A.R COACHING CENTRE

UG-TRB, PG-TRB, POLY-TRB, ENGG-TRB, TNSET COACHING FOR PHYSICS
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PG TRB - 2019

Subject Name: **Unit-III: Classical Mechanics - Slip Test-2** **Time**: 30 Minutes
Date: 22.06.2019 **Maximum Marks**: 25

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1. A heavy symmetrical top is rotating about its own axis of symmetry (the $z-$ axis). If I_1, I_2 and I_3 are the principle moment of inertia along x, y and$z$ axes respectively, then

   a. $I_2 = I_3$; $I_1 \neq I_2$
   b. $I_1 = I_3$; $I_1 \neq I_2$
   c. $I_1 = I_2$; $I_1 \neq I_3$
   d. $I_1 \neq I_2 \neq I_3$

2. Two bodies of masses m and $3m$ are connected by a spring of spring $'k'$. The frequency of the normal mode is

   a. $\sqrt{\frac{3k}{4m}}$
   b. $\sqrt{\frac{m}{k}}$
   c. $\sqrt{\frac{k}{4m}}$
   d. $\sqrt{\frac{4k}{3m}}$

3. Three masses are connected by two springs as shown. A longitudinal normal mode with frequency $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ is exhibited by, fig.

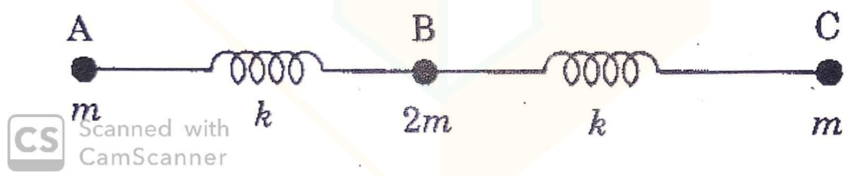

Figure 1: **Spring connected**

   a) A and C moving in same direction, with B being stationary.
   b) A and C moving in same direction with equal amplitudes and B moving in opposite direction with half the amplitude A .
   c) A and C moving in opposite direction with equal amplitudes and B being at rest.
   d) A, B, and C all moving in same direction with equal amplitudes.

4. The system is said to be in equilibrium, if the generalised forces acting on the system are equal to zero, then

   a. The potential energy has an extremum.
   b. The potential energy has minimum.
   c. The kinetic energy has extremum.
   d. None of these.

5. A particle of mass $'m'$ is attached to a thin uniform rod of length $'a'$ and mass $4m$. The distance of the particle from the centre of mass of the rod is $\frac{a}{4}$. The moment of inertia of the combination about an axis passing through $'O'$ normal to the rod is

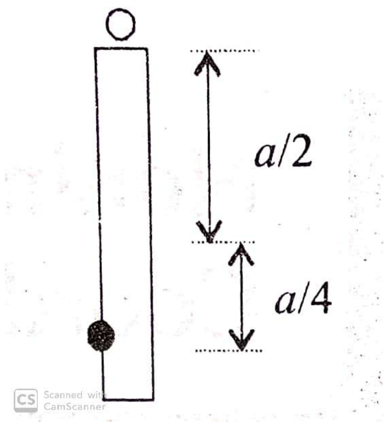

Figure 2: **Rod**

a. $\frac{64}{48}\, ma^2$

b. $\frac{91}{48}\, ma^2$

c. $\frac{27}{48}\, ma^2$

d. $\frac{51}{48}\, ma^2$

6. Choose the principle axes and their associated moment of inertia tensor for cube of mass M and side a

a. $I = \begin{bmatrix} \frac{2}{3} Ma^2 & -\frac{1}{4} Ma^2 & -\frac{1}{4} Ma^2 \\ -\frac{1}{4} Ma^2 & \frac{2}{3} Ma^2 & -\frac{1}{4} Ma^2 \\ -\frac{1}{4} Ma^2 & -\frac{1}{4} Ma^2 & \frac{2}{3} Ma^2 \end{bmatrix}$

