

GCE

Further Mathematics A

Y533/01: Mechanics

AS Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor
3. Log-in to RM Assessor and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.
5. **Crossed-Out Responses**
Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions

Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses

When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses

When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)

Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)

If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)

Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.
7. There is a NR (**No Response**) option. Award NR (No Response):
 - if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
 - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).
8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.
10. For answers marked by levels of response: Not applicable in F501
To determine the level – start at the highest level and work down until you reach the level that matches the answer
To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. Annotations

Annotation	Meaning
✓and✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

Subject Specific Marking Instructions

- a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)

- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

- b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

- c. The following types of marks are available.

M

A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words “Determine” or “Show that”, or some other indication that the method must be given explicitly.

A

Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B

Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

- d. When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep*’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.
- e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

- f. We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.

- When a value is **given** in the paper only accept an answer correct to at least as many significant figures as the given value.
- When a value is **not given** in the paper accept any answer that agrees with the correct value to **3 s.f.** unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.

NB for Specification B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads "2 s.f".

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.

Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

- g. Rules for replaced work and multiple attempts:

- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- If a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

- h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.

If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

- i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold "In this question you must show detailed reasoning", or the command words "Show" or "Determine". Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

- j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AO	Guidance	
1	(a)		$I = mv = 0.16 \times 15 = 2.4 \text{ Ns}$	B1	1.1		
				[1]			
	(b)		Initial energy = $\frac{1}{2} \times 0.16 \times 15^2$ (= 18 J)	B1	1.1	KE of ball	
			$30R = \frac{1}{2} \times 0.16 \times 15^2$	M1	3.4	Using Work-Energy principle correctly	i.e. their initial energy = WD against resistance with signs correct and no extra (non-zero) terms.
			Resistance to motion = 0.6 N	A1	1.1		If B0M0 then SC1 for using suvat $a = -3.75$ $F = 0.16 \times -3.75 \Rightarrow 0.6 \text{ N}$
				[3]			

Question			Answer	Marks	AO	Guidance	
2	(a)		$m \times 3 + 2m \times (-) = (m + 2m)v$	M1	1.1	Conservation of momentum with <i>A</i> and <i>B</i> having some post-‘collision’ velocity NB the solution assumes that the initial direction of <i>A</i> is positive	Condone sign error/signs reversed or separate (unknown) velocities assumed (but not both) M0 if <i>mg</i> used unless recovered later. Treat masses reversed as MR and FT subsequent parts.
			$v = \frac{3 - 2u}{3}$	A1	1.1	Accept $v = \frac{2u-3}{3}$	Could be expressed as e.g. $1 - \frac{2u}{3}$ but not $\frac{3m - 2um}{3m}$
				[2]			
	(b)	(i)	In the direction of travel of <i>A</i> or towards <i>A</i> or in the opposite direction of <i>B</i> ’s original projection	B1	1.1	Could be shown on a diagram if unambiguous.	Accept “left” if no contraindications are present.
				[1]			

	(b)	(ii)	Impulse on B = change in B 's momentum $= 2m \left(\frac{3-2u}{3} - (-u) \right)$	M1	1.1	Using their v from (a) . Condone global sign error. Must be same final velocity as A.	Using A's change of momentum: $m \left(\frac{3-2u}{3} - 3 \right) = m \left(\frac{-6-2u}{3} \right) \Rightarrow$ $\frac{2m(3+u)}{3}$
			$= 2m \left(\frac{3-2u+3u}{3} \right) = \frac{2m(3+u)}{3} \text{ Ns}$	A1	1.1	Condone $\left \frac{2m(3+u)}{3} \right $ oe	$2m+2/3 \text{ mu Ns}$ Do not allow a negative value
				[2]			
	(b)	(iii)	$-\frac{2m(3+u)}{3} \text{ Ns}$	B1FT	2.2a	FT –their (b)(ii) or (a) A fully correct answer must be negative if A's original direction is positive, or positive if A's original direction was negative (may be evidenced from a diagram or from previous working).	$\frac{2m(3+u)}{3} \text{ Ns towards B}$ Instead of being defined with a minus sign the magnitude could be the same as (b)(ii) and the direction the direct opposite of (b)(i) . Must be simplified if using A's change of momentum
				[1]			
	(c)		Final KE $= \frac{1}{2} \times (m+2m) \left(\frac{3-2u}{3} \right)^2$	B1FT*	3.1b	FT use of their v from (a) Condone separate velocities but both must be $\neq 0$ Or ΔKE for both A and B seen.	$= \frac{m(3-2u)^2}{6}$
			KE loss $= \frac{1}{2} \times m \times 3^2 + \frac{1}{2} \times 2m \times u^2$ $-\frac{m(3-2u)^2}{6}$	M1dep	1.1	Expression for KE Loss (or change) using their final KE (ie correct form with their v). Must be 3 (or 4) terms.	Allow 1 slip, e.g. incorrect mass Allow final – initial KE
			$= \frac{27m + 6mu^2 - m(3-2u)^2}{6}$ $= \frac{m(27 + 6u^2 - 9 + 12u - 4u^2)}{6}$ $= \frac{m(18 + 12u + 2u^2)}{6}$ $= \frac{2m(9 + u^2 + 6u)}{6} = \frac{m(3+u)^2}{3}$	A1	1.1	AG – check carefully for incorrect working. Must see sufficient working, including 3 term quadratic.	If answer is negative, must justify change of sign.

