Learning Outcomes of the Project:

In completing this project, the student will demonstrate the following skills and knowledge.

- Solving engineering problems using numerical methods.
- Write and use Matlab scripts and functions for solving problems in engineering
- Identify the efficiency, accuracy, and limitations of the methods used
- Display, graph, analyze and interpret the output of the calculations

General instructions

- Do not work together on this project, everyone must submit his own unique report.
- Read the whole document carefully before you begin.
- You are welcome to contact me for any clarification.
- Get started early.

Matlab

- Write your own scripts for all used methods according to the algorithms in the textbook.
- Do not use Matlab built-in functions for the methods.
- Use Matlab with the double precision IEEE arithmetic.
- Use "disp" and "sprintf" to format the output.
- Use %g or %e format to format the errors and very small numbers.
- Use the various options for the "plot" and "subplot" functions to produce professional graphs.
- Use "hold" to combine graphs for comparison purpose. Use appropriate plot symbols and colors.

Report

- Use MS Word and its equation editor to typeset the report.
- Matlab figures can be saved as .jpg files and then pasted into the word file.
- The report should contain all your work including scripts, output, graphs, tables, observations, explanations, conclusions, etc.
- Structure the report in a clear, legible, attractive and concise fashion.
- The report should include:
    - Cover page with name, section number, and student id.
        - A page on how the project is related to your discipline.
- In all the tasks, include all appropriate mathematical part, graphs, and tables.

Submission

Submit your report through blackboard by …
Save your code with name as "your_name_method_name.m".

Project 1a for Chemical Engineering Students

Ideal Gas Law: $pV = nRT$, where p is the absolute pressure, V is the volume, n is the number of moles, R is the universal gas constant, and T is the absolute temperature.

van der Waals equation: $\left(p + \frac{a}{v^2}\right)(v - b) = RT$, where $v = \frac{V}{n}$ is the molal volume and a and b are empirical constants that depend on the particular gas.

Using the value of the universal gas constant R= 0.082054 L atm /(mol K), compute the molal volume for Oxygen (a = 1.360 and b = 0.03183) at the following temperatures and pressures. Compare your results with the ideal gas law and van der Waals equation. Use Tolerance $Tol = 10^{-5}$

For each case, compute the relative error of molal volume obtained by the van der Waals equation from the Ideal gas law. Use Newton's method to solve this problem and complete the table.

Table using Newton's method

Temp K	Pressure atm	Molal Volume (Ideal Gas Law) L/Mol	Molal Volume (van der Waals) L/Mol Oxygen	Relative Error Oxygen	Number of Iterations
200	5				
	50				
	75				
400	5				
	50				
	75				

Define a suitable equation as $v = g(v)$ and use fixed point method to solve van der Waals equation for the above mentioned data.

Tale using Fixed points method

Temp K	Pressure atm	Molal Volume (Ideal Gas Law) L/Mol	Molal Volume (van der Waals) L/Mol Oxygen	Relative Error Oxygen	Number of Iterations
200	5				
	50				
	75				
400	5				
	50				
	75				

For K=200 and pressure = 5 and 50, chose a suitable interval for *v* to sketch the graphs of *f(v)*.

Project 1b for Chemical Engineering Students

In a chemical engineering process, water vapor (H2O) is heated to sufficiently high temperatures that a significant portion of the water dissociates, or splits apart, to form oxygen (O_2) and hydrogen (H_2):

$$H_2O \rightleftharpoons H_2 + \frac{1}{2}O_2$$

If it is assumed that this is the only reaction involved, the mole fraction *x* of H_2O that dissociates can be represented by

$$K = \frac{x}{1-x}\sqrt{\frac{2p_t}{2+x}}$$

where *K* = the reaction equilibrium constant and p_t= the total pressure of the mixture. If *K* = 0.05, determine the value of *x* that satisfies the above equation for the following values of $p_t = 3, 5, 7, 10$.

Use Newton's method. Use Tolerance $Tol = 10^{-5}$

p_t	x	Iterations
3		
5		
7		
10		

Define a suitable equation as $x = g(x)$ and use fixed point method to solve this problem and complete the table.

p_t	x	Iterations
3		
5		
7		
10		

For each pressure value, chose a suitable interval for *x* to sketch the graphs of *f(x)*.

