Recitation Problems

Wednesday, January 25 – Kinematics in One Dimension

A car travels down the road at $v_0 = 30$ m/s when it applies its brakes suddenly. The car's brakes cause it to decelerate at a rate of $5\,\text{m/s}^2$. In this problem, you'll find how much time it takes for the car to stop, and how far it travels before it does.

1. **Step 1:** Write expressions for the position $x(t)$ and the velocity $v(t)$ in terms of v_0, t, and the acceleration a.

2. **Step 2:** Consider the question "How much time does it take for the car to stop?" Write a sentence that tells you how to answer this question in terms of your physical variables; it will have the form "What is the value of _____ when _____ equals _____". Which of the expressions you wrote in step 1 will be helpful in answering this question?

3. **Step 3:** Do the algebra indicated by your sentence to find an algebraic expression for the time required.

4. **Step 4:** Substitute in the numeric quantities to get an answer. Does it make sense?

You can follow these steps for *all* kinematics problems. Now, apply them to the other part of the question:

1. Consider the question "How far does the car travel before it stops?" Write a sentence that tells you how to answer this question in terms of your physical variables; it will have the form "What is the value of ____ at the time when ____ equals ____?

2. Do the algebra your sentence suggests that you do. (You might want to refer to the first part of this question.)

3. Substitute in the numeric quantities to get an answer.

4. If the car is driving twice as fast, by what factor does its stopping distance increase? **You should be able to answer this question without a calculator.**

A person throws a baseball straight upward at a velocity $v_0 = 10$ m/s to a friend standing on top of a building that is $h = 15$ m tall.

Her friend isn't quite ready to catch it; it goes over his head, up to the top of its flight, and then comes back down; he catches it on the way back down.

1. How long is the ball in the air? To answer this question, follow the steps of the previous problem. (These steps can be used for *any* kinematics problem.) Your sentence and algebra will be different, of course.
2. You have to use the quadratic formula for this problem. How do you know which solution from the quadratic formula is the one you want?
3. Suppose the height of the building was $h' = 25$ m. What is the time now? How do you interpret what the quadratic formula tells you?

A rocket is fired straight up. Its motor burns for ten seconds. While the rocket's motor burns, it accelerates upward at 15 m/s^2; after it burns out, the rocket is in freefall.

Note: As you go through this problem, sketch position vs. time, velocity vs. time, and acceleration vs. time graphs for the rocket, as you gather the bits of information that enable you to make them. The part of the problem that asks you to graph them is listed last, but you shouldn't wait to the end to do it; you should do it as you go. Don't worry about putting numbers in until the end, but you can still make a sketch which will guide your thinking.

1. Since the rocket's acceleration changes in flight, you can't use the constant-acceleration kinematics formulae we've learned to understand the whole flight at once. How can you use constant-acceleration kinematics to understand this problem?

2. On a separate piece of paper, make a table of all of the variables you will use for this problem, and what they mean. You will want to introduce a variable, for instance, for "how fast the rocket is going when its motor burns out".

3. How high above the ground is the rocket once its motor burns out?

4. How fast is the rocket traveling once its motor burns out?

5. How fast is the rocket traveling when it reaches its maximum height?

6. What is that maximum height?

7. How long does it take for the rocket to land back on the ground?

8. Make position vs. time, velocity vs. time, and acceleration vs. time graphs for the rocket. Which of these is most accessible to make first?