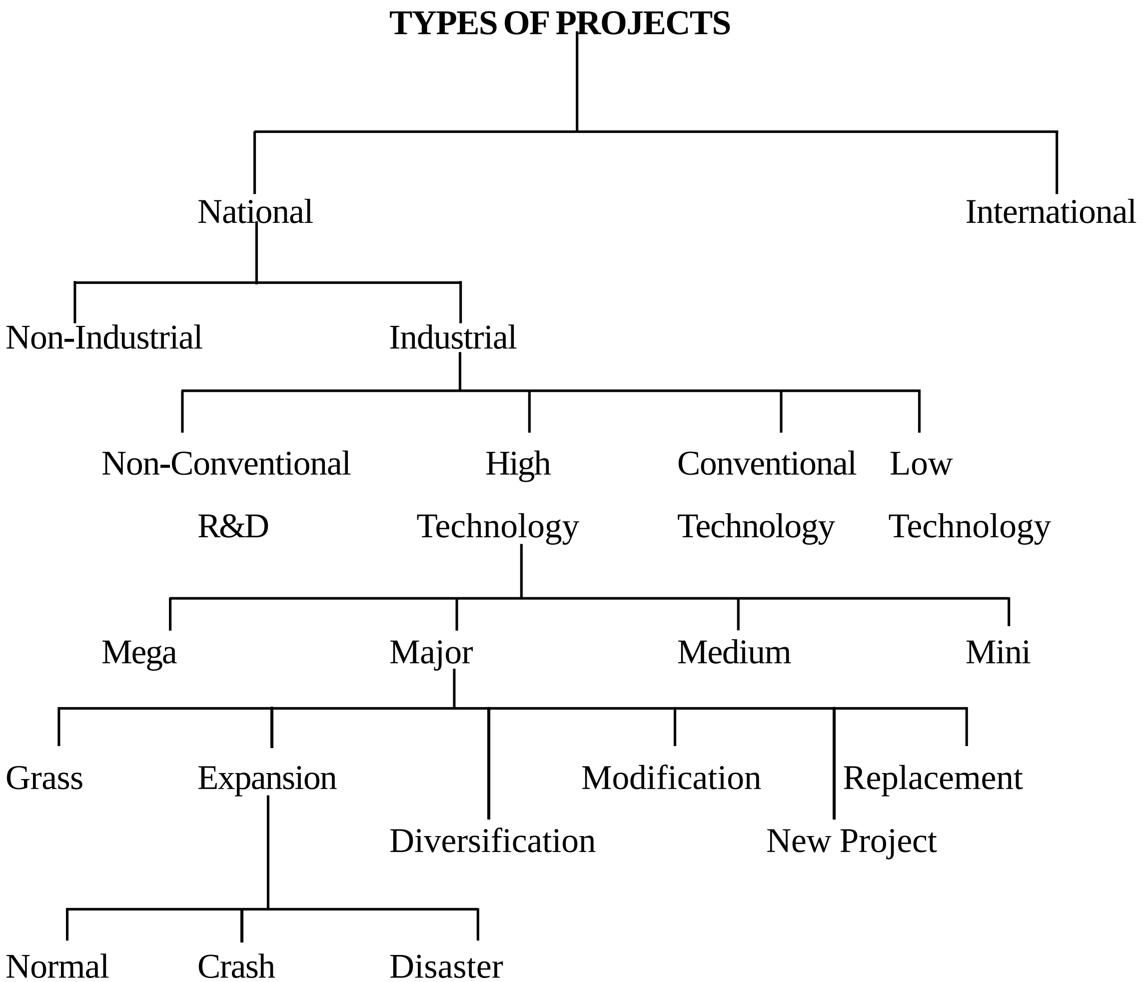


Fig. 1.2 Classification of Project

1.6 PROJECT SELECTION PROCESS

Identification of a new project is a complex problem. Project selection process starts with the generation of project ideas. In order to select the most promising project, the entrepreneur needs to generate a few ideas about the possible project one can undertake. The project ideas as a process of identification of a project begins with an analytical survey of the economy (also known as pre-investment surveys). The surveys and studies will give us ideas. The process of project selection consists of following stages :

- Idea generation
- Environment appraisal.
- Corporate appraisal
- Scouting for project ideas.
- Preliminary screening.
- Project rating index
- Sources of positive Net Present Value.
- Entrepreneur qualities.

Idea Generation :- Project selection process starts with the generation of a project idea. Ideas are based on technological breakthroughs and most of the project ideas are variants of present products or services. To stimulate the flow of ideas, the following are helpful:

SWOT Analysis :- SWOT is an acronym for strengths, weaknesses, opportunities and threats. SWOT analysis represents conscious, deliberate and systematic effort by an organisation to identify opportunities that can be profitably exploited by it. Periodic SWOT analysis facilitates the generation of ideas.

Operational objectives of a firm may be one or more of the following.

- Cost reduction.
- Productivity improvement.
- Increase in capacity utilisation.
- Improvement in contribution margin.

Fostering a conducive climate :- To tap the creativity of people and to harness their entrepreneurial skills, a conducive organisation climate has to be fostered. Two conspicuous examples of organisation which have been exceptionally successful in tapping the creativity of employees are the Bell Telephone Laboratory and the 3M Corporation. While the former has succeeded in harnessing creativity by providing an unconstrained environment, the latter has effectively nurtured the entrepreneurial skills of its employees as sources of idea generation. The project ideas can be generated from various internal and external sources. These are :-

- Knowledge of market, products, and services.
- Knowledge of potential customer choice.
- Emerging trends in demand for particular product.
- Scope for producing substitute product.
- Market survey & research.
- Going through Professional magazines.
- Making visits to trade and exhibitions.
- Government guidelines & policy.
- Ideas given by the experienced person.
- Ideas by own experience.
- SWOT analysis.

Environment appraisal :- An entrepreneur or a firm systematically appraise the environment and assess its competitive abilities. For the purposes of monitoring, the business environment may be divided into six broad sectors as shown in fig. no. 1.3. The key elements of the environment are as follow :

Economic Sector

- State of the economy
- Overall rate of growth

- Cyclical fluctuations
- Inflation rate
- Growth rate of primary, secondary and territory sector
- Growth rate of world economy
- Trade surplus and deficits
- Balance of Payment

Government Sector

- Industrial policy
- Government programmes and projects
- Tax structure
- EXIM policy
- Financing norms
- Subsidies incentives and concessions
- Monetary policy

Technological Sector

- Emergence of new technologies
- Access to technical know-how, foreign as well as indigenous

Socio-demographic Sector

- Population trends
- Age shifts in population
- Income distribution
- Educational profile
- Employment of women
- Attitudes toward consumption and investment

Competition Sector

- Number of firms in the industry and the market share of the top few
- Degree of homogeneity and differentiation among the products
- Entry barrier
- Comparison with substitutes in term of quality and price
- Marketing polices and practices

Supplier Sector

- Availability and cost of raw material
- Availability and cost of energy
- Availability and cost of capital

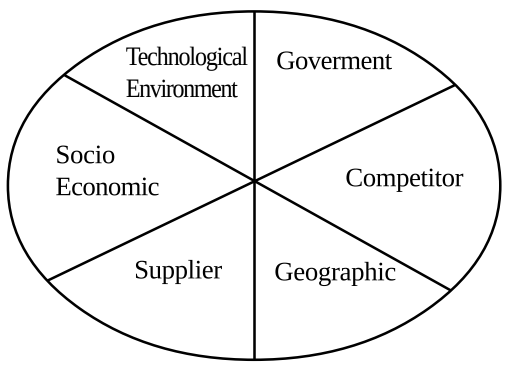


Fig. 1.3 Business Environment

Corporate Appraisal :- A realistic appraisal of corporate strengths and weaknesses is essential for identifying investment opportunities which can be profitably exploited. The broad areas of corporate appraisal and the important aspects to be considered under them are as follow :

Marketing and Distribution

- Market Image
- Product Line

- Product Mix
- Distribution Channels
- Customer loyalty
- Marketing & distribution costs

Production and Operations

- Condition and capacity of plant and machinery
- Availability of raw material and power
- Degree of vertical integration
- Locational advantage
- Cost structure

Research and Development

- Research capabilities of the firm
- Track record of new product developments
- Laboratories and testing facilities
- Coordination between research and operations

Corporate Resources and Personnel

- Corporate image
- Dynamism of top management
- Relation with government and regulatory agencies
- State of industry relations

Finance and Accounting

- **Financial leverage and borrowing capacity**
- Cost of capital
- Tax structure

- Relation with share holders and creditors
- Accounting & control system
- Cash flow and liquidity

1.7 PROJECT LIFE CYCLE

A project is not a one shot activity. Even a shooting star has a time and life span. Project lifecycle is spread over a period of time. There is an unavoidable gestation period for the complex of activities involved to attain the objectives in view. This gestation period, however, varies from project to project but it is possible to describe, in general term, the time phasing of project planning activities common to most projects**.** The principal stages in the life of a project are :

- Identification
- Initial formulation
- Evaluation (selection or rejection)
- Final formulation (or selection)
- Implementation
- Completion and operation

Development projects are expressly designed to solve the varied problems of the economics whether in the short or long run. The surveys or in depth studies would locate the problems and the project planner will have to identify the projects that would solve the problems most effectively. At this stage, we are concerned with the kind of action and type of project that would be required in rather broad term. In other words the surveys and studies will give us ideas and throw up suggestions which would be worked out in detail later and then evaluated objectively before being accepted for implementation.

What types of surveys and studies are to be undertaken? The current socio-political economic situation has to be critically assessed. It will also be necessary to review it in its historical perspective necessitating the undertaking of a survey of the behaviour and growth of the economy during the preceding decades. On the basis of past trends, extrapolation may be made of future possible trends and tendencies, short and long term. There are scientific techniques for doing so which can be broadly grouped as forecasting methodology. It is however not sufficient to view the socio-economic panorama on the historical canvas. More detailed investigations from an operational point of view would be called for in respect of each economic sector.

Initial Formulation :- Identification is only the beginning in the lifecycle of a project. Having identified the prospective projects, the details of each project will have to be worked out and analysed in order to determine which of them could be reckoned as suitable for inclusion in the plan, allocate funds and put into execution. As a follow up to the finding of techno-economic surveys, and number of feasibility study group are set up, as the name implies to examine the possibility of formulating suitable projects and to put concrete proposals in sufficient detail to enable authorities concerned to consider the feasibility of the proposal submitted.

Evaluation or Project Appraisal :- After the socio-economic problems of an economy have been determined and developments objectives and strategies agreed, concrete steps have to be taken. The main form this takes is that of formulating appropriate development projects to achieve plan objectives and meet the development needs of the economy. Proposals relating to them are then put to the plan authorities for consideration and inclusion in the plan. These proposals as pointed out above take the following forms of feasibility studies :

- Commercial viability
- Economic feasibility
- Financial feasibility
- Technical feasibility
- Management

The scope for scrutiny under each of these five heads would necessarily render their careful assessment and the examination of all possible alternative approaches.

The process almost invariably involves making decision relating to technology, scale, location, costs and benefits, time of completion (gestation period), degree of risk and uncertainty, financial viability, organisation and management, availability of inputs, know-how, labour etc. The detailed analysis is set down in what is called a **feasibility report.**

Formulation :- Once a project has been appraised and approved, next step would logically, appear to that of implementation. This is, however, not necessarily true, if the approval is conditional to certain modifications being affected or for other reasons, such as availability of funds, etc. The implementation stage will be reached only after these pre-conditions have been fulfilled. Project formulation divides the process of project development into eight distinct and sequential stages. These stages are

- General information
- Project description
- Market potential
- Capital costs and sources of finance
- Assessment of working capital requirement
- Other financial aspect
- Economic and social variables.

Project Implementation :- Last but not the least, every entrepreneur should draw an implementation time table for his project. The network having been prepared, the project authorities are now ready to embark on the main task of implementation the project. To begin with successful implementation will depend on how well the network has been designed. However, during the course of implementation, many factors arise which cannot be anticipated or adequately taken note of in advance and built into the initial network. A number of network techniques have been developed for project implementation. Some of them are PERT, CPM, Graphical Evaluation and Review Technique (GERT), Workshop Analysis Scheduling Programme (WRSP) and Line of Balance (LOB).

Project Completion :- It is often debated as to the point at which the project life cycle is completed. The cycle is completed only when the development objectives are realized.

1.8 PROJECT REPORT

In simple words project report or business plan is a written statement of what an entrepreneur proposes to take up. It is a kind of course of action what the entrepreneur hopes to achieve in his business and how he is going to achieve it. In other words, project report serves like a road map to reach the destination determined by the entrepreneur.

Contents of Project Report

- General Information
- Promoter
- Location
- Land and Building
- Plant and Machinery
- Production process
- Utilities
- Transport and communication
- Raw material
- Manpower
- Product
- Market

1.9 PROJECT APPRAISAL

Project appraisal means the assessment of a project. Project appraisal is made for both proposed and executed projects. In case of former project appraisal is called ex-ante analysis and in case of letter 'post-ante analysis'. Here, project appraisal is related to a proposed project.

Project appraisal is a cost and benefits analysis of different aspects of proposed project with an objective to adjudge its viability. A project involves employment of scarce resources. An entrepreneur needs to appraise various alternative projects before allocating the scarce resources for the best project. Thus project appraisal helps select the best project among available alternative projects. For appraising a projects its economic, financial, technical market, managerial and social aspect are analysed. Financial institutions carry out project appraisal to assess its creditworthiness before extending finance to a project.

Method of Project Appraisal

Appraisal of a proposed project includes the following analyses :

1 Economic analysis

2 Financial analysis

3 Market analysis

4 Technical analysis

5 Managerial competence

6 Ecological analysis

Economic Analysis :

Under economic analysis the aspects highlighted include

- Requirements for raw material
- Level of capacity utilization
- Anticipated sales
- Anticipated expenses
- Proposed profits
- Estimated demand

It is said that a business should have always a volume of profit clearly in view which will govern other economic variable like sales, purchase, expenses and alike.

Financial Analysis

Finance is one of the most important prerequisites to establish an enterprise. It is finance only that facilitates an entrepreneur to bring together the labour, machines and raw materials to combine them to produce goods. In order to adjudge the financial viability of the project, the following aspects need to be carefully analysed :

- Cost of capital
- Means of finance
- Estimates of sales and production
- Cost of production
- Working capital requirement and its financing
- Estimates of working results
- Break-even point
- Projected cash flow
- Projected balance sheet.

The activity level of an enterprise expressed as capacity utilization needs to be well spelled out. However the enterprise sometimes fails to achieve the targeted level of capacity due to various business vicissitudes like unforeseen shortage of raw material, unexpected disruption in power supply, instability to penetrate the market mechanism etc.

Market Analysis

Before the production actually starts, the entrepreneur needs to anticipate the possible market for the product. He has to anticipate who will be the possible customer for his product and where his product will be sold. This is because production has no value for the producer unless it is sold. In fact, the potential of the market constitutes the determinant of possible reward from entrepreneurial career.

Thus knowing the anticipated market for the product to be produced become an important element in business plan. The commonly used methods to estimate the demand for a product are as follows. :

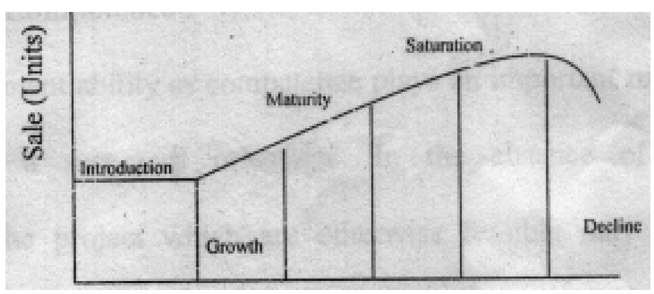
1 Opinion polling method

In this method, the opinion of the ultimate users. This may be attempted with the help of either a complete survey of all customers or by selecting a few consuming units out of the relevant population.

2. Life Cycle Segmentation Analysis

It is well established that like a man, every product has its own life span. In practice, a product sells slowly in the beginning. Barked by sales promotion strategies over period its sales pick up. In the due course of time the peak sale is reached. After that point the sales begins to decline. After sometime, the product loses its demand and dies. This is natural death of a product. Thus, every product passes through its life cycle. The product life cycle has been divided into the following five stage : Introduction, Growth, Maturity, Saturation and Decline.

The sales of the product varies from stage to stage as shown in figure No. 1.4



Time Period

Fig. 1.4 Product Life Cycle

Considering the above five stages of a product life cycle, the sale at different stages can be anticipated.

Technical Analysis

Technical analysis implies the adequacy of the proposed plant and equipment to prescribed norms. It should be ensured whether the required know how is available with the entrepreneur. The following inputs concerned in the project should also be taken into consideration.

- Availability of Land and site
- Availability of Water Power, transport, communication facilities.
- Availability of servicing facilities like machine shop, electric repair shop etc.
- Coping with anti pollution law
- Availability of work force
- Availability of required raw material as per quantity and quality.

Management Competence

Management ability or competence plays an important role in making an enterprise a success. In the absence of Managerial Competence the project which are otherwise feasible may fail. On the contrary, even a poor project may become a successful one with good managerial ability. Hence, while doing project appraisal, the managerial competence or talent of the promoter should be taken into consideration.

Ecological Analysis

In recent years, environmental concerns have assumed great deal of significance. Ecological analysis should also be done particularly for major projects which have significant implication like power plant and irrigation schemes, and environmental pollution industries like bulk-drugs, chemical and leather processing. The key factors considered for ecological analysis are :

- Environmental damage
- Restoration measure

1.10 TOOLS AND TECHNIQUES FOR PROJECT MANAGEMENT

There are several tools and techniques which would contribute significantly towards effective project management these can be broadly grouped under the following heads :

1. **Project selection techniques**

   (a) Cost benefit analysis and

   (b) Risk and sensitivity analysis

2. **Project execution planning techniques**

   (a) Work breakdown structure (WBS)

   (b) project execution plan (PEP)

   (c) Project responsibility matrix and

   (d) Project management manual

3. **Project scheduling and coordinating techniques**

   (a) Bar charts

   (b) Life cycle curves

   (c) Line of balance (LOB) and

   (d) Networking techniques (PERT/CPM)

4. **Project monitoring and progressing techniques**

   (a) Progress measurement technique (PROMPT)

   (b) Performance monitoring technique (PERMIT) and

   (c) Updating, reviewing and reporting technique (URT)

5. **Project cost and productivity control techniques**

   (a) Productivity budgeting techniques

   (b) Value engineering (VE) and

   (c) COST/WBS

6. **Project communication and clean-up techniques**

(a) Control room and

(b) Computerised information systems

1.11 THE PROJECT MANAGER'S ROLES & RESPONSIBILITIES

As things stand today, non of the present generation project manager, including the very successful ones, come from any of our management schools. They were just given the job-some succeeded and others did not. Those who succeeded are not many, because only a handful of projects in India were ever completed on time, within budget and performed to expectations. While the failures of these projects had been analysed in many seminars and workshops, the role of project managers and their development did not form the subject of any serious discussion. There could be two reasons for this: (a) Perhaps no one thinks that success or failure of a project depends on the project manager; and (b) It may also be that no one considers them as a special breed of managers. Surprisingly, even some of the practising project managers themselves subscribe to these views. The basic roles and responsibilities of a project manager that we are referring to could be grouped under twelve heads :

1 Defining and maintaining the integrity of a project;

2 Development of project execution plan;

3 Organization for execution of the plan;

4 Setting of targets and development of systems and procedures for accomplishment of project objectives and targets;

5 Negotiation for commitments;

6 Direction, coordination and control of project activities;

7 Contract management;

8 Non-human resource management including fiscal matters;

9 Problem-solving;

10 Man management;

11 Satisfaction of customer, Government and the public; and

12 Achievement of project objectives, cash surplus and higher productivity.

1.12 SUMMARY

A project is an organized programme of pre-determined group of activities that are non-routine in nature and that must be completed using the available resources within the given time limit. Project management is an organized venture for managing projects. The location, type, technology, size, scope and speed are normally the factors which determine the effort needed in executing a project. Project can be classified under different heads. The project ideas as a process of identification of a project begins with an analytical survey of the economy. Project life cycle is spread over a period of time. Project report is a kind of course of action what the entrepreneur hopes to achieve in his business and how he is going to achieve it. Project appraisal is made for both proposed and executed projects. For appraising a project, its economic, financial, technical, market and social aspect are analysed. There are several tools and techniques which contribute significantly towards effective project management.

1.13 KEYWORDS

Project: Project is the whole complex of activities involved in using resources to gain benefits.

SWOT Analysis: SWOT analysis represents conscious, deliberate and systematic efforts by an organisation to identify opportunities that can be profitably exploited by it.

Project Report: It is a written statement of what on entrepreneur proposes to take up.

Project Appraisal: Project appraisal means the assessment of a project.

1.14 SELF ASSESSMENT QUESTIONS

1. Define Project Management and outline its features clearly.
2. Discuss the process of generating and screening the project ideas.

3. What can a firm do to stimulate the flow of Project Ideas?
4. Discuss the concept of project life cycle.
5. What factors influence the project ideas?. Discuss their implications.
6. Define the term 'Project'. How will you classify the projects ?
7. What do you understand by project identification? Discuss, with examples, the process involved in project identification.
8. How would you use SWOT analysis to identify and select a project for SSI?
9. How are projects classified ? In your view which criterion seems to be more rational and acceptable for classification of a project?

1.15 SUGGESTED READINGS

1. Prasana Chandra: Projects-Planning Analysis, Selection, Implementation & Review, Tata McGraw Hill, New Delhi.
2. Prasana Chandra : Financial Management, Tata McGraw Hill, New Delhi.
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Lesson - 2

CAPITAL EXPENDITURE DECISION

STRUCTURE

2.0 OBJECTIVE

This lesson is designed to describe

a) meaning, nature and importance of capital expenditure decisions; and

b) criteria of capital expenditure decisions.

2.1 INTRODUCTION

The efficient allocation of funds is among the main functions of financial management. Allocation of funds means investment of funds in assets or activities. It is also called investment decision because we have to select the assests in which investment has to be made. These assets can be classified into two parts :-

i) Short-term or Current Assets.

ii) Long-term or Fixed Assets.

2.2 MEANING AND FEATURES OF CAPITAL EXPENDITURE OR BUDGETING DECISIONS

A capital budgeting decisions may be defined as the firm's decision to invest its current funds most efficiently in the long-term assets in anticipation of an expected flow of benefits over a series of years. In other words, "capital budgeting is used to evaluate the expenditure decisions such as acquisition of fixed assets, changes in old assets and their replacement." Activities such as change in the method of sales distribution or undertaking an advertisement campaign or a research and development programme have long-term implication for the firm's expenditure and benefits and therefore, they may also be evaluated as investment decisions.

Features of Capital Budgeting Decisions

Following are the features of investment decisions

- Investment of fund is made in long-term assets.
- The exchange of current funds for future benefits.
- Future profits accrue to the firm over several years.
- These decisions are more risky.

It is significant to emphasise that expenditure and benefits of an investment should be measured in cash. In the investment analysis, it is cash flow which is important, not the accounting profit. It may also be pointed out that investment decisions affect the firm's value. The firm's value will increase if investment are profitable. Investment should be evaluated on the basis of a criteria on which it is compatible with the objective of the shareholder's wealth maximisation. An investment will add to the shareholder's wealth if it yields benefits in excess of the minimum benefits as per the opportunity cost of capital.

2.3 IMPORTANCE OF CAPITAL EXPENDITURE DECISION

Investment decisions require special attention because of the following reasons :

1. **Growth :-** The effects of investment decisions extend into the future and have to endured for a longer period than the consequences of the current operating expenditure. A firm's decisions to invest in long-term assets has a decisive influence on the rate direction of its growth. A wrong decisions can prove disastrous for the continued survival of the firm.

2. **Risk :-** A long-term commitment of funds may also change the risk complexity of the firm. If the adoption of an investment increases average gain but causes frequent fluctuations in its earnings, the firm will become very risky.

3. **Funding :-** Investment decisions generally involve large amount of funds. Funds are scarce resource in our country. Hence the capital budgeting decision is very important.

4. **Irreversibility :-** Most investment decisions are irreversible

5. **Complexity :-** Investment decisions are among the firm's most difficult decisions. They are concerned with assessment of future events which are difficult to predict. It is really a complex problem to correctly estimate the future cash flow of investment.

Objectives of Capital Budgeting Decision

Capital budgeting helps in selection of profitable projects. A company should have system for estimating cash flow of projects. A multidisciplinary team of managers should be assigned the task of developing cash flow estimates. Once cash flow have been estimated, projects should be evaluated to determine their profitability. Evaluations criteria chosen should correctly rank the projects. Once the projects have been selected they should be monitored and controlled. Proper authority should exist for capital spending. Critical projects involving large sum of money may be supervised by the top management. A company should have a sound capital budgeting and reporting system for this purpose. Based on the comparison of actual and expected performance, projects should be reappraised and remedial action should be taken.

2.4 KINDS OF CAPITAL EXPENDITURE DECISIONS

Capital expenditure decisions are of following types :

Expansion and diversification

A company may add capacity to its existing product lines to expand existing operations. For example, a fertilizer company may increase its plant capacity to manufacture in more areas. Diversification of a existing business require investment in new product and a new kind of production activity within the firm. Investment in existing or new products may also be called as revenue-expansion investment.

Replacement and modernisation

The main objective of modernisation and replacement is to improve operating efficiency and reduce costs. Assets become out dated and obsolete as a result of technological changes . The firm must decide to replace those assets with new assets that operate more economically. If a cement company change from semi-automatic drying equipment to fully automatic drying equipment to fully automatic drying equipment, it is an example of modernisation and replacement. Yet an other useful way to classify investment is as follow :

- Mutually exclusive investments
- Independent investments
- Contingent investments

Mutually exclusive investment

Mutually exclusive investment serve the same purpose and compete with each other. If one investment is selected other will have to be rejected. A company may, for example, either use more labour-intensive, semi-automatic machine or employ a more capital intensive, highly machine for production.

Independent Investment

Independent investment serve different purposes and do not compete with each other. For example a heavy engineering company may be considering expansion of its plant capacity to manufacture additional excavators and adding new production facilities to manufacture a new product - Light commercial vehicles. Depending on their profitability and availability of funds, the company can undertake both investment.

Contingent Investment

Contingent investment are dependent projects. The choice of one investment necessitates under taking one or more other investments. For example, if a company decided to build a factory in a remote backward area, it may have to invest in houses, road, hospitals, schools etc. The total expenditure will be treated as one single investment.

2.5 CAPITAL BUDGETING PROCESS

Capital budgeting is a complex process which may be divided into five broad phases. These are :-

- Planning
- Analysis
- Selection
- Implementation
- Review

Planning

The planning phase of a firm's capital budgeting process is concerned with the articulation of its broad strategy and the generation and preliminary screening of project proposals. This provides the framework which shapes, guides and circumscribes the identification of individual project opportunities.

Analysis

The focus of this phase of capital budgeting is on gathering, preparing and summarising relevant information about various project proposals which are being considered for inclusion in the capital budget. Under this a detail analysis of the marketing, technical, economic and ecological aspects in undertaken.

Selection

Project would be selected in the order in which they are ranked and cut off point would be reached when the cumulative total cost of the projects become equal to the size of the plan funds. A wide range of appraisal criteria have been suggested for selection of a project. They are divided into two categories viz, non-discounting criteria and discounting criteria.

2.6 CRITERIA OF CAPITAL BUDGETING

There are two broad criteria of capital budgeting :

1. **Non discounting criteria**

   The method of capital budgeting are the techniques which are used to make comparative evaluation of profitability of investment.

   The non-discounting methods of capital are as follows :

   - Pay back period method (PBP)
   - Accounting rate of return method (ARR)

2. **Discounting Criteria**

   - Net present value method (NPV)
   - Internal rate of return method (IRR)
   - profitability index method (PVI)

Non-discounting criteria

Pay back period method : Under this method the pay back period of each project investment proposal is calculated. The investment proposal which has the least pay back period is considered profitable. Actual pay back is compared with the standard one if actual pay back period is less than the standard the project will be accepted and in case, actual payback period is more than the standard payback period, the project will be rejected. So, pay back period is the number of years required for the original investment to be recouped.

For example, if the investment required for a project is Rs. 20,000 and it is likely to generate cash flow of Rs. 10,000 for 5 years. Pay back Period will be 2 years. It means that investment will be recovered in first 2 years of the project. Method of calculating payback period is

$$PB = \frac{\text{Investment}}{\text{Annual Cash in Flow}}$$

Accounting Rate of Return : This method is also called average rate of return method. This method is based on accounting information rather than cash flows. It can be calculated as -

$$ARR = \frac{\text{Average annual profit after taxes}}{\text{Average Investment}} \times 100$$

$$\frac{\text{Total of after but profit it of all the years}}{\text{Number of years}}$$

$$\text{Average Investment} = \frac{\text{Original Investment + Salvage value}}{2}$$

Discounted Criteria

Under these methods the projected future cash flows are discounted by a certain rate called cost of capital. The second main feature of these methods is that they take into account all the benefits and costs accruing during the life time of the project. Discounted cash flow method are briefly described as follow :-

Net Present Value Method (NPV) : In this method present value of cash flow is calculated for which cash flows are discounted. The rate of discount is called cost of capital and is equal to the minimum rate of return which must accrue from the project. NPV is the difference between present value of cash inflows and present value of cash outflows. NPV can be calculated as under :-

$$NPV = \frac{CF_1}{(1+K)^1} + \frac{CF_2}{(1+K)^2} + \frac{CF_3}{(1+K)^3} + \ldots\ldots + \frac{CF_n}{(1+K)^n} - C$$

$$\sum_{t=1}^{n} = \frac{CF_1}{(1+K)^1} - C \qquad \text{OR}$$

Where Cf1, Cf2.. represent cash inflows, k is the firm's cost of capital, C is cost outlay of the investment proposal and n, is the expected life of the proposal. If the project has salvage value also it should be added in the cash inflow of the last year. Similarly, if some working capital is also needed it will be added to the initial cost of the project and to the cash flow's of the last year. If the NPV of a project is more than zero, the project should be accepted and if NPV is less than zero it should be rejected. When NPV of two more projects under consideration is more than zero, the project whose NPV is the highest should be accepted.

Internal rate of return method (IRR) : Under this method initial cost and annual cash inflows are given. The unknown rate of return is ascertained. In other words "The internal rate of return is that rate which equates the present value of cash inflows with the present value of cash outflows of an investment project." At the internal rate of return NPV of a project is zero. Like NPV method IRR method also considers time value of money. In IRR method, the discount rate (r) depends upon initial investment expenditure and the future cash inflows. IRR is calculated as follows :

$$C = \frac{A_1}{(1+r)^1} + \frac{A_2}{(1+r)^2} + \frac{A_3}{(1+r)^3} + \ldots\ldots + \frac{A_n}{(1+r)^n}$$

C = initial cash outflow

n = number of years

r = rate of return which is to be calculated.

$A_1\ A_2\ A_3$............................ A_n are cash inflows in various years.

Profitability index/ Benefit-cost ratio : It is the ratio of value of future cash benefits discounted at some required rate of return to the initial cash outflows of the investment PI method should be adopted when the initial costs of projects are different. NPV method is considered good when the initial cost of different projects is the same. PI can be calculated as under :-

$$PI = \frac{\text{Present value of Cash inflows}}{\text{Present value of Cash outflows}}$$

If PI>1 the project will be accepted. If PI<1 the project will be rejected. When PI>1, NPV will be positive, when PI<1 NPV will be negative. In case, more than one project have PI>1 then the project whose PI is the highest will be given first preference and the project with minimum PI will be given last preference.

Implementation

Every entrepreneur should draw an implementation scheme or a time table for his project to ensure the timely completion of all activities involved in setting upon enterprise. Timely implementation is important because if there is delay it causes, among other things, a project cost overrun. In India delay in project implementation has become a common feature. Implementation phase for an industrial project, which involves settings up of manufacturing facilities, consists of several stages. These are :-

- Project and engineering design
- Negotiation and contracting
- Construction
- Training
- Plant and commissioning

Translating an investment proposal into a concrete projects is a complex, time consuming and risky task. Delays in implementation, which are common can lead to substantial cost overruns. For expeditious implementation at a reasonable cost, the following are useful :

- Adequate formulation projects
- Use of the principle of responsibility accounting
- Use of network techniques

Hence, there is a need to draw up an implementation schedule for the project and then to adhere. Following is a simplified implementation schedule for a small project.

An illustrative implementation schedule

Task/months	1	2	3	4	5	6	7	8	9	10	11	12
1. Formulation of project report												
2. Application for term loan												
3. Term loan sanction												
4. Possession of land												
5. Construction of building												
6. Getting power and water												
7. Placing order for machinery												
8. Receipt and installation of machinery												
9. Man power recruitment												
10. Trail production												
11. Commencement of Production												

The above schedule can be broken up into scores of specific tasks involved in setting up the enterprise. Project evaluation and review technique (PERT) and critical path method (CPM) can also be used to get better in sight into all activities related to implementation of the project.

Review

Once the project is commissioned, the review phase has to be set in motion. Performance review should be dome periodically compare actual performance with projected performance. A feedback device is useful in several ways.

- ➢ It throws light on how realistic were the assumption underlying the project.
- ➢ It provides a documented log of experience that is highly valuable in future decision
- ➢ It suggests corrective action to be taken in the light of actual performance. It helps in uncovering judgmental basis.

2.7 RESOURCE ALLOCATION FRAMEWORK

The resource allocation framework of the firm, which shapes, guides, and circumscribes individual project decisions, addresses two key issues : What should be the strategic posture of the firm ? What pattern of resource allocation sub serves the chosen strategic posture ?. It is divided into following section :

- ✶ Key criteria
- ✶ Elementary investment strategies
- ✶ Portfolio planning tools
- ✶ Strategic position and action evaluation

2.7.1 Key criteria

The objective of maximising the wealth of shareholders is reflected, at the operational level, in three key criteria : profitability, risk, and growth.

1. **Profitability :** Profitability reflects the relationship between profit and investment. While there are numerous ways of measuring profitability, return on equity is one of the most widely used method. It is defined as :

$$\text{Profitability} = \frac{\text{Profit after tax}}{\text{Net Worth}}$$

2. **Risk :-** It reflects variability. How much do individual outcomes deviate from the expected value ? A simple measure of variability is the range of possible outcomes, which is simply the difference between the highest and net outcomes.

3. **Growth :-** This is manifested in the increase of revenue, assets, net worth, profits, dividends, and so on. To reflect the growth of a variable, the measure commonly employed is the compound rate of growth.

2.7.2 Elementary Investment Strategies

The building blocks of the corporate resource allocation strategy are the following elementary investment strategies :

- ✶ Replacement and modernisation
- ✶ Capacity expansion
- ✶ Vertical integration
- ✶ Concentric diversification
- ✶ Conglomerate diversification
- ✶ Divestment

Replacement and Modernisation

It means to maintain the production capacity of the firm, improve quality, and reduce costs. Without such investments, which are undertaken more or less routinely by well-managed firms, the competitive strength of the firm in its existing line of business can be significantly impaired.

Capacity Expansion

When a company anticipates growth in the market size of its product range or increase in the market share enjoyed by it in its product range, expansion of the capacity of the existing product range would have great appeal. Such an expansion offers several advantages : familiarity with technology, production methods and market conditions, lower capital costs due to the existence of surplus capacity in certain sections of the factory, reduction in unit overhead costs because of larger volume or production.

Vertical Integration

Vertical integration may be of two types : backward integration and forward integration. Backward integration involves manufacture of raw materials and components required for the existing operations of the company. For example, Reliance Industries Limited set up a unit for the manufacture of polyester filament yarn required for its textile units. Forward integration involves the manufacture of products which use the existing products of the company as input. For example, Bharat Forge Company set up a automotive axles unit which uses its forgings as input.

Concentric Diversification

Many companies seek to widen their product range by adding related products. For example, a soap manufacturer may enter the field of detergents; a scooter producer may add motorcycles to its product line; a truck manufacturer may go for passenger cars.

Conglomerate Diversification

Conglomerate diversification involves investment in fields unrelated to the existing line of business. For example, when an engineering company like Larsen and Toubro invests in shipping it is a case of conglomerate diversification.

Divestment

Divestment is the opposite of investment. It involves termination or liquidation of the plant or even a division of a firm. The disposal of the Chembur plant of Union Carbide to Oswal Agro is an example of divestment.

2.7.3 Portfolio Planning Tools

To guide the process of strategic planning and resource allocation, several portfolio planning tools have been developed. Two such tools highly relevant in this context are :

BCG Product Portfolio Matrix

General Electric's Stoplight Matrix

BCG Product Matrix

A tool for strategic (product) planning and resource allocation, the Boston Consulting Group (BCG) product portfolio matrix analyses products on the basis of (a) relative market share and (b) industry growth rate. The BCG matrix, shown in Exhibit 2.1, classifies products into four broad categories as follows :

BCG Product Portfolio Matrix

Relative Market Share

Industry Growth Rate

	High	Low
High	Stars	Question marks
Low	Cash cows	Dogs

Fig (2.1) BCG Product Portfolio Matrix

- ✶ **Stars** Product which enjoy a high, market share and a high growth rate are referred to as stars.
- ✶ **Question marks** Products with high growth potential but low present market share are called question marks.
- ✶ **Cash Cows** Products which enjoy a relatively high market share but low growth potential are called cash cows.
- ✶ **Dogs** Products with low markets share and limited growth potential are referred to as dogs.

From the above description, it is broadly clear that cash cows generate funds and dogs, if divested, release funds. On the other hand, stars and question marks require further commitment of funds.

General Electric's Stoplight Matrix

The General Electric Company of US is widely respected for the sophistication maturity, and quality of its planning systems. The matrix developed by his company for guiding resource allocation is called the General Electric's Stoplight Matrix. It calls for analyzing various products of the firm in terms of two key issues.

* **Business Strength** How strong is the firm vis-a-vis its competitors ?
* **Industry attractiveness :-** What is the attractiveness or potential of the industry.

Industry Attractiveness	Business Strength: Strong	Average	Weak
High	Invest	Invest	Invest
Medium	Invest	Hold	Divest
Low	Hold	Divest	Divest

Fig. No. 2.2 General Electric's Stoplight Matrix

2.7.4 Strategic Position and Action Evaluation (Space)

SPACE is an approach to hammer out an appropriate strategic posture for a firm arid its individual business. An extension of the two-dimensional portfolio analysis, SPACE involves a consideration of four dimensions :

* Company's competitive advantage.
* Company's financial strength.
* Industry strength.
* Environmental stability

2.8 CAPITAL BUDGETING DIFFICULTIES

While capital expenditure decisions are extremely important they also pose difficulties which stem from three principal sources :

✶ **Measurement problems :-** Identifying and measuring the costs and benefits of a capital expenditure proposal tends to be difficult. This is more so when a capital expenditure has a bearing on some other activities of the firm (like cutting into the sales of some existing product) or has some intangible consequences (like improving the morale of workers).

✶ **Uncertainty :-** A capital expenditure decision involves costs and benefits that extend far into future. It is impossible to predict exactly what will happen in future. Hence, there is usually a great deal of uncertainty characterizing the cost and benefits of a capital expenditure decision.

