Q1.

A car with a mass of 1.20×10^3 kg travelling to the right at a speed of 15.0 m/s collides head-on with a truck of mass 2.00×10^3 kg travelling at a speed of 15.0 m/s to the left. The vehicles stick together when they collide. Find their kinetic energy after collision.

A) 2.25×10^4 J
B) 1.40×10^4 J
C) 4.50×10^4 J
D) 3.60×10^5 J
E) 0

Ans:

$$K = \frac{1}{2}(m_1 + m_2)V^2 = 2.25 \times 10^4 J$$

To get $V_{after} \Rightarrow m_1V_1 + m_2V_2 = (m_1 + m_2)V$

$$V = \frac{\left(1.2 \times 10^3 \times 15 + 2 \times 10^3 \times (-15)\right)}{3.2 \times 10^3} = -3.75 \text{ m/s}$$

Q2.

The linear momentum of a system of colliding particles is conserved only if:

A) There are no external forces acting on the system.
B) The external forces equal to the internal forces.
C) The kinetic energy is conserved.
D) The collision is completely inelastic.
E) The collision is elastic.

Ans:

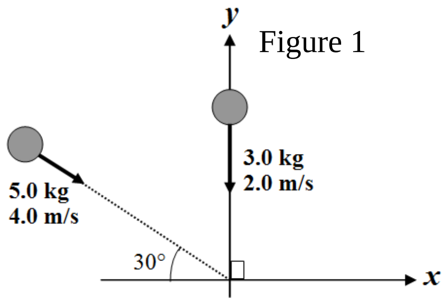
$$\vec{F}_{ext} = \frac{d\vec{p}}{dt} = 0$$

Q3.

Figure 1 shows two masses; 3.0 kg and 5.0 kg moving with velocities 2.0 m/s and 4.0 m/s, respectively. The masses collide and stick together. Find the final velocity (in m/s) of the combined mass.

A) $2.2\hat{i} - 2.0\hat{j}$
B) $2.6\hat{i} + 4.8\hat{j}$
C) $3.4\hat{i} - 3.1\hat{j}$
D) $0.2\hat{i} - 0.2\hat{j}$
E) $1.1\hat{i} - 1.2\hat{j}$

Figure 1



Ans:

$$m_1\vec{V}_1 + m_2\vec{V}_2 = (m_1 + m_2)\vec{V}$$

$$(3)(-2\hat{j}) + (5)(2\hat{i} - 3.46\hat{j}) = 8\vec{V}$$

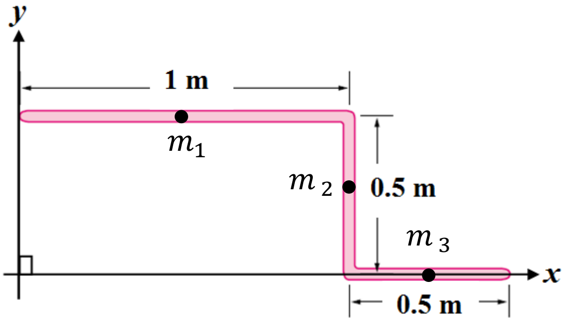
$$\vec{V} = 2.21\,\hat{i} - 2.0\hat{j}$$

Q4.

A thin uniform wire of 2 m total length and 4 kg mass is bent into the shape shown in **Figure 2**. Find the coordinates (in m) of the center of mass of this shape.

A) (0.8, 0.3)
B) (0.8, 0.5)
C) (0.5, 0.2)
D) (0.5, 0.3)
E) (0.5, 0.8)

Figure 2



Ans:

$$M_1 = \frac{M}{L} \times 1 = 2\text{ Kg}$$

$$M_2 = \frac{M}{L} \times (0.5) = 1\text{ Kg}$$

$$M_3 = 1\text{ Kg}$$

$$x_{com} = \frac{(2)(0.5) + (1)(1) + (1)(1.25)}{4} = 0.81\,m$$

$$y_{com} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{4} = 0.3\,m$$

Q5.

Force $\vec{F} = (3\hat{i} + \hat{j})N$ is acting on a particle with position vector $\vec{r} = (2\hat{i} + 4\hat{j})m$. What is resulting torque on the particle about a point (x = – 1 m, y = 6 m)?

