OCR
Oxford Cambridge and RSA

Wednesday 18 May 2016 – Morning

A2 GCE MATHEMATICS (MEI)

4762/01 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4762/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

6365395658

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- 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 $g\,\text{m}\,\text{s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- 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 being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

1 **(a)** Two model railway trucks are moving freely on a straight horizontal track when they are in a direct collision.

The trucks are P of mass 0.5 kg and Q of mass 0.75 kg. They are initially travelling in the same direction. Just before they collide P has a speed of $4\,\mathrm{m\,s^{-1}}$ and Q has a speed of $1\,\mathrm{m\,s^{-1}}$, as shown in Fig. 1.1.

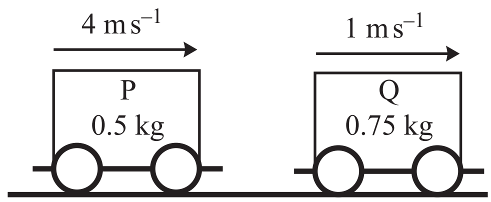

Fig. 1.1

(i) Suppose that the speed of P is halved in the collision and that its direction of motion is not changed. Find the speed of Q immediately after the collision and find the coefficient of restitution. **[5]**

(ii) Show that it is not possible for both the speed of P to be halved in the collision and its direction of motion to be reversed. **[3]**

Both of the model trucks have flat horizontal tops. They are each travelling at the speeds they had immediately after the collision.

Part of the mass of Q is a small object of mass 0.1 kg at rest at the edge of the top of Q nearest P. The object falls off, initially with negligible velocity relative to Q.

(iii) Determine the speed of Q immediately after the object falls off it, making your reasoning clear. **[2]**

Part of the mass of P is an object of mass 0.05 kg that is fired horizontally from the top of P, parallel to and in the opposite direction to the motion of P. Immediately after the object is fired, it has a speed of $10\,\mathrm{m\,s^{-1}}$ relative to P.

(iv) Determine the speed of P immediately after the object has been fired from it. **[4]**

(b) The velocities of a small object immediately before and after an elastic collision with a horizontal plane are shown in Fig. 1.2.

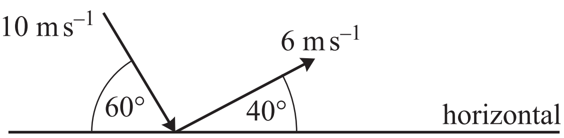

Fig. 1.2

Show that the plane cannot be smooth. **[3]**

2 **(a)** A bullet of mass 0.04 kg is fired into a fixed uniform rectangular block along a line through the centres of opposite parallel faces, as shown in Fig. 2.1.

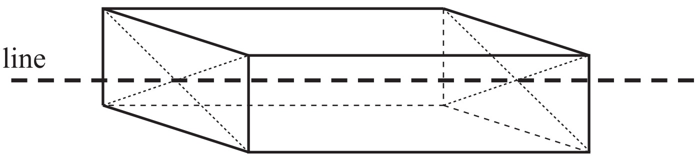

Fig. 2.1

The bullet enters the block at $50\,\mathrm{m\,s^{-1}}$ and comes to rest after travelling 0.2 m into the block.

(i) Calculate the resistive force on the bullet, assuming that this force is constant. **[3]**

Another bullet of the same mass is fired, as before, with the same speed into a similar block of mass 3.96 kg. The block is initially at rest and is free to slide on a smooth horizontal plane.

(ii) By considering linear momentum, find the speed of the block with the bullet embedded in it and at rest relative to the block. **[2]**

(iii) By considering mechanical energy, find the distance the bullet penetrates the block, given the resistance of the block to the motion of the bullet is the same as in part **(i)**. **[4]**

(b) Fig. 2.2 shows a block of mass 6 kg on a uniformly rough plane that is inclined at 30° to the horizontal.

