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MA01

(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.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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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)	$\frac{64}{125}$	**B1**	
		1	

Q	Answer	Marks	Comments
1(a)(ii)	-3	**B1**	
		1	

Q	*Answer*	Marks	Comments
1(b)	$\left[27^{2y} =\right]\ 3^{6y}$ or $\left[9^{\frac{1}{2}x} =\right]\ 3^{x}$ or $\left[\frac{1}{9\sqrt{3}} =\right]\ 3^{-\frac{5}{2}}$ or $\left[9\sqrt{3} =\right]\ 3^{\frac{5}{2}}$	B1	**PI** Expresses either 27^{2y}, $9^{\frac{1}{2}x}$, $\frac{1}{9\sqrt{3}}$ or $9\sqrt{3}$ as correct power of 3
	$\left[\frac{27^{2y}}{9^{\frac{1}{2}x}} = \frac{1}{9\sqrt{3}} \Rightarrow \frac{3^{6y}}{3^{x}} = 3^{-\frac{5}{2}} \Rightarrow\right]$ $3^{6y-x} = 3^{-\frac{5}{2}}$ or $6y - x = -\frac{5}{2}$ or $3^{6y} = 3^{x-\frac{5}{2}}$	M1	**PI** Correctly applies power rule to clear algebraic fractions in a correct equation. Could be seen without base 3, otherwise has no more than one base 3 each side.
	$[y =]\ \frac{1}{6}x - \frac{5}{12}$	A1	**CAO oe**
		3	
	Question 1 Total	**5**	

Q	Answer	Marks	Comments
2(a)	$\left[8\times 8-5\times 10=14\Rightarrow\right]\ 64-50=14$ or $\left[\frac{8}{5}\times 8-\frac{14}{5}\Rightarrow\right]\ \frac{64}{5}-\frac{14}{5}=10$ or $\left[8\times 8-5y=14\Rightarrow\right]$ $64-5y=14$ $\Rightarrow y=10$ and Hence l_1 passes through the point $A(8,10)$	B1	Either: Substitutes the coordinates of *A* into the LHS of the equation of l_1 and concludes it is equal to 14. Must see $64-50=14$ or Rearranges to $y=\frac{8}{5}x-\frac{14}{5}$ and substitutes into RHS concluding $y=10$ Must see $\frac{64}{5}-\frac{14}{5}=10$ or Substitutes $x=8$ into LHS and solves for y. Must see $64-5y=14$ before $y=10$ Must have a concluding statement
		1	

Q	Answer	Marks	Comments
2(b)	$\left[8x-5y=14 \text{ and } 7x+2y=-26\Rightarrow\right]$ $(-2,-6)$	B1	**PI** Solves equations simultaneously to find the coordinates of *B* Condone not given as coordinates but must be clearly identified.
	$\left[\lvert AB\rvert=\right]\ \sqrt{(8-(-2))^2+(10-(-6))^2}$	M1	**oe** **ft** their coordinates of *B*
	$2\sqrt{89}$ or $\sqrt{356}$	A1	**CAO**
		3	

Q	Answer	Marks	Comments
2(c)(i)	[Gradient of $l_1 =$] $\frac{8}{5}$	B1	**oe**
	$\frac{(k+7)-5}{3-(-2)}$ $\left[=\frac{8}{5}\right]$	M1	**oe** Correct method for finding the gradient of l_3 in terms of k
	$\left[\frac{k+2}{5}=\frac{8}{5}\Rightarrow\right]$ $k=6$	A1	**CAO**
		3	

Q	Answer	Marks	Comments
2(c)(ii)	$y-5=\frac{8}{5}(x-(-2))$ or $y-13=\frac{8}{5}(x-3)$ or $y=\frac{8}{5}x+\frac{41}{5}$	M1	**oe** Forms a correct equation for l_3 but not in the required form May see $y=\frac{8}{5}x+c$ or $8x-5y=c$ and substitution of coordinates of *P* or *Q* to find c but must be a complete method **ft** their gradient of l_1 from **part (c)(i)** **ft** their k from **part (c)(i)**
	$8x-5y+41=0$	A1	**CAO** Any integer multiple but must be in the correct form
		2	

