EDEXCEL | A-LEVEL MATHS | 9MA0/32

9MA0-32 A Level Mechanics - June 2025

June 2025 exam series

MARK SCHEME

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Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE
In Mathematics (9MA0)
Paper 32 Mechanics

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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 50.

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 √ 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 <u>and indicates which response they wish to submit</u>, examiners should mark this response.
   If there are several attempts at a question <u>which have not been crossed out</u>, examiners should mark the final answer which is the answer that is the <u>most complete</u>.

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)	$v = 15 + (2 \times 4)$	M1	3.1b
	$= 23$ (m s^{-1})	A1	1.1b
		(2)	
1(b)	$D - 400 = 800 \times 2$	M1	3.1b
	$(D =)$ 2000	A1	1.1b
		(2)	
			(4 marks)

Notes:

1(a)	M1	Use of $v = u + at$ or any other **complete** method to form an equation in v only. Condone sign errors. e.g. May find s first: $s = (15 \times 4) + \frac{1}{2} \times 2 \times 4^2 = 76$ then either: $76 = 4v - \frac{1}{2} \times 2 \times 4^2$ or: $76 = \frac{(15 + v)}{2} \times 4$ or: $v^2 = 15^2 + 2 \times 2 \times 76$ **N.B.** If they use $v = u + at$ and have $15 = u + (2 \times 4)$, M1A0 M0 if they clearly use an incorrect *suvat* formula or $u = 0$
	A1	cao. Must be positive. A0 if they get 23 but go on and do something with it. i.e. not ISW **N.B.** 23 with no working can score both marks.
1(b)	M1	Use of $F = ma$ to form an equation in D or a complete expression for D, with correct number of terms, condone sign errors and g in the ma term.
	A1	cao **N.B.** 2000 with no working can score both marks.

Question	Scheme	Marks	AOs
N.B. Penalise the use of $g = 9.81$ ONCE (the first time it is used) for the whole question.			
2(a)	Resolve vertically	M1	3.4
	$(\uparrow)\ 5\sin\alpha + R = 2g$ oe	A1	1.1b
	$(R =)\quad 19.6 - 3 = 16.6$ (N)*	A1*	1.1b
		(3)	
2(b)	The box decelerates, slows down, loses speed or velocity, will come to a stop or rest, loses momentum	B1	2.4
		(1)	
2(c)	$(S =)$ 19.6 or 20 (N)	B1	3.3
		(1)	
2(d)	Equation of motion along the plane: $-F = 2a$ or $F = 2a$	M1	3.4
	$F = 0.2\times$ their S	B1	1.1b
	$0^2 = 4^2 - 2\times 0.2g\times d$ or $0^2 = 4^2 + 2\times 0.2g\times d$ or $4^2 = 0^2 + 2\times 0.2g\times d$	M1	3.1b
	$(OX =)$ 4.1 (m) or 4.08 (m)	A1	1.1b
	OR		
	Work done against friction $= Fd$	M1	3.4
	$F = 0.2\times$ their S	B1	1.1b
	$0.2\times 2g\times d = \frac{1}{2}\times 2\times 4^2$	M1	3.1b
	$(d = OX =)$ 4.1 (m) or 4.08 (m)	A1	1.1b
		(4)	
2(e)	the box (it) has been modelled as a particle the box (it) will have size or shape or dimensions the coefficient of friction has been modelled as being constant the coefficient of friction may not be exactly 0.2 or may vary the friction may vary B0 : the ground may not be horizontal, an inaccurate value of g has been used, has not considered wind, the angle may not be accurate, any reference to the particle having mass (or not having mass). Ignore any reference to air resistance.	B1	3.5b
		(1)	

