OCR
RECOGNISING ACHIEVEMENT

Monday 10 June 2013 – 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 in the centre of 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)** In this part-question, all the objects move along the same straight line on a smooth horizontal plane. All their collisions are direct.

The masses of the objects P, Q and R and the initial velocities of P and Q (but not R) are shown in Fig. 1.1.

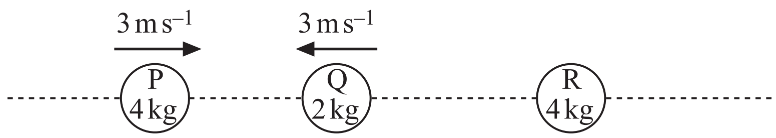

Fig. 1.1

A force of 21 N acts on P for 2 seconds in the direction PQ. P does not reach Q in this time.

(i) Calculate the speed of P after the 2 seconds. **[2]**

The force of 21 N is removed after the 2 seconds. When P collides with Q they stick together (coalesce) to form an object S of mass 6 kg.

(ii) Show that immediately after the collision S has a velocity of $8\,\text{m s}^{-1}$ towards R. **[2]**

The collision between S and R is elastic with coefficient of restitution $\frac{1}{4}$. After the collision, S has a velocity of $5\,\text{m s}^{-1}$ in the direction of its motion before the collision.

(iii) Find the velocities of R before and after the collision. **[6]**

(b) **In this part-question take $g = 10$.**

A particle of mass 0.2 kg is projected vertically downwards with initial speed $5\,\text{m s}^{-1}$ and it travels 10 m before colliding with a fixed smooth plane. The plane is inclined at α to the vertical where $\tan\alpha = \frac{3}{4}$. Immediately after its collision with the plane, the particle has a speed of $13\,\text{m s}^{-1}$. This information is shown in Fig. 1.2. Air resistance is negligible.

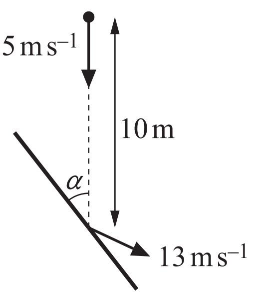

Fig. 1.2

(i) Calculate the angle between the direction of motion of the particle and the plane immediately after the collision.

Calculate also the coefficient of restitution in the collision. **[8]**

(ii) Calculate the magnitude of the impulse of the plane on the particle. **[2]**

2 A fairground ride consists of raising vertically a bench with people sitting on it, allowing the bench to drop and then bringing it to rest using brakes. Fig. 2 shows the bench and its supporting tower. The tower provides lifting and braking mechanisms. The resistances to motion are modelled as having a constant value of 400 N whenever the bench is moving up or down; the only other resistance to motion comes from the action of the brakes.

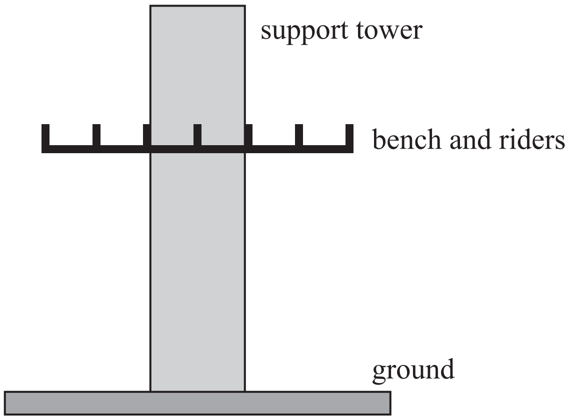

Fig. 2

On one occasion, the mass of the bench (with its riders) is 800 kg.

With the brakes not applied, the bench is lifted a distance of 6 m in 12 seconds. It starts from rest and ends at rest.

(i) Show that the work done in lifting the bench in this way is 49 440 J and calculate the average power required. **[4]**

For a short period while the bench is being lifted it has a constant speed of $0.55\,\mathrm{m\,s^{-1}}$.

(ii) Calculate the power required during this period. **[3]**

With neither the lifting mechanism nor the brakes applied, the bench is now released from rest and drops 3 m.