				[3]			
Question			Answer	Marks	AO	Guidance	
3	(a)	(i)	At constant speed, $D = \frac{12000}{40} = R = 300$ so resistance to motion is 300 N,	B1	3.3	Use of “ $P = Fv$ ” in NII with $a = 0$.	
			$\frac{10000}{15} - R = 900a$	M1	3.4	Using “ $P = Fv$ ” in NII with 2 force terms and an ma term with relevant numbers substituted in with their $R (=300)$	Allow 1 minor slip, e.g. sign error
			$a = \frac{11}{27}$ (awrt 0.407 ms^{-2})	A1	1.1	AG	Allow $v = 15.0$ from $a = 0.407$
				[3]			
	(a)	(ii)	$\frac{9600}{v} - 300 = 900 \times 0.2$	M1	3.4	Using “ $P = Fv$ ” in NII with 2 force terms and an ma term and relevant numbers substituted in.	Allow 1 minor slip, e.g. sign error
			$v = 20 \text{ (ms}^{-1}\text{)}$	A1	1.1		
				[2]			
	(a)	(iii)	$\frac{P}{40} + 900g \sin 1^\circ - 300 = 0$	M1	3.4	Using “ $P = Fv$ ” in NII with 3 force terms and $a = 0$ and relevant numbers substituted in.	NB $900g \sin 1^\circ = 153.93 \dots$ Condone missing g for this mark. (NB gives 11371)
			$P = 5842.79 \dots$ (W) awrt 5.84 kW (or awrt 5840 W)	A1	1.1	Condone 5.84 without units but not 5840.	
				[2]			
	(b)	(i)	If $R = kv$, then at constant speed, $D = \frac{12000}{40} = k \times 40$, so $k = 7.5$ $R = 7.5v$	B1	3.3	AG. Could just see $300 = 40k$ to find k but must see “ $R = kv$ ” in some form somewhere.	Allow verification, e.g. “At maximum speed, $7.5 \times 40 = 300$, so $R = 7.5v$ ”
				[1]			

	(b)	(ii)	The new model predicts that resistances are proportional to speed (or approach 0 as $v \rightarrow 0$), which is more realistic/closer to real life.	B1	3.5b	Any statement stating or clearly implying that air resistance tends to increase with speed in real life (but not necessarily in a linear fashion) and comparing this to the new model (or vice versa). E.g.: “In the refined model, the larger the speed, the larger the resistance, which is more realistic”. oe. “It is more accurate as air resistance is proportional to velocity”	Ignore contact forces like friction which tend not to be affected by speed. Do not accept e.g.: “The refined model more accurately models and air resistance (giving more accurate results)”. “More accurate powers will be obtained at different speeds”. “It allows the resistance to no longer be constant and can explain air resistance” “Friction is likely to increase as speed increases so more accurate”
				[1]			
	(b)	(iii)	$\frac{9600}{v} - 7.5v = 900 \times 0.2$	M1	3.4	Using “ $P = Fv$ ” in NII with 2 force terms and an <i>ma</i> term and relevant numbers substituted in.	Allow 1 minor slip, e.g. sign error Or obtaining an equation in terms of D , e.g. $D - \frac{7.5 \times 9600}{D} = 180$
			$7.5v^2 + 180v - 9600 = 0$ ($v^2 + 24v - 1280 = 0$) so $v = \dots$	M1	1.1	Rearranging to 3-term quadratic equation and attempting to solve (could be BC).	$D^2 - 180D - 72000 = 0$ and attempt to solve
			$v = -12 + 4\sqrt{89}$ awrt 25.7 ms^{-1}	A1	2.3	Other solution ($-49.73\dots$) must be rejected but could be implicitly.	$D = 90 \pm 30\sqrt{89}$ ($-193.019 \dots$ & $373.019 \dots$) and using positive value of D to find v
				[3]			

