DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

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Questions for EEE Department of 1st year B.Tech. Program

Subject: Physics (Waves and Optics, and Introduction to Quantum Mechanics)

Module 1: Waves

1. How electrical oscillators are different from mechanical oscillator?
2. Write expression for impedance matching? Derive expression for steady state motion of forced damped harmonic oscillator.

   A simple harmonic oscillator has an amplitude A and time- period T. The time require by it to travel from x =A to x = A/2 is _______________.

3. The reflection co-efficient of energy in case of string is given by.

   (a) $\left[\frac{Z_1 - Z_2}{Z_1 + Z_2}\right]^2$ (b) $\left[\frac{Z_1 + Z_2}{Z_1 - Z_2}\right]^2$ (C) $\frac{4Z_1Z_2}{(Z_1 + Z_2)^2}$ (d) $\frac{4Z_1Z_2}{(Z_1 - Z_2)^2}$

4. What are the essential properties of the medium must possess for propagation of mechanical waves?

   (a) Stable Pressure (b) Maximum friction (c) Constant temperature (d) Minimum Friction

5. In case of forced electric oscillator current and charge are related by the relation:

   (a) Current is ahead of charge by π/2 (b) Current lags behind of charge by π/2 (c) Both will be in same phase (d) Current is ahead of charge by π

6. When an unpolarized beam of light is incident on a dielectric at the polarizing angle,

(a)The reflected beam is plane polarized

(b) E- vector perpendicular to the plane of incidence (c) Both (a) and (b) (d) None

7. For a right circular polarized wave, the electric and magnetic field vectors:
   a) Perpendicular to each other
   b) Parallel to each other
   c) Makes a phase difference of $\pi/2$
   d) Makes a phase difference of π
8. Define Acoustics. Derive the wave equation for longitudinal waves in gases.
9. What is the significance of characteristic impedance? What are the applications of impedance matching?
10. Prove that the total energy in simple harmonic motion is constant.
11. What is the difference between mechanical and electrical simple harmonic oscillators?
12. Describe damped, forced damped and critically damped simple harmonic oscillators.

Module 2: Non-Dispersive Longitudinal and Transverse Waves

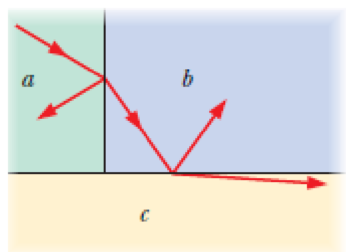
1. A 4 kg mass is hung on the end of a helical string and is pulled down and let go to vibrate vertically. The mass completes 100 vibrations in 55 seconds. Calculate the force constant of the string.
2. Pendulum A is on Jupitor and pendulum B is on Moon. Both the pendulum has same mass and length. Whish pendulum has the greater time- period and how?
3. A wave has a frequency of 10 Hz and a wavelength of 6 meters. What would be the period of the wave?
4. How the wavelength of stationary waves in a string are related to the length of the string? If the length of string is l what would be the wavelength of the wave form in creation of four nodes?
5. Derive expression for transmission and reflection of wave at the boundary of a string.
6. What are standing waves? Derive the expression for eigen frequency.
7. What are longitudinal waves? Find the wave equation for the longitudinal wave.
8. What is the difference between longitudinal and transverse wave?
9. What is the condition of impedance matching?
10. What do you understand by reflection and transmission co-efficient?

Module 3: Light and Optics

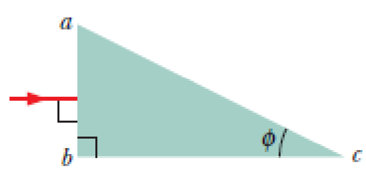
1. An object is placed beyond $2F_1$ of a convex lens. What is true about the image formed by the lens?
   a. The image is diminished in size
   b. The image is magnified in size
   c. The image is formed beyond $2F_2$
   d. The image is formed between F_2 and $2F_2$
2. Zoya decides to build her own projector to show her new film to friends and needs a suitable convex lens. In one of her experiments with a convex lens, she records the following distances in the Cartesian sign convention
   Object distance, u -0.3m, image distance, v = +3.6m.
   What is the magnification, m, produced by the lens?
   a. +0.08
   b. -0.08
   c. -12
   d. +12
3. How many lenses are used in Fresnel Diffraction?
   a. Two Convex Lenses
   b. Two concave lenses
   c. One Convex lens
   d. No lens used