	Question 2 Total	**9**	

Q	Answer	Marks	Comments
3(a)	Arithmetic	E1	
	The amount saved increases by the same amount each month	E1	Any statement implying a common difference between consecutive terms
		2	

Q	Answer	Marks	Comments
3(b)	$\left[a=240,\ d=8 \text{ and } n=22 \Rightarrow\right]$ $240+(22-1)\times 8$	M1	**PI oe** Correct use of the formula for the nth term of an arithmetic series with values substituted
	[$] 408	A1	**CAO**
		2	

Q	Answer	Marks	Comments
3(c)	$\left[a=240,\ d=8 \text{ and } n=36 \Rightarrow\right]$ $\frac{1}{2}\times 36\left(2\times 240+(36-1)\times 8\right)$	M1	**PI oe** Correct use of the formula for the sum of the first n terms of an arithmetic series with values substituted
	[$] 13 680	A1	**CAO**
		2	

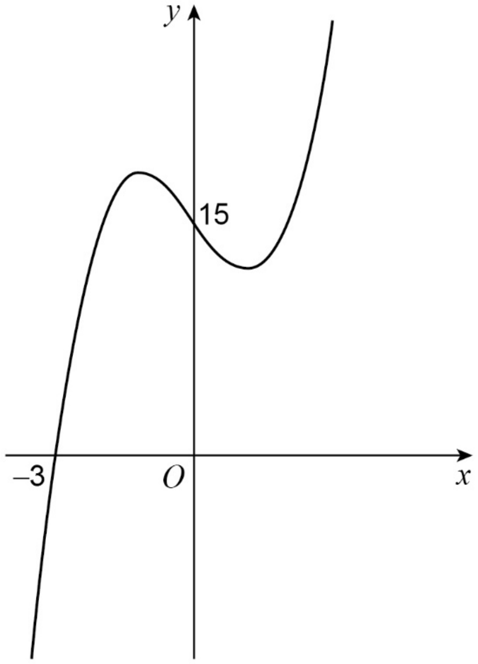
Q	Answer	Marks	Comments
3(d)	$[a=264,\ d=4\ \Rightarrow]$ $\frac{1}{2}\times n(2\times 264+(n-1)\times 4)\ [=15400]$	M1	**oe** Correct expression for the sum of the first n terms of an arithmetic series with values substituted
	$2n^2+262n-15400=0$ or $n^2+131n-7700=0$	M1	**oe** Sets their expression equal to 15400 and rearranges to form a three-term quadratic expression in the form $ax^2+bx+c=0$ **PI** By correct final answer or 44 and -175 both seen
	$[n=]\ 44$	A1	**CAO**
		3	

	Question 3 Total	**9**	

Q	Answer	Marks	Comments
4(a)	$(-3)^3 - 4(-3) + 15\ [= 0]$	M1	Factor Theorem used with $x = -3$ substituted
	$-27 + 12 + 15 = 0$	A1	**oe** Powers and products evaluated before being set equal to zero Factor Theorem not used scores **M0 A0**
		2	

Q	Answer	Marks	Comments
4(b)	$(x+3)(x^2 - 3x + 5)$	M1	b or c correct
		A1	**CAO**
		2	

Q	Answer	Marks	Comments
4(c)	$[b^2 - 4ac =]\ (-3)^2 - 4 \times 1 \times 5\ [= -11]$	M1	**oe** Correct attempt to evaluate the discriminant of $x^2 - 3x + 5$ **ft** Their answer to **part (b)** **PI** by -11 or a correct completed-square form for the quadratic factor
	$-11 < 0$ therefore the equation $f(x) = 0$ has exactly one real root	A1ft	Their discriminant evaluated correctly with an indication that it is negative and a final conclusion or an indication that the minimum value of their correct completed-square form is positive and a final conclusion
		2	

Q	Answer	Marks	Comments
4(d)		B1 B1 B1	Cubic curve of the correct form with minimum in the first quadrant and maximum in the second quadrant Correct value for y-intercept provided a graph is drawn Allow given as coordinates Correct value for x-intercept and no others provided a graph is drawn Allow given as coordinates
		3	

