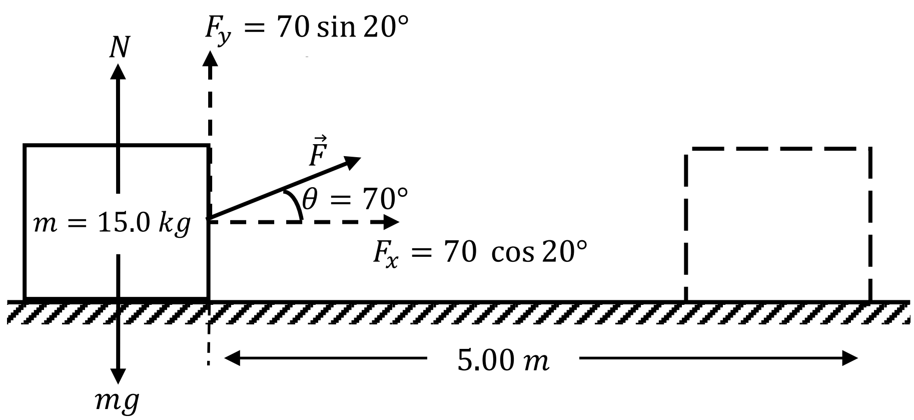
phys101-T102-second major

Q1.

A 15.0-kg block is pulled over a rough, horizontal surface by a constant force of 70.0 N acting at an angle of 20.0° above the horizontal. The block is displaced 5.00 m, and the coefficient of kinetic friction between the block and the horizontal surface $\mu_k = 0.200$. Find the work done by the force of friction.

A) − 123 J
B) + 123 J
C) − 147 J
D) + 147 J
E) − 329 J

Solution:



$W_f = -fd$ and $f = \mu_k N = \mu_k\ (mg - F \sin 20°)$

$f = 0.20\ (15 * 9.8 - 70 \sin 20°) = 24.6\ N$

$\therefore W_f = -24.6 * 5.0 = -123$ J

Sec# Kinetic Energy and Work - Work and kinetic Energy

Stat# A_28_DIS_0.26_PBS_0.26_B_9_C_38_D_9_E_17_EXP_49_NUM_581

Q2.

An elevator is designed to carry a load of 20.0×10^3 N from the ground to a height of 87.5 m in a time of 18.0 seconds. What is the average power that must be supplied by the motor of the elevator to lift this load?

A) 97.2×10^3 W
B) 78.4×10^3 W
C) 65.6×10^3 W
D) 89.2×10^4 W
E) 45.7×10^4 W

Solution:

$$\mathrm{P}_{avg} = \frac{W}{t}; \quad W = mgh$$

$$\therefore \; \mathrm{P}_{avg} = \frac{mgh}{t} = \frac{20.0 * 10^3 * 87.5}{18.0} = 97.2 \times 10^3 \text{ W}$$

Sec# Kinetic Energy and Work - Power

Stat# A_86_DIS_0.26_PBS_0.27_B_4_C_4_D_3_E_4_EXP_50_NUM_581

Q3.

A certain force $\vec{F}$ is acting on a body of mass m = 3.0 kg and changes its velocity from an initial value $\vec{v}_o = (6.0\hat{i} - 2.0\hat{j})$ m/s to a final value $\vec{v} = (8.0\hat{i} + 4.0\hat{j})$ m/s. Find the work done by $\vec{F}$.

A) 60 J
B) 55 J
C) 50 J
D) 80 J
E) 90 J

Solution:

$$W = \Delta K$$

$$\Delta K = \frac{1}{2} mv^2 - \frac{1}{2} mv_0{}^2 ; \quad v^2 = 80 \; m^2/s^2; \quad v_0{}^2 = 40 \; m^2/s^2$$

$$= \tfrac{1}{2} * 3 \, (80 - 40) = 60 \text{ J}$$

$$\Rightarrow W = 60 \text{ J}$$

Sec# Kinetic Energy and Work - Work and kinetic Energy

Stat# A_64_DIS_0.43_PBS_0.34_B_9_C_11_D_6_E_10_EXP_60_NUM_581

Q4.

A man pulls a box up a rough inclined plane at constant speed. Which one of the following statements is **FALSE**?