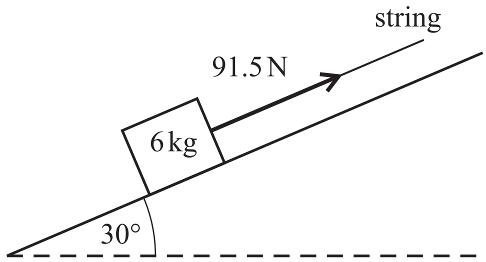

Fig. 2.2

A string with a constant tension of 91.5 N parallel to the plane pulls the block up a line of greatest slope. The speed of the block increases from $1\,\mathrm{m\,s^{-1}}$ to $7\,\mathrm{m\,s^{-1}}$ over a distance of 8 m.

(i) Use an energy method to find the magnitude of the frictional force acting on the block.

Calculate the coefficient of friction between the block and the plane. **[8]**

(ii) Calculate the power of the tension in the string when the block has a speed of $7\,\mathrm{m\,s^{-1}}$. **[2]**

3 Fig. 3.1 shows a thin planar uniform rigid rectangular sheet of metal, OPQR, of width 1.65 m and height 1.2 m. The mass of the sheet is M kg. The sides OP and PQ have thin rigid uniform reinforcements attached with masses $0.6M$ kg and $0.4M$ kg, respectively. Fig. 3.1 also shows coordinate axes with origin at O.

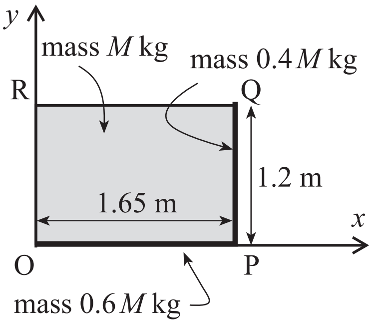

Fig. 3.1

The sheet with its reinforcements is to be used as an inn sign.

(i) Calculate the coordinates of the centre of mass of the inn sign. **[4]**

The inn sign has a weight of 300 N. It hangs in equilibrium with QR horizontal when vertical forces Y_Q N and Y_R N act at Q and R respectively.

(ii) Calculate the value of Y_Q and show that $Y_R = 120$. **[3]**

The inn sign is hung from a framework, ABCD, by means of two light vertical inextensible wires attached to the sign at Q and R and the framework at B and C, as shown in Fig. 3.2. QR and BC are horizontal. The framework is made from light rigid rods AB, BC, CA and CD freely pin-jointed together at A, B and C and to a vertical wall at A and D. Fig. 3.3 shows the dimensions of the framework in metres as well as the external forces X_A N, Y_A N acting at A and X_D N, Y_D N acting at D.

You are given that $\sin\alpha = \frac{5}{13}$, $\cos\alpha = \frac{12}{13}$, $\sin\beta = \frac{4}{5}$ and $\cos\beta = \frac{3}{5}$.

