8

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

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

040-35 - MATHEMATICS

THURSDAY, 17 DECEMBER 2020

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 & Coastguard Agency

SQA

MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Marks for each part question are shown in brackets

1. (a) Forces $F_1 = 3x - j7$, $F_2 = 2 - j5y$, $F_3 = -19 + j2x$ and $F_4 = -2y + j3$ are represented by complex numbers in rectangular form.

Given that the four forces are in equilibrium, determine the value of EACH of the real numbers x and y. (8)

(b) The impedance, z, of an electronic circuit is given by $z = 5 - j12$ and the current, i, is given by $i = 10 - j$.

Determine, in polar form, the voltage, v, across the impedance, given that $v = iz$. (8)

2. (a) Solve for x in the following equation:

$$\frac{2}{x^2 - 4} + \frac{4}{x + 2} = \frac{3}{x^2 + 3x + 2}$$

(8)

(b) Factorise EACH of the following as fully as possible:

(i) $4x^5 - 25x^3$; (4)

(ii) $x^3 + 2x^2 + x + 2$. (4)

3. (a) Make q the subject of the following formula:

$$\frac{pq}{\frac{p}{q} + \frac{1}{q}} = q^2 - 1$$

(8)

(b) A ship's fuel consumption varies directly as the square of the ship's speed and indirectly as the calorific value of the fuel.

If the ship burns 30 tonnes of fuel per day, of calorific value 41 MJ/kg, when sailing at 13 knots, calculate the daily consumption when using fuel of calorific value 45 MJ/kg and sailing at 15 knots. (8)

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4. Solve for x in EACH of the following equations:

(a) $5^{3x+1} = 2^{2x-1}$; (6)

(b) $\log\left(\frac{3-2x}{1-x}\right) = 0.8$; (6)

(c) $\sqrt{x^4 + 19} = 10$ (4)

5. (a) During a trial run towing a barge, the values of pull, P kN, and speed V knots, were recorded as shown in Table Q5.

Draw a straight line graph to verify that P and V are related by a law of the form. $P = kV^n$ where k and n are constants. (10)

V	2	3	4	5	6
P	140	289	485	725	1006

Table Q5

Suggested scales: *horizontal axis* 2 cm = 0.1
vertical axis 2 cm = 0.1

(b) Use the graph drawn in Q5(a) to estimate the values of k and n. (6)

6. (a) An observer on a level plain measures the elevation of a captive weather balloon to be 25° and after moving 400m towards the balloon the observer measures the elevation to be 38°.

Calculate EACH of the following:

(i) the horizontal distance of the balloon from the first observation point; (8)

(ii) the height of the balloon. (2)

(b) An alternating current, i milliamps, is given by:

$i = 30\sin(100\pi t - 0.45)$ where t is the time in seconds.

Calculate the least value of t, $t > 0$, for which the current $i = 15$ milliamps. (6)

7. (a) A liquid is evaporating from an open vessel such that the volume of the liquid remaining, V cm^3, after x hours, is given by $V = 15\left(c - x^{\frac{3}{4}} - x^{\frac{1}{2}}\right)$, where c is a constant.

The liquid evaporates completely after exactly 16 hours.

Determine EACH of the following:

(i) the initial volume of the liquid; (4)

(ii) the rate of evaporation after exactly 8 hours. (6)

(b) Determine the first and second derivatives of the following function:

$$u = 2\sin\theta + \frac{1-\cos^2\theta}{1+\cos\theta}$$ (6)

8. The region enclosed by the function $y = 2 + 3\sqrt{x}$, the x-axis and the lines $x = 1$ and $x = 9$, is represented by the shaded region in Fig Q8.

Determine EACH of the following for the shaded region, using integral calculus:

(a) its area: (7)

(b) the volume of solid of revolution formed by rotating it through one revolution about the x-axis. (9)

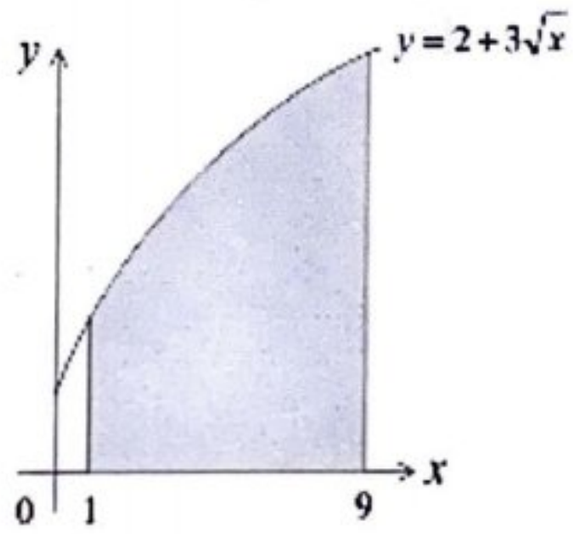

Fig Q8

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9. (a) Determine EACH of the following, *without using a calculator conversion function*

(i) the binary operation 11011×1011 (2)

(ii) the hexadecimal operation FACE + B4AD (2)

(iii) the conversion of $BD9E_{16}$ to decimal. (2)

(b) The logic circuit shown in Fig Q9(b) has three inputs A, B and C, and one output X

Produce EACH of the following for this circuit:

(i) an unsimplified Boolean expression for X; (4)

(ii) the truth table, by simplifying as fully as possible the Boolean expression obtained for X in (b) (i), or otherwise; (4)

(iii) the equivalent circuit with the minimum number of gates. (2)

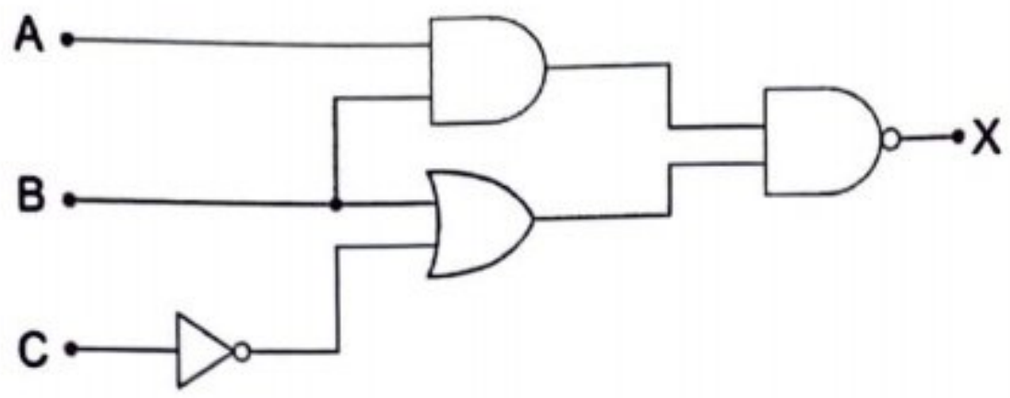

Fig Q9(b)