

**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 JULY 2018**

**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
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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) Given  $z = x + jy$ , where  $x$  and  $y$  are real, solve the following equation for  $x$  and  $y$ .

$$\frac{z}{1-j} + \frac{z}{j} = \frac{20}{3-j} \quad (8)$$

- (b) Given  $z_1 = 5\angle 20^\circ$ ,  $z_2 = 4\angle 30^\circ$  and  $z_3 = 2\angle 15^\circ$ ,

express  $\frac{z_1 + z_2}{z_3}$  as a complex number in polar form. (8)

2. (a) Calculate the mass of a metal containing 55% nickel which would be required to combine with 10 mg of pure nickel to form an alloy containing 85% nickel. (6)

- (b) Solve EACH of the following equations for  $x$ :

(i)  $\frac{3}{x+3} + \frac{2}{x-3} = \frac{5}{x-1}$  (6)

(ii)  $x^2 - 13x + 40 = 0$  (4)

3. Solve for  $x$  in EACH of the following equations:

(a)  $3^{1-x} = 2^{x+1}$  (8)

(b)  $\ln\left(\frac{3+x}{3-x}\right) = 1.25$  (8)

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

$$3a + b - 2c = 4$$

$$a - 2b + c = 6$$

$$7a - 6b - c = 10$$

(10)

- (b) The sag,  $y$  metres, in a cable of length  $L$  metres stretched between two supports,  $x$  metres apart, as illustrated in Fig Q4(b), is given by the formula:

$$L = \frac{8y^2}{3x} + x$$

Calculate the distance  $x$  when  $L$  is 75 m and  $y$  is 2.4 m.

(6)

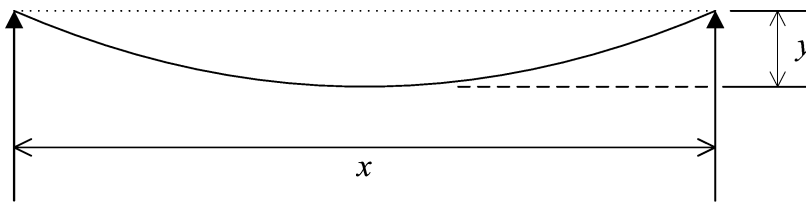


Fig Q4(b)

5. Variables  $P$  and  $V$  are thought to be related by a law of the form:

$$PV^n = C \text{ where } n \text{ and } C \text{ are constants.}$$

Observations of  $P$  and  $V$  are recorded in Table Q5.

- (a) Draw a straight line graph to verify this relationship.

(10)

P	15	20	30	40	50
V	4.42	3.55	2.60	2.06	1.74

Table Q5

*Suggested scales:* horizontal axis 2 cm = 0.1  
vertical axis 2 cm = 0.1

- (b) Use the graph drawn in Q5(a) to estimate the values of  $n$  and  $C$ .

(6)

6. In the diagram shown in Fig Q6, B and D represent the centres of two gear wheels.

An idler is to be placed at C.

Calculate the values of  $x$  and  $y$ .

(16)

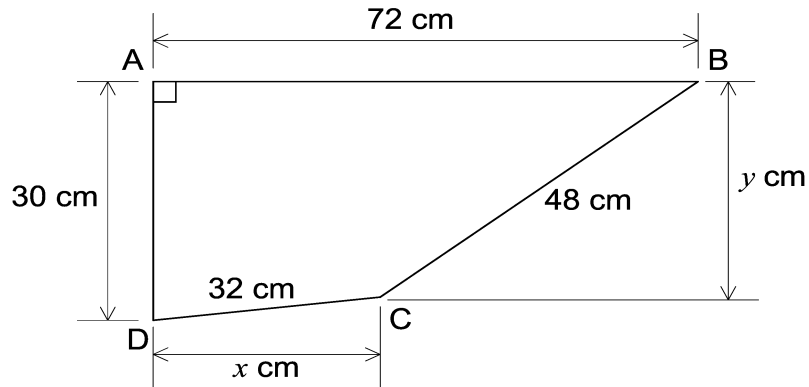


Fig Q6

7. (a) The rate  $R$ , in tonnes per hour, at which a particular vessel consumes fuel is given by:

$$R = 15 + 0.00048V^3, \text{ where } V \text{ is the speed of the vessel in knots.}$$

Determine EACH of the following for this vessel when it embarks on a passage of 500 nautical miles:

(i) the speed of the vessel which minimises the amount of fuel consumed; (10)

(ii) the minimum amount of fuel consumed. (2)

(b) Determine  $\frac{ds}{dt}$  given  $s = \frac{2(t^2 - t)}{\sqrt{t}}$ . (4)

8. (a) The work done during an adiabatic expansion follows the law  $PV^n = C$ , where  $C$  and  $n$  are constants, as the volume increases from  $V_1$  to  $V_2$ .

The work done can be represented by the shaded area in Fig Q8(a).

An amount of steam expands so as to satisfy the law  $PV^{1.13} = C$ .

Calculate the work done, in Joules, when the steam expands from a volume of  $0.2 \text{ m}^3$  at a pressure of  $850 \text{ kN/m}^2$  to a volume of  $0.5 \text{ m}^3$ . (12)

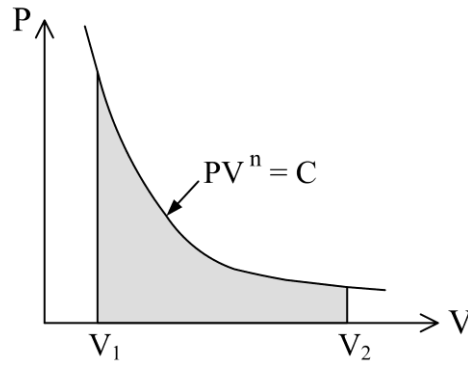


Fig Q8(a)

- (b) Evaluate  $\int_0^{\frac{\pi}{2}} \cos x \, dx$

(4)

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

(i) the binary operation  $11011 \times 1011$  ; (2)

(ii) the hexadecimal operation  $BC7E - 9ADF$  ; (1)

(iii) the conversion of  $DC4B_{16}$  to decimal; (2)

(iv) the conversion of  $1110111111_2$  to hexadecimal. (1)

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

$$X = \overline{A \oplus B + A \cdot B}$$

(i) without simplification, draw the circuit diagram for the expression, using only

XOR, NAND and NOR gates; (3)

(ii) simplify the expression as fully as possible. (4)

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

$$(\overline{C} + D) \cdot (C + D) \cdot \overline{E} \quad (3)$$