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(9660/MA01) Unit P1 Pure Mathematics

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

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Key to mark scheme abbreviations

M	Mark is for method
m	Mark is dependent on one or more M marks and is for method
A	Mark is dependent on M or m marks and is for accuracy
B	Mark is independent of M or m marks and is for method and accuracy
E	Mark is for explanation
√ **or ft**	Follow through from previous incorrect result
CAO	Correct answer only
CSO	Correct solution only
AWFW	Anything which falls within
AWRT	Anything which rounds to
ACF	Any correct form
AG	Answer given
SC	Special case
oe	Or equivalent
A2, 1	2 or 1 (or 0) accuracy marks
–*x* EE	Deduct *x* marks for each error
NMS	No method shown
PI	Possibly implied
SCA	Substantially correct approach
sf	Significant figure(s)
dp	Decimal place(s)
ISW	Ignore subsequent working

Q	Answer	Marks	Comments
1(a)(i)	$(0.5, 1)$	B1	
		1	

Q	Answer	Marks	Comments
1(a)(ii)	$(2, 4)$	B1	
		1	

Q	Answer	Marks	Comments
1(b)	$[y =]\ (x+3)^2 + 5(x+3)\ \ [-12-4]$ or $[y =]\ \left(x+\frac{5}{2}+3\right)^2\ \ \left[-\frac{73}{4}-4\right]$	M1	**oe** Correct substitution of $(x+3)$ for x Allow $(x-3)$ substituted.
	$[y =]$ $x^2+6x+9+5x+15\ \ [-12-4]$ or $x^2+11x+\frac{121}{4}\ \ \left[-\frac{73}{4}-4\right]$	M1	**oe** Brackets correctly expanded. **ft** their $(x+3)$
	$[b =]\ 11$ $[c =]\ 8$	A1 A1	**A1**: At least one of b or c correct. **A1**: Both b and c answer. Award if seen in their final equation.
		4	

	Question 1 Total	6	

Q	Answer	Marks	Comments
2(a)	$(3t+2)^2+(t-8)^2$ or $\sqrt{(3t+2)^2+(t-8)^2}$	**M1**	**oe** Correct expression AB^2 or AB in terms of t
	$9t^2+12t+4+t^2-16t+64=146$ or $10t^2-4t+68=146$ or $5t^2-2t+34=73$ or $\sqrt{10t^2-4t+68}=\sqrt{146}$	**M1**	**oe** Correct expansion of brackets and set equal to 146 or $\sqrt{146}$. Simplified or unsimplified.
	$\left[10t^2-4t-78=0\Rightarrow\right]$ $(10t+26)(t-3)$ $[=0]$	**M1**	**oe** An attempt to solve the correct quadratic equation, for example factorisation or use of the quadratic formula with correct substitution. **PI** by at least $t=-\frac{13}{5}$ and the correct three term quadratic equation set equal to zero seen.
	$[t=]$ 3 and $[t=]$ $-\frac{13}{5}$ or -2.6	**A1**	Both correct values. **M1 M1 M0 A1** not possible.
		4	

Q	Answer	Marks	Comments
2(b)	$\left[\left(\frac{3+11}{2}, \frac{7+(-5)}{2}\right)=\right] (7, 1)$	**B1**	Correct coordinates of midpoint of *AB* Need not be seen as coordinates but be convinced. **PI** in later working.
	$[m=]\ \frac{1-(-2)}{7}\ \left[=\frac{3}{7}\right]$	**M1**	**oe** Correct method for finding the gradient of l_2 **ft** their midpoint of *AB* **PI** by correct gradient.
	$y-1=\frac{3}{7}(x-7)$ or $y=\frac{3}{7}x-2$	**A1ft**	**oe** Correct equation of l_2 Simplified or unsimplified. **ft** their midpoint and gradient, but gradient must come from the correct method.
	$3x-7y-14=0$	**A1**	Correct equation in the correct form. Any correct integer multiple.
		4	

