

INTERNATIONAL AS MATHEMATICS MA02

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

Mark scheme

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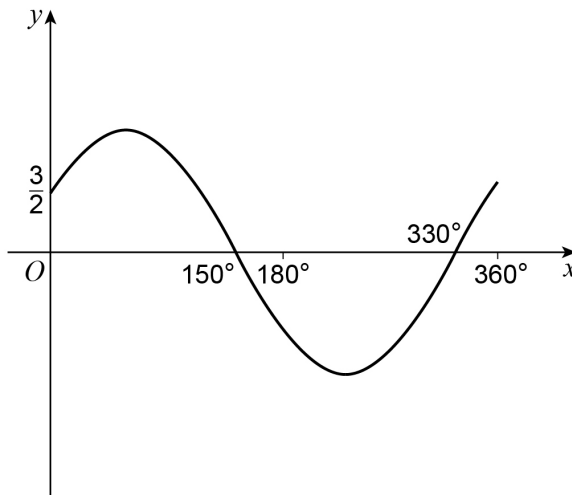
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Key to mark scheme abbreviations

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>B1</p> <p>B1</p> <p>B1</p>	<p>Sinusoidal curve in correct orientation with one maximum above the x-axis, one minimum below the x-axis and above the x-axis in two places</p> <p>The curve must intersect the x-axis exactly twice in the interval $0^\circ \leq x \leq 360^\circ$</p> <p>The curve must start from the positive y-axis with a positive gradient.</p> <p>Curve drawn with both correct values of x-intercepts and no others in the interval $0^\circ \leq x \leq 360^\circ$</p> <p>Condone missing units or given as coordinates.</p> <p>oe Correct value of y-intercept</p> <p>Condone given as coordinates.</p> <p>Must have a curve drawn.</p>
		3	

Q	Answer	Marks	Comments
1(b)	<p>[Period of f =] 180° or π [radians]</p> <p>or</p> <p>[Period of g =] $8 \times 180^\circ [= 1440^\circ]$</p> <p>or 8π [radians]</p> <p>or</p> <p>[Period of g =] $\frac{360^\circ}{k}$ or $\frac{2\pi}{k}$ [radians]</p> <p>[k =] $[\pm] \frac{1}{4}$</p>	<p>M1</p> <p>A1</p>	<p>Correct period of f or g</p> <p>Condone omission of units.</p> <p>PI by correct final answer.</p> <p>oe CAO</p>
		2	

	Question 1 Total	5	
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Q	Answer	Marks	Comments
2(a)	$\frac{x}{\sin\left(\frac{\pi}{6}\right)} = \frac{56}{\cancel{4}/5}$ $x = \sin\left(\frac{\pi}{6}\right) \times \frac{56}{\cancel{4}/5}$ or $2x = 70$ and $x = 35$	M1 A1	<p>oe Correct application of the sine rule with values substituted</p> <p>oe At least one intermediate line of working seen with x made the subject of the equation or equation of the form $ax = \dots$ with $\sin\left(\frac{\pi}{6}\right) = \frac{1}{2}$ used</p> <p>AG Must be convincingly shown</p>
		2	

Q	Answer	Marks	Comments
2(b)	<p>[Area of triangle $ACD =$ $\frac{1}{2} \times 16 \times 35 \times \sin\left(\frac{\pi}{6}\right)$</p> <p>[Area of triangle $ACD =$ 140 $[\text{cm}^2]$</p> <p>$\frac{1}{2} \times (5\sqrt{10})^2 \theta = 140$</p> <p>[$125\theta = 140 \Rightarrow \theta =$ $\frac{28}{25}$ or 1.12 [radians]</p> <p>[Length of arc $FG =$ $5\sqrt{10} \times 1.12 =$ 17.7 [cm]</p>	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>A1ft</p>	<p>oe Correct use of formula for area of triangle with values substituted PI by correct area of triangle, correct value of θ, or correct final answer</p> <p>Correct area of triangle. PI by correct value of θ or correct final answer.</p> <p>oe Correct substitution of values into formula for area of a sector and sets equal to 140 ft their 140 provided 1st M1 awarded. PI by correct value of θ or correct final answer</p> <p>oe Correct value of θ PI by correct final answer</p> <p>Correct length AWRT 17.7 Exact $\frac{28\sqrt{10}}{5}$ ft their θ provided both M1 marks awarded</p>
		5	

