U.G. 1st Semester Examination - 2021

PHYSICS

[HONOURS]

Generic Elective Course (GE)

Course Code : PHY-H-GE-T-01(A)&(B)

Full Marks : 40 Time : $2\frac{1}{2}$ 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 selected Option.

OPTION-A

PHYS-H-GE-T-01(A)

(Electricity & Magnetism)

1. Answer any **five** questions: 2×5=10

   a) Calculate the force on an electron which enters with a velocity $2\hat{\imath}+3\hat{\jmath}$ m/sec into a region containing an electric field of intensity $3\hat{\imath}+6\hat{\jmath}+2\hat{k}$ volts/metre and a magnetic field of $2\hat{\imath}+3\hat{k}$ Tesla.

   b) A point charge 'q' is kept at a corner of a cube. Determine the flux of the electric field due to 'q' through the three surfaces of the cube which do not meet at 'q'.

   c) A point charge $Q=30\times10^{-9}$ C is located at the origin in Cartesian coordinates. Find the electric flux density $\vec{D}$ at a point (1,3,4).

   d) $(x,y) = \alpha - \beta(x^2+y^2) - \gamma\, ln\sqrt{x^2+y^2}$ where α, β and γ are constants. Find the charge density in this region.

   e) If the polarisation in a dielectric is given by $\vec{P} = ax^2\,\hat{x} + by\,\hat{y}$, obtain the volume charge density.

   f) Show that dipole moment of a charge distribution is independent of origin chosen if total charge is zero.

   g) An electron is moving in a circular orbit of radius r with speed v. If we consider that it constitutes a steady current, find its magnitude.

   h) If magnetic vector potential $\vec{A} = e^{-x}\sin y\,\hat{\imath} + (1+\cos y)\hat{\jmath}$, calculate the magnetic induction.

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

a) A long hollow metal cylinder with inner radius 'a' and outer radius 'b' has a length'l'.

Show that the self-inductance of the cylinder is $L = \frac{l\mu_0}{2\pi}\ln\frac{b}{a}$.

Show that, a current placed in a magnetic field $\vec{B}$ experiences a force $\vec{F}=I\vec{dl}\times\vec{B}$, where the symbols have their usual meanings.

Find the inductance in Henry of a straight coil of 100 turns, wound on 25cm long paper tube having 4cm radius. 2+2+1

b) State and obtain the integral form of Gauss's law in a dielectric.

Write down the boundary conditions at the interface of two dielectrics of permittivities ϵ_1 *and* ϵ_2.

Two parallel plate capacitors, each of capacitance 40μF, are connected in series. The space between the plates of one capacitor is filled with a dielectric material of dielectric constant K=4. What is the equivalent capacitance of the system? 2+1+2

c) A charged particle moves with uniform velocity $\vec{v} = 4\hat{\imath}$ m/s in a region where $\vec{E}=20\hat{\jmath}$ V/m and $\vec{B} = B_0\hat{k}$ Wb/m^2. Determine B_0 such that the velocity of the particle remains constant.

Calculate the magnetic field at a distance r from the axis of a very long solenoid with radius R and having N turns per unit length, and carrying a steady current I.

Two long parallel wires each carrying 1 A cunent and placed 10 cm apart.What is the force per unit length between the two wires? 2+2+1

d) If A is a constant vector and **r = ix + jy + kz** prove that **∇(r.A) =A**

If F=(x+2y)i+(2x²+xy)j evaluate the line integral $\int \boldsymbol{F.dr}$ along the curve c in the xy plane having equation $y = x^2$ from the point (0,0) to (1,1). 2+3

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

a) Show that the electric and magnetic energy densities are equal in the propagation of electromagnetic waves in vacuum.

Derive the continuity equation $\nabla.\mathbf{J} = -\frac{\partial\rho}{\partial t}$ from Maxwell's equations.

