Q1.

A 3.00 x 10^3 N automobile accelerates from rest to 50.0 m/s in 6.00 s with a constant acceleration. Calculate the instantaneous power delivered by the engine at t = 6.00 s.

A) 12.8 x 10^4 W
B) 15.0 x 10^4 W
C) 9.45 x 10^5 W
D) 24.5 x 10^3 W
E) 4.51 x 10^7 W

Ans:

$$P=\vec{F}\times\vec{v}=(ma)v=m\left(\frac{v-v_0}{t}\right)v=12.8\times10^4\ W$$

Q2.

A man pushes a 30.0 kg box a horizontal distance of 4.50 m along a level floor at a constant velocity. The coefficient of kinetic friction between the box and the floor is 0.250. Find the total work done on the box.

A) 0
B) 74.0 J
C) 333 J
D) – 330 J
E) 350 J

Ans:

Constant velocity means zero acceleration or zero net force. So work is zero.

Q3.

A 5.0 kg box is taken from point A (1.0, 2.0, – 2.0) m to point B (6.0, – 3.0, – 2.0) m by applying a single constant force **F** = (3.0 N) **i** + (2.0 N) **j** + (5.0 N) **k**. Find the change in the kinetic energy of the box.

A) 5.0 J
B) 25 J
C) 10 J
D) 18 J
E) 2.0 J

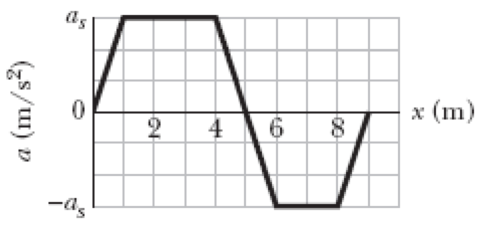
Ans:

$$\Delta K=W=\vec{F}\times\vec{d}=\vec{F}\times\left(\vec{r}_B-\vec{r}_A\right)$$

Q4.

Figure 1 shows a plot of the acceleration a_x versus the displacement x for a particle of mass m = 2.0 kg moving along the x-axis. The scale of the figure's vertical axis is set by a_s = 3.0 m/s^2 How much work is done on the particle as it moves from x = 2.0 to x = 6.0 m.

Figure 1



A) 12 J
B) 9.0 J
C) 6.0 J
D) 18 J
E) 24 J

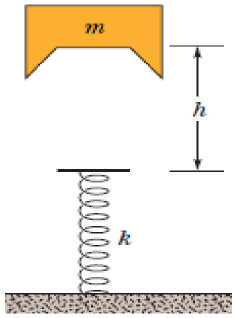
Ans:

Work is the area under the plot F(=ma) vs. x.

Q5.

A massless spring has a spring constant of 500 N/m. A 2.0 kg object is released from rest at a height h = 1.0 m above the spring and lands on it (**Figure 2**). Find the object's speed when the spring is compressed 20 cm.

Figure 2



A) 3.7 m/s
B) 3.1 m/s
C) 4.1 m/s
D) 4.5 m/s
E) 4.9 m/s

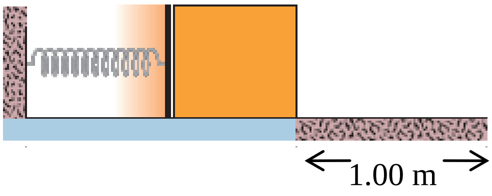
Ans:

$$mg(h+x)=\tfrac{1}{2}mv^2+\tfrac{1}{2}kx^2$$

Q6.

A block with mass m = 0.50 kg is forced against a horizontal spring of spring constant 100 N/m and negligible mass, compressing the spring a distance of 0.20 m (**Figure 3**). When released, the block moves on a horizontal tabletop for 1.0 m before coming to rest. Find the coefficient of kinetic friction μ_k between the block and the tabletop.

Figure 3



A) 0.41
B) 0.35
C) 0.25
D) 0.13
E) 0.53

Ans:

$$\tfrac{1}{2}kx^2=\mu_k mgd$$

Q7.

