Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number

Candidate Number

Mechanics M2

Advanced/Advanced Subsidiary

Friday 17 June 2016 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6678/01

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided *– there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for each question are shown in brackets *– use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

1. A particle P moves along a straight line. The speed of P at time t seconds ($t \geq 0$) is v m s^{-1}, where $v = (pt^2 + qt + r)$ and p, q and r are constants. When $t = 2$ the speed of P has its minimum value. When $t = 0$, $v = 11$ and when $t = 2$, $v = 3$.

Find

(a) the acceleration of P when $t = 3$,

(8)

(b) the distance travelled by P in the third second of the motion.

(5)

(Total 13 marks)

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2. A car of mass 800 kg is moving on a straight road which is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{20}$. The resistance to the motion of the car from non-gravitational forces is modelled as a constant force of magnitude R newtons. When the car is moving up the road at a constant speed of 12.5 m s^{-1}, the engine of the car is working at a constant rate of $3P$ watts. When the car is moving down the road at a constant speed of 12.5 m s^{-1}, the engine of the car is working at a constant rate of P watts.

(a) Find

(i) the value of P,

(ii) the value of R.

(6)

When the car is moving up the road at 12.5 m s^{-1} the engine is switched off and the car comes to rest, without braking, in a distance d metres. The resistance to the motion of the car from non-gravitational forces is still modelled as a constant force of magnitude R newtons.

(b) Use the work-energy principle to find the value of d.

(4)

(Total 10 marks)

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3. A particle of mass 0.6 kg is moving with constant velocity ($c\mathbf{i} + 2c\mathbf{j}$) m s^{-1}, where c is a positive constant. The particle receives an impulse of magnitude $2\sqrt{10}$ N s.

Immediately after receiving the impulse the particle has velocity ($2c\mathbf{i} - c\mathbf{j}$) m s^{-1}.

Find the value of c.

(6)

(Total 6 marks)

4.

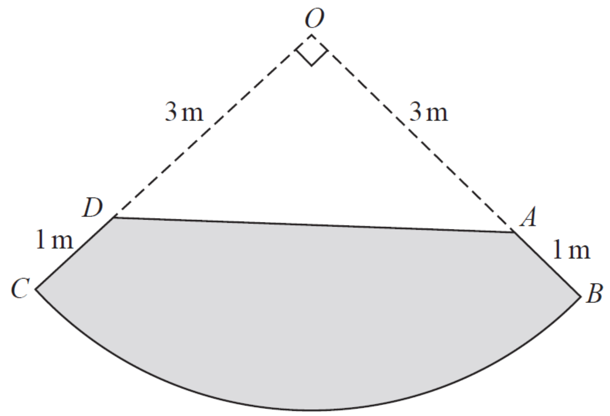


Figure 1

The uniform lamina *OBC* is one quarter of a circular disc with centre *O* and radius 4 m. The points *A* and *D*, on *OB* and *OC* respectively, are 3m from *O*. The uniform lamina *ABCD*, shown shaded in Figure 1, is formed by removing the triangle *OAD* from *OBC*.

Given that the centre of mass of one quarter of a uniform circular disc of radius *r* is at a distance $\frac{4\sqrt{2}}{3\pi}r$ from the centre of the disc,

(*a*) find the distance of the centre of mass of the lamina *ABCD* from *AD*.

(5)

The lamina is freely suspended from *D* and hangs in equilibrium.

(*b*) Find, to the nearest degree, the angle between *DC* and the downward vertical.

(4)

(Total 9 marks)

5.

