Q1.

An object moves in a horizontal circle at constant speed. The work done by the centripetal force is zero because:

A) the centripetal force is perpendicular to the velocity
B) the force and positon are perpendicular to each other
C) there is no friction
D) the magnitude of the acceleration is zero
E) the displacement for each revolution is zero

Ans:

A

Q2.

A machine carries a 4.0 kg package from an initial position of $\vec{d}_1 = (2.0\text{ m})\hat{j}$ at t = 0 to a final position of $\vec{d}_2 = (2.0\text{ m})\hat{i} + (3.0\text{ m})\hat{j}$ at t = 4.0 s. The constant force applied by the machine on the package is $\vec{F} = (4.0\text{ N})\hat{i}$. Find the average power of the machine's force on the package.

A) 2.0 W
B) 3.0 W
C) 1.0 W
D) 4.0 W
E) 5.0 W

Ans:

$$P_{av} = \frac{W}{t} = \frac{\Delta\vec{d}\cdot F}{(4-0)} = \frac{(2\,\hat{\imath} + 3\,\hat{\jmath} - 2\hat{\jmath})\cdot 4\hat{\imath}}{4} = \frac{8}{4} = 2\,W$$

Q3.

An 8000-N car is traveling at 12 m/s along a horizontal road. When the brakes are applied, the car skids (slides) to a stop in 4.0 s. Find the work done on the car.

A) -5.9×10^4 J
B) $+5.9 \times 10^4$ J
C) $+1.5 \times 10^4$ J
D) -2.1×10^4 J
E) $+2.1 \times 10^4$ J

Ans:

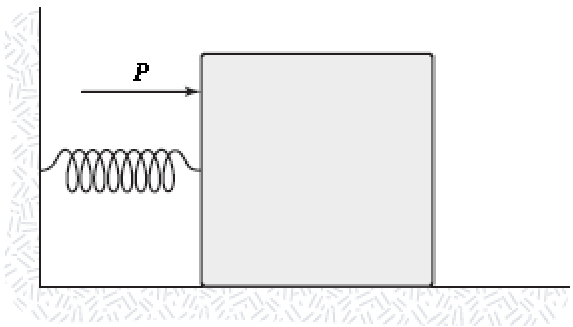
$$\Delta K = W \Rightarrow W = K - K_0 = 0 - \frac{1}{2} m v_0^2$$

Q4.

A 10-kg block on a horizontal frictionless surface is attached to a light spring (spring constant, k = 1.2×10^3 N/m). The block is initially at rest at its equilibrium position. Then a force of magnitude P is applied to the block parallel to the surface, as shown in **Figure 1**. When the block is 8.0×10^{-2} m from the equilibrium position, it has a speed of 0.80 m/s. How much work is done on the block by the force P as the block moves the 8.0×10^{-2} m?

A) 7.0 J
B) 6.4 J
C) 1.5 J
D) 4.0 J
E) 5.2 J

Figure 1



Ans:

$$\Delta K + \Delta U_s = W_a$$

$$\frac{1}{2} m v^2 + \frac{1}{2} k x^2 = W_a$$

$$\frac{1}{2} \times 10 \times 0.8^2 + \frac{1}{2} \times 1200 \times (8 \times 10^{-2}) = W_a$$

$$\Rightarrow W_a = 7.0\, J$$

Q5.

A particle is moved from point A to point B under the action of two forces. One of the forces is conservative and the other one is non-conservative, but none of the forces is a frictional force. The kinetic energies of the particle at points A and B are equal if

A) the sum of the works of the two forces is zero.
B) the work of the conservative force is equal to the work of the non-conservative force.
C) the work of the conservative force is zero.
D) the work of the non-conservative force is zero.
E) None of these answers

Ans:

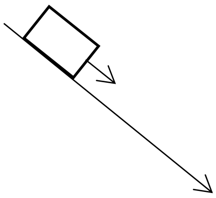
$$\Delta K - W_C = W_N$$

$$\Delta K = W_C + W_N$$

Q6.

A child whose weight is 267 N slides down a 6.10 m long slide that makes an angle of 20.0° with the horizontal. The coefficient of kinetic friction between the slide and the child is 0.100. If the child starts at the top with a speed of 0.457 m/s, what is the child's speed at the bottom? (Ignore air resistance)

A) 5.46 m/s
B) 2.35 m/s
C) 4.00 m/s
D) 1.41 m/s
E) 2.32 m/s



Ans:

$$\Delta K + \Delta U_g = W_a + W_4$$

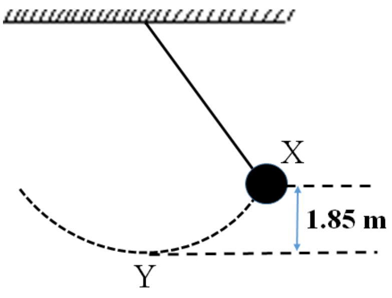
$$\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 - mgsin20° = -mgcos\theta\mu X$$

$$v = \sqrt{v_0^2 + 2gx(sin20 - cos20\mu)} = 5.46\, m/s$$

Q7.