(iii) Using an energy method, calculate the speed of the bench when it has dropped 3 m. **[4]**

The brakes are now applied and they halve the speed of the bench while it falls a further 0.8 m.

(iv) Using an energy method, calculate the work done by the brakes. **[5]**

Turn over

3 Fig. 3.1 shows a rigid, thin, **non-uniform** 20 cm by 80 cm rectangular panel ABCD of weight 60 N that is in a vertical plane. Its dimensions and the position of its centre of mass, G, are shown in centimetres. The panel is free to rotate about a fixed horizontal axis through A perpendicular to its plane; the panel rests on a small smooth fixed peg at B positioned so that AB is at 40° to the horizontal. A horizontal force in the plane of ABCD of magnitude P N acts at D away from the panel.

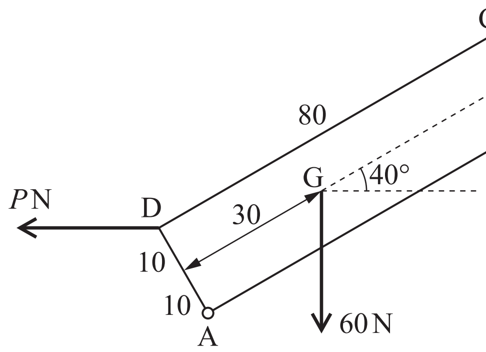

Fig. 3.1

(i) Show that the clockwise moment of the weight about A is 9.93 N m, correct to 3 significant figures. **[3]**

(ii) Calculate the value of P for which the panel is on the point of turning about the axis through A. **[2]**

(iii) In the situation where $P = 0$, calculate the vertical component of the force exerted on the panel by the axis through A. **[4]**

The panel is now placed on a line of greatest slope of a rough plane inclined at 40° to the horizontal. The panel is at all times in a vertical plane. A horizontal force in the plane ABCD of magnitude 200 N acts at D towards the panel. This situation is shown in Fig. 3.2.

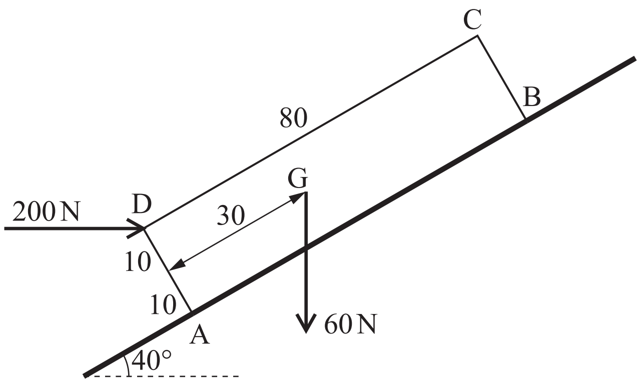

Fig. 3.2

(iv) Given that the panel is moving up the plane with acceleration up the plane of $1.75\,\mathrm{m\,s^{-2}}$, calculate the coefficient of friction between the panel and the plane. **[8]**

4 **(a)** Fig. 4.1 shows a framework constructed from 4 uniform heavy rigid rods OP, OQ, PR and RS, rigidly joined at O, P, Q, R and S and with OQ perpendicular to PR. Fig. 4.1 also shows the dimensions of the rods and axes Ox and Oy: the units are metres.

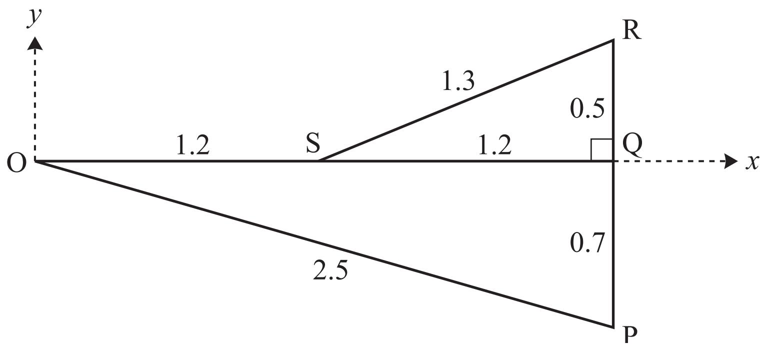

Fig. 4.1

Each rod has a mass of 0.8 kg per metre.

