A-level
MATHEMATICS
7357/2

Paper 2

Mark scheme

June 2024

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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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

Mark scheme instructions to examiners

General

The mark scheme for each question shows:
- the marks available for each part of the question
- the total marks available for the question
- marking instructions that indicate when marks should be awarded or withheld including the principle on which each mark is awarded. Information is included to help the examiner make his or her judgement and to delineate what is creditworthy from that not worthy of credit
- a typical solution. This response is one we expect to see frequently. However credit must be given on the basis of the marking instructions.

If a student uses a method which is not explicitly covered by the marking instructions the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

Key to mark types

M	mark is for method
R	mark is for reasoning
A	mark is dependent on M marks and is for accuracy
B	mark is independent of M marks and is for method and accuracy
E	mark is for explanation
F	follow through from previous incorrect result

Key to mark scheme abbreviations

CAO	correct answer only
CSO	correct solution only
ft	follow through from previous incorrect result
'their'	indicates that credit can be given from previous incorrect result
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
NMS	no method shown
PI	possibly implied
sf	significant figure(s)
dp	decimal place(s)

AS/A-level Maths/Further Maths assessment objectives

AO		Description
AO1	AO1.1a	Select routine procedures
	AO1.1b	Correctly carry out routine procedures
	AO1.2	Accurately recall facts, terminology and definitions
AO2	AO2.1	Construct rigorous mathematical arguments (including proofs)
	AO2.2a	Make deductions
	AO2.2b	Make inferences
	AO2.3	Assess the validity of mathematical arguments
	AO2.4	Explain their reasoning
	AO2.5	Use mathematical language and notation correctly
AO3	AO3.1a	Translate problems in mathematical contexts into mathematical processes
	AO3.1b	Translate problems in non-mathematical contexts into mathematical processes
	AO3.2a	Interpret solutions to problems in their original context
	AO3.2b	Where appropriate, evaluate the accuracy and limitations of solutions to problems
	AO3.3	Translate situations in context into mathematical models
	AO3.4	Use mathematical models
	AO3.5a	Evaluate the outcomes of modelling in context
	AO3.5b	Recognise the limitations of models
	AO3.5c	Where appropriate, explain how to refine models

Examiners should consistently apply the following general marking principles:

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to students showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the student to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Diagrams

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

Work erased or crossed out

Erased or crossed out work that is still legible and has not been replaced should be marked. Erased or crossed out work that has been replaced can be ignored.

Choice

When a choice of answers and/or methods is given and the student has not clearly indicated which answer they want to be marked, mark positively, awarding marks for all of the student's best attempts. Withhold marks for final accuracy and conclusions if there are conflicting complete answers or when an incorrect solution (or part thereof) is referred to in the final answer.

Q	Marking instructions	AO	Marks	Typical solution
1	Ticks 4th box	1.2	B1	$(x+1)^2+(y+2)^2=36$
	Question 1 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
2	Circles 3rd answer	2.2a	B1	125
	Question 2 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3	Ticks 1st box	1.1b	B1	$\{x: x<1\}\cup\{x: x>4\}$
	Question 3 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
4	Takes logs of both sides to same base PI by $x-2=\log_5 7^{1570}$	1.1b	B1	$\log_5\left(5^{x-2}\right)=\log_5 7^{1570}$ $x-2=1570\log_5 7$ $x=2+1570\log_5 7$ $=1900.23$
	Uses $\log A^n=n\log A$ PI by $x-2=\log_5 7^{1570}$	1.1a	M1	
	Completes a reasoned argument using logarithms to obtain AWRT 1900	2.1	R1	
	Question 4 Total		**3**	

