Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.Tech (OLD)/SEM-1/PH-101/2010-11

2010-11

ENGINEERING PHYSICS

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) A body of mass m moves with a velocity v and hits a stationary block of mass M and both of them start moving in the same direction with the same velocity, v'. Assuming the collision to be elastic the

      a) kinetic energy of the system is increased

      b) kinetic energy of the system is decreased

      c) $v' = v$ if $M >> m$

      d) $v' = v$ if $M << m$.

   ii) Degrees of freedom of a N-particle rigid body restricted to move on the surface of the earth along the equator is

      a) one b) $3N$-1

      c) four d) five.

iii) Angular momentum of a system is conserved when

a) the system comprizes of a single particle

b) total force on the system is zero

c) total torque on the system is zero

d) total force and torque both are zero.

iv) Generalized co-ordinates of a single particle (of mass m) system are chosen as the spherical polar co-ordinates r, θ, ϕ. If p_r, p_θ and p_ϕ denote the corresponding momenta then the Hamiltonian of the system which is constrained to move in $\phi = 0$ plane is

a) $\frac{1}{2m}\left(p_r^2 + p_\theta^2 + p_\phi^2\right)$

b) $\frac{1}{2m}\left(p_r^2 + \frac{p_\theta^2}{r^2}\right)$

c) $\frac{1}{2m}\left(p_r^2 + \frac{p_\theta^2}{r^2} + \frac{p_\phi^2}{r^2 \sin^2\theta}\right)$

d) none of these.

v) Electromagnetic wave and elastic wave

a) both can propagate through vacuum

b) both can be longitudinal

c) both can be transverse

d) both travel with same velocity in all media.

vi) If a charged capacitor (C) is discharged through a resistor (R) and an inductor (L) then the charge will

a) always decay without oscillation irrespective of the circuit elements

b) always show decaying oscillation irrespective of the values of the circuit elements

c) show decaying oscillation only when $R > 2\sqrt{\frac{L}{C}}$

d) show decaying oscillation only when $R < 2\sqrt{\frac{L}{C}}$.

vii) For a particle executing S.H.M. the phase difference between displacement and velocity is

a) π b) zero

c) $\frac{\pi}{2}$ d) $\frac{\pi}{4}$.

viii) The equation of the surface above x-y plane is $x^2 + y^2 = z$, the unit normal vector in the surface at (x, y, z) is given by

a) $\frac{x\hat{i} + y\hat{j} + 2\hat{k}}{\sqrt{3}}$ b) $\frac{x\hat{i} + y\hat{j}}{\sqrt{2}}$

c) $\frac{2x\hat{i} + 2y\hat{j} - \hat{k}}{3}$ d) $\hat{k}$.

ix) Electric field is

a) always irrotational

b) never irrotational

c) irrotational only in a charge-free region

d) irrotational if the magnetic field does not change with time.

x) Let (r, θ, ϕ) represent the spherical polar co-ordinates of a point in a region where the electrostatic potential is given by $V = k\phi^2$. Then the charge density in that region is

a) a function of ϕ only

b) a constant

c) a function of (r, θ) only

d) a function of all three co-ordinates (r, θ, ϕ).

xi) Ampere's circuital law is valid for

a) varying current only

b) steady current only

c) alternative current only

d) none of these.

xii) A point charge q is placed at the centre of a cube of side a, then the flux of the electric field at each surface of the cube is

a) $\dfrac{q}{4\pi\epsilon_0}$ b) $\dfrac{q}{\epsilon_0}$

c) $\dfrac{q}{6\epsilon_0}$ d) $\dfrac{qa^2}{\epsilon_0}$.

xiii) In a region electric field is uniform and pointing towards positive z direction. The electrostatic potential at $z = 0$ and at $z = 1$ are denoted by ϕ_0 and ϕ_z. Then

a) $\phi_0 = \phi_z$

b) $\phi_0 > \phi_z$

c) $\phi_0 < \phi_z$

d) the field will be changed if ϕ_0 is made $\phi_0 + \alpha$ and ϕ_z is made $\phi_z + \alpha$ when α is a constant.

