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Mathematics

MA02 – Unit 2 Pure, Statistics and Mechanics
Mark scheme

9660

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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)

Q	Answer	Mark	Comments
1 (a)	$\log_a 1 = 0$ or $\log_a a^b = b$	M1	PI. Condone omission of base
	$-2b$	A1	CSO
1 (b)	$8\log_a x$ or $6\log_a x$ or $\log_a x^8$ or $\log_a x^6$	M1	Condone omission of base
	$14\log_a x$	A1	CSO. Condone omission of base
	Total	**4**	

Q	Answer	Mark	Comments
2 (a) (i)	$(x-11)^2-121+(y-8)^2-64+135=0$	M1	$(x-11)^2-121$ or $(y-8)^2-64$ seen OE
	$(x-11)^2+(y-8)^2=50$	A1	CSO
2 (a) (ii)	$\sqrt{50},\ 5\sqrt{2},$	B1ft	Simplified or unsimplified ft their r^2 provided it is positive AWRT 7.07
	$(11,8)$	B1ft	ft their centre (a,b) provided M1 scored and their equation is of the form $(x-a)^2+(y-b)^2=r^2$ with a and b non-zero
2 (b)	An indication that the distance required is from the midpoint of the chord to the centre of the circle	M1	PI. May be evident in a right-angled triangle implying midpoint is 3 from one end of chord, or attempt at Pythagoras' theorem using 3.
	$(d^2)=(5\sqrt{2})^2-3^2$	M1	ft their r^2 provided that it is positive
	$d=\sqrt{41}$	A1	CSO. A0 for attempt to give d as a decimal
2 (c)	Translation	E1	
	$\begin{pmatrix}-11\\-8\end{pmatrix}$	B1ft	ft minus their a and minus their b from their centre of P
	Total	**9**	

Q	Answer	Mark	Comments
3 (a)	Area $= \frac{1}{2}r^2\theta$	M1	Area $= \frac{1}{2}r^2\theta$ seen or used.
	$0.648 = \frac{1}{2} \times 1.80^2 \times \theta \Rightarrow \theta$ $= \frac{0.648}{1.62} = 0.4$	A1	$\theta = 0.4$ oe. Be convinced
3 (b)	Length of arc *BC* = $r\theta$ = 1.80×0.4	M1	Arc $= r\theta$ seen or used in(b). PI by correct length of arc.
	(Length of arc *BC* =) 0.72	A1	OE
	Angle $CAD = \frac{\pi}{2} - 0.4$	B1	AWRT 1.17 radians or 67.1 degrees
	$CD^2 = 2.42^2 + 1.80^2 - 2 \times 2.42$ $\times 1.80 \times \cos 1.17$	M1	RHS of Cosine Rule used. Ft their angle CAD
	$5.8564 + 3.24 - 3.3926$ ...	M1	Correct order of evaluation
	CD = $\sqrt{5.7037...} = 2.3882$ $= 2.39$ m	A1	AWRT 2.39
	(Perimeter =) 7.33	A1	CAO
	Total	**9**	

Q	Answer	Mark	Comments
4 (a)	$\frac{\sin\theta}{10} = \frac{\sin 18^o}{4}$	M1	A correct equation sine rule with all known values substituted
	$\sin\theta = \frac{10 \times \sin 18^o}{4} = 2.5 \times \sin 18^o$	m1	A correct rearrangement to make $\sin\theta$ the subject
	Angle $ABC = 50.5827...^o = 50.6^o$	A1	AWRT $51°$
	Angle $ABC = 180^o - 50.5827...^o$ $= 129.4172...^o = 129.4^o$	A1ft	ft their 50.6^o AWRT $129°$ Extra solutions lose this mark
4 (b)	Area $= \frac{1}{2} \times 10 \times 4$ $\times \sin(180^o - 18^o$ $- 50.6^o)$ $= 20 \times \sin 111.4^o$	M1	Correct use of formula for area of a triangle using their acute angle from part (a)
	Area $= 18.6189... = 18.6$ [cm^2]	A1	AWRT 19 [cm^2]
	Total	**6**	

