1. **Correct response: D**

   The average velocity only depends on the initial and final positions and the interval of time.

2. **Correct response: E**

   Work is force, $\frac{[M][L]}{[T]^2}$, multiplied by displacement, $[L]$.

3. **Correct response: A**

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2 \qquad \Rightarrow \qquad a = \frac{2(x - x_0 - v_0 t)}{t^2} = \frac{2(120\,\mathrm{m} - 0)}{(10.0\,\mathrm{s})^2} = 2.40\,\mathrm{m/s^2}$$

4. **Correct response: D**

$$\bar{v} = \frac{x - x_0}{t} = \frac{120.\,\mathrm{m}}{10.0\,\mathrm{s}} = 12.0\,\mathrm{m/s}$$

5. **Correct response: A**

   Using a coordinate system with east the positive x direction and north the positive y direction:

$$F_{net\,x} = 30.0\mathrm{N} \quad \text{and} \quad F_{net\,y} = 20.0\mathrm{N} - 60.0\mathrm{N} = -40.0\mathrm{N} \quad \Rightarrow$$
$$F_{net} = \sqrt{F_{net\,x}^2 + F_{net\,y}^2} = \sqrt{(30.0\mathrm{N})^2 + (-40.0\mathrm{N})^2} = 50.0\mathrm{N}$$

6. **Correct response: A**

   As the two blocks move together, the applied force results in an acceleration of the total mass of both blocks:

$$F_{total} = m_{total} a \quad \Rightarrow \quad a = \frac{F_{total}}{m_{total}} = \frac{F}{(5.00\,\mathrm{kg})}$$

   The contact force accelerates the 2.00 kg block:

$$F_{2.00\,kg} = (2.00\,kg)a = (2.00\,kg)\frac{F}{(5.00\,\mathrm{kg})} = \tfrac{2}{5}F$$

7. **Correct response: A**

Using a coordinate system with east the positive x direction and north the positive y direction:

$$d_x = (400\,\text{mi})\cos 60.0° + (200\,\text{mi})\cos(-30.0°) = 373.2\,\text{mi}$$
$$d_y = (400\,\text{mi})\sin 60.0° + (200\,\text{mi})\cos(-30.0°) = 264.4\,\text{mi}$$
$$v = \frac{\sqrt{d_x^2 + d_y^2}}{t} = \frac{\sqrt{(373.2\,\text{mi})^2 + (264.4\,\text{mi})^2}}{3.00\,\text{h}} = 149.\text{mi/h}$$

8. **Correct response: C**

The work done by a constant force is the product of the magnitude of the force and the displacement component in the direction of the force.

$$W = (20.0\,\text{N})(4.00\,\text{m}) = 80.0\,\text{J}$$

9. **Correct response: B**

$$\Delta K + \Delta U = 0 \quad \Rightarrow \quad \tfrac{1}{2}mv_2^2 - \tfrac{1}{2}mv_1^2 + \tfrac{1}{2}kx_2^2 - \tfrac{1}{2}kx_1^2 + \Delta U_{gravitational} = 0 \quad \Rightarrow$$
$$\Delta U_{gravitational} = \tfrac{1}{2}mv_1^2 - \tfrac{1}{2}mv_2^2 + \tfrac{1}{2}kx_1^2 - \tfrac{1}{2}kx_2^2 = 0 - 0 + 0 - \tfrac{1}{2}(300.\text{N/m})(0.300\,\text{m})^2 = -13.5\,\text{J}$$

10. **Correct response: A**

With the +x-direction horizontal right and the +y direction vertical upward,

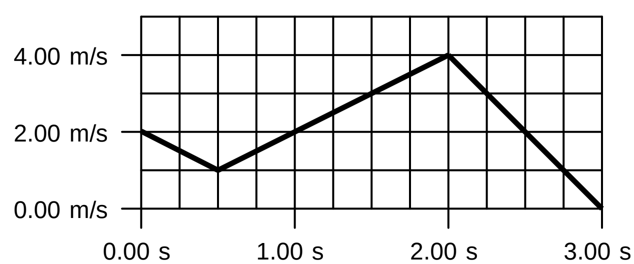
$$F_x = ma_x \qquad \Rightarrow \qquad (12.0\,\text{N})\cos 25.0° - \mu_k N = (4.00\,\text{kg})(2.00\,\text{m/s}^2)$$
$$F_y = ma_y \qquad \Rightarrow \qquad -(12.0\,\text{N})\sin 25.0° - mg + N = 0$$

Solving for μ_k

$$\mu_k = \frac{(4.00\,\text{kg})(2.00\,\text{m/s}^2) - (12.0\,\text{N})\cos 25.0°}{-(12.0\,\text{N})\sin 25.0° - (4.00\,\text{kg})(9.8\,\text{m/s}^2)} = 0.0650$$

