Xi'an Jiaotong-Liverpool University
西交利物浦大学

MEC104 Experimental, Computer Skills and Sustainability: MATLAB Assignment

Due on Friday, 12th April, 2024, 18:00

Assignment Regulations

- This is an individual assignment. Every student MUST submit one soft copy of the assignment via the Learning Mall before the due date.

- A cover sheet can be created by yourself, but the following information MUST be included: student ID number, full name and email address.

- In your answer sheet, all the formulas, derivations, completed MATLAB scripts and functions with original highlighted text format in MATLAB editor, computational results in the command window, and plotted figures, should be part of the answers. For each question, you can use screenshots to provide 1) your coding in MATLAB editor, 2) prompts in Command Window, 3) results in Command Window, 4) results shown by plots/figures.

- There is no hard requirement on how the answer sheet must be organized. You can organize your report question by question (i.e. give one section for each question). Then, for each section, you can organize it in your own way. However, the contents and information required by each question MUST be provided. You may follow a template on the next page to decide what information to be presented for each question.

- You may refer to textbooks and lecture notes to discover approaches to problems, however, the assignment should be your own work.

- Where you do make use of other reference, please cite them in your work. Students are reminded to refer and adhere to plagiarism policy and regulations set by XJTLU. References, in IEEE style can be attached as an appendix.

- Assignments may be accepted up to 5 working days after the deadline has passed; a late penalty of 5% will be applied for each working day late without an extension being granted. Submissions over 5 working days late will not be marked. Emailed submissions will NOT be accepted without exceptional circumstances.

A Suggestion on Information to be Presented for Each Question

For each problem, for example, Problem 4:

1. Equation derivations:
1) What equation do you use in your coding?
2) Also give all the coefficients, and source terms (e.g. external force/voltage), as necessary.

2. What initial conditions, boundary conditions, time periods, domain size, etc., (computational conditions) are used? Provide schematic diagrams as necessary.

3. Main programme:
Provide the coding below, with necessary comments.

4. Functions
1) Give information on what is this function used for, and what equation is solved, related to point 1.
2) Provide the coding below, with necessary comments.

5. Results
1) Present the results required by each question, which can be numbers, data tables, figures, as appropriate.
2) Comments and analysis of the results:
If required by a question, then you need to do this.
If not required, you can still do this if you wish, which is great!
If you think it is necessary to clarify your results and methods used, then please provide your comments.

6. Flow charts of your programme (if applicable).

Problem 1. Plotting (10 Marks)

P 1-1 (5 Marks)

Write a script that can generate the figure shown below using the conditions and provide a screenshot of the figure.

Conditions:

x = -pi:pi/20:pi;

y1 = sin(x); (linestyle:'-', marker: 'o', color: r)

y2 = 2*cos(2*x); (linestyle:'-', marker: '*', color: g)

y3 = tan(x); (linestyle:'-', marker: 'x', color: b)

'YOUR UNIVERSITY ID NUMBER' should be replaced with your university ID number (e.g., if your university ID number is '1111', then the Figure title should be 'Figure 1: 1111'.

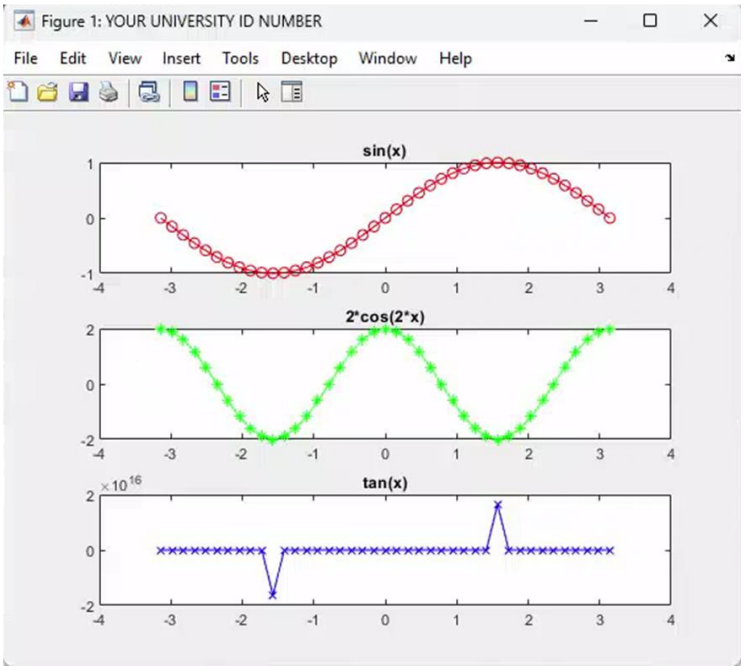

Figure 1. Conditions and the example of the figure plotted for P 1-1.

