[ESS04]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BEng (Hons) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER 1 EXAMINATIONS 2019/20

INTRODUCTORY ENGINEERING MATHEMATICS

MODULE NO: EEE4011

Date: Friday 17th January 2020 **Time: 10.00-12.00**

INSTRUCTIONS TO CANDIDATES:

1. **There are six questions. Please attempt FOUR of these questions.**
2. **Maximum marks for each part/question are shown in brackets.**
3. **Give all decimal answers correct to THREE decimal places.**
4. **A formula sheet appears on page 7.**

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Question 1

(a) Consider the 3-dimensional vectors $u = \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix}$ and $v = \begin{pmatrix} 5 \\ -4 \\ 6 \end{pmatrix}$

Calculate the following:

(i) $3u + 5v$ (2 marks)

(ii) $u.v$ (1 mark)

(iii) $|u|$ (1 mark)

(iv) $|v|$ (1 mark)

(v) the angle between u and v. (2 marks)

(b) Let A and B be the following matrices:

$$A = \begin{pmatrix} 2 & 1 & 0 \\ 5 & -4 & 3 \end{pmatrix} \qquad B = \begin{pmatrix} 1 & 4 \\ -2 & 3 \\ 0 & 5 \end{pmatrix}$$

Calculate the following matrices:

AB (4 marks)

BA (5 marks)

Explain why the sum of matrices $A + B$ is not defined. (1 mark)

(c) Write the following systems of simultaneous linear equations as an equation of matrices:

$$5x + 3y = 3$$
$$6x + 4y = -6$$

(2 marks)

By finding the inverse of the square matrix, solve the system of equations.

(6 marks)

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Question 2

(a) Find the complex solutions of the following quadratic equation:

$$x^2 - 6x + 34 = 0.$$

(5 marks)

Plot the solutions on a sketch of the Argand diagram. (2 marks)

(b) Let $z_1 = 4 + 32j$ and $z_2 = 8 - 5j$ be complex numbers. Calculate the following:

(i) $z_1 + 4z_2$ (2 marks)

(ii) $z_1 - z_2$ (2 marks)

(iii) $z_1 z_2$ (2 marks)

(iv) $\frac{z_1}{z_2}$. (3 marks)

(c) Let $z_1 = 64\angle 100^\circ$ and $z_2 = 2\angle -40^\circ$ be complex numbers in polar form.

Calculate the following complex numbers in polar form:

(i) $z_1 z_2$ (2 marks)

(ii) $\frac{z_1}{z_2}$ (2 marks)

(iii) z_2^4 (2 marks)

(iv) $\sqrt{z_1}$ (3 marks)

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Question 3

(a) Differentiate each of the following functions to find $\frac{dy}{dx}$:

(i) $y = 2x^4 - 6x^3 + 5x^2 + 7$ (3 marks)

(ii) $y = x^4 \cos 5x$ (4 marks)

(iii) $y = \sin x^7$ (4 marks)

(iv) $y = \frac{x^4}{e^{3x}}$ (4 marks)

(b) Find the turning points of the following function:

$$y = x^3 - 9x^2 - 48x + 25.$$

Determine whether each turning point is a local maximum or a local minimum.

(10 marks)

Question 4

(a) Evaluate each of the following definite integrals:

(i) $\int_1^3 (9x^2 + 10x - 5)dx$

(6 marks)

(ii) $\int_0^{\frac{\pi}{2}} (10\cos 2x + 8\sin 4x)dx$

(6 marks)

(b) Find each of the following indefinite integrals

(i) $\int x \sin 5x.dx$

(7 marks)

(ii) $\int (7x+3)^8 dx$

(6 marks)

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Question 5

(a) Solve the following differential equation by separating variables:

$$\frac{dy}{dx} = \frac{5x^4}{6\cos 2y}$$

The boundary condition is $y = \frac{\pi}{4}$ when $x = 1$.

(8 marks)

(b) Consider the following linear differential equation:

$$\frac{dy}{dx} - 2y = 16x.$$

(i) Find the complementary function. (4 marks)

(ii) Find the particular integral. (4 marks)

(iii) Hence find the solution given that when $x = 0$ we have $y = 2$. (2 marks)

(c) Find the general solution of the following second order linear differential equation:

$$\frac{d^2y}{dx^2} + 5\frac{dy}{dx} - 24y = 0.$$

(7 marks)

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Question 6

(a) The ages in years of ten employees are as follows:

38	24	65	38	28
51	40	34	23	29

Find the median age and calculate the mean age. (4 marks)

Calculate the standard deviation of the ages. (4 marks)

(b) Electrolytic capacitors are being manufactured.

It is known that 4% of these fail quality control testing, so that the probability that a single capacitor fails is 0.04.

Calculate the probability that in a batch of six of these capacitors:

(i) none fail (3 marks)

(ii) exactly one fails (3 marks)

(iii) exactly two fail (3 marks)

(c) Faults in an electrical cable are known to occur on average once per 2km of cable.

Find the expected number of faults in a 200m drum of cable. (2 marks)

Calculate the probability that in a 200m drum of cable

(i) there are no faults (2 marks)

(ii) there is exactly one fault (2 marks)

(iii) there are exactly two faults (2 marks)

END OF QUESTIONS

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Formulae

Derivatives and Integrals:

Integral	Function	Derivative
$\int y dx$	y	$\frac{dy}{dx}$
x	1	0
$\frac{1}{n+1}x^{n+1}$	x^n	nx^{n-1}
$-\frac{1}{a}\cos ax$	$\sin ax$	$a\cos ax$
$\frac{1}{a}\sin ax$	$\cos ax$	$-a\sin ax$
$\frac{1}{a}e^{ax}$	e^{ax}	ae^{ax}

Integration by Parts:

$$\int u\frac{dv}{dx}dx = uv - \int v\frac{du}{dx}dx$$

Binomial Distribution:

The probability of r successes in n trials is

$$\binom{n}{r}p^r q^{n-r}$$

where p is the probability of success in a single trial and $p + q = 1$.

Poisson Distribution:

The probability of r successes is

$$\frac{m^r}{r!}e^{-m}$$

where m is the expected number of successes.