collect Friday

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY - MARINE ENGINEER OFFICER

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

040-35 - MATHEMATICS

THURSDAY, 27 AUGUST 2020

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

Maritime & Coastguard Agency

SQA

MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

Marks will not be awarded unless relevant working is CLEARLY shown

1. (a) Given $Z = x + jy$, where x and y are real, solve the following complex equation for:

x and y: $\dfrac{2Z}{1+j} - \dfrac{Z}{2-j} = 9 + j3$ (8)

(b) Solve the following complex equation for r and θ, where r and θ are real numbers:

$$r\angle\theta^\circ = \left(2\angle 40^\circ \times 4\angle 30^\circ\right) + \frac{10\angle 65^\circ}{5\angle 20^\circ}$$ (8)

2. (a) Three currents i_1, i_2 and i_3 in an electrical network are given by the following equations:

$i_1 + 2i_2 - 5i_3 = -6.53$

$2i_1 + 3i_2 - i_3 = -0.55$

$-3i_1 + i_2 + 4i_3 = 7.42$

Solve the system for i_1, i_2 and i_3 (10)

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

$$\frac{3}{x-1} - \frac{2}{x+2} - \frac{6}{x^2+x-2}$$ (6)

3. (a) The crippling load P for a solid steel rod varies directly as the fourth power of its diameter, d, and indirectly as the square of its length, L.

A steel rod, 3m long and 5cm in diameter, used as a strut, fixed at both ends, has a crippling load of 265.4kN.

Determine the crippling load of a similar strut, 2.6m long and 4.5cm in diameter. (8)

(b) The bending moment in Newton metres at a point in a beam is given by:

$$M = \frac{5x(15 - x)}{4}$$

where x metres is the distance from the point of support.

Evaluate x, correct to two decimal places, when the bending moment is 60Nm (8)

4. (a) The value £V of a standby generator after t years is given by:

$$V = 95000e^{-0.226t}$$

The generator is to be replaced when its value falls to its scrap value of £10000.

Determine EACH of the following for the generator:

(i) its cost when new; (2)

(ii) its value after 5 years; (2)

(iii) its expected lifetime to the nearest year. (6)

(b) Solve the following equation for x:

$$2^{x^2} = 8^{2x-3}$$ (6)

5. (a) During a gas engine test, of a given mass of gas contained in a cylinder, the values of pressure P (kPa) and the volume V (m^3) were recorded as shown in Table Q5.

Plot a straight line graph to verify that the relationship between P and V is the gas law $PV^n = C$, where n and C are constants. (10)

P	100	80	60	40	20
V	1.000	1.173	1.440	1.924	3.157

Table Q5

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

(b) Use the graph plotted in Q5(a) to estimate the value of n and C. (6)

6. Fig Q6 shows a double crank mechanism where AB is the frame.

The distance between the centres A and B is 16 cm.

The crank BC is 30 cm, the crank AD is 24 cm and the link CD is 25 cm.

In the position shown angle BAD is 135°.

Calculate the size of angle ABC for this position. (16)

Note: angle BCD *is not a right angle.*

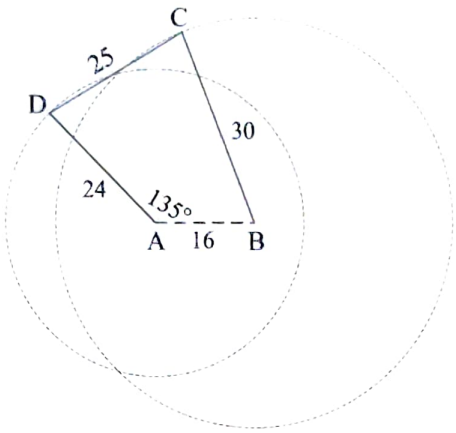

Fig Q6

7. (a) Bar staff in a pub are paid £8 an hour.

If the bar is understaffed the lost profit is £$\{\frac{512}{x}\}$ per hour, where x is the number of staff on duty.

Determine the staffing level which will minimise the total staffing cost per hour. (8)

(b) Given $P = 20x - 50\sin x$, solve EACH of the following for x in the range $0 \le x \le \pi$:

(i) $\frac{dP}{dx} = 0$; (5)

(ii) $\frac{d^2P}{dx^2} = 0$. (3)

8. The region in the first quadrant enclosed by the parabola $y = \frac{1}{4}x^2$, the x-axis and the line $x = 2$, is represented by the shaded region in Fig Q8.

Determine EACH of the following for the shaded region:

(a) its area; (4)

(b) the volume of solid of revolution formed by rotating it through one revolution about the x-axis; (6)

(c) the volume of solid of revolution formed by rotating it through one revolution about the y-axis. (6)

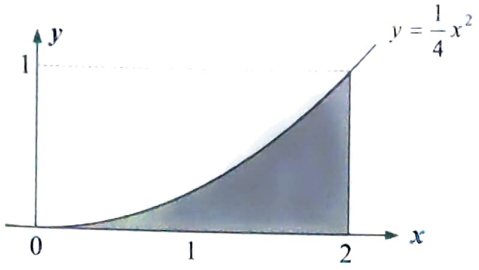

Fig Q8

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

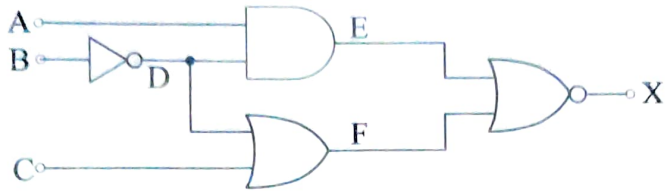

Fig Q9(a)

Produce EACH of the following for this circuit:

(i) an unsimplified Boolean expression for the output of EACH gate in terms of the inputs A, B and C; (4)

(ii) the truth table, including columns for A, B, C, D, E, F and X; (4)

(iii) the equivalent logic circuit using only NAND gates (*crossing out any redundant gates*). (4)

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

(i) the conversion of 7882_{10} to hexadecimal; (2)

(ii) the hexadecimal operation FAB7 – AC2B. (2)