NUI Galway
OÉ Gaillimh

Semester 2 2021 / 2022

Exam Code(s)	2BCT/2BSE
Exam(s)	2nd BSc (CS&IT), 2nd BE ESE
Module Code(s)	CT248
Module(s)	Introduction to Modelling
Paper No.	I
External Examiner(s)	Dr. Ramona Trestian
Internal Examiner(s)	Prof. Michael Madden
	*Prof. Jim Duggan

Instructions:

Answer any 3 questions.

Duration	2hrs
No. of Pages	6 (Including Cover Page)
Discipline	Computer Science
Course Co-ordinator	Dr. Des Chambers

Requirements:

Release in Exam Venue	Yes
MCQ Answersheet	No
Handout	None
Statistical/ Log Tables	None
Cambridge Tables	None
Graph Paper	None
Log Graph Paper	None
Other Materials	None
Graphic material in colour	Yes

1. (a) Given the following array M, write a command that will count the number of occurrences that are less than 5.

```
M =

     6     2     9    10     5
     3     7     3     9    10
     5     9     2     2     9
     9     2     2     9     4
     1     6     3     3     2
```

Show – using a single command - how all values that equal 10 can be set to zero.

Describe the benefits of using logical vectors in MATLAB.

[10 marks]

(b) Given the following matrices A and B, calculate results for the following operations in MATLAB, and explain the basis for your results.

```
A =                          B =

     6     9     7               2     0     0
     3     1     9               0     2     0
     5     2     2               0     0     2
```

A * B;

10 * A * B;

A + B;

A .^ B;

[8 marks]

(c) Assume that a grayscale picture is represented by a 256x256 array of uint8 values. Show what MATLAB commands would transform the picture as follows:

- Brighten the picture by 20%
- Use a threshold value of 100 to convert the picture to a binary file. Assume values greater than or equal to 100 are converted to white.

[7 marks]

2. (a) Show the general form of a function in MATLAB.

Explain the difference between a persistent and a global variable, and show how they can be defined in MATLAB.

[8 marks]

(b) Write a function (m file) that returns a handle to two functions that can operate on a matrix. Here is an example of the call.

```
[f1, f2] = get_handles();
```

The test input is as follows:

```
M =

     1     2
     3     4
```

The function referenced by f1 will operate on the rows of a matrix, and the function referenced by f2 operates on the matrix columns, where a summary function is also passed into each function. Here is an example of the outputs:

`>> f1(M,@sum)`
 	
`ans =`
 	
`1 2 3`
`3 4 7`
	`>> f2(M,@sum)`
	
	`ans =`
	
	`1 2`
	`3 4`
	`4 6`

`>> f1(M,@min)`
 	
`ans =`
 	
`1 2 1`
`3 4 3`
	`>> f2(M,@min)`
	
	`ans =`
	
	`1 2`
	`3 4`
	`1 2`

[10 marks]

(c) Explain what is happening in the following MATLAB code, and determine the values (and type) of the output.

```
f = @(x,y)[x.*y;x-y];

f(1:2, 3:4)
```

[7 marks]

3. (a) Build a function for the following set of differential equations that model the spread of disease. The function should accept values for the two parameters β (effective contact rate) and γ (recovery rate). Show how this function can be invoked from the MATLAB function **ode45().**

$$\frac{dS}{dt} = -\frac{\beta}{N} IS$$

$$\frac{dI}{dt} = \frac{\beta}{N} IS - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$

Where:

- ***S*** represents the number of people who are susceptible to a pathogen. Assume the initial value is 9999.
- ***I*** represents the number of people infected. Assume an initial value of 1.
- ***R*** represents the number of people who are recovered. Assume an initial value of 0.

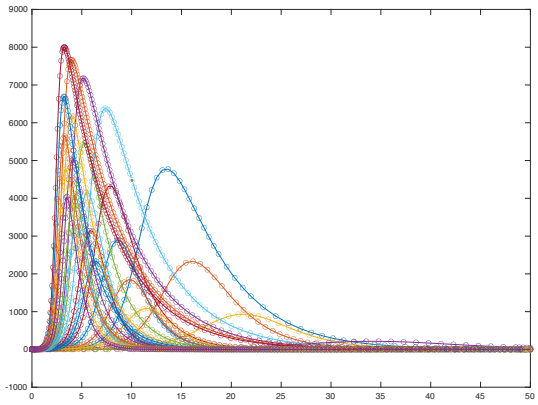
Note, at all times, the sum of S, I and R will be equal to the total population (N).

