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

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

040-35 - MATHEMATICS

THURSDAY, 21 OCTOBER 2021

1315 - 1615 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination paper inserts:

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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.



MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. (a) Given $Z = \sqrt{50} \angle 45^\circ$, determine EACH of the following as a complex number in polar form:
- (i) $Z + Z^{-1}$; (8)
- (ii) $\frac{Z}{Z^{-1}}$. (3)
- (b) Solve the following complex equation for r and θ : (5)
- $$1.34 + j12.32 + 10 \angle 30^\circ = r \angle \theta.$$
2. (a) Solve for x in the following equation: (8)
- $$\frac{4x}{3x-5} + \frac{3}{x+5} = 2$$
- (b) Solve the following system of equations for a , b and c : (8)
- $$\begin{aligned} a - 2b - 6c &= 1 \\ 2a + 3b - 3c &= 4 \\ 3a + b + 2c &= 16 \end{aligned}$$
3. (a) The resistance, R ohms, of a copper wire at $t^\circ\text{C}$ is given by $R = R' [1 + \alpha(t - 20)]$ where R' is the resistance of the wire at 20°C and α is the temperature coefficient of resistance of copper at 20°C . (10)
- Given $R = 16.86$ ohms when $t = 40^\circ\text{C}$ and $R = 19.07$ ohms when $t = 75^\circ\text{C}$, determine the values of R' and α .
- (b) Factorise fully EACH of the following: (3)
- (i) $24x^4y - 4x^3y^2 - 4x^2y^3$; (3)
- (ii) $3a^3b - 27ab^3$.

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4. (a) Make T the subject of the following formula:

$$I = GR^2 e^{-\frac{c}{T}}$$

(6)

- (b) Solve the following equation for x:

$$\ln(2 - 2x^2) = -0.5$$

(5)

- (c) Express the following in its simplest form:

$$5\sqrt[3]{a^3 b^6} + 7b\sqrt{a^2 b^2} - 4\sqrt[4]{a^4 b^8}$$

(5)

5. (a) On the same set of axes plot the graphs, in intervals of 0.5, of $y_1 = 2x^2 - 3x - 5$ in the range $-1 \leq x \leq 3.5$ and $y_2 = 5 - (2 - x)^2$ in the range $-1 \leq x \leq 4.5$.

(12)

Suggested scales: horizontal axis 2 cm = 1

vertical axis 1 cm = 1

- (b) Using the graphs plotted in Q5(a), solve the system of equations:

$$y = 2x^2 - 3x - 5$$

$$y = 5 - (2 - x)^2$$

(4)

6. TWO spheres of diameters 25 mm and 50 mm fit into an oil funnel spout as shown in Fig Q6.

Calculate EACH of the following for this spout:

- (a) the internal taper angle;

(8)

- (b) the diameter D at the top.

(8)

