OCR RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS (MEI) 4752

Concepts for Advanced Mathematics (C2)

QUESTION PAPER

Candidates answer on the Printed Answer Book

OCR Supplied Materials:
- Printed Answer Book 4752
- MEI Examination Formulae and Tables (MF2)

Other Materials Required:
- Scientific or graphical calculator

Thursday 27 May 2010
Morning

Duration: 1 hour 30 minutes

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These instructions are the same on the Printed Answer Book and the Question Paper.

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Printed Answer Book.
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- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

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- Do not send this Question Paper for marking; it should be retained in the centre or destroyed.

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Section A (36 marks)

1 You are given that

$$u_1 = 1,$$
$$u_{n+1} = \frac{u_n}{1 + u_n}.$$

Find the values of u_2, u_3 and u_4. Give your answers as fractions. **[2]**

2 **(i)** Evaluate $\sum_{r=2}^{5} \frac{1}{r-1}$. **[2]**

(ii) Express the series $2 \times 3 + 3 \times 4 + 4 \times 5 + 5 \times 6 + 6 \times 7$ in the form $\sum_{r=2}^{a} \mathrm{f}(r)$ where $\mathrm{f}(r)$ and a are to be determined. **[2]**

3 **(i)** Differentiate $x^3 - 6x^2 - 15x + 50$. **[2]**

(ii) Hence find the x-coordinates of the stationary points on the curve $y = x^3 - 6x^2 - 15x + 50$. **[3]**

4 In this question, $\mathrm{f}(x) = x^2 - 5x$. Fig. 4 shows a sketch of the graph of $y = \mathrm{f}(x)$.

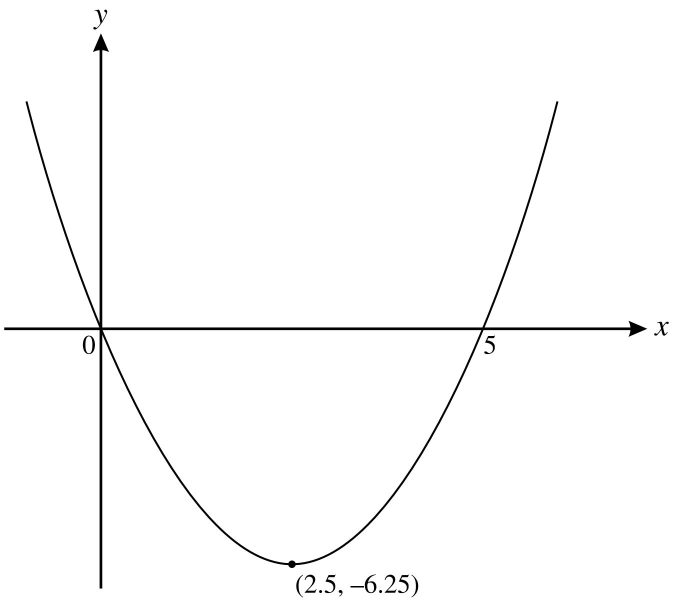

Fig. 4

On separate diagrams, sketch the curves $y = \mathrm{f}(2x)$ and $y = 3\mathrm{f}(x)$, labelling the coordinates of their intersections with the axes and their turning points. **[4]**

5 Find $\int_{2}^{5}\left(1-\frac{6}{x^3}\right)\mathrm{d}x$. **[4]**

6 The gradient of a curve is $6x^2 + 12x^{\frac{1}{2}}$. The curve passes through the point (4, 10). Find the equation of the curve. **[5]**

7 Express $\log_a x^3 + \log_a \sqrt{x}$ in the form $k \log_a x$. **[2]**

8 Showing your method clearly, solve the equation $4\sin^2\theta = 3 + \cos^2\theta$, for values of θ between 0° and 360°. **[5]**