Question			Answer	Marks	AO	Guidance	
4	(a)		A's direction unchanged: $4 \times 6 + 2 \times (-5) = 4 \times 1 + 2 \times v_B$ ($v_B = 5$)	M1	1.1	Conservation of momentum. Condone 5 instead of -5.	If using $4 \times 6 + 2 \times (-5) = 4 \times 1 - 2 \times v_B$, then v_B should be -5.
			$(e =) \frac{5' - 1}{6 - (-5)}$	M1	1.1	Attempt NLR with their v_B	Allow one sign error only.
			$e = \frac{4}{11}$ (awrt 0.364)	A1	1.1		
			A's direction changed: $4 \times 6 + 2 \times (-5) = 4 \times (-1) + 2 \times v_B$ ($v_B = 9$)	M1*	3.1b	Conservation of momentum. Condone 5 instead of -5.	This mark can be implied from a correct value of v_B after correctly finding the first value.
			$(e =) \frac{9' - (-1)}{6 - (-5)}$	DM1	1.1	Attempt NLR with their second v_B	
			Or $\frac{10}{11}$ (awrt 0.909)	A1	1.1	A0 if extra values found in addition to the correct values.	SC If A0A0A0 due to $u_B = 5$ then SCB1 for $e = 14$ and 20 both rejected as unfeasible.
				[6]			
	(b)		Perfectly elastic collision $\Leftrightarrow e = 1$ so we can tell that this is not a perfectly elastic collision (since neither of the possible values is 1)	B1	2.1	Argument must be complete so "Perfectly elastic $\Leftrightarrow e = 1$ " alone is insufficient. Allow "not perfectly elastic because $e \neq 1$ " in both/all cases NB all values of e must be within the range $0 < e < 1$ If their $e = 1$ (and no other values), allow conclusion that the collision is perfectly elastic.	If relying solely on a KE argument, this must include actual values for all their results in (a), e.g: Initial KE = 97 J Final KE = 27 J or 83 J KE is lost in the collision in both cases, so not perfectly elastic. FT from a).
				[1]			

Question			Answer	Marks	AO	Guidance	
5	(a)		$F = kd^\alpha m^\beta p^\gamma \dots$	B1	3.3		
			...where k is a (dimensionless) constant	B1	1.1	Accept omission of "dimensionless"	
			$[F] = \text{MLT}^{-2}$	M1	1.2		
			$[m] = \text{M}$, $[d] = \text{L}$ and $[p] = \text{F}$ so $\alpha = 1$, $\beta = 1$ and $\gamma = -2$ (so $F = kdm p^{-2}$ or $\frac{kdm}{p^2}$) isw	A1	3.4	If $F = (k)d^\alpha m^\beta p^\gamma$, given then no need for a final formula once the powers have all been correctly found.	If B0B0M1 then SCB1 for $F = dmp^{-2}$ oe. NB no mark if specific constant e.g. $4\pi^2$ is included.
				[4]			
	(b)		Because u can be expressed in terms of d and p (by $u = \frac{2\pi d}{p}$) (which <i>are</i> considered)	B1	2.4	Statements such as. " u can be derived from d and p " require further explanation, e.g. $u = \frac{2\pi d}{p}$, or mention of radius and time (without mention of dimensions).	Do not accept any argument based on dimensions (i.e. L and T), e.g. " $[u] = \text{LT}^{-1}$, but d and p already have L and T dimensions".
				[1]			
	(c)		Use of $a = \frac{u^2}{d}$	B1	1.1	Not just $\frac{v^2}{r}$	or $a = d\omega^2$
			$\text{NII} \Rightarrow F = ma = \frac{mu^2}{d}$	M1	1.1	Correct application of NII to their dimensionally correct a in terms of d , m and u or ω only.	$F = ma = md\omega^2$
			$u = \frac{2\pi d}{p} \Rightarrow F = \frac{m}{d} \left(\frac{2\pi d}{p} \right)^2 = \frac{4\pi^2 dm}{p^2}$	A1	1.1	Must be simplified. e.g. $md \left(\frac{2\pi}{p} \right)^2$ but not $\frac{md \left(\frac{2\pi}{p} \times d \right)^2}{d}$	$\omega = \frac{2\pi}{p} \Rightarrow F = md \left(\frac{2\pi}{p} \right)^2$ etc
				[3]			
	(d)		Dimensional analysis cannot give the value of constants in any formula	B1	3.5b		Do not allow anything that does not recognise the presence of an unknown constant e.g. "Does not include/account for constants"