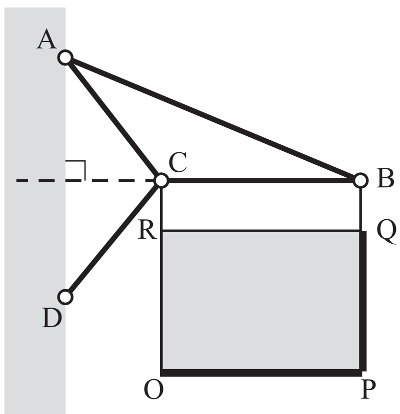

Fig. 3.2

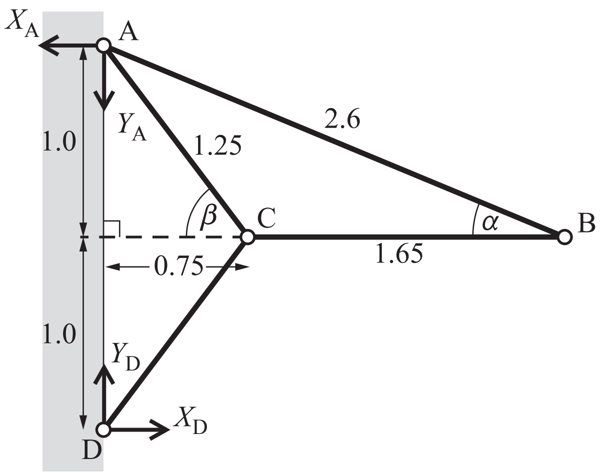

Fig. 3.3

(iii) Mark on the diagram in your Printed Answer Book all the forces acting on the pin-joints at A, B, C and D, including those internal to the rods, when the inn sign is hanging from the framework. **[1]**

(iv) Show that $X_D = 261$. **[2]**

(v) Calculate the forces internal to the rods AB, BC and CD, stating whether each rod is in tension or thrust (compression). Calculate also the values of Y_D and Y_A. [Your working in this part should correspond to your diagram in part **(iii)**.] **[8]**

4 Fig. 4.1 shows a hollow circular cylinder open at one end and closed at the other. The radius of the cylinder is 0.1 m and its height is h m. O and C are points on the axis of symmetry at the centres of the open and closed ends, respectively. The thin material used for the closed end has four times the density of the thin material used for the curved surface.

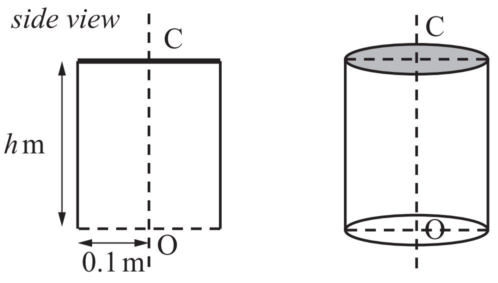

Fig. 4.1

Cylinders of this type are made with different values of h.

(i) Show that the centres of mass of these cylinders are on the line OC at a distance $\frac{5h^2+2h}{2+10h}$ m from O. **[6]**

Fig. 4.2 shows one of the cylinders placed with its open end on a slope inclined at an angle α to the horizontal, where $\tan\alpha = \frac{2}{3}$. The cylinder does not slip but is on the point of tipping.

(ii) Show that $50h^2 + 5h - 3 = 0$ and hence that $h = 0.2$. **[7]**

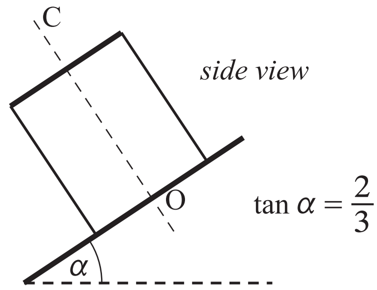

Fig. 4.2

Fig. 4.3 shows another of the cylinders that has weight 42 N and $h = 0.5$. This cylinder has its open end on a rough horizontal plane. A force of magnitude T N is applied to a point P on the circumference of the closed end. This force is at an angle β with the horizontal such that $\tan\beta = \frac{3}{4}$ and the force is in the vertical plane containing O, C and P. The cylinder does not slip but is on the point of tipping.

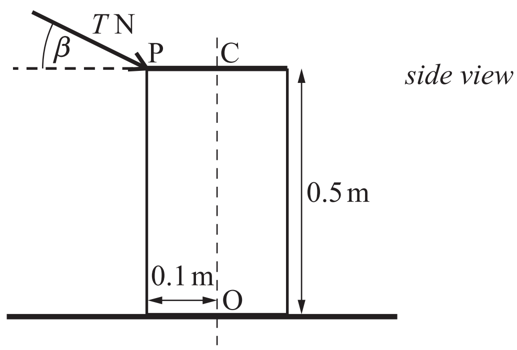

Fig. 4.3

(iii) Calculate T. **[5]**

END OF QUESTION PAPER

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A2 GCE MATHEMATICS (MEI)

