Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE
In A Level Further Mathematics (9FM0)
Paper 4C Further Mechanics 2

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.
   If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

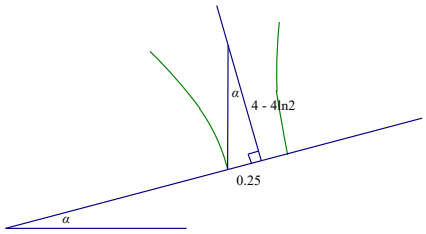
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

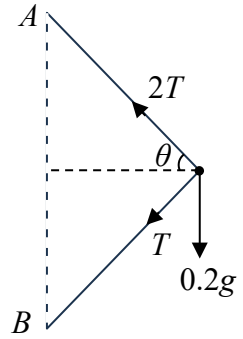
RHS, LHS Right hand side, left hand side.

Question	Scheme	Marks	AOs
1(a)	Correct method to find d	M1	3.1a
	$(2a\times 0)+2a\times a+2a\times 2a+2\sqrt{2}a\times a+\sqrt{2}a\times\frac{3a}{2}=d\left(6a+3\sqrt{2}a\right)$	A1 A1	1.1b 1.1b
	$\Rightarrow d=\frac{12+7\sqrt{2}}{12+6\sqrt{2}}a$ *	A1*	2.2a
		(4)	
1(b)	Correct method to form an equation in k	M1	3.1a
	$Mg\times\frac{12+7\sqrt{2}}{12+6\sqrt{2}}a=(kMg+Mg)a$	A1	1.1b
	$k=\frac{\sqrt{2}}{12+6\sqrt{2}}$ or equivalent	A1	1.1b
		(3)	
			(7 marks)

Notes:	
(a) M1	Take moments about AB or an axis parallel to AB. Need all terms and dimensionally correct (condone invisible brackets).
A1	Unsimplified equation with at most one error (repeated errors only count once; condone invisible brackets)
A1	Correct unsimplified equation (condone invisible brackets)
A1*	Obtain given answer including "$d=$" from correct exact working (A0 if there are missing brackets in the working)
(b)M1	Take moments about AB or an axis parallel to AB. Accept M consistently replaced by, e.g. $6+3\sqrt{2}$
A1	Correct unsimplified equation. Allow without any of M, g and a.
A1	Accept 0.069 or better $\left(\frac{-1+\sqrt{2}}{6}\right)$ Condone any exact form if given as a single fraction.

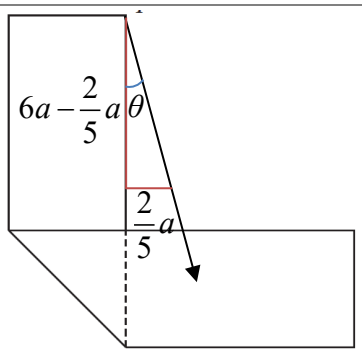
Question	Scheme	Marks	AOs
2(a)	Moments about O: $\int_2^4 (\pi\rho) y^2 x \, \mathrm{d}x$	M1	2.1
	$= (\pi\rho) \int_2^4 \frac{1}{x} \mathrm{d}x = \left[(\pi\rho) \ln x \right]_2^4 \quad \left(= (\pi\rho) \ln 2 \right)$	A1	1.1b
	Complete strategy to find distance:	M1	3.1a
	$\frac{\pi}{4} d = \pi \ln 2 \quad \Rightarrow d = 4 \ln 2$ (distance from base =) $4 - 4 \ln 2$ *	A1*	1.1b
		(4)	
2(b)			
	Use of trigonometry to find a relevant angle	M1	3.1b
	$\tan \alpha^\circ = \frac{0.25}{4 - 4 \ln 2}$	A1	1.1b
	$(\alpha =) 12$ or better	A1	1.1b
		(3)	
			(7 marks)

