WE NEED TO FIND $x$ (THE VERTICAL DISTANCE BETWEEN THE OBSERVER'S EYES AND THE TOP OF THE TREE) AND ADD IT TO THE HEIGHT FROM THE GROUND TO THE OBSERVER'S EYES.

\[
\tan \theta = \frac{h_o}{h_e}
\]

\[\tan (30^\circ) = \frac{x}{36\text{m}}\]

\[0.364 = \frac{x}{36\text{m}}\]

\[x = 11.65\text{ m}\]

\[h_T = x + 1.8\text{ m}\]

\[h_T = 11.65\text{m} + 1.8\text{m}\]

\[h_T = 13.45\text{m}\]

WE FIRST NEED TO FIND THE DISTANCE BETWEEN THE TWO SODIUM ATOMS ON THE BOTTOM.

\[a = 0.281\text{ nm}\]

\[a^2 + a^2 = c^2\]

\[c = \sqrt{a^2 + a^2}\]

\[c = \sqrt{0.281^2}\]

NOW WE CAN USE $c$ AND $a$ TO FIND $d$ (THE DISTANCE THE SODIUM + CHLORINE PAIRS IN QUESTION).
\[ A^2 + C^2 = D^2 \]
\[ A^2 + (\sqrt{3}A)^2 = D^2 \]
\[ A^2 + 3A^2 = D^2 \]
\[ D^2 = 3A^2 \]
\[ d = \sqrt{3} A^2 \]
\[ d = \sqrt{3} (0.381 \text{ nm})^2 \]
\[ d = 0.487 \text{ nm} \]

1.18) 

\[ h = \text{height of observer's eyes} \]
\[ r = \text{radius of Earth} \]
\[ d = \text{distance from observer's eyes to horizon} \]

(a) Using the formula \( A^2 + B^2 = C^2 \) where \( C \) is the hypotenuse, we get the following.

\[ R^2 + d^2 = (h + R)^2 \]
\[ d^2 = (h + R)^2 - R^2 \]
\[ d = \sqrt{(h + R)^2 - R^2} \]
\[ d = \sqrt{h^2 + 2Rh + R^2 - R^2} \]
\[ d = \sqrt{h^2 + 2Rh} \]
\[ d = \sqrt{(1.6 \text{ m})^2 + 2(6.38 \times 10^6 \text{ m})(1.6 \text{ m})} \]
\[ d = \sqrt{20416002.56} = 4518.41 \text{ m} \]

(b) Convert this distance into miles.

\[ 4518.41 \text{ m} = 4518.41 \times 10^3 \text{ km} \]
\[ 4.51841 \times 10^3 \text{ km} \times \frac{1}{1.609} \text{ m/km} = 2.81 \text{ mi} \]

1.30)

\[ L^2 = h^2 + x^2 \]

Plug in for \( x \rightarrow L^2 = h^2 + \frac{1}{3} L^2 \)
\[ h^2 = \frac{2}{3} L^2 \]
\[ \frac{h^2}{L^2} = \frac{2}{3} \Rightarrow \frac{h}{L} = \frac{\sqrt{2}}{\sqrt{3}} \]
1.\textit{a}) 

\[ \vec{A} = 445 \text{ newtons due west} \]
\[ \vec{B} = 325 \text{ newtons due north} \]

We can draw our picture the following way so that it is more obvious what to do.

\[ \vec{C} \]

What is the resulting vector \( \vec{C} \)?

\[ C^2 = A^2 + B^2 \]
\[ C = \sqrt{A^2 + B^2} \]
\[ C = \sqrt{(445 \text{ newtons})^2 + (325 \text{ newtons})^2} \]
\[ C = \sqrt{303650 \text{ newtons}^2} \]
\[ C = 551.04 \text{ newtons} \]

All we found here was the magnitude so the value for \( C \) above is not a vector. We also have to find the direction.

\[ \tan \theta = \frac{B}{A} \]
\[ \theta = \tan^{-1} \left( \frac{B}{A} \right) \]
\[ \theta = \tan^{-1} \left( \frac{325 \text{ newtons}}{445 \text{ newtons}} \right) \]
\[ \theta = 36.1^\circ \text{ north of west} \]

b) What would happen if the second worker applied a force of \( -\vec{B} \)?
First find the resulting vector \( \vec{C} \).