b. $I = \begin{bmatrix} \frac{3}{2} Ma^2 & -\frac{1}{4} Ma^2 & -\frac{1}{4} Ma^2 \\ -\frac{1}{4} Ma^2 & \frac{3}{2} Ma^2 & -\frac{1}{4} Ma^2 \\ -\frac{1}{4} Ma^2 & -\frac{1}{4} Ma^2 & \frac{3}{2} Ma^2 \end{bmatrix}$

c. $I = \begin{bmatrix} \frac{1}{6} Ma^2 & -\frac{11}{12} Ma^2 & -\frac{11}{12} Ma^2 \\ -\frac{11}{12} Ma^2 & \frac{1}{6} Ma^2 & -\frac{11}{12} Ma^2 \\ -\frac{11}{12} Ma^2 & -\frac{11}{12} Ma^2 & \frac{1}{6} Ma^2 \end{bmatrix}$

d. $I = \begin{bmatrix} \frac{11}{12} Ma^2 & -\frac{1}{6} Ma^2 & -\frac{1}{6} Ma^2 \\ -\frac{1}{6} Ma^2 & \frac{11}{12} Ma^2 & -\frac{1}{6} Ma^2 \\ -\frac{1}{6} Ma^2 & -\frac{1}{6} Ma^2 & \frac{11}{12} Ma^2 \end{bmatrix}$

7. Which one of the following statement is wrong in motion of a heavy symmetrical top.
   a) The frequency of nutation for fast top is more for faster spinning top.
   b) The average precession frequency decreases as the top is spun fast initially.
   c) $\dot{\psi}$, $\dot{\phi}$ and t are cyclic co-ordinate.
   d) The wobble condition is $\omega_{min} > \omega_z^{'}$.

8. In case of double pendulum, if the masses as well as thread are equal ($m_1 = m_2 = m, \quad l_1 = l_2 = l$).
   a) Two normal mode frequencies are equal to that of a pendulum of length $2l$ and mass m.
   b) Two normal mode frequencies are equal to that of a pendulum of length l and mass m.
   c) Two normal mode frequencies are same.
   d) The sum of squared frequencies of normal modes is equal to four times the squared frequency of a single pendulum of length l and mass m.

9. Find out the nature of statement given below,
   1. The two mode of oscillation involving a single frequency are called normal mode of vibration of the system.
   2. When the kinetic energy and potential energies are expressed in terms of normal coordinated, no cross terms of normal coordinates are present, (i.e) both T and V are homogenous quadratic equation.
   3. An example of stable equilibrium is a hanging spring-mass system in the stationary position.

   a. All the three statement are correct
   b. Statement 1 is correct, 2 and 3 are wrong
   c. Statement 1 and 2 are correct, 3 is wrong
   d. All the three statement are wrong

10. If a force is applied on the equilibrium body then the potential energy of the body is increase. this system is
    a. stable
    b. unstable
    c. balanced
    d. configuration

11. Which one is wrong
    a. $T = \frac{1}{2}\ \vec{\omega} L^2$
    b. $T = \frac{1}{2}\ I\omega^2$
    c. $I = \ mr^2$
    d. $L = m_i\ [\omega r_i^2 - r_i\ (r_i \cdot \omega)]$

12. Which one is wrong
    a) In principle axis all product of inertia vanishes.
    b) The principle moment of inertia cannot be negative.
    c) A scalar of is a tensor of two rank.
    d) The product of inertia coefficient is six.