4762/01 Mechanics 2

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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1 (a)(i)	

1 (a)(ii)	
1 (a)(iii)	

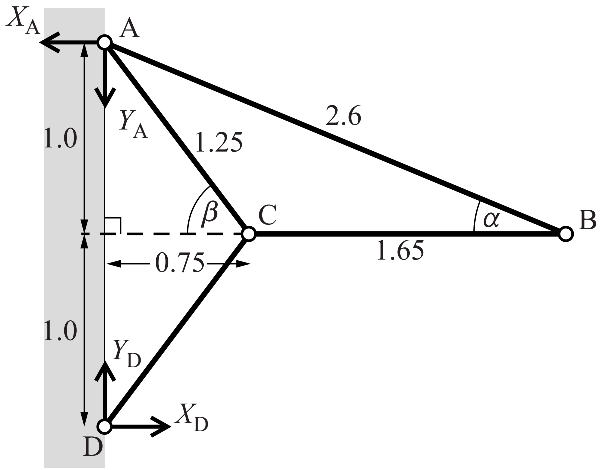
1 (a)(iv)	
1 (b)	

2 (a)(i)	
2 (a)(ii)	

2 (a)(iii)	

2 (b)(i)	
2 (b)(ii)	

3 (i)	
3 (ii)	

3 (iii)	**A spare copy of this diagram can be found on page 16** 
3 (iv)	

3 (v)

(answer space continued on next page)

3 (v)	(continued)
	(answer space continued on next page)

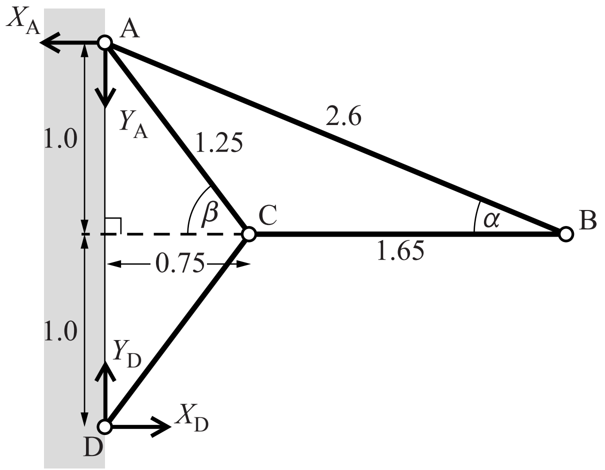
3 (v)	**(continued)**

4 (i)	

4 (ii)

4 (iii)	

3 (iii)	**Spare copy of diagram for question 3 (iii)**



OCR
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GCE

Mathematics (MEI)

Unit **4762**: Mechanics 2

Advanced GCE

Mark Scheme for June 2016

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
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method 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

Subject-specific Marking Instructions for GCE Mathematics (MEI) Mechanics strand

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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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, eg 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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 and we do not penalise over-specification.

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.

ft should be used so that only one mark is lost for each distinct error made in the accuracy to which working is done or an answer given. Refer cases to your Team Leader where the same type of error (e.g. errors due to premature approximation leading to error) has been made in different questions or parts of questions.

There are some mistakes that might be repeated throughout a paper. If a candidate makes such a mistake, (eg uses a calculator in wrong angle mode) then you will need to check the candidate's script for repetitions of the mistake and consult your Team Leader about what penalty should be given.

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 units. 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.

