Physics 121:
1D Motion, Problem Solving

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Any questions from the HW?

- If I know that a particle is at $x(t = 0) = 5m$, what is the position x at $t = 5s$?

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- If I know that a particle is at $x(t = 0) = 5m$ and $v(t = 0) = -2m/s$, what is the position x at $t = 5s$?
- If the particle is changing velocity then this isn't enough... generally we need to know all three, $\vec{r}$, $\vec{v}$, and $\vec{a}$ to fully describe the motion of an object.

- Those quantities are vectors and in three dimensions (3D) we would write them as

$$\vec{r} = x\hat{x} + y\hat{y} + z\hat{z} = (x, y, z)$$
$$\vec{v} = v_x\hat{x} + v_y\hat{y} + v_z\hat{z} = (v_x, v_y, v_z)$$
$$\vec{a} = a_x\hat{x} + a_y\hat{y} + a_z\hat{z} = (a_x, a_y, a_z)$$

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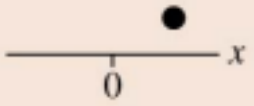
- In 1D this can be written more simply as x, v_x, a_x, where each of these can be positive or negative. I might get lazy and just call these x, v, a when we know that the motion is 1D.

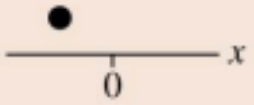
1D Motion - Signs of x, v_x, a_x

- Positive x means that the particle is on the positive side of the origin and negative x means that the particle is on the negative side of the origin... this is intuitive.
- Positive v means that the particle is moving in the positive direction as defined by the origin and visa-versa for negative v.
- What do you think positive and negative a mean? This is a bit more tricky.

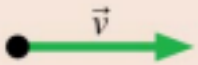
TACTICS BOX 1.4 **Determining the sign of the position, velocity, and acceleration**



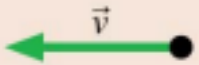
$x > 0$ Position to right of origin.



$x < 0$ Position to left of origin.



$v_x > 0$ Direction of motion is to the right.



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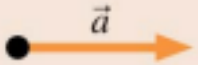
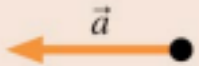


$a_x > 0$ Acceleration vector points to the right.



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Exercises 30–31

- The sign of acceleration tells us which way the acceleration vector points, **NOT** whether the object is speeding up or slowing down.

Slowing down (dwn) or speeding up (up)? Do you see a pattern?

Velocity	Acceleration	dwn/up
+	+	
-	+	
+	-	
-	-	

Slowing down (dwn) or speeding up (up)? Do you see a pattern?

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-	-	

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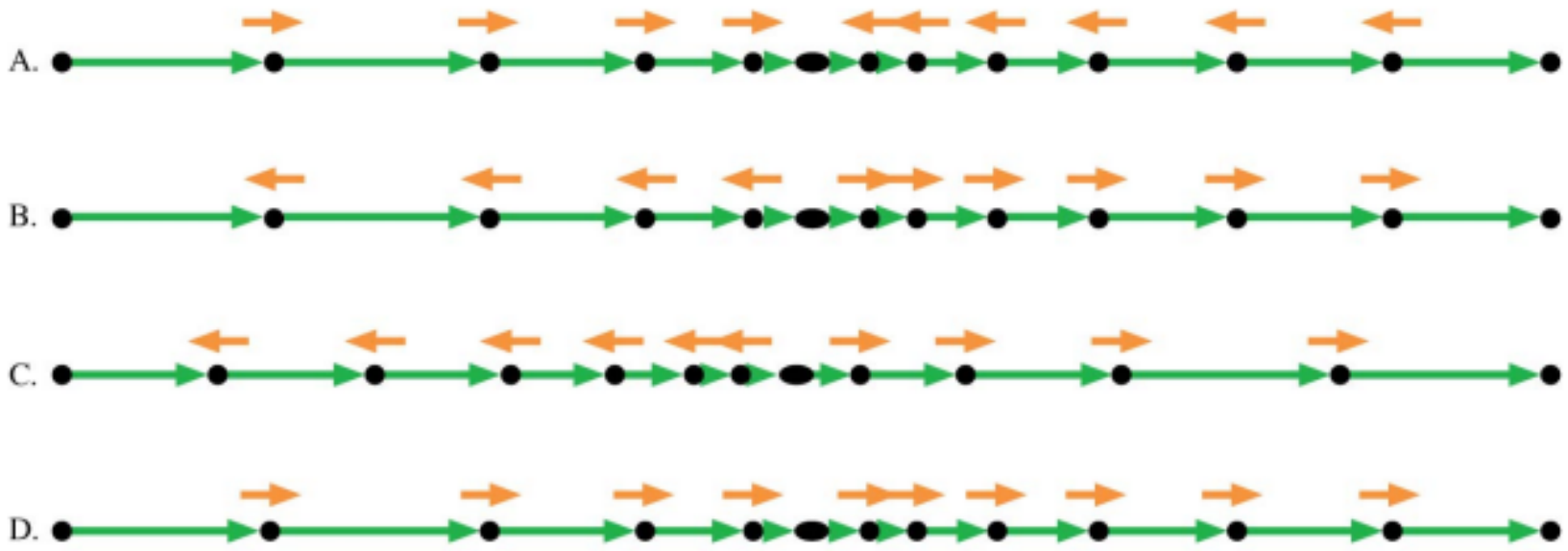
Pattern: Same sign means speeding up, oppositite means slowing down.

