CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-35 - MATHEMATICS

THURSDAY, 21 MARCH 2024

1315 - 1615 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination paper inserts:

Notes for the guidance of candidates:

1. Examinations administered by SQA on behalf of the Maritime & Coastguard Agency
2. Non-programmable calculators may be used.
3. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.
4. Candidates should note that 96 marks are allocated to this paper. To pass, candidates must achieve 48 marks.

Maritime & Coastguard Agency

SQA

MATHEMATICS

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

1. (a) Impedances $Z_1 = 10\angle 60°$ ohms and $Z_2 = 2\angle -30°$ ohms are connected in parallel to a voltage supply, v, of 200 volts.

Calculate the current, i amperes, as a complex number in cartesian form, given that $i = \frac{v}{Z}$ where $Z = \frac{Z_1 Z_2}{Z_1 + Z_2}$. $i = 96.66 + j32.69$ (10)

(b) Solve the following complex equation for x and y:

$$\frac{1}{0.2x - jy} = \frac{3 - j}{2 + j5}$$ $x = 0.5$, $y = -1.7$ (6)

2. (a) A ship's fuel consumption varies directly as the square of the ship's speed and indirectly as the calorific value of the fuel.

If the ship burns 90 tonnes of fuel per day of calorific value 48 MJ/kg when sailing at 20 knots, determine the daily consumption of the ship when using fuel of calorific value 44 MJ/kg and sailing at 22 knots. 113.8 tonnes (8)

(b) Fully factorise EACH of the following:

(i) $2x^3 - 3x^2 + 16x - 24$; (3)

(ii) $12x^3 - 3xy^2$; (2)

(iii) $9x^2 - 10x - 16$. (3)

3. (a) Solve for x in the following equation :

$$\frac{2x+3}{x+1} - \frac{4x+1}{x+3} = -1$$ $x = 9.196$ or $x = -1.196$ (8)

(b) Express the following as a single algebraic fraction in its simplest form :

$$\frac{2a+4b}{(a+3b)^2} \times \frac{a^2+ab-6b^2}{a^2-4b^2}$$ $= \frac{2}{(a+3b)}$ (8)

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4. (a) Given the formula :

$$\frac{T_1}{T_2} = \left[\frac{P_1}{P_2}\right]^{\frac{n-1}{n}}$$

$n = 1.801$

Calculate the value of n when $T_1 = 690$, $T_2 = 345$, $P_1 = 30$ and $P_2 = 1.5$. (8)

(b) Solve EACH of the following for x:

(i) $4e^{-0.5x} = 3$ $x = 0.5752$ (4)

(ii) $\log_e(e^x + 12) = 3.8$ $x = 3.4834$ (4)

5. (a) Draw the graph of $y = 3\sin\theta - \cos\theta$, in the range $0 \le \theta \le 4$, in intervals of 0.5 radians.

Suggested scales: *horizontal axis* 2 cm = 0.5
vertical axis 2 cm = 0.5 (10)

(b) Using the graph drawn in Q5(a), estimate the solution of the following equation for θ, in the range $0 \le \theta \le 4$:

$3\tan\theta = 1$ $\theta = 0.35$ radian and $\theta = 3.45$ radian (6)

$3\frac{\sin\theta}{\cos\theta} - 1 = 0$

$3\sin\theta - \cos\theta = 0$

$y = 0$

6. (a) Fig Q 6(a) shows a right angled triangle with its sides tangential to an inscribed circle.

Given AB = 60 cm and BC = 80 cm, calculate the diameter of the circle. (10)

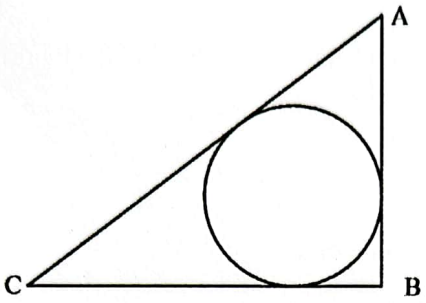

Fig Q6(a)

(b) An alternating current, i milliamps, is given by:

$i = 20\sin(100\pi t - 0.4)$ where t is the time in seconds.

Calculate the least value of t, $t > 0$, for which the current i = 12 milliamps. (6)

7. (a) A car wash operates daily from 1000 hours to 1730 hours.

The average queuing time, q minutes, for customers arriving x hours after opening time is given by the function $q = 0.2(2.5 + 7.5x^2 - x^3)$.

Calculate EACH of the following for this car wash:

(i) the busiest time of day; 15.00 hours. (8)

(ii) the expected queuing time at the busiest time. 13 minutes (2)

(b) Given $u = \dfrac{1-\sin^2\theta}{1-\sin\theta} - \cos\theta$, determine $\dfrac{du}{d\theta}$ and $\dfrac{d^2u}{d\theta^2}$ (6)

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8. (a) A body starts with an initial velocity of 2 ms^{-1} and its acceleration is $3 + 4t$ ms^{-2} where t is the time in seconds, from the start.

Given acceleration $a = \frac{dv}{dt}$ and velocity $v = \frac{ds}{dt}$, where s is the displacement of the body in metres, from the starting point, determine EACH of the following for the body:

(i) v as a function of t; (4)

(ii) its velocity after 5 seconds; (1)

(iii) its displacement, s, as a function of t; (4)

(iv) its displacement after 6 seconds. (1)

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

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 the outputs D, E and X in terms of the inputs A, B and C; (3)

(ii) the truth table, including columns for A,B,C,D,E and X; (3)

(iii) the simplest expression for X obtained in (i), by using Boolean algebra. (3)

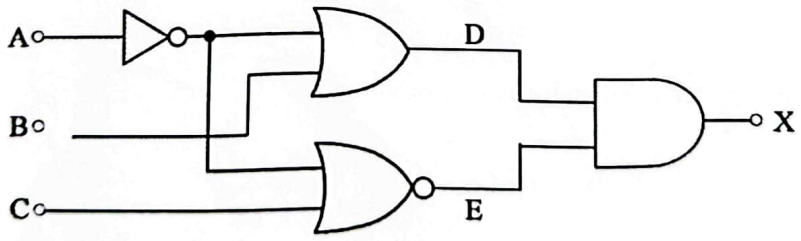

Fig Q9(a)

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

(i) the binary operation $1101101 - 1011010$; (1)

(ii) the binary operation 101110×101; (2)

(iii) the conversion of 1011101101_2 to hexadecimal; (2)

(iv) the conversion of 2766_{10} to hexadecimal. (2)