Question			Answer	Marks	Guidance
1	(a)	(i)	Take + ve → PCLM $0.5\times4+0.75\times1=0.5\times2+0.75\times v_Q$	M1 A1	Application of PCLM. Allow sign errors Correct. Any form
			so $v_Q=\frac{7}{3}$	A1	Exact or anything that rounds to 2.33 or better
			NEL $\frac{\frac{7}{3}-2}{1-4}=-e$	M1	NEL. Accept sign errors but not approach/separation
			so $e=\frac{1}{9}$ (or 0.11)	A1ft **[5]**	ft their v_Q
		(ii)	Suppose direction reversed. Given LM conserved $0.5\times4+0.75\times1=-0.5\times2+0.75\times v_Q$ so $v_Q=5$	B1	Award for the correct LM equation
			NEL gives $\frac{5+2}{1-4}=-e$ so $e=\frac{7}{3}$	M1	Using their re-calculated v_Q (not equal to 7/3 from (i))
			e > 1 so not an elastic collision	E1 **[3]**	www
			OR for last two marks: KE after collision = 10.375, before collision = 4.375:	M1	
			Increase in energy not possible, because no work put into system	E1	

Question			Answer	Marks	Guidance	
		(iii)	No (external horizontal) force acts on the truck so no change in momentum of truck (less object) (So no change in velocity. Still) $\frac{7}{3}$ m s^{-1}.	B1 B1 **[2]**	Force or momentum considered or correct momentum equation FT their value from (i): seen	
		(iv)	Before 0.5 kg at 2 m s^{-1} $\rightarrow$ After 0.05 kg at U m s^{-1} $\leftarrow$ and 0.45 kg at V m s^{-1} $\rightarrow$ PCLM $0.5\times 2 = -0.05\times U + 0.45\times V$ $U + V = 10$ Solving, $V = 3$ so 3 m s^{-1}	 M1 M1 B1 A1 **[4]**	 Allow if $(10-2) = 8$ used instead of U Allow only sign errors oe: relative velocity used correctly cao SC1 Using $U = 10$, giving $V = 10/3$	
	(b)		Consider the LM parallel to the plane Before: $m\times 10\cos 60 = 5m$ After: $m\times 6\cos 40 \approx 4.6\text{m}$ Not the same. (LM not conserved.) Plane cannot be smooth.	M1 A1 E1 **[3]**	Accept considering the horizontal components of velocity before and after o.e. and arguing/stating they should be the same Need not include *m*. Using sine gets 0/3 Accept arguments from velocity	

Question			Answer	Marks	Guidance	
2	(a)	(i)	WD against resistance = KE lost	M1		
			$\frac{1}{2}\times 0.04\times 50^2 = 0.2F$	A1		
			so F = 250 and resistive force is 250 N	A1	Accept -250	
			OR:			
			Use *suvat*: $v^2 = u^2 + 2as$: $a = -\frac{2500}{0.4}$ $a = -\frac{2500}{0.4}$	M1	Complete method: *suvat* and N2L	
			Use N2L: F = 0.04 $\times a$ = - 250 $F = 0.04 \times a = -250$	A1	Correct a	
			Resistive force = 250 N	A1	Correct F	
				[3]		
		(ii)	PCLM			
			$0.04\times 50 = (3.96+0.04)V$	M1		
			so V = 0.5 so 0.5 m s^{-1}	A1	cao	
				[2]		
		(iii)	Energy lost is			
			$\frac{1}{2}\times 0.04\times 50^2 - \frac{1}{2}\times 4\times 0.5^2$	M1	Correct masses	
			= 49.5 J	A1ft	ft their 0.5 from (ii). May be implied	
			equating WD against resistance to energy lost			
			$250x = 49.5$	M1	ft their 250 x = a difference in non-zero KEs	
			so x = 0.198 and distance is 0.198 m	A1	cao	
				[4]		

