Q1.

Two forces $\vec{F}_1$ and $\vec{F}_2$ are acting on an object of mass 2.50 kg and as a result the acceleration of the object is 5.00 m/s^2 making an angle of 20.0^o with the positive direction of the *x* axis (counter clockwise). Find $\vec{F}_2$ if $\vec{F}_1 = (43.3N)\hat{i} + (25.0N)\hat{j}$.

A) $\vec{F}_2 = -(31.6N)\hat{i} - (20.8N)\hat{j}$
B) $\vec{F}_2 = +(57.6N)\hat{i} + (10.5N)\hat{j}$
C) $\vec{F}_2 = -(11.0N)\hat{i} - (20.0N)\hat{j}$
D) $\vec{F}_2 = +(20.6N)\hat{i} + (33.8N)\hat{j}$
E) $\vec{F}_2 = -(21.6N)\hat{i} + (32.0N)\hat{j}$

Ans:

$$\sum \vec{F} = m\vec{a}$$

$$\Rightarrow \vec{F}_2 = m\vec{a} - F_1$$

$$= 2.5(5\cos 20\,\hat{i} + 5\sin 20\,\hat{j}) - (43.3\,\hat{i} + 25.0\,\hat{j})$$

$$\Rightarrow \vec{F}_2 = -31.6\text{ N}\,\hat{i} - 20.8\text{ N}\,\hat{j}$$

Q2.

A car that weighs 1.50×10^3 N is initially moving at a speed of 10.0 m/s when the brakes are applied and is brought to a stop in 20.0 m. Assuming that the force that stops the car is constant; find the magnitude of the force.

A) 3.83 x 10^2 N
B) 7.15 x 10^3 N
C) 5.43 x 10^3 N
D) 1.23 x 10^2 N
E) 10.0 x 10^{3}N

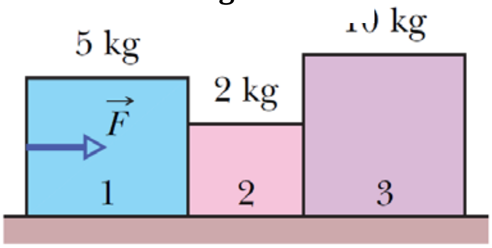
Ans:

$$a = \frac{-v_0^2}{2(x_f - x_0)} \Rightarrow |F| = ma = \frac{w}{g} \times a = 3.83 \times 10^2\text{N}$$

Q3.

Three blocks of masses m_1 = 5.00 kg, m_2 = 2.00 kg, m_3 = 10.0 kg are placed in contact with each other on a frictionless, horizontal surface as shown in **Figure 1**. A constant horizontal force $F = 102\,\text{N}$ is applied to m_1 as shown. Find the magnitude of the force of contact between block m_2 and block m_3.

Figure 1



A) 60.0 N
B) 72.0 N
C) 30.0 N
D) 40.0 N
E) 50.0 N

Ans:

$$\sum \vec{F} = m\vec{a}$$

$$\Rightarrow a = \frac{F}{\sum m} = 6\ \text{m/s}^2$$

$$\Rightarrow F_{23} = m_3 a = 60.0\ \text{N}$$

Q4.

A man of weight 600 N is riding an elevator. At a certain instant his feet push against the floor with a force greater than 600 N. At this instant, the elevator may be (find the correct answer):

A) Moving downward with decreasing speed.
B) Moving upward with decreasing speed.
C) Moving downward with increasing speed.
D) Stationary.
E) Moving with constant speed.

Ans:

$F_N = m(g + a)$

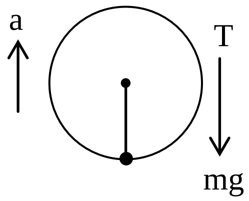
$\Rightarrow$ for the normal force to be greater than 600 N, g and a should have the same direction

Moving downward with decreasing speed

Q5.

A 2.00 kg ball is fastened to a string of 1.00 m length and set into vertical circular motion. Find the magnitude of the tension in the string when the ball is at the bottom of its path where its speed is 7.74 m/s.

A) 139 N
B) 100 N
C) 98.0 N
D) 65.0 N
E) 172 N



Ans:

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

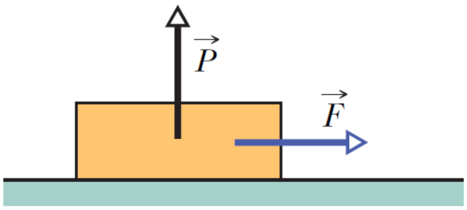
$$\Rightarrow T = m\left(g + \frac{v^2}{r}\right) = 139.4\ \text{N}$$

Q6.

