OCR
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AS Level Further Mathematics B (MEI)
Y411 Mechanics a
Sample Question Paper

Date – Morning/Afternoon
Time allowed: 1 hour 15 minutes

OCR supplied materials:
- Printed Answer Booklet
- Formulae Further Mathematics B (MEI)

You must have:
- Printed Answer Booklet
- Formulae Further Mathematics B (MEI)
- Scientific or graphical calculator

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes provided on the Printed Answer Booklet with your name, centre number and candidate number.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.**
- Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION
- The total number of marks for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is used. You should communicate your method with correct reasoning.
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

Answer **all** the questions

1 A clock is driven by a 5 kg sphere falling once through a vertical distance of 120 cm over 2 days.

Calculate, in watts, the average power developed by the falling sphere. **[4]**

2 A triangular lamina, ABC, is cut from a piece of thin uniform plane sheet metal. The dimensions of ABC are shown in Fig. 2.

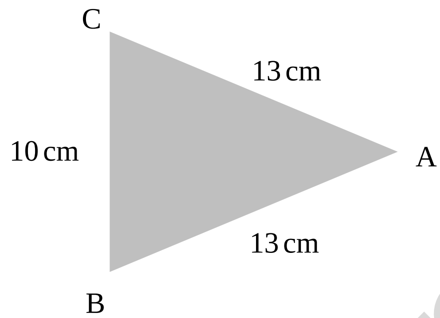

Fig. 2

This piece of metal is freely suspended from a string attached to C and hangs in equilibrium.

Calculate the angle of BC with the downward vertical, giving your answer in degrees. **[5]**

3 Solid toy aeroplane nose cones of various sizes are made in the shape shown in Fig. 3.1, where OA is its line of symmetry.

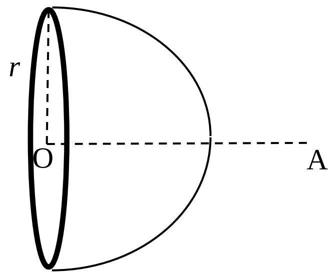

Fig. 3.1

The air resistance against the nose cone as the aeroplane flies through the air is initially modelled by $R = krv\eta$, where R is the air resistance, r is the radius of the circular flat end of the nose cone, v is the velocity of the nose cone, η is the viscosity of the air and k is a dimensionless constant.

(i) Use dimensional analysis to show that the dimensions of η are $\mathrm{ML}^{-1}\mathrm{T}^{-1}$. **[3]**

In an experiment conducted on a particular nose cone, measurements of air resistance are taken for different velocities. The viscosity of the air does not vary during the experiment. The graph in Fig. 3.2 shows the results. Measurements are given using the appropriate S.I. units.

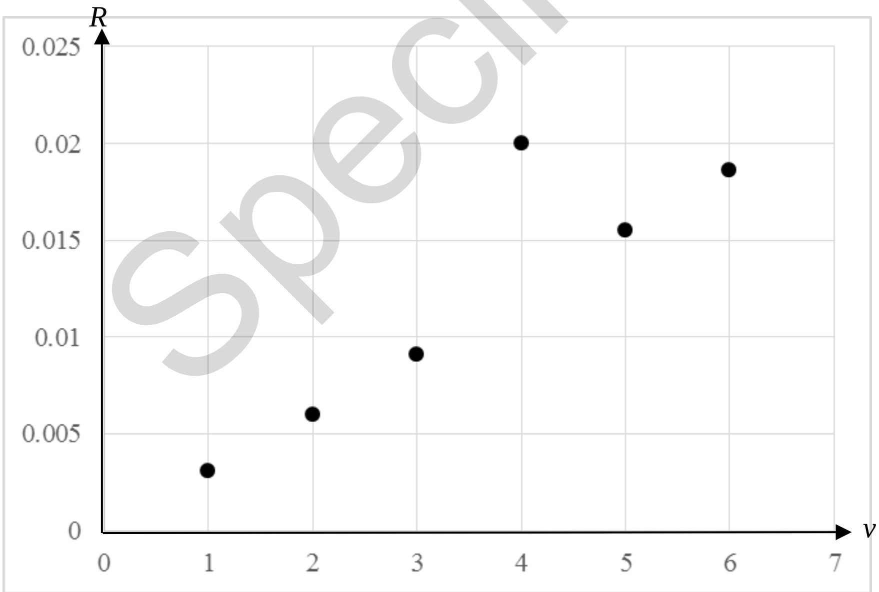

Fig. 3.2

(ii) Comment on whether the results of this experiment are consistent with the initial model. **[3]**

