Mark Scheme (Results)

October 2024

Pearson Edexcel International Advanced Level
In Mechanics M2 (WME02)
Paper 01

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

October 2024
Question Paper Log Number P76182A
Publications Code WME02_01_2410_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:
   - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
     - In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation, e.g., resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc. The following criteria are usually applied to the equation:
       - To earn the M mark, the equation
         - should have the correct number of terms
         - be dimensionally correct, i.e. all the terms need to be dimensionally correct

       e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
     - For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.
     - M marks are sometimes dependent (DM) on previous M marks having been earned, e.g., when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.
   - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
   - **B** marks are unconditional accuracy marks (independent of M marks)

   Marks should not be subdivided.

3. General Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:
   - bod – benefit of doubt
   - ft – follow through
     - the symbol √ ill be used for correct ft
   - cao – correct answer only
   - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC – special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent

- indep – independent
- dp – decimal places
- sf – significant figures
- ∗ – The answer is printed on the paper or ag- answer given
- ⌐ or d… – The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

Omission or extra g in a resolution is an accuracy error not method error.

Omission of mass from a resolution is a method error.

Omission of a length from a moments equation is a method error.

Omission of units or incorrect units is not (usually) counted as an accuracy error.

DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

Use of g = 9.81 should be penalised once per (complete) question.

N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.

Marks must be entered in the same order as they appear on the mark scheme.

In all cases, if the candidate clearly labels their working under a particular part of a question, e.g., (a) or (b) or (c), then that working can only score marks for that part of the question.

Accept column vectors in all cases.

Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Mechanics Abbreviations

M(A) Taking moments about A
N2L Newton's Second Law (Equation of Motion)
NEL Newton's Experimental Law (Newton's Law of Impact)
HL Hooke's Law
SHM Simple harmonic motion
PCLM Principle of conservation of linear momentum
RHS Right hand side
LHS Left hand side

Question	Scheme	Marks
1(a)	Use $\mathbf{r} = \int \mathbf{v}\,\mathrm{d}t$	M1
	Correct integration Eg $\left(t^3 + 6t^2 + 12t\right)\mathbf{i} + \left(\frac{5}{3}t^3 + 5t^2\right)\mathbf{j} + (\mathbf{C})$ Or $(t+2)^3\,\mathbf{i} + \left(\frac{5}{3}t^3 + 5t^2\right)\mathbf{j} + (K)$	A1
	Complete method using $t = 0, \mathbf{r} = -30\mathbf{i} - 45\mathbf{j}$ (m) and substitute $t = 3$ Indefinite integration Use of $t = 0, \mathbf{r} = -30\mathbf{i} - 45\mathbf{j}$ (m) to find constant of integration and substitute $t = 3$. Definite integration Use of $\mathbf{r} = \left(-30\mathbf{i} - 45\mathbf{j}\right) + \int_0^3 \mathbf{v}\,\mathrm{d}t$	DM1
	$\mathbf{r} = 87\mathbf{i} + 45\mathbf{j}$ (m)	A1
		(4)
1(b)	Use $\mathbf{a} = \frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t}$	M1
	Correct differentiation $\mathbf{a} = \left(6t + 12\right)\mathbf{i} + \left(10t + 10\right)\mathbf{j}$	A1
	Substitute $t = 3$ and find magnitude	DM1
	$\lvert\mathbf{a}\rvert = 50\left(\mathrm{m\,s^{-2}}\right)$	A1
		(4)
1(c)	$3(T+2)^2 = 10T(T+2)$ $\left(3T + 6 = 10T\right) \quad \left(7T^2 + 8T - 12 = 0\right)$	M1
	$T = \frac{6}{7}$	A1
		(2)
		(10)
	Notes	
1(a)		
M1	Integrate to obtain **r**. Powers increase by 1 in both components. Condone working with separated components. Condone missing brackets with **i-j** notation. M0 for *suvat.*	
A1	Correct integration. Condone missing constant of integration.	
DM1	• Dependent on the preceding M1. • Must have a constant of integration before using $t = 3$ (unless using definite integration) • Must use $\left(-30\mathbf{i} - 45\mathbf{j}\right)$ • Must substitute $t = 3$ Condone working with separated components. DM0 if substitution of $t = 3$ occurs before finding + C.	