✶ **Temporal spread :-**The costs and benefits associated with a capital expenditure decision are spread out over a long period of time, usually 10-20 years for industrial projects and 20-50 years for infrastructure projects.

Such a temporal spread creates some problems in estimating discount rates and establishing equivalence.

2.9 SUMMARY

NPV, IRR and PI are the discounted cash flow (DCF) criteria for appraising the worth of an investment project. The net present value (NPV) method is a process of calculating the present value of the projects cash flows, using the opportunity cost of capital as the discount rate, and finding out the net present value by subtracting the initial investment from the present value of cash flows. Under the NPV method, the investment project is accepted if its net present value is positive (NPV > 0). The market value of the firms share is expected to increase by the project positive NPV. Between the mutually exclusive projects, the one with the highest NPV will be chosen.

The internal rate of return (IRR) is the discount rate at which the projected net present value is zero. Under the IRR rule, the project value will be accepted when its internal rate of return is higher than the opportunity cost of capital (IRR>k). Both IRR and NPV methods account for the time value of money and are generally consistent with the wealth maximization objective.

However, under a number of situations, the IRR rule can give a misleading signal for mutually exclusive projects. The IRR rule also yields multiple rates of return for non conventional projects and fails to work under varying cost of capital conditions. Since the IRR violates the values-activity principal it may fail to maximize wealth under certain conditions, and since it is cumbersome, the use of the NPV rule of recommended.

Profitability index (PI) is the ratio of the present value of cash inflows to initial cash outlay. It is variation of the NPV rule. PI specifies that the project should be accepted when it has a profitability index greater than one (PI>1.0) since this implies a positive NPV. A conflict of ranking can arise between the NPV are IRR rules in case of mutually exclusive projects. Under such a situation, the NPV rule should be preferred since it is consistent with the wealth maximization principle.

In practice, two other methods have found favour with the business executives. They are the pay back (PB) and accounting rate of return (ARR) methods. PB is the number of years required to recoup the initial cash outlay of an investment project. The project would be accepted if its payback is less than the standard payback. The greatest limitation of this method are that it does not consider the time value of money, and does not consider cash flows after the payback period.

2.10 KEYWORDS

Capital Budgeting: It is the firm's decision to invest its current resources most efficiently in the long-term assets in anticipation of an expected flow of benefits over a series of years.

Net Present Value: It is the difference between present value of cash inflows and present value of cash out flows.

Internal Rate of Return: internal rate of return is that rate of return which equates the present value of cash flows with the present value of cash outflows.

Profitability Index Ratio: It is the ratio of value of future cash benefits discounted at some required rate of return to the initial cash outflows of the investment.

Profitability: It reflects the relationship between profits and investment.

Divestment: Divestment involves termination or liquidation of the plant or even a division of a firm.

2.11 SELF ASSESSMENT QUESTIONS

1. What is capital expenditure ? Explain its needs and significance.

2. Explain briefly the method of evaluating investment project.

3. What is capital budgeting ? Explain its significance. What are the various kind of capital budgeting decisions ?

4. Why are the capital expenditure often the most important decisions taken by a firm?

5. Discuss the various phases of capital expenditure projects.

6. Write short notes on

(i) Net present value

(ii) Internal rate of return

(iii) Average rate of return

(iv) Mutually exclusive projects

7. The following are the net cash flows of an investment project :

Cash flows (Rs.)	t_0	t_1	t_2
	-5000	**+3000**	**4000**

Calculate the net present value of the project at discount rates of 10, 20, 30 and 35 percent

2.12 SUGGESTED READINGS

1. I. M. Pandey : Financial Management, Vikas Publication Ed. 8
2. Prasanna Chandra : Financial Management, Tata McGraw Hill, New Delhi Ed. 2004.
3. Prasanna Chandra : Projects, Planning Analysis, Selection.
4. Van Horne, Wachowicz : Fundamental of Financial Management, PH I New Delhi, Ed. 10.

LESSON: 3

MARKET AND DEMAND ANALYSIS

STRUCTURE

3.0 Objectives

After reading this lesson, you should be able to

a) Discuss the type of information required for market and demand analysis.

b) Explain the various sources of secondary information.

c) Describe the procedure of conducting market survey.

d) Explain the different methods of demand forecasting.

e) Deal with uncertainties in demand forecasting.

3.1 INTRODUCTION

The exercise of project appraisal often begins with an estimation of the size of the market. Before a detailed study of a project is undertaken, it is necessary to know, at least roughly, the size of the market because the viability of the project depends critically on whether the anticipated level of sales exceeds a certain volume. Many a project has been abandoned because preliminary appraisal revealed a market of inadequate size. This chapter is divided into the following five sections dealing with various aspects of market and demand analysis.

1. Information required for market and demand analysis
2. Secondary sources of information
3. Market survey
4. Demand forecasting
5. Uncertainties in demand forecasting

3.2 INFORMATION REQUIRED FOR MARKET AND DEMAND ANALYSIS

The principal types of information required for market and demand analysis relate to-

(i) Effective demand in the past and present

To guage the effective demand in the past and present, the starting point typically is apparent consumption which is defined as-

Production + Imports – exports – changes in stock level

In a competitive market, effective demand and apparent consumption are equal. However, in most of the developing countries, where competitive markets do not exist for a variety of products due to exchange restrictions and controls on production and distribution, the figure of apparent consumption may have to be adjusted for market imperfections. Admittedly, this is often a difficult task.

(ii) Breakdown of demand

To get a deeper insight into the nature of demand, the aggregate (total) market demand may be broken down into demand for different segments of the market. Market segments may be defined by (i) nature of product, (ii) consumer group, and (iii) geographical division.

Nature of product— One generic name often subsumes many different products: steel covers sections, rolled products, and various semi-finished products; commercial vehicles cover trucks and buses of various capacities etc.

Consumer groups— Consumers of a product may be divided into industrial consumers and domestic consumers. Industrial consumers may be sub-divided industry-wise. Domestic consumers may be further divided into different income groups.

Geographical division— A geographical breakdown of consumers, particularly for products which have a small value-to-weight relationship and products which require regular, efficient after-sales service is helpful.

(iii) Price

Price statistics must be gathered along with statistics pertaining to physical quantities. It may be helpful to distinguish the following types of prices: (i) manufacturer's price quoted as FOB (free on board) price or CIF (cost, insurance, and freight) price, (ii) landed price for imported goods, (iii) average wholesale price, and (iv) average retail price.

(iv) Methods of distribution and sales promotion

The method of distribution may vary with the nature of product. Capital goods, industrial raw materials or intermediates, and consumer products tend to have differing distribution channels. Further, for a given product, distribution methods may vary. Likewise, methods used for sales promotion (advertising, discounts, gift schemes, etc.) may vary from product to product.

The methods of distribution and sales promotion employed presently and their rationale must be studied carefully. Such a study may explain certain patterns of consumption and highlight the difficulties that may be encountered in marketing the proposed products.

(v) Consumers

Two categories of information about the consumers may be required: demographic and sociological information, and attitudinal information. Under the first category, information on the following is required: age, sex, income, avocation, residence, religion, customs, beliefs, and social background. Under the second category, information on the following is required- preferences, intentions, attitudes, habits, and responses.

(vi) Governmental policy

The role of government in influencing the demand and market for a product may be significant. Governmental plans, policies, legislations, and fiats which have a bearing on the market and demand of the product under examination should be studied. These are reflected in: production targets in national plans, import and export trade controls, import duties, export incentives, excise duties, sales tax, industrial licensing, preferential purchases, credit controls, financial regulations, and subsidies/penalties of various kinds.

(vii) Supply and competition

It is necessary to know the existing sources of supply and whether they are foreign or domestic. For domestic sources of supply information along the following lines may be gathered: location, present production capacity, planned expansion, capacity utilization level, bottlenecks in production, and cost structure.

Competition from substitutes and near-substitutes should be examined because almost any good may be replaced by some other good as a result of changes in relative prices, quality, availability, promotional strategies, consumer taste, and other factors.

3.3 SECONDARY SOURCES OF INFORMATION

The information required for demand and market analysis is usually obtained partly from secondary sources and partly through a market survey. In marketing research, a distinction is usually made between primary information and secondary information. Primary information refers to information which is collected for the first time to meet the specific purpose on hand; secondary information, in contrast, is information which is in existence and which has been gathered in some other context. Secondary information provides the base and the starting point for market and demand analysis. It indicates what is known and often provides leads and cues for further investigation.

General secondary sources of information

The important sources of secondary information useful for market and demand analysis in India are mentioned below-

Census of India— A decennial publication of the Government of India, it provides information on population, demographic characteristics, household size and composition, and maps.

National sample survey reports— Issued from time to time by the Cabinet Secretariat, Government of India, these reports present information on various economic and social aspects like patterns of consumption, distribution of households by the size of consumer expenditure, distribution of industries, and characteristics of the economically active population. The information presented in these reports is obtained from a nationally representative sample by the interview method.

Plan reports— Issued by the Planning Commission usually at the beginning, middle, and end of the five-year plans, these reports and documents provide a wealth of information on plan proposals, physical and financial targets, actual outlays, accomplishments, etc.

Statistical abstract of the Indian Union— An annual publication of the Central Statistical Organisation, it provides, *inter alia*, demographic information, estimates of national income, and agricultural and industrial statistics.

India Year Book— An annual publication of the Ministry of Information and Broadcasting, it provides wide ranging information on economic and other aspects.

Other publications— Among other publications mention may be made of the following: (i) Weekly Bulletin of Industrial Licences, Import Licences and Export Licences (published by the Government of India); (ii) studies of the economic division of the State Trading Corporation; (iii) commodity reports and other studies of the Indian institute of Foreign Trade; (iv) studies and reports of export promotion councils and commodity boards; and (v) Annual report on Currency and Finance (issued by Reserve Bank of India).

Evaluation of secondary information

While secondary information is available economically and readily (provided the market analyst is able to locate it) its reliability, accuracy, and relevance for the purpose under consideration must be carefully examined. The market analyst should seek to know (i) Who gathered the information? What was the objective? (ii) When was information gathered? When was it published? (iii) How representative was the period for which information was gathered? (iv) Have the terms in the study been carefully and unambiguously gathered? (v) What was the target population? (vi) How was the sample chosen? (vii) How representative was the sample? (viii) How satisfactory was the process of information gathering? (ix) What was the degree of sampling bias and non-response bias in the information gathered? (x) What was the degree of misrepresentation by respondents? (xi) How properly was the information by respondents? (xii) Was statistical analysis properly applied?

3.4 MARKET SURVEY

Secondary information, though useful, often does not provide a comprehensive basis for demand and market analysis. It needs to be supplemented with primary information gathered through a market survey, specific for the project being appraised.

The market survey may be a census survey or a sample survey. In a census survey the entire population is covered. (The word 'population' is used here in a particular sense. It refers to the totality of all units under consideration in a specific study. Examples are- all industries using milling machines, all readers of the *Economic Times*). Census surveys are employed principally for intermediate goods and investment goods when such goods are used by a small number of firms. In other cases, a census survey is prohibitively costly and may also be infeasible. For example, it would be inordinately expensive to cover every user of Lifebuoy or every person in the income bracket Rs. 10,000-Rs. 15,000.

Due to the above mentioned limitations of the census survey, the market survey, in practice, is typically a sample survey. In such a survey a sample of the population is contacted/observed and relevant information is gathered. On the basis of such information, inferences about the population may be drawn.

The information sought in a market survey may relate to one or more of the following (i) Total demand and rate of growth of demand; (ii) Demand in different segments of the market; (iii) Income and price elasticity of demand; (iv) Motives for buying; (v) Purchasing plans and intentions; (vi) Satisfaction with existing products; (vii) Unsatisfied needs; (viii) Attitudes toward various products (ix) Distributive trade practices and preferences; (x) Socio-economic characteristics of buyers.

Steps in a sample survey

Typically, a sample survey consists of the following steps:

1. *Definition of the target population*— In defining the target population the important terms should be carefully and unambiguously defined. The target population may be divided into various segments which may have differing characteristics. For example, all television owners may be divided into three to four income brackets.

2. *Selection of sampling scheme and sample size*— There are several sampling schemes- simple random sampling, cluster sampling, sequential sampling, stratified sampling, systematic sampling, and non-probability sampling. Each scheme has its advantages and limitations. The sample size, other things being equal, has a bearing on the reliability of the estimates— the larger the sample size, the greater the reliability.

3. *Preparation of the questionnaire*— The questionnaire is the principal instrument for eliciting information from the sample of the respondents. The effectiveness of the questionnaire as a device for

eliciting the desired information depends on its length, the types of questions, and the wording of questions. Developing the questionnaire requires thorough understanding of the product/service and its usage, imagination, insights into human behaviour, appreciation of subtle linguistic nuances, and familiarity with the tools of descriptive and inferential statistics to be used later for analysis. It also requires knowledge of psychological scaling techniques if the same are employed for obtaining information relating to attitudes, motivations, and psychological traits. Industry and trade market surveys, in comparison to consumer surveys, generally involve more technical and specialized questions.

Since the quality of the questionnaire has an important bearing on the results of market survey, the questionnaire should be tried out in a pilot survey and modified in the light of problems/difficulties noted.

4. *Recruiting and training of field investigators* must be planned well since it can be time-consuming. Great care must be taken for recruiting the right kinds of investigators and imparting the proper kind of training to them. Investigators involved in industry and trade market survey need intimate knowledge of the product and technical background particularly for products based on sophisticated technologies.

5. *Obtaining information as per the questionnaire from the sample of respondents*— Respondents may be interviewed personally, telephonically or by mail for obtaining information. Personal interviews ensure a high rate of response. They are, however, expensive and likely to result in biased responses because of the presence of the interviewer. Mail surveys are economical and evoke fairly candid responses. The response rate, however, is often low. Telephonic interviews, common in western countries, have very limited applicability in India because telephone tariffs are high and telephone connections few.

6. Scrutiny of information gathered— Information gathered should be thoroughly scrutinized to eliminate data which is internally inconsistent and which is of dubious validity. For example, a respondent with a high income and large family may say that he lives in a one-room tenement. Such information, probably inaccurate, should be deleted. Sometimes data inconsistencies may be revealed only after some analysis.

7. Analysis and interpretation of data— Data gathered in the survey needs to be analysed and interpreted with care and imagination. After tabulating it as per a plan of analysis, suitable statistical investigation may be conducted, wherever possible and necessary. For purposes of statistical analysis, a variety of methods are available. They may be divided into two broad categories: parametric methods and non-parametric methods. Parametric methods assume that the variable or attribute under study conforms to some known distribution. Non-parametric methods do not presuppose any particular distribution.

Results of data based on sample survey will have to be extrapolated for the target population. For this purpose, appropriate inflatory factors, based on the ratio of the size of the target population and the size of the sample studied, will have be to be used.

The statistical analysis of data should be directed by a person who has a good background in statistics as well as economics.

It may be emphasized that the results of the market survey can be vitiated by- (i) non-representativeness of the sample, (ii) imprecision and inadequacies in the questions, (iii) failure of the respondents to comprehend the questions, (iv) deliberate distortions in the answers given by the respondents, (v) inept handling of the interviews by the investigators, (vi) cheating on the part of the investigators, (vii) slipshod scrutiny of data, and (viii) incorrect and inappropriate analysis and interpretation of data.

3.5 DEMAND FORECASTING

After gathering information about various aspects of the market and demand from primary and secondary sources, an attempt may be made to estimate future demand. Several methods are available for demand forecasting. The important ones are—

(i) Trend projection method

It consists of (i) determining the trend of consumption by analyzing past consumption statistics, and (ii) projecting future consumption by extrapolating the trend.

The trend of consumption may be represented by one of the following relationships:

Linear Relationship: $Y_t = a + bt$ ... (1)

Exponential Relationship: $Y_t = ae^{bt}$ ... (2)

On logarithmic transformation this becomes:

$\text{Log } Y_t = \log a + bt$

Polynomial Relationship: $Y_t = a_0 + a_1t + a_2t^2 + \ldots + a_nt^n$ ... (3)

Cobb Douglas Relationship: $Y_t = at^b$ ... (4)

On logarithmic transformation this becomes:

$\text{Log } Y_t = \log a + b \log t$

In the above equations Y_t represents demand for year t, t is the time variable, a, b and a_j's are constants.

Out of the above relationships the most commonly used relationship is-

$Y_t = a + bt$

This relationship may be estimated by using one of the following methods: (i) visual curve fitting method, and (ii) least squares method.

Evaluation— The basic assumption underlying the trend projection method is that the factors which influenced the behaviour of consumption in the past would continue to influence the behaviour of consumption in the future. This hypothesis is sometimes referred to as the hypothesis of "mutually compensating effects". Clearly, this is a deterministic hypothesis of questionable validity. Notwithstanding this weakness, the trend projection method is used popularly in practice. Often a starting point in the forecasting exercise, it is likely to be relied upon heavily when no other viable method seems available. The ease with which it can be applied may induce a sense of complacency.

(ii) Consumption level method

Useful for a product which is directly consumed, this method estimates consumption level on the basis of elasticity coefficients, the important ones being the income elasticity of demand and the price elasticity of demand.

Income elasticity of demand— The income elasticity of demand reflects the responsiveness of demand to variations in income. It is measured as follows:

$$E_1 = \frac{Q_2 - Q_1}{I_2 - I_1} \times \frac{I_1 + I_2}{Q_2 + Q_1}$$

Where E_1 = income elasticity of demand

Q_1 = quantity demanded in the base year

Q_2 = quantity demanded in the following year

I_1 = income level in the base year

I_2 = income level in the following year

Example— The following information is available on quantity demanded and income level: $Q_1 = 50$, $Q_2 = 55$, $I_1 = 1{,}000$, and $I_2 = 1{,}020$. The income elasticity of demand is-

$$E_1 = \frac{55 - 50}{1{,}020 - 1{,}000} \times \frac{1{,}000 + 1{,}020}{55 + 50} = 4.81$$

The information on income elasticity of demand along with projected income may be used to obtain a demand forecast. To illustrate, suppose the present per capita annual demand for paper is 1 kg and the present per capita annual income is Rs. 1,2000. The income elasticity of demand for paper is 2. The projected per capita annual income three years hence is expected to be 10 per cent higher than what it is now. The projected per capita demand for paper three years hence will be-

$$\left(\begin{array}{c}\text{Present per}\\ \text{capita income}\end{array}\right)\left(\begin{array}{cc}1 + \text{per capital change} & \text{income elasticity}\\ \text{in income level} & \text{of demand}\end{array}\right)$$

$$= (1)\ (1 + 0.10 \times 2) = 1.2 \text{ kg.}$$

The aggregate demand projection for paper will simply be-

Projected per capita demand × Projected population

The income elasticity of demand differs from one product to another. Further, for a given product, it tends to vary from one income group to another and from one region to another. Hence, wherever possible, disaggregative analysis should be attempted.

Price elasticity of demand— The price elasticity of demand measures the responsiveness of demand to variations in price. It is defined as—

$$E_p = \frac{Q_2 - Q_1}{P_2 - P_1} \times \frac{P_1 + P_2}{Q_2 + Q_1}$$

Where, E_p = price elasticity of demand

Q_1 = quantity demanded in the base year

Q_2 quantity demanded in the following year

P_1 = price per unit in the base year

P_2 = price per unit in the following year

Example— The following information is available about a certain product: P_1 = Rs. 600, Q_1 = 10,000, P_2 = Rs. 800, Q_2 = 9,000. The price elasticity of demand is:

$$E_p = \frac{9000 - 10{,}000}{800 - 500} \times \frac{600 + 800}{9{,}000 + 10{,}000} = -\ 0.37$$

The price elasticity of demand is a useful tool in demand analysis. The future volume of demand may be estimated on the basis of the price elasticity coefficient and expected price change. The price elasticity coefficient may also be used to study the impact of variable price that may obtain in future on the economic viability of the project. In using the price elasticity measure, however, the following considerations should be borne in mind: (i) the price elasticity coefficient is applicable to only small variations. (ii) The price elasticity measure is based on the assumption that the structure and behaviour remain constant.

(iii) End use method

Suitable for estimating the demand for intermediate products, the end use method, also referred to as the consumption coefficient method involves the following steps:

1. Identify the possible uses of the product.
2. Define the consumption coefficient of the product for various uses.
3. Project the output levels for the consuming industries.
4. Derive the demand for the product.

This method may be illustrated with an example. A certain industrial chemical is used by four industries, Alpha, Beta, Gamma, and Kappa. The consumption coefficients for these industries, the projected output levels for these industries for the year X, and the projected demand are shown in Exhibit 1.

Exhibit 1

Projected Demand

	Consumption coefficient*	Projected output in Year X	Projected demand in Year X
Alpha	2.0	10,000	20,000
Beta	1.2	15,000	18,000
Kappa	0.8	20,000	16,000
Gamma	0.5	30,000	15,000

Total = 69,000 tones
*This is expressed in tones per unit of output of the consuming industry.

As is clear from the foregoing discussion, the key inputs required for the application of the end-use method are— (i) projected output levels of consuming industries (units), and (ii) consumption coefficients. It may be difficult to estimate the projected output levels of consuming industries (units). More important, the consumption coefficients may vary from one period to another in the wake of technological changes and improvements in the methods of manufacturing. Hence, the end-use method should be used judiciously.

(iv) Leading Indicator Method

Leading indicators are variables which change ahead of other variables, the lagging variables. Hence, observed changes in leading indicators may be used to predict the changes in lagging variables. For example, the change in the level of urbanization a leading indicator may be used to predict the change in the demand for air conditioners a lagging variable.

Two basic steps are involved in using the leading indicator method: (i) First, identify the appropriate leading indicator(s). (ii) Second, establish the relationship between the leading indicator(s) and the variable to be forecast.

The principal merit of this method is that it does not require a forecast of an explanatory variable. It, however, is characterized by certain problems. (i) It may be difficult to find an appropriate leading indicator(s). (ii) The lead-lag relationship may not remain stable over time. In view of these problems this method has limited use.

(v) Econometric method

An econometric model is a mathematical representation of economic relationship/s derived from economic theory. The primary objective of econometric analysis is to forecast the future behaviour of the economic variables incorporated in the model.

Two types of econometric models are employed: the single equation model and the simultaneous equation model. The single equation model assumes that one variable, the dependent variable (also referred to as the explained variable), is influenced by one or more independent variables (also referred to as the explanatory variables). In other words, one-way causality is postulated. An example of the single equation model is given below:

$D_t = a_0 + a_1P_t + a_2N_t$

Where, D_t = demand for a certain product in year t

P_t = price for the product in year t

N_t = income in year t

The simultaneous equation model portrays economic relationships in terms of two or more equations. Consider a highly simplified three-equation econometric model of Indian economy.

$$GNP_t = G_t + I_t + C_t \quad \ldots (5)$$

$$I_t = a_0 + a_1\, GNP_t \quad \ldots (6)$$

$$C_t = b_0 + b_1\, GNP_t \quad \ldots (7)$$

Where GNP_t = gross national product for year t

G_t = governmental purchases for year t

I_t = gross investment for year t

C_t = consumption for year t

In the above model, Eq. (5) is just a definitional equation which says that the gross national product is equal to the sum of government purchases, gross investment and consumption. Eq. (6) postulates that investment is a linear function of gross national product; Eq. (7) posits that consumption is a linear function of gross national product.

The construction and use of an econometric model involves four broad steps.

1. *Specification*— This refers to the expression of an economic relationship in mathematical form. Equation (6), for example, posits that investments is a linear function of gross national product.
2. *Estimation*— This involves the determination of the parameter values and other statistics by a suitable method. The principal methods of estimation are the least squares method and the maximum likelihood method, the former being the most popular method in practice.
3. *Verification*— This step is concerned with accepting or rejecting the specification as a reasonable approximation to truth on the basis of the results of estimation and appropriate statistical tests applied to them.
4. *Prediction*— This involves projection of the value of the explained variable(s).

Evaluation— The econometric method offers certain advantages- (i) The process of econometric analysis sharpens the understanding of complex cause-effect relationships, (ii) the econometric model provides a basis for testing assumptions and for judging how sensitive the results are to changes in assumptions.

The limitations of the econometric method are— (i) it is expensive and data-demanding. (ii) to forecast the behaviour of the dependent variable, one needs the projected values of independent variable (s). The difficulty in obtaining these may be the main limiting factor in employing econometric method for forecasting purposes.

Market penetration for the product— Once a reasonably good handle over the aggregate demand is obtained, the next logical question is: What will be the likely demand for the product of the project under examination? The answer to this question depends on—

1. Aggregate potential supply
2. Nature of competition
3. Consumer preferences
4. Sales promotion efforts

If the aggregate potential domestic supply is likely to be significantly less than the aggregate potential domestic demand, the demand for the product of the project under examination is likely to be very strong, provided liberal imports which may hurt domestic manufacturers are not allowed. The nature of competition and market-sharing arrangement (if any) has a bearing on the demand for the product of the project under examination. Consumer preferences for competing products and the sales promotional efforts of various competitors obviously influence the relative market shares enjoyed by them.

3.6 UNCERTAINTIES IN DEMAND FORECASTING

Demand forecasts are subject to error and uncertainty which arise from three principal sources:

(i) Data about past and present market

The analysis of past and present market, which serves as the springboard for the projection exercise, may be vitiated by the following inadequacies of data:

Lack of standardization— Data pertaining to market features like product, price, quantity, cost, income etc. may not reflect uniform concepts and measures.

Few observations— Not enough observations may be available to conduct meaningful analysis.

Influence of abnormal factors— Some of the observations may be influenced by abnormal factors like war or natural calamity.

(ii) Methods of forecasting

Methods used for demand forecasting are characterized by limitations.

Inability to handle unquantifiable factors— Most of the forecasting methods, quantitative in nature, cannot handle unquantifiable factors which sometimes can be of immense significance.

Unrealistic assumptions— Each forecasting method is based on certain assumptions. For example, the trend projection method is based on the 'mutually compensation effects' premise and the end-use method is based on the constancy of technical coefficients. Uncertainty arises when the assumptions underlying the chosen method tend to be unrealistic and erroneous.

Excessive data requirement— In general, the more advanced a method, the greater the data requirement. For example, to use an econometric model one has to forecast the future values of explanatory variables in order to project the explained variable. Clearly, predicting the future value of explanatory variables is a difficult and uncertain exercise.

(iii) Environmental changes

The environment in which a business functions is characterized by numerous uncertainties. The important sources of uncertainty are mentioned below:

Technological change— This is a very important but hard-to-predict factor which influences business prospects. A technological advancement may create a new product which performs the same function more efficiently and economically, thereby cutting into the market for the existing product. For example, electronic watches have encroached on the market for mechanical watches.

Shift in governmental policy— In India, governmental regulation of business is extensive. Changes in governmental policy, which may be difficult to anticipate, may have a telling effect on business environment, e.g. granting of licenses to new companies, particularly foreign companies, may alter the market situation significantly.; banning the import of a certain product may create a sheltered market for the existing producers; liberalizing the import of some product may lead to stiff competition in the market place; relaxation of price and distribution controls may widen the market considerably.

Developments on the international scene— Developments on the international scene may have a profound effect on industries. The most classic example of recent times is the OPEC price hike, which led to near-stagnation in the Indian automobile industry.

Discovery of new sources of raw material— Discovery of new sources of raw materials, particularly hydrocarbons, can have a significant impact on the market situation of several products.

Vagaries of monsoon— Monsoon, which plays an important role in the Indian economy, is somewhat unpredictable. The behaviour of monsoon influences, directly or indirectly, the demand for a wise range of products.

3.7 COPING WITH UNCERTAINTIES

Given the uncertainties in demand forecasting, adequate efforts, along the following lines may be made to cope with uncertainties.

1. Conduct analysis with data based on uniform and standard definitions.
2. In identifying trends, coefficients, and relationships, ignore the abnormal or out-of-the-ordinary observations.
3. Critically evaluate the assumptions of the forecasting methods and choose a method which is appropriate to the situation.
4. Adjust the projections derived from quantitative analysis in the light of a due consideration of unquantifiable, but significant influences.
5. Monitor the environment imaginatively to identify important changes.
6. Consider likely alternative scenarios and their impact on market and competition.
7. Conduct sensitivity analysis to assess the impact on the size of demand for unfavourable and favourable variations of the determining factors from their most likely levels.

3.8 SUMMARY

An estimation of the size of the market is the first step in project appraisal. In many cases, a project has been abandoned because preliminary appraisal revealed a inadequate size of market. The information required for market and demand analysis relate to effective demand in the past and present, breakdown of demand, price, consumers, methods of distribution and sales promotion, government policy and supply and competition. The information required for demand and market analysis is generally obtained partly from secondary sources and partly through a market survey. The important sources of national sample survey reports, plan reports, India year book, statistical abstract of the Indian Union. Sometimes, secondary information does not provide a comprehensive basis for demand and market analysis. It needs to be supplemented with primary information gathered through a market survey. After collecting information about various aspects of the market and demand from primary and secondary sources, it is essential to make an estimate of future demand. The various methods of demand forecasting include trend projection method, consumption level method, end use method, leading indicator method econometric method. Given the uncertainties in demand forecasting adequate efforts are to be made to cope with uncertainties.

3.9 KEYWORDS

Market Survey: It refers to the systematic collection, recording and analysis of data in order to develop an appropriate information base for decision-making.

Trend Projection Method: It consists of determining the trend of consumption by analyzing past consumption statistics and projecting future consumption by exptrapolating the trend.

Survey: A survey consists of gathering data by interviewing a limited number of people selected from a larger group.

Econometric Method: It is a mathematical representation of economic relationship (s) derived from economic theory.

3.10 SELF ASSESSMENT QUESTIONS

1. What types of information are required for market and demand analysis?

2. Discuss the steps involved in constructing and using an econometric model.

3. What are the sources of uncertainties in demand forecasting? Discuss them.

4. “Often secondary information is not adequate for market and demand analysis”. Comment.

3.11 SUGGESTED READINGS

1. Projects Preparation, Appraisal, Budgeting and Implementation by Prasanna Chandra, Tata McGraw Hill Publishing Company Ltd., New Delhi.

2. Project Management by Vasant Desai, Himalaya Publishing House, New Delhi.

3. Project Management by C. Chaudhary, Tata McGraw Hill, New Delhi.

4. Project Management and Control by C. Keshava Rao, Sultan Chand and Sons, New Delhi.

LESSON: 4

TECHNICAL AND FINANCIAL ANALYSIS

STRUCTURE

4.0 Objective

4.1 Introduction

4.2 Technical analysis

4.3 Financial analysis

4.4 Summary

4.5 Keywords

4.6 Self assessment questions

4.7 Suggested readings

4.0 OBJECTIVES

After reading this lesson, you will become familiar with

a) Various aspects to be considered for technical analysis of the project.

b) Considerations involved in financial analysis of the project.

4.1 INTRODUCTION

The success of an enterprise depends upon the entrepreneur doing the right thing at the right time. Starting a new venture is a very challenging and rewarding task. A businessman has to take numerous decisions, right from the conception of a business idea, upon the start of production. Hence, the identification of the project to be undertaken, requires an analysis of the project in depth. Therefore, a technical and financial analysis of the project has to be undertaken.

4.2 TECHNICAL ANALYSIS

Analysis of technical and engineering aspects is done continually when a project is being examined and formulated. Other types of analyses are dependent and closely intertwined with technical analysis. Technical analysis is concerned primarily with:

4.2.1 Materials and inputs

An important aspect of technical appraisal is concerned with defining the materials and inputs required, specifying their properties in some detail, and setting up their supply programme. There is an intimate relationship between the study of materials and inputs and other aspects of project formulation, particularly those concerned with location, technology, and equipment.

Materials and inputs may be classified into four broad categories: (i) raw materials, (ii) processed industrial materials and components, (iii) auxiliary materials and factory supplies, and (iv) utilities.

(i) **Raw materials—** Raw materials (processed and /or semi-processed) may be classified into four types: (i) agricultural products, (ii) mineral products, (iii) livestock and forest products, and (iv) marine products.

(ii) **Processed industrial materials and components—** Processed industrial materials and components (base metals, semi-processed materials, manufactured parts, components, and sub-assembly represent an important input for a number of industries. In studying them the following questions need to be answered: In the case of industrial materials, what are their properties? What is the total requirement of the project? What quantity would be available from domestic source? What quantity would be available from foreign sources? How dependable are the supplies? What has been the past trend in prices? What is the likely future behaviour of prices?

(iii) **Auxiliary materials and factory supplies—** In addition to the basic raw materials and processed industrial materials and components, a manufacturing project requires various auxiliary materials and factory supplies, like chemicals, additives, packaging materials, paints, varnishes, oils, grease, cleaning materials, etc. The requirements of such auxiliary materials and supplies should be taken into account in the feasibility study.

(iv) **Utilities—** A broad assessment of utilizes (power, water, steam, fuel, etc.) may be made at the time of input study though a detailed assessment can be made only after formulating the project with respect to location, technology, and plant selection. Since the successful operation of a project critically depends on adequate availability of utilities the following points should be raised whiled conducting the input study: What quantities are required? What are the sources of supply? What would be the potential availability? What are the likely shortages/bottlenecks? What measures may be taken to augment supplies.

4.2.2 Production technology

For manufacturing a product/service often two or more alternative technologies are available. For example:

- Steel can be made either by the Bessemer process or the open hearth process.
- Cement can be made either by the dry process or the wet process.
- Soda can be made by the electrolysis method or the chemical method.

- Paper, using bagasse as the raw material, can be manufactured by the kraft process or the soda process or the simon cusi process.
- Vinyl chloride can be manufactured by using one of the following reactions: acetylene on hydrochloric acid or ethylene or chlorine.

4.2.3 Choice of technology

The choice of technology is influenced by a variety of considerations:

(i) **Principal inputs—** The choice of technology depends on the principal inputs available for the project. In some cases, the raw materials available influences the technology chosen. For example, the quality of limestones determines whether the wet or dry process should be used for a cement plant. It may be emphasized that a technology based on indigenous inputs may be preferable to one based on imported inputs because of uncertainties characterizing imports, particularly in a country like India.

(ii) **Investment outlay and production cost—** The effect of alternative technologies of investment outlay and production cost over a period of time should be carefully assessed.

(iii) **Use by other units—** The technology adopted must be proven by successful use by other units, preferably in India.

(iv) **Product mix—** The technology chosen must be judged in terms of the total product-mix generated by it, including saleable by-products.

(v) **Latest developments—** The technology adopted must be based on latest development in order to ensure that the likelihood of technological obsolescence in the near future, at least, is minimized.

(vi) **Ease of absorption—** The ease with which a particular technology can be absorbed can influence the choice of technology. Sometimes a high-level technology may be beyond the absorptive capacity of a developing country which may lack trained personnel to handle that technology.

4.2.4 Product Mix

The choice of product mix is guided primarily by market requirements. In the production of most of the items variations in size and quality are aimed the production of most of the items, variations in size and quality are aimed at satisfying a broad range of customers. For example, production of shoes to different customers. It may be noted that sometimes slight variations in quality can enable a company to expand its market and enjoy higher profitability. For example, a toilet soap manufacturing unit may by minor variation in raw material, packaging, and sales promotion offer a high profit margin soap to consumers in upper-income brackets.

While planning the production facilities of the firm, some flexibility with respect to the product mix must be sought. Such flexibility enables the firm to alter its product mix in response to changing market conditions and enhances the power of the firm to survive and grow under different situations. The degree of flexibility chosen may be based on a careful analysis of the additional investment requirements for different degrees of flexibility.

4.2.5 Plant capacity

Plant capacity (also referred to as production as capacity) refers to the volume or number of units that can be manufactured during a given period. Several factors have a bearing on the capacity decision.

(i) **Technological requirement—** For many industrial projects, particularly in process type industries, there is a certain minimum economic size determined by the technological factor. For example, a cement plant should have a capacity of at least 300 tonnes per day in order to use the rotary kiln method; otherwise, it has to employ the vertical shaft method which is suitable for lower capacity.

(ii) **Input constraints—** In a developing country like India, there may be constraints on the availability of certain inputs. Power supply may be limited; basic raw materials may be scarce; foreign exchange available for imports may be inadequate. Constraints of these kinds should be borne in mind while choosing the plant capacity.

(iii) **Investment cost—** When serious input constraints do not obtain, the relationship between capacity and investment cost is an important consideration. Typically, the investment cost per unit of capacity decreases as the plant capacity increases. This relationship may be expressed as follows:

$$C_1 = C_2\left(\frac{Q_1}{Q_2}\right)^{\alpha}$$

Where C_1 = derived cost for Q_1 units of capacity

C_2 = known cost for Q_2 units of capacity

α = a factor reflecting capacity-cost relationship. This is usually between 0.2 and 0.9.

(iv) **Market conditions—** The anticipated market for the product/service has an important bearing on plant capacity. If the market for the product is likely to be very strong, a plant of higher capacity is preferable. If the market is likely to be uncertain, it might be advantageous to start with a smaller capacity. If the market, starting from a small base, is expected to grow rapidly, the initial capacity may be higher than the initial level of demand-further additions to capacity may be affected with the growth of market.

(v) **Resources of the firm—** The resources, both managerial and financial, available to a firm define a limit on its capacity decision. Obviously, a firm cannot choose a scale of operations beyond its financial resources and managerial capability.

(vi) **Governmental policy—** The capacity level may be constrained by governmental policy. Given the level of additional capacity to be created in an industry, within the licensing framework of the government the government may decide to distribute the additional capacity among several firms.

4.2.6 Location and site

The choice of location and site follows an assessment of demand, size, and input requirement. Though often used synonymously, the terms 'location' and 'site' should be distinguished. Location refers to a fairly broad area like a city, an industrial zone, or a coastal area; site refers to a specific piece of land where the project would be set up.

The choice of location is influenced by a variety of considerations: proximity to raw materials and markets, availability of infrastructure, governmental policies, and other factors.

(i) Proximity to raw materials and markets— An important consideration for location is the proximity to sources of raw materials and nearness to the market for final products. In terms of a basic locational model, the optimal location is one where the total cost (raw material transportation cost plus production cost plus distribution cost for final product) is minimized. This generally implies that: (i) a resource-based project like a cement plant or a steel mill should be located close the source of basic material (for example, limestone in the case of a cement plant and iron-ore in the case of a steel plant); (ii) a project based on imported material may be located near a port; and (iii) a project manufacturing a perishable product should be close to the center of consumption.

However, for many industrial products proximity to the source of raw material or the center of consumption may not be very important. Petro-chemical units or refineries, for example, may be located close to the source of raw material, or close to the center of consumption, or at some intermediate point.

(ii) Availability of infrastructure— Availability of power, transportation, water, and communications should be carefully assessed before a location decision is made.

Adequate supply of power is a very important condition for location— insufficient power can be a major constraint, particularly in the case of an electricity-intensive project like an aluminium plant. In evaluating power supply the following should be looked into: the quantum of power available, the stability of power supply, the structure of power tariff, and the investment required by the project for a tie-up in the network of the power supplying agency.

For transporting the inputs of the project and distributing the outputs of the project, adequate transport connections—whether by rail, road, sea, inland water, or air— are reqired. The availability, reliability and cost of transportation for various alternative locations should be assessed.

