Monday 19 May 2014 – 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

3144522833

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 $g\,\mathrm{m\,s^{-2}}$. 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)** A particle, P, of mass 5 kg moving with speed u m s^{-1} collides with another particle, Q, of mass 30 kg travelling with a speed of $\frac{u}{3}$ m s^{-1} towards P. The particles P and Q are moving in the same horizontal straight line with negligible resistance to their motion. As a result of the collision, the speed of P is halved and its direction of travel reversed; the speed of Q is now V m s^{-1}.

(i) Draw a diagram showing this information.

Find the velocity of Q immediately after the collision in terms of u. Find also the coefficient of restitution between P and Q. **[6]**

(ii) Find, in terms of u, the impulse of P on Q in the collision. **[2]**

(b) Fig. 1 shows a small object R of mass 5 kg travelling on a smooth horizontal plane at 6 m s^{-1}. It explodes into two parts of masses 2 kg and 3 kg. The velocities of these parts are in the plane in which R was travelling with the speeds and directions indicated. The angles α and β are given by $\cos\alpha = \frac{4}{5}$ and $\cos\beta = \frac{3}{5}$.

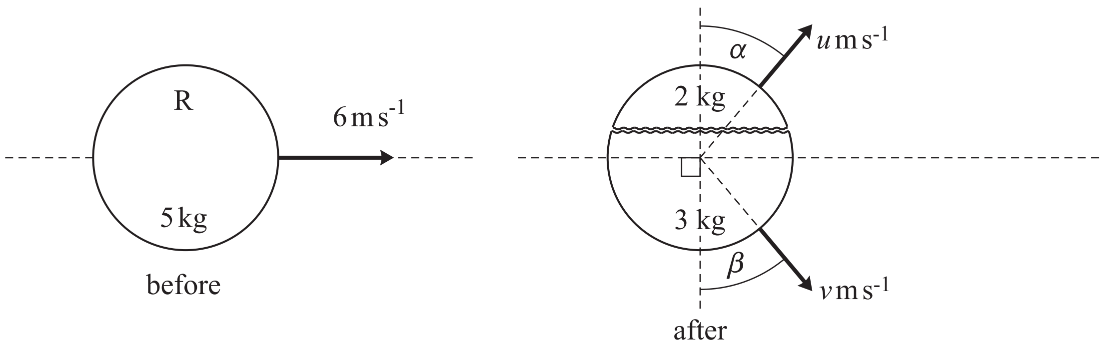

Fig. 1

(i) Calculate u and v. **[7]**

(ii) Calculate the increase in kinetic energy resulting from the explosion. **[2]**

2 Fig. 2.1 shows the positions of the points P, Q, R, S, T, U, V and W which are at the vertices of a cube of side a; Fig. 2.1 also shows coordinate axes, where O is the mid-point of PQ.

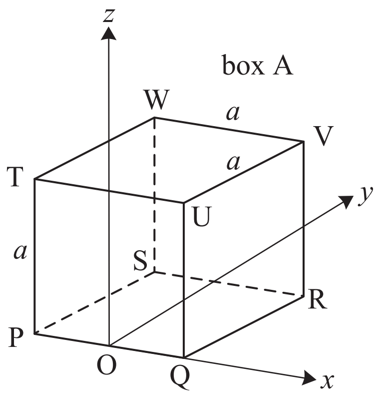

Fig. 2.1

An **open** box, A, is made from thin uniform material in the form of the faces of the cube with just the face TUVW missing.

(i) Find the z-coordinate of the centre of mass of A. **[3]**

Strips made of a thin heavy material are now fixed to the edges TW, WV and VU of box A, as shown in Fig. 2.2. Each of these three strips has the same mass as one face of the box. This new object is B.

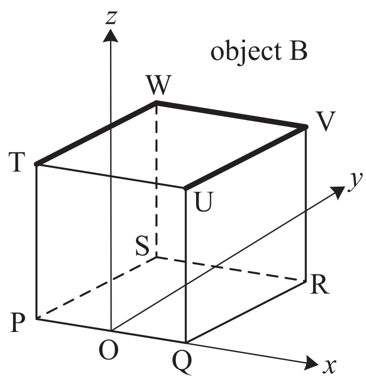

Fig. 2.2

(ii) Find the x- and z- coordinates of the centre of mass of B and show that the y-coordinate is $\frac{9a}{16}$. **[6]**

Object B is now placed on a plane which is inclined at θ to the horizontal. B is positioned so that face PQRS is on the plane with SR at right angles to a line of greatest slope of the plane and with PQ higher than SR, as shown in Fig. 2.3.

