

[ENG15]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

**BEng (Hons) ELECTRICAL
& ELECTRONIC ENGINEERING**

SEMESTER 1 EXAMINATIONS 2018/19

INTRODUCTORY ENGINEERING MATHEMATICS

MODULE NO: EEE4011

Date: Friday 18 January 2019

Time: 10.00am - 12noon

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 $u = \begin{pmatrix} 3 \\ -4 \\ 0 \end{pmatrix}$ and $v = \begin{pmatrix} 12 \\ 0 \\ 5 \end{pmatrix}$

- Calculate the following:
- (i) $2u + 3v$ (2 marks)
 - (ii) $u \cdot v$ (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:

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

Calculate the matrices AB and BA .

Explain why the sum of matrices $A + B$ is not defined.

(10 marks)

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

$$4x + 3y = 11$$

$$6x + 5y = 15$$

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

(8 marks)

Please turn the page.

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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 $z_1 = 23 + 14i$ and $z_2 = 4 - 3i$ be complex numbers. Calculate the following:

(i) $z_1 + 3z_2$ (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 $z_1 = 8 \angle 100^\circ$ and $z_2 = 4 \angle 40^\circ$ 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_1^3 (2 marks)

(iv) $\sqrt{z_2}$ (3 marks)

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Question 3

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

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

(ii) $y = x^6 e^{5x}$ (4 marks)

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

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

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

$$y = x^3 - 3x^2 - 45x + 15.$$

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) $\int_2^3 (9x^2 + 10x - 6) dx$ (6 marks)

(ii) $\int_0^{\frac{\pi}{2}} (6 \cos 3x + 4 \sin 2x) dx$ (6 marks)

(b) Find each of the following indefinite integrals

(i) $\int x \sin 3x dx$ (7 marks)

(ii) $\int (3x + 1)^5 dx$

(6 marks)

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Question 5

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

$$\frac{dy}{dx} = \frac{8x^3}{5y^4}$$

The boundary condition is $y = 1$ when $x = 1$.

(8 marks)

- (b) Consider the following linear differential equation:

$$\frac{dy}{dx} + 3y = 6x^2.$$

- (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 $y = 1$. (2 marks)

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

$$\frac{d^2y}{dx^2} - 7\frac{dy}{dx} + 12y = 0.$$

(7 marks)

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Question 6

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

22	43	45	27	35
52	29	61	38	28

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

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

- (b) Power transistors are being manufactured.

It is known that 2% of these fail quality control testing, so that the probability that a single transistor fails is 0.02.

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

- | | | |
|-------|-------------------|-----------|
| (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 100m drum of cable. (2 marks)

Calculate the probability that in a 100m 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

Formulae

Derivatives and Integrals:

$\int y dx$	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}

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.