Notes:	
(a)M1	Moments equation to obtain integral of the correct form (with or without limits; condone missing dx). Must be integrating y^2x and not just y. Allow missing volume / ρ / π
A1	Correct unsimplified integration with correct limits seen (need not be substituted). Allow missing volume / ρ / π
M1	Complete strategy to find a relevant distance (d or $4 - d$): use of moments equation, correct use of limits, division by volume. Condone calculation of volume.
A1*	Obtain given answer with correct working seen (condone poor integration notation). ρ / π if seen must be used consistently and correctly.
(b)M1	Use of trig to find a relevant angle. Condone use of 0.125 for radius.
A1	Correct unsimplified equation in α. Accept letters other than α.
A1	cao (11.512566…..)

Question	Scheme	Marks	AOs
3	 $\left(\sin\theta=\frac{2}{3},\ \cos\theta=\frac{\sqrt{5}}{3},\ r=\frac{\sqrt{5}}{5}\right)$		
	Resolve vertically	M1	3.4
	$\updownarrow 2T\sin\theta=0.2g+T\sin\theta \quad \left(T\sin\theta=0.2g\right)$	A1	1.1b
	Equation of motion	M1	3.4
	$0.2r\omega^2=2T\cos\theta+T\cos\theta \quad \left(0.12\omega^2=3T\right)$	A1 A1	1.1b 1.1b
	Complete strategy to find ω	DM1	3.1a
	$\omega^2=25T=\frac{5g}{\sin\theta}=\frac{15g}{2} \qquad \omega=8.6 \quad (8.57)$	A1	1.1b
			(7 marks)

Notes:

M1	Correct number of terms. Condone sin/cos confusion and sign errors
A1	Correct unsimplified equation. Accept $T_A\sin\theta=0.2g+T_B\sin\theta$ Allow m in place of 0.2 and their numerical sinθ / cosθ
M1	Circular motion. Correct number of terms. Condone sin/cos confusion. Acceleration must be $r\omega^2$ or v^2/r
A1	Unsimplified equation with at most one error. Allow m in place of 0.2 and their numerical sinθ / cosθ
A1	Correct unsimplified equation. Accept $0.2r\omega^2=T_A\cos\theta+T_B\cos\theta$ Allow m in place of 0.2 and their numerical sinθ / cosθ
DM1	Complete strategy to form sufficient equations to solve for ω including upper tension being twice lower tension and a method to find r. Dependent on both previous M marks.
A1	2 or 3 sf only

Question	Scheme	Marks	AOs
4(a)	<table><tr><td></td><td>Left rectangle</td><td>2 triangles</td><td>Right rectangle</td><td>Total</td></tr><tr><td>Mass ratio</td><td>$2\ (18a^2)$</td><td>$\left(2\times\frac{1}{2}\times\frac{9}{2}a^2\right)$</td><td>$2\ (18a^2)$</td><td>5 ($45a^2$)</td></tr><tr><td>From EF</td><td>$-1.5a$</td><td>$-a$</td><td>$3a$</td><td>d</td></tr></table>	B1 B1	1.1b 1.1b
	Moments about EF	M1	2.1
	$2\times-1.5a+1\times-a+2\times3a=5d$	A1	1.1b
	Distance $=\frac{2}{5}a$ *	A1*	2.2a
		(5)	
4(b)	The perpendicular bisector of BE is a line of symmetry	B1	2.4
		(1)	
4(c)			
	Vertical distance of c of m from $F=\frac{28a}{5}$	B1	3.1a
	$\tan\theta=\frac{2}{28}$	M1	1.1b
	$\theta=\tan^{-1}\left(\frac{1}{14}\right)=4.09°\quad(4.1°)\quad(0.071\ \text{rads})$	A1	1.1b
		(3)	
			(9 marks)

