Darbhanga College of Engineering, Darbhanga

ME Department

B.Tech [SEM IV (ME)]

QUESTION BANK WITH SOLUTIONS

INSTRUMENTATION AND CONTROL

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Total no. of questions:110

UNIT 1

Multiple Choice Questions

1. Decide whether each of these statements is True (T) or False (F). Sensors in a measurement system have: (i) An input of the variable being measured, (ii) An output of a signal in a form suitable for further processing in the measurement system
   Which option BEST describes the two statements?
   A T(ii)T
   B.(i)T(ii)F
   C. (i)F (ii)T
   D. (i)F (ii)F
2. The following lists the types of signals that occur in sequence at the various stages in a particular measurement system: (i)Temperature (ii) Voltage (iii) Bigger voltage (iv) Movement of pointer across a scale The signal processor is the functional element in the measurement system that changes the signal from:
   A (i)to(ii)
   B (ii) to (iii)
   C (iii) to (iv)
   D (ii) to (iv)
3. Decide whether each of these statements is True (T) or False (F). An ammeter, was inserted in the circuit .The discrepancy between the measured value of the current in an electrical circuit and the value before the measurement system, is bigger,when larger is: (i) The resistance of the meter, (ii) The resistance of the circuit.
   Which option BEST describes the two statements?
   A.(i)T (ii) T
   B.(i)T (ii)F
   C.(i)F (ii)T
   D.(i)F (ii)F
4. Decide whether each of these statements is True (T) or False (F).
   A highly reliable measurement system is one where there is a high chance that the system will: (i) Require frequent calibration. (ii) Operate to the specified level of performance. Which option BEST describes the two statements?
   A (i)T(ii)T
   B (i)T(ii)F
   C (i)F(ii)T
   D (i) F (ii) F

   Short Answer Questions
5. List and explain the functional elements of a measurement system.

6. Explain the terms (a) reliability and (b) repeatability when applied to a measurement system.
7. Explain what is meant by calibration standards having to be traceable to national standards.
8. Explain what is meant by 'fitness for purpose' when applied to a measurement system.
9. The reliability of a measurement system is said to be 0.6. What does this mean?
10. The measurement instruments used in the tool room of a company are found to have a failure rate of 0.01 per year. What does this mean?
11. Define limiting errors? Derive the expression for relative limiting error?
12. Define linear time invariant and line time variant systems. Give examples.
13. Why PMMC ammeters are the most widely used instrument?
14. Draw the equivalent circuit and phasor diagram of a potential transformer.
15. List out the types of input circuits used in the signal conditioning.

Long Answer Questions

16. Give the advantages and disadvantages of LCDS.
17. List out the basic components of a tape recorder.
18. An accelerometer has a seismic mass of 0.05kg and a spring constant of 3x103N/M. Maximum mass displacement is ±0.02m. Calculate.Maximum measurable acceleration (ii) Natural frequency
19. List out the advantages and disadvantages of RTD.
20. A set of independent ten measurement were made to determine the weight of a load shot. The weights in gramme were 1.570, 1.597, 1.591, 1.562, 1.577, 1.580, 1.564, 1.586, 1.550, 1.575. DetermineArithmetic mean
    - (i) Average deviation
    - (ii) Standard deviation
    - (iii) Variance
    - (iv) Proable error of one reading
    - (v) Proable error of the mean

UNIT 2

Multiple Choice Questions

1.Function of transducer is to convert
A. Electrical signal into non electrical quantity
B. Non electrical quantity into electrical signal
C. Electrical signal into mechanical quantity
D. All of these
2.Potentiometer transducers are used for the measurement of
A. Pressure
B. Displacement
C. Humidity
D. Both (a) and (b)
3.Thermistor is a transducer. Its temperature coefficient is
A. Negative
B. Positive
C. Zero
D. None of these
4.Strain gauge is a
A. Active device and converts mechanical displacement into a change of resistance
B. Passive device and converts electrical displacement into a change of resistance
C. Passive device and converts mechanical displacement into a change of resistance
D. Active device and converts electrical displacement into a change of resistance
5.Constantan is used for measurement of dynamic strains. It is an alloy of

A. Copper and Aluminium
B. Nickel and molybdenum
C. Nickel and chromium
D. Copper and nickel
6.The linear variable differential transformer transducer is
A. Inductive transducer
B. Non-inductive transducer
C. Capacitive transducer
D. Resistive transducer
7.The transducer used for the measurements is/are
A. Resistance temperature detectors
B. Thermistors
C. Ultrasonic
D. All of these
8.If at one end, the two wires made of different metals are joined together then a voltage will get produced between the two wires due to difference of temp between the two ends of wires. This effect is observed in
A. Thermocouples
B. Thermistors
C. RTD
D. Ultrasonics
9.For the measurement of pressure the instruments used can be
A. Mechanical
B. Electro-mechanical
C. Electronic
D. All of these
10.With the increase in the intensity of light, the resistance of a photovoltaic cell
A. Increases
B. Decreases
C. Remains same
D. None of these

Short Answer Questions

Suggest sensors which could be used in the following situations:

1. To monitor the rate at which water flows along a pipe and given an electrical signal related to the flow rate.
2. To monitor the pressure in a pressurised air pipe, giving a visual display of the pressure.
3. To monitor the displacement of a rod and give a voltage output.
4. To monitor a rapidly changing temperature.

