

# LIBRARY GUIDE

## Mathematics I (M101)

### FINAL EXAMINATION STUDY & PRACTICE GUIDE

#### BEng. Degree in Industrial Systems

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#### Instructions for Students

- This document contains **examination-style questions** only.
- Use it *after* studying the concepts to test your understanding.
- Simulate exam conditions: set a timer, no notes, no calculator where specified.
- Answers should be shown step-by-step – partial marks matter.
- The final exam is worth **50%** of your grade.

**Total marks (practice set): 100**

**Suggested time: 3 hours**

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#### Part A: Multiple Choice Questions (20 marks)

*Circle the correct answer. Each question is worth 2 marks.*

**A1.** Which of the following is an irrational number?

- a)  $\frac{22}{7}$    b)  $\sqrt{25}$    c)  $\sqrt{3}$    d)  $-4$

**A2.**  $\log_2(8)$  equals:

- a) 2   b) 3   c) 4   d) 16

**A3.** If  $f(x) = x^2$  and  $g(x) = x + 1$ , then  $f(g(2))$  is:

- a) 5   b) 9   c) 8   d) 4

**A4.** The gradient of the line through (2, 3) and (5, 11) is:

- a)  $\frac{8}{3}$    b)  $\frac{3}{8}$    c)  $\frac{4}{3}$    d) 3

**A5.**  $\sin^2 \theta + \cos^2 \theta =$

- a) 0   b) 1   c)  $\tan^2 \theta$    d)  $\sec^2 \theta$

**A6.** The determinant of  $\begin{bmatrix} 3 & 4 \\ 2 & 5 \end{bmatrix}$  is:

- a) 23   b) 7   c) 15   d) 22

**A7.**  $i^2 =$

- a) 1   b)  $-1$    c)  $i$    d)  $-i$
-

**A8.** The dot product of vectors  $\langle 1,2 \rangle$  and  $\langle 3,4 \rangle$  is:

- a) 10   b) 11   c) 12   d) 14

**A9.** The sine rule is correctly stated as:

- a)  $\frac{a}{\sin A} = \frac{b}{\sin B}$    b)  $\frac{\sin A}{a} = \frac{b}{\sin B}$    c)  $a \sin A = b \sin B$    d)  $\frac{a}{b} = \frac{\sin A}{\sin B}$

**A10.** Which is NOT a valid matrix operation?

- a)  $3 \times 3$  times  $3 \times 2$    b)  $2 \times 4$  times  $4 \times 1$    c)  $2 \times 3$  times  $2 \times 3$    d)  $1 \times 5$  times  $5 \times 2$
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## Part B: Short Answer Questions (30 marks)

Answer all questions. Show working where possible. Each question is worth 5 marks.

**B1.** Simplify  $\frac{16^{3/4} \times 8^{-2/3}}{4^{1/2}}$ .

**B2.** Solve for  $x$ :  $\log_3(x) + \log_3(x - 2) = 1$ .

**B3.** Rationalise the denominator:  $\frac{4}{\sqrt{6} + \sqrt{2}}$ .

**B4.** Find the inverse of  $f(x) = \frac{2x-5}{3}$ .

**B5.** Write the complex number  $\frac{2+3i}{1-i}$  in the form  $a + bi$ .

**B6.** Find the angle between vectors  $\mathbf{a} = \langle 2, -1, 3 \rangle$  and  $\mathbf{b} = \langle 1, 4, -2 \rangle$ .  
Round to the nearest degree.

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## Part C: Long Answer Questions (50 marks)

Answer all questions. Show complete working. Marks are indicated.

**C1. Polynomials (10 marks)**

Given  $P(x) = x^3 - 3x^2 - 4x + 12$ :

- Use the factor theorem to show  $x - 2$  is a factor. (2 marks)
- Factorise  $P(x)$  completely. (4 marks)
- Solve  $P(x) = 0$ . (2 marks)
- State the y-intercept of the graph of  $P(x)$ . (2 marks)

**C2. Trigonometry – Sine and Cosine Rules (10 marks)**

Triangle ABC has  $AB = 8$  cm,  $BC = 10$  cm, and angle  $B = 60^\circ$ .

- Find side  $AC$  using the cosine rule. (4 marks)
  - Find angle  $A$  using the sine rule. (4 marks)
  - Find the area of triangle ABC. (2 marks)
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**C3. Matrices – Solving Simultaneous Equations (10 marks)**

Solve the system using either Cramer's Rule or matrix inversion:

$$\begin{cases} 3x + 4y = 10 \\ 2x - y = 3 \end{cases}$$

- Write the system in matrix form  $AX = B$ . (2 marks)
- Find the determinant of  $A$ . (2 marks)
- Find  $A^{-1}$ . (3 marks)
- Solve for  $x$  and  $y$ . (3 marks)

**C4. Complex Numbers & Quadratics (10 marks)**

- Solve the quadratic equation  $x^2 - 6x + 25 = 0$ . Express roots in  $a + bi$  form. (5 marks)
- Verify that the sum of the roots equals 6. (2 marks)
- Plot the two roots as points in the complex plane. (3 marks)

**C5. Graphs and Linearisation (10 marks)**

Experimental data suggests the relationship  $y = ae^{bx}$ .

