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, 29 MARCH 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

MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. (a) Given $z_1 = 3 + j2$ and $z_2 = 1 + j2$, express $\frac{z_1^{\,2}}{z_2}$ in the form $a + jb$. (8)

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

$$10\angle 50° + 4\angle 30° = r\angle\theta°$$ (6)

(c) Simplify the following to a single complex number in the form $r\angle\theta$:

$$18\angle\frac{\pi}{8} \times 3\angle\frac{\pi}{4}$$ (2)

2. (a) The shortest side of a right angled triangle is 25 cm shorter than the hypotenuse and 23 cm shorter than the other side.

Calculate the length of the shortest side of this triangle. (8)

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

(i) $2ab - 5ac + 6bd - 15cd$; (3)

(ii) $4x^2 + 12xy + 9y^2$; (2)

(iii) $x^2 + y^2 - 2xy - 1$. (3)

3. (a) Poor weather conditions cause a reduction in a ship's speed of 2 knots throughout a passage of 850 nautical miles, resulting in the ship arriving at its destination 4 hours behind schedule.

Calculate the normal service speed of the ship: (10)

(b) Solve for x in the following equation:

$$\frac{1}{x-2} + 3 = \frac{x+3}{2}$$ (6)

4. (a) Solve for *a* and *b* in the following system of equations:

$$2^{3a} = 7^{b}$$

$$3^{a-1} = 13$$

(8)

(b) The impedance *Z* in an a.c. circuit is given by the formula:

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

Transpose the formula to make C the subject. (8)

5. (a) Draw the graph of the function $y = 4 - x - x^2$ for the range $-3 \leq x \leq 2$ in intervals of 0.5. (8)

(b) Use the graph drawn in Q5(a) to determine EACH of the following:

(i) the maximum value of *y*; (2)

(ii) the solutions of the equation $4 - x - x^2 = 0$; (3)

(iii) the solutions of the equation $2.5 - x - x^2 = 0$. (3)

6. An engine crank mechanism is shown in Fig Q6.

Arm OA is 120 mm long and rotates clockwise about centre O.

The connecting rod AB is 350 mm long and B is constrained to move horizontally.

(a) Calculate EACH of the following when angle AOB = 40°:

(i) the angle between the connecting rod and the horizontal; (4)

(ii) the distance OB. (4)

(b) Calculate the distance B moves when angle AOB changes from 40° to 150°. (8)

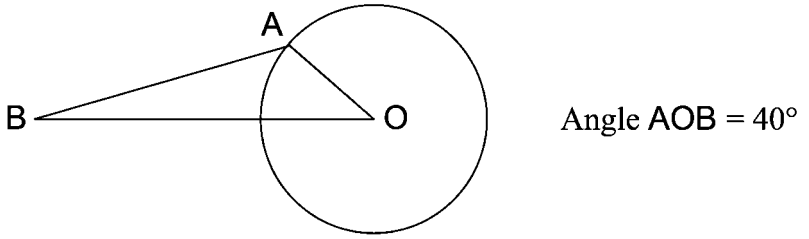

Fig Q6

7. (a) Given $H = 2 + \frac{x}{4} + \frac{512}{x^2}$, where $x > 0$,

calculate EACH of the following:

(i) the value of x such that H has a minimum value; (6)

(ii) the minimum value of H. (2)

(b) $A = 75t^{0.4} + 60\sqrt{t} - \frac{25}{t}$

Determine EACH of the following:

(i) $\frac{dA}{dt}$ (4)

(ii) $\frac{d^2A}{dt^2}$ (4)

8. (a) A drainage channel is to be made of moulded concrete blocks with a uniform cross-section as represented in Fig Q8(a).

Each block is 2.4 m in width, 1 m in height and 3 m in length.

Calculate the volume of concrete required to produce each block. (10)

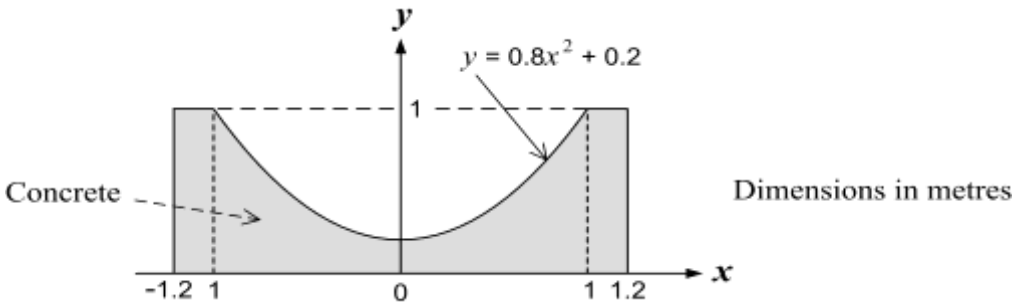

Fig Q8(a)

(b) A stone is dropped into a still pond and creates a series of circular ripples.

The rate of change of the area of disturbed water is given by:

$\frac{dA}{dt} = 9\sqrt{t}$ where A is the area of disturbed water in m^2 and t is the time in seconds.

(i) Determine, by integration, A in terms of t. (5)

(ii) Calculate the area of the pond covered by the ripples after 4 seconds. (1)

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

(i) the conversion of 85_{10} to binary; (1)

(ii) the conversion of 2095_{10} to hexadecimal; (2)

(iii) the value, in hexadecimal form, of $DC_{16} \div 10100_2$. (3)

(b) A logic circuit behaves according to the Boolean expression:

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

(i) produce the truth table for this circuit; (2)

(ii) simplify the expression for X as fully as possible, using a Karnaugh map or Boolean algebra. (4)

(c) Simplify the following expression as fully as possible:

$$\overline{\overline{L.\overline{M}} \; . \; \overline{L.M}}$$ (4)