It is now suggested that a better model for the air resistance is $R = Krv\eta\left(\frac{\rho rv}{\eta}\right)^{\alpha}$, where ρ is the density of the air, K is a dimensionless constant and R, r, v and η are as before.

(iii) (*A*) Find the dimensions of $\frac{\rho rv}{\eta}$. **[2]**

(*B*) Explain why you cannot use dimensional analysis to find the value of α. **[1]**

4 Fig. 4 shows a thin rigid non-uniform rod PQ of length 0.5 m. End P rests on a rough circular peg. A force of T N acts at the end Q at 60° to QP. The weight of the rod is 40 N and its centre of mass is 0.3 m from P.

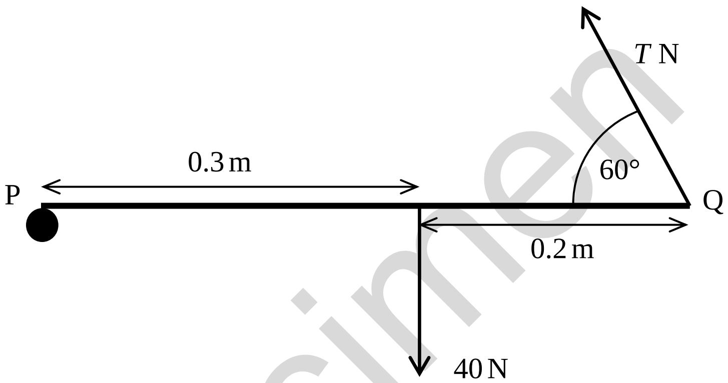

Fig. 4

The rod does not slip on the peg and is in equilibrium with PQ horizontal.

(i) Show that the vertical component of T is 24 N. **[2]**

(ii) F is the contact force at P between the rod and the peg.
Find

- the vertical component of F,
- the horizontal component of F. **[4]**

(iii) Given that the rod is about to slip on the peg, find the coefficient of friction between the rod and the peg. **[2]**

5 In this question, all coordinates refer to the axes shown in Fig. 5.1.

Fig. 5.1 shows a system of four particles with masses $4m$, $3m$, m and $2m$ at the points A, B, C and D. These points have coordinates (–3, 4), (0, 0), (2, 0) and (5, 4).

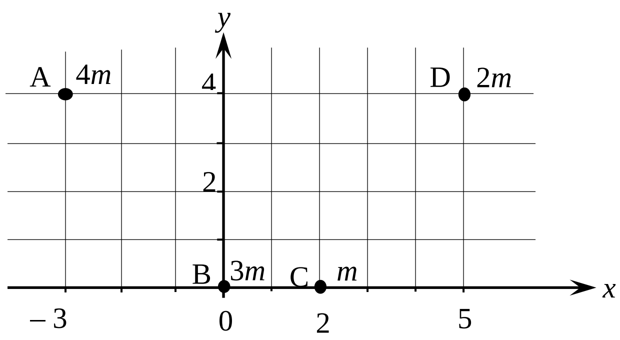

Fig. 5.1

(i) Calculate the coordinates of the centre of mass of the system of particles. **[4]**

A thin uniform rigid wire of mass $12m$ connects the points A, B, C and D with straight line sections, as shown in Fig. 5.2.