9 The points (2, 6) and (3, 18) lie on the curve $y = ax^n$.

Use logarithms to find the values of a and n, giving your answers correct to 2 decimal places. **[5]**

Section B (36 marks)

10 **(i)** Find the equation of the tangent to the curve $y = x^4$ at the point where $x = 2$. Give your answer in the form $y = mx + c$. **[4]**

(ii) Calculate the gradient of the chord joining the points on the curve $y = x^4$ where $x = 2$ and $x = 2.1$. **[2]**

(iii) (A) Expand $(2 + h)^4$. **[3]**

(B) Simplify $\frac{(2+h)^4 - 2^4}{h}$. **[2]**

(C) Show how your result in part **(iii)** (B) can be used to find the gradient of $y = x^4$ at the point where $x = 2$. **[2]**

11 (a)

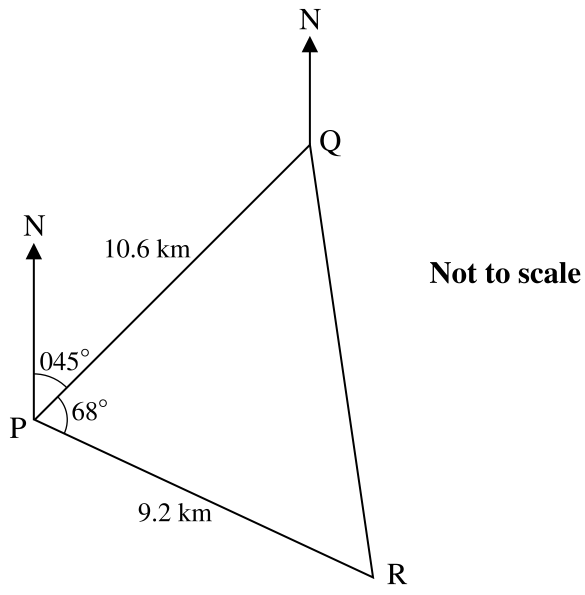

Fig. 11.1

A boat travels from P to Q and then to R. As shown in Fig. 11.1, Q is 10.6 km from P on a bearing of 045°. R is 9.2 km from P on a bearing of 113°, so that angle QPR is 68°.

Calculate the distance and bearing of R from Q. **[5]**

(b) Fig. 11.2 shows the cross-section, EBC, of the rudder of a boat.

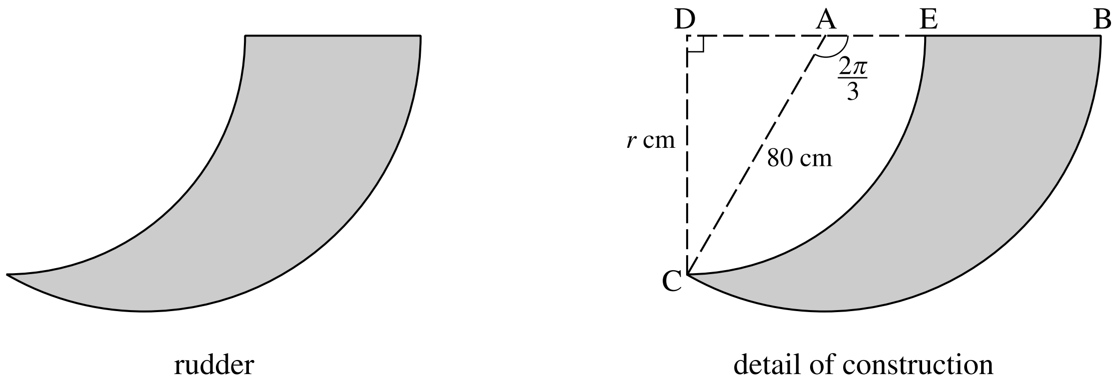

Fig. 11.2

BC is an arc of a circle with centre A and radius 80 cm. Angle CAB = $\frac{2\pi}{3}$ radians.

