OCR
RECOGNISING ACHIEVEMENT

Friday 13 January 2012 – Morning

A2 GCE MATHEMATICS (MEI)

4762 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

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

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

4733250112

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.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\text{m}\,\text{s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

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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 **12** 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 bus of mass 8 tonnes is driven up a hill on a straight road. On one part of the hill, the power of the driving force on the bus is constant at 20 kW for one minute.

(i) Calculate how much work is done by the driving force in this time. **[2]**

During this minute the speed of the bus increases from $8\,\mathrm{m\,s^{-1}}$ to $12\,\mathrm{m\,s^{-1}}$ and, in addition to the work done against gravity, 125 000 J of work is done against the resistance to motion of the bus parallel to the slope.

(ii) Calculate the change in the kinetic energy of the bus. **[3]**

(iii) Calculate the vertical displacement of the bus. **[4]**

On another stretch of the road, a driving force of power 26 kW is required to propel the bus up a slope of angle θ to the horizontal at a constant speed of $6.5\,\mathrm{m\,s^{-1}}$, against a resistance to motion of 225 N parallel to the slope.

(iv) Calculate the angle θ. **[6]**

The bus later travels up the same slope of angle θ to the horizontal at the same constant speed of $6.5\,\mathrm{m\,s^{-1}}$ but now against a resistance to motion of 155 N parallel to the slope.

(v) Calculate the power of the driving force on the bus. **[2]**

2 The shaded region shown in Fig. 2.1 is cut from a sheet of thin rigid uniform metal; LBCK and EFHI are rectangles; EF is perpendicular to CK. The dimensions shown in the figure are in centimetres. The Oy and Oz axes are also shown.

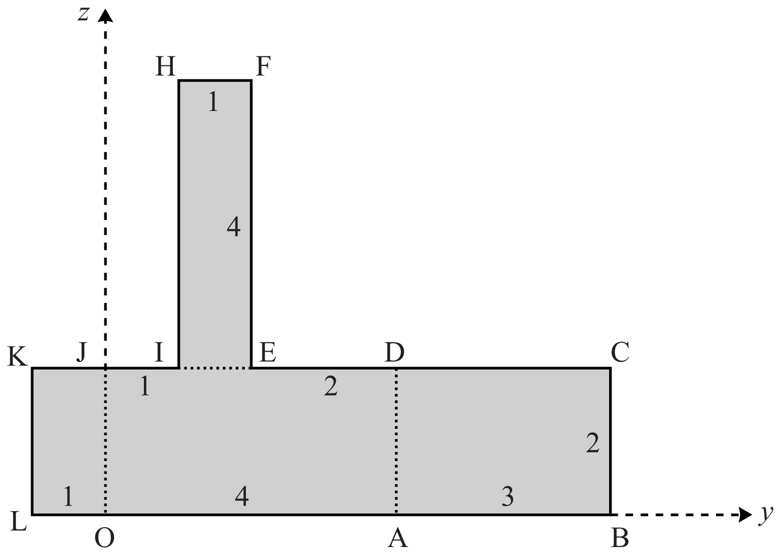

Fig. 2.1

(i) Calculate the coordinates of the centre of mass of the metal shape referred to the axes shown in Fig. 2.1. **[4]**

The metal shape is freely suspended from the point H and hangs in equilibrium.

(ii) Calculate the angle that HI makes with the vertical. **[4]**

The metal shape is now folded along OJ, AD and EI to give the object shown in Fig. 2.2; LOJK, ABCD and IEFH are all perpendicular to OADJ; LOJK and ABCD are on one side of OADJ and IEFH is on the other side of it.

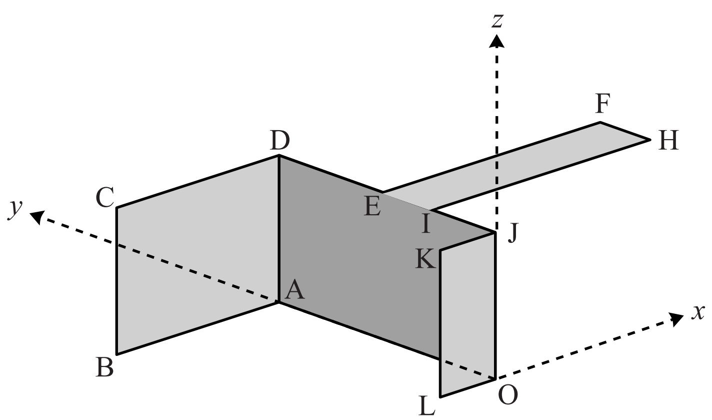

Fig. 2.2

(iii) Referred to the axes shown in Fig. 2.2, show that the x-coordinate of the centre of mass of the object is -0.1 and find the other two coordinates of the centre of mass. **[6]**