- Explain how to plot a graph to obtain a straight line. State what goes on the x-axis and y-axis. (4 marks)
- If the straight line has gradient 0.5 and vertical intercept 2, find  $a$  and  $b$ . (4 marks)
- Write the original equation. (2 marks)

## Final Advice

- Practice **timed conditions** – 3 hours for 100 marks.
- Show every step – partial credit adds up.
- Review **Unit 2 (algebra)** and **Unit 4 (trigonometry)** most heavily.
- Bring a ruler, pencil, eraser, and non-programmable calculator if allowed.

*Good luck on your final examination!*

## Answer Key (for self-assessment)

Do not look until you have attempted all questions.

### Part A – Multiple Choice

- |                  |                                        |
|------------------|----------------------------------------|
| 1. c) $\sqrt{3}$ | 6. b) 7                                |
| 2. b) 3          | 7. b) -1                               |
| 3. b) 9          | 8. b) 11                               |
| 4. a) $8/3$      | 9. a) $a/\sin A = b/\sin B$            |
| 5. b) 1          | 10. c) $2 \times 3$ times $2 \times 3$ |

### Part B – Short Answer (Brief solutions)

**B1.**  $16^{3/4} = 8$ ,  $8^{-2/3} = 1/4$ ,  $4^{1/2} = 2 \rightarrow (8 \times 1/4)/2 = 2/2 = 1$

**B2.**  $\log_3(x(x-2)) = 1 \rightarrow x^2 - 2x = 3 \rightarrow x^2 - 2x - 3 = 0 \rightarrow x = 3$  ( $x = -1$  invalid)

**B3.** Multiply numerator and denominator by  $\sqrt{6} - \sqrt{2} \rightarrow \frac{4(\sqrt{6}-\sqrt{2})}{6-2} = \sqrt{6} - \sqrt{2}$

**B4.** Swap x and y:  $x = \frac{2y-5}{3} \rightarrow 3x = 2y - 5 \rightarrow y = \frac{3x+5}{2} \rightarrow f^{-1}(x) = \frac{3x+5}{2}$

**B5.** Multiply by conjugate  $(1+i)$ : numerator =  $(2+3i)(1+i) = 2+2i+3i+3i^2 = -1+5i$ , denominator =  $1-i^2 = 2 \rightarrow$  result =  $-0.5+2.5i$

**B6.** Dot =  $2(1) + (-1)(4) + 3(-2) = 2 - 4 - 6 = -8$

$|a| = \sqrt{4+1+9} = \sqrt{14}$ ,  $|b| = \sqrt{1+16+4} = \sqrt{21}$

$\cos\theta = -8/(\sqrt{14}\sqrt{21}) \approx -0.466 \rightarrow \theta \approx 118^\circ$

### Part C – Long Answer (Summary of key steps)

**C1.**  $P(2)=0 \rightarrow$  factor  $(x-2)$ . Divide  $\rightarrow (x-2)(x^2 - x - 6) = (x-2)(x-3)(x+2)$ . Roots: 2,3,-2. y-intercept:  $P(0)=12$ .

**C2.**  $AC^2 = 8^2 + 10^2 - 2(8)(10)\cos60^\circ = 64+100-80 = 84 \rightarrow AC = \sqrt{84} \approx 9.17$  cm. Sine rule:  $\sin A/10 = \sin 60^\circ/9.17 \rightarrow A \approx 70.9^\circ$ . Area =  $\frac{1}{2}(8)(10)\sin 60^\circ = 34.64$  cm<sup>2</sup>.

**C3.**  $\det = 3(-1) - 4(2) = -11$ . Inverse =  $(-1/11)[[-1, -4],[-2, 3]] = [[1/11, 4/11],[2/11, -3/11]]$ . Solution:  $x=2$ ,  $y=1$ .


**C4.**  $x = [6 \pm \sqrt{(36-100)}]/2 = [6 \pm \sqrt{-64}]/2 = 3 \pm 4i$ . Sum =  $3+4i+3-4i = 6$ . Plot points (3,4) and (3,-4).

**C5.** Plot  $\ln y$  vs  $x$ . Gradient =  $b = 0.5$ , intercept =  $\ln a = 2 \rightarrow a = e^2 \approx 7.39$ . Equation:  $y = e^2 \cdot e^{0.5x} = e^{2+0.5x}$ .


## Additional Support

For assistance with research or accessing resources such as past papers, visit the CMU Library or contact:

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