CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

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

040-35 – MATHEMATICS

THURSDAY, 18 OCTOBER 2018

1315 - 1615 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph Paper

MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. (a) Given $Z = \dfrac{Z_1 + Z_3}{2Z_2 - Z_3}$, where $Z_1 = 2 + j10$, $Z_2 = 5 - j3$ and $Z_3 = 8 - j5$,

express Z as a complex number in polar form. (8)

(b) Three mooring lines exert horizontal forces on a bollard, positioned at O, as follows:

24 kN at 35°

37 kN at 162°

50 kN at 270°

The angles are those that the forces make with the real axis Ox.

Determine, *using complex numbers*, the magnitude and direction of the resultant force on the bollard. (8)

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

$$\frac{x+4}{x-2} - \frac{x+1}{2x-3} = \frac{5}{2}$$ (8)

(b) For a certain ship, at deadweight displacement, the power of the main engine is given by $P = V(a + bV^2)$ where V is the ship's speed, and a and b are positive constants.

The engine powers are 3650 kW and 11100 kW when the ship speeds are 10 and 15 knots, respectively.

Calculate the engine power when the speed of the ship is 12 knots. (8)

3. (a) Given $T = T_1 e^{\mu\theta}$, determine the value of μ, correct to three decimal places, when $T = 80$, $T_1 = 65.5$ and $\theta = 2$. (6)

(b) Solve the following equation for x:

$$2^{4x+1} = 8^{2x-1}$$ (6)

(c) Transpose the following formula to make B the subject :

$$L = 2C\left\{\log_e\left(\frac{B}{A}\right) + 1\right\}$$ (4)

4. (a) The resistance, R ohms, of copper wire at t°C, is given by :

$R = R_0(1 + \alpha t)$ where R_0 is the resistance of the wire at 0°C and α is the temperature coefficient of resistance of copper.

Calculate the values of R_0 and α, given that $R = 21.76$ ohms when $t = 22$°C and $R = 22.40$ ohms when $t = 30$°C. (10)

(b) The formula $T = 2\pi\sqrt{\frac{K^2 + h^2}{gh}}$ gives the period T of a compound pendulum.

Transpose the formula to obtain g. (6)

5. (a) Draw the graph of $y = 3\sin\theta - \cos\theta$ in the range $\theta = 0$ to $\theta = 4$ radians, in intervals of 0.5 radians. (9)

Suggested scales: *horizontal axis* 2 cm = 0.5
vertical axis 2 cm = 0.5

(b) Use the graph drawn in Q5(a) to estimate the solutions to EACH of the following equations:

(i) $3\sin\theta - \cos\theta = 1$ (3)

(ii) $3\sin\theta = \cos\theta$ (4)

6. Fig Q6 represents a roof truss.

Angle BAE = angle DEA = 60°.

Calculate the length of EACH of the following:

(a) BF; (4)

(b) CF. (12)

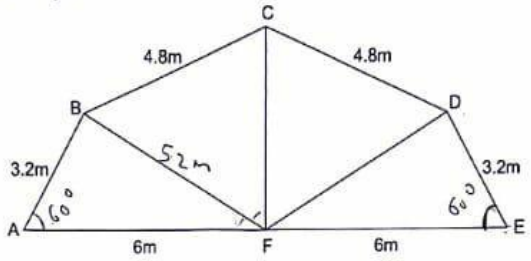

Fig Q6

7. (a) Determine the coordinates of the maximum and minimum turning points on the function: (9)

$y = x^3 - 27x + 8$

(b) Given $H = 2\sqrt{t} + \sin t + \log_e t$

determine $\frac{dH}{dt}$ and $\frac{d^2H}{dt^2}$ (7)

8. (a) Use integral calculus to determine the area of the shaded section shown in Fig Q8(a). (8)

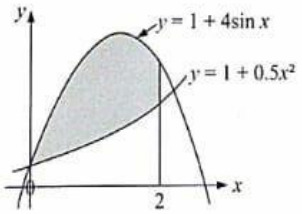

Fig Q8(a)

(b) Evaluate $\int_1^4 \left(\frac{1}{\sqrt{x}} + \frac{4}{x^2} - \frac{2}{x^3}\right) dx$ (8)

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

(i) the binary operation 1011001 – 100101; (1)

(ii) the conversion of 79_{10} to binary; (1)

(iii) the hexadecimal operation DFC5 + 3A8B; (2)

(iv) the conversion of 1769_{10} to hexadecimal. (2)

(b) The truth table for a logic system with inputs A, B and C, and output X, is shown in Table Q9(b).

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

Table Q9(b)

(i) Use Table Q9(b) to write down the unsimplified Boolean expression for X in terms of A, B and C. (2)

(ii) Simplify the expression in Q9(b)(i) as fully as possible, using a Karnaugh map and / or the rules of Boolean algebra. (3)

(iii) Produce the logic circuit for the system, with the minimum number of gates. (3)

(c) Simplify, as fully as possible, the following Boolean expression: (2)

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