A) $9\hat{k}$ N.m
B) $-9\hat{k}$ N.m
C) $14\hat{k}$ N.m
D) $-14\hat{k}$ N.m
E) $5\hat{k}$ N.m

Ans:

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

$$= [(2-^{-1})\hat{\imath} + (4-6)\hat{\jmath}] \times (3\hat{\imath} + \hat{\jmath})$$

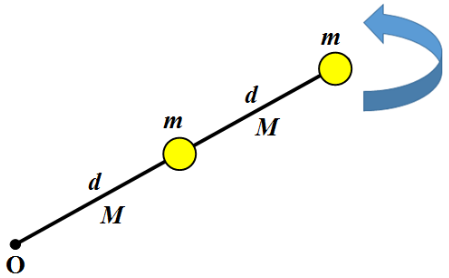
$$= 9\,\hat{k}\,N \cdot m$$

Q6.

In **Figure 3**, two particles, each with mass m = 0.85 kg, are fastened to each other, and to a rotation axis at O, by two thin rods, each with length d = 5.6 cm and mass M = 1.2 kg. The combination rotates around the axis at point O with an angular speed ω = 0.35 rad/s. Find the total kinetic energy of the system.

A) 1.4×10^{-3} J
B) 3.1×10^{-3} J
C) 5.5×10^{-3} J
D) 1.5×10^{-2} J
E) 1.9×10^{-3} J

Figure 3



Ans:

$$I_1 = m_1(2d)^2 = 0.0107 \text{ kgm}^2$$

$$I_2 = m_2 d^2 = 0.0027 \text{ kg m}^2$$

$$I_3 = \frac{1}{12}md^2 + m\left(\frac{d}{2}\right)^2 = 0.0088 \text{ kg m}^2$$

$$I_4 = \frac{1}{12}md^2 + m\left(\frac{3d}{2}\right)^2 = 0.00125 \text{ kg m}^2$$

$$I_{tot} = 0.0234 \text{ kg m}^2$$

$$K = \frac{1}{2}I\omega^2 = 1.4 \times 10^{-3}\,J$$

Q7.

A wheel is initially rotating at an angular speed of 18 rad/s. If the wheel is slowed down at a rate of 2.0 rad/s^2, then find the angular displacement by time it stops.

A) 81 rad
B) 23 rad
C) 87 rad
D) 69 rad
E) 65 rad

Ans:

$$\omega_f = \omega_o + \alpha t$$

$$0 = 18 - 2t \Rightarrow t = 9\ s$$

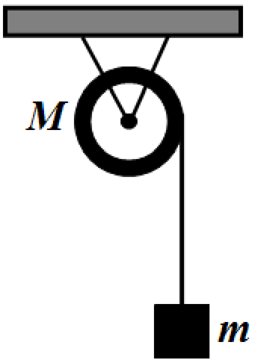
$$\theta - \theta_0 = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\Rightarrow \Delta\theta = 81\ \text{rad}$$

Q8.

In **Figure 4**, a block of mass *m* =1.00 kg hangs from a massless cord that is wrapped around the rim of a disk of mass *M* = 3.00 kg and radius *R* = 10.0 cm. Find the magnitude of the block's acceleration.

Figure 4



A) 3.92 m/s^2
B) 2.21 m/s^2
C) 1.97 m/s^2
D) 4.65 m/s^2
E) 9.81 m/s^2

Ans:

$$\text{mg} - \text{T} = \text{ma}$$

$$\text{TR} = \text{I}\frac{a}{R} \Rightarrow mg = a\left(m + \frac{I}{R^2}\right)$$

$$\Rightarrow \text{a} = \frac{9.8}{2.5} = 3.92\ m/s^2$$

Q9.

Two cylinders of the same size and mass roll without slipping down an incline, starting from rest. Cylinder *A* has most of its mass concentrated at the rim, while cylinder *B* has most of its mass concentrated at the center. Find the correct statement.

A) Cylinder *B* will reach the bottom of the incline first.
B) Cylinder *A* will reach the bottom of the incline first.
C) Both cylinders will reach the bottom at the same time.
D) The incline is frictionless.
E) Cylinder A will have higher acceleration than cylinder B.

Ans:

$$\mathrm{I}_B < \mathrm{I}_A$$

$$\mathrm{a} = \frac{\mathrm{g}\sin\theta}{1 + \mathrm{I}/\mathrm{mR}^2}$$

$$\mathrm{a}_B > \mathrm{a}_A$$

Q10.

A disk has a rotational inertia of 6.0 kg.m^2 and a constant angular acceleration of 2.0 rad/s^2. If the disk starts from rest, then find the work done during the first 5.0 s by the net torque acting on it.