1D Motion - Quick Check

A cyclist riding at 20 mph sees a stop sign and actually comes to a complete stop in 4 s. He then, in 6 s, returns to a speed of 15 mph. Which is his motion diagram? (Just think about what we just talked about)



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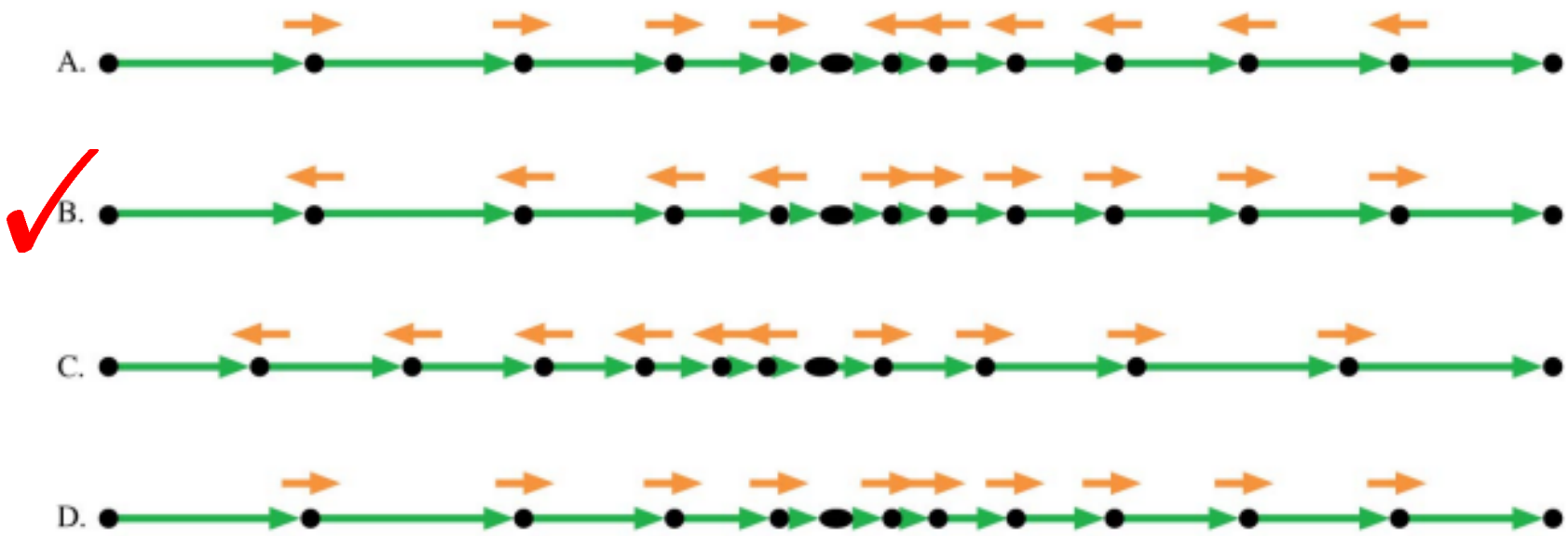

1D Motion - Quick Check

An X-wing (not the USS Enterprise) is traveling to the left and is slowing down in preparation for his attack run on the Death Star.

