

**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



## 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  $g \text{ m s}^{-2}$ . 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 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.

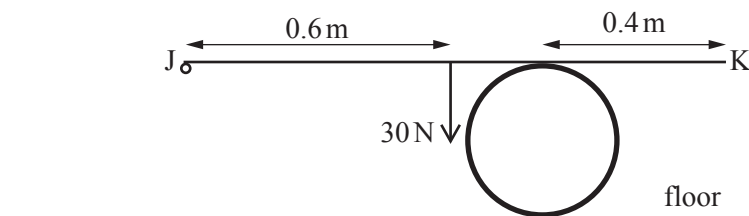


Fig. 1.1

- (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  $\theta^\circ$  to the horizontal, where  $\theta < 90$ .

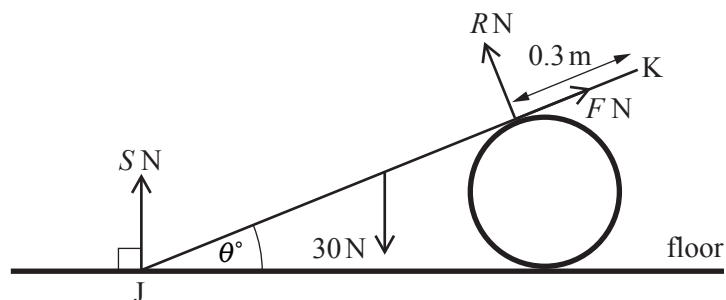


Fig. 1.2

- (iii) Find  $S$ . Find also expressions in terms of  $\theta$  for  $R$  and  $F$ . [8]

The coefficient of friction between the cylinder and the rod is  $\mu$ .

- (iv) Determine a relationship between  $\mu$  and  $\theta$ . [3]

- 2 Fig. 2 shows a wedge of angle  $30^\circ$  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.

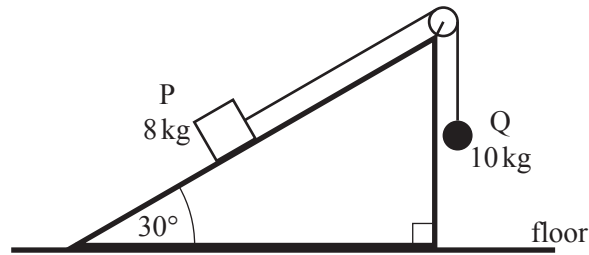


Fig. 2

- (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  $1.05 \text{ m s}^{-1}$ . [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  $2 \text{ m s}^{-1}$ .

- (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  $a > 1$ ).

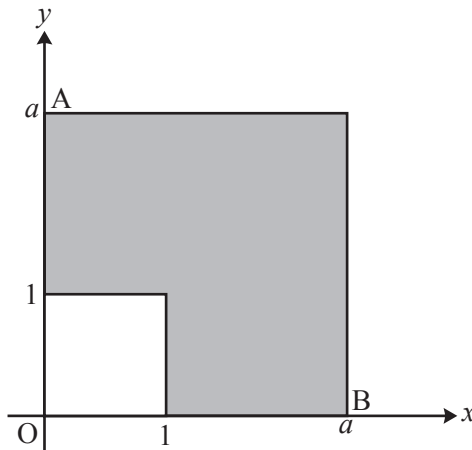


Fig. 3

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

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

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

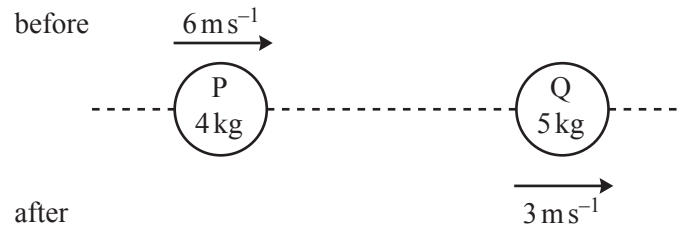


Fig. 4

- (i) Show that after the collision P has a velocity of  $4 \text{ m s}^{-1}$  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  $5.95 \text{ m s}^{-1}$  at an angle  $\theta$  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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Candidate forename		Candidate surname	
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Centre number						Candidate number				
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<b>1 (i)</b>	
<b>1 (ii)</b>	



<b>1 (iii)</b>	<b>(continued)</b>
<b>1 (iv)</b>	





<b>2 (iii)</b> (continued)	
<b>2 (iv)</b>	
<b>2 (v)</b>	











<b>4(a)(i)</b>	

<b>4(a)(ii)</b>	

<b>4(a)(iii)</b>	

<b>4 (b)(i)</b>	

<b>4 (b)(ii)</b>	



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## Annotations and abbreviations

<b>Annotation in scoris</b>	<b>Meaning</b>
✓ 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	
<b>Other abbreviations in mark scheme</b>	<b>Meaning</b>
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.

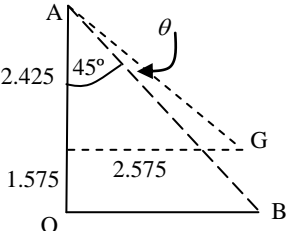
Question		Answer	Marks	Guidance	
1	(i)	Suppose $\uparrow U$ N at J and $V$ N at point of contact with cylinder Taking moments about point of contact with the cylinder or J $0.8U - 0.2 \times 30 = 0$ or $0.8V - 0.6 \times 30 = 0$ so $U = 7.5$ or $V = 22.5$ Resolve $\uparrow U + V - 30 = 0$ so $V = 22.5$ or $U = 7.5$	M1 A1 B1	A correct moments equation  FT use of 1 <sup>st</sup> 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 $F = 20 \sin \theta$ <b>SC</b> 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 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 $F \leq \mu R$ $20\sin\theta \leq \mu \times 20\cos\theta$ so $\mu \geq \tan\theta$	B1 M1 A1	Use of $F \leq \mu R$ 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: <i>Loss</i> must be stated	3
	(ii) (A)	$\frac{1}{2} \times 18 \times v^2 = 6g \times 1.2$ (= 70.56)  $v = 2.8$ so $2.8 \text{ m s}^{-1}$ 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 <i>suvat</i> Use of '18'. cao	3  3
	(ii) (B)	Q passes through point 0.3 m above floor going down at $1.05 \text{ m s}^{-1}$ $\frac{1}{2} \times 18 \times V^2 - \frac{1}{2} \times 18 \times 1.05^2 = 6g \times 0.3$  ( $V^2 = 3.0625$ ) and $V = 1.75$ so $1.75 \text{ m s}^{-1}$ OR $10g - 8g \sin 30^\circ = 18a$ and <i>suvat</i> eqn  $a = g/3$ (= 3.26) ( $V^2 = 3.0625$ ) and $V = 1.75$ so $1.75 \text{ m s}^{-1}$	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 <i>suvat</i> : must be using 18 cao cao	3

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

Question	Answer	Marks	Guidance	
3	<p>(i)</p> <p>either  <math>\bar{x} = \bar{y}</math> by symmetry            For <math>\bar{x}</math>  <math display="block">a^2\sigma\frac{a}{2} = (a^2 - 1)\sigma\bar{x} + 1\sigma\frac{1}{2}</math></p> <p>Hence <math display="block">\frac{a^3}{2} - \frac{1}{2} = (a^2 - 1)\bar{x}</math></p> <p>and <math display="block">\bar{x} = \frac{(a^3 - 1)}{2(a^2 - 1)} : \bar{x} = \frac{a^2 + a + 1}{2(a + 1)}</math></p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>E1</p>	<p>Consider a square side 1 removed from a square side <math>a</math>            Or by calculation</p> <p>Allow <math>\sigma</math> omitted</p> <p>Any one term correct            All correct</p> <p>At least one intermediate step shown</p>	5
	<p>or  <math>\bar{x} = \bar{y}</math> by symmetry</p> <p><math display="block">((a-1)a + 1(a-1))\sigma\bar{x} = (a-1)a \times \frac{a}{2}\sigma + (a-1)\frac{(a+1)}{2}\sigma</math></p> <p>.... hence <math display="block">(a+1)\bar{x} = \frac{a^2}{2} + \frac{(a+1)}{2}</math></p> <p>and <math display="block">\bar{x} = \frac{a^2 + a + 1}{2(a+1)}</math></p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>E1</p>	<p>Splitting horizontally into 2 rectangles            Or by calculation</p> <p>Allow <math>\sigma</math> omitted. o.e.</p> <p>Any one term correct            All correct</p> <p>Dividing by <math>(a - 1)</math> o.e.</p> <p>Some simplification shown</p> <p>[Or splitting vertically into 2 rectangles or...]</p>	
	<p>(ii)</p> <p>Need <math display="block">\bar{x} = \frac{a^2 + a + 1}{2(a + 1)} = 1</math></p> <p>so <math>a^2 + a + 1 = 2a + 2</math> and <math>a^2 - a - 1 = 0</math>            Solving for the +ve root gives  <math display="block">a = \frac{1 + \sqrt{1 + 4}}{2} = \frac{1 + \sqrt{5}}{2}</math></p>	<p>B1</p> <p>M1</p> <p>A1</p>	<p>oe</p>	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  $\theta = \arctan \frac{2.575}{2.425} - 45 \quad \theta = 45 - \arctan \frac{2.425}{2.575}$ $= 1.71835\dots \text{ so } 1.72^\circ \text{ (3 s. f.)}$	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
		<b>18</b>		

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

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

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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

<b>GCE Statistics (MEI)</b>										
			<b>Max Mark</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>	<b>e</b>	<b>u</b>	
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

<b>GCE Quantitative Methods (MEI)</b>										
			<b>Max Mark</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>	<b>e</b>	<b>u</b>	
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