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 SECOND ENGINEER REG. III/2 (UNLIMITED)

042-23 – MATHEMATICS

THURSDAY, 30 MARCH 2017

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 lubricating oil tank in a ship is filled to its maximum capacity of 1832 litres.

Oil consumption is 48 litres per day for the first 16 days and 56 litres per day thereafter.

Determine EACH of the following:

(i) the oil consumed after 20 days as a percentage of the full tank; (4)

(ii) the total number of days before the tank is empty. (4)

(b) A self-propelled barge is scheduled to complete a passage of 432 nautical miles at an average speed of 8 knots.

It covered the first third of the passage at an average speed of 9 knots.

Heavy weather during the remainder of the passage resulted in the barge arriving at its destination 7 hours late.

Calculate the average speed of the barge over the remainder of the passage. (8)

2. (a) A ship's No.1, No.2 and No.3 holds contain 2500 tonnes, 3050 tonnes and 4250 tonnes of cargo, respectively.

The cargoes of the three holds are to be redistributed so that the No.2 contains twice the load of the No.1 and the No.3 contains twice the load of the No.2.

Calculate the amount of cargo to be transferred to the No.3 from EACH of the No.1 and No.2 holds. (8)

(b) The amount of energy stored in flywheels of similar shapes is directly proportional to the squares of their speeds and to the fifth power of their diameters.

One wheel has a diameter 1.48 times that of the other and runs at 0.84 of the speed.

The smaller wheel stores 6.75 kJ.

Calculate the energy stored in the larger wheel. (8)

3. (a) Solve the following system of equations for x and y:

$2x^2 + y = 5$

$x + 4y = 13$ (10)

(b) The voltage drop, V, across an electronic component can be calculated using the equation $V = 4.5e^{-0.15t} \sin 0.2t$, where V is the voltage drop in millivolts and t is the time in seconds after the actuating switch is closed.

Determine the voltage drop 40 seconds after closure of the actuating switch. (6)

4. (a) The time, t hours, to charge a certain mobile phone to a level C (expressed as a decimal fraction of the battery's full charge) is given by:

$t = -2.5 \ln(1 - C)$

Determine EACH of the following for this mobile phone:

(i) the percentage of the full charge achieved after charging for $4\frac{1}{2}$ hours. (6)

(ii) the time taken, to the nearest $\frac{1}{4}$ hour, to achieve 90% of full charge. (4)

(b) Express the following in its simplest form:

$$\left(\frac{x^{\frac{3}{4}}}{y^{-\frac{2}{3}}}\right)^3 \times \sqrt{\frac{y^6}{x^{-\frac{3}{2}}}}$$ (6)

5. The temperature, T°C, of a cooling liquid was recorded at regular intervals of time, t minutes, as shown in Table Q5.

The relationship between T and t is given by the formula:

$T = T_0 e^{at}$ where a and T_0 are constants.

(a) Draw a straight line graph to verify this relationship. (8)

T	89.3	56.9	36.3	23.1	14.8
t	10	20	30	40	50

Table Q5

Suggested scales: *horizontal axis* 2 cm = 5
vertical axis 2 cm = 0.2

(b) Use the graph drawn in Q5(a) to determine EACH of the following:

(i) approximate values of a and T_0 ; (4)

(ii) the temperature after 25 minutes; (2)

(iii) the time taken for the temperature to fall to 20.1°C. (2)

6. (a) Given:

$\dfrac{ds}{dt} = 3t^2 - 2t + 5$ and $s = 9$ when $t = 2$:

(i) express s as a function of t ; (6)

(ii) determine s when $t = 3$. (2)

(b) Evaluate EACH of the following:

(i) $\displaystyle\int_1^4 3\sqrt{x}\,dx$ (4)

(ii) $\displaystyle\int_0^{\frac{\pi}{4}} (\cos\theta + \sin\theta)\,d\theta$ (4)

[OVER

7. An open rectangular test tank, with square ends of side x metres and a volume of 3136 m^3, is shown in Fig Q7.

The tank was constructed at a cost £60 per square metre for the base and £40 per square metre for the vertical sides and ends.

Determine EACH of the following for the tank:

(a) the length in terms of x; (2)

(b) the total construction cost in terms of x; (7)

(c) the dimensions, given that the construction cost was minimised. (7)

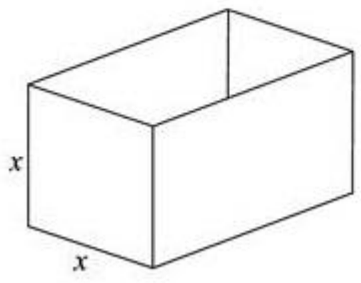

Fig Q7

8. (a) An idler gear 16 cm in diameter has to be fitted between a 50 cm diameter driving gear and a 70 cm diameter driven gear as shown in Fig Q8(a).

AC is 65cm.

Calculate the size of angle ACB. (8)

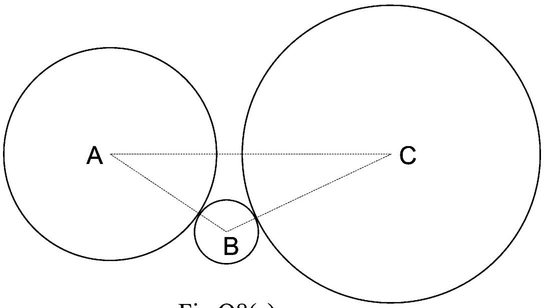

Fig Q8(a)

(b) The depth of water, *h* metres, over a rock on a particular day, is given by:

$$h = 4 + 3\cos\frac{\pi t}{6}$$

where *t* is the number of hours after local high-water.

Determine EACH of the following for that day:

(i) the minimum depth of water over the rock; (2)

(ii) the time when the minimum depth occurs; (3)

(iii) the clearance a yacht of draught 2 metres has when it passes over the rock four hours after local high water. (3)

[OVER

9. (a) A block of copper with a mass of 18 kg is drawn out to make 150 metres of wire of uniform cross-section.

The density of copper is 8.93 g/cm^3.

Calculate EACH of the following:

(i) the volume of the wire if 4% is lost through wastage; (4)

(ii) the diameter of the wire in millimetres. (6)

(b) The square ABCD of side 15 cm is drawn within a circle as shown in Fig Q9(b).

Calculate the area of the shaded segment. (6)

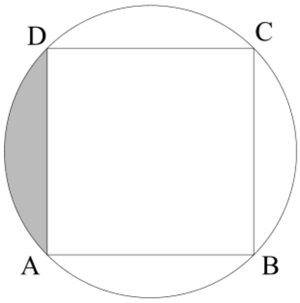

Fig Q9(b)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 042-23 Mathematics

DATE: March 2017 Diet

General Comments on Examination Paper

A relatively straightforward paper.
Due to the small population size no valid statistical inferences may be drawn.

General Comments of Specific Examination Questions

2. (b) A number of candidates attempted to calculate the constant of proportionality, rather than equating expressions for the constant.

3. (b) Most candidates evaluated the trig. function with the angle in degrees rather than radians.

4. (b) A number of candidates had difficulty with arithmetic operations involving fractional indices.

6. (a)(i) Some candidates differentiated instead of integrating.

8. (b) Most candidates did not demonstrate a knowledge or understanding of a cosine wave.

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

042-23 – MATHEMATICS

THURSDAY, 15 DECEMBER 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) In manufacturing an engineering component the costs of labour and materials are in the ratio 7:3.

The component is sold at £5568 producing a profit of 16%.

Determine EACH of the following:

(i) the cost of the materials; (4)

(ii) the percentage increase in material costs when labour costs increase by 5%, the percentage profit is $12\frac{1}{2}$% and the selling price is £5832. (6)

(b) A cable 200 m long has to be cut into four lengths.

Three of the lengths are to be equal and the fourth length must be 10 m shorter than the sum of the equal lengths.

Calculate the length of the longer piece. (6)

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

$4a + 6b - 5c = -3$

$5a + 2b + 3c = 13$

$15a + 4b - 8c = -16$ (10)

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

(i) $12r^2 + r - 6$; (3)

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

[OVER

3. (a) The lengths of the sides of a right-angled triangle are $2x - 3$, $5x$ and $5x - 1$ cm.

Determine the value of x. (8)

(b) Solve the following equation for x, $x > 0$, correct to 2 decimal places:

$$\frac{2x-1}{x+2} = \frac{3x-2}{x+1} + 1$$ (8)

4. (a) A formula associated with a thermodynamic process is given by:

$$\frac{T_1}{T_2} = \left(\frac{p_1}{p_2}\right)^{\frac{n-1}{n}}$$

Calculate the value of n when $T_1 = 740$, $T_2 = 296$, $p_1 = 30$, and $p_2 = 1.2$. (8)

(b) Solve for s in the following logarithmic equation:

$$ln \left(\frac{4-s}{3-s}\right) = 0.75$$ (8)

5. (a) Draw the graph of the function $y = \tan x$ for the range $1.2 \leq x \leq 1.45$ radians, in intervals of 0.05 radians. (10)

Suggested scales: *horizontal axis* 2 cm = 0.05
vertical axis 2 cm = 1

(b) By plotting a suitable straight line on the graph drawn in Q5(a), solve the equation:

$4x = \tan x$ (6)

6. A patrol boat is due north of a vessel at a distance of 40 nautical miles.

The vessel is making good a steady course of 120° at 15 knots.

