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MATHEMATICS

MA02

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

Mark scheme

January 2024

Version: 1.0 Final

241XMA02/MS

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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)	$[P]\,(0°, -2)$	**B1**	Condone omission of units.
	$[Q]\,(30°, 0)$	**B1**	Condone omission of units. Allow $\left(\frac{\pi}{6}, 0\right)$ If first two **B1** marks not awarded, then allow **SC1** for –2 for *P* and 30° for *Q*
	$[R]\,(300°, -4)$	**B1**	Condone omission of units. Allow $\left(\frac{5\pi}{3}, -4\right)$
		3	

Q	Answer	Marks	Comments
1(b)	Translation	**E1**	Correct single transformation named and no others
	$\begin{bmatrix} -105° \\ 0 \end{bmatrix}$ or $\begin{bmatrix} 255° \\ 0 \end{bmatrix}$	**E1**	**oe** Condone omission of units. Allow $\begin{bmatrix} -\frac{7\pi}{12} \\ 0 \end{bmatrix}$ or $\begin{bmatrix} \frac{17\pi}{12} \\ 0 \end{bmatrix}$ If more than one transformation described, then award **E0 E0**
		2	

	Question 1 Total	**5**	

Q	Answer	Marks	Comments
2(a)	$\frac{22-7}{3-(-2)}$ $[=3]$	**B1**	**oe** Correct unsimplified expression for the gradient of *AB* **PI** by correct gradient
	$3\times-\frac{1}{2}\neq-1$ or $-\frac{3}{2}\neq-1$ or $-\frac{1}{3}\neq-\frac{1}{2}$ and *AD* is not a diameter [of C_1]	**E1ft**	Shows or explains that the gradients are not perpendicular followed by a correct deduction **ft** their gradient of *AB* provided it is not equal to 2
		2	

Q	Answer	Marks	Comments
2(b)(i)	$\left(\frac{(-2)+18}{2}, \frac{7+17}{2}\right)=(8,12)$	**B1**	**oe** Correct unsimplified coordinates of the midpoint of *AE* and **AG**
		1	

Q	Answer	Marks	Comments
2(b)(ii)	$\left[r^2=\right]\ (18-8)^2+(17-12)^2$ or $\left[r^2=\right]\ (3-8)^2+(22-12)^2$ or $\left[r^2=\right]\ ((-2)-8)^2+(7-12)^2$	**M1**	**oe** Correct use of Pythagoras' Theorem **PI** by $r=5\sqrt{5}$ or $r^2=125$
	$\left[r^2=\right]\ 125$ or $[r=]\ 5\sqrt{5}$ or $\sqrt{125}$	**A1**	Correct value for r^2 or r
	$(x-8)^2+(y-12)^2=125$	**A1ft**	**ft** their r^2
		3	

Q	Answer	Marks	Comments
2(c)	$[m=]\ \frac{22-12}{3-8}\ [=-2]$	**M1**	Correct method for finding the gradient of the normal **PI** in later working
	$y-22=-2(x-3)$ or $y-12=-2(x-8)$ or $y=-2x+28$	**A1**	Correct equation of normal in any form, simplified or unsimplified May use $y = 0$ **PI** by correct final coordinates
	$[y=0 \Rightarrow x=14]$ $(14, 0)$	**A1**	**CAO** Condone x-coordinate given only
		3	

Q	Answer	Marks	Comments
2(d)	$(x-11)^2+(y-7)^2=125$	**B2ft**	**B2ft**: Answer in the correct form, **ft** their k from **part(b)(ii)** Award **B1ft** for one correct bracketed term in an equation of the correct form set equal to their k from **part(b)(ii)**
		2	

	Question 2 Total	**11**	

Q	Answer	Marks	Comments
3(a)	$(x-12)^2$... or $(y-10)^2$...	**M1**	
	$(x-12)^2-12^2+(y-10)^2-10^2+163\ [=0]$ or $(x-12)^2-144+(y-10)^2-100+163\ [=0]$ or $(x-12)^2+(y-10)^2=81$	**M1**	**oe** Correctly completes both squares simplified or unsimplified
	$[\lvert PQ\rvert=\sqrt{81}=]$ 9	**A1**	**CAO** **PI** in later working.
	$\frac{1}{2}\times 9\times 9\times\sin\theta=20.25$	**M1**	**oe** Forms correct equation using formula for the area of a triangle **ft** their $\lvert PQ\rvert$
	$\theta=\sin^{-1}\left(\frac{1}{2}\right)$ or $\sin\theta=\frac{1}{2}$ and $\theta=\frac{5\pi}{6}$	**A1**	Finds value for $\sin\theta$ and **AG** For $\frac{1}{2}$ accept 0.5
		5	

