PULCHOWK ENGINEERING CAMPUS

ENGINEERING PHYSICS ASSIGNMENT

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Theory Question

1. Write the difference between Simple pendulum and Physical pendulum. And derive the relations to show that the point of suspension and oscillation are interchangeable.

2. Write the differential equations of Free Oscillation, Damped Oscillation and Forced Oscillation. Also prove that the damped angular frequency is less than the natural frequency.

3. Show that in a progressive wave the average kinetic energy per unit volume and potential energy per unit volume $= \pi^2 \rho a^2 f^2$ where ρ, a and f have their usual meaning.

4. Derive Sabine's reverberation formula.

5. When the two thin lenses of focal lengths f_1 and f_2 are separated by a finite distance d show that power of the combined lenses is

$$P = P_1 + P_2 - dP_1P_2$$

6. When a parallel beam of light is incident on the lens, show that the diameter of circle of least confusion depends on the lens aperture and the dispersive power of the material of the lens but is independent of the focal length of the lens.

7. Prove that the condition for achromatism for the combination of two lenses of focal lenght f_1 and f_2 having dispersive power ω_1 and ω_2 placed at a separation x is

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = \frac{x}{f_1 f_2}\left[\omega_1 + \omega_2\right]$$

8. Classify optical fiber and derive the relation for Acceptance Angle.

9. Show that the conditions for maxima and minima are complementary in transmitted and reflected lights in plane parallel films.

10. Derive the relation to find the refractive index of the liquid using Newton's ring experiment.

11. What is a diffraction grating. Derive the relation for intensity distribution in single slit diffraction.

12. Write short notes on:
    (a) Double Refraction.
    (b) Nicol prism
    (c) Quarter-wave plate
    (d) Half-wave plate
13. What do you mean by Population inversion. Describe how $He - Ne$ LASER is produced.
14. Define Electric Dipole. Derive the relation to show that the potential due to an electric dipole is maximum along the axial line.
15. Show that the Electric Field intensity will be maximum at

$$z = \pm \frac{a}{\sqrt{2}}$$

    along the axis of the uniformly distribution of charge on the ring.
16. Derive the relation to show that the electric intensity of a quadrupole varies inversely with fourth power of the distance from its centre along its axis.
17. Show that the electric field within the non-conducting uniformly charged sphere is directly proportional to the distance from its centre.
18. Derive the relation for capacitance of a spherical capacitor.
19. Show that the capacitance of the cylinder is

$$C = 2\pi\epsilon_0 \frac{l}{\ln(\frac{b}{a})}$$

20. Derive the relation for instantaneous charge during charging and discharging of a capacitor.
21. What is a Cyclotron. Show that the time taken by a charge to travel a semi-circular path in a cyclotron is independent of the radius of the path and velocity of the charge.
22. State Ampere's Law and use it to find the magnetic field outside and inside a long straight current carrying wire.
23. Show that the work that we do in pulling the conductor through the magnetic field appears as thermal energy.
24. Derive the relation for rise and fall of current in LR-circuit.
25. Show that the energy stored in the inductor is directly proportional to the square of the current. And hence derive the relation for magnetic energy density.
26. Derive the differential equation of the LC-circuit and use its solution to find the total energy.
27. Derive differential form of Maxwell's Equation from integral form.

28. Define Poynting Vector. And prove

$$\vec{\mathbf{S}} = \frac{1}{\mu_0}\vec{\mathbf{E}} \times \vec{\mathbf{B}}$$

29. Derive time-dependent and time-independent Schrodinger Wave Equations.

30. Use time-independent Schrodinger Wave Equation to show that the energy of a particle confined in a 1-Dimensional infinite potential box is quantized.

1. A thin uniform rod ($mass = 0.50kg$) swings about an axis that passes through one end of the rod and is perpendicular to the plane of the swing. The rod swings with a period of 1.5 s and an angular amplitude of $10°$.
   (a) What is the length of the rod?
   (b) What is the maximum kinetic energy of the rod as it swings?

