OCR
Oxford Cambridge and RSA

Wednesday 13 May 2015 – 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

3269103962

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

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- 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 thin uniform rigid rod JK of length 1.2 m and weight 30 N is resting on a rough circular cylinder which is fixed to a floor. The axis of symmetry of the cylinder is horizontal and at all times the rod is perpendicular to this axis.

Initially, the rod is horizontal and its point of contact with the cylinder is 0.4 m from K. It is held in equilibrium by resting on a small peg at J. This situation is shown in Fig. 1.1.

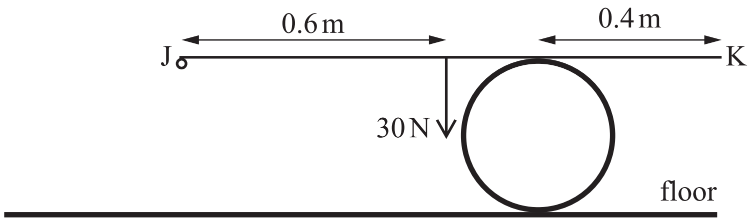

Fig. 1.1

(i) Calculate the force exerted by the peg on the rod and also the force exerted by the cylinder on the rod. **[3]**

A small object of weight W N is attached to the rod at K.

(ii) Find the greatest value of W for which the rod maintains its contact at J. **[2]**

The object at K is removed. Fig. 1.2 shows the rod resting on the cylinder with its end J on the floor, which is smooth and horizontal. The point of contact of the rod with the cylinder is 0.3 m from K. Fig. 1.2 also shows the normal reaction, S N, of the floor on the rod, the normal reaction, R N, of the cylinder on the rod and the frictional force F N between the cylinder and the rod.

Suppose the rod is in equilibrium at an angle of $\theta°$ to the horizontal, where $\theta < 90$.

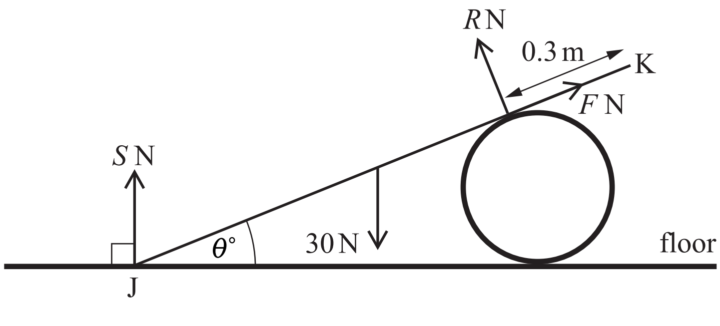

Fig. 1.2

(iii) Find S. Find also expressions in terms of θ for R and F. **[8]**

The coefficient of friction between the cylinder and the rod is μ.

(iv) Determine a relationship between μ and θ. **[3]**

2 Fig. 2 shows a wedge of angle 30° fixed to a horizontal floor. Small objects P, of mass 8 kg, and Q, of mass 10 kg, are connected by a light inextensible string that passes over a smooth pulley at the top of the wedge. The part of the string between P and the pulley is parallel to a line of greatest slope of the wedge. Q hangs freely and at no time does either P or Q reach the pulley or P reach the floor.

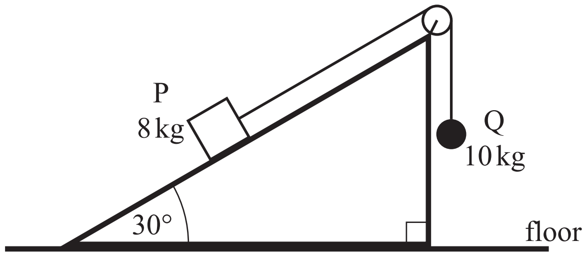

Fig. 2

(i) Assuming the string remains taut, find the change in the gravitational potential energy of the system when Q descends h m, stating whether it is a loss or a gain. **[3]**

Object P makes smooth contact with the wedge. The system is set in motion with the string taut.