A simple pendulum consists of a 2.00 kg mass attached to a string. The mass is released from rest at X as shown in **Figure 2**. If the height of X from the lowest point Y is 1.85 m, find the speed of the mass at point Y. (Ignore air resistance)

Figure 2



A) 6.02 m/s
B) 9.00 m/s
C) 8.45 m/s
D) 2.87 m/s
E) 3.53 m/s

Ans:

$$\Delta K + \Delta v_g = 0$$

$$K - K_0 + v_g - V_{0g} = 0$$

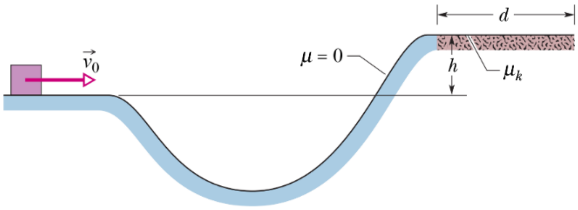
$$\frac{1}{2}mv^2 - mgh = 0$$

$$v = \sqrt{2mgh} = \sqrt{2 \times 9.8 \times 1.85} = 6.02\ m/s$$

Q8.

In **Figure 3**, a block slides along a track from one level to a higher level after passing through a valley. The track is frictionless until the block reaches the higher level. On the rough surface, a frictional force stops the block in a distance d. The block's initial speed v_0 is 6.0 m/s, the height difference h is 1.1 m, and μ_k is 0.60. Find d. (Ignore air resistance)

Figure 3



A) 1.2 m
B) 4.5 m
C) 2.6 m
D) 3.4 m
E) 5.7 m

Ans:

$$\Delta K + \Delta V_g = W_a + W_f$$

$$K - K_0 + V_g - V_{vg} = -mg\mu_k d$$

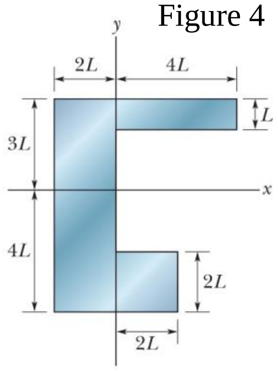
$$-\frac{1}{2}mv_0^2 + mgh = -mg\mu_k d$$

$$d = \frac{\frac{1}{2}v_0^2 - gh}{g\mu_k} = 1.2\ m$$

Q9.

What is the y-coordinate of the center of mass for the uniform plate shown in **Figure 4** if $L = 5.0$ cm?

Figure 4



A) –2.0 cm
B) –1.0 cm
C) +1.0 cm
D) +2.0 cm
E) +3.0 cm

Ans:

$$m_1 \frac{3}{2}L + m_2\left(3L - \frac{L}{2}\right) - m_3 2L - m_4 3L = (m_1 + m_2 + m_3 + m_4) y_{com}$$

$$L^2 \equiv m$$

$$m_1 = 6\,m, m_2 = 4\,m, m_3 = 8\,m, m_4 = 4\,m$$

$$\Rightarrow 6\,m\,\frac{3}{2}L + 4m\,\frac{5}{2}L - 8m \times 1L - 4m \times 1L y_{com} = 22 m y_{com}$$

$$\Rightarrow \frac{9L + 10\,L - 16\,L - 12\,L}{22} = y_{com}$$

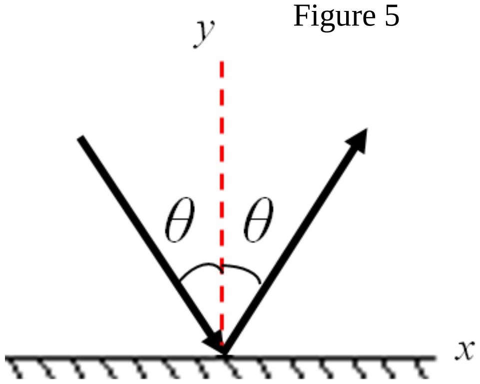
$$\Rightarrow \frac{19L - 28\,L}{22} = y_{com} \Rightarrow y_{com} = -\frac{9 \times 5}{22} \approx -2.0\,cm$$

Q10.

