

U.G. 3rd Semester Examination - 2020

PHYSICS

[HONOURS]

Generic Elective Course (GE)

Course Code : PHY-H-GE-T-1(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-1A

(Electricity and Magnetism)

1. Answer any **five** questions: 2×5=10
- Write down the Gauss theorem of electrostatics .Write the differential form of this theorem.
 - Find the angle between $\vec{A} = 2\hat{i} + 2\hat{j} - \hat{k}$ and $\vec{B} = 6\hat{i} - 3\hat{j} + 2\hat{k}$.
 - Calculate the magnetic susceptibility of a magnetic material having permeability $\mu = 9\mu_0$.

- Define Poynting Vector. Explain its physical meaning.
- Write the Faraday's laws of electromagnetic induction.
- Define self inductance and mutual inductance of coils.
- Write the equation of continuity of current mentioning each term.
- Calculate the energy per unit volume in a electrostatic field.

2. Answer any **two** questions: 5×2=10
- 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 $z = 3$. 5
 - Write the Biot-Savart's law. Using this law find the magnetic field at a point on the axis of a circular coil carrying current. 2+3
 - Calculate the capacitance of an isolated spherical conductor. Write the differential form of Gauss's law for dielectric. 3+2
 - Define displacement current. Write the Maxwell's equations of electromagnetic theory. 1+4

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. The potential in a medium is given by $\varphi = \frac{q}{4\pi\epsilon_0} \frac{e^{-\lambda r}}{r}$. Obtain the corresponding electric field and charge density. What is the physical significance of polarization of dielectric? $5+4+1$

b) Derive an expression of capacitance of a parallel plate capacitor completely filled with dielectric. State the Ampere's circuital law and write its mathematical form. What is the physical significance of $\vec{\nabla} \cdot \vec{B} = 0$. Define magnetic vector potential. $5+2+2+1$

c) Derive an expression of energy stored in a magnetic field in terms of self inductance. Briefly discuss the differences between paramagnetic and ferromagnetic material. Show that $\vec{\nabla} \cdot \vec{r}^n = n r^{(n-2)} \vec{r}$. $4+3+3$

d) Starting from the expression of \vec{B} prove that i) $\vec{\nabla} \cdot \vec{B} = 0$ and ii) of $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$. Find out the expression of potential and electric field due to an electric dipole. Calculate the expression of velocity of electromagnetic waves in a dielectric medium. $4+4+2$

OPTION-B
PHY-H-GE-T-1B
(Mechanics)

1. Answer any **five** questions: $2 \times 5 = 10$

- Define centre of mass of a system of particles.
- What is work-energy theorem?
- State and explain the principle of conservation of angular momentum.
- What is damped oscillations? Explain with an example.
- What is elastic modulus? What is its unit?
- Write down the postulates of special theory of relativity.
- What do you mean by homogeneous differential equations?
- What is geosynchronous orbit?

2. Answer any **two** questions: $5 \times 2 = 10$

- Solve the differential equation $\frac{dy}{dx} = \frac{y-x+1}{y+x+5}$
 - Find the general solution of the differential equation $\frac{d^2y}{dx^2} + 4y = 0$. $3+2$
- Establish the relationship among the elastic constants Y, k, n and σ . 5

- c) i) Explain how a moving rod is contracted along the direction of its motion.
- ii) Two spaceships with equal speeds $u=0.68c$ move in opposite directions. What will be the relative speed of the spaceships with respect to each other?

3+2

- d) Show that the average kinetic and average potential energies of a particle in SHM are half the total energy. Is restoring force on a SHM conservative? Explain.

4+1

3. Answer any **two** questions: $10 \times 2 = 20$

- a) What is central force? Show that it is conservative. Prove that the areal velocity of the line joining the centre of force and the particle is a constant of motion. A particle moving under a central force describes a spiral orbit given by $r = ae^{b\theta}$, where a and b are constants. Obtain the law of force.

1+3+3+3

- b) i) Deduce the expression for the torsional rigidity of a specimen in the form of a large cylindrical shell of inner and outer radii r_1 and r_2 .
- ii) Show the strain energy of a twisted wire

is $\frac{1}{2} \times \text{torsional couple} \times \text{twist}$.

- 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) Determine a unit vector perpendicular to the plane of $\vec{A} = 2\hat{i} - 6\hat{j} - 3\hat{k}$ and $\vec{B} = 4\hat{i} + 3\hat{j} - \hat{k}$.

- ii) Prove that

$$\vec{A} \cdot (\vec{B} \times \vec{C}) = \vec{B} \cdot (\vec{C} \times \vec{A}) = \vec{C} \cdot (\vec{A} \times \vec{B})$$

- iii) Find the volume of the parallelepiped whose edges are given by $\vec{A} = 2\hat{i} - 3\hat{j} + 4\hat{k}$, $\vec{B} = \hat{i} + 2\hat{j} - \hat{k}$ and $\vec{C} = 3\hat{i} - \hat{j} + 2\hat{k}$.

- iv) Find the velocity and acceleration of a particle which moves along the curve $x = 2\sin 3t$, $y = 2\cos 3t$, $z = 8t$ at any time $t > 0$. Find also the magnitude of the velocity and acceleration.

2+3+2+3

- d) i) What are the inertial and non-inertial frames of reference? Show that the Newton's 2nd law of motion is invariant in inertial frame of reference. Is it at all possible to have an inertial frame? Explain.

- ii) Prove that the total kinetic energy of a system of particles is equal to the kinetic energy of the centre of mass plus the kinetic energy of the particles with respect to the centre of mass.

$$(2+3+2)+3$$