	Question 2 Total	**8**	

Q	Answer	Marks	Comments
3	$\left[5\left(2xy^4\right)^3 =\right]\ 40x^3y^{12}$ or $\left[x^2\sqrt{y^7} =\right]\ x^2y^{\frac{7}{2}}$	M1	**oe** At least one correct expression in index form. Can be seen embedded. **PI** by b and c correct in their final answer.
	$40x^5y^{\frac{31}{2}}$	M1 A1	**oe** **M1**: Answer in correct form with at least two of a, b and c correct. **A1**: Correct answer in the correct form.
		3	

	Question 3 Total	**3**	

Q	Answer	Marks	Comments
4(a)	$(3k-1)x^2+(7k-4)x+(k+4)$ $=(3k-5)x$	M1	**oe** Equates the equations of the curve and the line
	$(3k-1)x^2+(7k-4)x-(3k-5)x$ $+(k+4)=0$ and $(3k-1)x^2+(4k+1)x+(k+4)=0$	A1	Extra line of working and **AG** Must be convincingly shown
		2	

Q	Answer	Marks	Comments
4(b)	$(4k+1)^2-4(3k-1)(k+4)\ [=0]$	M1	Forms the correct discriminant **PI**
	$16k^2+8k+1-4(3k^2+11k-4)\ [=0]$	M1	**oe** Correctly expands $(4k+1)^2$ or $(3k-1)(k+4)$ **PI**
	$4k^2-36k+17=0$	A1	Correct simplified equation set equal to zero **PI**
	$(2k-17)(2k-1)\ [=0]$	M1	**oe** An attempt to solve their quadratic equation, for example factorisation or use of the quadratic formula with correct substitution. **PI** by both correct values of k
	$[k=]\ \frac{1}{2}$ or $[k=]\ \frac{17}{2}$	A1	**oe** Both correct values and no others.
		5	

	Question 4 Total	**7**	

Q	Answer	Marks	Comments
5(a)	$[a =]$ 234	B1	Correct first term.
	$[d =]$ -6	B1	Correct common difference.
		2	

Q	Answer	Marks	Comments
5(b)	$3(240-6k)=240-6\times13$ or $234+(13-1)\times(-6)$ $=3(234+(k-1)\times(-6))$	M1	**oe** Equation equating the 13th term and 3 times the kth term. **ft** their a and d
	$[k =]$ 31	A1	**CAO**
		2	

Q	Answer	Marks	Comments
5(c)	$[\text{Sum} =]$ $\frac{1}{2}(54)(2(234)+(54-1)(-6))$	M1	**oe** Correct expression for the sum of the first 54 terms. **ft** their a and d
	$[\text{Sum} =]$ 4050	A1	**CAO**
		2	

	Question 5 Total	**6**	

Q	Answer	Marks	Comments
6			
	$na = 24$ or $\frac{1}{2}n(n-1)a^2 = 270$	**B1**	**oe** A correct equation in a and n set equal to the coefficient of x or x^2
	$\left[na = 24 \Rightarrow a = \frac{24}{n} \Rightarrow\right]$ $\frac{1}{2}n(n-1)\left(\frac{24}{n}\right)^2 = 270$	**M1**	**oe** Forms a correct equation with a eliminated. **PI** by correct value for n
	$576\left(\frac{n-1}{n}\right) = 540$ or $576 - \frac{576}{n} = 540$	**M1**	**oe** Brackets expanded to form an equation with a single term in n **PI** by correct value for n
	$[n =]$ 16	**A1**	Correct value of n
	$[a =] \frac{3}{2}$	**A1ft**	**oe** **ft** their n provided at least one previous **M1** awarded.
	$[b =] \frac{1}{6} \times 16 \times 15 \times 14 \times \left(\frac{3}{2}\right)^3$	**M1**	**oe** Substitutes the values of a and n into $\frac{1}{6}n(n-1)(n-2)a^3$ **ft** their a and n provided at least one previous **M1** awarded.
	$[b =]$ 1890	**A1**	**CAO**
		7	

