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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	MATHEMATICS FOR ENGINEERING TECHNOLOGY III
COURSE CODE	:	BDJ 22403
PROGRAMME CODE	:	BDJ
EXAMINATION DATE	:	JULY/ AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. DO ALL CALCULATIONS IN 3 DECIMAL PLACES. 3. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 4. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

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Q1 Given a nonlinear equation $f(x) = \cos(x) + x^3$.

(a) By using Intermediate Value Theorem (IVT), choose which of following 2 intervals that contains the root for $f(x) = 0$.

$$-1 \leq x \leq -0.75 \quad \text{or} \quad -0.25 \leq x \leq 0$$

(4 marks)

(b) Hence, estimate the root of $f(x) = 0$ by using bisection method. Iterate until $|f(x)| < 0.005$.

(6 marks)

Q2 A biologist has placed three strains of bacteria (denoted I, II and III) in a test tube, where they will feed on three different food sources (A, B and C) every day. Each bacteria consumes a certain number of units of each food per day. The number of units consumes and the number of food sources are shown in the **Table Q2.** Let x_1, x_2 and x_3 denoted as Bacteria Strain I, Bacteria Strain II and Bacteria Strain III respectively.

(a) Form a system of linear equations in (augmented matrix form) based on the above problem.

(2 marks)

(b) Hence, calculate the number of bacteria of each strain that can coexist in the test tube and consume all of the food by using Gauss elimination method.

(8 marks)

Q3 A tutoring service has kept records of performance on a standardized test and the number of days students attend their review classes as in **Table Q3**. The performance rating Y represents the percent improvement in the test score students attain after taking the exam a second time. X is the number of attendance days in the review class. By assuming $Y = f(X)$ is the true function relating X and Y, use Newton's divided difference method to estimate $f(10)$, that is the % improvement in one's score after 10 days of attending review classes.

(10 marks)

Q4 A set of discrete data is given in **Table Q4**.

(a) By taking $h = 0.2$, find approximate values of $y'(1.5)$ by using 2-point backward difference, 3-point forward difference and 5-point difference formulas.

(b) Then, find approximate values of $y''(1.5)$ by using 3-point central difference and 5-point difference formulas.

(10 marks)

Q5 Given the function $f(x) = e^x - 2x$. Compute the following integration by using $\frac{3}{8}$ Simpson's rule with 9 subinterval.

$$\int_{2}^{4.7} \frac{f(x)}{x+1}\, dx$$

(10 marks)

Q6 Given the matrix, $\mathbf{A} = \begin{bmatrix} 0 & 11 & -5 \\ -2 & 17 & -7 \\ -4 & 26 & -10 \end{bmatrix}$ and it dominat eigenvalue, $\lambda_{\text{largest}} = 4.018$.

(a) Find $\mathbf{A}_{\text{shifted}}$.

(b) Hence, determine the smallest eigenvalue, $\lambda_{smallest}$ of $\mathbf{A}$ and it corresponding eigenvector by using shifted power method. Use initial eigenvector, $\mathbf{v}^{(0)} = (1 \ 1 \ 1)^T$ and stop the iteration when $|m_{k+1} - m_k| < 0.005$.

(10 marks)

Q7 (a) Sketch the 3D-graph of the function, $f(x) = x^2 + y^2 - 3$.

(2 marks)

(b) Calculate the area of the shaded region R in **Figure Q7(b)** by using polar coordinate.

(8 marks)

Q8 Evaluate the volume of the solid in the first octant which bounded by $4x + y + 2z = 4$ and three coordinate planes.

(10 marks)

– END OF QUESTIONS –

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Table Q2: Bacteria Strains and the Number of Food Sources

	Bacteria Strain I	Bacteria Strain II	Bacteria Strain III	Number of Food Sources
Food A	4	2	0	350
Food B	0	2	3	500
Food C	5	3	1	600

Table Q3: Record of Attendance Days and Performance in Test

Attendance days (X)	1	3	4	7	11
% improvement (Y)	3	7	13	20	34

Table Q4

x	1.1	1.3	1.5	1.7	1.9
$y(x)$	0.672	3.527	9.891	22.438	45.146

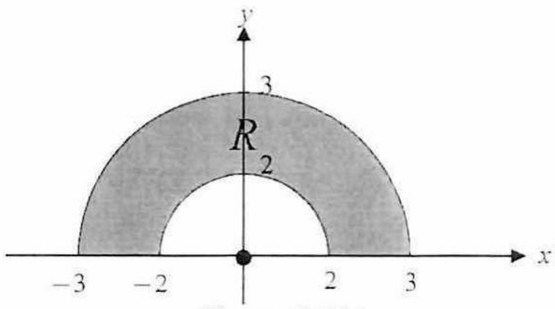

Figure Q7(b)

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Formulas

Nonlinear equations:

Bisection method : $c_i = \dfrac{a_i + b_i}{2}$, $i = 0, 1, 2, \ldots$

Interpolation:

Newton divided difference:

$$P_n(x) = f_0^{[0]} + f_0^{[1]}(x - x_0) + f_0^{[2]}(x - x_0)(x - x_1) + \ldots + f_0^{[n]}(x - x_0)(x - x_1)\ldots(x - x_{n-1})$$

Numerical differentiation:

First derivative:

2-point backward difference: $f'(x) \approx \dfrac{f(x) - f(x-h)}{h}$

3-point forward difference : $f'(x) \approx \dfrac{-f(x+2h) + 4f(x+h) - 3f(x)}{2h}$

5-point difference : $f'(x) \approx \dfrac{-f(x+2h) + 8f(x+h) - 8f(x-h) + f(x-2h)}{12h}$

Second derivative:

3-point central difference : $f''(x) \approx \dfrac{f(x+h) - 2f(x) + f(x-h)}{h^2}$

5-point difference : $f''(x) \approx \dfrac{-f(x+2h) + 16f(x+h) - 30f(x) + 16f(x-h) - f(x-2h)}{12h^2}$

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Formulas

Numerical integration:

$\frac{3}{8}$ Simson's Rule: $$\int_a^b f(x)dx \approx \frac{3}{8}h\begin{bmatrix} f_0 + f_n + 3(f_1 + f_2 + f_4 + f_5 + \ldots + f_{n-2} + f_{n-1}) \\ + 2(f_3 + f_6 + \ldots + f_{n-3}) \end{bmatrix}$$

Eigenvalue

Power Method : $\mathbf{v}^{(k+1)} = \dfrac{1}{m_{k+1}}\mathbf{A}\mathbf{v}^{(k)}, \quad k = 0, 1, 2, \ldots$

Shift Power Method : $\mathbf{A}_{\text{shifted}} = \mathbf{A} - s\mathbf{I}, \quad \lambda_{\text{smallest}} = \lambda_{\text{shifted}} + s, \quad s = \lambda_{\text{largest}}$

Multiple Integrals

Polar coordinates: $x = r\cos\theta,\ y = r\sin\theta,\ x^2 + y^2 = r^2, \quad 0 \le \theta \le 2\pi$

$$\iint_R f(x, y)\, dA = \iint_R f(r, \theta)\, r\, dr\, d\theta$$