M20 - Introduction to Computer Programming with MATLAB
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Fall 2023 – UCLA
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HOMEWORK 1

Task 1: Beam Analysis

Introduction

I am using MATLAB to graph 5 different functions, each graph aligned vertically, to analyze a beam with a linearly distributed load. I am graphing the displacement, slope, moment, shear, and loading of a beam, all against the horizontal displacement. Using MATLAB, I will be able to compare the graphs side-by-side, since they all are related to one another. MATLAB is a useful tool to be able to create such graphs.

Model and Theory

1) $y(x) = \frac{w_0}{120EIL}(-x^5 + 2L^2x^3 - L^4x)$
2) $\theta(x) = \frac{dy}{dx} = \frac{w_0}{120EIL}(-5x^4 + 6L^2x^2 - L^4)$
3) $M(x) = EI\frac{d^2y}{dx^2} = \frac{w_0}{120L}(-20x^3 + 12L^2x)$
4) $V(x) = EI\frac{d^3y}{dx^3} = \frac{w_0}{120L}(-60x^2 + 12L^2)$
5) $w(x) =- EI\frac{d^4y}{dx^4} = \frac{w_0}{L}x$
6) $L = 600cm$
7) $E = 50000\frac{kN}{cm^2}$
8) $I = 30000cm^4$
9) $w_0 = 2.5\frac{kN}{cm}$
10) $\Delta x = 2cm$

Methodology

I first cleared the workspace and command window. Then, I inputted variables for constants (6, 7, 8, 9) given in the problem, such as the modulus elasticity of the beam and the moment of inertia. Before I could plot the graphs, I had to solve the equations for slope (2), moment (3), shear (4), and loading (5). The equation for displacement (1) was already given to us. I calculated the derivatives by hand, and then inputted my equations as variables in MATLAB. Afterwards, I used subplot(), plot(), xlabel(), ylabel(), and title() functions to create each plot. Since there are 5 graphs that needed to be aligned vertically, I split the figure into a 5x1 grid with a space for each graph. I gave each graph appropriate axis labels and a title. Lastly, I added comments to make my code easier to understand for other users.

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Calculations and results

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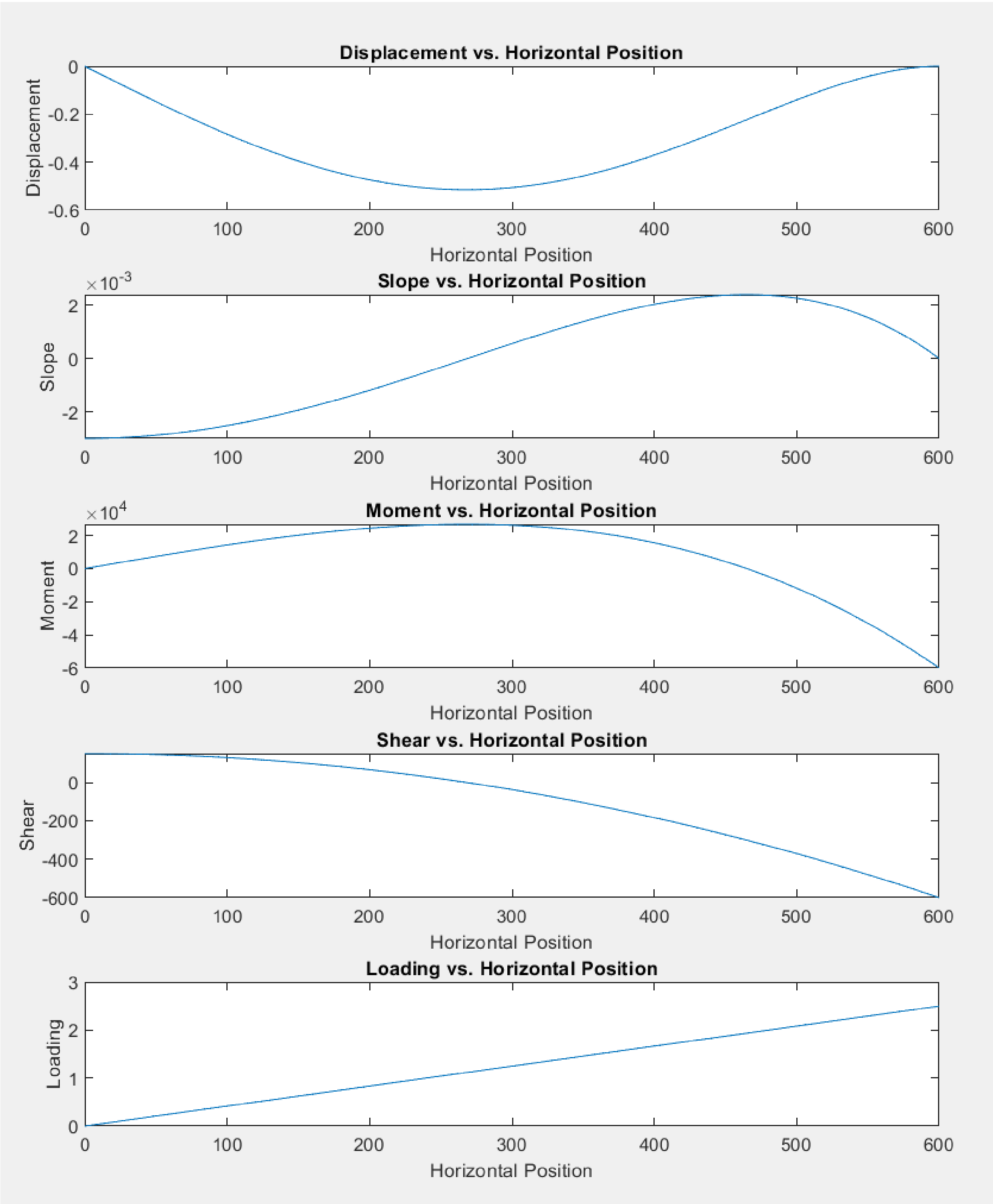