The patrol boat intercepts the vessel after 3 hours.

Calculate the course and speed made good by the patrol boat. (16)

7. (a) A stainless steel tank is to be fabricated in the shape of a triangular prism with a regular tetrahedron at each end, as shown in Fig Q7(a).

The length of each edge of the tetrahedron is x metres.

The external surface area, A, of the tank is given by:

$$A = \frac{3\sqrt{3}}{2}\left(x^2 + \frac{16}{x}\right)$$

Determine EACH of the following for the tank:

(i) $\dfrac{dA}{dx}$; (3)

(ii) the value of x which minimises the external surface area;
Verify that the result obtained gives minimum surface area. (5)

(iii) the minimum external surface area. (2)

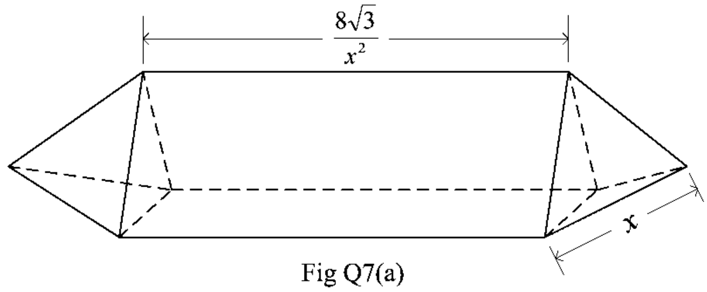


Fig Q7(a)

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

For a certain flywheel $\theta = 27t - 3t^2$.

Determine EACH of the following for this flywheel:

(i) the angular velocity when $t = 4$; (3)

(ii) the angular acceleration; (1)

(iii) the time that elapses before the angular velocity is zero. (2)

[OVER

8. An architectural feature of a grey sandstone building is a rectangular wall, 6 m × 5 m, with an arched window.

The curved edge of the window is part of the parabola with equation $y = 3x - \frac{1}{2}x^2$, as shown in Fig Q8.

Determine EACH of the following:

(a) the area of the window; (10)

(b) the area of the sandstone; (2)

(c) the distance of the top of the window from the base. (4)

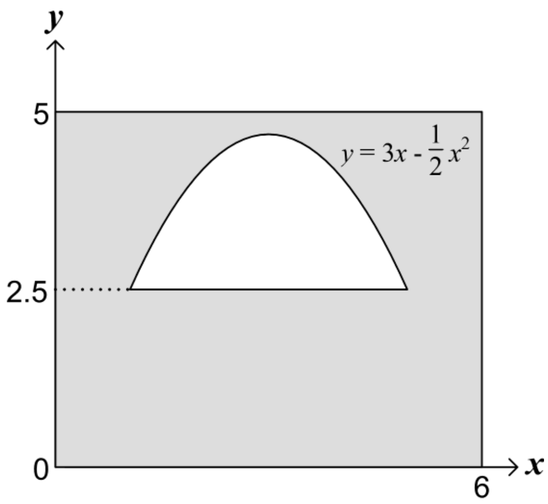


Fig Q8

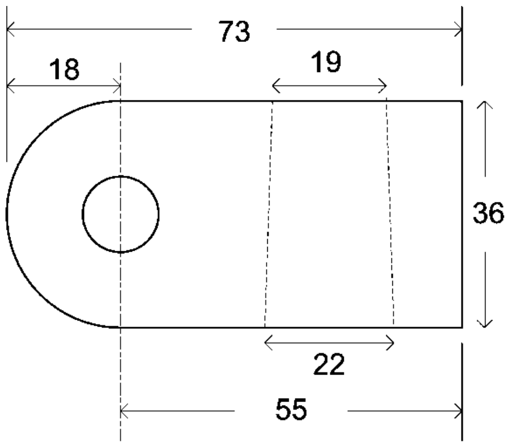
9. A tiller head fitting for a yacht is to be made from a solid block of stainless steel, density 8g /cm^3, as shown in Fig Q9.

A hole of diameter 12 mm is drilled horizontally along the axis of curvature of the left hand side of the block.

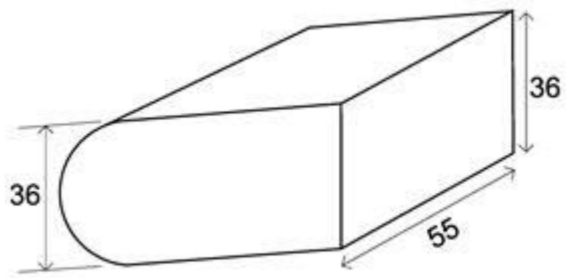
A tapered square hole is slotted vertically through the block, having sides of 19 mm at the top and 22 mm at the bottom.

The holes are set apart from each other.

Calculate the mass of the fitting. (16)

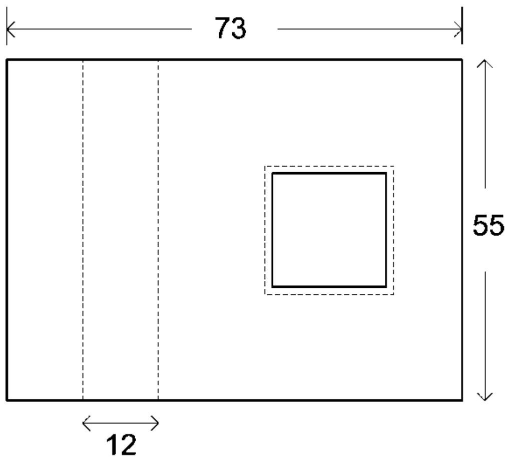


Front elevation



Original block

Dimensions in mm



Plan

Fig Q9

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM
PART I

SUBJECT: 042-23 Mathematics

DATE: December 2016 Diet

General Comments on Examination Paper

A relatively straightforward paper.

General Comments of Specific Examination Questions

1. (a) Many candidates interpreted the percentage profit as a percentage of the selling price rather than the manufacturing cost.

2. (a) A number of candidates had difficulty with the subtraction of negative numbers.

3. (a) A number of candidates had difficulty identifying the length of the hypotenuse in terms of x.

   (b) Many candidates did not round off the solution as required.

4 Attempted by almost all candidates, achieving mainly good results.

5. (b) Only a few candidates graphed the line $y = 4x$.

6. A number of candidates were unable to produce a suitable diagram.

7. (a) A number of candidates neglected to verify that the stationary point at $x = 2$ is a min. tp.

8. (a) Attempted by eleven candidates but most did not recognise the area of the window as the area enclosed by the curve $y = 3x - \frac{1}{2}x^2$ and the straight line $y = 2.5$.

9. Attempted by 20% of the candidates, with relatively poor results. Most were unable to calculate the volume of the truncated square based pyramid.

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

042-23 – MATHEMATICS

THURSDAY, 20 OCTOBER 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) Two ships heading on reciprocal courses pass each other.

One ship has a speed of 6.5 knots greater than the other.

Three hours after passing each other the ships are 111.3 nautical miles apart.

Calculate the speed of EACH ship. (8)

(b) A ship's fuel consumption varies inversely as the calorific value of the fuel and directly as the square of the ship's speed.

The ship burns 28 tonnes of fuel per day of calorific value 42MJ/kg when sailing at 14 knots.

Determine the daily consumption when the ship is burning fuel of calorific value 44 MJ/kg and sailing at 17 knots. (8)

2. (a)

$$Y = \frac{5x-10}{2x^2+3x-2} + \frac{x}{2x-1} - \frac{4}{x+2}$$

Express Y as a single fraction in its simplest form. (8)

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

$$\frac{a-1}{4} + \frac{b}{3} = 8$$

$$5a - 3b = 20$$ (8)

3. (a) The value, V, in thousands of pounds, of a propulsion unit after t years is given by:

$$V = 275e^{-0.085t}$$

Calculate EACH of the following for the propulsion unit:

(i) the initial value; (2)

(ii) the number of complete years before its value is less than £100k. (6)

(b) Use laws of indices to simplify EACH of the following:

(i) $\left[\dfrac{75a^{\frac{3}{8}}}{25a^{\frac{1}{4}}}\right]^4$ (4)

(ii) $\left[\dfrac{x^2}{y^4}\right]^{-\frac{1}{2}} \times \left[\dfrac{y^3}{x^{-6}}\right]^{\frac{1}{3}}$ (4)

4. (a) Solve the following equation , for $x > 0$, correct to 3 decimal places:

$$8x = \frac{50 + 3x^2}{15 + x}$$ (8)

(b) Transpose the following formula to make a the subject:

$$T = 2\pi\sqrt{\frac{a^2 + b^2}{gh}}$$ (8)

5. The luminosity, I, of an electric lamp with varying voltage, v, is shown in Table Q5.

v	50	70	90	110	130	150
I	4.66	18.20	52.97	109.65	208.45	364.75

Table Q5

(a) Draw a straight line graph to show that I and V are related by a law of the form

$I = av^n$,where a and n are constants. (10)

Suggested scales: *horizontal axis* 2 cm = 0.1
vertical axis 2 cm = 0.2

(b) Using the graph drawn in Q5(a), determine approximate values for a and n. (6)

6. (a) Fig Q6(a) represents a load suspended by a jib crane.

