

## Assignment 4: VBA Programming

Date Due: February 24, 2015

Instructor: Trani

### Problem 1

This problem deals with a beam supported at both ends and with a single load  $W$  at a known location. The beam is shown in Figure 1.

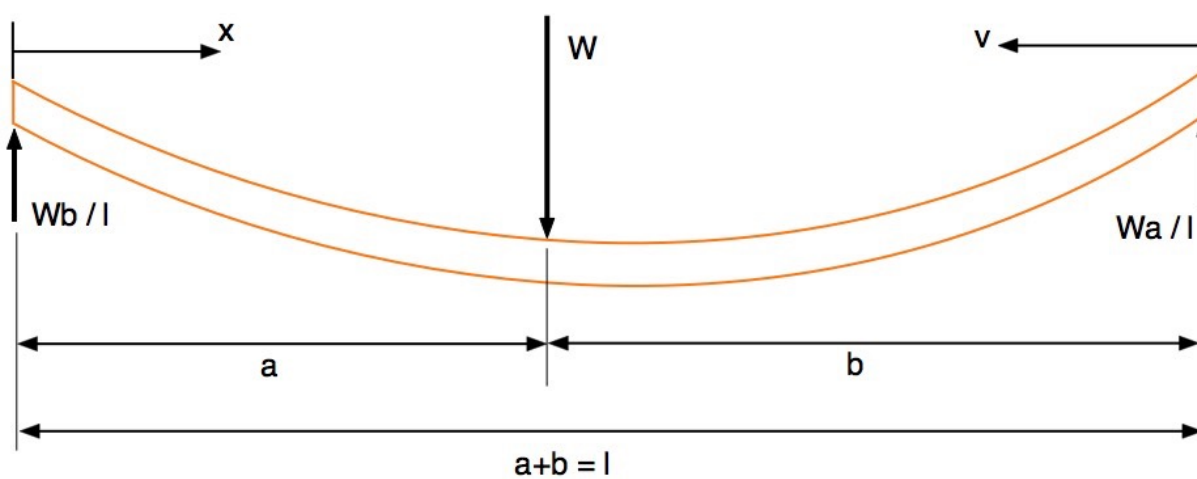


Figure 1. A simple beam supported at both ends with a load  $W$  at some known location. Adapted from: [http://www.engineersedge.com/beam\\_bending/beam\\_bending3.htm](http://www.engineersedge.com/beam_bending/beam_bending3.htm).

Nomenclature for beam deflection and stress calculation equations.

$W$  = load (N)

$E$  = Modulus of elasticity (N/m<sup>2</sup>)

$I$  = Moment of inertia (m<sup>4</sup>)

$x$  = Distance from left side of the beam to the loading point (m)

$v$  = Distance from right hand side beam end point to the loading point (m)

$l$  = beam length (m)

$a, b$  = distances from each beam end point towards the loading point (m)

Let:

$$y_a = \frac{-Wbx}{6EI}(l^2 - x^2 - b^2)$$

$$y_b = \frac{-Wav}{6EI}(l^2 - v^2 - a^2)$$

where:

$y_a$  = deflection of the beam from left datum point (section a) in meters

$y_b$  = deflection of the beam from right hand side datum point (section b) in meters

### Task 1:

Create a VBA Sub Procedure to estimate the deflections of the beam ( $y_a$  and  $y_b$ ) as a function of known quantities  $W$ ,  $E$ ,  $I$ ,  $l$ ,  $a$ , and  $b$ . Your subroutine should take as inputs the following beam parameters:  $W$ ,  $E$ ,  $I$ ,  $l$ ,  $a$  and  $b$ . These values will be entered by the user in the worksheet in the range A6-C11 (I suggest column A defines the parameter names, column B defines their numerical values and column C defines the units of each parameter).

The output of the VBA Sub Procedure consists of the values of beam deflections ( $y_a$  and  $y_b$ ) and their stations (values of  $x$  and  $v$ ). These values should be passed back to the worksheet and written in column format below the range of cells used to define the input parameters (i.e., below row 11). Write a loop inside the Sub Procedure to write the output back to the worksheet. The values of ( $y_a$  and  $y_b$ ) should be calculated every 0.1 meter along the beam using incremental values of  $x$  and  $v$  needed to estimate ( $y_a$  and  $y_b$ ). Make sure to clear the table before writing back to the spreadsheet as demonstrated in class.

### Task 2:

Test your VBA Sub procedure using the following values for the beam model parameters. Assume a steel beam is 8 meters long and has the following parameters.

$W = 6000$  N

$E = 200e9$  N/m-m

$I = 0.001$  m<sup>4</sup>

$l = 8$  meters

$a = 3$  meters

$b = 5$  meters

### Task 3:

Plot the results of the beam deflections as a continuous distance (from the left datum of the beam) and verify that the deflections make sense. Note that I added a negative sign to the deflection equations to show the deflections downwards.

