Code : 101101

B.Tech 1st Semester Exam., 2019
(New Course)

PHYSICS (MECHANICS)

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Choose the correct answer of the following (any *seven*) : 2×7=14

(a) The Newton's second law of motion gives a relation among force, mass and

(i) velocity

(ii) acceleration

(iii) inertia

(iv) momentum

(b) The system returns to equilibrium ____ is known as critical damped.

(i) with oscillating

(ii) without oscillating

(iii) Both *(i)* and *(ii)*

(iv) None of the above

(c) A point B on a rigid link AB moves with respect to A with angular velocity ω rad/s. The radial component of the acceleration of B with respect to A is

(i) $VBA \times AB$

(ii) $V^2BA \times AB$

(iii) VBA / AB

(iv) V^2BA / AB

(d) The Coriolis component of acceleration is taken into account for

(i) slider crank mechanism

(ii) four-bar chain mechanism

(iii) quick return motion mechanism

(iv) None of the above

(e) Earth is spinning about its axis which generates inertial forces known as

(i) centrifugal force

(ii) Coriolis force

(iii) Both (i) and (ii)

(iv) None of the above

(f) A rotating merry-go-round speed is the example of

(i) inertial reference frame

(ii) non-inertial reference frame

(iii) Both (i) and (ii)

(iv) None of the above

(g) The linear acceleration of a rotating body is given by the relation

(i) $a = r \cdot \alpha$

(ii) $a = r / \alpha$

(iii) $a = \alpha / r$

(iv) $a = \alpha^2 / r$

where r = radius of the circular path and α = angular acceleration of the body in radian/s^2

(h) The work done by a conservative force

(i) depends on path

(ii) is independent of the path

(iii) Both (i) and (ii)

(iv) None of the above

(i) The specific energy of a hyperbolic trajectory orbit is

(i) positive

(ii) negative

(iii) zero

(iv) None of the above

(j) Coriolis acceleration (a_c) is

(i) $V\omega$

(ii) $2\,V\omega$

(iii) $0 \cdot 5\,V\omega$

(iv) $3\,V\omega$

2. *(a)* State triangle law of forces and Lami's theorem. 4

(b) If a vector of magnitude A is rotated through certain degree, then what is the change in that vector? Explain. 3

(c) A projectile is launched from point O with an initial speed $v_0 = 500$ m/s directed as shown in Fig. 1 :

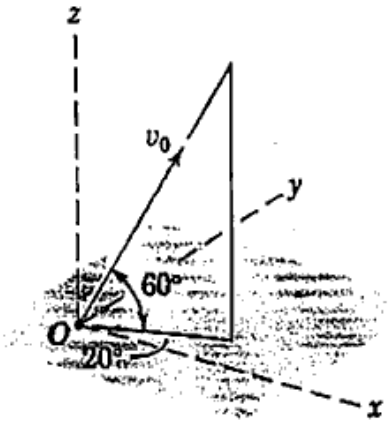

Fig. 1

Compute the x-, y- and z-components of position, velocity and acceleration 20 seconds after launch. Neglect aerodynamic drag. 7

3. *(a)* A tracking radar (Fig. 2) lies in the vertical plane of the path of a rocket which is coasting in unpowered flight above the atmosphere :

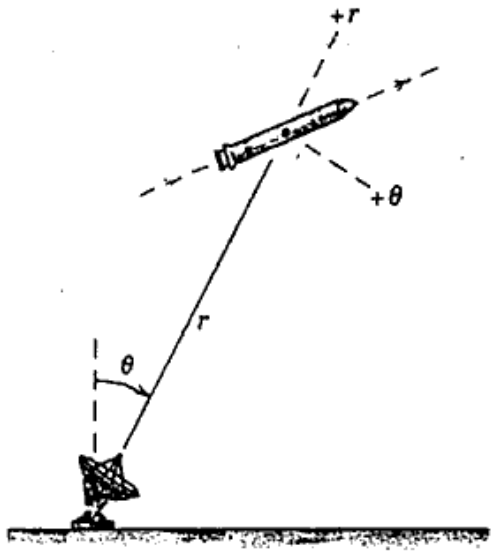

Fig. 2

For the instant when $\theta = 30°$, the tracking data give $r = 8 \times 10^4$ m, $\dot{r} = 1200$ m/s and $\dot{\theta} = 0{\cdot}80$ deg/s. The acceleration of the rocket is only due to gravitational attraction and its particular altitude is $9{\cdot}6$ m/s^2 vertically down. For these conditions, determine the velocity v of the rocket and the values of $\ddot{r}$ and $\ddot{\theta}$. 9

(b) Explain the conservative and non-conservative forces with examples. 5

4. (a) A flywheel of mass 8 tonnes starts from rest and gets up a speed of 180 r.p.m. in 3 minutes. Find the average torque exerted on it, if the radius of gyration of the flywheel is 60 cm. 7

(b) For the elliptical orbit of a spacecraft around the earth (Fig. 3), determine the speed v_A at point A which results in a perigee altitude at B of 200 km :

