Ref. No.: EX/I/SO1/7/2017

B. Sc. Examinations 2017

(1st year, 1st Semester)

Physics (Subsidiary)

Paper- SO1

Time: 2 hours — Full Marks: 50

Answer any four questions

1. (a) A solid cylinder of length l and radius a twisted through a certain angle. The lower end is clamped and a torque is applied at the upper end. Find out an expression for the torsional rigidity. (b) Two cylindrical shafts have the same length and mass and are made of the same material. One is solid, while the other, which is hollow, has an external radius twice the internal radius. Compare their torsional rigidities. 7+5.5

2. (a) How do you use Kepler's laws of planetary motion for the determination of the mass of sun? (b) What is the gravitational potential? (c) Consider two concentric spherical shells of uniform density of mass M_1 and M_2. Find the force of the particle of mass m when (i) the particle is located at r = a, outside both shells and (ii) the particle is located at the centre, r = 0. The distance r is measured from the centre of the shell. 4+2+6.5

3. (a) If a vector $\vec{V} = (x + 2y + az)\hat{\imath} + (bx - 3y - z)\hat{\jmath} + (4x + cy + 2z)\hat{k}$ is irrotational then find the values of constants a, b and c. (b) If a particle moves under the influence of a force field $\vec{F} = f(r)\hat{r}$ then prove that (i) its path must be a plane curve and (ii) its angular momentum is conserved. (c) If $\vec{B} = x^2\hat{\imath} + yz\hat{\jmath} - xy\hat{k}$ then find $\vec{\nabla}.\vec{B}$ and $\vec{B}.\vec{\nabla}$. 3.5 + (2.5+ 2.5) + (2 + 2)

4. (a) Show that the sum of the moments of inertia of a three dimensional body about any three perpendicular axes passing through a point is equal to twice the moment of inertia of the body about the same point. (b) Calculate the moment of inertia about a diagonal of a plane square lamina. (c) Find the ratio of the translational to the rotational kinetic energy of a solid sphere rolling down in an inclined plane without slip. (d) If $\vec{V} = \vec{\omega} \times \vec{r}$ prove $\vec{\omega} = \frac{1}{2}\vec{\nabla} \times \vec{V}$ where $\vec{\omega}$ is a constant vector. 2.5 + 3 + 4 + 3

5. (a) What do mean by streamline motion and turbulent motion? What is the Reynold's number? (b) Deduce the velocity profile for the streamline flow of a liquid through a capillary tube of circular cross section using Poiseulle's method. (c) State Stoke's law of viscosity. 3+7.5+2

6. (a) What do you mean by surface tension and surface energy? Discuss the molecular theory of surface tension. What is angle of contact? Deduce the Jurin's law for surface tension.(b) Pressure of air in a soap bubble of 0.7cm diameter is 8mm of water above at the atmospheric pressure. Calculate the surface tension of soap solution. T= 68.60dynes/cm. 4+5+3.5

7. Let (r, θ) represent the polar co-ordinate describing the position of a particle. If $\hat{r}$ and $\hat{\theta}$ are the unit vectors in the direction of the position vector $\vec{r}$ and in the direction of increasing θ respectively then show the following

i. $\hat{r} = \cos\theta\hat{\imath} + \sin\theta\hat{\jmath}$, $\quad \ddot{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$

ii. $\dot{\hat{r}} = \dot{\theta}\hat{\theta}$, $\quad \dot{\hat{\theta}} = -\dot{\theta}\hat{r}$

iii. $\vec{v} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta}$ and

iv. $\vec{a} = (\ddot{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$

where $\vec{v}$ and $\vec{a}$ are the velocity and acceleration of the particle respectively. (b) If $\vec{A}$ has constant magnitude then show that $\vec{A}$ and $\frac{d\vec{A}}{dt}$ are normal to each other provided $\frac{d\vec{A}}{dt} \neq 0$. (3 +3 + 2 +3) + 1.5