Question			Answer	Marks	Guidance	
	(b)	(i)	Using W-E equation. Friction is F N			
			$\frac{1}{2}\times 6\times\left(7^2-1^2\right)=\left(91.5-F-6g\sin 30\right)\times 8$	M1	o.e. All 5 terms present, no extras. Allow sign errors	
				B1	KE terms (both)	
				B1	Resolved weight or GPE term	
				M1	WD is Force × distance	
			so $F = 44.1$	A1	cao	
			(As slipping) $F=\mu R$	M1	Used	
			$R=6g\cos 30^\circ=6g\times\frac{\sqrt{3}}{2}$	B1	Does not need to be evaluated	
			so $\mu=\frac{44.1}{3g\times\sqrt{3}}=\frac{1.5}{\sqrt{3}}=\frac{\sqrt{3}}{2}$ (0.8660…)	A1	cao Any form. 0.87 or better	
				[8]	Using suvat and N2L: Max possible is B1 for resolved weight, then last 3 marks. Award SC(4) if N2L and suvat used, and μ correct, www	
		(ii)	Power is $T\times v$	M1		
			so $91.5\times 7 = 640.5$ W	A1	cao accept 640 or 641. Must be their final answer	
				[2]		

Question			Answer	Marks	Guidance	
3		(i)	$2M\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = M\begin{pmatrix}0.825\\ 0.6\end{pmatrix} + 0.6M\begin{pmatrix}0.825\\ 0\end{pmatrix} + 0.4M\begin{pmatrix}1.65\\ 0.6\end{pmatrix}$	M1 A1	Complete method At least 2 RHS vector terms or 3 component terms correct	
			$\bar{x} = 0.99$ $\bar{y} = 0.42$	A1 A1 **[4]**		
		(ii)	c.w moments about R $300 \times 0.99 - 1.65 \times Y_Q = 0$ so $Y_Q = 180$ $Y_Q + Y_R = 300$ so $Y_R = 120$	M1 A1 E1 **[3]**	Or moments about Q to find Y_R Must be established not using given Y_R AG	
		(iii)	Mark in 120 N and 180 N and all internal forces	B1 **[1]**	Accept labelled internal forces marked as T or C	
		(iv)	c.w moments about A $120 \times 0.75 + 180 \times 2.4 - 2 \times X_D = 0$ Or $300 \times (0.99 + 0.75) - 2 \times X_D = 0$ so $X_D = 261$	M1 E1 **[2]**	Appropriate moments considered Convincingly shown	

Question			Answer	Marks	Guidance	
		(v)	At B		This solution takes all internal forces +ve when T(ensions)	
			$\uparrow\ T_{AB}\sin\alpha - 180 = 0$	M1	Equilibrium at a pin-joint to find one of required forces (all relevant forces)	
			so $T_{AB} = 180\times\frac{13}{5} = 468$ so force in AB is 468 N (T)	A1	Do not need T/C here	
			$\leftarrow\ T_{BC} + T_{AB}\cos\alpha = 0$	M1	2nd equilibrium at the same or another pin-joint to find another required force (all relevant forces)	
			so $T_{BC} = -468\times\frac{12}{13} = -432$ so force in BC is 432 N (C)	F1	FT their values. Do not need T/C here	
			At D $\rightarrow\ T_{DC}\cos\beta + X_D = 0$	M1	3rd equilibrium at a pin-joint (complete method to find third required force)	
			so $T_{DC} = -261\times\frac{5}{3} = -435$ so force in DC is 435 N (C)	F1	FT their values and all T/C correct	
			$\uparrow\ Y_D + T_{DC}\sin\beta = 0$			
			so $Y_D = 435\times\frac{4}{5} = 348$ so 348 N	B1	cao for the first of Y_D or Y_A found	
			$Y_D - Y_A = 300$ so $Y_A = 48$ so 48 N	B1 **[8]**	ft for the second of Y_D or Y_A: difference = 300	