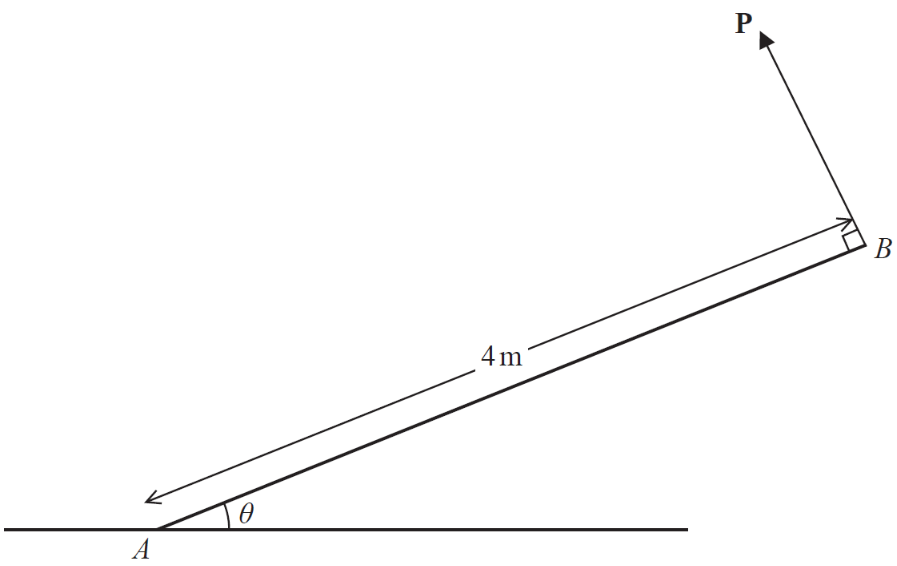


Figure 2

A non-uniform rod *AB*, of mass 5 kg and length 4 m, rests with one end *A* on rough horizontal ground. The centre of mass of the rod is *d* metres from *A*. The rod is held in limiting equilibrium at an angle θ to the horizontal by a force **P**, which acts in a direction perpendicular to the rod at *B*, as shown in Figure 2. The line of action of **P** lies in the same vertical plane as the rod.

(*a*) Find, in terms of *d*, *g* and θ,

(i) the magnitude of the vertical component of the force exerted on the rod by the ground,

(ii) the magnitude of the friction force acting on the rod at *A*.

(8)

Given that $\tan\theta = \frac{5}{12}$ and that the coefficient of friction between the rod and the ground is $\frac{1}{2}$,

(*b*) find the value of *d*.

(4)

(Total 12 marks)

6. [*In this question,* **i** *is a horizontal unit vector and* **j** *is an upward vertical unit vector*.]

A particle P is projected from a fixed origin O with velocity $(3\mathbf{i} + 4\mathbf{j})$ m s^{-1}. The particle moves freely under gravity and passes through the point A with position vector $\lambda(\mathbf{i} - \mathbf{j})$ m, where λ is a positive constant.

(*a*) Find the value of λ.

(6)

(*b*) Find

(i) the speed of P at the instant when it passes through A,

(ii) the direction of motion of P at the instant when it passes through A.

(7)

(Total 13 marks)

---

7. Two particles A and B, of mass $2m$ and $3m$ respectively, are initially at rest on a smooth horizontal surface. Particle A is projected with speed $3u$ towards B. Particle A collides directly with particle B. The coefficient of restitution between A and B is $\frac{3}{4}$.

(*a*) Find

(i) the speed of A immediately after the collision,

(ii) the speed of B immediately after the collision.

(7)

After the collision B hits a fixed smooth vertical wall and rebounds. The wall is perpendicular to the direction of motion of B. The coefficient of restitution between B and the wall is e. The magnitude of the impulse received by B when it hits the wall is $\frac{27}{4}mu$.

(*b*) Find the value of e.

(3)

(*c*) Determine whether there is a further collision between A and B after B rebounds from the wall.

(2)

(Total 12 marks)

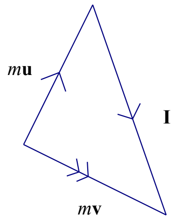
TOTAL FOR PAPER: 75 MARKS

Q	Scheme	Marks	Notes
1a	$t=0,\ v=11\ \Rightarrow r=11$	B1	
	$t=2,\ v=3\ \Rightarrow 4p+2q+11=3,$	M1	Accept $4p+2q+r=3$
	$4p+2q=-8$	A1	Any equivalent unsimplified form with 11 used
	Differentiate to find acceleration	M1	OR use symmetry, $t=4, v=11$
	$a=2pt+q$	A1	$\Rightarrow 11=16p+4q+11$, $4p+q=0$
	$t=2,\ a=0\ \Rightarrow 4p+q=0$	DM1	2nd eqn in p & q and solve for p & q Dependent on both previous m marks
	$\Rightarrow -q+2q=-8,\ q=-8,\ p=2$	A1	
	$\left(v=2t^2-8t+11\right)$		
	$t=3,\ a=4t-8=4\,(\text{ms}^{-2})$	A1	
		(8)	
1a alt	Min speed at $t=2\ \Rightarrow$ $v=\left(pt^2+qt+r\right)=k\left(t-2\right)^2+c$	B1	
		M1	Completed square form.
	$v=k\left(t-2\right)^2+3$	A1	Correct completed square form
	$t=0,\ v=11\ \Rightarrow 4k+3=11,$	M1	Solve for k
	$k=2$	A1	$v=2\left(t-2\right)^2+3\left(=2t^2-8t+11\right)$
	Differentiate to find acceleration	DM1	Dependent on both previous m marks
	$a=4\left(t-2\right)$	A1	
	$t=3,\ a=4\,(\text{m s}^{-2})$	A1	
		(8)	
1b	Integrate: $\int 2\left(t-2\right)^2+3\,\mathrm{d}t=\frac{2}{3}\left(t-2\right)^3+3t\left(+C\right)$ or $\int 2t^2-8t+11\,\mathrm{d}t=\frac{2}{3}t^3-4t^2+11t\left(+C\right)$	M1	follow their coefficients found in (a) Accept in p, q, r
	At most one error seen	A1ft	For their coefficients
	All correct	A1ft	For their coefficients provided $\neq 0$
	$\left[\frac{2}{3}\left(t-2\right)^3+3t\right]_2^3=\left(\frac{2}{3}+9\right)-\left(0+6\right)$ or $\left[\frac{2}{3}t^3-4t^2+11t\right]_2^3$ $=\left(18-36+33\right)-\left(\frac{16}{3}-16+22\right)$	DM1	Use of $t=2, t=3$ as limits on a definite integral (or subtract distances to cancel C). Dependent on having integrated. Allow with p, q, r