		(10 marks)
Notes:		
2(a)	M1	Form an equation in R and α only, with correct number of terms, condone sign errors and sin/cos confusion, $\sin\alpha$ may or may not be substituted. **N.B**. $3 + R = 2g$ oe , with no evidence of resolving the 5 N, e.g. not using $\sin\alpha$, is M0.
	A1	Correct equation, $\sin\alpha$ may or may not be be substituted.
	A1*	Given answer correctly obtained, with at least one line of working.
2(b)	B1	Any equivalent statement. B0 if any incorrect extras e.g. box is stationary or at rest, doesn't move, will stop moving.
2(c)	B1	Accept $2g$ if g is not substituted for. B0 if they use $g = 9.81$ unless they have already been penalised in part (a).
2(d)	M1	Correct number of terms. Condone an extra g in ma term. M0 if 2 is missing. **N.B**. M0 if they use a vertical force for F e.g. $2g$ or 16.6
	B1	Seen (e.g. on a diagram) or implied.
	M1	Complete method to form an equation in d (= OX) only, condone sign errors, using their calculated acceleration from an attempt at using $F = ma$ M0 if clearly using μ (0.2) or $-\mu$ for a without any calculation.. e.g. may find t first: $0 = 4 - 0.2gt$ => $t = \frac{20}{g}$ $(= \frac{100}{49})$ then $d = 4 \times \frac{20}{g} - \frac{1}{2} \times 0.2g \times \left(\frac{20}{g}\right)^2$ or $d = 0 - \frac{1}{2} \times (-0.2g) \times \left(\frac{20}{g}\right)^2$ or $0^2 = 4^2 + 2 \times (-0.2g) \times d$
	A1	Either answer. A0 for $\frac{40}{g}$
2(e)	B1	Any equivalent statement which refers to the model. B0 if incorrect extras.

Question	Scheme	Marks	AOs
3(a)	$(\mathbf{F} =)\ (\mathbf{i} - 1.2\mathbf{j})$	B1	3.4
		(1)	
3(b)	$\mathbf{v} = (-7\mathbf{i} + 7.8\mathbf{j}) + 2(2\mathbf{i} - 2.4\mathbf{j})$	M1	2.1
	$= (-3\mathbf{i} + 3\mathbf{j})\ \ (\text{m s}^{-1})$	A1	1.1b
		(2)	
3(c)	Use trig to find an equation in a relevant angle	M1	2.1
	e.g. $\tan\alpha = 1$ or -1 or $\sin\alpha = \dfrac{3}{\sqrt{3^2+3^2}}$ or $\dfrac{-3}{\sqrt{3^2+3^2}}$ or $\cos\alpha = \dfrac{3}{\sqrt{3^2+3^2}}$ or $\dfrac{-3}{\sqrt{3^2+3^2}}$	A1	1.1b
	315°	A1	2.2a
		(3)	
3(d)	$\overrightarrow{OA} = 5(-7\mathbf{i} + 7.8\mathbf{j}) + \frac{1}{2}(2\mathbf{i} - 2.4\mathbf{j}) \times 5^2$	M1	3.1a
	$= (-10\mathbf{i} + 9\mathbf{j})\ (\text{m})$	A1	1.1b
		(2)	
			(8 marks)

Notes:
Accept column vectors throughout apart from in the final answer for (a) and (d) which must be in terms of i and j, but only penalise ONCE for the whole question.
N.B. For final answers to (a), (b) and (d) , penalise incorrect vector notation.

3(a)	B1	Must be in terms of **i** and **j** Do not accept $0.5 \times (2\mathbf{i} - 2.4\mathbf{j})$ Do not need **F** =
3(b)	M1	Use of **v** = **u** + **a***t* or any other complete method, e.g. integration, to find an unsimplified expression for **v** at $t = 2$, condone sign errors. **N.B.** If using integration, must have used $t = 0$, $\mathbf{v} = (-7\mathbf{i} + 7.8\mathbf{j})$ to find the constant of integration and included it in their expression for **v** at $t = 2$.
	A1	cao. **N.B.** Ignore if they go on and find the speed.
3(c)	M1	Use trig to find an equation in a relevant angle for their **v**
	A1	Correct equation.
	A1	Cao (with or without the degree sign), must come from a correct **v** **N.B.** $\pm 45^{o}, \pm 135^{o}, \pm 225^{o}, -315^{o}$ with no working scores M1A1 315° with no working scores all 3 marks.

3(d)	M1	Use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ with $t = 5$ or any other complete method, e.g. integration of their $\mathbf{v} = f(t)$ and use of $t = 5$, to find an unsimplified expression for $\overrightarrow{OA}$ (No need to show that $\mathbf{C} = \mathbf{0}$) M0 if they use $\mathbf{u} = \mathbf{0}$
	A1	Must be in terms of **i** and **j** **N.B.** Ignore if they go on and find the length OA

