UG/1st Sem/H/20 (CBCS)

2020

PHYSICS (Honours)

Paper : PHYH - DC- 1T

[CBCS]

Full Marks : 25 Time : Two Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.

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

(a) Define scalar field and vector field. Give example of each.

(b) If a vector field is given by $\vec{F} = \left(x^2 + y^2 + x\right)\hat{i} - \left(2xy + y\right)\hat{j}$. Is this field irrotational ?

(c) If $\vec{r} = t\hat{i} - t^2\hat{j} + \left(t-1\right)\hat{k}$ and $\vec{S} = 2t^2\hat{i} + 6t\hat{k}$, evaluate $\int_0^2 \vec{r} \cdot \vec{S}\, dt$

(d) With the help of divergence theorem, show that $\int \left(\vec{\nabla}\phi \times \vec{\nabla}\psi\right) \cdot d\vec{s} = 0$

(e) Find the value λ, for the differential equation $\left(xy^2 + \lambda x^2 y\right)dx + \left(x+y\right)x^2 dy = 0$ is exact.

(f) Evaluate the integral $I = \int_0^\infty e^{-31}\delta\left(t-4\right)dt$

(g) Solve the following differential equation $\frac{d^5y}{dx^5} - \frac{d^3y}{dx^3} = 0$

(h) Find the unit normal to the surface $xy^3z^2 = 4$ at (–1,–1,2)

2. Answer any *three* questions : 5×3=15

(a) Use the Divergence Theorem, evaluate $\iint F.dS$ where $F = 4xi - 2y^2 j + z^2 k$ and S is the surface bounding the region $x^2 + y^2 = 4,\ z = 0$ and $z = 3$. 5

(b) Prove that the spherical polar coordinate system is orthogonal. 5

(c) Evaluate $\iiint (2x + y)\, dV$, where V is closed region bounded by the cylinder $z = 4 - x^2$ and the planes $x = 0,\ y = 0,\ y = 2$ and $z = 0$. 5

(d) Solve : $\cos^2 x \frac{dy}{dx} + y = \tan x$ 5

(e) Solve $(D^2 - 6D + 9) = 6e^{3x} + 7e^{-2x} - \log^2$ 5

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

(a) What do you mean by non-inertial frames ? Give an example of such frame.

(b) A particle moves in a field of force given by $F_x = yz(1-2xyz)$ and $F_z = xy(1-2xyz)$. Verify that the force is conservative.

(c) The trajectory of a particle of unit mass is given by the radius vector, $\vec{r} = \hat{i}\alpha \cos \omega t + \hat{j} b \sin \omega t$, where a, b are constants. Calculate angular momentum of the particle about the origin. Show that it is constant and along $\hat{k}$.

(d) Show that the rocket speed is twice the exhaust speed when $\frac{M_0}{M} = e^2$

(e) Explain why a hollow cylinder is stronger than a solid cylinder of the same length, mass and material.

(f) Calculate the Poisson's ratio for silver. Given Young's modulus for the silver is 7.25×10^{10} N/m^2 and bulk modulus is 11×10^{10} N/m^2.

(g) State Kepler's laws of planetary motion.

2. Answer any *three* questions : 5×3=15

(a) Prove that the kinetic energy of rotation of a rigid body can be expressed in the form $T = \frac{1}{2} I_{ij} \omega_i \omega_j$ with the convention that repeated indices are summed over x, y, z and show that relative to any point in the rigid body it can be simplified to the form $T = \frac{1}{2}\left(I_1\omega_1^2 + I_2\omega_2^2 + I_3\omega_3^2\right)$. 4+1=5

(b) Derive an expression for the equation of continuity of an ideal fluid of density ρ.What is the form of this equation, when the fluid is incompressible ? 4+1=5

(c) (i) If a body falls freely in the earth's gravitational field form infinity, show that it attains the same velocity as that attained by a free fall from a height above the earth equal to the radius R under a constant acceleration of gravity 'g'.

(ii) The differential equation of the orbit of a particle of mass m under a central force is given by $\frac{d^2u}{d\theta^2} + u = -\frac{m}{L^2u^2} f\left(\frac{1}{u}\right)$ where $u = \frac{1}{r}$, $L =$ constant, other notations have usual significance. Use the above relation and consider the following : A particle moves in a central orbit described by $r = e^{(-\alpha\theta)}, \alpha$ is a positive constant, with force centre at O. Find the nature of the force as a function of r. 3+2=5

(d) With necessary assumptions, deduce Poiseuille's formula for the viscous flow of a liquid in a capillary tube. 5

(e) Find the depression of a cantilever beam of uniform cross-section and weight W, when loaded at the free end by a weight W_0. 5