Given the plant capacity and the type of technology, the water requirement for the project can be assessed. Once the required quantity is estimated, the amount to be drawn from the public utility system and the amount to be provided by the project from surface or sub-surface sources may be determined. For doing this the following factors may be examined: relative costs, relative dependabilities, and relative qualities.

In addition to power, transport, and water, the project should have adequate communication facilities like telephone and fax etc.

(iii) Governmental policies— Governmental policies have a bearing on location. In the case of public sector projects, location is directly decided by the government. It may be based on a wider policy for regional dispersion of industries.

In the case of private sector projects, location is influenced by certain governmental restrictions and inducements. The government may prohibit the setting up of industrial projects in certain areas which suffer from urban congestion. More positively, the government offers inducements for establishing industries in backward areas. These inducements consist of outright subsidies, concessional finance, tax relief, and other benefits.

(iv) Other factors— Several other factors have to be assessed before reaching a location decision: ease in coping with environmental pollution, labour situation, climatic conditions, and general living conditions.

A project may cause environmental pollution in various ways: it may throw gaseous emission; it may produce liquid and solid discharges; it may cause noise, heat, and vibrations. The location study should analyse the costs of mitigating environmental pollution to tolerable levels at alternative locations.

The labour situation at alternative locations may be assessed in terms of: (i) the availability of labour, skilled, semi-skilled, and unskilled; (ii) the past trends in labour rates, the prevailing labour rates, and the projected labour rates; and (iii) the state of industrial relations judged in terms of the frequency and severity of strikes and lockouts and the attitudes of labour and management.

The climatic conditions (like temperature, humidity, wind, sunshine, rainfall, snowfall, dust and fumes, flooding, and earthquakes) have an important influence on location. They have a bearing on cost as they determine the extent of air-conditioning, de-humidification, refrigeration, special drainage, etc., required for the project.

General living conditions, judged in terms of cost of living, housing situation, and facilities for education, recreation, transport, and medical care, need to be assessed at alternative locations.

4.2.7 Machinery and equipment

The requirement of machinery and equipment is dependent on production technology and plant capacity. It is also influenced by the type of project. For a process-oriented industry, like a petrochemical unit, machinery and equipment required should be such that the various stages have to be matched well. The choice of machinery and equipment for a manufacturing industry is somewhat wider as various machines can perform the same function with varying degrees of accuracy. For example, the configuration of machines required for the manufacture of refrigerators could take various forms. To determine the kinds of machinery and equipment requirement for a manufacturing industry, the following procedure may be followed: (i) Estimate the likely levels of production over time. (ii) Define the various machining and other operations. (iii) Calculate the machine hours required for each type of operation. (iv) Select machinery and equipment required for each function.

The equipment required for the project may be classified into the following types: (i) plant (process) equipment, (ii) mechanical equipment, (iii) electrical equipment, (iv) instruments, (v) controls, (vi) internal transportation system, and (vii) other machinery and equipment.

In addition to the machinery and equipment, a list should be prepared of spare parts and tools required. This may be divided into: (i) spare parts and tools to be purchased with original equipment, and (ii) spare parts and tools required for operational wear and tear.

Constraints in selecting machinery and equipment— In selecting the machinery and equipment, certain constraints should be borne in mind: (i) there may be a limited availability of power to set up an electricity intensive plant like, for example, a large electric furnace; (ii) there may be difficulty in transporting a heavy equipment to a remote location; (iii) workers may not be able to operate, at least in the initial periods, certain sophisticated equipment such as numerically controlled machines; (iv) the import policy of the government may preclude the import of certain types of machinery and equipment.

4.2.8 Structures and civil works

Structures and civil works may be divided into three categories: (i) site preparation and development, (ii) buildings and structures, and (iii) outdoor works.

(i) **Site preparation and development—** This covers the following: (i) grading and leveling of the site, (ii) demolition and removal of existing structures, (iii) relocation of existing pipelines cables, roads, powerlines, etc., (iv) reclamation of swamps, draining and removal of standing water, (v) connections for the following utilities from the site to the public network: electric power (high tension and low tension), water (use water and drinking water), communications (telephone, fax, etc.), roads, railway sidings, and (vi) other site preparation and developmental work.

(ii) **Buildings—** Buildings and structures may be divided into: (i) factory or process buildings; (ii) ancillary buildings required for stores, warehouses, laboratories, utility supply centers, maintenance services, and others; (iii) administrative buildings; (iv) staff welfare buildings, cafetaria, and medical service buildings; and (v) residential buildings.

(iii) **Outdoor works—** Outdoor works cover (i) supply and distribution of utilities (water, electric power, communication, steam and gas); (ii) handling and treatment of emissions, wastages, and effluents; (iii) transportation and traffic arrangements (roads, railway tracks, paths, parking areas, sheds, garages, traffic signals, etc.): (iv) outdoor lighting; (v) landscaping; and (vi) enclosure and supervision (boundary wall, fencing, barriers, gates, doors, security posts, etc.).

4.2.9 Project charts and layouts

Once data is available on the principal dimension of the project— market size, plant capacity, required technology, equipment and civil works, conditions obtaining at plant site, and supply of inputs to the project— project charts and layouts may be prepared. These define the scope of the project and provide the basis for detailed project engineering and estimation of investment and production costs.

4.2.10 Work Schedule

The work schedule, as its name suggests, reflects the plan of work concerning installation as well as initial operation. The purpose of the work schedule is:

- To anticipate problems likely to arise during the installation phase and suggest possible means for coping with them.
- To establish the phasing of investments taking into account availability of finances.
- To develop a plant of operations covering the initial period (the running in period).

Often, it is found that the required inputs like raw material and power are not available in adequate quantity when the plant is ready for commissioning, or the plant is not ready when the raw material arrives.

4.3 FINANCIAL ANALYSIS

Financial analysis is defined as the process of discovering economic facts about an enterprise and/or a project on the basis of an interpretation of financial data. Financial analysis also seeks to look at the capital cost, operations cost and operating revenue. The analysis decisively establishes a relationship between the various factors of a project and helps in maneuvering the project's activities. It also serves as a common measure of value for obtaining a clear-cut understanding about the project from the financial point of view.

An analysis of several financial tools provide an important basis for valuing securities and appraising managerial programmes. Financial analysis is vital in the interpretation of financial statements. It can provide an insight into two important areas of management— return on investment and soundness of the company's financial position.

Internal management accounts provide information which is valuable for the purpose of control. The information is made available in the form of accounting data, which may be manifested as financial and accounting statements. A financial analysis reveals where the company stands with respect to profitability, liquidity, leverage and an efficient use of its assets. Financial reports provide the framework within which business planning takes place. They are the key through which an effective control of a business enterprise is exercised. It is the process of determining the significant financial characteristics of a firm. It may be external or internal. The external analysis is performed by creditors, stockholders and investment analysis. The internal analysis is performed by various departments of a firm.

4.3.1 Significance of financial analysis

Financial analysis primarily deals with the interpretation of the data incorporated in the proforma financial statements of a project and the presentation of the data in a form in which it can be utilized for a comparative appraisal of the projects. It is, in effect, concerned with the development of the financial profile of the project. Its purpose is to find out whether the project is attractive enough to secure funds needed for its various constituent activities and once having secured the funds, whether the project will be able to generate enough economic values to achieve the objectives for which it is sought to be implemented. It deals not only with the financial aspects of a project but also with its operational aspects. As such, it is necessary to undertake such an analysis not only in the case of industrial projects but also in the case of non-industrial projects.

Analysis of financial statements has become very significant due to the widespread interest of various parties in the financial results of a company. In recent years, the ownership of capital of most public companies has become broad-based. A number of parties and bodies, including creditors, potential suppliers, debenture-holders, credit institutions like banks, industrial finance corporations, potential investors, employees, trade unions, important customers, economists, investment analysts, taxation authorities and government have a stake in the financial results of a company. Various people look at the financial statements from various angles. A number of techniques have been developed to undertake analysis of financial statements in order to reach conclusions about the financial health, profitability and efficiency of an enterprise and also to compare an enterprise with other similar undertakings. The technique of ratio analysis is the most important tool of financial analysis. It helps in comparing the performance of various companies and judge their financial soundness.

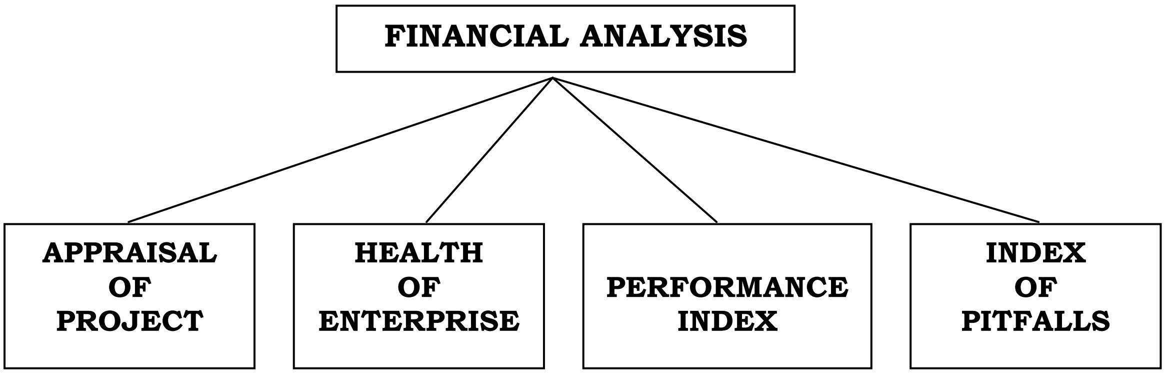

Fig. 1. Utility of financial analysis

4.3.2 Utility of financial and accounting statements

Financial statements play a vital role in the internal financial control of an enterprise. These should, therefore, the properly constructed, analyzed and interpreted by executives, bankers, creditors and investors.

The entire future of a company hinges on the manager's ability to decide relevant financial data with a view to planning profit ability moves. Learning to read financial statements is the first essential element in any businessman's attempt to acquire financial management skills. The change in the elitism of stock ownership to broad public ownership has necessitated a concomitant change in the entire process of reporting corporate financial results. The role of management in the matter of preparation of financial statements is to add understanding to these statements, the fairness of which is to be viewed through the eye of the user, while that of the accountant is to close the communication gap and of the auditor to add credibility to them. For evolving a good economic information system, accounting innovations are of great economic information system. Without these, communication with the financial community would be difficult, the interest of present and future potential investors would not be served, the ability of the company to raise additional capital would be impaired and the government's regulatory measures and policies would not serve the best interest of society. Though a financial statement reveals less than it conceals, it provides the indicators of the enterprise's performance during the year.

Financial analysis seeks to spotlight the significant facts and relationships concerning managerial performance, viz., corporate efficiency, financial strengths and weaknesses and creditworthiness of the enterprise.

4.4 SUMMARY

Technical analysis is done continually when a project is being formulated. Technical analysis is concerned with materials and inputs, production technology, choice of technology, product mix, plant capacity, location, machinery and equipment, structure and civil works and project charts and layouts. Financial analysis seeks to look at the operating cost, operating revenue and capital cost. The purpose of financial analysis is to find out whether the project is attraction enough to secure funds needed for its various constituent activities and once having secured the funds, whether the project will be able to generate enough economic values to achieve the objectives for which it is sought to be implemented. The future of a company depends on the manager's ability to decide relevant financial data with a view to profitability planning. A financial statement reveals less than it conceals, it provides the indicators of the performance of the enterprise during the year.

4.5 KEYWORDS

Technical Analysis: It establishes whether the project is technically feasible or not.

Plant Capacity: Plant capacity refers to the volume or number of units that can be manufactured during a given period.

Site: It refers to a specific piece of land where the project would be set-up.

Financial Analysis: It is the process of discovering economic facts about an enterprise and/or a project on the basis of interpretation of financial data.

4.6 SELF ASSESSMENT QUESTIONS

1. What aspects are considered in technical analysis?
2. Discuss the different aspects to be studied for making financial analysis of the project.
3. What factors have a bearing on choice of technology?

4. What considerations influence the choice of location of the project?

4.7 SUGGESTED READINGS

1. Projects Preparation, Appraisal, Budgeting and Implementation by Prasanna Chandra, Tata McGraw Hill Publishing Company Ltd., New Delhi.

2. Project Management by Vasant Desai, Himalaya Publishing House, New Delhi.

3. Dileep Kumar and Prabhu A.K.J., Project Management, Kalyani Publishers, Ludhiana.

LESSON: 5

ANALYSIS OF PROJECT RISK, MARKET RISK AND FIRM RISK

STRUCTURE

5.0 OBJECTIVES

After reading this lesson, you should be able to

(a) Describe the procedure for analyzing the project risk.

(b) Explain the various forms of market risk.

(c) Discuss about firm risk and its types.

5.1 INTRODUCTION

It is a well established fact that every project involves risk. Moreover, it is a practice to include a short summary of project risks in the project appraisal report. There are certain projects for which economic benefits can be quantified while for others, such quantification is not possible. Firm risk stem from technological change in production process, managerial inefficiency, availability of raw material, labour problems and changes in consumer preferences. The financial risk considers the difference between EBIT and EBT while business risk causes the variations between revenue and EBIT. These are ways and means to reduce the project risks.

5.2 ANALYSIS OF PROJECT RISKS

It is the normal practice to include a short summary of project risks in each appraisal report. The purpose of this chapter is to provide a summary of project risks in order to help ensure uniformity and consistency in appraisal reports. Section-1 relates to projects for which economic benefits can be quantified and section-2 deals with projects for which such quantification is not possible.

5.2.1 Projects with quantified benefits

The economic internal rate of return (EIRR) is the measure most often used to indicate the economic viability of financed projects. Calculation of the EIRR requires a set of assumptions regarding the conditions faced by the project which in the judgement of the appraisal mission are most likely to prevail during its life. However, since bank financed projects normally have a very long life, the conditions faced by the project may change for a variety of reasons. Sensitivity analysis is, therefore, carried out to determine the effects of possible changes in the values of key variables (costs, yields, and price of inputs and outputs) on the project's EIRR.

The number of risks facing a project could be large, and it is neither possible nor desirable to identify all possible risks associated with a project. The risks discussed in the appraisal report should essentially be those which entail major economic consequences. These should be identified from the sensitivity analysis and described in descending order of importance with regard to their impact on the EIRR.

Particular attention should be paid to risks that would substantially reduce the project's EIRR or render the project uneconomic by reducing its EIRR below the opportunity cost of capital. In this context, both the base-case EIRR and the sensitivity indicators are relevant. If the base-case EIRR is high, the discussion of project risks should generally include risks to which the project is highly sensitive. For example, the EIRR of most projects is highly sensitive to changes in project output, which may in turn depend on a number of factors. A discussion of the safeguards employed to minimize the risk of the outputs falling substantially below the level expected should therefore be included. For example, in an irrigation project, apart from the availability of water, output may depend on the supply of other inputs, provision of extension services, effectiveness of water management by farmer's groups, and availability of adequate infrastructure and storage facilities. Measures taken to ensure adequate and timely availability of each should be briefly explained.

Risks are obviously greater in projects for which the base-case EIRR is only marginally higher than the opportunity cost of capital. These larger risks are even greater if the EIRR is highly sensitive to changes in key variables since even a small reduction in the EIRR would render the project unviable. Even when the EIRR is relatively insensitive to changes in key variables, combinations of adverse changes might easily affect the project's viability. Thus, in such cases, the remedial action proposed or adopted should be fully explained.

If the project output is traded internationally, one risk may be future changes in the price of the output, particularly if the share of a project or the country's output is small relative to the world market. In such cases, a review of world demand and supply forecasts for the good in question should be included.

By their very nature, certain types of projects such as gas and oil exploration involve very high risks. For such projects, it is necessary to supplement the sensitivity analysis with a probability analysis. The latter provides a range of possible outcomes in terms of a probability distribution and based on that project related decision could be made more intelligently. But the analysis is more complex and requires more information about events affecting the project. Due to the considerable work involved,, probability analysis of risks is usually undertaken only for project carrying a high degree of risk or for large projects where miscalculations could lead to a major loss to the economy. For such projects, the nature of the risks involved and the measures taken or recommended to minimize the risks, together with the results of the analyses, should be discussed in the appraisal report.

5.2.2 Projects for which benefits are not quantifiable

For projects in certain sectors or sub-sectors such as education, health, sanitation and family planning, project benefits cannot be quantified and the risks cannot be measured by sensitivity analysis. In such cases, the relationship of project risks to the project's objectives should be explained. The eventualities that might impede the realization of the objectives should be discussed in relation to the project cost and output, and also in relation to the socio-economic objectives sought by the project.

In such projects, the risks are greater on the benefit side than on the cost side. For instance, in education projects, school buildings and equipment are provided to help achieve a prescribed annual output of graduates with a certain skill level. However, provision of the facilities alone may not ensure achievement of the project objectives. Their achievement may depend more upon the availability of trained teachers, provision of sufficient funds for the recurring expenditures of the institutions, curriculum and admission standards, and motivation of the students.

While it is not possible to eliminate all such risks, it is essential to minimize them. Major risks of this type should be identified and explained along with the remedial measures proposed in the section in which project risks are discussed.

The real benefits of this type of project relate to broad socio-economic goals. For education projects, these may include increased income level for the trainees and a higher level of industrial and agricultural productive. For family planning projects, the broad goals may be an increased number of acceptors and a consequent reduction in the rate of population growth. The success of these projects depends not merely on the facilities provided, but also on the continued favourable conditions assumed by the appraisal mission. For such projects, the assumptions made regarding the relationship between the facilities provided and project's long-term objectives should be clearly explained. The conditions or facilities necessary but external to the project should also be identified, together with relevant assurances received from the government. For projects such as these, this is one of the most important aspects to be discussed in the section dealing with project risks.

5.3 MARKET RISK

The market risk affects all the projects in an industry and not a particular project. In this section, the concept of market risk has been explained with respect to factors which are beyond the control of individual corporates. The market risk is further sub-divided into:

(i) **Security market risk:** Often we read in the newspaper that the stock market is in the bear hug or in the bull grip. This indicates that the entire market is moving in a particular direction either downward or upward. The economic conditions, political situations and the sociological changes affect the security market. The recession in the economy affects the profit prospect of the industry and the stock market. The 1998 recession experienced by developed and developing countries has affected the stock markets all over the world. The South East Asian crisis has affected the stock market world wide. There factors are beyond the control of the corporate and the investor. They cannot be entirely avoided by the investor. It drives home the point that the market risk is unavoidable.

Jack Clark Francis has defined market risk as that portion of total variability of return caused by the alternating forces of bull and bear markets. When the security index moves upward haltingly for a significant period of time, it is known as bull market. In the bull market, the index moves from a low level to the peak. Bear market is just a reverse to the bull market; the index declines haltingly from the peak to a market low point called trough for a significant period of time. During the bull and bear market more than 80 per cent of the securities' prices rise or fall along with the stock market indices.

The forces that affect the stock market are tangible and intangible events. The tangible events are real events such as earthquake, war, political uncertainty and fall in the value of currency. Another example that can be cited is the Pokhran blast on May 13, 1998, and the fall of BSE sensex by 162 points. Impending sanctions, dampened sentiments and FIIs selling of stocks set a bear phase. Several examples like fall in the value of rupee and post-budget blue can be cited for triggering the bear phase.

Intangible events are related to market psychology. The market psychology is affected by the real events. But reactions to the tangible events become over reactions and they push the market in a particular direction. Take for instance, the bull run in 1994 FII's investment and liberalization policies gave buoyancy to the market. The market psychology was positive. Small investors entered the market and prices of stocks without adequate supportive fundamental factors soared up. In 1996, the political turmoil and recession in the economy resulted in the fall of share prices and the small investors lost faith in the market. There was a rush to sell the shares and the stocks that were floated in the primary market were not received well.

Thus, any untoward political or economic event would lead to a fall in the price of the security which would be further accentuated by the over reactions and the herd like behaviour of the investors. If some financial institutions start disposing the stocks, the fear grips in and spreads to other investors. This results in a rush to sell the stocks. The actions of the financial institutions would have a snowballing effect. This type of over reaction affects the market adversely and the prices of the scrips' fall below their intrinsic values. This is beyond the control of the corporate.

(ii) **Interest rate risk:** Interest rate risk is the variation in the single period rates of return caused by the fluctuations in the market interest rate. Most commonly interest rate risk affects the price of bonds, debentures and stocks. The fluctuations in the interest rates are caused by the changes in the government monetary policy and the changes that occur in the interest rates of treasury bills and the government bonds. The bonds issued by the government and quasi-government are considered to be risk free. If higher interest rates are offered, investor would like to switch his investments from private sector bonds to public sector bonds. If the government to tide over the deficit in the budget floats a new loan/bond of a higher rate of interest, there would be a definite shift in the funds from low yielding bonds to high yielding bonds and from stocks to bonds.

Likewise, if the stock market is in a depressed condition, investors would like to shift their money to the bond market, to have an assured rate of return. The best example is that in April 1996, most of the initial public offerings of many companies remained under subscribed but IDBI and IFC bonds were oversubscribed. The assured rate of return attracted the investors from the stock market to the bond market.

The rise of fall in the interest rate affects the cost of borrowing. When the call money market rate changes, it affects the badla rate too. Most of the stock traders trade in the stock market with the borrowed funds. The increase in the cost of margin affects the profitability of the traders. This would dampen the spirit of the speculative traders who use the borrowed funds. The fall in the demand for securities would lead to a fall in the value of the stock index.

Interest rates not only affect the security traders but also the corporate bodies who carry their business with borrowed funds.

The cost of borrowing would increase and a heavy outflow of profit would take place in the form of interest t the capital borrowed. This would lead to a reduction in earnings per share and a consequent fall in the price of share.

(iii) **Purchasing Power Risk:** Variations in the returns are caused also by the loss of purchasing power of currency. Inflation, is the reason behind the loss of purchasing power. The level of inflation proceeds faster than the increase in capital value. Purchasing power risk is the probable loss in the purchasing power of the returns to be received. The rise in price penalizes the returns to the investor, and every potential rise in price is a risk to the investor.

The inflation may be demand-pull or cost-push inflation. In the demand pull inflation, the demand for goods and services are in excess of their supply. At full employment level of factors of production, the economy would not be able to supply more goods in the short run and the demand for products pushes the price upward.d the supply cannot be increased unless there is an expansion of labour force or machinery for production. The equilibrium between demand and supply is attained at a higher price level.

The cost-push inflation, as the name itself indicates that the inflation or the rise in price is caused by the increase in the cost.

The increase in the cost of raw material, labour and equipment makes the cost of production high and ends in high price level. The producer tries to pass the higher cost of production to the consumer. The labourers or the working force try to make the corporate to share the increase in the cost of living by demanding higher wages. Thus, the cost push inflation has a spiraling effect on price level.

5.4 FIRM RISK

Firm risk is unique and peculiar to a firm or an industry. Firm risk stems from managerial inefficiency, technological change in the production process, availability of raw material, changes in the consumer preference, and labour problems. The nature and magnitude of the above mentioned factors differ from industry to industry, and company to company. They have to be analysed separately for each industry and firm. The changes in the consumer preference affect the consumer products like television sets, washing machine, refrigerators, etc. more than they affect the iron and steel industry. Technological changes affect the information technology industry more than that of consumer product industry. Thus, it differs from industry to industry. Financial leverage of the companies that is debt-equity portion of the companies differs from each other. The nature and mode of raising finance and paying back the loans, involve a risk element. All these factors from the firm risk and contribute a portion in the total variability of the return. Broadly, firm risk can be classified into:

1. Business risk
2. Financial risk

1. Business risk: Business risk is that portion of the firm risk caused by the operating environment of the business. Business risk arises from the inability of a firm to maintain its competitive edge and the growth or stability of the earnings. Variation that occurs in the operating environment is reflected on the operating income and expected dividends. The variation in the expected operating income indicates the business risk. For example take ABC and XYZ companies. In ABC company, operating income could grow as much as 15 per cent and as low as 7 per cent. In XYZ company, the operating income can be either 12 per cent or 9 per cent. When both the companies are compared, ABC company's business risk is higher because of its high variability in operating income compared to XYZ company. Thus, business risk is concerned with the difference between revenue and earnings before interest and tax. Business risk can be divided into external business risk and internal business risk.

(a) Internal Business Risk: Internal business risk is associated with the operational efficiency of the firm. The operational efficiency differs from company to company. The efficiency of operation is reflected on the company's achievement of its pre-set goals and the fulfillment of the promises to its investors. The various reasons of internal business risk are discussed below:

(i) **Fluctuations in the sales—** The sales level has to be maintained. It is common in business to lose customers abruptly because of competition. Loss of customers will lead to a loss in operational income. Hence, the company has to build a wide customer base through various distribution channels. Diversified sales force may help to tide over this problem. Big corporate bodies have long chain of distribution channel. Small firms often lack this diversified customer base.

(ii) **Research and development (R&D)—** Sometimes the product may go out of style or become obsolescent. It is the management, who has to overcome the problem obsolescence by concentrating on the in-house research and development program. For example, if Maruti Udyog has to survive the competition, it has to keep its Research and Development section active and introduce consumer oriented technological changes in the automobile sector. This is often carried out by introducing sleekness, seating comfort and break efficiency in their automobiles. New products have to be produced to replace the old one. Short sighted cutting of R & D budget would reduce the operational efficiency of any firm.

(iii) Personnel management— The personnel management of the company also contributes to the operational efficiency of the firm. Frequent strikes and lock outs result in loss of production and high fixed capital cost. The labour productivity also would suffer. The risk of labour management is present in all the firms. It is up to the company to solve the problems at the table level and provide adequate incentives to encourage the increase in labour productivity. Encouragement given to the labourers at the floor level would boost morale of the labour force and leads to higher productivity and less wastage of raw materials and time.

(iv) Fixed cost— The cost components also generate internal risk if the fixed cost is higher in the cost component. During the period of recession or low demand for product, the company cannot reduce the fixed cost. At the same time in the boom period also the fixed factor cannot vary immediately. Thus, the high fixed cost component in a firm would become a burden to the firm. The fixed cost component has to be kept always in a reasonable size, so that it may not affect the profitability of the company.

(v) Single product— The internal business risk is higher in the case of firm producing a single product. The fall in the demand for a single product would be fatal for the firm. Further, some products are more vulnerable to the business cycle while some products resist and grow against the tide. Hence, the company has to diversify the products if it has to face the competition and the business cycle successfully. Take for instance, Hindustan Lever Ltd., which is producing a wide range of consumer cosmetics is thriving successfully in the business. Even in diversification, diversifying the product in the unknown path of the company may lead to an internal risk. Unwidely diversification is as dangerous as producing a single good.

(b) **External risk—** External risk is the result of operating conditions imposed on the firm by circumstances beyond its control. The external environments in which it operates exert some pressure on the firm. The external factors are social and regulatory factors, monetary and fiscal policies of the government, business cycle and the general economic environment within which a firm or an industry operates. A government policy that favours a particular industry could result in the rise in the stock price of the particular industry. For instance, the Indian sugar and fertilizer industry depend much on external factors. The various external factors are being discussed below:

(i) **Social and regulatory factors—** Harsh regulatory climate and legislation against the environmental degradation may impair the profitability of the industry. Price control, volume control, import/export control and environment control reduce the profitability of the firm. This risk is more in industries related to public utility sectors such as telecom, banking and transportation. The governments' tariff policy of the telecom sector has a direct bearing on its earnings. Likewise, the interest rates and the directions given in the lending policies affect the profitability of the banks. Calcutta Electric and Supply Company (CESC) has not been able to increase its power tariff due to the stiff resistance by the West Bengal government. The Pollution Control Board has asked to close most of the tanneries in Tamil Nadu, which has affected the leather industry.

(ii) **Political risk—** Political risk arises out of the change in the government policy. With a change in the ruling party, the policy also changes. When Sri. Manmohan Singh was the finance minister, liberalization policy was introduced. During the Bharathiya Janta Party government, even though efforts are taken to augment the foreign investment, more stress is given to Swadeshi. Political risk arises mainly in the case of foreign investment. The host government may change its rules and regulations regarding the foreign investment. From the past, an example can be cited. In 1977, the government decided that the multinationals must dilute their equity and share their growth with the Indian investors. This forced many multinationals to liquidate their holdings in the Indian companies.

(iii) Business cycle— The fluctuations of the business cycle lead to fluctuations in the earnings of the company. Recession in the economy leads to a drop in the output of many industries. Steel and white consumer goods industries tend to move in tandem with the business cycle. During the boom period, there would be hectic demand for steel products and white consumer goods. But at the same time, they would be hit much during the recession period. At present, the information technology industry has resisted the business cycle and moved counter cyclically during the recession period. The effects of the business cycle vary from one company to another. Sometimes, companies with inadequate capital and consumer base may be forced to close down. In some other case, there may be a fall in the profit and the growth rate may decline. This risk factor is external to the corporate bodies and they may not be able to control it.

2. Financial risk

It refers to the variability of the income to the equity capital due to the debt capital. Financial risk in a company is associated with the capital structure of the company. Capital structure of the company consists of equity funds and borrowed funds. The presence of debt and preference capital results in a commitment of paying interest or pre fixed rate of dividend. The residual income alone would be available to the equity holders. The interest payment affects the payments that are due to the equity investors. The debt financing increases the variability of the returns to the common stock holders and affects their expectations regarding the return. The use of debt with the owned funds to increase the return to the share holders is known as financial leverage.

Debt financing enables the corporate to have funds at a low cost and financial leverage to the shareholders. As long as the earnings of a company are higher than the cost of borrowed funds, shareholders' earnings are increased. At the same time when the earnings are low, it may lead to bankruptcy to equity holders. This can be illustrated with the help of the following example:

	Years		
	1996	1997	1998
Company A			
Equity capital Rs. 10 per share	20,00,000	20,00,000	20,00,000
Debt fund (10% interest)	10,00,000	10,00,000	10,00,000
Operating income	30,00,000	40,00,000	20,00,000
Earning per share	1.0	1.5	0.5
Company B			
Equity capital Rs. 10 per share	10,00,000	10,00,000	10,00,000
Debt fund (10% interest)	20,00,000	20,00,000	20,00,000
Operating income	30,00,000	40,00,000	20,00,000
Earnings per share	1.0	2.0	Nil

The above example deals with three different situations. In the year 1996, both the companies earned the same amount and the earnings per share were same. But, in the year 1997 there was 33.33 per cent hike in the earnings of the two companies. In company A 33.33 per cent rise in operating income has resulted in a 50 per cent increase in earnings per share. In the company B, earnings per share has increased by cent per cent i.e. from Rs. 1 to Rs. 2, because the bond holders receive only the fixed interest whether the company fared well or not. The increase in earnings per share would cause a change in the capital appreciation in the shares of the "B" company during a good year.

In the year 1998, the economic climate has changed and there is a fall in the operating profit by 33.33 per cent for both the companies. This has caused 50 per cent fall in earnings per share for company a compared to 1996. But company "B"s earnings per share has fallen to zero and the shareholders are affected adversely in the bad year,. If we assume another situation of negative earnings, the situation would be worse in company B and the shareholders will be affected much. A few years of persistent negative earnings will erode the shareholders' equity. Fixed return on borrowed capital either enhances or reduces the return to shareholders.

The financial risk considers the difference between EBIT and EBT (earnings before tax). The business risk causes the variations between revenue and EBIT. The payment of interest affects the eventual earnings of the company stock. Thus, volatility in the rates of return on the stock is magnified by the borrowed money. The variations in income caused by the borrowed funds in highly levered firms are greater compared to the companies with low leverage. The financial leverage or financial risk is an avoidable risk because it is the management who has to decide, how much to be funded with the equity capital and borrowed capital.

5.5 SUMMARY

As the problems and risk facing each project are unique, it is not possible to prescribe a standard format. The selection of project risks to be presented must thus be based on the appraisal mission's judgement. Nevertheless, the discussion of the project risks in the appraisal report should be concise, and should normally not exceed two or three paragraphs.

5.6 KEYWORDS

Market Risk: It is that portion of total variability of return caused by the alternating forces of bull and bear markets.

Interest Rate Risk: Interest rate risk is the variation in the single p3eriod rates of return caused by the fluctuation in the market interest rate.

Business Risk: It is that portion of the firm risk caused by the operating environment of the business.

External Risk: It is the result of operating conditions imposed on the firm by circumstances beyond its control.

Political Risk: Political risk arises out of the change in the government policy.

5.7 SELF ASSESSMENT QUESTIONS

1. Discuss the procedure for analyzing the project risk.
2. Explain the various forms of market risks.
3. "Market risks are not firm specific". Elucidate.
4. Discuss the various reasons of internal business risks.

5.8 SUGGESTED READINGS

1. Projects Preparation, Appraisal, Budgeting and Implementation by Prasanna Chandra, Tata McGraw Hill Publishing Company Ltd., New Delhi.
2. Project Management by Vasant Desai, Himalaya Publishing House, New Delhi.
3. Project Management by C. Chaudhary, Tata McGraw Hill, New Delhi.

LESSON: 6

SOCIAL COST-BENEFIT ANALYSIS

STRUCTURE

6.0 OBJECTIVES

After reading this lesson, you should be able to

(a) Highlight the importance for conducting social-cost benefit analysis.

(b) Explain the features of social-cost benefit analysis.

(c) Discuss the UNIDO approach and Little-Mirrlees approach to social-cost benefit analysis.

(d) Explain the social-cost benefit analysis in India.

6.1 INTRODUCTION

The term “social costs” refers to all those harmful consequences and damages which the community on the whole sustains as a result of productive processes and for which private entrepreneurs are not held responsible. The definition of the concept is comprehensive enough to include even certain “social opportunity costs”, avoidable wastes and social inefficiencies of various kinds. Implicit in such an appraisal is the assumption that the principal objective of investment decision-making is to maximize the net present value of monetary flow or some variant of it.

The social cost-benefit analysis is a tool for evaluating the value of money, particularly of public investments in many economies. It aids in making decisions with respect to the various aspects of a project and the design programs of closely interrelated projects. Cost benefit analysis has become important among economists and consultants in recent years.

6.2 NEED FOR COST-BENEFIT ANALYSIS

The essence of the theory of social cost-benefit analysis is that it does not accept that the actual receipts of a project adequately measure social benefits and actual expenditures measure social costs. The reason is that actual prices may be an inadequate indicator of economic benefits and costs. For example, in developing countries like India, the prices of necessities are set low, despite their economic importance, while the prices of less essential goods are set high (through a system of taxes and duties). As a result, some projects which appear very profitable when their outputs and inputs are valued at actual prices are, in fact, unattractive from the viewpoint of the national economy, while other apparently unprofitable projects have high economic returns. But the theory accepts that actual receipts and expenditures can be suitably adjusted so that the difference between them, closely analogous to ordinary profit, will properly reflect the social gain.

In Social-Cost Benefit Analysis (SCBA) the focus is on social costs and benefits of a project. These often tend to differ from the costs incurred in monetary terms and benefits earned in monetary terms by the project. The principal reasons for discrepancy are:

(i) *Market imperfections:* Market prices, which form the basis for computing the monetary costs and benefits from the point of view of project sponsor, reflect social values only under conditions of perfect competition, which are rarely, if ever, realized by developing countries. When imperfections obtain, market prices do not reflect social values.

The common market imperfections found in developing countries are: (i) rationing, (ii) prescription of minimum wage rates, and (iii) foreign exchange regulation. Rationing of a commodity means control over its price and distribution. The price paid by a consumer under rationing is often significantly less than the price that would prevail in a competitive market. When minimum wage rates are prescribed, the wages paid to labour are usually more than what the wages would be in a competitive labour market free from such wage legislations. The official rate of foreign exchange in most of the developing countries, which exercise close regulation over foreign exchange, is typically less than the rate that would prevail in the absence of foreign exchange regulation. This is why foreign exchange usually commands premium in unofficial transactions.

(ii) *Externalities*: A project may have beneficial external effects. For example, it may create certain infrastructural facilities like roads which benefit the neighbouring areas. Such benefits are considered in SCBA, though they are ignored in assessing the monetary benefits to the project sponsors because they do not receive any monetary compensation from those who enjoy this external benefit created by the project. Likewise, a project may have a harmful external effect like environmental pollution. In SCBA, the cost of such environmental pollution is relevant, though the project sponsors do not incur any monetary costs.

It may be emphasized that externalities are relevant in SCBA because in such analysis all costs and benefits, irrespective to whom they accrue and whether they are paid for or not, are relevant.

(iii) *Taxes and subsidies*: From the private point of view, taxes are definite monetary costs and subsidies are definite monetary gains. From the social point of view, however, taxes and subsidies are generally regarded as transfer payments and hence considered irrelevant.

(iv) *Concern for savings*: Unconcerned about how its benefits are divided between consumption and savings, a private firm does not put differential valuation on savings and consumption. From a social point of view, however, the division of benefits between consumption and savings (which leads to investment) is relevant particularly in capital-scarce developing countries. A rupee of benefits saved is deemed more valuable than a rupee of benefits consumed. The concern of society for savings and investment is duly reflected in SCBA wherein a higher valuation is placed on savings and lower valuation is put on consumption.

(v) *Concern for redistribution*: A private firm does not bother how its benefits are distributed across various groups in the society. The society, however, is concerned about the distribution of benefits across different groups. A rupee of benefit going to a poor section is considered more valuable than a rupee of benefit going to an affluent section.

(vi) *Merit wants*: Goals and preferences not expressed in the market place, but believed by policy makers to be in the larger social interest, may be referred to as merit wants. For example, the government may prefer to promote adult education or a balanced nutrition programme for school-going children even though these are not sought by consumers in the market place. While merit wants are not relevant from the private point of view, they are important from the social point of view.

6.3 PROCEDURE OF SCBA

The objective of social cost-benefit analysis is, in its widest sense, to secure and achieve the value of money in economic life by simply evaluating the costs and benefits of alternative economic choices and selecting an alternative which offers the largest net benefit, i.e. the highest margin of benefit over cost.

Very broadly, social-cost benefit analysis involves the following steps:

1. Estimates of costs and benefits which will accrue to the project-implementing body.

2. Estimates of costs and benefits which will accrue to individual members of society as consumers or as suppliers of factor input.

3. Estimates of costs and benefits which will accrue to the community.

4. Estimates of costs and benefits which will accrue to the National Exchequer.

5. Discounting the costs and benefits which accrue over a period of time to determine the feasibility of the project.

Here again, the non-quantifiable benefits are stated only in descriptive terms. These strategies will work towards the appropriate calculation of the profitability ratio. While this is the general approach to project formulation, implementation and evaluation, the same may be modified to suit the circumstances.

6.4 MAIN FEATURES OF SOCIAL COST-BENEFIT ANALYSIS

Prest and Turvey defined cost-benefit analysis as “a practical way of assessing the desirability of projects, where it is important to take a long view in the sense (looking at repercussions in the future as well as the near future and a wide view in the sense of allowing side-effects of many decisions relating to industries, regions etc.), i.e., it implies the enumeration and evaluation of all the relevant cost and benefits”. This definition focuses attention on the main features of cost-benefit analysis. It covers five distinct issues:

1. Assessing the desirability of projects in the public, as opposed to the private sector.

2. Identification of costs and benefits.

3. Measurement of costs and benefits.

4. The effect of (risk and uncertainty) time in investment appraisal.

5. Presentation of results– the investment criterion.

6.5 UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION (UNIDO) APPROACH

Towards the end of the sixties and in the early seventies two principal approaches for SCBA emerged: the UNIDO approach and the Little-Mirrlees approach. This section discusses the UNIDO approach; the following discusses the Little-Mirrlees approach.

