Homework 4

Goal: To learn to use anonymous functions, m-file functions and recursion.

Due: March 14

Problems:

1. Write an anonymous function `sphere.m` to calculate the volume of a sphere. The function should accept as input the radius of the sphere. Generalize your function so that it can accept an array of radius values. The program `P1.m` should prompt the user for the radius of a sphere and then print the volume.

   What to turn in:

   - `P1.m`

2. Write an m-file function `sphere.m` to calculate the volume and surface area of a sphere. The function should accept as input the radius of the sphere. Generalize your code so that it can accept an array of radius values. Write a program that prompts the user for the radius of a sphere and then print the volume and surface area.

   What to turn in:

   - `P2.m`
   - `sphere.m` - function that returns the volume and surface area of a sphere

3. ***Hermite Polynomials.*** Write a recursive m-file function to calculate hermite polynomials using the recursion relation

   $$H_{n+1}(x) = 2xH_n(x) - 2nH_{n-1}(x)$$

   and the fact that $H_0(x) = 1$ and $H_1(x) = 2x$. Hermite polynomials are defined on $-\infty < x < \infty$ for $n \geq 0$. Your function should be able to accept an array of values for x. Write a program to plot the n^{th} Hermite polynomial over a specified domain $-L \leq x \leq L$. Create a graph in pdf format for the n = 10 Hermite polynomial.

   What to turn it:

   - hermite.m - m-file function that returns the n^{th} Hermite polynomial.
   - P3.m - program that graphs the Hermite polynomial
   - P3.pdf - graph of n = 10

4. ***Quantum Harmonic Oscillator.*** Modify your program on HW 2, problem 5 to plot the quantum harmonic oscillator wave function $\psi_n(y)$ and the probability density $|\psi_n(y)|^2$ for a user-defined value of n. The n^{th} wave function is given by

   $$\psi_n(y) = \left(\frac{\alpha}{\pi}\right)^{1/4} \frac{1}{\sqrt{2^n n!}} H_n(y) e^{-y^2/2}$$

   where $H_n(y)$ is the n^{th} hermite polynomial. As before, your program should shade under the curve for $|\psi_n(y)|^2$ and show the classical turning points as vertical dashed lines. Your program should also auto scale the axis limits so the function fills the plot area.

   Code specifications:

- Use your hermite function (previous problem) to write another function `psi.m` that returns $\psi_n(y)$ for the simple harmonic oscillator. You should pass an array y and the value n to the function. The function should return the wave function $\psi_n(y)$.
- You can set $\alpha = m\omega/\hbar = 1$ if you like to simplify things.

Run your code for the $n = 10$ energy level.

What to turn it:

- `psi.m` - function that returns the n^{th} quantum harmonic oscillator wave function.
- P4.m - program that graphs the n^{th} quantum harmonic oscillator wave function
- P4.pdf - graph of the 10^{th} quantum harmonic oscillator wave function