Q	Marking instructions	AO	Marks	Typical solution
5	Differentiates x^3 and $\sin x$ to obtain $3x^2$ and $\cos x$ OE	1.1b	B1	$\frac{dy}{dx} = \frac{3x^2 \sin x - x^3 \cos x}{\sin^2 x}$
	Uses the quotient rule and obtains numerator $Ax^2 \sin x \pm Bx^3 \cos x$ Condone any denominator Or Writes as a product and applies the product rule to obtain $Ax^2 \text{cosec}(x) \pm x^3 \text{cosec}(x)\cot(x)$	3.1a	M1	
	Obtains $\frac{3x^2 \sin x - x^3 \cos x}{\sin^2 x}$ ACF No ISW	1.1b	A1	
	Question 5 Total		**3**	

Q	Marking instructions	AO	Marks	Typical solution
6	Expands brackets, at least one completely correct	1.1a	M1	$4\sin^2\theta+12\sin\theta\cos\theta+9\cos^2\theta$
	Expands both brackets correctly	1.1b	A1	$+36\sin^2\theta-12\sin\theta\cos\theta+\cos^2\theta=30$
	Uses $\sin^2\theta+\cos^2\theta=1$ correctly to eliminate $\cos^2\theta$ or $\sin^2\theta$ from their equation PI by $30\sin^2\theta+10=30$	3.1a	M1	$40\sin^2\theta+10\cos^2\theta=30$ $40\sin^2\theta+10\left(1-\sin^2\theta\right)=30$ $30\sin^2\theta+10=30$
	Obtains an equation of the form $\sin^2\theta=k$ or $\cos^2\theta=k$ where $0<k<1$ PI by $\sin\theta=\sqrt{k}$ or $\sin\theta=-\sqrt{k}$	1.1a	M1	$\sin^2\theta=\frac{2}{3}$ $\sin\theta=\pm\frac{\sqrt{6}}{3}$
	Obtains $\sin\theta=\pm\sqrt{\frac{2}{3}}$	1.1b	A1	since θ is obtuse $\sin\theta=\frac{\sqrt{6}}{3}$
	Completes reasoned argument to obtain $\sin\theta=\sqrt{\frac{2}{3}}$ **and** explains why $\sin\theta=\sqrt{\frac{2}{3}}$ Must come from $\sin\theta=\pm\sqrt{\frac{2}{3}}$ FT their $\sin^2\theta=k$ where $0<k<1$	2.4	R1F	
	Question 6 Total		**6**	

Q	Marking instructions	AO	Marks	Typical solution
7(a)	Obtains $50\times1.002^3+50\times1.002^2+50\times1.002$ with $\left(50\times1.002^2+50\times1.002+50\right)\times1.002$ or better seen	2.1	R1	$T_3=\left(50\times1.002^2+50\times1.002+50\right)\times1.002$ $=50\times1.002^3+50\times1.002^2+50\times1.002$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
7(b)(i)	Models the total as the **sum** to n terms of a geometric sequence Evidence for this could include at least two of a, r or n substituted into sum formula $a=50.1$, $r=1.002$, $n=120$ Condone $a=50$ or $n=10$ or 119 PI by AWRT 6724, 6737, 6801 or 505.53	3.3	M1	$T_{120}=\dfrac{50.1\left(1-1.002^{120}\right)}{1-1.002}$ $=6787.1595...$ Total in account = £ 6 787
	Forms the correct expression for the correct total $\left(T_{120}=\right)\dfrac{50.1\left(1-1.002^{120}\right)}{1-1.002}$ or $\sum_{x=1}^{120}50\times1.002^x$	3.3	A1	
	Obtains £6 787, £6 787.15 or £6 787.16	3.2a	A1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
7(b)(ii)	Makes a reasonable comment in context. For example: The interest rate is unlikely to remain fixed. Or May have needed to withdraw some amount. Or May change the monthly payments.	3.5b	E1	The interest rate is unlikely to remain fixed for the whole 10 years
	Subtotal		**1**	