### Task 4:

Create a second VBA Sub procedure to estimate the reactions on both ends of the beam. Write the results back to the spreadsheet in the area of your choice.

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

## Problem 2

A civil engineer is designing an acceleration ramp on a highway using data provided by a truck manufacturer. The truck manufacturer provides a mathematical model based on the solution of two differential equations of motion to predict the velocity and distance profiles of the truck as a function of time. The equations are shown below.

The velocity profile is,

$$V_t = \frac{k_1}{k_2}(1 - e^{-k_2 t}) + V_0 e^{-k_2 t}$$

The distance traveled (S) is,

$$S_t = \frac{k_1}{k_2} t - \frac{k_1}{k_2^2}(1 - e^{-k_2 t}) + \frac{V_0}{k_2}(1 - e^{-k_2 t})$$

where:

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

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

$k_1$  = is an acceleration constant ( $\text{m/s}^2$ )

$k_2$  = is another acceleration constant (1/s)

$S_t$  = is the distance traveled by the truck (m)

$t$  = is the time (seconds)

### Task 1:

Create a VBA subroutine to estimate the velocity and distance profiles ( $V_t$  and  $S_t$ ) for any time ( $t$ ), initial velocity, and truck acceleration constants ( $k_1$  and  $k_2$ ). Test your subroutine with the following parameters:

$$V_0 = 0 \text{ m/s}$$

$$k_1 = 1.0 \text{ (m/s}^2\text{)}$$

$$k_2 = 0.03 \text{ (1/s)}$$

$$t = 60 \text{ (seconds)}$$

### Task 2:

Use the computer program created in Task 1 to examine the sensitivity of  $V_t$  and  $S_t$  with time ( $t$ ). Create a table in Excel for values of ( $t$ ) starting at time = 0 and ending at 90 seconds (steps of 1 second). Use these values to estimate the velocity and distance traveled every 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 variations of  $V_t$  and  $S_t$  with time ( $t$ ). Find the speed and distance traveled by the truck after 90 seconds.

### Task 3:

Plot the velocity and distance profiles of the truck (in Excel) as the results of the analysis in Task 2.

**Task 4:**

Find the length of the acceleration ramp needed for this vehicle if the design speed of the highway is 65 mph (~29 m/s). Comment on the process to select such value.

### Problem 3

Figure 2 illustrates the basic forces acting on a suspension bridge. The weight per unit length ( $w$ ) is 168 kN/meter for the bridge in question. Formulas to calculate the horizontal ( $H$ ) and vertical ( $V$ ) forces acting on the bridge tower are:

$$V = \frac{1}{2} wS$$

$$H = \frac{wS^2}{8d}$$

$$T = \sqrt{H^2 + V^2}$$

where:  $w$  is the load applied on the suspension cable per unit length (kN/m),  $S$  is the span of the suspension bridge (meters),  $d$  is the maximum dip (meters) of the cable (see Figure 2) and  $T$  is the suspension cable tension (N).

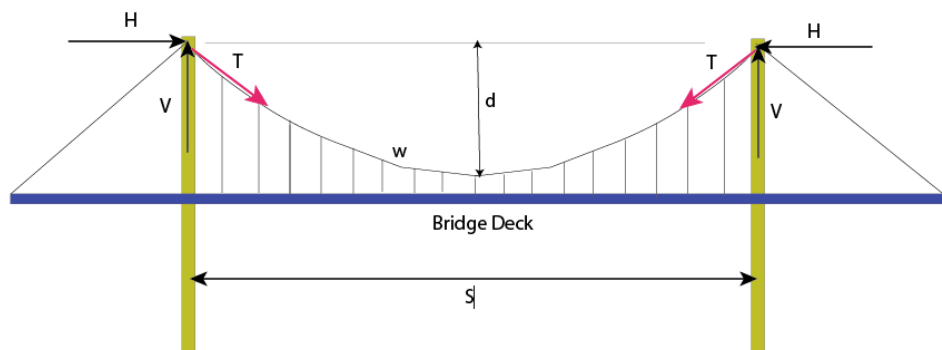


Figure 2. Suspension Bridge.

#### Task 1:

Create a simple VBA program to calculate the values of  $V$ ,  $H$  and  $T$ . Produce three outputs in your subroutine and send them back to a separate worksheet that acts as user interface. In your program declare all variables explicitly (use the Option Explicit command as shown in class).

Test your program with the following values:  $w = 168$  kN/meter,  $S = 200$  meters,  $d = 20$  meters

#### Task 2:

Test your program and predict the tension in the bridge cable if  $w$  is 173 kN/m,  $S = 230$  meters,  $d = 24$  meters.