Displacement, Slope, Moment, Shear, and Loading of the beam are all plotted against horizontal position from 0cm to 600cm. Graphs are stacked vertically for easy comparison between them.

Discussions and Conclusions

In Figure 11), each graph is a derivative graph of some order of the displacement function, with some graphs that are multiplied by a constant. The graphs being stacked on top of each other makes it easy to compare them. There are a lot of comments you can make to these graphs. For example, the magnitude of maximum loading, shear, and moment all happen at the horizontal position of 600cm. The magnitude of maximum slope occurs at the horizontal position of 0cm.

Task 2: Surface Areas in the Solar System

Introduction

Because planets are not perfectly spherical and are better modeled as oblate spheroids, I wanted to compare the surface areas of all of the planets in our Solar System, modeled as both a sphere and an oblate spheroid. The oblate spheroid surface area calculations require an equatorial radius and a polar radius. I used the values for the radii for each planet from NASA's Planetary Fact Sheet. I then calculated both surface areas for each planet only using vector operations, and organized the data on a table.

Model and Theory

1) $A(r) = 4\pi r^2$
2) $A(r_1, r_2) = 2\pi(r_1^2 + \frac{r_2^2}{sin\gamma} ln(\frac{cos\gamma}{1-sin\gamma}))$
3) $\gamma = arccos\frac{r_2}{r_1}$
4) $r_{avg} = \frac{r_1+r_2}{2}$

Methodology

I first cleared the workspace and command window. I then inputted all of the data I already knew of (planet names, equatorial radius, and polar radius) into 3 separate column vectors variables, one for each type of data. I then created an equation for gamma (3) that will be used for the true surface area equation for the oblate spheroid model. Afterwards, I created equations for the true surface area (2) and the approximate surface area (3) I also created an average radius equation (4) that was used to calculate the approximate surface area for the perfect spheroid model. I then used the table() function to input my 5 column vectors in a table and add column headings. Lastly, I added comments to make my code easier to understand for other users.

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Calculations and results

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Planet	Equatorial Radius r1 [km]	Polar Radius r2 [km]	True Surafce Area [km^2]	Approximate Surafce Area [km^2]
"Mercury"	2440.5	2438.3	7.4801e+07	7.4778e+07
"Venus"	6051.8	6051.8	NaN	4.6023e+08
"Earth"	6378.1	6371	5.1082e+08	5.1063e+08
"Mars"	3396.2	3376.2	1.4437e+08	1.4409e+08
"Jupiter"	71492	66854	6.1469e+10	6.0129e+10
"Saturn"	60268	54364	4.2694e+10	4.1282e+10
"Uranus"	25559	24973	8.084e+09	8.022e+09
"Neptune"	24764	24341	7.6188e+09	7.5753e+09

My MATLAB code generated this table and filled in the missing values of the True Surface Area and the Approximate Surface Area.

Discussions and Conclusions

By comparing the true surface area and approximate surface area values for each planet (except Venus, which will be described further in the next paragraph) in figure 5), you can see that both values are close and on the same order of magnitude, but not exactly the same. The true surface area for all planets is larger than the approximate surface area. That means the approximate surface area is an underestimate for the true surface area.

The true surface area value for Venus in the table is “NaN”, meaning “Not a Number”. This value makes sense, because the equation used to calculate the true surface area involves the gamma equation, which requires you to take the inverse cosine function of the ratio of the equatorial radius and the polar radius. However, the equatorial radius and the polar radius for Venus are the same value, making gamma equal to 0 for Venus. The true surface area equation requires you to divide by the sine of gamma, but since dividing by the sine of gamma is a division by 0, the true surface area for Venus is incomputable!