ENSC 180: Introduction to Engineering Analysis

Assignment 2

Due: 6.00 p.m., February 7, 2018

Note: *MATLAB codes should include definition of all variables; headings to identify the program structure plan; and appropriate captions and labels for tables and figures. M-files together with your input/output for each problem should be submitted. Marks will be deducted for solutions that are unrealistic/impractical (as future engineers students should learn to think practically) and poorly documented.*

1. A solid sphere of radius r and density ρ_s is placed in a fluid of density ρ_0. The sphere sinks to a depth of h. The volume of sphere below the fluid surface is $\frac{\pi(3rh^2-h^3)}{3}$. Develop a MATLAB function to calculate h based on input values r, ρ_s and ρ_0. Your function should prompt a user to input r, ρ_s and ρ_0 and print the output as 'The sphere depth below the fluid surface is:'. Test your code with $r=40mm$, ρ_s =0.6 g/mm^3 and ρ_0 =1.0 g/mm^3. Next, develop a function that calculates the ratio h/r for a given (ρ_s/ρ_0) ratio. Plot the graph of h/r vs. (ρ_s/ρ_0). Discuss the results using your knowledge of engineering and Physics. (25 marks)

2. The height of a rocket is approximated by the following equation.

   $$H = 2.13t^2 - 0.0013t^4 + 0.000034t^{4.751}$$

   where H is the height (meters) and t is the time (seconds).

   a) Create a function, *R_motion* to calculate the rocket height and speed at a given time; and b) create a function handle to R_motion. C) plot the rocket height and velocity with time using a function named R_motionplot. (25 marks)

3. Legendre and Chebyshev polynomials are a class of orthogonal polynomials used in the solution of engineering problems, especially in numerical integration. Consider the Legendre polynomial $(693x^6-945x^4+315x^2-15)/48$ and the Chebyshev polynomial $(32x^6-48x^4+18x^2-1)$. Find the roots of these polynomials in the range $-1.0 \leq x \leq 1.0$ to an accuracy of 0.001. Comment on the behaviour of roots. (25 marks)

4. Fourier transforms are widely used in signal processing, control theory, earthquake engineering and other engineering applications. It involves representing an arbitrary periodic function by a trigonometric series. Consider a periodic function of the following form:

$$f(x) = \begin{matrix} -k\ when & -\pi < x < 0 \\ k\ when & 0 < x < \pi \end{matrix} \ and\ f(x + 2\pi) = f(x)$$

The above function is approximated using the Fourier series, $\sum_{n=1}^{\infty} b_n \sin(nx)\ \ where\ b_n = \frac{2k(1-cosn\pi)}{n\pi}$. Write a MATLAB code to approximate *f(x)* using the above series and determine an appropriate value (i.e. N) for the upper limit of the series expansion. Comment on the behavior of each term of the series and the solution for *f(x)* by using different values for N. Use *k=1* in your numerical trials. (25 marks)