**11/11 in Class – Review for Exam 2**

Summary

I can't review everything in one class period, so this worksheet is NOT exhaustive. Anything we learned, and especially what we have done problems on (both in class and as homework) is fair game for the exam.

The topics and section numbers:

- if/then (sec 2.8)
- plotting stuff (9.1, plus old code)
- structure plans (Ch 3)
- functions (Ch 3)
- save and load (Ch 4)
- solving systems of linear eq.s (Ch 4)
- matrix stuff (Ch 4)
- least squares fitting (my notes, Ray's 5.4)
- polyfit (my notes, book example 14.9)
- simulations (Ch 13)

Review Problems:

**Make one .m file for all!**

As practice for the exam, make all of this one .m file. Label each problem number in a comment, and be sure that it runs!

Call it `Yourname_revEx2.m` and turn it in to me at the end of class.

Unlike the exam, you may work together. Some of these are harder than I would give on the exam. (Although now that you will have them, that's less true.)

1. **Write a function**:
   (a) Write the function `xyComp` to find the $x$ and $y$ components of a vector if you are given the magnitude and direction.
   (b) Call your function from the (main) script file for a vector $\vec{A}$ that has magnitude 15m and makes an angle of 30° with respect to the $+x$ axis.
   (c) Now call it for a $\vec{B}$ that has magnitude 10m and makes an angle of 135° with respect to the $+x$ axis.
   (d) Don't forget that the function has to be at the end of the script file.

2. On the class website (and today's date), you can find a file called `revEx2_JCK.txt`
   The data file consists of two columns of data, $x$ and $y$.

(a) `load` **practice**: Read the data in and assign the first column to $x$ and the second to $y$.

(b) And plot $y$ vs $x$ on Figure 1 (or name the figure if you like). Do you think a line would be a good fit?

(c) Use one of the methods we learned in class to determine the $m$ and $b$ for the line of best fit.

(d) Plot your line of best fit on top of the data. (Same panel of same Figure 1.)

(e) Make the plot look nice. Include title, axis labels, and a legend.

3. In Modern Physics (60), you probably learned the Lorentz Transformations. You may or may not have seen the space-time four vector (column vector), $x^\mu = (x^0, x^1, x^2, x^3) = (ct, x, y, z)$. (They should be column vectors as shown below, but it just takes too much space!) For these equations, $S'$ is moving at speed $v$ in the $+x$-direction relative to $S$.

$$
\begin{aligned}
x^{0\prime} &= ct' = \gamma(x^0 - \beta x) \\
x^{1\prime} &= x' = \gamma(x - \beta x^0) \\
x^{2\prime} &= y' = y \\
x^{3\prime} &= z' = z
\end{aligned}
$$

where

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \text{ and } \beta = \frac{v}{c}$$

Define $\Lambda$ to be a 4-by-4 matrix and use it to find the 4-vector in $S'$ given the one in $S$. (In other words, use it to find column vector $(ct', x', y', z')$ given column vector $(ct, x, y, z)$.)

Test your code with an initial vector in $S$ of

$$x4 = \begin{bmatrix} 3c \\ 5 \\ 0 \\ 0 \end{bmatrix}$$

where the 5 is in meters. You also need to know that $S'$ is moving at speed $.6c$ relative to $S$. What is $x^{\mu\prime}$ for this test case?

4. Another simulation (for the DE you solved in Problem 2 on the 11/8 worksheet.) A muon is a particle that is often created during collisions between cosmic rays and the earth's atmosphere. A muon is a bit like a heavy electron (about 200 times heavier, with the same charge). Unlike an electron, a muon is unstable, meaning it decays. The muon has a mean lifetime, $\tau$, of $2.197 \times 10^{-6}$ s. The decay rate per unit time, $\Gamma$, is equal to the inverse of the mean lifetime.

$$\Gamma = \frac{1}{\tau}$$

The probability (P) that any given muon will decay in some time interval, $dt$, is $P = \Gamma dt$. Imagine starting with 1000 muons. Your task is to run a simulation using the random number generator to determine if a given muon decays, and plot the number of muons as a function of time as detailed below.

(a) Go to the board and work together to write a detailed structure plan for how you will code a simulation of the decay of 1000 muons. (You won't work together on the exam, but this entire worksheet is longer than the exam can be.) Be sure your structure plan answers:

   i. What do you think is a reasonable size for the time interval, $dt$?

   ii. What do you think is a reasonable time scale for the entire simulation to run?

   iii. What constants do you need?

   iv. Will you use for loops or vectorize? Explain how you will implement either in words.

(b) Code it. This could be iterative. Go back to your group and your structure plan if you need a new one!

(c) Run the simulation of this case and plot the number of particles as a function of time. Use blue circles for the simulated data. This should be Figure 2. (FIgure 1 should still be visible.)

(d) `save` **practice**: Write out your data for $t$ and $N$ as two columns in a (text) data file called `muonDecay_YourName.txt`

(e) From Problem 2 on 11/8, you calculated the theoretical curve, plot this on top of your simulated data. This time make it a black line. (Which should be close to your blue circles.)