ME 2450 Assignment 2 – Roots of Equations

Name: ____________________

Due: February 7, 2019

Collaborators: ____________________

I declare that the assignment here submitted is original except for source material explicitly acknowledged.

I also acknowledge that I am aware of University policy and regulations on honesty in academic work, and of the disciplinary guidelines and procedures applicable to breaches of such policy and regulations, as contained in the University website.

Name ____________________ Date __________

Signature ____________________ Student ID __________

Score

Exercise Graded:	
Presentation:	/2
Technical Content:	/8
Total:	/10

Exercise 1

(1 pt) Consider a Taylor series approximation to

$$f(x) = e^{-x}$$

at $x_{i+1} = 1$ using a base value of $x = 0.25$ and a step size of $h = 0.75$:

Calculate the second-order approximation for $f(0.25)$ by substituting the given values for x_i and h into the second-order Taylor Series expansion for $f(x)$. Calculate the true (absolute value) error, ϵ_t. Show your work.

Exercise 2

(3 pts) Determine the real root of: $f(x) = x^3 - 13x - 12$

a. Graphically. Report your graph and your estimates of the roots from the graph.

b. Using matlab or python, write a script to determine one of the roots using the bisection method. Set $a = 2$ and $b = 7$. Print the approximate relative percent error, $\epsilon_a(\%)$, over 5 iterations. Submit your code, along with the printed table of results. Your table should have 5 rows (1 for each iteration of the bisection method) and 3 columns: the iteration count, the approximate root at each iteration, and $\epsilon_a(\%)$ at each iteration.

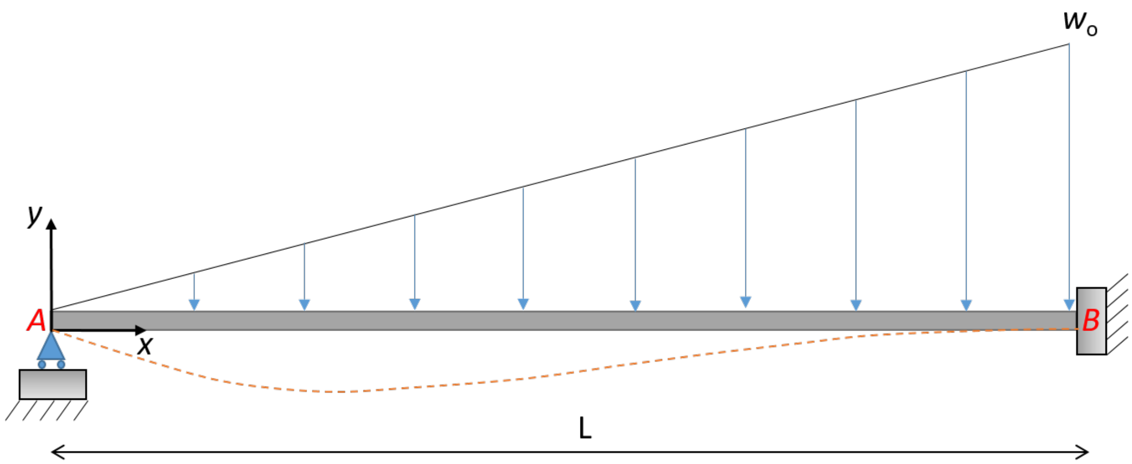
c. Compare your results of the previous step to the results from Müller's method given in Example 7.2 of the textbook (pg. 185-186). Report the difference in convergence between the two methods.

Exercise 3

(4 pts) Determine the maximum deflection of a beam. You will not need any previous knowledge of structural mechanics to solve this problem. The beam illustration and problem statement are only here to provide engineering context to the polynomial for which you will be determining roots.

A beam with uniform cross section is carrying a load that increases linearly from the pinned end (point A) to the fixed end (point B). The beam has the following properties:

- $E = 29x10^4\ psi$ (Young's modulus)
- $I = 723\ in^4$ (Cross-section moment of inertia)
- $w_o = 3000\ \frac{lbs}{ft}$ (applied load, see figure)
- $L = 15\ ft$ (beam length, see figure)



The deformed shape of the beam, $y(x)$, (illustrated by the orange dashed line in the figure) is given by the following equation (note, the origin is placed at A):

$$y(x) = \frac{w_o}{(120EIL)}\left(-x^5 + 2L^2x^3 - L^4x\right)$$

a. Solve for the first derivative of $y(x)$ with respect to x, $\frac{dy}{dx}$.

b. Next, the maximum deflection can be determined by setting $\frac{dy}{dx} = 0$ and solving for the root (the value of x where $\frac{dy}{dx} = 0$). Write a matlab or python script to determine the root using the Newton-Raphson method. Report the root in inches. Submit your code, along with what you used as the initial guess, tolerance, and how many iterations were required to achieve your tolerance.

c. Verify your obtained root using the built-in Matlab function `fzero`, Python function `scipy.optimize.fsolve` or `scipy.optimize.root`, or by solving analytically. Report a comparison of this result to that from your Newton-Raphson code.

d. Plug the determined root into the equation for deformed shape, $y(x)$, to determine the value of the maximum displacement. Report the value of maximum displacement, along with your intuition about whether the maximum deflection is too large.