13. Match the following

    (X) Space $z-$ axis – (1) Nutation angle (θ)

    (Y) Line of nodes – (2) Nutation angle (θ)

    (Z) Body $z'-$ axis – (3) Body angle (ψ)

    (A) New x_1- axis – (4) Precession angle (ϕ)

    a) (X) - 2, (Y) - 1, (Z) - 3, (A) - 4
    b) (X) - 4, (Y) - 1, (Z) - 3, (A) - 2
    c) (X) - 4, (Y) - 3, (Z) - 1, (A) - 2
    d) (X) - 3, (Y) - 4, (Z) - 2, (A) - 1

14. If I_1, I_2 and I_3 represent the principle moments of inertia of a rigid body and $\omega = (\omega_1, \omega_2, \omega_3)$ is the angular velocity with components along the three principle axis.

   a) The $z-$ component of the torque acting on the body in general is $\tau_3 = I_3\ \dot{\omega}_3$.
   b) The $z-$ component of the torque acting on the body in general is $\tau_3 = I_3\dot{\omega}_3 + (I_2 - I_1)\ \omega_1\omega_2$.
   c) For torque free motion of the rigid body, always we have $I_3\omega_3 =$ constant.
   d) for torque free motion of the rigid body in general we have, $I_3\dot{\omega}_3 = (I_2 - I_1)\ \omega_1\omega_2$.

15. Moment of inertia tensor of uniform hemisphere about its of symmetry and about an axis lying in the base perpendicular to the symmetry axis

   a. $I_{xx} = \frac{5}{2}\ MR^2\ \ ;\ \ I_{yy} = \frac{2}{5}\ MR^2$
   b. $I_{xx} = \frac{2}{5}\ MR^2\ \ ;\ \ I_{yy} = \frac{5}{2}\ MR^2$
   c. $I_{xx} = I_{yy} = \frac{2}{5}\ MR^2$
   d. $I_{xx} = I_{yy} = \frac{5}{2}\ MR^2$

16. Which one is not moment of inertia

   a. I_{xx}
   b. I_{yy}
   c. I_{yx}
   d. I_{zz}

17. The modified Hamilton's principle is given by

   a. $\delta \sum_j \int_{t_1}^{t_2} p_j\ dq_j - \delta \int_{t_1}^{t_2} H\ dt = 0$
   b. $\delta \sum_j \int_{t_1}^{t_2} p_j\ dq_j + \delta \int_{t_1}^{t_2} H\ dt = 0$
   c. $\delta \sum_j \int_{t_1}^{t_2} p_j\ dq_j - \delta \int_{t_1}^{t_2} H\ dq_j = 0$
   d. $\delta \sum_j \int_{t_1}^{t_2} p_j\ dq_j + \delta \int_{t_1}^{t_2} H\ dq_j = 0$

18. According to principle of least action

   a. $\Delta \int \left(\sum_k p_k\dot{q}_k - H\right)\ dt = 0$
   b. $\Delta \int \left(\sum_k \dot{p}_k q_k - H\right)\ dt = 0$
   c. $\Delta \int (H + L)\ dt = 0$
   d. $\int \sum_k p_k\dot{q}_k\ dt = 0$

19. Consider a homogeneous cube of density ρ, mass $'M'$ and side $'a'$. For origin $'O'$ at one corner and axes along the edges of the cube. Then the inertia tensor is

   a. $I = \frac{Ma^2}{12}\begin{bmatrix} 8 & -3 & -3 \\ -3 & 8 & 3 \\ -3 & 3 & 8 \end{bmatrix}$
   b. $I = \frac{Ma^2}{6}\begin{bmatrix} 8 & -3 & -3 \\ -3 & 8 & -3 \\ -3 & -3 & 8 \end{bmatrix}$
   c. $I = \frac{Ma^2}{12}\begin{bmatrix} 8 & -3 & -3 \\ -3 & 8 & -3 \\ -3 & -3 & 8 \end{bmatrix}$
   d. $I = \frac{Ma^2}{6}\begin{bmatrix} 8 & -3 & -3 \\ -3 & 8 & -3 \\ -3 & 3 & 8 \end{bmatrix}$

20. The most general displacement of rigid body is

   a. translational
   b. rotational
   c. translational and rotational
   d. translational an vibrational

21. Choose the kinetic energy of rotation of a rigid body with respect to principle axes in terms of Euler's angles and interpret the results when $I_1 = I_2$.

