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, 7 APRIL 2016

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

MATHEMATICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. (a) A job is advertised at a starting salary of £24 000 with an annual percentage increase of 5% plus an annual increment of £1 500.

Calculate the expected salary at the start of the fifth year in the job. (8)

(b) The distance of the visible horizon varies as the square root of the height of the eye above sea level.

The distance of the visible horizon observed from an oil platform is 19.12 nm when the height of the eye is 100 metres above sea level.

Calculate the height of the eye when the distance of the visible horizon is 14.34 nm. (8)

2. (a) Express y as a single fraction in its simplest form:

$$y = \frac{2x^2 + 8x}{2x^2 + 13x + 20} - \frac{2x^2 - 3x}{2x^2 + 3x - 9}$$ (10)

(b) Solve for z in the following equation:

$$\frac{z+1}{z+2} = \frac{2z-1}{2z-3}$$ (6)

3. (a) The minimum diameter, d, of a shaft with rotational frequency f and subjected to a bending moment M and torque T can be derived from the formula:

$$\mathrm{d}^2 = \frac{16}{\pi f}\left(M + \sqrt{M^2 + \mathrm{T}^2}\right)$$

Transpose this formula to make M the subject. (8)

(b) Factorise EACH of the following as fully as possible:

(i) $x^2 - y^2 - 6x + 9$ (4)

(ii) $20\mathrm{a}^3\mathrm{b}^3 - 36\mathrm{a}^2\mathrm{b}^2 - 8\mathrm{ab}$ (4)

4. (a) U^{235} is a radioactive isotope used in a nuclear propulsion system.

It decays into lead according to the law:

$m = m_0 e^{kt}$, where m_0 is the original mass of U^{235} present and m is the mass present after t years.

The time taken for half of the isotope to decay (i.e. its half-life) is 7.04×10^8 years.

Determine EACH of the following:

(i) the value of k; (5)

(ii) the time taken for a 100 mg sample of U^{235} to reduce to 99 mg. (3)

(b) Solve the following equation for x:

$4^x \times 10^{2x+1} = 3^{x+1}$ (8)

5. During a trial run towing a barge, the values of pull, P kN, and speed, V knots, were recorded as shown in Table Q5.

(a) By drawing a straight line graph verify that P and V are related according to the law:

$P = kV^n$ where k and n are constants. (10)

V	2.3	2.8	3.5	4.0	4.7
P	178	254	379	483	645

Table Q5

Suggested scales: *horizontal axis* 5 cm = 0.1
vertical axis 2 cm = 0.1

(b) Use the graph drawn in Q5(a) to determine approximate values for k and n. (6)

6. Fig Q6 shows a double crank mechanism.

The distance between the centres A and B is 50 cm.

The crank BC is 10 cm and the crank AD is 20 cm.

In the position shown the length DC is 56 cm and angle ABC is 140°.

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

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

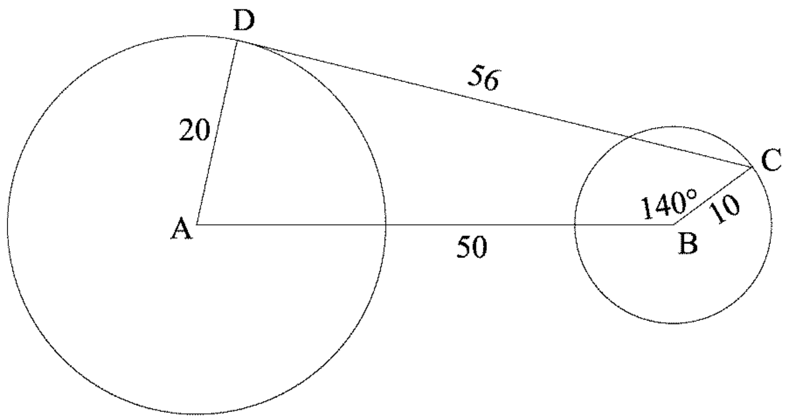

Fig Q6

7. (a) The cost of pumping crude oil to a refinery is related to the radius of the transport pipeline.

For a pipeline of radius r centimetres, the cost per day, C in £thousands, is given by

$$C = r + \frac{2025}{r} + 6$$

Calculate EACH of the following:

(i) the radius which minimises the cost; (8)

(ii) the minimum cost per day. (2)

(b) Determine the first and second derivatives of the function:

$$y = x^3 + \sqrt{x} + 2e^x$$ (6)

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8. A dam is to be built to contain water in a new reservoir.

Relative to axes, as shown in Fig Q8, the inner and outer walls can be represented by parts

of the graphs of $y = \frac{1}{4}x^2$, $0 \le x \le 10$, and $y = 95 - 5x$, $x \ge 14$.

The shaded area represents the constant cross-section of the dam wall.

Calculate EACH of the following for the dam wall, given that the dimensions are in metres:

(a) its height; (2)

(b) its cross-sectional area; (12)

(c) its volume, given that it is 200 m in length. (2)

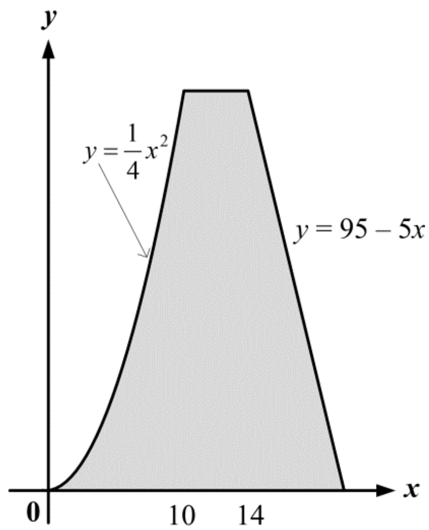

Fig Q8

9. A vessel has a water plane area made up of an entrance with a bulbous bow and truncated triangle, a parallel body and a square stern section, as shown in Fig Q9 (which is not drawn to scale).

The water plane area of the bulbous bow is in the shape of a major segment of a circle.

Calculate the total water plane area of the vessel. (16)

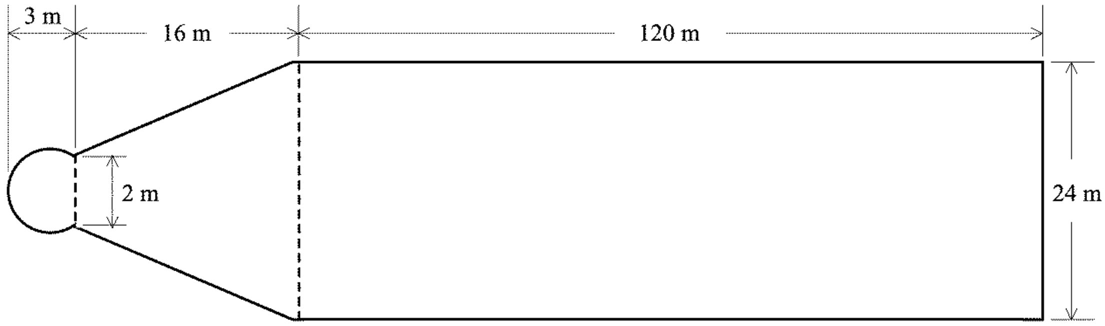

Fig Q9 (not to scale)