[12 marks]

(b) Write a script that plots model output (I variable) for the following combinations of parameters, which will generate 25 runs. Use a MATLAB function to generate these two parameter vectors.

```
beta = 1.0000    1.7500    2.5000    3.2500    4.0000

gamma = 0.2000    0.4000    0.6000    0.8000    1.0000
```



[8 marks]

(c) Explain the workings of following code, and fix the error that it contains.

```
f = @(t,x)[2*t 3*t];

[t,y] = ode45(f,0:10,[0 0]);
```

[5 mark

4. (a) Given the following MATLAB table T (2 rows are shown), write a command that will add a new column that indicates whether a person is 40 or over (true), or less than 40 (false).

Age	Smoker	Height	Smoker_1
38	true	71	true
43	false	69	false

Here is the resulting table.

Age	Smoker	Height	Smoker_1	GT40
38	true	71	true	false
43	false	69	false	true

[5 marks]

(b) Consider the following dataset (variable name=mpg)

manufacturer	model	class	displ	cty
"toyota"	"corolla"	"compact"	1.8	24
"toyota"	"corolla"	"compact"	1.8	24
"toyota"	"corolla"	"compact"	1.8	26
"toyota"	"corolla"	"compact"	1.8	28
"toyota"	"corolla"	"compact"	1.8	26
"volkswagen"	"gti"	"compact"	2	21
"volkswagen"	"gti"	"compact"	2	19
"volkswagen"	"gti"	"compact"	2	21
"volkswagen"	"gti"	"compact"	2	22
"volkswagen"	"gti"	"compact"	2.8	17

Explain (using a diagram) how the **splitapply** process works. Assume you want to get the average **cty** for the manufacturers "toyota" and "volkswagen". Show the **splitapply** code as part of your solution, and present the results in the following format.

manufacturer	mean_cty
"toyota"	25.6
"volkswagen"	20

[10 marks]

(c) A summary of annual weather data for two stations, Mace Head and Dublin airport, is contained in the table (17,520 rows)

The first five rows of W are:

Station	Month	Day	Hour	Temp
{'DUBLIN AIRPORT'}	1	1	0	5.3
{'DUBLIN AIRPORT'}	1	1	1	4.9
{'DUBLIN AIRPORT'}	1	1	2	5
{'DUBLIN AIRPORT'}	1	1	3	4.2
{'DUBLIN AIRPORT'}	1	1	4	3.6

The final five rows of W are:

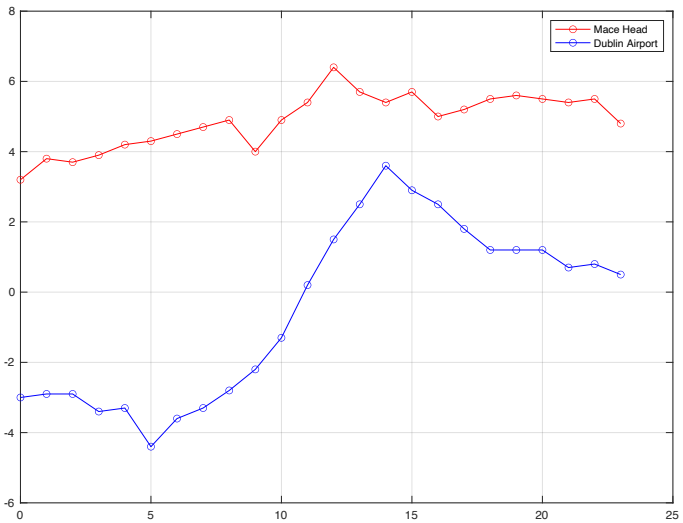
Station	Month	Day	Hour	Temp
{'MACE HEAD'}	12	31	18	8.1
{'MACE HEAD'}	12	31	19	7.6
{'MACE HEAD'}	12	31	20	7
{'MACE HEAD'}	12	31	21	8.1
{'MACE HEAD'}	12	31	22	7.9
{'MACE HEAD'}	12	31	23	8.5

Write a query that creates the following table.

DayMin =

Station	Month	Day	Hour	Temp
{'DUBLIN AIRPORT'}	12	11	5	-4.4

Use this information to extract (in two tables) the data for both stations on this day (e.g. 11th December), and write code to plot the following graph for Dec 11th.



[10 marks]