The tie rod AC is 10 metres long, AB is 5.5 metres long and angle CAB is 140°.

Calculate EACH of the following:

(i) the length of the jib BC; (6)

(ii) the angle between the jib and the tie rod. (4)

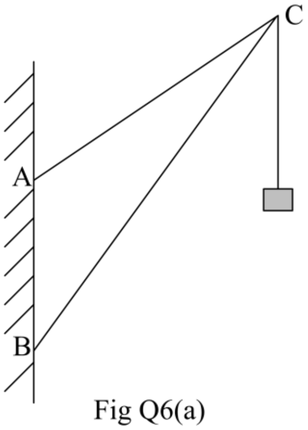

Fig Q6(a)

(b) Given:

$$i = \sqrt{3 - 2\sin t}$$

Determine the smallest positive value of t when $i = 2.2$. (6)

Note: the angle is in radian measure.

[OVER

7. (a) The yearly profit, P thousand pounds made by a company and the amount, x thousand pounds spent on advertising for the year, are related by:

$P = 8x^3 - x^4$

Calculate EACH of the following:

(i) the amount to spend on advertising to maximise the profit; (8)

(ii) the maximum yearly profit. (2)

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

$$v = \frac{1 - \sin^2 \theta}{1 + \sin \theta}$$ (6)

8. (a) Use integral calculus to determine the volume of solid of revolution obtained when the shaded area enclosed by the function $y = \sqrt{9 - x^2}$ and the x-axis, as shown in Fig Q8(a), is rotated about the x-axis through one complete revolution. (10)

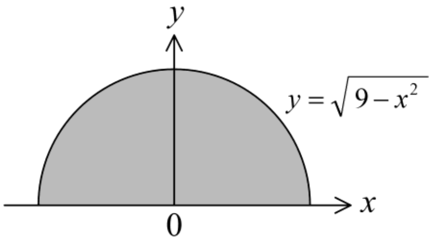

Fig Q8(a)

(b) Evaluate:

$$\int_1^4 \frac{2.8}{v^{1.4}}\, dp$$ (6)

9. A right solid steel cone, height 15 cm and base diameter 10 cm, is placed base down in a cylindrical container, 16 cm diameter.

Water is poured into the container until the water is halfway up the cone.

The cone is then removed.

Calculate the resulting drop in water level. (16)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM
PART I

SUBJECT: 042-23 Mathematics

DATE: October 2016 Diet

General Comments on Examination Paper

A relatively straightforward paper.

General Comments of Specific Examination Questions

1. (a) A few candidates misinterpreted "6.5 knots greater than" as "6.5 times greater than".

2. In (a) a number of candidates did not factorise $2x^2 + 3x - 2$, leading to a more complex expression for Y.

3. (a) A number of candidates used t = 1 to determine the initial value (instead of t = 0) and / or inserted a factor of 1000 unnecessarily.

   (b)(i) A number of candidates did not raise the numerical factors to the power of 4.

4. (a) A number of candidates worked to only 3 or fewer decimal places and in general rounding off accurately appeared to be ignored. The quadratic formula was inaccurately stated on occasion.

5. A number of candidates produced a curve using the raw data.

6. (b) A number of candidates produced a result in degrees rather than in radians.

7. (a) A number of candidates neglecting to verify that the stationary point at $x = 6$ is a max. tp.

8. (a) A number of candidates squared y twice.

9. Attempted by a few candidates, with relatively good results.

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

042-23 – MATHEMATICS

THURSDAY, 14 JULY 2016

1315 - 1615 hrs

Examination paper inserts:

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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 2400 litre water tank can be filled by two supply pipes A and B working together in 30 minutes.

   On its own, pipe A can fill the tank in 32 minutes less than pipe B.

   Calculate the rate of flow of water from each pipe. (10)

   (b) Make R the subject of the formula:

   $$T = 2\pi\sqrt{\frac{L}{g}\left(L + \frac{R^2}{r^2}\right)}$$ (6)

2. (a) Determine the value of z, $(z > 0)$, which satisfies the equation:

   $$\frac{3z}{z+1} - \frac{2}{z+2} = 1$$ (8)

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

   $$x^2 + y^2 + 6x - 6y - 7 = 0$$

   $$y + 1 = 2x$$ (8)

3. (a) The modulus of rigidity, G, is given by:

   $G = \dfrac{R^4\theta}{L}$, where R is the radius, θ the angle of twist and L the length.

   Calculate the percentage error in G when R is measured 1.5% too small, θ is measured 1% too small, and L is measured 1.6% too large. (8)

   (b) Given $y = 32$, solve the following equation for x, correct to 3 decimal places:

   $$y = \frac{25}{3x} + x$$ (8)

4. (a) Solve the following equation for t, $0 < t < 2$:

$ln\,(12 - 3t^2) = -\,0.78$ (6)

(b) Express the following in its simplest form:

$$5a\sqrt{9b^4} + 4b\left(\sqrt[3]{8a^3b^3}\right) - 7\left(\sqrt[4]{a^4b^8}\right)$$ (6)

(c) Evaluate the following, without the using mathematical tables or calculator:

$$\frac{log\,27 - log\,9}{2\,log\,3}$$ (4)

5. The current, i, in an electrical component, was recorded at regular intervals of time t.

The results are shown in Table Q5.

(a) Draw a straight line graph to show that i and t are related by a law of the form

i = ae^{-kt} where a and k are constants. (10)

t	0	2	4	6	8
i	4.95	3.39	2.27	1.52	1.01

Table Q5

Suggested scales: *horizontal axis* 2 cm = 1
vertical axis 2 cm = 0.2

(b) Using the graph drawn in Q5 (a), determine approximate values for a and k. (6)

6. Fig Q6 shows part of a mechanism.

AB is a link 77 cm long which has a block pivoted to each end.

The blocks can slide in grooves as shown.

The point of intersection of the line of centres is at C.

Initially, BC = 52.3 cm and AC = 38.5 cm.

Calculate EACH of the following:

(a) the angle between the line of centres (i.e. angle BCA); (4)

(b) the inclination of AB to AC; (3)

(c) the distance A moves if block B moves 16 cm towards C from the given position. (9)

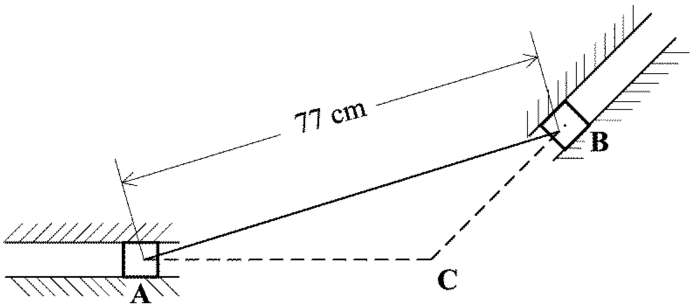

Fig Q6

7. (a) Use differential calculus to determine EACH of the following for the function

$y = x^3 - 3x^2 - 9x + 10$

(i) the coordinates of the turning points; (7)

(ii) the nature of the turning points. (3)

(b) The area, A cm^2, of a pool of oil under a leaking sump is given by

$A = t + \frac{t^2}{16}$ where t is the time in minutes.

Calculate EACH of the following for the pool of oil after 20 minutes:

(i) the area; (2)

(ii) the rate the area is growing. (4)

[OVER

8. (a) The velocity v, in ms^{-1}, of a particle at time t, in seconds, is given by

$$v = \frac{ds}{dt} = 30 - 8t$$

Given $s = 0$ when $t = 0$, determine EACH of the following :

(i) s in terms of t; (5)

(ii) the distance travelled in 4 seconds from $t = 0$. (2)

(b) Integrate EACH of the following functions, with respect to the given variable:

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

(ii) $2\theta + 3\cos\theta - 4\sin\theta$. (3)

(c) Evaluate $\int_1^2 \frac{4}{x^2}\, dx$ (4)

9. A paper cup has internal dimensions: height 12 cm, top diameter 9 cm, and bottom diameter 6 cm, as shown in Fig Q9.

Water is poured into the cup to a depth of 7 cm.

