Assignment 4: VBA Programming

Date Due: September 25, 2013   Instructor: Trani

Problem 1

The velocity distribution of wind speeds assumed in the construction of tall buildings in Australia is given by the following equation:

$$V_z = \frac{u^*}{0.4} \log_e \left(\frac{z}{z_0} \right)$$

where:

V_z = design hourly mean wind speed (m/s)

u^* = friction velocity (m/s)

z_0 = roughness length (m)

z = height above terrain (m)

The values of roughness length and friction velocity have been set empirically to model wind events encountered in various design environments.

Table 1. Values of roughness length and friction velocity used in wind speed model.

Design Environment	Roughness Length (m)	Friction velocity (m/s)
Open water	0.002	1.204
Open country	0.020	1.385
City suburbs	0.200	1.626
Downtown areas	2.000	1.963

Task 1:

Create a spreadsheet and organize the inputs to the problem to calculate the hourly wind velocity at any height z given the design environment (i.e., open water, open country, suburb or downtown). It is suggested that you follow the format of the example shown in class to estimate the flexible pavement thickness at an airport in doing this assignment. Create the necessary VBA code to estimate the wind speed (Vz) for a selected design environment as shown in Figure 1. Your VBA program should do the following steps:

a) Read the "Design Condition" as a string from cell B6 and calculate the values of roughness length (m) and friction speed (m/s). The values of roughness length and friction velocity are shown in Figure 1 and they should be part of your code. You should use the **Excel data validation** to write a list of 4 strings representing 4 design conditions (open water, open country, suburb or downtown) as shown in Figure 1.

   I suggest using a standard if-then-else statement to assign the correct values of roughness length and friction velocity. Write the value of roughness length back to cell B7

b) Read the values of starting height, ending height and delta height from cells B8, B9 and B10, respectively. These values are used to estimate the number of iterations required in the calculation.

   noIterations = round ((ending height - start height) / delta height, 0) ' the round off value of the quantity in parenthesis

c) Write back to the spreadsheet the value of number of iterations (in cell B11)

d) Create a table with values of height (starting in cell A14) and design wind speed (starting in cell B14) as shown in Table 2.

	A	B	C	D	E	F
1						
2	Australian Wind Model			Formula Vz = uStar/0.4 * log(z/zo)		
3	Prorammer: A. Trani					
4	9/14/13 22:25					
5			Units			
6	Design Condition	Open Water	dim	Calculation		
7	Zo	0.002	m/s			
8	Start height	1.00	m			
9	End height	500.00	m			
10	Height step size	1.00	m			
11	No. Iterations	500.00				
12						
13	Height Above Ground (m)	Wind Speed (m/s)				
14	1	18.71				
15	2	20.79				

Figure 1. Sample Computational Spreadsheet.

NOTE: to estimate the natural logarithm in VBA use LOG (in the VBA program)

Task 2:
Test the program created by estimating the hourly design wind speed for Open Water. Use 500 iterations starting at a height of 1 m and ending at 500 meters. Use steps of 1 meter (delta height).

Task 3:
Test the program created by estimating the hourly design wind speed for Downtown design conditions. Use a starting height of 1 m, ending height of 500 meters and steps of 5 meters. Make sure the VBA code erases the previous results so that your new table is displaying the range of new values calculated in Task 3. In VBA the command Range("A1:C5").Clear clears all cells between cells A1 and C5.

Task 4:
Copy the design wind speed profiles for "Open Water" and "Downtown" design conditions and compare the velocity profiles. Comment.

Show all your screen captures of the output and the VBA code.

Problem 2

This problem deals with a cantilever beam (i.e., supported at one end) with a total load *W* distributed along the beam (see Figure 2). More information about the equations of the beam can be found at: http://www.engineersedge.com/beam_bending/beam_bending8.htm.
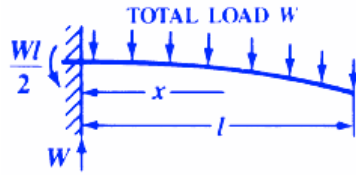

Figure 2. A simple beam supported at one end. Source: http://www.engineersedge.com/beam_bending/beam_bending8.htm

Nomenclature for beam deflection and stress calculation equations.