	Question 7 Total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)(i)	Obtains $12 = a + b\log_{10} 24$ ISW	3.4	B1	$12 = a + b\log_{10} 24$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)(ii)	Eliminates a to obtain an equation in b	3.1a	M1	$12 = a + b\log_{10} 24$ $-(6.4 = a + b\log_{10} 3)$ $5.6 = b\log_{10} 24 - b\log_{10} 3$ $= b\log_{10} \frac{24}{3}$ $= b\log_{10} 8$ $b = \frac{5.6}{\log_{10} 8}$
	Obtains $b\log_{10} h$ from $b\log_{10} \text{their } 24 - b\log_{10} 3$ or $b\log_{10} \frac{\text{their } 24}{3}$ where $3h$ = their 24	1.1a	M1	
	Completes a reasoned argument to show $b = \frac{5.6}{\log_{10} 8}$ Must include $\log_{10} \frac{24}{3}$ OE or $\log_{10} 24 = \log_{10} 8 \times 3$ AG	2.1	R1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)(iii)	Obtains AWRT 3.44	1.1b	B1	$a = 3.44$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
8(b)	Substitutes a value for $0 < x \leq 0.25$ into the model with their a and b = AWRT 6.2 PI by correct negative y-value Or Substitutes x = 0 into the model with their a and b = AWRT 6.2 **and** states that the value for y is undefined Or Substitutes y = 0 into the correct model with and gets x = AWRT 0.28	3.4	M1	When $x = 0.25$ $y = 3.44 + 6.2\log_{10} 0.25$ $= -0.29$ The model predicts a negative median mass for a monkey that is one week old, therefore it is unsuitable for use with monkeys 1 week old or less.
	Completes reasoned argument to find a correct median mass for their value of x **and** concludes that the model cannot be used to predict the median mass of monkeys less than one week old. Condone that the model cannot be used to predict the median mass of monkeys for their value of x where $0 < x \leq 0.25$ Condone omittance of median or use of weight throughout	3.5a	R1	
	Subtotal		**2**	

	Question 8 Total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
9(a)(i)	Obtains $1+(-1)(3x)+\dfrac{(-1)(-2)(3x)^2}{2!}$ OE with at least two terms correct	1.1a	M1	$(1+3x)^{-1} \approx 1+(-1)(3x)+\dfrac{(-1)(-2)(3x)^2}{2!}$ $=1-3x+9x^2$
	Obtains $1-3x+9x^2$	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
9(a)(ii)	Writes fraction as $(2-3x)^{-1}$ PI by $\dfrac{1}{2}+\dfrac{3}{4}x+\dfrac{9}{8}x^2$	1.1b	B1	$\dfrac{1}{2-3x}=(2-3x)^{-1}$ $=2^{-1}\left(1+\left(-\dfrac{3x}{2}\right)\right)^{-1}$ $\approx \dfrac{1}{2}\left(1+(-1)\left(-\dfrac{3x}{2}\right)+\dfrac{(-1)(-2)}{2!}\left(-\dfrac{3x}{2}\right)^2\right)$ $\dfrac{1}{2-3x}\approx \dfrac{1}{2}+\dfrac{3}{4}x+\dfrac{9}{8}x^2$ $\dfrac{1}{2}$, $\dfrac{3}{4}x$ and $\dfrac{9}{8}x^2$ form a geometric sequence with common ratio $\dfrac{3}{2}x$
	Factorises to obtain the form $2^{-1}(1-Ax)^{-1}$ PI by $\dfrac{1}{2}+\dfrac{3}{4}x+\dfrac{9}{8}x^2$	1.1a	M1	
	Expands $\left(1-\dfrac{3x}{2}\right)^{-1}$ to obtain $1+(-1)\left(\pm\dfrac{3x}{2}\right)+\dfrac{(-1)(-2)}{2!}\left(\pm\dfrac{3x}{2}\right)^2$ OE Condone one sign error	1.1a	M1	
	Completes a correct argument to show $\dfrac{1}{2-3x}\approx\dfrac{1}{2}+\dfrac{3}{4}x+\dfrac{9}{8}x^2$	2.1	R1	
	States that the common ratio is $\dfrac{3}{2}x$	2.2a	B1	
	Subtotal		**5**	