4. Why light is known as electromagnetic wave?
5. Write down Fresnel's equations.
6. Explain angle of polarization. When the waves are circularly polarized?
7. Name some of the optical instruments. What is the magnification power of compound microscope?
8. What do you mean by resolving power of an optical instrument?
9. Define Brewster's formula. How it is useful in creating polarization?
10. What are the conditions of creating total internal reflection? Write four applications of this phenomenon.

11. How many types of mirror are there? Differentiate between them.
12. Convex and concave lenses are used in which devices/equipment. Write down their benefits.
13. How reflectance and transmittance are related to the refractive index of the medium?
14. Define reflectance and transmittance.
15. A certain polarizer has a refractive index of 1.33. Find the polarization angle and angle of refraction?
16. Figure shows rays of monochromatic light passing through three materials a, b, and c. Rank the materials according to the index of refraction, greatest first.



17. Figure shows ray of light is perpendicular to the face ab of a glass prism (n _ 1.52).Find the largest value for the anglef so that the ray is totally reflected at face ac if the prism is immersed(a) in air and (b) in water.



Module 4: Wave Optics

1. Derive expression for interference of light by wave front splitting and amplitude splitting.
2. Determine the expression for fringe width when interference occur via Young's double slit experiment.
3. Differentiate between Michelson and Mach Zehnder Interferometer.
4. How Farunhofer diffraction patter appears from a single slit? Write the equation of Farunhofer diffraction.

5. How Farunhofer diffraction pattern forms through a circular aperture?
6. Write down the Rayleigh criteria for limit of resolution and its application to vision.
7. Define diffraction grating. How the resolving power of a grating can be determined?
8. In a double slit experiment, a light of λ = 5460 Å is exposed to slits which are 0.1 mm a part. The screen is placed 2 m away from the slits. What is the angular position of the 10^{th} maximum and 1^{st} minimum?
9. In a Newton's rings experiment the diameter of the 15^{th} ring was found to be 0.59 cm and that of the 5^{th} ring is 0.336 cm. If the radius of curvature of the lens is 100 cm, find the wave- length of the light.
10. Why the diffraction fringes appear in Newton's ring method are circular in nature?
11. Newton's rings are observed in the reflected light of wave- length 5900 Å. The diameter of 10^{th} dark ring is 0.5 cm. Find the radius of curvature of the lens used.
12. Two coherent sources whose intensity ratio is 36:1 produce interference fringes. Deduce the ratio of maximum intensity to minimum intensity.
13. In a Newton's ring experiment, the diameter of the 5^{th} ring is 0.30 cm and diameter of the 15^{th} ring is 0.62cm. Find the diameter of the 25^{th} ring.
14. What does a Michelson Interferometer physically do?
    1. Splits light into two beams, and then recombine them.
    2. Combine to beams into one, and then splits them again.
    3. Shows interference pattern on a screen
    4. Makes coffee
    5. Measures the speed of light
15. What is the purpose of a half-silvered mirror in Michelson interferometer?
    1. Half the light is reflected, and half goes straight through, creating two beams.
    2. Half the light is reflected one way, and half is reflected another way, creating two beams.
    3. It disposes of half the light, dimming the beam.
    4. It reduces the cost of the equipment.
    5. It shows interference patterns.
16. Which of the following is NOT a use of a Michelson Interferometer?
    1. Creating a laser light-show

2. Measure the position of an object
3. Split light into a spectrum
4. Test optical components.
5. Study wind and temperature patterns.