W = load (lb)
E = Modulus of elasticity (lb/sq-in)
I = Moment of inertia (in^4)
x = distance from datum point (in)
l = beam length (in)
d_N = distance from edge of beam to neutral axis (in)

y = deflection (in)
s = stress at the cross-section being evaluated (lb/in-in)
Z = section modulus of the cross section of the beam

Z is calculated as I / d_N

The stress (in lb/sq. inch) at the cross section of the beam is calculated according to the formula:

$$s = \frac{W}{2Zl}(l-x)^2$$

The deflection of the beam (y) (in inches) at any point along the beam (x distance from datum point) is given by:

$$y = \frac{Wx^2}{24EIl}[2l^2 + (2l-x)^2]$$

Task 1:

Create a VBA Sub Procedure to estimate the stress (s) at any station along a beam and the deflection of the beam (y) as a function of known quantities W, E, I, d_N and x. Your VBA subroutine should read the input values: W, E, I, d_N and I from the spreadsheet. These values will be entered by the user in the worksheet as shown in Figure 3. The output of the VBA Sub Procedure consist of values of stress (s) and displacement (y). These values should be passed back to the worksheet and written as a function of the beam station length x (see Figure 3). Write a loop inside the Sub Procedure to write the output back to the worksheet. The values of s and y should be calculated every 5 inches along the beam.

	A	B	C	D	E
1					
2	Beam Calculations				
3	Programmer: A. Trani				
4	Date: 02/14/07				
5			Units		
6	W	2000.00	lb	Calculation	
7	E	30000000.00	psi		
8	I	240.00	in-in-in-in		
9	*l*	300.00	inches		
10	dN	12.00	in		
11	Beam Station (in)	Stress (lb/sq.in.)	Deflection (in)		
12	0.000	15000.000	0.000		
13	5.000	14504.167	0.000		
14	10.000	14016.667	-0.001		
15	15.000	13537.500	-0.002		

Figure 3. Worksheet of the Beam Calculation Problem.

Task 2:

Test your VBA Sub procedure using the following values for the beam model parameters. Assume a beam is 350 inches in length and that we need to calculate the stress and deflection of the beam at various stations (say every 5 inches).

W = 1100 lb
E = 28e6 psi (soft steel)
I = 128 in^4
l = 350 inches
distNeutralAxis = 10 inches

Task 3:

Try the analysis for a 350 inch beam made of Aluminium-Lithium with a value of E = 13e6.

Show all your screen captures of the output and the VBA code.

Task 4:

Copy the beam deflections obtained for steel and AL-Li and compare the deflection profiles. Comment.

Problem 3

A highway engineer studies the acceleration and the velocity profiles of new Volvo trucks. This information is important for safety in highway design and to estimate the size of acceleration lanes of highways. The truck manufacturer provides a simple mathematical model to predict the velocity profile of a truck as follows:

$$V_t = V_{max} + (V_0 - V_{max})e^{-kt}$$

where:

$V_t = $ is the velocity (m/s) of the truck as a function of time (t)

$V_{max} = $ maximum velocity (m/s)

$V_0 = $ is the initial velocity of the truck (m/s)

$k = $ is an acceleration constant (1/s)

$t = $ is the time (seconds)

Task 1:

Create a VBA subroutine to estimate the velocity profile (V_t) for any time (t) given using the following parameters:

$V_{max} = $ 35 m/s

$V_0 = $ 0 m/s

$k = $ 0.1 (1/s)

$t = $ 30 (seconds)

Task 2:

Create a simple interface using Excel Form controls for this program to select the input parameters and in the same interface display all output parameters. The following ranges of the parameters are suggested:

$V_0 = $ 0-20 m/s

$V_{max} = $ 30 to 40 m/s

$k = $ 0.1 to 0.12 (1/s)

Task 3:

Use the computer program created in Task 2 to examine the sensitivity of V_t with time (t). Create a table in Excel for values of (t) starting at time = 0 and ending at 30 seconds (steps of 1 second). As usual, create the headers for the table in VBA code in the same VBA subroutine. Pass the output results to the spreadsheet and create a plot outside VBA showing the variation of V_t with time (t). Find the speed of the truck of with the default parameters shown in Task 1 after 30 seconds.

Task 4:

Plot the velocity profile of the truck using the default parameters shown in Task 1.