The UNIDO method of project appraisal involves five stages:

1. Calculation of financial profitability of the project measured at market prices.

2. Obtaining the net benefit of project measured in terms of economic (efficiency) prices.

3. Adjustment for the impact of the project on savings and investment.

4. Adjustment for the impact of the project on income distribution.

5. Adjustment for the impact of project on merit goods and demerit goods whose social values differ from their economic values.

Each stage of appraisal measures the desirability of the project from a different angle.

The measurement of financial profitability of the project in the first stage is similar to the financial evaluation. So, skipping the first stage, the remaining stages are being discussed here.

Net benefit in terms of economic (efficiency) prices

Stage two of the UNIDO approach is concerned with the determination of the net benefit of the project in terms of economic (efficiency) prices, also referred to as shadow prices.

The UNIDO approach suggests three sources of shadow pricing, depending on the impact of the project on national economy. A project as it uses and produces resources may for any given input or output (i) increase or decrease the total consumption in the economy, (ii) decrease or increase production in the economy, (iii) decrease imports or increase imports, or (iv) increase exports or decrease exports.

If the impact of the project is on consumption in the economy the basis of shadow pricing is consumer willingness to pay. If the impact of the project is on production in the economy, the basis of shadow pricing is the cost of production. If the impact of project is on international trade-increase in exports, decrease in imports, increase in imports, or decrease in exports— the basis of shadow pricing is the foreign exchange value.

Shadow pricing of tradable inputs and outputs: A good is fully traded when an increase in its consumption results in a corresponding increase in import or decrease in export or when an increase in its production results in a corresponding increase in export or decrease in import. For fully traded goods, the shadow price is the border price, translated in domestic currency at market exchange rate. The above definition of a fully traded good implies that domestic changes in demand or supply affect just the level of imports or exports.

Non-tradable inputs and outputs: A good is non-tradable when the following conditions are satisfied: I) its import price (CIF price) is greater than its domestic cost of production and (ii) its export price (FOB price) is less than its domestic cost of production.

The valuation of non-tradables is done as per the principles of shadow pricing discussed earlier. On the output side, if the impact of the project is to increase the consumption of the product in the economy, the measure of value is the marginal consumers' willingness to pay; if the impact of the project is to substitute other production of the same non-tradable in the economy, the measure of value is the saving in cost of production. On the input side, if the impact of the project is to reduce the availability of the input to other users, their willingness to pay for the input represents social value; if the project's input requirement is met by additional production of it, the production cost of it is the measure of social value.

Externalities: An externality, also referred to as an external effect, is a special class of good which has the following characteristics: (i) It is not deliberately created by the project sponsor but is an incidental outcome of legitimate economic activity, (ii) It is beyond the control of the persons who are affected by it, for better or for worse. (iii) It is not traded in the market place.

An external effect may be beneficial or harmful. Examples of beneficial external effects are:

(i) An oil company drilling in its own fields may generate useful information about oil potential in the neighbouring fields.

(ii) The approach roads built by a company may improve the transport system in that area.

(iii) The training programme of a firm may upgrade the skills of its workers thereby enhancing their earning power in subsequent employments.

Examples of harmful external effects are:

(i) A factory may cause environmental pollution by emitting large volume of smoke and dirt. People living in the neigbourhood may be exposed to health hazards and put to inconvenience.

(ii) The location of an airport in a certain area may raise noise levels considerably in the neighbourhood.

(iii) A highway may cut a farmer's holding in two, separating his grazing land and his cowsheds, thereby adversely affecting his physical output.

Since SCBA seeks to consider all costs and benefits, to whomsoever they may affect, external effects need to be taken into account. The valuation of external effects is rather difficult because they are often intangible in nature and there is no market price, which can be used as a starting point. Their values are estimated by indirect means.

The above examples serve to emphasize the difficulties in measuring external effects. In view of this, some economists have suggested that these effects be ignored. In order to justify their suggestion, they argue that since a project is likely to have both beneficial and harmful external effects, one may not err much in assuming that the net effect would be zero. This argument, seemingly a rationalization for one's ignorance, lacks validity. External effects must be taken into account wherever it is possible to do so. Even if these effects cannot be measured in monetary terms, some qualitative evaluation must be attempted.

Measurement of the impact on distribution

Stages three and four of the UNIDO method are concerned with measuring the value of a project in terms of its contribution to savings and income redistribution. To facilitate such assessments we must first measure the income gained or lost by individual groups within the society.

For income distribution analysis, the society may be divided into various groups. The UNIDO approach seeks to identify income gains and losses by the following: (i) Project, (ii) Other private business, (iii) Government, (iv) Workers, (v) Consumers, (vi) External sector.

There are, however, other equally valid groupings.

The gain or loss to an individual group within the society as a result of the project is equal to the difference between shadow price and market price of each input or output in the case of physical resources or the difference between price paid and value received in the case of financial transaction.

Savings impact and its value— Most of the developing countries face scarcity of capital. Hence the governments of these countries are concerned about the impact of a project on savings and its value thereof. Stage three of the UNIDO method, concerned with this, seeks to answer the following questions:

(i) Given the income distribution impact of the project what would be its effect on savings?

(ii) What is the value of such savings to the society?

Impact on savings of a project is equal to

$\sum \Delta Y_i MPS_i$

where, ΔY_i = change in income of group i as a result of the project

MPS_i = marginal propensity to save of group i

Value of savings of a rupee is the present value of the additional consumption stream produced when that rupee of savings is invested at the margin. The additional stream of consumption generated by a rupee of investment depends on the marginal productivity of capital and the rate of reinvestment from additional income. If the marginal productivity of capital is r and the rate of reinvestment from additional income a, the additional stream of consumption generated by a rupee of investment can be worked out. The consumption stream starts with r (1 – a) and grows annually at the rate of ar forever. Its present value when discounted at the social discount rate k is:

$$I = \frac{r(1-a)}{(1+k)} + \frac{r(1-a)(1+ar)}{(1+k)^2} + \ldots + \frac{r(1-a)(1+ar)^{n-1}}{(1+k)^n} + \ldots$$

$$= \frac{\frac{r(1-a)}{(1+k)}}{1 - \frac{(1+ar)}{(1+k)}} \qquad = \frac{r(1-a)}{(k-ar)}$$

where, I = social value of a rupee of savings (investment)

r = marginal productivity of capital

a = reinvestment rate on additional income arising from investment

k = social discount rate.

Income distribution impact— Many governments regard redistribution of income in favour of economically weaker sections or economically backward regions as a socially desirable objective. Due to practical difficulties in pursuing the objective of redistribution entirely through the tax, subsidy, and transfer measures of the government, investment projects are also considered as instruments for income redistribution and their contribution toward this goal is considered in their evaluation. This calls for suitably weighing the net gain or loss by each groups, measured earlier, to reflect the relative value of income for different groups and summing them.

Adjustment for merit and demerit goods

In some case, the analysis has to be extended beyond stage four to reflect the difference between the economic value and social value of resources. This difference exists in the case of merit goods and demerit goods. A merit good is one for which the social value exceeds the economic value. For example, a country may place a higher social value than economic value on production of oil because it reduces dependence on foreign supplies. The concept of merit goods can be extended to include a socially desirable outcome like creation of employment. In the absence of the project, the government perhaps would be willing to pay unemployment compensation or provide mere make-work jobs.

In the case of a demerit good, the social value of the good is less than its economic value. For example, a country may regard alcoholic products as having social value less than economic value.

The procedure for adjusting for the difference between social value and economic value is as follows: (i) Estimate the economic value. (ii) Calculate the adjustment factor as difference between the ratio of social value to economic value and unity. (iii) Multiply the economic value by the adjustment factor to obtain the adjustment. (iv) Add the adjustment to the net present value of the project as calculated in stage four.

6.6 LITTLE-MIRRLEES APPROACH

I.M.D. Little and J.A. Mirrlees have developed an approach (hereafter referred to as the L-M approach) to social cost benefit analysis. The LM technique assumes that a country can buy and sell any quantity of a particular good at a given world price. Hence, all traded inputs and outputs are valued at their international prices (CIF for importables and FOB for exportables) which is the opportunity cost/value of the particular good to the country. Every input is treated as a forex outgo and every output is treated as a forex inflow. All non-tradable inputs are valued at accounting prices. These costs are broken up into tradable goods and other non-traded goods. Following this chain of production, commodities that are either exported or imported are determined for application of accounting prices. The theory assumes that non-tradables form an insignificant part of operating costs

Despite considerable similarities there are certain differences between the two approaches:

1. The UNIDO approach measures costs and benefits in terms of domestic rupees whereas the L-M approach measures costs and benefits in terms of international prices, also referred to as border prices.

2. The UNIDO approach measures costs and benefits in terms of consumption whereas the Little-Mirrlees approach measures costs and benefits in terms of uncommitted social income.

3. The stage-by-stage analysis recommended by the UNIDO approach focuses on efficiency, savings and redistribution considerations in different stages. The Little-Mirlees approach, however, tends to view these considerations together.

6.7 SCBA IN INDIA

In India, SCBA of projects is carried out mainly by the Project Appraisal Division of Planning Commission and the Central financial institutions.

Project Appraisal Division

The Project Appraisal Division (PAD, hereafter) of the Planning Commission, set up in April 1972, was entrusted with the following functions:

1. To suggest standard formats for submission of projects and procedures for their techno-economic evaluation;

2. To conduct actual techno-economic evaluation of selected major projects and programmes posed to the Planning Commission;

3. To assist state government and central ministries in giving effect to standardized formats and procedures for project evaluation; and

4. To undertake and support research leading to progressive refinement of methodology and procedure of project evaluation.

The Project Appraisal Division follows a modified version of the L-M methodology. In order to eliminate the trade-offs between growth (efficiency) and equity, PAD divides investments into three categories: (i) capital-intensive industrial projects, (ii) infrastructural investments, and (iii) agriculture, rural development and related projects. The procedure followed by PAD for evaluating capital intensive industrial projects is described briefly below:

Capital Intensive Industrial Projects— Efficiency is the key criterion in the evaluation of capital intensive industrial projects which represent about 20 per cent of the total projects appraised by PAD. The methodology followed for evaluating these projects is as follows:

1. All tradeable inputs and outputs are valued at border prices.

2. Transfer cost items (taxes, duties, etc.) are ignored.

3. All non-tradeable items, especially power and transport, are evaluated in terms of marginal cost.

4. Foreign exchange involved in the inputs and outputs are valued at specified premia.

5. Saving in domestic rupees rather than foreign exchange.

Central Financial Institution

The Central financial institutions—ICICI, IFCI, and IDBI—appraise investment proposals primarily from the financial point of view. However, in recent years they have recognized the need for scrutinizing projects from the larger social point of view. ICICI was perhaps the first financial institution to introduce a system of economic analysis as distinct from financial profitability analysis. IFCI adopted a system of economic appraisal in 1979. Finally, IDBI also introduced a system for economic appraisal of projects financed by them. Though there are some minor variations, the three institutions follow essentially a similar approach which is a simplified version of the L-M approach. The appraisal procedure followed by IDBI is described below:

IDBI, in its economic appraisal of industrial projects, considers three aspects:

- Economic rate of return
- Effective rate of protection
- Domestic resource cost

Economic rate of return— The method followed by IDBI to calculate economic rate of return may be described as 'partial Little-Mirrlees' method because while international prices are used for valuation of tradeable inputs and outputs, L-M method is not followed in its entirety. The significant elements of IDBI's method are described below:

1. International prices are regarded as the relevant economic prices and, hence, it is necessary to substitute market prices with international prices for all non-labour inputs and outputs.

2. For tradeable items, where international prices are directly available, CIF prices are used for inputs and FOB prices are used for outputs.

3. For tradeable items where international prices are not directly available and for non-tradeable items (like electricity, transportation, etc.) social conversion factors are used to convert actual rupee cost into social cost. In some cases (like land) a social conversion factor is applied directly to the actual rupee cost. In other cases (like transport) the actual rupee cost is broken down

into three components— tradeable component, labour component, and residual component— and these components are valued in social terms. Generally, the social cost of the tradeable component is obtained by multiplying it by a factor of 1/1.5; the social cost of labour component is obtained by multiplying it by a factor of 0.5 (shadow price of labour is considered to be 50 per cent of the actual); the social cost of the residual component is obtained by multiplying it by a factor of 0.5.

Effective rate of protection— The effective rate of protection (ERP) is calculated as follows:

$$\frac{\text{Value added at domestic prices - Value added at world prices}}{\text{Value added at world prices}} \times 100$$

Domestic resource cost— The domestic resource cost (DRC) is calculated as follows:

$$\frac{\text{Value added at domestic prices}}{\text{Value added at world prices}} \times \text{Exchange Rate}$$

6.8 PUBLIC INVESTMENT DECISION MAKING IN INDIA

The public sector has been assigned a pre-eminent role in the Indian economy. Though public investment was made in the infrastructure even before independence, the bulk of the investment in the public sector has been made after independence. The public sector today commands a predominant position in many basic industries: coal, crude oil and refining, steel, copper, basic drugs, locomotives, fertilizers, earth movers, machine tools, etc.

The public investment board (PIB) appraises and recommends the projects coming under the purview of the central government. The PIB is assisted by various agencies in its appraisal work. The criteria adopted by the PIB are as follows:

1. Conformity of the project with the priorities specified in the plan for allocation of funds.

2. Advisability of undertaking the project in the public sector or joint sector.

3. Adequacy of financial internal rate of return.

4. Adequacy of economic internal rate of return. (This is the internal rate of return of the stream of social costs and benefits.)

5. Contribution of the project to foreign exchange earnings.

6. Availability of plan funds and convenience of budgetary allocation.

7. Logical sequencing of project schedule.

8. Adequacy of safety and anti-pollution measures.

9. Soundness of marketing strategy.

6.9 LIMITATION OF SOCIAL COST-BENEFIT ANALYSIS

The nature of social benefits and costs are such that there cannot be any standard method or technique applicable to all types of investment projects. A bridge, a road, a housing colony, or an industrial project will each require a different approach while identifying and measuring its social benefits and costs. For one thing, the nature of inputs and outputs of projects involving very large investment— and their impact on the ecology and people of the particular region and the country as a whole are bound to differ from case to case.

At another level too, the problems of qualification and measurement of social costs and benefits are formidable. This is because many of these costs and benefits are intangible and their evaluation in terms of money is bound to be subjective. Even with honesty of purpose, assessment of social good and social evil is likely to be tained by the analyst’s own ideas and subjective preferences and the resulting decision may not serve the socio-economic goals which might have been initially formulated.

Moreover, a successful application of the techniques of analysis depends upon the accuracy and reliability of forecasts. Even when evaluation of social costs and benefits has been completed for one project, it may be difficult to judge whether any other project would yield better results from the social point of view. If all possible alternative investments are sought to be socially assessed, the costs would be prohibitive.

However, the limitations of analysis should not deter one from applying the techniques so far evolved. The element of subjectivity can be reduced by cross-checks. Even economic assessments suffer from certain drawbacks due to distortions in the price-mechanism caused by imperfections in the labour market, government controls, tariffs and quotas, and price inflation. Finally, while the limitations should not be ignored, it would be a folly to disregard the gains of social evaluation of investments.

6.10 SUMMARY

The social cost-benefit analysis is a very significant tool to assess the overall feasibility of a project, both in the private and public sectors by providing a useful framework for clarifying important issues and separating factors and judgements. Although the process is bound by limitation, its value is not diminished. Broadly, it is applicable to tactical decision-making within the broad planning framework that is based on a wider range of considerations, which are usually socio-political and socio-cultural in nature. As for the entrepreneurs, an awareness of social cost-benefit will enhance their contribution to society. In the coming years, efforts will be made by social scientists to perfect this analytical process by removing or overcoming the limitations and universally accepting it in deciding on a project. As in all matters of social evaluation, we would be on safer grounds if we could rely on objective standards of social minima and measure social costs in terms of shortfalls or deficiencies from such minima. In short, economic science would then be said to deal with the problem of social economy and would finally prove its status as a system of knowledge concerned with the study of the nature and causes of wealth of nations. Thus, social costs, social returns and social values are important dimensions in project analysis.

6.11 KEYWORDS

Social Cost: It refers to all those harmful consequences and damages which the community on the whole, sustains as a result of productive processes and for which private entrepreneurs are not held responsible.

Social-Cost Benefit Analysis: It is a tool for evaluating the value of money particularly of public investments.

Non-tradable: A good is non-tradable when its import price si greater than its domestic cost of production and its export price is less than its domestic cost of production.

6.12 SELF ASSESSMENT QUESTIONS

1. Discuss the need for conducting social-cost benefit analysis.
2. Explain the UNIDO approach to conduct social-cost benefit analysis.
3. Write a detailed note on social-cost benefit analysis in India.
4. Discuss the limitations of social cost benefit analysis.

6.13 SUGGESTED READINGS

1. Projects Preparation, Appraisal, Budgeting and Implementation by Prasanna Chandra, Tata McGraw Hill Publishing Company Ltd., New Delhi.

2. Project Management by Vasant Desai, Himalaya Publishing House, New Delhi.

3. Project Management and Control by C. Keshava Rao, Sultan Chand and Sons, New Delhi.

Lesson - 7

MULTIPLE PROJECTS AND CONSTRAINTS

STRUCTURE

7.0 OBJECTIVE

After reading this lesson, you should be able to

a) Understand the constraints in the selection of new projects.

b) Explain the techniques of mathematical programming that may be applied in project management.

7.1 INTRODUCTION

When investment projects are considered individually, any of the discounted cash flow technique may be applied for obtaining a correct accept or reject criteria. In an existing organisation, however, capital investment projects often cannot be considered individually or in isolation. This is because the pre-conditions for viewing projects individually- project independence, lack of capital rationing, and project divisibility- are rarely, if ever, fulfilled. Under the constraints obtained in the real world, the so-called rational criteria per se may not necessarily signal the correct decision.

7.2 CONSTRAINTS

Project Dependence : Project A and B are economically dependent if the acceptance or rejection of one changes the cash flow stream of the other or affects the acceptance or rejection of the other. The most conspicuous kind of economic dependency occurs when projects are mutually exclusive. If two or more projects are mutually exclusive, acceptance of any one project out of the set of mutually exclusive project automatically precludes the acceptance of all other projects in the set. From an economic point of view, mutually exclusive projects are substitutes for each other. For example, the alternative possible uses of a building represent a set of mutually exclusive projects. Clearly if the building is put to one use, it cannot be put to any other use.

Economic dependency also exists when projects, even though not mutually exclusive, negatively influence each other's cash flows if they are accepted together. Bierman and Smidt have given an excellent illustration of this kind of economic dependency: a project for building a toll bridge and a project for operating a toll ferry. These two project are such that when they are undertaken together, the revenues of one will be negatively influenced by the other.

Further, the projects are said to have positive when there is complementarity between projects. If undertaking a project influences favourably the cash flows of another project, the two projects are complementary projects. Complementarity may be of two types: asymmetric complementarity and symmetric complementarity. In asymmetric complementarity, the favourable effect extends only in one direction.

Capital Rationing: Capital rationing exists when funds available for investment are inadequate to undertake all projects which are otherwise acceptable. Capital rationing may arise because of an internal limitation or an external constraint. Internal capital rationing is caused by a decision taken by the management to set a limit to its capital expenditure outlays; or, it may be caused by a choice of hurdle rate higher than the cost of capital of the firm. Internal capital rationing, in either case, results in rejection of some investment projects which otherwise are acceptable.

External capital rationing arises out of the inability of the firm to raise sufficient amounts of funds at a given cost of capital. In a perfect market, a firm can obtain all its funds requirement at a given cost of capital. In the real world, however, the firm can raise only a limited amount of funds at a given cost of capital. Beyond a certain point, the cost of capital tends to increase.

Project Indivisibility : Capital projects are considered indivisible, i.e. a capital project has to be accepted or rejected in toto - a project cannot be accepted partially.

Given the indivisibility of capital projects and the existence of capital rationing, the need arises for comparing projects. To illustrate this point, consider an example. A firm is evaluating three projects A, B, and C which involve an outlays of Rs. 0.5 million, Rs. 0.4 million, and Rs. 0.3 million respectively. The net present value of these projects are Rs. 0.2 million, Rs. 0.15 million, Rs. 0.1 million respectively. The funds available to the firm for investment are Rs. 0.7 million. In this situation, acceptance of project A (project with the highest net present value) which yields a net present value of Rs. 0.2 million results in the rejection of projects B and C which together yield a combined net present value of Rs. 0.25 million. Hence, because of the indivisibility of projects, there is a need for the comparison of projects before the acceptance/rejection decisions are taken.

7.3 METHOD OF RANKING

Two approaches are available for determining which project to accept and which projects to reject : (i) the method of ranking, and (ii) the method of mathematical programming. This section discusses the method of ranking ; the following section discusses the method of mathematical programming.

The method of ranking consists of two steps : (i) Rank all projects in a decreasing order according to their individual NPV's, IRR's or BCR's. (ii) Accept project in that order until the capital budget is exhausted.

The method of ranking, originally proposed by Joel Dean is seriously impaired by two problems: (i) conflict in ranking as per discounted cash flow criteria, and (ii) project indivisibility.

Conflict in Ranking

In a given set of projects, preference ranking tends to differ from one criterion to another. For example, NPV and IRR criteria may yield different preference rankings. Likewise, there may be a discrepancy between the preference rankings of NPV and BCR (benefit cost ratio) criteria. When preference rankings differ, the set of projects selected as per one criterion tends to differ from the set of projects selected as per some other criterion. This may be illustrated by an example.

Consider a set of five projects, A, B, C, D, and E, for which the investment outlay, expected annual cash flow, and project life are as shown below:

Project	Investment outlay	Expected annual cash flow	Project life
	(Rs)	(Rs)	(Years)
A	10,000	4,000	12
B	25,000	10,000	4
C	30,000	6,000	20
D	38,000	12,000	16
E	35,000	12,000	9

The NPV, IRR and BCR for the five projects and the ranking along these dimensions are shown in Exhibit 7.1

Exhibit 7.1 NPV, IRR and BCR for the Five Projects

Project	NPV (Rs)	NPV Ranking	IRR (Per cent)	IRR Ranking	BCR	BCR Ranking
A	14,776	4	39	1	2.48	1
B	5,370	5	22	4	1.21	5
C	14,814	3	19	5	1.49	4
D	45,688	1	30	2	2.20	2
E	28,936	2	29	3	1.83	3

It is clear that in the above case the three criteria rank the projects differently. If there is no capital rationing, all the projects would be accepted under all the three criteria though internal ranking may differ across criteria. However, if the funds available are limited, the set of projects accepted would depend on the criterion adopted.

What causes ranking conflicts? Ranking conflicts are traceable to differing assumptions made about the rate of return at which intermediate cash flows are re-invested.

Project Indivisibility

A problem in choosing the capital budget on the basis of individual ranking arises because of indivisibility of capital expenditure projects. To illustrate, consider the following set of projects (ranked according to their NPV) being evaluated by a firm which has a capital budget constraint of Rs. 2,500, 000.

Project	Outlay	NPV
	Rs.	Rs.
A	1,500,000	400,000
B	1,000,000	350,000
C	800,000	300,000
D	700,000	300,000
E	600,000	250,000

If the selection is based on individual NPV ranking, projects A and B would be included in the capital budget- these projects exhaust the capital budget. A cursory examination, however, would suggest that it is more desirable to select projectsB, C, and D. These three projects can be accommodated within the capital budget of Rs. 2,500,000, and have a combined NPV of Rs. 850,000, which is greater than the combined NPV of projects A and B.

Feasible Combinations Approach

The above example suggests that the following procedure may be used for selecting the set of investments under capital rationing.

1. Define all combinations of projects which are feasible, given the capital budget restriction and project interdependencies.

2. Choose the feasible combination that has the highest NPV.

To illustrate this procedure, consider the following projects that are being evaluated by a firm which has a capital budget constraint of Rs. 3,000,000.

Project	Outlay	NPV
	Rs.	Rs.
A	1,800,000	750,000
B	1,500,000	600,000
C	1,200,000	500,000
D	750,000	360,000
E	600,000	300,000

Projects B and C are mutually exclusive. Other projects are independent

Given the above information the feasible combinations and their NPV are shown below:

Feasible combination	Outlay	NPV
	Rs.	Rs.
A	1,800,000	750,000
B	1,500,000	600,000
C	1,200,000	500,000
D	750,000	360,000
E	600,000	300,000
A and C	3,000,000	1,250,000
A and D	2,550,000	1,110,000
A and E	2,400,000	1,050,000
B and D	2,250,000	960,000
B and E	2,100,000	900,000
C and D	1,950,000	860,000
C and E	1,800,000	800,000
B,D and E	2,850,000	1,260,000
C, D and E	2,550,000	1,160,000

The most desirable feasible combination consists of projects B, D and E as it has the highest NPV.

7.4 MATHEMATICAL PROGRAMMING APPROACH

The ranking procedure described above becomes cumbersome as the number of projects increases and as the number of years in the planning horizon increases. To cope with a problem of this kind, it is helpful to use mathematical programming models. The advantage of mathematical programming models is that they help in determining the optimal solution without explicitly evaluating all feasible combinations.

A mathematical programming model is formulated in terms of two broad categories of equations: (i) the objective function, and (ii) the constraint equations. The objective function represents the goal or objective the decision maker seeks to achieve. Constraint equations represent restrictions-arising out of limitations of resources, environmental restrictions, and managerial policies-which have to be observed. The mathematical model seeks to optimize the objective function subject to various constraints.

Though a wide variety of mathematical programming models is available, but we should discuss two types:

- Linear programming model.
- Integer programming model.

7.5 LINEAR PROGRAMMING MODEL

The linear programming model is based on the following assumptions :

- The objective functions and the constraint equations are linear.
- All the coefficients in the objective function and constraint equations are defined with certainty.
- The objective function is unidimensional.
- The decision variables are considered to be continuous.
- Resources are homogeneous. This means that if 100 hours of direct labour are available, each of these hours is equally productive.

Linear Programming Model of a Capital Rationing Problem

The general formulation of a linear programming model for a capital rationing problem is:

Maximize $$\sum_{j=1}^{n} NPV_J X_J \qquad (7.1)$$

Subject to $$\sum_{j=1}^{n} CF_{jt} X_j \leq \mathbf{K_t (t = 0,1,.....,m)} \qquad (7.2)$$

$$0 \leq X_j \leq 1 \qquad (7.3)$$

where NPV_J = net present value of projects j

X_j = amount of projects j accepted

CF_{jt} = cash outflow required for project j in period t

K_t = capital budget available in period t

The following features of the model may be noted.

1. All the input parameters-NPV_J,CF_{JT}, K_t- are assumed to be known with certainty.
2. The X_j decision variables are assumed to be continuous but limited by a lower restriction (0) and an upper restriction (1).
3. The NPV calculation is based on a cost of capital figure which is known with certainty.

Lorie and Savage Problem

In their classic paper, "Three Problems in Rationing Capital," Lorie and Savage discussed the following nine-project, two-period problem:

Project	Net present value (NPV_j)	Cash outflow in period (CF_{j1})	Cash outflow in period 2 (CF_{j2})
1.	14	12	3
2.	17	54	7
3.	17	6	6
4.	15	6	2
5.	40	30	35
6.	12	6	6
7.	14	48	4
8.	10	36	3
9.	12	18	3

The linear programming formulation of this problem is as follows :

Maximize $14X_1 + 17X_2 + 17X_3 + 15X_4 + 40X_5$
$+ 12X_6 + 14X_7 + 10X_8 + 12X_9$

Subject to

$12X_1 + 54X_2 + 6X_3 + 6X_4 + 30X_5 + 6X_6$
$+ 48X_7 + 36X_8 + 18X_9 + S_1$ = 50 Funds constraint for year1

$3X_1 + 7X_2 + 6X_3 + 2X_4 + 35X_5 + 6X_6$

$+ 4X_7 + 3X_8 + 3X_9 + S_2$ $= 20$ Funds constraint for year 2

$X_1 + S_3 = 1$	$X_4 + S_6 = 1$	$X_7 + S_9 = 1$	Upper limit
$X_1 + S_3 = 1$	$X_4 + S_6 = 1$	$X_7 + S_9 = 1$	Upper limit
$X_2 + S_4 = 1$	$X_5 + S_7 = 1$	$X_8 + S_{10} = 1$	on project
$X_3 + S_5 = 1$	$X_6 + S_8 = 1$	$X_9 + S_{11} = 1$	acceptance

$$X_j \geq \mathbf{0\ (\ j = 1,2\ ,\ldots\ldots,\ 9)}$$

$$S_j \geq \mathbf{0\ (\ i = 1,2\ ,\ldots\ldots,\ 11)}$$

The linear programming solution for the above problem is shown in Exhibit 7.2 . From Exhibit 7.2 we find that

1. The basic variables (variables which take a positive value in the optimal solution) are X_1, X_3, X_4, X_6, X_7, X_9, S_4, S_7, S_8, S_9, and S_{10}. Their values are shown in the last coloumn of the tableau ($X_1 = 1.0$; $X_3 = 1.0$; $X_4 = 1.0$; $X_6 = .969697$, and so on).
2. The rest of the variables (X_2, X_5, X_8, S_1, S_2, S_3, S_5, S_6, and S_{11}) are non-basic variables, which means that they take a zero value. A value of zero for X_1, X_3, and X_8 means that these three projects are completely rejected in the optimal solution. A value of zero for S_1 and S_2 implies that the budgets of 50 in year 1 and 20 in year 2 are fully exhausted on the six accepted projects.

7.6 INTEGER LINEAR PROGRAMMING MODEL

Weingartner discussed the integer linear programming approach. The principal motivation for the use of integer linear programming approach are : (i) It overcomes the problem of partial projects which besets the linear programming model because it permits only 0 or 1 value for the decision variables. (ii) It is capable of handling virtually any kind of project interdependency.

The basic integer linear programming model for capital budgeting under capital rationing is as follows :

Exhibit 7.2 ***Linear Programming Formulation of Optimum Lorie-Savage Nine-Project Problem***

Basic Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	RHS
X_1	1.0											1.0									1.00
X			1.0											1.0							1.00
X_4				1.0											1.0						1.00
X_6		.455			5.91	1.0				-.015	.1818	-3.64			-2.73					-2.73	.96969
X_7		1.068			-.144		1.0	.75		.023	-.023	-.205		-1.0	-0.91					-.341	.04545
X_9									1.0											1.0	1.00
S_4		1.0											1.0								1.00
S_7					1.0											1.0					1.00
S_8		-.455			5.91					0.15	.1818	.364		-1.0	.273		1.0			.273	.03030
S_9		-1.068			.114			-.75		-.023	.023	.205			.091			1.0		.341	.95454
S_{10}								1.0											1.0		1.00
Z	0	3.41	0	0	29.32	0	0	.50	0	.1364	1.864	6.77	0	5.0	10.45	0	0	0		3.957	0.273
	μ_1	μ_2	μ_3	μ_4	μ_5	μ_6	μ_7	μ_8	μ_9	p_1	p_2	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7	γ_8	γ_9	

Maximize $$\sum_{j=1}^{n} X_J NPV_J \qquad (7.4)$$

Subject to $$\sum_{j=1}^{n} CF_{jt} X_j \leq \mathbf{K_t (t=0,1,.....,m)} \qquad (7.5)$$

$$X_j = (0, 1) \qquad (7.6)$$

It may be noted that the only difference between this integer linear programming model and the basic linear programming model discussed earlier is that the integer linear programming model ensures that a project is either completely accepted (X_j = 1) or completely rejected (Xj = 0).

Incorporating Project Interdependencies in the Model

By constraining the decision variables to 0 and 1, the integer linear programming model can handle almost any kind of project interdependency. To illustrate, let us see how the following kinds of projects interdependencies are incorporated in the integer linear programming model :

- Mutual exclusiveness
- Contingency
- Complementariness

Mutual Exclusiveness If two or more projects are mutually exclusive, acceptance of any one project out of the set of mutually exclusive projects, automatically precludes the acceptance of all other projects in the set. From an economic point of view, mutually exclusive projects are substitutes for each other. Mutual exclusiveness is reflected in the integer programming model by the following constraint :

$$\sum_{J \in J} X_j \leq 1 \qquad (7.7)$$

where J = the set of mutually exclusive projects under consideration

$J \in J$ = an expression which means that project J belongs to set J

Constraint (7.7) means that the upper limit on the number of projects that can be selected from the set J is 1. This , of course, means that the firm may not select any project from the set J. If it is necessary to choose one project but only one project, constraint (7.11) would become :

$$\sum_{J \in J} X_j = 1 \tag{7.8}$$

An important variant of the mutual exclusiveness condition is one in which the firm may delay a projects for one or more years. Consider, for example, projects X :

Time	Cash flow
0	-10,000
1	3,000
2	3,000
3	3,000
4	3,000
5	3,000

The NPV of this project, given a cost of capital of 12 percent, is 814. If the firm can delay this project by 1 or 2 years, two new projects X' and X" can be defined :

Time	Cash flow of X'	Cash flow of X"
0	-	-
1	-10,000	-
2	3,000	-10,000
3	3,000	3,000
4	3,000	3,000
5	3,000	3,000
6	3,000	3,000
7	-	3,000

The NPV's of projects X' and X" to be included in the objective function are respectively 727 and 649. These values naturally differ from the NPV of X because of delays in cash flows associated with X' and X". Since at best only one of the projects-X, X' and X"-can be accepted, the following constraint is incorporated in the integer linear programming model :

$$X + X' + X'' \leq 1 \qquad (7.9)$$

Contingency: A contingency relationship between two or more projects implies that the acceptance of one project is contingent on the acceptance of some other project (s). For example, if project B cannot be accepted without accepting project A, we say that project B is contingent on project A. Put differently, project A is a prerequisite project for project B. Such a relationship is represented by the following constraint in the integer linear programming model.

$$X_B \leq X_A \qquad (7.10)$$

It may be noted that as per constraint (7.10), project B can be accepted only when project A is accepted; project A however, can be accepted independently.

A project may be contingent on not one but two (or even more) projects. Suppose, the acceptance of project R is contingent on the acceptance of projects P and Q. Such a contingency relationship is reflected in the following constraint.

$$2X_R \leq X_P + X_Q \qquad (7.11)$$

Mutual Exclusiveness and Contingency : Project dependency may reflect both mutual exclusiveness and contingency requirements. Some examples are described below :

1. P and Q are mutually exclusive projects; a third project, Z, is contingent on the acceptance of either P or Q. This condition is reflected in the following constraints:

$$X_P + X_Q \leq 1 \qquad (7.12)$$

$$X_Z \leq X_P + X_Q \qquad (7.13)$$

2. Out of the set of projects, A, B, C and D, only three projects can be accepted. Further, for accepting project E at least two projects out of the above set should be accepted. This condition is reflected in the following constraints :

$$X_A + X_B + X_C + X_D \leq 3 \quad (7.14)$$

$$2X_E \leq X_A + X_B + X_C + X_D \quad (7.15)$$

Complementariness If undertaking a project influences favourably the cash flows of an other project, the two projects are complementary projects. To illustrate how complementarity is reflected in the integer linear programming model, consider two projects R and S. Either of them can be accepted individually. However, if both are accepted together the following benefits will accrue : (i) The cost will reduce by 5 percent. (ii) The net cash inflow will increase by 10 percent. To reflect a complementary relationship of this kind, a composite project *RS* representing the combination of R and S is set up; the cash inflows of RS would be 10 percent higher than the sum of the cash inflows of R and S. Further, since it is not possible to accept R and S as well as RS, because the latter is the composite project consisting of R and S, the following constraint is incorporated in the integer linear programming formulation:

$$X_R + X_S + X_{RS} \leq 1 \quad (7.16)$$

Integer Linear Programming Formulation : An Illustration

Consider the following projects.

Project	Net present value (NPV_J)	Cash outflow in year 1 (CF_{J1})	Cash outflow in year 2 (CF_{J2})
1	44	50	48
2	30	40	22
3	20	10	40
4	25	36	5
5	35	25	60
6	24	43	15
7	42	40	0
8	28	33	14
9	60	75	48

The budget constraints for the two years are 150 and 180 respectively. The following project interdependencies obtain:

1. Projects 1 and 2 are mutually exclusive.
2. Out of the set of projects 4, 5, and 6 at least too must be accepted.
3. Project 9 cannot be accepted unless projects 4 and 6 are accepted.
4. Project 7 can be delayed by one year. Such a delay would not change the cash outflows but reduce NPV to 35.
5. Project 8 and 9 are complementary. If the two are accepted together, the total outflows will be less by 8 percent whereas the NPV will be more by 10 percent.

Given the nature of the problem, in addition to the decision variables X_1 through X_9 for the original 9 projects, few additional decision variables are required as follows:

X_{10} is the decision variable to represent the delay of project 7 by one year.

X_{11} is the decision variable for the composite project which represents the combination of projects 8 and 9.

The integer linear programming formulation is as follows:

Maximize $44X_1 + 30X_2 + 20X_3 + 25X_4 + 35X_5 + 24X_6$

$+ 42X_7 + 28X_8 + 60X_9 + 35X_{10} + 96.8X_{11}$

Subject to

$$50X_1 + 40X_2 + 10X_3 + 36X_4 + 25X_5 + 43X_6$$
$$+ 40X_7 + 33X_8 + 75X_9 + 0X_{10} + 99.4X_{11} \leq 150$$
$$48X_1 + 22X_2 + 40X_3 + 5X_4 + 60X_5 + 15X_6$$
$$+ 0X_7 + 14X_8 + 48X_9 + 40X_{10} + 47.88X_{11} \leq 180$$
$$X_1 + X_2 \leq 1$$
$$2X_9 \leq X_4 + X_6$$
$$X_7 + X_{10} \leq 1$$

$$X_8 + X_9 + X_{11} \leq 1$$

$$X_j = \{0,1\} \; j = 1, 2, ..., 11$$

Evaluation

The merits of the integer linear programming model are :

1. It overcomes the problem of partial projects which besets the linear programming model.
2. It is capable of handling virtually any kind of project interdependency.

The main limitations of the integer linear programming model are :

1. The solution of linear programming model takes considerably more time than the solution of the integer of the linear programming model. Pettway reported that for an integer linear programming model with 28 projects and 15 budget constraints, four out of six algorithms that he tried failed to reach an optimal solution in 5 minutes in CPU time on an IBM 360-65 system; the two algorithms which located the optimal solution took 118 seconds and 181 seconds. By contrast, the solution time for the linear programming model of the same problem would take just one to two seconds.

2. Meaningful shadow prices are not available for the integer programming formulation. This happens because the integer linear programming model permits only discrete variation, not continuous variation, of the decision variable. In the integer linear programming model, constraints which are not binding in the optimal solution are assigned zero shadow prices though the objective function would decrease when the availability of resources representing non-binding constraints, is diminished.