(ii) Find the speed at which Q hits the floor if

(A) the system is released from rest with Q a distance of 1.2 m above the floor, **[3]**

(B) instead, the system is set in motion with Q a distance of 0.3 m above the floor and P travelling **down** the slope at 1.05 m s^{-1}. **[3]**

The sloping face is roughened so that the coefficient of friction between object P and the wedge is 0.9. The system is set in motion with the string taut and P travelling down the slope at 2 m s^{-1}.

(iii) How far does P move before it reaches its lowest point? **[5]**

(iv) Determine what happens to the system after P reaches its lowest point. **[2]**

(v) Calculate the power of the frictional force acting on P in part **(iii)** at the moment the system is set in motion. **[2]**

Question 3 begins on page 4.

3 A uniform heavy lamina occupies the region shaded in Fig. 3. This region is formed by removing a square of side 1 unit from a square of side a units (where $a > 1$).

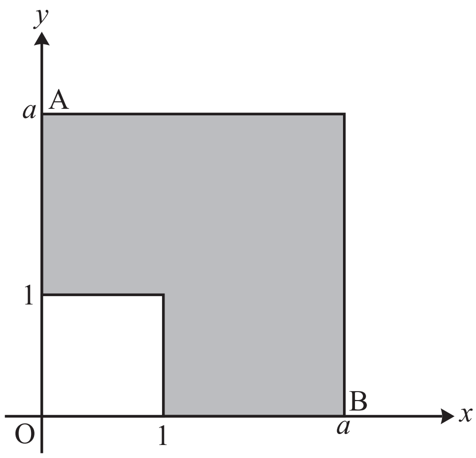

Fig. 3

Relative to the axes shown in Fig. 3, the centre of mass of the lamina is at $(\bar{x}, \bar{y})$.

(i) Show that $\bar{x} = \bar{y} = \dfrac{a^2 + a + 1}{2(a+1)}$.

[You may need to use the result $\dfrac{a^3 - 1}{2(a^2 - 1)} = \dfrac{a^2 + a + 1}{2(a+1)}$.] **[5]**

(ii) Show that the centre of mass of the lamina lies on its perimeter if $a = \frac{1}{2}(1 + \sqrt{5})$. **[3]**

In another situation, $a = 4$.

A particle of mass one third that of the lamina is attached to the lamina at vertex B; the lamina with the particle is freely suspended from vertex A and hangs in equilibrium. The positions of A and B are shown in Fig. 3.

(iii) Calculate the angle that AB makes with the vertical. **[10]**

4 **(a)** Two discs, P of mass 4 kg and Q of mass 5 kg, are sliding along the same line on a smooth horizontal plane when they collide. The velocity of P before the collision and the velocity of Q after the collision are shown in Fig. 4. P loses $\frac{5}{9}$ of its kinetic energy in the collision.

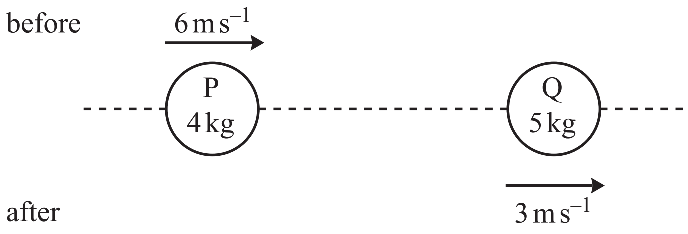

Fig. 4

(i) Show that after the collision P has a velocity of $4\,\mathrm{m\,s^{-1}}$ in the opposite direction to its original motion. **[4]**

While colliding, the discs are in contact for $\frac{1}{5}$ s.

(ii) Find the impulse on P in the collision and the average force acting on the discs. **[4]**

(iii) Find the velocity of Q before the collision and the coefficient of restitution between the two discs. **[4]**

(b) A particle is projected from a point 2.5 m above a smooth horizontal plane. Its initial velocity is $5.95\,\mathrm{m\,s^{-1}}$ at an angle θ below the horizontal, where $\sin\theta = \frac{15}{17}$. The coefficient of restitution between the particle and the plane is $\frac{4}{5}$.