The work done by a conservative force acting on a body (Choose the CORRECT answer):

A) Does not change the total energy.
B) Does not change the potential energy.
C) Is always equal to zero.
D) Does not change the kinetic energy.
E) Is always equal to the sum of the changes in potential and kinetic energy.

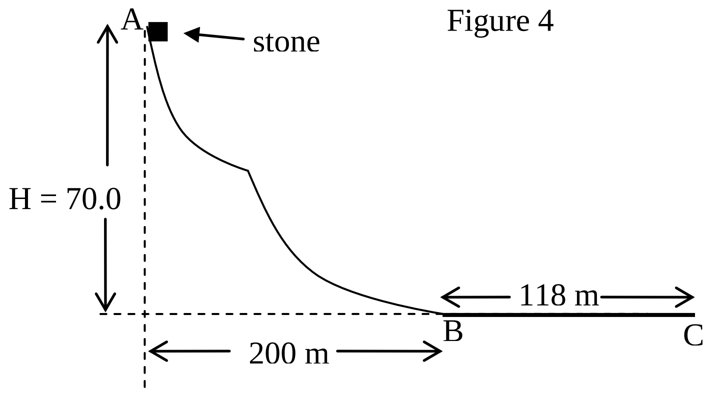
Ans:

A

Q8.

A 15.0 kg stone slides down a smooth snow-covered hill (**Figure 4**), leaving point A with a speed of 4.0 m/s. Then it slides a distance of 118 m on a rough horizontal surface from point B to point C before coming to rest. Find the coefficient of kinetic friction μ_k between the stone and the surface.

A) 0.600
B) 0.500
C) 0.400
D) 0.550
E) 0.450



Ans:

$$mgH + \tfrac{1}{2}mv^2 = \mu_k mgd$$

Q9.

Two particles of masses 3.0 kg and 5.0 kg are moving with initial velocities of (–3.0 **i** + 4.0 **j**) m/s and (2.0 **i** + 3.0 **j**) m/s respectively. They collide completely inelastically. Find the velocity of the center of mass of the two particles after the collision.

A) (0.13 **i** + 3.4 **j**) m/s
B) (3.2 **i** + 4.4 **j**) m/s
C) (5.13 **i** + 1.34 **j**) m/s
D) (–9.00 **i** + 12.0 **j**) m/s
E) (10.0 **i** + 15.0 **j**) m/s

Ans:

V of the C.M. after collision equals V of the C.M. before collision.

Q10.

A car with a mass of 1.2 x10^3 kg is travelling to the right at a speed of 15 m/s when it collides head-on with a truck of mass 2.0 x10^3 kg travelling at a speed of 15 m/s to the left. The vehicles lock together when they collide. Find the average force (both magnitude and direction) exerted on the car if the collision lasts for 0.20 s.

A) 1.1 x 10^5 N to the left
B) 1.1 x 10^5 N to the right
C) 2.2 x 10^4 N to the left
D) 3.1 x 10^4 N to the right
E) 5.3 x 10^5 N to the left

Ans:

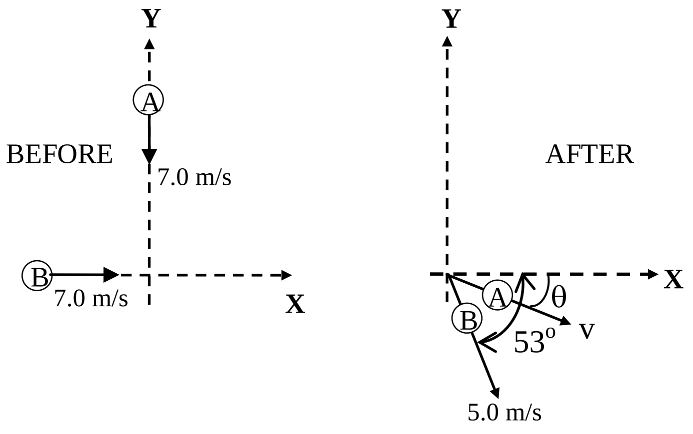
$$m_C v_C + m_T v_T = (m_C + m_T)V \Rightarrow V = -3.75\ m/s$$

$$F_C = \frac{\Delta p_C}{\Delta t} = -112500\ N$$

Q11.

