Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	ADVANCED ENGINEERING MATHEMATICS
COURSE CODE	:	MEE 10103
PROGRAMME CODE	:	MEE
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS. THE ANSWERS MUST BE IN **FOUR (4)** DECIMAL PLACES
		OPEN BOOK EXAMINATION

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

Q1 (a) Given,

$$R_1(i_1 - i_2) + R_2(i_1 - i_3) = V_1$$

$$R_3 i_2 + R_4(i_2 - i_3) + R_1(i_2 - i_1) = V_2$$

$$R_5 i_3 + R_4(i_3 - i_2) + R_2(i_3 - i_1) = V_3$$

where R is the resistance and i is the current. If $R_1 = 20, R_2 = 10, R_3 = 25, R_4 = 10, R_5 = 30,\ V_1 = 0, V_2 = 0\ and\ V_3 = 200$.

(i) Shows the voltage, V for the electrical circuit shown in **Figure Q1(a)** can be expressed in the given three equations.

(10 marks)

(ii) Evaluate the system of linear equations as given in **Q1(a)(i)** by using the inverse matrix method.

(8 marks)

(b) A researcher had collected data on the forces exerted on the wires in a prosthetic limb during a controlled movement. Unfortunately, the electronics sensor was faulty and some data points were missing from the collected data as shown in **Table Q1(b)**. Determine the value of x that corresponds to $f(x)$=2.5 by using Lagrange's inverse interpolation with cubic approximation.

(7 marks)

Q2 (a) A company is involved in the production of two items (X and Y). The resources needed to produce X and Y are two fold, namely machine time for automatic processing and craftsman time for hand finishing. **Table Q2(a)** gives the number of minutes required for each item. The company has 40 hours of machine time available in the next working week but only 35 hours of craftsman time. Machine time is costed at £10 per hour worked and craftsman time is costed at £2 per hour worked. Both machine and craftsman idle times incur no costs.The revenue received for each item produced (all production is sold) is £20 for X and £30 for Y. The company has a specific contract to produce 10 items of X per week for a particular customer. Formulate the problem of deciding how much to produce per week as a linear program without solving.

(5 marks)

(b) Consider the following linear programming problem

$$\begin{aligned} \text{Minimize} \quad & z = 10I_d x_1 + 8x_2 \\ \text{subject to} \quad & x_1 + x_2 \geq 8 \\ & 3x_1 + 5x_2 \geq 10 \\ & -2x_1 - x_2 \leq -7 \\ & x_1, x_2, \geq 0 \end{aligned}$$

(i) Construct the primal and dual problem.

(5 marks)

(ii) Obtain the value of Id

$$I_d = \frac{m}{d}$$

where $\boldsymbol{m}$ is your month of birth and $\boldsymbol{d}$ is your day of birth.

(1 marks)

(iii) Determine the solution for dual problem by using answers from **Q2(b)(i)** and **Q2(b)(ii).**

(13 marks)

(iiv) Proof that your answer in **Q2(b)(iii)** is correct.

(1 marks)

Q3 (a) Solve the following linear programming problem using dual simplex method based on the answer from **Q2(b)(ii)**

Minimize $z = 2x_1 + x_2$

subject to

$$3x_1 + x_2 \geq 3$$
$$4x_1 + 3x_2 \geq 6$$
$$x_1 + x_2 \geq -3Id$$
$$x_1, x_2 > 0$$

(12 marks)

(b) Forecasting or in other words, the ability to see into the future and make predictions about any number of production elements. Based on the following data on widget production as given in **Table Q3(b)**, used curve fitting forecasting method.

(i) Formulate the best fitting linear function for the data.

(4 marks)

(ii) Construct the new table for predicted widget production based on **Q3(b)(i)** function.

(4 marks)

(iii) Predict the production value for May 2020.

(3 marks)

(iv) Predict the production value for July 2020.

(2 marks)

Q4 Production costs reflect all of the expenses associated with a company conducting its business. **Table Q4** shows the data for operational cost to run a factory with three types of product.

By using Multiple Linear Regression

(a) Formulate the estimated regression equation for the full model with all 3 variables with residual.