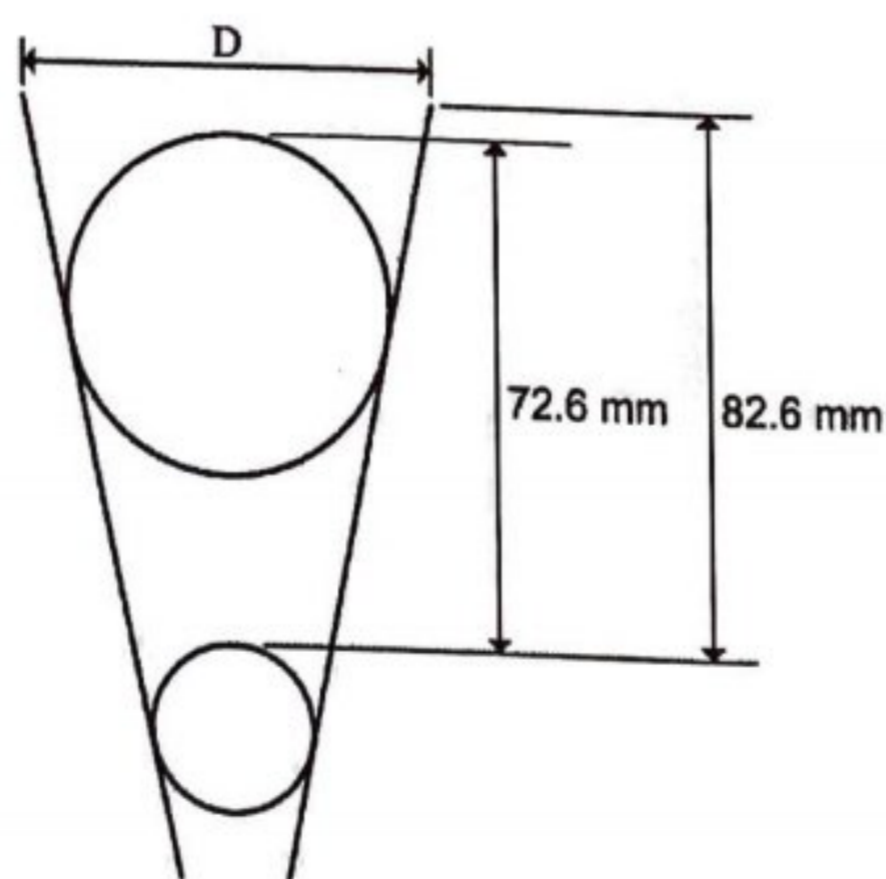


Fig Q6

7. (a) Use differential Calculus to determine EACH of the following for the function $y = 8x^3 - 6x^2 - 36x + 41$:
- (i) the coordinates of the stationary points; (8)
 - (ii) the nature of the stationary points. (4)
- (b) Given $y = \sqrt{x} - \ln x^2$,
determine $\frac{dy}{dx}$. (4)
8. The plain nylon sheave of a pulley-block may be considered as being formed by rotating the area bounded by the curve $y = x^2 + 3$ and the lines $x = -1$, $x = 1$ and $y = 0.8$, about the x -axis through one complete revolution.
- (a) Sketch the bounded area. (4)
 - (b) State the bore of the sheave. (2)
 - (c) Calculate the volume of nylon comprising the sheave. (10)

Note: that the unit of length is the centimetre.

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9. (a) The logic circuit shown in Fig Q9(a) 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 the outputs D, E and X in terms of the inputs A, B and C;

(3)

(ii) the truth table, including columns for A, B, C, D, E, and X.

(3)

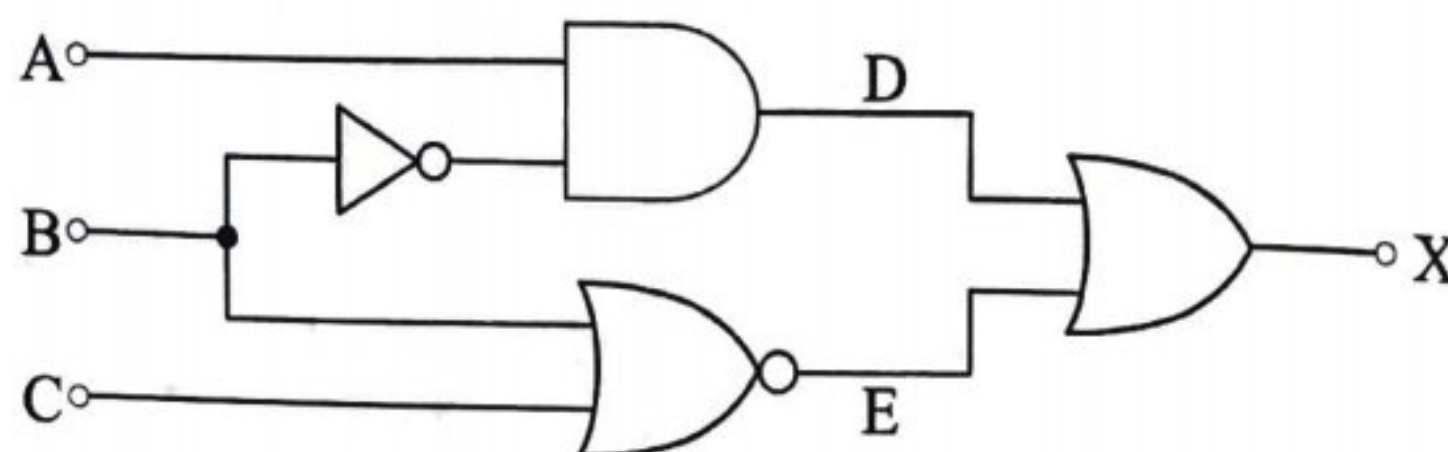


Fig Q9(a)

(b) Simplify, as fully as possible, the following Boolean expression:

$$\overline{\overline{(A + B)} + \overline{A}}$$

(4)

(c) Determine EACH of the following, *without using a calculator conversion function*:

(i) the binary operation ; 11001×1011 ;

(2)

(ii) the hexadecimal operation ; $DF8A + BCE9$;

(2)

(iii) the conversion of $FA2E_{16}$ to decimal.

(2)