Q	Answer	Marks	Comments
6 ALT	$na = 24$ or $\frac{1}{2}n(n-1)a^2 = 270$	**B1**	**oe** A correct equation in a and n set equal to the coefficient of x or x^2
	$\left[na = 24 \Rightarrow n = \frac{24}{a} \Rightarrow\right]$ $\frac{1}{2}\left(\frac{24}{a}\right)\left(\frac{24}{a}-1\right)a^2 = 270$	**M1**	**oe** Forms a correct equation with n eliminated. **PI** by correct value for a
	$576 - 24a = 540$	**M1**	**oe** Brackets expanded to form an equation with a single term in a **PI** by correct value for a
	$[a =]\ \frac{3}{2}$	**A1**	**oe** Correct value of a
	$[n =]\ 16$	**A1ft**	**ft** their a provided at least one previous **M1** awarded.
	$[b =]\ \frac{1}{6}\times 16\times 15\times 14\times\left(\frac{3}{2}\right)^3$	**M1**	**oe** Substitutes the values of a and n into $\frac{1}{6}n(n-1)(n-2)a^3$ **ft** their a and n provided at least one previous **M1** awarded.
	$[b =]\ 1890$	**A1**	**CAO**
		7	

	Question 6 Total	**7**	

Q	Answer	Marks	Comments
7(a)	$\left[\int_9^a 0.3x^2 - 3.6x + 9.2 \ \mathrm{d}x = \right]$ $0.1x^3 - 1.8x^2 + 9.2x \ [+c]$	M1A1	**oe** **M1:** At least two correct terms. **A1:** Correct integration.
	$\left[\left[0.1x^3 - 1.8x^2 + 9.2x\right]_9^a = \right]$ $0.1a^3 - 1.8a^2 + 9.2a$ $\quad - \left(0.1\times 9^3 - 1.8\times 9^2 + 9.2\times 9\right)$	M1	**oe** Correct substitution of limits into their integration.
	$0.1a^3 - 1.8a^2 + 9.2a$ $\quad - \left(72.9 - 145.8 + 82.8\right)$ or $0.1a^3 - 1.8a^2 + 9.2a - 9.9$	M1	**oe** Powers and products correctly evaluated from their substitution. Must have scored first A1 **PI**
	$0.1a^3 - 1.8a^2 + 9.2a - 9.9 = 2.1$ or $0.1a^3 - 1.8a^2 + 9.2a - 12 = 0$ and $a^3 - 18a^2 + 92a - 120 = 0$	A1	**oe** Further line of working with powers and products evaluated and set equal to 2.1 before **AG**
		5	

Q	Answer	Marks	Comments
7(b)(i)	$6^3 - 18\left(6^2\right) + 92\left(6\right) - 120$	**M1**	$a = 6$ correctly substituted. Must use the Factor Theorem.
	$216 - 648 + 552 - 120 = 0$	**A1**	Powers and products evaluated and shows equal to zero.
		2	

Q	Answer	Marks	Comments
7(b)(ii)	$\left[\left(a-6\right)\right]\ \left(a^2 - 12a + 20\right)$	**M1 A1**	**M1:** At least two terms correct in the quadratic factor **A1:** Correct quadratic factor, could be factorised into two linear factors **M1 A1 PI** by the correct product of three linear factors.
	$\left(a-2\right)\left(a-6\right)\left(a-10\right)$	**A1**	Correct product of three linear factors.
	$\left[\left(a-2\right)\left(a-6\right)\left(a-10\right) = 0 \Rightarrow a = \right]\ 10$	**A1**	**CAO** from the correct product of three linear factors.
		4	

	Question 7 Total	**11**	

Q	Answer	Marks	Comments
8(a)	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\ 6x-15x^{\frac{1}{2}}+6$	M1A1	**oe** **M1:** At least two correct terms. **A1:** Correct derivative.
		2	

