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MA02

(9660/MA02) Unit PSM1 Pure Mathematics, Statistics and Mechanics

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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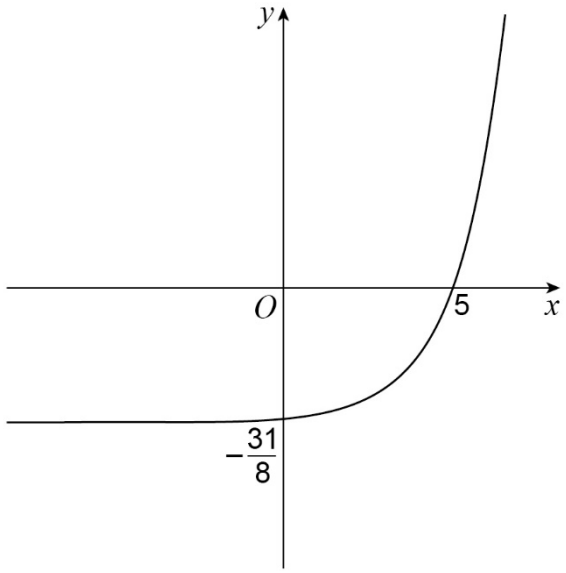
Key to mark scheme abbreviations

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)		**B1** **B1** **B1**	Positive exponential curve of the correct form passing through the third, fourth and first quadrants Correct value of x-intercept provided a graph is drawn. Condone given as coordinates **oe** Correct value of y-intercept provided a graph is drawn. Condone given as coordinates
		3	

Q	Answer	Marks	Comments
1(b)	$\left[10 = 2^{k-3} - 4 \Rightarrow 2^{k-3} = 14 \Rightarrow\right]$ $k - 3 = \log_2 14$ or $(k-3)\log_a 2 = \log_a 14$ or $2^k \times \frac{1}{8} = 14$	**M1**	**oe PI** $x = k$ and $y = 10$ substituted and logarithms used to form a linear equation in k with at least one side correct. or $x = k$ and $y = 10$ substituted with use of index rule to write as an equation in 2^k Condone x used for k throughout
	$\left[k = 3 + \log_2 14 \Rightarrow\right]$ $[k =]\ \log_2 8 + \log_2 14$ or $k - \log_2 8 = \log_2 14$ or $2^k = 112$	**M1**	**oe PI** Substitutes $\log_2 8$ for 3 to obtain a correct equation. or Correct value of 2^k
	$[k =]\ \log_2 112$	**A1**	**CAO** Must be in the correct form
		3	

	Question 1 Total	**6**	

Q	Answer	Marks	Comments
2(a)	$\frac{1}{2}\times 6^2\times\theta = 16.2$	**M1**	**oe** Forms correct equation using $\frac{1}{2}r^2\theta$
	$\theta = \frac{16.2}{18}$ and $\theta = 0.9$	**A1**	**oe** Correct calculation with θ as subject leading to **AG**
		2	

Q	Answer	Marks	Comments
2(b)(i)	$[\text{Area of Triangle } ACD =]$ $\frac{1}{2}\times 6\times 14\times \sin 0.9$	**M1**	**oe** Correct method for calculating the area with values substituted. **PI** by correct area of the triangle or correct final answer.
	$[\text{Area of Triangle } ACD =]$ $32.89973...\ [\text{cm}^2]$	**A1**	**CAO** **AWRT** 32.9 **PI** by correct final answer.
	$[\text{Shaded Area} = 32.89973... - 16.2 =]$ $16.7\ [\text{cm}^2]$	**A1ft**	**CAO** **AWRT** 16.7 **ft** their area of the triangle provided **M1** scored.
		3	

