Assignment 5: VBA and Data Validation

Date Due: March 8, 2021   Instructor: Trani

Show all your work including VBA code and results of your computation in the spreadsheet as screen captures. All code needs to use Option Explicit to define the variables.

Problem 1

Reuse the program created in Assignment 4 of the class (Problem 2 of Assignment 4) to create a more user friendly version of the program. Refer to Problems 1 and 2 of Assignment 4 for the full description of the problem.

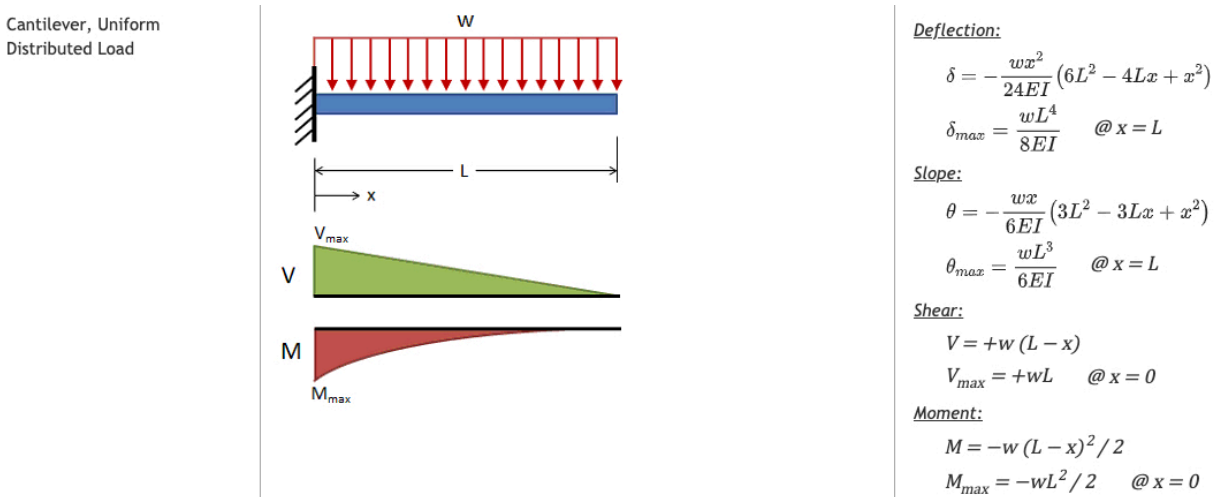Review the formulas to estimate the deflection of a uniformly loaded beam at: https://mechanicalc.com/reference/beam-deflection-tables.

Cantilever, Uniform Distributed Load

W

L

x

V_{max}

V

M

M_{max}

Deflection:

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

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

Slope:

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

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

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)

    a)   Improve the code created in Assignment 4 by adding a separate worksheet to the problem to act as Graphic User Interface to the program. In this new worksheet include the description of the problem and add a slider control to set the value of W (applied load) allowing the user to specify the value of W to be used in the problem solution. The interface should let the user select the lower and upper bounds of W (from 2000 to 10000 N) to be used in the VBA code behind the spreadsheet. Test the solution with values of W = 2500 N and W = 7500 N.

b) Improve the code created in part (a) to add a slider control allowing the user to specify the value of L (beam length) to be used in the problem solution. The new interface should let the user select the lower and upper bounds of L (4 to 10 meters) to be used in the VBA code behind the spreadsheet. Test the solution with values of L = 4.5 m and L = 6.5 m and W = 5000 N.

c) Improve the code created in parts a and b and create a data validation list linked to a cell in your program allowing the user to select among a predefined set of step sizes to calculate the deflection along the beam. The data validation should specify the values of step size as follows: 0.10, 0.25, 0.35, and 0.5 meters. Test the solution with values of L = 7.0 m, W = 4500 N, and step sizes of 0.25 and 0.35 meters.