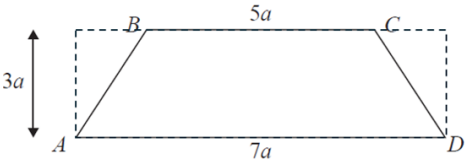
	$\left(t^3+6t^2+12t-30\right)\mathbf{i}+\left(\frac{5}{3}t^3+5t^2-45\right)\mathbf{j}$ $\quad C=\left(-30\mathbf{i}-45\mathbf{j}\right)$ $\left(\left(t+2\right)^3-38\right)\mathbf{i}+\left(\frac{5}{3}t^3+5t^2-45\right)\mathbf{j}$ $\quad K=\left(-38\mathbf{i}-45\mathbf{j}\right)$	
A1	Correct answer, accept column vector $\begin{pmatrix}87\\45\end{pmatrix}$ A0 for poor notation in final answer eg $\begin{pmatrix}87\mathbf{i}\\45\mathbf{j}\end{pmatrix}$ ISW if they continue and find |**r**|	
1(b)		
M1	Differentiate to obtain **a**. Powers decrease by 1 in both components. Condone working with separated components and missing brackets with **i**-**j** notation. M0 for *suvat*	
A1	Correct differentiation	
M1	Dependent on the preceding M1 Use of Pythagoras seen or implied $\sqrt{30^2+40^2}$	
A1	Correct only	
1(c)		
M1	Correct method using the ratio of **i** and **j** components of **v**. Form an equation in T only. Accept working in t or T.	
A1	0.86 or better. Condone t instead of T.	

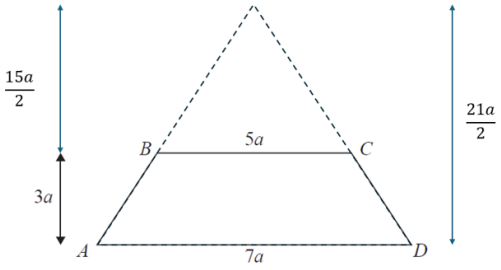
Question	Scheme	Marks
2	Use of Impulse momentum equation	M1
	$\mathbf{I} = 3(x\mathbf{i} + y\mathbf{j}) - 3\times 5\mathbf{i}$ $\left(= 3(x-5)\mathbf{i} + 3y\mathbf{j}\right)$	A1
	$\lvert I\rvert^2 = 9\left((x-5)^2 + y^2\right) = 9\times 82\ (=738)$	M1
	Equation for change in KE	M1
	$\frac{1}{2}\times 3\left(x^2 + y^2 - 25\right) = 138$ $\left(x^2 + y^2 - 25 = 92\right)$	A1
	$(x-5)^2 + y^2 = 82$ $x^2 + y^2 = 117 \ \Rightarrow 10x = 60$	DM1
	$\mathbf{v} = 6\mathbf{i} + 9\mathbf{j}\left(\text{m s}^{-1}\right)$	A1
		(7)
ALT	Use of $I = \begin{pmatrix} 3\sqrt{82}\cos\theta \\ 3\sqrt{82}\sin\theta \end{pmatrix}$ $I = \begin{pmatrix} 3\sqrt{82}\cos\theta \\ 3\sqrt{82}\sin\theta \end{pmatrix} = 3\begin{pmatrix} x \\ y \end{pmatrix} - 3\begin{pmatrix} 5 \\ 0 \end{pmatrix}$	M1 A1
	$\lvert I\rvert^2 = 9\left((x-5)^2 + y^2\right) = 9\times 82$	M1
	Equation for change in KE $\frac{1}{2}\times 3\left(x^2 + y^2 - 25\right) = 138$	M1 A1
	Leads to $\theta = 83.66...$ $x = 5 + 3\sqrt{82}\cos\theta = 6$ $y = 3\sqrt{82}\sin\theta = 9$ $\mathbf{v} = 6\mathbf{i} + 9\mathbf{j}\left(\text{m s}^{-1}\right)$	DM1 A1
	Notes	
M1	Find the difference in momenta. Dimensionally correct. Condone subtraction in wrong order. Must use both components. (Ignore $3\sqrt{82}$ if it appears on LHS)	
A1	Correct unsimplified expression for difference in momentum. Condone subtraction the wrong way round.	
M1	Correct use of Pythagoras with $3\sqrt{82}$ and both components of impulse. Ignore poor **i**-**j** notation, eg $\mathbf{i}^2$ for this mark, if recovered by correct subsequent working.	
M1	Use change in KE to produce an equation in terms of x and y. Dimensionally correct, requires 2 KE terms of correct structure. Condone subtraction in wrong order. Ignore poor **i**-**j** notation eg $(x\mathbf{i})^2 + (y\mathbf{j})^2$ for this mark, if recovered by correct subsequent working.	

