

## Assignment 4: VBA Programming

Date Due: February 21, 2020

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.

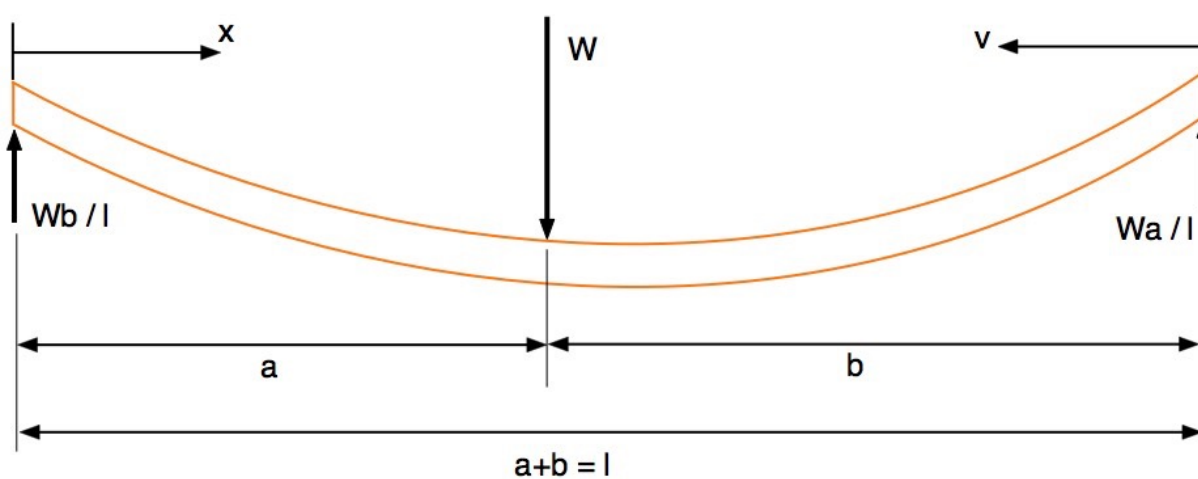


Figure 1. A beam supported at both ends with a load  $W$  at some known location. This problem is adapted from: [http://www.engineersedge.com/beam\\_bending/beam\\_bending3.htm](http://www.engineersedge.com/beam_bending/beam_bending3.htm).

Nomenclature for beam deflection and stress calculation equations.

$W$  = load (lb)

$E$  = Modulus of elasticity (lbs/in<sup>2</sup>)

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

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

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

$l$  = beam length (inches)

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

The deflections of the beam at stations (a) and (b) are:

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

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

where:

$y_a$  = deflection of the beam at a station measured from the **left datum point** (left support) in inches

$y_b$  = deflection of the beam at a station measured from the **right hand side datum** point (section b) in inches

### Task 1:

Create a VBA Sub Procedure to estimate the deflections of a steel beam ( $y_a$  and  $y_b$ ) as a function of known beam parameters  $W$ ,  $E$ ,  $I$ ,  $l$ ,  $a$ , 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. 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. Write a loop inside the Sub Procedure to estimate the deflection of the beam every 5 inches along the beam (i.e., beam station). Use a column format to write down the beam deflection at every station similar to the problem solved in class to estimate the pavement thickness at the airport. Make sure to clear the table before writing back to the spreadsheet as demonstrated in class. Include a screen capture of the VBA code.

### Task 2:

Test your VBA Sub procedure using the following values for the beam model parameters. Assume a steel beam is 300 inches long and has the following technical parameters.

$W = 2000$  lb

$E = 29e6$  lbs/in<sup>2</sup>

$I = 450$  in<sup>4</sup>

$l = 300$  inches

$a = 200$  inches

$b = 100$  inches

In your solution include a screen capture of the table that shows the beam deflections as a function of beam station (values of  $x$  and  $v$ ).

### Task 3:

Plot the results of the beam deflections ( $y_a$  and  $y_b$ ) individually (for stations every 5 inches for values of  $x$  and  $v$ , respectively) 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:

Plot the results of the beam deflections as a continuous distance (from the left support point 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 5:

Create a second VBA Sub procedure to estimate the reactions on both ends (see Figure 1) of the beam and the deflection at the station where the load is applied. The formula for the deflection at the station of the load is:

$$y_{load} = \frac{Wa^2b^2}{3EI}$$

Verify if the calculation matches the maximum observed deflection estimated in Task 4.

Show sample screen captures of the spreadsheet output and the VBA code.

## Problem 2

### Task 1:

Enhance the VBA code created in Problem 1 by adding a table in the spreadsheet to select the Modulus of Elasticity (E) of the beam material. Use the following table allowing the user to select among all 6 materials listed in Table 1. Use the appropriate IF-Then statements in the code to detect the material entered by the user in the spreadsheet.

Table 1. Modulus of Elasticity of Various Engineering Materials. Note that Values of E are in millions.

Material	Modulus of Elasticity E (lbs/in <sup>2</sup> ) x 10 <sup>6</sup>
Steel (ASTM - A36)	29
Berylium	42
Aluminium	10
Copper	17
High Strength Concrete (in compression)	4.5

### Task 2:

Compare the maximum deflections of the beam estimated when using steel vs. concrete. Briefly comment.

## Problem 3

A civil engineer is designing large parking lot for a stadium. The runoff is the amount of water generated by the large parking area as a function of time. Using computer simulations the engineer developed the following empirical formula to estimate the runoff (Q) in cubic meters per second during the 100-year design storm.

$$Q = k_1 * k_2 * \sin(t / k_3) * e^{(-t/k_4)}$$

where:

Q = water runoff (cubic meters/s)

t = time (seconds)

and

$$k_1 = 1.25;$$

$$k_2 = 56;$$

$$k_3 = 900;$$

$$k_4 = 375;$$

**Task 1:**

Create a VBA subroutine to estimate the runoff ( $Q$ ) as a function of time ( $t$ ). The code should read the model parameters presented above from the spreadsheet and calculate the runoff ( $Q$ ) for a given value of time.

Create a FOR-LOOP in the VBA code to estimate the values of runoff between  $t=0$  and  $t=3600$  seconds (i.e., a one hour storm). Since there are numerous values of  $Q$ , create an output table with  $Q$  values every 10 seconds.

**Task 2:**

Plot the values of  $Q$  vs time obtained in Task 1 using Excel.

**Task 3:**

Using the plot in Task 2 and the table generated, find the maximum value of runoff.

**Task 4:**

Do not calculate, however, use your knowledge of Calculus to tell me how would you calculate the total volume of water generated by the parking lot during the design storm.