Q	Answer	Marks	Comments
8(b)	$\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]\ 6-\frac{15}{2}x^{-\frac{1}{2}}$	M1	**oe** Correct second derivative. **PI** by correct value of second derivative. **ft** their first derivative provided that their first derivative has a term with a fractional power of x
	$\left[x=4\Rightarrow\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]\ 6-\frac{15}{2}\times4^{-\frac{1}{2}}$	A1ft	Substitutes $x=4$ into their second derivative. **ft** their second derivative. **PI** by correct value of second derivative.
	$\left[\text{Since }\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]\ \frac{9}{4}>0$ [then *P* is a] minimum [point.]	E1	Must be using the correct second derivative. $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ correctly evaluated, indication that it is positive with correct conclusion.
		3	

Q	Answer	Marks	Comments
8(c)	$\left[x=1 \Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x}=\right]\ 6\times1-15\left(1^{\frac{1}{2}}\right)+6\ \ [=-3]$	M1	**oe** Correct method to find gradient of tangent at Q **PI** by correct gradient of tangent or normal. **ft** their first derivative.
	$[m'=]\ \frac{1}{3}$	A1ft	Correct gradient of normal at Q **ft** their gradient of tangent provided first **M1** scored. **PI** in later working.
	$y-(-3)=\frac{1}{3}(x-1)$ or $y=\frac{1}{3}x-\frac{10}{3}$	m1	**oe** Correct equation of normal at Q **ft** their gradient of normal. **PI** by correct value of y-intercept.
	$\left[\text{Area}=\frac{1}{2}\times\frac{10}{3}\times4=\right]\frac{20}{3}$	A1	**oe CAO** Must be exact.
		4	

Q	Answer	Marks	Comments
8(d)	$\left[\mathrm{f}'(0.2)=\right]\ 6(0.2)-15\left(0.2^{\frac{1}{2}}\right)+6$	M1	**oe** Correct unsimplified expression for $\mathrm{f}'(0.2)$ **PI** by correct value of $\mathrm{f}'(0.2)$ Must be using the correct first derivative.
	$\mathrm{f}'(0.2)=0.49179...$	A1	Correct value for $\mathrm{f}'(0.2)$ Must be evaluated. **AWRT** 0.5
	$\mathrm{f}'(0.2)>0$ [hence f is an] increasing [function at $x=0.2$]	E1	Indication that $\mathrm{f}'(0.2)$ is positive and correct conclusion. Value of $\mathrm{f}'(0.2)$ must be correct.
		3	

	Question 8 Total	**12**	

Q	Answer	Marks	Comments
9	$x^2+\frac{7b}{2a}x \quad \left[+\frac{2c}{a}=0\right]$ or $2a\left(x^2+\frac{7b}{2a}x\right) \quad [+4c=0]$	**M1**	**oe** Divides by $2a$ or factors out $2a$ with at least the terms in x May be seen embedded. **PI**
	$\left(x+\frac{7b}{4a}\right)^2 ...$ or $2a\left(x+\frac{7b}{4a}\right)^2 ...$	**A1**	Correctly deals with the terms in x in completing the square.
	$-\left(\frac{7b}{4a}\right)^2$ or $-2a\left(\frac{7b}{4a}\right)^2$	**B1**	Sight of $-\left(\frac{7b}{4a}\right)^2$ or $-2a\left(\frac{7b}{4a}\right)^2$ **PI** by simplified expression seen in later working.
	$\left(x+\frac{7b}{4a}\right)^2-\frac{49b^2}{16a^2}+\frac{2c}{a}=0$ or $2a\left(x+\frac{7b}{4a}\right)^2-\frac{49b^2}{8a}+4c=0$	**A1**	**oe** Correct equation in completed square form.
	$x+\frac{7b}{4a}=\pm\sqrt{\frac{49b^2-32ac}{16a^2}}$ or $x+\frac{7b}{4a}=\pm\frac{\sqrt{49b^2-32ac}}{4a}$	**A1**	**oe** Correct equation rearranged with square roots of both sides taken. Must have common denominator. Must have $\pm$
	$x=\frac{-7b\pm\sqrt{49b^2-32ac}}{4a}$	**A1**	**CAO** Must be convincingly shown by completing the square and all previous marks awarded.
		6	