Suggest the type of signal processing element that might be used to:

5. Transform an input of a resistance change into a voltage.
6. Transform an input of an analogue voltage into a digital signal.
7. A potentiometer with a uniform resistance per unit length of track is to have a track length of 100 nmi and used with the output being measured with an instrument of resistance 10 kQ. Determine the resistance required of the potentiometer if the maximum error is not to exceed 1% of the full-scale reading.
8. A platinum resistance coil has a resistance at O^'C of 100 Q. Determine the change in resistance that will occur when the temperature rises to 30°C if tlie temperature coefficient of resistance is 0.0039 K-'.
9. A platinum resistance thermometer has a resistance of 100.00 Q at OT, 138.50 Q at lOOT and 175.83 Q at 200T. What will be the non-linearity error at 100°C if a linear relationship is assumed between 0°C and 200C?

10. An electrical resistance strain gauge has a resistance of 120 Q and a gauge factor of 2.1. What will be the change in resistance of the gauge when it experiences a uniaxial strain of 0.0005 along its length?

Long Answer Questions

11. A capacitive sensor consists of two parallel plates in air, the plates being 50 mm square and separated by a distance of 1 mm. A sheet of dielectric material of thickness 1 mm and 50 mm square can slide between the plates. The dielectric constant of the material is 4 and that for air may be assumed to be 1. Determine the capacitance of the sensor when the sheet has been displaced so that only half of it is between the capacitor plates. .
12. An operational amplifier circuit is required to produce an output that ranges from 0 to -5 V when the input goes from 0 to 100 mV. By what factor is the resistance in the feedback arm greater than that in the input?
13. What will be the feedback resistance required for an inverting amplifier which is to have a voltage gain of 50 and an input resistance of 10 kQ?
14. What will be the feedback resistance required for a non-inverting amplifier which is to have a voltage gain of 50 and an input resistance of 10 kQ?
15. A differential amplifier is to have a voltage gain of 100 and input resistances of 1 kQ. What will be the feedback resistance required?
16. A differential amplifier is to be used to amplify the voltage produced between the two junctions of a thermocouple. The input resistances are to be 1 kfl. What value of feedback resistance is required if there is to be an output of 10 mV for a temperature difference between the thermocouple junctions of lOO^C with a copper-constantan thermocouple. The tliermocouple can be assumed to give an output of 43 mv/degree Celsius.
17. What is the resolution of an analogue-to-digital converter with a word length of 12 bits? 39 A sensor gives a maximum analogue output of 5 V. What word length is required for an analogue-to-digital converter if there is to be a resolution of 10 mV? 40 What is the voltage resolution of an 8-bit DAC when it has a fiillscale input of 5 V?

UNIT 3

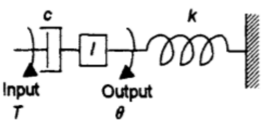
Multiple Choice Questions

1. In an open loop control system
    a. Output is independent of control input
    b. Output is dependent on control input
    c. Only system parameters have effect on the control output
    d. None of the above
2. For open control system which of the following statements is incorrect ?
    a. Less expensive
    b. Recalibration is not required for maintaining the required quality of the output
    c. Construction is simple and maintenance easy
    d. Errors are caused by disturbances
3. A control system in which the control action is somehow dependent on the output is known as
    a. Closed loop system
    b. Semiclosed loop system
    c. Open system
    d. None of the above
4. In closed loop control system, with positive value of feedback gain the overall gain of the system will
    a. decrease
    b. increase
    c. be unaffected
    d. any of the above
5. Which of the following is an open loop control system ?
    a. Field controlled D.C. motor
    b. Ward leonard control
    c. Metadyne

   d. Stroboscope
6. Which of the following statements is not necessarily correct for open control system ?
   a. Input command is the sole factor responsible for providing the control action
   b. Presence of non-linearities causes malfunctioning
   c. Less expensive
   d. Generally free from problems of non-linearities

<u>Short Answer Questions</u>

1. If a system has a gain of 5, what will be the output for an input voltage of 2 V?
2. An open-loop system consists of three elements in series, the elements having gains of 2, 5 and 10. What is the overall gain of the system?
3. A closed-loop control system has a forward loop with a gain of 6 and a feedback loop with a gain of 2. What will be the overall steady-state gain of the system if the feedback is (a) positive, (b) negative?
4. .A closed-loop negative feedback system for the control of the height of liquid in a tank by pumping liquid from a reservoir tank can be considered to be a system with a differential amplifier having a transfer function of 5, its output operating a pump with a transfer function 5/(s + 1). The coupled system of tanks has a transfer function, relating height in the tank to the output from the pump, of 3/(s + 1)(s + 2). The feedback sensor of the height level in the tank has a transfer function of 0.1. Determine the overall transfer function of the system, relating the input voltage signal to the system to the height of liquid in the tank.
5. For a rotational system, the output theta is related to the input T.For the system to be critically damped, what is the realtion between *c*,*I* and *k*

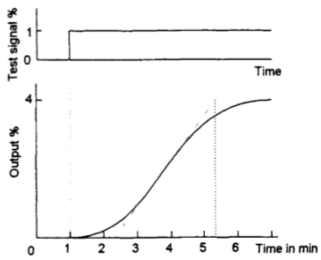


6.

7. Derive a differential equation relating the input and output for each of the systems shown in the following figures.

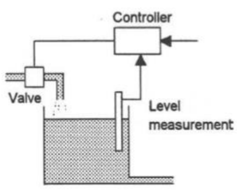
<u>Long Answer Questions</u>

8. Write down the steps involved in the Ziegler-Nichols method for tuning PID controllers.Figure below shows the open-loop response of a system to a unit step in controller output. Using the Ziegler-Nichols data, determine the optimum settings of the PID controller to be used in the system to give good performance.



9.