(i) Show that, after bouncing off the plane, the greatest height reached by the particle is 2.5 m. **[5]**

(ii) Calculate the horizontal distance between the two points at which the particle is 2.5 m above the plane. **[3]**

END OF QUESTION PAPER

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Centre number						Candidate number				

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1 (i)

1 (ii)

1 (iii)	
	(answer space continued on next page)

1 (iii)	**(continued)**
1 (iv)	

2 (i)	
2 (ii)(*A*)	

2 (ii)(*B*)	
2 (iii)	
	(answer space continued on next page)

2 (iii)	(continued)
2 (iv)	
2 (v)	

3 (i)	

3 (ii)

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

3 (iii)	**(continued)**

4 (a)(i)

4 (a)(ii)

4 (a)(iii)	

4 (b)(i)	

4 (b)(ii)

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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.

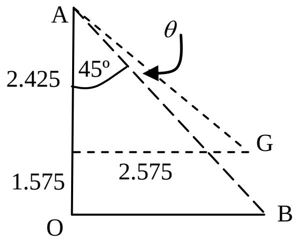
j If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	Guidance	
1	(i)		Suppose ↑ U N at J and V N at point of contact with cylinder Taking moments about point of contact with the cylinder or J $0.8U - 0.2 \times 30 = 0$ or $0.8V - 0.6 \times 30 = 0$ so $U = 7.5$ or $V = 22.5$ Resolve ↑ $U + V - 30 = 0$ so $V = 22.5$ or $U = 7.5$	M1 A1 B1	A correct moments equation FT use of 1st answer. (Or use moments again)	3
	(ii)		Taking moments about point of contact with the cylinder $0.4W - 0.2 \times 30 = 0$ so $W = 15$	M1 A1	A correct moments equation and reaction at J = 0 Award SC2 for 15 seen WWW	2
	(iii)		Taking moments about point of contact $S \times 0.9\cos\theta - 30 \times 0.3\cos\theta = 0$ so $S = 10$ cw moments about J $30 \times 0.6\cos\theta - R \times 0.9 = 0$ so $R = 20\cos\theta$ resolve up the rod $S\sin\theta + F - 30\sin\theta = 0$ so $F = 20\sin\theta$ **SC** Resolving vert and horiz leads to simultaneous eqns. $R = 20\cos\theta$ $F = 20\sin\theta$	M1 A1 M1 A1 A1 M1 A1 A1 M1 A1 M1 A1 A1 A1	A moments equation about point of contact: allow sin instead of cos: Must be trig fn in both terms. Allow slip in distances if clearly taking moments about point of contact Award SC2 for 10 seen WWW Attempt at moments or resolution, involving F or R but not both, with all appropriate terms present and no extras. No need to substitute for S, if it is present. Or $R = (30 - S)\cos\theta$ o.e. FT their S Attempt at another moments or resolution, that will enable F or R to be found, with all appropriate terms present and no extras No need to substitute for S, if it is present. Or $F = (30 - S)\sin\theta$ o.e. FT their S One eqn in F and R Second eqn in F and R AND attempt to solve simult eqns for F or R Or $R = (30 - S)\cos\theta$ o.e. FT their S Or $F = (30 - S)\sin\theta$ o.e.FT their S	8