7.7 SUMMARY

In the selection of new projects, these are many constraints which include project dependence, capital rationing and project indivisibility. Capital rationing exists when funds available for investment are inadequate to undertake all projects which are otherwise acceptable. Method of ranking and method of mathematical programming are the two approaches available for determining the acceptance or rejection of projects.

The method of ranking consists of ranking of all projects in a decreasing order according to their individual NPV or IRR or BCR and acceptance of projects in that order until the capital budget is exhausted. Mathematical programming models help in determining the optimal solution without explicitly evaluating all feasible combinations. The mathematical model seeks to optimize the objective function subject to various constraints. Linear programming model and integer programming model are the important types of mathematical programming model.

7.8 KEYWORDS

Capital Rationing: It exists when funds available for investment are inadequate to undertake all project which are otherwise acceptable.

Project Indivisibility: When a capital project is to accepted or rejected in toto and cannot be accepted partially it is said to be project in divisibility.

Mathematical Programming Model: It is a model which helps in determining the optimal solution without explicitly evaluating all feasible combinations.

7.9 SELF ASSESSMENT QUESTIONS

1. Discuss the sources of capital rationing.
2. Construct a set of five projects for which there is conflict in ranking as per the NPV, IRR, and BCR criteria.
3. Describe the feasible combinations approach. Illustrate it with a numerical example.
4. What assumptions underlie the linear programming model?
5. Critically evaluate the integer linear programming model as a tool for capital budgeting.
6. Discuss the following in the context of a goal programming model: objective function, economic constraints, and goal constraints.

7.10 SUGGESTED READING

J.H. Lorie and L.J.Savage, "Three Problems in Rationing Capital," Journal of Business, vol. 28 (Oct 1955), pp. 227-239.

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Joel Dean : Capital Budgeting, Columbia University Press.

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Lesson - 8

NETWORK TECHNIQUES FOR PROJECT MANAGEMENT

STRUCTURE

8.0 OBJECTIVE

After reading this lesson, you should be able to

a) Explain the role of network techniques in project management.

b) Make use of the network techniques for planning scheduling and controlling the different activities of the project.

8.1 INTRODUCTION

Projects are successful if they are completed on time, within budget, and to performance requirements. Management of any project involves planning, coordination and control of a number of interrelated activities with limited resources, namely men, machines, money and time. Furthermore, it becomes necessary to incorporate any change from the initial plan as they occur, and immediately know the effects of the change. Therefore the managers are compelled to look for and depend on a dynamic planning and schedule system which will not only produce the best possible initial plan and schedule, but will also sufficiently dynamic to react instantaneously to changed in the original plan and schedule. The question of such a dynamic system/ technique led to the development of *network analysis.* It provides a framework which :

- defines the job to be done,
- integrates them in a logical time sequence and finally,
- affords a system of dynamic control over the progress of the plan.

Network analysis is a generic name for a number of associated project planning and control procedures that are all based on the concept of network. PERT, an acronym for Program Evaluation and Review Technique and CPM, an acronym for Critical Path Method are the two widely used techniques of project management that were developed, independently and simultaneously, during the 1950s. The network analysis underlying PERT and CPM helps to support the three phases of effective project management.

Planning

- identify the distinct activities,
- determine their durations and interdependencies,
- construct a network diagram,
- determine minimum overall project duration (using the network diagram), and
- identify the tasks critical (i.e. essential) to this minimum duration.

Scheduling

- construct schedule ('time chart'),
- schedule contains start and finish times for each activity, and
- evaluate cost-time trade-offs (evaluate effects of putting extra money, people or machines in a particular task in order to shorten project duration).

Controlling

- monitor/control project by use of network diagram,
- follow progress of the various activities ; and
- make adjustment where appropriate.

8.2 PERT/CPM : BACKGROUND and DEVELOPMENT

PERT and CPM- both techniques use similar network models and methods are have the same general purpose. They were developed during the late 1950s. PERT was originally developed by the U S Navy's Special Product Office in cooperation with the consulting firm of Booz, Allen and Hamilton. It was developed as a network flow chart to facilitate the planning and scheduling of the Polaris Fleet Ballistic Missile Project, a massive project with about 250 contractors and about 9000 sub contractors and its application is credited with saving two years from the original of five years required to complete the project. Designed to handle risk and uncertainty, PERT is eminently suitable for research and development and programmes, aerospace projects, and other projects involving new technology. In such projects the time required for completing various jobs or activities can be highly variable. Hence the orientation of PERT is 'probabilistic'. CPM, is akin to PERT. It was developed (Independently) in 1956-57 by the Du Pont Company in the US to solve scheduling problems in industrial settings. CPM is primarily concerned with the trade-off between cost and time. It has been applied mostly to projects that employ fairly stable technology and are relatively risk free. Hence its orientation is 'deterministic'.

As both PERT and CPM approaches to Project Management use similar network models and methods, the term PERT and CPM are sometimes used interchangeably or collectively as PERT-CPM methods. The differences between those tools come from how they treat the activity time. PERT treats activity time as a random variable whereas CPM requires a single deterministic time value for each activity. Another difference is that PERT focuses exclusively on the time variable whereas CPM includes the analysis of the time/Cost trade-off.

The PERT/CPM is capable of giving answers to the following questions to the project manager :

- when will the project be finished ?
- when is each individual part of the scheduled to start and finish ?
- of the numerous jobs in the project, which one must be timed to avoid being late ?
- is it possible to shift resources to critical jobs of the project from other non-critical jobs of the project without affecting the overall completion time of the project ?
- among all the jobs in the project, where should management concentrate its efforts at one time ?

Methodologically, PERT/CPM were developed from traditional GANTT Charts used for scheduling and reviewing the progress of activities. Developed by Harry Gantt in 1916, these charts give a time line for each activity. They are used for planning, scheduling and then recording progress against these schedules.

Basically there are two basic types of Gantt Charts : Load Charts and Project Planning Charts.

Load Charts : This type of chart is useful for manufacturing projects during peak or heavy load periods. The format of the Gantt Load Chart is very similar to the Gantt Project Planning Chart, but, Load Chart, uses time as well as departments, machines or employees that have been scheduled.

Project Planning Chart

It addresses the time of individual work elements giving a time line for each activity of a project. This type of chart is the predecessor of the PERT. As it can be seen in the Figure, it is really easy to understand the graph, but in developing it you need to take into consideration certain precedence relationship between the different activities of the project. On the chart, everyone is able to see when each activity start and finishes but there is no possibility to determine when each activity may start or if we can start a particular activity before finishing the immediate predecessor activity. Therefore, we need somehow know the precedence relationship between activities. This is the main reason for using the PERT/CPM tools instead of using exclusively Gantt Charts. Widely diverse kind of projects can be analyzed by the techniques of PERT/CPM. In fact they are suitable for any situation where :

(a) the project consists of well-defined collection of activities or tasks.

(b) the activities can be started and terminated independently of each other, even if the resources employed on the various activities are not independent.

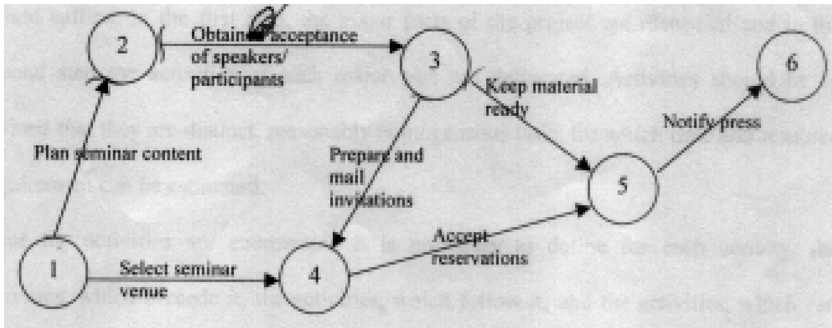
(c) the activities are ordered so that they can be performed in a technological sequence. Thus precedence relationships exist which preclude the start of certain activities until other are completed. For instance, road levelling cannot start unless the roadbed is laid.

We now proceed to discuss the techniques to provide answers to the types of questions stated earlier. The initial step in each of these is to portray the given project graphically by means of network, which provide the basic tool for analysis.

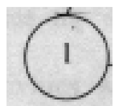
8.3 DEVELOPMENT OF PROJECT NETWORK

Basic to network analysis is the networks diagram. Both the methods of PERT and CPM graphic representation of a project that it is called “Project Network” or “Project Diagram” or “CPM Diagram”, and it is used to portray graphically the interrelationships of the elements of a project and to show the order in which the activities must be performed. A simple network chart for a ‘Seminar Planning Project’ is shown in Figure 8.1 as an example.

Figure 8.1 Project Network



In order to represent a project network, two basic elements are used :



A circle called **"node",** represents an event. An event describes a checkpoint. It does not symbolize the performance of work, bit it represents the point in time in which the event is accomplished.

An arrow, called **"arc"**, represents an activity-a recognizable part of the project involving mental or physical work and requiring time and resources for its completion. The network will try to reflect all the relationships between the activities.

Since activities are the basic building blocks of a network diagram, it is necessary to enumerate all the activities of the project. For this purpose, it is helpful to break the project in several steps. The number of steps, of course, would depend on the magnitude and complexity of the project. For industrial projects generally a two-step procedure would suffice. In the first step, the major parts of the project are identified and in the second step the activities of each major part are delineated. Activities should be so defined that they are distinct, reasonably homogeneous tasks for which time and resources requirement can be estimated.

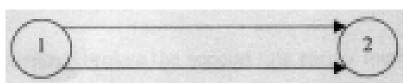
Once the activities are enumerated it is necessary to define for each activity, the activities, which precede it, the activities which follow it, and the activities which can take place concurrently. Given this information, the network diagram, showing the logical relationship between activities and events may be developed following either the forward method or the backward method.

The forward method begins with the initial events, marking the beginning of the project, and proceeds forward till the end event is reached. The backward method begins with the end event and works backwards till the beginning event is reached.

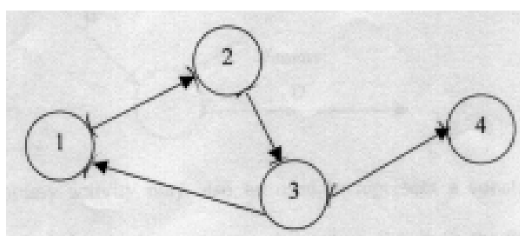
Rules for constructing a project network :

Three simple rules govern the construction of a project network :

1) Each activity must be represented by only one directed arc or arrow.
2) No two activities can begin and end on the same two nodes circle. A situation like the one shown in the following figure is not permissible.



3) There should be no loops in the network. A situation like the one shown in the figure given below is not permissible.

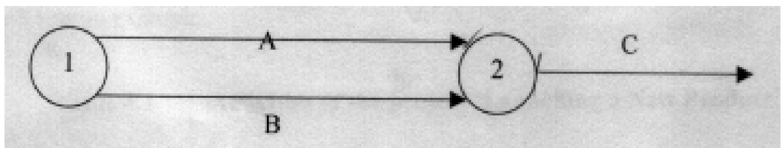


Another element to represent a project network is a "*dummy activity*".

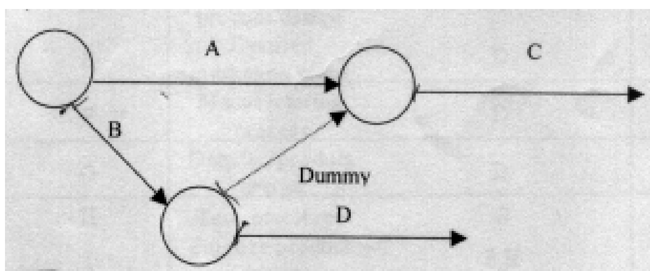
Tasks that must be completed in sequence but that don't require resources or completion time are considered to have event dependency. These are represented by dotted lines with arrows and are called dummy activities. To explain it, we will consider the following example :

ACTIVITY	IMMEDIATE PREDECESSOR
A	....
B	....
C	A, B
D	B

The temptation is to represent these relationships as :



But then we have broken the second earlier mentioned. To show that activities A and B precede C, whereas activity B precedes activity D, we use a dummy activity as shown in the following figure.



A dummy activity may also be used to represent a constraint necessary to show the proper relation ship between activities. As shown in the following figure, activities A and B must be completed before activity C can be start, only activity B must be completed before activity D can start.

To construct a project network, first of all, we need a list of activities, showing the precedence relationships between the different activities involved is shown in Table 8.1 as an example.

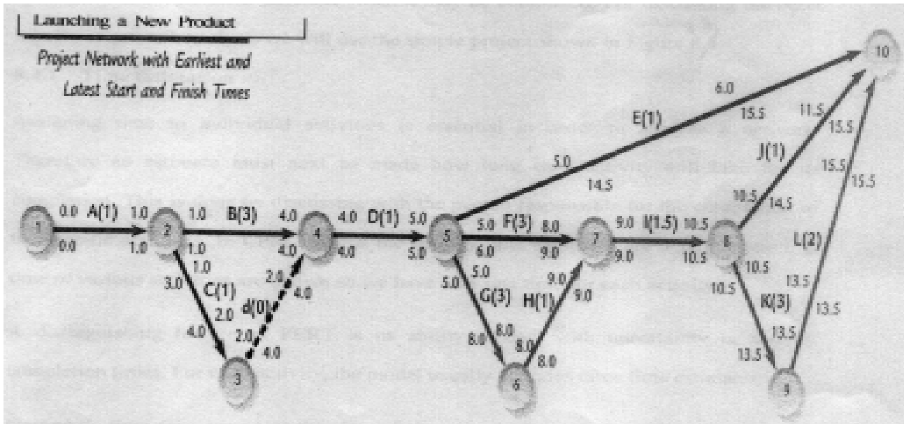
Table 8.1 Activities of the Project 'Launching a New Product'

ACTIVITY	NAME	IMMEDIATE PREDECESSOR	DURATION (months)
A	Market analysis	....	1
B	Product Design	A	3
C	Manufacturing study	A	1
D	Select best product design	B, C	1
E	Detailed marketing plans	D	1
F	Manufacturing process	D	3
G	Detailed project design	D	3
H	Test prototype	G	1
I	Finalize product design	F, H	1,5
J	Order components	I	1
K	Order production equipment	I	3
L	Install production equipment	K	2

Figure 8.2 shows the network with the Earliest Start time, Earliest Finish time, Latest Start time and Latest Finish time of the activities (these will be discussed later in the lesson).

Because each activity must have a unique pair of starting and ending nodes, we must use a dummy activity to draw the first four activities, as shown in the figure. Constructing a project network is a trial-and-error process. It usually takes two or three attempts to produce a neatly constructed network.

Figure 8.2 Network of the Project 'Launching a New Product'



8.4 TIME ANALYSIS

Once the logic and details of the project network have been established, time estimates must be assigned to each activity. With this representation we can determine the minimum completion time for the project i.e. the critical path and the critical activities and the slack or float of other activities, so that we can find the activity schedule i.e. when each activity should start and when it may be completed. For discussing these aspects of network analysis we will use the simple project shown in Figure 8.3.

8.4.1 Time Estimation

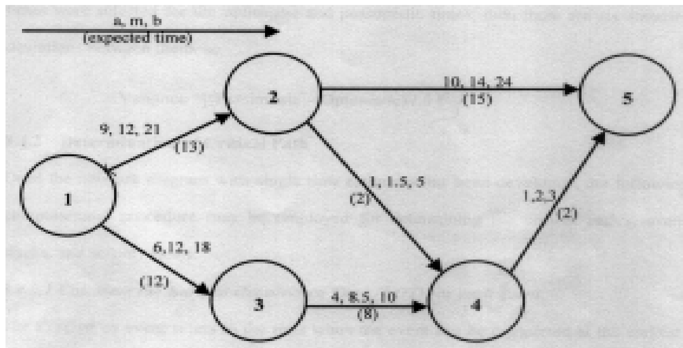
Assigning time to individual activities is essential in order to analyze a network. Therefore an estimate must next be made how long each activity will take for its completion. This is done by discussing with the people responsible for the completion of the specific activities. In CPM analysis the activity time estimates are deterministic i.e. time of various activities are known so we have only one time for each activity.

A distinguishing feature of PERT is its ability to deal with uncertainty in activity completion times. For each activity, the model usually includes three times estimates:

Optimistic time (a) - generally the shortest time in which the activity can be completed under ideal, favorable conditions. It is common practice to specify optimistic times to be three standard deviations from the mean so that there is approximately a 1% chance that the activity will be completed within the optimistic time.

Most likely time (m) **-** the completion time under the normal conditions, having the highest probability. Note that this time is different from the expected time.

Figure 8.3 Network with Three Time Estimates (in weeks)



Pessimistic time (b) - the longest time under worst, externally unfavorable conditions, which an activity might require. Three standard deviations from the mean is commonly used for the pessimistic time.

PERT assumes a beta probability distribution for the time estimates. For a beta distribution, the expected time for each activity can be approximated using the following weighted average :

Expected time = (Optimistic + 4 x Most likely + Pessimistic) / 6

$t_e = (a + 4m + b)/6$

This expected time might be displayed on the network diagram as shown in Figure 8.3

8.4.2 Determination of Critical Path

Once the network diagram with single time estimates has been developed, the following computational procedure may be employed for determining the critical path/s, event slacks, and activity floats.

8.4.2.1 Calculate the Earliest Occurrence Time (EOT) for each Event.

The EOT of an event refers to the time when the event can be completed at the earliest. Looking at event we find that the since the paths leading to it, viz, (1-2-4) and (1-3-4) take 15 weeks and 20 weeks, respectively, the EOT of event 4 is 20 weeks. In general terms, the EOT of an event is the duration of the longest path (from the beginning event whose EOT is set at 0) leading to that event. The EOTs of various events in our illustrative project are shown in Figure 8.4. It may be noted that in Figure 8.4 a circle represents an event. The upper half of the circle denotes the event number, the left quarter in the lower half denotes the EOT, and the right quarter in the lower half denotes the Latest Occurrence Time, (LOT) a term described the later.

The EOT of the end event obviously represents the minimum time required for completing the project. To obtain the EOT of various events we start from the beginning event and move forward towards the end event. This computational procedure is referred to as the *forward pass. In* this computation we assume that each activity starts immediately on the occurrence of the event preceding it. Hence the starting and finishing time for various activities obtained from this computation are the Earliest Starting Time (EST) and the Earliest Finishing Time (EFT).

The general formula for EOT is :

EOT (i) = Max [Eot(k) + d(k-i)]

where EOT (i) = earliest occurrence time of event i

EOT (k)=earliest occurrence time of event k (k precedes i and there may be several k's)

d (k-i) = duration of activity (k-i)

The maximisation shown is done considering all activities (k-i) leading to event node i have been completed.

The formulae for EST and EFT are :

EST (i-j) = EOT (i)

EFT (i-j) = EST (i-j)+d(i-j)

where EST (i-j) = earliest starting time for activity (i-j)

EOT (i) = earliest occurrence time of event (i)

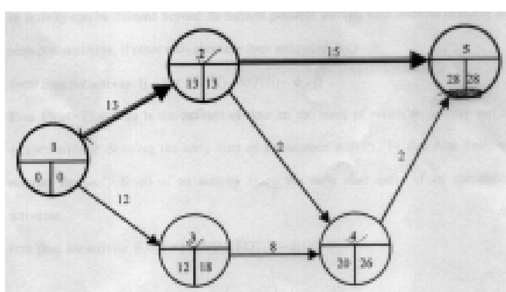
EFT (i-j) = earliest finishing time for activity (i-j)

d(i-j) = duration of activity (i-j)

8.4.2.2 Calculate the Latest Occurrence Time (LOT) for each Event.

The LOT for an event represents the latest allowable time by which the event can occur, given the time that is allowed for the completion of the project (occurrence of end event). Normally the time allowed for the completion of the project is set equal to the EOT of the end event (In other words, the project is supposed to be completed at the earliest possible time). This means that for the end event the LOT and EOT are set equal. The LOT for various events is obtained by working backward for the end event. This procedure is known as the *backward pass*. The LOT for event 4 in our illustrative project, for example, is equal to the LOT for event 5, the end event, minus the duration of the activity (4-5), which connects event 4 with 5. Since the LOT for event 5 is 28 weeks and duration of activity (4-5) is 2 week the LOT for event 4 is 26 weeks (28-2). This represents the latest time by which event 4 should occur to enable the project to be completed in 28 weeks. Likewise, the LOT for other events can be calculated by moving backward. The LOT for various events is shown (in the right quarter of the lower half of event nodes) in Figure 8.4

Figure 8.4 Network with EOT and LOT of Events



The general formula for LOT is :

LOT(i) = Min [LOT(i) - d(i-j)]

where LOT(i) = latest occurrence time of event i

LOT(i) = latest occurrence time of event j (ij follows i & there may be several j's)

d(i-j) = duration of activity (i-j).

The minimization shown here is done with respect to all activities (i-j) starting from i Given the LOT for various events we can calculate the Latest Finishing Time (LFT) and Latest Starting Time (LST) for various activities

The formulae for LFT and LST are :

LFT (i-j) = LOT (i)

LST (i-j) = LFT (i-j) -d (i-j)

where LFT (i-j) = latest finishing time for activity (i-j)

LOT (j) = latest occurrence time of event (j)

LST (i-j) = latest starting time for activity (i-j)

d (i-j) = duration of activity (i-j)

8.4.2.3 Calculate the Slack for each Event

The slack for an event is the difference between its LOT and EOT. The slacks for various events of our illustrative project are shown in Table 8.2

Table 8.2 Event Slack

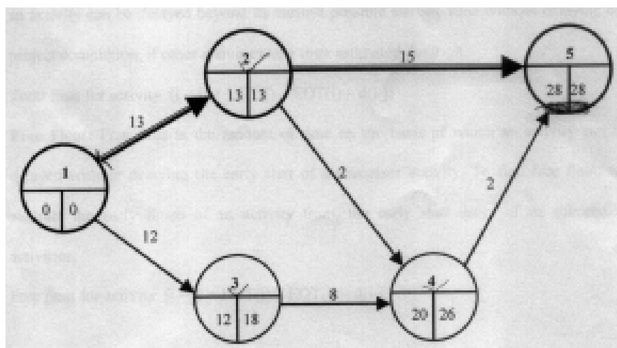
Event	LOT	EOT	Slack = LOT - EOT
1	0	0	0
2	13	13	0
3	18	12	6
4	26	20	6
5	28	28	0

8.4.2.4 Obtain the Critical and Slack Paths

A path is a sequence of activities that leads from the starting node to the finishing node. The critical path parts with the beginning event, terminates with the end event, and is marked by events, which have a zero slack. This is obviously the path on which here is no slack, no cushion. Other paths are slack paths with some cushion. The critical path for our illustrative project is (1-2-5). Dark arrows in Figure 8.5 indicate it.

Table 8.3 Critical and Slack Paths			
Path	Activities	Duration	Path Slack
1-2-4-5	1-2, 2-4, 4-5	17	28 - 17 = 11
1-3-4-5	1-3, 3-4, 4-5	22	28-22 = 6
1-2-5	1-2, 2-5	28	0

Figure 8.6 Critical Path in the Network



The critical path is the longest path from the beginning event to the end event. Since the end can be reached, i.e., project completed, only when this longest path is traversed, the minimum time required for completing the project is the duration on the critical path. The duration on the critical path of our project is 28 weeks; this is the minimum time required completing the project. (It is already indicated by the EOT of event 5, the end event.)

8.4.2.5 Calculate the Activity Floats

Activity float analysis provides the information on the margin on allowance available for the commencement and completion of various activities. Activities with zero slack value represent activities on the critical path. Three types of activities floats are identified:

- Total float
- Free float
- Independent float

Total Float : Total float usually referred to as simply float or slack, is the amount of time an activity can be delayed beyond its earliest possible starting time without delaying the project completion, if other activities take their estimated duration.

Total float for activity (i-j) = LOT(i) - EOT(i) - d(i-j)

Free Float : Free float is the amount of time on the basis of which an activity can be delayed without delaying the early start of a successor activity. To find free float, we subtract the early finish of an activity from the early start times of its succeeding activities.

Free float for activity (i-j) = EOT(i) - EOT(i) - d(i-j)

Independent Float : This indicates the time span by which the activity (i-j) can be expanded or shifted if, for the event (i) the LOT and for the event (j) the EOT shall be maintained. A shifting of activity in this area has no influence on the further progress of the project. Independent float is taken as zero is negative.

Independent float for activity (i-j) = EOT(i) - LOT(i) - d(i-j)

The floats of various activities of our illustrative project are shown in Table 8.4

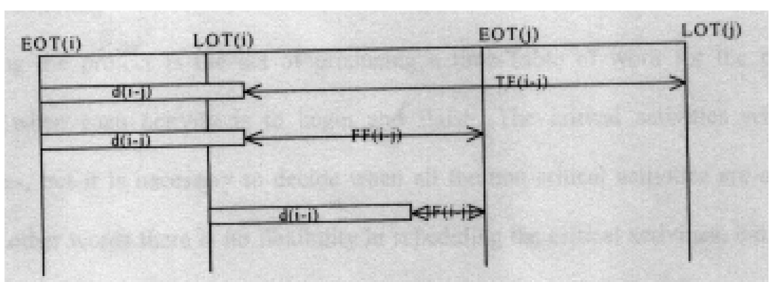


Table 8.4 Activities Floats

Activity	Duration	EST	EFT	LST	LFT	Total	Free	Independent
1-2	13	0	13	0	13	0	0	0
1-3	12	0	12	6	18	6	0	0
2-4	2	13	15	24	26	11	5	5
3-4	8	12	20	18	26	6	0	-6 i.e. 0
2-5	15	13	28	13	28	0	0	0
4-5	2	20	22	26	28	6	6	0

8.4.2.6 Scheduling

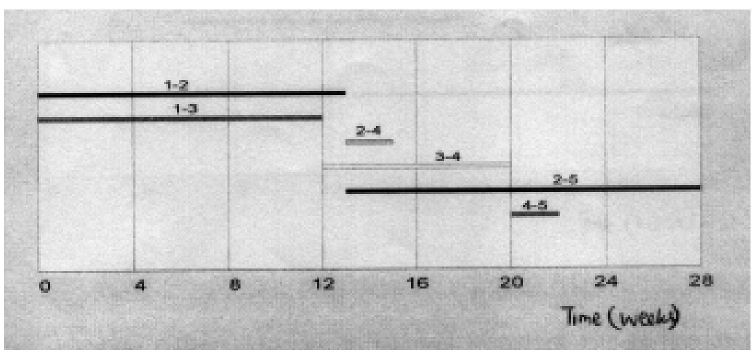
Scheduling the project is the act of producing a time-table of work for the project showing when each activity os to begin and finish. The critical activities schedule themselves, but it is necessary to decide when all the non-critical activities are to take place. In other words there is no flexibility in scheduling the critical activities, but floats available with non-critical activities provide flexibility in scheduling them. The choice available in this respect is bounded by two schedules: Early Start Schedule and Late Start Schedule

Early Start Schedule

The early start schedule refers to the schedule in which all activities start as possible. In this schedule

- all events occur at their earliest because all activities start at their earliest starting time and finish at their earliest finishing time;

Figure 8.6: Early Start Schedule



- there may be time legs between the completion of certain activities and the occurrence of events which these activities lead to; and
- all activities emanating from an event begin at the same time.

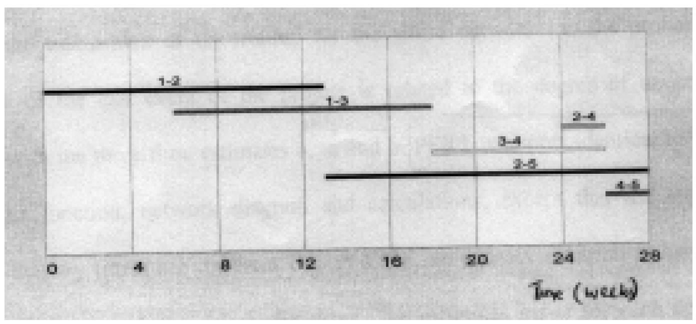
The early start schedule suggests a caution attitude towards the project and a desire to minimize the possibility of delay. It provides a greater measure of protection against uncertainties and adverse circumstances. Such a schedule, however, calls for an earlier application of resources.

Late Start Schedule

The late start schedule refers to the schedule arrived at when all activities started as late as possible. In this schedule

- all events occur at their latest because all activities start at their latest finishing time;
- some activities may start after a time lag subsequent to the occurrence of the preceding events; and
- all activities leading to an event are completed at the same time.

Figure 8.7: Late Start Schedule



The late start schedule reflects a desire to commit resources late-as late as possible. However, such a schedule provides no elbow room in the wake of adverse developments. Any anticipated delay results in increased project duration.

The early start schedule and the late start schedule for our illustrative project are shown in Figure 8.6 and 8.7 respectively. Here the project schedules are shown as graphs with a horizontal time scale.

8.4.2.7 PERT Analysis Variability in Time Estimates :

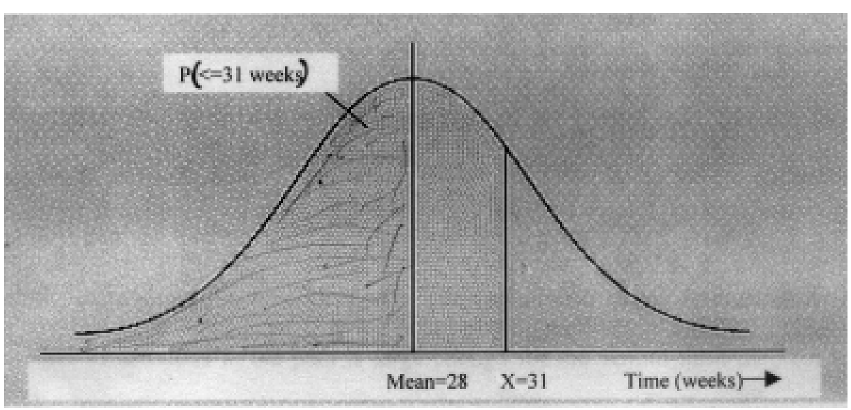
So far, we have discussed the procedure for determining the project completion time, the earliest and latest times for the start and completion of activities and the occurrence of events. In CPM analysis, activity duration are assumed to be known where as, in PERT, the activity duration is given by probability distributions.

PERT calculates the expected duration of an activity as a weighted average of the three time estimates-optimistic (a), most likely (m) and pessimistic (b) The PERT network provides a measure of the probability of completing the project by the scheduled date. The probability concept is only associated with PERT and not CPM, because, the activity time estimates in CPM are deterministic (i.e. known) and not probabilistic. In PERT, the assessment of uncertainty for the entire network i.e. the probability of occurrences of the end event of the project is related to the degree of uncertainty - associated with the three time estimates ***a,m*** and ***b***.

PERT is almost identical to CPM to regard to its function, network diagram and calculations, except that the method of estimating activities times are different i.e., in CPM, an activity duration is based on a single time estimate, whereas, there are three time estimates made for each activity in PERT, which is converted into one time estimate (i.e., expected time t_e) using the formula te = (a+4m+b)/6

Variability in PERT analysis is measured by standard deviation or its square, variance. The variance in the project completion time can be calculated by summing the variances in the completion of the time activities in the critical path. Given the expected time and the variance, one can calculate the probability that the project will be completed by a certain time assuming a normal probability distribution for the critical path. The normal distribution assumption holds if the number of activities in the path in large enough for the central limit theorem to be applied.

Figure 8.8 Normal Distribution of Critical Path Duration



Variance and Standard Deviation of activities :

To calculate the variance for each activity completion time, if three standard deviation times were selected for the optimistic and pessimistic times, then there are six standard deviations between them, so

$$\text{Variance} = [(\text{Pessimistic} - \text{Optimistic}) / 6]^2$$

$$\text{Standard Deviation} = [(\text{Pessimistic} - \text{Optimistic}) /6]$$

Table 8.5 Variance of activities

Activity	b	A	Var = $[(b-a)/6]^2$
1-2	21	9	4.00
2-5	24	10	5.44

Variance and Standard Deviation of Critical Path :

$$\text{Variance} = [(\text{Pessimistic} - \text{Optimistic}) /6]^2$$

$$= 4.00+5.44$$

$$= 9.44$$

$$\text{S.D} = (9.44)^{1/2}$$

$$= 3.07$$

Now we know that mean and standard deviation of the critical path duration for our project are 28 and 3.07 weeks, respectively. Given this information, we can calculate the probability that the project will be completed by a certain date.

Probability of Completion by a Specified Date

- Convert our specific normal distribution into standard normal distribution (with mean and standard deviation equal to 0 and 1 restrictively) i.e.

  Find z= (X- mean)/s.d.
- Obtain cumulative probablity up to z looking at the probability distribution of the standard normal variate (see Figure 8.8)

Example 1: Find the probability of completing the project by 31 weeks

Solution : $Z = (31-28)/3.07$

$= 0.97$

Required probability

($P<=31$ weeks)= 0.8340

Example 2 : Find the probability of completing the project by 20 weeks

Solution $Z = (20-28)/3.07$

$= -2.6$

Required probability

($P<=20$ weeks) = 0.0197

8.5 RESOURCE ANALYSIS AND ALLOCATION

In our discussion on the scheduling of activities in determining the scheduling timings, we have considered only the technological restriction, which lay that an activity in a project can not start unless all its predecessors have been scheduled and ignored the question of resource required the performing various activities. Now we will consider the question of resource requirement for different activities, the availability of resources and their allocation.

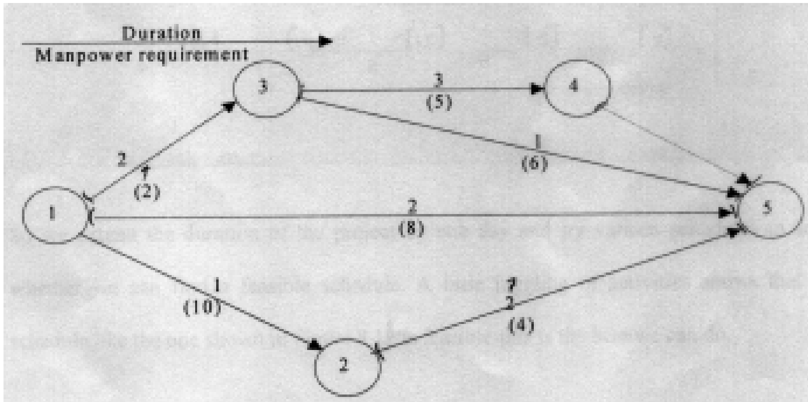
8.5.1 Scheduling in view of Resource Constraints

In real life situations, there may be restrictions on the availability of resource. For example, manpower supply may be limited or funds made available period wise may be rigidly budgeted. When restrictions exist various schedules may have to be considered to find out which one is most appropriate in the light of these restrictions. We shall discuss two example to indicate the broad approach to scheduling in the face of resource constraints.

Example 1: Scheduling to Match Availability of Manpower

Let us consider a small project for which the network diagram is shown in Figure 8.9. In this project network, activity duration is shown above the activity arrow and manpower requirement is shown below the activity arrow.

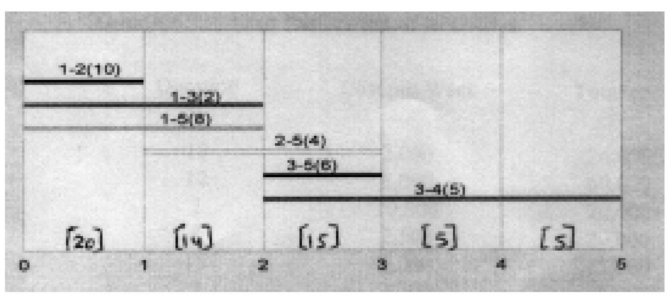
Figure 8.9 Network with Manpower Requirement of Activities



Only 12 men are available for the project (a manpower resource constraint). The early start schedule of this project is shown in Figure 8.10

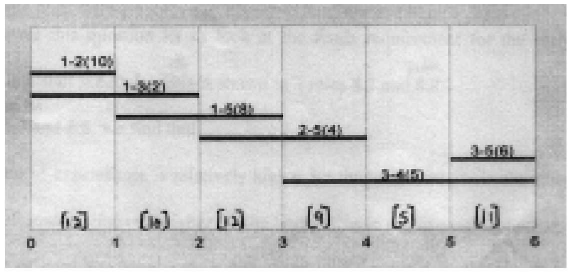
Looking at the manpower requirement for the early start schedule we find that it is 20 for the first day, 14 for the second day, 5 for the fourth day, and 5 for the fifth day. Obviously, this schedule is unacceptable in view of the manpower constraint. So, we explore the possibility of shifting activities. Our efforts of shifting activities, keeping the project duration at five days, soon reveals that no schedule is feasible with only 12 men.

Figure 8.10 Early Start Schedule and Manpower Requirement



So we extend the duration of the project by one day and try various schedules to see whether we can find a feasible schedule. A little juggling of activities shown that a schedule like one shown in Figure 8.11 is feasible-this is the best we can do.

Figure 8.11 Schedule to Match Manpower Supply



Example 2 : Scheduling to Match the Release of Funds

The cost estimates for various activities of our illustrative project are given in Table 8.6

Table 8.6 Cost Estimates of Activities

Activity	Duration	Cost per week	Total cost
1-2	13	2,000	26,000
1-3	12	5,000	60,000
2-4	2	10,000	20,000
3-4	8	2,500	20,000
2-5	15	1,000	15,000
4-5	2	7,500	15,000
		Total Cost	**156,000**

The Management has decided to release Rs 156,000 required for the project, in the following manner :

Rs 69,000 in the first 12 weeks; Rs 68,000 in the next 12 weeks, and Rs 19,000 in the 12 weeks. It has also stipulated that the unspent amount would lapse and hence cannot be carried forward.

Before we develop the project schedule, a preliminary question may be asked: Is it possible *prima facie* to schedule this project without extending its duration beyond 28 weeks, which is the minimum time required given the network logic and activity duration? To answer question let us look at the funds requirement for the early start schedule and late start schedule. As shown in Table 8.7 and Table 8.8

From the tables, we find that :

- The rate of expenditure is relatively higher for the earlier stages in the early start schedule and is relatively higher for the later stages in the late start schedule.
- A rate of spending greater than that of the early start schedule is not possible. (This is so because in the early start schedule all activities start as early as possible.) Any release of funds above the early start schedule requirement curve is beyond the capacity of the project to spend.

Table 8.7 Funds Requirements for ESS

Weeks	Activities	Funds Required	Cumulative Total
1-12	1-2, 1-3	7*12	84
13	1-2, 3-4	4.5*1	88.5
14-15	2-4, 3-4, 2-5	13.5*5	115.5
16-20	3-4, 2-5	8.5*2	150
21-22	2-5, 4-5	1 * 1	151
23	2-5, 4-5	1 * 1	152
25-27	2-5	1 * 3	155
28	2-5	1 * 1	156

Table 8.8 Funds Requirements for LSS

Rs (in thousand)

Weeks	Activities	Funds Required	Cumulative Total
1-6	1-2,	2*6	12
1-12	1-2,1-3	7*6	54
13	1-2,1-3	7*1	61
14-18	1-3,2-5	6*5	91
19-24	3-4,2-5	3.5*6	112
25-26	2-4,3-4,2-5	13.5*2	139
27-28	2-5,4-5	8.5*2	156

- The rate of spending corresponding to the late start schedule is the absolute minimum necessary to complete the project on time. If the rate of spending is less than that corresponding to the late start schedule the project duration will have to be necessarily extended.
- A pattern of funds release lying between the two buouds, early start schedule requirements and late start schedule requirement, *'prima facie'* suggests that a schedule can be worked out without extending project duration.