Question			Answer	Marks	Guidance
4		(i)	Let centre of mass be at G		
			G is on CO by symmetry	B1	
			Let CG = Y and curved surface density be σ		Accept σ taken to be 1 without comment. o. e.
			$\left(\pi(0.1)^2 \times 4\sigma + 2\pi \times 0.1 \times h \times \sigma\right)Y = \pi(0.1)^2 \times 4\sigma \times h + 2\pi \times 0.1 \times h \times \sigma \times \frac{h}{2}$	M1	Complete method
				B1	'masses' in correct ratios: 0.04: 0.2h
				B1	Correct use of 'h' and 'h/2'
				A1	All correct
			so $Y = \frac{(5h^2 + 2h)}{2 + 10h}$	E1	Convincingly shown
				[6]	
		(ii)	Let the lowest point of contact of the cylinder with the plane be A		
			On point of tipping G is vertically above A	B1	May be shown on a diagram
			Angle AGO is α	B1	May be shown on a diagram can be implied by subsequent work
			$\tan\alpha = \frac{0.1}{Y} = \frac{2}{3}$	M1	Allow reciprocal of RHS
			so $0.3 = 2 \times \frac{(2h + 5h^2)}{2 + 10h}$	A1	
			so $50h^2 + 5h - 3 = 0$ **AG**	A1	cwo and convincingly shown
			Either		
			$(5h - 1)(10h + 3) = 0$	M1	Clear evidence of 2 roots
			(only positive root is) h = 0.2.	E1	No need to comment on the negative root
			or		
			$50 \times (0.2)^2 + 5 \times 0.2 - 3 = 2 + 1 - 3 = 0$	B1	
			And this is the only positive root	E1	Need statement but no need to show this.
				[7]	

Question			Answer	Marks	Guidance
		(iii)	($\sin\beta$ =0.6; $\cos\beta$ =0.8) c.w. moments about 'furthest' point of the base (through which acts the NR)	M1	Both forces present in a moments equation
			$T\cos\beta\times0.5-T\sin\beta\times0.2-42\times0.1=0$	M1	Attempt to find moment of force of magnitude T in horizontal and vertical components oe
				A1	Correct distances oe
				A1	Correct equation, numerical values of cos/sin do not need to be substituted
			(so $T\left(0.4-0.12\right)=4.2$)		
			so T = 15	A1 **[5]**	cao

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4762 Mechanics 2

General Comments:

The standard of the solutions presented by candidates was pleasing. Most candidates were able to make a reasonable attempt at most parts of the paper. There was some evidence that candidates felt rushed towards the end of the paper.

As always, candidates should draw clear and labelled diagrams and these are always appropriate when dealing with forces or velocities. A lot of potentially very good work was marred by sign errors that, perhaps, could have been avoided by having a clear diagram.

Comments on Individual Questions:

Question No. 1

Momentum and Impulse

Candidates showed that they were able to write down equations using the principle of conservation of linear momentum and Newton's experimental law, but these equations were often inaccurate in the detail. This appeared to be due to a lack of understanding of some of the situations described in the question.

(a)(i) Most candidates scored full marks.

(ii) The best approach was to find the resulting speed of Q in this new situation and show that it led to an invalid value for the coefficient of restitution. A significant number of candidates did not realise that this part of the question had to refer to a different situation to that in part **(i)**. As a consequence, they carried forward the values of the coefficient of restitution and the speed of Q found in part **(i)**.

(iii) There were some good, well-reasoned answers to this part, leading to the conclusion that the speed of Q was unchanged and equal to the value found in part **(i)**. A common error was to attempt to find a new value for the speed of Q. Other candidates realised that the speed of Q was unchanged but were not able to support their realisation with a convincing argument involving the absence of an external force or conservation of momentum for the truck.

(iv) Only a minority of candidates earned more than a single mark. Most candidates did not appreciate the significance of the fact that the speed of the object was given *relative* to P. This relative speed was often used as the actual speed.

(b) The majority of candidates considered the horizontal components of the velocity before and after impact and concluded that since these components were not equal, the plane could not be smooth. A common error was to interpret an elastic collision as one in which the coefficient of restitution must be equal to one. This led them to compare the vertical components of the velocity before and after impact.

Question No. 2

Work, Energy and Power

As is often the case in problems on the topic of work and energy, an alternative method of solution using Newton's second law and *suvat* equations is available. In parts of the question where no method is specified, either approach is acceptable, but when there is an instruction to use a method involving a particular part of the specification such as "use an energy method" candidates should follow the instruction.