11. **Correct response: D**

The displacement is the area between the velocity versus time plot and the time axis. That area can be broken into the trapezoid between 0.00 s and 0.50 s, the trapezoid between 0.50 s and 2.00 s, and the triangle between 2.00 s and 3.00 s. The area is



$$\Delta x = \tfrac{1}{2}(2.00\,\text{m/s} + 1.00\,\text{m/s})(0.50\,\text{s-}0.00\,\text{s}) + \tfrac{1}{2}(1.00\,\text{m/s} + 4.00\,\text{m/s})(2.00\,\text{s-}0.50\,\text{s}) +$$
$$\tfrac{1}{2}(4.00\,\text{m/s})(3.00\,\text{s-}2.00\,\text{s}) = 6.50\,\text{m}$$

12. **Correct response: B**

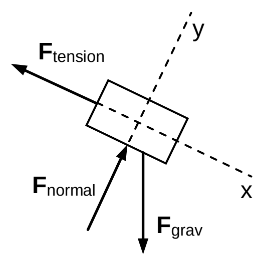
The maximum mass without tipping results in a net zero net torque on the object. If the torque about the edge of the table is used,

$$+r_1 m_1 g - r_{cm\,block} m_{block} g = 0 \quad \Rightarrow$$
$$+(6.00\,\mathrm{cm})m(9.80\,\mathrm{m/s^2}) - (4.00\,\mathrm{cm})(2.00\,\mathrm{kg})(9.80\,\mathrm{m/s^2}) = 0 \quad \Rightarrow$$
$$m = \frac{(4.00\,\mathrm{cm})(2.00\,\mathrm{kg})(9.80\,\mathrm{m/s^2})}{(6.00\,\mathrm{cm})(9.80\,\mathrm{m/s^2})} = 1.33\,\mathrm{kg}$$

13. **Correct response: B**

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \quad \Rightarrow \quad v_{2f} = \frac{m_1 v_{1i} + m_2 v_{2i} - m_1 v_{1f}}{m_2} \quad \Rightarrow$$
$$v_{2f} = \frac{(3.00\,\mathrm{kg})(2.00\,\mathrm{m/s}) + (5.00\,\mathrm{kg})(2.00\,\mathrm{m/s}) - (3.00\,\mathrm{kg})(-1.00\,\mathrm{m/s})}{(5.00\,\mathrm{kg})} = 3.80\,\mathrm{m/s}$$

14. **Correct response: B**



The free-body diagram of the block is shown. Using the coordinate system shown, the sum of the y components of the force must sum to zero.

$$-F_{tension} + F_{grav} \sin 25.0° = 0 \quad \Rightarrow \quad F_{tension} = F_{grav} \sin 25.0° = w \sin 25.0°$$

15. **Correct response: A**

An explosion occurs in a very short time interval, so the center of mass remains at rest during the time the explosion occurs.

$$0 = m_1 \mathbf{v}_1 + m_2 \mathbf{v}_2 + m_3 \mathbf{v}_3 \quad \Rightarrow \quad \mathbf{v}_3 = -\frac{(m_1 \mathbf{v}_1 + m_2 \mathbf{v}_2)}{m_3}$$
$$\mathbf{v}_3 = -\frac{[(2.00\,\mathrm{kg})(300.\,\mathrm{m/s}, 200.\,\mathrm{m/s}, 100.\,\mathrm{m/s}) + (1.00\,\mathrm{kg})(-400.\,\mathrm{m/s}, 400.\,\mathrm{m/s}, 200.\,\mathrm{m/s})]}{3.00\,\mathrm{kg}}$$
$$= (-66.7\,\mathrm{m/s}, -267.\,\mathrm{m/s}, -133.\,\mathrm{m/s})$$

16. **Correct response: D**

$$F = kx \quad \Rightarrow \quad F_1 = k(L_1 - L_0) \quad \text{and} \quad F_2 = k(L_2 - L_0) \quad \Rightarrow$$
$$L_0 = \frac{F_1 L_2 - F_2 L_1}{(F_1 - F_2)} = \frac{(100.\,\mathrm{N})(30.0\,\mathrm{cm}) - (200.\,\mathrm{N})(20.0\,\mathrm{cm})}{(100.\,\mathrm{N}) - (200.\,\mathrm{N})} = 10.0\,\mathrm{cm}$$

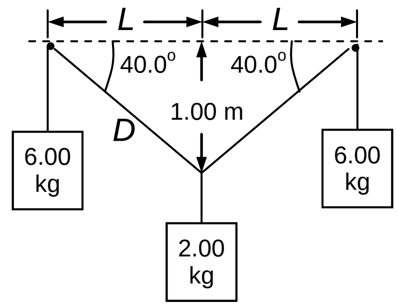
17. **Correct response: B**

$$P = \frac{W}{t} = \frac{\Delta K + \Delta U}{t} = \frac{(40.0\,\text{J} - 70.0\,\text{J}) + (80.0\,\text{J} - 20.0\,\text{J})}{(8.00\,\text{s})} = 3.75\,\text{W}$$

18. **Correct response: D**

As the skater moves arms in closer to the body, the moment of inertia decreases. To conserve angular momentum, the rate of rotation must increase.