(i) Show that, referred to the axes in Fig. 4.1, the x-coordinate of the centre of mass of the framework is 1.5 and calculate the y-coordinate. **[5]**

The framework is freely suspended from S and a small object of mass m kg is attached to it at O. The framework is in equilibrium with OQ horizontal.

(ii) Calculate m. **[3]**

[Question 4 is continued overleaf.]

(b) Fig. 4.2 shows a framework in equilibrium in a vertical plane. The framework is made from 5 light, rigid rods OP, OQ, OR, PQ and QR. Its dimensions are indicated. PQ is horizontal and OR vertical.

The rods are freely pin-jointed to each other at O, P, Q and R. The pin-joint at O is fixed to a wall.

Fig. 4.2 also shows the external forces acting on the framework: there are vertical loads of 120 N and 60 N at Q and P respectively; a horizontal string attached to Q has tension T N; horizontal and vertical forces X N and Y N act on the framework from the pin-joint at O.

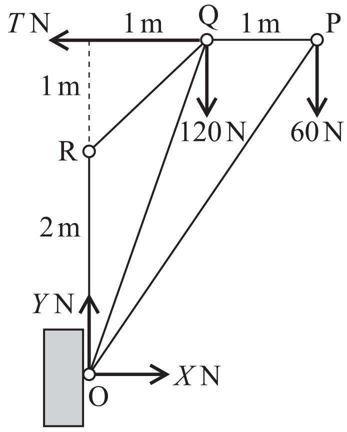

Fig. 4.2

(i) By considering only the pin-joint at R, explain why the rods OR and RQ must have zero internal force. **[2]**

(ii) Find the values of T, X and Y. **[3]**

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

(iv) Calculate the forces internal to the rods OP and PQ, stating whether each rod is in tension or compression (thrust). [You may leave answers in surd form. Your working in this part should correspond to your diagram in part **(iii)**.] **[5]**

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Monday 10 June 2013 – Morning

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4762/01 Mechanics 2

PRINTED ANSWER BOOK

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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

1 (a) (iii)	(continued)

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

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

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

2 (iii)	(continued)

2 (iv)	

3 (i)	
3 (ii)	

3 (iii)	

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

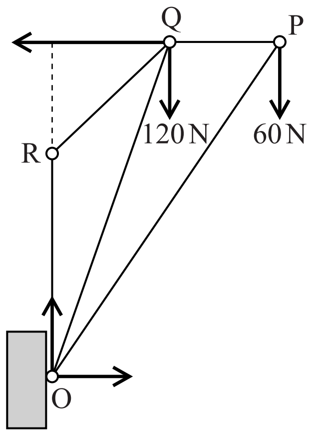
3 (iv)	**(continued)**
4 (a) (i)	
	(answer space continued on next page)

(answer space continued on next page)

4 (a) (i)	**(continued)**
4 (a) (ii)	

4 (b) (i)

4 (b) (ii)

4 (b) (iii)	
4 (b) (iv)	

(answer space continued on next page)

4 (b) (iv)	(continued)

RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

Unit **4762:** Mechanics 2

Mark Scheme for June 2013

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

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

a. Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c. The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

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

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper
Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper
Accept any answer that agrees with the correct value to 2 s.f.

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

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

There is no penalty for using a wrong value for *g*. E marks will be lost except when results agree to the accuracy required in the question.

g. Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h. For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

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

'Fresh starts' will not affect an earlier decision about a misread.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i. If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