Let us now look at the cumulative funds release pattern for our illustrative project. This lies between the early start schedule requirement and late start requirement. So *'prima facie'* it suggests that a feasible schedule without extending the project duration can be developed. Let us proceed further and consider scheduling to match the release of funds. The activities that begin in first 12 weeks, according to the early start schedule are (1-2) and (1-3). If both these activities are commenced as early as possible, the fund requirement for this period would be Rs 84,000. Since this amount exceeds Rs 69,000 (the amount to be released in first 12 weeks), the expenditure in this period has to be reduced by Rs 15,000. For this we consider the possibility of shifting activities to subsequent periods. Looking at activities (1-2) and (1-3) we find that (1-2) is on the critical path, so there is no flexibility available with respect to it. Activity (1-3), however, can be shifted, as it is not on the critical path. Since activity (1-3) requires Rs 5,000 per week, it has to be shifted by three weeks so that the amount spent in first 12 weeks is equal to the amount released in first 12 weeks. Since there is a free float of six weeks for activity (1-3), we shift it by three weeks.

We now go to the next period of 12 weeks. The effects of shifting activity (1-3) by three weeks are as follows.

(a) The funds requirement for the next period of 12 weeks on account of activity (1-3) increases by Rs 15,000 over and above what it is for the early start schedule.

(b) The earliest starting time for activity (3-4) moves to 15 weeks from 12 weeks and the earliest finishing time moves to 23 weeks from 20 weeks. Since this shift.

Table 8.9 Funds Requirements for our Proposed Schedule

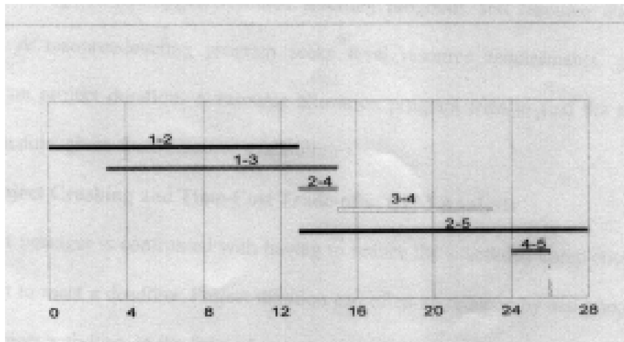
Rs (in thousand)

Weeks	Activities	Funds Required	Cumulative Total
1-3	1-2	2*3	6
4-12	1-2,1-3	7*9	69
13	1-2,1-3	7*1	76
14-15	1-3,2-4,2-5	16*2	108
16-23	3-4,2-5	3.5*8	136
24	2-5	1	137
25-26	2-5,4-5	8.5*2	154
27-28	2-5	1*2	156

occurs within the second period of 12 weeks, there is no change in funds requirement on account of activity (3-4).

(c) The earliest starting time for activity (4-5) moves to 23 weeks from 20 weeks and the earliest finishing time for activity (4-5) moves to 25 weeks from 23 weeks. This decreases the fund requirement for the second period of 12 weeks by the Rs 7,500. The net effect, therefore, is to increase funds requirement funds by Rs 7,500 over and above what it is for the earliest start schedule. Hence the total requirement becomes Rs 68,000+Rs 7,500 = Rs 75,500. However, the funds budgeted for the second period of 12 weeks are only Rs 68,000. So we consider the possibility of shifting some activities to the third period of 12 weeks. We find that by shifting activity (4-5) to the third period of 12 weeks the expenditure in the second period of 12 weeks can be reduced to Rs 68,000, the budget of that period. As a result of this shifting the expenditure for the third period of 12 weeks (first four weeks of it) equals the budgeted funds release for this period. The schedule arrived at finally is shown in Figure 8.12.

Figure 8.12 Schedule to Match Release of funds



Problems in Scheduling Real Life Projects

In the above discussion we have considered simple examples comprising few activities and one constraints, to indicate the broad approach. In real life projects the activities run into hundreds and there may be several constraints. The problem of scheduling in such cases tends to become very complex. For solving such problems the technique of linear programming can be used. However, when a problem has numerous activities, say, more than 100, the technique of linear programming becomes computationally unwieldy and inordinately expensive, even with the aid of fastest computer available.

In view of the practical difficulties in using linear programming for solving large scale scheduling problems, heuristic programs have been developed.

A heuristic is a rule of thumb like 'schedule critical activities first or schedule the activity which has the largest independent float in the end'. A heuristic program consists of a collection of such heuristic. In recent years many heuristic programs have been developed- they are formulated usually as computer programs. These programs may be broadly divided into two types : resource levelling programs and resource allocation programs. A resource - leveling programs seeks to resource requirements, given a constraint on project duration. A resource allocation program tries to find the shortest project schedule, given fixed resource availabilities.

8.5.2 Project Crashing and Time-Cost Trade-offs: CPM Analysis

The project manager is confronted with having to reduce the scheduled completion time of a project to meet a deadline. Project duration can often be reduced by assigning more labor to project activities, in the form of over time, and by assigning more resources, such as material, equipment, etc. However, the additional labor and resources increase the project cost. So, the decision to reduce the project duration must be base on analysis of the trade-off between time and cost.

'Project crashing' is a method for shortening the project duration by reducing the time of one or more of the critical project activities to less than its normal activity time. Crashing may become necessary because of many reasons, such as

- ➢ to reduce the scheduled completion time to reap the results of the project sooner.
- ➢ as project continuous over time, the team consumes indirect costs.
- ➢ there may be direct financial penalties for nor completing a project on time.

The goal of crashing is to reduce project duration at minimum cost. To reduce project duration while minimizing the cost of crashing, the project them should estimate normal time, normal cost, crash time, crash cost for each activities. And then the team can estimate total crash time, total crash cost, the crash cost per time unit to reduce project duration at minimum cost.

Assumptions underlying CPM analysis are :

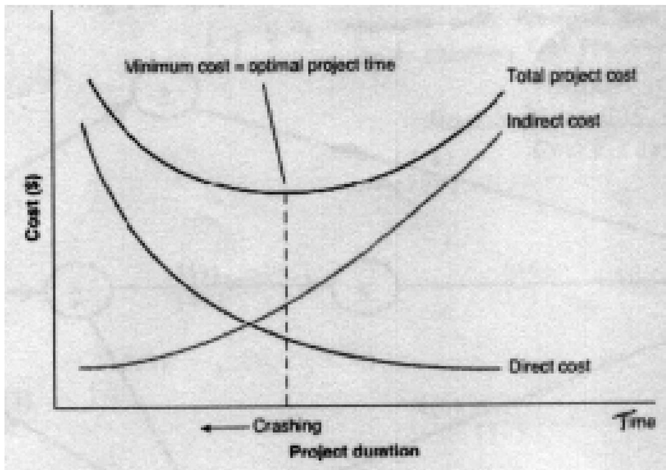
1. The cost associated with a project can be divided into two components: direct cost and indirect cost. Direct cost are incurred on direct material and direct labor. Indirect costs consists of overhead items like indirect supplies, rent, insurance, managerial services etc.

2. Activities of the project can be expedited by crashing which involves employing more resources.

3. Crashing reduces time but enhances direct cost because of factors like overtime payments, extra payments, and wastage. Project crashing cost and indirect costs have an inverse relationship; crashing costs are highest when the project is shortened, whereas

indirect costs increase as the project duration increase. So, the project time is at the minimum point on the total cost curve as below :

Figure 8.13 Project Costs



The Time-Cost trade-off analysis comprises the following steps.

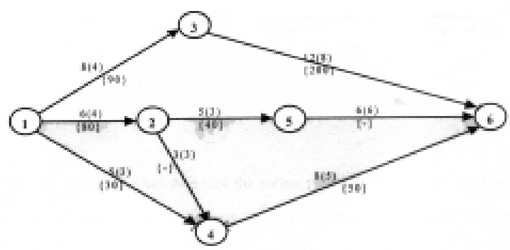
Step 1 The first step is to identify and crash the critical activity that has the minimum incremental cost of crashing. In the event of multiple critical paths, an activity from each such path is chosen. Of the various combinations available, the one with the least cost is selected. In particular, it may be economical to consider joint critical activities-activities that are common to two or more critical paths.

In each case, the crashing is done for one time unit-by a day if the activities times are given is days.

Step 2 In the second step, the network is revised by adjusting the time and the cost of the crashed activity. The critical path (s) is identified again, and we revert to the step1. This process is continued till no more crashing of the project is possible.

Now the optimal duration of the project can be determined. It would be the time duration corresponding to which the total cost-direct cost plus indirect cost-is the minimum. Let us consider the following example.

Figure 8.14 Network with Normal Time, Crash Time and Crashing Cost per day of activities duration.



Example : The network diagram in Figure 8.14 shows for each activity need to completes the project the normal time, the shortest time in which the activity can be completed of a building contract and the cost per day for reducing the time of each activity. The contract includes a penalty clause of Rs 100 per day over 17 days. The overhead cost per day is Rs 160. The cost of completing the eight activities in normal time is Rs 6,500.

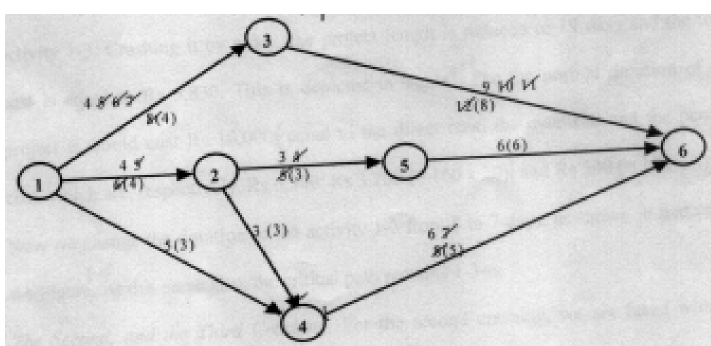
(a) Calculate the normal duration of the project, its cost and the critical path.

(b) Calculate and plot on a graph the cost/time function for the project and state:

(i) the lowest cost and the associated time.

(ii) the shortest time and associated cost.

Figure 8.15 Crashing of Activities



From the network, we can determine the normal project duration by the length of the critical path using normal activity time. The length of the critical path based of the crash times as shown here gives the minimum duration of the project :

Path	Normal Length	Crash Length
1-3-6	20 (critical)	12
1-4-6	13	8
1-2-4-6	17	12
1-2-5-6	17	13 (critical)

Accordingly, we have the normal and the minimum duration of the project equal to 20 and 13 days respectively.

Now we shall consider the time-cost relationship for this project when it is crashed successively by a period of one day, to know the total cost of the project for durations of 20 days through 13 days.

The First Crashing : In this example, the critical activities are 1-3 and 3-6 for which the cost of reduction per day is Rs 90 and Rs 200. Obviously, we would decide to crash the activity 1-3. Crashing it by a day, the project length is reduced to 19 days and the total cost is equal to Rs 9,380. This is depicted in Table 8.10. For the normal duration of the project it would cost Rs 10,000.(equal to the direct cost, the overhead and the penalty cost, which are, respectively, Rs 6,500; Rs 3,200(= 160 x 20); and Rs 300(= 100 x 3)). Now we change the duration of the activity 1-3 from 8 to 7 days, as shown in Figure 8.15. At this stage also, the critical path remains 1-3-6.

The second and the Third crashing : For the second crashing, we are faced with the same activities to choose from as in the first crashing, viz. 1-3 and 3-6. The situation is the same in the third crashing. The total project cost equals Rs 9,660 and Rs 9,490 after the second and the third crashing. Notice that the crashing cost at any given stage is equal to the cumulative cost of crashing till that point. After the third crashing, the critical paths, each with a length of 17 days, are : 1-3-6; 1-2-4-6; and 1-2-5-6.

The Fourth Crashing : To reduce the project length from 17 days to 16, an activity from each of these paths should be chosen. The various alternatives, along with their cost are as follows :

Alternative	Activities	Total Crashing Cost
1	1-3,1-2	90+80 = 170
2	1-3, 4-6, 2-5	90+50+40 = 180
3	3-6, 1-2	200+80 = 280
4	3-6, 4-6, 2-5	200+50+40 = 290

Thus we would crash activities 1-3 and 1-2 at a cost of Rs 170. The total cost of the project at this stage is Rs 9,500, and the critical paths, after adjusting the activity timings, are the same as above.

The Fifth Crashing : For reducing the length of the project time to 15 days, we have the following alternatives. Notice that the activity 1-3 cannot be crashe any more.

Alternative	Activities	Total Crashing Cost
1	3-6, 1-2	200+80 = 280
2	3-6, 4-6, 2-5	200+50+40 = 290

Now we decide to crash activities 3-6 and 1-2 by a day each, at the additional cost of Rs 280. The project cost now equals Rs 9,620, the critical paths still being 1-3-6; 1-2-4-5 and 1-2-5-6.

The Sixth and the Seventh Crashing : At each of these crashings, the only choice open is to crash each of the following activities-one activity from every path at a cost of Rs 290: 3-6, 4-6 and 2-5.

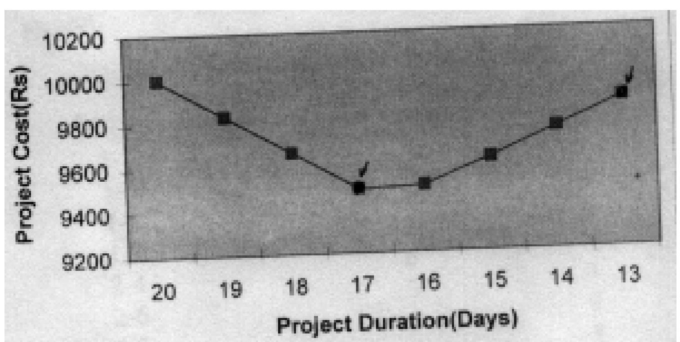
The total cost of the project is Rs 9,750 and Rs 9,880, respectively, after these crashings. From the table 8.10, it is clear that the lowest cost is Rs 9,490 corresponding to the project duration equal to 17 days, whereas the shortest time to complete the project is 13 days at a total cost of Rs 9,880.

Table: 8.10 Determination of Time-cost Relationship

Project Duration (days)	Direct Cost (Rs)				Indirect Cost (Rs)		
	Normal	Crashing	Total	Overhead	Penalty	Total	(Rs)
20	6500	-	6500	3200	300	3500	10000
19	6500	90	6590	3040	200	3240	9830
18	6500	180	6680	2880	100	2980	9660
17	6500	270	6770	2720	-	2720	9490
16	6500	440	6940	2560	-	2560	9500
15	6500	720	7220	2400	-	2400	9620
14	6500	1010	7510	2240	-	2240	9750
13	6500	1300	7800	2080	-	2080	9880

The time-cost function is shown graphically in Figure 8.16

Figure 8.16 Time-Cost Function for the Project



8.6 SUMMARY

Network analysis is a generic name for a number of associated project planning and control procedures that are all based on the concept of network. PERT and CPM are the two widely used techniques of project management that are developed, independently and simultaneously, during 1950s. PERT treats activity time as a random variable whereas CPM requires a single deterministic time value for each activity. After establishment of logic and details of the project network, time estimate must be assigned to each activity. With this one can determine the minimum completion time for the project. In determining the scheduling timing, the technological restriction, resource requirement for different activities, availability of resources and their allocation must be considered.

8.7 KEYWORDS

Load Chart: This chart is used for manufacturing projects during peak or heavy load periods.

Network: It is a set of symbols connected with each other with a sequential relationship with each step making the completion of a project or event.

PERT: It schedules the sequence of activities to be completed in order to accomplish the project within a short period of time.

Scheduling: It refers to the introduction of time schedule for each activity of the project.

8.8 SELF ASSESSMENT QUESTIONS

1. Discuss the role of network techniques in project planning, scheduling and controlling.
2. Bring out the difference between PERT and CPM. In what ways these techniques are similar ?
3. State the rules for network construction. What are dummy activities ?
4. Explain the determination of EOT and LOT of the different events of the project. Also state how are the EST, LST, EFT and LFT of activities obtained?
5. What is critical path ? What is the procedure for determining critical path ?
6. Explain the concept of float. What is the difference between total float, free float and independent ?
7. What are the earliest start schedule and late start schedule ?
8. What are the three time estimates used in the context of PERT ? How are the expected duration of the project and its standard deviation calculated ? Illustrate with the help of an example how would you calculate the probability of completion at a specified time.

9. With the help of an example, illustrate the problem of activity scheduling in the view of resource constraint.

10. Explain crashing of CPM network with the help of an example.

Problem

(a) In the following table three times estimates (in weeks)-optimistic (a), pessimistic (b) and most likely (m)- are given for different activities of a project.

Activity	a	m	b
1-2	4	6	10
1-3	3	7	12
1-4	5	6	9
1-7	2	4	6
2-4	6	10	20
2-6	3	4	7
2-7	5	9	15
3-4	3	7	12
4-5	2	4	5
5-6	1	3	6
3-7	2	5	8
6-7	1	2	6

b. Draw the network.

c. Determine the critical path and critical activities.

d. Calculate the events slack and activities floats.

e. Find the expected duration of the project and the standard deviation of the expected duration.

f. Compute the probability of completing the project in 30 weeks.

8.9 SUGGESTED READINGS

1. Projects: Planning, Analysis, Selection, Implementation and Review *by* Pasanna Chadra. Tata McGraw Hills Publishing Company Ltd., New Delhi.
2. Quantitative Techniques in Management *by* N.D. Vohra. Tata McGraw Hill Publishing Company Ltd., Delhi.
3. Introduction to Management Science *by* William J. Stevenson. IRWIN, Australia.
4. Principals of Operations Research *by* Hervey M. Wagner. PHI Pvt. Ltd., New Delhi.
5. Production and Operations Management *by* K. Ashwathapa and K. Shridhara Bhat. Himalaya Publishing House, Delhi.

Lesson 9

PROJECT FINANCING IN INDIA

STRUCTURE

9.0 OBJECTIVE

After studying this lesson, you should be able to explain

a) Meaning and importance of project finance
b) Discuss the various sources of project financing and financial institutions structure in India.
c) Describe the SEBI guidelines regarding public issues and debentures.

9.1 INTRODUCTION

Finance is the lubricant of the process of economic growth. When finance mode is available, industrial activities can be initiated which gives rise to new investment opportunities towards industrialization. The Indian financial institutions have been very important constituent of the Indian economy. This importance they have derived from their financial muscle and they have linked it to the industrial development in the country.

For years now the Indian financial institutions have been the life line of credit for the Indian corporate. This has been mainly because of their strong financial muscle and the various concessions they received from the Central Government for their role.

In India, special financial institutions have been developed to provide finance to the upliftment of industrial activities in all regions so as to sustain an equitable industrial growth in the county. Financial assistance is being extended to the industrial enterprises by the financial institutions and development banks on confessional terms of finance as per their bye laws in the state.

9.2 MEANING AND IMPORTANCE OF PROJECT FINANCE

Project finance refers to the financing of long-term infrastructure, industrial projects and public services based upon a non-recourse or limited recourse financial structure where project debt and equity used to finance the project are paid back from the cash flow generated by the project.

Project finance is used by private sector companies as a means of funding major projects off balance sheet. At the heart of the project finance transaction is the concession company, a special purpose Vehicle (SPV) which consists of the consortium shareholders who may be investors or have other interests in the project (such as contractor or operator). The SPV is created as an independent legal entity which enters into contractual agreements with a number of other parties necessary in the project finance deals.

The attractiveness of project finance is the ability to fund projected in the off balance sheet with limited or non-recourse to the equity investors i.e. if a project fails, the project lenders recourse is to ownership of the actual project and they are unable to pursue the equity investors for debt. For this reason lenders focus on the projects cash flow as the main source for repaying project debt.

Importance of Project finance

Project financing is being used throughout the world across a wide range of industries and sectors. This funding technique is growing in popularity as governments seek to involve the private sector in the funding and operation of public infrastructure.

Private sector investment and management of public sector assets is being openly encouraged by governments and multilateral agencies who recognize that private sector companies are better equipped and more efficient than government in developing and managing major public services.

Project finance is used extensively in the following sectors.

- Oil and gas
- Mining
- Electricity Generation
- Water
- Telecommunications
- Road and highways
- Railways and Metro systems
- Public services

9.3 MEANS OF FINANCE AND SOURCES OF PROJECT IN INDIA

The long-term sources of finance used for meeting the cost of project are referred to as the means of finance. To meet the cost of project, the following sources of finance may be available :

- Equity Capital
- Preference Capital
- Debentures
- Rupees term loans
- Foreign currency term loans
- Euro issues
- Deferred credit
- Bill rediscounting scheme
- Suppliers line of credit
- Seed capital assistance

- Government subsidies
- Sales tax deferment and exemption
- Unsecured loans and deposits
- Lease and hire purchase finance
- Public Deposit
- Bank Credit

Equity Capital

This is the contribution made by the owners of business, the equity shareholders, who enjoy the rewards and bear the risks of ownership. However, their liabilities, limited to their capital contribution. From the point of view of the issuing film, equity capital offers, two important advantages: (i) It represents permanent capital. Hence there is no liability for repayment. (ii) It does not involve any fixed obligation for payment of dividend. The disadvantages of raising funds by way of equity capital are : (i) The cost of equity capital is high because equity dividend are not tax-deductible expenses. (ii) The cost of issuing equity capital is high.

Preference Capital

A hybrid form of financing, preference capital partakes some characteristics of equity capital and some attributes of debt capital. It is similar, to equity capital because preference dividend, like equity dividend, is not a tax-deductible payment. It resembles debt capital because the rate of preference dividend is fixed. Typically, when preference dividend is skipped it is payable in future because of the cumulative feature associated with it. The near-fixity of preference dividend payment renders preference capital somewhat unattractive in general as a source of finance. It is, however, attractive when the promoters do not want a reduction in their share: share of equity and yet there is need for widening the net worth base (net worth consists of equity and preference capital) to satisfy the requirements of financial institutions. In addition to the conventional preference shares, a company may issue Cumulative Convertible Preference Shares (CCPS). These shares carry a dividend rate of 10 per cent (which; if unpaid, cumulates) and are compulsory convertible into equity shares between three and five years from the date of issue.

Debenture Capital

In the last few years, debenture capital has emerged as an important source for project financing. There are three types of debentures that are commonly used in India: Non-Convertible Debentures (NCDs), Partially Convertible Debentures (PCDs), and Fully Convertible Debentures (FCDs). Akin to promissory, NCDs are used by companies for raising debt that is generally retired over a period of 5 to 10 years. They are secured by a charge on the assets of the issuing company. PCDs are partly convertible into equity shares as per pre-determined terms of conversion. The unconverted portion of PCDs remains like NCDs. FCDs, as the name implies, are converted wholly into equity shares as per pre-determined terms of conversion. Hence FCDs may be regarded as delayed equity instruments.

Rupee Term Loans

Provided by financial institutions and commercial banks, rupee term loans which represent secured borrowings are a very important source for financing new projects as well as expansion, modernisation, and renovation schemes of existing units. These loans are generally repayable over a period of 8-10 years which includes a moratorium period of l-3 years.

Foreign Currency Terms Loans

Financial institutions provide foreign currency term loans for-meeting the foreign currency expenditures towards import of plant, machinery, equipment and also towards payment of foreign technical know-how fees. Under the general scheme, the periodical liability towards interest and principal remains in the currency/currencies of the loan/s and is translated into rupees at the then prevailing rate of exchange for making payments to the financial institution. Apart from approaching financial institutions (which typically serve as intermediaries between foreign agencies and Indian borrowers), companies can directly obtain foreign currency loans from international lenders. More and more companies appear to be doing so presently.

Euro issues

Beginning with Reliance Industries' Global Depository Receipts issue of approximately $150 ml in May 1992, a number of companies have been making euro issues. They have employed two types of securities: Global Depository Receipts (GDRs) and Euroconvertible Bonds (ECBs). .

Denominated in US dollars, a GDR is a negotiable certificate that represents the publicly traded local currency (Indian Rupee) equity shares of a non-US (Indian) company. (Of course, in. theory, a GDR may represent a debt security; in practice it rarely does so.) GDRs are issued by the Depository Bank (such as the Bank of New York) against the local currency shares (such as Rupee shares) which are delivered to the depository's local custodian banks. GDRs trade freely in the overseas markets.

A Euroconvertible Bond (ECB) is an equity-linked debt security. The holder of an ECB has the option to convert it into equity shares at a pre-determined conversion ratio during a specified period. ECBs are regarded as advantageous by the issuing company because (i) they carry a lower rate of interest compared to a straight debt security, (ii) they do not lead to dilution of earnings per share in the near future, and (iii) they carry very few restrictive covenants.

Deferred Credit

Many a time the suppliers of machinery provide deferred credit facility under which payment for the purchase of machinery is made over a period of time. The interest rate on deferred credit and the period of payment vary rather widely. Normally, the supplier of machinery when he offers deferred credit facility insists that the bank guarantee should be furnished by the buyer.

Bills Rediscounting Scheme

Operated by the IDBI, the bills rediscounting scheme is meant to promote the sale of indigenous machinery on deferred payment basis. Under this scheme, the seller realises the sale proceeds by discounting the bills or promissory notes accepted by the buyer with a commercial bank which in turn rediscounts them with the IDBI. This scheme is meant primarily for balancing equipments and machinery required for expansion, modernisation, and replacement schemes.

Suppliers' Line of Credit

Administered by the ICICI, the Suppliers' Line of Credit is somewhat similar to the IDBI's Bill Rediscounting Scheme. Under this arrangement, ICICI directly pays to the machinery manufacturer against usance bills duly accepted or guaranteed by the bank of the purchaser.

Seed Capital Assistance

Financial institutions, through what may be labelled broadly as the 'Seed Capital Assistance scheme, seek to supplement the resources of the promoters and of medium scale industrial units which are eligible for assistance from All-India financial institutions and/ or state-level financial institutions. Broadly three schemes have been formulated:

(i) *Special Seed Capital Assistance Scheme* The quantum of assistance under this scheme is Rs 0.2 million or 20 per cent of the project cost, whichever is lower. This scheme is administered by the State. Financial Corporations.

(ii) *Seed Capital Assistance Scheme* The assistance order this scheme is applicable to projects costing not more then Rs 20 million. The assistance per project is restricted to Rs 1.5 million. The assistance is provided by IDBI through state level financial institutions. In special cases, the IDBI may provide the assistance directly.

(iii) *Risk Capital Foundation Scheme* Under this scheme, the Risk Capital Foundation, an autonomous foundation set up and funded by the IFCI, offers assistance to promoters of projects costing between Rs 20 million and Rs 150 million. The ceiling on the assistance provided between Rs 1.5 million and Rs 4 million depending on the number of applicant promoters.

Government Subsidies

Previously the central government as well as the state governments provided subsidies to industrial units located in backward areas. The central subsidy has been discontinued but the state subsidies continue. The state subsidies vary between 5 per cent to 25 per cent of the fixed capital investment in the project, subject to a ceiling varying between Rs 0.5 million and Rs 2.5 million depending on the location.

Sales Tax. Deferments and Exemptions

To attract industries, the states provide incentives, *inter alia,* in the form of sales tax deferments and sales tax exemptions. Under the sales tax deferment scheme, the payment of sales tax on the sale of finished goods may be deferred for a period ranging between five to twelve years. Essentially, it implies that the project gets an interest-free loan, represented by the quantum of sales tax deferred, during the deferent period.

Under the sales tax exemption scheme, some states exempt the payment of sales tax applicable on purchases of raw materials, consumables, packing, and processing materials from within the state which are used for manufacturing purposes. The period of exemption ranges from three to nine years depending upon the state and the specific location of the project within the state.

Unsecured Loans and Deposits

Unsecured loans are typically provided by the promoters to fill the gap between the promoters' contribution required by financial institutions and the equity capital subscribed by the promoters. These loans are subsidiary to the institutional loans. The rate of interest chargeable on these loans is less than the rate of interest on the institutional loans. Finally these loans cannot be taken back without the prior approval of financial institutions.

Deposits from public, referred to as public deposits, represent unsecured borrowing of two to three years' duration. Many existing companies prefer to raise public deposits instead of term loans from financial institutions because restrictive covenants do not accompany public deposits. However, it may not be possible for a new company to raise public deposits. Further, it maybe difficult for it to repay public deposits within three years.

Foreign Currency Loans

Apart from rupee term loans, financial institutions provide foreign currency loans. This assistance is now provided only for the import of capital equipment (as per the liberalised exchange risk management system, foreign currency required for other purposes has to be purchased from authorised dealers at market rates). On foreign currency loans sanctioned under the general scheme, the interest rate charged is typically a floating rate as determined by the lenders, (the foreign agency that has given a line of credit to the financial institution for onward lending) and the risk of exchange rate fluctuation is born by the borrower. On foreign currency loans sanctioned under the Exchange Risk Administration Scheme, the principal repayment obligations of the borrower are rupee tied at the rate of exchange prevailing on the dates of disbursement. On such rupee-tied loan liability, the borrower pays by way of servicing his loan a composite, cost every quarter. The composite cost consists of three elements: (i) the interest portion which is arrived on the basis of the weighted average interest cost of the various components of the currency pool, (ii) the spread of the financial institutions, and (iii) the exchange risk premium. The 'composite cost' is a variable rate determined at six-monthly intervals. It has a floor and a cap. Both the floor and the cap as well as the rate of interest applicable for the period is reviewed and announced from time to time.

Leasing and Hire Purchase Finance

With the emergence of scores of finance companies engaged in the business of leasing and hire purchase finance, it may be possible to get a portion, albeit a small portion, of the assets financed under a lease or a hire purchase arrangement.

Typically, a project is financed partly by financial institutions and partly through the resources raised from the capital market. Hence, in finalising the financing scheme for a project, you should bear in mind the norms and policies of financial institutions and the guidelines of Securities Exchange Board of India and the requirements of the Securities Contracts Regulation Act (SCRA).

Public Deposit

Public deposits have been a peculiar feature or industrial finance in India. Companies have been receiving public deposits for a long time in order to meet their medium-term and long-term requirements for finance. This system was very popular in the cotton textile mills or Bombay, Ahmedabad and Sholapur and in the tea gardens or Assam and Bengal. In recent years, the method or raising finance through the public deposits has again become popular for various reasons. Rates or interest offered by the companies are higher than those offered by banks. At the same time the cost of deposits to the company is less than the cost or borrowings from banks.

While accepting public deposits, a company must follow the provisions or the companies Act and the directions issued by the Reserve bank of India. According to the companies (Acceptance of Deposits Rules, 1975 as amended in 1984) Act, no company can receive secure and unsecured deposits in excess of 10% and 25% respectively of paid up share capital plus free reserves. The Central Government has laid down that no company shall invite a deposit unless an advertisement, including a statement showing the financial position of the company, has been issued in the prescribed form. Under the new rule, deposits can be renewed. The rate of interest payable on deposits must not exceed 15% per annum. In order to repay the deposits maturing in a particular year, the company must deposit 110% or the deposits with a scheduled bank or in specified securities.

Bank Credit

Commercial banks in the country serve as the single largest source or short-term finance to business firms. They provide it in the form of Outright Loans. Cash credit, and Lines of Credit.

9.4 FINANCIAL INSTITUTION STRUCTURE AND FINANCIAL ASSISTANCE

This part concerned with the various aspects of financial institutions and their functioning in India, is divided into six sections as follows :

- Institutional Structure

- Financial assistance : direct and indirect
- Special schemes
- Term loan procedures
- Project appraisal
- Key financial indicators

Institutional Structure

The structure of financial institutions in India is as follows :

I. All India institutions

- Industrial Finance Corporation of India
- Industrial Credit and Investment Corporation of India
- Industrial Development Bank of India
- Other all-India institutions

II. State-level institutions

- State Financial Corporations
- State Industrial Development Corporations

Industrial Finance Corporation of India (IFCI)

Industrial Finance Corporation of India (IFCI)- The IFCI is the first industrial financing institution to be Set up in India soon alter independence. It was set up as a statutory corporation in July, 1948 But was later converted in to a Government Company. The IFCI provides financial assistance to any public limited company and co-operative society registered in India. Such units must be engaged in the manufacture, preservation or processing of goods, or in the shipping, mining or hotel industry, or in the generation and distribution of electricity or any other form of power. Public limited companies in the public sector are also eligible to receive assistance from the IFCI. But proprietary concerns, partnership firms and private companies are not eligible for financial assistance from the corporation. The corporation may grant assistance ranging from Rs.30 lakhs to Rs.2 crores to a single enterprise. Assistance may be given in anyone or more of the above forms for a maximum period of 25 years.

State Financial Corporations (SFC's)- As the Industrial finance Corporation does not provide industrial finance to all types or enterprises, the need was felt for state level financial institutions to finance the needs or non-corporate and other small enterprises. On September 2, 1951, the Parliament passed the State Financial Corporations Act. The Act came in to force with effect from 1st August, 1952. It empowers the State Governments to establish financial institutions for their respective States.

Industrial Credit and Investment Corporation of India (lCICI)

In view of the limited risk capital which IFCI and SFC s provide, need was felt far a more enterprising and flexible institution to facilitate industrial development in the private sector in India. A World Bank-cum-American Investment Mission visited India in 1954 and recommended the establishment or special institution the purpose of assisting industries in the private sector. Accordingly, the ICICI was set up on January 5, 1955 as a public limited company under the Companies Act. The Corporation was set up as a privately owned institution but later on the Life Insurance Corporation of India (a statutory corporation) became its major shareholder.

The lCICI has wide powers. It can provide any amount of financial assistance to any public or private company in the private sector. It can now give assistance to projects in the joint sector and co-operative sector. 11 is authorized to provide foreign currency loans to partnerships and proprietary concerns also. Ordinarily Rs.5 lakhs is the minimum limit and Rs.l crore is the higher limit for financial assistance to a single concern. Loans are given generally for the purpose of buying capital assets like land, buildings and machinery. In fact, the ICICI specializes in providing loans in foreign currency. The Corporation helps in the promotion of new enterprises as well as in the expansion and modernization of existing concerns so as to build up a sound industrial.

Industrial Development Bank of India

The Industrial Development Bank of India was established in 1964 as a subsidiary of the Reserve Bank of India. It is headquartered in Bombay. It is the apex term-lending financial institution in India. It has been designated as the principal financial institution of the country for coordinating, in conformity with national priorities, the working of institutions engaged in financing, promoting, and developing industry. IDBI finances the industry directly and also provides principal support to State Finance Corporations and State Industrial Development Corporations and commercial banks in their financing of industries, through refinancing and bill discounting facilities. The resources of IDBI consist of paid-up capital, reserves repayment of loans, market borrowings both within and outside the country, temporary credit from the Reserve Bank of India, and foreign lines of credit from the World Bank, Asian Development Bank and others.

Life Insurance Corporation of India

The Life Insurance Corporation of India (LIC, hereafter) came into being in 1956 after the nationalization and merger of about 250 independent life insurance societies. It is headquartered in Bombay. The primary activity of LIC is to conduct the life insurance business, but it has gradually developed into an important all-India financial institution which provides substantial support to industry.

General Insurance Corporation

The General Insurance Corporation (GIC, hereafter) was founded when the management of general insurance business in India was taken over by the government in 1971 and subsequently nationalised in 1973. It is headquartered in Bombay. GIC provides substantial assistance to industrial projects be way of term loans, subscription to equity capital and debentures, and underwriting of securities.

Industrial Reconstruction Bank of India

The industrial Reconstruction Bank of India, headquartered in Calcutta, was set up when its precursor, the Industrial Reconstruction Corporation of India, was reconstituted in 1984. IRBI is primarily an agency to help the reconstruction and rehabilitation of industrial units which have closed down or which face the risk of closure. IRBI offers assistance in various forms : (i) financial assistance which is not available from normal channels of finance and banking, (ii) technical assistance and guidance to sick units to revive them, (iii) managerial in the fields of administration, finance, marketing, industrial relations, etc. and (iv) suggestions for reconstruction and rationalization.

State Level Institutions

State Financial Corporations

The State Financial Corporation, set up under the State Financial Corporation Act, 1951, render assistance to medium and small scale industries in their respective states. Their shareholders are the respective state governments, IDBI, insurance companies, credit cooperatives and private shareholders.

State Industrial and Development Corporations

The State Industrial Development Corporation, were set up by the state governments during the 1960s to serve as catalytic agents in the industrialization process of their respective states. Presently almost every state has an SIDC which is fully owned by the respective state government.

Financial Assistance : Direct and Indirect

Direct Financial Assistance

Financial institutions provide direct financial assistance in the following ways :

- Rupee term loans
- Foreign currency term loans
- Subscription to equity shares
- Seed capital

Indirect Financial Assistance

Besides providing direct financial assistance, financial institutions extend help to industrial units in obtaining finance/credit through the following ways :

- Deferred payment guarantee
- Guarantee for foreign currency loans
- Underwriting

Deferred Payment Guarantee

Financial institutions issue guarantee on behalf of the buyer of industrial machinery to the supplier offering the facility of deferred payments. Should there be a default by the buyer in the payment of deferred installments, financial institutions make the payment and subsequently recover the amount form the assisted unit. A nominal commission is charged for providing such guarantee.

Guarantee for Foreign Currency Loans

Financial institutions provide guarantee for foreign currency loans obtained by industrial concerns from institutions and banks abroad. A nominal commission is charged to the assisted unit for such guarantee.

Underwriting

As part of the overall financial package, financial institutions generally participate in underwriting equity issues of assisted units. This helps the assisted units in raising funds from the capital market.

Special Schemes

Several special schemes have been designed to serve the varied needs of industry. The important ones are :

- Bill rediscounting scheme
- Suppliers line of credit
- Soft loan scheme
- Equipment finance scheme

9.5 NORMS OF FINANCE AND TERM LOAN PROCEDURE

The principal norms and policies of financial institutions are described below:

Eligibility

Till recently, long term loans were provided by financial institutions to concerns in certain industries and denied to concerns in industries placed in the negative list. Now, however, a shift is taking place in their policy, They are inclined to finance almost every kind of industry. Further, till recently financial institutions followed a consortium approach as per the advice of the Ministry of Finance. Now they are permitted to lend individually as well as participate in consortium lending.

Debt-equity Ratio

Presently, the general debt-equity norm for medium and large scale projects is 1.5:1. This serves as a broad guideline against which variations are permitted on a case to case basis, especially under the following circumstances: (a) high degree of capital intensity, (b) location in a backward area, and (c) background' of the promoter. Other things being equal: (i) a capital intensive project is eligible for a higher debt-equity ratio, (ii) a project in a backward area qualifies for a higher debt-equity ratio, and (ill) a project promoted by a technocrat-promoter is entitled to a higher debt-equity ratio.

How are debt and equity defined for the purpose of calculating the debt-equity ratio? Debt consists of the following: (i) loans and deposits that are repayable after one year (this includes interest bearing unsecured loans from government agencies, promoters, etc.), (ii) non-convertible debentures and convertible debentures (except that part which is compulsorily convertible into equity) until they are converted, irrespective of the maturity period, (ill) deferred payments, and (iv) preference shares due for redemption within three years.