	Question 4 Total	9	

Q	Answer	Marks	Comments
5(a)	$\frac{7x\sqrt{x}+14x-3\sqrt{x}-6}{\sqrt{x}+2}\times\frac{\sqrt{x}-2}{\sqrt{x}-2}$	M1	**PI** Intention to multiply numerator and denominator by $\sqrt{x}-2$
	$x-4$	B1	Correct denominator Must be seen as the denominator
	$7x^2+14x\sqrt{x}-3x-6\sqrt{x}-14x\sqrt{x}$ $-28x+6\sqrt{x}+12$	M1	Unsimplified expression for the numerator Allow one error
	$7x^2-31x+12$	A1	Correct simplified numerator
	$\left[\frac{7x^2-31x+12}{x-4}=\right]$ $\frac{(7x-3)(x-4)}{x-4}$ and $7x-3$	A1	Correct algebraic fraction with numerator factorised before correct answer in given form. If numerator not factorised allow evidence of correct algebraic division. **SC2** for final answer of $7x-3$ for methods other than rationalising the denominator
		5	

Q	Answer	Marks	Comments
5(b)	$\left[(7x-3)\left(x^2\sqrt{x}-4\right)=\right]$ $7x^3\sqrt{x}-28x-3x^2\sqrt{x}+12$ or $7x^{\frac{7}{2}}-28x-3x^{\frac{5}{2}}+12$	**M1**	Correct expansion of integrand using their result from **part (a)**
	$\left[\int\left(7x^{\frac{7}{2}}-28x-3x^{\frac{5}{2}}+12\right)\mathrm{d}x=\right]$ $\frac{14}{9}x^{\frac{9}{2}}-14x^2-\frac{6}{7}x^{\frac{7}{2}}+12x+c$	**M1 A1ft**	**M1: oe** At least three correct terms simplified or unsimplified **ft** Their integrand using their $ax+b$ from **part (a)** **A1ft:** **ft** Their $ax+b$ from **part (a)** Coefficients must be simplified Must include '$+c$'
		3	

	Question 5 Total	**8**	

Q	Answer	Marks	Comments
6(a)	$\left[(1+3x)^9 =\right]$ $\left[(1)^9 + 9(1)^8(3x) + \right]$ $36(1)^7(3x)^2 + 84(1)^6(3x)^3$	M1	For either $[1, 9]$, 36, 84 **oe** unsimplified or $\binom{9}{2}(1)^7(3x)^2$ or $\binom{9}{3}(1)^6(3x)^3$ **oe**, x not needed **PI**
	$[a =]$ 324	A1	Condone $324x^2$
	$[b =]$ 2268	A1	Condone $2268x^3$
		3	

Q	Answer	Marks	Comments
6(b)	$1+3x=\frac{17}{20}$	M1	**PI** by $x=-\frac{1}{20}$ seen substituted Method for finding correct value of x
	$[x=]-\frac{1}{20}$	A1	Possibly seen embedded in later working.
	$\left[\left(\frac{17}{20}\right)^9 \approx\right]$ $1+27\left(-\frac{1}{20}\right)+324\left(-\frac{1}{20}\right)^2+2268\left(-\frac{1}{20}\right)^3$	m1	**oe** Substitutes their $x=-\frac{1}{20}$ into their expansion in **part (a)**
	$1-\frac{27}{20}+\frac{81}{100}-\frac{567}{2000}$ and $\frac{353}{2000}$	A1	**oe** Extra line of working simplifying powers and products before **AG**
		4	

Q	Answer	Marks	Comments
6(c)	$\left[\left(\frac{17}{10}\right)^9 = \left(2\times\frac{17}{20}\right)^9\right]$ $2^9\times\frac{353}{2000}$ or $512\times\frac{353}{2000}$ or $2^9\times\left(\frac{17}{20}\right)^9$	**M1**	
	$\frac{11296}{125}$ or 90.368	**A1**	**oe CAO**
		2	

	Question 6 Total	**9**	

Q	Answer	Marks	Comments
7(a)(i)	$\left[y = ax^3 + bx^2 + cx^{-\frac{3}{2}} \Rightarrow\right]$ $\left[\frac{\mathrm{d}y}{\mathrm{d}x} =\right] 3ax^2 + 2bx - \frac{3}{2}cx^{-\frac{5}{2}}$	M1 A1	**M1**: **oe** At least two correct terms **A1**: **oe** Correct first derivative
		2	