17. Explain what is meant by Fraunhofer diffraction. [Your answer should contain no reference to parallel light or observation at infinity.] Why is it of such great practical importance? Plane waves of monochromatic light of wavelength λ fall on a slit of width a: (a) Estimate the minimum distance from the slit of the plane of observation if the observed diffraction pattern is to fulfil the Fraunhofer condition. (b) Derive an expression for the angular distribution of the intensity in the Fraunhofer pattern, and sketch it, indicating the relative distances from the centre to any minima in intensity.
18. The Fresnel-Kirchhoff diffraction integral reads where up is the amplitude of the diffracted wave at position r from the centre of a diffracting aperture of area S, in which the amplitude is uo per unit area and the other symbols have their usual meanings. (a) Explain the physical significance of the factor 1/r in the integral and the quantity $\eta(n,r)$. (b) Using this integral show that the angular distribution of the Fraunhofer diffraction pattern of a single long narrow slit, width a, may be represented by the Fourier transform of the amplitude distribution u(x) in the aperture, making clear any assumptions and approximations required. x is the dimension transverse to the long axis of the slit.
19. A grating with N slits of spacing d is illuminated normally with monochromatic light of wavelength λ , and the pth order principal maximum is observed at an angle θp . (a) Show that the intensity at angle θ is given by Hence show that the adjacent minima fall at angles $\theta p \pm \delta\theta p$ where (b) Show that the dispersion of the grating in the pth order of interference is . (c) Hence show that the instrumental width of the grating (in terms of λ) is . (d) Deduce that the resolving power of the grating is Np. (e) Does the resolving power of a grating change if it is used in a medium of high refractive index?
20. Give a brief account of the principal features of a Michelson interferometer used with visual observation and illuminated by an extended monochromatic source. Explain what configurations of the mirrors will give (i) circular fringes (ii) straight, equally spaced fringes. State where the fringes are localised and why. Why in case (ii) does the mirror spacing have to be small?

Module 5: Lasers

1. Define Laser. Describe different level systems in laser.
2. Why can't two- level system show lasing action?
3. Derive expression for Einstein's theory of matter radiation interaction and A and B co-efficient.
4. Describe different types of Lasers.
5. Explain the working of He-Ne Laser. What is the wavelength of He-Ne Laser?
6. Give complete working of Solid state Laser. What is the differenc between Ruby and Neodymium Laser?
7. What are the properties of Laser?
8. What are the differences between incandescent light and laser light?
9. What do you understand by population inversion? Why it is essential for lasing action?
10. Define spontaneous and stimulated emission.
11. What would be the output intensity of a helium-neon laser operating at 632.8 nm if it has a small-signal gain of 0.15/m? The laser has two mirrors of reflectivity 99.99% and 98%, a gain-medium length of 0.2 m, and essentially no scattering losses.
12. Determine the saturation energy of the following lasers: (a) Nd:YAG at 1.06 ,um; (b) Ti:Ab03 at 800 nm; (c) ruby at 694.3 nm; (d) Nd:YV04 at 1.06 ,um.
13. Which of the following is a unique property of laser?
    a)Directional
    b)Speed
    c)Coherence
    d) Wavelength
14. Which of the following is an example of optical pumping?
    a) Ruby Laser
    b)Helium-Neon
    c)Semiconductor d) Dye laser
15. When laser light is focussed on a particular area for a long time, then that particular area alone be heated.
    1. True
    2. False

16. Calculate the number of photons, from green light of mercury (λ = 4961 Å), required to do one joule of work.

a)$4524.2\times10^{18}/m^3$

b)$2.4961\times10^{18}/m^3$

c)$2.4961/m^3$

d)2.4961/m

17. Which of the following can be used for the generation of laser pulse?
    a) Ruby laser
    b) CO2 laser
    c) He-Ne Laser
    d) Nd-Yag Laser
18. What is the need to achieve population inversion?
    a) To excite most of the atoms
    b) To bring most of the atoms to ground state
    c) To achieve stable condition
    d) To reduce the time of production of laser
19. DVD uses the laser.
    a) True
    b) False
20. Which of the following can be used for the vibrational analysis of structure?
    a) Masers
    b) Quartzs
    c) Electrical waves
    d) Laser

Module 6: Introduction to Quantum Mechanics

1. Write down Heisenberg uncertainty relation?
2. What are the experiments which show particle nature of radiation?
3. Prove that the electrons do not exist inside the nucleus.
4. What do you mean by wave function? What is the physical significance of this?