	Question 2 Total	7	
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Q	Answer	Marks	Comments
3(a)	$[\text{Gradient of } PQ =] \frac{14-9}{10-8} \left[= \frac{5}{2} \right]$ $[\text{Gradient of } l =] -\frac{2}{5}$ $y = -\frac{2}{5}x + 18$ or $y - 14 = -\frac{2}{5}(x - 10)$ $[QR ^2 =] 10^2 + (18 - 14)^2 \quad [= 116]$ or $[QR =] \sqrt{10^2 + (18 - 14)^2}$ $\quad [= \sqrt{116} \text{ or } 2\sqrt{29}]$ $\left[\text{Area} = \frac{1}{2} \times \sqrt{29} \times \sqrt{116} = \right] 29 [\text{square units}]$	<p>M1</p> <p>A1</p> <p>M1</p> <p>m1</p> <p>A1</p>	<p>oe Correct method for finding the gradient of PQ PI by correct value for the gradient of PQ or l</p> <p>oe Correct gradient of l</p> <p>oe Correct equation of l ACF simplified or unsimplified ft their gradient of l PI by correct y-coordinate of R</p> <p>Dependent on M1 M1 oe Correct method to find $QR ^2$ or QR PI by correct value of $QR ^2$ or QR or correct final answer ft their y-coordinate of R from their equation of l</p> <p>CAO</p>
		5	

Q	Answer	Marks	Comments
3(b)(i)	$(x+2)^2 \dots + (y+3)^2 \dots [= 0]$ or $(x^2 + 4x + 4) \dots + (y^2 + 6y + 9) \dots [= 0]$	M1	oe Attempts to complete the square twice.
	$(x+2)^2 + (y+3)^2 = 29$	A1	CAO
	[Radius =] $\sqrt{29}$	B1ft	CAO ft their equation of C_2
	[Centre] $(-2, -3)$	B1ft	If not given as coordinates must be clearly identified. ft their equation of C_2
		4	

Q	Answer	Marks	Comments
3(b)(ii)	Translation	E1	
	$\begin{bmatrix} -10 \\ -12 \end{bmatrix}$	E1ft	Must be given as a vector ft their centre of C_2 in part (b)(i)
		2	

	Question 3 Total	11	
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Q	Answer	Marks	Comments
4(a)	$\left[5 = 8 \times 3^{k-7} \Rightarrow \frac{5}{8} = 3^{k-7} \right]$ $\log_3 \frac{5}{8} = k - 7$ $[k =] 7 + \log_3 \frac{5}{8}$	<p>M1</p> <p>A1</p>	<p>oe Substitutes the coordinates into the equation of the curve, rearranges and takes $\log_3$ of both sides Must be correct equation Condone x used for k throughout</p> <p>Condone $[k =] 7 + \log_3 0.625$</p>
		2	

Q	Answer	Marks	Comments
4(b)	$3 \times (1.2)^{n-1} > 8700$ $\left[(1.2)^{n-1} > \frac{8700}{3} \right]$ <p>or</p> $\left[(1.2)^{-1} (1.2)^n > \frac{8700}{3} \Rightarrow \right]$ $n - 1 > \log_a 2900 \div \log_a 1.2$ <p>or</p> $n - 1 > \log_{1.2} 2900$ <p>or</p> $n > \log_a 3480 \div \log_a 1.2$ <p>or</p> $n > \log_{1.2} 3480$ $[n - 1 >] 43.7[2750...]$ <p>or</p> $[n >] 44.7[2750...]$ <p>and</p> $n = 45$	<p>M1</p> <p>M1</p> <p>A1</p>	<p>oe Correct expression for the nth term with values substituted set to be greater than 8700 Condone equality</p> <p>oe Uses logarithms to find a correct inequality with $n - 1$ or n on one side Condone equality. PI by 43.7[2750...] or 44.7[2750...]</p> <p>Correct decimal value rounded to 1dp or better and Correct integer value of n</p>
		3	