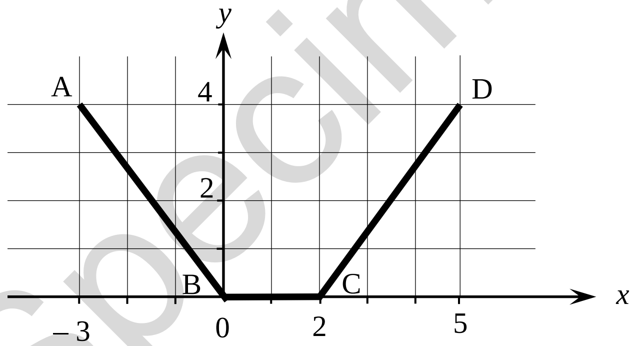

Fig. 5.2

(ii) Calculate the coordinates of the centre of mass of the wire. **[4]**

The particles at A, B, C and D are now fixed to the wire to form a rigid object, *R*.

(iii) Calculate the x-coordinate of the centre of mass of *R*. **[2]**

6 A sack of beans of mass 40 kg is pulled from rest at point A up a non-uniform slope onto and along a horizontal platform. Fig. 6 shows this slope AB and the platform BC, which is a vertical distance of 12 m above A.

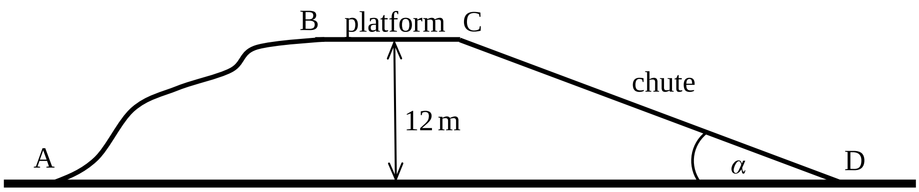

Fig. 6

(i) Calculate the gain in the gravitational potential energy of the sack when it is moved from A to the platform. **[1]**

The sack has a speed of $4\,\text{m}\,\text{s}^{-1}$ by the time it reaches C at the far end of the platform. The total work done against friction in moving the sack from A to C is 484 J. There are no other resistances to the sack's motion.

(ii) Calculate the total work done in moving the sack between the points A and C. **[3]**

At point C, travelling at $4\,\text{m}\,\text{s}^{-1}$, the sack starts to slide down a straight chute inclined at α to the horizontal. Point D at the bottom of the chute is at the same vertical height as A, as shown in Fig. 6. The chute is rough and the coefficient of friction between the chute and the sack is 0.6. During this part of the motion, again the only resistance to the motion of the sack is friction.

(iii) Use an energy method to calculate the value of α given that the sack is travelling at $3\,\text{m}\,\text{s}^{-1}$ when it reaches D. **[7]**

For safety reasons the sack needs to arrive at D with a speed of less than $3\ \text{m}\ \text{s}^{-1}$. The value of α can be adjusted to try to achieve this.

(iv) (*A*) Find the range of values of α which achieve a safe speed at D. **[1]**

(*B*) Comment on whether adjusting α is a practical way of achieving a safe speed at D. **[1]**

7 Rose and Steve collide while sitting firmly on trays that are sliding on smooth horizontal ice. There are no external driving forces. Fig. 7 shows the masses of Rose and of Steve with their trays, their velocities just before their collision and the line of their motion and of their impact.

Immediately after the collision, Rose has a velocity of $0.28\,\mathrm{m\,s^{-1}}$ in the direction of her motion before the collision.

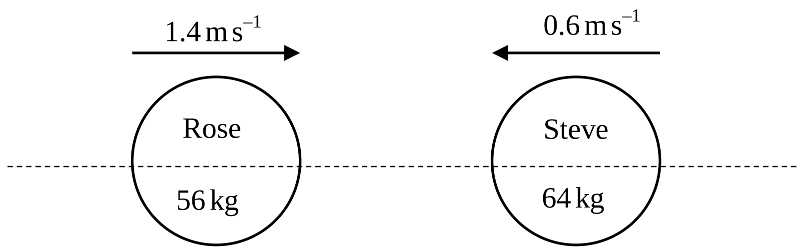

Fig. 7

(i) Find Steve's velocity after the collision. **[3]**

(ii) Find the coefficient of restitution between Rose and Steve on their trays. **[2]**

Shortly after the collision, Steve catches Rose's hand, pulls her towards him with a horizontal impulse of $4.48\,\mathrm{N\,s}$ and then lets go of her hand.