The object is placed on a rough inclined plane with LOAB in contact with the plane. OL is parallel to a line of greatest slope of the plane with L higher than O. The object does not slip but is on the point of tipping about the edge OA.

(iv) Calculate the angle of OL to the horizontal. **[4]**

  Turn over

3 A thin rigid non-uniform beam AB of length 6 m has weight 800 N. Its centre of mass, G, is 2 m from B.

Initially the beam is horizontal and in equilibrium when supported by a small round peg at C, 1 m from A, and a light vertical wire at B. This situation is shown in Fig. 3.1 where the lengths are in metres.

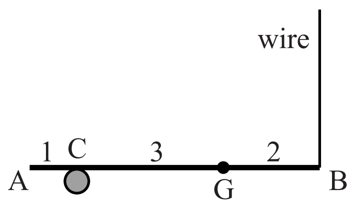

Fig. 3.1

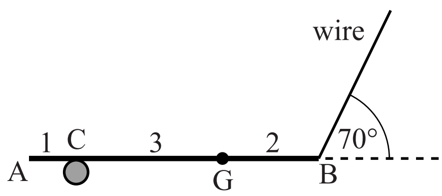

Fig. 3.2

(i) Calculate the tension in the wire and the normal reaction of the peg on the beam. **[4]**

The beam is now held horizontal and in equilibrium with the wire at 70° to the horizontal, as shown in Fig. 3.2. The peg at C is rough and still supports the beam 1 m from A. The beam is on the point of slipping.

(ii) Calculate the new tension in the wire.

Calculate also the coefficient of friction between the peg and the beam. **[7]**

The beam is now held in equilibrium at 30° to the vertical with the wire at $\theta°$ to the beam, as shown in Fig. 3.3. A new small **smooth** peg now makes contact with the beam at C, still 1 m from A. The tension in the wire is now T N.

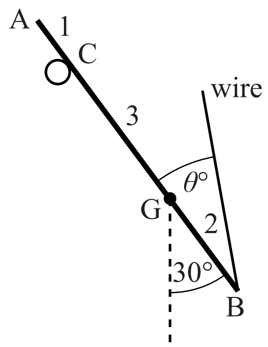

Fig. 3.3

(iii) By taking moments about C, resolving in a suitable direction and obtaining two equations in terms of θ and T, or otherwise, calculate θ and T. **[7]**

4 **(a)** A large nail of mass 0.02 kg has been driven a short distance horizontally into a fixed block of wood, as shown in Fig. 4.1, and is to be driven horizontally further into the block. The wood produces a constant resistance of 2.43 N to the motion of the nail. The situation is modelled by assuming that linear momentum is conserved when the nail is struck, that all the impacts with the nail are direct and that the head of the nail never reaches the wood.

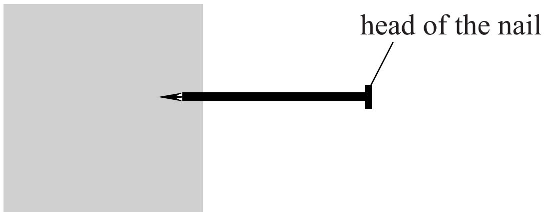

Fig. 4.1

The nail is first struck by an object of mass 0.1 kg that is moving parallel to the nail with linear momentum of magnitude 0.108 N s. The object becomes firmly attached to the nail.

(i) Calculate the speed of the nail and object immediately after the impact. **[2]**

(ii) Calculate the time for which the nail and object move, and the distance they travel in that time. **[4]**

On a second attempt to drive in the nail, it is struck by the same object of mass 0.1 kg moving parallel to the nail with the same linear momentum of magnitude 0.108 N s. This time the object does not become attached to the nail and after the contact is still moving parallel to the nail. The coefficient of restitution in the impact is $\frac{1}{3}$.