EC is an arc of a circle with centre D and radius r cm. Angle CDE is a right angle.

(i) Calculate the area of sector ABC. **[2]**

(ii) Show that $r = 40\sqrt{3}$ and calculate the area of triangle CDA. **[3]**

(iii) Hence calculate the area of cross-section of the rudder. **[3]**

12

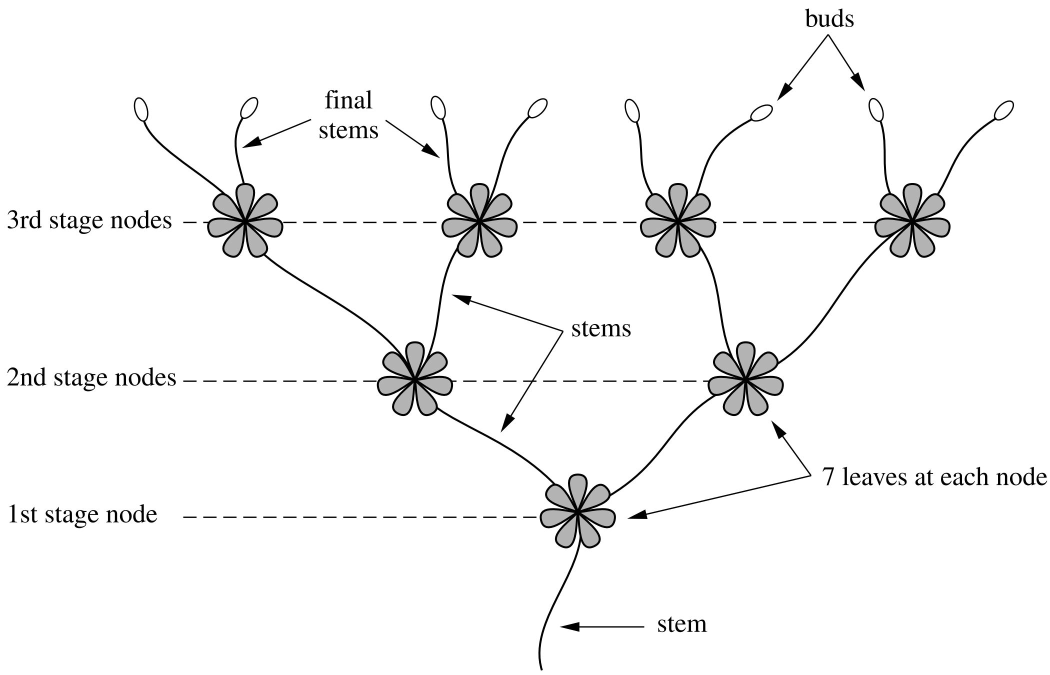

Fig. 12

A branching plant has stems, nodes, leaves and buds.

- There are 7 leaves at each node.
- From each node, 2 new stems grow.
- At the end of each final stem, there is a bud.

Fig. 12 shows one such plant with 3 stages of nodes. It has 15 stems, 7 nodes, 49 leaves and 8 buds.

(i) One of these plants has 10 stages of nodes.

(A) How many buds does it have? **[2]**

(B) How many stems does it have? **[2]**

(ii) (A) Show that the number of leaves on one of these plants with n stages of nodes is

$$7(2^n - 1).$$ **[2]**

(B) One of these plants has n stages of nodes and more than 200 000 leaves. Show that n satisfies the inequality $n > \frac{\log_{10} 200\,007 - \log_{10} 7}{\log_{10} 2}$. Hence find the least possible value of n. **[4]**

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MATHEMATICS (MEI) 4752

Concepts for Advanced Mathematics (C2)

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Turn over

Section A (36 marks)

1	
2 (i)	
2 (ii)	

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3 (i)	
3 (ii)	

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4	
5	

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6	
7	
8	

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9	

Section B (36 marks)

10 (i)	

