UG 1st Semester Examination 2021

PHYSICS (HONOURS)

Paper : DC- 2 [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.

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

   (a) If a force $\vec{F}$ satisfies the relation $\vec{\nabla} \times \vec{F} = 0$, then show that the force field is conservative.

   (b) A circular disc of mass M and radius r is set rolling on a horizontal table. If ω be the angular velocity of the disc, show that its total energy is $\frac{3}{4}Mr^2\omega^2$.

   (c) Consider a rocket moving vertically upward against uniform gravity $\vec{g}$, that ejects gas with a constant velocity $\vec{v}$ with respect to itself. Obtain the equation of motion of the rocket.

   (d) By using Euler's equations, show that the rotational kinetic energy of a rigid body is conserved when the applied torque is zero.

   (e) Derive gravitational field intensity due to a point mass M at a distance r from it, using Gauss's theorem of Gravitation.

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

   (g) What is Reynold's number? How is it used to determine whether the nature of flow of a liquid is streamline or turbulent?

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

(a) Prove that the total energy of a particle of mass m moving under a central force is given by

$$E = \frac{h^2}{2m}\left[u^2 + \left(\frac{du}{d\theta}\right)^2\right] + V(r)$$

where $u = \frac{1}{r}$, h = angular momentum of the particle and $V(r)$ is the potential energy at r.

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(b) (i) The density of a sphere varies as the depth below the surface. Show that the gravitational attraction is greatest at a depth equal to $1/3$ of the radius.

(ii) What do you understand by gravitational self-energy of a homogeneous sphere?

3+2=5

(c) (i) A reference frame is rotating with an angular velocity $\vec{\omega}$ with respect to the laboratory frame. Establish the transformation relation $\frac{d}{dt} = \frac{d'}{dt} + \vec{\omega}\times$. How does a vector transform in such cases, if it is parallel to the axis of rotation?

(ii) Calculate the principal moments of inertia of a homogeneous cube of mass M and side a.

1+1+3=5

(d) (i) Establish that shear is equivalent to elongation and contraction at right angles to each other.
(ii) A metal rod of length L and cross-section α suffers a small longitudinal strain and is stretched by l in length. Show that the potential energy stored in the rod due to this strain is $(Y\alpha l^2)/2L$ if the Young's modulus of the material is Y. 3+2=5

(e) (i) Write down the equation of continuity in case of fluid motion.

(ii) A capillary tube of radius a and length l is fitted horizontally at the bottom of a cylindrical flask of cross-section A. Initially, there is water in the flask up to a height h_1. Show that the time $T = (8\eta lA/\pi\rho g a^4)\ln\frac{h_1}{h_2}$ is required for the height to be reduced from h_1 to h_2. Here η is the coefficient of viscosity of water. 1+4=5

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