	Question 4 Total	5	
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Q	Answer	Marks	Comments
5(a)	$9 \frac{\sin x}{\cos x} - 4 \cos x = \frac{5}{\cos x}$ $\left[9 \sin x - 4 \cos^2 x = 5 \Rightarrow \right]$ $9 \sin x - 4(1 - \sin^2 x) = 5$ $4 \sin^2 x + 9 \sin x - 9 = 0$ <p>and</p> $(4 \sin x - 3)(\sin x + 3) = 0$	<p>M1</p> <p>M1</p> <p>A1</p>	<p>Replaces $\tan x$ with $\frac{\sin x}{\cos x}$ or replaces $\tan x \cos x$ with $\sin x$</p> <p>oe Use of $\sin^2 x + \cos^2 x = 1$</p> <p>CSO Forms correct three-term quadratic equation in $\sin x$ set equal to zero and gives correct quadratic equation in factorised form.</p>
		3	

Q	Answer	Marks	Comments
5(b)	$\sin 2\theta = \frac{3}{4}$ and $\sin 2\theta = -3$ (rejected) $[2\theta =] 0.84[80620\dots]$ or $2.29[35305\dots]$ $[\theta =] 0.42, 1.15$	B1ft M1 A2,1	ft their k from part (a) Both correct values for $\sin 2\theta$ with $\sin 2\theta = -3$ clearly rejected Anything that rounds or truncates correctly to 2 dp PI by AWRT 0.42 or 1.15 A1 : At least one correct value, eg AWRT 0.42 or AWRT 1.15 A2 : Both correct values and no others in the given interval. Both values must be to 2 dp
		4	

	Question 5 Total	7	
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Q	Answer	Marks	Comments
6	$\log_5 x^7 - \log_5 625 + \log_5 49x - \log_5 x^6$ $7\log_5 x - \log_5 625 + \log_5 49x - 6\log_5 x$ $7\log_5 x - \log_5 625 + \log_5 49$ $\quad + \log_5 x - 6\log_5 x$ $2\log_5 x - 4 + \log_5 49$ or $2\log_5 x - \log_5 625 + 2\log_5 7$ or $\log_5 49x^2 - 4$ or $2\log_5 7x - 4$ $2((\log_5 7x) - 2)$	M1 M1 M1 M1 A1	oe Correct use of the quotient rule for logarithms oe Correct use of the power rule for logarithms with at least one term oe Correct use of the product rule for logarithms oe Correct three-term expression or two-term expression with at least either $\log_5 625$ replaced by 4 or $\log_5 49$ replaced by $2\log_5 7$ CAO
	Question 6 Total	5	

Q	Answer	Marks	Comments
6 ALT	$\log_5 \left(\frac{49x^8}{625} \right) - \log_5 x^6$ or $\log_5 \left(\frac{x^7}{625} \right) + \log_5 \left(\frac{49}{x^5} \right)$ $\log_5 \left(\frac{49x^2}{625} \right)$ or $\log_5 \left(\frac{7x}{25} \right)^2$ $2\log_5 \frac{7x}{25}$ $2(\log_5 7x - \log_5 25)$ $2((\log_5 7x) - 2)$	M1 M1 M1 M1 A1	oe Correct use of the product or quotient rule for logarithms oe Correct use of a different logarithm rule to write as a single logarithm oe Correct use of the power rule for logarithms oe Correct use of the quotient rule for logarithms CAO
	Question 6 Total	5	

Q	Answer	Marks	Comments
7(a)	$\left[\binom{6}{2} \times 0.15^2 \times (1-0.15)^{6-2} = \right] 0.176$	B1	AWRT 0.176
		1	

Q	Answer	Marks	Comments
7(b)	$P(X \geq 1) = 1 - P(X = 0)$ $[= 1 - 0.3771]$ $P(X \geq 1) = 0.623$	M1 A1	Identifies correct calculation PI AWRT 0.623
		2	

Q	Answer	Marks	Comments
7(c)	$P(3 \leq X \leq 4) = P(X \leq 4) - P(X \leq 2)$ $[= 0.9996 - 0.9527]$ $P(3 \leq X \leq 4) = 0.047$	M1 A1	Identifies correct calculation oe PI AWRT 0.047
		2	