10. Figure below shows a control system designed to control the level of water in the container to a constant level. It uses a proportional controller with Kp equal to 10. The valve gives a flow rate of 10 m^3/hr per percent of controller output, its flow rate being proportional to the controller input. If the controller output is initially set to 50% what will be the outflow from the container? If the outflow increases to 600 m^3/h, what will be the new controller output to maintain the water level constant?



11.

12. Fig.Proportional controller for water level control

13. A temperature control system has a set point of 20°C and the measured value is 18°C. What is (a) the absolute deviation, (b) the percentage deviation?
14. What is the controller gain of a temperature controller with a 80% PB if its input range is 40°C to 90° and its output is 4 mA to 20 mA?
15. Using the Ziegler-Nichols ultimate cycle method for the determination of the optimum settings of a PID controller, oscillations began with a gain of 2.2 with a period of 12 min. What would be the optimum settings for the PID controller?
16. Sketch graphs showing how the controller output will vary with time for the error signal shown in Figure 5.34 when the controller is set initially at 50% and operates as (a) just proportional with a Kp = 5, (b) proportional plus derivative with Kp = 5 and Kd = 1.0 s, (c) proportional plus integral with Kp = 5 and Ki= 0.5 /s

UNIT 4

Multiple Choice Questions

1. A pneumatic cylinder has a piston of cross-sectional area 0.02 m^2 The force exerted by the piston when tlie working pressure applied to the cylinder is 2 MPa will be:
   A 100 MN
   B 40MN
   C 40kN
   D 20kN
2. A hydraulic cylinder with a piston having a cross-sectional area of 0.01 m^ is required to give a workpiece an average velocity of 20 mm/s. The rate at which hydraulic fluid should enter the cylinder is:
   A 4 X 10-* m^3/s
   B 2 X 10 m^3/s
   C 0.2 m^3/s
   D 2 m^3/s
3. A flow control valve has a diaphragm actuator. The air pressure signals from the controller to give 0 to 100% correction vary from 0.02 MPa to 0.1 MPa above the atmospheric pressure. The diaphragm area needed to 100% open the control valve if a force of 400 N has to be applied to the stem to fiiUy open the valve is:
   A 0.02 m^3
   B 0.016 m^3
   C 0.004 m^3
   D 0.005 m^3
4. For a system which can be represented by a second-order differential equation relating its input and output, for a step input to give an output which rises to the steady-state value with no oscillations about the steady-state value and take the minimum amount of time, the damping constant has to be:
   A Zero
   B Less than 1
   C 1
   D More than 1

Short Answer Questions

5. A force of 400 N is required to fully open a pneumatic flow control valve having a diaphragm actuator. What diapliragm area is required if the gauge pressure from the controller is 100 kPa?
6. An equal percentage flow control valve has a rangeability of 25. If the maximum flow rate is 50 mVs, what will be the flow rate when the valve is one-third open?
7. A stepper motor has a step angle of 7.5". What digital input rate is required to produce a rotation of 10.5 rev/s?
8. A control valve is to be selected to control the rate of flow of water into a tank requiring a maximum flow of 0.012 mVs. The permissible pressure drop across the valve at maximum flow is 200 kPa. What valve size is required ? Use Table 6.1. The density of water is 1000 kg/ml
9. A control valve is to be selected to control the flow of steam to a process, the maximum flow rate required being 0.125 kg/s. The permissible pressure drop across the valve at maximum flow is 40 kPa. What valve size is required? The specific volume of the steam is 0.6 mVs.

10. If a system has a gain of 5, what will be the output for an input voltage of 2 V?

Long Answer Questions

11. An open-loop system consists of three elements in series, the elements having gains of 2, 5 and 10. What is the overall gain of the system?

12. A closed-loop control system has a forward loop with a gain of 6 and a feedback loop with a gain of 2. What will be the overall steady-state gain of the system if the feedback is (a) positive, (b) negative?
13. Determine the delay time and the rise time for the following firstorder systems: (a) G{s) = 1/(4s + 1)
14. .Determine the natural angular frequency, the damping factor, the rise time, percentage overshoot and 2% settling time for a system where the output *y* is related to the input *x* by the differential equation:

$$\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 16y = 16x$$

15. State if the following systems are stable, the relationship between input X and output y being described by the differential equations

$$(a)\ \frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 2y = x,\ (b)\ \frac{d^2y}{dt^2} + \frac{dy}{dt} - 6y = x$$

16. If a system has a gain of 5, what will be the output for an input voltage of 2 V?
17. An open-loop system consists of three elements in series, the elements having gains of 2, 5 and
18. . What is the overall gain of the system? 10 A closed-loop control system has a forward loop with a gain of 6 and a feedback loop with a gain of 2. What will be the overall steady-state gain of the system if the feedback is (a) positive, (b) negative?
19. A system has an input of a voltage of 3 V which is suddenly applied by a switch being closed. What is the input as an 5 function?
20. A system has an input of a voltage impulse of 2 V. What is the input as an 5 function?

