Q1. A light body and a heavy body have equal linear momenta. The one having the larger kinetic energy is:

A) The light body.
B) The heavy body.
C) Neither; they will have the same kinetic energy.
D) Dependent on the system of units used.
E) Not determinable without data on the ratio of the masses.

Ans:

$$KE = \frac{P^2}{2m}$$
$$\Rightarrow \frac{P^2}{2m} > \frac{P^2}{2M} \text{ for } M > m$$

Q2. Two particles of masses 3.00 kg and 5.00 kg are moving with velocities of: $(-3.00\hat{i} + 4.00\hat{j})$ m/s and $(2.00\hat{i} + 3.00\hat{j})$ m/s, respectively. They collide completely inelastically. Find the velocity of the center of mass after collision.

A) $(0.125\hat{i} + 3.38\hat{j}) m/s$
B) $(3.23\hat{i} + 4.32\hat{j}) m/s$
C) $(5.13\hat{i} + 1.34\hat{j}) m/s$
D) $(-9.00\hat{i} + 1.34\hat{j}) m/s$
E) $(10.0\hat{i} + 15.0\hat{j}) m/s$

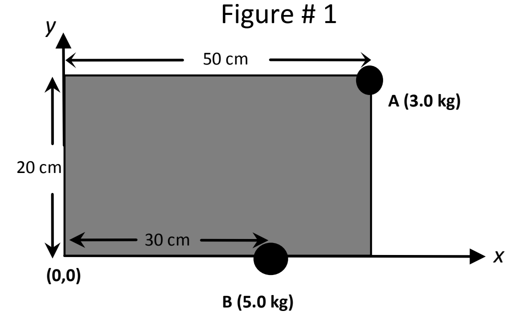
Ans:

$$v_{com,x} = \frac{m_1 v_{1x} + m_2 v_{2x}}{m_1 + m_2} = \frac{(3)(-3) + (5)(2)}{8} = 0.125 \text{ m/s}$$

$$v_{com,y} = \frac{m_1 v_{1y} + m_2 v_{2y}}{m_1 + m_2} = (3)(4) + (5)(3) = 3.38 \text{ m/s}$$

Q3. A uniform and thin rectangular piece of wood of width 20 cm and length 50 cm has a mass of 2.0 kg. Two point masses 3.0 kg and 5.0 kg are attached to it at points A and B, respectively (see **Figure 1**). Find the *x* and *y* coordinates, respectivelv. of the center of mass of the system relative to the origin.

Figure # 1



A) (35 cm, 8.0 cm)
B) (25 cm, 10 cm)
C) (30 cm, 20 cm)
D) (50 cm, 10 cm)
E) (20 cm, 20 cm)

Ans:

$$x_{com} = \frac{(5)(30) + (3)(50) + (2)(25)}{10} = 35 \text{ cm}$$

$$y_{com} = \frac{(2)(10) + (3)(20)}{10} = 8 \text{ cm}$$

Q4. A body, initially at rest, suddenly explodes into two fragments of masses 0.100 kg and 0.500 kg. The 0.500 kg fragment moves in the positive *x* direction. Of the energy released in the explosion, ONLY 9.60×10^3 J were converted into kinetic energy of the two fragments. Calculate the speed of 0.100 kg and 0.500 kg fragments, respectively.

A) 400 m/s, 80.0 m/s
B) 250 m/s, 150 m/s
C) 300 m/s, 300 m/s
D) 300 m/s, 500 m/s
E) 500 m/s, 300 m/s

Ans:

$$\vec{P}_{bef} = \vec{P}_{aft} \Rightarrow v_{f0.5} = 0.2\, v_{f0.1}$$

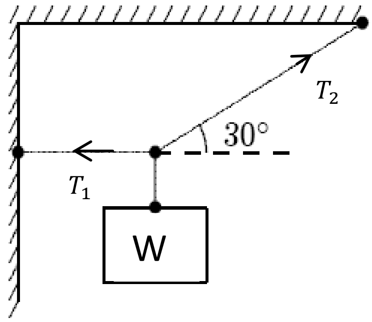
$$\Rightarrow KE_{tot} = KE_{0.1} + KE_{0.5}$$

$$9.6 \times 10^3 \text{ J} = \frac{1}{2}(0.1)v_{f0.1}^2 + \frac{1}{2}(0.5)v_{f0.5}^2$$

$$\Rightarrow v_{f0.1} = 400 \text{ m/s}, \qquad v_{f0.5} = (0.2)v_{f0.1} = 80 \text{ m/s}$$

Q5. A weight W = 100 N is hung from two ropes as shown in **Figure 2**. Find the magnitude of the tension in the horizontal rope.

