PHYSICS I
(PHYS 1001)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The value of m for which $\vec{A} = m(x+y)\hat{\imath} + 4y\hat{\jmath} + 3\hat{k}$ is solenoidal is equal to
(a) 4 (b) 0 (c) -4 (d) -3.

(ii) The quality factor of a series L-C-R circuit is
(a) $\frac{1}{R}\sqrt{\frac{L}{C}}$ (b) $\sqrt{RLC}$ (c) $\frac{1}{R}\sqrt{\frac{1}{LC}}$ (d) $\sqrt{\frac{RL}{C}}$

(iii) When a plane polarised light is passed through a half wave plate, then the emergent light is
(a) elliptically polarised (b) plane polarised
(c) mixture of elliptically and circularly polarised (d) circularly polarised

(iv) The volume element in cylindrical polar coordinates (ρ, φ, z) is
(a) $\rho d\rho d\varphi dz$ (b) $\rho d\varphi dz$ (c) $\rho d\rho dz$ (d) $d\rho d\varphi dz$

(v) Magnetic dipole moment per unit volume of material is called
(a) polarization (b) permeability
(c) magnetization (d) magnetic induction

(vi) Poisson equation in electrostatic is given by the following relation
(a) $\vec{\nabla}.\vec{E} = \varepsilon_0 \rho$ (b) $\vec{\nabla}.\vec{E} = -\frac{\rho}{\varepsilon_0}$ (c) $\nabla^2\phi = -\frac{\rho}{\varepsilon_0}$ (d) $\nabla^2\phi = 0$
Where the terms have their usual meaning.

(vii) Motion of a system in a critically damped oscillation is
(a) oscillatory (b) harmonic (c) linear (d) non-oscillatory

(viii) A moving charge produces
(a) $\vec{E}$ field only (b) $\vec{B}$ field only
(c) both $\vec{E}$ and $\vec{B}$ field (d) none of these
Where $\vec{E}$ and $\vec{B}$ have their usual meaning.

(ix) Susceptibility χ of a paramagnetic gas varies with temperature T as

(a) $\chi \propto T$ (b) $\chi \propto T^{-1}$ (c) $\chi \propto T^{-2}$ (d) $\chi \propto T^{2}$

(x) A wind is flowing from the tropic of cancer towards the equator. Due to the earth's rotation it will be deflected towards the

(a) north (b) east (c) south (d) west.

Group – B

2. (a) Show that the infinitesimal length element in cylindrical polar coordinate system is given by $|d\vec{r}|^2 = d\rho^2 + \rho^2 d\theta^2 + dz^2$ where $\vec{r}(\rho,\theta,z)$ is the position vector and is function of the cylindrical coordinates which have their usual meaning.

(b) Show that $\vec{\nabla}.(\vec{\nabla} \times \vec{A}) = 0$ in general , where $\vec{A}$ is a vector field.

(c) Show that $\vec{F}(x,y) = x\hat{\imath} + y\hat{\jmath}$ is a conservative vector field. Find the corresponding potential. Also show that $\vec{F}$ represents a source.

(d) If $\vec{B}$ be a constant vector field and $\vec{A} = \vec{B} \times \vec{r}$, where $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$. Show that $\vec{A}$ is solenoidal.

3 + 3 + (1 + 2 + 1) + 2 = 12

3. (a) What do you mean by central force? Show that for a particle undertaking motion in a central force field, the angular momentum remains conserved.

(b) Given that a particle under central force, $mr^2\dot{\theta} = L$ and $\ddot{r} - r\dot{\theta}^2 = f(r)$ (symbols have their usual meaning) then show that the equation of the orbit under the influence of a force $\vec{F} = F(r)\hat{r}$ is given by $\frac{d^2u}{d\theta^2} + u = -\frac{m^2}{L^2u^2} f(\frac{1}{u})$, where m being mass of particle and $u = \frac{1}{r}$.

(c) Construct the Coriolis formula for time derivatives $(\frac{d}{dt})_{fix} = (\frac{d}{dt})_{rot} + \vec{w} \times$, where w is the angular velocity.

(d) Comment on the relation $\vec{g}_{eff} = \vec{g} - \vec{\omega} \times (\vec{\omega} \times \vec{r})$ that represents acceleration due to gravity in a rotating frame of reference rotating with constant angular velocity ω.

(1 + 3) + 3 + 4 + 1 = 12

Group – C

4. (a) Write down the differential equation of motion of a damped harmonic system explaining all the terms. Solve the differential equation to find the variation of displacement as a function of time in under damped condition.

(b) The amplitude of the n^{th} oscillation and the 1^{st} oscillation are A_n and A_1 respectively of a damped harmonic oscillator. Find out the logarithmic decrement of the oscillator.