Q	Answer	Marks	Comments
2(b)(ii)	$[r\theta = 6 \times 0.9 =]$ 5.4 [cm]	**B1**	Correct length of arc *BD* **PI** by correct final answer.
	$\left[\lvert CD\rvert^2\right] = 6^2 + 14^2 - 2 \times 6 \times 14 \times \cos 0.9$ or $\left[\lvert CD\rvert^2\right] = 36 + 196 - 168\cos 0.9$	**M1**	**oe** Correct application of the Cosine Rule with values substituted. **PI** by correct length of *CD* or 127.56… or correct final answer.
	$\left[\lvert CD\rvert = \sqrt{127.56952...}\right] = 11.29466...$ [cm]	**A1**	Correct length of *CD* **AWRT** 11.3 **PI** by correct final answer.
	$\left[\text{Perimeter} = 11.29466... + 5.4 + (14 - 6) =\right]$ 24.7 [cm]	**A1**	Correct perimeter **AWRT** 24.7
		4	

	Question 2 Total	**9**	

Q	Answer	Marks	Comments
3(a)	$\left[\left(\frac{9+12}{2}, \frac{5+2}{2}\right)=\right] \left(\frac{21}{2}, \frac{7}{2}\right)$	B1	**oe** Correct mid-point of *QR*
	$\left[\left(\frac{5-2}{9-12}\right)=\right] -1$	B1	Correct gradient of *QR* **PI** in later working
	$y-\frac{7}{2}=x-\frac{21}{2}$ or $y=x-7$ or $\frac{\frac{7}{2}}{\frac{21}{2}-x}$	M1	**oe** Correct equation of the perpendicular bisector of *QR* **ACF** or Correct expression for the gradient of the line from the mid-point of *QR* to *P*
	$[y=0\Rightarrow] -\frac{7}{2}=x-\frac{21}{2}$ and $x=7$ or $[y=0\Rightarrow] 0=x-7$ and $x=7$ or $\frac{\frac{7}{2}}{\frac{21}{2}-x}=1\Rightarrow x=7$	A1	**oe** Indicates $y=0$ implies $x=7$ Could see $y=0$ substituted into the equation of the perpendicular bisector of *QR* or Sets the expression for the gradient of the line from the mid-point of *QR* to *P* equal to 1 and states $x=7$ Must be convincingly shown
		4	

Q	Answer	Marks	Comments
3(b)(i)	$(17, 4)$	B1	Correct centre of C_2
	$\left[r^2=\right] (9-7)^2+5^2$ or $\left[r=\right] \sqrt{(9-7)^2+5^2}$ or $\left[r^2=\right] (12-7)^2+2^2$ or $\left[r=\right] \sqrt{(12-7)^2+2^2}$	M1	Correct method for finding the radius or the square of the radius of C_1 **PI** by $\left[r^2=\right] 29$ or $\left[r=\right] \sqrt{29}$
	$(x-17)^2+(y-4)^2=29$	A2,1	**A1**: Correct LHS of equation in the correct form **A2**: Correct equation in the correct form
		4	

Q	Answer	Marks	Comments
3(b)(ii)	Translation $\begin{bmatrix}10\\4\end{bmatrix}$	**E1** **E1ft**	Transformation named Correct vector. **ft** Their equation of C_2 from **part (b)(i)**
		2	

	Question 3 total	**10**	

Q	Answer	Marks	Comments
4(a)(i)	7	B1	
		1	

Q	Answer	Marks	Comments
4(a)(ii)	$[x =]$ $227°$	B1	
		1	

Q	Answer	Marks	Comments
4(b)(i)	$\left[\dfrac{31-29\sin\theta-21\cos^2\theta}{2-3\sin\theta}=\right]$ $\dfrac{31-29\sin\theta-21\left(1-\sin^2\theta\right)}{\left[2-3\sin\theta\right]}$ or $\dfrac{31-29\sin\theta-21+21\sin^2\theta}{\left[2-3\sin\theta\right]}$ or $\dfrac{10-29\sin\theta+21\sin^2\theta}{\left[2-3\sin\theta\right]}$	M1	**oe** Correct use of $\cos^2\theta+\sin^2\theta=1$ to find a correct expression for the numerator in $\sin\theta$ only. Simplified or unsimplified.
	$\dfrac{(2-3\sin\theta)(5-7\sin\theta)}{2-3\sin\theta}$	M1	**oe** Correct fraction with numerator factorised.
	$5-7\sin\theta$	A1	**CAO**
		3	