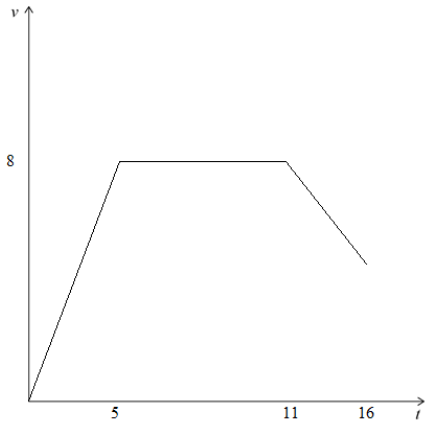
Q	Answer	Mark	Comments
5 (a)	$2^{8x-4\sqrt{x}}$ or $2^{6x-4\sqrt{x}+14}$	B1	For giving either numerator or denominator of LHS as correct power of 2. Accept equivalent as along as it is a power of 2.
	$2^{4(2x-\sqrt{x})-2(3x-2\sqrt{x}+7)}$ or $2^{8x-4\sqrt{x}-6x+4\sqrt{x}-14}$ oe	M1	Correctly applies index rules to LHS. Ft their numerator and denominator dep on B1 scored. Power must not be fully simplified at this stage
	$\frac{16^{2x-\sqrt{x}}}{4^{3x-2\sqrt{x}+7}} \equiv 2^{2x-14}$	A1	CSO. Must show method otherwise award zero.
5(a) ALT	$\frac{4^{4x-2\sqrt{x}}}{4^{3x-2\sqrt{x}+7}} = 4^{(4x-2\sqrt{x})-(3x-2\sqrt{x}+7)} = 2^{\cdots}$	M1	Numerator given as power of 4 and correctly applies index rules to LHS then attempts to write as a power of 2
	$4^{x-7} = 2^{2(x-7)}$	B1	Uses $4 = 2^2$
	$\frac{16^{2x-\sqrt{x}}}{4^{3x-2\sqrt{x}+7}} \equiv 2^{2x-14}$	A1	CSO. Must show method otherwise award zero.
5 (b)	$2x - 14 = \log_2 6$ (do not condone omission of base)	M1	Equates RHS of part (a) to 6 and takes $\log_2$ of both sides. Do not condone omission of base. Must appear as an equation with correct linear expression
	$(x =)\ 7+\frac{1}{2}\log_2 6$	A1	Accept *b* as 0.5 Do not condone omission of base.
	Total	**5**	

Q	Answer	Mark	Comments
6 (a)	$(\sin^2\theta + \cos^2\theta)(\sin^2\theta - \cos^2\theta)$	M1	LHS factorized as the difference of two squares
	$\sin^2\theta - \cos^2\theta$ $= \sin^2\theta - (1 - \sin^2\theta)$	M1	$\sin^2\theta + \cos^2\theta = 1$ used at least once
	$(=)\ 2\sin^2\theta - 1$	A1	CSO. AG
6(a) ALT 1	$\sin^2\theta(1 - \cos^2\theta)$ $-\cos^2\theta(1 - \sin^2\theta)$ $= \sin^2\theta - \sin^2\theta\cos^2\theta - \cos^2\theta$ $+\cos^2\theta\sin^2\theta$	M1	$\sin^2\theta + \cos^2\theta = 1$ used twice in LHS and result multiplied out
	$\sin^2\theta - \cos^2\theta$ $= \sin^2\theta - (1 - \sin^2\theta)$	M1	$\sin^2\theta + \cos^2\theta = 1$ used at least once
	$(=)\ 2\sin^2\theta - 1$	A1	CSO. AG
6(a) ALT 2	$\sin^4\theta - (1 - \sin^2\theta)^2$	M1	$\sin^2\theta + \cos^2\theta = 1$ used once in LHS
	$\sin^4\theta - (1 - 2\sin^2\theta + \sin^4\theta)$	M1	Bracket multiplied out
	$(=)\ 2\sin^2\theta - 1$	A1	CSO. AG
6 (b)	$2\sin^2\theta - 1 = -0.28$ $2\sin^2\theta = 0.72$ $\sin^2\theta = 0.36$	M1	Uses result from part (a) to obtain the value of $\sin^2\theta$. Condone one arithmetic slip in manipulation.
	$\sin\theta = 0.6$ and $\sin\theta = -0.6$	A1	Need both
	$\theta = 37^o, 143^o, \theta = 217^o, 323^o$	B2	Condone more accurate answers. (36.8698…, 143.1301…; 216.8698…, 323.1301…) Ignore answers outside interval. If more than 2 answers for each inside interval, -1 for each extra from Bs to a min of 0
	Total	**7**	