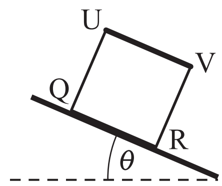

Fig. 2.3

(iii) Assuming that B does not slip, find θ if B is on the point of tipping. **[5]**

B is now placed on a different plane which is inclined at 30º to the horizontal. When B is released it accelerates down the plane at $2\,\mathrm{m\,s^{-2}}$.

(iv) Calculate the coefficient of friction between B and the inclined plane. **[5]**

3 **(a)** Fig. 3.1 shows a framework in equilibrium in a vertical plane. The framework is made from 3 light rigid rods AB, BC and CA which are freely pin-jointed to each other at A, B and C. The pin-joint at A is attached to a fixed horizontal beam; the pin-joint at C rests on a smooth horizontal floor. BC is 2 m and angle BAC is 30°; BC is at right angles to AC. AB is horizontal.

Fig. 3.1 also shows the external forces acting on the framework; there is a vertical load of 60 N at B, horizontal and vertical forces X N and Y N act at A; the reaction of the floor at C is R N.

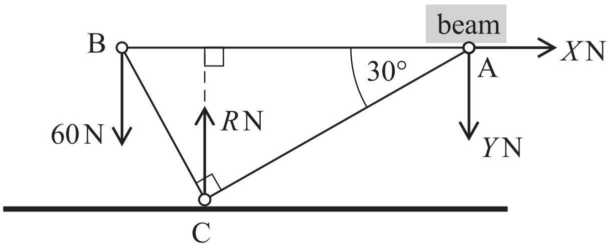

Fig. 3.1

(i) Show that $R = 80$ and find the values of X and Y. **[4]**

(ii) Using the diagram in your printed answer book, show all the forces acting on the pin-joints, including those internal to the rods. **[1]**

(iii) Calculate the forces internal to the rods AB, BC and CA, stating whether each rod is in tension or thrust (compression). [You may leave your answers in surd form. Your working in this part should correspond to your diagram in part **(ii)**.] **[6]**

(b) Fig 3.2 shows a non-uniform rod of length 6 m and weight 68 N with its centre of mass at G. This rod is free to rotate in a vertical plane about a horizontal axis through B, which is 2 m from A. G is 2 m from B. The rod is held in equilibrium at an angle θ to the horizontal by a horizontal force of 102 N acting at C and another force acting at A (not shown in Fig. 3.2). Both of these forces and the force exerted on the rod by the hinge (also not shown in Fig 3.2) act in a vertical plane containing the rod. You are given that $\sin\theta = \frac{15}{17}$.

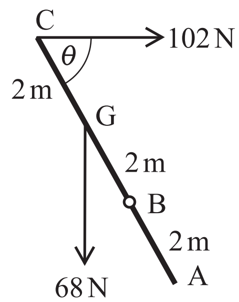

Fig. 3.2

(i) First suppose that the force at A is at right angles to ABC and has magnitude P N.

Calculate P. **[4]**

(ii) Now instead suppose that the force at A is horizontal and has magnitude Q N.

Calculate Q.

Calculate also the magnitude of the force exerted on the rod by the hinge. **[5]**

4 **(a)** A small heavy object of mass 10 kg travels the path ABCD which is shown in Fig. 4. ABCD is in a vertical plane; CD and AEF are horizontal. The sections of the path AB and CD are smooth but section BC is rough.

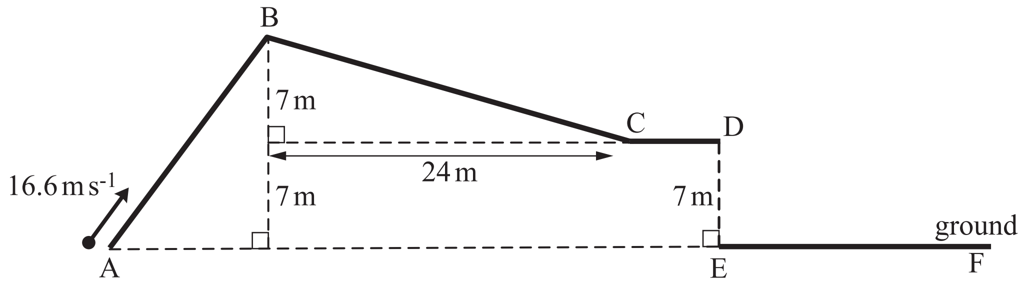

Fig. 4

You should assume that

- the object does not leave the path when travelling along ABCD and does not lose energy when changing direction
- there is no air resistance.