UNIT 5

Multiple Choice Questions

1. 1 The system giving the Nyquist diagram shown in Figure 12.14 is:
   A Stable for all frequencies
   B Stable only at low frequencies
   C Unstable at all frequencies
   D Marginally stable
2. 2The system giving the Nyquist diagram shown in Figure 12.15 has a value of A^/10 where it cuts tlie negative real axis and so is:
   A Stable when K is greater than 10
   B Stable when K is equal to 10
   C Stable when K is less than 10
   D Stable for all values of K
3. The system giving the Nyquist diagram shown in Figure 12.16 is:
   A Stable for all frequencies B Stable only at low frequencies C Unstable at all frequencies D Marginally stable

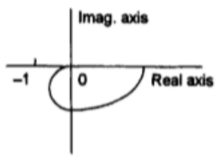


Figure 12.14 *Problem 1*

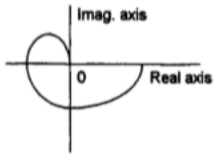


Figure 12.15 *Problem 2*

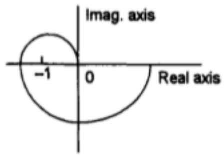


Figure 12.16 *Problem 3*

4. The gain of a system is |G(jw)| = 0 dB. For an input of a sinusoidal signal of frequency coi, the output will have a magnitude which is:
   A Zero B Reduced in size compared with input C Same size as input D Larger in size than input
5. 1 The phase difference between the two signals y1 = 2 sin (3t + pi/2) and y2 = -5 sin (3t + pi/2) is:
   A. pi/2
   B. -pi/2
   C.pi
   D .-pi

6. The phase crossover frequency of a system is the frequency at which the phase angle first reaches:

   A -180° B -90 C 90° D +180°

<u>Short Answer Questions</u>

1. A system has an input of a voltage of a ramp voltage which increases at 5 V per second. What is the output function?
2. A system gives an output of l/(s + 5) V(s). What is the output as a function of time? 15 A system has a transfer function of 5/(s - 3). What will be its output as a function of time when subject to (a) a unit step input of 1 V
3. A system gives an output of l/(s + 5) V(s). What is the output as a function of time? 15 A system has a transfer function of 5/(s - 3). What will be its output as a function of time when subject to , (b) a unit impulse input of 1 V?
4. A system has a transfer function of 2/(s + 1). What will be its ouQ)ut as a function of time when subject to (a) a step input of 3 V, (b) an impulse input of 3 V?
5. A system has a transfer function of l/(s + 2). What will be its output as a function of time when subject to (a) a step input of 4 V, (b) a ramp input unit impulse of 1 V/s?
6. Determine the gain margin and the phase margin for a system that gave the following open-loop experimental frequency response data: at frequency 0.01 Hz a gain of 1.00 and phase -130°, at 0.02 Hz a gain of 0.55 and phase -180°.
7. Determine the maximum phase lead introduced by a phase-lead compensator with a transfer function of (1 + 0.1s)/{1- 0.01s).
8. A system has an open-loop transfer function of 12/[s(s +1) What will be the transfer function of a phase-lead compensator which, when added in cascade, will increase the uncompensated phase margin of 15° to 40°?
9. A system has an open-loop transfer function of 4/[s{s + 1)]. What will be the transfer function of a phase-lag compensator which, when added in cascade, will give a phase margin of 40°?
10. Sketch the Nyquist diagram for a system having an open-loop transfer function of l/[s(s + 1)].
11. With a Nyquist diagram for the open-loop frequency response for a system, what is the condition for the system to be stable?
12. Determine the gain margin and tlie phase margin for a system which gave the following open-loop frequency response:
    1 /s(0.2s+1)(0.05s+1)
13. Sketch the Nyquist diagram for a system having an open-loop transfer function of 9/[s(s + 1)].
14. With a Nyquist diagram for the open-loop frequency response for a system, what is the condition for the system to be stable?

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SOLUTIONS

UNIT 1

Multiple Choice Questions

1.A

2.B

3.B

4.C

Short Answer Questions

5. An instrumentation system for making measurements consists of several elements which are used to cany out particular functions. These functional elements are:

Sensor This is the element of the system which is effectively in contact with the process for which a variable is being measured and gives an output which depends in some way on the value of the variable and which can be used by the rest of the measurement system to give a value to it. For example, a thermocouple is a sensor which has an input of temperature and an output of a small e.m.f. which in the rest of the measurement system might be amplified to give a reading on a meter. Another example of a sensor is a resistance thermometer element which has an input of temperature and an output of a resistance change

Signal processor This element takes the output from the sensor and converts it into a form which is suitable for display or onward transmission in some control system. In the case of the thermocouple this may be an amplifier to make the e.m.f. big enough to register on a meter

Data presentation This presents the measured value in a form which enables an observer to recognise it

The term transducer is often used in relation to measurement systems. Transducers are defined as an element that converts a change in some physical variable into a related change in some other physical variable. It is generally used for an element that converts a change in some physical variable into an electrical signal change. Thus sensors can be transducers. However, a measurement system may use transducers, in addition to the sensor, in other parts of the system to convert signals in one form to another form

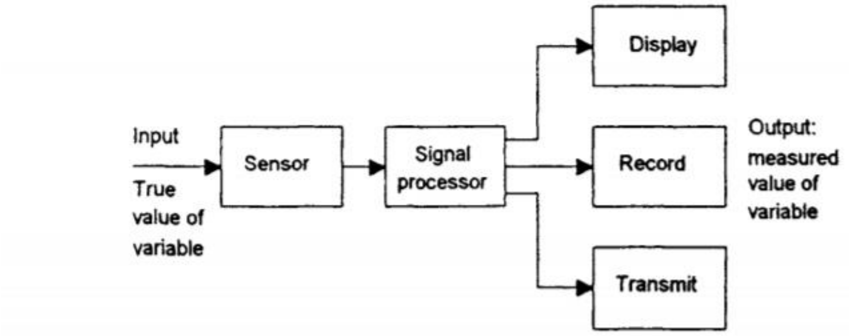


Figure 1.10 *Measurement system elements*

6. The terms repeatability and reproducibility are ways of talking about precision in specific contexts. The term repeatability is used for the ability of a measurement system to give the same value for repeated measurements of the same value of a variable. Common cause of lack of repeatability are random fluctuations in the environment, e.g. changes in temperature and humidity. The error arising from repeatability is usually expressed as a percentage of the full range output. For example, a pressure sensor might be quoted as having a repeatability of ±0.1% of fiill range. Thus with a range of 20 kPa this would be an error of ±20 Pa Reliability is an important requirement of a measurement system. The reliability of a measurement system, or element in such a system, is defined as being the probability that it will operate to an agreed level of performance, for a specified period, subject to specified environmental conditions.