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10 (ii)	
10 (iii) (A), (B) and (C)	

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11 (a)	
11 (b) (i)	

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11(b)(ii)	
11(b)(iii)	

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12(i)(*A*)	
12(i)(*B*)	
12(ii)(*A*)	

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12(ii)(*B*)	

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GCE

Mathematics (MEI)

Advanced GCE **4752**

Concepts for Advanced Mathematics (C2)

Mark Scheme for June 2010

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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SECTION A

1	[1], $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}$	**2**	**B1** for [1], $\frac{1}{2}, \frac{1}{3}$
2 (i)	$2\frac{1}{12}$ or $\frac{25}{12}$ or 2.08(3…)	**2**	**M1** for $\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}$
2 (ii)	$\sum_{r=2}^{6} r(r+1)$ o.e.	**2**	**M1** for [f(r) =] $r(r + 1)$ o.e. **M1** for [a =] 6
3 (i)	$3x^2 - 12x - 15$	**2**	**M1** if one term incorrect or an extra term is included.
3 (ii)	Their $\frac{dy}{dx} = 0$ s.o.i. $x = 5$ $x = -1$	**M1** **B1** **B1**	
4	crossing x-axis at 0 and 2.5 min at (1.25, −6.25) crossing x-axis at 0 and 5 min at (2.5, −18.75)	**1** **1** **1** **1**	
5	$x - \frac{6x^{-2}}{-2}$ o.e. their [5 + $\frac{3}{25}$] − [2 + $\frac{3}{4}$] = 2.37 o.e. c.a.o.	**2** **M1** **A1**	M1 for 1 term correct Dependent on at least **M1** already earned i.s.w.
6	attempt to integrate $6x^2 + 12x^{\frac{1}{2}}$ [y =] $2x^3 + 8x^{1.5}$ + c Substitution of (4, 10) [y =] $2x^3 + 8a^{1.5}$ −182 or c = −182	**M1** **A2** **M1** **A1**	accept un-simplified; **A1** for 2 terms correct dependent on attempted integral with + c term
7	3.5 $\log_a x$ or k = 3.5	**2**	**B1** for 3 $\log_a x$ or ½ $\log_a x$ or $\log_a x^{3½}$ seen

8	Subst. of $1-\cos^2\theta$ or $1-\sin^2\theta$	**M1**	
	$5\cos^2\theta = 1$ or $5\sin^2\theta = 4$	**A1**	
	$\cos\theta = \pm\sqrt{\text{their }\frac{1}{5}}$ or $\sin\theta = \pm\sqrt{\text{their }\frac{4}{5}}$ o.e.	**M1**	
	63.4, 116.6, 243.4, 296.6	**B2**	Accept to nearest degree or better; **B1** for 2 correct (ignore any extra values in range).
9	$\log 18 = \log a + n\log 3$ and $\log 6 = \log a + n\log 2$	**M1***	or $18 = a \times 3^n$ and $6 = a \times 2^n$
	$\log 18 - \log 6 = n(\log 3 - \log 2)$	**DM1**	$3 = \left(\frac{3}{2}\right)^n$
	$n = 2.71$ to 2 d.p. c.a.o.	**A1**	$n = \frac{\log 3}{\log 1.5} = 2.71$ c.a.o.
	$\log 6 = \log a + 2.70951\ldots\log 2$ o.e.	**M1**	$6 = a \times 2^{2.70951}$ o.e.
	$a = 0.92$ to 2 d.p. c.a.o.	**A1**	$= 0.92$ c.a.o.