(iii) Calculate Rose's velocity after the pull. **[2]**

When they collide again they hold one another and move together with a common speed of $V\,\mathrm{m\,s^{-1}}$.

(iv) Calculate V. **[3]**

(v) Why did you need to know that there are no driving forces and that the ice is smooth? **[1]**

END OF QUESTION PAPER

OCR
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…day June 20XX – Morning/Afternoon

AS Level Further Mathematics B (MEI)

Y411 Mechanics a

SAMPLE MARK SCHEME

Duration: 1 hour 15 minutes

MAXIMUM MARK 60

This document consists of 12 pages

Text Instructions

1. Annotations and abbreviations

Annotation in scoris	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
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining a result or establishing a given result
U1	Mark for correct units
G1	Mark for a correct feature on a graph
dep*	Mark dependent on a previous mark, indicated by *
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 indicates that the instruction **In this question you must show detailed reasoning** appears in the question.

2. Subject-specific Marking Instructions for AS Level Further Mathematics B (MEI)

a Annotations should be used whenever appropriate during your marking. The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded. For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

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 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
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.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

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 Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.) 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. This rule should be applied to each case. When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination. There is no penalty for using a wrong value for g. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work: if a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests; if there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others. NB Follow these maths-specific instructions rather than those in the assessor handbook.

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 papers. This is achieved by withholding one A mark in the question. Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working. 'Fresh starts' will not affect an earlier decision about a misread. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). 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.

k Anything in the mark scheme which is in square brackets […] is not required for the mark to be earned on this occasion, but shows what a complete solution might look like.

Question			Answer	Marks	AOs	Guidance	
1			Power is $\frac{5\times 9.8\times 1.2}{2\times 24\times 3600}$ = 0.00034027…W	M1	1.2	Power is WD/time	
				B1	1.1a	WD is *mgh*	
				M1	3.4	Units put into SI	
			0.000 340 W (3 s.f.)	A1	1.1	Accept e.g. 341 μW (3 s.f.) Don't insist on W	
				[4]			
2			Suppose X is the midpoint of BC				
			XC = 5 and AX = 12	B1	3.1b	Finding length of the median	
			CoM, G, is on AX, so XG = 4 cm	M1	1.1	CoM $\frac{1}{3}$ along median from the base	
				A1	1.1	GX = 4	
			CG is vertical and required angle is GCX				
			= arctan($\frac{4}{5}$)	M1	2.1	soi	
			= 38.6598… so angle is 38.7° (3 s. f.)	A1	1.1		
				[5]			
3	(i)		$MLT^{-2} = L\times LT^{-1}\times[\eta]$	B1	1.1	Correct dimensions for *R* and one other	
				M1	1.1	Equating dimensions with $[\eta]$.	
			so $[\eta]=\frac{MLT^{-2}}{L^2T^{-1}}=ML^{-1}T^{-1}$ AG	E1	3.3	Clearly shown	
				[3]			

Question			Answer	Marks	AOs	Guidance	
3	(ii)		E.g. Most of the points seem to lie on a straight line, which passes through or near the origin.	B1	1.1	For discussing a possible linear model	This mark is for a comment about the experimental data suggesting a proportional relationship.
			either E.g. The result for $v = 4$ seems inconsistent with the others, perhaps some experimental error, so discard it.	E1	2.2b	For commenting on the experimental data	
			E.g. Model suggests a proportional relationship between R and v [with r and η fixed], so experiment [with one point discarded] is consistent with the model.	A1	3.5a	For a conclusion which is consistent with their comments on the experimental data.	A1 can only be awarded for claiming proportionality if the line was claimed to pass through the origin.
			or E.g. The result at $v = 4$ looks inconsistent with the others, so possibly the linear relationship is not correct.	E1			
			E.g. The experiment is not consistent with the model.	A1 [3]			
3	(iii)	(*A*)	$\left[\frac{\rho r v}{\eta}\right] = \frac{\text{ML}^{-3} \times \text{L} \times \text{LT}^{-1}}{\text{ML}^{-1}\text{T}^{-1}} = 1$	B1	1.1	Find the dimensions of the expression	
				B1 [2]	1.1	Dimensions of density	
3	(iii)	(*B*)	Dimensionless so raising to power α will not affect the dimensions of the term	E1 [1]	2.4	Could say $\text{M}^0\text{L}^0\text{T}^0$ instead of dimensionless.	
4	(i)		Let the vertical cpt be U N a.c. moments about P	M1	3.1b	Moments with only and all appropriate forces	
			$0.5U - 0.3 \times 40 = 0$ so $U = 24$	E1 [2]	1.1	Clearly shown	