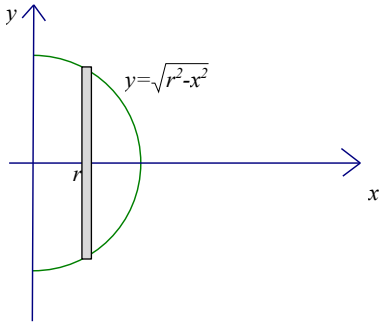
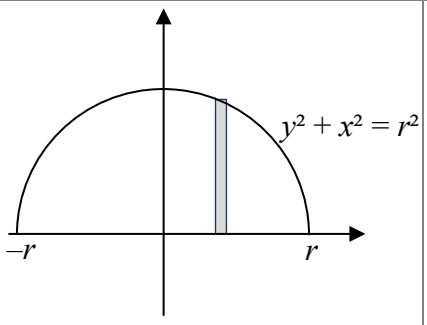
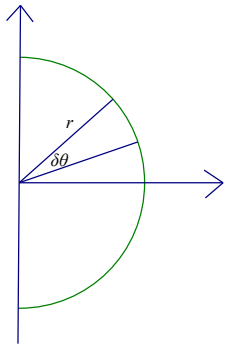
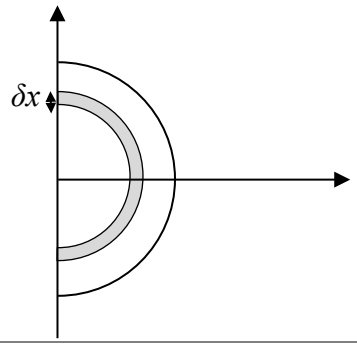
Notes:

(a)B1	Correct mass ratios
B1	Correct distances from EF or a parallel axis
M1	Moments about EF or a parallel axis. Need all terms. Dimensionally correct. Condone sign errors.
A1	Correct unsimplified moments equation (E.g. $45d = 18\times1.5a + 9\times2a + 18\times6a$)

A1*	Obtain given answer from correct working.
(b)B1	Or equivalent reasoning mentioning symmetry with no incorrect statements.
(c)B1	Correct vertical distance using symmetry or a second moments equation
M1	Use of trig to find a relevant angle. Must be dimensionally correct. Award if using an incorrectly evaluated vertical distance of the form $6a \pm \bar{y}$, where $\bar{y} = \frac{2a}{5}$ or is calculated from a moments equation.
A1	Correct only. $4.1°$ or better (4.08561678…)

Question	Scheme	Marks	AOs
5(a)	Equation of motion	M1	3.4
	$800-2v^2=1000\dfrac{\mathrm{d}v}{\mathrm{d}t}$	A1 A1	1.1b 1.1b
	$\Rightarrow \int \dfrac{500}{400-v^2}\,\mathrm{d}v=\int 1\,\mathrm{d}t$	M1	2.1
	$\dfrac{25}{2}\ln\left\lvert\dfrac{20+v}{20-v}\right\rvert=t\,(+C)$	A1	1.1b
	$T=\left[\dfrac{25}{2}\ln\left(\dfrac{20+v}{20-v}\right)\right]_5^{15}$	M1	1.1b
	$=\dfrac{25}{2}\ln\left(\dfrac{35}{5}\times\dfrac{15}{25}\right)=\dfrac{25}{2}\ln\left(\dfrac{21}{5}\right)$ *	A1*	2.2a
		(7)	
5(b)	$t=0, v=2 \Rightarrow C=\dfrac{25}{2}\ln\dfrac{22}{18}\left(=\dfrac{25}{2}\ln\dfrac{11}{9}\right)$	M1	3.1b
	$\left(\dfrac{20+v}{20-v}\right)=\dfrac{11}{9}\mathrm{e}^{\frac{2t}{25}}$ *	A1*	2.2a
		(2)	
5(c)	As $\mathrm{e}^{qt}>0,\quad v<20$ *	B1ft *	2.4
		(1)	
			(10 marks)

