Q1.

A particle moves from the point (0,1,2) m to point (3,5,3) m while being acted upon by a constant force $\vec{F} = (4.0\ N)\hat{i} + (2.0\ N)\hat{j} + (4.0\ N)\hat{k}$. The work done on the particle by this force is:

A) 24 J
B) 10 J
C) 34 J
D) 30 J
E) 20 J

Ans:

$W = \vec{F}.\vec{d}; \qquad \vec{d} = 3.0\hat{i} + 4.0\hat{j} + 1.0\ \hat{k}$

$= \left(4.0\hat{i} + 2.0\hat{j} + 4.0\ \hat{k}\right).\left(3.0\hat{i} + 4.0\hat{j} + 1.0\ \hat{k}\right)$

$= 12 + 8 + 4\ = 24\ \text{J}$

Q2.

An object is constrained by a cord to move in a circular path of radius 0.5 m on a horizontal frictionless surface. The cord will break if its tension exceeds 20 N. The maximum kinetic energy the object can have is:

A) 5.0 J
B) 10 J
C) 16 J
D) 32 J
E) 2.0 J

Ans:

$$T = \frac{mv^2}{r}$$

$$\therefore \frac{1}{2}mv^2 = \frac{1}{2}\ Tr = \frac{1}{2} \times 20 \times 0.5 = 5.0\ \text{J}$$

Q3.

A car accelerates from rest to 40 m/s in 1.5 s. Assuming the same average power is delivered by the engine of the car, how long does it take to accelerate it from zero to 80 m/s. (Ignore friction).

A) 6.0 s
B) 3.0 s
C) 4.5 s
D) 1.5 s
E) 8.0 s

Ans:

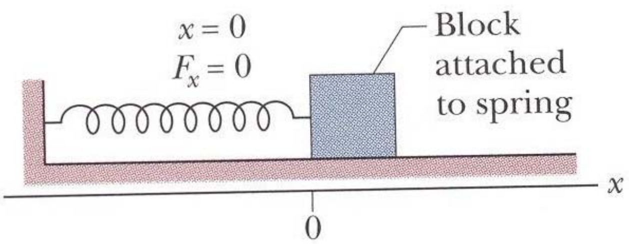
$$\begin{matrix} \Delta K_1 = Pt_1 \\ \Delta K_2 = Pt_2 \end{matrix} \Rightarrow \begin{matrix} \frac{1}{2}mv_1^2 - 0 = Pt_1 \\ \frac{1}{2}mv_2^2 - 0 = Pt_2 \end{matrix}$$

$$\therefore \frac{v_2^2}{v_1^2} = \frac{t_2}{t_1} \Rightarrow t_2 = \left(\frac{v_2}{v_1}\right)^2 \times t_1 = \left(\frac{80}{40}\right)^2 \times 1.5 \text{ s} = 6.0 \text{ s}$$

Q4.

A spring and a block are in the arrangement shown in Fig. 1. When the block is pulled out to x = + 4.0 cm, we must apply a force of magnitude 400 N to hold it there. We pull the block to x = 11 cm and then release it. How much work does the spring do on the block as the block moves from x_i = + 5.0 cm to x_f = + 3.0 cm?

Fig# 1



A) + 8.0 J
B) – 8.0 J
C) + 4.0 J
D) – 4.0 J
E) + 12 J

Ans:

$$F_x = k\,x$$

$$k = \frac{F_x}{x} = \frac{\cancel{4}00^{100} \text{ N}}{\cancel{4} \times 10^{-2}\text{m}}$$

$$k = 10^4 \text{ N/m}$$

$$W_s = \frac{1}{2}k\,(x_i^2 - x_f^2)$$

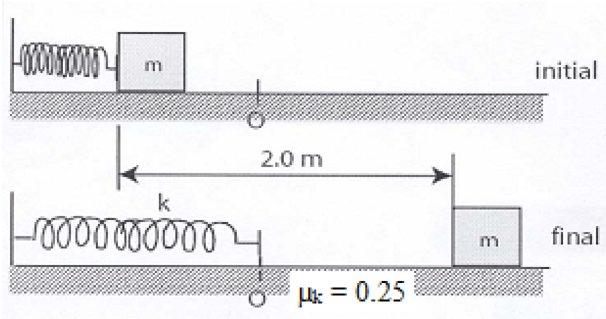
$$W_s = \frac{1}{2} \times 10^4\,(25 \times 10^{-4} - 9 \times 10^{-4}) = \frac{1}{2} \times \cancel{10^4} \times 16 \times \cancel{10^{-4}} \text{ J}$$

$$\Rightarrow W_s = 8.0 \text{ J}$$

Q5.