				[1]			
Question			Answer	Marks	AO	Guidance	
6	(a)	(i)	$R = 2g\cos 15^\circ$	M1*	3.1b	Balancing forces in the perpendicular direction to find the normal contact force	18.932... Allow sin/cos confusion Allow use of m
			$Fr = 0.2 \times 2g\cos 15^\circ$	M1dep	1.1	Finding the (maximum) frictional force	3.7864...
			$a = (-2g\sin 15^\circ - 0.2 \times 2g\cos 15^\circ)/2$	M1*	1.1	Using $F = ma$ with a resolved component of the weight and their frictional force ($\neq 0.2$) acting in the same direction to find the acceleration.	$\pm 4.4296...$ NB $2g \sin 15^\circ = 5.07285 ...$ Condone missing g for this mark. Do not allow $Fr = 0.2$
			$s = 16.4 \times 3 + \frac{1}{2}(-4.4296...) \times 3^2$	M1dep	3.1b	Using <i>suvat</i> equation(s) to find the distance travelled Or final velocity = $16.4 + (-4.4296...) \times 3 = 3.1110...$	29.266... No need to confirm that v is non-zero in the period $0 < t < 3$ 3.111076215406
			WD by $Fr = -3.7864... \times 29.266...$	M1dep	1.1	Using “WD = Fd ”. Condone incorrect sign here. Or WD = Final KE – Initial KE + gain in GPE $= \frac{1}{2} \times 2 \times (3.1110...) ^2 - \frac{1}{2} \times 2 \times 16.4^2 + 2g \times (29.266...) \sin 15^\circ$ Or finding average velocity from initial and final velocity	-110.81... Dependent on previous two M marks NB resolving vertically and/or horizontally and assuming equilibrium in either direction scores 0 marks.
			Av Power = $-110.81.../3 = \text{awrt } -36.9 \text{ W}$	A1	1.1	Or multiplying average velocity by frictional force	Allow +36.9
				[6]			

	(a)	(ii)	The resistive force is reducing the energy of the body it is acting on	B1FT	2.2a	work is being done against friction or wtte. B0 if there is no appropriate working to justify their value in (i)	Previous answer needs to be negative but allow this mark if the modulus has been used after a negative result. “Power is being taken away”, “Shows the direction of the work done” are B0
				[1]			
	(b)		Initial energy = $\frac{1}{2} \times 2 \times 16.4^2$ J (= 268.96 J)	B1	1.1	Finding correct numerical expression for the initial KE	
			Final energy = $2gd\sin 15^\circ$ where d is the distance moved up the slope	M1	1.1	Finding correct expression for the final PE in terms of distance travelled (not just $2gh$ – mark then awarded on use of $\sin 15^\circ = h/d$).	NB 5.07d Allow sin/cos confusion
			$268.96 = 2gd\sin 15^\circ + 0.2 \times 2g\cos 15^\circ d$	M1	1.1	Using W-E principal to set up a three term equation (KE, PE and WD) in d or h . M0 if using $t = 3$.	Condone sign errors and sin/cos confusion but terms must be dimensionally correct. Could use incorrect Fr from (a)(i), but do not allow $Fr = 0.2$
			$d = 30.35911\dots$ awrt 30.4 (m)	A1	1.1		Use of <i>suvat</i> scores 0/4
				[4]			