Q	Marking instructions	AO	Marks	Typical solution
9(b)	Uses a valid method to find P or Q Substitution of $x=-\frac{1}{3}$ or $x=\frac{2}{3}$ Or Rearranging and substitution or comparison of coefficients	1.1a	M1	$\frac{36x}{(1+3x)(2-3x)}=\frac{P}{(2-3x)}+\frac{Q}{(1+3x)}$ $36x=P(1+3x)+Q(2-3x)$ Let $x=-\frac{1}{3}$ $\Rightarrow -12=3Q$ $Q=-4$ $x=\frac{2}{3}$ $\Rightarrow 24=3P$ $P=8$
	Obtains P = 8	1.1b	A1	
	Obtains Q = – 4	1.1b	A1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
9(c)(i)	Multiplies their P by their expansion in (a)(ii) and multiplies their Q by their expansion in (a)(i) Condone a sign error Or Multiplies their $\frac{P}{3}$ by their expansion in (a)(ii) and multiplies their $\frac{Q}{3}$ by their expansion in (a)(i) Condone a sign error Or Writes the product of $12x$ or $36x$ with their three-term expansion in (a)(i) and their three-term expansion in (a)(ii) Condone a sign error	3.1a	M1	$\frac{8}{(2-3x)}-\frac{4}{(1+3x)}$ $\approx 8\left(\frac{1}{2}+\frac{3}{4}x+\frac{9}{8}x^2\right)-4\left(1-3x+9x^2\right)$ $=18x-27x^2$ $\therefore \frac{12x}{(1+3x)(2-3x)}\approx 6x-9x^2$
	Obtains $6x-9x^2$	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
9(c)(ii)	Deduces $\lvert x\rvert<\frac{1}{3}$ ACF	2.2a	R1	$\lvert x\rvert<\frac{1}{3}$
	Subtotal		**1**	

	Question 9 Total		**13**	

Q	Marking instructions	AO	Marks	Typical solution
10	Differentiates to obtain $2x \pm 2\sin x$	1.1a	M1	
	Differentiates again to obtain $2 - 2\cos x$	1.1b	A1	
	Concludes $f''(0) = 0$ and tests the sign of their $f'(x)$ or $f''(x)$ either side of $x = 0$ Or Deduces that $f''(x) \geq 0$	2.1	M1	$f'(x) = 2x - 2\sin x$ $f''(x) = 2 - 2\cos x$ $f''(0) = 2 - 2\cos(0) = 0$ $f''(-0.1) = 9.99 \times 10^{-3}$ $f''(0.1) = 9.99 \times 10^{-3}$
	Completes a reasoned argument to conclude that $y = f(x)$ does not have a point of inflection at $x = 0$ Or Completes a reasoned argument to conclude that $y = f(x)$ does not have a point of inflection by consideration of the function	2.4	R1	$f''(x)$ does not change sign either side of $x = 0$ Therefore, the curve does not have a point of inflection at $x = 0$
	Question 10 Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
11(a)	Explains that 3 is not in $3 < k < 4$ OE	2.4	E1	3 is not in the interval
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
11(b)(i)	Explains that $3 < y < x$ which contradicts the definition of x as the smallest value OE	2.4	E1	y is between 3 and x which contradicts the definition of x as the smallest value in (3, 4)
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
11(b)(ii)	Assumes there is a largest value in (3, 4) OE	2.1	B1	Step 1: Assume there is a largest number in the interval $3 < k < 4$ and let this largest number be x Step 2: let $y = \frac{x+4}{2}$ Step 3: $x < y < 4$ which is a contradiction. Step 4: Therefore, there is no largest value in $3 < k < 4$
	Constructs a value "y" in (3, 4) which is greater than their "x" Must have referenced their "x" before this step	2.2a	B1	
	States that $x < y < 4$ which is a contradiction OE	2.4	E1	
	Concludes that there is no largest value in (3, 4) OE CSO	2.1	R1	
	Subtotal		**4**	