P 1-2 (5 Marks)

The Arrhenius equation is widely used to describe plenty of physical phenomena. Based on the equation and conditions shown below, write a script that can generate the figure of k as a function of T.

Equation:

$$k = k_0 e^{-Q/RT}$$

This equation is an equation that models reaction-rate constants for chemical reactions.

Conditions:

$k_0 = 15/s$ (constant with units that depend on the reaction)
$Q = 900\ J/mol$ (activation energy, $kJ/kmol$)
$R = 8.314\ J/mol\ K$ (ideal gas constant, $kJ/kmol\ K$)
$T = 300\ K\ to\ 1000\ K$ with an increment of $25\ K$ (temperature in K)

xlabel: 'Temperature (K)'
ylabel: 'Reaction-rate constant (/s)'
title: 'Reaction-rate constants for chemical reactions

Figure 2. Conditions and the equation of P 1-2

Problem 2 Matrix Operation (15 Marks)

P 2-1 (5 Marks, 1 Mark for each small question)
Type this matrix in MATLAB and use MATLAB to carry out the following instructions.

$$\boldsymbol{AA} = \begin{bmatrix} 1 & 7 & -3 & 8 \\ -3 & -7 & 10 & 8 \\ 6 & 4 & 91 & 14 \\ 17 & 10 & 3 & -1 \end{bmatrix}$$

a) Create a vector $\boldsymbol{v}$ consisting of the elements in the third column of $\boldsymbol{AA}$.
b) Create a vector $\boldsymbol{w}$ consisting of the elements in the second row of $\boldsymbol{AA}$.
c) Create a 4 x 3 array $\boldsymbol{BB}$ consisting of all elements in the second through fourth columns of $\boldsymbol{AA}$.
d) Create a 3 x 4 array $\boldsymbol{CC}$ consisting of all elements in the second through fourth rows of $\boldsymbol{AA}$.
e) Create a 2 x 3 array $\boldsymbol{DD}$ consisting of all elements in the first two rows and the last three columns of $\boldsymbol{AA}$.

P 2-2 (5 Marks, 1 Mark for each small question)
Consider the following arrays:

$$\boldsymbol{A} = \begin{bmatrix} 2 & 5 & 6 \\ 2 & 3 & 25 \\ 16 & 9 & 8 \\ 12 & 2\pi & 42 \end{bmatrix}, \qquad \boldsymbol{B} = \ln \boldsymbol{A}$$

Write MATLAB expressions to do the following.
a) Select just the third row of **B**.
b) Evaluate the sum of the second row of **B**.
c) Multiply the second column of **B** and the first column of **A** element by element.
d) Evaluate the maximum value in the vector resulting from element-by-element multiplication of the second column of **B** with the first column of **A**.
e) Use element-by-element division to divide the first row of **A** by the first three elements of the third column of **B**. Evaluate the sum of the elements of the resulting vector.

P 2-3 (5 Marks)

The figure shows the forces in the eight-member truss. The forces can be determined by solving a system of linear equations using the sets of equations shown below. Using the equations shown below, set the system of linear equations and get the solutions of the forces.

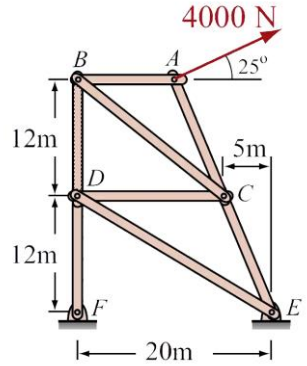

Figure 3. Forces in the eight-member truss for P 2-3.