Q	Answer	Marks	Comments
7(a)(ii)	$\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2} =\right] 6ax + 2b + \frac{15}{4}cx^{-\frac{7}{2}}$	M1 A1ft	**oe** At least two correct terms **ft** Through their first derivative **oe** Correct second derivative **ft** Their answer to **part (a)(i)** provided it contains a fractional power of x
		2	

Q	Answer	Marks	Comments
7(b)	Since a, b and c [and x] are positive then $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} > 0$ Hence *P* is a minimum point	E1ft E1	States a, b and c [and x] are positive and therefore the second derivative is positive **ft** Their answer to **part (a)(ii)** provided all terms are positive Correct conclusion **E0 E1** not possible
		2	

Q	Answer	Marks	Comments
7(c)	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]$ $3a+2a-\frac{3}{2}a$ or $3b+2b-\frac{3}{2}b$ or $3c+2c-\frac{3}{2}c$	M1	**oe** Correct unsimplified expression for the first derivative in terms of a, b or c only. Allow use of another letter but not x **ft** Their answer to **part (a)(i)**
	$\frac{7}{2}a$ or $\frac{7}{2}b$ or $\frac{7}{2}c$	A1ft	**oe** Correct simplified expression for the first derivative in terms of a, b or c only. Allow use of another letter but not x **ft** Their answer to **part (a)(i)**
	[Hence since $\frac{\mathrm{d}y}{\mathrm{d}x}>0$ then] the gradient of the curve *C* is positive [at the point where $x=1$]	E1ft	**ft** Correct conclusion for their $\frac{7}{2}a$ or $\frac{7}{2}b$ or $\frac{7}{2}c$ Previous two marks must have been awarded for the award of this mark
		3	

	Question 7 Total	**9**	

Q	Answer	Marks	Comments
8(a)	$\left[y=\frac{3}{4}x^2-12x+21\Rightarrow\right]$ $\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\ \frac{3}{2}x-12$	M1	**oe** Correct derivative simplified or unsimplified. **PI** by correct gradient of tangent to *C* at *P*
	$\left[x=6\Rightarrow\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{3}{2}\times 6-12=\right]\ -3$	A1	Correct gradient of tangent to *C* at *P*
	$\left[m'\times(-3)=-1\Rightarrow\right]$ $[m'=]\ \frac{1}{3}$ or $(-3)\times\frac{3}{2}$ or $-\frac{9}{2}$	B1ft	Correct gradient of normal to *C* at *P* or Correct expression for, or value of, the product of the gradient of tangent to *C* at *P* and the gradient of l **ft** Their gradient of tangent to *C* at *P*
	$\frac{1}{3}\neq\frac{3}{2}$ or $(-3)\times\frac{3}{2}\neq-1$ or $-\frac{9}{2}\neq-1$ or $-3\neq-\frac{2}{3}$ therefore l is not the normal to *C* at *P*	E1ft	Compares gradient of normal to *C* at *P* to gradient of l and makes correct conclusion. or Compares $-\frac{9}{2}$ or $(-3)\times\frac{3}{2}$ to -1 and makes correct conclusion. **ft** Their gradient of normal to *C* at *P* provided it is not $\frac{3}{2}$
		4	

Q	Answer	Marks	Comments
8(b)(i)	$\frac{3}{4}x^2 - 12x + 21 = \frac{3}{2}x - 33$	M1	**oe** Equates the equation of *C* with the equation of l
	$\frac{3}{4}x^2 - \frac{27}{2}x + 54 = 0$ or $3x^2 - 54x + 216 = 0$ and $x^2 - 18x + 72 = 0$	A1	**oe** Extra line of working showing a simplified quadratic equation set equal to zero before **AG** Must be convincingly shown
		2	

Q	Answer	Marks	Comments
8(b)(ii)	$\left[x^2 - 18x + 72 = 0 \Rightarrow\right]$ $[x =]$ 12	M1	Correct x-coordinate of *Q* Ignore $x = 6$ if seen as well
	$(12, -15)$	A1	Correct coordinates of *Q* Condone not given as coordinates but must be clearly identified
		2	