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

Question			Answer	Marks	Guidance
1	(a)	(i)	$3 \times 4 + 21 \times 2 = 4U$ $4U = 54$ so $U = 13.5$ and speed is 13.5 m s^{-1} **OR** $21 = 4a : a = 5.25$ and $v = 3 + 2 \times 5.25$ speed is 13.5 m s^{-1}	M1 A1 **[2]** M1 A1 **[2]**	Use of PCLM and $I = Ft$ Use of $F = ma$ and *suvat*
1	(a)	(ii)	Let V be the speed of S in direction PQ $54 - 2 \times 3 = (4 + 2)V$ $6V = 48$ so $V = 8$ and velocity is 8 m s^{-1} in direction PQ	 M1 E1 **[2]**	 PCLM for coalescence Answer given. Accept no reference to direction.
1	(a)	(iii)	Let velocities of R be u before and v after, both in the direction SR $6 \times 8 + 4u = 6 \times 5 + 4v$ $v - u = 4.5$ $\frac{v-5}{u-8} = -\frac{1}{4}$ $4v + u = 28$ Solving $u = 2$ so 2 m s^{-1} in the direction SR $v = 6.5$ so 6.5 m s^{-1} in the direction SR	 M1 A1 M1 A1 A1 A1 **[6]**	 Use of PCLM. Allow any sign convention. All masses and speeds must be correct. Any form. Use of NEL correct way up; allow sign errors Any form signs consistent with PCLM eqn cao **NOTE that a sign error in NEL leads to *u* =-2; this gets A0** cao. Withhold only 1 of the final A marks if the directions not clear. Directions can be inferred from a CLEAR diagram

Question			Answer	Marks	Guidance
1	(b)	(i)	Find v, the speed at which particle hits the plane $\frac{1}{2} \times 0.2 \times v^2 - \frac{1}{2} \times 0.2 \times 5^2 = 0.2 \times 10 \times 10$ so $v^2 = 225$ and $v = 15$ $\cos\alpha = \frac{4}{5}$, $\sin\alpha = \frac{3}{5}$ Let velocity after be at β to the plane Parallel to the plane $15\cos\alpha = 13\cos\beta$ So $\cos\beta = \frac{12}{13}$ and $\beta = 22.61..$ so 22.6° (3 s. f.) Perpendicular to the plane: $13\sin\beta = e \times 15\sin\alpha$ $\sin\beta = \frac{5}{13}$ so $13 \times \frac{5}{13} = 15 \times \frac{3}{5} \times e$ and $e = \frac{5}{9}$	 M1 A1 B1 M1 A1 M1 A1 A1 **[8]**	 Use of WE or *suvat* must use distance of 10 allow $g = 9.8$ Answer not required ($v = 14.9$ if $g = 9.8$) Use of either expression or use of 36.9° Attempt to conserve velocity component parallel to plane. Allow use of 5 instead of 15 ($\beta = 23.8^\circ$ if $g = 9.8$) Attempt to use NEL perpendicular to plane: Allow use of 5 instead of 15 or use $\tan\beta = e\tan\alpha$ o.e. find $\tan\beta = \frac{5}{12}$ cao Accept 0.56 ($e = 0.589$ if $g = 9.8$)
			OR: First three marks as above Parallel to plane, $u_x = 15\cos\alpha (= 12)$ and $v_x = u_x (= 12)$ $\cos\beta = \frac{v_x}{v} = \frac{12}{13}$ $\beta = 22.6^\circ$ Perpendicular to plane, $u_y = 15\sin\alpha (= 9)$ and $v_y = eu_y (= 9e)$ $v_x^2 + v_y^2 = 13^2$ $12^2 + (9e)^2 = 13^2$ so $e^2 = \frac{25}{81}$ $e = \frac{5}{9}$	M1A1B1 M1 A1 M1 A1 A1 **[8]**	 Attempt to conserve velocity component parallel to plane. Allow use of 5 instead of 15 Attempt to use NEL perpendicular to plane. Allow use of 5 instead of 15 Use Pythagoras' theorem for velocities after collision in attempt to find e

Question			Answer	Marks	Guidance
1	(b)	(ii)	Impulse is perp to plane with mod $0.2(13\sin\beta-(-15\sin\alpha))$ = 0.2(5 – (– 9)) = 2.8 N s	 M1 A1 **[2]**	 For use of $I = m(v - u)$ perp to the plane 0.2(5-9) gets M1A0 cao
2	(i)		WD is 800 × 9.8 × 6 + 400 × 6 J = 49 440 Power is 49440 ÷ 12 = 4120 W	M1 E1 M1 A1 **[4]**	WD as *Fd* Used in TWO terms Power is WD / Δt cao
2	(ii)		Power is (800 × 9.8 + 400) × 0.55 = 4532 W	M1 A1 A1 **[3]**	Power as *Fv* in one term All correct cao
2	(iii)		Let speed be v $\frac{1}{2}\times 800v^2 = 800\times 9.8\times 3 - 400\times 3$ $v^2 = 55.8$ so v = 7.4699… and speed is 7.47 m s^{-1} (3 s.f.)	 M1 A1 A1 A1 **[4]**	 Use of W-E equation Must include KE and at least one WD term Allow only sign errors All correct SC: Use of N2L and *suvat* : M1 Complete method A1 7.47 cao
2	(iv)		$\frac{1}{2}\times 800\times\frac{v^2}{4} - \frac{1}{2}\times 800\times v^2$ = (800 × 9.8 – 400) × 0.8 – WD WD is 22 692 so 22 700 J (3 s. f.)	M1 B1 B1 A1 A1 **[5]**	Use of W-E equation Must include 2 KE terms and a WD term Final KE term correct. FT their v. One correct WD term All terms present. Allow sign errors and FT their v. cao SC Use of N2L and *suvat*: Award maximum of B1 for 'Average force (28365) x 0.8'

Question			Answer	Marks	Guidance
3	(i)		c.w. moments about A $60\cos 40 \times 0.3 - 60\sin 40 \times 0.1$ $=$ 9.93207… so 9.93 N m (3 s. f.)	M1 A1 E1 **[3]**	Condone using cm not m in moments in any part if consistent oe e.g. $60(0.3 - 0.1\tan 40)\sin 50$ or $60 \times \frac{1}{\sqrt{10}}\cos(90^\circ - \arctan 3 + 40^\circ)$ Method of dealing with moment of weight. Allow $\cos \leftrightarrow \sin$ Both weight terms correct. Allow wrong overall sign but not both terms with the same sign
3	(ii)		$P\cos 40 \times 0.2 - 9.93207... = 0$ P = 64.827… so 64.8 (3 s. f.)	M1 A1 **[2]**	Moments of all relevant forces attempted. No extra terms. Allow $\cos \leftrightarrow \sin$ cao (64.813… if 9.93 used)
3	(iii)		a.c. moments about A to find NR, R, at B $R \times 0.8 = 9.93$ or $R \times 0.8 + 60\sin 40 \times 0.1 - 60\cos 40 \times 0.3 = 0$ R = 12.4150… Resolve vertically Y – 60 + Rcos 40 = 0 so Y = 50.489… so 50.5 N (3 s. f.)	M1 A1 depM1 A1 **[4]**	Attempt to use moments to find R. Moments of all relevant forces attempted. No extra terms. Allow $\cos \leftrightarrow \sin$ Note that mmts about B can score M1 only if mmt of horiz compt of force at A is included. If R is taken as vertical, M0 FT their moment of weight from (i) Not a required answer Note that the second M mark awarded in this part must be for a complete method to find Y: FT their calculated R

Question			Answer	Marks	Guidance
3	(iv)		resolve perp to plane		
			$R - 60\cos 40 - 200\sin 40 = 0$	M1	All terms present and no extra terms. Components of 60 and 200; allow $\cos \leftrightarrow \sin$
				A1	
			R = 174.52…		Not a required answer
			N2L up the plane		
			$200\cos 40 - F - 60\sin 40 = \frac{60}{9.8} \times 1.75$	M1	Use of N2L with all terms present and no extras. Components of 60 and 200; allow $\cos \leftrightarrow \sin$ Allow use of 60 for mass
				B1	Use of mass not weight
				A1	FT use of weight and/or sign errors
			F = 103.927…	A1	All correct. Not a required answer
			As friction limiting $F = \mu R$ so		
			$\mu = \frac{103.927...}{174.520...}$	M1	FT their F and their R
			= 0.59550.. so 0.596 (3 s. f.)	A1	cao
				[8]	

Question			Answer	Marks	Guidance
4	(a)	(i)	Write d = 0.8		
			$(2.5+1.2+1.3+2.4)\times d\times\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}$	M1	Method for c.m (length is 7.4 m, mass is 5.92 kg)
			$=2.5d\begin{pmatrix}1.2\\ -0.35\end{pmatrix}+1.2d\begin{pmatrix}2.4\\ -0.1\end{pmatrix}+1.3d\begin{pmatrix}1.8\\ 0.25\end{pmatrix}+2.4d\begin{pmatrix}1.2\\ 0\end{pmatrix}$	B1	One rod mass and cpts correct or if done by separate x and y equations 2 rod components and masses correct. (Allow length used instead of mass)
			OR: $(2+0.96+1.04+1.92)\times\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}$		
			$=2\begin{pmatrix}1.2\\ -0.35\end{pmatrix}+0.96\begin{pmatrix}2.4\\ -0.1\end{pmatrix}+1.04\begin{pmatrix}1.8\\ 0.25\end{pmatrix}+1.92\begin{pmatrix}1.2\\ 0\end{pmatrix}$		
				B1	Another rod dealt with correctly or if done by separate x and y equations, the other equation attempted with 2 rod components and masses correct. (Allow length used instead of mass)
			$7.4\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=\begin{pmatrix}3+2.88+2.34+2.88\\ -0.875-0.12+0.325+0\end{pmatrix}=\begin{pmatrix}11.1\\ -0.67\end{pmatrix}$		
			OR:		
			$5.92\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=\begin{pmatrix}2.4+2.304+2.304+1.872\\ -0.7-0.096+0.26+0\end{pmatrix}=\begin{pmatrix}8.88\\ -0.536\end{pmatrix}$		
			$\bar{x}=1.5$	E1	Clearly shown, with at least one intermediate step
			$\bar{y}=-0.090540...$ = – 0.0905 (3 s. f.)	A1	Condone - 0.09
				[5]	

Question			Answer	Marks	Guidance
4	(a)	(ii)	EITHER: New c.m. has $\bar{x} = 1.2$ $(5.92 + m) \times 1.2 = 5.92 \times 1.5 + m \times 0$ $m = 1.48$	M1 M1 A1 **[3]**	Identifying and using a suitable condition. Complete method cao
			OR: Moment about any point is zero e.g. about S: $1.2mg = 0.3 \times 5.92g$ $m = 1.48$	M1 M1 A1 **[3]**	Identifying a suitable condition. Allow *g* omitted. Correct number of terms must be included cao
4	(b)	(i)	Consider the equilibrium at R Resolving horizontally gives $T_{QR} = 0$ Then resolving vertically gives $T_{OR} = 0$	E1 E1 **[2]**	
4	(b)	(ii)	c.w. moments about O $120 \times 1 + 60 \times 2 = 3T$ so $T = 80$ Resolve to give $X = 80$ and $Y = 180$	M1 A1 A1 **[3]**	May also be argued by first considering internal forces FT $X = T$. Only Y =180 scores 0
4	(b)	(iii)		B1 **[1]**	All correct. Accept *T*, *X* and *Y* labelled but not substituted. Accept mixes of T and C. Require pairs of arrows with label on OQ, OP and PQ.
4	(b)	(iv)	Take angle OPQ as α At P ↓ $60 + T_{OP} \sin\alpha = 0$ $\sin\alpha = \frac{3}{\sqrt{13}}$: $\alpha = 56.3°$ $T_{OP} = -\frac{60}{\sin\alpha} = -20\sqrt{13}$ so $20\sqrt{13}$ N (C) At P ← $T_{QP} + T_{OP}\cos\alpha = 0$ so $T_{QP} = 40$ so 40 N (T)	 M1 A1 A1 M1 A1 **[5]**	Forces internal to the rods have been taken to be tensions. Equilibrium at ANY pin-joint (not R) Correct equation(s) that leads directly to finding T_{OP} or T_{QP} o.e. Accept 72.1 N A second equilibrium equation leading to a second internal force cao T/C correct for both rods

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GCE

Mathematics (MEI)

Advanced GCE **A2 7895-8**

Advanced Subsidiary GCE **AS 3895-8**

OCR Report to Centres

June 2013

4762 Mechanics 2

General Comments

The performance of candidates on this paper was variable. On certain topics, such as centres of mass and collisions, solutions were of a high standard, demonstrating candidates' familiarity with the subject matter and ability to apply their knowledge to good effect. In the parts of questions that seemed less familiar, candidates fared less well. In many cases, a good clear diagram would have been an invaluable aid to potentially making meaningful progress, and would certainly have helped to eliminate sign errors.
There was evidence that candidates were finding the paper rather long and some of the more straightforward parts of Question 4 were omitted by a significant number of candidates.

Comments on Individual Questions

1) **Momentum and Impulse**

Part (a) was approached with confidence, and the majority of candidates showed that they knew the principles involved. Those who drew a clear diagram in part (iii) usually scored full marks, whereas those who did not make a clear statement, in a diagram or in words, frequently made sign and arithmetical errors. Part (b) was tackled with much less confidence. There were a pleasing number of excellent solutions, but about half of the candidates demonstrated a wide range of misconceptions about impulse when a smooth inclined plane is involved.

(a)(i) The vast majority of candidates used the principle of conservation of linear momentum together with the formula 'Impulse = Force x Time' and earned full marks. A minority of candidates opted to use Newton's second law and *suvat* as an alternative approach, and again were successful.

(a)(ii) Most candidates earned both marks and it was pleasing that they showed sufficient working to support the given answer.

(a)(iii) Almost all candidates knew that they were required to apply the principle of conservation of linear momentum and Newton's experimental law to the collision. However, many attempted to proceed without a diagram or a clear statement about which was the positive direction, and many sign errors appeared, particularly in the equation resulting from Newton's experimental law. Of those candidates who did have two correct linear simultaneous equations, many made arithmetic errors in solving them.

(b)(i) There were some excellent, concise solutions to this part, from about half of the candidates. The other half of the candidates seemed to have little idea about how to make any creditable progress. There were several common errors, with any individual candidate making one, some or all of them. Some did not take into account the motion of the particle before it collided with the plane and used the initial speed as the speed of contact. Some attempted to consider horizontal and vertical motion at the collision, rather than motion parallel and perpendicular to the plane. Some seemed confused about the direction in which momentum was conserved. Some brought the coefficient of restitution into the motion parallel to the plane. Some did not appreciate the vector nature of momentum and impulse and worked with 15 and 13 instead of the components of the velocities, with $e = \frac{13}{15}$ being a common incorrect answer.

(b)(ii) Again, candidates did not recognise the vector nature of the problem and it was rare to see a correct solution. The vast majority gave the impulse as $0.2(15 - 13)$, rather than considering the change in momentum perpendicular to the plane.

2) **Work, energy and power**

On the whole, candidates demonstrated that they have a grasp of the principles of work and energy, and most secured more than half of the available marks. The most common errors in each part were to omit one of the necessary terms and to work in an unstructured way that led to sign errors.

(i) The majority of candidates scored full marks, although a significant minority seemed not to realise that there were two separate parts to the request.

(ii) Again, many fully correct solutions. The most common error was to omit the weight and find the power required to overcome the resistance only.

(iii) Most candidates demonstrated that they understood how to set up a work-energy equation and many scored full marks. Common errors were to omit the resistance, even though it had been included correctly in part (ii) of the question, and sign errors.

(iv) The majority of candidates knew that the energy equation needed to involve kinetic energy terms and work done terms, but only a minority had a systematic approach that led them to the correct answer. Often, the terms were evaluated separately, and then put together into an equation in what appeared a random fashion, with sign errors prevalent. The work done against the resistance was omitted by many candidates.

3) **Forces and equilibrium**

The majority of candidates did not perform well on this question and did not appreciate the help that was available; for example, they did not realise that the given answer in part (i) was significant for a solution to part (ii). It was surprising, and disappointing, that so many candidates attempted to solve part (iii) without drawing a diagram. A clear diagram with all the relevant forces labelled is key to solving problems on equilibrium.

(i) Those candidates who split the 60N weight into two components were usually successful in achieving the given answer. Those who tried to find the perpendicular distance from A to the weight force often made trigonometrical mistakes and had to make dubious adjustments to reach the given answer. Candidates should be reminded that examiners check through all the working for consistency and, in the case of a given answer, need to be totally convinced by the candidate's working.

(ii) There were some good solutions to this part, but many candidates either did not see the relevance of part (i) or, having failed to complete part (i) successfully, did not even attempt part (ii).

(iii) This was the least well-attempted part of any question on this paper, with less than 10% of candidates scoring any marks at all. There were two common invalid assumptions: firstly, the assumption that the reaction at B was vertical and secondly, the assumption that there was only a vertical reaction force at A and no horizontal component of the force. It cannot be stressed enough that candidates need to draw a diagram when attempting equilibrium questions. A significant number of candidates proceeded without a diagram and most of these scored zero marks.

(iv) Most candidates were back on familiar territory here and knew the method of approach. The most common error was to use the weight as the mass in the equation for Newton's second law. Another common error was to ignore the component of the 200 N force when considering equilibrium perpendicular to the slope. Other candidates confused themselves by using the notation F to mean both the force in $F = ma$ and the frictional force.

4) **Centre of mass and light framework**

Candidates performed strongly in part (a) of this question, with some good well-presented solutions. Performance in part (b) was quite patchy, with evidence that some candidates were short of time and writing down what they could in the hope of securing some marks. Again, in part (iii) of part (b), candidates seemed reluctant to label a force diagram with all the relevant forces.

(a)(i) The majority of candidates made a good attempt at this part, with clearly presented solutions, identifying the masses and centres of mass of the individual rods before taking moments. Errors were usually due to an incorrect calculation of distances parallel to the x-axis or an omission of minus signs in some of the y distances.

(a)(ii) Most candidates had the idea that they needed to take moments, but there were many errors, either in identifying distances or in the omission of g from one side of the moments equation.

(b)(i) Only about one-quarter of the candidates were able to offer an acceptable explanation as to why the internal forces in OR and RQ must be zero. The most common attempts suggested simply that because the system was in equilibrium, the internal forces had to be zero. Those who resolved horizontally and vertically at R and wrote down equations were almost always successful.

(b)(ii) Candidates who took moments about O usually earned full marks, while those who did not, rarely made any progress.

(b)(iii) Few diagrams were completely labelled, showing both the external and internal forces.

(b)(iv) Many candidates did not attempt this part. Some appeared to have run out of time, others seemed to have given up because they could not do the earlier parts of the question. However, those who did attempt it usually did so with some success. Most were able to write down two relevant equilibrium equations, usually at P. Any errors were due to sign errors and/or a sine/cosine confusion.

Unit level raw mark and UMS grade boundaries June 2013 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	62	56	51	46	41	0
	UMS	100	80	70	60	50	40	0
4752/01 (C2) MEI Concepts for Advanced Mathematics	Raw	72	54	48	43	38	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	46	40	33	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	66	59	53	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	61	54	48	42	36	0
	UMS	100	80	70	60	50	40	0
4757/01 (FP3) MEI Further Applications of Advanced Mathematics	Raw	72	60	52	44	36	28	0
	UMS	100	80	70	60	50	40	0
4758/01 (DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	62	56	51	46	40	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	33	25	0
	UMS	100	80	70	60	50	40	0
4762/01 (M2) MEI Mechanics 2	Raw	72	50	43	36	29	22	0
	UMS	100	80	70	60	50	40	0
4763/01 (M3) MEI Mechanics 3	Raw	72	64	56	48	41	34	0
	UMS	100	80	70	60	50	40	0
4764/01 (M4) MEI Mechanics 4	Raw	72	56	49	42	35	29	0
	UMS	100	80	70	60	50	40	0
4766/01 (S1) MEI Statistics 1	Raw	72	55	48	41	35	29	0
	UMS	100	80	70	60	50	40	0
4767/01 (S2) MEI Statistics 2	Raw	72	58	52	46	41	36	0
	UMS	100	80	70	60	50	40	0
4768/01 (S3) MEI Statistics 3	Raw	72	61	55	49	44	39	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	58	52	46	40	35	0
	UMS	100	80	70	60	50	40	0
4772/01 (D2) MEI Decision Mathematics 2	Raw	72	58	52	46	41	36	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	56	50	44	38	31	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	55	48	41	35	29	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