(a) Calculate the surface area of the water. (8)

(b) A sphere submerged in the water increases the depth to 10 cm.

Calculate the diameter of the sphere. (8)

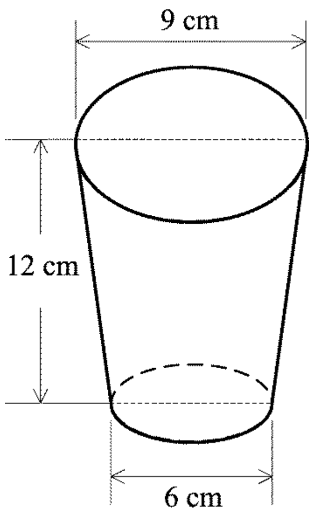

Fig Q9

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM
PART I

SUBJECT: 042-23 Mathematics

DATE: July 2016 Diet

General Comments on Examination Paper

A relatively straightforward paper.
A few candidates were not well-prepared.

General Comments of Specific Examination Questions

1 Attempted by ~ 2/3 of the candidates, with relatively poor results for part (a).

2. Attempted by all candidates, with relatively good results.

4. Attempted by most candidates, with relatively good results.

6. Trig. Question. Attempted by ~ 1/3 of the candidates, with relatively good results for parts (a) & (b) but relatively poor results for part (c).

7. Differential Calculus questions. Attempted by 80% of the candidates with relatively good results for part (a) but relatively poor results for part (b), possibly due to the practical nature of the problem.

8. Integral Calculus questions. Attempted by ~ 1/2 of the candidates, with relatively good results for part (b) but relatively poor results for part (a), possibly due to the practical nature of the problem.

9. Mensuration type question. Attempted by five candidates, with mainly poor results.

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.*

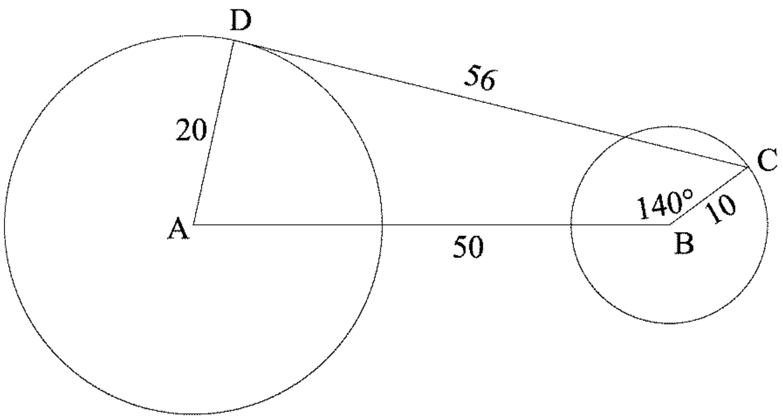

Fig Q6

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)

[OVER

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 $y = \frac{1}{4}x^2$, $0 \leq x \leq 10$, and $y = 95 - 5x$, $x \geq 14$.

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)

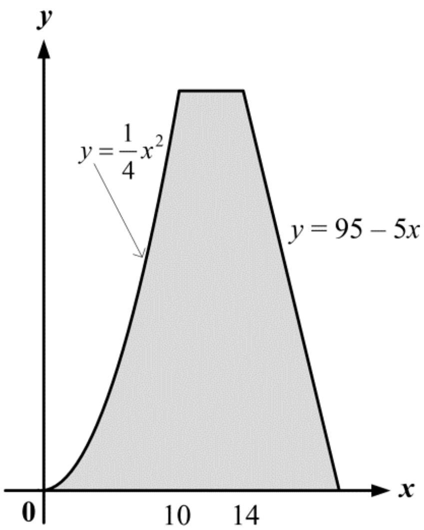

Fig Q8

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)

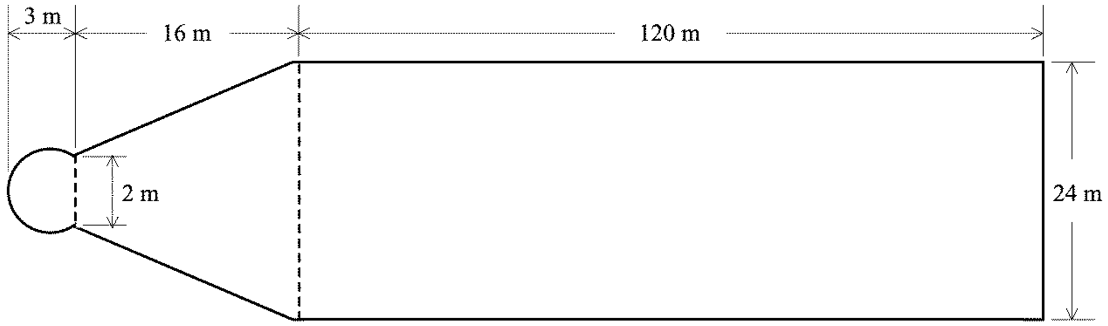

Fig Q9 (not to scale)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 042-23 Mathematics

DATE: 7 April 2016

General Comments on Examination Paper

A relatively straightforward paper.
A number of candidates were not well-prepared (~ 30%).

General Comments of Specific Examination Questions

1 (a) A number of candidates assumed that the annual percentage increase produced the same cash increase per annum.

(b) A number of candidates did not recognise this as a variation type problem.

3. Attempted by all candidates, with relatively poor results.

4. Attempted by most candidates, with relatively good results.

6. Trig. question, attempted by < 25% of the candidates, with relatively good results.

7. Differential Calculus problem attempted by 75% of the candidates, with fairly good results.

8. Integral Calculus problem attempted by ~ 25% of the candidates, with relatively good results.

9. Mensuration type question, attempted by 1/3 of the candidates, with very poor results.

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, 17 DECEMBER 2015

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 dealer buys 45 portable welding machines at £260 each.

One third of the machines were sold at a profit of 40% and the remainder were sold at a profit of 20%.

Calculate the overall percentage profit. (6)

(b) The fuel consumption per unit of time, C, of a ship, is directly proportional to the cube of its speed *v*.

On a particular day the ship's speed is increased by 8% above normal for 5 hours, decreased by 12% for 10 hours and is normal for the remaining 9 hours.

Calculate the percentage decrease in the fuel consumption below normal for that day. (10)

2. (a) A communications mast stands vertically on a horizontal base area.

An anchor point on the base area is 20 m from the foot of the mast.

The distance from the anchor point to the top of the mast is 5 m more than the height of the mast.

Calculate the height of the mast. (6)

(b) Solve the following equation for *x*:

$$\frac{(3x+1)(2x-1)}{3x(x-1)} - 2 = 0$$

(6)

(c) Fully factorise:

$a^2 b - 3a^2 - 4b + 12$ (4)

[OVER

3. The general equation of a circle is $x^2 + y^2 + 2gx + 2fy + c = 0$, where g, f and c are constants.

The points (1, 8), (-2, -1) and (2, 1) lie on the same circle.

Determine EACH of the following for this circle:

(a) the values of g, f and c; (13)

(b) the radius, r, given that $r = \sqrt{g^2 + f^2 - c}$ (3)

4. (a) The pressure, P units, in a defective tyre, t hours after being inflated to a pressure of 50 units, is given by:

$P = 50e^{-0.01kt}$ where k is a constant.

After 24 hours the tyre pressure falls to 40 units.

Calculate EACH of the following:

(i) the value of k, correct to 3 decimal places; (4)

(ii) the tyre pressure after 48 hours; (2)

(iii) the tyre pressure after 1 week. (2)

(b) Solve for x, $x > 0$, in the following equation:

$$3^{x^2} = 27^{x+1}$$ (8)

5. The current, I milliamps, and the voltage, V volts, recorded during an experiment are shown in Table Q5.

(a) Using the values in Table Q5, draw a straight line graph to show that I and V are related by a law of the form $I = aV + bV^2$ where a and b are constants. (10)

V	10	30	50	70	90
I	0.6	5.0	13.0	24.9	41.4

Table Q5

Suggested scales: *horizontal axis* 2 cm = 10
vertical axis 5 cm = 0.1

(b) Using the graph drawn in Q5(a), determine approximate values for a and b. (6)

6. A ship leaves port A and sails for $2\frac{1}{2}$ hours on a course 210°.

It then sails for 4 hours on a course 105° to reach port B.

The ship sails at a constant speed of 16 knots throughout the passage.

Calculate EACH of the following:

(a) the total distance covered; (4)

(b) the distance of port A from B; (6)

(c) the bearing of port A from B. (6)

7. (a) The drag, *D*, acting on an aircraft operating under certain conditions, is given by:

$$D = aV^2 + \frac{b}{V^2}$$

where V is the airspeed of the aircraft and a and b are positive constants.