Q	Answer	Mark	Comments
7 (a) (i)	$P(G \cup S) = P(G) + P(S) - P(G \cap S)$ $= 0.3 + 0.8 - 0.25$	M1	Use of the Addition Rule of probability May be implied by a correct answer
	$= 0.85$	A1	(Accept $17/20$ OE)
7 (a) (ii)	$P(G\|S) = \frac{P(G \cap S)}{P(S)}$ $= \frac{0.25}{0.8}$	M1	Use of the Multiplication Law of probability to calculate the required conditional probability May be implied by a correct answer
	$= 0.3125$	A1	(Accept $5/16$ OE)
7(b)	$P(G) \times P(S) = 0.3 \times 0.8 = 0.24$	B1	Correct multiplication Value must be seen (Accept $6/25$ OE)
	$P(G) \times P(S) \neq P(G \cap S)$ G and S are not independent	E1	Correct statement and conclusion Statement may be in words
7(b) ALT	$P(G) = 0.3$ $P(G\|S) = 0.3125$	(B1)	Gives values of $P(G)$ and their $P(G\|S)$ May find $P(G\|S') = 0.25$ instead of $P(G)$
	$P(G\|S) \neq P(G)$ or $P(G\|S')$ G and S are not independent	(E1)	Correct statement and conclusion Statement may be in words
	Total	**6**	

Q	Answer	Mark	Comments
8 (a)	$\binom{25}{18} 0.612^{18}(1-0.612)^{25-18}$	M1	Correct expression Can be implied by **correct answer** Ignore extra terms
	$= 0.0923$	A1	AWRT Accept percentage equivalent
8 (b) (i)	$\mathrm{E}(X) = 7.5$	B1	(Accept $15/2$ OE)
	$\mathrm{Var}(X) = 6.375$	B1	(Accept $51/8$ OE)
8 (b) (ii)	$\mathrm{P}(6 \leq X < 9) = \mathrm{P}(X \leq 8)$ $- \mathrm{P}(X \leq 5)$	M1	Correct expression Can be implied by further correct working
	$= 0.6681 - 0.2194$	M1	Correct values for their two Poisson probabilities given to at least 4 s.f. (From calculator 0.66810072 – 0.21935333)
	$= 0.449$	A1	AWRT Accept percentage equivalent
8 (b) (ii) ALT	$\mathrm{P}(6 \leq X < 9) = \mathrm{P}(X = 6) + \mathrm{P}(X = 7) + \mathrm{P}(X = 8)$	(M1)	Correct expression Can be implied by further correct working
	$= 0.1419 + 0.1575 + 0.1493$	(M1)	Correct values for $\mathrm{P}(X = 6)$, $\mathrm{P}(X = 7)$ and $\mathrm{P}(X = 8)$ given to at least 4 s.f. (From calculator 0.1419460509 + 0.1574527623 + 0.149348576)
	$= 0.449$	(A1)	AWRT Accept percentage equivalent
	Total	**7**	