A) The work done on the box by the gravitational force is zero.
B) The gravitational potential energy of the box increases.
C) The net work done by all the forces acting on the box is zero.
D) The work done on the box by the normal force of the plane is zero.
E) The man does positive work in pulling the box up the incline.

Ans.

A.

Sec# Kinetic Energy and Work - Work done by the Gravitational Force

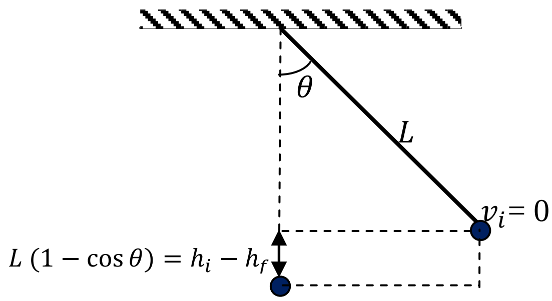
Stat# A_43_DIS_0.48_PBS_0.37_B_13_C_22_D_9_E_13_EXP_51_NUM_581

Q5.

A small mass suspended from a string of length 0.20 m is pulled sideways until the string makes an angle ϕ = 60° with the vertical. It is then released from rest. Find the speed of the mass when it passes through the lowest point of its path during its motion.

A) 1.4 m/s
B) 1.9 m/s
C) 2.4 m/s
D) 2.9 m/s
E) 3.4 m/s

Solution:



$$E_i = E_f \implies \frac{1}{2}m{v_i}^2 + mgh_i = \frac{1}{2}m{v_f}^2 + mgh_f$$

$$mgL(1-\cos\theta) = \frac{1}{2}m{v_f}^2 \implies {v_f}^2 = 2gL(1-\cos 60°) = 1.96\,m^2/s^2$$

$$v_f = 1.4\,m/s$$

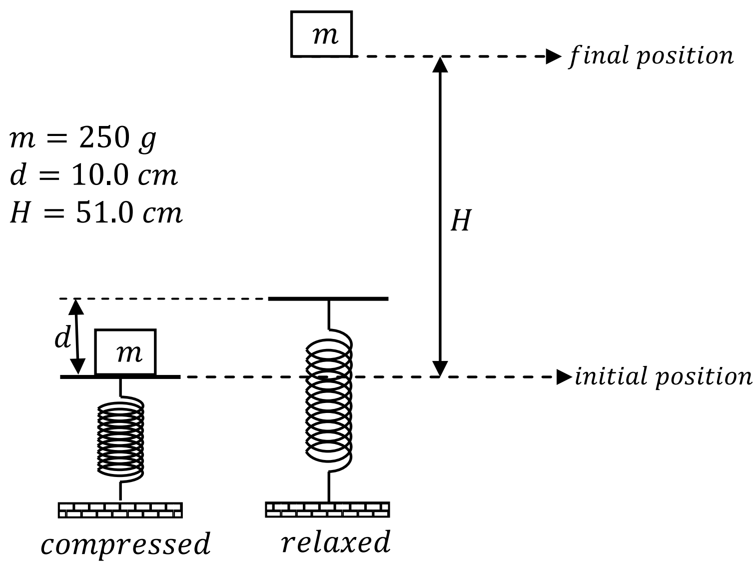
Sec# Potential Energy And Conservation of Energy - Conservation of Mechanical Energy

Stat# A_38_DIS_0.57_PBS_0.46_B_25_C_18_D_10_E_9_EXP_44_NUM_581

Q6.

As shown in **Figure 1**, a 250 g mass is fired vertically upward using a spring. The spring must be compressed d =10.0 cm from its relaxed position if the mass is to just reach a maximum height H = 51.0 cm above the mass's initial position on the compressed spring. Find the spring constant of the spring.