19. **Correct response: D**



When the system has reoriented so the strings are horizontal, the 2.00 kg mass has risen 1.00 m and the 6.00 kg masses have dropped a distance *D* – *L*.

$$D - L = \frac{1.00\,\text{m}}{\sin 40.0°} - \frac{1.00\,\text{m}}{\tan 40.0°} = 0.364\,\text{m}$$

Applying conservation of energy,

$$\Delta K + \Delta U = 0 \quad \Rightarrow \quad \left(\tfrac{1}{2} m_{2.00\,kg} v_{2.00\,kg}^2 - 0\right) + 2m_{6.00\,kg} g\Delta h_{6.00kg} + m_{2.00\,kg} g\Delta h_{2.00kg} = 0$$

$$\Rightarrow \quad v_{2.00\,kg} = \sqrt{\frac{-2m_{6.00\,kg} g\Delta h_{6.00kg} - m_{2.00\,kg} g\Delta h_{2.00kg}}{\tfrac{1}{2} m_{2.00\,kg}}}$$

$$= \sqrt{\frac{-2(6.00\,\text{kg})(9.80\,\text{m/s}^2)(-0.364\,\text{m}) - (2.00\,\text{kg})(9.80\,\text{m/s}^2)(1.00\,\text{m})}{\tfrac{1}{2}(2.00\,\text{kg})}} = 4.82\,\text{m/s}$$

20. **Correct response: D**

$$\frac{T_2}{T_1} = \frac{R_2^{3/2}}{R_1^{3/2}} \quad \Rightarrow \quad T_2 = T_1 \frac{R_2^{3/2}}{R_1^{3/2}} = (30.0\,\text{h}) \frac{(8.00R)^{3/2}}{R^{3/2}} = 679.\,\text{h}$$

21. **Correct response: E**

$$v = \omega r = 2\pi \left(6.00\,\text{s}^{-1}\right)(20.0\,\text{cm}) = 754.\,\text{cm/s}$$

22. **Correct response: B**

The change in entropy must be greater than or equal to the entropy change that occurs with the reversible removal and addition of the heat to the reservoirs.

$$\Delta S \geq \frac{Q_{hot}}{T_{hot}} + \frac{Q_{cold}}{T_{cold}} = \frac{-200.0\,\text{J}}{(800. + 273.15)\text{K}} + \frac{100.0\,\text{J}}{(200. + 273.15)\text{K}} = 0.0250\,\text{J/K}$$

23. **Correct response: B**

$$0 = Q_{total\ to\ system} - W_{total\ by\ system} \quad \Rightarrow \quad W_{total\ by\ system} = (200.\mathrm{J}) + (-100.\mathrm{J}) = 100.\mathrm{J}$$

24. **Correct response: D**

When only the raft is floating:

$$0 = \mathbf{F}_{grav} + \mathbf{F}_{buoyant} = -m_{raft}g + \rho_{water}gV_{submerged1} = -m_{raft}g + \rho_{water}g(0.500V_{raft}) \quad \Rightarrow$$

$$V_{raft} = \frac{2.00m_{raft}}{\rho_{water}}$$

When people are on the raft:

$$0 = \mathbf{F}_{grav} + \mathbf{F}_{buoyant} = -(m_{raft} + 2m_{person})g + \rho_{water}gV_{submerged2}$$
$$= -(m_{raft} + 2m_{person})g + \rho_{water}g(XV_{raft}) \quad \Rightarrow$$
$$X = \frac{m_{raft} + 2m_{person}}{\rho_{water}V_{raft}} = \frac{m_{raft} + 2m_{person}}{2.00m_{raft}} = \frac{(200.\mathrm{kg}) + 2(80.0\,\mathrm{kg})}{2(200.\mathrm{kg})} = 0.900 = 90.0\%$$

where X is the fraction of the raft submerged with people on it.