The coordinate system is

$\rightarrow +x$

The velocity and acceleration are

A. Velocity is positive, acceleration is positive.

B. Velocity is negative, acceleration is positive.

C. Velocity is positive, acceleration is negative.

D. Velocity is negative, acceleration is negative.

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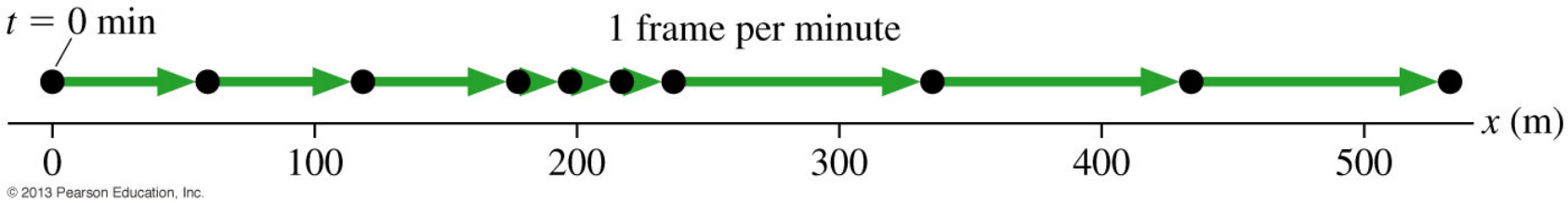
1D Motion

- Another useful tool (in addition to a motion diagram) is an x vs. t graph, like the ones you are generating in lab. Let's see if you are able to convert this motion diagram into an x vs. t graph.



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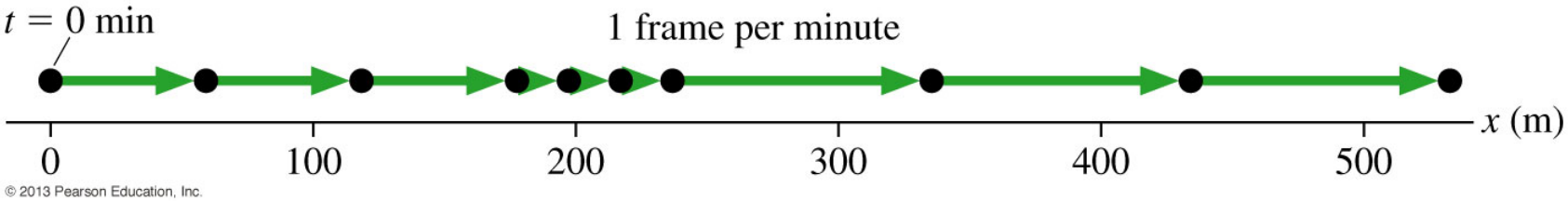
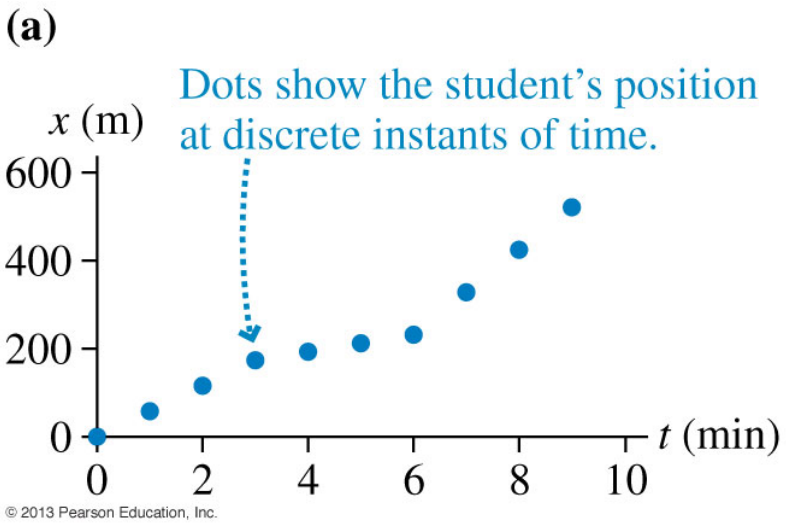
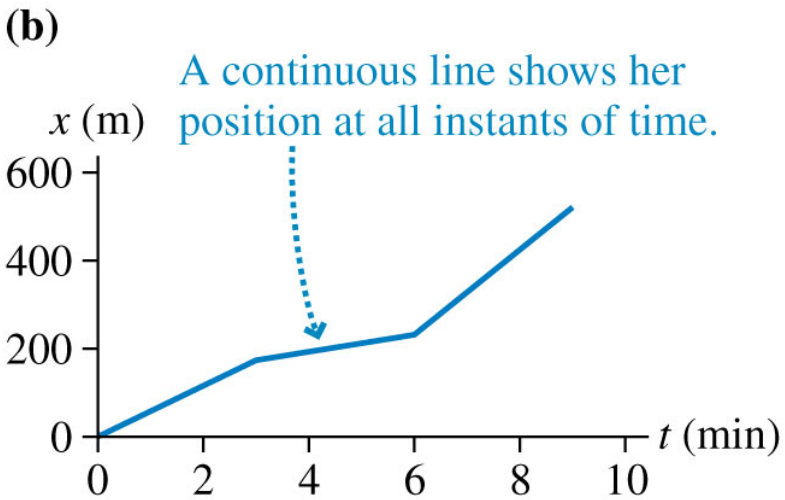