	Question 11 Total		**6**	

Q	Marking instructions	AO	Marks	Typical solution
12	Circles the 2nd answer	3.3	B1	3 m s^{-2}
	Question 12 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
13	Ticks the 3rd box	2.2a	B1	The acceleration of the car can change instantaneously
	Question 13 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
14(a)	Obtains – 8	1.1b	B1	-8
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
14(b)	Forms an equation or inequality to compare $6t-2t^2$ with 0 PI by $6t=2t^2$, $6t>2t^2$ or t = 0 and t = 3	3.1a	M1	$-2t^2+6t>0$ So $0<t<3$
	Obtains $0<t<3$ OE	1.1b	A1	
	Subtotal		**2**	

	Question 14 Total		**3**	

Q	Marking instructions	AO	Marks	Typical solution
15	Obtains a + 4 and b + 23 OE	1.1b	B1	$\begin{bmatrix} a+4 \\ b+23 \end{bmatrix}$
	Uses F = ma with m = 3 and a = $\begin{bmatrix} 4b \\ a \end{bmatrix}$	3.3	M1	$\begin{bmatrix} a+4 \\ b+23 \end{bmatrix}=3\begin{bmatrix} 4b \\ a \end{bmatrix}$
	Obtains two linear simultaneous equations in a and b	1.1a	M1	$a+4=12b$ $b+23=3a$
	Obtains $a=8$ and $b=1$	1.1b	A1	$a=8$ and $b=1$
	Question 15 Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
16	Forms correct constant acceleration equation for displacement with t = 0.5 for first apple Condone 0 not shown for u	1.1b	B1	$s_1 = 0 + \frac{1}{2}(9.8)(0.5)^2 = 1.225$ m
	Forms constant acceleration equation for displacement with t = 0.6 for second apple Condone 0 not shown for u	3.1b	M1	$s_2 = 0 + \frac{1}{2}(9.8)(0.6)^2 = 1.764$ m
	Finds the difference in heights between the two apples	1.1a	M1	$s_2 - s_1 = 0.539$ m $d = 53.9$ cm
	Completes reasoned argument to show d is approximately 54 Must see 53.9 or 0.539 Condone d = 54 AG	2.1	R1	So $d \approx 54$ cm
	Question 16 Total		**4**	

Q	Marking Instructions	AO	Marks	Typical Solution
17	Forms a dimensionally correct moment in L and x May see : $(L-x)R$ $(L-(x+0.1))2R$ $(L-x)mg$ $(2L-(2x+0.1))2R$ OE	3.3	B1	The reaction at A is R $(L-x)R=(L-(x+0.1))2R$ $L-x=2(L-(x+0.1))$ $L-x=2L-2x-0.2$ $L-x=0.2$
	Forms dimensionally correct moments equation with at least one term correct May also see: $(L-x)mg=(2L-(2x+0.1))2R$ Or $(L-(x+0.1))mg=(2L-(2x+0.1))R$ Condone missing brackets	1.1a	M1	
	Obtains a fully correct equation in L and x only	1.1b	A1	
	Completes reasoned argument to obtain $L-x=0.2$ Must show expansion of all brackets before the final answer	2.1	R1	
	Question 17 Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
18(a)	Uses $v = \frac{dr}{dt}$ to obtain an expression for v with one term correct PI by $-0.04qe^{-0.2t}$	3.4	M1	Using $a = \frac{d^2r}{dt^2}$ $v = 2 + 0.2qe^{-0.2t}$ $a = -0.04qe^{-0.2t}$ Using $a = -1.8$ when $t = 3$ $-1.8 = -0.04qe^{-0.6}$ $q = 81.995 \approx 82$
	Obtains $2 + 0.2qe^{-0.2t}$ ACF PI by $-0.04qe^{-0.2t}$	1.1b	A1	
	Obtains $-0.04qe^{-0.2t}$ ACF	1.1b	A1	
	Substitutes t = 3 and a = – 1.8 into their expression for a	1.1a	M1	
	Completes reasoned argument and concludes that $q \approx 82$ Accept q rounds to 82 Must show either a correct expression for q or q = 81.9… CSO AG	2.1	R1	
	Subtotal		**5**	