7. Calibration should be carried out using equipment which can be traceable back to national standards with a separate calibration record kept for each measurement instrument. This record is likely to contain a description of the instrument and its reference number, the calibration date, the calibration results, how frequently the instrument is to be calibrated and probably details of the calibration procedure to be used, details of any repairs or modifications made to the instrument, and any limitations on its use.

The national standards are defined by international agreement and are maintained by national establishments, e.g. the National Physical Laboratory in Great Britain and the National Bureau of Standards in the United States.

There are seven such primary standards, and two supplementary ones, the primary ones being:

1 Mass The mass standard, the kilogram, is defined as being the mass of an alloy cylinder (90% platinum-10% iridium) of equal height and diameter, held at the International Bureau of Weights and Measures at Sevres in France. Duplicates of this standard are held in other countries.

2 Length The length standard, the metre, is defined as the length of the path travelled by light in a vacuum during a time interval of duration 1/299 792 458 of a second.

3 Time The time standard, the second, is defined as a time duration of 9 192 631 770 periods of oscillation of the radiation emitted by the caesium-133 atom under precisely defined conditions of resonance.

4 Current The current standard, the ampere, is defined as that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed

one metre apart in a vacuum, would produce between these conductors a force equal to 2 x 10'^ N per metre of length.

5 Temperature The kelvin (K) is the unit of thermodynamic temperature and is defined so that the temperature at which liquid water, water vapour and ice are in equilibrium (known as the triple point) is 273.16 K.

6 Luminous intensity The candela is defined as the luminous intensity, in a given direction, of a specified source that emits monochromatic radiation of frequency 540 x 10'^ Hz and that has a radiant intensity of 1/683 watt per unit

7 Amount of substance The mole is defined as the amount of a substance which contains as many elementary entities as there are atoms in 0.012 kg of the carbon 12 isotope.

8. The main requirement of a measurement system is fitness for purpose. This means that if, for example, a length of a product has to be measured to a certain accuracy that the measurement system is able to be used to carry out such a measurement to that accuracy. For example, a length measurement system might be quoted as having an accuracy of ±1 nun. This would mean that all the length values it gives are only guaranteed to this accuracy, e.g. for a measurement which gave a length of 120 mm the actual value could only be guaranteed to be between 119 and 121 mm. If the requirement is that the length can be measured to an accuracy of ±1 mm then the system is fit for that purpose. If, however, the criterion is for a system with an accuracy of ±0.5 mm then the system is not fit for that purpose. In order to deliver the required accuracy, the measurement system must have been calibrated to give that accuracy. Calibration is the process of comparing the output of a measurement system against standards of known accuracy. The standards may be other measurement systems which are kept specially for calibration duties or some means of defining standard values. In many companies some instruments and items such as standard resistors and cells are kept in a company standards department and used solely for calibration purposes.

9. it typically only giving the required accuracy6times in ten measurements, 60 times in a hundred measurements.

10. If 100 systems are observed, 1 will fail to meet the required level of performance.

11. *A system is called Time Invariant if we delay an input before processing, output will be equal to output delayed after processing. And if we delay an input before processing, output will not be equal to input delayed after processing, the system is Time Variant.*

Linear systems follow principle of homogeneity and superposition while non linear doesnor.

12. Definition: The limited deviation of the measured value from the true value is known as the limiting error or guarantee error. Such type of error is fixed on the instrument. The magnitude of the limiting error depends on the design, material and the workmanship used for the construction of the instrument.

For obtaining a high degree of accuracy the high-quality material and workmanship are used. The instrument always has some amount of limiting error. The value of the limiting error could be least but never be zero.

Relative Limiting Error or Fractional Error

The relative limiting error is defined as the ratio of the limiting error to the nominal value of the measuring quantity. It is expressed as

$$\varepsilon_r = \frac{\delta A}{A_s} = \frac{\varepsilon_0}{A_s} \dots\dots\dots equ(2)$$

$$\varepsilon_0 = \delta A = \varepsilon_r A_s \dots\dots\dots equ(3)$$

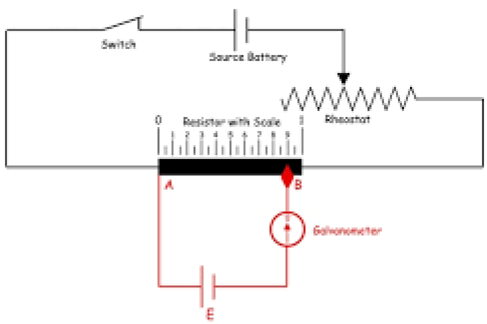
13. A Permanent Magnet Moving Coil (PMMC) meter – also known as a D’Arsonval meter or galvanometer – is an instrument that allows you to measure the current through a coil by observing the coil’s angular deflection in a uniform magnetic field.

A PMMC meter places a coil of wire (i.e. a conductor) inbetween two permanent magnets in order to create stationary magnetic field. According to Faraday’s Laws of electromagnetic induction, a current carrying conductor placed in a magnetic field will experience a force in the direction determined by Fleming’s left hand rule.

The magnitude (strength) of this force will be proportional to the amount of current through the wire. A pointer is attached to the end of the wire and it is put along a scale.

