Recitation Problems

Friday, January 20

In class, you learned the kinematics relations $x(t) = x_0 + vt + \frac{1}{2}at^2$ and $v(t) = v_0 + at$. These relations aren't generally true, however; they are true only in a specific case. What must be true for these relations to apply?

Two runners start at opposite ends of a $L = 100m$ long soccer pitch and sprint toward each other. One runs at 8 m/s and starts on the east side, while the other runs at 6 m/s and starts at the west side. The slower runner has a $\tau = 2$ s head start. You'd like to know where on the field they meet.

1. As with all physics problems, you should work this problem using variables, substituting numbers only as the very last step. In physics, we often use subscripts to give more information about a variable. For instance, $x_1(t)$ means "the position of object 1 as a function of time". You can even combine them: "$x_{0,1}$" means "the initial position of object 1". Choose variables to use for:
   - the initial position of each runner
   - the velocity of each runner
   - the length of the head start (I suggest τ for this)
2. Draw position vs. time graphs for both runners on a single set of axes.

3. Write position vs. time equations (of the form $x = x_0 + vt$) for both runners, using the algebraic variables you instead of the numbers.

4. I asked you to tell me where the runners meet. Write down an English sentence using the physical quantities that can help you answer this question.

5. Perform the algebra indicated by the sentence and equations you wrote.

6. Finally, substitute in the numerical values to find where they meet. How do you take into account the fact that they run in opposite directions?

A car is traveling at 30 m/s and applies its brakes to slow down to 10 m/s. If it is able to decelerate at 5 m/rms^2, how far does it travel during the braking period? As always, introduce these numbers as the very last step, along with their units; do the first steps in terms of variables only.

1. Write expressions for the car's position and velocity as a function of time.

2. How can you translate the question "How far does it travel during the braking period?" into an algebraic statement? Write a sentence like the ones you have written before.

3. What intermediate quantity must you find before you find the distance traveled? Find it.

4. Finally, how far does the car travel during the braking period?

Challenge question: Consider a basketball bouncing on the floor.

Draw position vs. time, velocity vs. time, and acceleration vs. time graphs for the ball on the next page. Look at your graphs carefully and make sure they are self-consistent:

- Regions of constant acceleration should correspond to places where the velocity graph is a straight line (are there any?)
- Regions of constant velocity should correspond to places where the position graph is a straight line (are there any?)
- Places where the position graph is flat should correspond to v=0

Remember, the slope of the position graph is the value of the velocity graph; the slope of the velocity graph is the value of the acceleration graph

How would these graphs be different for a bouncing bowling ball?

Note: This is a bit tricky! As with all problems in recitation, work together with your peers and ask your TA/coach for guidance if you have questions.