6. Using the dimensions for the variables given in the table,

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f$</td>
<td>$[T]$</td>
</tr>
<tr>
<td>$l$</td>
<td>$[L]$</td>
</tr>
<tr>
<td>$g$</td>
<td>$[T]$</td>
</tr>
</tbody>
</table>

determine which one of the following expressions is correct.

A) $f = 2\pi \sqrt{\frac{g}{l}}$  \[ \frac{1}{T} \]  \[ \frac{2 \Delta T}{\sqrt{\pi \Delta T^2}} \]  \[ \frac{1}{T^2} \]  \[ \frac{2 \Delta T}{\pi \Delta T} \]  \[ \frac{2}{\pi} \]  \[ \text{no} \]

B) $f = \frac{g}{2\pi l}$  \[ \frac{1}{T} \]  \[ \frac{2 \Delta T}{\sqrt{\pi \Delta T^2}} \]  \[ \frac{1}{T^2} \]  \[ \frac{2 \Delta T}{\pi \Delta T} \]  \[ \frac{2}{\pi} \]  \[ \text{yes} \]

C) $f = \frac{g}{2\pi l}$  \[ \frac{1}{T} \]  \[ \frac{2 \Delta T}{\sqrt{\pi \Delta T^2}} \]  \[ \frac{1}{T^2} \]  \[ \frac{2 \Delta T}{\pi \Delta T} \]  \[ \frac{2}{\pi} \]  \[ \text{no} \]

D) $f = \sqrt{\frac{l}{g}}$  \[ \frac{1}{T} \]  \[ \frac{2 \Delta T}{\sqrt{\pi \Delta T^2}} \]  \[ \frac{1}{T^2} \]  \[ \frac{2 \Delta T}{\pi \Delta T} \]  \[ \frac{2}{\pi} \]  \[ \text{no} \]

E) $f = 2\pi \sqrt{gl}$  \[ \frac{1}{T} \]  \[ \frac{2 \Delta T}{\sqrt{\pi \Delta T^2}} \]  \[ \frac{1}{T^2} \]  \[ \frac{2 \Delta T}{\pi \Delta T} \]  \[ \frac{2}{\pi} \]  \[ \text{no} \]
7. A 2.5-m ladder leans against a wall and makes an angle with the wall of 32° as shown in the figure. What is the height \( h \) above the floor where the ladder makes contact with the wall?

\[
\begin{align*}
\theta &= 2.5 \text{ m} \\
\cos 32° &= \frac{b}{h} \\
h &= 2.5 \text{ m} \cos 32° = 2.12 \text{ m}
\end{align*}
\]

A) 1.6 m  
B) 1.9 m  
C) 1.3 m  
D) 2.4 m  
E) 2.1 m

8. Three vectors \( A \), \( B \), and \( C \) add together to yield zero: \( A + B + C = 0 \). The vectors \( A \) and \( C \) point in opposite directions and their magnitudes are related by the expression: \( A = 2C \). Which one of the following conclusions is correct?

A) \( A \) and \( B \) have equal magnitudes and point in opposite directions.  
B) \( B \) and \( C \) have equal magnitudes and point in the same direction.  
C) \( B \) and \( C \) have equal magnitudes and point in opposite directions.  
D) \( A \) and \( B \) point in the same direction, but \( A \) has twice the magnitude of \( B \).  
E) \( B \) and \( C \) point in the same direction, but \( C \) has twice the magnitude of \( B \).}

9. The \( x \) and \( y \) components of a displacement vector are \(-3.00 \text{ m}\) and \(+4.00 \text{ m}\), respectively. What angle does this vector make with the positive \( x \) axis?

\[
\begin{align*}
\tan \alpha &= \frac{4}{3} \\
\alpha &= 53° \\
\theta &= 180° - \alpha = 127°
\end{align*}
\]

