1. A girl throws a ball up in the air and then catches it when it comes back down. At the ball's highest point, what is true about the ball's velocity and acceleration? Take up to be the positive direction.
   a) $v < 0$ and $a < 0$  
   b) $v = 0$ and $a < 0$  
   c) $v > 0$ and $a > 0$
   d) $v = 0$ and $a > 0$  
   e) $v = 0$ and $a = 0$

2. A ball rolls horizontally off of a desk at a speed of 4.0 m/s. If the ball lands 2.0 m away from the base of the desk, how tall is the desk?
   a) 0.78 m  
   b) 1.2 m  
   c) 5.0 m  
   d) 1.0 m  
   e) 1.4 m

   $v_{0x} = 4.0 \text{ m/s}$  
   $v_{0y} = 0$  
   $\Delta x = 2.0 \text{ m}$  
   $h = -\Delta y = ?$  
   $a_x = 0$  
   $a_y = -9.8 \text{ m/s}^2$

   $\Delta x = v_{0x} t + \frac{1}{2} a_x t^2$

   $2.0 \text{ m} = 4.0 \text{ m/s} t + 0$
   
   $t = 0.5 \text{ s}$

   $\Delta y = v_{0y} t + \frac{1}{2} a_y t^2$

   $\Delta y = 0 + \frac{1}{2} (-9.8 \text{ m/s}^2)(0.5 \text{ s})^2$

   $\Delta y = -1.2 \text{ m} \Rightarrow h = 1.2 \text{ m}$

3. An object is on a frictionless inclined plane. The plane is inclined at an angle of 35° with the horizontal. What is the magnitude of the acceleration of the object?
   a) 1.3 m/s$^2$  
   b) 5.6 m/s$^2$  
   c) 8.0 m/s$^2$  
   d) 4.9 m/s$^2$

   $\theta = 35^\circ$  
   $a_x = ?$

   $\Sigma F_x = m a_x$

   $m g \sin \theta = m a_x$

   $a_x = 9.8 \text{ m/s}^2 \sin 35^\circ = 5.6 \text{ m/s}^2$
4. An athlete swings a 5.50-kg ball horizontally on the end of a rope. The ball moves in a circle of radius 0.750 m at an angular speed of 4.82 rad/s. What is the ball’s centripetal acceleration?

\( m = 5.50 \text{ kg} \) \( r = 0.750 \text{ m} \) \( \omega = 4.82 \text{ rad/s} \) \( a_c = ? \)

\[ a_c = r \cdot \omega^2 = (0.750 \text{ m}) (4.82 \text{ rad/s})^2 = 17.4 \text{ m/s}^2 \]

5. The pressure at the bottom of a glass filled with ethyl alcohol (\( \rho = 806 \text{ kg/m}^3 \)) is \( P \). The water is poured out and the glass is filled with water (\( \rho = 1000 \text{ kg/m}^3 \)). The pressure at the bottom of the glass is now

a) smaller than \( P \).

b) equal to \( P \).

c) larger than \( P \).

d) unable to determine.

\[ P_1 = \rho_1 \cdot g \cdot h \quad \rho_1 < \rho_2 \]

\[ P_2 = \rho_2 \cdot g \cdot h \quad \Rightarrow \quad P_1 < P_2 \]

6. A wrench is fitted to a stuck bolt and makes an angle of 30° with respect to the horizontal. The wrench is 0.45 m long and a force of 115 N is applied vertically downward at the end of the wrench farthest from the bolt. How much torque is applied to the bolt by this force.

a) 25.9 N m

b) 44.8 N m
c) 51.8 N m
d) 59.6 N m

\[ \tau = r \cdot F \cdot \sin(\theta) \]

\[ \tau = (0.45 \text{ m})(115 \text{ N}) \cos(30°) \]

\[ \tau = 44.8 \text{ N m} \]
7. A wooden block is pulled 12 m across a frictionless surface using a rope. The tension in the rope is 30 N; and the net work done on the block is 291 J. What angle does the rope make with the horizontal?