A) 250 N/m
B) 300 N/m
C) 150 N/m
D) 173 N/m
E) 223 N/m



Solution:

$$\begin{Bmatrix} \Delta K = 0 \\ \Delta U_g = mgH \\ \Delta U_s = -\frac{1}{2}kd^2 \end{Bmatrix}$$

$$\Delta K + \Delta u_g + \Delta u_s = 0$$

$$mgH - \frac{1}{2}kd^2 = 0 \Longrightarrow k = \frac{2mgH}{d^2}$$

$$= \frac{2 * 2.50 * 9.8 * 0.51}{0.10^2} = 249.9\frac{N}{m} = 250\ N/m$$

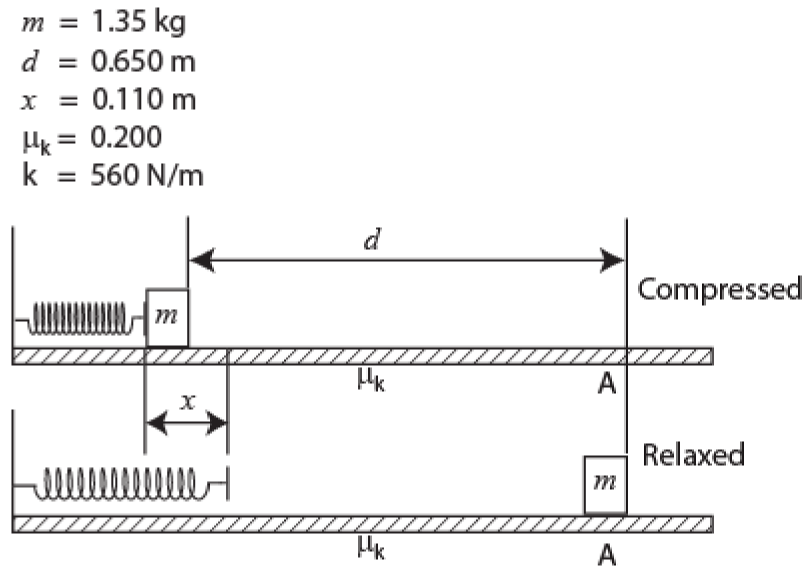
Sec# Potential Energy and Conservation of Energy - Conservation of Mechanical Energy

Stat# A_56_DIS_0.52_PBS_0.39_B_13_C_8_D_10_E_12_EXP_45_NUM_581

Q7.

As shown in **Figure 2**, a block of mass m = 1.35 kg is held against a compressed spring of spring constant k = 560 N/m. The spring is compressed by x = 0.110 m. The block is released and slides a distance d = 0.650 m to point A. Find the speed of the block at point A if the coefficient of kinetic friction between the block and the surface is μ_k = 0.200.

A) 1.57 m/s
B) 3.45 m/s
C) 7.54 m/s
D) 10.3 m/s
E) 4.21 m/s



Solution:

$$\begin{Bmatrix} \Delta K = \frac{1}{2} m v_A{}^2 - 0 \\ \Delta U_g = 0 \\ \Delta U_s = -\frac{1}{2} k x^2 \\ f = \mu_k m g \end{Bmatrix}$$

$$\Delta K + \Delta U_g + \Delta U_s = -fd$$

$$\frac{1}{2} m v_A{}^2 + 0 - \frac{1}{2} k x^2 = -\mu_k m g d$$

$$v_A{}^2 = \frac{k}{m} x^2 - 2\mu_k g d = \frac{560}{1.35} * (0.110)^2 - 2 * 0.20 * 9.8 * 0.65$$

$$v_A{}^2 = 2.47 \Longrightarrow v_A = 1.57\ m/s$$

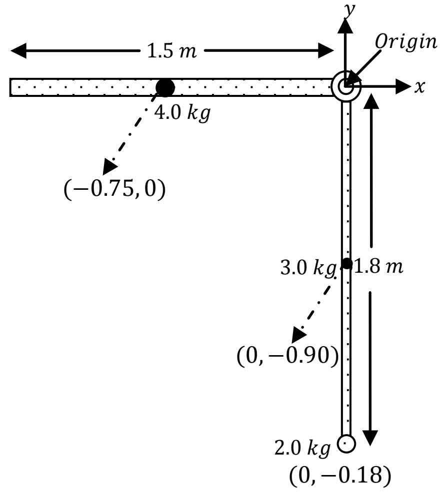
Sec# Potential Energy And Conservation of Energy - Conservation of Mechanical Energy

Stat# A_42_DIS_0.57_PBS_0.43_B_17_C_16_D_9_E_16_EXP_43_NUM_581

Q8.

An object consists of a uniform 4.0-kg rod of length 1.5 m which is hinged perpendicular to another uniform rod of length 1.8 m and mass 3.0 kg (see **Figure 3**). The longer rod has a 2.0-kg ball at one end. What are the coordinates of the center of mass of the system? Treat the ball as a point particle.

