CEE 3804: Computer Applications in Civil Engineering   Spring 2020

Quiz # 2

Open Notes and Internet Access   Instructor: Trani

Due Date: 9 AM Friday, March 24, 2020

Honor Code Pledge

The information provided in this exam is my own work. I have not received information from another person while doing this exam.

_____ (your signature)

Use the Word processor of your choice to assemble your solutions. Include all screen captures of your Matlab scripts and plots created as outputs. Create a single PDF file and submit to Canvas.

Problem 1 (40 points)

Show all your work. Include screen captures of your code.

One of the fundamental properties used by civil engineers in the analysis of open channel flow is the calculation of the hydraulic radius (R). The hydraulic radius is defined as follows:

$$R = \frac{A}{W_p}$$

(1)

where:

R = hydraulic radius (feet)

A = area of the open channel section (ft^2)

W_p = wetted perimeter (ft)

The wetted perimeter is the perimeter length of the channel in contact with the water (the dark blue line shown in Figure 1).

A section of a large natural channel is shown in Figure 1. The section depth has been derived using a bathymetric survey with a sonar and mapping GPS equipment. The file called channelDepth.m contains the channel depth data as a function of horizontal station for a 500-foot channel cross section.
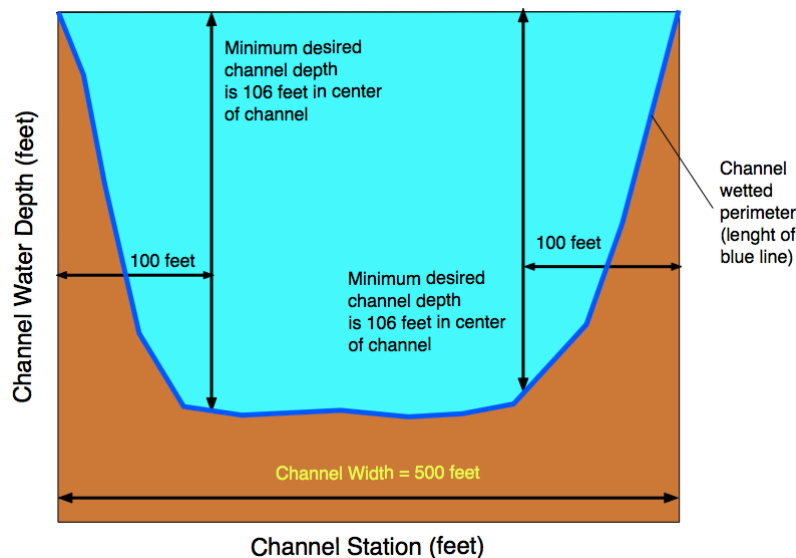

Figure 1. Water Channel Depth Profile in a Navigation Canal.

a) Create a Matlab script to read the channel depth file and plot the water depth level as a function of station as shown Figure 1. Label the axes and make sure you include units in your labels. **(10 Points)**

b) Create a single Matlab function to calculate the wetted perimeter (Wp) and the hydraulic radius (R). The inputs to the function are the station and the water depth coordinates read in part (a). the function should produce two outputs: Wp and R. Note: It is valid to estimate the wetted perimeter as the total linear distance between the points provided in the file channelDepth.m. Hint: you can assume a line between each successive pair of points. **(10 Points)**

c) Enhance the Matlab script created in part (a) to estimate the cross-section area (A) of the natural channel at the section shown in Figure 1. Use any integration method of your choice. **(10 Points)**

d) The specification of the minimum depth of the channel is 106 feet deep for the central part of the channel as shown in Figure 1. The central part of the channel is 300 feet wide (as shown in Figure 1). Enhance the Matlab script created in part (b) to estimate the cross section of soil that needs to be removed from the bottom of the channel to meet the specification. **(10 Points)**

Problem 2 (30 points)

Show all your work and include screen captures of your code.

A civil engineer wants to calculate the forces acting in a suspension bridge. Figure 2 shows the geometry of the suspension bridge including the basic forces acting on the bridge support points.
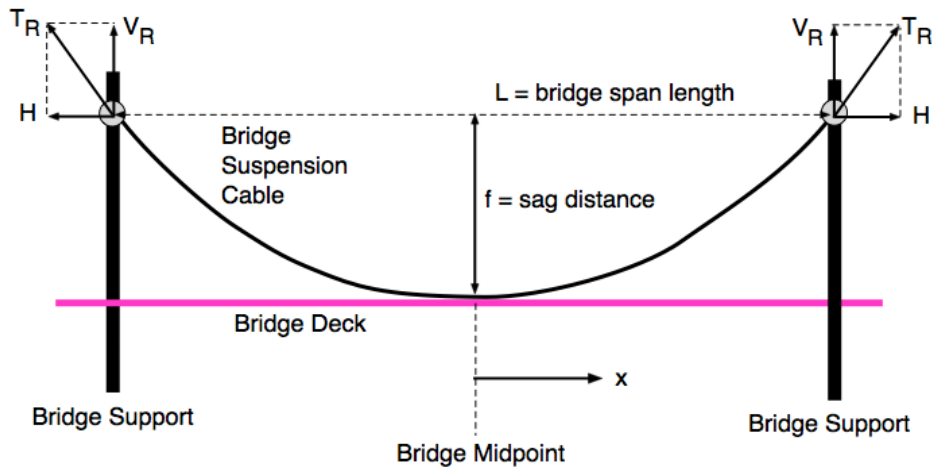

Figure 2. Suspension Bridge Geometry and Forces.

