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 95 SECOND ENGINEER REG. III/2 (UNLIMITED)

042-23 – MATHEMATICS

THURSDAY, 18 DECEMBER 2014

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) An alloy contains by mass 50% copper, 27% zinc and the remainder nickel.

Brass contains copper and zinc in the ratio 33:17 by mass.

15 kg of the alloy and 25 kg of the brass are melted together to form a new alloy.

Determine the percentage by mass of EACH element in the final alloy. (8)

(b) Painter A can antifoul a fishing boat in 15 hours.

Painter B can antifoul the same fishing boat in 10 hours.

Painter A begins antifouling the boat and after a period of time painter B joins in and assists A to complete the job in a total of 9 hours.

Determine how long painter A was working on his own before being assisted by B. (8)

2. (a) Solve the following system of equations for a, b and c:

$$2a + 3b - c = 20$$
$$5a + b + 2c = 4$$
$$7a - 2b - 3c = 6$$

(10)

(b) Solve for x in the following equation:

$$\frac{2x-3}{3} = \frac{x-2}{4} + 1$$

(6)

3. (a) Make R the subject of the formula:

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$ (6)

(b) The minimum diameter d of a shaft subjected to a bending moment M and a torque T is given by the formula:

$$d^2 = \frac{16}{\pi n}\left(M + \sqrt{M^2 + \mathrm{T}^2}\right)$$

Determine the value of d when $n = 6\,500$, $M = 10\,480$ and $\mathrm{T} = 22\,500$. (6)

(c) Factorise as fully as possible:

$6x^4y + x^3y^2 - 2x^2y^3$ (4)

4. (a) Evaluate without using tables or calculator:

$$\frac{7\log 27 + \log 81 - \log 243}{2\log 3}$$ (5)

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

$\log 3x^4 - \log x^2 = \log x + \log 12$ (5)

(c) The temperature T°C of a cooling liquid after t minutes is given by:

$\mathrm{T} = 150e^{-0.05\,\mathrm{t}}$

Calculate the time taken for the temperature of the liquid to fall to 50 °C. (6)

5. The resistance, R ohms, and the voltage, V volts, recorded during an experiment are shown in Table Q5.

(a) Draw a straight line graph to show that R and V are related by a law of the form

$$R = \frac{a}{V} + b \quad \text{where a and b are constants.}$$ (10)

R	20.9	24.6	28.8	33.2	36.3
V	0.287	0.245	0.206	0.180	0.168

Table Q5

Suggested scales: *horizontal axis* 2 cm = 0.4
vertical axis 2 cm = 2

(b) Using the graph drawn in Q5(a), determine approximate values for a and b. (6)

6. A vertical mast AB stands on horizontal ground as shown in Fig Q6.

At position C, due East of the mast, the angle of elevation to the top of the mast is 50°.

At position D, 25 metres due South of C, the angle of elevation to the top of the mast is 47°.

Calculate the height of the mast. (16)

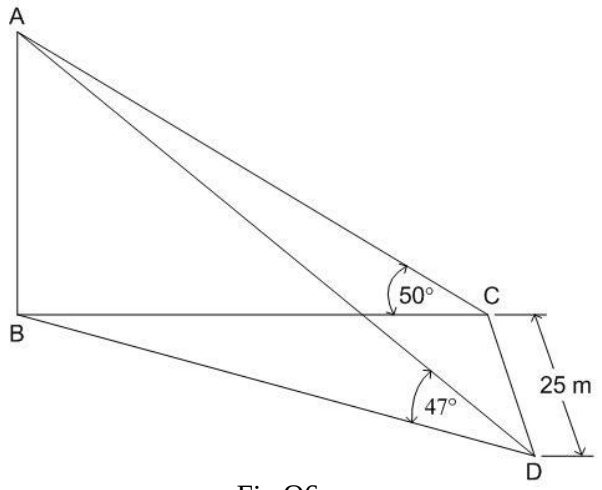

Fig Q6

7. (a) Determine the first and second derivatives of the function:

$$u = \frac{1+4t}{\sqrt{t}}$$ (6)

(b) Use differential calculus to determine EACH of the following for the function

$y = x^3 - 12x + 8$

(i) the coordinates of the turning points; (7)

(ii) the nature of the turning points. (3)

8. (a) The angular velocity, ω radians per second, of a flywheel under a constant braking torque, τ newton metres, is given by

$$I\frac{\mathrm{d}\omega}{\mathrm{dt}} + \tau = 0 \text{ where } I \text{ is its moment of inertia.}$$

The time in seconds that lapse since the brake is applied is t.

Given that at time $t = 0$, $\omega = \omega_0$, determine EACH of the following for a flywheel:

(i) an expression for ω in terms of t ; (6)

(ii) the time to bring to rest from a speed of 70π rads s^{-1} , when I is 120 kgm^2 and τ is 80 Nm. (4)

(b) Evaluate $\int_1^4 \left(2 + 3\sqrt{x} + \frac{1}{\sqrt{x}}\right) dx$ (6)

9. A solid metal cube of side 25 cm is machined down to form the largest possible sphere.

The metal removed is then melted down and cast as a solid cylinder of height 20% greater than the base diameter.

Determine EACH of the following for the cylinder:

(a) the dimensions; (11)

(b) the surface area. (5)