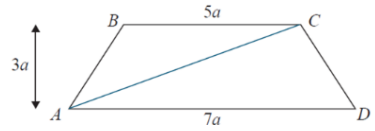
	M0 For use of velocity.	
A1	Correct unsimplified equation A0 for incorrect notation. A0 for subtraction the wrong way round.	
DM1	Dependent on all preceding M marks. Solve for x or y	
A1	Correct velocity only. Accept column vector. ISW if continue to find speed.	

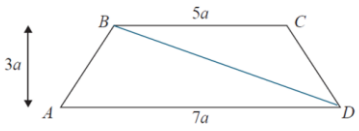
Question	Scheme	Marks
3(a)	Equation of motion for whole system.	M1
	$F - 640 - 1100g\sin\alpha = 1100a$	A1 A1
	Use of $P=Fv$ $\quad F = \frac{15000}{12}\left(=1250\right)$	M1
	$a = 0.16\left(\text{m s}^{-2}\right)$ or $a = 0.163\left(\text{m s}^{-2}\right)$	A1
		(5)
3(b)	Work-energy equation for the trailer.	M1
	$\frac{1}{2}\times 200\times 14^2 = 240d + 200g\times\frac{1}{25}d$	A1 A1
	$\left(AB=\right)62\left(\text{m}\right)$ or $\left(AB=\right)61.6\left(\text{m}\right)$	A1
		(4)
		(9)
	Notes	
3(a)		
	Over-accuracy or under-accuracy is penalised max **once** per complete question. Penalise final A mark in the appropriate part. Use of g = 9.81 or 10 is penalised max **once** per complete question. Penalise final A mark in the appropriate part. If both errors occur, could lose the final two A marks.	
M1	Equation of motion for whole system. All terms required. Dimensionally correct. Condone sign errors and sin/cos confusion. May form two equations of motion (van and trailer) and combine to eliminate *T*. Condone slip with zeroes for M mark. The forces on the LHS must be consistent with the mass in the '*ma*'. Note that $\sin\left(\frac{1}{25}\right)$ is an accuracy error, **not** a method error.	
A1	Unsimplified equation in *F* or *P* with at most one error. Missing *g* from both weight terms counts as 1 error.	
A1	Correct unsimplified equation in *F* or *P*	
M1	Use of $P = Fv$. Condone slip with zeroes for M mark.	
A1	Correct answer, 2 sf or 3 sf.	
3(b)		
M1	Work-energy equation. Condone slip with zeroes for M mark. Dimensionally correct, all terms required and with correct structure: KE, GPE, WD. No repeats. Must use mass of trailer only. Condone sign errors and sin / cos confusion. M0 for *suvat*. Note that $\sin\left(\frac{1}{25}\right)$ is an accuracy error, **not** a method error.	
A1	Unsimplified equation with at most one error.	
A1	Correct unsimplified equation with mass replaced.	
A1	Correct answer, 2 sf or 3 sf No need for *AB* =	

