

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 $M \gg m$
 - d) $v' = v$ if $M \ll m$.
- 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
- the system comprises of a single particle
 - total force on the system is zero
 - total torque on the system is zero
 - 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
- $\frac{1}{2m} (p_r^2 + p_\theta^2 + p_\phi^2)$
 - $\frac{1}{2m} \left(p_r^2 + \frac{p_\theta^2}{r^2} \right)$
 - $\frac{1}{2m} \left(p_r^2 + \frac{p_\theta^2}{r^2} + \frac{p_\phi^2}{r^2 \sin^2 \theta} \right)$
 - none of these.
- v) Electromagnetic wave and elastic wave
- both can propagate through vacuum
 - both can be longitudinal
 - both can be transverse
 - 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
- always decay without oscillation irrespective of the circuit elements
 - always show decaying oscillation irrespective of the values of the circuit elements
 - show decaying oscillation only when $R > 2\sqrt{\frac{L}{C}}$
 - 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
- π
 - zero
 - $\frac{\pi}{2}$
 - $\frac{\pi}{4}$.
- 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
- $\frac{x\hat{i} + y\hat{j} + 2\hat{k}}{\sqrt{3}}$
 - $\frac{x\hat{i} + y\hat{j}}{\sqrt{2}}$
 - $\frac{2x\hat{i} + 2y\hat{j} - \hat{k}}{3}$
 - \hat{k} .
- ix) Electric field is
- always irrotational
 - never irrotational
 - irrotational only in a charge-free region
 - 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 function of ϕ only
 - a constant
 - a function of (r, θ) only
 - a function of all three co-ordinates (r, θ, ϕ) .
- xi) Ampere's circuital law is valid for
- varying current only
 - steady current only
 - alternative current only
 - 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
- $\frac{q}{4\pi\epsilon_0}$
 - $\frac{q}{\epsilon_0}$
 - $\frac{q}{6\epsilon_0}$
 - $\frac{qa^2}{\epsilon_0}$.
- 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
- $\phi_0 = \phi_z$
 - $\phi_0 > \phi_z$
 - $\phi_0 < \phi_z$
 - 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 × 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 Lagrangian 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 $x = \frac{f}{\sqrt{(\omega^2 - p^2)^2 + 4b^2 p^2}} \sin(pt - \alpha)$ and $\alpha = \tan^{-1} \frac{2bp}{(\omega^2 - p^2)}$.

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

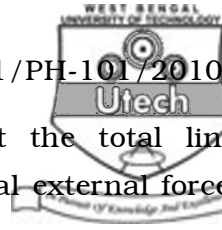
6. State Ampere's circuital law in the integral form. Cast it into differential form. Show that this law implies a steady current. 1 + 2 + 2

GROUP – C

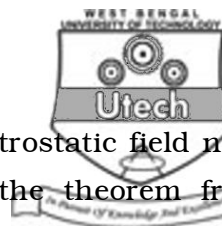
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

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 $V = (x^2 + y^2 + z^2)/6$, 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
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