A) (– 0.33, – 0.70) m
B) (– 0.33, + 0.70) m
C) (+ 0.33, – 0.70) m
D) (+ 0.33, + 0.70) m
E) (– 0.70, + 0.33) m



Solution:

$i)\ Find\ COM\ for\ the\ rod\ 1.5\ m: (-0.75, 0)m$
$ii)\ Find\ COM\ for\ the\ rod\ 1.8\ m: (0, -0.90)m$
$iii)\ 2Kg: (0, -1.8)m$

$$x_{cm} = \frac{4(-0.75)}{9} = -0.33\ m$$

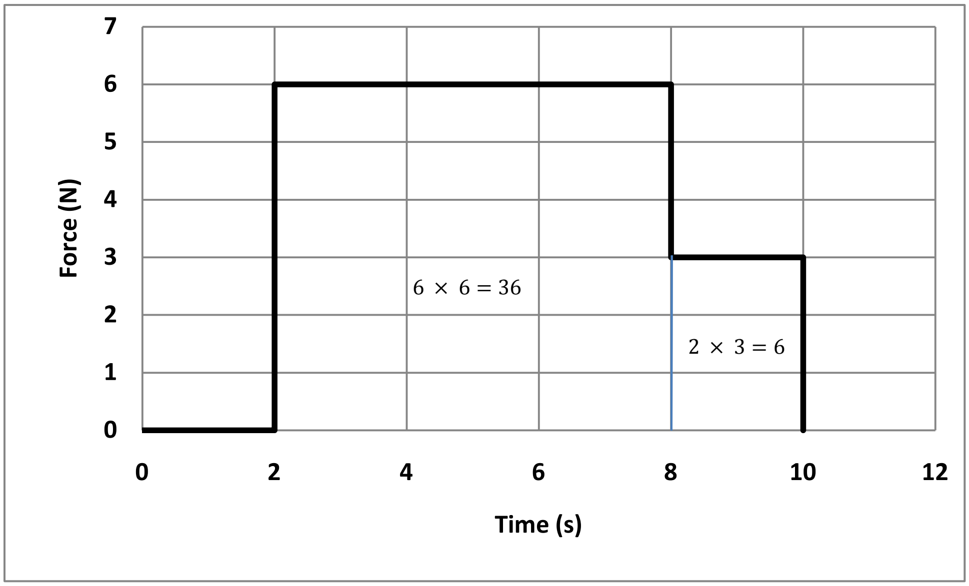
$$y_{cm} = \frac{3(-0.90) + 2(-1.80)}{9} = -0.70\ m$$

Sec# Center of Mass and Linear Momentum - The Center of Mass

Stat# A_66_DIS_0.54_PBS_0.41_B_8_C_9_D_4_E_12_EXP_51_NUM_581

Q9.

At time t = 0, a 3.0-kg block slides along a frictionless surface with a constant speed of 5.0 m/s in the positive x-direction. A horizontal, time dependent force is applied along the positive x-direction to the block as shown in **Figure 4**. What is the speed of the block at *t* = 10 seconds?



A) 19 m/s
B) 5.0 m/s
C) 25 m/s
D) 75 m/s
E) 16 m/s

Solution:

$$\text{Impulse} = \Delta p = p_f - p_i = \text{Area} = 42$$

$$\therefore mv_f - mv_i = 42$$

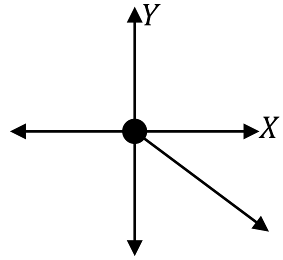
$$v_f = \frac{42}{m} + v_i = \frac{42}{3} + 5.0 = 19\ m/s$$

Stat# A_33_DIS_0.56_PBS_0.50_B_37_C_13_D_8_E_9_EXP_44_NUM_581

Q10.

An object is at rest at the origin. It explodes into three equal pieces. One piece moves to the west. What are the possible directions of motion of the other two pieces?

A) north, south-east
B) north, north-east
C) south, south-east
D) south, south-west
E) east, north



Ans.

