

**CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER**

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-35 - MATHEMATICS

THURSDAY, 18 JULY 2024

1315 - 1615 hrs

Materials to be supplied by examination centres

Candidate's examination workbook
Graph paper

Examination paper inserts:

Notes for the guidance of candidates:

1. Examinations administered by SQA on behalf of the Maritime & Coastguard Agency
2. Non-programmable calculators may be used.
3. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.
4. Candidates should note that 96 marks are allocated to this paper. To pass, candidates must achieve 48 marks.



Maritime &
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MATHEMATICS

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. (a) Given $Z = \frac{1-j}{1+j2}$, determine $Z - Z^{-1}$ as a complex number in polar form. (10)

(b) Solve the following complex equation for r and θ : (6)

$$r \angle \theta = 14.5 - j0.67 - 5 \angle 60^\circ.$$

2. (a) Solve the following system of equations for x and y . (10)

$$4x^2 + xy + 9y^2 = 91$$
$$3y - 2x = 13$$

(b) Transpose the following formula to make r the subject: (6)

$$T = A \left(1 - \frac{1}{r^{n-1}} \right)$$

3. (a) TWO positive integers differ by 6. (8)

The sum of the squares of the two numbers is 818.

Determine the value of EACH of the two numbers.

(b) Solve for x in the following equation: (6)

$$\frac{x+3}{x+2} = \frac{3x-7}{2x-3}$$

(c) Factorise the following as fully as possible: (2)

$$x^2 + 4xy + 4y^2$$

4. (a) The value, £C, of a piece of machinery after t years is given by:

$$C = 92000e^{-0.205t}$$

Calculate the number of complete years before its value falls to less than £18,000. (6)

- (b) Solve for x in the following equation:

$$\log 4x^5 - \log x = \log 16x + \log 2 \quad (5)$$

- (c) Evaluate the following expression for A *without using tables or calculator* :

$$A = \frac{4 \log 9 - 2 \log 27 + \log 243}{7 \log 3} \quad (5)$$

5. The stress, σ MN/m², in an alloy steel plate was recorded at different distances, x cm, from one end.

The results are shown in Table Q5.

- (a) Draw a straight line graph to verify that the relationship between σ and x is a law of the form $\sigma = ax^2 + bx$ where a and b are constants. (10)

x	4.0	7.0	8.0	10.0	11.0
σ	24	104	142	236	294

Table Q5

Suggested scales: horizontal axis 2 cm = 1

vertical axis 2 cm = 2

- (b) Use the graph drawn in Q5(a) to estimate the value of a and b. (6)

6. At 0900 hours a customs cutter is set on a course to intercept a vessel as soon as possible.

The vessel is 15 nautical miles distant, bearing 035° and is sailing on a steady course of 095° at a speed of 20 knots.

The best speed of the cutter is 32 knots.

Calculate the earliest possible interception time, to the nearest minute. (16)

✓ The displacement, s metres, of a body from a fixed point is given by:

$$s = 4t^3 - 16.5t^2 + 18t \text{ where } t \text{ is the time in seconds.}$$

(a) Determine EACH of the following for this body:

(i) its initial velocity, given that velocity $v = \frac{ds}{dt}$; (3)

(ii) the times when it is stationary; (4)

(iii) its displacement at EACH of the stationary points. (3)

(b) Sketch the curve $s = 4t^3 - 16.5t^2 + 18t$ for $0 \leq t \leq 3$. (6)

8. (a) A tunnel entrance has a stone walled arch.

Determine, using integral calculus, the area of the stonework represented by the shaded area in the rectangular cross section of the tunnel entrance, shown in Fig Q8(a), given that the unit of length is the metre. (8)