Determine the value of V, in terms of a and b, for minimum drag. (8)

(b) Differentiate EACH of the following functions:

(i) $y = x^2 + 2x - \frac{1}{x} + \frac{4}{\sqrt{x}}$; (4)

(ii) $v = 10 - t + 5\sin t - 3\cos t$. (4)

8. The end wall of a building is in the shape of a parabolic arch.

Relative to axes, as shown in Fig Q8, the wall can be represented by the graph of

$$y = 9 - \frac{1}{4}x^2.$$

A rectangular area of the wall is to be painted white and the remainder is to be painted grey, as shown in Fig Q8.

Calculate the area to be painted grey, given that the dimensions are in metres. (16)

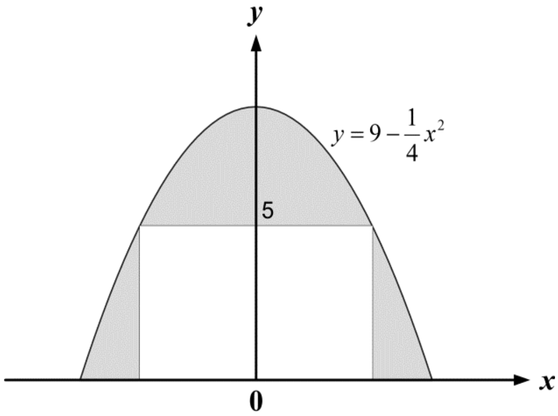

Fig Q8

9. (a) The debris from excavating a tunnel is estimated to be 174720 m^3.

This debris is to be stacked in the form of a frustum of a cone such that the vertical height is 18 m and the area of the base is four times the area of the top.

Calculate the base area of the stack. (10)

(b) Metal washers have an outside diameter of 30 mm, an inside diameter of 10 mm and a thickness of 2.5 mm.

The density of the metal is 7500 $kg\,m^{-3}$.

Calculate, to the nearest kilogram, the mass of a batch of 20000 such washers. (6)

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 042-23 Mathematics

DATE: 17 December 2015

General Comments on Examination Paper

A relatively straightforward paper.
Some candidates were very well prepared but some were ill prepared.

General Comments of Specific Examination Questions

1. Attempted by 75% of candidates, with relatively good results for (a) but relatively poor results for (b).
2. (a) A few candidates attempted a trigonometric solution rather than applying Pythagoras' Theorem.

   (c) Many candidates failed to factorise the *difference of squares* factor.
3. Attempted by 50% of the candidates, with relatively good results.
4. Attempted by most candidates, with relatively good results.
5. Attempted by almost 50% of the candidates, with relatively good results.
6. Attempted by 50% of the candidates, of whom a number had difficulty in producing a suitable diagram.
7. (b)(i) A number of candidates integrated the $-\frac{1}{x}$ term instead of differentiating.
8. A number of candidates evaluated the definite integral using incorrect limits.
9. Attempted by almost 50% of the candidates, with relatively poor results.

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 15 OCTOBER 2015

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) In a three cylinder engine the power developed in the No. 1 cylinder is 5% less than in the No. 2 cylinder.

   The power developed in the No. 3 cylinder is 20% more than in the No.1 cylinder.

   Express the power developed by EACH of the cylinders as a percentage of the total power of the engine. (8)

   (b) The mass of a square bar varies as its length and the square of its side.

   The length of bar A is $\frac{3}{4}$ of the length of bar B and the side of bar A is $\frac{2}{3}$ of that of bar B.

   The mass of bar A is 14 kg and both bars are composed of the same material.

   Calculate the mass of bar B. (8)

2. (a) Solve for x, $x > 0$, in the following equation:

$$\frac{x-2}{x+3} - \frac{x-3}{2x-1} = \frac{5}{2}$$ (8)

   (b) For a particular ship, at deadweight displacement, the power of the main engine is given by:

   P = v (av^2 + b) where v is the speed of the ship in knots, and a and b are positive constants.

   The powers are 3456 kW and 7632 kW when the speeds are 9 and 12 knots respectively.

   Calculate the power when the speed of the ship is 14 knots. (8)

3. (a) A formula associated with the magnetic field strength of a solenoid is given by:

$$B = \frac{\mu_0 N r^2 I}{2\left(r^2 + x^2\right)^{\frac{3}{2}}}$$

Calculate the value of x when $B = 0.01$, $\mu_0 = 4\pi \times 10^{-7}$, $N = 1000$, $r = 0.1$ and $I = 10$. (8)

(b) Solve the following system of equations for A and B in the range of $0 \leq \mathrm{A} \leq \frac{\pi}{2}$ and $0 \leq \mathrm{B} \leq \frac{\pi}{2}$ radians.

$3\sin \mathrm{A} + 4\cos \mathrm{B} = 1.77$
$2\sin \mathrm{A} - \cos \mathrm{B} = 0.52$ (8)

4. Solve for x in EACH of the following equations:

(a) $7^{2x - 1} = 4^{x + 1}$ (6)

(b) $\log\left(\frac{5-x}{3-x}\right) = 0.5$ (6)

(c) $\sqrt{x^5} = 7$ (4)

5. (a) Plot the graph of $y = 2x^3 - x^2 - 7x + 4$, at intervals of 0.5 from $x = -2$ to $x = 2$. (13)

Suggested scales: horizontal axis 2 cm = 0.5
vertical axis 2 cm = 1

(b) Using the graph drawn in Q5(a), estimate the solutions, to 1 decimal place, of the equation:

$2x^3 - x^2 - 7x + 4 = 0$ (3)

6. A parallelogram has sides of 25 cm and 15 cm.

The two acute angles between the sides are 30°.

Calculate EACH of the following for the parallelogram:
.
(a) the lengths of the diagonals; (12)

(b) the area. (4)

7. (a) The displacement s metres of a body from a fixed point is given by the equation:

$$s = \frac{10}{3}t^3 - \frac{33}{2}t^2 + 20\,t + 6 \text{ where t is the time in seconds.}$$

Determine EACH of the following for this body:

(i) its initial velocity; (3)

(ii) the times when it is at rest; (4)

(iii) the time when its acceleration is 7 ms^{-2}. (3)

(b) Given $h = 4 - 3\sin t + 5\cos t$, where t is the time in seconds, evaluate.

$$h - \frac{dh}{dt} \quad \text{when } t = 1 \text{ second}$$ (6)

8. A solid of revolution is formed when the area bounded by the curve $y = 2x^2 + 3$ and the lines $y = 1$, $x = -1$ and $x = 2$, as shown by the shaded area in Fig Q8, is rotated about the x-axis through one complete revolution.

The dimensions are in centimetres.

Calculate EACH of the following for this solid of revolution:

(a) its volume; (12)

(b) its mass, if its density is 2720 kg m^{-3}. (4)

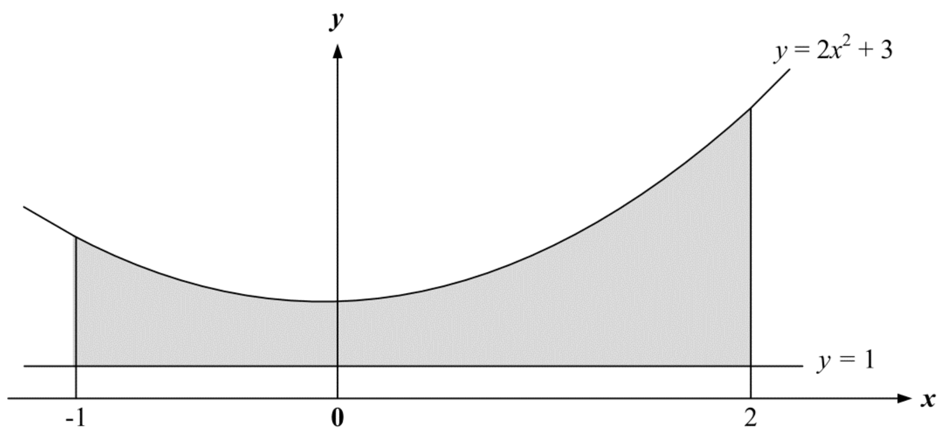

Fig Q8

[OVER

9. A solid right pyramid stands on an equilateral triangular base BCD, as shown in Fig Q9.

The vertical height of the pyramid is 30 cm and each side of the base is 16 cm.