Notes:	
(a)M1	Form equation of motion. Need all terms and dimensionally correct. Condone any correct form for acceleration and sign errors
A1 A1	Unsimplified equation in v and t with at most one error Correct unsimplified equation in v and t
M1	Separate variables and integrate to a correct logarithmic form. May see attempts using substitution / trig etc. but need to get to logarithmic form.
A1	Any equivalent form. Constant of integration and modulus signs not required.
M1	Use correct limits correctly in an expression containing $\lambda \ln(20-v)$ and $\mu \ln(20+v)$
A1*	Obtain **given answer** from correct working (condone disappearance of "dv" or "dt" on integrals)
(b)M1	Use boundary condition to find constant of integration for their integral.
A1*	Obtain given conclusion from correct working. Allow any exact equivalent for p & q.
(c) B1*	Obtain given conclusion. Follow their $p > 0$ but must be referring to the idea that the expression must be positive because it is an exponential function.

Question	Scheme		Marks	AOs
6(a)				
	$\left(\frac{1}{2}\pi r^2 d=\right)\int_0^r 2yx\,\mathrm{d}x$	$\left(\frac{1}{2}\pi r^2 d=\right)\int_{-r}^r \frac{1}{2}y^2\,\mathrm{d}x$	M1	2.1
	$\int_0^r 2xy\,\mathrm{d}x=\int_0^r 2x\sqrt{r^2-x^2}\,\mathrm{d}x$	$\int_{-r}^r \frac{1}{2}y^2\,\mathrm{d}x=\int_{-r}^r \frac{1}{2}\left(r^2-x^2\right)\mathrm{d}x$	M1	3.1a
	$=-\left[\frac{2}{3}\left(r^2-x^2\right)^{\frac{3}{2}}\right]_0^r=\frac{2}{3}r^3$	$=\left[\frac{1}{2}\left(r^2x-\frac{1}{3}x^3\right)\right]_{-r}^r=\frac{2}{3}r^3$	A1ft	1.1b
	$\Rightarrow d=\frac{\frac{2}{3}r^3}{\frac{1}{2}\pi r^2}=\frac{4r}{3\pi}$ *		A1*	2.2a
			(4)	
6(a) alt				
	CoM of "triangle" is $\frac{2}{3}r\cos\theta$ from O	CoM of "arc" is $\frac{2x}{\pi}$ from O	M1	2.1
	$\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\frac{1}{2}r^2\times\frac{2}{3}r\cos\theta\,\mathrm{d}\theta$	$\int_0^r \pi x\times\frac{2x}{\pi}\mathrm{d}x$	M1	3.1a
	$=\frac{1}{3}r^3\left[\sin\theta\right]_{-\frac{\pi}{2}}^{\frac{\pi}{2}}=\frac{2}{3}r^3$	$=\left[\frac{2}{3}x^3\right]_0^r=\frac{2}{3}r^3$	A1ft	1.1b
	$\Rightarrow d=\frac{\frac{2}{3}r^3}{\frac{1}{2}\pi r^2}=\frac{4r}{3\pi}$ *		A1*	2.2a

		(4)	
6(b)	<table><tr><td></td><td>Rectangle</td><td>Large sc</td><td>Small sc</td><td>Total</td></tr><tr><td>Mass ratio</td><td>16</td><td>8π</td><td>2π</td><td>$16 + 6\pi$</td></tr><tr><td>From DC</td><td>$-a$</td><td>$\frac{16a}{3\pi}$</td><td>$\frac{8a}{3\pi}$</td><td>$\bar{x}$</td></tr></table>	B1 B1	1.1b 1.1b
	Moments about DC	M1	2.1
	$8\pi \times \frac{16a}{3\pi} - 2\pi \times \frac{8a}{3\pi} - 16a = (16 + 6\pi)\bar{x}$	A1	1.1b
	$\bar{x} = \frac{a\left(\frac{7\times16}{3} - 16\right)}{16 + 6\pi} = \frac{64a}{3(16 + 6\pi)} = \frac{32a}{3(8 + 3\pi)}$ *	A1*	2.2a
		(5)	
6(c)	Moments about A:	M1	3.1a
	$W \times \left(2a + \frac{32a}{3(8 + 3\pi)}\right) = 8a\lambda W$	A1	1.1b
	$\lambda = \left(\frac{(9\pi + 40)}{12(8 + 3\pi)}\right)$ = 0.33 or better (0.3265…)	A1	1.1b
		(3)	
			(12 marks)