This is a graph of an object moving along a straight line. The most likely interpretation is:

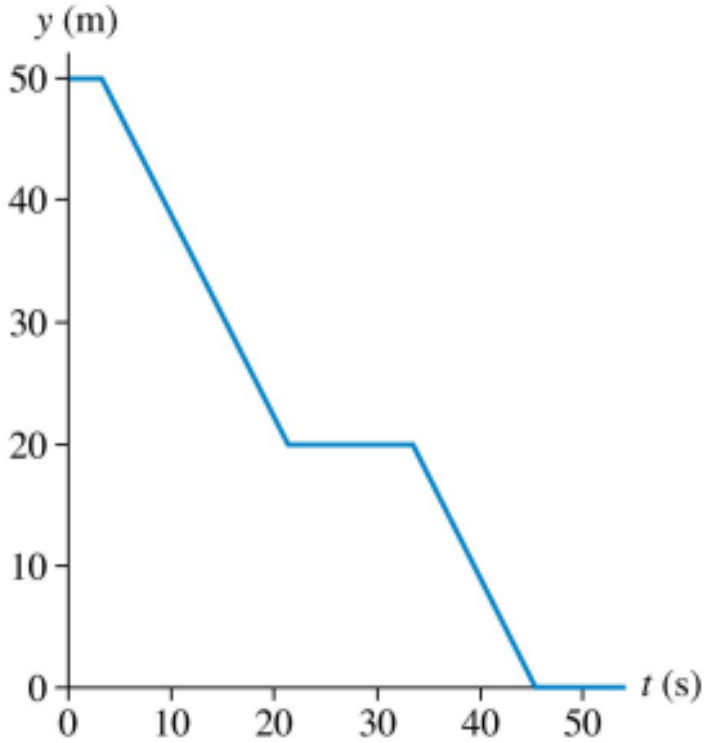
A. A person walking down a steep mountain.