Calculate EACH of the following for the pyramid:

(a) the volume; (6)

(b) the total surface area. (10)

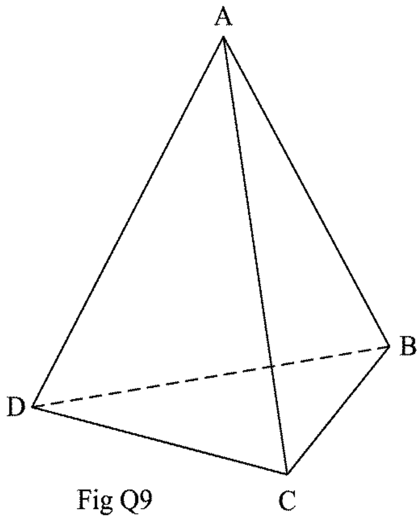

Fig Q9

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM

SUBJECT: 042-23 Mathematics

DATE: 15 October 2015

General Comments on Examination Paper

A relatively straightforward paper.

Some candidates were very well prepared but some were ill prepared.

General Comments of Specific Examination Questions

Q1.
Q2. } Attempted by majority of candidates, achieving average mark of 13/16.

Q3(b). Many candidates produced solution in degrees.

Q4(b) Some candidates interpreted log as $\log_e$.

Q6. Attempted by eight candidates, achieving average mark of 8/16.

Q7(a)(i). Many candidates did not appear to understand that initial velocity is velocity at $t = 0$.

(b). Many candidates evaluated trig. functions using degree measure rather than rads.

Q8(a). Some candidates used incorrect formula.

(b). Some candidates did not convert density to kg cm^{-3}.

Q9. Attempted by five candidates, achieving average mark of 9/16.

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 26th MARCH 2015

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 cruise line contracts to purchase two identical ships at a cost of £364 M each.

During construction of the first ship the costs of labour and materials are in the ratio of 3:4 and the ship builders make a profit of 4%.

Determine EACH of the following:

(i) the cost of the materials for the first ship; (5)

(ii) the percentage profit made on the second ship if the labour costs have increased by 2% and the material costs have decreased by 5%. (5)

(b) The ratio of the volumes of two solid cubes is 729:64.

Determine the side length of the larger cube if the surface area of the smaller cube is 384 cm^2. (6)

2. (a) Solve the following system of equations for x and y:

$$3x^2 + 2y^2 + y = 13$$
$$3x + 2y - 7 = 0$$

(10)

(b) Fully factorise EACH of the following:

(i) $30ab^2 + 39ab - 126a$; (3)

(ii) $(2x - 5y)^2 - 9y^2$. (3)

3. (a) Make L the subject of the following formula:

$$S = \frac{1}{t}\log_e\left(\frac{L}{L - V^2}\right)$$ (7)

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

(i) $4^{5x-1} = 8^{2x+1}$; (6)

(ii) $2^x = 10$. (3)

4. (a) The force, F, produced on a ship's rudder is proportional to the area, A, of the rudder, the square of the ship's speed, V, in knots and the sine ratio of the rudder angle, α.

For a ship travelling at 10 knots, with a rudder area of 24 m^2 operating at an angle of 23°, the rudder force is 144 kN.

Calculate the force on a similar rudder of area 29 m^2 operating at an angle of 15° when the ship's speed is 14 knots.

(8)

(b) $$Y = \frac{3 + \dfrac{9}{x-2}}{x - \dfrac{3}{x-2}}$$

Express Y as a single algebraic fraction in its simplest form. (8)

5. The power, P watts, dissipated by a resistor, was measured for various currents, I amps, as shown in Table Q5.

P	105	214	359	692	955
I	2.09	2.95	3.94	5.37	6.31

Table Q5

(a) Verify, by drawing a straight line graph, that P and I are related according to the law:

$P = RI^n$ where R and n are constants. (10)

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

(b) Use the graph in Q5(a) to determine the values of R and n. (6)

6. A tower 45 m high stands on the top of a hill which has a 15º incline.

The angle of depression from the top of the tower to a point A on the hill is 60º. Further down the hill at an angle of depression of 35º from the top of the tower is point B.

Calculate the distance between the points A and B. (16)

7 (a) The blade efficiency E of a particular turbine is given by:

$$E = \frac{2u(\mathrm{V} - u)}{\mathrm{V}^2}$$

Where u = the speed of the blade
V = the constant velocity of the jet.

Determine EACH of the following:

(i) the value of u for maximum efficiency; (6)

(ii) the maximum percentage efficiency. (2)

(b) Differentiate EACH of the following functions:

(i) $\frac{3}{x^3} - \frac{4}{x^2} + \frac{2}{\sqrt{x}} - \sqrt{x}$ (4)

(ii) $2\sin t - \cos t - t + \ln t$. (4)

8.

(a) Evaluate $\int_{\frac{\pi}{6}}^{\frac{5\pi}{6}} (2\sin\theta - \cos\theta)\,d\theta$ (6)

(b) Determine the volume of solid of revolution when the shaded area shown in Fig Q8(b) is rotated about the *x*-axis through one complete revolution. (10)

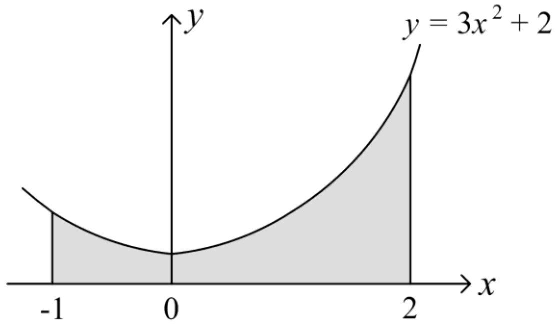

Fig Q8(b)

9. A solid metal cylinder has diameter 12 cm and length 25 cm.

Nine holes of diameter 2 cm are drilled through the cylinder, parallel to its axis, as shown in Fig Q9.

Calculate EACH of the following:

(a) the percentage decrease in the volume of the cylinder; (6)

(b) the total surface area of the original cylinder; (4)

(c) the percentage increase in the total surface area after the nine holes have been drilled. (6)

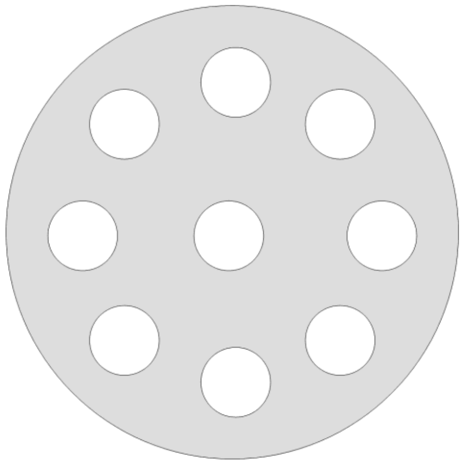

Fig Q9

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM
PART I

SUBJECT: 042-23 Mathematics

DATE: 26 March 2015

General Comments on Examination Paper

A relatively straightforward paper.
Some candidates were very well prepared but some were ill prepared.

General Comments of Specific Examination Questions

Q1. Attempted by a majority of the candidates but many calculated the builders profit for the first ship as 4% of the buyers purchase price.

Q2. Attempted by all save two of the candidates but with mainly poor results due to poor algebraic manipulation and factorising skills.

Q4. Attempted by a majority of the candidates achieving generally good results.

Q6. Attempted by a minority of the candidates achieving generally mediocre results.
Some candidates produced incorrect diagrams possibly due to not understanding the term "angle of depression".

Q9. Attempted by a majority of the candidates achieving generally good results.

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, 16 OCTOBER 2014

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 cruise ship has cabin accommodation for passengers on four separate decks A, B, C and D. Deck B has 25 cabins more than deck A. Deck C has 20% more cabins than deck B. Deck C has three quarters of the number of cabins on deck D. `

The total number of cabins on the four decks is 671.

Determine the number of cabins on EACH of the four decks. (8)

(b) Calculate the number of litres of 80% antifreeze solution that are required to be mixed with 45 litres of 15% antifreeze solution to obtain a mixture that is 50% antifreeze. (8)

2. (a) Make v the subject of the following formula:

$$T = \frac{T_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$ (8)

(b) Solve the following system of equations for A and B in the ranges $0 \le \text{A} \le \frac{\pi}{2}$ and $0 \le \text{B} \le \frac{\pi}{2}$ radians:

4sin A – 5cos B = 0.42
3sin A + cos B = 1.25 (8)

3. (a) Solve the following equation for x, ($x \ge 0$):

$$\frac{x-1}{x+2} - \frac{x-3}{x-2} = \frac{2}{x}$$ (10)

(b) Factorise fully EACH of the following:

(i) 4ab + 5ac -8bd – 10cd (3)

(ii) $9x^3y + 15x^2y^2 - 6xy^3$ (3)

[OVER

4. (a) In a drive belt pulley system, the tension T newtons in the taut side is given by $T = T_0 e^{\mu\theta}$ where T_0 is the tension in newtons in the slack side, μ is the coefficient of friction between the belt and pulley and θ is the angle of lap, in radians, of the belt on the pulley.