(c) Verify if the wave function $\varphi(x,t) = cos^2(wt - kx)$ represents a classical wave.

(d) If the damping constant is $1s^{-1}$ calculate the damped frequency of oscillation if the system has mass 20gm and spring constant $0.1kg\ s^{-2}$.

(2 + 3) + 3 + 2 + 2 = 12

5. (a) Write two differences between circularly polarized light and un-polarized light.

(b) Draw the state of polarization of a light vector whose x and y components are given by, $E_x = E_0\cos(\omega t - kz + \frac{\pi}{4})$ and $E_y = \frac{E_0}{\sqrt{2}} cos(\omega t - kz)$.

(c) A right circularly polarized beam of light (λ = 5250Å) is incident normally on a doubly refracting crystal with optic axis parallel to its surface. The thickness of the crystal is 0.00075 mm. The difference between the refractive indices due to the E-wave and O-wave is 0.175. Find the state of polarization of the emergent light beam.

(d) Why population inversion is an essential condition for stimulated emission? Why existence of metastable state is an essential requirement for achieving population inversion?

2 + 4 + 3 + 3 = 12

Group – D

6. (a) A ring of radius R and uniform linear charge density λ is placed on XY plane with the centre coinciding with the origin. Calculate the electrostatic field at $(0, 0, z_0)$. Comment on the situation when $z_0 >> R$.

(b) In an electric field the electric potential is given by $U(x, y, z) = (x^2 + y^2 + z^2)^{\frac{-1}{2}}$. Calculate the electric field at point (1, 1, 1).

(c) Two concentric spheres of radii a and b are kept at potentials V_a and V_b. If the intervening space is vacuum, then write the appropriate differential equation that the electrostatics potential satisfies. Solve this equation to find out potential at any point between the spheres. Calculate the surface charge density on the outer sphere.

(3 + 2) + 2 + (1 + 2 + 2) = 12

7. (a) Find out the expression of electric potential due to an electric dipole and also find the electric field due to the same dipole at a point $(5, \frac{\pi}{3})$.

(b) Show by using image method that the induced charge on a grounded infinite conducting plane is equal and opposite to that of the charge that is placed before it.

(c) Show that the electric displacement $\vec{D}$, electric field $\vec{E}$ and polarization $\vec{P}$ are related by the following vector relation, $\vec{D} = \varepsilon_0\vec{E} + \vec{P}$ in case of di-electric medium.

(3 + 2) + 4 + 3 = 12

Group – E

8. (a) Magnetic vector potential at any position (x,y,z) is given as $\vec{A} = x^2y\hat{\imath} + y^2z\hat{\jmath} + z^2x\hat{k}$. Find the magnetic field at point (1, 1, 1).

(b) Using Biot-Savart law, obtain the expression of magnetic field at a point on the axis of a circular loop carrying a steady current I.

(c) Draw the hysteresis curve for soft iron and steel and compare the two loops.

(d) Write Curie-Weiss law mentioning each term. Plot the relation between magnetic susceptibility and absolute temperature of a ferromagnetic material in its paramagnetic phase.

3 + 3 + 3 + (2 + 1) = 12

9. (a) Obtain differential form of Faraday's law from its integral form.

(b) The magnetic field is given by $\vec{B} = B_0 \sin \omega t(\hat{i} + 2\hat{j})$. If a closed conductor of area $A_0(\hat{j} + \hat{k})$ and 100 number of turns is kept in that magnetic field, calculate the maximum emf induced in the loop.

(c) Explain why ferromagnetic materials can be permanently magnetized whereas paramagnetic ones cannot.

(d) A sample of gold having magnetic susceptibility -3.6×10^{-5} is placed in a magnetising field of strength $60 \times 10^{3}\ A-turn/m$. Find the magnetic induction within the sample.

3 + 3 + 3 + 3 = 12

Department & Section	Submission Link
BT	https://classroom.google.com/c/MjMwMTcyNjc5MjYx/a/MjkzODY0OTY2ODE3/details
CE A	https://classroom.google.com/c/MjMwMDQ0MjgxMDA0/a/MjkzODU4NTUwNzYw/details
CE B	https://classroom.google.com/c/MjMwMDQ3MDQ3OTQ4/a/MjkzODYxNzkzOTgw/details
CHE	https://classroom.google.com/c/MjMwMDQ3MDQ3OTMz/a/Mjg4MDQwMDM0MTMz/details
EE	https://classroom.google.com/c/OTI0NzIyNzgxNDJa/a/Mjg4MDUzMDc4MDI1/details
ME A	https://classroom.google.com/c/MjMwMDQ3OTcxMzgw/a/MjkzODU4NTUwNjU1/details
ME B	https://classroom.google.com/c/MjMwMDYxOTU3ODQ1/a/MjkzODk5MjA0MjM4/details

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