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1A (Sem-1/ITEP) PHY01 MN

2025

PHYSICS

(Minor)

Paper : PHY0100104-N

(Mathematical Physics and Mechanics)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : $1 \times 5 = 5$
 - (a) What are solenoidal and irrotational vectors?
 - (b) Define Dirac-Delta function.
 - (c) Define central force.
 - (d) State the principle of conservation of linear momentum.
 - (e) Define moment of inertia.
2. Answer the following questions : **(any five)**
 $2 \times 5 = 10$
 - (a) Express gradient, divergence in spherical coordinates.

(b) Find the value of 'a' if

$$\vec{F} = (ax^2y + yz)\hat{i} + (xy^2 - xz^2)\hat{j} + (2xyz - 2x^2y^2)\hat{k}$$

is solenoidal.

(c) Find $\vec{\nabla} \cdot \vec{r}$ where \vec{r} is any position vector.

(d) Differentiate between inertial and non-inertial frame of reference.

(e) Two particles of masses 2kg and 4kg are placed at points $x = 1m$ and $x = 5m$ on the X-axis. Find the position of their centre of mass.

(f) State the theorem of parallel axes.

(g) Define torque.

(h) Distinguish between conservative and non-conservative forces.

(i) What do you mean by SHM?

(j) On what factors does the bending of a cantilever depend?

3. Answer the following questions : **(any four)**
5×4=20

(a) Find the divergence and curl of
 $\vec{v} = (xyz)\hat{i} + (3x^2y)\hat{j} + (xz^2 - y^2z)\hat{k}$
at (2, -1, 1).

(b) (i) If

$$\vec{A} = (3x^2 + 6y)\hat{i} - 14yz\hat{j} + 20xz^2\hat{k},$$

evaluate the line integral $\oint_C \vec{A} \cdot d\vec{r}$ from (0, 0, 0) to (1, 1, 1) along the curve C and $x = t, y = t^2, z = t^3$.

(ii) $\int_{-\infty}^{\infty} e^{-3t} \delta(t-4) dt$.

3+2=5

(c) Derive the equation of motion of reduced mass of a system of two bodies moving under the effect of gravitational force.

(d) State and explain Kepler's law of planetary motion.

(e) In case of an elastic collision between two bodies in one dimension, derive the expression for final velocities of the bodies.

(f) Obtain the average value of K.E. and P.E. of a particle executing SHM.

(g) A body of mass 5kg is moving with a velocity of 10m/s. Find its initial kinetic energy. If work done by friction is -100J, find its final kinetic energy and velocity.



(h) Derive the expression for twisting couple per unit twist of a cylindrical wire.

4. Answer the following questions : **(any one)**
10×1=10

(a) Define gradient and divergence of a vector function. State Stokes theorem and mention its significance. Evaluate

$$\int_C [(2x - y) dx - yz^2 dy - y^2 z dz]$$

where C is the circle $x^2 + y^2 = 1$, corresponding to the surface sphere of unit radius. 1+1+3+2+3=10

(b) Derive the expression for finding gravitational potential and field due to a spherical shell at a point (a) outside the shell (b) at the surface of the sphere (c) inside the shell.

(c) Derive the expression for moment of inertia of both the solid and hollow cylinder (a) about its own axis, (b) about an axis passing through its centre and perpendicular to its own axis.

Acc. No. (d) (i)

Date

Obtain the differential equation of a particle executing SHM and hence its solution. 5

(ii) Obtain the average value of K.E. and P.E. of a particle executing SHM. 5