(10 marks)

(b) Formulate the estimated regression equation for the model with only *Product B* and *Product C* variables with residual.

(7 marks)

(c) Justify which model gives better estimated results for *Month 1*, where *Product A (515 units), Product B (541 units)* and *Product C (928 unit).*

(4 marks)

(d) Based on **Q4 (a),** predict the operational cost for

i. *Product A* (1200 units), *Product B* (800 units) and *Product C* (1000 unit).

(2 marks)

ii. *Product A* (721 units), *Product B* (701 units) and *Product C* (925 units).

(2 marks)

- END OF QUESTIONS –

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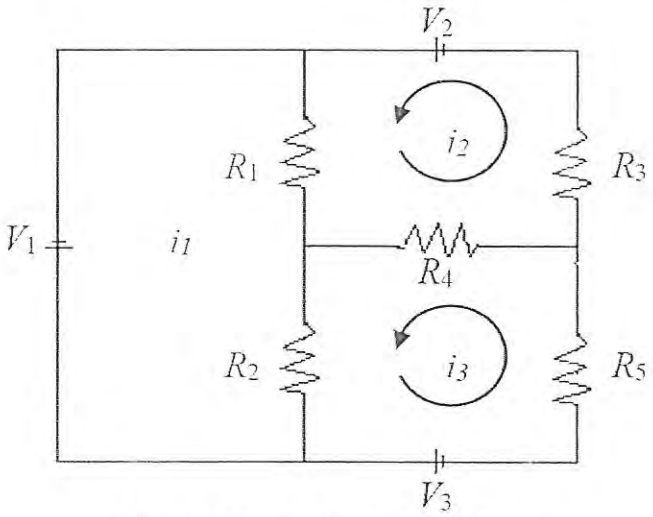

Figure Q1(a) : An electrical circuit

Table Q1(b): Exerted forces during controller movement

x	1	2	3	4	5
$f(x)$	1.0986	1.7918	2.1972	2.4849	2.7081

Table Q2(a): Processing time for item X and Y

	Machine time	Craftsman time
Item X	13	20
Item Y	19	29

Table Q3(b): Widget production for 2020

Month	Jan	Feb	Mar	Apr	May
Production	16,597	30,687	48,441	55,751	79,606

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Table Q4: Factory operational cost

Month	*Operational Cost (RM)*	*Product A*	*Product B*	*Product C*
1	44439	515	541	928
2	43936	929	692	711
3	44464	800	710	824
4	41533	979	675	758
5	46343	1165	1147	635
6	44922	651	939	901
7	43203	847	755	580
8	43000	942	908	598
9	40967	630	738	682
10	48582	1113	1175	1050
11	45003	1086	1075	984
12	44303	843	640	828
13	42070	500	752	708
14	44353	813	989	804
15	45968	1190	823	904
16	47781	1200	1108	1120
17	43202	731	590	1065
18	44074	1089	607	1132
19	44601	786	513	839

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FORMULA

Matrix Inversion Method: $x = A^{-1}b, \quad A^{-1} \neq 0$

Lagrange interpolation: $y = P_n(x) = \sum_{i=0}^{n} L_i(x) f_i$ for $i = 0,1,2,3,\ldots,n$ with

$$L_i(x) = \prod_{\substack{j=0 \\ j \neq i}}^{n} \frac{(x - x_j)}{(x_i - x_j)}$$

Centered moving average

$$u_t = \frac{1}{m} \sum_{j=t-\frac{m}{2}}^{t+\frac{m}{2}-1} y_{t-\frac{m}{2}} + \cdots y_{t+\frac{m}{2}-1}$$

$$v_t = \frac{u_t + u_{t+1}}{2}$$

$$s_t = \frac{y_t}{v_t}$$

$$s_m = \frac{1}{n} \sum_{t=1}^{n} s_{t,m}$$

$$D_t = \frac{y_t}{s_m}$$

$$T_t = a + bt$$

Simple exponential shooting

$\hat{y}_1 = y_1, \ \hat{y}_{t+1} = \alpha y_t + (1 - \alpha)\hat{y}_t,$
$1<=t<=n$