Form A

1. A net force of 25.0 N is applied for 5.70 s to a 12.0-kg box initially at rest. What is the speed of the box at the end of the 5.70 s interval?

A) 1.80 m/s   E) 31.0 m/s
B) 11.9 m/s   F) 22.8 m/s
C) 3.07 m/s   G) 15.9 m/s
D) 7.52 m/s   H) 53.0 m/s

$$\vec{F}_{Net}\Delta t = \Delta\vec{p} = m\Delta v$$

$$(25.0\,N)(5.70\,s) = (12.0\,kg)\Delta v \quad \Rightarrow \quad v = 11.9\,m/s$$

2. A 2.00-kg projectile is fired upward at an angle of 20.0°. What is the magnitude of the force exerted on the projectile when it is at the highest position in its trajectory? Neglect any effects of air resistance.

A) 6.24 N   E) 0.34 N
B) 10.4 N   F) 9.81 N
C) 15.8 N   G) 19.6 N
D) 0.68 N   H) 0.00 N

$\mathbf{F} = mg$ (downward), throughout motion

$F = (2.00\,kg)(9.81\ N/kg) = 19.6\,N$

3. A block with mass 8.00-kg is set moving with an initial speed of 6.00 m/s on a rough horizontal surface. If the force of friction is 12.0 N, approximately how far does the block travel before it stops?

A) 1.50 m
B) 3.00 m   F) 15.0 m
C) 6.00 m   G) 18.0 m
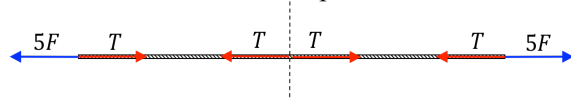D) 9.00 m   H) 21.0 m

$$W = \Delta K$$

$$F(\cos\theta)\Delta x = \tfrac{1}{2}m\Delta v^2 = \tfrac{1}{2}m(v^2 - v_0^2)$$

$$\Delta x = \tfrac{1}{2}(8.00\,kg)\frac{-(6.00\,m/s)^2}{-12\,N} = 12.0\,m$$

4. In a tug-of-war, two 5-man teams, one team on each end of the rope pulls as hard as they can on the rope. If each man pulls with an average force of 500 N, what is the tension at the center of the rope?

A) 0.00 N   E) 2000 N
B) 500 N   F) 2500 N
C) 1000 N   G) 5000 N
D) 1500 N   H) 100 N

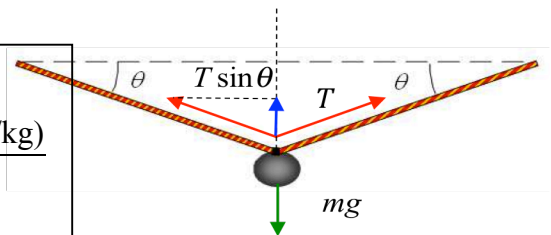(Tension forces are action-reaction pairs of Newton's 3rd law)

5. A rope is tied between two walls and a mass of 7.90 kg is then hung from its center. If the angle θ the rope makes with the horizontal is 6°, what is the rope tension?

A) 371 N   E) 157 N
B) 790 N   F) 320 N
C) 960 N   G) 720 N
D) 233 N   H) 435 N

$$2T\sin 6° = mg$$

$$T = \frac{(7.90\,kg)(9.81\,N/kg)}{2\sin 6°}$$

$$= 371\,N$$

6. On a horizontal frictionless surface, a block with a 4.00 kg mass in contact with a block of mass 2.00 kg, is accelerated by a +12.0 N force. Determine the force that the 2.00 kg block exerts on the 4.00 kg block.
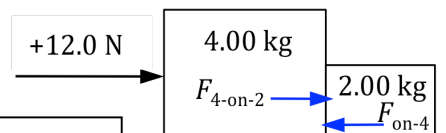
A) – 4.00 N   E) + 8.00 N
B) – 12.0 N   F) – 6.00 N
C) – 0.00 N   G) + 6.00 N
D) + 4.00 N   H) + 12.0 N