Question			Answer	Marks	Guidance	
	(iv)		Need $F \le \mu R$ $20\sin\theta \le \mu \times 20\cos\theta$ so $\mu \ge \tan\theta$	B1 M1 A1	Use of $F \le \mu R$ or $F = \mu R$ or $F < \mu R$ Needs an inequality, using their F and R from **(iii)** FT incorrect S (Strict inequality gets 2/3)	3
				16		
2	**(i)**		The system *loses* $10gh - 8g\frac{h}{2} = 6gh$ or $58.8h$ *J*	M1 B1 A1	Difference of GPEs Use of $\frac{h}{2}$ or $h\sin 30^\circ$ (sight of $39.2h$) Clearly shown: *Loss* must be stated	3
	(ii)	**(*A*)**	$\frac{1}{2}\times 18\times v^2 = 6g\times 1.2$ (= 70.56) v = 2.8 so 2.8 m s^{-1} OR $10g - 8g\sin 30^\circ = 18a$ $a = g/3$ or 3.26: $v^2 = 0.8g = 7.84$: $v = 2.8$	M1 B1 A1 M1 B1 A1	Use of WE equation (a KE = a GPE) Use of '18'. cao Use N2L AND use *suvat* Use of '18'. cao	3 3
	(ii)	**(*B*)**	Q passes through point 0.3 m above floor going down at 1.05 m s^{-1} $\frac{1}{2}\times 18\times V^2 - \frac{1}{2}\times 18\times 1.05^2 = 6g\times 0.3$ ($V^2 = 3.0625$) and V = 1.75 so 1.75 m s^{-1} OR $10g - 8g\sin 30^\circ = 18a$ and *suvat* eqn $a = g/3$ (= 3.26) ($V^2 = 3.0625$) and V = 1.75 so 1.75 m s^{-1}	M1 A1 A1 M1 A1 A1	WE with 2 KE terms and a difference in GPE terms: must be using 18; may consider motion of P and motion of Q separately Allow FT on their 6g cao Use N2L (both particles considered) AND use *suvat:* must be using 18 cao cao	3

Question			Answer	Marks	Guidance	
	(iii)		$F_{max} = 0.9 \times 8g\cos 30$	M1	Attempt to use $F = \mu R$ with weight of $8g$	
				A1	May not be evaluated (61.10675…or $35.28\sqrt{3}$)	
			$\frac{1}{2} \times 18 \times 2^2 = 6gh + F_{max}h$	M1	WE. Correct KE term (with 18), a GPE term and Fh. Allow sign errors	
				A1	All correct	
			h = 0.30023… so 0.300 m (3 s. f.)	A1	cao	5
			OR			
			$F_{max} = 0.9 \times 8g\cos 30$	M1	Attempt to use $F = \mu R$ with mass of 8	
				A1	May not be evaluated (61.10675…)	
			$F + 10g - 8g\sin 30^\circ = 18a$	M1	Use N2L for both particles, or combined system, must be 18*a*; all terms present and use *suvat*	
			$a = -6.66$	A1	cao	
			h = 0.30023… so 0.300 m (3 s. f.)	A1	cao	
						5
	(iv)		Could P stay at rest in equilibrium? Force up the plane on P is 10g = 98 N. Force down plane on P due to its weight is 8$g$sin30 = 39.2 N	M1	Attempt to compare forces up and down the plane including friction OR: Force needed for equilibrium = $10g - 8g\sin 30^\circ = 58.8$ and compare with max frictional force 61.1	
			39.2 + F_{max} $\approx$ 100.3 > 98 so yes, stays at rest	E1	A clear argument 58.8 is less than 61.1 so equilibrium possible	2
	(v)		2× 61.10675… = 122.21… so 122 W (3 s. f.)	M1 F1	Attempt to use $P = Fv$ with v = 2 and their frictional force	2
				18		

Question			Answer	Marks	Guidance	
3		(i)	either $\bar{x} = \bar{y}$ by symmetry For $\bar{x}$ $a^2\sigma\frac{a}{2} = (a^2-1)\sigma\bar{x} + 1\sigma\frac{1}{2}$ Hence $\frac{a^3}{2} - \frac{1}{2} = (a^2-1)\bar{x}$ and $\bar{x} = \frac{(a^3-1)}{2(a^2-1)}$: $\bar{x} = \frac{a^2+a+1}{2(a+1)}$	 B1 M1 A1 A1 E1	Consider a square side 1 removed from a square side a Or by calculation Allow σ omitted Any one term correct All correct At least one intermediate step shown	5
			or $\bar{x} = \bar{y}$ by symmetry $((a-1)a + 1(a-1))\sigma\bar{x} = (a-1)a \times \frac{a}{2}\sigma + (a-1)\frac{(a+1)}{2}\sigma$ …. hence $(a+1)\bar{x} = \frac{a^2}{2} + \frac{(a+1)}{2}$ and $\bar{x} = \frac{a^2+a+1}{2(a+1)}$	 B1 M1 A1 A1 E1	Splitting horizontally into 2 rectangles Or by calculation Allow σ omitted. o.e. Any one term correct All correct Dividing by (a – 1) o.e. Some simplification shown [*Or splitting vertically into 2 rectangles or…*]	
		(ii)	Need $\bar{x} = \frac{a^2+a+1}{2(a+1)} = 1$ so $a^2+a+1 = 2a+2$ and $a^2-a-1=0$ Solving for the +ve root gives $a = \frac{1+\sqrt{1+4}}{2} = \frac{1+\sqrt{5}}{2}$	B1 M1 A1	 oe	3