Question			Answer	Marks	AOs	Guidance	
4	(ii)		Take cpts to be X N→ and Y N↑ Components ↑ $Y + 24 - 40 = 0$ so $Y = 16$ Components → $X - T\cos 60 = 0$ From (i) $T\sin 60 = 24$ So $X = 24\frac{\cos 60}{\sin 60} = 8\sqrt{3}$	 **B1** **B1** **M1** **A1** **[4]**	 3.4 1.1 1.1a 1.1	 cao cao FT **their** result BC	 Accept 13.9 or 13.86
4	(iii)		As on the point of slipping, $F = F_{max} = \mu R$ So $\mu = \frac{8\sqrt{3}}{16} = \frac{\sqrt{3}}{2}$	**M1** **A1** **[2]**	2.2a 1.1	Using $F_{max} = \mu R$ and substituting their X and Y BC FT their **(ii)**	 Accept 0.866 or 0.8660
5	(i)		$10m\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 4m\begin{pmatrix}-3\\4\end{pmatrix} + 3m\begin{pmatrix}0\\0\end{pmatrix} + m\begin{pmatrix}2\\0\end{pmatrix} + 2m\begin{pmatrix}5\\4\end{pmatrix}$ $\bar{x} = 0$ $\bar{y} = 2.4$	**M1** **A1** **A1** **A1** **[4]**	1.1 1.1 1.1 1.1	Any correct method for at least 1 cpt Allow 1 error including its consequences	
5	(ii)		By symmetry, $\bar{x} = 1$ $12m\bar{y} = 5m \times 2 + 2m \times 0 + 5m \times 2$ $\bar{y} = \frac{5}{3}$	**B1** **M1** **B1** **A1** **[4]**	2.4 3.3 1.1a 1.1	May be established from 1st principles. Correct method using mid-points Masses in the correct ratio	

Question			Answer	Marks	AOs	Guidance	
5	(iii)		$(10m+12m)\bar{x}=10m(0)+12m(1)$	M1	3.1b	Method for combining (accept start again)	
			$\bar{x}=\frac{6}{11}$ (0.5454…)	A1 [2]	1.1	FT their **(i)**, **(ii)**	
6	(i)		Change in GPE is 40 × 9.8 × 12 = 4704 J	B1 [1]	1.1	4 s.f. not required	
6	(ii)		$4704+\frac{1}{2}\times 40\times 4^2$ + 484	M1	3.3	Use of GPE and KE and WD. Accept wrong sign	
				B1	1.1	KE term correct	
			= 5508 J	A1 [3]	1.1	FT only from (i). 4 s.f. not required	
6	(iii)		Distance travelled is $\frac{12}{\sin\alpha}$	B1	1.1		
			Frictional force is $0.6\times 40g\cos\alpha$	M1	3.4	Use of $F=\mu R$	
				B1	1.1	Value of R	
			Using the WE equation	M1	1.1	All terms present. Allow sign errors	
			$\frac{1}{2}\times 40\times 3^2-\frac{1}{2}\times 40\times 4^2=4704-0.6\times 40g\cos\alpha\times\frac{12}{\sin\alpha}$	B1	3.4	KE terms. Allow sign errors	
				B1	1.1	Friction term. Allow sign errors	
			$\tan\alpha=0.5826589...$ so α = 30.227599… so 30.2° (3 s.f.)	A1 [7]	1.1	FT only from **(i)** Must show ° or rad (0.52757…)	