Two objects A and B, with the same mass collide on ice with negligible friction. **Figure 5** gives speeds and directions of the objects BEFORE and AFTER the collision. Find the speed v and angle θ for object A after the collision.

Figure 5



A) 5.0 m/s , 37°
B) 7.0 m/s , 45°
C) 10 m/s, 30°
D) 3.5 m/s, 50°
E) 1.4 m/s, 20°

Ans:

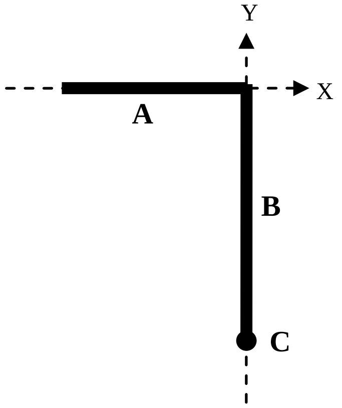
$$m_A v_A = m_A v_A^f \sin\theta + m_B v_B^f \sin 53$$

$$m_B v_B = m_A v_A^f \cos\theta + m_B v_B^f \cos 53$$

Q12.

A machine part consists of three objects welded together: A) a thin, uniform 4.00 kg bar that is 1.50 m long, B) a vertical bar of mass 3.00 kg and length 1.80 m and C) dense 2.00 kg ball attached to the end of object B (**Figure 6**). Find the center of mass of this system.

Figure 6



A) (– 0.333m, – 0.700 m)
B) (– 0.750m, – 0.900 m)
C) (– 0.250m, – 0.450 m)
D) (– 0.453 m, – 0.767 m)
E) (– 0.670 m, – 0.767 m)

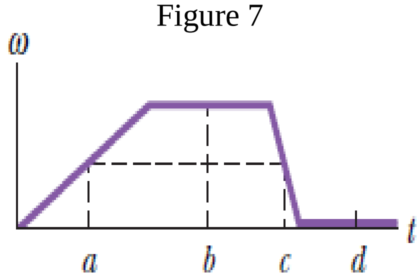
Ans:

$$X_{CM} = \frac{-0.75\times4}{4+3+2} = -0.333\text{ m}, Y_{CM} = \frac{-0.9\times3-1.8\times2}{4+3+2} = -0.700\text{ m}$$

Q13.

Figure 7 shows a plot of the angular velocity versus time for a disk rotating about a fixed axis through its center. Rank the time intervals according to the magnitude of the angular acceleration, greatest first.

Figure 7



A) c,a,then b and d tie
B) a,b,c,d
C) b,c,a,d
D) d,a,b,c
E) All tie

Ans:

A

Q14.

A wheel is rotating with a constant angular acceleration of – 2.0 rad/s^2. In the first 4.0 seconds, it makes 8.0 revolutions. What is the total number of revolutions (starting from t = 0) will it make before stopping?

A) 11
B) 16
C) 19
D) 22
E) 14

Ans:

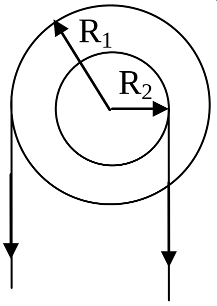
$$\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 \Rightarrow \omega_0 = 16.6\ rad/s$$

$$\omega^2 = \omega_0^{\ 2} + 2\alpha\theta \Rightarrow \theta = 68.6\ rad = 11\ rev$$

Q15.

Figure 8 shows a disk with a moment of inertia I = 10.0 kg-m^2 about an axis passing through its center. Two strings are wrapped around different parts of the disk which have radii R_1 = 40.0 cm and R_2 = 25.0 cm. Find the magnitude of the angular acceleration of the disk if the tensions are T_1 = 5.0 N and T_2 = 15 N.