Equity consists of the following: (i) paid-up ordinary share capital, (ii) irredeemable preference shares, cumulative convertible preference shares where the redemption period is due after three years, (iii) premium on share issues, (iv) central/ state cash subsidy, (v) long term interest-free unsecured loans from state governments or government agencies or promoters subordinate to loan from financial institutions, and (vi) free reserves (including surplus in profit and loss account) less any accumulated losses, arrears or unabsorbed depreciation, intangible assets (like goodwill), expenditures not written off (like preliminary expenses), and investments in other undertakings where these are 'prima facie' considered unrealisable.

Promoters Contribution

Financial institutions require promoters to contribute 25 to 30 per cent of the project cost. This is lowered selectively in certain cases like capital-intensive projects, high priority projects, and technocrat-promoted projects. Contributions made by the following or of the following kinds represent promoters' contribution (i) equity investment by promoters, their friends, relatives and associates (including NRIs), (ii) equity investment by other companies controlled by promoters, (iii) equity participation by shareholders of other promoter companies, (iv) foreign collaborators,' (v) investment from oil exporting developing countries, (vi) state government, in the case of joint sector or assisted sector projects, (vii) seed capital assistance, (viii) unsecured loan from promoters, (ix) venture capital participation, (x) mutual fund participation, (xi) internal accruals in the case of an existing company, (xii) rights issue to existing shareholders, and (xiii) any other contribution approved as promoters' contribution.

Term Loan Procedure

The procedure associated with a term loan involves the following principal steps.

1. Submission of loan application

   The borrower may submit the application to any of the three term lending institutions, viz, IDBI, ICICI, and IFCI. The borrower is required to fill out a common application form.

2. Initial processing of loan application
3. Appraisal of the proposed projects
4. Issue of the letter of sanction
5. Acceptance of the terms and conditions by the borrowing unit
6. Execution of loan agreement
7. Disbursement of loans
8. Creation of security
9. Monitoring

Project Appraisal

Financial institutions appraise a project form the marketing, technical, financial, economic, and managerial angles. The principal issues considered and the criteria employed in such appraisal are discussed below (for detail see in lesson 1)

1. Market Appraisal
2. Technical Appraisal
3. Financial Appraisal
4. Economic Appraisal
5. Managerial Appraisal

Key Financial Indicators

The key financial indicators used by financial institutions while evaluating projects are the internal rate of return, the debt service coverage ratio, and the break-even point. The manner in which these indicators are calculated is discussed below.

Internal Rate of Return

For calculating the internal rate of return of project, its cash outflows and cash inflows are defined as follows :

Cash Outflows

Outlay on fixed assets	:	Cost of Project • Working capital margin • Interest during construction period
Outlay on current assets	:	Current asset investment in the beginning As well as additional investment in current assets in future.

Cash Inflows

Operating inflows	:	Earnings before depreciation, interest, and taxes (EBDIT)
Terminal inflow	:	Residual value of fixed assets + Realisable value of current assets

Debt service Coverage Ratio

The debt service coverage ratio is defined as :

$$\frac{\text{Profit after tax + Depreciation + Other non-cash charges + Interest on term loan}}{\text{Interest on term loan + Repayment of term loan}}$$

Break-even Point

The break-even point for a project is calculated with reference to the year when the project is expected to reach its target level of capacity utilisation, which is usually the third of the fourth operating year.

9.6 SEBI GUIDELINES

The Capital Issues Control Act, 1947 (and the exemption orders and rules made there under) was the primary legislation regulating the issue of securities by the corporate sector till recently. This Act was repealed in May 1992 and capital issues were brought under the purview of the Securities Exchange Board of India (SEBI hereafter) which was clothed with statutory powers when the SEBI Act, 1992 was passed.

On June 12, 1992, SEBI released its guidelines applicable to capital issues. A comparison of these guidelines with the guidelines that were followed under the earlier regime (that is under the Capital Issues Control Act, 1947) suggests that the thrust of regulation is no longer on product and price control. In the earlier regime, there were restrictions on the kinds of securities that could be issued, the pricing of these securities, and .the interest rates or dividend rates payable on them. Under the new regime there is virtually no restriction on the types of securities (financial instruments) that can be issued, there is substantial freedom in pricing these securities, and there is no ceiling on interest/ dividend rate payable ‘on these securities. While the new regime more or less does away with product and price controls, it lays stress on adequate disclosure, seeks to safeguard the interest of investors, and emphasises prudential controls. The key SEBI guidelines are summarised below.

New Instruments

While there is no restriction on the kinds of financial instruments, the issuer of capital shall make adequate disclosures’ regarding the terms and conditions, redemption, security, conversion, and any other features of the instrument so that an investor can make a reasonable determination of risks, returns, safety, and liquidity of the instruments. The disclosures shall be vetted by SEBI in this regard.

Pricing of Public Issues of Equity Capital

The salient features of SEBI guidelines with respect to the pricing of public issues of equity capital are as follows:

- A new company set up by entrepreneurs without a track record will be permitted to issue capital to public only at par.
- A new company set up by existing companies with a five year track record of consistent profitability will be .free to price its issue provided the participation of the promoting companies is not less than 50 per cent of the equity of the new company and the issue price is made applicable to all new investors uniformly.
- An existing private/closely held company with a three year track record of consistent profitability shall be permitted to freely price the issue.
- An existing listed company can raise fresh capital by freely pricing further issue.

Fully Convertible Debentures (FCDs)/Partially Convertible Debentures (PCDs)/Non-convertible Debentures (NCDs)

The guidelines relevant to these instruments are as follows:

1. Credit rating is compulsory in the case of FCDs if the conversion is effected after 18 months and in the case of NCDs/PCDS if the maturity period exceeds 18 months.
2. In the case of FCDs/PCDs the terms of conversion (time of conversion and conversion price) shall be predetermined and stated in the prospectus.
3. Any conversion in part or whole of the debenture will be optional at the hands of the debenture holder, if the conversion takes place at or after 18 months from the date of allotment, but before 36 months. FCDs having a conversion period exceeding 36 months must have ‘put’ and ‘call’ option (the ‘put’ option gives the debenture holder the right to sell the debentures back to the company at a specified price whereas the ‘call’ option gives the company first right to buy back the debentures at a specified price).

4. A Debenture Redemption Reserve (DRR) shall be created by all companies raising debentures, except when the debenture issue has a maturity of 18 months or less, on the following basis: (a) A moratorium up to the date of commercial production can be provided for creation of the DRR in respect of debentures raised for project finance. (b) The DRR may be created either in equal installments for the remaining period or higher amounts if profits permit. (c) In the case of PCDs, the DRR should be created in respect of the non-convertible portion of the debenture issue on the same lines as applicable to NCDs. In respect of convertible issues by new companies, the creation of the DRR should commence from the year the company earns profits for the remaining life of debentures. (d) Companies may distribute dividends out of general reserves in certain years if residual profits after transfer to the DRR are inadequate to distribute reasonable dividends. (e) The DRR will be treated as a part of general reserve for consideration of bonus issue proposals and for price fixation related to post-tax return. (f) In the case of new companies, distribution of dividend shall require approval of the trustees to the issue and the lead institution, if any. (g) The company should create the DRR equivalent to 50 per cent of the amount of debenture issue before the debenture redemption commences. Drawl from the DRR is permissible only after 10 per cent of the debenture liability has been actually redeemed by the company.

Promoters' Contribution and Lock-In Period

The key provisions in this regard are as follows: (a) Equity capital to be subscribed in any issue to the public by promoters, i.e., those described in the prospectus as promoters, directors, friends, relatives and associates should not be less than 25 per cent of the total issue of equity capital up to Rs 1000 million and 20 per cent of the issue above Rs 1000 million. In the case of FCDs, one third of issue amount should be contributed by promoters, directors, friends, relatives and associates by way of equity before the issue is made. In the case of PCDs, one third of the convertible portion should be brought in as contribution of promoters, directors, friends, relatives and associates before the issue is made. The minimum subscription by each of the friends/relatives and associates under the promoters' quota should not be less than Rs 0.1 million. (b) The promoters' contribution shall not be diluted for a lock-in period of five years from the date of commencement of the production or date of allotment whichever is later. Promoters must bring in their "full subscription to issues in advance before public issue. (c) All firm allotments, preferential allotments to collaborators, shareholders of promoter companies, whether corporate or individual, shall not be transferable for three years from the date of the commencement of production or date of allotment whichever is later.

9.7 SAMPLE FINANCING PLANS

Four sample financing plans follow:

XYZ Co. Limited

The project cost and means of finance for a project of XYZ Co. Limited for the manufacture of 155,000 sq. mts. of granite and slabs that was appraised by SBI Capital Markets Limited in the month of May 1992 are given below:

Project Cost		**in Millions**
- Land and Site Development		12.1
- Buildings		16.6
- Plant and Machinery		
Imported	142.7	
Indigenous	2.5	
Foundation	5.0	150.2
- Training Expenses		0.2
- Miscellaneous Fixed Assets		26.2
- Preliminary and Capital Issue Expenses		7.9
- Preoperative Expenses		13.3
- Provision for Contingencies		21.7
- Margin for Working Capital		11.9
		260.1

Means of Finance

		Rs *in million*
- Equity Share Capital		
Promoters	38.7	
UTI	5.0	
EEC	15.0	
Public (Convertible portion of debentures)	40.0	98.7
- Debt		
Non-convertible portion of debentures	40.0	
Foreign Exchange Loan	117.8	157.8
- Capital Subsidy		2.0
- Lease Finance		1.6
		260.1

9.8 SUMMARY

The role of project financing is becoming predominant in the funding, construction and operation of infrastructure around the world. World Bank estimates predict that this source of finance is set to expand and that the private sector will have an increasingly crucial role to play in the provision of public services.

Private sector brings with it private sector management skills and innovation which aid the improved delivery of key services such as power, transportation, water telecoms and health care. Governments should set policy and delegate the provision of services to the private sector who are best equipped to provide.

9.9 KEYWORDS

Project Finance: It refers to financing of long-term projects based upon a non-recourse or limited recourse financial structure.

Equity Capital: Equity capital is the contribution made by the owners of business.

Preference Capital: It is a hybrid form of financing which partakes some characteristics of equity capital and some attributes of debt capital.

Leasing: It is an agreement between two parties whereby one party gives the right to use an asset to another party for a consideration for a definite period of time.

Break-even Point: It is that point where total sales are equal to total cost.

9.10 SELF ASSESSMENT QUESTIONS

1 Define the project finance. Discuss the role of project finance.

2 What is the means of finance? Explain the various sources of project finance in India

3 Write a detail note on
- Euro issues
- Consortium Finance
- Subordinate debt
- Debenture

4. Discuss in detail financial institution structure in India

5 Explain the SEBI guidelines regarding public issues and debentures

9.11 SUGGESTED READINGS

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10.1 INTRODUCTION

In the post second world war period the public sector enterprises have generally increased in number and importance for various reasons. After the Great depression 1929-33 people post faith in the market mechanism. It was thought that the invisible hand of the market would have to be replaced at least partly by the visible hand of the government. In other words, there was the need for government participation in the economic affair of the nation. It was felt that one of the way in which the government could play a active role in modern economy was by nationalizing those industries and setting up a wide range of public sector units. The developing country like India have accepted today the technique of economic planning as a means of development and have given importance to the public sector. India the first important step in the direction was taken immediately after achieving independence. In the real sense, public enterprise in India are of recent origin. But the scholars have traced the history of Public enterprises as far as back as 300 B.C. Kautilya, the founder prime Minister of Maurya Empire in India in his 'Arthshastra' (a book in Sanskrit) Spoke of public enterprises. There was a 'Lavanadhyaksha' incharge of Manufacture of salt and fixation of its price. Likewise the 'Akaradhyaksha' the'Rupadarasaka' and the 'Suvarnadhyaksha' seem to have been Incharge of mining, coinage and gold all in the control of the state.

In the medieval period India was cynosure of all eyes in the west. The golden period India was famous for its steel and cloth. The iron pillar near Kutub Minar has baffled many melallur gist have a pillar of his huge size and rustles quality could have been cast in those for off days. The fine cloth particularly, Dacca Muslim' was favorite wear of western women.

In modern India, we find two sort of efforts – one by the alien government and he other by Swadeshi Movement heached by Indian National Congress which paned the base for public enterprise. The working committee of congress in August 1937 recommended its provincial government to appoint committee of expert to draw up schemes of "National Reconstruction and Social planning" The conference of 1938

LESSON: 11

PROJECT APPRAISAL: ASSESSING THE TAX BURDEN

STRUCTURE

11.0 OBJECTIVE

The main objective of this lesson is to make the students gain knowledge of the relating provisions that provide the assessment of possible tax burden vis-à-vis project appraisal.

11.1 INTRODUCTION

For preparing the profitability projection, the expected tax burden for the forecast period, which is usually eight to ten years, has to be figured out. This calls for familiarity with the provisions of the Income Act those are relevant for determining the magnitude and timing of the tax burden for a new project. This lesson seeks to provide help in this respect. It discusses the broad framework for deriving the taxable income, important provisions relevant for computing the taxable income; process for the determination of tax burden and payment of tax, and finally, a comprehensive illustration for the purpose. It should be emphasized here that taxation is a complex and specialized field, which is best, handled by experts. Our purpose here is to build a basic understanding of the tax framework relevant for financial appraisal of projects and not to provide a detailed exposition of the field.

11.2 FRAMEWORK FOR DERIVING TAXABLE INCOME

Income tax is a charge calculated by applying the rates prescribed annually in the Finance Act on the base called the total income. The total income, also known as taxable income, is computed with reference to a period defined as the previous year. *Figure B.1* shows the schematic diagram for determining the total income of a corporate assessee under the Income Tax Act. As a part of rationalization and simplification process, the Income Tax Act is being amended by doing away with many of the incentive schemes, and at the same time reducing the overall corporate income tax rates. By the way, the Government hopes to reduce the complexities involved in the calculation of tax and administration of tax law would become easier.

Figure B.1: Diagram for Determining the Total Taxable Income for Corporate Assessees
Income from Business ***Plus*** Income from Other Heads under Tax Law ***Equal to*** Gross Total Income ***Minus*** Deductions u/s 80 from Gross Total Income ***Equal to*** Total Taxable Income

11.2.1 Income from Business

This broadly consists of receipts less deduction associated with activities, which can be attributed to the character of business/profession. The principal sources of receipts are sale proceeds, professional fees, and labour charges.

The deductions can be classified as follows:

- Actual business expenses incurred. The major items included under this head are: (i) rent, rates, taxes, insurance, repairs and maintenance in respect of premises used for business (section 30); (ii) repairs, maintenance and insurance in respect of plant and machinery (section 31); (iii) expenditure on scientific research not being in the nature of capital expenditure related to the business of the assessee (section 35); (iv) expenditure on scientific research by certain notified businesses get weighted deductions; (v) insurance premium paid in respect of insurance of stock or stores of the business; bad debt etc. (section 36); (vi) any other expenditure (not being in the nature of capital expenditure or personal expenses of the assessee) laid out or expended wholly and exclusively for the purposes of the business/profession (section 37).
- Amortization of certain expenses. Certain expenses are incurred at one time and a percentage of such expenses are allowed to be deducted against the income over a number of years by way of amortization. These include: (i) outlays on fixed assets which are depreciated at the rates prescribed under rule 5 of the Income Tax Rules (section 32); (ii) expenditure on patents and copyrights (section 35A); (iii) expenditure for acquiring know-how (section 35 AB); (iv) preliminary expenses (section 35D); (v) expenditure on prospecting of minerals (section 35A); (vi) expenditure incurred by an Indian Company, for amalgamation or demerger of a company (section 35 DD) and (vii) capital expenditure on family planning of employees (section 36).
- Capital expenditures of certain types. Though capital expenditures are not normally allowed as a deduction in computing the business income, the following capital expenditure can be deducted by virtue of certain provisions of the Act: (i) capital expenditures on scientific research related to the business carried on by the assessee [section 35 (1) (iv)]; (ii) capital expenditure incurred in connection with the business consisting of prospecting

for or extraction or production of mineral oils (section 42). (iii) capital expenditure incurred in connection with acquiring any rights to operate telecommunication services (section 35 ABB).

- Certain contribution. Payments made to (a) certain recognized scientific research institutions to be used for scientific research [section 35 (1) (ii)]; (b) certain recognized institutions to be used for research in social science or statistical research [section 35 (1) (iii)]; (c) approved public sector companies and institutions for promoting the social and economic welfare of, or the uplift of, the public (section 35 AC); and (d) certain associations and institutions for carrying out programmes of conservation of natural resources (section 35 CC B) can be deducted for tax purposes.

In respect of contributions made to approved National Laboratories or a University or an Indian Institute of Technology with a specific direction that the amounts be used for scientific research undertaken under an approved programme, an amount equal to 125% of the contribution is allowed as deduction (35 2AA).

- Carried forward losses and allowances. In computing the business income, losses and allowances carried forward from the previous year can be deducted subject to compliance with certain conditions.

11.2.2 Income from other Heads Under Tax Law

The various other heads, the nature of income, and the deductions allowed under these heads by the Act are shown below;

Head	**Nature of Income**	**Deduction Allowed**
Income from house Property	Income arising from building and land appurtenant thereto owned by the assessee	Deductions are specified under Sections 23 and 24 of the Act
Capital gains	Full value of consider-ation on transfer of capital assets	(a) Indexed cost of acquisition (b) Indexed cost of improvements (c) Expenses on transfer (d) Certain exemptions
Income from other Sources	Interest and other incomes, which cannot be taken under any other head	Expenses incurred to earn the income and depreciation where applicable

11.2.3 Gross Total Income

This represents the summation of income from business and income from other heads under the Act as described above. This aggregation process involves setting off negative figures in the manner as prescribed in the Act. Such set off is done at two levels as follows:

(a) Setting off negative figures under any source against positive figures under any other source within the same head of income; and

(b) Setting off negative figures under any head of income against positive figures under any other head of income.

Exemptions/Deductions from Gross Total Income Certain incomes enjoy special exemptions under Chapter III, and do not form part of the total income.

The important exemptions are

1. Exemption of such profits or gains from the export of articles or things or computer software established in a Free Trade Zone etc. (Section 10A)

2. Exemptions of such profits or gains from the export of articles or things or computer software from 100% export oriented unit (Section 10B).

11.2.4 Deduction from Gross Total Income

Chapter VI A of the Act deals with various deductions that are allowed from the gross total income. The deductions under this chapter are allowed irrespective of the source of income and are akin to incentives. They are different from other deductions discussed earlier, which are related to a specific head of income. If the gross total income is negative than no deduction under chapter VI A is allowable. These deductions cannot make a gross total negative.

The important deductions under chapter VI A are as follows:

1. Deduction in respect of profits and gains from projects or execution of work outside India (Section 80 HHB).
2. Deduction in respect of profits and gains from housing projects in certain areas and which are aided by World Bank (Section 80 HHBA).
3. Deduction in respect of export of goods or merchandise outside India subject to certain conditions. (Section 80 HHC)
4. Deduction in respect of earnings in convertible foreign exchange from the business of hotel and tour operators (Section 80 HHD)
5. Deduction in respect of profits from export of computer software etc. (Section 80 HHE)
6. Deduction in respect of profits from export or transfer of film software, television software etc. (Section 80 HHF)
7. Deduction in respect of profits and gain from new industrial undertaking providing infrastructure facility after a certain date (Section 80IA)
8. Deduction in respect of profits and gain of business from new industrial undertaking other than infrastructure facility as mentioned above (Section 80JJ)

9. Deduction in respect of profits and gain from business of collecting and processing bio-degradable waste (Section 80JJ)
10. Deduction in respect of employment of new workmen (Section 80JJAA)
11. Deduction in respect of royalties etc received from certain foreign enterprises (Section 80O)

(Deduction under Section 80HHB, 80HHBA, 80HHC, 80HHD, 80HHE, 80HHF, 88 are being phased out in a gradual manner such that no deduction will be available for the assessment years commencing on 1.4.2005 and subsequent years).

11.2.5 Total Taxable Income

This represents the difference between the gross total income and the deductions from the gross total income and is the base on which the tax rate is applied to arrive at the tax liability.

11.3 IMPORTANT PROVISIONS RELEVANT FOR DERIVING TAXABLE INCOME

In applying the framework for deriving the taxable income, discussed in the preceding section, certain provisions and considerations relating to the following must be borne in mind:

- Expenses incurred during construction period
- Depreciation
- Deduction in respect of expenditure on scientific research
- Deduction in respect of certain capital expenditure
- Deduction in respect of profits derived from export business
- Deduction in respect of profits and gains from projects outside India
- Deduction in respect of profits from the export of computer software and other related technical services

- Exemptions in respect of profits and gains of newly set up industrial undertakings in free trade zone
- Deduction in respect of profits and gains from newly set up industrial undertakings engaged in infrastructure development
- Deduction in respect of profits and gains from certain industrial undertakings other than infrastructure development undertakings
- Disallowances of expenditures
- Set off, carry forward, and order of deduction for computing income from business

Expenses Incurred During Construction Period : The first question that needs to be answered is what is construction period or what is the data from which the computation of profits and gains of the business should be reckoned for the purpose of income tax. Section 3 of the Act dealing with the definition of previous year (the period with reference to which total income is computed) provides a clue in the matter. According to this Section, the previous year in respect of any business commences from the date on which it is 'set up'. In the case of a factory, the date of 'set up' will be the date on which the unit is 'ready' to commence production after trial run, etc, though the actual commercial production may not start due to various reasons such as non-availability of raw material, power supply etc. This date of 'set up' is the cut off date and all the expenditures incurred after this date is to be treated as revenue expenditure deductible in computing the income from business. It may not matter at this stage whether the unit is effecting sales or not for computing income under the head 'Profits and Gains of Business or Profession' for the purposes of income tax.

Once the date of 'set up' of business is determined, the treatment of various expenses incurred up to the date of the setting up of the unit (other than direct expenses relating to construction) may be discussed.

During the construction stage of a project, new company incurs various expenses. These expenses can be broadly classified as: (a) direct expenses relating to construction and (b) expenses other than direct expenses.

The expenses, which are directly related to construction, are considered as part of plant, machinery, building etc. The treatment of other expenses needs some consideration. These expenses (other than direct) may be classified as follows: (i) preliminary expenses, (ii) indirect expenditure relating to construction, (iii) indirect expenditure not relating to construction, (iv) expenditure relating to technical know-how, (v) expenditure relating to a new project of an existing company, and (vi) income earned during the construction period.

Preliminary Expenses : Preliminary expenses consists of following: (a) expenditure in connection with preparation of feasibility report, preparation of project report, engineering services, market survey or any other survey necessary for the business of the assessee; (b) legal charges for drafting any agreement between the assessee and any other person for any purpose relating to the setting up or conduct of the business of the assessee; (c) legal charges for drafting the memorandum and articles of association, fees for registration of the company under the provisions of the Companies Act, cost of issue for public subscription of shares and debentures of the company; (d) such other items of expenditure (not being expenditure eligible for any allowance or deduction under any other provision of this Act) as may be prescribed.

According to Section 35D of the Act, 20 percent of the preliminary expenses can be claimed as deduction for each of the five successive previous years beginning with the previous year in which the business commences or the extension of the industrial undertaking is completed. The maximum amount of preliminary expenses that can be amortized is five percent of the cost of the project or capital employed (as defined in Section 35D) whichever is more.

Indirect Expenditure Relating to Construction: These consist of expenses like financial charges, remuneration of various personnel engaged in construction activity, traveling and other expenses incurred for the purpose of implementing the project, depreciation on various assets used for the purpose of construction and trial production expenses. These expenses are allowed to be capitalized, i.e., added to the value of various assets set up by allocating them over the items of plant, machinery, buildings, etc., on some reasonable basis. The unit is permitted to claim depreciation on the enhanced value of these assets arrived at after such allocation and this value is referred to as the 'actual cost' of the assets. Such actual cost is reduced by that portion, if any, as has been met directly or indirectly by any other person or authority [Section 43 (1)].

Indirect Expenditure not Relating to Construction: There are several expenses incurred during the construction period, which are not in any way related to construction. Examples: expenses on the marketing department, expenses incurred due to the corporate status of the unit. Such expenses are not allowed to be capitalized nor are they allowed to be deducted from the income of the subsequent years. From the point of view of financial accounting, these expenses are treated as deferred revenue expenses and are written off over a period of time. From the income tax point of view, however, the company does not derive the benefit of charging these expenses against revenue. Hence, it is preferable that such expenses are incurred, as far as possible, after the date of setting up of the unit.

Expenditure on Technical Know-how: Capital Expenditure incurred on technical know-how, incurred after 1st April, 1998 can be capitalized as direct expenditure related to construction or can be by itself treated as an intangible asset, on which depreciation can be claimed under section 32. Revenue expenditure on technical know how can be claimed as expenses under section 37 (1).

Expenditure Relating to a New Project of an Existing Company: When an existing company with ongoing business activities sets up a new project, expenses that are directly relatable to the construction of the project is capitalized. Other indirect expenses incurred during the construction period are allowed to be claimed as a deduction from the incomes earned from other existing activities of the company. However, this does not preclude the company from capitalizing all indirect expenses relating to construction without claiming it as a deduction from other incomes as previously mentioned.

Income Earned during Construction Period: Income earned during construction period, which is attributable to construction activity, can be reduced from the construction cost of the asset itself. Examples of such income are sale of products produced during trial run, sale of packing material used for machinery, hire charges received for plant and machinery which was given to the sub contractor, sale of packing material used of machinery etc. Other types of incomes like interest received and share transfer fees received are normally treated as income for the purpose of Income Tax Act.

Depreciation According: According to Section 31 (1) of the Income Tax Act, depreciation at prescribed rates on the actual cost (as determined in the manner stated in the preceding heading) in respect of (i) buildings, plant and machinery and furniture and fittings being tangible assets and (ii) know-how, patents, copyrights, trademarks, licences, franchises or other business other business or commercial rights being intangible assets used for business/professional purposes is a tax deductible expenses. For claiming the depreciation allowance, the assets should be owned and used for the purpose of business by the assessee.

When a capital asset is imported, by incurring a liability in foreign exchange and the rupee equivalent of such liability is outstanding at the end of each year or at the time of repayment increases/decreases due to fluctuation in rates of exchange then such increases/decreases are adjusted against the actual cost (Section 43 A). The actual cost so adjusted at the end of each year is treated as if it was the actual cost from the date of acquisition of the asset. This necessitates adjustment toward depreciation in each year in respect of earlier years.

Depreciation is charged on blocks of assets, which represent a group of assets, within the broad class of assets, of buildings, plant, machinery, and furniture, for which a common rate of depreciation is applicable. Depreciation will be calculated by applying the prescribed rate (which varies between 5% and 100%) on the written down value (WDV) of the entire block. When an asset is sold the amount realized from the sale of such asset (after deducting expense on sales) will simply be deducted from the WDV of that block. If the amount realized is greater than the WDV of the block, the difference will be treated as short term capital gain. In a case where all the assets in the block are disposed off and there is still a balance in the account of the block, such amount will be treated as short-term capital loss.

To illustrate the above provisions, let us consider an example. A block of assets consisting of 10 items acquired during 2000 to 2005 has a written down value of Rs.3 million as on 1st April 2005. During 2004-2005, the assessee sells an asset for Rs.2 million (on which an expense of Rs.0.1 million is incurred on sale) and acquires an asset for Rs.0.5 million.

The net block of assets for depreciation purposes at the end of 2004-2005 will be:

Opening WDV	Rs.2 million
Value of addition during the year	$\frac{Rs.0.5 million}{Rs.2.5 million}$
Less	
Sale proceeds (after deducting selling expense)	Rs. 1.9
For the asset sold	
Net block for purposes of depreciation	Rs.0.6 million

In the above example, if the sale proceeds (after deducting selling expense) had been Rs.5 million, the difference between this amount and Rs.2.5 million should be treated as short-term capital gain and the net block for purposes of depreciation will be zero. Suppose, all the assets in the block (including the assets acquired during the year) are sold for Rs.2.2 million (after deducting selling expense), the balance of Rs.0.3 million remaining in the block amount will be treated as short-term capital loss.

In may be noted that when any asset is acquired and put to use during the previous year for a period less than 180 days then depreciation will be allowed only to the extent of 50 percent of the prescribed rate for that asset in respect of the year of acquisition.

Deduction in Respect of Expenditure on Scientific Research: Under Section 35, the following expenses relating to scientific research incurred during the previous year are allowed as deduction in computing the income from business:

All expenses, both revenue and capital (other than cost of land) incurred on scientific research relating to the business of the assessee. Such expenditures incurred within three years before the commencement of business shall also be deemed to be incurred in the year of commencement of business and accordingly deductible in that year.

Contributions to approved scientific research associations/institutions, University / College, and to be used for scientific research are eligible for deduction of 125% of the contribution made [section 35 (1)(ii)].

In respect of contributions made to approved National Laboratories or University or Indian Institute of Technology, with a specific direction that the amounts be used for scientific research undertaken under an approved programme, an amount equal to 125% of the contribution is allowed as a deduction. [section 35 (2AA)].

Contributions to approved institutions to be used for research in social science or statistical research whether related to business or not are eligible for a deduction of 125% of the contribution [section 35 (1)(iii)].

Section 35 (2 AB) allows a weighted deduction of one and one half times, on revenue and capital expenditure (other than land and building) incurred on approved in house research and development, of companies engaged in manufacturing and production of drugs and pharmaceuticals, telecommunication equipment, chemicals, bio-technology, computers and others notifies from time to time. This deduction is available up to March 31, 2005. [section 35(2AB)].

Expenditure in the nature of capital expenditure incurred for acquiring any right to operate telecommunication services, either before the commencement of business or thereafter. Deduction can be claimed under section 35 ABB, starting from the year in which the payment is made (or the business had commenced), in equal instalments and ending in the year in which the licence comes to an end.

Deduction in Respect of Profits Derived from Export Business: Section 80 HHC allows deduction of a certain percentage out of the profits derived from export business of a resident business entity or an Indian company. Various conditions governing the grant of this deduction are as follows.

1. The assessee should be engaged in the business of export out of India of any goods and merchandise. Exports of mineral oils and minerals and ores (other than processed minerals and ores specified in the twelfth schedule to the Income Tax Act) do not qualify for this deduction.
2. The sale proceeds from exports of such goods are receivable by the assessee in convertible foreign exchange within a period of six months or such extended time given by the Appropriate Authority from the end of the previous year in which the export took place.

3. The profits derived from export business (hereinafter referred to as exempted profits) is determined under 3 cases, viz. where the exported goods are manufactured or processed by the assessee, where the exported goods are trading goods and where the exported goods consist of both types.

Case 1: Export of manufactured goods

Eligible profit = Profit of the business x $\frac{Export\,turnover\,of\ Manufactured\ goods}{Total\,turnover\,of\ the\,bu\sin ess}$

Case 2: Export of trading goods

Eligible profit = Export turnover of trading goods – Direct and indirect costs attributable to export of such goods.

Case 3: Export of both manufactured and trading goods

(a) For manufactured goods:

Eligible profit =Adjusted profit of the business x $\frac{Adjusted\ \exp ort\,turnover}{Adjusted\,total\,turnover}$

(b) For trading goods:

Eligible profit = Export turnover of trading goods – Direct and indirect costs attributable to export of such goods.

The percentage rate of deduction of the eligible profits shall be an amount equal to: 70, 50 and 30 percent for the financial year beginning from April 1, 2001, 2002. And 2003 respectively.

No deduction is allowed from the assessment year beginning 1.4.2005.

Note: For purposes of making the above computations various expressions used there under have the meanings as stated below:

(a) 'Total Turnover' does not include freight, insurance and export incentives;

(b) 'Export Turnover' means the sale proceeds received or brought into India in convertible foreign exchange within six months of the previous year or such extended time limit but does not include freight and insurance (beyond customs limit)

(c) ‘Profits of the Business’ means the amount computed under the head ‘Profits and Gains of Business or Profession’ and reduced by (i) 90% of the export incentives, brokerage, commission, interest, rent or receipt of similar nature included in such profit and (ii) the profits of any branch office, warehouse or any other establishment of the assessee situated outside India;

(d) ‘Direct Costs’ means costs directly attributable to the exported trading goods including the purchase price of such goods;

(e) ‘Indirect Costs’ means costs, not being direct costs, allocated in the ratio of the export turnover of trading goods to the total turnover;

(f) ‘Adjusted Total Turnover’ means the total turnover of the business as reduced by the export turnover of trading goods;

(g) ‘Adjusted Export Turnover’ means the export turnover as reduced by the export turnover of trading goods.

(h) ‘Adjusted Profits of the Business’ means the profits of the business as reduced by the profits derived from the business of export of trading goods.

4. An assessee selling the eligible goods to an Export/Trading house holding a valid certificate issued by the Chief Controller of Imports and Exports is entitled to the deduction as stated above on the basis of a certificate of export turnover issued by such Export Trading House and a Chartered Accountant. On issue of such certificate, the amount of deduction available to the Export Trading House will be reduced by the amount calculated as follows:
5. A certificate from a Chartered Accountant certifying that the deduction has been correctly claimed is to be furnished along with the return of income.

Deduction in Respect of Profits and Gains Projects Outside India (Sec. 80 HHB): This deduction is applicable to Indian companies or to persons resident in India, engaged in executing foreign projects like construction of buildings, dams, roads, the assembly or installation of plant or machinery etc., for which compensation is payable in convertible foreign exchange [Section 80 HHB].

The conditions governing the deduction are as follows:

- Separate books of accounts are to be maintained for such projects
- The accounts must be audited and a report prepared in the prescribed format
- The assessee is required to credit the Foreign Projects Reserve Account the specified percentage of profits. The amount credited to the 'Reserve Account' is required to be utilized by the assessee before the expiry of a period of five years following the previous year in which the amount was credited which must be used for the purpose of the business and not for distribution as dividends.
- The specified percentage of profits is also required to be remitted to India in convertible foreign exchange
- The amount that can be claimed is specified percentage of the profits and gains of such business.

The specified percent is 30% for the assessment year commencing from 1.4.2002 and there after this deduction is reduced by 10% each year. No deduction is allowed from the assessment year beginning 1.4.2005.

Profits from the Export of Computer Software and Other Related Technical Service [Section 80 HHE]: The deduction is allowed for an Indian Company or a person other than company resident in India, and is a Software developer, and has export out of India of computer software or its transmission from India to a place outside India by any means or has providing technical services outside India in connection with the development or production of computer software.

For the purpose, profit derived from the business specified above is determined as follows:

$$\text{Eligible Profits} = \frac{\textit{Export turnover}}{\textit{Total turnover}} \times \text{Profit of the business}$$

The deduction allowable is 60% of eligible profits for the assessment year 2002-2003, reduced to 40% and so on in the subsequent assessment years, and is being phased out in a gradual manner such that no deduction will be available for the assessment years commencing on 1.4.2005 and subsequent years.

The terms export turnover, total turnover and profit of business have been defined specifically in the section.

In order to claim the deduction, the assessee is required to furnish an audit report in the prescribed form along with the return of income.

Exemptions in Respect of Profits and Gains of Newly Set Up Industrial Undertakings in Free Trade Zones [Section 10A]: Newly established industrial undertakings in free trade zones, electronic hardware technology parks, software technology parks, or special economic zones, can claim exemption of 100% of their profits and gains derived from such exports for a period of ten years beginning with assessment year relevant to the previous year in which the industrial undertaking begins to manufacture or produce articles or things.

Sale proceeds must be brought into India in convertible foreign exchange within the specified period. The exemption will not go beyond assessment year 2009-2010. The amount of profit that is eligible for deduction is calculated in the ratio of the export turnover to total turnover of the business. This section applies to Kandla Free Trade Zone, Santacruz Electronics Export Processing Zone or any other free trade zone as prescribed by the central government by notification in the Official Gazette or the technology parks set up under a scheme notified by the central government, for the purposes of this section.

Newly Established Hundred Per Cent Export Oriented Undertakings [Section 10B]: This provision extends the same type of benefit as allowed for the industrial undertakings set up in a free trade zone or technology park, to newly established undertakings recognized as 100% Export Oriented Undertaking. For the purposes of this section, “hundred per cent export oriented undertakings” means an undertaking, which has been approved as a hundred per cent export oriented undertaking by the Central Government. All the other provisions are similar to the above Section 10 A.

Deduction in Respect of Profits and Gains from Newly Set Up Industrial Undertakings Engaged in Infrastructure Development: Section 80 IA, allows a certain deduction in respect of profits and gains of an industrial undertaking, being an Indian company or a consortium, carrying on the business of developing, or maintaining and operating, or developing, maintaining and operating.

(a) Infrastructure facility like roads, bridges, airports, inland waterways, ports, highway projects water supply projects, irrigation sanitation and sewerage treatment system

(b) Telecommunication service

(c) Industrial parks

(d) Generation, distribution and transmission of power

The allowable deductions are as follows:

Infrastructure Facility started after 1.4.95

- The deduction will be hundred percent (from assessment year 2002-03) of profits and gains derived from such business for ten consecutive years beginning from the initial assessment year and falling within the fifteenth (twenty in some cases) assessment year from the year in which the enterprise begins operating and maintaining the infrastructure facility.

Telecommunication Services

- Telecommunication services are services that include basic or cellular services including radio paging, domestic satellite services, network of trucking and broadband network and Internet services.
- These services should have started or starts providing telecommunication service after a 1st April 1995 but before 31.2.2003;

- The deduction will be hundred percent for the fist five years and thirty percent thereafter (next five years) for ten consecutive year starting from the initial assessment year and falling within fifteen years from which the enterprise begins operations.

Industrial Park:

- An undertaking which develops and operates industrial parks or (or special economic zones from the assessment year 2002-2003) on or after 1 April 1997 but before 31.3.2006.
- The amount of deduction is 100 percent of profits from the assessment year 2002-2003 for ten consecutive years starting from the initial assessment year and falling within fifteen years from which the enterprise begins operations.

Generation and Distribution of Power

- An undertaking, which is set up in any part of India for, generation or generation and distribution of power or transmission or distribution by laying network of new lines, begins on the 1st April, 1999 but before 31.3.06.
- Splitting up or reconstruction of a business does not form the industrial undertaking already in existence. However, if the business is re-established or revived by the assessee which was discontinued due to damage of building machinery etc. on account of floods, earthquake typhoon etc. or riots and civil disturbances or by fire or explosion or act of war etc. the business will be treated as a new industrial undertaking.
- Amount of deduction will be 100 percent from the assessment year 2002-2003. For ten consecutive years starting from the initial assessment year and falling within fifteen years from which the enterprise begins operations.
- The amount of profits eligible for deduction will be limited to the activities undertaken by the undertaking for example: If the undertaking is engaged in generation of power, then profits generation of power is eligible.

Additional conditions that need to be fulfilled by the business are:

(i) For calculating the amount of deduction, such industrial undertaking or eligible business is treated as if it was the only source of income.

(ii) Goods and services transferred by the eligible business or those transferred to the eligible business by any other business carried on by the assessee has to be at the market value. In addition, the assessing officer has the right to recomputed the profits and gains as he may deem fit.