Figure # 2



A) 173 N
B) 410 N
C) 650 N
D) 321 N
E) 258 N

Ans:

$$T_2 \sin 30 = 100 \Rightarrow T_2 = 200 \text{ N}$$

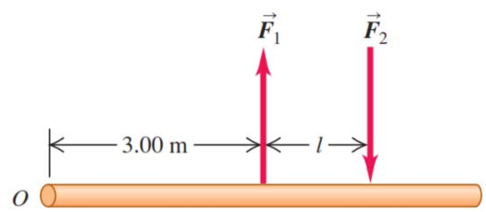
$$T_2 \cos 30 - T_1 = 0$$

$$(200)\cos 30 - T_1 = 0$$

$$\Rightarrow T_1 = 173 \text{ N}$$

Q6. Two antiparallel forces of equal magnitudes $F_1 = F_2 = 8.00$ N are applied to a rod as shown **Figure 3**. Find the distance l between the forces if the magnitude of the net torque due to these two forces about the end O is 6.40 N.m.

Figure # 3



A) 0.800 m
B) 0.540 m
C) 0.235 m
D) 0.458 m
E) 0.995 m

Ans:

$$\sum \tau_z = \tau_1 + \tau_2$$

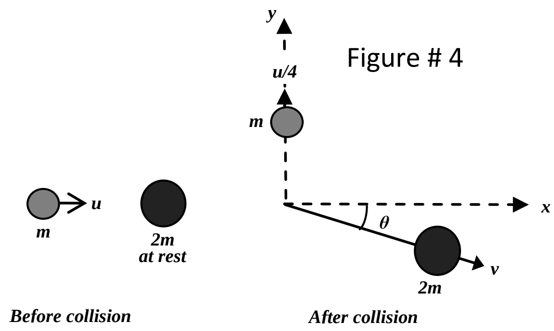
$$= (3)(8) - (8)(l + 3)$$

$$= 24 - 8l - 24 = 6.4 \text{ N} \cdot \text{m}$$

$$\Rightarrow l = 0.8 \text{ m}$$

Q7. A particle of mass *m* moving in the positive *x* direction with speed *u* collides with a particle of mass *2m* at rest. After collision, the particle of mass *m* scatters with speed *u/4* in the positive *y* direction and the particle of mass *2m* moves with speed *v* making an angle *θ* with the positive *x* direction (see **Figure 4**). Find the angle *θ*.

A) 14°
B) 25°
C) 35°
D) 45°
E) 55°



Ans:

$$\vec{P}_{before} = \vec{P}_{after}$$

x − axis:

$$mu + 0 = 2mv\cos\theta \rightarrow (1)$$

y − axis:

$$0 = \frac{mu}{4} - 2mv\sin\theta \rightarrow (2)$$

$$\Rightarrow \frac{(2)}{(1)} \Rightarrow \frac{1}{4} = \tan\theta \Rightarrow \theta = 14°$$

Q8. A force of 5.00×10^{3} N is applied outwardly perpendicular to one end of a 5.00 m long cylindrical rod with a radius of 34.0 cm and a Young's modulus of 1.25×10^{8} N/m^2, while the other end is tightly fixed to the wall. Find the elongation of the rod.

A) 0.551 mm
B) 0.263 mm
C) 0.149 mm
D) 0.348 mm
E) 0.644 mm

Ans:

$$\frac{F}{A} = E\,\frac{\Delta L}{L}$$

$$\Rightarrow \Delta L = \frac{F}{A}\cdot\frac{L}{E} = \frac{5\times10^{3}}{\pi(0.34)^2}\times\frac{5}{1.25\times10^{8}}$$

$$\Rightarrow \Delta L = 0.551\ \text{mm}$$

Q9. A constant torque of 25.0 N.m is applied to a disk that has a rotational inertia of 0.130 kg.m^2 about an axis passing through its center. Find the angular speed after the disk has made 15.0 revolutions starting from rest.

A) 190 rad/s
B) 120 rad/s
C) 155 rad/s
D) 138 rad/s
E) 105 rad/s

Ans:

$$\tau = I\alpha \rightarrow \alpha = \frac{\tau}{I} = \frac{25}{0.13} = 192.3 \text{ rad/s}^2$$

$$\theta = 15 \text{ rev} = 94.25 \text{ rad}$$

$$\Rightarrow w_f^2 = 0 + 2\alpha\theta = 2 \times 192.3 \times 94.25$$

$$\Rightarrow w_f = 190 \text{ rad/s}$$

Q10. A turntable rotates with constant 2.25 rad /s^2 angular acceleration. After 4.00 s it has rotated through an angle of 60.0 rad. What was the angular speed of the wheel at the beginning of the 4.00 s interval?

