

**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, 21 OCTOBER 2010**

**1315 - 1615 hrs**

Examination paper inserts:

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Notes for the guidance of candidates:

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| <ol style="list-style-type: none"><li>1. Non-programmable calculators may be used.</li><li>2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.</li></ol> |
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Materials to be supplied by examination centres:

Candidate's examination workbook Graph Paper
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## MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. (a) A ship is scheduled to complete a journey of 540 nautical miles at an average speed of 12 knots. It covers the first quarter of the journey at an average speed of 13.5 knots. However due to a series of factors its speed in the last three quarters of the journey is reduced and it arrives at its destination 1 hour 40 minutes late.

Calculate the average speed of the ship over the second part of its journey. (8)

- (b) The wind force  $W$  on a vertical surface varies directly as the area,  $A \text{ m}^2$ , of the surface and directly as the square of the wind velocity,  $v \text{ km/hr}$ . When the wind speed is 36 km/hr the force on an area of  $2.5 \text{ m}^2$  is 320 Newtons.

Calculate the force on a surface of area  $4 \text{ m}^2$  when the wind speed is 60 km/hr. (8)

2. (a) Solve for  $x$  in the following equation: (6)

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

- (b) Solve the system of equations for  $A$  in the range  $0 \leq A \leq \frac{\pi}{2}$  (6)

$$4 \sin A + 5 \cos A = 6.353$$
$$13 \sin A - 8 \cos A = 3.752$$

- (c) Factorise completely: (4)

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

3. (a) The bending moment,  $M$ , at a point on a beam is given by:

$$M = \frac{3x(20-x)}{2}$$

where  $x$  metres is the distance from the point of support to the end of the beam.

Calculate the value of  $x$  when the bending moment is 50 Nm. (8)

- (b) Transpose the terms in the following equation to make  $C$  the subject: (8)

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

4. (a) Determine the value of  $x$  correct to three decimal places that satisfies the following equation: (6)

$$0.027^{x-1} = 3.26$$

- (b) The tension,  $T$  Newtons, in the tight side of a belt passing round a pulley wheel and in contact with the pulley for an angle  $\theta$  radians is given by the equation:

$$T = 43.8e^{0.32\theta}$$

Determine the value of  $\theta$  when  $T$  is 75 Newtons. (5)

- (c) The life expectancy,  $N$  years, of a certain machine costing  $\pounds C$ , and its value  $\pounds V$  after  $n$  years are related by the formula:

$$n = \frac{\ln V - \ln C}{\ln\left(1 - \frac{2}{N}\right)}$$

Calculate the age of the machine which cost  $\pounds 75000$  with a life expectancy of 6 years that has depreciated to a value of  $\pounds 10000$ . (5)

5. Table Q5 shows the values of the resistance, R ohms, and the voltage, V volts, recorded in an experiment.

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

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

(b) Determine approximate values of a and b. (6)

R ohms	47.4	52.2	55.9	59.9	62.1
V volts	0.111	0.102	0.093	0.088	0.085

Table Q5

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

6. (a) A tower 55 metres high stands on the top of a hill which has a  $10^\circ$  incline. The angle of depression from the top of the tower to a point A on the slope is  $72^\circ$ . B is a point further down the slope from A. The angle of depression from the top of the tower to B is  $48^\circ$ . Points A and B and the top of the tower all lie in the same vertical plane.

Calculate the distance between the points A and B. (12)

(b) Given:  $2 \tan \theta = \tan \alpha + \tan \beta$

Solve for  $\theta$  in the range  $0^\circ \leq \theta \leq 360^\circ$  when  $\alpha = 30^\circ$  and  $\beta = 45^\circ$ . (4)

7. (a) The rate at which a particular ship's engine consumes fuel is given by:

$$\text{rate} = 30 + 0.002v^3 \text{ tonnes per hour (where } v \text{ is the speed of the ship in km/hr).}$$

Calculate EACH of the following:

(i) the speed at which the minimum amount of fuel is used on a voyage of 1500 km; (10)

(ii) the minimum amount of fuel for the journey. (2)

(b) Determine the first derivative of the following function: (4)

$$R = h + 4\sqrt{h} - \frac{3}{h\sqrt{h}} + \frac{1}{h}$$

8. (a) Fig Q8(a) shows the graph of the function  $y = -\frac{1}{2}[x^4 + x^3 - 2x^2]$

Determine the area enclosed by the function and the  $x$  axis.

(10)

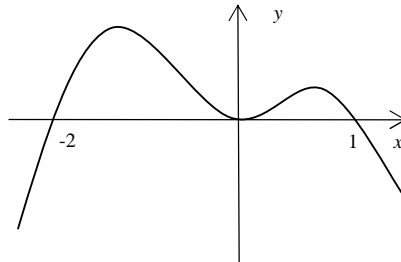


Fig Q8(a)

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

(6)

9. (a) (i) Determine the mass of a hemispherical copper container whose external and internal diameters are 28 cm and 26 cm respectively.

(4)

*Note: Copper weighs  $8.9 \times 10^3$  kg per  $m^3$ .*

- (ii) The entire surface of the container is given a protective coating.

Determine the total surface area to be covered.

(4)

- (b) Fig Q9(b) represents a regular pentagon of side 200 mm.

Calculate the shaded area.

(8)

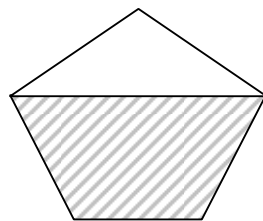


Fig Q9(b)