Question			Answer	Marks	Guidance	
			OR Substitute expression for a into expression for $\bar{x}$ and attempt to simplify Obtain $\bar{x}=1$ This is on perimeter of shape	M1 A1 B1	Includes an attempt at squaring out.. Decimals used M0	3
		(iii)	a = 4 gives $\bar{x}=\bar{y}$ = 2.1 Take the mass of the particle to be m $4m\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=m\begin{pmatrix}4\\ 0\end{pmatrix}+3m\begin{pmatrix}2.1\\ 2.1\end{pmatrix}$ $\bar{x}$ = 2.575 $\bar{y}$ = 1.575 G is vertically below A  $\theta=\arctan\frac{2.575}{2.425}-45$ $\theta=45-\arctan\frac{2.425}{2.575}$ = 1.71835… so 1.72º (3 s. f.)	B1 M1 A1 A1 A1 B1 M1 M1 A1 A1	 Allow if a not substituted as 4 At least 1 correct term Allow if a not substituted as 4 FT for 1 of the final answer marks if there is a single error May be implied Note: Can use cosine rule in triangle AGB: AG = 3.537, AB = 5.657, GB = 2.124: M1 for attempt to find all three lengths A1 all correct M1 use cosine rule A1 1.72 cao Correct angle attempted (may be scored below) Use of arctan oe to find angle OAG must be using their 2.575 and 4 - their 1.575 Use of appropriate lengths. FT their values. cao	10
				18		

Question			Answer	Marks	Guidance	
4	(a)	(i)	Let speed of P after collision be u m s^{-1}			
			$\frac{1}{2}\times 4\times u^2 = \frac{1}{2}\times 4\times 36\times\frac{4}{9}$	M1	Use of KE; allow use of $\frac{5}{9}$ in an equation involving only u	
				B1	Correct use of $\frac{4}{9}$ of a KE term	
			$u = 4$	E1	Condone ± 4	
			Cannot be in the direction of Q as 4 > 3	E1	Can use PCLM and NEL to show 'in direction of Q' gives negative e	4
		(ii)	Taking $\leftarrow$ +ve			
			Impulse is $4(4-(-6))$	M1	Allow sign error. Must be 4(final vel - initial vel); condone 4(6 +4)	
			= 40 N s	A1	Note: impulse on Q = 5(3 - - 5) = 40 needs to be related to impulse on P to score any marks	
			Let force be F N			
			$40 = F\times\frac{1}{5}$	M1	Use of Impulse = Ft	
			so $F = 200$	A1	Sign consistent with sign of impulse	4
		(iii)	Taking $\rightarrow$ +ve and vel of Q as U m s^{-1}			
			PCLM $24+5U=-4\times 4+5\times 3$	M1	o.e. e.g. using impulse	
			so $U=-5$ i.e. to the left	A1	Must state direction but could be implied by diagram or equivalent	
			$e=\dfrac{4+3}{6+5}=\dfrac{7}{11}$ (0.636 to 3 sig figs)	M1		
				F1	FT their U	4

