53 (PH 101) ENPH

2014

ENGINEERING PHYSICS

Paper : PH 101

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(A)* What is meant by gradient of scalar function ? If a scalar function is given by $V(x, y, z) = 3x^2y + e^z$, find the gradient of the function at (2, 3, –1). 1+3=4

(B) Express the vector $\vec{V} = 2x\hat{a}_x - z\hat{a}_y + y\hat{a}_z$ in *(a)* cylindrical co-ordinates and *(b)* spherical co-ordinates. 5

(C) Write the expression of $\vec{\nabla}$ and ∇^2 in cylindrical and spherical co-ordinates. 5

(D) State Stoke's Theorem. Verify Stoke's theorem for the function $\vec{F} = x^2\hat{i} - xy\,\hat{j}$ integrated round the square in the plane $z = 0$ and bounded by the lines $x = 0,\ y = 0,$ $x = a,\ y = a.$ 1+5=6

2. (A) State Gauss's law in electrostatics and write its integral and differential form. 1+3=4

(B) A uniform volume charge $0 \cdot 3c/m^3$ is distributed throughout a sphere of radius $3cm$. Find the electric field intensity at a distance of $5cm$ from the centre of sphere. 3

(C) A spherical volume charge density distribution is given by 2×5=10

$$\rho_v = \rho_0\left(1 - \frac{r^2}{a^2}\right) \quad ; \quad \text{for } r \le a$$

$$= 0 \quad ; \quad \text{for } r > a$$

(i) Calculate the total charge Q.

(ii) Find the electric field intensity outside the charge distribution.

(iii) Find the electric field intensity inside the charge distribution.

(iv) Show that the maximum value of field is at $r = 0 \cdot 745a$

(v) Show the variation of electric field with distance from the centre of spherical charge distribution.

(D) Write Laplace's and Poisson's equations in cylindrical and spherical co-ordinates. What is uniqueness theorem ? 3

3. (A) Write the *four* Maxwell's fundamental equations of electromagnetic wave in differential form. 4

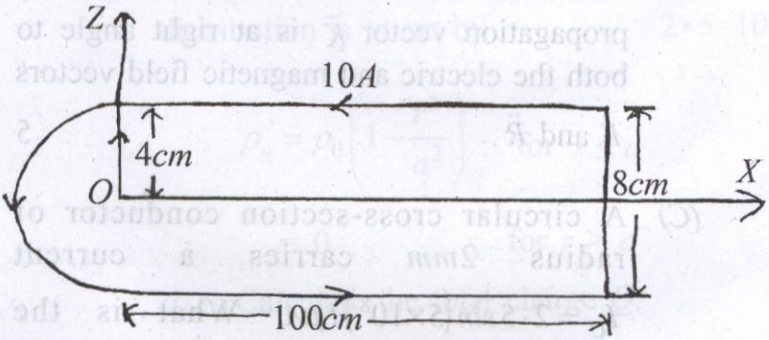
(B) Show that for electromagnetic wave, the propagation vector $\vec{K}$ is at right angle to both the electric and magnetic field vectors $\vec{E}$ and $\vec{R}$. 5

(C) A circular cross-section conductor of radius $2mm$ carries a current $I_C = 2 \cdot 5 sin\left(5 \times 10^8\right) t\, \mu A$. What is the amplitude of the displacement current density if $\sigma = 35 Ms/m$ and $\varepsilon_r = 1$? 5

(D) What is the condition of resonance in an LCR circuit? A resistance $R = 160\Omega$, a capacitance $C = 15\mu F$ and an inductance $L = 230mH$ are connected in series with a source $E(t) = 36\sin(wt - \phi)$. At what frequency, the resonance takes place in the circuit? Calculate the maximum current appeared in the circuit. 2+4=6

4. (A) State Biot-Savart's law and Ampere's law. 2

(B) For the given filamentary loop as shown in the figure, calculate the magnetic field at point O. 8



(C) Apply Ampere's law to obtain the expression of magnetic field intensity due to an infinite solenoid at any point on its axis. 4

(D) A solenoid with radius $2cm$ is wound with $20 turns/cm$ and carries $10mA$. Find $\vec{H}$ at the centre of solenoid if the length is $10cm$. If all the turns of the solenoid were compressed into a ring of radius $2cm$, what would be the magnetic field intensity at the centre of the ring ? 6

5. (A) Define a simple harmonic motion. Discuss the theory of a simple spring mass system and derive an expression for its time period and frequency. 2+5=7

(B) A particle executes SHM of amplitude $5cm$ when the particle is $3cm$ from its mean position its acceleration is found to be $48 cm/S^2$. Calculate its velocity at the same instant, its time period and its maximum velocity. 6

(C) What are Lissajous figures ? Compute analytically the resultant of two simple harmonic vibrations at right angles to each other when their periods are in the ratio of 1 : 2. 2+5=7

6. *(A)* Write short notes on Damped vibration. 3

(B) *(i)* Distinguish between free and forced vibrations. State the conditions of resonance. Give some important examples of resonance. 2+2+1=5

(ii) What are the important engineering applications of resonance ? 2

(C) What is the principle of superposition of waves ? Find the resultant of two plane simple harmonic waves of same period travelling in the same direction but differing in phase and amplitude. 5

(D) The equation of a transverse wave in a stretched wire is $y = 2\sin\pi\left(t/0{\cdot}02 - x/30\right) cm$. Find amplitude, wavelength frequency and speed of the wave. 5

7. *(A)* Define angular momentum. Derive an expression for the angular momentum of a system of particles and hence find an expression for the torque acting on the system. 5

(B) Define Poisson's ratio and derive the relation between Poisson's ratio and other moduli of elasticity. 6

(C) A capillary tube $10^{-3}m$ in diameter and $0{\cdot}2m$ in length is fitted horizontally to a vessel kept full of alcohol of density $0{\cdot}8\times10^{3}\,kg/m^{3}$. The depth of the centre of the capillary tube below the surface of alcohol is $0{\cdot}3m$. Viscosity of alcohol is $0{\cdot}0012Nsm^{-2}$. Calculate the volume of alcohol that flows in $5min$. 4

(D) State Stoke's law and apply it to find the terminal velocity of a sphere falling through a fluid. 5

8. (A) State first law of Thermodynamics. Give its physical significance. What are the limitations of first law ? 5

(B) State and prove Carnot's theorem. 5

(C) Define Entropy. Show that for a reversible adiabatic process the entropy of the system remains constant. 5

(D). Calculate the increase in entropy when 1 $gm.$ of ice at $-10°C$ is converted into steam at $100°C$. (Given : Specific heart of ice = 0·5 ; Latent heat of $80\,cal/gm$, Latent heat of steam $= 540\,cal/gm$). 5