A

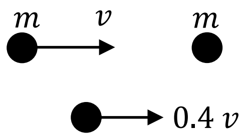
Sec# Center of Mass and Linear Momentum - Conservaton of Linear Momentum

Stat# A_53_DIS_0.37_PBS_0.30_B_5_C_5_D_13_E_24_EXP_45_NUM_581

Q11.

Two objects with the same mass move along the same line in opposite directions. The first object is moving with speed *v* to the right. The two objects collide in a perfectly inelastic collision and move with speed 0.40 *v* to the right, just after the collision. What was the speed of the second object before the collision?

A) 0.20 *v*
B) 0.60 *v*
C) 1.8 *v*
D) 2.0 *v*
E) 0.50 *v*



Solution:

Conservation of linear momentum $\vec{P_i} = \vec{P_f}$

$$m\vec{v_1} + m\vec{v_2} = (m_1 + m_2)\vec{v_f} \Rightarrow \cancel{m}v_1 - \cancel{m}v_2 = 2\cancel{m}v_f$$

$$v_2 = v_1 - 2v_f = v - 2 + 0.4\,v = 0.2\,v$$

Sec# Center of Mass and Linear Momentum - Inelastic Collisions in One Dimension

Stat# A_48_DIS_0.43_PBS_0.36_B_37_C_8_D_3_E_4_EXP_56_NUM_581

Q12.

A uniform disk is rotating about an axis perpendicular to its plane and passing through a point on its edge. Find the ratio of its moment of inertia about this axis of rotation to its moment of inertia about a parallel axis passing through its center of mass.

A) 3
B) 9
C) $\sqrt{3}$
D) 3/4
E) 1/3

Solution:

$$I_{COM} = \frac{1}{2}MR^2$$

$$I_{rot} = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

$$\frac{I_{rot}}{I_{COM}} = 3$$

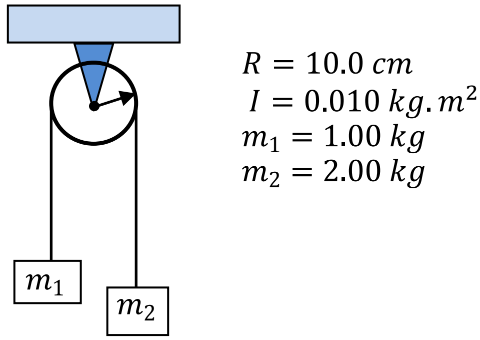
Sec# Rotation - Rotational Inertia

Stat# A_34_DIS_0.45_PBS_0.41_B_8_C_11_D_20_E_28_EXP_56_NUM_581

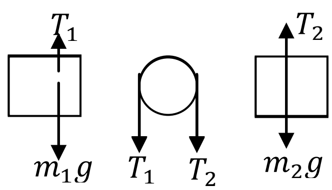
Q13.

Two objects of masses m_1 = 1.00 kg and m_2 = 2.00 kg hang at the ends of a massless string that passes over a pulley of radius R = 10.0 cm and moment of inertia I = 0.010 kg.m^2, as shown in **Figure 5**. What is the linear acceleration of the masses?

A) 2.45 m/s^2
B) 9.80 m/s^2
C) 4.50 m/s^2
D) 2.00 m/s^2
E) 3.34 m/s^2



Solution:



m_1: $\quad T_1 - m_1 g = m_1 a$ —— ①

m_{21}: $\quad m_2 g - T_2 = m_2 a$ —— ②

M: $\quad (T_2 - T_1)R = I\alpha$

$$T_2 - T_1 = \frac{I\alpha}{R} = \frac{I\alpha}{R^2} \quad \text{——} ③$$

① + ② + ③ :

$$m_2 g - m_1 g = \left(m_1 + m_2 + \frac{I}{e^2}\right) a$$

$$a = \frac{(m_2 - m_1)g}{m_1 + m_2 + \frac{I}{R^2}} = \frac{(2-1)9.8}{1+2+1} = 2.45\ m/s^2$$

Sec# Rotation - Rotation with Constant Angular Acceleration

Stat# A_23_DIS_0.14_PBS_0.17_B_29_C_14_D_13_E_21_EXP_51_NUM_581

Q14.

A constant torque of 10.0 N·m accelerates an object from rest to an angular speed of 10.0 rad/s after a rotation of π/2 radians. What is the moment of inertia of the object about the rotational axis?