Problem 2

Reuse the program created in Assignment 4 of the class (Problem 3 of Assignment 4) to create a more user friendly version of the program. Refer to Problem 3 of Assignment 4 for the full description of the problem.

The equations of motion of the vehicle 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) Improve the code created in Assignment 4 (Problem 3) by adding a separate worksheet to the problem to act as Graphic User Interface to the program. In this new worksheet include the description of the problem and a data validation list to control the values of acceleration constants (k_1 and k_2). Table 1 shows the values of (k_1 and k_2) needed to solve the problem. Test the solution implemented for all four vehicles.

Table 1. Acceleration Constants for the Problem.

Vehicle	k_1	k_2
Mid-size Sedan	1.95	0.032

Vehicle	k_1	k_2
Light Truck	1.2	0.029
Heavy Truck	1.0	0.031
Off-Highway Truck	0.9	0.037

b) Improve the code solution of part (a) by adding a slider control allowing the user to specify the value of the final time to be used in then calculations (t). Allow the slider control to accept values of final time ranging from 60 to 120 sends at intervals of 1 second. Test the solution implemented for the Mid-size sedan with final values of 75 and 110 seconds.

c) Add an input cell to the interface of your program created in part (a0 and (b) connected to a slider control allowing the user to specify the speed to the highway (in meters per second). Create code to detect the the distance traveled by the vehicle to reach the speed limit and send the result back to the spreadsheet.

Problem 3

In hydraulics, one of the fundamental problems is to determine the reaction force (F) generated by a leaking tank is shown in the figure below. The following formulas apply to the problem using basic hydrostatic analysis: v is the velocity of the leaking water flow (m/s), d is the horizontal distance traveled by the leaking water (meters), Q is the volumetric flow rate (m³/s), and F is the reaction force acting on the tank (Newtons).

$$v = \phi\sqrt{2gh_1}$$
$$d = 2\sqrt{h_1 h_2}$$
$$Q = \phi\mu A\sqrt{2gh_1}$$
$$F = 2\gamma g A h_1$$

where: g is the gravity constant (9.81 m/s²), h_1 is the water depth to the leaking point (meters), h_2 is the distance from the bottom of the tank to the leaking point (meters), A is the area of the leaking orifice (m²), μ is the contraction coefficient (0.62 for thin-walled tanks, 0.97 otherwise), ϕ is the equivalent friction (0.97 for water) and γ is the specific weight of the water (1000 kg/m³).
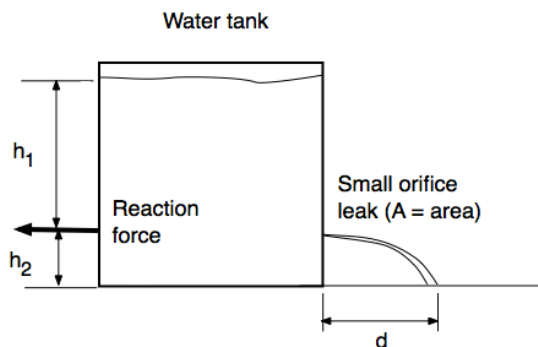

Figure 1. Leaking Water Tank Geometry.

a) Create a **Matlab script** to estimate the four parameters of the leaking water tank problem (v, d, Q, F). The inputs to the script should be the values of h_1, h_2, A, ϕ, and γ. The value of μ should be calculated in the script based on the wall properties of the tank (i.e., thin or thick). It is required that the key word "thin" or "thick" be an input to the script to determine the appropriate value of μ. Write the output of the script to the command line and label accordingly.

b) Test your script with the following values: $h_1 = 21$, $h_2 = 4.75$, $A = 0.05$, $\phi = 0.97$, $\gamma = 1000$ for both thin and thick wall tanks. Comment on the results obtained.

c) Use the script developed in Task 1 to examine the sensitivity of d with water tank depth. Create solutions for Q when h_1 varies from 8 meters to 20 meters at steps of 0.1 meters. Make a plot of h_1 versus Q.