2. A uniform rod of length l oscillates through small angles about a point a distance x from its centre.
   (a) Prove that its angular frequency is

$$\omega = \sqrt{\frac{gx}{\frac{l^2}{12} + x^2}}$$

   (b) Show that its maximum angular frequency occurs when

$$x = \frac{l}{\sqrt{12}}$$

3. The amplitude of a lightly damped oscillator decreases by 3.0 % during each cycle. What percentage of the mechanical energy of the oscilltor is lost in each cycle?

4. If the potential energy of a particle can be expressed as

$$U = A - \frac{B}{x} + \frac{C}{x^2}$$

   where A,B and C are positive constants, find the force constant for small oscillations.

5. The volume of the room is $980m^3$. The wall area of the room is $150m^2$, ceiling area $95m^2$ and the floor area is $90m^2$. The average sound absorption coefficient (i) for wall is 0.03, (ii) for ceiling is 0.80 and (iii) for the floor is 0.06. Calculate the average sound absorption coefficient and reverberation time.

6. A room has dimensions $(6 \times 4 \times 5)m$. Find (i) the mean free path of the sound wave in the room. (ii) Number of reflections made per sec by sound waves with the walls of the room. (Given the velocity of sound in air $= 350ms^{-1}$).

7. The time of reverberation of an empty hall without and with 500 audiences is 1.5 sec and 1.4 sec respectively. Find the reverberation time with 800 audiences in the hall.

8. Sound wave are emitted uniformly in all direction from the speaker in a large hall. Prove that the amplitude of the sound wave change with the distance r at any point from the speaker is

$$a = \frac{1}{r}\sqrt{\frac{P}{2\pi\rho v\omega^2}}$$

   where P is power of the sound wave moving with velocity v in the medium of density ρ and ω is the angular frequency.

9. Two thin lenses of focal lengths 8cm each are identical and coaxially separated by 4cm. Determine the equivalent focal length of its combination. If the image is formed at infinity at a particular position of the object, find the object distance.

10. The object glass of a telescope is an achromat of focal length 90cm. If the magnitude of the dispersive powers of the two lenses are 0.024 and 0.036, calculate their foal lengths.

11. What is the power of the combination of lenses of focal lengts 50cm and 10cm which are separated by 10cm.

12. The focal length of a lens in air is 10cm. What will be its focal length if air is replaced by water? (Refractive index of glass = $\frac{3}{2}$ and refractive index of water = $\frac{4}{3}$).

13. Calculate the numerical aperture, acceptance angle, and the critical angle of the fiber having core refractive index 1.50 and the cladding refractive index 1.45.

14. When oil is introduced into the air film space between the lens and the plate in Newton's arrangement, the radius of the 8^{th} dark ring decreases from 1.8cm to 1.64cm. What is the refractive index of the oil.

15. Find the specific rotation of a given sample of sugar solution, if the plane of polarization is turned through 26.4°. The length of the tube containing 20% sugar solution is 20cm.

16. Plane polarized light is incident on a piecee of quartz cut parallel to the axis. Find the least thickness for which the ordinary and extraordinary rays combined to form plane polarized light. (Given $n_0 = 1.5442$, $n_e = 1.5533$, $\lambda = 5 \times 10^{-5}$).

17. Two long charged, thin walled, concentric cylindrical shells have radii of 3.0 and 6.0 cm. The charge per unit length is 5.0×10^{-6} C/m on the inner shell and -7.0×10^{-6} C/m on the outer shell. What are (a) magnitude and direction of the field at radial distance $r = 4.0$ cm (b) magnitude and direction at $r = 8.0$ cm?

18. Charge of uniform volume density ρ=3.2 μC/m^3 fills a non-conduncting solid sphere of radius 5.0cm. What is the magnitude of the electric field (a) 3.5 cm and (b) 8.0 cm from the sphere's centre?

