Physics 102, Fall 2019

9/16 In Class – more visualization of motion

Keep all the scripts you write today. We will use them again.

Building off our previous work in class:

9. An object in 1D motion falling near the surface of the earth–with air resistance.

   Let's start at 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!. (Use one of your old codes from last time that has 1D motion in it, and modify it to include your new equations of motion–and the old–see below.)

    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 (any of the 1D scripts from last time would be fine), 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 I'll ask for both.)

    (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.

12. **The incline plane**: An object released from rest slides down a frictionless incline plane. Start with the plane at an angle of 30° wrt the horizontal. Use θ in your code so you can change the angle and test different θ's.

    Part of what I hope you'll see in this exercise: the power of the computer to do calculations that you and I would find painful. I'll ask you too

look at both rotated and unrotated axes. I called s the position along the incline plane, and so v_s and a_s could be velocity and acceleration along plane

(a) Go to the board and draw a free body diagram for the object. Then start from Newton's Second Law and find the acceleration along the incline ($a_s = \cdots$)

(b) Is the acceleration constant? If it is, you can use the kinematic equations to find the position of the object as a function of time. (You pretty much derived them last time. Ask me if you don't remember.)

(c) Write your structure plan

(d) Back to the computers to code it.

(e) On one figure, plot s vs t. (If you haven't used it yet, `figure(1)` will create a new figure on its own page.)

(f) On another page, say `figure(2)`, plot unrotated x vs t and y vs t. (x is horizontal, not along incline.) Look up how to put two panels on one figure. You can use google or your text.

(g) As a check, on a third page `figure(3)`, plot y vs x. Do you get what you expect?

(h) Play with the angle of the incline as another check. What happens if you use $\theta = 90°$? Is that what you expect?

(i) What happens if you use $\theta = 0°$? Is it what you expect?

(j) Put θ back to some angle other than 0 or 90°.

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

13. **For homework:** Do the incline plane problem with friction! Use $\theta = 30°$, $\mu = 0.2$, and $m = 1$kg as starting values. But make them all variables in your code. Your program should make the same plots as the last problem, and show both without and with friction on same plots. Turn in your script for this to me, call it something like `YourName_inclineWithFriction.m`