Group Number		Name		Type
List Number		Surname		A
Student ID		Signature		
E-mail				

ATTENTION: There is normally only one correct answer for each question and each correct answer is equal to 1 point. Only the answers on your answer sheet form will be evaluated. Please be sure that you have marked all of your answers on the answer sheet form by using a pencil (*not* pen).

Questions 1-5

1. A mass m is revolving in a circular path of radius R with an angular acceleration $\alpha = A\,t$, where A is a positive constant. Calculate the angular speed $\omega(t)$ in terms of ω_0 (initial angular speed at $t = 0$), A and time t.
(a) $\omega_0 + 2\,A\,t^2$ (b) $\omega_0 + 2\,A\,t$ (c) $\omega_0 + A\,t$ (d) $\omega_0 + \frac{1}{2}\,A\,t^2$ (e) $\omega_0 + A\,t^2$

2. Calculate the angular position $\theta(t)$ in terms θ_0 (initial angular position at $t = 0$), ω_0, A and t.
(a) $\theta_0 + \omega_0\,t + A\,t^2$ (b) $\theta_0 + \omega_0\,t + \frac{1}{2}\,A\,t^2$ (c) $\theta_0 + \omega_0\,t + \frac{1}{6}\,A\,t^3$ (d) $\theta_0 + \omega_0\,t + \frac{1}{3}\,A\,t^3$ (e) $\theta_0 + \omega_0\,t + \frac{2}{3}\,A\,t^3$

3. Calculate the speed $v(t)$ of the particle in terms of ω_0, A, R and time t.
(a) $\omega_0\,R + A\,Rt^2$ (b) $\omega_0\,R + 2\,A\,Rt^2$ (c) $\omega_0\,R + \frac{1}{2}\,A\,R\,t^2$ (d) $\omega_0\,R + 2\,A\,R\,t$ (e) $\omega_0\,R + A\,R\,t$

4. Calculate the magnitude of radial acceleration $a_r(t)$ in terms of ω_0, A, R and time t.
(a) $(\omega_0 + A\,t^2)^2\,R$ (b) $(\omega_0 + \frac{1}{2}\,A\,t^2)^2\,R$ (c) $(\omega_0 + 2\,A\,t)^2\,R$ (d) $(\omega_0 + 2\,A\,t^2)^2\,R$ (e) $(\omega_0 + A\,t)^2\,R$

5. Calculate the magnitude of the linear acceleration $a(t)$ in terms of ω_0, A, R and time t.
(a) $R\sqrt{A^2\,t^2 + (\omega_0 + \frac{1}{2}\,A\,t^2)^4}$ (b) $R\sqrt{A^2\,t^2 + (\omega_0 + A\,t)^4}$ (c) $R\sqrt{A^2\,t^2 + (\omega_0 + 2\,A\,t^2)^4}$
(d) $R\sqrt{A^2\,t^2 + (\omega_0 + 2\,A\,t)^4}$ (e) $R\sqrt{A^2\,t^2 + (\omega_0 + A\,t^2)^4}$

Questions 6-7

Position vectors of $m_1 = 1\,kg$, $m_2 = 2\,kg$ and $m_3 = 3\,kg$ are given as $\vec{r}_1 = 2t^2\hat{\imath}$, $\vec{r}_2 = (2-3t)\hat{\imath} + 2t\hat{\jmath}$ and $\vec{r}_3 = (1-t)\hat{\jmath} - \frac{1}{6}(t^3-1)\hat{k}$ in units of meters.