19. A spherical drop of water carrying a charge of 30 pC has a potential of 500 V at its surface (with $V = 0$ at infinity). (a) What is the radius of the drop? (b) If two charge of the same charge and radius combine to form a single spherical drop, what is the potential at the surface of the new drop?

20. What is the potential at a point P, located at the centre of the square of point charges $q_1 = +12$ nC, $q_2 = -24$ nC, $q_3 = +31$ nC and $q_4 = +17$ nC. (the side of the square $a = 1.3$ m).

21. Three point charges 7 μC, 2 μC and -4 μC are located at the corner of an equilateral triangle of side 0.5 m, calculate the resultant force on the charge of 7 μC.

22. A particle of charge -q and mass m is placed midway between two equal positive charges q_o of separation d. If the negative charge $-q$ is displaced in perpendicular direction to the line joining them and released, Show that the particle describes a SHM with a period

$$T = \left[\frac{\epsilon_0 m\pi^3 d^3}{qq_0}\right]^{1/2}$$

23. A plastic rod contains uniformly distributed charge $-q$. The rod has been bent in 120° circular arc of radius r. Prove that the electric intensity at the centre of the bent rod is

$$E = \frac{0.83q}{4\pi\epsilon_0 r^2}$$

24. Two equal and opposite charged q plastic rod of same length turn a circle of radius r in xy plane. Prove that the magnitude of the electric field E produced at the centre of the circle is

$$E = \frac{q}{\pi^2\epsilon_0 r^2}$$

25. A spherical charge distribution is given by

   (a) $\rho = \rho_0\left[1 - \frac{r^2}{a^2}\right]$ for r $\leq$ a and

   (b) $\rho = 0$ for r $>$ a. Find the total amount of charge.

26. What is the magnitude of the electric field at the point $(3.00\hat{\imath} - 2.00\hat{\jmath} + 4.00\hat{k})$ m if the electric potential is given by $V = 2xy^2z$, where V is in volts and x,y and z are in meters ?

27. Over certain region of the space the electric potential is $V = 5x - 3x^2y + 2yz^2$. Find the expression for the x, y, and z components of the electric field over this region. What is the magnitude of the field at the point P that has coordinates (1, 0, -2) m ?

28. For a given short electric dipole potential at any point at a distance r is given by;

$$V = \frac{p\cos\theta}{r^2}$$

   Where θ is the angle made by r to the dipole and p is its dipole moment. Using above ralation, find an expression for the resultant electric intensity at that point.

29. If the electric intensity of a charged disc of radius a at a point P at a distance x along its axis from centre is

$$E = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{x}{\sqrt{x^2 + a^2}}\right]$$

   Find the electric potential at P, where σ is the surface charge density.

30. Charge is distributed uniformly throughout the volume of an infinitely large cylinder of radius a. Show that E at a distance r from the cylinder axis r $> a$ is given by

$$E = \frac{\rho r}{2\epsilon_0}$$

   Where, ρ is volume charge density.

31. A capacitor of a capacitance C is discharged through a resistor of resistance R. After how much time is the stored energy 1/4 of its initial maximum value?

32. The space between two concentric conducting spherical shells of radii $b = 1.70\ cm$ and $a = 1.20\ cm$ is filled with a substance of dielectric constant $k = 23.5$. A potential difference $V = 73\ V$ is applied across the inner and outer shells. Determine
    (a) the capacitance of the device,
    (b) the free charge q on the inner shell, and
    (c) the charge $q^{'}$ induced along the surface of the inner shell.

33. A spherical drop of mercury of radius r has capacitnce $C = 4\pi\epsilon_0 r$. Calculate the capacitance if two such drops combine to form a single large drop?

34. If a parallel plate capacitor is designed to operate in an environment of fluctuating temperature, prove that the rate of change of capacitance C with temperature T is given by
$$\frac{dC}{dT} = C\left[\frac{1}{A}\frac{dA}{dT} - \frac{1}{x}\frac{dx}{dT}\right]$$
symbols carries its usual meaning.

