

Assignment 4: VBA

Date Due: February 22, 2021

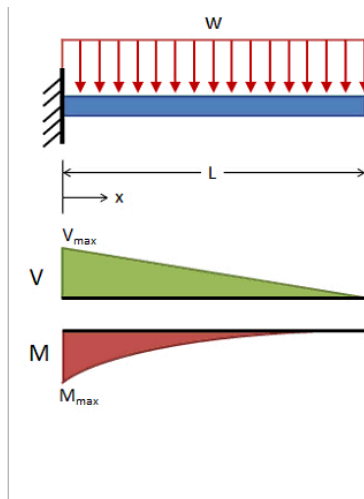
Instructor: Trani

Show all your work including VBA code and results of your computation in the spreadsheet as screen captures.

Problem 1

Review the formulas to estimate the deflection of a uniformly loaded beam at: <https://mechanicalc.com/reference/beam-deflection-tables>.

Cantilever, Uniform
Distributed Load



Deflection:

$$\delta = -\frac{wx^2}{24EI}(6L^2 - 4Lx + x^2)$$

$$\delta_{max} = \frac{wL^4}{8EI} \quad @ x = L$$

Slope:

$$\theta = -\frac{wx}{6EI}(3L^2 - 3Lx + x^2)$$

$$\theta_{max} = \frac{wL^3}{6EI} \quad @ x = L$$

Shear:

$$V = +w(L - x)$$

$$V_{max} = +wL \quad @ x = 0$$

Moment:

$$M = -w(L - x)^2 / 2$$

$$M_{max} = -wL^2 / 2 \quad @ x = 0$$

Figure 1. Uniformly Loaded Beam. Source: <https://mechanicalc.com/reference/beam-deflection-tables>.

Note: You will get no credit if you just do regular Excel computations in a spreadsheet and do not show your VBA code.

L = beam length (m)

x = beam station (m) measured from the wall

E = Modulus of Elasticity (N/m²)

I = moment of inertia of the beam (m⁴)

W = applied load in Newtons

δ = deflection in meters at beam station (x)

- Create a Subroutine (Sub) in Excel (using VBA) to calculate the deflection of the beam at any point x. The VBA code must read the values of L, E, I, W and x from cells you designate in the spreadsheet and calculate the deflection (δ). See the example shown in Figure 2. **Note:** This problem requires you to create a subroutine and not a function like in Assignment 2.
- Use the subroutine created above to estimate the deflections along the beam every 50 centimeters (user-defined parameter). Use the numerical values W = 3000, L=5.5 m, I = 0.0001 (m⁴) and E = 180e9 (N/m²). Use Figure 2 as a guideline of your calculations. The VBA code should include a FOR-NEXT loop to calculate the values of

deflection at stations specified in the Spreadsheet. For example include a parameter that controls the distance between successive deflection calculations (e.g., 50 centimeters).

- c) Link the subroutine created in Part (a) to a button as shown in Figure 2.

Simple Supported Beam Programmer: A. Trani 2/15/21 7:10		Write the beam equations here	
		Units	Calculation
E	Numerical value here	write units here	
I	Numerical value here	write units here	
Other parameters as needed		Numerical value here	write units here
Beam Station (m)		Deflection (m)	
	0.0	Numerical value here	
	0.5	Numerical value here	
	1.0	Numerical value here	
Other values here		Numerical value here	
Make the table as long as needed			

Figure 2. Suggested Spreadsheet Layout for Uniformly Loaded Beam Problem.

Problem 2

- a) Improve the VBA code created in Problem 1 by adding code to automatically estimate the value of E (modulus of elasticity) from a list of materials provided in Table 1. Use the data validation in Excel to create a list of values for Modulus of Elasticity (N/m²) for five materials. The user of the spreadsheet should be able to select the material from a drop down list as demonstrated in the class notes and assign/pass the correct value of E to the VBA subroutine before the beam deflection calculations.

Table 1. List of Materials for Problem 2.

Material	Modulus of Elasticity (10 ⁹ N/m ²)
Structural Steel	200
Stainless Steel	180
Titanium	120
Aluminum	70
High Strength Concrete	30

- b) Test the improved code with the following choices: 1) Structural Steel and 2) Aluminum. Show screen captures with the Spreadsheet solution showing deflections every 50 centimeters.

Problem 3

A civil engineer is designing an acceleration ramp for 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 of motion of the truck 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 (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)

a) Create a VBA subroutine (not a function) to estimate the truck velocity and distance profiles (V_t and S_t) for any time (t), initial velocity, and truck acceleration constants (k_1 and k_2). The VBA code must read the values of V_0 , k_1 , k_2 and t from the spreadsheet. Test your subroutine with the following parameters:

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

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

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

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

b) 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 120 seconds.

c) Use Excel to plot the velocity and distance profiles of the truck using the results of the table created in part (b).

d) Find the length of the acceleration ramp needed for this vehicle if the design speed of the highway is 65 mph (~29 m/s). Select the value from the table created in part (b).