A) 127°  
B) -53.0°  
C) 53.0°  
D) 233°  
E) 37.0°
10. Use the component method of vector addition to find the components of the resultant of the four displacements shown in the figure. The magnitudes of the displacements are: $A = 2.25 \text{ cm}$, $B = 6.35 \text{ cm}$, $C = 5.47 \text{ cm}$, and $D = 4.19 \text{ cm}$.

\[ \begin{align*}
A_x &= 2.25 \cos 60^\circ = 1.125 \\
A_y &= 2.25 \sin 60^\circ = 1.948 \\
B_x &= 6.35 \cos 20^\circ = 5.967 \\
B_y &= -6.35 \sin 20^\circ = -2.172 \\
C_x &= 5.47 \sin 36^\circ = 3.215 \\
C_y &= -5.47 \cos 36^\circ = -4.425 \\
D_x &= -4.19 \cos 30^\circ = -3.590 \\
D_y &= 4.19 \sin 30^\circ = 2.195 \\
A_x + B_x + C_x + D_x &= 6.917 \\
A_y + B_y + C_y + D_y &= -2.186
\end{align*} \]

11. A car starts from rest and accelerates at a constant rate in a straight line. In the first second the car covers a distance of 2.0 meters. How fast will the car be moving at the end of the second second?

\[ \begin{align*}
A) \ 32 \text{ m/s} \\
B) \ 4.0 \text{ m/s} \\
C) \ 8.0 \text{ m/s} \\
D) \ 16 \text{ m/s} \\
E) \ 2.0 \text{ m/s}
\end{align*} \]

\[ \begin{align*}
\chi &= \chi_0 + v_0 t + \frac{1}{2} a t^2 \\
\chi_0 &= 0 \quad v_0 = 0 \\
\chi &= 2.0 \text{ m} \quad t = 1 \\
50 &= \frac{1}{2} a (1)^2
\end{align*} \]

\[ \begin{align*}
\chi &= \chi_0 + v_0 t + \frac{1}{2} a t^2 \\
\chi_0 &= 0 \quad v_0 = 0 \\
\chi &= 8.0 \text{ m/s} \quad t = 2 \text{ s} \\
\chi &= 8.0 + \frac{1}{2} (-4) (2)^2 \\
\chi &= 8.0 - 8.0 \\
\chi &= 0 \text{ m} \\
\chi &= 8.0 + \frac{1}{2} (-4) (20)^2 \\
\chi &= 8.0 - 800 = 800 \text{ m}
\end{align*} \]
Use the following to answer question 13:

An object is moving along the x axis. The graph shows its position from the starting point as a function of time.

Various segments of the graph are identified by the letters A, B, C, and D.

13. During which interval(s) is the object moving in the negative x direction?
   A) during interval B only
   B) during intervals B and C
   C) during intervals C and D
   D) during intervals B and D
   E) during intervals B, C, and D

Moving in negative x direction means x vs. t graph must have a negative slope. Since v is the slope, only in B is slope negative.

Use the following to answer question 14:

A tennis ball is shot vertically upward with an initial speed of 20.0 m/s from the surface of planet Krypton—a planet with no atmosphere. One second later, the ball has an instantaneous velocity in the upward direction of 15.0 m/s.

14. How long does it take the ball to reach its maximum height?
   A) 4.0 s
   B) 2.3 s
   C) 8.0 s
   D) 4.6 s
   E) 2.0 s

\[ v_t = v_0 + at \]
\[ a = \frac{v_t - v_0}{t} \]

\[ v_t = 15.0 \text{ m/s} \]
\[ v_0 = 20.0 \text{ m/s} \]

\[ t = 1 \text{ s}, \quad 50 \quad a = \frac{15.0 - 20.0}{-1} = -5.0 \text{ m/s}^2 \]

For maximum height, \( v = 0 \)

\[ v = v_0 + at \]
\[ v_{max} = 20.0 - 5.0 \]

\[ \therefore t_{max} = 4.0 \text{ s.} \]
Use the following to answer question 15:

A projectile is fired at an angle of 60.0° above the horizontal with an initial speed of 30.0 m/s.

