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1 SEM TDC PHY M 1

2017

(November)

PHYSICS

(Major)

Course : 101

(Mechanics and Properties of Matter)

Full Marks : 80

Pass Marks : 32/24

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option from the following : 1×8=8

(a) Newton's law of motion is represented by a differential equation which is

(i) first order

(ii) second order

(iii) second degree

(iv) second order second degree

(b) The Lagrangian of a system is written as $L = T - V = \frac{1}{2}m(\dot{r}^2 + r^2\dot{\theta}^2) - V(r)$. Which of the following quantities is conserved?

(i) $mr\dot{\theta}^2$

(ii) $mr\dot{\theta}$

(iii) $mr^2\dot{\theta}$

(iv) $mr^2\dot{\theta}^2$

(c) For the special case of inverse square law forces, the virial theorem takes the form

(i) $\overline{T} = -\frac{1}{2}\overline{V}$

(ii) $\overline{T} = -\frac{1}{4}\overline{V}$

(iii) $\overline{T} = -\overline{V}$

(iv) $\overline{T} = \overline{V}$

(d) For a spherical shell, the gravitational potential at a point inside the shell is (R = radius of the shell, r = distance of the point from the centre of the shell)

(i) $-\frac{MG}{R^2}$

(ii) $-\frac{MG}{R}$

(iii) $-\frac{MG}{R^2} \cdot r$

(iv) None of the above

(Continued)

(e) The value of the radius of gyration of a body about the axis of rotation depends on

(i) the position of the axis of rotation

(ii) the direction of the axis of rotation

(iii) the distribution of the mass of the body about the axis

(iv) All of the above

(f) The relationship between the elastic constants is

(i) $\frac{9}{\eta} = \frac{3}{Y} + \frac{1}{K}$

(ii) $\frac{Y}{9} = \frac{\eta}{3} + \frac{1}{K}$

(iii) $\frac{9}{Y} = \frac{3}{\eta} + \frac{1}{K}$

(iv) $\frac{3}{Y} = \frac{1}{\eta} + \frac{9}{K}$

(g) The constraint of rigidity is

(i) conservative

(ii) scleronomic

(iii) holonomic

(iv) All of the above

(Turn Over)

(h) Which of the following is a fictitious force?

(i) Coriolis force

(ii) Centrifugal force

(iii) Both (i) and (ii)

(iv) None of the above

2. (a) What is reduced mass of a two-body system? 2

(b) Prove that in absence of external torque, the angular momentum of a system of particles is conserved under the strong law of action and reaction. 2

(c) Show that the field $\vec{F}_1 = -2x\hat{i} - 2y\hat{j} - 2z\hat{k}$ is conservative but the field $\vec{F}_2 = y\hat{i} - x\hat{j}$ is not. 3

(d) Show that excess pressure inside a liquid drop is $p = \frac{2T}{r}$, where symbols have their usual meaning. 3

(e) What are generalized coordinates? 2

(f) Define virtual work. What is d'Alembert's principle? 1+1=2

(Continued)

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(g) Prove that in absence of any non-potential forces, the generalized momentum corresponding to any cyclic coordinate is a conserved quantity. 2

3. (a) Prove that the gravitational force exerted by a symmetric of mass M on a particle external to itself is exactly the same as if the share were replaced by a particle of mass M located at the centre. 5

(b) In an elastic collision between two particles of mass m_1 and m_2 moving with velocities $\vec{v}_1$ and $\vec{v}_2$ respectively, prove that the opening angle between the paths of the emerging particles is given by

$$\cos\theta = \frac{(m_1 - m_2)v_2}{2m_1v_1}$$ 4

(c) Show that the law of conservation of momentum is invariant to Galilean transformation. 5

(d) Reduce the two-body central force problem to the equivalent one-body problem. 5

(Turn Over)

(e) Show that the kinetic energy for a system of particles consists of two parts : (i) the kinetic energy obtained if all the mass were concentrated at the centre of mass, (ii) the kinetic energy of motion about the centre of mass. 5

4. (a) What is Kepler's second law of planetary motion? Show that angular momentum conservation is equivalent to Kepler's second law. 1+3=4

(b) Show that the moment of inertia of a circular lamina about a tangent in its own plane is given by $I = \frac{5MR^2}{4}$. 5

(c) Show that a shear is equivalent to a compression and an extension at right angles to each other. 5

(d) Derive the Jurin's equation for rise of a liquid in a capillary tube. 4

Or

The pressure of air in a soap bubble of 0·7 cm diameter is 8 mm of water above the atmospheric pressure. Calculate the surface tension of the soap solution. 4

(Continued)

5. (a) Using the d'Alembert's principle, obtain the Euler-Lagrange equation of motion. 5

(b) How does the earth's rotation affect the small oscillations of an ordinary pendulum? 5

(c) Obtain the Lagrangian for a charged particle subject to an electromagnetic field. 4

Or

A bead is sliding on a uniformly rotating wire in a force-free space. Write down the Lagrangian for this bead and hence obtain the equation of motion of the bead. 4

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