Q	Scheme	Marks	Notes
	$3\frac{2}{3}$ (m)	A1	Accept exact equivalent or 3.7 or better
		(5)	
		[13]	

Q	Scheme	Marks	Notes
2a		M1	Equation of motion up or down the road. Requires all 3 terms. Condone sign errors and trig confusion. Must be dimensionally correct.
	$F = mg\sin\theta + R \quad (F = R + 392)$	A1	Correct equation up the road
	$G + mg\sin\theta = R \quad (G = R - 392)$	A1	Correct equation down the road
	$F = \frac{3P}{12.5}$ or $G = \frac{P}{12.5}$ $\Rightarrow \frac{3P}{12.5} = 392 + R$ or $\frac{P}{12.5} = R - 392$	B1	Use of $F = \frac{P}{v}$ at least once
	$\frac{2P}{12.5} = 2\times 392$, $2R = \frac{4P}{12.5}$	M1	Solve simultaneous equations for *P* or *R*, provided $F \neq G$ and *P* and 3*P* used correctly
	$P = 4900\,(500\text{g}), \quad R = 784\,(80\text{g})$	A1	CSO. Both values correct. Accept 2sf, 3sf or an exact multiple of g
		(6)	
2b	**Must be using work-energy.**		
	KE lost = PE gained + WD against R	M1	Equation needs all 3 terms and no extras. Condone sign errors.
	$\frac{1}{2}\times 800\times 12.5^2$ $= 800\times 9.8\times\frac{d}{20} + (\text{their } R)\times d$	A1	At most 1 error. Allow with *R* (with trig. substituted) $(62500 = 392d + Rd)$
		A1ft	Correct equation in their *R*(with trig. substituted)
	$d = \frac{62500}{1176} = 53.1\text{(m)}$	A1	CSO. Accept 53(m)
		(4)	
		[10]	

Q	Scheme	Marks	Notes
3.	Since this question is about the magnitude of the impulse, condone subtraction in the "wrong order" throughout.		
	$m\mathbf{v}-m\mathbf{u}=0.6(2c\mathbf{i}-c\mathbf{j}-c\mathbf{i}-2c\mathbf{j})$	M1	Impulse = change in momentum Marking the RHS only
	$=0.6(c\mathbf{i}-3c\mathbf{j})$	A1	
	Magnitude $=0.6\sqrt{c^2+9c^2}$	DM1	Correct use of Pythagoras' theorem on $m\mathbf{v}-m\mathbf{u}$ or $\mathbf{v}-\mathbf{u}$ Marking the RHS only. Dependent on the previous M1
	$=0.6\sqrt{10}c \quad \left(=0.6\sqrt{10c^2}\right)$	A1	Accept $\sqrt{10}c$ for change in velocity
	The next two marks are not available to a candidate who has equated a scalar to a vector.		
	$2\sqrt{10}=0.6\sqrt{10}c$	DM1	Equate & solve for c Dependent on the previous M1
	$c=\frac{10}{3}$	A1	Accept 3.3 or better
		(6)	
alt	$m\mathbf{v}-m\mathbf{u}=0.6(2c\mathbf{i}-c\mathbf{j}-c\mathbf{i}-2c\mathbf{j})$	M1	change in momentum
	$=0.6(c\mathbf{i}-3c\mathbf{j})$	A1	
	Square of magnitude	DM1	
	$=0.36(10c^2)$	A1	
	The next two marks are not available to a candidate who has equated a scalar to a vector.		
	$40=0.36(c^2+9c^2)$,	DM1	Equate & solve for c
	$c=\frac{10}{3}$	A1	
		(6)	
alt	$\begin{pmatrix}2\sqrt{10}\cos\theta\\2\sqrt{10}\sin\theta\end{pmatrix}=0.6\begin{pmatrix}2c-c\\-c-2c\end{pmatrix}$	M1	Impulse momentum equation
	$=0.6c\begin{pmatrix}1\\-3\end{pmatrix}$	A1	Correct equation
	$2\sqrt{10}\cos\theta=0.6c$ $2\sqrt{10}\sin\theta=-3\times0.6c$	DM1	Compare coefficients and form equation for θ
	$\tan\theta=-3 \Rightarrow \cos\theta=(\pm)\frac{1}{\sqrt{10}}$	A1	$\cos\theta$ or $\sin\theta$ correct
	$2\sqrt{10}\cos\theta=0.6c$	DM1	
	$\Rightarrow c=\frac{10}{3}$	A1	