5. Derive expression for the time independent Schrodinger wave equation.
6. Derive the expression for time dependent Schrodinger wave equation.
7. What do you understand by phase and group velocities? How are both related?
8. Is light made up of particles or wave?
9. A particle with mass m is in an infinite square well potential with walls at x = −L/2 and x = L/2. Write the wave functions for the states n = 1, n = 2 and n = 3.
10. A particle is in the nth energy state ψn(x) of an infinite square well potential with width L. Determine the probability Pn(1/a) that the particle is confined to the first 1/a of the width of the well. Comment on the n-dependence of Pn(1/a).
11. What is operator form of momentum and energy? Why are these called operators?
12. Matter waves are
    a) Longitudinal
    b) Electromagnetic
    c) Always travel with the speed of light
    d) Show diffraction
13. According to Schrodinger, a particle is equivalent to a
    a) Wave packet
    b) Single wave
    c) Light wave
    d) None
14. The de-Broglie wavelength of a particle having KE = Ek is given by
    a) $\lambda = \frac{h}{\sqrt{E_k}}$
    b) $\lambda = \frac{h}{\sqrt{2mE_k}}$
    c) $\lambda = \frac{h}{\sqrt{mE_k}}$
    d) $\lambda = \frac{h}{\sqrt{3mE_k}}$
15. Find the de- Broglie wavelength of a charge q and accelerated through a potential difference of V volts.

16. If the wavefunction of a particle trapped in space between x = 0 and x = L is given by $\psi(x) = A\sin(\frac{2\pi x}{L})$, where A is a constant for which value(s) x will be the probability of the finding of particle maximum
    a) L/4
    b) L/2
    c) L/6 and L/3
    d) L/4 and 3L/4

Module 7: Solution of Wave Equation

1. Find the expression for energy when particle is in one dimensional box.
2. What do you mean by Kronecker delta function? How it works?
3. Draw the graph of potential versus position in case if linear harmonic oscillator.
4. What is the meaning of zero point energy?
5. Write down the expressions for scattering co-efficient.
6. What are the conditions for tunneling to occur in semiconductor structures?
7. Why the energy levels of a particle in three- dimensional box are degenarrate?
8. Explain the phenomenon in case of potential barrier.
9. What is the meaning of orthonormality of wave function?
10. Write down the expression for wave function and energy in case of three-dimensional symmetrical box.
11. The time independent Schrodinger's equation of a system represents the conservation of system represents the conservation of the
    a) Total kinetic energy of the system
    b) Total potential energy of the system
    c) Total binding energy of the system
    d) Total energy of the system
12. For the particle in one dimensional box, how many nodes will be formed if it is in uantum state 5?
13. A particle is in three dimensional cubic well of width L with impenetrable walls. What would be the sum of energies of third and fourth levels.

14. The degeneracy of fourth level of a particle in a three -dimensional box system -------------.
15. Why the value of energy of ground state of harmonic oscillator is not zero?

Module 8: Introduction to Solids and Semiconductors

1. What are the differences between metal, semiconductor, and conductor?
2. What are the types of semiconductor?
3. What do you mean by p and n type semiconductor?
4. Write short notes on diffusion and drift in case of semiconductors.
5. What is the free electron theory of metals?
6. What is fermi level? How its position varies in different types of materials?
7. How fermi level depends on temperature and carrier concentrations?
8. Write down Bloch's theorem. Derive expression for particles in periodic potential.
9. Write down Kronig-Penney model and origin of energy bands.
10. The effective mass of an electron in a semiconductor can be
    a) Negative near the bottom of the band
    b) A scalar quantity with a small magnitude
    c) Zero at the centre of the band
    d) Negative near the top of the band
11. Which of the following has a direct band gap
    a) Diamond
    b) Si
    c) Ge
    d) Te
12. In a one-dimensional Kronig Penny model, the total number of possible wavefunctions is equal to
    a) Twice the number of unit cells
    b) Number of unit cell
    c) Half the number of unit cells
    d) Independent of number of unit cell

13. For an intrinsic semiconductor, m_e^* and m_h^* are respectively the effective masses of electrons and holes near the corresponding band edges. At a finite temperature, the position of the Fermi level

a) Depends on m_e^* but not on m_h^*

b) Depends on m_h^* but not on m_e^*

c) Depends on both m_e^* and m_h^*

d) Depends neither on m_h^* nor on m_e^*