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>
<table>
<tr><td></td><td>Rectangle</td><td>2 x Triangle</td><td>Trapezium</td></tr>
<tr><td>Mass</td><td>$15a^2$</td><td>$2\times\frac{3}{2}a^2$</td><td>$18a^2$</td></tr>
<tr><td>From AD</td><td>$\frac{3}{2}a$</td><td>a</td><td>d</td></tr>
</table>
</td><td>B1

B1</td></tr>
<tr><td></td><td>Some examples of alternatives
 



<table>
<tr><td></td><td>Large rectangle</td><td>2 removed triangles</td><td>Trapezium</td></tr>
<tr><td>Mass</td><td>$21a^2$</td><td>$2\times\frac{3a\times a}{2}$</td><td>$18a^2$</td></tr>
<tr><td>Distance from AD</td><td>$\frac{3a}{2}$</td><td>$\frac{2}{3}\times 3a = 2a$</td><td>$d$</td></tr>
</table>
<table>
<tr><td></td><td>Large triangle</td><td>Removed triangle</td><td>Trapezium</td></tr>
<tr><td>Mass</td><td>$\frac{147a^2}{4}$</td><td>$\frac{75a^2}{4}$</td><td>$18a^2$</td></tr>
<tr><td>Distance from AD</td><td>$\frac{1}{3}\times\frac{21a}{2}=\frac{7a}{2}$</td><td>$3a+\frac{1}{3}\times\frac{15a}{2}=\frac{11a}{2}$</td><td>$d$</td></tr>
</table>




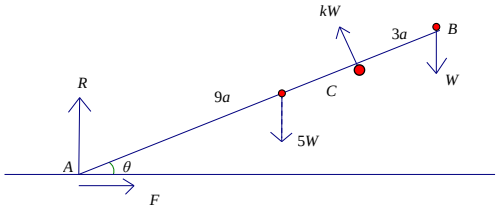
<table>
<tr><td></td><td>Triangle ABC</td><td>Triangle ACD</td><td>Trapezium</td></tr>
<tr><td>Mass</td><td>$\frac{5a\times 3a}{2}=\frac{15}{2}a^2$</td><td>$\frac{7a\times 3a}{2}=\frac{21}{2}a^2$</td><td>$18a^2$</td></tr>
<tr><td>Distance from AD</td><td>$\frac{2}{3}\times 3a = 2a$</td><td>$\frac{1}{3}\times 3a = a$</td><td>$d$</td></tr>
</table>
<table>
<tr><td></td><td>Triangle ABD</td><td>Triangle ACD</td><td>Trapezium</td></tr>
<tr><td>Mass</td><td>$\frac{7a\times 3a}{2}=\frac{21}{2}a^2$</td><td>$\frac{5a\times 3a}{2}=\frac{15}{2}a^2$</td><td>$18a^2$</td></tr>
<tr><td>Distance from AD</td><td>$\frac{1}{3}\times 3a = a$</td><td>$\frac{2}{3}\times 3a = 2a$</td><td>$d$</td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td>Moments about AD</td><td>M1</td></tr>
<tr><td></td><td>$15a^2\times\frac{3}{2}a+3a^2\times a=18a^2d$</td><td>A1</td></tr>
<tr><td></td><td>$\frac{51}{2}a=18d\Rightarrow d=\frac{17a}{12}$ *</td><td>A1*</td></tr>
<tr><td></td><td></td><td>(5)</td></tr>
<tr><td>4(b)</td><td>$\bar{x}=\frac{9}{2}a$</td><td>B1</td></tr>
<tr><td></td><td>Moments about PS or a parallel axis for Lamina</td><td>M1</td></tr>
<tr><td></td><td>From PS: $27a^2\bar{y}=45a^2\times 2.5a-18a^2\left(a+\frac{17}{12}a\right)$

From AD: $27a^2\bar{Y}=45a^2\times 1.5a-18a^2\left(\frac{17}{12}a\right)$</td><td>A1
A1</td></tr>
<tr><td></td><td>$\bar{y}=\frac{69}{27}a=\frac{23}{9}a$</td><td>A1</td></tr>
<tr><td></td><td>Expression for relevant angle</td><td>M1</td></tr>
</table>

