Unit 4.1

We are going to continue to look at position, velocity, and acceleration.

- Use of words.
- Fan cart and motion sensor.
- Mathematical modeling of motion.
- Kinematics equations.

Unit 4.2

Position, velocity, & acceleration are vectors (magnitude and direction).

⇒ We have to be very careful with our language.
On a math number line, which represents pure numbers (scalars):

\[-4 < -2 < 0 < 1 < 4 \quad \text{etc.}\]

But for velocity (which is a vector):

Is \( v_x = -4 \, \text{m/s} \) less than \( v_x = +1 \, \text{m/s} \) ?

<table>
<thead>
<tr>
<th>Bad (ambiguous) words</th>
<th>Good words</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than</td>
<td>slower } magnitude</td>
</tr>
<tr>
<td>greater than</td>
<td>faster }</td>
</tr>
<tr>
<td>smaller</td>
<td>positive } direction</td>
</tr>
<tr>
<td>larger</td>
<td>negative }</td>
</tr>
</tbody>
</table>
We have a similar problem for acceleration:

Deceleration: we usually mean slowing down.

⇒ What is the direction (sign) of $a_x$? Positive? Negative?

If the object is **speeding up**, the acceleration vector points in the **same direction** as the velocity vector.

If the object is **slowing down**, the acceleration vector points in the **opposite direction** as the velocity vector.
Two examples using math:

\[ v_{1x} = -4 \frac{\text{m}}{\text{s}} \text{ at } t_1 = 1\text{s} \quad v_{2x} = -2 \frac{\text{m}}{\text{s}} \text{ at } t_2 = 3\text{s} \]
Two examples using math:

\[ v_{1x} = -4 \frac{m}{s} \text{ at } t_1 = 1s \quad \quad v_{2x} = -2 \frac{m}{s} \text{ at } t_2 = 3s \]

object is moving in the negative \( x \)-direction & is slowing down
Two examples using math:

\[ v_{1x} = -4 \frac{\text{m}}{\text{s}} \text{ at } t_1 = 1\text{s} \quad v_{2x} = -2 \frac{\text{m}}{\text{s}} \text{ at } t_2 = 3\text{s} \]

Object is moving in the negative \( x \)-direction & is slowing down

\[ <a_x> \equiv \frac{\Delta v_x}{\Delta t} = \frac{(-2 \text{m/s}) - (-4 \text{m/s})}{3\text{s} - 1\text{s}} = +1 \frac{\text{m/s}}{\text{s}} \]

Acceleration vector points in the positive \( x \)-direction
Two examples using math:

\[ v_{1x} = -2 \frac{\text{mi}}{\text{hr}} \text{ at } t_1 = 10 \text{ s} \]

\[ v_{2x} = -4 \frac{\text{mi}}{\text{hr}} \text{ at } t_2 = 12 \text{ s} \]
Two examples using math:

\[ v_{1x} = -2 \frac{\text{mi}}{\text{hr}} \text{ at } t_1 = 10 \text{ s} \]

\[ v_{2x} = -4 \frac{\text{mi}}{\text{hr}} \text{ at } t_2 = 12 \text{ s} \]

object is moving in the negative \( x \)-direction & is speeding up
Two examples using math:

\[ v_{1x} = -2 \frac{\text{mi}}{\text{hr}} \quad \text{at} \quad t_1 = 10 \text{ s} \quad v_{2x} = -4 \frac{\text{mi}}{\text{hr}} \quad \text{at} \quad t_2 = 12 \text{ s} \]

object is moving in the negative \( x \)-direction & is speeding up

\[ <a_x> \equiv \frac{\Delta v_x}{\Delta t} = \frac{(-4 \text{ mi/hr}) - (-2 \text{ mi/hr})}{12 \text{ s} - 10 \text{ s}} = -1 \frac{\text{mi/hr}}{\text{s}} \]

acceleration vector points in the negative \( x \)-direction
Two examples using math:

\[ v_{1x} = -4 \frac{m}{s} \text{ at } t_1 = 1s \quad v_{2x} = -2 \frac{m}{s} \text{ at } t_2 = 3s \]

Object is moving in the negative \( x \)-direction & is slowing down

\[ < a_x > \equiv \frac{\Delta v_x}{\Delta t} = \frac{(-2 \text{ m/s}) - (-4 \text{ m/s})}{3s - 1s} = +1 \frac{\text{ m/s}}{s} \]

\[ \begin{align*}
v_{1x} &= -2 \frac{\text{ mi}}{\text{ hr}} \text{ at } t_1 = 10s \\
v_{2x} &= -4 \frac{\text{ mi}}{\text{ hr}} \text{ at } t_2 = 12s
\end{align*} \]

Object is moving in the negative \( x \)-direction & is speeding up

\[ < a_x > \equiv \frac{\Delta v_x}{\Delta t} = \frac{(-4 \text{ mi/hr}) - (-2 \text{ mi/hr})}{12s - 10s} = -1 \frac{\text{ mi/hr}}{s} \]