Question			Answer	Marks	Guidance	
	(b)	(i)	Vert cpt of vel in m s^{-1} is $5.95\times\frac{15}{17}=5.25$	B1	May be implied	
			Particle hits the plane with vert speed			
			$\sqrt{5.25^2+2\times 9.8\times 2.5}$	M1	Must be vertical component	
			= 8.75	A1	May be implied	
			Particle leaves plane with vert speed			
			8.75×0.8 = 7	B1	Award for the ×0.8 on vert cpt (dependent on M1)	
			Height reached is given by			
			$0=7^2-2\times 9.8\times h$ so h = 2.5	E1	Clearly shown cwo	
						5
		(ii)	Time taken in seconds is			
			down $\frac{8.75-5.25}{9.8}=\frac{5}{14}=0.357$:up $\frac{7}{9.8}=\frac{5}{7}=0.714$:	M1	Finding both times and adding	
			so $\frac{15}{14}$ s	F1	FT only their 8.75 from (i)	
			Horiz distance is $\frac{15}{14}\times 5.95\times\frac{8}{17}$ = 3 m	A1	cao	
						3
				20		

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4762 Mechanics 2

General Comments

The standard of the solutions presented by candidates was generally pleasing. There was the usual wide spread of marks, but 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.

The responses to Question 3 were particularly pleasing, with candidates showing themselves very capable of applying their knowledge of algebra dealing with an unusual example involving centres of mass.

The work-energy scenario for Question 2 did not seem familiar to some candidates and many seemed to struggle with the presence of two connected objects.

Comments on Individual Questions

Question 1

Forces and Equilibrium

Candidates seemed confident in their attempts at this question, and many earned the majority of the marks. Some solutions were much longer and more complicated than they need have been. Candidates should choose carefully the points about which they take moments and the directions in which they resolve.

(i) Most candidates realised that taking moments about the peg or the point of contact of the rod with the cylinder resulted in an equation involving only one of the unknown forces. The second of the forces was then found by a second moments equation or, more commonly, by resolving in the vertical direction.

(ii) Again, the point about which candidates took moments was key to the success of their solution. Those who did not opt for the point of contact of the rod with the cylinder usually missed out at least one relevant force. Some candidates did not use the fact that for the greatest value of W the reaction at the peg is zero.

(iii) In this part, the key to a concise solution was to make appropriate choices for the point(s) about which to take moments and the directions in which to resolve. Taking moments about the point of contact of the rod with the cylinder, leaves S as the only unknown force. Resolving parallel and perpendicular to the rod gives equations involving only one of F and R, together with known forces. Those candidates who adopted this approach almost always scored full marks.

Many candidates had a clear idea as to what needed to be done but made errors, notably with the inclusion, or not, of the correct trigonometric functions in moments equations and resolutions.

(iv) The vast majority of candidates considered the particular case of limiting friction rather than the general case. They found an equality instead of an inequality for μ in terms of $\tan\theta$.

Question 2

Work, Energy and Power

There were two different approaches to this question, one using energy methods and the other using Newton's second law of motion and *suvat* equations. Candidates opted for these approaches in roughly equal measure, with the second often proving more successful. For a significant number of candidates, the scenario involving two particles connected by a string seemed to cause confusion.

(i) Candidates were required to find the change in the gravitational potential energy of each of the particles P and Q, as each moved through a distance *h* m. Most candidates did this successfully, the most common error being omission of the $\sin 30^\circ$ needed in calculating the vertical distance moved by Q.

(ii) *(A)* and *(B)* A very common error in this part was to use different masses in different parts of either the work-energy equation or Newton's second law equation. For example, in the work-energy equation, many candidates used both masses in the gravitational potential energy term, but only one of the masses, usually that of P, in the kinetic energy term.

(iii) The majority of candidates calculated correctly the magnitude of the frictional force, and gained two marks. Confusion arose again over which mass should be used in the gravitational potential energy and kinetic energy terms required for one method or in the force terms in Newton's equation required in the other.

(iv) An attempt at a comparison of the forces up and down the plane was required here. Those candidates who stated these forces and reached the conclusion that the system stayed at rest usually gained both available marks. However, many candidates stated that the system stayed at rest, with no reference to the situation under consideration, and often in a verbose essay-type response. Without reference to the numerical values of the forces involved, no marks were awarded.

(v) Most candidates multiplied their frictional force from part (iii) by the given speed and gained both marks.

Question 3

Centre of Mass

Candidates were on familiar territory with the content of this question and there were many very good, well-presented solutions.

(i) In this part, candidates were asked to find the position of the centre of mass of a lamina made from the removal of a square of side 1 unit from the corner of a larger square of side *a* units. Many candidates tackled this problem by considering the removal of the smaller square. This led to a simple formula, which could be simplified further by use of a given identity. Some candidates preferred to look at the problem by considering two or even three rectangles of different sizes. This led to more tricky algebra and often resulted in errors.

(ii) Candidates were asked to show that the centre of mass of the lamina was on its perimeter for $a = \frac{1}{2}\left(1+\sqrt{5}\right)$. Only a minority of candidates transformed this into the fact that $\bar{x} = 1$ and solved the resulting quadratic equation $a^2 - a - 1 = 0$. Most candidates substituted $a = \frac{1}{2}\left(1+\sqrt{5}\right)$ into the formula for $\bar{x}$ and with a small amount of surd algebra were able to show that $\bar{x} = \bar{y} = 1$, a point on the perimeter of the lamina.

(iii) Candidates were asked to consider a lamina formed by adding a mass to the lamina used in part (i), and to find the angle made by line AB to the vertical when it was suspended from A. Most candidates obtained the first five marks for finding the centre of mass (G) of the new shape and many went on to find the angle between AB and the vertical. The most common method was to find the angle that AG made with AO and then subtract this from 45^0. There were many other ingenious solutions, with techniques including

- the use of the cosine rule in the triangle AGB
- the dot product of vectors $\overrightarrow{AB}$ and $\overrightarrow{AG}$
- the intersection of lines the $y = 4 - x$ and $y = x - 1$ at a point M leading to the formation of triangle AGM from which the angle could be found.

Question 4

Momentum and Impulse

Candidates showed confidence in their working for this question and many applied the relevant principles and equations to good effect. It was disappointing that some marks could not be awarded for otherwise good work, because of a lack of clarity about directions. It seems very likely that copying the diagram given in part **(a)** and adding the magnitude and direction of the velocity of each disc would have led to more clarity and accuracy.

(a) (i) The majority of candidates were able to interpret and use the given information that P lost $\frac{5}{9}$ of its kinetic energy in the form that the final kinetic energy of P was $\frac{4}{9}$ of its initial value. The speed of P was usually found correctly, but it was rare to see a convincing argument as to why the *velocity* should be - 4 and not 4.

(ii) Most candidates knew the appropriate formulae to calculate the impulse on P and the average force on the discs, but sign errors were common. It was almost invariably the case that a candidate who had drawn a clear diagram, with directions shown, used the correct signs in the ensuing calculations.

(iii) The equations resulting from applications of the Principle of conservation of linear momentum and of Newton's law of restitution were usually correct and most candidates solved them correctly to find the speed of Q and the coefficient of restitution. As in part (i), there was a lack of clarity in identifying the resulting direction of motion.

(b) (i) There are four stages in calculating the height reached by the particle after it bounces from the plane: finding the vertical component of the initial velocity, finding the vertical speed with which the particle hits the plane, applying Newton's law of restitution at the collision and finally, using a *suvat* equation to find the height of the bounce. The majority of candidates worked methodically and accurately through these stages.

(ii) Candidates were required to find the horizontal distance travelled by the projectile from its projection to reaching its maximum height after bouncing off the surface. The calculation of the time for each part of the motion was often not completed by candidates. It was not clear whether this was due to a misunderstanding of the problem, or that the end of the examination prevented any further work.

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GCE Mathematics (MEI)											
				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	58	53	48	43	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	50	44	39	34	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	56	51	46	41	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	74	67	60	54	48	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	62	57	53	49	45	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	65	58	52	46	40	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	63	57	51	45	38	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	62	54	46	39	32	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	54	47	40	33	27	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	64	56	48	41	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	53	45	38	31	24	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	65	60	55	50	46	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	64	58	52	47	42	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	56	51	46	41	37	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	54	49	44	39	34	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	56	50	45	40	34	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	61	54	47	41	35	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	61	54	47	41	35	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	56	51	46	41	37	0
		UMS	100	80	70	60	50	40	0