Q	Answer	Marks	Comments
3(b)	$\left[9\times\frac{5\pi}{6}=\right]\ \frac{15\pi}{2}$ or $23.5[6194...]$	**B1ft**	**oe** Correct arc length of QR **ft** their $\lvert PQ\rvert$ from **part (a)** **AWRT** 23.6 **PI** by correct final answer.
	$\left[\lvert QR\rvert^2=\right]$ $9^2+9^2-2\times9\times9\times\cos\left(\frac{5\pi}{6}\right)$ $\left[=302.2[9611...]\right]$ or $162-162\cos\left(\frac{5\pi}{6}\right)$ or $\left[\lvert QR\rvert=\right]\ \frac{9\sin\left(\frac{5\pi}{6}\right)}{\sin\left(\frac{\pi}{12}\right)}$	**M1**	**oe ft** their $\lvert PQ\rvert$ from **part (a)** Correct use of the Cosine Rule or Sine Rule Condone use of $\frac{\pi}{6}$ or 30°
	$\left[\lvert QR\rvert=\right]\ 17.3[8666...]$	**A1**	Correct value **AWRT** 17.4 **PI** by correct final answer.
	40.9	**A1**	**AWRT** 40.9 Condone 41.0 as final answer
		4	

	Question 3 total	**9**	

Q	Answer	Marks	Comments
4(a)	$\left[6^{3t-1}=\frac{27}{8}\Rightarrow\right]$ $3t-1=\log_6\left(\frac{27}{8}\right)$	**M1**	**oe** Correct equation with use of $\log_6 6^k = k$
	$\left[\frac{1}{3}\log_6\left(\frac{27}{8}\right)=\right]\ \log_6\left(\frac{27}{8}\right)^{\frac{1}{3}}$	**M1**	Use of a logarithm property **PI, oe**
	$[t=]\ \frac{1}{3}+\log_6\left(\frac{3}{2}\right)$	**A1**	**CAO**
		3	

Q	Answer	Marks	Comments
4(b)(i)	$[y=]\ \log_{10} x^2\ \left[+\log_{10}(x+5)\right]$	**M1**	Use of log property for powers **PI**
	$[y=]\ \log_{10}\left(x^2(x+5)\right)$ and $y=\log_{10}\left(x^3+5x^2\right)$	**A1**	Use of log property for addition **AG** Must be convincingly shown
		2	

Q	Answer	Marks	Comments
4(b)(ii)	$[m=]\ \frac{\log_{10}(396)-\log_{10}(144)}{6-4}$	**M1**	**oe** Expression for the gradient with values substituted **PI**
	$[m=]\ \frac{\log_{10}\left(\frac{11}{4}\right)}{2}$	**M1**	**oe** Use of logarithm property Accept fractions equivalent to $\frac{11}{4}$
	$[m=]\ \log_{10}\left(\frac{1}{2}\sqrt{11}\right)$	**A1**	Correct answer in correct form **A1** dependent upon both method marks scored
		3	

	Question 4 Total	**8**	

Q	Answer	Marks	Comments
5(a)	$7\tan^2 x - \tan x = \dfrac{6}{\cos^2 x}$	**M1**	**oe** Use of $\tan x = \dfrac{\sin x}{\cos x}$ to obtain terms in $\tan x$ and $\tan^2 x$
	$\sin^2 x - \sin x \cos x - 6\cos^2 x = 0$ or $7\tan^2 x - \tan x = \dfrac{6\left(\sin^2 x + \cos^2 x\right)}{\cos^2 x}$ or $7\tan^2 x - \tan x = 6\left(\tan^2 x + 1\right)$ or $7\sin^2 x - \sin x \cos x = 6\left(\sin^2 x + \cos^2 x\right)$	**M1**	**oe** Use of $\sin^2 x + \cos^2 x = 1$
	$\tan^2 x - \tan x - 6 = 0$ and $(\tan x - 3)(\tan x + 2) = 0$	**A1**	Simplified quadratic equation set equal to zero **AG** Must be convincingly shown
		3	