$$m\vec{a} = +12\,N$$

$$\vec{a} = +12\,N/6.00\,kg = +2\,m/s^2$$

$$\vec{F}_{on\text{-}2kg} = m\vec{a} = (2kg)(+2\,m/s^2) = +4\,N$$

$$\vec{F}_{on\text{-}4kg} = -\vec{F}_{on\text{-}2kg} = -4\,N$$

+12.0 N   4.00 kg

$F_{4\text{-on-}2}$ 2.00 kg

$F_{on\text{-}4}$

Form A

7. How much energy is dissipated in braking a 1.20×10^3 kg car to a stop from an initial speed of 30.0 m/s?

A) 2.80×10^5 J
B) 2.40×10^3 J
C) 5.40×10^5 J
D) 8.20×10^5 J

E) 1.20×10^3 J
F) 9.60×10^4 J
G) 8.30×10^4 J
H) 7.29×10^5 J

$$\Delta E = K - K_0 = -\tfrac{1}{2}mv^2$$
$$= -\tfrac{1}{2}\left(1.20 \times 10^3 \, \text{kg}\right)(30.0\,\text{m/s})^2$$
$$= -5.40 \times 10^5 \, \text{J} \, (- \text{ means lost})$$

8. Which one of the following statements concerning kinetic energy is true?

A) Kinetic energy can be measured in watts
B) Kinetic energy is always equal to the potential energy.
C) Kinetic energy is always conserved.
D) Kinetic energy is always positive.
E) Kinetic energy is directly proportional to momentum.
F) Kinetic energy is a quantitative measure of inertia.
G) Kinetic energy is inversely proportional to momentum.
H) Kinetic energy is directly proportional to velocity.

9. Two boxes are connected to each other as shown. The system is released from rest and the 1.00-kg box falls through a distance of 1.00 m. The surface of the table is frictionless. What is the kinetic energy of box B just before it reaches the floor?

A) 9.81 J
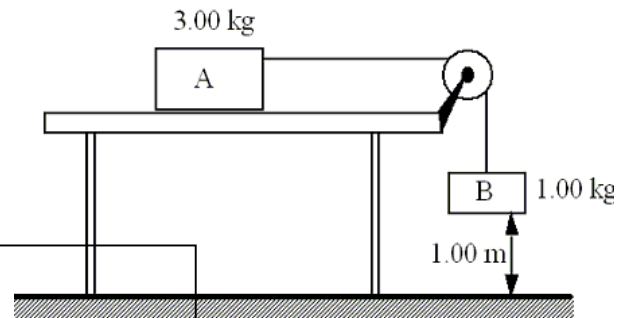B) 4.90 J
C) 17.3 J
D) 29.4 J

E) 39.2 J
F) 2.45 J
G) 13.7 J
H) 45.0 J

$$K + U = K_0 + U_0$$
$$K_A + K_B = m_B g y \qquad K_A = 3K_B$$
$$4K_B = (1.00\,\text{kg})(9.81\,\text{m/s}^2)(1.00\,\text{m})$$
$$K_B = 2.45\,\text{J}$$

10. A 51.0 kg woman runs up a flight of stairs in 5.00 s. Her net upward displacement is 5.00 m. Approximately, what average power did the woman exert while she was running?

A) 5.60 kW
B) 1.00 kW
C) 0.75 kW
D) 0.50 kW

E) 0.25 kW
F) 2.00 kW
G) 9.70 kW
H) 4.90 kW

$$P = \frac{\Delta E}{\Delta t} = \frac{U}{\Delta t} = \frac{mgy}{\Delta t} = \frac{(51.0\,\text{kg})(9.81\,\text{N/kg})(5.00\,\text{m})}{5.00\,\text{s}}$$
$$= 500\,\text{J/s} = 500\,\text{W} = 0.50\,\text{kW}$$

11. A machine gun fires 25.0 g bullets at the rate of 4 bullets per second. The bullets leave the gun at a speed of 1000 m/s. What is the average recoil force experienced by the machine gun?

A) 10.0 N
B) 20.0 N
C) 100 N
D) 200 N

E) 1000 N
F) 150 N
G) 250 N
H) 50 N

$$F\Delta t = \Delta p = mv$$
$$F = \frac{m}{\Delta t}v = \frac{4(0.025\,\text{kg})(1000\,\text{m/s})}{1\text{s}} = 100\,\text{N}$$

Form A

12. During hockey practice, two pucks are sliding across the ice in the same direction. At one instant, a 0.18-kg puck is moving at 16 m/s while the other puck has a mass of 0.14 kg and a speed of 3.8 m/s. What is the velocity of the center of mass of the two pucks?