Assuming the cable adopts a parabolic shape, the equations to estimate the reaction forces (H and V_R) and the suspension cable tension at the support point (T_R) can be approximated using the following equations.

$$H = \frac{w_0 l^2}{8f}$$

$$V_R = \frac{w_0 l}{2}$$

$$T_R = \frac{w_0 l}{2}\sqrt{1 + \frac{l^2}{16 f^2}}$$

where:

H = horizontal reaction force at support point (N)
V_R = vertical reaction force at support point (N)
T_R = tension on the cable at support point (N)
w_0 = distributed load (N/m)
l = cable length (m)
f = cable sag distance (m)

The tension (T) at any point along the cable is given by:

$$T = \sqrt{H^2 + w_o^2 x^2} \qquad \text{(in Newtons)}$$

where: x is the horizontal distance (in meters) measured from the midspan point (x=0) to any station along the bridge as shown in Figure 2. For a given length of the suspension cable (l), the length of the bridge span between supports (L) can be calculated using the following equation.

$$L = \frac{1}{2}\sqrt{1+\left(\frac{w_o l}{2H}\right)^2} + \frac{H}{w_o}\sinh\left(\frac{w_o l}{2H}\right) \tag{2}$$

where all variables in equation (2) have been defined.

a) Create a **Matlab function** to estimate the forces (H, T_R and V_R) acting at each support element of the bridge. This function should also calculate the length of the bridge span (L). Test your function using the following parameters: **(10 points)**

$$w_0 = 1e5 \text{ (N/m)}$$
$$l = 300 \text{ (m)}$$
$$f = 20 \text{ (m)}$$

b) Create a second **Matlab function** to estimate the tension of the cable (T) at any station(x) along the bridge from the midpoint (x=0) to the support location (L/2). Your Matlab function should produce one output (the cable tension T in Newtons) and should have three input variables (H, w_o and x). **(10 points)**

c) Create a Matlab script that calls both functions created in parts (a) and (b). The new script should allow a user to specify numerical values for Wo, l and f (see part a). Use this script to estimate the bridge cable tension (T) from station (x=0) to station (L/2). Also use the script to estimate forces (H, T_R and V_R) acting at each support element. Finally, the script should end with code to plot the cable tension as a function of bridge station (from midspan to L/2). Comment about the location where the maximum tension is observed. **(10 points)**

Problem 3 (30 Points)

A civil engineer wants to estimate the distribution of aircraft touchdown locations on a runway (see Figure 3). This is important in the design of airport pavements and the location of runway markers. The engineer collects data and finds that touchdown locations are normally distributed. The equation of the Probability Density Function (PDF) (i.e., the value of f(x) of the Gaussian (or Normal) distribution is given in any statistics textbook and repeated here for completeness (http://en.wikipedia.org/wiki/Normal_distribution).

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left[\frac{(x-\mu)^2}{2\sigma^2}\right]}$$

where: *x* is the random variable representing the aircraft touchdown location in feet, and μ and σ are the mean and standard deviation (in feet) of the touchdown locations.

The engineer estimates that for the Atlanta airport the mean touchdown location (μ) is 1,230 feet from the runway threshold (the starting point of the runway). The standard deviation (σ) is found to be 310 feet.

Task 1

Create a function in Matlab to calculate f(x), Your function should have three input parameters (x, μ and σ). The function should produce the value of f(x) – the probability that an aircraft lands at location x measured from the runway threshold. **(10 Points)**

Task 2

Create a Matlab script that uses the function created in part (a). This script also plots the value of f(x) as a function of touchdown distance (x). Your plot should start with a value of x at (μ - 4 σ) and end at a value of x at (μ + 4 σ). Label your axes accordingly. Verify that the PDF plot is the well-known bell-shape curve of the Normal distribution. **(10 Points)**

Task 3

Enhance the Matlab script created in Task 2 to estimate the probably that an aircraft touches down at locations between 365 and 2,050 feet from the runway threshold. This is an area where the pavement could be reinforced. Find the probability that an aircraft lands outside the pavement area to be reinforced. Note: The probability that and aircraft lands between two points is the area under the Normal curve f(x) or the PDF. **(10 Points)**

Figure 3. FEDEX MD-10 Landing at Charlotte-Douglas International Airport (A. Trani).