Q	Answer	Mark	Comments
9(a)	$0.3 + k + 0.25 + 2k = 1$	M1	Uses sum of probabilities equals one to form an equation Accept equivalent expressions
	$k = 0.15$ AG	A1	CSO AG
9(b)	$\mathrm{E}(X)$ $= 1 \times 0.3 + 2 \times k + 3 \times 0.25 + 4 \times 2k$ $= 2.55$	B1	Award on value only (Accept $51/20$ OE)
9(c)	$\mathrm{Var}(X)$ $= 1^2 \times 0.3 + 2^2 \times k + 3^2 \times 0.25 + 4^2 \times 2k$ – their 2.55^2	M1	Correct expression with their $\mathrm{E}(X)$ Can be implied by a correct answer
	$= 1.4475$	A1	(Accept $579/400$ OE)
9(d)	$\mathrm{Var}(4X - 5) = 4^2\,\mathrm{Var}(X)$	M1	Correct expression $\mathrm{Var}(X)$ can be replaced with their $\mathrm{Var}(X) > 0$ Can be implied by a correct answer
	$= 23.16$	A1ft	ft their $\mathrm{Var}(X) > 0$ (Accept $579/25$ OE)
	Total	**7**	

Q	Answer	Mark	Comments
10 (a)		B1	Correct shape of graph and 5, 11 and 16 marked on t axis
		B1	Horizontal part of graph at 8 ms^{-1} (could be indicated on vertical axis)
10 (b)	$(11 - 5) \times$ their $8 = 48$	M1	Finds area under rectangle
	$\frac{1}{2}(8 + v) \times 5 = 100 - 20 -$ their 48	m1	Finds area of trapezium and sets equal to $100 - 20 -$ their 48 OE Accept use of $s = ut + \frac{1}{2}at^2$ to find a (-0.64 ms^{-2}) $100 - 20 -$ their $48 = 8 \times 5 + \frac{1}{2}a \times 5^2$
	$v = 4.8$ ms^{-1} (could be indicated on vertical axis)	A1	
	Total	**5**	

Q	Answer	Mark	Comments
11	Solution Let mass of $A = m$ Mass of $B = m + 2$		
	Momentum before $= 6m + 2(m + 2) = 8m + 4$	M1	Can be unsimplified
	Momentum after $= 3.6\ (m + m + 2) = 7.2m + 7.2$	M1	Can be unsimplified
	Conservation of momentum $8m + 4 = 7.2m + 7.2$	M1	for equation for conservation of momentum
	$m = 4$ kg	A1	
	Total	**4**	

Q	Answer	Mark	Comments
12	$a = \frac{dv}{dt}$	M1	Accept at least one term reduced in power by one
	$= 6t^2 - 30t + 24$	A1	May be unsimplified
	$6t^2 - 30t + 24 = 0$	M1	Set their a equal to zero
	$t^2 - 5t + 4 = 0$ $(t - 1)(t - 4) = 0$ $t = 1$ [or $t = 4$]	A1	Solves to find $t = 1$
	when $t = 1$, $v = 20$ m s^{-1}	A1	Mark not awarded if $v = -7$ m s^{-1} (or other) given but not rejected
	Total	**5**	

Q	Answer	Mark	Comments
13(a)	Whole system $\pm 2200 \pm 600 \pm S = \pm 5000 \times 0.15$ **or** Van $\pm 2200 \pm S \pm T = \pm 3000 \times 0.15$ **and** Ride $\pm T \pm 600 = \pm 2000 \times 0.15$	M1	Attempt at equation of motion for whole system or equations of motion for both the van and the ride Allow slips in signs for this mark
	Whole System $2200 - 600 - S = 5000 \times 0.15$ **or** Van $2200 - S - 900 = 3000 \times 0.15$	A1	For a correct equation in terms of S only OE
	$S = 850$ [N]	A1	
13(b)	Van $\pm 2200 \pm S \pm T = \pm 3000 \times 0.15$ **or** Ride $\pm T \pm 600 = \pm 2000 \times 0.15$	M1	Attempt at equation of motion for the van or the ride Allow slips in signs for this mark May be seen in part (a)
	Van $2200 -$ their $S - T = 3000$ x 0.15 **or** Ride $T - 600 = 2000 \times 0.15$	A1	Correct equation of motion for the van or the ride ft for their S for the correct equation for the van May be seen in part (a)
	$T = 900$ N	A1ft	for correct T ft their S from part (a) if equation of motion for the van is used Must be seen in part (b)
	Total	**6**	