15. How long does it take the projectile to reach the highest point in its trajectory?

A) 1.5 s  
B) 4.0 s  
C) 2.7 s  
D) 9.8 s  
E) 6.2 s

\[ v_{oy} = 3.0 \sin 60° = 25.98 \text{ m/s} \]
\[ t = \frac{v_{oy}}{g} = \frac{25.98}{9.8} \approx 2.65 \text{ s} \]

16. A projectile is fired horizontally with an initial speed of 57 m/s. What are the horizontal and vertical components of its displacement 3.0 s after it is fired?

<table>
<thead>
<tr>
<th>horizontal</th>
<th>vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>210 m</td>
<td>44 m</td>
</tr>
<tr>
<td>170 m</td>
<td>-44 m</td>
</tr>
<tr>
<td>210 m</td>
<td>0 m</td>
</tr>
<tr>
<td>44 m</td>
<td>29 m</td>
</tr>
<tr>
<td>170 m</td>
<td>-29 m</td>
</tr>
</tbody>
</table>

Horizontal component is 57 m/s.

It does not change so

\[ x = x_0 + v_{ox} t = 0 + 57 \cdot 3.0 = 171 \text{ m} \]

Vertical component stays at zero and accelerates downward due to gravity

\[ y = y_0 + v_{oy} t + \frac{1}{2} a t^2 \]
\[ y = 0 + 25.98 \cdot 3.0 + \frac{1}{2} (-9.8) (3.0)^2 = -814.1 \text{ m} \]
A rock is kicked \textit{horizontally} at a speed of 5 m/s from the edge of a cliff. The rock strikes the ground 55 m from the foot of the cliff of height $H$ as suggested in the figure. Neglect air resistance.

17. How long is the rock in the air?
   
   \begin{itemize}
   \item[A)] 11.0 s
   \item[B)] 22.0 s
   \item[C)] 1.2 s
   \item[D)] 3.4 s
   \item[E)] 1.0 s
   \end{itemize}

18. What is the approximate value of $H$, the height of the cliff?

   \begin{itemize}
   \item[A)] 700 m
   \item[B)] 595 m
   \item[C)] 830 m
   \item[D)] 540 m
   \item[E)] 270 m
   \end{itemize}

   \[
   \text{Vertical velocity } v_{oy} = 0
   \]

   \[
   y = -H = y_0 + v_{oy} t + \frac{1}{2} a t^2
   \]

   \[
   -H = 0 + 0 \cdot 11 + \frac{1}{2} (-9.8) (11)^2
   \]

   \[
   -H = -593 \text{ m}
   \]
Use the following to answer question 19:

A spaceship is observed traveling in the positive x direction with a speed of 150 m/s when it begins accelerating at a constant rate. The spaceship is observed 25 s later traveling with an instantaneous velocity of 1500 m/s at an angle of 55° above the +x axis.

19. What was the magnitude of the acceleration of the spaceship during the 25 seconds?
   A) 57 m/s²
   B) 1.5 m/s²
   C) 28 m/s²
   D) 48 m/s²
   E) 7.3 m/s²

\[ \Delta v_x = 1500 \cos 55° - 150 = 710 \text{ m/s} \]
\[ \Delta v_y = 1500 \sin 55° = 1229 \text{ m/s} \]
\[ \Delta v = \sqrt{(\Delta v_x)^2 + (\Delta v_y)^2} = \sqrt{1229^2 + 710^2} = 1419 \text{ m/s} \]
\[ a = \frac{\Delta v}{\Delta t} = \frac{1419}{25} = 56.8 \text{ m/s}^2 \]

20. The figure shows the velocity versus time curve for a car traveling along a straight line.

Which of the following statements is false?
A) No net force acts on the car during interval B.
B) Net forces act on the car during intervals A and C.
C) Opposing forces may be acting on the car during interval B.
D) Opposing forces may be acting on the car during interval C.
E) The magnitude of the net force acting during interval A is less than that during C.