A) 5.0 m/s   E) 13 m/s
B) 7.0 m/s   F) 6.0 m/s
C) 9.0 m/s   G) 14 m/s
D) 11 m/s   H) 4.0 m/s
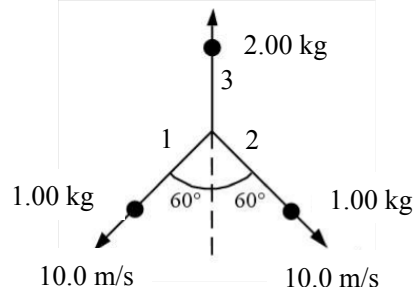
$$v_{cm} = \frac{m_A v_A + m_B v_B}{m_A + m_B}$$

$$= \frac{\left[(0.18)(16) + (0.14)(3.8)\right] \text{kg·m/s}}{(0.18 + 0.14)\text{kg}}$$

$$= 10.7 \text{ m/s} \rightarrow 11 \text{m/s (2 significant figs.)}$$

13. A stationary 4.00 kg shell explodes into three pieces. Two of the fragments have a mass of 1.00 kg each and move along the paths shown with a speed of 10.0 m/s. The third fragment moves upward as shown. What is the speed of the third fragment?

A) zero m/s   E) 2.00 m/s
B) 9.00 m/s   F) 3.00 m/s
C) 8.00 m/s   G) 4.00 m/s
D) 10.0 m/s   H) 5.00 m/s

2.00 kg
3
1   2
1.00 kg   60°   60°   1.00 kg
10.0 m/s   10.0 m/s

$$p_{3y} = -(p_{1y} + p_{2y}) \qquad p_{1y} = p_{2y} = -(1.00\text{kg})(10.0\text{m/s})\cos60° = -5.00\text{kg·m/s}$$

$$v_{3y} = -(p_{1y} + p_{2y})/m_3 = 10.0\text{kg·m/s}/2.00\text{kg} = 5.00\text{m/s}$$

14. A bullet of mass m is fired at speed $\mathbf{v}_0$ into a wooden block of mass M. The bullet instantaneously comes to rest in the block. The block with the embedded bullet slides along a horizontal surface with a coefficient of kinetic friction μ.

initial position   final position

$\vec{v}_0$ M

$\Delta \vec{x}$
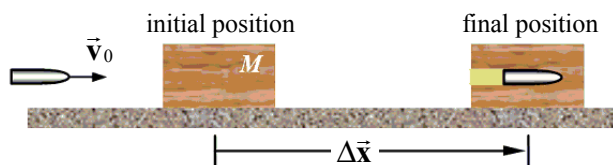
Which one of the following expressions determines how far the block slides before it comes to rest (the magnitude of displacement $\Delta \vec{x}$ in the figure)?

A) $\Delta x = \dfrac{mv_0^2}{M\mu g}$ E) $\Delta x = \dfrac{v_0^2}{\mu g}$

B) $\Delta x = \dfrac{m}{m+M}\left(\dfrac{v_0^2}{\mu g}\right)$ F) $\Delta x = \sqrt{\dfrac{m}{m+M}\left(\dfrac{v_0^2}{\mu g}\right)}$

C) $\Delta x = \left(\dfrac{m}{m+M}\right)^2\sqrt{\dfrac{v_0^2}{2\mu g}}$ G) $\Delta x = \sqrt{\dfrac{m}{m+M}}\sqrt{\dfrac{v_0^2}{2\mu g}}$

D) $\Delta x = \left(\dfrac{m}{m+M}\right)^2\dfrac{v_0^2}{2\mu g}$ H) $\Delta x = \dfrac{m^2 v_0^2}{M^2\mu g}$

$$p_0 = mv_0; \quad p_f = (M+m)v_f$$

$$p_0 = p_f \quad \Rightarrow \quad v_f = \frac{m}{M+m}v_0$$

$$w = \Delta K = -\tfrac{1}{2}(M+m)v_f^2$$

$$-f\Delta x = -\tfrac{1}{2}(M+m)\left(\frac{m}{M+m}v_0\right)^2$$
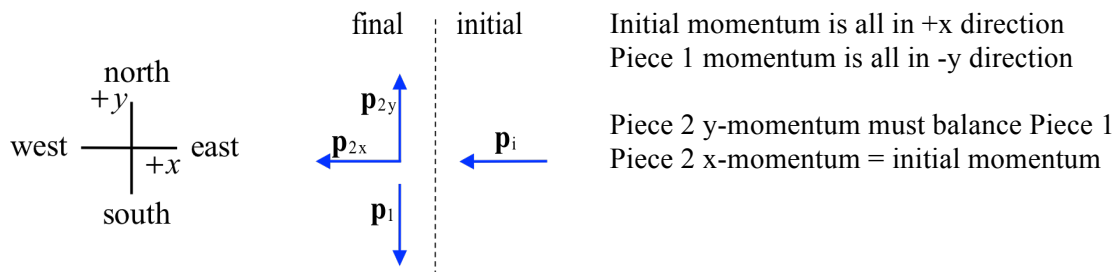
$$\mu(M+m)g\Delta x = \tfrac{1}{2}\frac{m^2}{M+m}v_0^2$$