25. **Correct response: A**

$$R_{eq} = 800.\Omega + \frac{(600.\Omega)(1.20\,\mathrm{k\Omega})}{600.\Omega + 1.20\,\mathrm{k\Omega}} = 1.20\,\mathrm{k\Omega} \quad \Rightarrow \quad P = \frac{V^2}{R_{eq}} = \frac{(12.0\,\mathrm{V})^2}{1.20\,\mathrm{k\Omega}} = 0.120\,\mathrm{W}$$

26. **Correct response: C**

$$\frac{h_i}{h_o} = -\frac{s_i}{s_o} = -s_i\left(\frac{1}{f} - \frac{1}{s_i}\right) \quad \Rightarrow \quad f = \left(\frac{1}{s_i} - \frac{h_i}{s_ih_o}\right)^{-1} = \left(\frac{1}{300.\mathrm{cm}} - \frac{-20.0\,\mathrm{cm}}{(300.\mathrm{cm})(1.00\,\mathrm{cm})}\right)^{-1} = 14.3\,\mathrm{cm}$$

27. **Correct response: E**

Completing this process would result in a decrease in entropy.

28. **Correct response: C**

$$EMF = -\frac{\Delta\phi_B}{\Delta t} = -B\frac{\Delta A}{\Delta t}$$

When the loop enters the magnetic field, the flux through the loop is increasing at a greater and greater rate until the vertical diameter of the circle reaches the edge of the magnetic field region (t = 2.00 s). Then the rate of increase begins to drop until the center of the loop is at the center of the magnetic field region (t = 3.00 s), at which time the induced EMF is zero. The flux then begins to decrease at an increasing rate until the vertical diameter of the loop is at the right edge of the field region (t = 4.00 s). After that, the rate of flux decrease begins to drop until the loop exits the right side of the magentic field region (t = 6.00 s). Lenz's Law is used to determine the polarity of the induced EMF.

29. **Correct response: A**

$$F = qv_{\perp}B = ma \quad \text{and} \quad a = \frac{v^2}{r} \qquad \Rightarrow$$

$$r = \frac{mv_{\perp}^2}{qv_{\perp}B} = \frac{\left(9.11\times10^{-31}\,\text{kg}\right)\left(80.0\times10^{3}\,\text{m/s}\right)^2}{\left(1.602\times10^{-19}\,\text{C}\right)\left(80.0\times10^{3}\,\text{m/s}\right)\left(6.00\,\text{T}\right)} = 7.58\times10^{-8}\,\text{m/s}$$

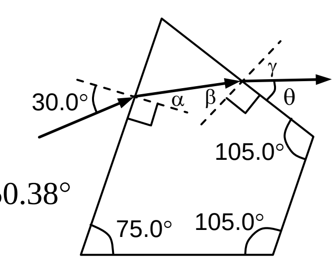
30. **Correct response: A**

The magnetic force is perpendicular to the magnetic field, so there will be no component of acceleration along the direction of the magnetic field.

31. **Correct response: D**

$$|V_R| = |I|R = \frac{|V|}{Z}R = \frac{10.0\text{ V}}{\sqrt{\left[2\pi(200.\text{Hz})\left(20\times10^{-3}\text{ H}+40\times10^{-3}\text{ H}\right)\right]^2+(40.0\,\Omega)^2}}(40.0\,\Omega) = 4.69\text{ V}$$

32. **Correct response: E**



$$1.00\sin 30.0° = 1.20\sin\alpha \quad \Rightarrow \quad \alpha = \sin^{-1}\frac{1.00\sin 30.0°}{1.20} = 24.62°$$

$$(\alpha+90.0°)+(\beta+90.0°)+105.0°+105.0°+75.0° = 540.0° \quad \Rightarrow \quad \beta = 50.38°$$

$$1.20\sin\beta = 1.00\sin\gamma \quad \Rightarrow \quad \gamma = \sin^{-1}\frac{1.20\sin 50.38°}{1.00} = 67.57°$$

$$\theta+\gamma = 90.0° \quad \Rightarrow \quad \theta = 90.0° - 67.57° = 22.4°$$

33. **Correct response: E**

$$L = L_0\sqrt{1-\frac{v^2}{c^2}} \qquad \Rightarrow \qquad L_0 = \frac{L}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{20.0\,\text{m}}{\sqrt{1-(0.500)^2}} = 23.1\,\text{m}$$

34. **Correct response: C**

$$\lambda = \frac{1}{R}\left(\frac{1}{n_{final}^2} - \frac{1}{n_{initial}^2}\right)^{-1} \qquad \Rightarrow$$

$$n_{final} = \frac{1}{\sqrt{\frac{1}{\lambda R} + \frac{1}{n_{initial}^2}}} = \frac{1}{\sqrt{\frac{1}{\left(1.280\times10^{-6}\text{ m}\right)\left(1.0974\times10^{7}\text{ m}^{-1}\right)} + \frac{1}{5^2}}} = 3$$

35. **Correct response: D**

$$A = \lambda N = \frac{\ln 2}{t_{1/2}} N = \frac{\ln 2}{2000.\text{s}} 2.00\times10^{12} = 6.93\times10^{8}\text{ decays/s}$$