When the torques are balanced the moving coil will stop, and its angular deflection can be measured by the scale. If the permanent magnet field is uniform and the spring linear, then the pointer deflection is also linear. Hence we can use this linear relationship to determine the amount of electrical current passing through the wire.

PMMC instruments (i.e. D’Arsonval meters) are only used for measuring the Direct Current (DC) current. If we were to use Alternating Current (AC) current, the direction of current will be reversed during the negative half cycle, and hence the direction of torque will also be reversed. This results in an average value of zero torque – hence no net movement against the scale.



14.

15. Signal inputs accepted by signal conditioners include DC voltage and current, AC voltage and current, frequency and electric charge. Sensor inputs can

be accelerometer, thermocouple, thermistor, resistance thermometer, strain gauge or bridge, and LVDT or RVDT. Specialized inputs include encoder, counter or tachometer, timer or clock, relay or switch, and other specialized inputs. Outputs for signal conditioning equipment can be voltage, current, frequency, timer or counter, relay, resistance or potentiometer, and other specialized outputs.

16. Advantages and Disadvantages LCDs have many characteristics that have caused their demand to increase over the past several years. They are lightweight, aesthetically appealing, energy efficient and long-term cost effective. Some of the disadvantages are that they are not suitable for dimly lit applications, can require frequent adjustments throughout the day, have limited viewing angles, and their purchase cost is relatively expensive. LCD Advantages Brightness Produces very bright images due to high peak intensity. Very suitable for environments that are brightly lit . Emissions Produce considerably lower electric, magnetic and electromagnetic fields than CRTs. Geometric Distortion No geometric distortion at the native resolution. Minor distortion can occur for other resolutions. Power Consumption Energy efficient.

17. A magnetic tape recorder consists of the following basic components.

1. Recording Head
2. Magnetic Head
3. Reproducing Head
4. Tape transport mechanism
5. Conditioning device

19. The major advantages that an RTD has over Thermocouples are: Stability, Precision, and Repeatability. The disadvantages are the price and response time. The following table explains in more detail. Stability is the ability of a sensor to measure temperature with precision for a given length of time.

SENSOR	ADVANTAGES	DISADVANTAGES
Thermocouple	Simple Inexpensive Large variety Large temperature range Rugged « Self-powered »	Non linear Low voltage Require reference Less stable

SENSOR	ADVANTAGES	DISADVANTAGES
RTD	More Stable More accurate More linear	Expensive Current source required Small Self heating Small base resistance

20. Mean= $\bar{x} = \frac{x_1 + x_2 + \ldots x_n}{n}$

$$\text{standard deviation} = \sqrt{\frac{(d_1^2 + d_2^2 + \ldots d_n^2)}{n-1}}$$

$$\text{standard error} = \frac{\text{standard deviation of the set of results}}{\sqrt{n}}$$

UNIT 2

MCQ

1.B

2.B

3.A

4.A

5.D

6.A

7.D

8.A

9.D

10 B

SHORT ANSWER QUESTIONS

1.TURBINE METER

2.BOURDON GAUGE

3.LVDT

4.THERMOCOUPLE

5.WHEATSTONE BRIDGE

6.ADC

7.454 OHMS

8.117 OHMS

9.0.13 OHMS

10.0.126 OHMS

11 55.5 PF

12. 50 OHMS

13.10 KILO OHMS

14.490 KILO OHMS

15.100 KILO OHMS

16. 2.33KILO OHMS

17. 0.0002442

UNIT 3

MCQ

1.A

2.B

3.A

4.A

5.A

6.B

SHORT ANSWER

PROVIDED AT THE LAST AS HANDWRITTEN NOTES WITH SOLVED PROBLEMS

UNIT 4

MCQ

1.C

2A

3C

4D

SHORT ANSWER QUESTIONS

5. 0.004METER SQUARE
6. 5.85 METER CUBE PER SEC

7.1260 mm

9. 10v

10.10v

11.100

12.6/11 .6/13

13. 1 s, 0.63 s

14. 4 rad/s,0.63 s.0.51 sec,7.8 %, 1.6 sec

15 a. stable b. unstable

16. 10v

19. step

20. impluse

UNIT 5

MCQ

1.A

2.C

3.C

4.C

5.C

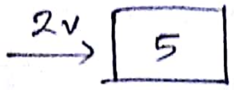
SHORT ANSWER

PROVIDED AT THE LAST AS HANDWRITTEN NOTES WITH SOLVED PROBLEMS

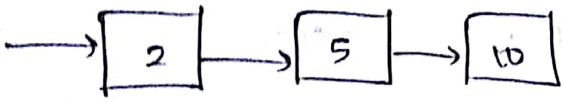
Solutions :

UNIT 3

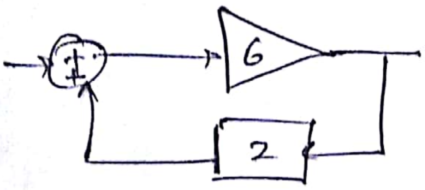
Short Answer Questions :

1. 

$= 2 \times 5 = 10V$

2. 