alt		M1	Impulse momentum triangle Units used for the vectors must be dimensionally correct
	Sides of magnitude $\sqrt{5}c, \sqrt{5}c, \frac{10\sqrt{10}}{3}$ or $\frac{3\sqrt{5}c}{5}, \frac{3\sqrt{5}c}{5}, 2\sqrt{10}$	A1	
	$\mathbf{u}\cdot\mathbf{v} = \begin{pmatrix} c \\ 2c \end{pmatrix}\cdot\begin{pmatrix} 2c \\ -c \end{pmatrix}$	DM1	Use of scalar product
	$= 2c^2 - 2c^2 = 0 \ \therefore$ at 90°	A1	...to show velocities perpendicular
	$\left(0.6\times\sqrt{5}c\right)^2 + \left(0.6\times\sqrt{5}c\right)^2 = \left(2\sqrt{10}\right)^2$	DM1	Use of Pythagoras' theorem in a right angled triangle
	$\frac{18c^2}{5} = 40$, $c = \frac{10}{3}$	A1	
		(6)	

<table>
<tr><th>Q</th><th>Scheme</th><th>Marks</th><th></th></tr>
<tr><td>4a</td><td>
<table>
<tr><th></th><th>Triangle</th><th>sector</th></tr>
<tr><td>mass</td><td>4.5</td><td>4π
$(=12.56..)$</td></tr>
<tr><td>c of m from O</td><td>$\frac{2}{3}\times\frac{3\sqrt{2}}{2}$
$(=1.41...)$</td><td>$\frac{16\sqrt{2}}{3\pi}(=2.40....)$</td></tr>
</table>
</td><td>B1

B1</td><td>Mass ratios

Distances
Distances from AD are $-\frac{1}{3}\times\frac{3\sqrt{2}}{2}$
and $\frac{16\sqrt{2}}{3\pi}-\frac{3\sqrt{2}}{2}(=0.280)$</td></tr>
<tr><td></td><td>:
$4\pi\times\frac{16\sqrt{2}}{3\pi}-4.5\sqrt{2}\left(=\frac{101\sqrt{2}}{6}\right)=(4\pi-4.5)d$</td><td>M1</td><td>Moments about an axis through O and parallel to DA.
Terms must be dimensionally correct.
Shapes combined correctly.</td></tr>
<tr><td></td><td></td><td>A1</td><td>Correct unsimplified equation</td></tr>
<tr><td></td><td>$d=\frac{101\sqrt{2}}{6(4\pi-4.5)}=2.951.....$</td><td></td><td>(distance from O)</td></tr>
<tr><td></td><td>Distance from DA $=2.951...-\frac{3\sqrt{2}}{2}$
$=0.830\,(0.83)$ m</td><td>A1</td><td>Accept $\frac{101\sqrt{2}}{6(4\pi-4.5)}-\frac{3\sqrt{2}}{2}$</td></tr>
<tr><td></td><td></td><td>(5)</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>4a
alt</td><td>
<table>
<tr><th></th><th>Triangle</th><th>sector</th></tr>
<tr><td>mass</td><td>4.5</td><td>$4\pi(=12.56..)$</td></tr>
<tr><td>c of m from both axes OC,OB</td><td>1</td><td>$\frac{16\sqrt{2}}{3\pi}\times\frac{1}{\sqrt{2}}=\frac{16}{3\pi}$</td></tr>
</table>
</td><td>B1

