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, 19 OCTOBER 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) Solve the following complex equation for x and y :

$$2+j=\left(\frac{1-j}{1+j}\right)^2+\frac{1}{x+jy} \qquad (8)$$

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

35 kN at 50°
44 kN at 190°
29 kN at 305°

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) Simplify the following as fully as possible:

$$\frac{\left(3a^2bc^4\right)^2}{\left(a^3b^6c^9\right)^{\frac{1}{3}}} \qquad (4)$$

(b) Solve the following equation for x :

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

(c) The value of a vessel at any age can be determined from the formula:

$$R_V = C\left(1-\frac{r}{100}\right)^n$$ where n = the age of the vessel in years

$\frac{r}{100}$ = the annual rate of depreciation as a percentage

C = the value of the vessel when new in £M

R_V = the residual value of the vessel after n years in £M

Use the formula to determine how long it will take a vessel, which cost £23 M to build and depreciates in value by 16% each year, to fall to its scrap value of £0.92 M. (8)

3. (a) $S = \dfrac{6x-17}{2x^2+5x-3} + \dfrac{4}{2x-1} + \dfrac{x}{x+3}$

Express S as a single fraction in its simplest form. (8)

(b) Solve the following system of equations for x, y and z :

$4x + 5y - 2z = -3$

$3x + 4y - 3z = -7$

$2x - 2y - z = 3$ (8)

4. (a) A box-shaped vessel, floating on an even keel, has a water-plane area of 72 m^2.

The length of the vessel is 11.5 m greater than its beam.

Calculate the length and beam of the vessel. (8)

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

(i) $x^2 - y^2 + 2y - 1$ (4)

(ii) $4a^3b - 6a^2b - 4ab$ (4)

5. (a) Draw the graph of $y = 2sin\ A + 3cos\ A$ in the range $0° \leq A \leq 180°$ in intervals of 20°. (10)

(b) Using the graph drawn in Q5(a), determine EACH of the following:

(i) the value of A when $y = 0$; (2)

(ii) the maximum value of y; (2)

(iii) the value of A at the maximum value of y . (2)

6. (a) A vessel travels 64.5 miles on a bearing 075°.

It then travels 48 miles on a bearing 130°.

Calculate EACH of the following:

(i) the distance of the vessel from its starting position; (6)

(ii) the bearing of the vessel from its starting position. (6)

(b) Determine the value of θ in the range $0° < \theta < 90°$ which satisfies the equation:

$3\sin^2\theta - \cos^2\theta = 1$ (4)

Note: $\sin^2\theta + \cos^2\theta = 1$

7. (a) The displacement s metres of a body from a fixed point is given by the equation:

$s = \frac{2}{3}t^3 - \frac{13}{2}t^2 + 15t + 8$ where t is the time in seconds.

Determine EACH of the following for the body:

(i) its initial velocity; (3)

(ii) the times when it is at rest; (4)

(iii) the time when its acceleration is 3 ms^{-2}. (3)

(b) Determine the first and second differential coefficients of the expression:

$y = 6\sqrt{x} + 3\ln x + 5\sin x$ (6)

8. (a) A watertight bulkhead can be represented by the area enclosed by the curves:

$y_1 = 6 - 0.01x^2$, $-10 \le x \le 10$

$y_2 = -0.005x^3$, $-10 \le x \le 0$

$y_3 = 0.005x^3$, $0 \le x \le 10$

as shown by the shaded area in Fig Q8(a).

Calculate the area of the bulkhead. (10)

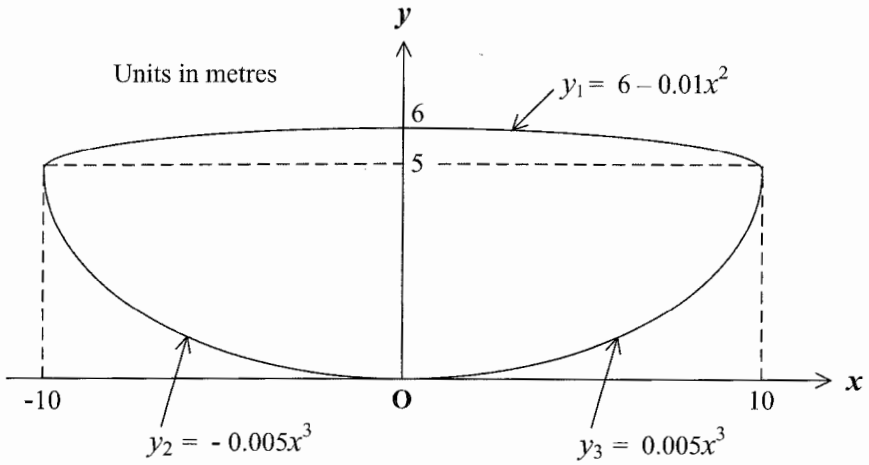

Fig Q8(a)

(b) Evaluate $\int_{\frac{\pi}{4}}^{\frac{\pi}{3}} (\cos\theta - 4\sin\theta)\, d\theta$ (6)

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

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

Table Q9(a)

Produce EACH of the following for the logic system:

(i) a Boolean expression in its simplest form; (4)

(ii) the logic circuit, with the minimum number of gates; (3)

(iii) the logic circuit, using only NAND gates. (3)

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

(i) the binary operation 10111011 – 1010111; (1)

(ii) the hexadecimal operation CD4B + EA7; (2)

(iii) the conversion of $B5EA_{16}$ to decimal; (2)

(iv) the conversion of 111001100111_2 to hexadecimal . (1)