APPLIED MATHEMATICS

AMAT 26553 – Scientific Computing using Appropriate Software I

No. of Questions: Six (06) **No. of Pages: Nineteen (19)**

Time Allowed: Two & half ($2\frac{1}{2}$) hrs

Instructions to candidates

Programmable Calculators Are Not Allowed

Answer only **Five (05)** Questions. **Question 01** is **compulsory** and **FOUR** other questions should be attempted from rest of the five questions.
All questions are to be **answered in the boxes** provided within this booklet.
You are **not allowed** to remove any page from this booklet.

1. Answer **ALL** the following multiple-choice questions by writing the letter corresponding to the correct answer in the table provided below.
Note: Only one letter can be written in each box for each question.
[10 marks for each correct answer – Total for Question 1 is 100 marks]

Question No.	Answer
(i)	
(ii)	
(iii)	
(iv)	
(v)	

Question No.	Answer
(vi)	
(vii)	
(viii)	
(ix)	
(x)	

(i) Executing in the editor window the following code displays.

```
a = 1;  sin(a)      a = 2;
```

A. 0.4815 **B.** 2 **C.** 0.8415 **D.** 1 **E.** 0.9093

(ii) Which of the following is an invalid variable name in MATLAB?

A. myVar **B.** Data_1 **C.** Var123 **D.** 2ndValue **E.** total_sum

Continued ...

(iii) What will be the output of the following MATLAB code?

```
x = 7;
y = 3;

if x > 5 && y < 5
    disp('Case 1')
elseif x + y == 10 || y == 2
    disp('Case 2')
elseif ~(x < 0)
    disp('Case 3')
else
    disp('Case 4')
end
```

A. `Case 1` **B.** `Case 2` **C.** `Case 3` **D.** `Case 4` **E.** `Error`

(iv) What is the value of *B*?

```
A = [3 7 1; 4 6 9];
B = A(A > 5)
```

A. `[7 6 9]` **B.** `[6 7 9]` **C.** `[7; 6; 9]`
D. `[4 6 9]` **E.** `[3 7 6 9]`

(v) What will be displayed after running the following code?

```
x = 0:0.1:2*pi;
plot(x, sin(x))
hold on
plot(x, cos(x))
hold off
```

A. Only sin(x) **B.** Only cos(x) **C.** Error due to hold off
D. Two separate figures **E.** sin(x) and cos(x) on the same axes

(vi) The **velocity.txt** file contains 3 rows of header text followed by 20 rows of numerical data. Open the file with **`fid=fopen('velocity.txt')`**. How many times will **`M=fgetl(fid)`** need to be run for M to extract the 6th row of numerical data?

A. 1 **B.** 6 **C.** 7 **D.** 9 **E.** 12

Continued ...

(vii) The value of `eps(1)= 2.220446049250313e-16`. What is the value of `end_total` after running the following code?

```
end_total=1;

for n=1:100000

    end_total= end_total+1e-17;

end

end_total
```

A. end_total=1 **B.** end_total=1+100000*1e-17
C. end_total=1+100000*eps(1) **D.** end_total=0 **E.** end_total=Inf

(viii) Consider the code below:

```
a=4; b=7;

ab=[num2str(a) num2str(b)]

result=str2num(ab)*3
```

Which of the following is the output of **result**?

A. [1 41] **B.** 84 **C.** 141 **D.** [12 21] **E.** Error

(ix) Which of the following statements is true about the following code?

```
A=2; B=A+eps(A)/100
```

A. A is equal to B **B.** A is less than B **C.** A is greater than B
D. B is undefined **E.** Error

(x) Which of the following if conditions will check if both x and y are equal to 75?

A. `if 75==x|y` **B.** `if (x==75)&&(y==75)`
C. `if x&y==75` **D.** `if~(x==75)&~(y==75)` **E.** None of the above

Continued ...

2. (i) Let

```
P=45,Q=[2,8,10],R=7,S=zeros(1,3)
```

Find the results of the following operations:

(a) `X=(P>R)` (b) `Y=ones(size(Q))`

(c) `Z=S+P.*Q` (d) `W=P(Q<R)`

(a)
(b)
(c)
(d)

[20 marks]

(ii) The following matrix has been created in MATLAB.

$$A = \begin{bmatrix} 4 & 0 & 6 \\ 1 & 9 & 3 \\ 7 & 2 & 8 \end{bmatrix}$$

Write a **single-line MATLAB commands** to perform each of the following tasks.

(a) Copy the **second row and the last row** of the matrix A into a variable called B.

