

**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, 20 JULY 2017

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 $Z = \frac{Z_1 - 2Z_2}{Z_3}$ where $Z_1 = 3 + j$, $Z_2 = 1 - j$ and $Z_3 = 1 + j$,
express Z as a complex number in polar form. (8)

- (b) Solve the following complex equation for x and y :

$$\frac{5\angle\frac{\pi}{6} \times 2\angle\frac{\pi}{4}}{4\angle -\frac{\pi}{3}} = x + jy \quad (8)$$

2. (a) The deflection, y , at the centre of a rod under constant load, is directly proportional to the cube of the length, L , and inversely proportional to the fourth power of the diameter, d , of the rod.

Calculate the percentage change in y if L increases by 2% and d decreases by 1%. (8)

(b) $H = \frac{x^2 - 9y^2}{3x + 6y} \times \frac{x^2 + 4xy + 4y^2}{x^2 + 5xy + 6y^2}$

Express $\frac{1}{H}$ as a single algebraic fraction in its simplest form. (8)

3. (a) Two ferries leave the same port half an hour apart and arrive at the same destination together.

The faster ferry averaged 5 knots more than the other.

The distance between the two ports is 75 nautical miles.

Calculate the average speed of each ferry.

(8)

(b) The formula $T = \frac{T_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$ is associated with the study of relativity.

$$\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}$$

Make v the subject of the formula.

(8)

4. (a) The amount, A_t micrograms, of a certain radioactive substance remaining after t years decreases according to the formula:

$$A_t = A_0 e^{-0.001t}$$

where A_0 is the amount present initially.

(i) Determine the amount of this substance present initially if 500 micrograms remain after 1000 years.

(4)

(ii) The half-life of a substance is the time taken for the amount to decrease to half its initial amount.

(4)

Determine the half-life of this substance.

(b) Solve for x , $x > 0$, in the following equation:

$$5^{x^2} = 25^{5-3x}$$

(8)

5. The stress σ (MN/m^2) in an alloy steel plate was recorded at different distances x (cm) from one end.

The results are shown in Table Q5

- (a) Plot a straight line graph to show that the results follow the law

$$\sigma = ax^2 + bx, \text{ where } a \text{ and } b \text{ are constants.} \quad (10)$$

x	5.0	6.5	7.5	9.0	10.0	11.5
σ	39	78	111	171	218	299

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. A tower stands at the top of a 20° incline.

From a point A on the incline the angle of elevation to the top of the tower is 50° from the horizontal.

At a point B, which is 120 metres further down the incline in the same vertical plane, the angle of elevation to the top of the tower is 40° from the horizontal.

Calculate the height of the tower.

(16)

7. (a) An open water tank in the shape of a triangular prism, as shown in Fig Q7(a), has a length of l cm and a capacity of 62.5 litres.

The triangular cross-section of the tank is right-angled and isosceles, with equal sides of length x cm.

The tank is to be lined on the inside to make it watertight.

Determine EACH of the following for the tank:

- (i) the capacity in cm^3 ; (1)
- (ii) an expression, in terms of x , for the surface area to be lined; (5)
- (iii) the value of x which minimises the surface area to be lined. (4)

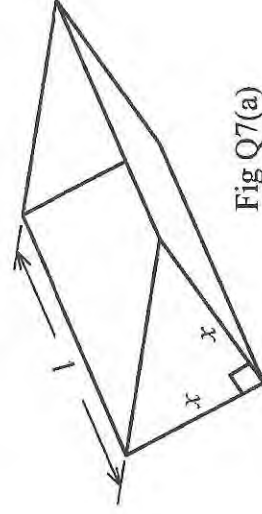


Fig Q7(a)

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

$$Q = 12x^3 + 8x + \frac{6}{x^2} \quad (6)$$

8. (a) Calculate the area bounded by the parabolas $y = 1 + 8x - 2x^2$ and $y = 1 + 4x - x^2$, as shown by the shaded area in Fig Q8(a). (10)

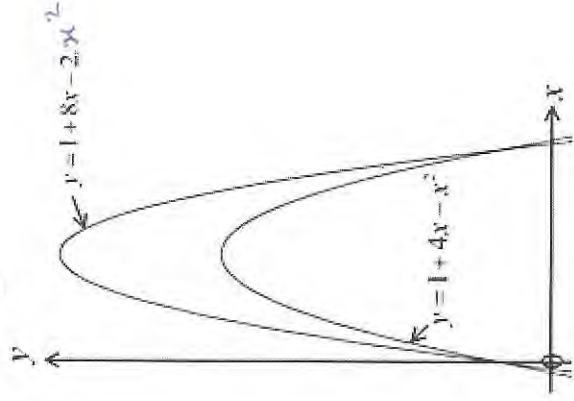


Fig Q8(a)

- (b) Evaluate:

$$\int_1^2 \frac{9}{p^{1.6}} dp$$

(6)

9. (a) The dimensions, in binary form, of a cuboid are shown in Fig Q9(a). Working in binary form, without using a calculator, determine EACH of the following for the cuboid:

- (i) its volume; (3)
- (ii) a quarter of its volume. (3)

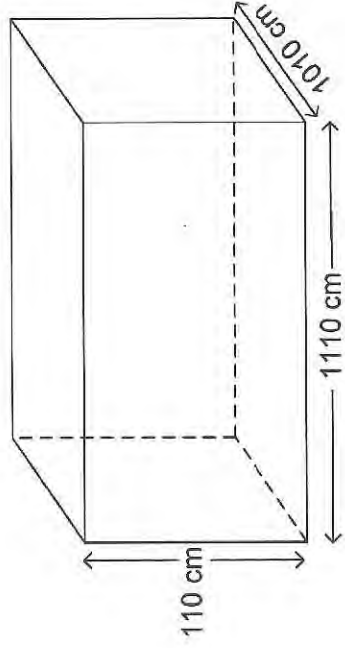


Fig Q9(a)

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

Determine EACH of the following for this circuit:

- (i) the truth table; (4)
- (ii) a Boolean expression; (2)
- (iii) an equivalent circuit drawn using only two gates. (4)

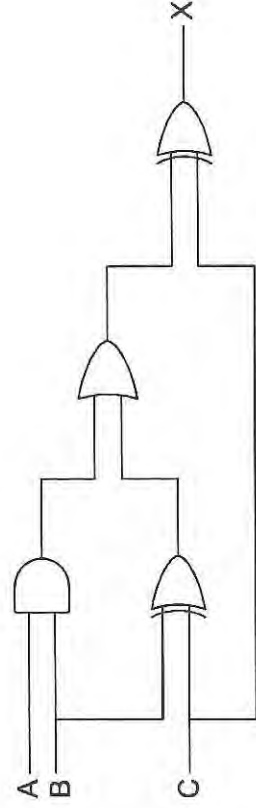


Fig Q9(b)