Determine EACH of the following for this system when μ = 0.25:

(i) the tension T when T_0 = 20.5 newtons and θ = 1.15 radians. (3)

(ii) the value of θ when T = 24 newtons and T_0 = 19 newtons. (5)

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

(i) $ln\,(1 + 3x) = -0.63$; (4)

(ii) $log\, 5x^3 - log\, x^2 = log\, (3x + 1)$. (4)

5. (a) Plot the graph of $y = 3x^3 - 3x^2 - 12x + 7$ at unit intervals from $x = -3$ to $x = 3$. (13)

Suggested scales: *horizontal axis* 2 cm = 1
vertical axis 2 cm = 10

(b) Using the graph drawn in Q5(a) determine the solutions of the equation:

$3x^3 - 3x^2 - 12x + 7 = 0$ (3)

6. Two spheres of diameters 30 mm and 60 mm fit into an oil funnel spout as shown in Fig Q6.

Calculate EACH of the following:

(a) the internal taper angle of the spout; (8)

(b) the dimension D. (8)

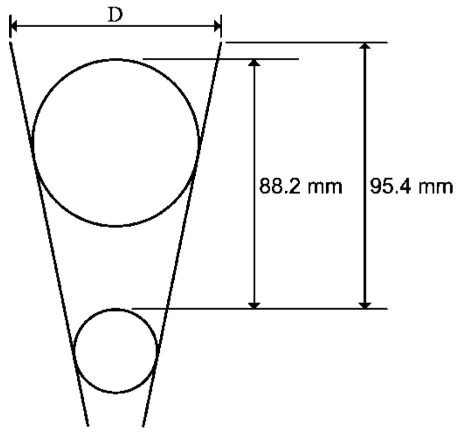

Fig Q6

7. (a) The rate at which a particular vessel consumes fuel is given by:

rate = $10 + 0.000625V^3$ tonnes per hour (where V is the speed of the vessel in knots).

Calculate EACH of the following:

(i) the speed of the vessel which minimises the amount of fuel consumed on a passage of 1 000 nautical miles; (10)

(ii) the amount of fuel consumed during the passage when the vessel sails at its most economical speed. (2)

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

$P = \sin\theta + \cos\theta$ (4)

8. (a) Calculate the shaded area enclosed by the functions $y_1 = 20 - 3x^2$, $y_2 = 50 - x^3$ and the ordinates $x = -1$ and $x = 2$ as shown in Fig Q8(a). (10)

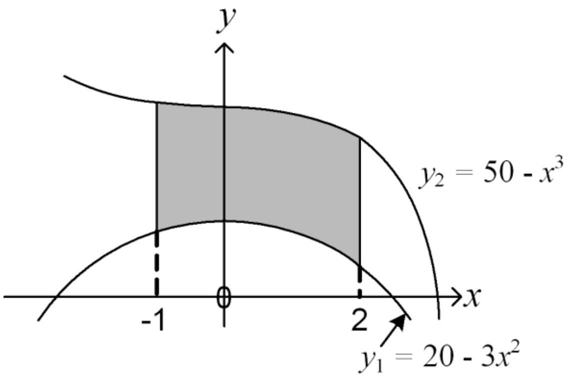

Fig Q8(a)

(b) Evaluate $\int_1^3 \left(\frac{7}{p^{2.4}}\right) dp$ (6)

[OVER

9. A hexagonal steel bar of side 8 cm and length 45 cm is machined, without reducing its overall length, into a composite solid as shown in Fig Q9.

The top third is conical with maximum possible base diameter.
The middle third is cylindrical with the same diameter as the base of the cone.
The lower third remains intact.

Calculate EACH of the following:

(a) the total volume of steel removed; (14)

(b) the percentage volume of steel removed. (2)

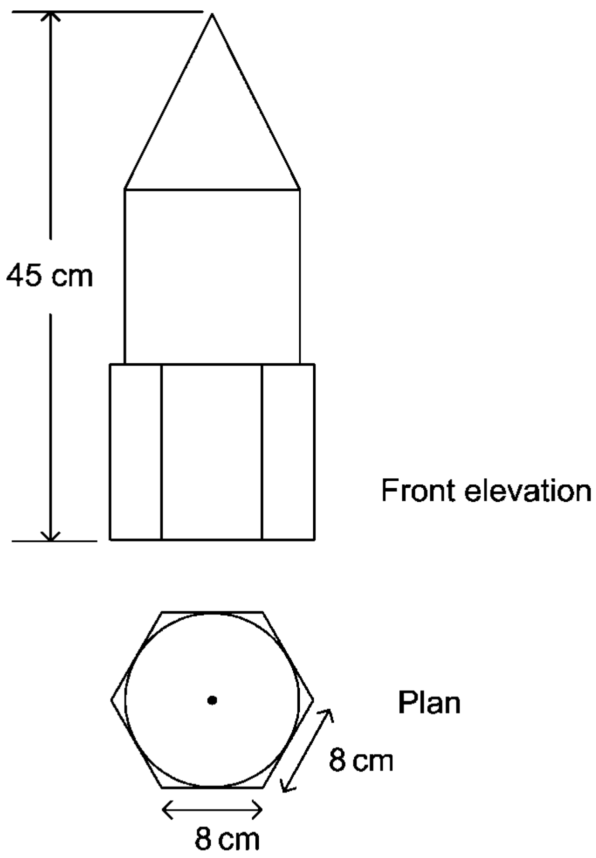

Fig Q9

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM
PART I

SUBJECT: 042-23 Mathematics

General Comments on Examination Paper

A relatively straightforward paper.

A few candidates were not well-prepared.

General Comments of Specific Examination Questions

Q2. Attempted by most candidates but few stating the answer to (b) in radians, as required.

Q3. Attempted by all candidates. A few had difficulties with the use of brackets and/or negative signs.

Q4. Attempted by most candidates. A few had a poor understanding of the Laws of Logarithms.

Q5. Attempted by most candidates. Only a few produced a graph with a smooth flowing curve, with the remainder joining plotted points with straight lines.

Q6. Attempted by relatively few candidates.

Q7(a). Attempted by about half of the candidates. Many did not fully understand the problem.

Q9. Attempted by only five candidates but with mainly good results produced.

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY –
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SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 95 SECOND ENGINEER REG. III/2 (UNLIMITED)

042-23 – MATHEMATICS

THURSDAY 24 JULY 2014

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) Tank A contains a fuel mixture of petrol and oil in the ratio 12:1 and tank B contains a fuel mixture of petrol and oil in the ratio 11:2.

   Determine the ratio in which fuel should be drawn from A and B to give a petrol and oil mixture in the ratio 10:1. (8)

   (b) The crippling load, P, for a steel rod is directly proportional to the fourth power of its diameter, D, and is inversely proportional to the square of its length, L.

   Determine the approximate percentage change in P if D is increased by 1% and L is decreased by 1%. (8)

2. (a) $$Y=\frac{7x+17}{2x^2-7x-4}+\frac{2x}{2x+1}-\frac{5}{x-4}$$

   Express Y as a single fraction in its simplest form. (8)

   (b) Solve for x in the following equation:

   $(2x + 1)(4x - 1) = 5$ (8)

3. (a) A propulsion problem causes a reduction in a ship's speed of 3 knots throughout a passage of 520 nautical miles, resulting in the ship arriving at its destination 3 hours behind schedule.

   Calculate EACH of the following for the ship:

   (i) the normal service speed; (7)

   (ii) the passage time. (3)

   (b) Solve for x in the following equation:

   $7^{3x-1}=0.5$ (6)

4. A keyway, of width 14 mm, is cut into a steel shaft, of radius 25 mm, along its entire length, as shown in Fig. Q4.

Calculate EACH of the following for the shaft:

(a) the maximum depth of the keyway; (8)

(b) the percentage of steel removed. (8)

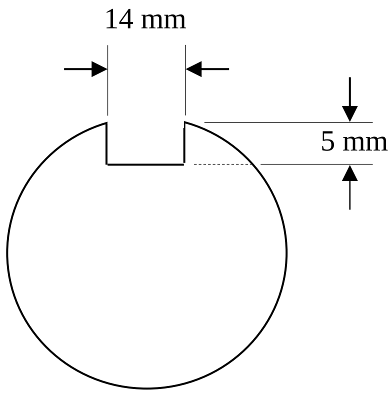

Fig Q4

5. The fuel consumption, F tonnes per day, at a speed, V knots, for a certain vessel are related by:

$F = aV^2 + b$ where a and b are constants.

Table Q5 indicates recorded values of F and V.

(a) Using the values in Table Q5 draw a graph to verify the relationship between F and V: (10)

F	1.1	2.9	6.5	11.2	17.5
V	2	4	6	8	10

Table Q5

Suggested scales: horizontal axis 2 cm = 10
vertical axis 2 cm = 2

(b) Use the drawn graph to determine approximate values of a and b. (6)

6. (a) A quadrilateral shaped metal plate has dimensions as shown in Fig Q6(a).