Initially, the object is projected from A at a speed of $16.6\,\text{m s}^{-1}$ up the slope.

(i) Show that the object gets beyond B. **[2]**

The section of the path BC produces a constant resistance of 14 N to the motion of the object.

(ii) Using an energy method, find the velocity of the object at D. **[5]**

At D, the object leaves the path and bounces on the smooth horizontal ground between E and F, shown in Fig. 4. The coefficient of restitution in the collision of the object with the ground is $\frac{1}{2}$.

(iii) Calculate the greatest height above the ground reached by the object after its first bounce. **[3]**

(b) A car of mass 1500 kg travelling along a straight, horizontal road has a steady speed of $50\,\text{m s}^{-1}$ when its driving force has power P W.

When at this speed, the power is suddenly reduced by 20%. The resistance to the car's motion, F N, does not change and the car begins to decelerate at $0.08\,\text{m s}^{-2}$.

Calculate the values of P and F. **[6]**

END OF QUESTION PAPER

OCR

Monday 19 May 2014 – Morning

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4762/01 Mechanics 2

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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1 (a) (i)	
	(answer space continued on next page)

1 (a) (i)	(continued)
1 (a) (ii)	

1 (b) (i)	
	(answer space continued on next page)

1 (b) (i)	**(continued)**
1 (b) (ii)	

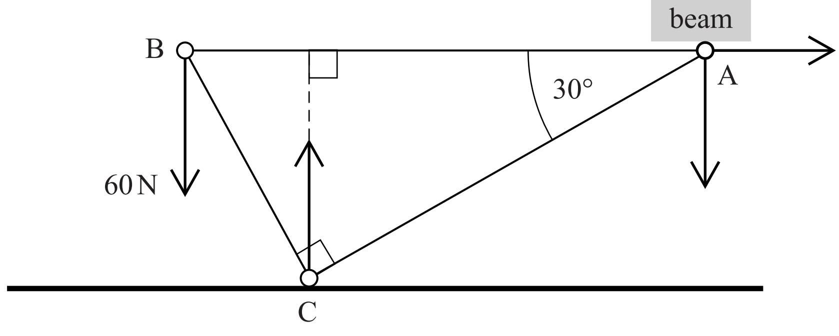
2 (i)	
2 (ii)	
	(answer space continued on next page)

2 (ii)	(continued)

2 (iii)	

2 (iv)

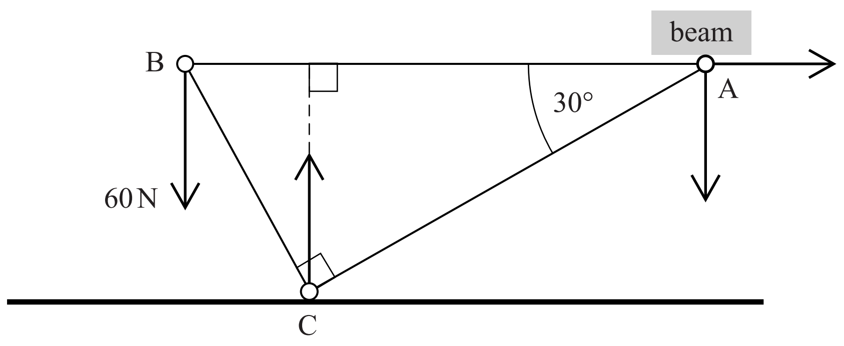
3 (a) (i)	
3 (a) (ii)	**A spare copy of this diagram can be found on page 13**



3 (a) (iii)	

3 (b) (i)	
3 (b) (ii)	
	(answer space continued on next page)

3 (b) (ii)	**(continued)**
3 (a) (ii)	**Spare copy of diagram for question 3 (a) (ii)**



4 (a) (i)	
4 (a) (ii)	
	(answer space continued on next page)

4 (a) (ii)	(continued)
4 (a) (iii)	

4 (b)	

OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4762**: Mechanics 2

Advanced GCE

Mark Scheme for June 2014

1. Annotations and abbreviations

Annotation in scoris	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓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

2. 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.

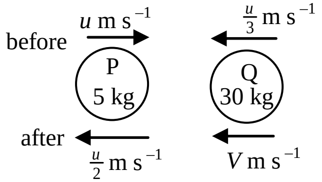
Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

'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.