Question			Answer	Marks	AOs	Guidance	
6	(iv)	(*A*)	For speed 0 at D, $\alpha = 29.3°$ $29.3° < \alpha < 30.2°$.	**B1** **[1]**	**3.4**		
6	(iv)	(*B*)	Not practical to keep angle within such small margins.	**B1** **[1]**	**3.5a**		
7	(i)		In whole question take +ve → Suppose Steve's final speed is v_s m s^{-1} PCLM $56 \times 1.4 - 64 \times 0.6 = 56 \times 0.28 + 64 v_s$ so $v_s = 0.38$ in Rose's original direction	**M1** **A1** **A1** **[3]**	**3.3** **3.4** **1.1**	+ve could be either way Use of PCLM. Allow sign errors. Accept implied (e.g. by a diagram)	
7	(ii)		Using NEL $\frac{0.38 - 0.28}{-0.6 - 1.4} = -e$ so e = 0.05	**M1** **A1** **[2]**	**3.4** **1.1**	Must be right way up. FT. Accept sign errors. FT only from (i)	
7	(iii)		Suppose R's final speed is U → $4.48 + 56 \times 0.28 = 56\,U$ so $U = 0.36$ m s^{-1}	**M1** **A1** **[2]**	**3.4** **1.1**	Use of PCLM cao Direction stated or clear (e.g. from a diagram)	

Question			Answer	Marks	AOs	Guidance	
7	(iv)		Let final speed be $V \rightarrow$ **either** LM is conserved in all the interactions so $56 \times 1.4 - 64 \times 0.6 = (56 + 64)V$ so $V = \frac{1}{3}$	 **M1** **A1** **A1**	 **3.1b** **1.1** **1.1**	 Using PCLM Allow only sign errors cao (Accept e.g. 0.333 to 3 s. f.)	
			or Use momentums after 1st collision or after hand pulling $(56 + 64)V = 56 \times 0.28 + 64 \times 0.38$ or $(56 + 64)V = 56 \times 0.36 + 64 \times 0.31$ so $V = \frac{1}{3}$	 **M1** **A1** **A1** **[3]**		 If after hand pulling, must have attempted Steve's speed (0.31) Either form. Allow only sign errors. cao	
7	(v)		So that linear momentum is conserved (after the first collision)	**B1** **[1]**	**3.5b**		

Question	AO1	AO2	AO3(PS)	AO3(M)	Total
1	3	0	0	1	4
2	3	1	1	0	5
3i	2	0	0	1	3
3ii	1	1	0	1	3
3iiiA	2	0	0	0	2
3iiiB	0	1	0	0	1
4i	1	0	1	0	2
4ii	3	0	0	1	4
4iii	1	1	0	0	2
5i	4	0	0	0	4
5ii	2	1	0	1	4
5iii	1	0	1	0	2
6i	1	0	0	0	1
6ii	2	0	0	1	3
6iii	5	0	0	2	7
6ivA	0	0	0	1	1
6ivB	0	0	0	1	1
7i	1	0	0	2	3
7ii	1	0	0	1	2
7iii	1	0	0	1	2
7iv	2	0	1	0	3
7v	0	0	0	1	1
Totals	36	5	4	15	60

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AS Level Further Mathematics B (MEI)

Y411 Mechanics a

Printed Answer Booklet

Date – Morning/Afternoon

Time allowed: 1 hour 15 minutes

OCR supplied materials:
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You must have:
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- Scientific or graphical calculator

First name	
Last name	

Centre number						**Candidate number**				

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- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION

- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is used. You should communicate your method with correct reasoning.
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

1	
2	

3 (i)	
3 (ii)	

3 (iii) (*A*)	
3 (iii) (*B*)	
4 (i)	

4 (ii)	
4 (iii)	

5 (i)	
5 (ii)	

5 (iii)	

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6 (i)	
6 (ii)	
6 (iii)	
	(answer space continues on next page)

6 (iii)	**(continued)**
6 (iv) (*A*)	
6 (iv) (*B*)	

7 (i)	
7 (ii)	

7 (iii)	
7 (iv)	
7 (v)	

DO NOT WRITE IN THIS SPACE