Question	Scheme	Marks	AOs
4(a)	$\mathbf{r} = (32\mathbf{i} - 16\mathbf{j})$	B1	1.1b
		(1)	
4(b)	Use Pythagoras: $\sqrt{32^2 + 16^2}$ oe for their **r**	M1	3.1a
	$16\sqrt{5}$ (m)	A1	1.1b
		(2)	
4(c)	Differentiate **r** wrt t to obtain **v**	M1	3.4
	$6t^{\frac{1}{2}}\mathbf{i} - 2t\mathbf{j}$ oe (m s^{-1})	A1	1.1b
		(2)	
4(d)	Differentiate their **v** wrt t to obtain **a**	M1	3.4
	$3t^{-\frac{1}{2}}\mathbf{i} - 2\mathbf{j}$	A1	1.1b
	$\frac{3T^{-\frac{1}{2}}}{-2} = -\frac{1}{3}$ must see $\frac{\mathbf{i} \text{ component of their } \mathbf{a}}{\mathbf{j} \text{ component of their } \mathbf{a}} = -\frac{1}{3}$ oe	M1	2.1
	$(T =)\ \frac{81}{4}$ oe	A1	1.1b
		(4)	
			(9 marks)

Notes: N.B. Accept column vectors throughout apart from in the answer to (c).

4(a)	B1	cao. **N.B.** Must be using correct vector notation, including brackets if using column vectors.
4(b)	M1	For an unsimplified expression, using their **r**, with the square root
	A1	Accept any surd equivalent isw **N.B**. Must come from $\mathbf{r} = (32\mathbf{i} - 16\mathbf{j})$
4(c)	M1	Both powers of t decreasing by 1 (but not just division by t) **N.B.** M0 if **i** and/or **j** are missing and never reappear.
	A1	Must be in terms of t, **i** and **j**
4(d)	M1	Both powers of t decreasing by 1 (but not just division by t) **If no i's and/or j's,** can score M1 if **EITHER** they have 2 separate components, provided they are clearly treated as such in the subsequent working **OR** the **i's** and **j's** reappear **otherwise** M0.
	A1	Correct vector **or** 2 correct separate components, provided they are clearly treated as such in the subsequent working

	M1	Complete method to form a correct equation in $T(t)$ only, for their **a,** using the 2 components from their **a**
	A1	Accept 20.3 or 20.25 or any equivalent fraction (allow t instead of T)

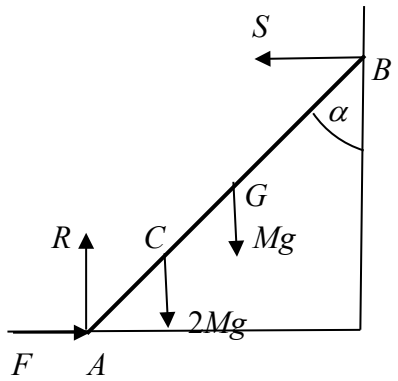
Question	Scheme	Marks	AOs
5(a)	Using horizontal motion	M1	3.3
	$14\cos\theta \times t = 40$	A1	1.1b
	Using vertical motion	M1	3.4
	$(s =)14\sin\theta \times t - \frac{1}{2}gt^2$ oe with down as positive.	A1	1.1b
	OR		
	Using the equation of the path		
	$(s =)40\tan\theta - \frac{g \times 40^2}{2 \times 14^2 \cos^2\theta}$ oe	M2 A2	
	$(H =)$ 30 or 30.0	A1	1.1b
		(5)	
5(b)	Using vertical motion **OR** Using cons. of energy	M1	2.1
	$0^2 = (14\sin\theta)^2 - 2gh$ $\frac{1}{2}m(14^2 - (14\cos\theta)^2) = mgh$	A1	1.1b
	32 (m)	A1**ft**	1.1b
		(3)	
			(8 marks)

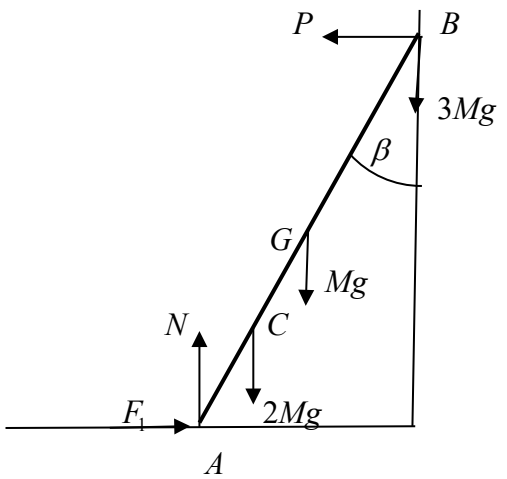
Notes:

N.B. Penalise the use of g = 9.81 **once** (the first time it is used) for the whole question.
All marks available if they use a different letter for θ