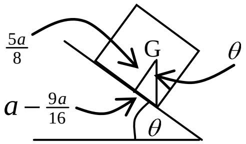
i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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)		B1	Accept V in either direction. Given velocities and masses must be correct.	
			PCLM $\rightarrow$ + ve $5u - 30\frac{u}{3} = -5\frac{u}{2} - 30V$	M1	PCLM. Allow sign errors only	
			so $V = \frac{u}{12}$	A1	Award even if direction of V used in PCLM does not match their diagram, so $\frac{u}{12}$ or $-\frac{u}{12}$ will get this A1	
				A1	WWW. Direction of V correct (may be implied from diagram).	
			$e = \dfrac{\frac{u}{2} - \frac{u}{12}}{u + \frac{u}{3}}$	M1	FT **their** V : allow sign errors, but must be right way up	
			$= \dfrac{\frac{5}{12}}{\frac{4}{3}} = \frac{5}{16}$ (= 0.3125)	A1	cao	
				[6]		
1	(a)	(ii)	$\rightarrow$ +ve $30\left(-\frac{u}{12} - \left(-\frac{u}{3}\right)\right)$	M1	Allow sign errors.	
			$7.5u$	A1		
			Or: find impulse on P **and** reverse the sign	M1 A1	$5\left(-\frac{u}{2} - u\right) = -\frac{15}{2}u$ **and** $7.5u$ cao M0A0 unless sign is reversed Direction must be given (may be implicit from diagram).	
				[2]		

Question			Answer	Marks	Guidance
1	(b)	(i)	**Either**		
			As the parts move at 90°, PCLM in final directions	M1	
			For 2kg: $5\times 6\sin\alpha = 2u$	M1	PCLM
			so $5\times 6\times \frac{3}{5} = 2u$	A1	Any form
			and $u = 9$	A1	
			For 3kg: $5\times 6\sin\beta = 3v$	M1	PCLM
			so $5\times 6\times \frac{4}{5} = 3v$	A1	Any form
			and $v = 8$	A1	
			Or PCLM $\rightarrow$ $5\times 6 = 2u\sin\alpha + 3v\sin\beta$	M1	PCLM Allow cos instead of sin if error in both terms; allow sign errors; masses need to be there. Award if embedded in vector method
			so $30 = 2u\times\frac{3}{5} + 3v\times\frac{4}{5}$	A1	Any form
			PCLM $\uparrow$		
			$2u\cos\alpha - 3v\cos\beta = 0$	M1	PCLM Allow sin instead of cos if error in both terms and cos used in previous PCLM eqn; allow sign errors; masses need to be there. Award if embedded in vector method
			so $2u\times\frac{4}{5} = 3v\times\frac{3}{5}$	A1	Any form
			Solving	M1	A complete method involving 2 equations each in u and v
			$u = 9$	A1	cao for one of u or v
			$v = 8$	F1	for the other: FT substitution into their eqn
					Note: Award SC5 for v = 6, u = 12 (from cos/sin reversal)
					Uses velocity instead of mmtum: M0M0M1A0F1 max 2/7
					Uses mass in one eqn only: M1A1M0M1A0F1 max 4/7
				[7]	
1	(b)	(ii)	Δ KE is		
			$\frac{1}{2}\times 2\times 9^2 + \frac{1}{2}\times 3\times 8^2 - \frac{1}{2}\times 5\times 6^2$	M1	M1 for attempt at difference of KE (3 terms of correct form)
			= 87 J	A1	cao
				[2]	

Question			Answer	Marks	Guidance	
2	(i)		Let the mass of each face be m			
			$5m\bar{z} = 4m \times \frac{a}{2} + 0 \times m$	M1	Any complete method. Accept no mention of m oe.	
				A1		
			so $\bar{z} = \frac{2a}{5}$	A1	CLOSED/bottomless box is NOT a MR. Mark as per scheme giving method mark if appropriate: max 1/3	
				[3]		
2	(ii)		By symmetry, $\bar{x} = 0$ or by calculation	M1		
				A1	Can be awarded if closed/bottomless box used	
			$8m\bar{y} = 5m\frac{a}{2} + 2m\frac{a}{2} + ma$	M1	Any complete method. Accept no mention of m oe.	
			$= \frac{9a}{2}$ so $\bar{y} = \frac{9a}{16}$	E1	Shown (answer given)	
			$8m\bar{z} = 5m\frac{2a}{5} + 3ma$	M1	Any complete method. Accept no mention of m oe.	
			$= 5a$ so $\bar{z} = \frac{5a}{8}$	A1	cao CLOSED/bottomless box: max M1A1M1A0M1A0	
				[6]		
			Alternative form of solution:			
			$8m\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix} = m\begin{pmatrix}0\\ 0\\ a/2\end{pmatrix} + m\begin{pmatrix}0\\ a/2\\ 0\end{pmatrix} + m\begin{pmatrix}a/2\\ a/2\\ a/2\end{pmatrix} + m\begin{pmatrix}0\\ a\\ a/2\end{pmatrix}$ $+m\begin{pmatrix}-a/2\\ a/2\\ a/2\end{pmatrix} + m\begin{pmatrix}-a/2\\ a/2\\ a\end{pmatrix} + m\begin{pmatrix}0\\ a\\ a\end{pmatrix} + m\begin{pmatrix}a/2\\ a/2\\ a\end{pmatrix}$	M1	Each coordinate	
			$= m\begin{pmatrix}0\\ 9a/2\\ 5a\end{pmatrix}$	A1	cao	
			so $\bar{x} = 0$, $\bar{y} = 9a/16$, $\bar{z} = 5a/8$			