A spring of k = 100 N/m is fixed at one end. A 5.00-kg block is pushed against the spring on a horizontal rough surface with a coefficient of kinetic friction μ_k = 0.250. When the block is released from rest it travels a distance of 2.00 m before coming to full stop, (Fig. 2). How far was the spring compressed before being released?

Fig# 1



A) 0.700 m
B) 0.490 m
C) 0.230 m
D) 0.630 m
E) 0.850 m

Ans:

$$\cancelto{0}{\Delta k} + \cancelto{0}{\Delta u_g} + \Delta u_s = W_{nc}$$

$$\frac{1}{2}k(x_f^2 - x_i^2) = -\mu_k mgd$$

$$\frac{1}{2}(100)(0 - x^2) = -0.25 \times 5 \times 9.8d$$

$$\cancel{-}50x^2 = \cancel{-}(0.25 \times 5 \times 9.8 \times 2)$$

$$x^2 = 0.49 \Rightarrow x = 0.700\text{ m}$$

Q6.

We would like to raise a heavy object (at a constant speed) to a certain height h. We attach a rope to the object. It is preferable to pull it along a frictionless inclined plane rather than pulling it vertically upward because:

A) it reduces the force required
B) it reduces the work required
C) it reduces the change in the gravitational potential energy
D) it reduces the distance covered
E) it increases the acceleration due to gravity

Q7.

An 80.0-kg parachutist releases himself off a tower that is 90.0 m high. Assume that he starts from rest and reaches the ground with a speed of 10.0 m/s. How much work was done by the nonconservative forces on him?

A) -6.66×10^{4} J
B) $+0.66\times10^{4}$ J
C) -4.53×10^{4} J
D) -9.85×10^{4} J
E) -4.50×10^{5} J

Ans:

$$\Delta k + \Delta u_g = W_{nc}$$

$$\left(\frac{1}{2}mv^2 - 0\right) - mgh = W_{nc}$$

$$\frac{1}{\cancel{2}} \times \overset{40}{\cancel{80}} \times 100 - 80 \times 9.8 \times 90 = W_{nc}$$

$$W_{nc} = (4{,}000 - 70{,}560)\ \text{J} = -66{,}560\ \text{J}$$

Q8.

A single conservative force is acting on a 10.0-kg body. If the work done on the body by this force is 60.0 J, find the change in its potential energy.

A) -60.0 J
B) $+60.0$ J
C) $+50.0$ J
D) -50.0 J
E) -10.0 J

Ans:

$$\Delta k = -\Delta u$$

$$\therefore \Delta u = -\Delta k = -60.0\ \text{J}$$

Q9.

A 10-kg bomb initially at rest explodes, breaking into two pieces of masses 4.0 kg and 6.0 kg. The 4.0 kg piece flies off along the positive x axis with a speed 30 m/s. Find the velocity of the 6.0 kg piece.

A) 20 m/s along the negative x axis
B) 30 m/s along the negative x axis
C) 30 m/s along the positive x axis
D) 20 m/s along the positive x axis
E) 15 m/s along the negative x axis

Ans:

$$\vec{p}_i = \vec{p}_{1f} + \vec{p}_{2f}$$

$$0 = 4 \times 30\,\hat{i} + 6\vec{v}_f$$

$$\therefore \vec{v}_f = -\frac{120\,\hat{i}}{6} = -20\,\hat{i}\ (\text{m/s})$$

Q10.

Two 2.0-kg bodies, A and B, collide. Before collision the velocity of body A is $(10\,m/s)\hat{i} + (20\,m/s)\hat{j}$ and after the collision body A moves with velocity $(-5.0\,m/s)\hat{i} + (10\,m/s)\hat{j}$. Find the impulse delivered to body B (in unit vector notation).

A) $(+30\text{ kg.m/s})\hat{i} + (20\text{ kg.m/s})\hat{j}$
B) $(+30\text{ kg.m/s})\hat{i} - (60\text{ kg.m/s})\hat{j}$
C) $(-30\text{ kg.m/s})\hat{i} + (20\text{ kg.m/s})\hat{j}$
D) $(-30\text{ kg.m/s})\hat{i} + (60\text{ kg.m/s})\hat{j}$
E) $(+60\text{ kg.m/s})\hat{i} + (30\text{ kg.m/s})\hat{j}$