A ball hits a ground and rebounds with the same speed and same angle, as shown in **Figure 5**. Which one of the following statements is correct regarding the change in momentum of the ball?

A) Δp_y is greater than zero
B) Δp_y is equal to zero
C) Δp_x is greater than zero
D) Δp_y is less than zero
E) Δp_x is less than zero

Figure 5



Ans:

A

Q11.

Cart A, with a mass of 0.20 kg, travels on a horizontal air track at 3.0 m/s and hits cart B, which has a mass of 0.40 kg and is initially at rest. After the collision, the center of mass of the two cart system has a speed of:

A) 1.0 m/s
B) 2.0 m/s
C) 3.0 m/s
D) 4.0 m/s
E) zero

Ans:

$$m_1 v_{i2} + m_1 v_{2i} = (m_1 + m_2) v_{com}$$

$$v_{com} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

$$v_{1i} = 20\ m/s\,, v_{1i} = 0$$

Q12.

A 2.0-kg object sliding on a frictionless horizontal surface explodes into two 1.0-kg pieces. After the explosion, the velocities of the pieces are (1) 8.0 m/s, north; and (2) 4.0 m/s, 30° south of west. What was the magnitude of the original velocity of the 2.0-kg object?

A) 3.5 m/s
B) 1.0 m/s
C) 2.6 m/s
D) 4.2 m/s
E) 5.3 m/s

Ans:

$$2v_x = 1 \times 4\cos 30$$

$$v_x = -2cos30° = -1.732\ m/s$$

$$v_y = \left(\frac{8 - 4sin30°}{2}\right) = 3\ m/s$$

$$v = \sqrt{v_x^2 + v_y^2} = 3.46\ m/s$$

Q13.

A wheel starts from rest and rotates with constant angular acceleration about a fixed axis passing through its center. It completes the first revolution 6.0 s after it started. How long after it started will the wheel complete the second revolution?

A) 8.5 s
B) 5.0 s
C) 1.9 s
D) 3.2 s
E) 6.7 s

Ans:

$$\omega_0 = 0; \quad \theta = 2\pi; \ \ t = 6\ s$$

$$\theta = \omega_0 t + \frac{1}{2}\ \alpha t^2$$

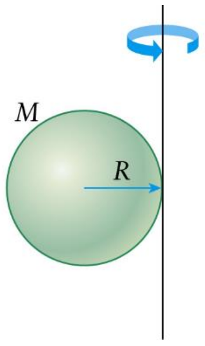
$$\alpha = \frac{2\theta}{t^2} = \frac{4\pi}{36}$$

$$t_2 = \sqrt{\frac{2 \times 4\pi}{\alpha}} = \sqrt{\frac{2 \times 4\pi \times 36}{4\pi}} = 8.5\ s$$

Q14.

A uniform sphere of radius R = 2.0 m and mass M = 3.0 kg rotates freely with constant angular speed of 10 rad/s about a vertical axis that is tangent to an equatorial plane of the sphere, as shown in **Figure 6**. Find the kinetic energy of the sphere.

Figure 6



A) 840 J
B) 950 J
C) 700 J
D) 325 J
E) 150 J

Ans:

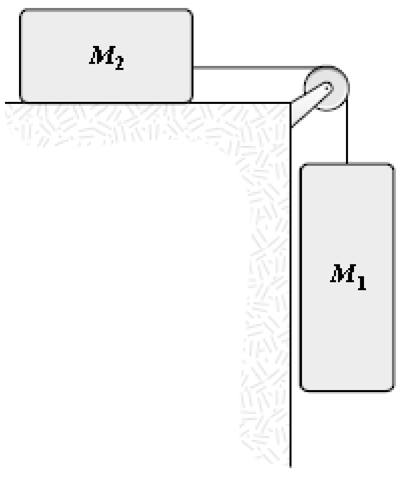
$$I = \frac{1}{2}I\omega^2 = \frac{1}{2}\left(\frac{2}{5}mR^2 + mR^2\right)\omega^2$$

$$= \frac{1}{2} \times \frac{7}{5}mR^2\omega^2$$

Q15.

A mass (M_1 = 5.0 kg) is connected by a light cord to a mass (M_2 = 4.0 kg) which slides on a frictionless surface, as shown in the **Figure 7**. The pulley (a disc of radius = 0.20 m) rotates about a frictionless axle. If the magnitude of acceleration of M_2 is 3.5 m/s^2, what is the moment of inertia of the pulley?