\[ F_{net} = ma \]
\[ \text{If } a = 0 \Rightarrow F_{net} = 0 \]
\[ \text{No change in } V \Rightarrow a = 0 \text{ TRUE} \]
\[ \text{Change in } V \Rightarrow a \neq 0 \text{ TRUE} \]

\[ \text{Could be true if net force is negative, } \]
\[ \text{So } a < 0, \]
\[ |a_A| > |a_C| \]
\[ |F_A| > |F_C| \]
Use the following to answer question 21:

In space, a 70.0-kg astronaut pushes to the left on a spacecraft with a force \( F \). (In orbit, both the astronaut and the spacecraft are weightless). The spacecraft has a total mass of \( 1.0 \times 10^4 \) kg.

During the push, the astronaut accelerates to the right with an acceleration of \( 0.36 \text{ m/s}^2 \).

21. Determine the magnitude of the acceleration of the spacecraft.
   A) \( 3.97 \times 10^{-4} \text{ m/s}^2 \)
   B) \( 51.4 \text{ m/s}^2 \)
   C) \( 0.36 \text{ m/s}^2 \)
   D) \( 7.0 \times 10^{-3} \text{ m/s}^2 \)
   E) \( 2.5 \times 10^{-3} \text{ m/s}^2 \)

\[ a_{\text{spacecraft}} = \frac{F}{M_{\text{spacecraft}}} = \frac{F}{1.0 \times 10^4 \text{ kg}} \]

Astronaut feels reaction force \( F \), in opposite direction (right), accelerates at

\[ a_{\text{astronaut}} = \frac{F}{M_{\text{astronaut}}} \]

\[ 0.36 \text{ m/s}^2 = \frac{F}{70.0 \text{ kg}} \Rightarrow F = 70.0 \times 0.36 \text{ kg m/s}^2 \]

\[ F = 25.2 \text{ N} \]

THerefore \( a_{\text{spacecraft}} = \frac{25.2 \text{ N}}{1.0 \times 10^4 \text{ kg}} = 2.52 \times 10^{-3} \text{ m/s}^2 \)
Use the following to answer question 22:

A force $P$ pulls on a crate of mass $m$ on a rough surface. The figure shows the magnitudes and directions of the forces that act on the crate in this situation. $W$ represents the weight of the crate. $F_N$ represents the normal force on the crate, and $f$ represents the frictional force.

22. What is the magnitude of $F_N$, the normal force on the crate?

A) 57 N  
B) 80 N  
C) 196 N  
D) 230 N  
E) 160 N

\[ P_{\text{vertical}} = 160 \, \text{N} \times \cos 60^\circ = 139 \, \text{N} \]
\[ F_N = 196 - 139 = 57 \, \text{N} \]

23. A boy pulls a sled of mass 5.0 kg with a rope that makes an 60.0° angle with respect to the horizontal surface of a frozen pond. The boy pulls on the rope with a force of 10.0 N; and the sled moves with constant velocity. What is the coefficient of friction between the sled and the ice?

A) 0.10  
B) 0.18  
C) 1.0  
D) 0.12  
E) 0.20

The free body diagram is just like the one in problem 22, and since there is no acceleration the friction $f$ must balance $P_{\text{horizontal}} = 10.0 \, \text{N} \times \cos 60^\circ$
\[ f = 10.0 \, \text{N} \cos 60^\circ = 5.0 \, \text{N} \]
\[ f = \mu F_N \]
So now we need to find $F_N$, that will be the weight of the sled less the vertical part of $P$.
\[ F_N = m g - P \sin 60^\circ \]
\[ F_N = 5.0 \, \text{kg} \times (9.8 \, \text{m/s}^2) - 10.0 \sin 60^\circ \]
\[ F_N = 49 - 8.66 = 40.3 \, \text{N} \]