Q	Answer	Marks	Comments
5(b)	$\tan(\theta-35°)-3=0$ or $\tan(\theta-35°)=3$ or $\theta-35°=\tan^{-1}(3)$ or $\tan(\theta-35°)+2=0$ or $\tan(\theta-35°)=-2$ or $\theta-35°=\tan^{-1}(-2)$ $[\theta-35°=]$ $71.5[6505...]$ and $[\theta-35°=]$ $-63.4[3494...]$ $[\theta=]$ -73.4 and $[\theta=]$ -28.4	**M1** **A1** **B2,1**	Clear use of result in **part (a)** Condone x used instead of $\theta-35°$ Both correct values Anything that rounds or truncates to 1 dp **B2**: Both correct values given to 3 sf and no others **B1**: One correct value given to 3 or more sf
		4	

	Question 5 Total	**7**	

Q	Answer	Marks	Comments
6(a)	8	**B1**	**CAO**
		1	

Q	Answer	Marks	Comments
6(b)	30	**B1**	**CAO**
		1	

Q	Answer	Marks	Comments
6(c)	9	**B1**	**CAO**
		1	

Q	Answer	Marks	Comments
6(d)	$1+6+4+3+\text{Var}\left(X_5\right)=39$ or $\left[\text{Var}\left(X_5\right)=\right]$ 25	**M1**	**PI** by correct final answer
	$\left[\text{SD}\left(X_5\right)=\right]$ 5	**A1**	**CAO** Accept $\sqrt{25}$
		2	

	Question 6 Total	**5**	

Q	Answer	Marks	Comments
7(a)(i)	Bernoulli	**B1**	Accept binomial
		1	

Q	Answer	Marks	Comments
7(a)(ii)	$\mathrm{E}(X) = 0.286$	**B1**	
		1	

Q	Answer	Marks	Comments
7(b)(i)	$\mathrm{Var}(Y) = 5 \times \frac{1}{6}\left(1 - \frac{1}{6}\right)$ $\mathrm{Var}(Y) = \frac{25}{36}$	**M1** **A1**	**oe** $np(1-p)$ with correct values substituted **PI** by correct final answer **AWRT** 0.694
		2	

Q	Answer	Marks	Comments
7(b)(ii)	$\mathrm{P}(Y = 2) = \binom{5}{2}\left(\frac{1}{6}\right)^2\left(\frac{5}{6}\right)^3$ $\mathrm{P}(Y = 2) = \frac{625}{3888}$	**M1** **A1**	**oe** Correct calculation **PI** by correct answer **AWRT** 0.161
		2	

Q	Answer	Marks	Comments
7(c)	$0.286 \times \frac{625}{3888}$ $= \frac{715}{15552}$	**M1** **A1ft**	$0.286 \times$ their answer to **part (b)(ii)** **PI** by correct final answer. **AWRT** 0.046 **ft** their answer to **part (b)(ii)** but answer must be at least 3 dp
		2	

	Question 7 Total	**8**	

Q	Answer	Marks	Comments
8(a)	$\frac{44}{101}$	**M1 A1**	**M1**: Correct numerator or denominator, with fraction in interval (0, 1) **A1**: **CAO**, 0.435[64…]
		2	

Q	Answer	Marks	Comments
8(b)	$\mathrm{P}(A) = \frac{78}{200}$ and $\mathrm{P}(B) = \frac{91}{200}$	**B1**	**oe** **PI** by sight of 78 and 91 within a correct calculation, or 270 seen
	$\mathrm{P}(A \cup B) = 1 - \left(\frac{101 - 26 - 44}{200}\right)$	**M1**	Correct calculation of $\mathrm{P}(A \cup B)$ or finds corresponding frequency 169 or correct calculation of $\mathrm{P}(A \cup B)'$ **PI**, for example by sight of $101 - 26 - 44$ in a calculation
	$\mathrm{P}(A \cap B) = \frac{78}{200} + \frac{91}{200} - \frac{169}{200}$	**M1**	Uses addition law or sets up a correct equation with their probabilities to find $\mathrm{P}(A \cap B)$ or finds corresponding frequency. **PI** by $78 + 101 + 91 - 26 - 44 \left[= 200\right]$ or $78 + 101 + 91 - 26 - 44 - 200 \left[= 0\right]$
	$\mathrm{P}(A \cap B) = 0$	**B1**	Must be expressed as a probability, e.g. $A \cap B = \varnothing$ is **B0**
	Hence mutually exclusive	**A1**	Dependent on both previous **M1** marks and all working correct
		5	