5(a)	M1	Complete method, using the horizontal motion, to give an equation in t and θ only, condone sin/cos confusion and sign errors (θ may or may not be substituted for)
	A1	Correct equation (t and/or θ may or may not be substituted for)
	M1	Complete method, using the vertical motion, to give an equation in t and θ only, condone sin/cos confusion and sign errors (t and/or θ may or may not be substituted for)
	A1	Correct equation (t and/or θ may or may not be substituted for) **N.B.** Just mark the RHS of the equation for this A mark.
	OR	
	M2 A2	Quoting and using correctly the equation of the path. **N.B.** No marks if they misquote the equation and no marks if they put in 14 and/or 40 incorrectly. These 4 marks are indivisible i.e. all 4 or 0.
	A1	H = 30 or 30.0 to 2 or 3 sf, after use of g = 9.8, **obtained correctly**.

5(b)	M1	Complete method to give equation in h and θ only, condone sin/cos confusion and sign errors They may find t first: $0 = 14\sin\theta - gt \Rightarrow t = \dfrac{14\sin\theta}{g}$ then $h = (14\sin\theta)\dfrac{14\sin\theta}{g} - \dfrac{1}{2}g\left(\dfrac{14\sin\theta}{g}\right)^2$ or $h = -\dfrac{1}{2}(-g)\left(\dfrac{14\sin\theta}{g}\right)^2$ or $h = \dfrac{(14\sin\theta + 0)}{2}\left(\dfrac{14\sin\theta}{g}\right)$
	A1	Correct equation
	A1**ft**	$\lvert\text{their } H\rvert + 2$, to 2sf or 3sf

Question	Scheme	Marks	AOs
6(a)			
	(↑): ($R =$) $3Mg$	B1	3.4
		(1)	
6(b)	**N.B.** Allow consistent use of a different letter for the angle in the working but must be α in the final answer. BOD if their a's and α's look the same.		
	EITHER:		
	Obtain an equation in S, M, a and α only, by taking moments about A	M1	3.1a
	M(A): $S \times 2a\cos\alpha = Mga\sin\alpha + 2Mg \times 0.5a\sin\alpha$	A1	1.1b
	OR		
	Obtain an equation in S, M, a and α only, by taking moments about B, C or G **and** resolving once **and** eliminating F and R (**N.B.** $R = 3Mg$ from (a))	M1	3.1a
	Correct equation in S, M, a and α only	A1	1.1b
	<u>Possible Moments equations</u>: M(B): $R \times 2a\sin\alpha = Mga\sin\alpha + 2Mg \times 1.5a\sin\alpha + F \times 2a\cos\alpha$ or M(C): $F \times 0.5a\cos\alpha + S \times 1.5a\cos\alpha = R \times 0.5a\sin\alpha + Mg \times 0.5a\sin\alpha$ or M(G): $Sa\cos\alpha + Fa\cos\alpha + 2Mg \times 0.5a\sin\alpha = Ra\sin\alpha$ <u>Possible resolution equations</u>: (→): $F = S$ or (↗): $R\cos\alpha + F\sin\alpha = S\sin\alpha + (2Mg + Mg)\cos\alpha$ or (↖): $R\sin\alpha + S\cos\alpha = (2Mg + Mg)\sin\alpha + F\cos\alpha$		
	$S = Mg\tan\alpha$ *	A1*	2.2a

		(3)	
6(c)	The friction force at B will provide an extra **upward (**not just vertical**)** force so R_1 will be less i.e. R will be greater. R (is greater than R_1) as the friction act against the weight of the rod. R (is greater) as the friction acts in the same direction as R_1 $R($ is greater)as the friction holds the rod up as well. $R = 3Mg = R_1 + F$ so R will be greater **N.B**. Allow R_1 will be smaller with a correct reason. B0 R is greater as there is no friction from the wall.	B1	3.5a
		(1)	
6(d)	**N.B.** Allow consistent use of a different letter for the angle and could score FULL marks.		
			