Q	Answer	Marks	Comments
8(c)	$\left[\int \left(\frac{3}{4}x^2 - 12x + 21\right) \mathrm{d}x = \right]$		
	$\frac{1}{4}x^3 - 6x^2 + 21x\ [+c]$	M1 A1	**M1**: At least two correct terms simplified or unsimplified **A1**: Correct integration simplified or unsimplified
		2	

Q	Answer	Marks	Comments
8(d)	$\left[\int_{12}^{14}\left(\frac{3}{4}x^2 - 12x + 21\right)\mathrm{d}x =\right]$ $\left(\frac{1}{4}(14)^3 - 6(14)^2 + 21(14)\right)$ $-\left(\frac{1}{4}(12)^3 - 6(12)^2 + 21(12)\right)$	**M1**	**oe** Correct attempt to evaluate the definite integral **ft** Their x-coordinate of *Q* **PI** by the correct value of the integral.
	$\left[\int_{12}^{14}\left(\frac{3}{4}x^2 - 12x + 21\right)\mathrm{d}x =\right] -16$	**A1**	**CAO**
	$\frac{1}{2}\times(22-12)\times 15 \ [=75]$	**M1**	Correct method for finding the area of a relevant triangle **ft** Their coordinates of *Q*
	$[75-16=]$ 59	**A1ft**	**ft** Their value for the definite integral provided it was negative and their value for the area of a relevant triangle provided both method marks awarded
		4	

	Question 8 Total	**14**	

Q	Answer	Marks	Comments
9(a)	$ar = -48$ or $\frac{a}{1-r} = 200$	B1	**oe** Correct equation in terms of a and r using the second term or the sum to infinity
	$\left[a = -\frac{48}{r}\right.$ and $\left.a = 200(1-r) \Rightarrow\right]$ $-\frac{48}{r} = 200(1-r)$	M1	**oe** Starts to solve the equations simultaneously and forms a single equation in r
	$200r^2 - 200r - 48 = 0$ or $25r^2 - 25r - 6 = 0$	M1	**oe** Forms a correct quadratic equation in r set equal to zero
	$r = -\frac{1}{5}$ and $r = \frac{6}{5}$ and [since the series has a sum to infinity then] $r = \frac{6}{5}$ is rejected	A1	**oe** Finds both possible values of r and rejects $r = \frac{6}{5}$
	$[a =]$ 240	B1	**CAO**
		5	

Q	Answer	Marks	Comments
9(a) ALT	$ar = -48$ or $\frac{a}{1-r} = 200$	**B1**	**oe** Correct equation in terms of a and r using the second term or the sum to infinity
	$\left[r = -\frac{48}{a} \Rightarrow\right]$ $\frac{a}{1-\left(-\frac{48}{a}\right)} = 200$ or $\frac{a^2}{a+48} = 200$	**M1**	**oe** Starts to solve the equations simultaneously and forms a single equation in a
	$a^2 - 200a - 9600 = 0$ $[a = -40 \text{ or } 240]$	**M1**	**oe** Forms a correct quadratic equation in a set equal to zero
	If $a = -40$ then $r = \frac{6}{5}$ If $a = 240$ then $r = -\frac{1}{5}$ and [since the series has a sum to infinity then] $r = \frac{6}{5}$ is rejected	**A1**	**oe** Finds the correct corresponding value of r for each value of a and rejects $r = \frac{6}{5}$
	$[a =]$ 240	**B1**	**CAO**
		5	

Q	Answer	Marks	Comments
9(b)	$\left[\sum_{n=1}^{2k}\frac{625}{8}u_n=\right]\left[\frac{625}{8}\times\right]\frac{240\left(1-\left(-\frac{1}{5}\right)^{2k}\right)}{1-\left(-\frac{1}{5}\right)}$ $\left[\sum_{n=1}^{2k}\frac{625}{8}u_n=\right]5^6\left(1-5^{-2k}\right)$	M1 m1 A1	**oe** Substitutes $r=-\frac{1}{5}$ and their $a=240$ into the formula for the sum of the first $2k$ terms of the series In the correct form with the correct values of b and c or b and d or $b=\frac{1}{5}$, $c=-6$ and $d=2$ Condone $(-5)^{-2k}$ in place of 5^{-2k} **CAO** Correct final answer in the correct form
		3	

	Question 9 Total	**8**	