\[
\begin{align*}
C &= \sqrt{a^2 + b^2} \\
C &= \sqrt{(445 \text{ newtons})^2 + (-325 \text{ newtons})^2} \\
C &= \sqrt{3031650 \text{ newtons}^2} \\
C &= 551.04 \text{ newtons}
\end{align*}
\]

Now we can find the direction.

\[
\begin{align*}
\Theta &= \tan^{-1} \left( \frac{b}{a} \right) \\
\Theta &= \tan^{-1} \left( \frac{-325}{445} \right) \\
\Theta &= -36.1^\circ \quad \text{This means that it's } 36.1^\circ \text{ south of west.}
\end{align*}
\]

Finding the magnitude of the horizontal component of the plane's velocity should be simple. The x component will be the cosine of the angle multiplied by the magnitude of the velocity vector.

\[
\begin{align*}
\cos \Theta &= \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{A_x}{A} \\
A_x &= A \cdot \cos \Theta \\
A_x &= (180 \text{ m/s}) \cos(34^\circ) \\
A_x &= 149.2 \text{ m/s}
\end{align*}
\]
For the sum of the three forces to be 0, the sum of the x-components and the sum of the \( \mu \)-components must both be 0.

The way to solve this is to break all of the forces down, set the sums to 0, and solve for \( F_3 \).

\[ F_1 = 31 \text{ N at } 30^\circ \text{ left of the } \mu \text{-axis} \]
\[ F_2 = 15 \text{ N on the positive x-axis} \]

\[ F_{1x} = \sin(30^\circ)(31 \text{ N}) \]
\[ F_{1x} = -10.5 \text{ N} \]

\[ F_{ax} = F_3 \]

\[ 0 = F_{3x} + F_{1x} + F_{ax} \]
\[ 0 = F_{3x} -10.5 \text{ N} + 15 \text{ N} \]
\[ F_{3x} = 4.5 \text{ N} \]

\[ F_{1\mu} = \cos(30^\circ)(31 \text{ N}) \]
\[ F_{1\mu} = 18.19 \text{ N} \]

\[ F_{a\mu} = 0 \]

\[ 0 = F_{3\mu} + F_{a\mu} + F_{1\mu} \]
\[ 0 = F_{3\mu} + 18.19 \text{ N} + 0 \]
\[ F_{3\mu} = -18.19 \text{ N} \]

Now that we know the x and \( \mu \) components
Of the third force we can find its magnitude and direction.

\[ F_3 = \sqrt{F_{3x}^2 + F_{3y}^2} \]

\[ F_3 = \sqrt{(-4.57 \text{ N})^2 + (-18.19 \text{ N})^2} \]

\[ F_3 = 18.73 \text{ N} \]

\[ \cos \theta = \frac{\text{Adjacent}}{\text{Hypotenuse}} = \frac{F_{3x}}{F_3} \]

\[ \theta = \cos^{-1} \left( \frac{F_{3x}}{F_3} \right) \]

\[ \theta = 75.7^\circ \text{ towards -x from the -x axis} \]

3.2) \[ x = 27.4 \text{ m} \]

The batter moves from point A to point B around the square as shown. His displacement vector (marked as d) is 27.4 m long. This is because it is just the distance from 3rd base to home plate.

3.3) \[ \theta = 35^\circ \]

\[ V_x = 7.7 \text{ m/s} \]

\[ V_y = 3 \]

\[ \tan \theta = \frac{\text{Opposite}}{\text{Adjacent}} \]

\[ \tan \theta = \frac{V_y}{V_x} \]

\[ V_y = V_x \tan \theta \]

\[ V_y = (7.7 \text{ m/s}) \tan(35^\circ) \]

\[ V_y = 5.4 \text{ m/s} \]
we know...
\( \theta = 65^\circ \)
\( v_0 = 11\text{ m/s} \)
\( v_{yF} = 0 \)
\( a = -9.8\text{ m/s}^2 \)

we can find the x-component of the initial velocity pretty easily,

\[
\sin \theta = \frac{v_{0x}}{v_0} \\
v_{0x} = v_0 \sin \theta \\
v_{0x} = (11\text{ m/s}) \sin (65^\circ) \\
v_{0x} = 10\text{ m/s}
\]

we know from chapter 2 an equation that relates final velocity, initial velocity, acceleration, and height.

