9/13 In Class Chapter 2

Today we have enough MATLAB under our belts to do some real physics! Yay! For the parts that are pure Physics, please do them in groups of two at the white boards. Even the Structure Plans of the code could be good to put on the board. Then each person goes back to their computer and writes code.

1. The first example in section 2.4 is vertical motion under the influence of gravity and no air resistance. (vertical = 1D) Please try this without looking at section 2.4. You can use it to check your plot when you have a plot. You may use google and the book to look up things you forgot – like the format to create a vector or the plot command or things like that.

   Do you remember the kinematic equations? If so, just use them to check your answer(s). I want you to practice some Newton's Second Law and some Calculus.

   (a) Start with Newton's Second Law for an object starting from height zero (to match the book) and initial velocity, $v_0 = 60$m/s (to match the book.) Please start with using symbols, so, v_0 for initial velocity. (Not a match with book.) Choose positive to be up, negative down.

   (b) Integrate to get velocity as a function of time. Use either definite integrals, or use the given initial conditions (symbols!) to solve for C, the constant of integration.

   (c) Now that you have $v(t)$, integrate that to get $y(t)$. (I chose y since it's vertical.)

   (d) Check it with the instructor before you go on.

2. (Still at the board.) Write a Structure Plan (pseudo code) for how you would write code that would plot the motion (y vs t) of a particle falling near the surface of the earth.

3. Now go back to your computers and see if you can write a script to plot the motion (position vs time) of a particle falling near the surface of the earth.

   Feel free to keep talking to each other. If you get stuck, or just want to check your answer, read Section 2.4. And you can ask me.

   It's entirely possible to do something that is correct and is not much like the book's version. If you do something different from the text, please show me! Oh, show me anyway :)

4. Write the script the book uses. I think they call it `throw.m`

   Please get me to check it off before you go on.

   Now that you've used the book's example, you know how to title a graph and label the axes. Please do that for all future graphs!

5. Modify the code so that it accepts the initial velocity as input. Enter an initial velocity of 60 m/s, and your graph should look just like the book's. Try values of $v_0 = 0$ and -60 m/s. What changes? Is it what you expect each time? What does the $(-)$ in -60m/s mean?

6. Modify the code so that it accepts an initial height as input. Enter an initial height of 0m, initial velocity of 60m/s, and your graph should look just like the book's. Play around with several different values of initial height and velocity.

7. Add an input for the duration of the motion. Play with different values of all three: initial height, initial velocity, and duration. Save this script. Call it throwMod.m or something you can remember.

8. **Projectile Motion**: You can either start over, or copy that script and rename the copy something like projectile.m (Save the old, we will come back to it.) See if you can figure out how to make it a graph of 2D motion. I break it down to the following steps:

   (a) Your variable from the old code will be the vertical part. (The book used s, you may want to use y now.) You will now need to add the horizontal component. Find or derive an expression for x as a function of time for a projectile near the surface of the earth. For this problem, assume there is no air resistance.

(b) Back to the code: You will also probably want to enter the initial velocity as a magnitude and direction. Do that.

(c) How could you add the x to your code? Try it. For now, plot x vs t. Is the plot what you expect? If not, see if you can find your bug. If so, please let me check.

(d) Plot y vs x.

(e) Check it with me.

(f) Play with the initial conditions. This is one of the amazing things about the power of computers. Once you have this code, it is easy to visualize many different cases. One of the ways I will evaluate your code is to use test cases.

9. Now with air resistance! Back to the white boards!

Physics first, then coding. So treat this like a (tough) Physics 1 problem. Air resistance opposes the motion of the particle. It generally takes the form $F_R \propto v^n$, or, the resistant force is generally proportional to some power of the velocity. Let's start with the most straightforward case:

$$\vec{F}_R = -mb\vec{v}$$

where m is the mass of the object, b is a constant proportional to the strength of the air resistance, and v is the velocity of the particle.

Let's also start with an object released from a height, h above the ground, and initial velocity of v_0.

(a) Write Newton's Second Law for this problem.

(b) Substitute $a = \frac{dv}{dt}$ and use separation of variables to solve for v as a function of t.

Separation of variables means: put all the 'v's on one side with 'dv' in the numerator, and all the 't's on the other side, with 'dt' in the numerator, then integrate both sides. For the integral, you could either do a definite integral, or an indefinite integral and use the initial conditions to solve for the constant of integration.

(c) What is the limit of v as t gets very very large? This is called terminal velocity. You can also find it easily from the second law. Do you see how? What does that mean? = Can you define terminal velocity in terms of forces?

(d) You should now have $v(t)$. Do the same trick again, and integrate to get $y(t)$.

10. Pseudo code! Write your structure plan for how you will plot both v vs t and y vs t for this last problem.

11. Back to the computers to do it!.

    You will need some numerical values! Let's all start with $b = 0.02$, $y_0 = h = 30$m and $v_0 = 0$. You know g.

    (a) Modify your throwMod.m script, or write a new script, to plot this v_r as a function of t. (I called the velocity with air resistance v_r and the one without just v, because:)

    (b) Modify it to plot both v vs t and v_r vs t on the same graph. (You will have to look this up.)

    (c) You may have to increase the duration to see the difference.

    (d) Increase to very long duration to check terminal velocity. Show me this plot.

    (e) Play with initial values of height and velocity. Get a feel for the power of having written this code!

    (f) Modify it to plot both v_r vs t and y_r vs t on the same figure (Same page, not same plot).

    (g) Modify it to keep both plots, but add the v vs t and y vs t with no air resistance on top of the plots of v_r vs t and y_r vs t with air resistance. (Two separate graphs on same page, two curves on each graph.)

    (h) Show me the final plots. Make them look nice, and print them. Put your name on them and turn them in.