PHYS 35100 - FALL 2024

Homework Set 1

Due Sep 11th via Blackboard submission, before 12:00 pm.

Instructions: Prepare responses to the following questions. Each one is worth the same amount. [A] means that a problem is meant to be done *analytically*, i.e. with paper and a pencil. [C] means that the problem is meant to be done with *computationally*, i.e. with software. Homework sets will be submitted electronically. Please submit one pdf documents that contains all the work you want me to see. For the [A] ones, please scan your original, handwritten work and include in the pdf. For [C] problems, save your code/notebook as a pdf (not a screenshot) and include that pdf in the submission. Also link to the Colab notebook online and make sure it is viewable/commentable by me (jhedberg@ccny.cuny.edu). Please title your submission `PHYS35100-HW1-LASTNAME-FIRSTNAME.pdf` .

1. Forces [A]

A force acts on a particle. It's a non-constant force.

a. Here's the force function - it's *time* dependant:

$$F_x = F_0 + kt$$

(F_0 and k are just positive constants, and t is time)

Find expressions for the velocity and position as functions of time.

b. Here's the force function - it's *position* dependant:

$$F_x = F_0 + kx$$

(F_0 and k are just positive constants, and x is position)

Find an expression for the velocity as a function of position.

2. Little Guys [A + C]

Goal: Make quantitative plots for a bacteria free to move in a linear drag environment. We'll say the bacteria is moving in room temperature water. You can look up sizes and other characteristics appropriate for a small bacterial object (let's assume it is indeed a sphere). It can give itself a small initial velocity of 100 microns per second.

a. Solve the 2nd law force equation for both the resulting velocity and position of the bacteria in general terms.

b. Now think about some numbers and what would be appropriate for a little spherical bacteria cell. Carefully list your system parameters. (i.e. make a list of all the variables and the values you are assuming)

c. Now, assume a linear drag force acting. Use the analytically derived equations for $a(t)$, $v(t)$, and $x(t)$. Plot the acceleration, speed, and position of the bacterial cell after it gives itself the initial velocity until it is effectively no longer moving.

d. How far did it travel during this *squirt*? Show that your plot matches the expected position when t is very large.

3. Mr. Taylor [A + C]

Work out the Taylor Series for the following:

a. $\ln(1+x)$
b. $\cos x$
c. $\sin x$
d. e^x
e. Pick one of the above and make a plot showing how the Taylor series polynomial approximates the expression within a suitable range.

* This means that I'd like you to extend the techniques we use, and not use other software, libraries, etc. That means for plotting, use matplotlib, not plotly for example.