Q	Marking instructions	AO	Marks	Typical solution
18(b)	Substitutes t = 0, r = 5 and their q into $r = p + 2t - qe^{-0.2t}$	3.4	M1	$5 = p - 82e^{-0.2\times0}$ $p = 5 + 82$ $p = 87$
	Obtains AWRT 87	1.1b	A1	
	Subtotal		**2**	

	Question 18 Total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
19(a)(i)	Substitutes three of the four given values into $v^2 = u^2 + 2as$ Condone inconsistent signs for the substituted values	3.1b	M1	$v = 0,\ u = 7, a = -9.8$ Using $v^2 = u^2 + 2as$ then: $0 = 49 - 2(9.8)h$
	Completes reasoned argument to obtain the correct fourth value and concludes the claim is correct Must have clearly stated three out of the following four $v = 0$ $u = 7$ $a = -9.8$ or $-g$ $s = 2.5$ Allow a consistent swapping of signs AG	2.1	R1	$h = \frac{49}{2(9.8)} = 2.5\,\text{m}$ The claim is correct
	Subtotal		**2**	

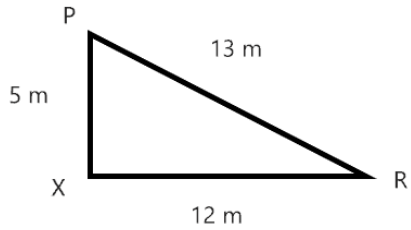
Q	Marking instructions	AO	Marks	Typical solution
19(a)(ii)	States one valid assumption from: • No air resistance • The ball is a particle • The ball is shot from the ground	3.5b	E1	• The ball experiences no air resistance • Ball projected from ground level
	States a second valid assumption from • No air resistance • The ball is a particle • The ball is shot from the ground	3.5b	E1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
19(b)	States or uses 7cos11 for the vertical component of velocity OE	2.2a	B1	$s = k$ $u = 7\cos 11$ $v = 0$ $a = -9.8$ $v^2 = u^2 + 2as$ $0 = 49\cos^2 11 + 2(-9.8)k$ $k = 2.4$
	Uses $v^2 = u^2 + 2as$ with u = their vertical component of velocity, v = 0 and a = – 9.8	3.1b	M1	
	Obtains $0 = 49\cos^2 11 + 2(-9.8)k$ Accept any variable for k	1.1b	A1	
	Obtains AWRT 2.4	1.1b	A1	
	Subtotal		**4**	