Q	Answer	Marks	Comments
4(b)(ii)	$\left[\begin{array}{l} 5-7\sin y = 5+4\cos y \\ \Rightarrow \dfrac{\sin y}{\cos y} = -\dfrac{4}{7} \Rightarrow \end{array}\right]$ $\tan y = -\dfrac{4}{7}$	**M1**	Rearranges the equation to find the correct value for $\tan y$ **PI** **ft** their k from **part (b)(i)**
	$[y =]$ 2.62 , 5.76 [radians]	**A2,1**	**A1**: At least one correct value **AWRT** 2.62 or **AWRT** 5.76 **A2**: Both correct values and no others in the given range. Both must be to 2dp.
		3	

	Question 4 Total	**8**	

Q	Answer	Marks	Comments
5(a)	$y = a^{\frac{1}{2}}$ or $a = 64^{x+5}$	**B1**	For correctly expressing y as a power of a or a as a power of 64 **PI** by $y^2 = a$
	$y^2 = 64^{x+5}$ or $y^2 = 2^{6(x+5)}$ or $y = \left(64^{x+5}\right)^{\frac{1}{2}}$ or $y = 64^{\frac{1}{2}(x+5)}$	**M1**	**oe** Correctly using both equations to obtain a correct equation relating x and y
	$\left[y = 64^{\frac{1}{2}(x+5)} = \left(2^6\right)^{\frac{1}{2}(x+5)} \Rightarrow \right]$ $y = 2^{3(x+5)}$	**A1**	Correct equation in the correct form
		3	

Q	Answer	Marks	Comments
5(b)	$\left[\log_7\frac{216}{5}=\right]\ \log_7 216-\log_7 5$	**M1**	**oe** Correctly expressing $\log_7\frac{216}{5}$ as the difference between two logarithms
	$\left[\log_7 216-\log_7 5=\right]$ $\log_7 6^3-\log_7 625^{\frac{1}{4}}$	**M1**	**oe PI** Correct expression for $\log_7\frac{216}{5}$ with powers of 6 and 625 substituted
	$3\log_7 6-\frac{1}{4}\log_7 625$	**M1**	**oe PI** Correct expression using the multiple property of logarithms with both terms
	$\left[\log_7\frac{216}{5}=\right]\ 3q-\frac{1}{4}p$	**A1**	**CAO**
5(b) Alt	$\left[\log_7\frac{216}{5}=\right]\ \log_7 216-\log_7 5$	**M1**	**oe** Correctly expressing $\log_7\frac{216}{5}$ as the difference between two logarithms
	$\left[\log_7 216=\right]\ \log_7 6^3$ and $\left[\log_7 625=\right]\ \log_7 5^4$ or $\left[\log_7 5=\right]\ \log_7 625^{\frac{1}{4}}$	**M1**	**oe PI** Correct expression for $\log_7 216$ with power substituted. And Correct expression for $\log_7 625$ or $\log_7 5$ with power substituted.
	$\left[\log_7 216=\right]\ 3\log_7 6$ and $\left[\log_7 625=\right]\ 4\log_7 5$ or $\left[\log_7 5=\right]\ \frac{1}{4}\log_7 625$	**M1**	**oe PI** Correct expressions using the multiple property of logarithms.
	$\left[\log_7\frac{216}{5}=\right]\ 3q-\frac{1}{4}p$	**A1**	**CAO**
		4	

	Question 5 Total	**7**	

Q	Answer	Marks	Comments
6(a)	$\left[\binom{40}{6} \times 0.09^6 \times (1-0.09)^{40-6} = \right]$ 0.0826	B1	**AWRT** 0.0826
		1	

Q	Answer	Marks	Comments
6(b)	[P(Number of customers > 4) $= 1 - $ P(Number of customers ≤ 4)] $1 - 0.7103$ 0.2897	M1 A1	**PI** By correct answer. **AWRT** 0.2897
		2	