A) 0.314 kg.m^2
B) 2.14 kg.m^2
C) 41.3 kg.m^2
D) 14.3 kg.m^2
E) 0.123 kg. m^2

Solution:

$$\tau = I\alpha \implies I = \frac{\tau}{\alpha}; \quad To\ find\ \alpha\ we\ use$$

$$w_f{}^2 - w_i{}^2 = 2\alpha\Delta\theta \implies \alpha = \frac{w_f{}^2}{2\Delta\theta}$$

$$\alpha = 31.82\ \frac{rad}{s^2}$$

$$\therefore I = \frac{10}{31.82} = 0.314\ \ kg \cdot m^2$$

Sec# Rotation - Newton's Second Law for Rotation

Stat# A_50_DIS_0.64_PBS_0.47_B_14_C_10_D_17_E_9_EXP_63_NUM_581

Q15.

The angular position of a rotating disk is given by $\theta(t) = t^2 - 10t + 2$, where θ is in radians and *t* is in seconds. Find the time at which the disk reverses its rotational direction.

A) 5 s
B) 2 s
C) 10 s
D) The rotational direction of the disk never changes
E) 0.20 s

Solution:

$$\theta(t) = t^2 - 10t + 2$$

It will reverse its rotational direction when its velocity becomes zero

$$w = \frac{d\theta}{dt} = 2t - 10 = 0; \quad t = 5.0\ s$$

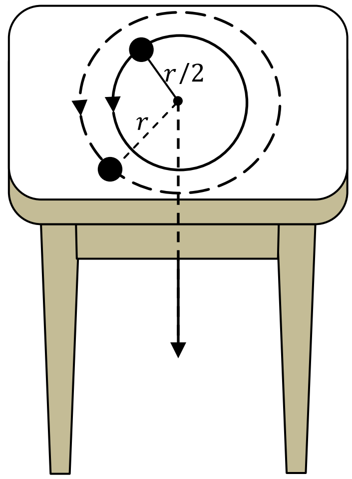
Sec# Rotation - The Rotational Variables

Stat# A_48_DIS_0.53_PBS_0.41_B_9_C_9_D_26_E_8_EXP_50_NUM_581

Q16.

A small disk, tied to one end of a light string, moves with speed *v* in a circular path of radius *r*, on a horizontal, frictionless table. The string passes through a hole in the center of the table as shown in **Figure 6**. If the string is slowly pulled down, thereby reducing the radius of the path of the disk to half its initial value, the new speed of the disk is:

A) $2v$
B) $v/2$
C) $v/4$
D) $4v$
E) v



$[r_1 = 2r_2 \ and \ v_1 = v]$

Solution:

Conservation of angular momentum:

$$L_i = L_f$$

$$\not{m}v_1 r_1 = \not{m}v_2 r_2 \implies v_2 = \frac{r_1}{r_2} v_1 = 2v$$

$$v_2 = 2v$$

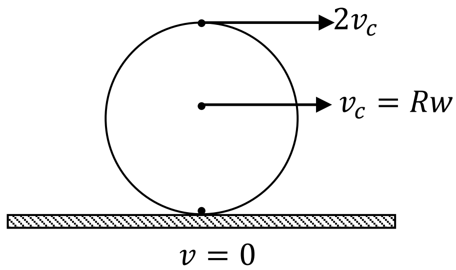
Sec# Rolling, Torque and Angular Momentum - Conservation of Angular Momentum

Stat# A_34_DIS_0.23_PBS_0.19_B_24_C_17_D_13_E_12_EXP_49_NUM_581

Q17.

A wheel of 0.25-m radius is rolling without sliding at a constant angular speed of 10 rad/s. What is the linear speed of a point at the top of the wheel?