Deduction in Respect of Profits and Gains from Certain Industrial Undertakings Other than Infrastructure Development Undertakings: Section 80 IB allows a certain deduction in respect of the profits and gains derived from any newly set up industrial undertaking, other than infrastructure development undertaking referred to as eligible business which must have commenced operation before 31.3.2002.

The allowable deductions are as follows:

- In the case of industrial undertakings located in an industrially backward state for district as specified or set up in any part of India for the generation, or generation and distribution, of power which begins to manufacture or produce articles or things or to operate its cold storage plant or plants or to generate power at any time during the period from 1st April, 1994 to 31st March, 2002, the deduction will be 100% for the first five years and 30% for the next 5 years. An undertaking refining mineral oil gets 100% deduction for initial seven assessment years.
- Other small scale Industrial undertakings manufacturing or things or operating its cold storage plants, for initial assessment year and nine succeeding assessment years the deduction allowed is @ 30% of profits and gains derived from such industries.

For purposes of computing the amount of deduction, such industrial undertakings are treated as if it was the only source of income.

For computing the profits of the eligible business as previously mentioned, past losses and Unabsorbed allowances relating to such business is deducted even though such past losses, etc., have already been absorbed by other incomes in the past.

For both Sections 80IA and 80 IB the following conditions apply;

- The splitting up, or reconstruction, of a business already in existence, does not form it.
- The transfer does not form it to a new business of a machinery or plant previously used for any purpose.
- In the case of an industrial undertaking other than a small scale industry or an industry set up in a backward state, it manufactures or produces any articles or things other than articles or things specified on the list in the Eleventh Schedule;
- It employs ten or more workers in a manufacturing process carried on with the aid of power or employ twenty, or more workers in a manufacturing process carried on without the aid of power.

Disallowances : The Income Tax Act provides that though certain expenses are incurred by the assessee during the previous year, they will not be allowed as a deduction (partly or fully) in computing the income under the head 'Profits and Gains of Business or Profession' under certain circumstances. The more important of these items are mentioned below:

1. Advertisement expenditure in the material published by any political party is disallowed in full [Section 37 (2B)].
2. Any expenditure incurred by the assessee who is prohibited by law will not be allowed as deduction. (Section 37).

3. Expenditure because supply of goods, services, or facilities by certain specified related persons/organizations, which is in the opinion of the assessing officer, is excessive or unreasonable can be disallowed [Section 40A (2)].
4. Expenditure in respect of which payment is made in a sum exceeding Rs.20,000/-, at a time, otherwise than by crossed cheque or bank draft (except in certain exempted cases) is disallowed in full [Section 40A (3)].
5. Contributions to unapproved gratuity or other funds of employees are disallowed in full [Section 40 A (7 and 9)].
6. Expenditures of the following kinds are allowed if they are not paid for within the previous year or within a stipulated time after the previous year: (a) expenses on account of tax, duty, or fees, (b) contributions to any provident/superannuating / gratuity/other welfare fund of employees, (c) payment of bonus or commission to employees, and (d) interest on any loan or borrowing from public financial institution (e) Interest on term loan from scheduled banks (f) provision made for amount payable as in lieu of any leave (leave encashment) (as defined in Section 4A of the Companies Act, 1956) (Section 43B).

11.4 SET OFF, CARRY FORWARD, AND ORDER OF DEDUCTION FOR COMPUTING INCOME FROM BUSINESS

Various deductions and allowances are considered in computing the income from business as discussed in the previous section. If the result after providing for such deductions and allowances is a negative figure in any year, this is allowed to be set off against income from other heads and the remaining unabsorbed amount, if any, can be carried forward to the next year and set off against the income of that year and so on. The provisions relating to set off negative income and aggregation and the order of deduction for computing income from business are as follows:

- The first step in the aggregation process is the determination of income under each head by setting off losses against incomes under different sources. The rules for such set off are as follows:
  (a) Losses from any source under a given ‘head of income’ can be set off only against income from any other source under the same ‘head of income’ with exceptions noted in (b) below,
  (b) Losses from speculation business (which falls under the head of income ‘profits and gains of business or profession’) can be set off only against profits from speculation business. Likewise, losses from owning and maintaining racehorses can be set off against profits from similar activity.

- Setting off losses does aggregation of income from all heads of income from one head of income against income from other head/s. The rules regarding set off and carry forward are as follows:
  (a) Subject to (i) above losses under any head of income other than the head capital gains can be set off against the income under any other head of income. Losses under the head house property to the extent it relates to the interest on loan taken for construction, purchase or repair of such property can be set off against income from any other head. In the subsequent year, the carried forward loss should be set off against income from house property and the balance loss can be carried forward for a period of eight subsequent years from the year in which the loss was first computed.
  (b) Losses that remain under the head capital gains can be carried forward and set off against income under the head capital gains of subsequent years

and so on. Such carry forward can be done for a period of eight subsequent years from the year in which the loss was computed.

(c) Unabsorbed business loss (other than speculation business loss) of any year can be carried forward and set off against income under the head of business of subsequent years. Such carry forward can be done for eight subsequent years from the year in which the loss was computed.

(d) Unabsorbed loss from speculation business can be carried forward and set off against income from speculation business. Such carry forward can be done for eight subsequent years.

- Unabsorbed depreciation can be carried forward and set off against the income from any other head of subsequent years without any limitation as to the number of years.
- Capital expenditure on scientific research, which is not absorbed by available current profits, is treated in the same way as unabsorbed depreciation.

Order of Deduction for Computing Income from Business For the purposes of carry forward and set off, the unabsorbed benefits from an earlier year are divided into various categories and are considered for set off, along with certain current allowances, in the order given below in computing the income from business of the current year:

- Current scientific research capital expenditure
- Current depreciation
- Carried forward business loss
- Unabsorbed depreciation and Unabsorbed capital expenditure on scientific research

A loss cannot be carried forward unless the return of Income Tax is filed within the time allowed under Section 139 (1) of the Act.

11.5 SUMMARY

Once the taxable income of the company (assessing the project appraisal) is derived, the next step is the determination of the tax burden and its payment. For this purpose, we need to know; (i) tax rates for companies, (ii) calculation of Minimum Alternate Tax, (iii) provisions for payment of advance tax, and (iv) provisions for payment of tax along with the filing return.

For tax purposes, companies are classified as domestic companies and foreign companies and are taxed at 35% and 48% respectively. Though the rates of income tax are prescribed annually in the Finance Act, the Income Tax Act it self stipulates the rates of income tax in respect of certain types of incomes and these generally relate to foreign companies in respect of incomes of the nature of royalties, technical know-how fees, interest and dividends. In respect of long-term capital gains, the Act prescribes rates of tax both for domestic as well as foreign companies.

Such incomes are taxed at rates mentioned in the Act and the remaining total income is taxed at the rates stated above.

The total tax liability computed as above is increased by an amount of surcharge (at present 2 percent) on the tax computed.

In the case of an assessee, being a company, if the income tax is payable on the total income as computed under the Act, is less than 7.5% of its book profit, the tax payable for the relevant previous year shall be deemed to be 7.5% of such book profit. That is every company will now be paying at least 7.5% of the book profits as tax. [Section 115JB (1), inserted with effect from 1.4.2001].

In addition, a report in the prescribed format, from the accountant certifying that the book profit has been computed in accordance with the provisions of this section must be field along with the return of income.

The annual accounts prepared are in accordance with Parts II and III of Schedule VI of the Companies Act using the accounting policies, accounting standards and methods of depreciation and which are presented before the annual general meeting of the company.

Book profits means the net profit shown in the profit and loss account and should be increased by:

- The amount of provision for income tax
- The amount carried to any reserve
- The amount set aside for unascertained liabilities
- The provisions for losses of subsidiary companies
- The amounts paid or proposed as dividends

Similarly, the following should be deducted from the profit and loss account

- The amount withdrawn from any reserves or provision credited to profit and loss account
- The amount of loss brought forward or unabsorbed depreciation whichever is less as per books of accounts
- The net amount of income as reduced by expenses included in the profit and loss account, which is exempt from tax under Sections 10, 10A or 10B, shall be excluded.
- The amounts of profit which are eligible for deduction under Section 80 HHC, or 80 HHE or 80 HHF and is also excluded for the purposes of calculation if MAT. No tax credits are available under the MAT as calculated under Section 115JJB.

Advance tax is payable on the current income of the company in four installments during the financial year as follows:

On or before	Advance tax that should have been paid by the due date (As a percentage of the estimated total tax liability)
15th June	15
15th September	45
15th December	75
15th March (succeeding)	100

For practical purposes, these provisions mean that income tax is payable along with the earnings. Thanks to this 'pay as you earn' principle, there is hardly any lag between earnings and tax payment.

At the time of filing return, the assessee is required to compute the tax liability based on the income stated in the return of income. If there is a shortfall between this tax liability and the sum of the advance tax paid and the tax deducted at source on incomes due to the company, then such shortfall is required to be paid before the return is filed. Such tax is referred to as self-assessment tax. Along with such shortfall in tax the assessee is also required to pay interest on (a) the shortfall in the advance tax payable in any installment and (b) the self assessment tax, if the return is filed beyond the due date. The due date for filing of return for companies is 31st October of the relevant assessment year.

11.6 KEYWORDS

Gross Total Income: It represents the summation of income from business and income from other heads.

Total Taxable Income: It represents the difference between the gross total income and the deductions from the gross total income and is the base on which the tax rate is applicable to arrive at the tax liability.

Direct Costs: It means costs directly attributable to the exported trading goods including the purchase price of such goods.

Book Profits: Book profits means the net profit shown in the Profit and Loss Account.

11.7 SELF ASSESSMENT QUESTIONS

1. "A company assessing the tax burden of new project under consideration needs to carry out detailed examination of relevant tax provisions." Explain the statement with example.

2. Discuss the provisions relating to the depreciation and set off and carry forward of losses under income tax act. What is the relevance of such provisions in case of a new project?
3. Reliance India Ltd is engaged in infrastructure projects in the area of construction of National Highways. You as an expert are requested to advice to the company as what steps the company should take in order to avoid any undesirable action from the tax department.
4. What is written down value (WDV)? How far it is useful in calculating the depreciation on capital assets. Bring out the detailed account with some suitable examples.

11.8 SUGGESTED READINGS

1. Chandra, Prasanna: Projects-planning, analysis, financing, implementation and review.
2. Desai, Vasant: Project Management
3. Mahrotra, H. C : Income Tax Law and Practice.
4. Singhania, V K : Income Tax Law and Practice.

LESSON: 12

ENVIRONMENTAL APPRAISAL OF PROJECTS

STRUCTURE

12.0 OBJECTIVE

After reading this lesson, you should be able to

a) Discuss the environmental dimensions of a project.

b) Explain the different stresses on environment.

c) Make the Environmental Impact Assessment.

12.1 INTRODUCTION

The effects of actions that are not accounted for in the normal market transactions need to be considered explicitly in the decision making process on projects. These effects are to be identified, assessed, and evaluated against the economic advantages arising out of a given action. In this context, the environmental impact appraisals are considered the first step in the process because they give an opportunity to man to consider the effects of his actions on the environment.

Economic development is the result of the interaction between natural resources and technology supported by and designed for people. People are the centre for development. Therefore, it is rightly said that all human activity, be it economic, social or anything else is essentially directed at satisfying “needs” and “wants” of man through “altering” and “using” environmental resources.

12.2 TYPES AND ENVIRONMENTAL DIMENSIONS OF A PROJECT

Broadly, there are two types of projects. The first one refers to those projects that produce physical goods like cement, steel, paper, chemicals etc. These projects, in fact, convert the natural resources into saleable and exchangeable products. In fact, these projects inflict a large number of physical changes and disruptions on environment and, hence, disturb the environmental and ecological balance. Environmentalists are mostly concerned with such type of projects. The second type refers to those that produce/render various kinds of services such as health, education, transport, energy, defense, law etc. Such projects also cover actions like land reforms, agricultural extension, services, sales promotion campaigns, etc. Projects of these types are non-physical in nature and they do not directly cause any physical changes in the environment. However, they bring about significant changes of far-reaching consequences on values, attitudes, lifestyles, social relations, and so on. The net effect of such projects is the creation of new wants and needs in society. They ultimately promote consumerism in the society and thereby increase the number of manufacturing projects. Thus, both are interrelated.

Each project has two dimensions: (a) the intended objectives – they are also called stated goals/benefits; and (b) the unintended consequences. They are also called externalities or social costs which are unplanned, unwanted, and unanticipated. Environmental management or planning is the study of the unintended consequences of a project. Its purpose is to identify, examine, assess, and evaluate the likely and probable impacts of a proposed project on environment and, thereby, to work out the remedial action plans to minimize the incidence of adverse impacts. It is not anti-development nor is it against the projects. Its goal is development without damage or least damage.

12.3 STRESSES ON ENVIRONMENT

Environmentalists have identified four types of different stresses or pressures that are being continuously inflicted on environment. They are:

i) **Atrophic Stress** Refers to the release of various kinds of wastes into the river and other water bodies and their consequent drying.

ii) **Exploitative Stress** Refers to the exploitation of natural resources endowment for production and consumption purposes through agriculture, industry, extraction, fishing etc. It is important to note that the rate of exploitation has a relevance to the nature's capacity to reproduce.

iii) **Disruptive Stress** Refers to the physical alterations in nature resulting from such activities like forest clearance, highways, railways, factory buildings and so on. These physical changes disturb the environmental and ecological balance.

iv) **Chemical and Industrial Stress** results mainly from the developments in "science and technology" and their applied fields like industry, warfare and agriculture. This comprises mainly the pollutants and effluents of all types, radiation etc.

Strategies to face these threats to natural environment through pollution, destruction and over-use can be: (a) preventive or (b) regulatory. It is in this context that the environmental appraisal of projects is gaining significance with a hope of achieving sustainable development in harmony with environment.

12.3.1 Meaning and Scope of Environment

The word "environment" is defined to include everything external to man/organism. It covers the region, surroundings, or circumstances in which anything exists. It is broadly divided into two components. The first one is the biotic or inorganic milieu, comprising the physical elements like land, water, atmosphere, climate, sound, odours, and tastes. They are the inanimate elements of the habitat systems. The other one is the biotic or the organic milieu consisting of animals, plants, bacteria, viruses, all other living organisms, and the social factors including aesthetics. They are the animate elements.

The is another definition particularly relevant in the context of projects. Here, the term "environment" is defined as:

The surrounding zone (the specific zone to be affected by the project), all natural resources (physical and biological), and the human resources (people, economic development and quality of life values).

This definition is comparatively more specific, focused, and clear-cut than the earlier one, which was too general and unfocussed. This is more suited to operationalise, quantify, and measure the environmental impacts of a given action. The contentious issue in this definition is the surrounding zone or the project vicinity. However, a distinction has to be made between the "legal boundary" which is the area legally occupied by a project, and the "environmental boundary" which stretches much beyond the legal boundary. In fact, this is the area around the project that is likely to be affected environmentally by the project operations. The extent of environmental boundary for a project depends, among other things, on the diffusion factors like wind speeds and directions, elevations, etc. It varies from project to project and location to location for the same project.

There is yet another definition of environment as below:

The external, natural, physical and residential conditions which affect man directly and indirectly and which are, in turn, influenced by economic decisions and technological developments.

This definition implies a complex interactive model between man, environment, and science and technology, the outcome of which will be economic development. As a matter of fact, projects facilitate such an interaction.

Environmental management, a term encompassing environmental planning, protection, monitoring, assessment, research, education, conservation, and sustainable use of resources, is now accepted as a major guiding factor in all the economic decision making processes on development or otherwise. Subsequently, a wide network of legislation came into being. Now, environmental clearance for all the major projects on the basis of their Environmental Impact Statement (EIS) has become legally mandatory.

12.3.2 Environmental resources/values (ER/VS)

Since the word 'environment' is an all-inclusive concept encompassing everything external to us, it is difficult to operationalise and applies to particular situations like the projects. For the purposes of operationalisation and practical application, the environmentalists have developed a concept called 'Environmental Resources/Values' (ER/Vs). It is defined as an aspect of environment which is of benefit to man. The environmentalists have identified and classified various components of environment (that is, ER/Vs) into four levels as below:

(a) Level – 1: Physical Resources, covering land, water and air,

(b) Level – 2: Ecological Resources, consisting of aquatic, terrestrial and endangered (rare) species (other than man).

(c) Level – 3: Human Use Values, covering transport, agriculture, water supply, recreation, mining, industry, flood control, etc.

(d) Level – 4: Quality of Life Values, covering socio-economic, cultural and aesthetic aspects.

Thus, the whole environment is decomposed into several operationally feasible components for elements. These elements can further be subdivided into several related items. Alternatively, some other environmentalists identify and classify the various elements of environment broadly under eight types, which are called Environmental Attributes (EA). They are: (a) air, (b) water, (c) land, (d) ecology, (e) sound, (f) human aspects, (g) economics, and (h) resources. Each one can further be subdivided into different related elements.

In the context of environmental appraisal of projects, one can follow either of the classifications, viz., Environmental Resources/values (ER/Vs) or the Environmental Attributes (EA). As a mater of fact, they can be evaluated and assessed individually with respect to the impacts they receive or the changes they undergo due to the proposed project. Since there will be a variety of types of impacts of varying degrees from a project, the decomposition of environment unit into various quantifiable elements will enable the analyst to give focus and direction to his impact assessment analysis.

An environmental effect is considered as the effect of natural or fabricated actions, which alter environment (as measured by physical, chemical, and biological parameters). Our concern is, however, on man made actions. The nature and extent of environmental impacts including magnitude, severity, urgency, risk etc., of a project in the ultimate analysis depends upon:

(a) Nature, size and type of the project: such as manufacturing, services, agriculture, mining, logging, power, hardour, chemicals, sugar, etc.
(b) Technology.
(c) Location/eco-region: such as urban or rural areas, coastal, river valley, forest/hill areas or any of the eco-systems as described earlier.

12.3.3 Environmental impact assessment (EIC) and environmental impact statement (EIS)

Environmental Impact Assessment (EIA) and the Environmental Impact Statement (EIS) are said to be the instruments through which the environmental management tries to accomplish its objective. The basic premise behind the EIS/EIA is that no one has any right to use the precious environmental resources resulting in greater loss than gain to society. From this, it follows that the aim of EIS is to seek ways by which the project can proceed without any irreparable losses to environment and minimum losses if any, so that the net effect will be a desirable gain.

Environmental Impact Assessment (EIA) is defined as: "An activity designed to identify, predict, interpret, and communicate information about the impact of an action on man's health and well-being (including the well-being of ecosystems on which man's survival depends). In turn, the action is defined to include any engineering project, legislative proposal, policy programme, or operational procedure with environmental implications." An EIA, therefore, is a study of the probable changes in the various socio-economic and biophysical attributes of the environment, which may result from a proposed action.

On the other hand, Environmental Impact Statement (EIS) is defined as:

> *A report, based on studies, disclosing the likely or certain environmental consequences of a proposed action, thus alerting the decision maker, the public and the government to environmental risks involved; the findings enable better informed decisions to be made, perhaps to reject or defer the proposed action or permit it subject to compliance with specific conditions.*

The EIS is a document prepared by an expert agency on the environmental impacts of a proposed action/project that significantly affects the quality of environment. The EIS is used mainly as a tool for decision-making. At times, the EIA and EIS are used interchangeably as synonyms. However, both are different activities with many commonalities and with a common purpose. The basic difference between the two is that the EIA is carried out by the expert agency while the EIS as a tool is given to the decision-makers in different formats. As a matter of fact, the EIS is the outcome of EIA. It is better to consider the environmental consequences during the project planning and design stage itself so to avoid higher costs of future remedial actions by prudent planning and early preventive measures.

Objectives of EIS: To identify and describe (in as quantified a manner as possible) the environmental resources/values (ER/Vs) or the environmental attributes (EA) which will be affected by the proposed project, under existing or "with or without project" conditions.

(a) To describe, measure, and assess the environmental effects that the proposed project will have on the ER/Vs (again, in as quantified a manner as possible), including positive effects, which enhance ER/Vs, as well as the negative effects, which impair them. Direct or indirect and short term or long term effects are to be considered. This would also include the description of the specific ways by which the project plan or design will minimize the adverse effects and maximize positive effects.

(b) To describe the alternatives to the proposed project which could accomplish the same results but with a different set of environmental effects. Energy generation by thermal, hydel, and nuclear modes would explain the case in point. Further, alternative locations are also considered.

Guidelines on the Scope and Contents of EIS/EIA: The following are the commonly accepted points to be covered in an EIA study/report:

(a) A description of the project proposed action; a statement of its purpose and a description of all relevant technical details to give a complete understanding of the proposed action, including the kinds of materials, manpower/resources etc., involved.

(b) The relationship of the proposed action to the land-use plans, policies and controls in the affected area or the project-vicinity. It is necessary to gain a complete understanding to the affected environment. What is the nature of biophysical and socio-economic characteristics that may be changed by the action?

(c) The probable impacts of the proposed project on environment are a very important aspect to be considered in detail. It is necessary to project the project action into the future and to determine the possible impacts on the environmental attributes. The changes are to be quantities wherever possible.

(d) Alternatives to the proposed action, including those not within the existing authority/agency.

(e) Any probable adverse environmental effects that cannot be avoided and stating how each avoidable impact will be mitigated.

(f) The relationship between local short term uses of man's environment and the maintenance of an enhancement of long-term productivity.

(g) Any irreversible and irretrievable commitments of resources (including natural, cultural, labour, and materials).

(h) An indication of what other interests and considerations of governmental policy or programme are thought to offset the adverse effects identified.

As seen by its purpose, scope and contents, the EIA is a very complex exercise due to the fact that many and varied types of projects are proposed for an equally numerous and varied kinds of environmental settings. Each combination of projects and the complex environmental settings results in a unique cause-condition-effect relationships with regard to their impacts. Therefore, each combination must be studied individually in order to accomplish a comprehensive analysis.

Methodology for Conducting an EIS Study: So far, there is no consensus on any particular procedure. This is because of the difficulties in quantifying the effects which are often intangible, complex, and imperceptible in nature. It is difficult to develop meaningful parameters to represent the effects and their quantification. The major problems in this regard are:

(i) The diffused nature of impacts both over time and space; and the lags in impacts after the cause worked.

(ii) An environmental effect is the joint product of several pollutants.

(iii) Inadequacy of techniques to estimate the impacts and their costs.

(iv) Since the impacts are imperceptible, people are not aware of the impacts.

Due to the complex problems involved in identification and quantification of effects, all attempts to develop quantitative approach to EIA (including the checklists, matrices, networks, flowchart relationships, and map overlays) have been essentially subjective with the quantification depending mostly on the background and bias of the investigator or observer.

At present, the generally accepted approach for making the EIS is an item-by-item review of effects on the individual environmental resources/values (ER/Vs), including both the identification of ER/Vs, and description and quantification of the effect to the extent possible. Then, it is possible to group these effects in a systematic manner. The following are the major practical steps in this approach.

(a) Make a rapid or quick scanning or appraisal of the basic environmental resources viz., land, water and air, at the macro level, say at the district level in which the project is to be located. This scanning is meant to evaluate the extent of fragility and exploitation of the endowed resource-base, including the human resources. Then relate the project to the regional environmental in broad terms.

(b) Demarcate the project vicinity or the surrounding zone of the project. Maps can also be used.

(c) Identify, assess, and describe all the environmental attributes as given in a tabular form earlier; or the environmental resources/values (ER/Vs under four levels) as given earlier, endowed in the project vicinity. This would give a total description of the environment before the start of the project.

(d) Rank or prioritise the identified ER/Vs by their fragility, importance, relevance and quality. This would help to concentrate on the very significant items rather than spreading the efforts too thinly over a large number of items of lesser significance.

(e) Carry out the item-by-item review of effects of the proposed project on the already identified individual ER/Vs embedded in the project vicinity.

(f) Arrange or group the effects in a systematic manner, preferably in a format.

(g) Prepare the remedial plans for mitigating the adverse effects. They can be: (i) Corrective; (ii) Compensatory; or (iii) Enhancing.

By following the above practical steps sequentially in that order, one can make an environmental appraisal of any type of project. Through EIS/EIA, the environmental protection planning is made compatible with the developmental perspectives.

Some Major Issues in the Preparation of EIS/EIA: The following are the major issues reported to be encountered commonly while conducing and preparing the EIS/EIA. Some of the issues cannot be resolved. In the absence of better alternatives, the analyst has to accept the issues as they are.

- Determining the Environmental Impacts This is the central theme in any EIS/EIA. It is a very complex process. At the outset, a distinction has to be made between the environmental impact and the changes in environmental attributes. Our interest is on the "impacts" and not on the 'changes', which normally take place even without the project. The determination of environmental impacts involves: (a) identification of impacts on environmental attributes or the ER/Vs, (b) measurement of impacts on attributes, and (c) aggregation of impacts on attributes to reflect the total impact on environment.
- With and Without the Project the environmental impacts are measurement of attributes with and without the project or activity at a given point in time. However, the changes in the attributes take place over time without the activity. Therefore, the impact must be measured in terms of "net" change in the attribute at a given point in time.
- Identifying the Impacts the number of attributes to be evaluated is practically infinite because any characteristic of the environment is considered an attribute. Therefore, they have to be reduced to manageable numbers. Thus, duplicative, redundant, difficult to measure, and obscure attributes may be eliminated in favour of those that are more tractable. This implies that some attributes, which are difficult to measure or conceptualize, may remain to be examined. In this case, bias and subjectivity are likely to be crept in.

- Characteristics of the Base Conditions Prior to the Activity: The nature of the impact is determined by the conditions of the environment existing before the project. The assessment of the characteristics of the base is a critical factor.
- Geographic Characteristics: The same activity produces different impacts on a particular attribute; say water quality, over different geographical areas. The spatial distribution of different activities introduces one of the difficult elements in comparing one activity and its impact with another. This issue becomes particularly critical while making choices between projects.
- Role of Attributes Though the impacts are considered the effects on the definite discrete attributes of the environment, the actual impacts are not correspondingly well categoriesed. Nature does not necessarily respect man's discrete categories. Rather, the actual impacts may be the effects of varying severity on a variety of interrelated attributes. The issue is one of identifying and assessing the cause-condition-effect in order to work out the remedial measures.
- Measurement of Impact Ideally, all impacts must be translatable into common units. However, this not possible because of the difficulty in defining affects in common units (e.g., on income and on water quality). In addition, the quantification of some impacts may be beyond the state of the art.
- Aggregation Problem After measuring the project impacts on various individual attributes or ER/Vs, one encounters the problem of how to aggregate all impacts (quantitative and qualitative) thus assessed to arrive at a single composite measure to represent the 'total activity impact'. This would involve expressing the various impact measures in common units, which is very difficult. Some use a weighting

procedure to accomplish this, which is again subjective. There is another associated problem of summing up and comparing with the impact of an alternative activity.

- Secondary Impacts Secondary or indirect impacts on environment should also be considered particularly in relation to the infrastructure investments that stimulate or induce secondary effects in the form of associated investments and changed patterns of social and economic activity. Such induced growth brings significant changes in the natural conditions. Similarly, there can also be significant secondary impacts in the biophysical environment.
- Cumulative Impacts Here, cumulation refers to the similar activities spread over in all environmental setting like hotels, beach resorts, surface or underground mines, industrial estates, etc. A single individual activity may produce a negligible effect on environment. However, services of similar activities may produce significant cumulative effects on certain aspects of environment. This raises the question of how to deal with these significant cumulative effects. Therefore, it is suggested to prepare an environmental impact assessment (EIA) on broad programmes rather than on a series of component actions (e.g., industrial estates, mining sector, tourism industry, etc.). On the other hand, alternatively, one can prepare and EIA for a particular geographical area where a series of similar activities are located (e.g., mining areas, coastal line for beach resorts, etc.).
- Reporting Findings The results should be displayed in such a way that it makes easy and clear to comprehend the total impacts of an activity from a brief review. It is suggested to display the impacts on a summary sheet in a matrix form.

The knowledge about the issues as explained above, however complex they are, will be useful in understanding the processes and complexities involved in preparing an EIS/EIA. Such awareness will help improve the understanding of EIS, leading to more objectives, informed and unbiased decision-making on activities/projects.

Choice of a Methodology: Many impact assessment methodologies have been developed in the western industrialized countries as a response to the various legislative control and regulatory measures as also to suit divergent environmental situations and purposes.

The choice will decide the depth of analysis to the carried out in a particular impact assessment. The choice of a methodology depends on; (a) needs of the user, (b) type of project; its size and technology, and (c) location; type of ecosystem.

Depending on these factors, one may be more useful than the other methodology. Therefore, the analyst must decide which one will best fit for a given task and situation. The following are the important considerations for making a choice on the methodology for preparing an EIS/EIA.

- Use: It the EIS for a decision or for information? If it is for a decision, it required greater emphasis on identification of key issues, quantification and comparison of alternatives. If it is for information, it requires a more comprehensive analysis and concentration on interpretation of the significance of a broad list of possible impacts.
- Alternatives: Are alternatives fundamentally or incrementally different?
- Resources: How much time, skills, money, and data are available? More in-depth and quantitative analysis requires more of everything.

- Familiarity: Is the analyst familiar with both the types of project proposed and the physical site?
- Issue Significance: How big is the issue? The bigger the issue, the greater the need to be explicit, to quantify, and to identify key issues.
- Administrative Constraints: Are choices limited by governmental procedures and format requirements? Some policy guidelines may rule out some tools by specifying the range of impacts to be addressed.

12.4 ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGIES

The impact identification and assessment can be made through several ways. Each one represents a methodology. Besides the one already explained, there are six other different methodologies in the literature based on the way the impacts are identified and assessed. A critical overview of the methodologies is given in Figure-1.

1. Ad Hoc: These methodologies provide a minimum guidance for impact assessment. They merely suggest broad areas of possible impacts (e.g., impacts on lakes, forests, etc.,) rather than defining specific parameters to be investigated. This is given exogenously to the analyst.
2. Overlays: These methodologies depend upon a set of maps on the environmental characteristics (physical, social, ecological, and aesthetic) of the proposed project's vicinity. These maps are overlaid to produce a composite characterization of the regional environment. Noting the impacted environmental attributes within the project boundaries then identifies impacts.
3. Checklists: The methodologies present a specific list of environmental attributes to be investigated for possible. They need not necessarily attempt to establish the cause-effect links to project activities. They may or may not include guidelines about how attribute data are to be measured and interpreted.

4. Matrices: These methodologies incorporate a list of project activities with a checklist of potentially impacted environmental attributes. Then, the two lists are related in a matrix form, which identifies the cause-effect relationships between specific activities and impacts. The matrix methodologies may either specify which actions affect, which attributes, or may simply list the range of project activities and environmental attributes in an open matrix to be completed by the analyst.
5. Network: These methodologies work from a list of project activities to establish cause-condition-effect relationships. It is generally felt that a series of impacts may be triggered by a project action. They define a set of possible networks and allow the user to identify impacts by selecting and tracing out the appropriate project actions.
6. Combination Computer-aided: These methodologies use a combination of matrices, networks, analytical models, and a computer-aided systematic approach. Since this is a combination of difficult methodologies, it is a multiple-objective approach to; (a) identify activities associated with the governmental policies and programmes; (b) identity potential environmental impacts at different levels; (c) provide guidance for abatement and mitigation techniques; (d) provide analytical models to establish cause-effect relationships and to quantitatively determine potential environmental impacts, and (e) provide a methodology and a procedure to utilize this comprehensive information in decision-making.

12.5 SUMMARY

An environmental impact assessment (EIA) must effectively deal with four key problems; (a) impact identification; (b) impact measurement; (c) impact interpretation, and (d) impact communication to users. These criteria can be used for analyzing a methodology and determining its weaknesses and strengths. It also helps in choosing methods, which are most appropriate for a particular situation.

The above six methodologies display variety in conceptual framework, data formats and data requirements as well as work force, monetary and time resource requirements. An EIA team can use more than one method.

Figure-1 An Overview of EIA Methodologies

Methodology		Areas of usefulness	Drawbacks
(a)	Ad Hoc	Simple and no training/skills needed. In-depth and focused analysis on few; When no expertise and resources available, this is the best. Given preliminary understanding Project's effects on environment given without any weighting and cause-effect relations.	Restricts to broad areas only. Not all relevant impacts covered. Selective and biased. Lacks consistency due to different criteria to evaluate different groups of factors.
(b)	Checklists	Strong in impact identification. Effective in evoking public attention. Simple and easy to understand; comprehensive. Most useful at the stage of initial Environmental examination (IEE).	Scaling and weighting subjective. Leaves interpretation to Decision makers. Measurement deficient.
(c)	Matrices	Provides cause-effect relations between project activities and impacts on various attributes. Graphical display of impacts given better understanding. Strong in impact identification and their interaction is possible.	Information is lost due to quantification. Scaling and weighting become subjective.
(d)	Networks	Capable of identifying both direct and indirect effects and their interaction. Capable of incorporating mitigation and management measures at the planning stage of a project.	Less useful in considering. socio-economic environment. Display becomes large and unwidely when large Industrial complexes or regional plans are considered.
(e)	Overlays	Useful in site and route selection. Effective presentation and display. Useful in transport projects and road route alternative land use planning.	Quantification and measurement weak. Not all impacts covered. Higher order impacts cannot Be identified. Social environment not considered. Subjective Self-limiting in scope.

12.6 KEYWORDS

Atrophic Stress: It refers to the release of various kinds of waste in the river and other water bodies and their consequent drying.

Environment: Environment is defined to include everything external to man/organism.

Environmental Resources/Values: It is defined as an aspect of environment which is of benefit to man.

Environmental Impact Assessment: It is a study of the probable changes in the various socio-economic and bio-physical attributes of the environment, which may result from a proposed action.

Cumulation: It refers to the similar activities spread over in all environmental setting like surface or underground mines, hotels, beach resorts etc.

12.7 SELF ASSESSMENT QUESTIONS

1. Discuss and illustrate the issues involved in the assessment of environmental feasibility of a project.
2. Write short notes on the followings:
   a.) Environmental Methodologies.
   b.) Environmental Standards.
   c.) Environmental Considerations in a Projects.

12.8 SUGGESTED READINGS

1. Chandra, Prasanna: Projects-planning, analysis, financing, implementation and review.
2. Desai, Vasant: Project Management
3. Bedi, Suresh : Business Environment.
4. Ashwathapa, A K : Business Environment

Darbhanga College of Engineering, Darbhanga

8th Sem. (2016-20), Civil Engineering Dept.

Subject (Theory):- CONSTRUCTION PLANNING AND MANAGEMENT (CODE: 011827)

S.N.	Registration No.	Student Name	Attendance 5_Marks	Assignment / Class_Test 5_Marks	Online_Internal_Exam 20_Marks	Total (Out_of_30)
1	16101111001	KANHAIYA KUMAR YADAV	4	5	16	25
2	16101111002	VISHAL RAJ	5	5	15	25
3	16101111003	VINEET KUMAR	5	4	19	28
4	16101111004	RISHI KUMAR	5	5	16	26
5	16101111005	KIRTHI	4	5	18	27
6	16101111006	MITESH KUMAR MITESH	5	5	16	26
7	16101111007	ANKESH KUMAR	5	5	17	27
8	16101111008	SHUDHANSHU SHEKHAR JHA	5	5	15	25
9	16101111009	SHIKHA	5	5	16	26
10	16101111010	KUMARI PRIYANSHU	5	5	16	26
11	16101111011	MOTILAL MANJHI	4	4	18	26
12	16101111012	KESHAV KUMAR	5	4	17	26
13	16101111013	CHANDAN KUMAR	4	4	19	27
14	16101111014	PREMRANJAN KUMAR	4	5	17	26
15	16101111015	RAJNISH KUMAR	5	4	19	28
16	16101111016	AMAR KUMAR	5	5	19	29
17	16101111017	SAURAV KUMAR SHANU	4	4	18	26
18	16101111018	RAHUL KUMAR	5	5	16	26
19	16101111019	ABHISHEK KUMAR SHUKLA	5	4	18	27
20	16101111020	NARENDRA KUMAR	4	5	17	26
21	16101111021	RUPAK RAJ	5	5	16	26
22	16101111022	RAHUL RAVI	5	4	17	26

23	16101111023	SANTOSH KUMAR	5	5	18	28
24	16101111024	PRINCE KUMAR	5	5	18	28
25	16101111025	NEERAJ KUMAR	4	5	15	24
26	16101111026	PRABHAT RANJAN	5	4	17	26
27	16101111027	MD ZAKI AHMAD	4	5	17	26
28	16101111028	HEMANT KUMAR	5	5	17	27
29	16101111029	AMIT RAJ	4	5	17	26
30	16101111030	RAKESH KUMAR	5	5	18	28
31	16101111031	MUSAFIR KUMAR	5	4	16	25
32	16101111032	AJAZ AHMAD	4	4	17	25
33	16101111033	POOJA KUMARI	5	5	18	28
34	16101111034	SHIVAMVEER KUMAR	5	5	18	28
35	16101111035	SUNIL KUMAR	5	5	18	28
36	16101111036	ATISH DEEPANKAR	5	4	17	26
37	16101111037	VIKRAM BHARTI	5	5	16	26
38	16101111038	DIPESH KUMAR	5	5	17	27
39	16101111039	CHANDRAMANI KUMAR	5	5	16	26
40	16101111040	AMIT KUMAR	5	5	16	26
41	16101111041	RAJEEV RANJAN	5	5	18	28
42	16101111042	SOPHIA KHATOON	5	5	17	27
43	16101111043	ADITI	4	5	14	23
44	16101111044	PRIADARSHI KUMAR	4	5	17	26
45	16101111045	RAJVANSHI KUMAR SINGH	5	4	19	28
46	16101111046	BHUDEV KUMAR	4	4	17	25
47	16101111047	SUDHIR KUMAR	5	5	17	27
48	16101111048	CHANDRESH KUMAR	5	5	18	28
49	16101111049	DILIP KUMAR	5	4	17	26

50	16101111050	RAMESH KUMAR SAH	4	4	18	26
51	16101111051	UMANG BHARDWAJ	5	5	16	26
52	16101111053	MD SALIK ANWAR	4	5	14	23
53	16101111054	RAUSHAN KUMAR	5	5	18	28
54	16101111055	SAIMA FIRDAUS	5	5	17	27
55	16101111056	DURGESH KUMAR	4	5	18	27
56	16101111058	RAMRATAN KUMAR	5	5	15	25
57	16101111059	SHANKAR RAM	4	4	16	24
58	17101111901	PANKAJ KUMAR SAH	4	4	18	26
59	17101111902	RAHUL KUMAR	5	5	17	27
60	17101111903	ANKESH KUMAR	4	4	18	26
61	17101111904	ADARSH ANAND	5	5	18	28
62	17101111905	PRATEEK KUMAR	4	5	15	24
63	17101111906	SANATAN KUMAR JHA	5	4	17	26
64	17101111907	SACHIN KUMAR	4	5	15	24
65	17101111908	MRITYUNJAY KUMAR	5	5	18	28
66	17101111909	BIBEKANAND KUMAR	5	5	18	28
67	17101111910	KUMAR SUMAN SAURABH	5	5	18	28
68	17101111911	PINKEE KUMARI	5	5	17	27
69	17101111912	JAI KUMAR	5	5	17	27

Signature