35. A cylindrical capacitor has radii a and b. Show that half the stored electric potential energy lies with a cylinder of radius $r = \sqrt{ab}$.

36. If a typical copper wire of household wiring has a cross-sectional area 3.31×10^{-6} m^2 and carries a current of 10 A. What is the drift speed of the electrons? (Given, Density of copper is 8.95 gm/cm^3 and Avogadro's number $N_A = 6.023 \times 10^{23}\ mol^{-1}$.

37. Calculate the (i) mean free time and (ii) mean free path between collisions for the conduction electrons in copper having electron density $8.5 \times 10^{28}\ m^{-3}$ and resistivity $1.7 \times 10^{-8}\ \Omega m$. Charge of electron $= 1.6 \times 10^{-19}\ C$, mass of electron $= 9.1 \times 10^{-31}$ Kg, and effective speed of electron $= 1.6 \times 10^{6}\ m/s$.

38. A copper wire of cross-sectional area $5 \times 10^{-6}\ m^2$ carries a steady current of 50 A. Assuming one free electrons per atoms, Calculate
    (a) free electron density and
    (b) average drift velocity.

    Density of $Cu = 8.9 \times 10^{3}\ Kg/m^3$, Molar mass of $Cu = 64$ and Avogadro's number $= 6.023 \times 10^{23}\ mol^{-1}$.

39. The magnitude J of the current density in certain wire with a circular cross section of radius $R = 2\ mm$ is given by $J = (3 \times 10^{8})r^2$, with J in amperes per square meter and radial distance r in meters. What is the current through the outer section bounded by $r = 0.9R$ and $r = R$?

40. Two conductors are made of the same material and have the same length. Conductor A is a solid wire of diameter 1 mm, conductor B is a hollow tube of outside diameter 2 mm and inside diameter 1 mm. What is the resistance ratio $\frac{R_A}{R_B}$ measured between their ends?

41. A cylindrical resistor of radius 5 mm and length 2 cm is made of material that has a resistivity of $3.5 \times 10^{-5}\ \Omega m$. When the energy dissipation rate in the resistor is 1 W, Calculate

    (a) the magnitude of the current density and

    (b) the potential difference.

42. A wire of length L carries a current I. If the wire is formed into a circular coil, then the maximum torque in a given magnetic field B developed for a sinlge turn is

$$\tau = \left[\frac{1}{4\pi}\right] L^2 IB$$

.

43. A coil of magnetic moment 1.45 Am^2 is oriented initially with its magnetic moment anti-parallel to a uniform 0.835 T magnetic field. What is the change in potential energy of the coil when it is rotated 180° so that its magnetic moment is parallel to the field.

44. An electron moves through a uniform magnetic field given by $\vec{B} = B_x\hat{\imath} + 3B_x\hat{\jmath}$. At a particular instant, the electron has velocity $\vec{v} = (2\hat{\imath} + 4\hat{\jmath})\ m/s$ and the magnetic force acting on it is $(6.4 \times 10^{-19})N\ \vec{k}$. Find B_x.

45. A long rigid conductor lying about the x-axis carries a current of 5 A in the (-)x-direction. A magnetic field $\vec{B}$ is present given by $\vec{B} = (3\hat{\imath} + 8x^2\hat{\jmath})mT$. Calculate the force on the 2 m segment of the conductor that lies between $x = 1.2\ m$ and 3.2 m.

46. A copper strip 2 cm wide and 1.0 mm thick is placed in a magnetic field 1.5 T. If a current of 200 A is setup in the strip, Calculate

    (a) Hall voltage and

    (b) Hall mobility

    If the number of electrons per unit volume is $8.4 \times 10^{28}\ m^{-3}$ amd resistivity 1.72×10^{-8} Ωm.

47. In a certain cyclotron a proton moves in a circle of radius 0.5 m. The magnitude of the magnetic field is 1.2 T. (a) What is the oscillator frequency (b) What is the kinetic energy of the proton?

