1 SEM TDC PHY M 1

2015

(November)

PHYSICS

(Major)

Course : 101

(Mechanics and Properties of Matter)

Full Marks : 80

Pass Marks : 32 (Backlog)/24 (2014 onwards)

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) Suppose that a reference frame fixed to the earth is exactly inertial. Which of the following is then an inertial frame?

A frame fixed to a motorcar which is

(i) moving with a constant speed around a flat race track

(ii) moving with a constant speed along a straight undulating road

(iii) moving with a constant speed up a constant gradient

(iv) freewheeling down a hill

(b) Two particles P_1 and P_2 with masses m_1 and m_2 can move freely under their mutual gravitation. Initially both particles are at rest and separated by a distance r. With what speed must P_1 be projected so as to escape from P_2?

(i) $v^2 \geq \frac{2(m_1 + m_2)G}{r}$

(ii) $v^2 \leq \frac{2(m_1 + m_2)G}{r}$

(iii) $v^2 \geq \frac{2Gm_1}{(m_1 + m_2)r}$

(iv) $v^2 \geq \frac{2Gm_2}{(m_1 + m_2)r}$

(c) The point of closest approach, in the case of orbits around the sun, is called

(i) aphelion

(ii) perihelion

(iii) perigee

(iv) apogee

(d) If a central force does not depend on time explicitly, then it is

(i) a dissipative force

(ii) a conservative force

(iii) a non-conservative force

(iv) None of the above

(e) The excess pressure inside a soap bubble is

(i) $T\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$

(ii) $\frac{2T}{r}$

(iii) $2T\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$

(iv) $\frac{4T}{r}$

(f) The relation between the three elastic moduli is given by

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

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

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

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

(g) Constraint relations which are or can be made independent of velocities are known as

(i) scleronomic

(ii) rheonomic

(iii) holonomic

(iv) non-holonomic

(h) The kinetic energy of any holonomic mechanical system has the form

(i) $T = \sum_{j=1}^{n} \sum_{k=1}^{n} a_{jk}(q) \dot{q}_j \dot{q}_k$

(ii) $T = \sum_{j=1}^{n} \sum_{k=1}^{n} a_{jk}(\dot{q}) \dot{q}_j \dot{q}_k$

(iii) $T = \sum_{j=1}^{n} \sum_{k=1}^{n} a_{jk}(q) q_j \ddot{q}_k$

(iv) All of the above

2. (a) What are the fictitious forces that may arise in a rotating frame? Why are they called fictitious? 1+1=2

(b) Show that the law of conservation of linear momentum is invariant under Galilean transformation.

(c) Show that only radial dependence and no angular dependence in a force F implies that the total angular momentum of the system about the origin is conserved. 2

(d) A cat leaps off a table and lands on the floor. Show that, while the cat is in the air, its centre of mass moves on a parabolic path. 2

(e) Express the torque on a body in terms of its moment of inertia. 2

(f) What is the origin of elastic properties of solids? 2

(g) What are the generalized coordinates? Define degrees of freedom of a system. 1+1=2

(h) Obtain an expression for the horizontal acceleration of an incline required to prevent the sliding of a block placed on the incline using the principle of virtual work. 2

3. (a) Show that purely internal forces, if they obey Newton's third law of motion, have no effect on the motion of the centre of mass. 4

(b) Show that falling objects on the earth are deflected in the horizontal direction. Obtain an expression for the deflection. 6

(c) Derive an expression for reduced mass of a two-body system. What is the kinetic energy of an equivalent one-body system? 2+2=4

(d) What are weak and strong laws of action and reaction? Discuss the motion of a system of particles in terms of the motion of the centre of mass. 2+3=5

Or

Demonstrate the effect of the earth's rotation on a simple pendulum. 5

4. (a) In an experiment, particles of mass m and energy E are used to bombard stationary target particles of mass $2m$. The expreimenters wish to select particles, that, after scattering, have energies $E/3$. At what scattering angle will they find such particles? In one collision, the scattering angle was measured to be 45°, what was the recoil angle? 2+2=4

Or

Obtain an expression for the gravitational potential at a point inside a spherical shell. 4

(b) Show that the height of a liquid rising in a capillary tube is inversely proportional to the radius of the capillary tube. 5

(c) What is the moment of inertia of a solid sphere about a tangent? 5

(d) Obtain an expression for the strain energy in a twisted cylinder. 4

5. (a) What are generalized momenta of a holonomic mechanical system? Consider a system whose Lagrangian is given by

$$L = \frac{1}{2} M(\dot{x})^2 + \frac{1}{2} m(\dot{x}^2 + \dot{y}^2 + 2\dot{x}\dot{y}\cos\alpha) + mgy\sin\alpha$$

Calculate the acceleration of the system. 2+4=6

(b) Using Lagrange's approach, obtain an expression for the frequency of oscillation for a particle executing simple harmonic motion. 4

(c) Show that d'Alembert's principle may be used to derive the Lagrange's equations of motion when the forces are derivable from a scalar potential function. 6

(d) Show that homogeneity of space leads to the conservation of linear momentum. (Use Lagrange's formulation of mechanics.) 3

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