A) 300 J
B) 200 J
C) 100 J
D) 400 J
E) 0

Ans:

$$\mathrm{P} = \frac{\mathrm{W}}{\mathrm{t}} = \tau\mathrm{W}$$

$$\Rightarrow \mathrm{W} = 300\ \mathrm{J}$$

Q11.

A car of total mass 1000 kg has four wheels each of 10 kg mass and moves with speed *v*. What fraction of its total kinetic energy is due to the rotation of the wheels about their axles? [Assume that the wheels are uniform disks of the same mass and size].

A) 0.02
B) 0.03
C) 0.04
D) 0.05
E) 0.06

Ans:

$$(\mathrm{ICE})_{tot} = \frac{1}{2}M_{com}V_{com}^2 + 4\left(\frac{1}{2}I_{com}\omega^2\right)$$

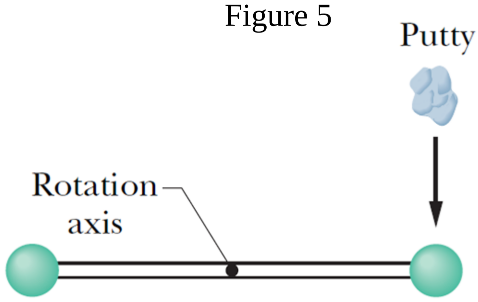
$$Fraction = \frac{M_{wheel}}{\frac{1}{2}M_{car} + M_{wheel}} = 0.02$$

Q12.

In **Figure 5**, two 2.00 kg balls are attached to the ends of a thin rod of length 50.0 cm and negligible mass. The rod is free to rotate in a vertical plane without friction about a horizontal axis through its center. With the rod initially horizontal, a 50.0 g piece of putty (wet mud) drops onto one of the balls, hitting it with speed of 3.00 m/s and sticking to it. Find the angular speed of the system just after the putty hits.

A) 0.148 rad/s
B) 0.296 rad/s
C) 0.228 rad/s
D) 0.318 rad/s
E) 0.102 rad/s

Figure 5



Ans:

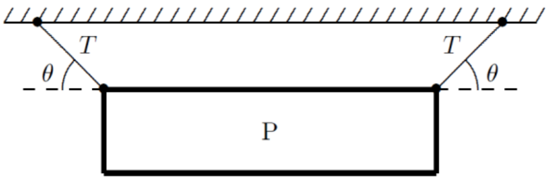
$$\mathrm{m_p v_p r} = \left(\mathrm{I_{masses}} + \mathrm{I_{putty}}\right)\omega$$

$$\Rightarrow \omega = 0.148\ \mathrm{rad/s}$$

Q13.

Figure 6 shows a picture P hanging by two strings making angle θ = 30° with the dashed horizontal line. If the magnitude of the tension force *T* of each string is 20 N, then the weight of the picture is:

Figure 6



A) 20 N
B) 10 N
C) 17 N
D) 40 N
E) 25 N

Ans:

$$2T\sin\theta = W$$

$$(2)(20)\left(\frac{1}{2}\right) = W$$

$$20\ \text{N} = W$$

Q14.

A steel wire 2.3 mm in diameter with one end fixed to a ceiling stretches by 0.030% when an object is suspended from its other end. If the steel Young Modulus is 200×10^{9} N/m^2, then find the mass of the suspended object.

A) 25 kg
B) 21 kg
C) 17 kg
D) 29 kg
E) 15 kg

Ans:

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

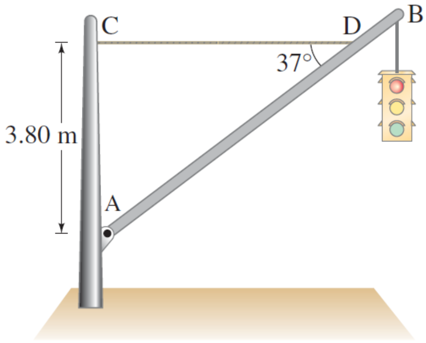
$$\frac{\Delta L}{L} = 0.03 \times 10^{-2}$$

$$\Rightarrow m = 25\ \text{kg}$$

Q15.

A traffic light hangs from a pole AB as shown in **Figure 7**.The uniform aluminum pole AB is 7.20 m long and has a mass of 12.0 kg. The mass of the traffic light is 21.5 kg. Find the tension in the horizontal massless cable CD

Figure 7



A) 408 N
B) 328 N
C) 570 N
D) 370 N
E) 608

Ans:

$$W_{TL} \times L_{AB}\cos\theta + W_{Pole}\frac{L_{AB}}{2}\cos\theta = TCA$$

$$\Rightarrow T = 408 \text{ N}$$