A 3.0 kg block is initially at rest on a horizontal rough surface. A horizontal force F = 7.0 N and a vertical force P = 7.0 N are applied to the block as shown in Figure 2. Determine the magnitude of the frictional force if the coefficients of static and kinetic friction between the block and surface are μs = 0.40 and μk = 0.25, respectively.

Figure 2

A) 7.0 N
B) 12 N
C) 8.1 N
D) 9.2 N
E) 5.6 N



Ans:

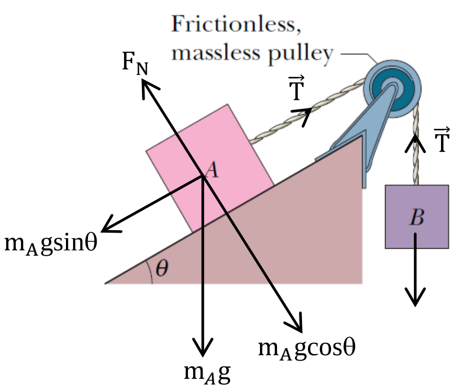
$\vec{f}_s = \vec{F} \Rightarrow$ 7.0 N. The block will not move till the static frictional force equals the horizontal force F

Q7.

As shown in **Figure 3**, two blocks A and B are connected over a massless and frictionless pulley. The mass of block A is 10 kg and the coefficient of kinetic friction between block A and the surface is $\mu_k = 0.25$. Find the mass of block B if block A slides down the incline of angle $\theta = 30°$ with constant speed.

A) 2.8 kg
B) 6.4 kg
C) 3.6 kg
D) 1.8 kg
E) 9.8 kg

Figure 3



Ans:

$$T + f_k = m_A g\sin\theta$$

$$T = \mu_k m_A g\cos\theta = m_A g\sin\theta$$

$$\Rightarrow T = m_B g$$

$$\Rightarrow m_B g + \mu_k m_A g\cos\theta = m_A g\sin\theta$$

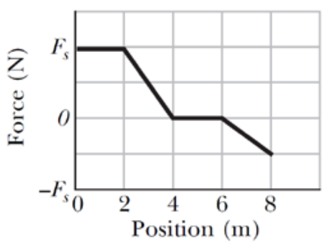
$$\Rightarrow m_B = m_A(\sin\theta - \mu_k g\cos\theta)$$

$$= 2.8 \text{ kg}$$

Q8.

A 3.0 kg block moves in a straight line on a horizontal frictionless surface under the influence of a force that varies with position as shown in Figure 4. If Fs = 20 N, how much work is done by the force as the block moves from the origin to x = 8.0 m?

Figure 4



A) 50 J
B) 70 J
C) 85 J
D) 60 J
E) 25 J

Ans:

$$W = \int F_x\, d_x = (2)(20) + \frac{1}{2}(2)(20) - \frac{1}{2}(10)(2)$$

$$= 50 \text{ J}$$

Q9.

A block of mass 10 kg moves at a constant speed of 25 m/s on a frictionless horizontal surface. The block hits an initially uncompressed horizontal massless spring of spring constant $k = 3.4 \times 10^4$ N/m with one end of the spring fixed to a rigid wall. Find the maximum compression of the spring.

A) 0.43 m
B) 0.21 m
C) 0.69 m
D) 0.86 m
E) 0.92 m

Ans:

$$\Delta k + \Delta V_s = 0$$

$$-\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = 0$$

$$x = \sqrt{\frac{mv^2}{k}} = 0.428\text{ m}$$

Q10.

A constant force $\vec{F} = (6.0\hat{i} - 2.0\hat{j})N$ acts on a 2.0 kg block, initially at rest at point A of coordinates (1.0m, 3.0m), on a frictionless horizontal surface. If the force causes the block to be displaced from point A to point B of coordinates (4.0m, 4.0m) on an *xy* coordinate system, find the block's final speed.