\[ W_{\text{net}} = 291 \text{ J} \quad \Delta x = 12 \text{ m} \quad F_p = 30 \text{ N} \]

\[ W_{\text{net}} = F_{\text{net}} \cdot \Delta x \]

\[ 291 \text{ J} = (30 \text{ N} \cos \theta)(12 \text{ m}) \]

\[ \theta = 36^\circ \]

8. A 0.16 kg hockey puck is initially at rest on the ice. When the puck is struck by a hockey stick, the average force exerted on the puck is 250 N. If the puck’s speed after being struck is 12 m/s, how long was the stick in contact with the puck?

\[ m = 0.16 \text{ kg} \quad v_0 = 0 \quad F = 250 \text{ N} \quad v_f = 12 \text{ m/s} \quad t = ? \]

\[ F \Delta t = \Delta p \]

\[ F \Delta t = m v_f - m v_0 \]

\[ 250 \text{ N} \Delta t = (0.16 \text{ kg})(12 \text{ m/s}) - 0 \]

\[ \Delta t = 0.008 \text{ s} \]
9. How much energy is required to change a 30-g ice cube from ice at \(-25^\circ C\) to steam at \(130^\circ C\)? Use the following table of values as needed.

<table>
<thead>
<tr>
<th>Freezing/melting point of water</th>
<th>0°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point of water</td>
<td>100°C</td>
</tr>
<tr>
<td>Specific heat of ice</td>
<td>2,090 J/(kg \cdot ^\circ C)</td>
</tr>
<tr>
<td>Specific heat of water</td>
<td>4,186 J/(kg \cdot ^\circ C)</td>
</tr>
<tr>
<td>Specific heat of steam</td>
<td>2,010 J/(kg \cdot ^\circ C)</td>
</tr>
<tr>
<td>Latent heat of fusion for water</td>
<td>(3.33 \times 10^5) J/kg</td>
</tr>
<tr>
<td>Latent heat of vaporization for water</td>
<td>(2.26 \times 10^6) J/kg</td>
</tr>
</tbody>
</table>

\[
Q = mC_i \Delta T + mL_f + mC_w \Delta T + mL_v + mC_s \Delta T \\
= m[C_i \Delta T + L_f + C_w \Delta T + L_v + C_s \Delta T] \\
= 0.03 \text{ kg}\left[(2090 \text{ J/(kg \cdot } ^\circ \text{C}) \cdot (0-(-25)^\circ C)) + 3.33 \times 10^5 \text{ J/kg} + 4186 \text{ J/kg} \cdot ^\circ C \cdot (100^\circ C - 0^\circ C) + 2.26 \times 10^6 \text{ J/kg} + 2010 \text{ J/kg} \cdot ^\circ C \cdot (130^\circ C - 100^\circ C)\right] \\
= 93700\text{ J}
\]

10. It takes \(1.67 \times 10^6\) J to melt a cup of ice cubes completely to water. What is the mass of the water? (Use the table from number 9.)

| a) 0.739 kg | Q = 1.67 \times 10^6 \text{ J} | m = ? |
| b) 799 kg   | Q = mL_f                      |
| c) 5.02 kg  | 1.67 \times 10^6 \text{ J} = m \times 3.3 \times 10^5 \text{ J/kg} |
| d) 399 kg   | m = 5.02 \text{ kg}          |
| e) 7.99 kg  |                                |

11. Suppose you have 1 kg each of iron, ice, and water at \(10^\circ C\). Rank the amount of energy required to heat each sample by \(20^\circ C\), from least energy to greatest energy. The specific heat of iron is \(448\) J/(kg \cdot ^\circ C) and other values are in the table from number 9.

| a) iron, ice, water | \(Q = cm\Delta T\) |
| b) iron is the least, ice and water would require equal amounts of energy |
| c) ice and water would require equal amounts of energy, iron is the greatest |
| d) water, ice, iron |
| e) ice, water, iron |

\[
C_{iron} = 448 \text{ J/kg} \cdot ^\circ C \\
C_{ice} = 2090 \text{ J/kg} \cdot ^\circ C \\
C_{water} = 4186 \text{ J/kg} \cdot ^\circ C \\
\Rightarrow C_{iron} < C_{ice} < C_{water}
\]
12. A block of mass $m = 0.63 \text{ kg}$ is attached to a spring with force constant $150 \text{ N/m}$ is free to move on a frictionless, horizontal surface as in the figure below. The block is released from rest after the spring is stretched a distance $x = 0.13 \text{ m}$ to the right. At that instant, find the force on the block. (Indicate the direction with the sign of your answer. Assume that the positive direction is to the right.)

