Applied Engineering Problem Solving (CHEN.3170)

Homework Assignment #3a -- Fall 2017

Programming in Matlab

Problem #1: The Dew Point Temperature

According to Wikipedia, “the dew point (sometimes spelled dewpoint) is the temperature to which a given parcel of air must be cooled, at constant barometric pressure, for water vapor to condense into water. The condensed water is called dew. The dew point is a saturation point.”

The dew point is associated with relative humidity. A high relative humidity indicates that the dew point is closer to the current air temperature -- if the relative humidity is 100%, the dew point is equal to the current temperature.

Humans tend to react with discomfort to high dew points, as a high dew point corresponds with a high ambient temperature (causing the body to perspire and produce sweat) and/or a high relative humidity (which inhibits the evaporation of sweat, by which the body is cooled); as a result, the body may overheat, resulting in discomfort. A lower dew point, meanwhile, corresponds to a lower ambient temperature or lower relative humidity, either of which allows the body to more effectively regulate its temperature to avoid overheating.

The dew point temperature, T_d, can be estimated from the relative humidity, RH, and the actual temperature, T, as follows

$$T_d = \frac{b\,f(T,RH)}{a - f(T,RH)} \qquad \text{where} \quad f(T,RH) = \frac{a\,T}{b+T} + \ln\left(\frac{RH}{100}\right)$$

where the temperature T is in degrees Celsius, RH is in percent, and the empirical constants are a = 17.27 and b = 237.7 ºC.

a. Write a Matlab function file to compute the dew point temperatures for a given temperature and a vector of relative humidity values ranging from 30 to 100% with increments of 10%. In particular, the function should pass in the desired **scalar** ambient temperature and a **vector** of relative humidity values, and return a vector containing the corresponding dew point temperatures. For consistency, the first line of your function file should be

   function [Td] = dewpoint(T,RH)

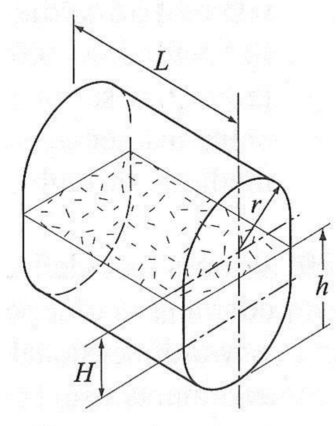
b. Once your function file is working properly, write a main program that uses **dewpoint.m** to generate a well-formatted table that shows the dewpoint temperature vs. relative humidity for ambient temperatures of 20, 25, 30, and 35 ºC. Use a series of Matlab’s ***fprintf*** commands to generate the desired table to look as follows:

Dewpoint Temperature vs. Relative Humidity

Ambient Temperature:	T = 20 C	T = 25 C	T = 30 C	T = 35 C
Relative Humidity (%)	Dewpoint Temperatures (C)			
30	xx.x	xx.x	xx.x	xx.x
40	xx.x	xx.x	xx.x	xx.x
Etc.				

Problem #2: Volume of Fuel in a Standard Fuel Tank

A fuel tank is made of a rectangular prism central region and half cylinders at the top and bottom as shown in the diagram. For a given fuel level, h, as measured from the lowest point in the tank, the fuel volume can be determined using the following arguments.



First, note that the volume of liquid in a horizontal cylindrical tank is given by

$$V_{cyl} = \left[r^2 \cos^{-1}\left(\frac{r-d}{r}\right) - (r-d)\sqrt{2rd-d^2} \right] L \qquad (1)$$

where r is the tank inside radius, L is the length, and d is the height of liquid in the horizontal cylindrical tank (this equation is derived in the Lesson #5 Lecture Notes for this course). Now, for the liquid volume in the fuel tank, if $h \le r$, then the fuel volume is simply given by eqn. (1) with d = h, or

$$V_{fuel} = \left[r^2 \cos^{-1}\left(\frac{r-h}{r}\right) - (r-h)\sqrt{2rh-h^2} \right] L \qquad (2)$$

The liquid volume in a rectangular tank of width W = 2r, length L, and depth d is simply

$$V_{rect} = WLd = 2rLd \qquad (3)$$

For the fuel tank geometry, if $r < h \le H+r$, then the fuel volume is given by a combination of eqns. (1) and (3). In particular, when eqn. (1) is evaluated at d = r, the volume simply reduces to that associated with half of the volume of a cylinder of radius r and length L. Thus, for $r < h \le H+r$, the fuel volume in the fuel tank is given by

$$V_{fuel} = \frac{\pi r^2 L}{2} + 2rL(h-r) \qquad (4)$$

When $H+r < h \le H+2r$, we again use a combination of eqns. (1) and (3). This time the central region is full [i.e. d = H in eqn. (3)] and the volume of the cylindrical portion, V_{cyl}, is given by eqn. (1) with d = h-H (this represents a simple cylinder made from the lower and upper portions of the fuel tank). Thus, for $H+r < h \le H+2r$, the liquid volume in the fuel tank is given by

$$V_{fuel} = 2rLH + \left[r^2 \cos^{-1}\left(\frac{r-d}{r}\right) - (r-d)\sqrt{2rd-d^2} \right] L \qquad \text{with } d = h-H \qquad (5)$$

For the fuel tank shown in the diagram, assume the following values:

r = 0.95 ft   H = 2.0 ft   L = 5.0 ft

a. **Method #1:** Write a Matlab function file to evaluate the fluid volume (in ft^3) given a **scalar value of height, h**, in the range $0 \le h \le H+2r$. The geometry parameters for the fuel tank are passed into the function via the ***global*** command. In particular, the first two lines of the file should be as follows:

```
function V = fuelvol1(h)
global r H L
```

You need to write the rest of the function (***remember h and V are scalars***)…

b. **Method #2:** Write a Matlab function file to evaluate the fluid volume (in ft^3) given a **vector of heights, h**, in the range $0 \le h \le H+2r$. The output of the function will be a vector with the same size as h. The geometry parameters for the tank are passed into the function via the ***global*** command. In particular, the first two lines of the file should be as follows:

```
function V = fuelvol2(h)
global r H L
```

You need to write the rest of the function (***remember h and V are vectors***)…

c. Write a separate Matlab script file that uses both **fuelvol1.m** and **fuelvol2.m** to evaluate and plot the volume of water in the fuel tank (in gallons) versus fluid height, h, over the range $0 \le h \le H+2r$. Plot the results for both methods on the same axis to show that both methods give exactly the same result (do they?).

d. What is the key difference in these two approaches to solving this problem? Explain clearly what is being illustrated here…

Documentation

Documentation for this assignment should include a listing of the Matlab script and function files, the resultant Matlab plots and/or tabular data, as appropriate, and a brief description of the data and results of your analyses for each of the problems. Keep all the parts for a given problem together. An overall professional job is expected!

See HW#1 for a description of the expected format -- every HW in this course should follow these basic instructions…