	Question 9 Total	**6**	

Q	Answer	Marks	Comments
10(a)	$\left[10x\sqrt{x}-18\sqrt{x}-14+\frac{4}{\sqrt{x}}=\right]$ $10x^{\frac{3}{2}}-18x^{\frac{1}{2}}-14+4x^{-\frac{1}{2}}$	**B1**	**oe** Correctly expresses terms in x in index form. **PI** by correct integration.
	$\left[\int \mathrm{f}(x)\,\mathrm{d}x=\right]$ $\frac{2}{5}\left(10x^{\frac{5}{2}}\right)-\frac{2}{3}\left(18x^{\frac{3}{2}}\right)-14x+2\left(4x^{\frac{1}{2}}\right)$	**M1** **A1ft**	**oe** **M1:** At least three terms correctly integrated. Coefficients simplified or unsimplified. **A1:** Correct integration. Coefficients simplified or unsimplified. **ft** their integrand provided at least one term in x has a fractional power.
	$\left[\int \mathrm{f}(x)=\right]$ $4x^{\frac{5}{2}}-12x^{\frac{3}{2}}-14x+8x^{\frac{1}{2}}+c$	**A1**	**oe CAO** Must have coefficients simplified and have '$+c$'
		4	

Q	Answer	Marks	Comments
10(b)	$[x=4$ and $y=23\Rightarrow]$ $4\left(4^{\frac{5}{2}}\right)-12\left(4^{\frac{3}{2}}\right)-14(4)+8\left(4^{\frac{1}{2}}\right)+c=23$ or $128-96-56+16+c=23$	**M1**	**oe** Substitutes $x=4$ and sets equal to 23 **ft** their integral from **part (a)** **PI** by $c=31$
	$y=4x^{\frac{5}{2}}-12x^{\frac{3}{2}}-14x+8x^{\frac{1}{2}}+31$	**A1**	**oe CAO**
		2	

	Question 10 Total	**6**	

Q	Answer	Marks	Comments
11	$\frac{a}{1-r}=2304$ or $\frac{a}{1-\frac{3}{4}r}=1536$	**B1**	**oe** At least one correct equation in a and r using the values for the sums to infinity.
	$\left[\begin{array}{l} a=2304(1-r) \text{ and} \\ a=1536\left(1-\frac{3}{4}r\right) \Rightarrow \end{array}\right]$ $2304(1-r)=1536\left(1-\frac{3}{4}r\right)$ or $\frac{2304-a}{2304}=\frac{1536-a}{1152}$	**M1**	**oe** Uses their equations for both sums to infinity to form a single equation in either r or a **PI** by correct value of r or a
	$[r=]\ \frac{2}{3}$	**A1**	**oe CAO** Correct value for r **PI** In later working.
	$[a=]\ 768$	**A1ft**	Correct value of a **ft** their value for r
	[Common ratio of $Y=$] $\frac{1}{4}$	**B1ft**	**oe PI** **ft** $\left(\frac{3}{4}\times \text{their } r\right)^2$
	[First term of $Y=$] 384	**B1ft**	**PI** **ft** $\frac{3}{4}\times$ their $r\times$ their a
	$\frac{384\left(1-\left(\frac{1}{4}\right)^{2k}\right)}{1-\frac{1}{4}}$	**M1**	**oe** Correct use of the formula for the sum of the first n terms of a geometric series with values and $n=2k$ and substituted. **ft** their common ratio and first term of Y
	$512\left(1-\left(\frac{1}{16}\right)^{k}\right)$	**A1**	**CAO**
		8	

	Question 11 Total	**8**	