48. What current must be passed through a flat circular coil of 10 turns and raduis 5 cm to produce a flux density of $2 \times 10^{-4}\ T$ at its centre.

49. In a hydrogen atom of radius $5.3 \times 10^{-11}\ m$, an electron revolves round the nucleus with a speed of $2.2 \times 10^6\ m/s$. Calculate the magnitude of magnetic field at the centre of the atom.

50. A hollow cylindrical conductor of inner radius a and outer radius b carries a uniform distribution of current I. Show that for $a < r < b$

$$B = \frac{\mu_0 I (r^2 - a^2)}{2\pi (b^2 - a^2) r}$$

51. A solenoid is designed to produce a magnetic field of 0.14 T at its centre. The radius is 3 cm and the length 50 cm, carries a maximum current of 10 A.

   (a) What is the minimum number of turns per unit length of the solenoid?

   (b) What total length of the wire is required?

52. A loop of wire of radius r is placed in a uniform magnetic field perpendicular to its plane. The magnitude of the field varies with time according to $B = B_0 e^{-t/\tau}$. Where B_0 and τ are constant. Find the emf in the loop as a function of time.

53. A uniform magnetic field B is perpendicular to the plane of a circular loop of diameter 10 cm formed from wire of diameter 2.5 mm and resistivity 1.69×10^{-8} Ωm. At what rate must the magnitude of $\vec{B}$ change to induce a 10 A current in the loop?

54. Calculate inductance of a solenoid having length l, number of turns N, area of cross-section A and current I is flowing.

55. A solenoid having inductance $L = 5.5$ H is connected in series with a 6.7 Ω resistor. If a 10 V battery is connected across the pair. Calculate

   (a) The time to reach the current to 80 % of its maaximum value.

   (b) The current through the circuit after $2s$.

   (c) The potential across inductor and resistor after $2s$.

   (d) The energy delivered by the battery during the first 2 s.

   (e) The energy stored in the indutor after $2s$.

   (f) The energy dissipated in the resistor after $2s$.

56. In a circular parallel plate capacitor of radius a with rate of change of electric field dE/dt. Show that magnetic filed

$$B = \frac{1}{2}\mu_0 \epsilon_0 r \left[\frac{dE}{dt}\right] for (r \leq a)$$

$$B = \frac{1}{2}\frac{\mu_0 \epsilon_0 a^2}{r}\left[\frac{dE}{dt}\right] for (r \geq a)$$

57. The induced magnetic field at radial distance 6 mm from the central axis of a cicular parallel-plate capacitor is 2×10^{-7} T. The plates have radius 3 mm. At what rate is the electric field between the plates changing?

58. An oscillating LC circuit consists of a 75 mH inductor and a 3.6 μF capacitor. If the maximum charge on the capacitor is 2.9 μC, what are (a) the total energy in the circuit and (b) the maximum current?

59. Using Maxwell's equation, prove the charge conservation theorem (equation of continuity)

$$\frac{\partial \rho}{\partial t} + \nabla . \vec{J} = 0$$

60. The maximum electric field 10 m from an isotropic point source of light is 2 V/m. Calculate

   (a) The maximum value of the magnetic field

   (b) The average intensity of the light there and

   (c) The power of the source.

61. An isotropic point source emits light at wavelength 500 nm, at the rate of 200 W. A light detector is positioned 400 m from the source. What is the maximum rate $\partial B/\partial t$ at which the magnetic component of the light changes with time at the detector's location?

62. Calculate the de-Broglie wavelength of (a) a 1 KeV electron (b) a 1 KeV proton and (c) a 1 KeV photon.

63. A football of 500 gm is confined between impenetrable walls of Dasharath Rangashala that can be modelled as a box of length 100 m. Calculate the minimum speed of the ball.

64. Electron of energy 2 eV are incident on a barrier 3 eV height and 0.4 nm wide. Find the transmission probability.

65. Normalize the wave function

$$\psi = Be^{-x^2/2\sigma^2}$$

BEST WISHES