The angle ABC is 48°

Calculate EACH of the following for the plate:

(i) the distance from A to C; (4)

(ii) the size of angle DAB. (8)

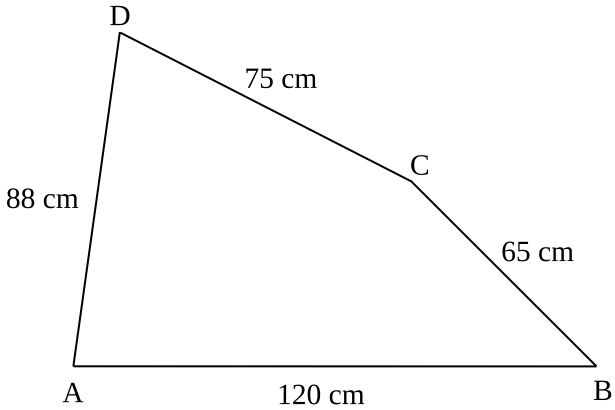

Fig Q6(a)

(b) Solve for Θ in the following equation in the range $90° < \Theta < 180°$

$\sin 2\Theta = -0.95$ (4)

7 (a) Determine the first and second differential coefficients of the expression:

$y = 9x^{\frac{4}{3}} + 2\ln x - 4\sin x$ (6)

(b) The displacement, s metres, of a body from a fixed point is given by the equation:

$s = 45t + 3t^2 - t^3$ where t is the time in seconds.

Determine EACH of the following for the body:

(i) the time when its velocity is zero; (6)

(ii) its acceleration after 3 seconds. (4)

[OVER

8. The uniform cross-section of a 60 metres long cargo space, in a small bulk carrier, can be represented by the area enclosed by the curve $y = \frac{1}{4}x^2$ and the lines y = 1 and y = 9, as shown by the shaded part in Fig Q8.

Calculate EACH of the following for the cargo space:

(a) the area of its cross-section; (13)

(b) its capacity in cubic metres. (3)

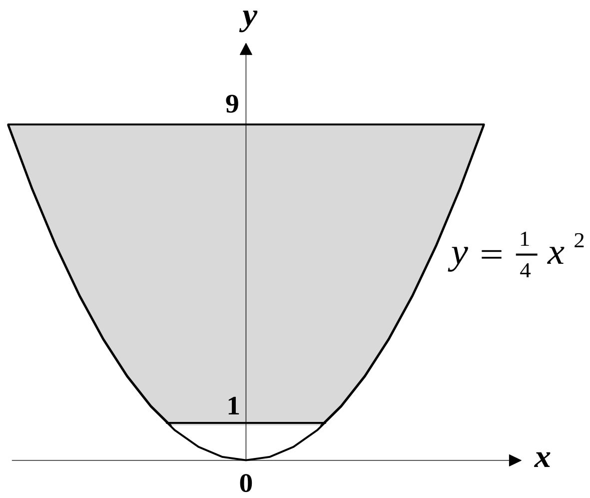

Fig Q8

9. A rectangular swimming pool is 25 metres long and 12 metres wide.

When full, the water is 1 metre deep at the shallow end and the bottom slopes uniformly along its length to the opposite end, where it is 4 metres deep.

The pool was filled by water flowing through a pipe, of internal diameter 100 millimetres, flowing at the rate of 4 metres per second, the pipe always being full.

Calculate EACH of the following for the pool:

(a) the volume of water when full; (6)

(b) the filling rate in cubic metres per hour; (7)

(c) the total filling time. (3)

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, 10 APRIL 2014

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 ship leaves port A at 0600 hours and heads for port B at a speed of 15 knots.

A tug leaves port B at 1100 hours and heads for port A at 9 knots.

Ports A and B are 243 nautical miles apart.

Calculate the time at which the ship and tug will pass each other. (8)

(b) Solve for x in the following equation:

$$\frac{x+2}{x-2}+\frac{x+21}{x+3}=5$$
(8)

2. (a) Under certain conditions the thrust T of a propeller varies jointly as the fourth power of its diameter d and the square of the number of revolutions n per second.

Determine the approximate percentage change in T if d is decreased by 1% and n is increased by 3%. (8)

(b) Solve the following system of equations for A and B in the ranges

$0 \leq A \leq \frac{\pi}{2}$ and $0 \leq B \leq \frac{\pi}{2}$ radians.

$4\sin A + 5\cos B = 1.8$
$3\sin A - 2\cos B = 0.4$
(8)

[OVER

3. (a) Fully factorise EACH of the following:

(i) $ax - bx + ay - by$ (3)

(ii) $a^2x^2 + b^2y^2 - a^2y^2 - b^2x^2$ (4)

(b) The formula $M = \dfrac{wx(l-x)}{2}$ gives the bending moment M at a point in a beam.

Calculate the values of x when M = 80, l = 30, and w = 2 . (5)

(c) Solve the following equation for x:

$$\frac{x^2-4}{x+2} = x^2 + 4x$$ (4)

4. (a) Solve the following equation for x in the range $x > 0$:

$\log(x^2 + 23) - \log(x + 1) = \log 8$ (6)

(b) Simplify fully using rules of indices:

$$\frac{(8a^6b^9c^3)^{\frac{2}{3}}}{(2a^2bc^3)^2}$$ (5)

(c) Solve for t in the following equation:

$3 = 14e^{-0.05t}$ (5)

5. (a) Draw the graph of $y = 2\cos\theta - \sin\theta$ in the range $1 \le \theta \le 5$ radians in intervals of 0.5 radians. (10)

Suggested scales: *horizontal axis* 2 cm = 0.5
vertical axis 2 cm = 0.4

(b) Determine EACH of the following using the graph drawn in Q5(a):

(i) the minimum value of y; (2)

(ii) the values of θ such that $y = 0$. (4)

6. A ship, maintaining a constant course, is observed from a coastguard watchtower to be 4.2 miles distant and bearing 030°.

Later the ship was observed to be 6.4 miles off on a bearing of 110°.

Calculate EACH of the following:

(a) the ship's course; (11)

(b) the shortest distance between the ship and the watchtower. (5)

7. (a) The cost, in £ millions per day, of pumping oil from an offshore oil terminal is related to the radius of the pipe carrying the oil.

For a pipe of radius r metres the cost is given by $C = \mathrm{r} + \frac{4}{\mathrm{r}} + 0.5$

Calculate EACH of the following:

(i) the radius of pipe which minimises the cost; (6)

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

(b) $y = 10x^{0.4} + e^{2x} - 60\sqrt{x}$

Determine EACH of the following:

(i) $\frac{dy}{dx}$ (4)

(ii) $\frac{d^2y}{dx^2}$ (4)

8. The sheave of a pulley-block may be considered as being formed by rotating the area bounded by the curve $y = x^2 + 6$ and the lines $x = -1$, $x = 1$ and $y = 1$, about the x-axis through one complete revolution.

(a) Sketch the bounded area. (4)

(b) State the diameter of the axle hole of the sheave. (2)

(c) Calculate the volume of the sheave. (10)

9. The end section of a cylindrical oil tank of diameter 220 cm as shown in Fig Q9, and the tank is lying with its axis horizontal and the level of oil in the tank is 60 cm.

Oil is pumped into the tank until the level of oil in the tank is 100 cm.

Calculate the percentage increase in the volume of oil in the tank.

(16)

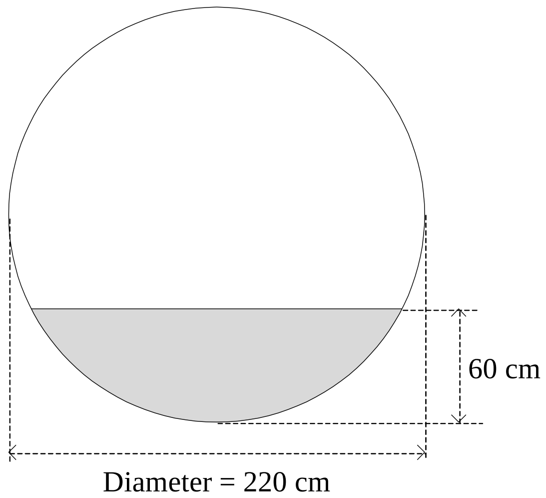

Fig Q9

SCOTTISH QUALIFICATIONS AUTHORITY
MARKERS REPORT FORM
PART I

SUBJECT: 042-23 Mathematics

General Comments on Examination Paper

A relatively straightforward paper.
Due to the small population size no valid statistical inferences may be drawn.

General Comments of Specific Examination Questions

Q2.(b) A number of candidates had difficulty with radian measure.

Q4. Attempted by most candidates but laws of indices and logarithms and base of a logarithm were not fully understood by some.

Q8. Attempted by four candidates, none of whom were able to sketch the bounded area correctly.

Q9. Attempted by three candidates, with only one producing a successful result.