(a)(i) Almost all candidates scored full marks.

(ii) Most candidates used linear momentum to find the speed of the block. Some candidates did not include the mass of the bullet, using 3.96 kg instead of 4 kg as the final mass.

(iii) The majority of candidates followed the instruction to consider mechanical energy, and equated a loss in kinetic energy to a work done against the resistance. A common error was to use incorrect masses in the kinetic energy terms, neglecting to include the mass of the bullet embedded in the block.

(b)(i) Most candidates used an energy method, as instructed, but a significant minority of candidates used Newton's second law and *suvat* equations. The energy equation required 5 terms: two kinetic energy terms; a gravitational potential energy term; two work done terms, one involving the tension and the other involving the frictional force. The common errors were

- omitting the work done by the tension
- including the weight component term twice, once as a work done term and once as a gravitational potential energy term
- omitting one of the kinetic energy terms
- using forces instead of work done terms in an energy equation.

(ii) Most candidates multiplied their frictional force from part (b)(i) by the given speed and gained both marks.

Question No. 3

Forces and Equilibrium

Candidates appeared to be confident with the content of this question and there were many very good, well-presented solutions.

(i) Almost all candidates produced clear and concise moments equations followed by accurate working to give the coordinates of the centre of mass of the inn sign.

(ii) Again, almost all candidates scored full marks.

(iii) The single mark available in this part required the labelling of the internal forces to all of the rods and the external forces at B and C. The internal force in each rod should be marked with a pair of arrows and a label such as T_{AB}. This would help candidates to produce accurate equations when evaluating the magnitudes of the forces.

(iv) Most candidates took moments about A and used the results from part (ii) to find X_D.

(v) There were many fully correct solutions to this part. The clear and logical presentation of most of these solutions was very pleasing and demonstrated an ability to work out a strategy before embarking on writing down equations. A minority of candidates resolved horizontally and vertically at A, B, C and D and then faltered in trying to evaluate the forces that were required. Apart from numerical and sign errors, the most common errors were to assume that, because triangle ACD is isosceles, $Y_A = Y_D$ and the internal force in AC = the internal force in CD.

Question No. 4

Centre of mass

There were many pleasing responses to this question, with good diagrams and logically presented work. When a given answer has to be shown, it is important to remember that clear explanations are required. The majority of candidates produced moments equations that were dimensionally correct, but a minority of candidates omitted the distance part of at least one of the terms in their equations.

(i) Most candidates knew the method of approach to use, but there were two common errors:

- the ratio of the densities of the two materials was reversed or ignored
- the formula used for the surface area of the cylinder was incorrect.

Many candidates did not address the fact that they needed to show that the centre of mass of the cylinder was on OC. A simple statement that this was true by symmetry was sufficient.

(ii) Candidates who drew a clear diagram usually gained full marks in this part. The significant number of candidates who did not draw a diagram often had the expression for tan α upside down.

(iii) Almost all candidates attempted to take moments about an appropriate point. Most candidates attempted to resolve T into two components. A very common error was to consider only one of the components of the force T. Some candidates worked with T and attempted to find the perpendicular distance from the tipping point to the line of action of T. This was rarely accomplished successfully.

Oxford Cambridge and RSA

GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	47	42	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	55	49	44	39	33	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0

	UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

Level 3 Certificate Mathematics for Engineering

			Max Mark	a*	a	b	c	d	e	u
H860	01 Mathematics for Engineering		This unit has no entries in June 2016							
H860	02 Mathematics for Engineering									

Level 3 Certificate Mathematical Techniques and Applications for Engineers

			Max Mark	a*	a	b	c	d	e	u
H865	01 Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H866	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

			Max Mark	a	b	c	d	e	u
H867	01 Introduction to quantitative reasoning	Raw	72	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6989	01 Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867