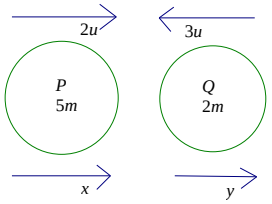
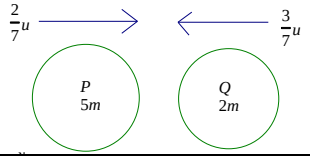
	$\tan\theta° = \frac{\bar{y}}{"\left(9a/2\right)"} \quad \left(=\frac{46}{81}\right)$	
	$\theta = 29.6$	A1
		(7)
		(12)
	Notes	
4(a)		
B1	Correct mass ratio.	
B1	Correct distances from *AD*, for an appropriate division of *ABCD* Distances may be measured from a parallel axis	
M1	Dimensionally consistent equation with all required terms. Accept working from a parallel axis. Accept an equation embedded in vector form.	
A1	Correct unsimplified equation. Accept embedded in vector form.	
A1*	Obtain given answer from correct working. Working must include simplification or rearrangement (may be seen from table to equation). Answer must be extracted from vector form and have *d* =	
4(b)		
B1	Distance of c of m of lamina from *PQ* seen or implied. May not be seen until the trig ratio.	
M1	Complete method to find c of m of Lamina (remaining mass) from *PS* or a parallel axis. Dimensionally consistent equation containing all required terms. If one distance is from *PS* and the other is from *AD*, treat as an accuracy error.	
A1	Unsimplified equation for *PS* or their parallel axis, with at most one error	
A1	Correct unsimplified equation for *PS* or their parallel axis.	
A1	Correct distance of c of m from *PS*, $2.6a$ or better	
M1	Correct use of trig for a relevant angle where $"\left(9a/2\right)"$ is their distance of the c of m of the lamina from *PQ* and $\bar{y}$ is their **calculated** distance from *PS*. Allow with both *a*'s or neither. Allow reciprocal.	
A1	30 or better (29.59229…) cao	

Question	Scheme	Marks
5(a)	Horizontal motion to find expression for the distance	M1
	$(XY =) u\cos\theta t$	A1
	Method using vertical motion to find relevant equation in t, u, g, θ. Eg • Using vertical distance $= 0$ to find expression for time. • Find expression for time to max height and $\times 2$	M1
	Correct unsimplified equation in t, u, g, θ. $u\sin\theta t - \frac{1}{2}gt^2 = 0$	A1
	Solve to obtain the distance in terms of u, g and θ	DM1
	$XY = u\cos\theta \times \frac{2u\sin\theta}{g} = \frac{u^2\sin 2\theta}{g}$ *	A1*
		(6)
5(b)	$CB = \frac{20^2 \times \sin 120°}{g} - 12$	M1
	$CB = 23(\text{m})$ or $CB = 23.3(\text{m})$	A1
		(2)
5(c)	Horizontal motion	M1
	$12 = 20\cos 60° t$	A1
	Vertical motion $y = 20\sin 60° \times 1.2 - \frac{1}{2} \times g \times 1.2^2 (-5)$	M1
	Height above D = $8.7(\text{m})$ or $8.73(\text{m})$	A1
		(4)
		(12)
	Notes	
	Over-accuracy or under-accuracy is penalised max **once** per complete question. Penalise final A mark in the appropriate part. Use of g = 9.81 or 10 is penalised max **once** per complete question. Penalise final A mark in the appropriate part. If both errors occur they could lose the final two A marks.	
5(a)		
M1	Use horizontal motion to find an expression for the horizontal distance.	
A1	Correct unsimplified equation.	
M1	Method using vertical motion with relevant *suvat* to find an equation in t, u, g, θ (condone use of 9.8). M0 if $t = \frac{2u\sin\theta}{g}$ or $t = \frac{u\sin\theta}{g}$ is quoted (ie if it appears without any evidence of method)	
A1	Correct equation, (condone use of 9.8) Eg • $u\sin\theta t - \frac{1}{2}gt^2 = 0$	