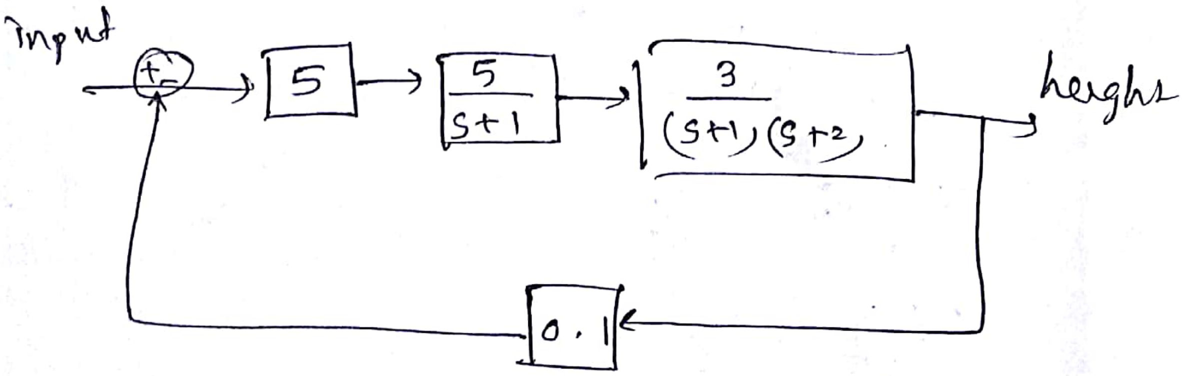
$= 2 . 5 . 10 . = 100$

3. 

a) $\frac{G}{1 - GH}$

$= \frac{6}{1 - 12} = -6/11$

b) $\frac{G}{1 + GH} = \frac{6}{1 + 12} = \frac{6}{13}$

4. 

$T.F = \frac{G}{1 + GH}$

$$\frac{\frac{30}{(s+1)^2(s+2)}}{1 - \frac{3}{(s+1)^2(s+2)}} = \frac{30}{(s+1)^2(s+2) - 3}$$

5. $$T = C\frac{d\theta}{dt} + K\theta + I\frac{d^2\theta}{dt^2}$$

$$T(s) = Cs\,\theta(s) + K\theta(s) + s^2 I\,\theta(s)$$

$$T(s) = (s^2 I + Cs + k)\,\theta(s)$$

$$\frac{\theta(s)}{T(s)} = \frac{1}{s^2 I + Cs + K} = \frac{1/I}{s^2 + \frac{C}{I}s + \frac{K}{I}}$$

Comparing with. $$\frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$\omega_n = \sqrt{\frac{K}{I}}$$

$$2\xi\omega_n = C/I$$

$$2\xi\sqrt{\frac{K}{I}} = C/I.$$

$$\xi = \frac{C}{2\sqrt{KI}}$$

for $\xi = 1$ = $$\frac{C}{2\sqrt{KI}} = 1$$

$$C = 2\sqrt{KI}$$

$$PID = K_p \left[error + \frac{1}{T_i} \int e + T_D \frac{de}{dt} \right].$$

9. Here $P = I$

$M = 4$

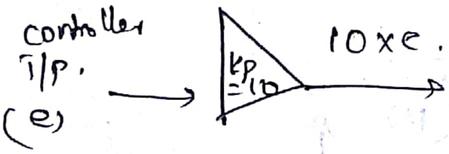
$L = 2$

PID : $K_p = 1.2 \, P/ML = \frac{1.2}{8} = 0.15$

$T_i = 2L = 4$

$T_d = 0.5L = \underline{\underline{1}}$

10.



To maintain same height level. input flow rate = o/p flow rate.

$K_p = 10$.

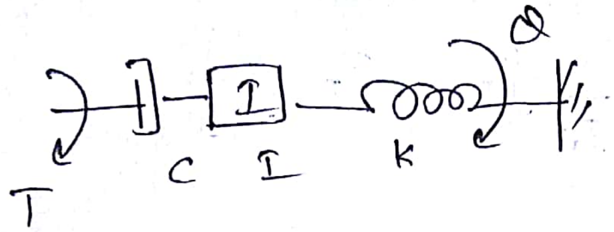
if control o/p = $10 \, m^3/hr$ valve flow rate.

11) a) To maintain same height, outflow from container = 50%.

12) b). inflow = $500 \, m^3/hr$; outflow = $600 \, m^3/hr$.

∴ new controller o/p = 60% //

7.

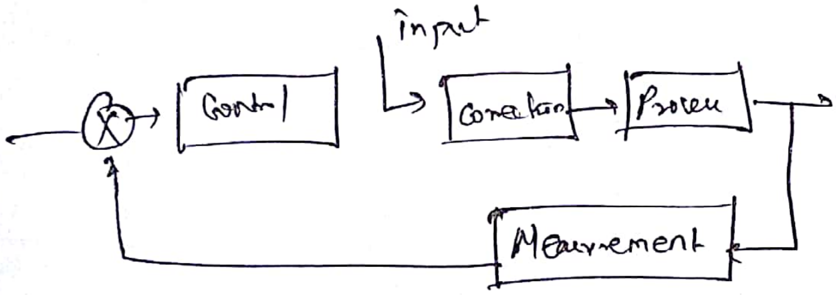


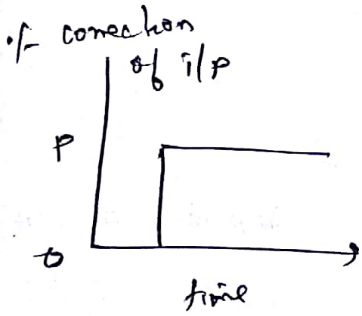
$$T = c\frac{d\theta}{dt} + K\theta + I\frac{d^2\theta}{dt^2}$$

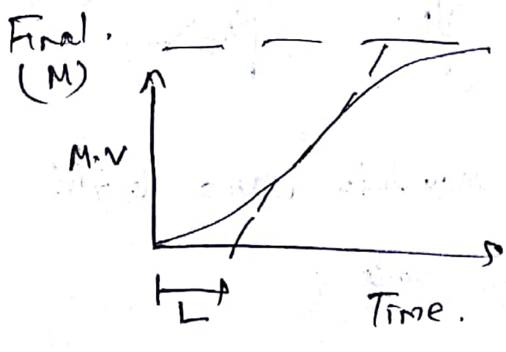
8. Ziegler Nichols uses 2 methods.

a) <u>Process reaction tuning method.</u>

× No control action required.