Project 1c for Chemical Engineering Students

The volume *V* of liquid in a hollow horizontal cylinder of radius *r* and length *L* is related to the depth of the liquid *h* by

$$V = \left[r^2 cos^{-1}\left(\frac{r-h}{r}\right) - (r-h)\sqrt{2rh-h^2}\right] L$$

Determine *h* for the following data using Newton's method. Use Tolerance $Tol = 10^{-5}$

V	L	r	h	Iterations
8	5	2		
15	6	4		
10	12	5		

Define a suitable equation as $h = g(h)$ and use fixed point method to solve this problem and complete the table for the above data values.

V	L	r	H	Iterations
8	5	2		
15	6	4		
10	12	5		

For each case, chose a suitable interval for *h* to sketch the graphs of *f(h).*

Project 1-C for Civil Engineering Students

Figure (*a)* shows a uniform beam subject to a linearly increasing distributed load. The equation for the resulting elastic curve is (see Fig. (*b)*)

$$y = \frac{w_0}{120ELI}(-x^5 + 2L^2x^3 - L^4x)$$

Determine the point of maximum deflection (that is, the value of *x* where *dy*/*dx* = 0). Then substitute this value into the above equation to determine the value of the maximum deflection. Use the following parameter values in your computation:

Use Newton's method to solve this problem and complete the table with Tolerance

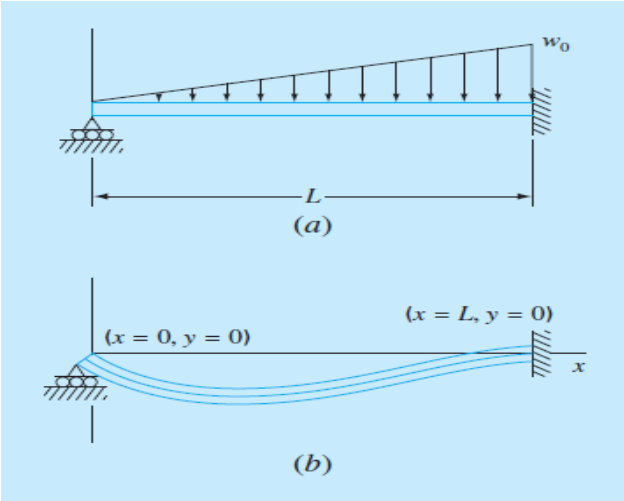
$$Tol = 10^{-5}$$

L	E	I	w_0	*X*	*y(x)*
450	50,000	30,000	1.75		
550	60,000	35,000	1.75		
650	70,000	40,000	1.75		

Use Bisection method to solve this problem and complete the table for the above data values.

L	E	I	w_0	*X*	*y(x)*
450	50,000	30,000	1.75		
550	60,000	35,000	1.75		
650	70,000	40,000	1.75		

For each case, chose a suitable interval for *x* to sketch the graphs of *f(x).*



Project 1-M for Mechanical Engineering Students

Real mechanical systems may involve the deflection of nonlinear springs. In Figure below, mass *m* is released a distance *h* above a nonlinear spring. The resistance force *F* of the spring is given by

$$F = -\left(k_1 d + k_2 d^{\frac{3}{2}}\right).$$

Conservation of energy can be used to show that

$$0 = \frac{2k_2 d^{\frac{5}{2}}}{5} + \frac{1}{2}k_1 d^2 - mgd - mgh$$

Solve for *d*, given the following parameter values and compute F.
Use Newton's method to solve this problem and complete the table with Tolerance

$$Tol = 10^{-5}$$

$k_1\ in\ \frac{g}{s^2}$	$k_2\ in\ \frac{g}{s^2\ m^{0.5}}$	$m\ in\ gram$	h *in meters*	D	F
40,000	40	95	0.5		
50,000	45	110	0.6		

Define a suitable equation as $d = g(d)$ and use fixed point method to solve this problem and complete the table for the above data values.

$k_1\ in\ \frac{g}{s^2}$	$k_2\ in\ \frac{g}{s^2\ m^{0.5}}$	$m\ in\ gram$	h *in meters*	D	F
40,000	40	95	0.5		
50,000	45	110	0.6		

For each case, chose a suitable interval for *d* to sketch the graphs of *f(d).*