a) 0.082 N  
 b) -0.082 N  
 (c) 19.5 N  
 d) 19.5 N  
 e) 94.5 N

\[ F = -kx \]
\[ = - (150 \text{ N/m})(0.13 \text{ m}) = -19.5 \text{ N} \]

13. A block of mass $m = 0.63 \text{ kg}$ is attached to a spring with force constant $150 \text{ N/m}$ is free to move on a frictionless, horizontal surface as in the figure above (see number 6). The block is released from rest after the spring is stretched a distance $x = 0.13 \text{ m}$ to the right. At that instant, find the potential energy.

a) 0.78 J  
 b) 9.8 J  
 (c) 13 J  
 d) 5.7 J  
 e) 30 J

\[ PE = \frac{1}{2}kx^2 = \frac{1}{2} (150 \text{ N/m})(0.13 \text{ m})^2 = 1.3 \text{ J} \]
14. The sinusoidal wave shown in the figure below is traveling in the positive x-direction and has a frequency of 13.7 Hz. What is the wavelength?

a) 5.20 cm
b) 10.4 cm
c) 8.26 cm
d) 4.13 cm
e) 13.7 cm

\[ \lambda = 2 \times 5.20 \text{ cm} = 10.4 \text{ cm} \]

15. The sinusoidal wave shown in the figure below is traveling in the positive x-direction and has a frequency of 13.7 Hz. What is the speed of the wave?

a) 142 m/s
b) 71.2 m/s
c) 113 m/s
d) 1.42 m/s
e) 0.71 m/s

\[ f = 13.7 \text{ Hz} \]
\[ v = \lambda f = (10.4 \text{ cm})(\frac{1 m}{100 \text{ cm}})(13.7 \text{ Hz}) \]
\[ = 1.42 m/s \]

16. When an object moving in simple harmonic motion is at its maximum displacement from equilibrium, which of the following is at its maximum?

a) velocity
b) potential energy
c) kinetic energy
d) torque
17. There are two wave pulses on a string travelling towards each other as shown.

When the two pulses overlap, what will the string look like?

(a)  

(b)  

(c)  

(d)  

18. A pendulum has a mass of 0.75 kg and a length of 2.0 m. What is the period of oscillation of this pendulum?

a) 10 s  

b) 7.7 s  

c) 2.8 s  

d) 1.3 s  

e) 14 s

\[ m = 0.75 \text{ kg} \quad l = 2.0 \text{ m} \]

\[ T = 2\pi \sqrt{\frac{l}{g}} = 2\pi \sqrt{\frac{2.0\text{ m}}{9.8\text{ m/s}^2}} = 2.8\text{ s} \]
19. What is the speed of sound in air at 30 °C?

a) 110 m/s  b) 331 m/s  c) 343 m/s  d) 349 m/s  e) 352 m/s

\[ V = 331 \text{ m/s} \sqrt{\frac{T}{273K}} \quad T_c = T - 273.15 \]

\[ 30°C = T - 273.15 \quad T = 303.15K \]

\[ V = 331 \text{ m/s} \sqrt{\frac{303.15K}{273K}} = 349 \text{ m/s} \]

20. A block of mass \( m = 0.75 \text{ kg} \) is attached to a spring with force constant 239 N/m is free to move on a frictionless, horizontal surface. The block is released from rest after the spring is stretched a distance \( A = 0.20 \text{ m} \) to the right. What is the maximum speed that the block moves with as it undergoes simple harmonic motion?