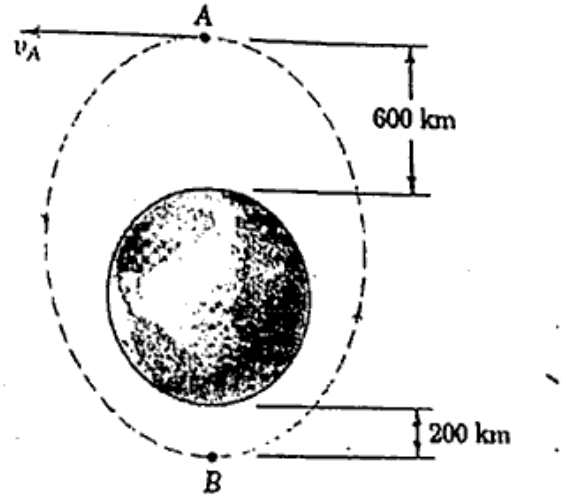

Fig. 3

What is the eccentricity e of the orbit? 7

5. (a) How does Foucault pendulum explain Earth's rotation? 3

(b) Describe the centripetal and Coriolis accelerations. 4

(c) At the instant represented in Fig. 4, the disk with the radial slot is rotating about O with a counterclockwise angular velocity of 4 rad/s which is decreasing at the rate of 10 rad/s^2. The motion of slider A is separately controlled, and at this instant, $r = 150$ mm, $\dot{r} = 125$ mm/s, and $\ddot{r} = 2025$ mm/s^2 :

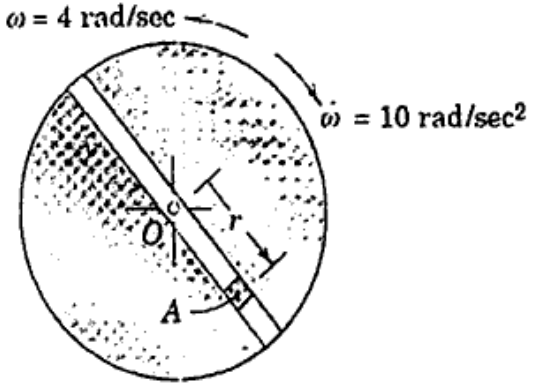

Fig. 4

Determine the absolute velocity and acceleration of A for this position. 7

6. *(a)* A body, moving with simple harmonic motion, has amplitude of 1 metre and the period of complete oscillation is 2 seconds. What will be the velocity and acceleration of the body after 0·4 second from the extreme position? 6

(b) Determine the amplitude X of the steady-state motion of the 10 kg mass (Fig. 5), if *(i)* $c = 500$ N.s/m and *(ii)* $c = 0$: 8

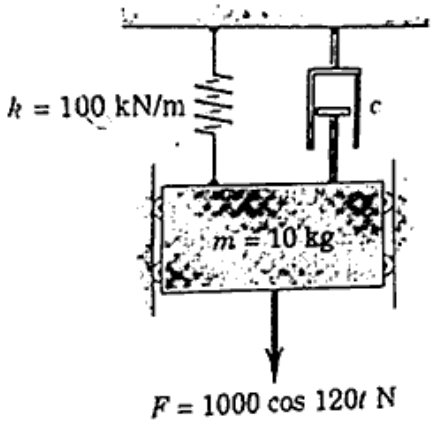

Fig. 5

7. *(a)* Show that if the total linear momentum of a system of particles is zero, the angular momentum of the system is the same around all origins. 5

(b) A particle with a mass of 4 kg has a position vector in metre given by $r = 3t^2\hat{i} - 2t\hat{j} - 3t\hat{k}$, where t is the time in

seconds. For $t = 3$ seconds, determine the magnitude of the angular momentum of the particle and the magnitude of the moment of all forces on the particle, both about the origin of coordinates. 9

8. *(a)* A mouse sits at the edge of a 40 cm diameter record, rotating on a turntable at 15 revolutions per minute. If the mouse walks straight inwards to a point 10 cm from the centre, what will be its new angular velocity? Assume the mass of the record is negligible. 7

(b) In a crank and connecting rod mechanism, the crank is 300 mm long and the connecting rod is 1500 mm long. If the crank rotates uniformly at 300 r.p.m., find the velocity of the cross head, when the crank is inclined at 30° with the inner dead centre. 7

9. *(a)* The slender rod of mass m and length l rotates about the y-axis as the element of a right-circular cone. If the angular velocity about the y-axis is ω, determine the expression for the angular momentum of the rod with respect to

the x-y-z axes for the particular position shown in Fig. 6 : 7

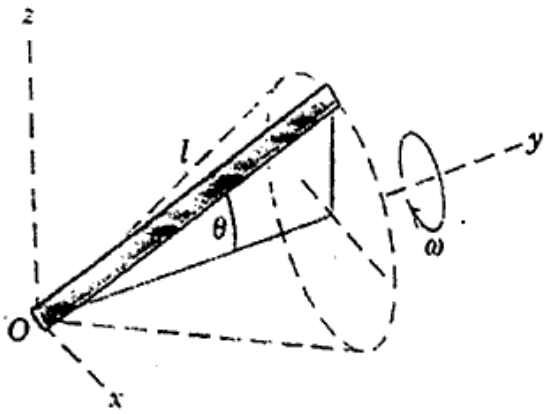

Fig. 6

(b) A slender rod bent into the shape shown in Fig. 7, rotates about the fixed line CD at a constant angular rate ω. Determine the velocity and acceleration of point A : 7

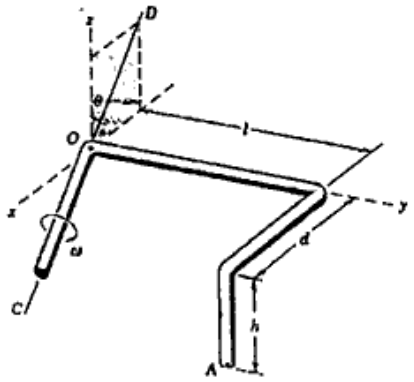

Fig. 7

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