B. A car that drives and stops and drives and stops.

C. An elevator descending.

D. A rock that falls, bounces, and falls some more.

E. A ball that is hit, caught, and thrown to someone else.



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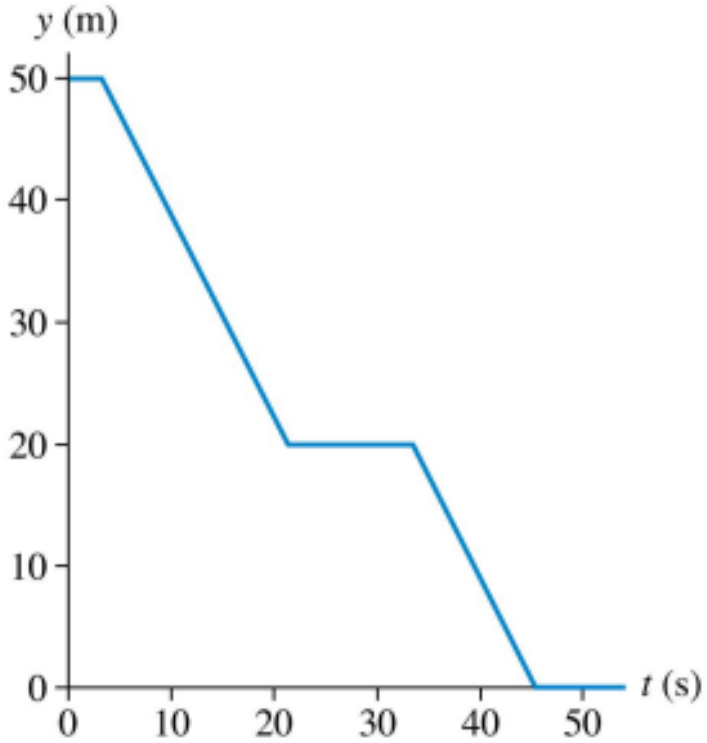

Uniform Motion

- **Uniform Motion** is motion in which each each successive equal-time interval has the same displacement. This is a subset of 1D motion. You can only have motion in a straight line, but also you don't change velocity (speed or direction).
- For example, if you drive your car at a perfectly steady 60 mph, this means you change your position by 60 miles for every time interval of 1 hour.

$$v_{ave} = \frac{\Delta x}{\Delta t}$$

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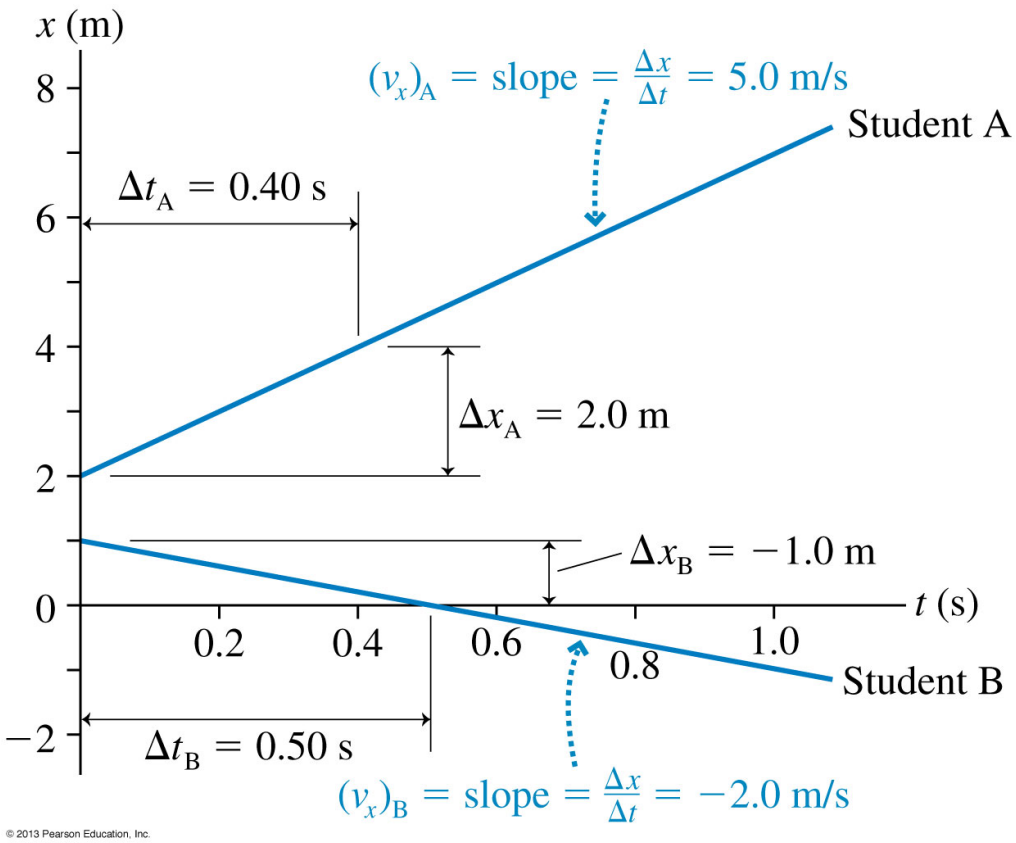