a) $T = \frac{1}{2}\, I_1 \left[\dot{\phi}^2 \sin^2\theta + \dot{\theta}^2\right] + \frac{1}{2}\, I_3 \left[\dot{\phi} \cos\theta + \dot{\psi}\right]^2$

b) $T = \frac{1}{2}\, I_1 \left[\dot{\theta}^2 \sin^2\theta + \dot{\psi}^2\right] + \frac{1}{2}\, I_3 \left[\dot{\phi}^2 \cos\theta + \dot{\theta}^2\right]^2$

c) $T = \frac{1}{2}\, I_1 \left[\dot{\theta}^2 \sin^2\theta + \dot{\psi}^2\right] - \frac{1}{2}\, I_3 \left[\dot{\phi}^2 \cos\theta + \dot{\theta}^2\right]^2$

d) $T = \frac{1}{2}\, I_1 \left[\dot{\theta}^2 \cos^2\theta + \dot{\psi}^2\right] + \frac{1}{2}\, I_3 \left[\dot{\phi}^2 \sin^2\theta + \dot{\theta}^2\right]^2$

22. Moment of inertia of a disc of radius R and mass M rotating about an axis is shown in fig.

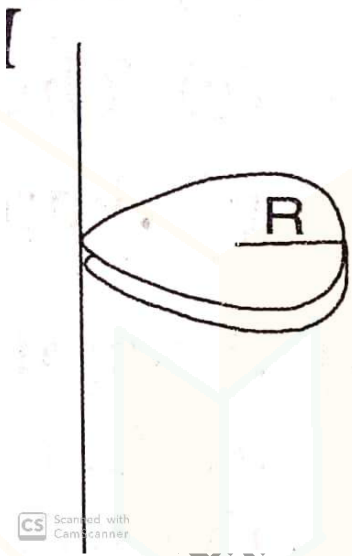

Figure 3: **Disc rotation**

a. $\frac{1}{2}\, MR^2$

b. MR^2

c. $\frac{3}{2}\, MR^2$

d. $2\, MR^2$

23. Potential energy of the linear triatomic molecule is

a. $V = \frac{1}{2}\, m\, (\dot{q}_1^2 + \dot{q}_3^2) + \frac{1}{2}\, M\dot{q}_2^2$

b. $V = \frac{1}{2}\, m\, (\dot{q}_1^2 + \dot{q}_3^2) - \frac{1}{2}\, M\dot{q}_2^2$

c. $V = \frac{1}{2}\, k\, (q_2 + q_1)^2 + \frac{1}{2}\, k\, (q_3 + q_2)^2$

d. $V = \frac{1}{2}\, k\, (q_2 - q_1)^2 + \frac{1}{2}\, k\, (q_3 - q_2)^2$

24. Choose the correct statement

a) In $\delta-$ variation, time as well as position coordinates are allowed to vary.

b) In $\Delta-$ variation, time as well as position coordinates are allowed to vary.

c) $\delta-$ variation does involve time.

d) $\Delta-$ variation does not involve time.

25. The system of four point masses 1 gm, 2 gm, 3 gm and 4 gm located at the points (1, 0, 0), (1, 1, 0), (1, 1, 1) and (1, 1, −1) cm. The inertia is

a. $I = \begin{bmatrix} 16 & -9 & 1 \\ -9 & 17 & 1 \\ 1 & 1 & 19 \end{bmatrix}$

b. $I = \begin{bmatrix} 16 & 9 & -1 \\ 9 & 17 & -1 \\ -1 & -1 & 19 \end{bmatrix}$

c. $I = \begin{bmatrix} 16 & -9 & -1 \\ -9 & 17 & 1 \\ -1 & 1 & 19 \end{bmatrix}$

d. $I = \begin{bmatrix} 16 & -1 & 9 \\ -1 & 17 & -1 \\ -9 & -1 & 18 \end{bmatrix}$

Answer Key:

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
1	c	6	a	11	a	16	c	21	c
2	d	7	c	12	c	17	a	22	a
3	c	8	d	13	b	18	c	23	d
4	a	9	a	14	d	19	c	24	b
5	b	10	a	15	c	20	c	25	a