Question			Answer	Marks	Guidance
2	(iii)			B1 B1 M1	G vertically above bottom edge Use of their $\bar{z}$ and $a-\bar{y}$ oe. Use of tan (or equivalent) with either $\bar{z}$ or $a-\bar{z}$ and $\bar{y}$ or $a-\bar{y}$
			$\tan\theta = \frac{\frac{7a}{16}}{\frac{5a}{8}} = 0.7$	M1	(or equivalent)
			so θ = 34.992... so 35° (3 s. f.)	A1 **[5]**	cao. 55 as answer can get B1B1M1M0A0: 3/5
2	(iv)		Friction F N, normal reaction R N $R = Mg\cos 30$	 B1	Allow $8a^2$ as M throughout
			N2L down plane $Mg\sin 30 - F = 2M$	 M1 A1	Attempt to use N2L with all terms (allow a missing g). Allow sign errors
			$F = \mu R$	M1	Used correctly
			so $\mu = \dfrac{g\sin 30 - 2}{g\cos 30} = 0.34169\ldots$		
			so 0.342 (3 s. f.)	A1 **[5]**	

Question			Answer	Marks	Guidance	
3	(a)	(i)	Vertical through C intersects AB at X			
			BX = 1 and XA = 3	B1	May be implied	
			$\uparrow$ $R - Y - 60 = 0$	B1	Must have an correct equation involving Y .	
			ac moments about A			
			$60 \times 4 - R \times 3 = 0$ so $R = 80$	B1	AG	
			$Y = R - 60 = 20$ and $X = 0$	B1	Both. Can be awarded independent of previous B1	
				[4]	MR-1 for AB = 2	
3	(a)	(ii)		B1	All (8 forces, with labelled pairs of arrows for internal forces) present and consistent . R and Y can be used	
			In the solutions below all internal forces are set as tensions			
				[1]		
3	(a)	(iii)	For example: B $\downarrow$ $60 + T_{BC} \cos 30 = 0$	M1	Attempt an equation for the equilibrium in any direction at any pin-joint (all correct (resolved) terms present, allow sign errors, $s \leftrightarrow c$	
			so $T_{BC} = -40\sqrt{3}$ (Force of $40\sqrt{3}$ N (C))	A1	Ignore T/C ; sign of force must be consistent with their T/C convention	
			A $\downarrow$ $20 + T_{AC} \sin 30 = 0$	M1	2nd equilibrium equation attempted	
			so $T_{AC} = -40$ Force of 40 N (C)	A1	Ignore T/C ; sign of force must be consistent with their T/C convention	
			A $\leftarrow$ $T_{AB} + T_{AC} \cos 30 = 0$	M1	3rd equilibrium equation attempted	
			so $T_{AB} = 20\sqrt{3}$ Force of $20\sqrt{3}$ N (T)		Ignore T/C	
			All three internal forces correct, including T/C	A1	NOTE: Award first A1 for ANY force correct (need not be first one calculated) Award second A1 for a second force correct, FT if dependent on first one. Award third A1 as cao for everything correct, including T/C.	
				[6]		

Question			Answer	Marks	Guidance
3	(b)	(i)	Take force as P to give + ac moment about B ac moments about B $\cos\theta = \frac{8}{17}$ $2P + 68\times 2\times\cos\theta - 102\times 4\times\sin\theta = 0$ P = 148	 B1 M1 A1 A1 **[4]**	 Seen or implied, e.g. in $\cos 61.9^\circ$ Moments equation with all terms attempted and no extras. Allow $s \leftrightarrow c$ and sign errors Moments about other points must include all relevant forces Substitution of sin/cos not required cao
3	(b)	(ii)	Take Q $\rightarrow$ ac moments about B $2Q\sin\theta + 68\times 2\times\cos\theta - 102\times 4\times\sin\theta = 0$ so Q = 167.7333… so 168 (3 s. f.) Horiz force at B is 102 + 167.733.. Magnitude is $\sqrt{269.7333..^2 + 68^2}$ = 278.172… so 278 N (3 s. f.) Alternative for the B1M1A1: finding compts of force at B along and perpendicular to the rod: $Y = 102\sin\theta - 68\cos\theta + Q\sin\theta$ $X = 102\cos\theta - 68\sin\theta + Q\cos\theta$ $X = 187.06;\quad Y = 206.34$ Magnitude is $\sqrt{187.06^2 + 206.34^2}$ = 278.172… so 278 N (3 s. f.)	 M1 F1 B1 M1 A1 B1 M1 A1 **[5]**	 Moments equation with all terms attempted and no extras. Allow $s \leftrightarrow c$ and sign errors Moments about other points must include all relevant forces FT errors in 2,4,cos,sin, sign from part(i) in 2nd and 3rd terms Adding. FT their Q FT their horizontal force at B; Must use 68 cao FT their Q FT their X and Y cao

Question			Answer	Marks	Guidance	
4	(a)	(i)	KE at A is ½ × 10 × 16.6^2 = 1377.8 J			
			GPE at B is 10 × 9.8 × 14 = 1372 J	M1	Calculate relevant quantities (KE at A and PE at B or v = 1.08 at B or h = 14.1)	
			KE at A > GPE at B so gets beyond B	E1	Clear argued comparison (e.g. 1377.8 > 1372)	
				[2]		
4	(a)	(ii)	Let speed at D be v m s^{-1}		Note: No use of friction can get B1 max	
				M1	Use of WD = 14x	
				B1	x = 25	
			A to D: $\frac{1}{2}\times 10\times v^2-\frac{1}{2}\times 10\times 16.6^2$	M1	WE equation with at least one KE, ΔGPE and WD by friction terms, all of correct form	
			$=-10\times 9.8\times 7-25\times 14$	A1	Allow only sign errors	
			($v^2=68.36$)			
			so v = 8.2680… so 8.27 (3 s. f.)	A1	cao	
			OR:			
			B to D: $\frac{1}{2}\times 10\times v^2-$ 1377.8 − 1372	M1	WE equation with at least one KE, ΔGPE and WD by friction terms, all of correct form	
			$=10\times 9.8\times 7-25\times 14$	M1	Use of WD = 14x	
				B1	x = 25	
				A1	Allow only sign errors	
			($v^2=68.36$)			
			so v = 8.2680… so 8.27 (3 s. f.)	A1	cao	
				[5]		

Question			Answer	Marks	Guidance
4	(a)	(iii)	Consider only the vertical motion. Suppose the object hits the ground at V m s^{-1} and rises h m		
			$V = \sqrt{2 \times 9.8 \times 7}$ (11.7) AND $\frac{1}{2}V = \sqrt{2 \times 9.8 \times h}$ (5.86)	M1	Use of $v^2 = 2gs$ oe Must be 7 in V. Using '8.27' as u gives M0
				M1	e used appropriately: must use their attempt at a vertical velocity
			so $h = ¼ \times 7 = 1.75$	A1	cao
					[Award SC 2 if 1.75 seen WWW]
				[3]	
4	(b)		Driving force (D) = $\frac{P}{50}$	B1	Use of P = force x velocity. May be implied e.g. by sight of 0.8P/50 or 0.2P/50 in N2L
			$P = 50F$ ($D = F$)	B1	Accept any form
			N2L along the road		
			$\frac{0.8P}{50} - F = 1500 \times -0.08$	M1	Use of N2L with all terms attempted and consistent with power reduction. Allow sign errors.
			so $0.8P - 50F = -6000$	A1	Accept any form
			Solving gives		
				M1	Attempt to solve 2 equations each involving P and F. Dependent on N2L equation attempted with 3 terms.
			$F = 600$ $P = 30\ 000$	A1	cao both
					[Taking 80% reduction in P gives P = 7500 and F = 150 for 5/6]
				[6]	

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 and the final part of the last question proved to be a stumbling-block for many, both because it was unusual and because of the time pressure.

As always, candidates should be encouraged to draw clear and labelled diagrams when appropriate, particularly 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 a clear diagram.

A particular issue revealed itself this session in the need for a clear use and understanding of notation. In Question 2(iv) many candidates used the letter F both to represent force in Newton's second law and to represent friction and almost invariably managed to confuse themselves. Similarly in Question 4(b), F was defined to be the resistance, but candidates chose also to use F as the total force in $F = ma$.

Comments on Individual Questions:

Question No. 1

Momentum and Impulse

(a)(i) Many candidates produced a diagram with the masses and velocities all marked clearly and these candidates usually scored full marks in the subsequent calculations. A significant minority of candidates, however, seemed to confuse themselves because of an unclear sign convention. Others made sign errors when writing down the conservation of linear momentum equation.

(a)(ii) Candidates had no problems in writing down the fact that the impulse was equal to the change of momentum, but relatively few scored both marks. A significant number of candidates calculated the impulse of Q on P, without realising that a sign change was required to obtain the requested impulse of P on Q.

(b)(i) Most candidates were able to form a pair of simultaneous equations based on motion parallel and perpendicular to the motion R. A very common error was a sign error in the second of these equations. Other errors resulted from mixing sine and cosine when resolving and from the omission of the masses in all or part of the conservation of momentum equations.

(b)(ii) Almost all candidates who had obtained values for u and v in part (i) were able to calculate the corresponding increase in kinetic energy.

Question No. 2

Centres of mass

(i) The vast majority of candidates were able to find the z-coordinate of the centre of mass of the box A. A few candidates chose to consider either a closed box or a bottomless box, even though the question gave two separate and clear indications that the box was open.

(ii) Many of the solutions to this part were of a high quality, with candidates presenting their work in a clear and concise way. Few candidates used symmetry to find the x-coordinate of the centre of mass of B, preferring instead to use a vector method to find all three coordinates.

(iii) Many candidates produced completely correct solutions using the geometry of the situation. A minority of candidates chose to take moments about the point of tipping, usually successfully.

(iv) A significant number of candidates confused the *F* in $F = ma$ with the frictional force *F* in $F = \mu R$ and this often led to the omission of any meaningful attempt at applying Newton's second law; it was also common to find *g* omitted from the reaction force *R*.

Question No. 3

Forces

(a) (i) This part was usually answered competently, with many candidates scoring the full four marks. The most common error was to ignore the fact that the length of BC was given in the question, as 2 metres. This omission led to some candidates either assuming the length of AB was 2 metres or guessing its value. In such cases, candidates were able to gain the remainder of the marks with accurate use of resolution of forces and/or taking moments.

(ii) Candidates were asked to show all of the forces acting on the pin-joints and most did so. Internal forces should be shown with a pair of arrows, either as a tension or a compression, and also with a label, for example, $T_{AB}, T_{BC},$ and T_{AC}, The external forces, *X*, *Y* and *R* needed to be shown, either as letters or with the values calculated in part (i).

(iii) Many candidates scored full marks in this part, offering accurate and concise solutions. Most errors that occurred were as a result of taking moments in directions other than horizontally and vertically. Less often, arithmetic and algebraic errors crept in when simplifying the moments equations.

(b) The two parts of this question were the least well done on the whole paper, with many errors in taking moments and also in understanding what was required in part (ii).

(i) Candidates needed to realise that B was the only sensible point about which to take moments. Almost all those who opted for taking moments about A, G or C omitted to include the force at the hinge at *B* and so made no creditable progress. Of those candidates who did take moments about *B*, a significant number made errors in identifying the correct distances for some of the moments and/or in confusing sine and cosine.

(ii) Very few candidates realised that $Q = P / \sin q$ and the majority simply repeated their work as in part (i), with all of its errors. Follow-through marks were awarded for Q, where possible. The majority of candidates did not attempt to find the force exerted on the rod by the hinge at B. Of those candidates who did make an attempt, most found only the component of the force at right angles to the rod. The simplest method of solution was to write down the horizontal and vertical components of this force ($(Q+102)$ N and *X* N and then use Pythagoras' theorem to find the magnitude of the total force.

Question No. 4

Work and Energy

(a) (i) The majority of candidates used an energy method, finding the kinetic energy at A (1378 J) and the potential energy at B (1372 J) and noting that the first exceeded the second. Other candidates calculated the speed of the object at B, noting that it was positive, or found the height at which the object would come to rest as 14.1 m, noting that it exceeded 14m.

(iii) Most candidates made a good attempt at calculating the work done, using the distance of 25 m correctly calculated by use of Pythagoras' theorem. They then wrote down a work-energy equation, enabling them to find a value for the required velocity of the object at D. Unfortunately, a significant number of candidates had wrong or missing terms in their equation, usually because of some confusion with their reference points. It was equally satisfactory to consider energy changes from A to C or from B to C, but not a mixture of the two.

(iv) Although some candidates grasped what was required in this part, and almost all of these candidates scored full marks, many other candidates seemed convinced that they had to use their answer to part (ii) in some way. The key point of understanding was to realise that the initial vertical velocity at D was zero. The speed with which the object reached the ground could then be found from a simple application of a suvat equation, with $u = 0$.

(b) Only a minority of candidates scored more than two of the six marks available in this part of the question. These two marks were awarded for the equation $P = 50F$. Most candidates struggled to find another equation involving P and F and many seemed confused about how to deal with the percentage reduction in the power. Candidates also confused the *F* in $F = ma$ with the resistance force *F* given in the question.
Having said this, some very neat and fully correct solutions were seen where candidates realised that 20% of the driving force was equal to the mass times the acceleration.

Unit level raw mark and UMS grade boundaries June 2014 series
AS GCE / Advanced GCE / AS GCE Double Award / Advanced GCE Double Award

GCE Mathematics (MEI)

		Max Mark	a	b	c	d	e	u
4751/01 (C1) MEI Introduction to Advanced Mathematics	Raw	72	61	56	51	46	42	0
	UMS	100	80	70	60	50	40	0
4752/01 (C2) MEI Concepts for Advanced Mathematics	Raw	72	57	51	45	39	33	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
4753 (C3) MEI Methods for Advanced Mathematics with Coursework	UMS	100	80	70	60	50	40	0
4754/01 (C4) MEI Applications of Advanced Mathematics	Raw	90	68	61	54	47	41	0
	UMS	100	80	70	60	50	40	0
4755/01 (FP1) MEI Further Concepts for Advanced Mathematics	Raw	72	63	57	51	45	40	0
	UMS	100	80	70	60	50	40	0
4756/01 (FP2) MEI Further Methods for Advanced Mathematics	Raw	72	60	54	48	42	36	0
	UMS	100	80	70	60	50	40	0
4757/01 (FP3) MEI Further Applications of Advanced Mathematics	Raw	72	57	51	45	39	34	0
	UMS	100	80	70	60	50	40	0
4758/01 (DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	63	56	50	44	37	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
4758 (DE) MEI Differential Equations with Coursework	UMS	100	80	70	60	50	40	0
4761/01 (M1) MEI Mechanics 1	Raw	72	57	49	41	34	27	0
	UMS	100	80	70	60	50	40	0
4762/01 (M2) MEI Mechanics 2	Raw	72	57	49	41	34	27	0
	UMS	100	80	70	60	50	40	0
4763/01 (M3) MEI Mechanics 3	Raw	72	55	48	42	36	30	0
	UMS	100	80	70	60	50	40	0
4764/01 (M4) MEI Mechanics 4	Raw	72	48	41	34	28	22	0
	UMS	100	80	70	60	50	40	0
4766/01 (S1) MEI Statistics 1	Raw	72	61	53	46	39	32	0
	UMS	100	80	70	60	50	40	0
4767/01 (S2) MEI Statistics 2	Raw	72	60	53	46	40	34	0
	UMS	100	80	70	60	50	40	0
4768/01 (S3) MEI Statistics 3	Raw	72	61	54	47	41	35	0
	UMS	100	80	70	60	50	40	0
4769/01 (S4) MEI Statistics 4	Raw	72	56	49	42	35	28	0
	UMS	100	80	70	60	50	40	0
4771/01 (D1) MEI Decision Mathematics 1	Raw	72	51	46	41	36	31	0
	UMS	100	80	70	60	50	40	0
4772/01 (D2) MEI Decision Mathematics 2	Raw	72	46	41	36	31	26	0
	UMS	100	80	70	60	50	40	0
4773/01 (DC) MEI Decision Mathematics Computation	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	54	48	43	38	32	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
4776 (NM) MEI Numerical Methods with Coursework	UMS	100	80	70	60	50	40	0
4777/01 (NC) MEI Numerical Computation	Raw	72	55	47	39	32	25	0
	UMS	100	80	70	60	50	40	0
4798/01 (FPT) Further Pure Mathematics with Technology	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 (Z1) Statistics 1	Raw	72	61	53	46	39	32	0
	UMS	100	80	70	60	50	40	0
G242/01 (Z2) Statistics 2	Raw	72	55	48	41	34	27	0
	UMS	100	80	70	60	50	40	0
G243/01 (Z3) Statistics 3	Raw	72	56	48	41	34	27	0
	UMS	100	80	70	60	50	40	0