Section A Total: 36

SECTION B

10 (i)	$\frac{dy}{dx} = 4x^3$	**M1**	
	when $x = 2$, $\frac{dy}{dx} = 32$ s.o.i.	**A1**	i.s.w.
	when $x = 2$, $y = 16$ s.o.i.	**B1**	
	$y = 32x - 48$ c.a.o.	**A1**	
10 (ii)	34.481	**2**	**M1** for $\frac{2.1^4 - 2^4}{0.1}$
10 (iii) (*A*)	$16 + 32h + 24h^2 + 8h^3 + h^4$ c.a.o.	**3**	**B2** for 4 terms correct **B1** for 3 terms correct
10 (iii) (*B*)	$32 + 24h + 8h^2 + h^3$ or ft	**2**	**B1** if one error
10 (iii) (*C*)	as $h \to 0$, result $\to$ their 32 from (iii) (B)	**1**	
	gradient of tangent is limit of gradient of chord	**1**	

11	**(a)**	$10.6^2 + 9.2^2 - 2\times10.6\times9.2\times\cos68°$ o.e. QR = 11.1(3…) $\frac{\sin 68}{\text{their QR}} = \frac{\sin Q}{9.2}$ or $\frac{\sin R}{10.6}$ o.e. Q = 50.01..° or R = 61.98..° bearing = 174.9 to 175°	**M1** **A1** **M1** **A1** **B1**	 Or correct use of Cosine Rule 2 s.f. or better
11	**(b) (i)**	(*A*) ½ × 80^2 × $\frac{2\pi}{3}$ $= \frac{6400\pi}{3}$	**M1** **A1**	 6702.(…) to 2 s.f. or more
11	**(b) (ii)**	DC = 80 sin($\frac{\pi}{3}$) = 80$\frac{\sqrt{3}}{2}$ Area = ½×their DA×40√3 or ½×40√3×80×sin(their DCA) o.e. area of triangle = 800√3 or 1385.64… to 3s.f. or more	**B1** **M1** **A1**	both steps required s.o.i.
11	**(b) (iii)**	area of ¼ circle = ½ × $\frac{\pi}{2}$ × $(40\sqrt{3})^2$ o.e. "6702" + "1385.6" – "3769.9" = 4300 to 4320	**M1** **M1** **A1**	[=3769.9…] i.e. their(b) (i) + their (b) (ii) – their ¼ circle o.e. 933⅓π + 800√3

12	**(i) (*A*)**	1024	**2**	**M1** for number of buds = 2^{10} s.o.i.
12	**(i) (*B*)**	2047	**2**	**M1** for 1+2+4+…2^{10} or for $2^{11} - 1$ or (their 1024) + 512 + 256 +…+ 1
12	**(ii) (*A*)**	no. of nodes = 1 + 2 +..+ 2^{n-1} s.o.i. $\frac{7\times(2^n-1)}{2-1}$	**1** **1**	no. of leaves = 7 + 14 +…+ $7\times2^{n-1}$
12	**(ii) (*B*)**	$7(2^n - 1) > 200\,000$ $2^n > \frac{200\,000}{7} + 1$ or $\frac{200\,007}{7}$ $n \log 2 > \log(\frac{200\,007}{7})$ and completion to given ans [n =] 15 c.a.o.	**M1** **M1** **M1** **B1**	 or $\log 7 + \log 2^n > \log 200\,007$

Section B Total: 36

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4752 Concepts for Advanced Mathematics

General comments

A full range of marks was achieved on this paper; however, very few obtained full marks or even close to full marks. Some candidates lost easy marks because they were unable to use algebra (eg solving simultaneous equations) or arithmetic (eg dealing with index numbers) expected of GCSE candidates correctly, even though they understood the ideas from the Core 2 course. Similarly, what is essentially GCSE work on transformations of curves seldom earned full marks. Some candidates used degrees when radians were required, although very few used radians when degrees were required. Failure to show adequate working cost marks for many – a small number of candidates relied on a "clever" calculator to produce the answer - and even some strong candidates failed to appreciate what is required when asked to show a given result.

Comments on individual questions

1) Almost half the candidates scored full marks on this question. A few lost a mark through poor arithmetic or for failing to express all three answers as fractions. However, a considerable number of candidates were not able to cope with the notation, and treated it as a *substitution* instead of appreciating that it was a *recurrence relation,* so $\frac{1}{2},\frac{2}{3},\frac{3}{4}$ and $\frac{2}{3},\frac{3}{4},\frac{4}{5}$ were common (incorrect) answers.

2) (i) Approximately three quarters of candidates obtained full marks on this question. Some candidates made mistakes with the arithmetic, but only a few did not understand the meaning of sigma. In some cases no working was shown, but full credit could still be earned.

2) (ii) Approximately one quarter of candidates failed to score on this question. $a = 5$ and $f(r) = (r + 1)(r + 2)$ was sometimes seen, but more frequent errors were to use other letters (frequently n or a) instead of r, or to confuse $f(r) = r(r + 1)$ with $f \times (r + 1)$. Another common error was $r \times r + 1$ instead of $r(r + 1)$.

3) (i) Almost everyone scored full marks. Only a few made slips such as "+ c" or "- $6x$" or "$2x^2$".

3) (ii) Over three quarters of candidates obtained full marks. Nearly everyone appreciated the need to set $\frac{dy}{dx}$ equal to zero. A few made sign errors in factorising, or slipped up in using the quadratic formula or completing the square.

4) Just over 40% of candidates achieved full marks, but approximately a quarter failed to score at all. Those candidates who tried to construct the equations for $f(2x)$ or $3f(x)$ generally found the approach too challenging. The majority used transformations of $y = f(x)$, and were usually successful in sketching $y = 3f(x)$, although a few candidates lost marks by labelling the vertex incorrectly. A common error was to sketch $y = f(\frac{1}{2}x)$ instead of $y = f(2x)$.

5) Most candidates understood that integration was required; only a small minority differentiated or substituted the values into the original function. The majority obtained the first term correctly, although $\frac{1^2}{2}$ was seen surprisingly often. The second term caused more difficulty. Sign errors were common, but some candidates made more significant errors such as $x^{\frac{6}{3}}$ or $6x \div \frac{x^4}{4}$. Most candidates scored the second M1 by evaluating their "F(5) – F(2)"; only a few calculated F(5) + F(2). Over 50% of candidates scored full marks. A very small number of candidates presented the correct numerical value, but showed no working. This earned no marks.

6) More than half of the candidates scored full marks on this question, and many others earned at least the first three marks. However, approximately one quarter of candidates failed to score. Some candidates misunderstood what was required, and went straight into "$y = mx + c$" with m = $6x^2 + 12x^{½}$, thus failing to score. A small number differentiated first, thinking this would give them the gradient function.

7) This question was well done, with almost 70% of candidates obtaining both marks. Of those that didn't, more than half obtained M1, usually for 3log*x*. A surprising number made the basic error 3log*x* + ½log*x* = $\frac{3}{2}$ log*x*, or a version of this. A small minority wrote 3log*x* + ½log*x* = 3½logx^2 , and $\sqrt{x} = x^{-1}$ or $x^{-½}$ were sometimes seen.

8) Most candidates realised that $1-\sin^2\theta$ or $1-\cos^2\theta$ needed to be substituted, many had problems rearranging the equation in a suitable form. Many who obtained, say, $5\cos^2\theta = 1$ failed to take the square root and found $\cos^{-1}0.2$ – a few of these then went on to square root the angle. Approximately one third of candidates did take the square root correctly at this stage; of these approximately one quarter dealt with the negative root. Some candidates failed to score at all, either because they substituted $\cos^2\theta - 1$ or because they divided through by $\cos\theta$ and fudged the algebra.

9) The majority of candidates struggled with this question: many thought that *n* was the gradient of the line joining (2,6) to (3,18). In general they then formed only one correct log equation, and failed to score any marks. Of those who realised that two equations needed to be formed and solved simultaneously, a surprisingly high proportion made basic errors. $\log(ax^n) = n\log(ax)$ was frequently seen, and many made basic errors in attempting to eliminate one of the variables. A small number of candidates obtained the correct numerical values for *n* and *a*, but failed to give the answers to the required degree of precision.

10) (i) More than half of candidates scored full marks on this question. Of the rest, the majority found *y* correctly, and most appreciated the need to differentiate. A significant minority of candidates found $\frac{dy}{dx}$ and evaluated it correctly, but went on to use m = $-\frac{1}{32}$.

10) (ii) More than 60% of candidates obtained full marks; only a few candidates lost a mark for premature rounding. A small number of candidates evaluated $\frac{dy}{dx}$ at the endpoints of the chord, found the mean and came up with an answer of 34.5 to 1 d.p. This did not score. A few candidates calculated $\frac{x_{\text{step}}}{y_{\text{step}}}$ and also failed to score.

10) (iii) The majority of candidates obtained full marks in part (A). A few candidates who used the binomial expansion lost marks because they failed to simplify one or more of the terms. Those who expanded the brackets one by one often made errors. Some candidates wrote down the answer $16 + h^4$.
Part (B) was generally well done, with many candidates obtaining both marks on a follow through basis. A few candidates just reduced the power of *h* in one term only.
Many candidates failed to understand what was required in part (C), approximately 80% of candidates failed to score. Very few managed to earn both marks.

11) (a) The majority of candidates appreciated the need to use the cosine rule to find QR, and by and large they were successful. The sine rule (and occasionally the cosine rule) was often correctly applied to find either angle Q or angle R. A surprising number of candidates needlessly changed the labelling to A or B, and sometimes lost marks when putting their answers back in context. The response often broke down at this stage, but many who did proceed correctly lost the final mark by using rounded answers and then giving the bearing to an unreasonable level of precision which fell outside the acceptable range: 174.8° was a common (incorrect) answer.

11) (b) Part (i) was very well done: approximately 70% of candidates earned both marks. A few used the correct method and then converted to degrees, and others worked in degrees from the start. A small number of candidates carelessly used $r\theta$ or $r\theta^2$.
In part (ii) approximately half of the candidates failed to score. Generally this was because they attempted to show the requested result, but only gave one step, and didn't attempt to find the area. Those who did attempt to calculate the area were generally successful – but some lost marks by using the wrong angle in $\frac{1}{2}dc\sin A$ or by obtaining an incorrect value for AD before using ½ AD × DC.
Some candidates generally appreciated the steps involved here, and often benefitted from the follow through mark. However, a significant proportion made the mistake of thinking that the area of the sector minus the area of the quarter circle gave the area of the rudder. A surprising number of candidates found the area of triangle ADC when responding to part (iii) instead of part (ii).

12) (i) More than half of candidates obtained both marks in part (*A*). A minority used a formula connected with arithmetic progressions, but the most common wrong answer was 512.
Approximately one quarter of candidates earned both marks in part (*B*) – the overwhelming majority failed to score. Common incorrect answers were 2046, 1024 and 1023 obtained from $\frac{1-2^{10}}{1-2}$.

12) (ii) Very few candidates obtained both marks in part (*A*), and approximately 80% of candidates were awarded zero or failed to respond. Most candidates opted for a verification of the formula by substitution of 1, 2, 3… or gave wordy explanations – neither approach earned any marks.
The modal mark for part (*B*) was zero, but a reasonable number of candidates managed to extract the least value of *n* correctly. A surprising number failed to appreciate that *n* had to be an integer: 14.8 was seen frequently, as was $n > 15$.
Some candidates obtained the first method mark. Thereafter various mistakes were presented. $7 \times 2^n = 14^n$ was frequently seen, as was $\log(2^n - 1) = \log 2^n - \log 1 = \log 2^n$.
Some candidates worked with = or < instead of > and usually failed to recover. A surprising proportion decimalised their working and obtained 2 marks out of 4 in total.