Q	Answer	Marks	Comments
7(d)	The probability of winning is unlikely to be constant for different games or Winning one game may not be independent of winning another game	E1	A correct explanation
		1	

	Question 7 Total	6	
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Q	Answer	Marks	Comments
8(a)	$6 \times 0.257[0] + 12 \times 0.5418 + 15 \times 0.2012$ $= 11.0616$	B1	AG Must be convincingly shown
		1	

Q	Answer	Marks	Comments
8(b)	$E(X^2) = 6^2 \times 0.257[0] + 12^2 \times 0.5418$ $+ 15^2 \times 0.2012$ $[E(X^2) = 132.5412]$ $\text{Var}(X) = 132.5412 - 11.0616^2$ $\text{Var}(X) = 10.18$	M1 M1 A1	Applies the correct formula for $E(X^2)$ Applies the correct formula for $\text{Var}(X)$ using their $E(X^2)$ AWRT 10.18
		3	

Q	Answer	Marks	Comments
8(c)(i)	$11.0616 + 3 + p = 14.5$ $p = 0.4384$	M1 A1	Sets up a correct equation to find p oe eg $\frac{274}{625}$
		2	

Q	Answer	Marks	Comments
8(c)(ii)	$\text{Var}(Z) = 0.4384 \times (1 - 0.4384)$ $[\text{Var}(Z) = 0.24620544]$ $[\text{Var}(X + Y + Z) = 10.18 + 2.4 + 0.24...]$ $\text{Var}(X + Y + Z) = 12.8$	M1 A1ft	Attempts to calculate $\text{Var}(Z)$ for their value of p AWRT 12.8 ft their $\text{Var}(X)$ and their value of p
		2	

	Question 8 Total	8	
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Q	Answer	Marks	Comments
9(a)	$\frac{3}{28}$	M1 A1	M1: Obtains $\frac{3}{k}$ or $\frac{c}{28}$ oe PI A1: CAO oe
		2	

Q	Answer	Marks	Comments
9(b)	$\frac{\left(\frac{2}{28}\right)}{\left(\frac{3}{7}\right)}$ [=] $\frac{1}{6}$	M1 A1	Applies conditional probability formula with a correct numerator or denominator PI oe
		2	

Q	Answer	Marks	Comments
9(c)	$P(X) = \frac{2}{4}$ $P(X \cap Y) = \frac{2}{28}$ $P(X) \times P(Y) = \left[\frac{2}{4} \times \frac{3}{28} \right] = \frac{3}{56}$ $P(X \cap Y) \neq P(X) \times P(Y)$ So X and Y are not independent	M1 A1ft	Finds correct $P(X)$ and $P(X \cap Y)$ oe Finds $P(X) \times P(Y)$, compares to $P(X \cap Y)$ and makes correct conclusion ft their part (a)
9(c) Alt 1	$P(Y X) = \frac{2}{28} \div \frac{2}{4} \left[= \frac{1}{7} \right]$ $P(Y X) = \frac{1}{7}$ and $\frac{1}{7} \neq \frac{3}{28}$ or $P(Y X) \neq P(Y)$ So X and Y are not independent	M1 A1ft	oe Correct expression for $P(Y X)$ PI by correct value Correct value of $P(Y X)$ and compares $P(Y X)$ to $P(Y)$ and makes correct conclusion ft their $P(Y)$ from part (a)
9(c) Alt 2	$P(X) = \frac{2}{4}$ $P(X Y) = \frac{2}{28} \div \frac{3}{28} \left[= \frac{2}{3} \right]$ $P(X Y) = \frac{2}{3}$ and $\frac{2}{3} \neq \frac{2}{4}$ or $P(X Y) \neq P(X)$ So X and Y are not independent	M1 A1ft	Finds correct $P(X)$ and correct expression for $P(X Y)$ ft their part (a) Correct value of $P(X Y)$ ft their $P(Y)$ from part (a) And Compares $P(X Y)$ to $P(X)$ and makes correct conclusion
		2	
Question 9 Total		6	