A) 10.5 rad/s
B) 20.6 rad/s
C) 15.8 rad/s
D) 42.6 rad/s
E) 32.7 rad/s

Ans:

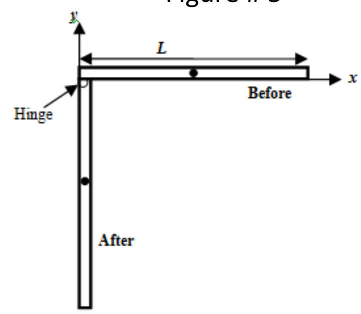
$$\theta - \theta_0 = w_0 t + \frac{1}{2}\alpha t^2$$

$$60 = w_0(4) + \frac{1}{2}(2.25)(4)^2$$

$$\Rightarrow w_0 = 10.5 \text{ rad/s}$$

Q11. A thin uniform rod with mass M and length L is hinged at one end and connected to the wall, as shown in **Figure 5**. Initially, the rod is held out horizontally then released. Then the magnitude of the rod's angular velocity just before it hits the wall:

Figure # 5



A) $\sqrt{\frac{3g}{L}}$

B) $\sqrt{\frac{2g}{L}}$

C) $\sqrt{\frac{7g}{4L}}$

D) $\sqrt{\frac{5g}{4L}}$

E) $\sqrt{\frac{L}{g}}$

Ans:

$$\frac{1}{2}I\omega^2 + Mgh = 0$$

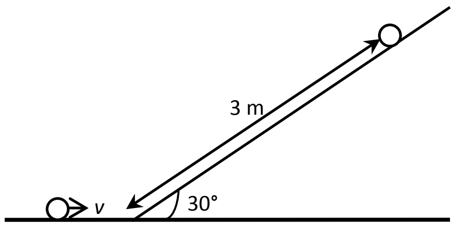
$$\frac{1}{2}\left(\frac{1}{3}ML^2\right)\omega^2 - Mg\frac{L}{2} = 0$$

$$h = -\frac{L}{2}$$

$$\Rightarrow \quad \omega = \sqrt{\frac{3g}{L}}$$

Q12. A uniform solid sphere is rolling without slipping along a horizontal surface with a speed of 5.50 m/s when it starts rolling up a ramp that makes an angle of 30.0° with the horizontal. Find the speed of the sphere after it has rolled 3.00 m up the ramp, measured along the surface of the ramp (see **Figure 6**).

Figure # 6



A) 3.04 m/s
B) 8.02 m/s
C) 1.91 m/s
D) 2.16 m/s
E) 5.37 m/s

Ans:

$$a = \frac{-g\sin\theta}{1 + I_{com/MR^2}}$$

$$I_{sphere} = \frac{2}{5} MR^2$$

$$\Rightarrow a = \frac{-9.8 \times \sin 30}{1 + \frac{2}{5}} = -3.5 \text{ m/s}^2$$

$$v_f^2 = v_0^2 + 2a\Delta x \Rightarrow v_f^2 = (5.5)^2 + (2)(-3.5)(3)$$

$$\Rightarrow v_f = 3.04 \text{ m/s}$$

Q13. The angular momentum of a system remains constant

A) When no net external torque acts on the system.
B) When the total kinetic energy is constant.
C) When no net external force acts on the system.
D) When the linear momentum and the energy are constant.
E) All the time since it is a conserved quantity.

Ans:

$$\vec{\tau} = \frac{d\vec{L}}{dt} = 0$$

$$\Rightarrow \vec{L} \textit{ is constant}$$

Q14. An object is rotating with an angular momentum of magnitude 20.0 kg.m^2/s in the east direction. A torque of magnitude 10.0 N.m in a direction of 30° north of east acts on the object for 5.00 s. Find the magnitude of angular momentum at the end of the 5.00 s interval.

A) 68.1 kg.m^2/s
B) 45.0 kg.m^2/s
C) 25.0 kg.m^2/s
D) 93.3 kg.m^2/s
E) 32.0 kg.m^2/s

Ans:

$$\vec{L}_{tot} = L\hat{\imath} + t\tau\cos 30\hat{\imath} + t\,\tau\sin 30\hat{\jmath}$$

$$= 20\hat{\imath} + (10)(5)\,(0.866)\hat{\imath} + (5)(10) + \left(\frac{1}{2}\right)\hat{\jmath} = 63.3\,\hat{\imath} + 25\hat{\jmath}$$

$$\Rightarrow |\vec{L}| = \sqrt{(63.3)^2 + (25)^2} = 68.1\text{ kg.m}^2/\text{s}$$

Q15. A piece of putty is dropped vertically onto a freely rotating turntable and gets stuck to the turntable. If the rotational inertia of the putty about the center of the turntable is 0.54 times that of the turntable about its center. Find the ratio of the final rotational kinetic energy to the initial rotational kinetic energy of the turntable.

A) 0.65
B) 0.18
C) 0.46
D) 0.28
E) 0.87

Ans:

$$L_i = L_f$$

$$I_t W_{it} = (I_t + I_P)\,w_f$$

$$\Rightarrow w_f = \frac{w_{it}}{1.54} \;\Rightarrow\; K_i = \frac{1}{2} I_t w_i^2 \text{ and } K_f = \frac{1}{2} I_f w_f^2$$

$$\frac{K_f}{K_i} = 0.65$$