\[
v^2 = v_0^2 + 2ax \\
v_{yF}^2 = v_{0y}^2 + 2ay
\]

now we can solve for \( y \).

\[
2ay = v_{yF}^2 - v_{0y}^2 \\
ay = \frac{v_{yF}^2 - v_{0y}^2}{2a} \\
y = \frac{-10^2}{2a}(-9.8\text{ m/s}^2) \\
y = 5.1\text{ m}
\]

3.20) we are asked to calculate the maximum height that a 65 jump would attain.

since the entire jump takes as the time until the maximum height is reached is one second. we also know that at the top the x-component of velocity is zero.
\[ V_x = 0 \quad A_x = -9.8 \text{ m/s}^2 \quad t = 1.0 \text{ s} \quad \mu = ? \]

\[ V_x^2 = V_{0x}^2 + 2a_x\Delta x \]
\[ \Delta x = -V_{0x} \]
\[ \mu = \frac{-V_{0x}^2}{2a_x} \]

Now we need to find \( V_{0x} \).

\[ V_x = V_{0x} + at \]
\[ V_{0x} = -at \]
\[ V_{0x} = (-9.8 \text{ m/s}^2)(1.0 \text{ s}) \]
\[ V_{0x} = 9.8 \text{ m/s} \]

Now we can solve for \( \mu \).

\[ \mu = \frac{-V_{0x}^2}{2(-9.8 \text{ m/s}^2)} \]
\[ \mu = 4.0 \text{ m} \]

If M.I.'s estimated jump height is 1 m, there is no way that he can stay in the air for 2 s.

3.6(b) \[ \begin{align*}
V_{0x} &= 41 \text{ m/s} \\
A_x &= -9.8 \text{ m/s}^2 \\
X &= 17.0 \text{ m} \\
V_{0y} &= 0
\end{align*} \]

What is \( \mu \)?

For the \( x \) direction, we know the initial velocity, distance, and acceleration. This means we can find the time it takes for the ball to reach the pitcher.

\[ x = v_0t + \frac{1}{2}at^2 \]
\[ x = V_{ox}t + \frac{1}{2}a_x t^2 \]
\[ t = \frac{x}{V_{ox}} \]
\[ t = \frac{17}{41.35} \]
\[ t = 0.415 \text{s} \]

For the x direction we have time, acceleration, and initial velocity. This means that we can solve for height.

\[ x = V_{ox}t + \frac{1}{2}a_x t^2 \]
\[ x = 0 + \frac{1}{2}(-9.8 \text{ m/s}^2)(0.415 \text{s})^2 \]
\[ x = -0.84 \text{ m} \]

The negative means the ball is going down so 0.84 m is how far the ball dropped.

\[ V_{ox_1} = V_{ox_2} = V_{ox} \]
\[ a_{x_1} = a_{x_2} = -9.8 \text{ m/s}^2 \]
\[ a_{x_1} = a_{x_2} = 0 \]
\[ x_1 = 3x_2 \quad \therefore \quad \frac{x_2}{x_1} = \frac{1}{3} \]
\[ V_{ox_1} = V_{ox_2} = 0 \]

\[ x_1 = V_{ox}t + \frac{1}{2}a_{x_1} t^2 \]
\[ x_2 = V_{ox} t_2 + \frac{1}{2}a_{x_2} t_2^2 \]

\[ \frac{x_2}{x_1} = \frac{V_{ox} t_2}{V_{ox} t_1} = \frac{t_2}{t_1} = 3 \]
\[ x_1 = y_0 + \frac{1}{2} a t^2 \]
\[ x_1 = \frac{1}{2} a t^2 \]
\[ y_0 = y_0 + v_0 t + \frac{1}{2} a t^2 \]
\[ y_0 = \frac{1}{2} a t^2 \]

The tall building is 4 times taller than the short one.