	EITHER: Moments about B **or** D, the intersection of the normals	M1	3.4
	M(B): $N \times 2a\sin\beta = Mga\sin\beta + 2Mg \times 1.5a\sin\beta + F_1 \times 2a\cos\beta$	A1	1.1b
	or M(D): $F_1 \times 2a\cos\beta = Mga\sin\beta + 2Mg \times 0.5a\sin\beta + 3Mg \times 2a\sin\beta$	A1	1.1b
	and resolve vertically: $(\uparrow)\ N = Mg + 2Mg + 3Mg$	B1	3.3
	OR: Moments about A or C or G	M1	3.4
	A correct moments equation.	A1	1.1b
	A correct resolution (**N.B**. Treat as a B mark so M0A0A1 is a possible score)	A1	1.1b
	A correct second resolution or a correct second moments equation	B1	3.3
	<u>Possible Moments equations:</u> M(A): $2Mg \times 0.5a\sin\beta + Mga\sin\beta + 3Mg \times 2a\sin\beta = P \times 2a\cos\beta$		

	N.B. (You may see the first 2 terms collected as a single term) **or** M(C): $0.5aF_1\cos\beta + 1.5Pa\cos\beta = 0.5Na\sin\beta + 0.5Mga\sin\beta + 3Mg\times 1.5a\sin\beta$ **or** M(G): $F_1a\cos\beta + Pa\cos\beta + 2Mg\times 0.5a\sin\beta = Na\sin\beta + 3Mga\sin\beta$ <u>Possible resolution equations</u>: ($\uparrow$): $N = Mg + 2Mg + 3Mg$ ($\rightarrow$): $F_1 = P$ (or $P = \mu N$) ($\nearrow$): $F_1\sin\beta + N\cos\beta = P\sin\beta + (3Mg + Mg + 2Mg)\cos\beta$ ($\nwarrow$): $N\sin\beta + P\cos\beta = (3Mg + Mg + 2Mg)\sin\beta + F_1\cos\beta$		
	(N.B. $F_1 = P = 2Mg$)		
	Use of $F_1 = \mu N$, their equations (which must be correct) and $\tan\beta = \frac{1}{2}$, to obtain an equation in μ only. **N.B.** This mark is only available if the previous 4 marks have all been earned.	**d**M1	3.1a
	$\mu = \frac{1}{3}$*	A1*	2.2a
		(6)	
			(11 marks)

Notes:

6(a)	B1	Cao. Must be in terms of M and g.
6(b)	M1	M(A): Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1	Correct equation in S, M, a and α only. **N.B.** Must see use of $0.5a$
	A1*	Given answer correctly obtained. (Must be in α but allow a different angle used in the equations). Penalise incorrect use of brackets. e.g. if they use $(90^o - \alpha)$, penalise missing brackets. **N.B.** Must see at least one line of intermediate working which will involve : like terms collected, division by $\cos\alpha$,which does not need to be seen explicitly, division by 2 in some order. **N.B.** Allow the order of the terms on the RHS to be different and allow m for M.
		OR
	M1	M(B) or M(C) or M(G) and a resolution and elimination of F and R. Both equations used must have correct no. of terms, dim correct, condone sin/cos confusion and sign errors

	A1	Correct equation in S, M, a and α only
	A1*	Given answer correctly obtained. **N.B.** Must see at least one line of intermediate working which will involve : like terms collected and division by $\cos\alpha$
6(c)	B1	Correct explanation B0 if any incorrect extras
6(d)		**N.B.** If there is a combination of the two alternatives, mark both and award the higher mark. If there are errors in their equations for both methods and the total mark out of 4 is the same, enter the first 4 marks on ePEN for whichever of the 2 methods they use to try to find μ. If they don't try and find μ, enter marks for the EITHER method.
		EITHER
	M1	M(B) or M(D): Correct no. of terms, dim correct, condone sin/cos confusion and sign errors, allow use of a different letter, θ say, for β. (θ could even be α) **N.B.** Condone consistent missing a's **N.B.** M0 if they are clearly using R from part (a) for N.
	A1	Correct equation with at most one error
	A1	Correct equation
	B1	Correct vertical resolution
		OR
	M1	M(A or C or G): Correct no. of terms, dim correct, condone sin/cos confusion and sign errors, allow use of a different letter, θ say, for β. **(**θ could even be α) **N.B.** Condone consistent missing a's **N.B.** M0 if they are clearly using S from part (b) for P
	A1	Correct equation
	A1	This is treated as a B mark for a correct resolution, seen or implied.
	B1	For another correct resolution or another correct moments equation (NOT about B) seen or implied.
		N.B. when entering marks on ePEN for the two resolutions, if only ONE is correct enter as A1 B0.
	dM1	Dependent for using $F_1 = \mu N$ and their **correct** equations, to produce an equation in μ only. **N.B**. Allow if they use $F_1 \leqslant \mu N$
	A1*	Given answer correctly obtained

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