a) 12.7 m/s  b) 9.52 m/s  c) 7.98 m/s  d) 5.27 m/s  e) 3.57 m/s

\[ m = 0.75 \text{ kg} \quad k = 239 \text{ N/m} \quad A = 0.20 \text{ m} \]

\[ V_{\text{max}} = A\omega \quad \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{239 \text{ N/m}}{0.75 \text{ kg}}} = 17.85 \text{ rad/s} \]

\[ = (0.20 \text{ m}) (17.85 \text{ rad/s}) = 3.57 \text{ m/s} \]

21. A pedestrian hears a car horn sound from a car 5 m away with an intensity \( I \). What is the intensity of the car horn to a second pedestrian who is 15 m away from the same car?

a) 9I  b) 3I  c) I  d) \( \frac{1}{3} I \)  e) \( \frac{1}{9} I \)

\[ I_1 = \frac{\rho}{4\pi r_1^2} \quad r_1 = 5 \text{ m} \quad r_2 = 15 \text{ m} \]

\[ I_1 = \frac{\rho}{4\pi (5)^2} \quad I_2 = \frac{\rho}{4\pi (15)^2} \]

\[ = \frac{\rho}{4\pi (25)} \quad = \frac{\rho}{4\pi (225)} \]

\[ = \frac{\rho}{4\pi (25)(9)} = \frac{1}{9} I_1 \]
22. A sound wave takes 0.01 seconds to travel 50 m along a bar of metal. If the metal has a density of 8050 $\frac{kg}{m^3}$ what is the Young’s modulus of the metal?

\[ t = 0.01 \text{ s} \quad \Delta x = 50 \text{ m} \quad \rho = 8050 \frac{kg}{m^3} \quad Y = ? \]

\[ V = \sqrt{\frac{Y}{\rho}} \]

\[ \Delta x = v \cdot t \]

\[ 50 \text{ m} = v (0.01 \text{ s}) \]

\[ v = 5000 \frac{m}{s} \]

\[ 5000 \frac{m}{s} = \sqrt{\frac{Y}{8050 \frac{kg}{m^3}}} \]

\[ Y = 2.01 \times 10^{11} \text{ Pa} \]

23. A block with a mass of 15 kg is attached to the end of a horizontal spring and set into simple harmonic motion along a frictionless surface. What is the spring constant of the spring if the block moves with a frequency of 0.2 Hz?

\[ \text{a) } 23.7 \text{ N/m} \quad \text{b) } 51.9 \text{ N/m} \quad \text{c) } 18.8 \text{ N/m} \quad \text{d) } 9.34 \text{ N/m} \quad \text{e) } 12.9 \text{ N/m} \]

\[ m = 15 \text{ kg} \quad f = 0.2 \text{ Hz} \quad k = ? \]

\[ f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = \frac{1}{2\pi} \sqrt{\frac{k}{15 \text{ kg}}} = 0.2 \text{ Hz} \]

\[ k = 23.7 \text{ N/m} \]
24. The speed of a wave along a taught string is 175 m/s. If the string is under a tension of 65 N what is the mass per unit length of the string?

\[ \text{a) 74.3 g/m \quad \text{b) 16.8 g/m \quad \text{c) 2.12 g/m \quad d) 371 g/m \quad e) 8.55 g/m} \]

\[ v = 175 \text{ m/s} \quad T = 65 \text{ N} \quad \mu = ? \]

\[ v = \sqrt{\frac{F}{\mu}} \]

\[ 175 \text{ m/s} = \sqrt{\frac{65 \text{ N}}{\mu}} \]

\[ \mu = 0.00212 \text{ kg/m} = 2.12 \text{ g/m} \]

25. A block of mass M is attached to a horizontal spring set into simple harmonic motion along a frictionless table on earth and the period of oscillation is measured to be \( T_E \). If this system were moved to the moon which has an acceleration due to gravity that is much lower than that on earth how would the period change?

\[ \text{a) The period of oscillation on the moon would be greater than } T_E \]
\[ \text{b) The period of oscillation on the moon would be equal to } T_E \]
\[ \text{c) The period of oscillation on the moon would be less than } T_E \]
\[ \text{d) More information is needed to answer.} \]

\[ T = 2\pi \sqrt{\frac{m}{k}} \quad \text{independent of } g \]