Type of Controller	Kp	Ti	Td.
P	P/ML	—	—
PI	0.9 P/ML	3.3 L	—
PID	1.2 P/ML	2 L	0.5 L

13. a) Abs. deviation = SP − MV = 20 − 18 = 2°c

b) % deviation = $\frac{2}{20} \times 100 = 10\%$

14. PB = 80% PB

$\% PB = \frac{1}{Kp} \cdot \frac{\text{controller o/p span}}{\text{measurement span}} \times 100$

$80 = \frac{1}{Kp} \left(\frac{16}{50} \right)$

$Kp = \frac{16 \times 100}{50 \times 80} = 4$

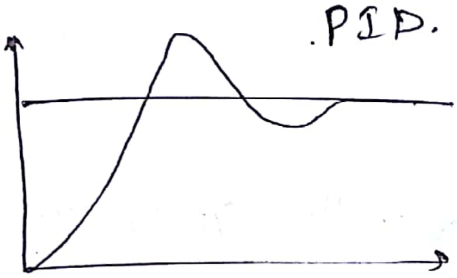
15. PID = Kp 0.6 Kpu = 0.6 × 2.2 = 1.32

$Ki = Tu/2 = \frac{12}{2} = 6$

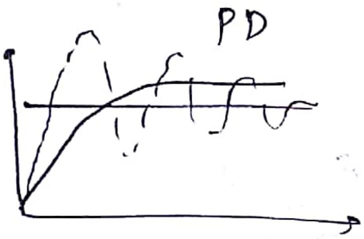
$Td = Tu/8 = \frac{12}{8} =$ ~~0.95~~ 1.5

16. a)

b) c)



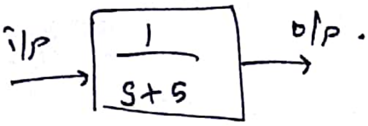
b) d)



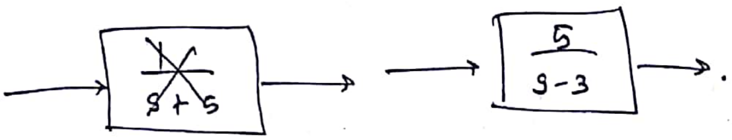
UNIT-5

Short Answer Qs

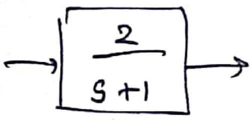
1. O/P = ramp function with. 5 V/sec.

2. 

for unit step of 1V : $o/p = \frac{1}{s} \times \frac{1}{s+5}$.

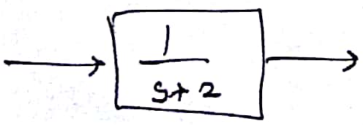
3. 

for impulse i/p, $o/p = \frac{5}{s-3}$.

4. 

a) $o/p = \frac{2 \cdot 3}{s(s+1)}$

b) . $\frac{3 \cdot 2}{s^2(s+1)}$.

5. 

a) $\frac{4}{s(s+2)}$ b). $\frac{1}{s+2}$

7. $\dfrac{1+0.1s}{1-0.01s}$.

$G(j\omega) = \dfrac{1+0.1j\omega}{1-0.01j\omega}$.

$\angle G(j\omega) = \tan^{-1}(0.1\omega) - \tan^{-1}(0.01\omega)$.

$= \tan^{-1}\dfrac{0.1\omega - 0.01\omega}{1+0.1\times0.01\omega^2}$.

differentiate w.r.t ω.

8. $\sin 35^\circ = \dfrac{a-1}{a+1}$

find 'a'

$G\omega = \dfrac{1+a\tau s}{1+\tau s}$.

9. Same as above.

UNIT-5

12. $G(j\omega) = \dfrac{1}{j\omega(0.2j\omega+1)(0.05j\omega+1)}$.

$|G(j\omega)| = \dfrac{1}{\omega\sqrt{1+(\omega\,0.2)^2}\sqrt{1+(0.05\omega)^2}} = 1$

find ω and hence $|G(j\omega)|$: for GM.

$\angle G(j\omega) = -90 - \tan^{-1}\omega(0.2) - \tan^{-1}(0.05\omega)$

Equating to $180°$, find ω, & hence $\angle G(j\omega)$ for PM.

13. $\therefore G(j\omega) = \dfrac{9}{j\omega(1+j\omega)}$

at $\omega = 0$: $M = \infty$, $\angle = 90°$

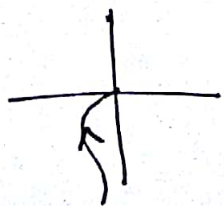
$|G(j\omega)| = \dfrac{9}{\omega\sqrt{1+\omega^2}}$

at $\omega = \infty$

$M = 0$

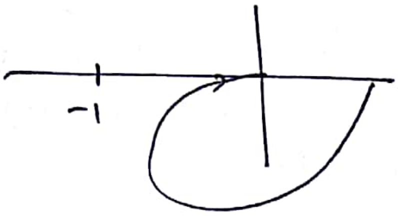
$\angle = 0°$

$\angle G(j\omega) = -90 - \tan^{-1}\omega$



11. &

14.



for stability Nyq. plot

as ω goes from 0 to ∞

plot. 1) Doesnot encircle -1 : Stable.

2) Encircle -1 : Unstable

3) Pass through -1 : Marginally stable.