	• $-u\sin\theta = u\sin\theta - gt$ • $u\sin\theta - gt = 0$ double the time.	
DM1	Dependent on the preceding M marks. Solve to obtain the distance in terms of u, g and θ.	
A1*	Obtain given answer from correct working. Must recover g if 9.8 is used. Must have $XY =$ at this stage.	
5(b)		
M1	Complete method using result in (a), or using horizontal motion from first principles, to find the horizontal distance *CB*.	
A1	Correct answer, 2sf or 3sf	
5(c)		
M1	Complete method for horizontal motion to obtain an equation in t. If t =1.2 o.e. is seen in earlier working, it must be used in (c) to earn the marks.	
A1	Correct unsimplified equation (t = 1.2)	
M1	Method using *suvat* with vertical motion to obtain a relevant vertical distance. Height of pole not required.	
A1	Correct answer, 2 sf or 3 sf	

Question	Scheme	Marks
6(a)		
	Moments about A	M1
	$5W\times 6a\cos\theta + W\times 12a\cos\theta = 9akW$ $\left(30\times\frac{12}{13}+12\times\frac{12}{13}=9k\right)$	A1 A1
	$\Rightarrow k=\frac{56}{13}$ *	A1*
		(4)
6(b)	First relevant equation	M1
	Correct unsimplified equation Relevant equations: • Vert: $R+kW\cos\theta = 6W$ $\left(R=\frac{342}{169}W\right)$ • Horiz: $F = kW\sin\theta$ $\left(F=\frac{280}{169}W\right)$ • // to AB: $F\cos\theta + R\sin\theta = 6W\sin\theta$ • Perp to AB: $kW + R\cos\theta = 6W\cos\theta + F\sin\theta$ • M(G): $R\cos\theta\times 6a + W\cos\theta\times 6a = F\sin\theta\times 6a + kW\times 3a$ • M(C): $W\cos\theta\times 3a + R\cos\theta\times 9a = 5W\cos\theta\times 3a + F\sin\theta\times 9a$ • M(B): $kW\times 3a + R\cos\theta\times 12a = 5W\cos\theta\times 6a + F\sin\theta\times 12a$	A1
	Second relevant equation	M1
	Correct unsimplified equation	A1
	Use of $F=\mu R$ to form an equation in μ only	DM1
	$\mu=\frac{280}{342}\left(=\frac{140}{171}\right)=0.8187....$	A1
		(6)
		(10)
	Notes	
	Note that an extra g in a resolution or moments equation is an accuracy error and not a method error.	
6(a)		
M1	Complete method eg moments about A. All required terms present and no extra. Dimensionally correct, product of perpendicular force and distance (a and W present throughout). Condone sign errors and sin/cos confusion. Condone R_c (or similar) instead of kW.	
A1	Unsimplified equation with at most one error	
A1	Correct unsimplified equation	
A1*	Obtain given answer from correct working. Trig replaced and R_c (or similar) replaced in terms of k. At least one line of working required	

	between the equation and the given answer. Do not accept embedded value for *k*.	
6(b)		
M1	First relevant equation. All required terms present and no extra. Dimensionally consistent. Condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation. Trig does not need to be replaced. Condone R_c (or similar) instead of kW.	
M1	Second relevant equation. To be relevant it must be possible to use with the first equation to find μ (at least one equation must be a horizontal, vertical, parallel or perpendicular resolution). All required terms present and no extra. Dimensionally consistent. Condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation. Trig does not need to be replaced. Condone R_c (or similar) instead of kW.	
DM1	Depending on the two previous M marks. Use of $F = \mu R$ to reach $\mu = \ldots$	
A1	$\frac{280}{342}\left(=\frac{140}{171}\right) = 0.8187....$ Accept 0.82 or better	

