Assignment 7, PHYS 490
Computers in Physics
Due 3/11/10 at start of class

We're going to be spending most of the rest of the semester working in MATLAB. The strengths of MATLAB have probably been outlined in excruciating detail by your instructor by now, but to summarize – MATLAB screams super-fast at anything linear algebra based. (MATLAB, after all, stands for MATRIX LABORATORY).

Writing effective, efficient code in MATLAB relies on the ability to vectorize code. This means that normally, "for" loops are to be avoided when possible. That being said, in THIS HOMEWORK ONLY, the use of for loops is not going to be discouraged. In many of these cases, it'll be by far the easiest way to do things.

1. Following the example set up by Dr. Trantham in the C lectures, write (and submit) an m-file that does the following. (To prevent confusion, put all three array generation codes in the same m-file called `matrixgen.m`.
   a) Generates a 50 x 50 array. In the 3rd row of the array, put the number +10 for the 3rd through 48th columns. In the 48th row of the array, put the number -10 in the 3rd through 48th columns. Put a zero everywhere else. Call the array `twolines`.
   b) Generates another 50 x 50 array in a stop-sign shape, with +10 on the horizontal and vertical segments. -10 on the diagonals of the octagon. Zero everywhere else. Call the array `octagon`.
   c) Generates a third 50 x 50 array that puts random numbers between -10 and 10 (uniformly distributed) on the boundary and keeps zeros everywhere else. Call the array `randbound`.

2. An approximate expression to compute π is:

$$\pi \approx \left[4 - \frac{4}{3} + \frac{4}{5} - \frac{4}{7} + \frac{4}{9} - \frac{4}{11} + \ldots\right]$$

   write an m-file that uses this approximation technique to estimate π using the first n terms of this expression. Call this file `piapprox.m`. (For some bonus points, write this m-code as a function that takes the argument n and outputs the approximate value. If you do it this way, the next question can be done in a simple m-file as a function call).

3. Use the code you wrote above to find the estimate for π using n equal to 1,2,3,5,10,20,30,50,100,200,300,500, and 1000 terms. For each of these, use the following formula to estimate your error:

$$\text{error}(n) = \left|\frac{\pi - \pi_{\text{computed}}(n)}{\pi}\right|$$

On a loglog graph, plot error(n) as function of n. Label your axes appropriately. For full extra-credit on the previous question, submit the m-code that does this with a function call to `piapprox.m`. Call this code `pierror.m` and submit it with the rest of your homework. If you don't want to go to extra credit, all you have to do for this question is submit a copy of the `.fig` or `.jpg` file generated by creating the graph. Call this graph `pierror.fig` or `pierror.jpg` as appropriate.

4. If the principal amount is $P_\circ$, the annual interest rate is r, and interest is added to an account n times each year, then the amount of an account at the end of t years is given by:

$$P = P_\circ \left(1 + \frac{r}{n}\right)^{nt}$$

Create an interactive m-file script called `interest.m`. This m-file must ask the user to input a principal amount, the annual interest rate (as a decimal), how many times to add the interest each year, and the number of years. The output of the script is in two variables: `principal` (P) and `int` (which can be computed by taking $P - P_\circ$).

5. (Extra Credit) Rewrite `interest.m` as a function called `interestfn.m` that takes the user inputs in the above script as arguments of the function, but n isn't included and t doesn't correspond to the only time of concern; now we want to explore the behavior for the interval $[0, t]$. The function generates a plot that shows (as a black solid line) the P as a function of t ranging from 0 to the user inputted value of t compounded hourly. It also shows (on the same axes) the value of P as a function of t for the same time interval compounded daily (red solid line), monthly (maroon dotted line), and yearly (blue dot-dash line). You may assume the user will put in a value of t that is larger than 1 (year).

A completed assignment will include the following files emailed to me:

- `matrixgen.m` (which generates three variables: `twolines`, `octagon`, and `randbound`).
- `piapprox.m`
- `pierror.jpg` or `pierror.fig`
- `interest.m` (which generates two variables: `principal` and `int`).
- Additionally, if you complete all the extra credit, you will also be submitting `pierror.m` and `interestfn.m`.