

**U.G. 3rd Semester Examination - 2021**

**PHYSICS**

[HONOURS]

Generic Elective Course (GE)

Course Code : PHY-H-GE-T-03(A&B)

Full Marks : 40

Time : 2½ Hours

*The figures in the right-hand margin indicate marks.*

*Candidates are required to give their answers in their own words as far as practicable.*

**Answer all the questions from the selected Option.**

**OPTION–A**

**PHY-H-GE-T-3A**

**(Electricity and Magnetism)**

1. Answer any **five** questions: 2×5=10
- a) Find a unit vector perpendicular to the plane of  $\vec{A} = 2\hat{i} + 2\hat{j} - \hat{k}$  and  $\vec{B} = 6\hat{i} - 3\hat{j} + 2\hat{k}$ .
- b) Write down the Thevenin theorem and Norton theorem.
- c) What are the Current and Charge Sensitivity, CDR (Critical Damping Resistance) of a Ballistic Galvanometer?

- d) Define Electrical susceptibility and Dielectric constant.
- e) What do you mean by Complex Reactance and Impedance?
- f) Define displacement current.
- g) What is the physical significance of  $\vec{\nabla} \cdot \vec{B} = 0$ ?
- h) Write the Gauss's theorem in dielectrics.

2. Answer any **two** questions: 5×2=10

- a) Write the Ampere's Circuital law. A charge Q is placed on a spherical conductor of radius R. Calculate the electrostatic energy density at a distance  $r(>R)$  from the centre of the sphere. Hence, find the electrostatic energy of the system. 2+3
- b) Write the differences between dia-, para-and ferro magnetic materials. Write the Lenz's law of electromagnetic induction. 3+2
- c) Derive an expression of capacitance of a parallel plate capacitor completely filled with dielectric. 5
- d) Write the Maxwell's equations of electromagnetic theory. What is Poynting Vector? 4+1

3. Answer any **two** questions:  $10 \times 2 = 20$
- a) Using Gauss's theorem of electrostatics, find the electric field inside and outside of a uniformly charged sphere of radius  $r$ . Find out the expression of Potential and Electric Field due to an electric dipole. Derive the expression of velocity of electromagnetic waves in a dielectric medium.  $4+4+2$
- b) Write the Biot-Savart's law. Apply this law to find the magnetic field at a distance  $r$  due to a straight current carrying conductor of finite length. Derive an expression of energy stored in a magnetic field in terms of self inductance. Define polarization of a dielectric. What is its physical significance?  $2+3+3+2$
- c) Write down the relation between  $B$ ,  $H$  and  $M$ . What is ferromagnetism? Explain hysteresis in a ferromagnetic material in terms of  $B$ - $H$  loop. Show that the hysteresis loss per unit volume per cycle of magnetization is equal to the area enclosed by the  $B$ - $H$  loop. Verify the divergence theorem for  $\vec{A} = 4x\hat{i} - 2y^2\hat{j} + z^2\hat{k}$  taken over the region bounded by  $x^2 + y^2 = 4$ ,  $z = 0$  and  $z = 3$ .  $(1+1+2)+2+4$

- d) A spherical shell of inner radius  $r_1$  and outer radius  $r_2$  is uniformly charged with charge density  $\rho$ . Calculate the electric field and potential at a distance  $r$  from the centre of the spherical shell for i)  $r > r_2$  ii)  $r_1 \leq r \leq r_2$  and iii)  $r \leq r_1$ . Derive an expression of Magnetic force on a current carrying wire. What is magnetic vector potential?  $6+3+1$

**OPTION-B**  
**PHY-H-GE-T-03B**  
**(Mechanics)**

1. Answer any **five** questions:  $2 \times 5 = 10$
- a) What do you mean by inertial and non-inertial frames of reference?
- b) Find the degree and order of the differential equation  $(1 + \frac{d^2y}{dx^2})^{\frac{3}{2}} = a \frac{d^2y}{dx^2}$ .
- c) State and explain the principle of conservation of angular momentum.
- d) Write down the Kepler's laws of planetary motion.
- e) State and explain Hooke's law of elasticity.

- f) Define angular velocity and angular momentum.
- g) Write down the necessary and sufficient condition of a first order differential equation to be exact.
- h) Give the basic concept of GPS.

2. Answer any **two** questions: 5×2=10

- a) i) Solve the differential equation  

$$y^2 + x^2 \frac{dy}{dx} = \frac{dy}{dx} .$$
- ii) Find the general solution of the differential equation  $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = 0 .$   
2+3

b) What is torsional pendulum? How will you measure the rigidity modulus of a material using this pendulum? Deduce the necessary formula. 1+4

c) State and prove Einstein's velocity addition theorem. 5

d) What is damped oscillation? Write down the differential equation of damped oscillation. Distinguish among critical damping, under damping and over damping. 1+2+2

3. Answer any **two** questions: 10×2=20

- a) i) Write down the characteristics of motion

under central force. Show that the areal velocity is a constant of motion in central force.

ii) A particle moving under a central force describes an orbit given by  $r = a(1 + \cos\theta)$ , where  $a$  is a constant. Obtain the law of force.

iii) Show that the Newton's 2nd law of motion is invariant under Galilean transformation. (2+2)+4+2

b) i) Write down the relation among Young's modulus, bulk modulus and Poisson's ratio and then prove it.

ii) Show that the strain energy per unit volume of a stretched wire is  $\frac{1}{2} \times \text{stress} \times \text{strain}$ .

iii) A rod of circular cross-section of length  $l$  and radius  $r$  is stretched such that the volume of the rod is not changed. Show that the Poisson's ratio is 0.5. 4+3+3

c) i) Find the projection of the vector  $4\hat{i} - 5\hat{j} + \hat{k}$  on the line passing through the points  $(2, -3, -1)$  and  $(-2, 4, 3)$ .

ii) Prove that  $\vec{A} \times (\vec{B} \times \vec{C}) = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B})$ .

- iii) Find the velocity and acceleration of a particle which moves along the curve  $x = 2\sin 3t$ ,  $y = 2\cos 3t$ ,  $z = 4t$  at any time  $t > 0$ . Find also the magnitude of the velocity and acceleration. 3+4+3
- d) i) Define centre of mass of a system of particles. Show that it is a unique point. Show that the total linear momentum is zero in the centre of mass frame.
- ii) Show that the average kinetic and average potential energies of a particle in SHMs are equal.
- iii) Write down the Lorentz transformation formulae. (1+2+2)+3+2
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