	Question 8 Total	**7**	

Q	Answer	Marks	Comments
9	$3 = 0.6\left(u - \left(-3u\right)\right)$ $\left[3 = 2.4u\right]$ $u = 1.25$	**M1** **A1**	Allow sign errors **oe**

	Question 9 Total	**2**	

Q	Answer	Marks	Comments
10(a)	$1800 - 170 \times 9.8 = 170a$ $\left[a =\right] \frac{67}{85}$ m s^{-2}	**M1** **A1**	A three-term equation with at least two fully correct Condone 9.81 m s^{-2} for g, but not 10 m s^{-2} **AWRT** 0.79 If 9.81 m s^{-2} used then final answer is $\frac{1323}{1700} = 0.778\ldots$ m s^{-2}, **AWRT** 0.78 Condone omission of units
		2	

Q	Answer	Marks	Comments
10(b)	The resultant force is downwards [, so the acceleration is downwards.] The velocity of the box may be upwards	**B1** **E1**	Calculation or explanation implying resultant force is downwards **PI** by statement that box could be accelerating downwards Allow 'moving upwards' **B0 E1** not possible
		2	

	Question 10 Total	**4**	

Q	Answer	Marks	Comments
11(a)(i)	$3t - 0.1t^2 = 0$ or $3 - 0.2t = 0$ $0.1t(30 - t)\ [= 0]$ or $t = 0$ and $t = 30$ or $[3 - 0.2t = 0 \Rightarrow]\quad t = 15$ [Therefore] $k = 30$	**M1** **A1**	Uses $v = 0$ to form a quadratic equation in t or differentiates expression for v and sets equal to zero. At least one further intermediate line of working and **AG** Must be convincingly shown.
		2	

Q	Answer	Marks	Comments
11(a)(ii)	$\left[v = 3 \times 15 - 0.1 \times 15^2 = \right]\ 22.5\ \text{m s}^{-1}$ $[t =]\ 15\ \text{s}$	**B1** **B1**	**oe**, condone omission of units Condone omission of units
		2	
Q	**Answer**	**Marks**	**Comments**
11(b)	$\left[\int \left(3t - 0.1t^2\right) \text{d}t = \right]\ \frac{3}{2}t^2 - \frac{0.1}{3}t^3$ $\left[\left[\frac{3}{2}t^2 - \frac{0.1}{3}t^3\right]_0^{30} = \right]$ $\frac{3}{2}(30)^2 - \frac{0.1}{3}(30)^3\ \left[-\left(\frac{3}{2}(0)^2 - \frac{0.1}{3}(0)^3\right)\right]$ $= 450$ [m] $\left[\text{Average speed } = \frac{450}{30} = \right]\ 15\ \text{m s}^{-1}$	**B1** **M1** **A1** **B1ft**	Correctly integrates expression for v **PI** Substitutes correct limits into their integration **PI** Correct change in displacement **ft** their 450 divided by 30, provided their 450 comes from integration Condone omission of units
		4	

Q	Answer	Marks	Comments
11(c)	$a = \frac{\mathrm{d}v}{\mathrm{d}t} = 3 - 0.2t$ $\left[\text{When } t = 0,\ \ a = 3 - 0.2 \times 0\right]$ $\left[a =\right]\ 3\ \text{m s}^{-2}$	**M1** **A1**	Differentiates v with respect to t **PI** by correct final answer Condone omission of units
		2	

	Question 11 Total	**10**	

Q	Answer	Marks	Comments
12	$\left[\text{Friction} =\right]\ 5\mu g$ $\left[-\mu \times 5g = 5a \Rightarrow\right] \qquad a = -\mu g$ $v^2 = u^2 + 2as$ $0 = 36 + 2 \times -\mu g \times x$ $x = \frac{18}{\mu g}$	**B1** **B1** **M1** **A1**	Correct expression for friction, such as 49μ **PI** by $a = -\mu g$ or $a = \mu g$ Correct expression for acceleration Condone $a = \mu g$ Uses a valid constant acceleration formula to find an expression for displacement Must be working with $a = -\mu g$

	Question 12 Total	**4**	