Discus the origin of the displacement current in Maxwell's equations. 4+4+2

b) An electromagnetic wave is travelling in a linear, homogeneous and isotropic conducting medium where there are no charges and external currents. Derive the wave equations for the fields. Apply Gauss theorem calculate the electric field due to a uniformly charged sphere of radius R at points inside and outside the sphere. Represent the above result graphically. 4+4+2

c) Calculate the electrostatic potential in free space due to a dipole. For a uniformly charged disc of radius a, find the electric field at a distance $h(h >> a)$ from the centre along the axis of the disc.

Show that the vector $\vec{E} = yz\hat{\imath} + zx\hat{\jmath} + xy\hat{k}$ represents an electric field. Find the corresponding electrostatic potential V, given that $V = V_0$ at x=y=z=0. 4+3+3

d) Starting with the expression $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$, where the symbols have their usual meanings, show that, the line integral of the magnetic induction around a closed path is equal to μ_0 times the total current enclosed by the path.

Determine the force acting on an electric dipole placed within an inhomogeneous electric field.

Two magnetic media are separated by a plane interface. Establish a relation of angles between the normal to the boundary and the **B** fields on either side. 4+3+3

OPTION-B

PHYS-H-GE-T-01(B)

(Mechanics)

1. Answer any **five** questions: 2×5=10

a) Find the unit vector perpendicular to $\vec{A} = 4\hat{\imath} - \hat{\jmath} + 3\hat{k}$, and $\vec{B} = -2\hat{\imath} + \hat{\jmath} - 2\hat{k}$.

b) What is homogeneous differential equation? Give an example of a second order homogeneous differential equation with constant coefficients.

c) Define angular velocity and angular momentum. Write down their units.

d) If the kinetic energy and the potential energy of a particle in a SHM are equal, find the displacement of the particle from its equilibrium position.

e) What is torsional modulus?

f) State Hooke's law of elasticity.

g) Write down the postulates of special theory of relativity.

h) What is geosynchronous orbit?

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

a) i) Find the primitive of the differential equation $\frac{dy}{dx} = \frac{2x-5y+3}{2x+4y-6}$.

ii) Find the general solution of the differential equation $\frac{d^2x}{dt^2} - 6\frac{dx}{dt} + 9x = 0$.

$2\frac{1}{2}+2\frac{1}{2}$

b) If y, k,and σ represent Young's modulus, Bulk modulus and Poisson's ratio respectively, prove that $Y = 3k(1\text{-}2\sigma)$. State the limiting values of σ.

4+1

c) i) Write down the Lorentz transformation formulae and explain length contraction.

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) Write down the differential equation of SHM. Show that the average kinetic and average potential energies of a particle in SHM are half the total energy. 1+4

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

a) i) Show that the central force is conservative. Prove that the areal velocity of the line joining the centre of force and the particle is a constant of motion.

ii) Deduce Newton's law of gravitation from Kepler's laws of planetary motion.

iii) Given that the distance of the planet Jupiter from the Sun is 5.20 times the earth's distance, find the period of Jupiter's revolution round the sun in earth years. (2+3)+3+2

b) i) What is torsional oscillation? Discuss how the modulus of rigidity of the material of a long wire can be determined, using torsional oscillation.

ii) Describe Searle's method for the determination of Young's modulus and rigidity modulus. (2+3)+5

c) i) If $\vec{A} = 5u^2\hat{i} - 2u\hat{j} - u^3\hat{k}$ and

$\vec{B} = sinu\hat{i} - cosu\hat{j}$,

Find $\frac{d}{du}(\vec{A}.\vec{B})$ and $\frac{d}{du}(\vec{A} \times \vec{B})$

ii) Prove that

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

iii) A particle moves along the curve $x = 2t^2$, $y = t^2-4t$, $z = 3t-5$ at any time $t>0$. Find the components of the velocity and acceleration at $t = 1$ in the direction $4\hat{\imath} - 3\hat{\jmath} + \hat{k}$. 4+3+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.

ii) Define centre of mass of a system of particles. Calculate the kinetic energy and potential energy of a system of particles.

(2+3)+1+4