Continued ...

(b) Modify matrix A so that its elements become

$$A = \begin{bmatrix} 4 & 1 & 7 \\ 0 & 9 & 2 \\ 1 & 5 & 6 \end{bmatrix}$$

[20 marks]

(iii) Let

```
B = [3 7 1; 4 6 9];
```

(a) Write the MATLAB command to extract all elements of B that are **greater than 5**.

(b) State the **form of the output vector** (row or column).

(c) Write the MATLAB command to count the number of elements in B that are **less than or equal to 4**.

[30 marks]

Continued ...

(iv) Consider,

```
A = [-3 5 0; 2 -1 4; 0 6 -2];
```

a) Write the MATLAB command to replace all **negative elements** in A with zero.

b) Write the MATLAB command to count the number of **non-zero elements** in A.

c) Write the MATLAB command to find the **sum of each column** of A.

d) Write the MATLAB command to compute the **trace** of A.

[30 marks]

Continued ...

(3) Consider a physical system where the displacement x of a particle depends on time t as:

$$x(t) = A \cdot e^{-bt} \cdot \cos(\omega t)$$

where $A = 5$, $b = 0.2$, $\omega = 3$, and $t = [0, 0.1, 0.2, \ldots, 2]$.

(i) Write the MATLAB expression to calculate the displacement vector X at all points.

[20 marks]

(ii) Write the MATLAB expression to calculate the velocity vector v using the derivative formula: $v(t) = \frac{dx}{dt} \approx \frac{X_{i+1} - X_i}{\Delta t}$

[20 marks]

(iii) Find the time points where the displacement is greater than 2 units.

[10 marks]

Continued ...

(iv) Create a vector Y where each element is $x(t)^2 + v(t)^2$ at that time.

[20 marks]

(v) Write a MATLAB function `dampedOsc` that takes inputs $A, b, omega, t$ and returns two vectors: displacement x and velocity v using finite differences.

[30 marks]

Continued ...

(4) **(i)** The displacement of a damped harmonic oscillator is given by:

$$x(t) = 5\,e^{-0.2t}\cos(3t), 0 \leq t \leq 10$$

Complete the following MATLAB snippet of code.

```
%Write MATLAB code to generate a plot of x(t) versus t.
_____________________________________________________________
_____________________________________________________________
_____________________________________________________________
% Label the x-axis as "Time (s)" and y-axis as "Displacement
(m)".
_____________________________________________________________
_____________________________________________________________
% Add a title: "Damped Harmonic Oscillator".
_____________________________________________________________
%Make the plot red with a line width of 2.


_____________________________________________________________
%Add grid lines.


_____________________________________________________________
```

[25 marks]

(ii) The following MATLAB script is intended to plot the function

$$y = \sin(2t) + \cos(t)$$

for $0 \leq t \leq 10$.

Continued ...

```
t = 0:10
y = sin(2*t) + cos t
plot(t y,'r--','LineWidth',2)
xlabel('Time (seconds')
ylabel('Amplitude')
title 'Trigonometric Plot'
grid on
legend('y(t)')
```

(a) Identify any FIVE (05) errors in the above MATLAB code.

(b) Rewrite the corrected MATLAB code so that it executes without errors and produces the required plot.

Continued ...

(c) State TWO improvements that can be made to enhance the clarity of the plot (other than correcting errors).

[25 marks]

(iii) (a) Consider the following Matlab program

```
clc; clear all; close all

while p>=1
    for i=1:q
        r=r+i;
    end
  t=r
    if t>s;
       s=s+p
    else
       s=s-p
    end
  p=p-1
  q=p+1
end
```

Complete the following table. **[25 marks]**

Continued ...

Iteration	*p*	*q*	*t*	*s*
1	5	3	7	15
2				
3				
4				
5				
6				

(b) There are some errors in the following program. Identify the command lines where the errors are and write down the correct command in the table provided. **[25 marks]**

```
1. clc
2.   clear all
3.   close all
4.   x=[2 4 6 8 10 12 14 7 18 20 11 24 9 28 14];
5.   n=length(x);
6.    for i=1:n
   % if the ith element in x is greater than to 10 then
   % square it else multiply it by 3
7.       if x>10
8.           f=x.^2;
9.       else
10.          f=3x;
11.      end
12.   end

13.    g=@ t.^2-3*t+7; % g is an anonymous function
14.    t=min(x):0.001:max(x);

15.    plot(x, f, 'rd', t, g ))
16.    grid on
```

Continued ...