Question			Answer	Marks	AO	Guidance	
7	(a)		Initial KE = $\frac{1}{2}m(5.6)^2$	B1	1.1	15.68m	
			Initial PE = $mg(12.6 - 12.6 \cos \alpha)$	B1	1.1	Correct form for PE with 12.6 substituted but $\cos \alpha$ can be left. 54.88m or 5.6mg	Calculation here assumes zero PE level is at lowest point of motion. If eg initial level chosen as zero PE level then this mark can be awarded on sight of correct PE (with correct sign) for general form relative to this level. Or could use O as the initial level
			Energy at $\theta = \frac{1}{2}mv^2 + mg(12.6 - 12.6 \cos \theta) = 15.68m + 54.88m (= 70.56m)$	M1*	1.1	Expression for KE + PE at general angle equated to initial energy. Zero PE level must be consistent. Condone missing 'g' for this mark	This could be expressed as "gain in KE = loss in PE" or similar but signs must be consistent/correct. 2 nd B mark could be awarded here for eg $mg(12.6 \cos \theta_0 - 12.6 \cos \theta)$ if initial PE = 0.
			$\therefore \frac{1}{2}m(8.4 \cos \theta)^2 + 12.6mg(1 - \cos \theta)$ $= 70.56m$ $\therefore 35.28 \cos^2 \theta + 123.48 - 123.48 \cos \theta$ $= 70.56$ $\therefore 35.28 \cos^2 \theta - 123.48 \cos \theta + 52.92 [= 0]$ NB $70.56x^2 - 246.96x + 105.84 = 0$	M1dep	3.1b	Substituting for v, cancelling m and reducing to 3 term quadratic equation in $\cos \theta$. Allow $8.4 \cos^2 \theta$ for M mark if recovered later $2\cos^2 \theta - 7\cos \theta + 3 = 0$ Allow one sign error and one other minor slip in the working, e.g. omission of g Allow omission of "= 0" provided recovery takes place	Or similarly substituting for $\cos \theta$. $\frac{1}{2}v^2 + g\left(12.6 - \frac{12.6v}{8.4}\right) = 70.56$ $v^2 + 246.96 - 29.4v = 141.12$ $v^2 - 29.4v + 105.84 = 0$ NB do not penalise candidates who substitute x for $\cos \theta$.

		$\cos\theta = '3'$ is not a valid solution since $(-1) \leq \cos\theta \leq 1$	B1dep	3.2a	Explicitly rejecting <i>their</i> unfeasible solution with a valid reason. $\cos^{-1}(3)$ has no solution since $(-1) \leq \cos\theta \leq 1$; θ is not real	$v = 25.2$ is not a valid solution since $(-8.4) \leq v \leq 8.4$ (or $0 \leq v \leq 8.4$) Condone strict inequalities NB max $v = 11.88$ (or $v \leq 11.88$) is also a valid argument (speed at the lowest point).
		$\cos\theta = \frac{1}{2} \Rightarrow v = 4.2$	A1	1.1	Must be only one solution.	$v = 4.2$
			[6]			
	(b)	PE at top = $mg \times 2 \times 12.6$	M1	3.1b	Finding expression for PE at top using same zero PE level as initial energy. $246.96m$ Allow omission of m throughout	If starting from second point (to the right of the vertical), $\Delta GPE = mg \times (1 + \cos\theta) \times 12.6 = 185.22m$ (if $\cos\theta = \frac{1}{2}$)
		Initial energy = $70.56m < 246.96m$ so P does not have enough energy to reach the top	A1FT	2.2a	Comparing their initial energy from part a) with required energy to reach the top. Could see a KE term ($= -176.4m$) which needs to be explained as non-negative.	Max height = $70.56/g = 7.2$ m and 7.2 m is less than 25.2 m so does not reach the top.
		Alternative method: $mg(12.6 - 12.6 \cos\theta) = 15.68m + 54.88m$	M1		Equating general KE to 0 and setting general PE to initial energy (using same zero PE level).	
		$\therefore \cos\theta = \frac{5.4}{12.6} = \frac{5.4}{12.6} = \frac{3}{7}$ $\therefore \theta = 64.6^\circ$ (1 dp) so P stops before it reaches the top.	A1		1.13 rads (3 sf). Or equivalent explanation.	
			[2]			

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