Q	Answer	Marks	Comments
10(a)	$1000 - 400 - 180 = (1600 + m)a$ $1000 - 400 - 180 = 1600a + ma$ $\frac{420}{a} = m + 1600$ or $420 - 1600a = ma$ and $m = \frac{420}{a} - 1600$	<p>M1</p> <p>A1</p> <p>A1</p>	<p>oe but must be in the form $F = ma$ All relevant forces must be present, allow mass error eg $1000 - 400 - 180 = 1600a$ $1000 - 400 - 180 = ma$ Ignore sign errors or as two separate equations (eg with T present) as long as all relevant forces appear</p> <p>oe but must be in the form $F = ma$ Fully correct equation (signs correct)</p> <p>oe Divides through by a or makes ma the subject, leading to AG Must be convincingly shown</p>
		3	

Q	Answer	Marks	Comments
10(b)	$m = \frac{420}{0.175} - 1600 = 800$ <p>Either: $1000 - 400 - T = 1600 \times (0.175)$ or $T - 180 = 800 \times (0.175)$</p> $T = 320 \text{ [N]}$	<p>B1</p> <p>M1</p> <p>A1ft</p>	<p>$m = 800$ PI</p> <p>Valid correct equation of motion for either the car or the trailer. ft their m</p> <p>ft their m</p>
		3	

Q	Answer	Marks	Comments
10(c)	The magnitudes of the resistive forces are likely to change as the speed of the vehicle and trailer increases	E1	A plausible explanation
		1	

	Question 10 Total	7	
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Q	Answer	Marks	Comments
11	$3 = 10 + (-9.8)t_A$ $t_A = 0.714[2857\dots]$ $[T =] \ 1.42[857][\text{seconds}]$	<p>M1</p> <p>A1</p> <p>A1ft</p>	<p>Use of constant acceleration formula Condone sign errors and use of $a = 9.81$ Allow for a pair of equations in terms of t and one other unknown</p> <p>oe Allow exact $t_A = \frac{5}{7}$ or AWRT 0.71 PI by correct final answer</p> <p>ft $2 \times$ their 0.714... AWRT 1.4 Allow $T = \frac{10}{7}$</p>

	Question 11 Total	3	
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Q	Answer	Marks	Comments
12	$3qp - (4q - 3q)p \quad [= 2pq]$ $2pq = 10 - 4$ $p = \frac{3}{q}$	<p>B1</p> <p>M1</p> <p>A1</p>	<p>A correct expression for change in speed in terms of p and q PI or embedded</p> <p>ft their difference in velocities set equal to $10 - 4 [= 6]$</p> <p>CAO</p>

	Question 12 Total	3	
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Q	Answer	Marks	Comments
13(a)	$6 \times 4 = 6 \times 2.5 + 2v$	M1	Allow sign errors
	$24 - 15 = 2v$ and $v = 4.5 \text{ [m s}^{-1}\text{]}$	A1	At least one line of intermediate working seen before AG Must be convincingly shown
		2	

Q	Answer	Marks	Comments
13(b)(i)	$[d = 2 \times 4.5 =] \quad 9$	B1	Deduces correct distance between first collision and the fixed surface
		1	

Q	Answer	Marks	Comments
13(b)(ii)	$2.5t + 3(t - 2) = 9$ or $(2.5 + 3)T = 9 - 2.5 \times 2$ or $\frac{9 - 2.5 \times 2}{2.5 + 3} \times 3 \text{ [= 2.18...]}$ $t = 2.7 \text{ [2727...]}$ or $T = 0.72 \text{ [7272...]}$ $2.18 \text{ [1818...]} \text{ [metres]}$ $[9 + 2.18...] = 11.2 \text{ [metres]}$	M1	Equation combining the distance travelled for both particles in terms of time since first collision, t , or time since particle B rebounds from the fixed surface, T ft their answer to part (b)(i)
		A1	Correct value for t or T PI AWRT 2.7 or AWRT 0.73 Exact values: $t = \frac{30}{11}$, $T = \frac{8}{11}$
		A1	PI by correct final answer AWRT 2.2 Exact value: $\frac{24}{11}$
		A1ft	ft their answer to part (b)(i) + their 2.18 [1818...] AWRT 11.2 Exact value: $\frac{123}{11}$
		4	

	Question 13 Total	7	
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