Line Number	Correct command

(05) **(i)** Write a MATLAB program using a for loop along with a *continue* statement to print only the odd numbers from 10 to 100. **[30 marks]**

Continued ...

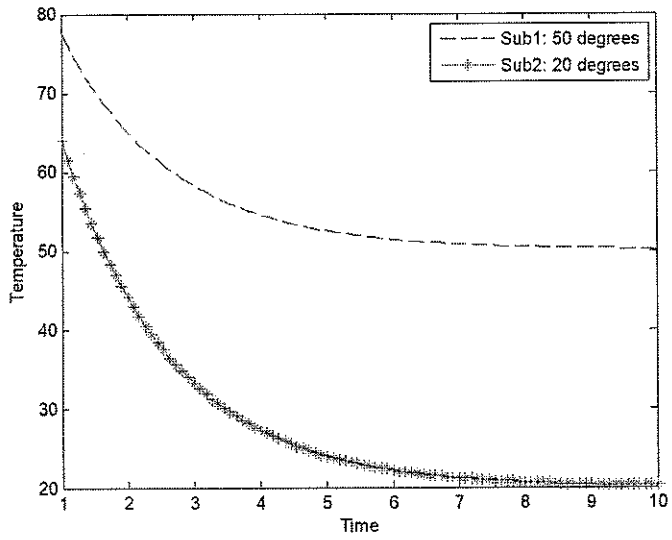
(ii) Using the MATLAB **break** statement with a **for** loop, implement the following problem.

Request a number x from the user. If this number is divisible by 3 then exit the loop. Otherwise request the number x again while displaying a text '**x is not divisible by 4: Enter another number**' by letting user to input x five times only. **[20 marks]**

(iii) When an object with an initial temperature T is placed in a substance that has a temperature S, according to Newton's law of cooling, in t minutes it will reach a temperature T_t and it is given by $T_t = S + (T - S)e^{-kt}$, where k is a constant value that depends on properties of the object.

(a) For an initial temperature of 100 and $k = 0.6$, write down the correct MATLAB commands to obtain following figure to display the resulting temperatures from 1 to 10 minutes for two different substances which have temperatures 50 and 20. **[25 marks]**

Continued ...



(b) Write down the MATLAB commands to print the two temperature values to a text file 'TempSub1vsSub2.txt' as the following form of table. **[25 marks]**

Continued ...

Temperature of the two substances from 1 to 10 min

time	Temp_Sub 1	Temp_Sub 2
1.0000	77.4406	63.9049
1.0909	75.9839	61.5743
1.1818	74.6046	59.3673
1.2727	73.2984	57.2775
⋮	⋮	⋮

(06) **(i)** The Newton–Raphson Method is the best-known method of finding roots as it is simple and fast. In the usual notation, the Newton–Raphson formula is given by,

$$x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}.$$

Answer/Complete each of the following question to develop a Pseudo code and a MATLAB function file for Newton–Raphson Method.

(a) Complete the Pseudo code below written for the Newton–Raphson Method.

[35 marks]

Continued ...

1. Let x_i be the initial guess for the root of $f(x) = 0$
2. Calculate .....and .....
3. Calculate the estimated root .....
4. Repeat Steps ..... to .....4.....as long as .....not close enough to ..... (>.....)

(b) Complete the following MATLAB function file to implement the Pseudo code in part (a). **[45 marks]**

```
function root=NewRaph(.....,.....,.....,.....)
%root=NewRaph()uses Newton-Raphson method to find the root
% of a %function
% input:
% .....
% .....
% .....
% .....
% output:
% root = the root of the equation
% Calculate ..... and .....
.....
%Iteration for Newton-Raphson starts
while ..... > .....
.....
.....
.....
end
root = xi; % The final xr value is the root
```

Continued ...

(ii) It costs a firm $C(q)$ dollars to produce q grams per day of a certain chemical, where

$$C(q) = 1000 + 2q + 3q^{\frac{2}{3}}.$$

The firm can sell any amount of the chemical at \$4 a gram. The firm needs to find the break-even point, that is, ***how much it should produce per day*** in order to have neither a profit nor a loss. If they sell q grams per day, the revenue and cost functions are equal at the break-even point, that is $4q = 1000 + 2q + 3q^{2/3}$. Complete the following script file to find the break-even point using the Newton–Raphson Method using the initial guess $q = 595$ grams.

[20 marks]

```
%fun:f(q)

fun= .....

% dfun:f'(q)

dfun=  .....

% Initial condition

  .....

% Call the NewRaph.m

  .....
```

..... **End of the Examination** .....