CHEN.3170 Applied Engineering Problem Solving

Exam #1 Fall 2017

Problem 1 General Syntax, Arrays, Indexing, Conditionals, Etc., Etc. in Matlab (40 points)

Given the following matrices: $\mathbf{A} = \begin{bmatrix} 1 & -2 & 2 \\ -1 & 0 & 1 \\ 3 & 2 & -1 \end{bmatrix} \qquad \mathbf{x} = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix} \qquad \mathbf{y} = \begin{bmatrix} -3 \\ 1 \\ -2 \end{bmatrix}$

What is the result of the following Matlab commands (be careful here…)?

1. y'*(A.*A)

2. A*A′

3. x > A(:,3)

4. [A x]

5. j = [1 2]; k = [2 3]; A(j,k)

6. z = 0; if x > y, z = 1; end, z

7. x.*(A*x)

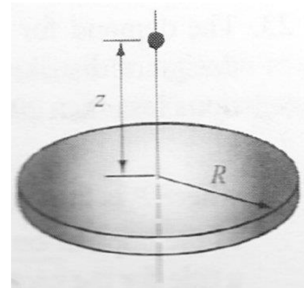
8. sum(A(3,:) > 0)

9. A(:,3) = y; A ?

10. u = -2; z = -5 < u < -1

Problem 2 Function Evaluation and Plotting using Function Subprograms (30 points)

The electric field (force per unit charge) acting along the z-axis due to a round disk with radius R and a uniform charge density Q (charge per unit area) is given by



$$E(z) = \frac{Q}{2\varepsilon_o}\left(1 - \frac{z}{\sqrt{z^2 + R^2}}\right)$$

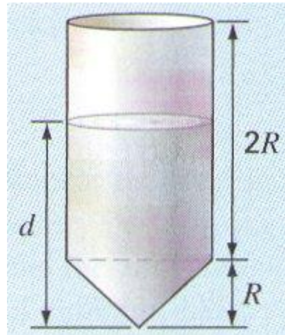
where $\varepsilon_o = 8.85\times10^{-12}$ $C^2/N\text{-}m^2$ is the permittivity of air and z is the distance from the disk to the particle.

Note: The questions below ask you to write a series of Matlab routines to evaluate and plot the electric field vs distance along the centerline of the disk. Of course, this can be done in a number of ways, but the tasks here take you down a specific path to evaluate your understanding of several features within Matlab -- so **please follow the steps/instructions given here carefully**.

a. Write a function routine to compute the electric field, E, given the values of z, R, and Q as inputs with the value of the permittivity defined inside the function. The function file should allow a **vector input for the distance z**, but the other variables are **scalar values**. The output E should be the same size as z.

b. Write a Matlab script file that uses your function file from Part a to evaluate and plot E vs. z for five different values of R, with R = [0.05 0.1 0.3 0.5 1.0] meters. Let $Q = 9.4\times10^{-6}$ C/m^2 and let z vary over the range $0 \le z \le 0.5$ m. Note that the electric field is now a function of two variables (z and R) and it should be stored as a 2-D array in your Matlab program. The program should plot the computed results in a quantitative fashion, E vs. z, for the different R values used here (you do not need to worry about different line styles in the plot, but be sure to annotate the plot properly). **Be sure to write your main program to be consistent with the instructions for writing/using the function file as given in Part a...**

Problem 3 Use of if…else…end Statements within Matlab (15 points)



Consider a cylindrical tank with a conical base as shown in the sketch. The radius of the cylindrical portion is denoted as R, and the respective heights of the conical base and the main cylindrical tank are R and 2R, as shown (not to scale). Note that the depth of the fluid in the tank, d, is measured relative to the bottom of the base section.

For this system, the volume of fluid versus the fluid depth is given by

$$V(d) = \frac{1}{3}\pi R^2 d \qquad \text{for} \quad 0 \le d \le R$$

$$V(d) = \frac{1}{3}\pi R^3 + \pi R^2 (d - R) \qquad \text{for} \quad R < d \le 3R$$

Write a Matlab script file that computes and plots the fluid volume, V, versus fluid depth, d, given that R = 2 ft. For this geometry, the range for the fluid depth is $0 \le d \le 3R$.

Problem 4 Implementation of Discrete Equations within a Matlab Function (15 points)

Write a complete Matlab function file to compute the mean value and variance of a set of N experimental data values. The mean value, $\bar{y}$, and variance, σ^2, should be output from the function, and a vector, **y**, containing the experimental values should be the only input argument (the length of **y** can be determined inside the function). Assume that the input vector is known and is passed into the function via the calling program. The discrete expressions for $\bar{y}$ and σ^2 in terms of the individual measurements, y_i, are given by

$$\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i \qquad\qquad \sigma^2 = \frac{1}{N-1}\sum_{i=1}^{N}\left(y_i - \bar{y}\right)^2$$

For consistency, assume that the first line of the function file is given by

function [ym,var] = meanv(y)

where **ym** = $\bar{y}$ and **var** = σ^2. Your job is to write the remainder of this file to compute the mean value and variance associated with a set of data. Be careful to use the proper Matlab syntax in your program!

Note: Matlab has built-in functions for the quantities evaluated here. However, even if you are familiar with these functions, **do not use them here**, since I am interested in your approach to implementation of the above discrete equations…