Question	Scheme	Marks
		
7(a)	CLM	M1
	$10mu-6mu=5mx+2my$ $\left(4u=5x+2y\right)$	A1
	Impact law	M1
	$y-x=5ue$	A1
	$4u=5x+2x+10ue\left(=7x+10ue\right)$	DM1
	$(x>0\Rightarrow)\ 10ue<4u$	DM1
	$\Rightarrow 0\text{ ,, }\ e<\frac{2}{5}$ o.e.	A1
		(7)
7(b)	Impulse momentum equation	M1
	$\frac{60}{7}mu=2m\left(3u-\left(-y\right)\right)$ or $-\frac{60}{7}mu=5m\left(x-2u\right)$	A1
	Solve to find a correct expression for either x or y $\left(y=\frac{9}{7}u\ ,\ x=\frac{2}{7}u\text{ but may not be seen explicitly}\right)$	DM1
	Use both impulse equations and impact law with their x **and** y to form an equation in e (and u). $5ue=\frac{9}{7}u-\frac{2}{7}u$ Using CLM and impact law from part (a) to form an equation in e (and u). For example $\frac{2u}{7}=\frac{4u-10eu}{7}$	M1
	$e=\frac{1}{5u}\left(\frac{9}{7}u-\frac{2}{7}u\right)=\frac{1}{5}$ *	A1*
		(5)
7(c)		
	Speed of $Q=\frac{1}{3}\times\frac{9}{7}u\ \left(=\frac{3}{7}u\right)$	B1ft
	Magnitude of impulse = $\frac{1}{7}\times\frac{60}{7}mu$	M1
	$=\frac{60}{49}mu$	A1

		(3)
		(15)
	Notes	
7(a)		
M1	Form CLM equation. All terms required. Mass and velocity correctly paired. Dimensionally consistent, condone consistent additional g in each term. Condone sign errors.	
A1	Correct equation or equivalent. Condone consistent additional g in each term. Condone $\pm y$.	
M1	Use Impact Law. Dimensionally correct. Used the right way round (separation and approach must not be interchanged). Condone sign errors.	
A1	Correct equation or equivalent. Directions of P and Q after impact must be consistent with CLM.	
DM1	Dependent on the preceding M marks. Eliminate velocity of Q to form an equation in x, e and u only. $\left(x = \frac{4u - 10eu}{7}\right)$	
DM1	Dependent on all preceding M marks. May be implied by $e < 0.4$ Use direction of P to form an inequality in e (and u). Use correct inequality for their diagram: if they had P changing direction should now be using $x < 0$	
A1	Both ends required 0 „ $e < 0.4$ but condone $0 < e < 0.4$	
7(b)		
M1	Impulse-momentum equation. Dimensionally correct, using the correct mass and velocity pair for a single particle. Must be subtracting momenta but allow incorrect order. May use working in terms of e from (a) $x = \frac{4u - 10eu}{7}$ $y = \frac{25eu + 4u}{7}$	
A1	At least one correct unsimplified equation.	
DM1	Solve impulse-momentum equation to find either $y = \frac{9}{7}u$ or $x = \frac{2}{7}u$	
M1	Complete method to form an equation in e (and u) only with the usual rules for CLM and Impact Law.	
A1*	Obtain given answer from complete and correct working. A0 for 0.2	
7(c)		
B1	Follow $\frac{1}{3} \times$ their y from part (b). If y is given in terms of e then $e = \frac{1}{5}$ must be substituted at some point. Seen or implied. May appear on diagram. Accept $\pm$.	

M1	Complete method using (a) and (b) and working from first principles to find the impulse in the second collision between *P* and *Q*. Must see: • Usual rules for CLM and Impact Law to **find** V_p or V_q after second collision. CLM $\frac{10mu}{7}-\frac{6mu}{7}=5mV_p+2mV_q$ Impact Law $\frac{1}{5}\times\left(\frac{2u}{7}+\frac{3u}{7}\right)=V_q-V_p$ • **Then** use of Impulse – momentum equation with usual rules to find magnitude of impulse. Impulse – momentum Either $I=2m\left(\frac{9u}{49}--\frac{3u}{7}\right)$ or $I=5m\left(\frac{2u}{49}-\frac{2u}{7}\right)$	
A1	1.2*mu* or better (1.2244897…)	

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom