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, 28TH MARCH 2019

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

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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) Solve the following complex equation for a and b, where a and b are real numbers:

$$\frac{3+ja}{3+jb}=\frac{2a+b}{2b+j3}$$

(8)

(b) Two impedances, $Z_1 = 3 + j8$ and $Z_2 = 5 - j4$ are connected in series to a supply voltage, v, of 250 volts.

Calculate the current, i amperes, as a complex number in polar form, given that

$$i=\frac{v}{Z} \quad \text{where } Z=Z_1+Z_2$$

(8)

2. (a) The wind force, ω Newtons, on a vertical surface varies directly with the area of the surface, A m^2, and the square of the wind velocity, v knots. When the wind velocity is 20 knots, the force on a ship's vertical bridge window, of area 2 m^2 is 130 N.

Calculate the force on a similar window of area 1.8 m^2 when the wind velocity is 60 knots.

(6)

(b) Factorise fully EACH of the following:

(i) $12x^5 - 17x^4 + 6x^3$ (4)

(ii) $200 - 50x - 32x^2 + 8x^3$ (6)

3. (a) A hydrofoil, on a ferry run, takes 10 minutes to overtake a vessel on a parallel course 4 nautical miles ahead.

On the return journey, the hydrofoil takes 5 minutes to pass the same vessel which is still on the same course and speed, again from a distance of 4 nautical miles.

Calculate the speed of the hydrofoil and the vessel. (8)

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

$2x^2 - 3y^2 = 5$

$2x - 3y = 1$

(8)

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4. (a) The pressure in a particular life raft falls according to the formula $P_t = P_0 e^{-kt}$

where P_0 is the initial pressure, P_t is the pressure t hours after inflation and k is a constant.

When $t = 0$, the initial pressure is 100 units.

After 15 hours the pressure was 70 units.

If the pressure falls to 50 units or less, the raft is deemed unsafe.

Calculate EACH of the following for the raft :

(i) the value of k, correct to 3 decimal places; 0.019 (5)

(ii) the safe lifetime in hours, to the nearest hour, assuming the pressure is not topped up. 36 (5)

(b) Calculate the value of x, correct to 3 decimal places, such that

$$\log_e\left(2-\frac{1}{x}\right) = -0.3$$

(6)

5. (a) On the same set of axes plot the graphs, in intervals of 1, of $y = x^2 + 2x - 3$ in the range $-4 \le x \le 3$ and $y = 4 - x^2$ in the range $-3 \le x \le 3$

(12)

Suggested scales: *horizontal axis* 2 cm = 1
vertical axis 1 cm = 1

(b) Using the graphs drawn in Q5(a), solve the system of quadratic equations:

$y = 4 - x^2$

$y = x^2 + 2x - 3$

(4)

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6. A diesel engine has a vertical stroke of 280 mm and a connecting rod AB of length 530 mm as shown in Fig Q6.

Angle CAB is the angle between the vertical and the position of the connecting rod.

Twice during each down stroke of the piston angle CAB equals 10°.

Determine, *by calculation*, the piston travel between these two positions. (16)

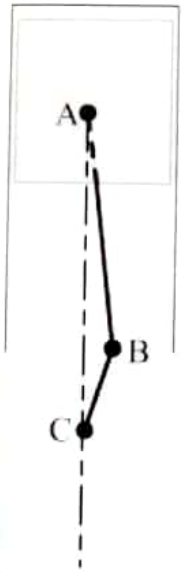

Fig Q6

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7. (a) The cost, £C per 10 metres, of laying a pipeline of cross–sectional area, x m^2, is given by

$$C = 2000x + \frac{500}{x}$$

Calculate EACH of the following for the pipeline:

(i) the cross-sectional area which minimises the cost per 10 metres; (8)

(ii) the minimum cost per 10 metres. (2)

(b) When a flywheel rotates through an angle of θ radians in t seconds, its angular velocity is given by $\frac{d\theta}{dt}$ radian/s, and its angular acceleration is given by $\frac{d^2\theta}{dt^2}$ radian/s^2.

For a certain flywheel $\theta = 21t - 1.5t^2$.

Determine EACH of the following for this flywheel :

(i) the angular velocity when $t = 5$; (3)

(ii) the time that elapses before the angular velocity is zero; (2)

(iii) the angular acceleration. (1)

8. (a) A gas expands in a cylinder according to the relationship $PV^{1.2} = 1480$. The initial volume of the gas is 0.05 m^3 and the final volume of the gas is 0.075 m^3.

Calculate the work done by the gas as it expands from 0.05 m^3 to 0.075 m^3. (8)

Note: the work done by the gas as it expands from V_1 to V_2 units of volume is W,

where $W = \int_{V_1}^{V_2} P\,dV$

(b) Given $\frac{d^2H}{dt^2} = 8 + \sin t - 2\cos t$ and $\frac{dH}{dt} = -2$ when $t = \frac{\pi}{2}$ and $H = 0$ when $t = 0$,

express H as a function of t. (8)

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9. (a) The logic circuit shown in Fig Q9(a) has three inputs A, B and C, and one output X.

Produce EACH of the following for this circuit:

(i) an unsimplified Boolean expression for X; (4)

(ii) the truth table, by simplifying as fully as possible the Boolean expression obtained for X in Q9(a)(i), or otherwise; (4)

(iii) the equivalent circuit with the minimum number of gates. (2)

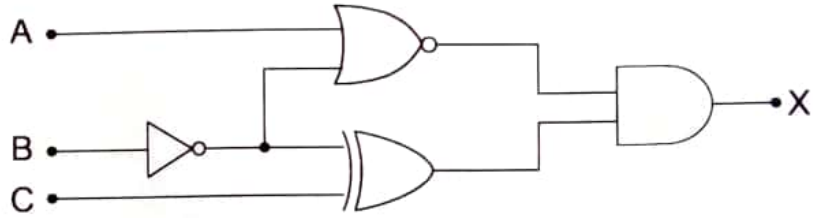

Fig Q9(a)

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

(i) the conversion of 101110_2 to decimal; (1)

(ii) the conversion of $DABE_{16}$ to decimal; (2)

(iii) the value, in hexadecimal form, of the operation $AB_{16} \div 10011_2$. (3)

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