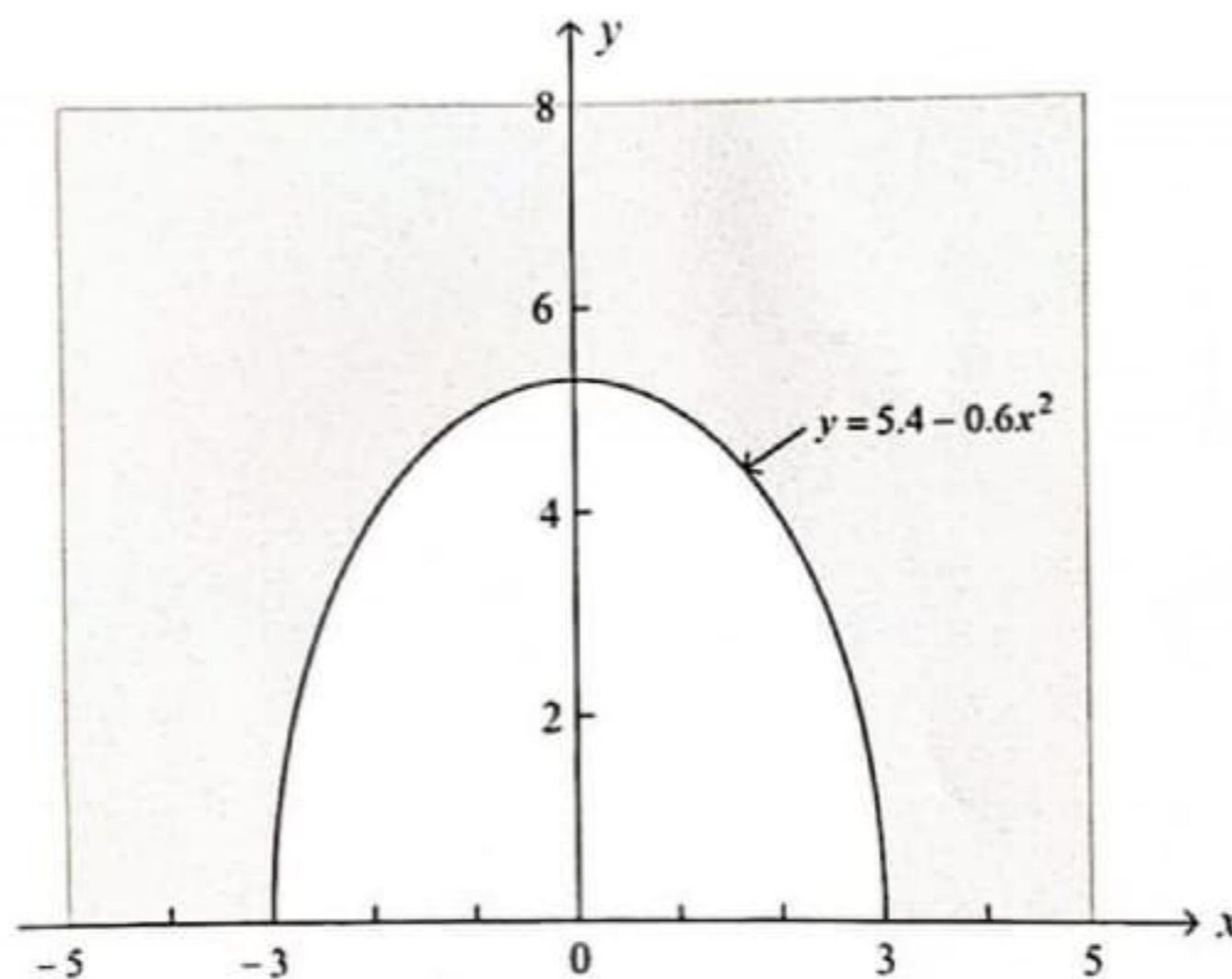


Fig Q8(a)

(b) Given $\frac{dv}{dt} = \frac{4t^2 + 4t - 15}{2t - 3}$, and $v = 5 \text{ ms}^{-1}$ when $t = 1 \text{ s}$,

determine v as a function of t .

(8)

9. (a) A logic circuit behaves according to the Boolean expression:

$$X = \overline{A \cdot B + C \cdot B}$$

Produce EACH of the following for this expression:

- (i) A logic circuit, *using only* AND, OR and NOT gates; (4)
- (ii) the equivalent circuit diagram to that obtained in (i), *using only* NAND gates. (4)
- (b) Determine EACH of the following, *without using a calculator conversion function*:
- (i) the conversion of 87_{10} to binary; (2)
- (ii) the conversion of 101101101111_2 to hexadecimal; (2)
- (iii) the conversion of $BD4E_{16}$ to decimal; (2)
- (iv) the hexadecimal operation $DA5C - ABCD$. (2)