	Question 19 Total		**8**	

Q	Marking instructions	AO	Marks	Typical solution
20(a)	Subtracts the two given position vectors for Q Condone either order	3.1a	M1	$(14\mathbf{i} + 5\mathbf{j}) - (5\mathbf{i} - 7\mathbf{j})$ $= 9\mathbf{i} + 12\mathbf{j}$ $= 3(3\mathbf{i} + 4\mathbf{j})$ P and Q move along parallel lines.
	Obtains $9\mathbf{i} + 12\mathbf{j}$ for the displacement of Q ACF Or Demonstrates that the average velocity for Q is $3\mathbf{i} + 4\mathbf{j}$	1.1b	A1	
	Completes reasoned argument to show that $9\mathbf{i} + 12\mathbf{j} = 3(3\mathbf{i} + 4\mathbf{j})$ and concludes that P and Q move along parallel lines	2.1	R1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
20(b)	States one of the following expressions • constant velocity is not the same as average velocity • Q's speed may change • Q could accelerate	2.3	E1	Constant velocity is not the same as average velocity
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
20(c)	Obtains 12 m for distance from *X* to *R*	1.1b	B1	P's speed $= \left\|3\mathbf{i}+4\mathbf{j}\right\| = 5$ m s^{-1} Distance from *X* to *P* $= 5(3-2)$ $= 5$ m Distance from *X* to *R* $= 12$ metres $5^2+12^2=13^2$  *P* and *R* are moving along perpendicular lines.
	Obtains 5 m s^{-1} for the speed of *P* PI by *XP* = 5 m	3.1a	B1	
	Calculates the distance travelled by *P* using their speed for *P* and $t = 1$ Condone $t = 2$	1.1a	M1	
	Identifies 5, 12 and 13 as a Pythagorean triple May be seen on a diagram Or Correctly applies the cosine rule $13^2 = 12^2+5^2-2\times12\times5\times\cos\theta$ and concludes that $\theta = 90^o$	1.1b	A1	
	Completes a reasoned argument that *PXR* is a right-angled triangle with hypotenuse *PR* and concludes that *P* and *R* move along perpendicular lines Or Completes a reasoned argument that angle *PXR* is a right angle and concludes that *P* and *R* move along perpendicular lines	2.1	R1	
	Subtotal		**5**	

	Question 20 Total		**9**	

Q	Marking instructions	AO	Marks	Typical solution
21(a)	States that the resultant force is 80g – T and states $F = ma$	3.4	E1	$80g - T$ is the resultant force and as $F = ma$, 80g – T = 80a
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
21(b)	States $50g$ cos60 = $25g$ OE	3.1b	B1	Resolve perpendicular to slope $R = 50g\cos 60 = 25g$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
21(c)	Resolves parallel to the slope to obtain $50g$ sin 60 or better PI OE	1.1b	B1	parallel to slope $T - 50g\sin 60 - F = 50a$ $F = 25g\mu$ $T - 50g\sin 60 - 25g\mu = 50a$ Using given equation for *N*: $80g - T = 80a$ $80g - 50g\sin 60 - 25g\mu = 130a$ $a = \dfrac{80g - 50g\sin 60 - 25g\mu}{130}$ $a = \dfrac{\left(16 - 5\sqrt{3} - 5\mu\right)g}{26}$ Acceleration will be at its minimum when $\mu = 1$ Therefore $a \geq \dfrac{(11 - 5\sqrt{3})g}{26}$
	Obtains $\mu \times 25g$ for friction OE Or States $\mu = 1$ and obtains $25g$ for friction	3.3	B1	
	Forms a three or four-term equation of motion for *M* using $F = ma$ parallel to slope Condone cos60 OE and sign errors	3.3	M1	
	Obtains single correct equation or inequality with μ Or $T - 50g$ sin60 $- 25g = 50a$ where $\mu = 1$ is stated Or $T - 50g$ sin60 $- 25g \leq 50a$ where $\mu = 1$ is stated	1.1b	A1	
	Eliminates T using the equation in 21 (a) and their equation or inequality with μ Condone use of $T = 80a + 80g$	1.1a	M1	
	Completes reasoned argument to show $a \geq \dfrac{(11 - 5\sqrt{3})g}{26}$ Must include clear reason for using $\mu = 1$ or uses $0 \leq \mu \leq 1$ or uses $\mu \leq 1$ AG	2.1	R1	
	Subtotal		**6**	

Q	Marking instructions	AO	Marks	Typical solution
21(d)	States any one of the following valid assumptions • Rope is light • rope inextensible • pulley is fixed • No air resistance	3.5b	E1	Rope has no mass
	Subtotal		**1**	

	Question 21 Total		**9**	

	Question Paper Total		**100**	