6. Find the centre of mass velocity $\vec{v}_{\rm cm}$ when $t = 2$ s.
(a) $\frac{1}{6}(-3\hat{\jmath} + 2\hat{k})$ (b) $\frac{1}{2}(3\hat{\imath} - 2\hat{\jmath} + 1\hat{k})$ (c) $\frac{1}{6}(2\hat{\imath} + \hat{\jmath} - 6\hat{k})$ (d) $\frac{1}{6}(-3\hat{\imath} - 2\hat{\jmath} + 4\hat{k})$ (e) $\frac{1}{5}(-4\hat{\imath} - 2\hat{k})$

7. Find the centre of mass acceleration $\vec{a}_{\rm cm}$ when $t = 2$ s.
(a) $\frac{1}{3}(2\hat{\imath} - 3\hat{k})$ (b) $\frac{1}{2}(2\hat{\jmath} - 5\hat{k})$ (c) $\frac{1}{6}(4\hat{\imath} - 3\hat{\jmath} - 5\hat{k})$ (d) $\frac{1}{6}(4\hat{\imath} - 3\hat{\jmath})$ (e) $\frac{1}{6}(2\hat{\imath} + 3\hat{k})$

Questions 8-10

Two objects with masses $m_1 = 2\,kg$ and $m_2 = 3\,kg$ collide elastically with initial velocities given as $\vec{v}_{1i} = 4\,\hat{\imath}\,\frac{m}{s}$ and $\vec{v}_{2i} = -6\,\hat{\imath}\,\frac{m}{s}$.

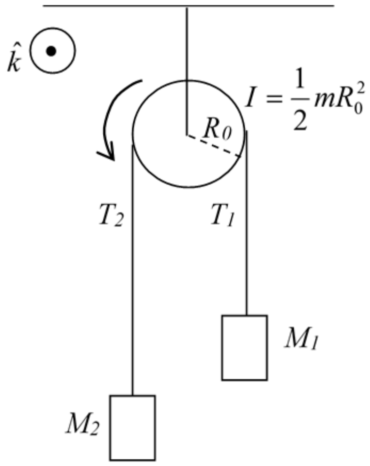
8. Calculate the centre of mass velocity $\vec{v}_{\rm cm}$ of the system **before** the collision.
(a) $+1\,\hat{\imath}\,\frac{m}{s}$ (b) $-4\,\hat{\imath}\,\frac{m}{s}$ (c) $-1\,\hat{\imath}\,\frac{m}{s}$ (d) $-2\,\hat{\imath}\,\frac{m}{s}$ (e) $-3\,\hat{\imath}\,\frac{m}{s}$

9. Calculate the velocities of m_1 and m_2 with respect to centre of mass frame (velocities relative to an observer moving with $\vec{v}_{\rm cm}$) **before** the collision.
(a) $\vec{v'}_1 = -2\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_2 = +4\,\hat{\imath}\,\frac{m}{s}$ (b) $\vec{v'}_1 = 6\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_2 = -4\,\hat{\imath}\,\frac{m}{s}$ (c) $\vec{v'}_1 = 3\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_2 = -2\,\hat{\imath}\,\frac{m}{s}$ (d) $\vec{v'}_1 = 2\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_2 = -8\,\hat{\imath}\,\frac{m}{s}$
(e) $\vec{v'}_1 = 5\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_2 = -5\,\hat{\imath}\,\frac{m}{s}$

10. Calculate the velocities of m_1 and m_2 with respect to centre of mass frame (velocities relative to an observer moving with $\vec{v}_{\rm cm}$) **after** the collision.
(a) $\vec{v'}_{1f} = -3\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_{2f} = +2\,\hat{\imath}\,\frac{m}{s}$ (b) $\vec{v'}_{1f} = -6\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_{2f} = +4\,\hat{\imath}\,\frac{m}{s}$ (c) $\vec{v'}_{1f} = -4\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_{2f} = +6\,\hat{\imath}\,\frac{m}{s}$
(d) $\vec{v'}_{1f} = +2\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_{2f} = -4\,\hat{\imath}\,\frac{m}{s}$ (e) $\vec{v'}_{1f} = -8\,\hat{\imath}\,\frac{m}{s}, \vec{v'}_{2f} = +2\,\hat{\imath}\,\frac{m}{s}$

Questions 11-13

An Atwood machine is represented in figure where the pulley is in disc form and its moment of inertia is $I = \frac{1}{2}mR_0^2$. Here, $m = 2$ kg is the mass of the pulley and $R_0 = 20$ cm is the radius of the pulley. Initially the masses $M_1 = 1$ kg and $M_2 = 3$ kg are kept at rest and released at time, $t = 0$. The direction of z-axis is out of the page. Ignore friction on the axis of rotation. Take $g = 10$ m/s^2.