Notes:

(a)M1	Correct strategy to find d by integration
M1	Integrate a function of the form $\lambda x\sqrt{r^2 - x^2}$ / $\lambda(r^2 - x^2)$. Allow without limits.
A1ft	Follow their λ. Allow without limits.
A1*	Obtain given answer including "d =" from correct exact working
(a) alt M1	Correct strategy to find d by integration
M1	Integrate a function of the form $\lambda r^3 \cos\theta$ or λx^2. Allow without limits.
A1ft	Follow their λ
A1	Obtain given answer including "d =" from correct working
(b)B1	Correct mass ratios
B1	Distances from DC or a parallel axis

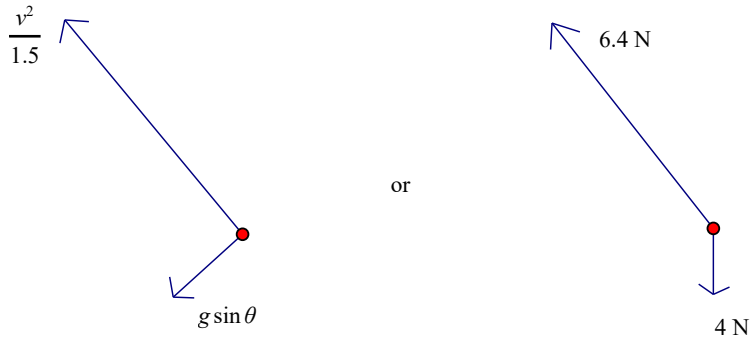
M1	Moments about *DC* or a parallel axis. All terms required. Dimensionally correct.
A1	Correct unsimplified equation for their axis
A1*	Obtain given answer from correct working.
(c)M1	Moments about *A*. Dimensionally correct. Allow if *a* missing throughout.
A1	Correct unsimplified equation
A1	Correct only. Accept 0.33 or better (0.3265…). Condone an exact answer in terms of π if given as a single fraction.

Question	Scheme	Marks	AOs
7(a)	$a\omega = 5$	B1	3.4
	$a\omega^2 = 12.5$	B1	3.4
	Complete method to find T	M1	2.1/3.1a
	$\omega = \frac{12.5}{5} \Rightarrow T = \frac{2\pi}{\omega} = \frac{4\pi}{5}$ *	A1 *	1.1b
		(4)	
7(b)	$a = 2 \quad \Rightarrow \quad x = 2\cos\frac{5}{2}t$ or $x = 2\sin\frac{5}{2}t$	M1	3.4
	$\frac{1}{2} = 2\cos\frac{5}{2}t \Rightarrow t = \frac{2}{5}\cos^{-1}\frac{1}{4}$ or $\frac{1}{2} = 2\sin\frac{5}{2}t \Rightarrow t = \frac{2}{5}\sin^{-1}\frac{1}{4}$	M1	3.1a
	Total time: $4\left(\frac{2}{5}\cos^{-1}\frac{1}{4}\right)$ or $\frac{4\pi}{5} - 4\left(\frac{2}{5}\sin^{-1}\frac{1}{4}\right)$	M1	1.1b
	$= 2.1$ (s)	A1	1.1b
		(4)	
7(c)	$v^2 = \frac{25}{4}\left(4 - \frac{1}{25}\right)$	M1	3.4
	$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.4 \times \frac{99}{4}$	M1	1.2
	$= \frac{99}{20}(\text{J}) = 4.95$ (J)	A1	1.1b
		(3)	
			(11 marks)