A) 4.0 m/s
B) 5.0 m/s
C) 7.0 m/s
D) 3.0 m/s
E) 2.0 m/s

Ans:

$$W = \Delta K = \vec{F} \cdot \vec{d}$$

$$\frac{1}{2}mv^2 = (6\hat{i} - 2\hat{j}) \cdot (3\hat{i} - \hat{j}) \Rightarrow v = 4.0\text{ m/s}$$

Q11.

An elevator cab, of mass 3.00×10^3 kg, moves 225 m upward with constant speed in 22.0 s. At what average rate does the force from the elevator cable do the work on the cab?

A) 3.00×10^5 W
B) 2.00×10^5 W
C) 2.70×10^5 W
D) 2.70×10^3 W
E) 1.25 W

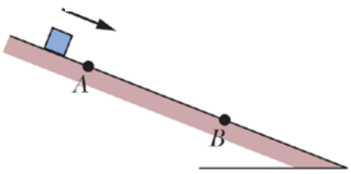
Ans:

$$P = \frac{W}{\Delta t} = \frac{mgd}{\Delta t} = 3 \times 10^5\text{ W}$$

Q12.

In **Figure 5**, a block is sent sliding down a frictionless incline. Its speeds at points A and B are 2.10 m/s and 2.50 m/s, respectively. Then, it is again sent sliding down the incline, but this time its speed at point A is 3.00 m/s. What (now) is its speed at point B?

Figure 5



A) 3.29 m/s
B) 2.10 m/s
C) 2.50 m/s
D) 3.00 m/s
E) 3.80 m/s

Ans:

Initial change in KE = Final change in KE

$$\Rightarrow \frac{1}{2}mv_{iB}^2 - \frac{1}{2}mv_{iA}^2 = \frac{1}{2}mv_{fB}^2 - \frac{1}{2}mv_{fA}^2$$

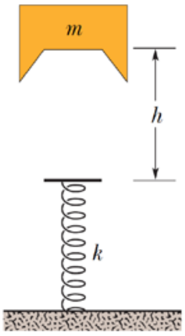
$$\Rightarrow v_{fB}^2 = v_{fA}^2 + v_{iB}^2 - v_{iA}^2$$

$$\Rightarrow v_{fB} = \sqrt{v_{fA}^2 + v_{iB}^2 - v_{iA}^2} = 3.29\ \text{m/s}$$

Q13.

A block of mass m = 2.0 kg is thrown vertically from height h = 30 cm, with an initial speed v_i, onto a spring of spring constant k = 2200 N/m, see **Figure 6**. If the maximum compression of the spring is 15 cm, find the initial speed v_i of the block.

Figure 6



A) 4.0 m/s
B) 1.5 m/s
C) 6.7 m/s
D) 8.2 m/s
E) 9.7 m/s

Ans:

$$E_i = E_f$$

$$\frac{1}{2}mv_i^2 + mg(h + x) = \frac{1}{2}kx^2$$

$$\frac{1}{2}(2)v_i^2 + (2)(9.8)(0.3 + 0.15) = \frac{1}{2}(2200)(0.15)^2$$

$$\Rightarrow v_i = 4.0\ m/s$$

Q14.

A golf ball is struck by a stick, and after passing through the maximum height it lands on a hill 3 m vertically above the initial point. Consider the potential energy to be zero at the initial point and ignoring air resistance, find the correct statement:

A) The mechanical energy of the ball remains constant.
B) The kinetic energy of the ball is maximum at the landing point.
C) The potential energy of the ball-earth system is maximum at the landing point.
D) The mechanical energy of the ball-earth system is zero at the maximum height.
E) The potential energy of the ball-earth system is zero at maximum height.

Ans:

$E_i = E_f = \text{constant} \Rightarrow$ The mechanical energy of the ball remains constant

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Q15.

A block of mass 4.00 kg is moving across a rough horizontal floor where the coefficient of kinetic friction is 0.600. If the block slides for 3.00 m across the floor, and the thermal energy of the block increases by 30.0 J. Find the increase in the thermal energy of the floor.

A) 40.6 J
B) 30.0 J
C) 98.0 J
D) 35.0 J
E) 12.2 J

Ans:

$$\Delta E_{th} = f_k d = \mu_k mgd = 70.6\ \text{J}$$

$$\Delta E_{th}(\text{total}) = \Delta E_{th}(\text{floor}) + \Delta E_{th}(\text{block})$$

$$\Rightarrow \Delta E_{th}(\text{floor}) = (70.6 - 30.0)\ \text{J} = 40.6\ \text{J}$$