Q	Answer	Marks	Comments
6(c)(i)	[Var(Monday) $= 40 \times 0.09 \times (1 - 0.09) =$] 3.276 [Var(total) $= 3.276 + 2.3751 + 2.1294 =$] 7.7805	M1 A1	**PI** Finds variance for first day **AWRT** 3.28 **oe** **AWRT** 7.78
		2	

Q	Answer	Marks	Comments
6(c)(ii)	$\frac{7.7805}{0.09(1-0.09)}$ or $\frac{7.7805}{0.0819}$ 95	M1 A1	**oe** Divides their 7.7805 by $0.09(1 - 0.09)$ **CAO**
		2	

	Question 6 Total	**7**	

Q	Answer	Marks	Comments
7(a)	$\frac{\mathrm{P}(R \cap C')}{\mathrm{P}(C')} = \frac{23}{36}$	**M1**	Forms a correct equation with $\mathrm{P}(R \cap C')$ **PI** by correct value of $\mathrm{P}(R \cap C')$
	$\mathrm{P}(R \cap C') = \frac{23}{36}\left(1 - \frac{17}{23}\right) = \frac{1}{6}$	**A1**	Finds correct value of $\mathrm{P}(R \cap C')$
	$\mathrm{P}(R \cap C) = \mathrm{P}(R) - \mathrm{P}(R \cap C') = \frac{1}{6} - \frac{1}{6}$ or $\frac{1}{6} = \frac{1}{6}$ or $\mathrm{P}(R) = \mathrm{P}(R \cap C')$ or $\mathrm{P}(R \cap C) = 0$	**m1**	States and uses correct identity **oe PI**
	So they are mutually exclusive	**A1**	Gives correct conclusion.
		4	

Q	Answer	Marks	Comments
7(b)	$\frac{1}{6} + \frac{5}{7} - \frac{9}{50}$	**M1**	Correct calculation **PI**
	$\frac{368}{525}$	**A1**	**oe** **AWRT** 0.701
		2	

	Question 7 Total	**6**	

Q	Answer	Marks	Comments
8(a)	$k+5k+9k+14k=1$	M1	Forms correct equation **PI**
	$k=\frac{1}{29}$	A1	Sight of $\frac{1}{29}$ **oe**
	$1\times\frac{1}{29}+5\times\frac{5}{29}+9\times\frac{9}{29}+14\times\frac{14}{29}$	M1	Correct calculation for the mean for their k or correct expression in terms of k
	Mean $=\frac{303}{29}$	A1	**AG** Correct calculation must be seen before final answer
		4	

Q	Answer	Marks	Comments
8(b)	$\mathrm{E}(B)=1-\frac{11}{16}=\frac{5}{16}$	B1	**oe**
	$\frac{303}{29}+\frac{5}{16}+\mathrm{E}(C)=11$	M1	Correct equation to find $\mathrm{E}(C)$ or correct expression for $\mathrm{E}(C)$ using their $\mathrm{E}(B)$
	$\mathrm{E}(C)=\frac{111}{464}$	A1	**AWRT** 0.239
		3	

	Question 8 Total	**7**	

Q	Answer	Marks	Comments
9	$0.7g - T = 0.7a$ $T - 0.4g = 0.4a$	M1	**PI oe** Condone LHS of both multiplied by -1 or award for one correct equation.
	$0.7g - 0.4g = 1.1a$	M1	**oe** Correct equation with T eliminated **PI** by correct final answer.
	$a = 2.7 \left[\text{m s}^{-2}\right]$	A1	**AWRT** 2.7, accept $\frac{147}{55}$