1) $0.9231F_{AC} = 1690;$
2) $-F_{AB} - 0.3846F_{AC} = 3625;$
3) $F_{AB} - 0.7809F_{BC} = 0;$
4) $0.6247F_{BC} - F_{BD} = 0;$
5) $F_{CD} - 0.8575F_{DE} = 0;$
6) $F_{BD} - 0.5145F_{DE} - F_{DF} = 0;$
7) $0.3846F_{CE} - 0.3856F_{AC} - 0.7809F_{BC} - F_{CD} = 0;$
8) $0.9231F_{AC} + 0.6247F_{BC} - 9231F_{CE} = 0.$

Problem 3 (30 Marks)

P 3-1 (15 Marks, 10 Marks for programming and 5 Marks for displaying results)

The equation of motion for a pendulum whose base is accelerating horizontally with an acceleration *a(t)* is

$$L\ddot{\theta} + g\sin\theta = a(t)\cos\theta$$

Suppose that $g = 9.81\ m/s^2$, $L = 1.5\ m$, and $\dot{\theta}(0) = 0$. Plot $\theta(t)$ for $0 \le t \le 10\ s$ for the following three cases:

a) The acceleration is constant: $a = 5\ m/s^2$, and $\theta(0) = 0.5\ rad$.

b) The acceleration is constant: $a = 6\ m/s^2$, and $\theta(0) = 3\ rad$.

c) The acceleration is linear with time: $a = 0.5t\ m/s^2$, and $\theta(0) = 3\ rad$.

P 3-2 (15 Marks, 10 Marks for programming and 5 Marks for displaying results)
The following equation describes the motion of a certain mass connected to a spring, with no friction

$$3\ddot{y} + 60y = f(t)$$

where $f(t)$ is an applied force. Suppose the applied force is sinusoidal with a frequency of $\omega\ rad/s$ and an amplitude of 10 N: $f(t) = 10\sin(\omega t)$.

Suppose that the initial conditions are $y(0) = \dot{y}(0) = 0$. Plot $y(t)$ for $0 \le t \le 20\ s$. Do this for the following three cases. Compare the results of each case:
a) $\omega = 2\ rad/s$
b) $\omega = 5\ rad/s$
c) $\omega = 10\ rad/s$

Problem 4 (25 Marks, with 1) 15 Marks, 2) 10 Marks)

Consider a circuit system as shown in Figure 4.

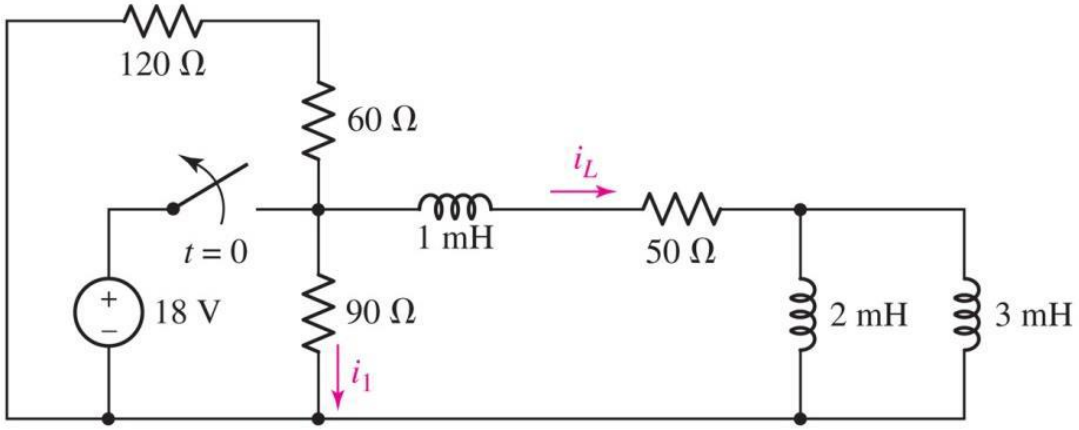

Figure 4. A circuit with multiple resistors and inductors for Problem 4.

Question:
1) Derive the equations for $i_1(t)$ and $i_L(t)$ for all t.
2) Obtain the plots of $i_1(t)$ and $i_L(t)$ for all t.

Problem 5 (20 Marks, with 1) 5 Mark, 2) 5 Marks, 3) 10 Marks)

1) In Simulink, generate a model that simulates 5sin(2pi * 60t) with time between 0 and 0.2 seconds and show the result using the scope of Simulink.

2) In Simulink, generate a model that simulates 2sin(50t) with time between 0 and 5 seconds and show the result using the scope of Simulink.

3) Using Simulink, generate a model that can solve $\frac{1}{2}\ddot{u} + \frac{2}{5}\dot{u} + u = t$ with the initial conditions of $u(0) = 1$ $\dot{u}(0) = 2$. Set the simulation time between 0 to 10 seconds and show the result using the scope of Simulink.