1) Including air resistance would decrease the speed of the ball on the way down at the same point and space that it was initially thrown up from. As the ball goes up the force acting on the ball created by air resistance slows the ball down so it will reach a height that is less than the height reached by the ball without air resistance. There is now a shorter distance for gravity to pull the ball down to the starting position. This shorter distance and the air resistance of the ball on the way down means that the velocity will be less than the velocity of the ball without air resistance.

\[ \text{\textbf{h}} \}
\[ y' - v_0 \]
\[ y_0 \text{ Air resistance} \]
\[ y' \text{ Air resistance} \]
3) We are given the following information about the minivan.

\[ v_0 = 0 \quad v = 60 \text{ km/hr} \]
\[ t_0 = 0 \quad t = 30 \text{ s} \]

What is the minivan's acceleration in m/s²?

\[ a = \frac{\Delta v}{\Delta t} = \frac{v-v_0}{t-t_0} = \frac{v}{t} \]

We need to convert the velocity to m/s.

\[ v = 60 \text{ km/hr} = 16.67 \text{ m/s} \]

\[ a = \frac{16.67 \text{ m/s}}{30 \text{ s}} = 0.55 \text{ m/s}^2 \]

3) \[ \vec{a} = 1 \text{ m} \hat{x} + 1 \text{ m} \hat{y} \]

Now we are asked to rotate our coordinate system by 45° counter-clockwise. And verify that the \( \mathbf{x}' \) and \( \mathbf{y}' \) axes are perpendicular. We can first draw our new coordinate system with respect to the old one.

Since we know that the angle between \( \mathbf{x} \) and \( \mathbf{y} \) is 90°, we can find \( \theta \) and then add...
Put to the 45° between \( \hat{\mathbf{A}} \) and \( \hat{\mathbf{A}}' \) to get the angle between \( \hat{x}' \) and \( \hat{\mathbf{A}}' \).

\[
\theta = 90° - 45° = 45°
\]

\[
\angle \text{between } \hat{x}' \text{ and } \hat{\mathbf{A}}' = 45° + \theta = 90°
\]

Now we can write \( \hat{\mathbf{A}} \) in terms of \( \hat{x}' \) and \( \hat{\mathbf{A}}' \).

First let's find the length of \( \hat{\mathbf{A}} \).

\[
\hat{\mathbf{A}} = 1\mathbf{m}\hat{x} + 1\mathbf{m}\hat{\mathbf{A}}
\]

\[
|\hat{\mathbf{A}}| = \sqrt{1^2 + 1^2} = \sqrt{2}\ \mathbf{m}
\]

The length of \( \hat{\mathbf{A}} \) will not change when the coordinate system is rotated. We can also find the angle between \( \hat{\mathbf{A}} \) and \( \hat{x} \).

\[
\theta = \cos^{-1}\left(\frac{1\mathbf{m}}{\sqrt{2}\ \mathbf{m}}\right)
\]

\[
\theta = \cos^{-1}\left(\frac{1}{\sqrt{2}}\right)
\]

\[
\theta = 45°
\]

Since \( \hat{\mathbf{A}} \) is pointing 45° "north" of the \( x \)-axis, we know that in the new coordinate system \( \hat{\mathbf{A}} \) will lie completely along the \( x' \)-axis because it also points 45° "north" of the \( x \)-axis. Now we can write \( \hat{\mathbf{A}} \) in terms of \( \hat{x}' \) and \( \hat{\mathbf{A}}' \).
4) We know that the velocity of the boat is $v_0$ and the velocity of the river is $v_r$. We are also told that the width of the river is $w$ and the pilot of the boat wants to reach a point directly across the river from where she started.

If the boat points directly across the river the current will displace the boat so that it ends up at point $A$. Since we know the velocity of the river and the velocity of the boat we can find the angle of displacement.

$$\sin \theta = \frac{v_b}{v_0}$$

$$\theta = \sin^{-1} \frac{v_b}{v_0}$$

Since the velocities are the same in all parts of the river we can say that the pilot should aim the boat at an angle of $\theta = \sin^{-1} \frac{v_b}{v_0}$ up river to reach the point directly across the river.
Now we need to find out how long it will take for the boat to cross the river.

\[
v_2 = \frac{d}{t}
\]

\[
t = \frac{d}{v}
\]

\[
v = \sqrt{V_0^2 - V_R^2}
\]

Then the time becomes the following.

\[
t = \frac{\omega}{\sqrt{V_0^2 - V_R^2}}
\]

Note that there is no solution for \( \theta \) or \( t \) if \( V_R > V_0 \). It is obvious to see this in our equation for \( t \) because we would have a negative value under the square root.