Notes:

(a)B1	Correct formula for max speed. Accept $a^2\omega^2 = 25$
B1	Correct formula for max acceleration. Must be same sign on both sides in their solution.
M1	Complete method e.g. solve for ω and use $T = \frac{2\pi}{\omega}$
A1 *	cso
(b)M1	Use their ω to solve for a and state or imply equation in x and t
M1	Find a relevant value of t
M1	Find the required value of t Some candidates will find two times and combine:

	$a \sin \omega t = 0.5$ [$t_1 = 0.10107$, $t_2 = 1.15556$] → Time = $2(t_2 - t_1)$ $a \cos \omega t = 0.5$ [$t_3 = 0.52724$, $t_4 = 0.72939$] → Time = $4\pi/5 - 2(t_4 - t_3)$
A1	2.1 (s) or better (2.108985…)
(c)M1	Use of $v^2 = \omega^2\left(a^2 - x^2\right)$ or equivalent to find v or v^2
M1	Correct method for kinetic energy for their v
A1	cao

Question	Scheme	Marks	AOs
8(a)	Conservation of energy:	M1	3.1a
	$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mg \times r(1-\cos\theta)$	A1 A1	1.1b 1.1b
	Equation of motion	M1	3.1a
	$T - mg\cos\theta = \frac{mv^2}{r}$	A1	1.1b
	Complete strategy to find T	M1	2.1
	$T = \frac{4\times 18}{15} + 1.6 = 6.4\ (\text{N})$ *	A1*	2.2a
		(7)	
8(b)	$\cos\theta = 0.4$	B1	1.1b
		B1 B1	1.1b 1.1b
	Use of Pythagoras **or** cosine rule and $F = ma$	M1	3.1a
	$\lvert a\rvert = \sqrt{12^2 + 100\times\frac{21}{25}} = 2\sqrt{57} = 15\ (\text{m s}^{-2})$	A1	1.1b
		(5)	
			(12 marks)

Notes:	
SC	**Candidates who use $g = 9.8$ are eligible for all marks except the final A1 in each of parts (a) and (b).** **If they only use $g = 9.8$ in one part, then this penalty only applies to that part.** **In part (b) candidates are also eligible for all marks except the final A1 if they use the given answer of 6.4 from (a) along with $g = 9.8$ in their other work.**
(a)M1	Need all terms. Dimensionally correct. Condone sign errors and sin/cos confusion
A1 A1	Unsimplified equation with at most one error Correct unsimplified equation. Accept with g or 10
M1	Need all terms. Dimensionally correct. Condone sign errors and sin/cos confusion

A1	Correct unsimplified equation. Accept with g or 10
M1	Complete strategy to find T e.g. use conservation of energy, circular motion and substitute value for v to form sufficient equations to find T
A1*	Obtain **given answer** from correct working. N.B. $g = 9.8$ gives $T = 6.32$ (but scores A0)
(b)B1	Correct only. Must be seen or used in part (b). Award for $\sin\theta = \frac{\sqrt{21}}{5}$ N.B. $g = 9.8$ gives $\cos\theta = \frac{19}{49} (= 0.38775...)$, $\sin\theta = \frac{2\sqrt{510}}{49} (= 0.92176...)$
B1 B1	One component of acceleration or force correct (unsimplified) Both components of acceleration or force correct (unsimplified) N.B. $g = 9.8$ gives components as 12 & 9.03 (velocity) or 6.32 and 3.92 (force)
M1	Complete strategy to find magnitude of acceleration. $\lvert F \rvert = \sqrt{6.4^2 + 4^2 - 2\times 6.4\times 4\times\cos\theta} = 0.4a$
A1	Accept 15 or better (15.09966887…) including exact equivalent N.B. $g = 9.8$ gives 15.01998… but scores A0 $g = 9.8$ and $T = 6.4$ gives 15.18025… but scores A0

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