Figure 8



A) 0.18 rad/s^2
B) 10 rad/s^2
C) 0.40 rad/s^2
D) 0.25 rad/s^2
E) 1.2 rad/s^2

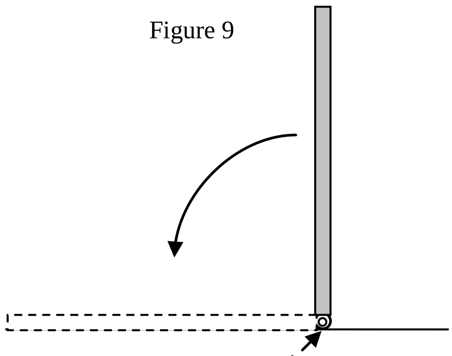
Ans:

$$\alpha = \frac{\tau}{I} = \frac{T_1R_1 - T_2R_2}{I}$$

Q16.

A meter stick is held vertically with one end pivoted on the floor. It is then allowed to fall as shown in **Figure 9**. Find the speed of the other end just before it hits the floor.

Figure 9



A) 5.4 m/s
B) 2.0 m/s
C) 7.7 m/s
D) 3.3 m/s
E) 12 m/s

Ans:

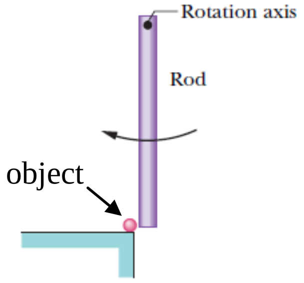
$$\tfrac{1}{2}I\omega^2 = mg\frac{L}{2} \Rightarrow \omega = \sqrt{\frac{mg}{I}} = \sqrt{\frac{mg}{\frac{1}{3}mL^2}} = \sqrt{3g} = 5.4\ rad/s \Rightarrow v = \omega$$

Q17.

Figure 10 shows a uniform rod of length 0.6 m and mass 1.0 kg, rotating in the plane of the figure about an axis through one end. When it is at its lowest point, it collides with a stationary 0.2 kg object that sticks to the end of the rod. If the rod's angular speed just before collision is 2.4 rad/s, then what is its angular speed just after the collision?

A) 1.5 rad/s
B) 0.52 rad/s
C) 2.1 rad/s
D) 1.2 rad/s
E) 1.9 rad/s

Figure 10



Ans:

Conservation of angular momentum: $I\omega_i = (mL^2 + I)\omega_f$

Q18.

At t = 0, a 2.0 kg particle with velocity **v** = (5.0 **i** + 3.0 **j**) m/s is at the origin. It is pulled by a 6.0 N force in the negative y direction. What is the torque (in units of N.m) about the origin at t = 3.0 s?

A) – 90 **k**
B) – 21 **k**
C) 88 **k**
D) 0
E) 62 **k**

Ans:

After 3 s, x=$v_{0y}t = 15\ m.\ \tau = Fx = 90\ N.m$ clockwise

Q19.

Two wheels A and B of the same radius and mass start rolling from rest, down the same incline (without slipping) from the same initial height. The difference between the two wheels is that wheel A has more mass near the rim while wheel B has more mass near the center. When they reach the bottom, which one of the following statements is TRUE?

A) Wheel B rolls down faster than wheel A
B) Wheel A rolls down faster than wheel B
C) Both wheels roll at the same speed
D) The change in the potential energy of wheel A at the bottom of the incline is greater than that of wheel B
E) The wheels will have the same kinetic energy at the bottom of the incline

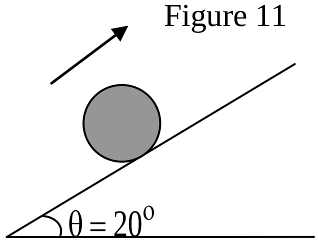
Ans:

A

Q20.

Figure 11 shows a disk of mass = 2.0 kg rolling up an incline ($\theta = 20^o$) starting with an initial (total) kinetic energy of 88 J. How far does the disk travel along the incline before stopping momentarily?

Figure 11



A) 13 m
B) 4.5 m
C) 4.8 m
D) 1.7 m
E) 2.5 m

Ans:

$$K = 88 = mgh \Rightarrow h = \frac{88}{mg} = 4.49\ m \Rightarrow d = \frac{h}{\sin 20} = 13\ m$$