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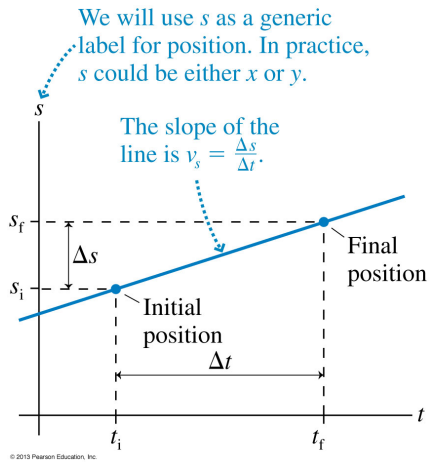

If the position of a particle is given by s and the velocity is the slope then we can write

$$v_s = \frac{\text{rise}}{\text{run}} = \frac{\Delta s}{\Delta t} = \frac{s_f - s_i}{t_f - t_i}$$

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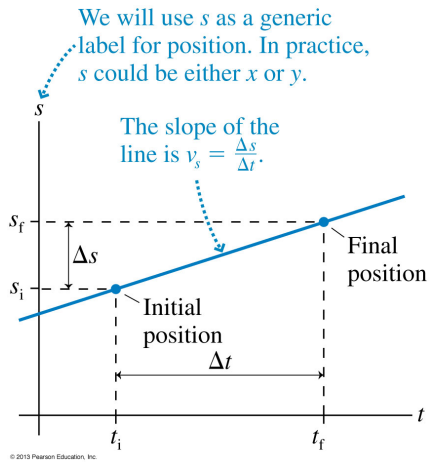

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$$s_f = s_i + v_s \Delta t \qquad \text{(UniformMotionEquation)} \qquad (1)$$

Problem Solving Strategy

1. **Draw a motion diagram:** This developes intuition/visualize of the motion.
2. **Establish a coordinate system:** Choose an axis and origin that seem "good" for the motion.
3. **Sketch the situation:** Show the object at the beginning and end of the motion, and at any point where the motion changes in the middle.
4. **Define symbols:** Place the symbols at relevant places on the sketch.
5. **List known information:** Make a table of quantities that you know, or that are easily found out.
6. **Identify the desired unknowns:** Make a table of quantities that you need to find to solve the problem.

Uniform Motion Example using the problem solving strategy

An hocker player is on a break away headed toward the other teams goal. He travels the whole time at 10 m/s. He is currently in the middle of the two goals which are about 52 m apart. How long does the goalie have to prepare for the shot? (Assume he shoots right as he gets to the goal)

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$t = 2.6$ s

Uniform Motion Example using the problem solving strategy

Two billiard balls, labeled 1 and 2, are initially at rest on a smooth pool table and are separated by a distance of 50.0 m. Simultaneously, each ball is given a quick hit, and they begin to roll directly toward each other. Ball 1 moves with a speed of 5.23 m/s , and ball 2 moves with a speed of 2.67 m/s. What is the distance covered by ball 1 by the time the two balls collide?

Picture References

Hockey Player, accessed 28 Aug 2017: http://www.kevinneeld.com/breakaway-hockey-speed-qa/
Billiard Balls, accessed 28 Aug 2017: http://www.healingtalks.com/wp-content/uploads/2011/12/billiard-balls.jpg