	Question 9 Total	**3**	

Q	Answer	Marks	Comments
10(a)	$\left[\dfrac{\mathrm{d}v}{\mathrm{d}t} = a = \right] -t + 1.9 \ \left[= 0\right]$ or $p(t-1.9)^2 + q$	**M1**	Correct differentiation. or Attempts to complete the square where p and q can take any value. **PI** by $\left[\dfrac{-b}{2a} = \right] \ \dfrac{-1.9}{-1}$ **oe** or $t = 1.9$
	$t = 1.9$ or $(-0.5)(t-1.9)^2 + q$	**A1**	**oe**
	$\left[v_{\max} = \right] -0.5(1.9)^2 + 1.9(1.9)$ or $(-0.5)(t-1.9)^2 - \left((-0.5)\times 1.9^2\right)$	**M1**	**oe** Substitutes their t into the correct velocity equation.
	$1.805 \ \left[\text{m s}^{-1}\right]$	**A1**	Must be convincingly shown.
		4	

Q	Answer	Marks	Comments
10(b)	$\left[\int v\mathrm{d}t =\right] \quad -\frac{1}{6}t^3+\frac{19}{20}t^2$	**M1**	Allow one error in a coefficient **PI**
	$\left[\int_0^2 v\mathrm{d}t =\right] \quad \left(-\frac{1}{6}(2)^3+\frac{19}{20}(2)^2\right)\left[-(0)\right]$	**M1**	Use of $t=2$ with their integrated expression **PI**
	$\left[\int_0^2 v\mathrm{d}t =\right] \quad \frac{37}{15}$	**A1**	**PI** by correct final answer. **AWRT** 2.47
	[Average speed =] $\frac{37}{30}\ \left[\mathrm{m\,s^{-1}}\right]$	**A1**	**AWRT** 1.2
		4	

Q	Answer	Marks	Comments
10(c)	$\left[\frac{56}{3}-\left(\frac{37}{15}\right)=\right]$ 16.2 or $\frac{81}{5}$	**B1ft**	Total distance travelled between $t=2$ and $t=T$ **PI** by an equation that would lead to the final answer. **ft** Their $\left(\frac{37}{15}\right)$ from **part (b)**
	$\left[u=\right]-0.5(2)^2+1.9(2)$ $\left[=1.8\right]$ $\left[u=\right]1.8-k(2-2)$ $\left[=1.8\right]$	**M1**	**oe** Correct attempt to find u by using $t=2$ in either equation. **PI** by correct value of u
	$\left[16.2=\right]$ $\frac{(1.8+0)(T-2)}{2}$	**M1**	**oe** **ft** their 1.8 Correct expression in terms of T for the total distance travelled between $t=2$ and $t=T$
	$16.2=\frac{(1.8+0)(T-2)}{2}$ or $18=T-2$ and $T=20$	**A1**	**oe** Sets correct expression in terms of T for the total distance travelled between $t=2$ and $t=T$ to equal 16.2 and **AG**
		4	

	Question 10 Total	**12**	

Q	Answer	Marks	Comments
11(a)	$\left[I =\right] 2\times 12 - 2v$ $\left[0 < v \leq 4\right]$ $16 \leq I < 24$	M1 A1	Condone $2v - 2\times 12$ **PI** By correct lower or upper bound in the final answer. Condone $16 < I < 24$
		2	

Q	Answer	Marks	Comments
11(b)	$2\times 12 - 2mq = 2v + 4m$ $v = 12 - 2m - mq$ or $v = 12 - m\left(2 + q\right)$ or $0 < 12 - 2m - mq \leq 4$ $0 < 12 - m(2 + q) \leq 4$	M1 m1 A1	Correct equation. Correctly rearranges to make v the subject of the equation. Could be seen in an inequality but if so must be unsimplified. **AG** Must be convincingly shown
		3	

Q	Answer	Marks	Comments
11(b) ALT	$I = 2mq + 4m$ $\left[16 \leq I < 24\right]$ $16 \leq 2mq + 4m < 24$ $\left[8 \leq mq + 2m < 12\right]$ $\left[-4 \leq m(2+q) - 12 < 0\right]$ $0 < 12 - m(2+q) \leq 4$	**M1** **m1** **A1**	Magnitude of impulse in terms and m and q Forms an inequality in m and q **ft** their 16 and 24 from **part (a)** as long as they are both positive. **AG** Must be convincingly shown
		3	

	Question 11 Total	**5**	