A) 5.0 m/s
B) 10 m/s
C) 0.25 m/s
D) 2.5 m/s
E) 25 m/s



Solution:

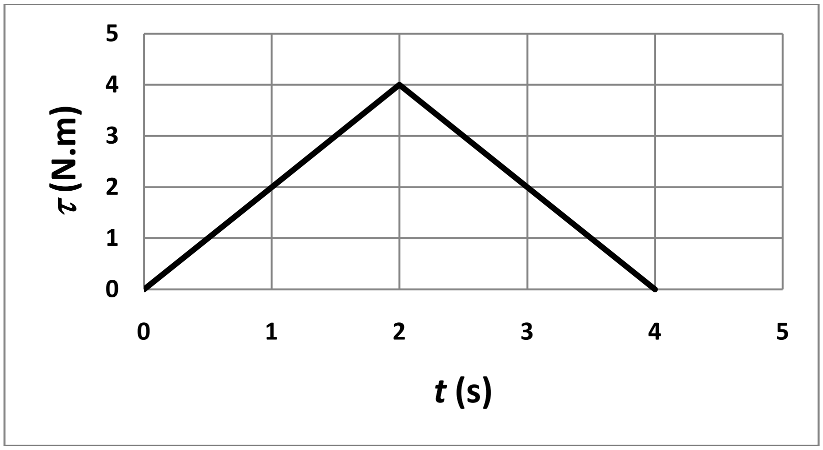
$v_{top} = 2Rw$

$= 2 * 0.25 * 10 = 5.0\ m/s$

Stat# A_23_DIS_0.43_PBS_0.38_B_6_C_3_D_60_E_8_EXP_55_NUM_581

Q18.

Figure 7 shows a graph of a torque applied to a rotating body as a function of time. What is the angular momentum of the rotating body at t = 4.0 s, assuming it was initially at rest?



A) 8.0 kg·m^2/s
B) 4.0 kg·m^2/s
C) 16 kg·m^2/s
D) 0
E) 2.0 kg·m^2/s

Solution:

$$\tau = \frac{dL}{dt} \Longrightarrow \Delta L = \int \tau dt$$

$$\therefore\ L_f - L_i = Area\ under\ the\ curve$$

$$L_f = Area = \frac{1}{2}(4)(4) = 8.0\ kg \cdot m^2/s$$

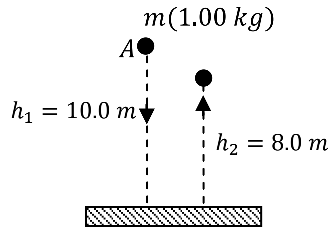
Sec# Rolling, Torque and Angular Momentum - Newton's Second Law in Angular Form

Stat# A_40_DIS_0.48_PBS_0.38_B_8_C_9_D_34_E_8_EXP_50_NUM_581

Q19.

A 1.00 kg ball falls to the ground from a height of 10.0 m and bounces back to a height of 8.00 m. What is the total work done by the gravitational force on the ball?

A) +19.6 J
B) −19.6 J
C) −176 J
D) +176 J
E) Zero



Solution:

i. $Work\ done\ by\ the\ gravitational\ force\ (W_{gravity})\ when\ m\ goes\ from\ point\ A\ to\ the\ ground\ = +mgh_1$

ii. $W_{gravity}\ when\ m\ goes\ from\ ground\ to\ point\ B = -mgh_2$

$$W_{total} = mg(h_1 - h_2) = 1 * 9.8 * 2 = +19.6\ J$$

Sec# Kinetic Energy and Work - Work done by the Gravitational Force

Stat# A_47_DIS_0.22_PBS_0.18_B_37_C_5_D_8_E_3_EXP_60_NUM_581

Q20.

A rigid body is initially at rest. At time $t = 0$, it is given a constant angular acceleration of 0.060 rad/s^2. Find the magnitude of the centripetal acceleration of a point that is a distance of 2.5 m from the axis of rotation at $t = 8.0$ s.

A) 0.58 m/s^2
B) 0.15 m/s^2
C) 0.68 m/s^2
D) 0.48 m/s^2
E) 0.38 m/s^2

Solution:

$$\alpha = 0.060\ \frac{rad}{s^2}$$

$$\omega = \omega_0 + \alpha t = 0 + 0.06\ * 8 = 0.48\frac{rad}{s}$$

$$a_c = a_r = \frac{v^2}{r} = r\omega^2(\omega\ at\ t = 8.0\ s)$$

$$\therefore\ a_c = a_r = 2.5\ * (0.48)^2 = 0.576\ \frac{m}{s^2} = 0.58\frac{m}{s^2}$$

Sec# Rotation - Relating the Linear and Angular Variables

Stat# A_38_DIS_0.57_PBS_0.46_B_24_C_9_D_14_E_14_EXP_50_NUM_581