11. What is the magnitude of the acceleration a of the masses in unit of m/s^2 ?
(a) 20/3 (b) 2 (c) 4 (d) 5 (e) 10/3

12. What is the ratio of the tensions, T_1/T_2, shown in the figure?
(a) 5/3 (b) 5/7 (c) 3/5 (d) 3/2 (e) 7/9

13. What is the angular speed, ω, of the pulley at $t = 2$ s, in unit of rad/s ?
(a) 40 (b) 30 (c) 10 (d) 20 (e) 5

Questions 14-15

A horizontal table in the form of a circular disk rotates around a vertical axis passing through its centre of mass without friction, with an angular speed $\omega_0 = 0.5$ rad/s. The mass of the table is 100 kg and the radius is 2 m. A child with a mass of 32 kg walks slowly from the edge of the rotating table towards the centre. The moment of inertia of the table is $I = \frac{1}{2}MR^2$.

14. What is the angular speed of the child, in rad/s, when he reaches a point 0.5 m away from the centre of the disk?
(a) 30/14 (b) 50/32 (c) 52/41 (d) 32/50 (e) 41/52

15. What is the rotational kinetic energy of the system, in N.m, when he reaches a point 0.5 m away from the centre of the disk?
(a) 2704/26 (b) 1681/26 (c) 1024/13 (d) 250/32 (e) 900/32

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16. If the escape speed from the surface of a star of mass M and radius R is v, then what it would be for a star of mass $18M$ and radius $R/2$?

(a) $3v$ (b) $9v$ (c) $1296v$ (d) $36v$ (e) $6v$

17. What is the weight w of a particle of mass m at a distance $r < R$ from the centre of a homogenous (constant density) spherical body of mass M and radius R.

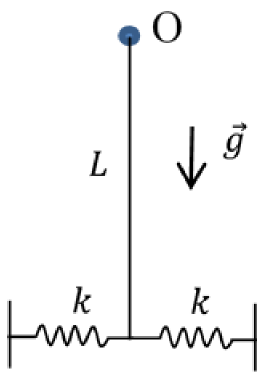
(a) $w = G\frac{mM}{r^2}$ (b) $w = 0$ (c) $w = G\frac{mM}{R^2}r$ (d) $w = G\frac{mM}{R^3}r$ (e) $w = G\frac{mM}{r^2}R$

18. Which of the following is correct for a planet revolving in an elliptical orbit around the sun? ϕ is the angle between the velocity $\vec{v}$ of the planet and the line with a length r from the sun to the planet. (Hint: Recall Kepler's Second Law. r_{min} and r_{max} are the minimum and maximum distances of the planet from the sun. v_{min} and v_{max} are the minimum and maximum speeds of the planet in its orbit.)

(a) $rv\sin\phi = r_{\text{min}}v_{\text{min}}$ (b) $rv = r_{\text{min}}v_{\text{max}}$ (c) $rv\cos\phi = r_{\text{min}}v_{\text{max}}$ (d) $vr = \text{constant}$ (e) $rv\sin\phi = r_{\text{min}}v_{\text{max}}$

Questions 19-20

A homogeneous rod of mass $M = 5$ kg and length $L = 3$ m is suspended from one end to rotate around the point O in the vertical plane. From the other end, as shown in figure, the rod is attached to two identical springs with spring constants $k = \frac{100}{6}$ N/m (take $\pi = 3\,, g = 10\,m/s^2$ and $I_{\text{cm}} = \frac{1}{12}ML^2$). For small vibrations;



19. What is the magnitude of the angular acceleration of the rod as function of θ?
(a) 25 θ (b) 125 θ (c) 120 θ (d) 5 θ (e) 2 θ

20. What is the period of the vibration in units of seconds?
(a) 3/5 (b) 5/3 (c) 5/6 (d) 6/5 (e) 7/4