Q1.

For a completely inelastic two-body collision the kinetic energy of the objects after the collision is the same as:

A) (1/2) MV^2, where M is the total mass and V is the speed the center of mass of the two objects after the collision
B) the difference in the kinetic energies of the objects before the collision
C) the total kinetic energy before the collision
D) the kinetic energy of the more massive body before the collision
E) the kinetic energy of the less massive body before the collision

Ans:

A

Q2.

Bullets, each having a mass of 3 g are fired at a wall from a gun at the rate of 100 bullets/min. The speed of each bullet is 500 m/s. Suppose that the bullets rebound straight back with no change in speed, what is the magnitude of the average force on the wall?

A) 5 N
B) 3 N
C) 2 N
D) 9 N
E) 7 N

Ans:

$$|F| = \left|\Delta v \frac{\Delta m}{\Delta t}\right| = 2 \times 500 \times \frac{3 \times 10^{-3} \times 100}{60} = 5\text{N}$$

Q3.

A 5.20 g bullet moving at 672 m/s strikes a 700 g wooden block at rest on a frictionless surface. The bullet emerges out of the block, traveling in the same direction with its speed reduced to 428 m/s. What is the speed of the block after the bullet leaves the block?

A) 1.81 m/s
B) 0.600 m/s
C) 2.42 m/s
D) 1.15 m/s
E) 4.22 m/s

Ans:

$$m_{bull} v_{bull-i} = M_{Block} v_{Block-f} + m_{bull} v_{bull-f}$$

$$v_{Block-f} = \frac{m_{bull}\left[v_{bull-i} - v_{bull-f}\right]}{M_{Block}} = \frac{5.2 \times 10^{-3}[672 - 428]}{0.7} = 1.81\ m/s$$

Q4.

Block 1 of mass m_1 slides along a frictionless floor and collides in a one-dimensional elastic collision with stationary block 2 of mass $m_2 = 3m_1$. Prior to the collision, the center of mass of the two-block system has a speed of 3.00 m/s. After the collision, what is the speed of block 2?

A) 6.00 m/s
B) 3.00 m/s
C) 1.25 m/s
D) 9.22 m/s
E) 7.43 m/s

Ans:

$$m_1 v_{1i} = (m_1 + m_2) v_{com} \Rightarrow v_{1i} = \frac{m_1 + m_2}{m_1} v_{com} = \frac{m_1 + 3m_1}{m_1} \times 3 = 12\ m/s$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i} = \frac{2m_1}{m_1 + 3m_1} \times 12 = \frac{2\cancel{m_1}}{4\cancel{m_1}} \times 12 = 6\ m/s$$

Q5.

A disk is free to rotate about its central axis. A constant force $\vec{F}$, acting in the plane of the disk, is to be applied to the disk. The greatest angular acceleration is obtained if the force is:

A) applied tangentially at the rim
B) applied tangentially halfway between the axis and the rim
C) applied radially halfway between the axis and the rim
D) applied radially at the rim
E) applied at the rim but neither radially nor tangentially

Ans:

A

Q6.

The angular position of a point on the rim of a rotating wheel is given by $\theta = 4.00\ t + 3.00\ t^2$, where t is in seconds and θ is in radians. The wheel has a radius of 1.00 m and rotates about its central axis. What is the magnitude of the radial acceleration a_r of the point at t = 1.00 s?

A) 100 m/s^2
B) 6.00 m/s^2
C) 200 m/s^2
D) 60.0 m/s^2
E) 15.0 m/s^2

Ans:

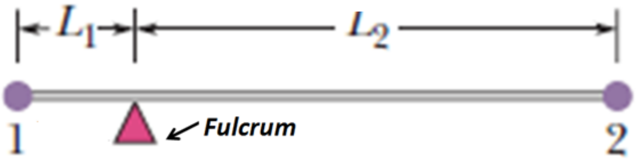
$$a_r = r\omega^2\ but\ \omega = \frac{d\theta}{dt} = 4 + 6\,t;\ \omega\,(t = 1.00\ s) = 4 + 6 = 10\ rad/s$$

$$a_r(\,t = 1.0\ s) = 1 \times (10)^2 = 100\ m/s^2$$

Q7.

Figure 1 shows particles 1 and 2, each of mass *m*, attached to the ends of a rigid massless rod of length $L_1 + L_2$, with L_1 = 20 cm and L_2= 80 cm. The rod is held horizontally on the fulcrum and then released. When released, it rotates in vertical plane .What is the magnitude of the initial acceleration (tangential acceleration a_t) of particle 2 after release? (ignore air resistance)

Figure 1



A) 6.9 m/s²
B) 1.7 m/s²
C) 3.2 m/s²
D) 8.7 m/s²
E) 2.2 m/s²

Ans:

$$\tau_{net} = I\alpha = (m_1 L_1 - m_2 L_2)\, g = (m_1 L_1^2 + m_2 L_2^2) \cdot \frac{a_t}{L_2}$$

$$|a_t| = \left|\frac{L_2(L_1 - L_2)g}{L_1^2 + L_2^2}\right| = \left|\frac{0.8(0.2 - 0.8)9.8}{0.2^2 + 0.8^2}\right| = 6.9\ m/s^2$$

Q8.

A 32.0 kg thin hoop with radius 1.20 m, is rotating at 280 rev/min about its central axis. What is the average power required to bring the hoop to a stop in 15.0 s? (ignore air resistance)

A) 1.32 kW
B) 0.050 kW
C) 0.910 kW
D) 2.53 kW
E) 3.19 kW

Ans:

$$P_{avg} = \frac{W}{\Delta t} = \frac{\Delta k}{\Delta t} = \frac{k_{rot-f} - k_{rot-i}}{\Delta t} = \frac{-k_{rot-i}}{\Delta t}$$

$$P_{avg} = \left|\frac{k_{rot-i}}{\Delta t}\right| = \frac{\frac{1}{2} I \omega_i^2}{\Delta t} = \frac{\frac{1}{2} M R^2 \omega_i^2}{\Delta t}$$

$$P_{avg} = \frac{\frac{1}{2} \times 32 \times (1.2)^2 \times \left(\frac{280 \times 2\pi}{60}\right)^2}{15} = 1.32\ kW$$

Q9.

When a man standing on a frictionless rotating turntable extends his arms out horizontally, which of the following statements is **true**?

A) His angular momentum increases
B) His angular momentum remains constant
C) his angular momentum decreases
D) his angular momentum and his angular speed both decrease
E) his angular momentum and his angular speed both increase

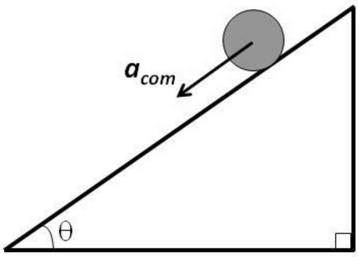
Ans:

A

Q10.

A uniform solid sphere rolls down an incline without slipping, as shown in **Figure 2**. What must be the incline angle θ if the magnitude of the linear acceleration of the center of mass of the sphere a_{com} = 1.2 m/s^2 (ignore air resistance)?

Figure 2



A) 9.9°
B) 8.0°
C) 5.8°
D) 15°
E) 7.3°

Ans:

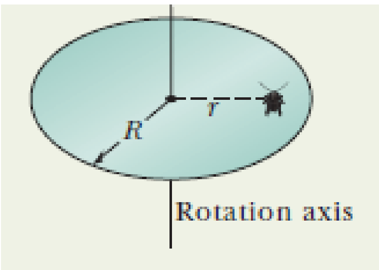
$$|a_{com}| = \frac{g\,sin\theta}{I + \frac{I_{com}}{MR^2}} = \frac{g\,sin\theta}{I + \frac{\frac{2}{5}MR^2}{MR^2}} = \frac{5}{7}\,g\,sin\theta$$

$$\theta = \sin^{-1}\left(\frac{7|a_{com}|}{5g}\right) = \sin^{-1}\left(\frac{7 \times 1.2}{5 \times 9.8}\right) = 9.9°$$

Q11.

In **Figure 3**, a cockroach with mass *m* rides on a disk of mass 4.00 *m* and radius *R*. The disk rotates like a merry-go-round about its central axis at angular speed $\omega_i = 1.60$ rad/s. The cockroach is initially at radius r = 0.800 R, but then it crawls towards the center of the disk. What is the final angular speed of the disk when the cockroach reaches the center of the disk? (Treat the cockroach as a particle)

Figure 3



A) 2.11 rad/s
B) 1.60 rad/s
C) 3.11 rad/s
D) 1.00 rad/s
E) 3.94 rad/s

Ans:

$$L_i = L_f \; ; (I_{cock} + I_{disk})\omega_i = I_{disk}\omega_f$$

$$\omega_f = \frac{(I_{cock} + I_{disk}}{I_{disk}} = \frac{\left(m_{cock}r^2 + \frac{M_{disk}R^2}{2}\right)\omega_i}{\frac{M_{disk}R^2}{2}}$$

$$\omega_f = \frac{\left(m \times (0.8R)^2 + \frac{4.00m \times R^2}{2}\right)1.6}{\frac{4.00m \times R^2}{2}} = \frac{((0.8)^2 + 2)\,1.6}{2} = 2.11\ \mathrm{rad/s}$$

Q12.

A non-zero net torque applied to a purely rotating rigid body always tends to produce:

A) angular acceleration of the rigid body
B) rotational equilibrium of the rigid body
C) None of the other answers
D) rotational inertia of the rigid body
E) constant angular velocity of the rigid body

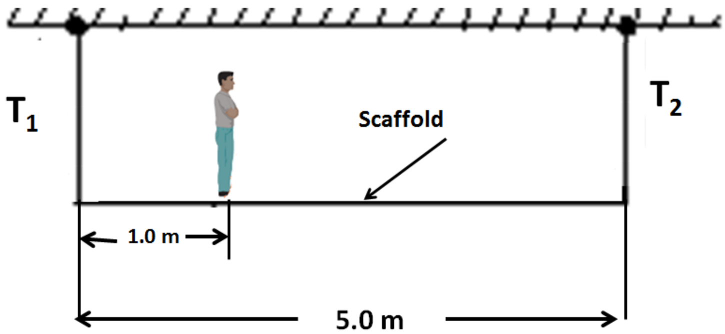
Ans:

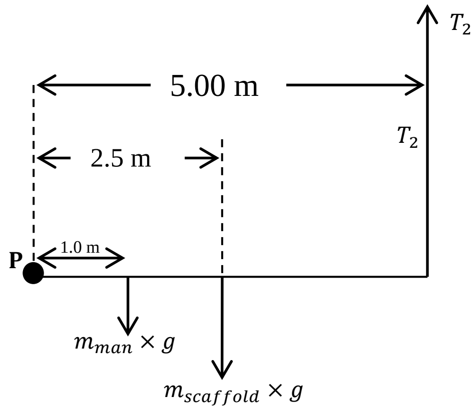
A

Q13.

A scaffold of mass 50.0 kg and length 5.00 m is supported in a horizontal position by a vertical cable at each end. A person of mass 80.0 kg stands at a point 1.00 m from one end of the scaffold as shown in **Figure 4**. In the equilibrium position of the system (scaffold + person), what is the tension in the cable T_1 and the cable T_2?

Figure 4





A) $T_1 = 872$ N, $T_2 = 402$ N
B) $T_1 = 402$ N, $T_2 = 872$ N
C) $T_1 = 272$ N, $T_2 = 372$ N
D) $T_1 = 512$ N, $T_2 = 252$ N
E) $T_1 = 612$ N, $T_2 = 333$ N

Ans:

Taking moments about P

$$\sum \tau = 0 = T_2 \times 5 - m_{man} \times g \times 1 - m_{scaffold} \times g \times 2.5$$

$$T_2 = \frac{(m_{man} \times 1 + m_{scaffold} \times 2.5)}{5} g = \left(\frac{80 \times 1 + 50 \times 2.5}{5}\right) \times 4.8 = 402\ N$$

For T_1 calculation apply $\sum F_y = 0$

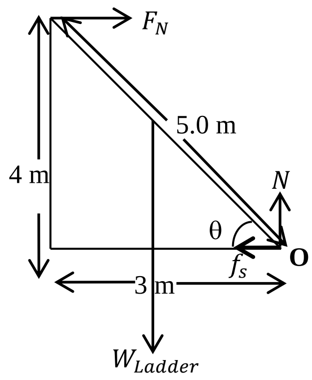
$$T_2 + T_1 - m_{man} \times g - m_{scaffold} \times g = 0$$

$$T_1 = (m_{man} + m_{scaffold})g - T_2 = 130 \times 9.8 - 401.8 = 872.2 \approx 872\ \text{N}$$

Q14.

A uniform ladder whose length is 5.0 m and whose weight is 4.0×10^2 N leans against a frictionless vertical wall. The foot of the ladder can be placed at a maximum distance of 3.0 m from the base of the wall on the floor without the ladder slipping. Determine the coefficient of static friction between the foot of the ladder and the floor.

A) 0.38
B) 0.22
C) 0.28
D) 0.43
E) 0.11



Ans:

$$\theta = tan^{-1}\left(\frac{4}{3}\right) = 53.1°$$

Applying $\sum F_x = 0 = F_N - f_s = 0 \Rightarrow f_s = F_N = \mu_s N$

Also $\sum F_y = 0 = N - W_{ladder} \Rightarrow N = W_{ladder} = 4 \times 10^2\ N$

About O, $\sum \tau = 0 = W_{ladder} \times 2.5 \times cos\ 53.1 - F_N \times 4 = 0$

$$F_N = \frac{W_{ladder} \times 2.5 \times \cos 53.1}{4} = \frac{400 \times 2.5 \times \cos 53.1}{4} = 150.1\ N$$

$$\mu_s = \frac{f_s}{N} = \frac{F_N}{N} = \frac{150.1}{400} = 0.38$$

Q15.

A solid copper cube has an edge length of 85.5 cm. How much hydraulic stress must be applied to the cube to reduce the edge length to 85.0 cm? The bulk modulus of copper is 1.40×10^{11} N/m^2.

A) 2.44×10^9 N/m^2
B) 1.12×10^9 N/m^2
C) 3.75×10^9 N/m^2
D) 4.44×10^9 N/m^2
E) 7.54×10^9 N/m^2

Ans:

$$|p| = \beta\left|\frac{\Delta V}{V}\right| = 1.40 \times 10^{11} \times \left[\frac{(85)^3 - (85.5)^3}{(85.5)^3 \times 10^{-6}}\right] \times 10^{-6}$$

$$= 2.44 \times 10^9 \text{N/m}^2$$