(iii) Calculate the speed of the nail immediately after this impact. **[6]**

(b) A small ball slides on a smooth horizontal plane and bounces off a smooth straight vertical wall. The speed of the ball is u before the impact and, as shown in Fig. 4.2, the impact turns the path of the ball through 90°. The coefficient of restitution in the collision between the ball and the wall is e. Before the collision, the path is inclined at α to the wall.

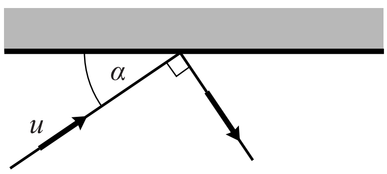

Fig. 4.2

(i) Write down, in terms of u, e and α, the components of the velocity of the ball parallel and perpendicular to the wall before and after the impact. **[3]**

(ii) Show that $\tan \alpha = \dfrac{1}{\sqrt{e}}$. **[3]**

(iii) Hence show that $\alpha \geqslant 45°$. **[1]**

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4762 Mechanics 2

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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1 (i)	
1 (ii)	
1 (iii)	

1 (iv)	
1 (v)	

2 (i)	
2 (ii)	

2 (iii)	
2 (iv)	

3 (i)	
3 (ii)	

3 (iii)	

4(a)(i)	
4(a)(ii)	

4(a)(iii)	

4 (b)(i)

4 (b)(ii)	

4(b)(iii)	

RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

Unit **4762:** Mechanics 2

Mark Scheme for January 2012

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Any enquiries about publications should be addressed to:

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Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

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

a Annotations should be used whenever appropriate during your marking.

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

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

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

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

c The following types of marks are available.

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

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

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

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

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

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

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

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

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

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

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

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

ft should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination.

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.

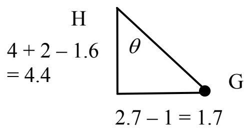
'Fresh starts' will not affect an earlier decision about a misread.

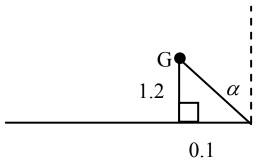
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

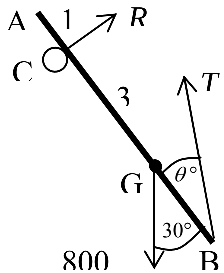
i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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.

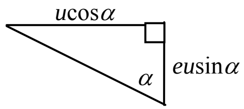
Question			Answer	Marks	Guidance
1					In this question, penalise use of 8 instead of 8000 only in (ii) and final mark in each of (iv) and (v)
1	(i)		$20\,000 \times 60$ $= 1\,200\,000$ J (1.2 MJ)	M1 A1 [2]	Use of $WD = Pt$. Allow use of 1 for 60 and 20 for 20 000 isw
1	(ii)		$\frac{1}{2} \times 8000 \times (12^2 - 8^2)$ $= 4000 \times 80 = 320\,000$ J (increase)	M1 B1 A1 [3]	Use of difference of non-zero KE terms ONLY Use of 8000 cao Neglect reference to increase.
1	(iii)		$1\,200\,000 = 320\,000 + 125\,000 + 8000 \times 9.8 \times h$ $h = 9.63010\ldots$ so 9.63 m (3 s.f.)	M1 B1 A1 A1 [4]	Use of W - E. Must include their (i), PE and at least one other term (KE terms count as one) Use of *mgh* Award for *g* written instead of 9.8 All terms present and correct. Accept sign errors cao
1	(iv)		$P = Fv$ so $26\,000 = 6.5F$ and $F = 4000$ Using N2L $4000 - 8000 \times 9.8 \times \sin\theta - 225 = 0$ $\theta = 2.759888\ldots$ so 2.76° with the horizontal	M1 A1 M1 A1 B1 A1 [6]	Use of $P = Fv$ All terms present. No extras. Allow sign errors; allow $\sin \leftrightarrow \cos$ All correct; allow missing g in weight term weight term correct cao
1	(v)		EITHER $26\,000 + (155 - 225) \times 6.5$ $= 25\,545$ W	M1 A1 [2]	
			OR $(8000g\sin\theta + 155) \times 6.5$ $= 25\,545$ W	M1 A1 [2]	Allow only sign errors

Question			Answer	Marks	Guidance
2	(i)		$20\begin{pmatrix}\bar{y}\\ \bar{z}\end{pmatrix}=16\begin{pmatrix}3\\1\end{pmatrix}+4\begin{pmatrix}1.5\\4\end{pmatrix}$	M1	A systematic method for at least 1 cpt
				A1	*Either* all *y* or all *z* values correct *or* 1 vector term correct
			so $20\begin{pmatrix}\bar{y}\\ \bar{z}\end{pmatrix}=\begin{pmatrix}54\\32\end{pmatrix}$		Need not be explicit
			Hence $\bar{y}=2.7$	A1	
			and $\bar{z}=1.6$	A1 [4]	Allow FT for either if only error is common
2	(ii)				
				M1	Identifying correct angle. May be implied
				B1	At least 1 relevant distance found. FT (i)
			$\tan\theta=\frac{1.7}{4.4}$	M1	Use of arctan **their** $\frac{1.7}{4.4}$ or $\frac{4.4}{1.7}$ o.e.
			so $\theta=21.1247\ldots$ so 21.1° (3 s.f.)	A1 [4]	cao
2	(iii)		$20\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix}=4\begin{pmatrix}2\\1.5\\2\end{pmatrix}+2\begin{pmatrix}-0.5\\0\\1\end{pmatrix}+6\begin{pmatrix}-1.5\\4\\1\end{pmatrix}+8\begin{pmatrix}0\\2\\1\end{pmatrix}$	M1	A systematic method for at least 1 cpt
				A1	*Either* all *x* or all *y* or all *z* values correct *or* 2 vector terms correct on RHS
				A1	Completely correct expressions seen for all components
			$20\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix}=\begin{pmatrix}-2\\46\\24\end{pmatrix}$		Need not be explicit
			Hence $\bar{x}=-0.1$	E1	
			$\bar{y}=2.3$	A1	
			and $\bar{z}=1.2$	A1 [6]	

Question			Answer	Marks	Guidance
2	(iv)		Let c.m. be at G To be on point of tipping G is vert above OA  For G to reach the vertical the bracket must rotate through α where $\alpha = \arctan \frac{0.1}{1.2}$ so angle is 4.76324… so 4.76° (3 s.f.)	 B1 B1 M1 A1 [4]	 May be implied Appropriate lengths found. FT (iii). Use of arctan **their** $\frac{0.1}{1.2}$ or $\frac{1.2}{0.1}$ o.e. or take moments for component parts cao Note that 85.24 will get 3/4
3	(i)		In these solutions R N is reaction at peg and T N the tension in the string a.c. moments about C $5T - 3\times 800 = 0$ so $T = 480$. Tension is 480 N $\uparrow\ T + R - 800 = 0$ so $R = 320$. Normal reaction is 320 N	 M1 A1 M1 F1 [4]	 Moments with all forces present May take moments again
3	(ii)		a.c. moments about C $5T\sin 70 - 3 \times 800 = 0$ so $T = 510.80533\ldots$ so 511 N (3 s.f.) $R = 320$ Friction is $F \leftarrow$ $\leftarrow\ F - T\cos 70 = 0$ (so $F = 174.7057\ldots$) $\mu = \frac{F_{max}}{R}$ $= \frac{174.7057\ldots}{320} = 0.54595\ldots$ so 0.546 (3 s.f.)	 M1 A1 B1 M1 A1 M1 A1 [7]	 Attempt at moments with resolution. All forces present. Could use (i) Accept WW. May derive again. Resolve horizontally; allow $\sin \leftrightarrow \cos$ Correct expression seen cao

Question			Answer	Marks	Guidance
3	(iii)		 a.c. moments about C		
			$5 \times T\sin\theta - 3 \times 800\sin 30 = 0$	M1	Attempt at moments: requires at least T or 800 resolved
			so $T\sin\theta = 240$	A1	Any form
			up the beam		
			$T\cos\theta - 800\cos 30 = 0$	M1	Attempt at resolution or moments to establish a second equation in T and θ
			so $T\cos\theta = 400\sqrt{3}$	A1	Any form
			Dividing		
			$\tan\theta = 0.3464101\ldots$	M1	Dependent on at least one of previous M1's being earned
			so $T = 733.212111$ so 733 (3 s. f.)	A1	cao
			so $\theta = 19.1066\ldots$ so 19.1 (3 s.f.)	A1	FT
					[Award 1st of θ and T found cao and 2nd FT]
			alternative method		
			Use of concurrence to find θ	M1	A clear attempt
				A1	A clear diagram showing *R,T and W*
				M1	Indicating all the required values and the correct angle
			$\theta = 19.1066\ldots$so 19.1 (3 s.f.)	A1	
			Finding an equation connecting T and θ	M1	Attempt at moments or resolution
				A1	Any form
			$T = 733.212111$ so 733 (3 s.f.)	F1	
				[7]	
4	(a)	(i)	$(0.02 + 0.1)V = 0.108$	M1	PCLM: must be sum of masses on lhs
			so $V = 0.9$ and speed is 0.9 m s^{-1}	A1	Accept no direction given
				[2]	

Question			Answer	Marks	Guidance
4	(a)	(ii)	**method 1**		
			$2.43t = 0.108$	M1	Equate given LM to impulse of the resistance
			$t = \frac{2}{45}$ so $\frac{2}{45}$ s [0.0444 (3 s.f.)]	A1	0.04 gets A0
			Acceleration constant so	M1	Using $s = 0.5(u+v)t$ or use W-E
			$s = \frac{1}{2}\times(0.9+0)\times\frac{2}{45} = 0.02$ so 0.02 m	A1	
					[Could use both W-E and I-M in either order or either with *suvat* for M1A1]
			method 2		
			N2L $\leftarrow$: $-2.43 = 0.12a$		Use N2L to find acceleration
			$a = -20.25$		
					Whichever of t and s found first, FT to second calculation; also FT a
			$0.9 = 20.25t$	M1	Using (N2L and) *suvat*
			time is $\frac{2}{45}$ s [0.0444 (3 s.f.)]	A1	Accept sign errors
			$s = \frac{1}{2}\times(0.9+0)\times\frac{2}{45}$	M1	Using (N2L and) *suvat*
			distance is 0.02 m	A1	Accept sign errors
				[4]	
4	(a)	(iii)	Speed of object is 0.108/0.1 so 1.08 m s^{-1}	B1	
			take +ve $\leftarrow$		
			PCLM		
			$0.108 = 0.02v_N + 0.1\,v_O$	M1	PCLM
				A1	Any form
			NEL		
			$\frac{v_N - v_O}{0-1.08} = -\frac{1}{3}$	M1	Fraction must be correct way up
				F1	Any form. FT their 1.08
			Solving for v_N: $v_N = 1.2$ so 1.2 m s^{-1}	A1	cao. Accept no direction
				[6]	

Question			Answer	Marks	Guidance
4	(b)	(i)	Up and towards plane +ve Before parallel: $u\cos\alpha$; perp: $u\sin\alpha$ After parallel: $u\cos\alpha$ perp: $-eu\sin\alpha$	B1 B1 B1 [3]	Both FT FT (direction must be clearly indicated: a diagram with correct arrows is sufficient)
4	(b)	(ii)	vel cpts after impact  $\tan\alpha = \frac{u\cos\alpha}{eu\sin\alpha}$ $\tan\alpha = \frac{1}{e\tan\alpha} \Rightarrow \tan^2\alpha = \frac{1}{e} \Rightarrow \tan\alpha = \frac{1}{\sqrt{e}}$	M1 A1 E1 [3]	Any relevant argument: position of α o.e. must be explicit o.e.
4	(b)	(iii)	$e \le 1 \Rightarrow \tan\alpha \ge 1 \Rightarrow \alpha \ge 45°$	E1 [1]	Convincing argument with no errors seen

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General Comments

Candidates found this paper to be very accessible and many scored well on the majority of the questions. The presentation of the responses was, in general, of a pleasingly good standard. As always, it is important to stress the need for clear and labelled diagrams, particularly when dealing with forces. Armed with a good diagram, the evidence suggests that a candidate is more likely to achieve accuracy.

Comments on Individual Questions

1 This question tested an understanding of work, energy and power and it was pleasing to see that most candidates demonstrated a working knowledge of the principles and methods involved. In some cases, there was some confusion with the given units, but most handled successfully the necessary conversion to standard units.

1 (i) The vast majority of candidates scored full marks on this question and it was pleasing to note how competently the mix of units was handled.

1 (ii) Again, this was well-answered. A minority of candidates did not appreciate that a mass of 8 tonnes is equivalent to 8000 kg.

1 (iii) A common error in the application of the work-energy equation was the omission of the work done by the driving force on the bus, calculated in part (i).

1 (iv) About two thirds of candidates scored full marks on this response, offering solutions which indicated a good understanding of the principles involved. For the remaining candidates, the most common error was the omission of g in the weight term when applying Newton's second law of motion. The successful solutions almost invariably used $P = Fv$ followed by Newton's second law of motion. Those candidates who attempted to combine the two stages in a single expression, often seemed to confuse themselves.

1 (v) The majority of candidates realised that the total force was the sum of the weight component parallel to the slope and the new resistance to motion. No marks were earned until this sum was multiplied by the constant speed. A minority of candidates did not attempt this essential multiplication and offered the total force as the answer for the power.

2 The standard of the presentation of the solutions to this question on centres of mass was pleasingly high. Candidates have learned to set out their calculations in a way which enables them to work through methodically and, usually, accurately. This sound approach enabled them to be unfazed by the three-dimensional shape configured in part (iii).

2 (i) The vast majority of candidates scored full marks on this question. In the work of the other candidates, there was almost always the loss of a single mark resulting from a miscalculation in one of the co-ordinates of the centre of mass of one of the component parts.

2 (ii) Most candidates showed that they understood which angle was needed and many correctly calculated its value. The common error was a miscalculation of one of the lengths in the right angled triangle being used.

2 (iii) As in part (i), solutions were usually very well-presented and accurate. Errors were minor slips in calculations within the application of a known method.

2 (iv) Again, many candidates had a clear vision of the triangle needed to calculate the required angle and did so with brevity. Others seemed to struggle with identifying the angle, a minority drawing very complicated three-dimensional diagrams that did not seem to help them. A minority of candidates made little or no attempt at any calculation.

3 Most candidates scored well on this question, with many aided by clear diagrams with labelled forces. In part (iii), there was evidence of some candidates trying to merge the methods of resolution and of taking moments.

3 (i) Almost all candidates used resolution and the principle of moments to secure full marks.

3 (ii) Many candidates scored full marks. Other candidates did not realise that the reaction at the peg was unchanged from part (i).

3 (iii) There were some excellent concise solutions to this part of the question. Some candidates, however, seem to believe that there are two moments equations, one horizontal and one vertical, about a single point. Forces were resolved and then each component used in a moments equation, in what appeared to be a merging of resolution and moments ideas. Other candidates were not able to make good use of the instruction in the question that they should resolve in a *suitable* direction. Unnecessarily, the reaction at the peg was introduced into the mix.

4 This was the least well-answered question on the paper, with part (b) being a source of few marks for many candidates. Unsurprisingly, working in the general case, rather than with particular numerical values, proved more challenging for many.

4 (a) (i) This was usually well-answered, although there was, at times, confusion between velocity and linear momentum.

4 (ii) The response to this part of the question was mixed in quality. The preferred method was to use Newton's second law of motion to find the acceleration, and then use the *suvat* equations to find time and distance. For some, the confusion between velocity and linear momentum continued. A surprising number of candidates, having found the acceleration correctly, then assumed zero acceleration and used 'distance equals speed times time.'

4 (iii) Candidates demonstrated their knowledge of Newton's experimental law and the principle of conservation of linear momentum, but often their efforts were hindered by algebraic or arithmetical inaccuracies.

4 (b) (i) Most candidates were able to write down the components of the speed of the ball before and after the collision with the wall, but many did not assign the appropriate, or indeed any, direction to these components.

4 (ii) This was the least well-answered part of the whole paper. The common response was to fill the page with spurious equations relating speeds and angles. The key was to note the deflection through 90° and use this to find an expression for $\tan\alpha$.

4 (iii) Most candidates found this final mark on the paper difficult to gain. A coherent and convincing argument for the given result was required, and not often seen. A significant minority of candidates substituted particular numerical values and hoped that this was sufficient to prove the general case.

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