Ans:

$$\vec{p}_{iA} + \vec{p}_{iB} = \vec{p}_{fA} + \vec{p}_{fB}$$

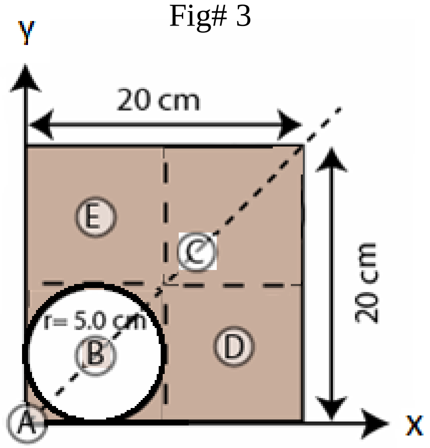
$$2\left(10\,\hat{i} + 20\,\hat{j}\right) + \vec{p}_{iB} = 2\left(-5.0\,\hat{i} + 10\,\hat{j}\right) + \vec{p}_{fB}$$

$$\vec{p}_{fB} - \vec{p}_{fi} = \left(20\,\hat{i} + 40\,\hat{j}\right) + \left(10\,\hat{i} - 20\,\hat{j}\right) = \left(30\,\hat{i} + 20\,\hat{j}\right)\text{kg. m/s}$$

Q11.

A circular hole of radius 5.0 cm is cut from a uniform square of metal sheet having sides 20 cm as shown in Fig. 3. Which point in the figure could possibly be the center of mass of this sheet?

Fig# 3

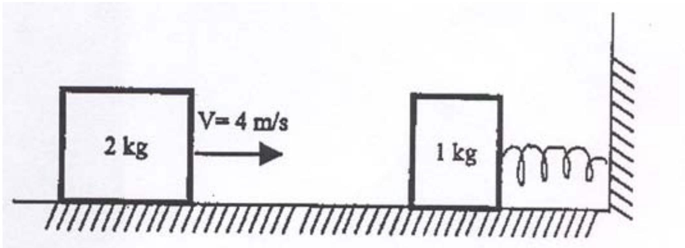


A) Point C
B) Point A
C) Point B
D) Point D
E) Point E

Q12.

A 1.0-kg block at rest on a horizontal frictionless surface is connected to a spring (k = 200 N/m) whose other end is fixed (Fig. 4). A 2.0-kg block moving at 4.0 m/s collides with the 1.0-kg block. If the two blocks stick together after the one-dimensional collision, what maximum compression of the spring does occur when the blocks momentarily stop?

Fig#4



A) 0.33 m
B) 0.23 m
C) 0.43 m
D) 0.13 m
E) 0.54 m

Ans:

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$$

$$2 \times 4 + 0 = 3\,v$$

$$v = \frac{8}{3}\ \mathrm{m/s}$$

$$\frac{1}{2}(m_{\mathrm{total}})v^2 = \frac{1}{2}\,kx^2$$

$$x^2 = \frac{3 \times \frac{64}{9}}{200} = 0.1067\ \mathrm{m}^2 \ \Rightarrow x = 0.327\ \mathrm{m}$$

Q13.

A wheel starting from rest, turns through 10 revolutions in a time interval of 20 s. Assuming constant angular acceleration, the angular speed at the end of this time interval is:

A) 6.3 rad/s
B) 8.5 rad/s
C) 7.0 rad/s
D) 1.7 rad/s
E) 3.5 rad/s

Ans:

$$\Delta\theta = w_i t + \frac{1}{2}\,\alpha t^2; \ \ w_i = 0$$

$$10 \times 2\pi = \frac{1}{2}\alpha \times 400$$

$$\alpha = \frac{20 \times 2\pi}{400}\mathrm{rad/s^2} = 0.314\ \mathrm{rad/s^2}$$

$$w_f = w_i + \alpha t = 0 + 0.314 \times 20 = 6.3\ \mathrm{rad/s}$$

Q14.

A disk has a moment of inertia of 10.0 kg.m^2 and a constant angular acceleration of 2.0 rad/s^2 about its axis of rotation. If it starts from rest, find the work done by the net torque during the first 5.0 s.

A) 500 J
B) 300 J
C) 50.0 J
D) 100 J
E) 0 J

Ans:

$$I = 10.0\ \mathrm{kg.m^2}\ ; \quad \alpha = 2.0\ \mathrm{rad/s^2}\ ; \quad w_i = 0$$

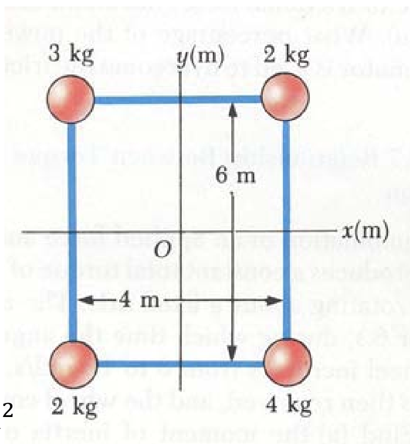
$$w_f = w_i + \alpha t = 0 + 2 \times 5 = 10\ \mathrm{rad/s}$$

$$W = \frac{1}{2} I \left(w_f^2 - w_i^2\right) = \frac{1}{\cancel{2}} \times \overset{5}{\cancel{1}}0 \times 10^2\ \mathrm{J} = 500\ \mathrm{J}$$

Q15.

The four particles in Fig. 5 are connected by rigid rods of negligible mass. If the system rotates in the xy plane about the z-axis passing through point O with an angular velocity of 6.0 rad/s, calculate the kinetic energy of the system?

Fig # 5



A) 2.6×10^3 J
B) 7.9×10^2 J
C) 5.4×10^2 J
D) 1.5×10^2 J
E) 3.0×10^3 J

Ans:

$$K = \frac{1}{2} I\omega^2$$

$$I = \sum m_i r_i^2 = 11 \times (13)\ \mathrm{kg.m^2} = 143\ \mathrm{kg.m^2}$$

$$\therefore K = \frac{1}{2}(143)(36) = 2574\ \mathrm{J}$$

$$K = 2.6 \times 10^3\ \mathrm{J}$$

Q16.

The moment of inertia of an object does not depend on

A) its angular velocity
B) its mass
C) its size and shape
D) the location of the axis of rotation
E) the distribution of its mass

Q17.

A uniform solid sphere of radius 0.10 m rolls smoothly across a horizontal table at a speed 0.50 m/s with total kinetic energy of 0.70 J. Find the mass of the sphere.

A) 4.0 kg
B) 8.0 kg
C) 2.0 kg
D) 1.0 kg
E) 5.0 kg

Ans:

$$\omega = \frac{v}{R}; \quad I = \frac{2}{5}\, mR^2$$

$$\frac{1}{2} m v_{cm}^2 + \frac{1}{2} I\omega^2 = 0.70 \text{ J}$$

$$K = \frac{1}{2} \times m(0.50)^2 + \frac{1}{\cancel{2}}\left(\frac{\cancel{2}}{5}\, m\cancel{R^2}\right)\left(\frac{v^2}{\cancel{R^2}}\right)$$

$$K = m(0.125) + \frac{1}{5}(0.25)m$$

$$m = \frac{K}{0.175} = \frac{0.70}{0.175} = 4.0 \text{ kg}$$

Q18.

A 2.0-kg block is located on the x-axis 3.0 m from the origin and is acted upon by a force $\vec{F} = (8.0N)\hat{i}$. Find the net torque acting on the block relative to the origin.

A) 0.0
B) $-12\ \hat{k}$ N.m
C) $-24\ \hat{k}$ N.m
D) $+18\ \hat{k}$ N.m
E) $+24\ \hat{k}$ N.m

Ans:

$$\vec{F} = (8.0 \text{ N})\,\hat{i}$$

$$\vec{r} = 3.0\,\hat{i}$$

$$\vec{\tau} = \vec{r} \times \vec{F} = 0$$

Q19.

A 10.0-kg particle is moving in a horizontal circular path of radius 2.00 m with a constant angular speed of 10.0 rad/s. Find the magnitude of its angular momentum (in kg.m^2/s) about a vertical axis passing through the center of the circle.

A) 400
B) 40.0
C) 25.0
D) 50.0
E) 500

Ans:

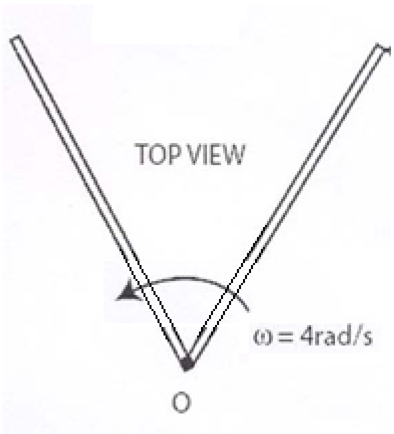
$$L = mvr = mr^2\omega$$

$$L = 10 \times 4 \times 10 \text{ kg.m}^2/\text{s} = 400 \text{ kg.m}^2/\text{s}$$

Q20.

Consider two identical thin rods each of length (L = 2.0 m) and mass 60 g, arranged on a frictionless table as shown in Fig. 6. The system rotates about a vertical axis through point O with constant angular speed of 4.0 rad/s. What is the angular momentum of the system about O?

Fig# 6



A) 0.64 kg.m^2/s
B) 0.54 kg.m^2/s
C) 1.5 kg.m^2/s
D) 0.27 kg.m^2/s
E) 0.0

Ans:

$$I = 2\left(\frac{1}{3}mL^2\right)$$

$$I = 2\left(\frac{1}{3} \times 0.06 \times 4\right) = 0.16 \text{ kg . m}^2$$

$$L = I\,\omega$$

$$L = 0.16 \times 4 = 0.64 \text{ kg . m}^2/\text{s}$$