$$\Delta x = \tfrac{1}{2}\frac{m^2}{\mu g(M+m)^2}v_0^2$$

3

Form A

15. Two objects of equal mass traveling toward each other with equal speeds undergo a head on collision. Which one of the following statements concerning their velocities after the collision is necessarily true?

A) They will exchange velocities
B) Their velocities will be reduce
C) Their velocities will be reduced by a factor of 2.
D) Their velocities will be unchanged

E) Their velocities will be doubled
F) Their velocities will be zero
G) Their velocities will be reversed
H) Their velocities may be zero

16. A 0.50-kg bomb is sliding along an icy pond (frictionless surface) with a velocity of 2.0 m/s to the west. The bomb explodes into two pieces. After the explosion, a 0.20-kg piece moves south at 4.0 m/s. What are the components of the velocity of the 0.30-kg piece?

A) 4.0 m/s north, 0 m/s west
B) 4.0 m/s north, 3.3 m/s east
C) 4.0 m/s north, 2.7 m/s west
D) 0 m/s north, 2.0 m/s east

E) 3.5 m/s north, 1.5 m/s east
F) 2.7 m/s north, 3.3 m/s west
G) 5.0 m/s south, 1.8 m/s west
H) 2.0 m/s north, 2.7 m/s west

final | initial

north
$+y$

west ——+——+—— east
$+x$

south

$\mathbf{p}_{2y}$

$\mathbf{p}_{2x}$

$\mathbf{p}_1$

$\mathbf{p}_i$

Initial momentum is all in +x direction
Piece 1 momentum is all in -y direction

Piece 2 y-momentum must balance Piece 1
Piece 2 x-momentum = initial momentum

let east = $+x$, and let north = $+y$

$$Y: \quad \vec{\mathbf{p}}_{iy} = 0 = \vec{\mathbf{p}}_{1y} + \vec{\mathbf{p}}_{2y} \quad \Rightarrow \quad \vec{\mathbf{p}}_{2y} = -\vec{\mathbf{p}}_{1y}$$

$$\vec{\mathbf{p}}_{1y} = m_1\vec{\mathbf{v}}_{1y} = -(0.20\,\text{kg})(4\,\text{m/s}) = -0.80\,\text{kg} \cdot \text{m/s (south)}$$

$$\Rightarrow \vec{\mathbf{p}}_{2y} = -\vec{\mathbf{p}}_{1y} = +0.80\,\text{kg} \cdot \text{m/s (north)}$$

$$\mathbf{v}_{2y} = \vec{\mathbf{p}}_{2y} / m_2 = (+0.80\,\text{kg} \cdot \text{m/s})/0.30\,\text{kg} = +2.7\,\text{m/s, (north)}$$

$$X: \quad \vec{\mathbf{p}}_{ix} = \vec{\mathbf{p}}_{1x} + \vec{\mathbf{p}}_{2x} \quad \Rightarrow \quad \vec{\mathbf{p}}_{2x} = \vec{\mathbf{p}}_{ix} - \vec{\mathbf{p}}_{1x}$$

$$\vec{\mathbf{p}}_{ix} = m\vec{\mathbf{v}}_x = -(0.50\,\text{kg})(2.0\,\text{m/s}) = -1.0\,\text{kg} \cdot \text{m/s (west)}$$

$$\vec{\mathbf{p}}_{1x} = m_1\vec{\mathbf{v}}_{1x} = 0$$

$$\Rightarrow \vec{\mathbf{p}}_{2x} = \vec{\mathbf{p}}_{ix} = -1.0\,\text{kg} \cdot \text{m/s (west)}$$

$$\mathbf{v}_{2x} = \vec{\mathbf{p}}_{2x} / m_2 = (-1.0\,\text{kg} \cdot \text{m/s})/0.30\,\text{kg} = -3.3\,\text{m/s, (west)}$$