xiv) $\vec{\nabla} \cdot \vec{B} = 0$ signifies that

a) $\vec{B}$ is a conservative field

b) magnetic monopole does not exist

c) $\vec{B} = 0$

d) there exist magnetic monopole.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) Write down the equations of constraint and obtain degrees of freedom for a simple pendulum, constrained to move in a plane, suspended by a rigid string of negligible mass. Mass of the pendulum is M. 1 + 1

b) Write down the Langragian of a system and derive the equation of motion. 1 + 2

3. If the damping force for a forced harmonic oscillator is proportional to $2bv$ (where v is the velocity of the particle), natural frequency is ω_0, the periodic driving force is $f \sin pt$ then the steady state displacement is given by $x = \dfrac{f}{\sqrt{\left(\omega^2 - p^2\right)^2 + 4b^2p^2}} \sin(pt - \propto)$ and $\alpha = \tan^{-1} \dfrac{2bp}{\left(\omega^2 - p^2\right)}$.

Find out the frequency corresponding to the velocity resonance. Find the value of the phase factor at this frequency. Find the value of the frequency of amplitude resonance. 2 + 1 + 2

4. If a vector field $\vec{B} = \vec{\nabla} \times \vec{A}$, where $\vec{A}$ is another vector field, then show that $\vec{\nabla} \cdot \vec{B} = 0$. 2

If $\vec{E}$ is electrostatic field then show that it can be derived from a scalar potential, ϕ. Prove the necessary vector identity. 1 + 2

5. a) In a region of space, the electric field is given by $\vec{E} = 8\hat{i} + 4\hat{j} + 3\hat{k}$, calculate the electric flux through a surface area 10 units in *x-y* plane. 2

   b) Find out the potential at the centre of a 1·0 metre square having charges q, $-2q$, $3q$ and $2q$ at its corners. 3

6. State Ampere's circuital law in the integral form. Cast it into differential form. Show that this law implies a steady current. 1 + 2 + 2

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Write down the differential equation of damped vibration and explain each term. 2

   b) Obtain the solution for such equation for small damping. Hence calculate the time period. 6 + 2

   c) What is relaxation time ? Show that relaxation time depends on damping constant. 2 + 3

8. a) For a two-body system, show that the total linear momentum is constant when the total external force is zero. 5

b) A ball falls on the floor from a height H and rebounds to a height H. Calculate the coefficient of resitution in this case. 5

c) Show that the Hamiltonian remains conserved when the Lagrangian does not explicitly depend on time. 5

9. a) Derive equation of continuity from the principle of conservation of charge. 5

b) Define drift velocity and current density. Derive the relation between the two quantities. 5

c) Find the electrostatic potential within a infinitely long hollow uniform cylinder of radius a, maintained at a potential V_0 by solving the appropriate Laplace equation. 5

10. a) If the electrostatic potential is given by $V = \left(x^2 + y^2 + z^2\right)/6$, then calculate the total charge within a sphere of radius R. Calculate the electrostatic field vector at the surface of this sphere. 5

b) State Biot-Savart law in its vector form. Explain the symbols with the help of a diagram. Find out the magnetic field at the centre of a circular current carrying loop of radius b (current is I). 2 + 2 + 4

c) Find the magnetic field due to solid cylinder of radius a carrying current I at a distance $r > a$. 2

11. a) State Coulomb's theorem on the electrostatic field near the surface of a conductor. Prove the theorem from Gauss' law of electrostatics. 2 + 4

b) Derive Poisson's equation from Gauss law. Verify that the electrostatic potential due to an isolated point charge at the origin satisfies Poisson's equation at a point whose distance from the origin, $r \neq 0$. 2 + 4

c) A charge q is placed at the origin of the coordinate system. Calculate the work done in bringing another charge q from infinity to a point of distance r from the origin directly from the definition of the work done. 3

12. a) State Maxwell's equations. Show that in a charge free, current free region the electric field vector satisfies a wave equation. Identify the velocity of this wave.
2 + 3 + 1

b) What is a cyclic coordinate ? From Hamilton's equation of motion show that the conjugate momentum corresponding to a cyclic co-ordinate is conserved. Give an example of a system with cyclic co-ordinate and the conserved corresponding momentum. 1 + 3 + 2

c) If a particle executing simple harmonic motion simultaneously at two perpendicular directions with the same amplitude and frequency then find out the condition that the Lissajous figure will be a circle. 3