Figure 7



A) 0.20 kg . m^2
B) 0.70 kg . m^2
C) 0.95 kg . m^2
D) 0.63 kg . m^2
E) 0.36 kg . m^2

Ans:

$$T_1 - M_1 g = -M_1 a \Longrightarrow T_1 = Mg - M_1 a$$

$$T_2 = M_2 a$$

$$-T_1 R + T_2 R = -I\alpha$$

$$M_1 gR - M_1 aR - M_2 aR = I\frac{a}{R}$$

$$I = \left(+\frac{M_1 g}{a} - M_1 - M_2\right)R^2 = 0.2\ Kg\ m^2$$

Q16.

An engine delivers a power of 1.20×10^5 W to rotate a disc with the constant angular speed ω. If the work done by the engine in one revolution is 3000 J, find the value of ω.

A) 251 rad/s
B) 360 rad/s
C) 140 rad/s
D) 438 rad/s
E) 523 rad/s

Ans:

$$P = \frac{W}{t} \Rightarrow t = \frac{W}{P}$$

$$\theta = \frac{2\pi}{t} = 251\ rad/s$$

Q17.

A forward force acting on the axle accelerates a smoothly rolling wheel on a horizontal surface. If the wheel does not slide, the frictional force of the surface on the wheel is:

A) in the backward direction
B) in the forward direction
C) in the upward direction
D) zero
E) into the ground

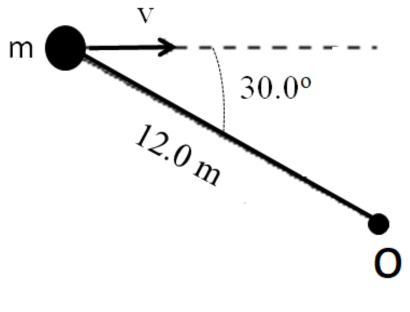
Ans:

A

Q18.

A particle of mass m = 6.00 kg moves to the right at the velocity v = 4.00 m/s as shown in **Figure 8**. The magnitude of its angular momentum about the point O is:

Figure 8



A) 144 kg·m^2/s
B) 288 kg·m^2/s
C) 324 kg·m^2/s
D) 412 kg·m^2/s
E) 549 kg·m^2/s

Ans:

$$\hat{L} = mvrsin(180 - 30°)$$

$$= 6 \times 4 \times 12 \sin(150°) = 144\ kg \cdot m^2/s$$

Q19.

A 2.0-kg block is rotating in horizontal xy-plane. While it is at the point P(2.0 m, 3.0 m), the block has an acceleration of $\vec{a} = (4.0\ \text{m/s}^2)\hat{i} - (3.0\ \text{m/s}^2)\hat{j}$. Find the torque on the block at point P, relative to the origin.

A) $(-36\ \text{N·m})\ \hat{k}$
B) $(+36\ \text{N·m})\ \hat{k}$
C) $(+24\ \text{N·m})\ \hat{k}$
D) $(-24\ \text{N·m})\ \hat{k}$
E) $(+14\ \text{N·m})\ \hat{k}$

Ans:

$$\hat{r} = 2\hat{\imath} + 3\hat{\jmath}$$

$$\tau = \Delta\hat{r} \times \hat{F} = (2\hat{\imath} + 3\hat{\jmath}) \times m\hat{a}$$

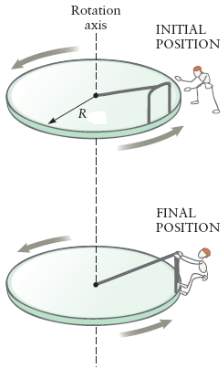
$$= (2\hat{\imath} + 3\hat{\jmath}) \times (8\hat{\imath} - 6\hat{\jmath})$$

$$= 24\hat{k} - 12\hat{k} = -36\ \hat{k}$$

Q20.

A merry-go-round of radius R = 2.0 m has a rotational inertia I = 200 kg.m^2 and is rotating at 20 rev/min, about a frictionless vertical axle as shown in **Figure 9**. A 50 kg boy jumps onto the edge of the merry-go-round and sits down on the edge. Considering the boy to be a point mass, the new angular speed of the merry-go-round is:

Figure 9



A) 10 rev/min
B) 5.0 rev/min
C) 15 rev/min
D) 20 rev/min
E) 30 rev/min

Ans:

$$I\omega_0 = (I_m O + I)\omega$$

$$\omega = \left(\frac{I}{mR^2 + I}\right)\omega_0 = \left(\frac{200}{200 + 50 \times 2^2}\right)20$$

$$= \left(\frac{200}{200 + 200}\right)20 = \frac{1}{2} \times 20 = 10\ rev/min$$