B1</td><td>Mass ratios

Distances</td></tr>
<tr><td></td><td>$4\pi\times\frac{16}{3\pi}-4.5\,1=(4\pi-4.5)\bar{x}$</td><td>M1</td><td>Moments about an axis through O.
Terms must be dimensionally correct. Condone sign error(s)</td></tr>
<tr><td></td><td>$\left(\bar{x}=\bar{y}=\frac{101}{6(4\pi-4.5)}\right)$</td><td>A1</td><td>Correct unsimplified equation</td></tr>
<tr><td></td><td>$d=\frac{101\sqrt{2}}{6(4\pi-4.5)}$</td><td></td><td>Distance from O</td></tr>
<tr><td></td><td>Distance from DA $=2.951...-\frac{3\sqrt{2}}{2}$
$=0.830\,(0.83)$ m</td><td>A1</td><td></td></tr>
<tr><td></td><td></td><td>(5)</td><td></td></tr>
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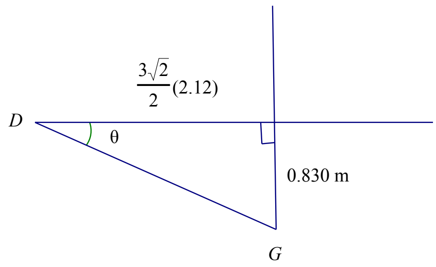
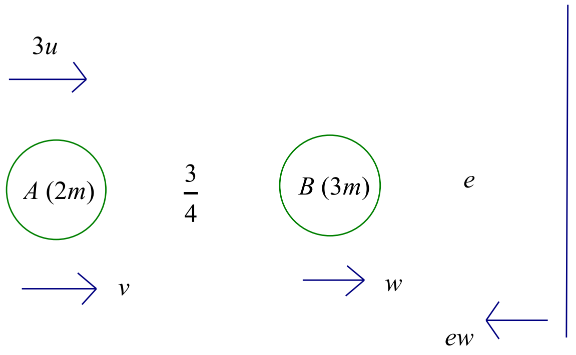
4b			
	$\tan\theta = \dfrac{\text{their } 0.830}{2.12}$ or $\tan\phi = \dfrac{2.12}{\text{their } 0.830}$	M1	Use of tan to find a relevant angle:
	21.4° or 68.6°	A1	
	Angle between DC and downward vertical = 135˚ - their θ	M1	Correct method for the required angle
	= 114˚	A1	The Q asks for the angle to the nearest degree.
		(4)	
4balt	$GD^2 = OD^2 + OG^2 - 2OD.OC\cos 45$ $(GD = 2.28)$ $\dfrac{\sin 45}{DG} = \dfrac{\sin\theta}{OG}$	M1	Complete method to find angle *ODG*
	$\Rightarrow \theta = 66.4°$	A1	
		M1	Correct method for the required angle
	Required angle $= 180 - 66.4 = 114°$	A1	The Q asks for the angle to the nearest degree.
		(4)	
		[9]	

Q	Scheme	Marks	Notes
5a	M(A): $d\cos\theta \times 5g = 4P$	M1	Terms must be dimensionally correct. Condone trig confusion
		A1	
	Resolving horizontally: $P\sin\theta = F$	B1	
	Resolving vertically: $P\cos\theta + R = 5g$	M1	Requires all 3 terms. Condone trig confusion and sign errors
		A1	Correct equation
		DM1	Substitute for P to find R or F Dependent on both previous M marks
	$R = 5g - \dfrac{5gd\cos^2\theta}{4}$	A1	One force correct. Accept equivalent forms e.g. $R = \dfrac{20g - 5gd + 20g\tan^2\theta}{4\left(1+\tan^2\theta\right)}$
	$F = \dfrac{5gd\cos\theta\sin\theta}{4}$	A1	Both forces correct. Accept equivalent forms e.g. $F = \dfrac{5gd\tan\theta}{4\sec^2\theta}$
		(8)	
5a alt	M(B): $5g\cos\theta \times \left(4-d\right) + F\sin\theta \times 4 = R\cos\theta \times 4$	M1	Needs all three terms. Terms must be dimensionally correct. Condone trig confusion
		A1	At most one error
	Resolve parallel to the rod: $5g\sin\theta = R\sin\theta + F\cos\theta$	M1	Requires all 3 terms. Condone trig confusion and sign errors
		B1	At most one error
		A1	Correct equation
	$\Rightarrow R = 5g - \dfrac{F\cos\theta}{\sin\theta}$		
	$5g\cos\theta \times \left(4-d\right) + F\sin\theta \times 4 = 4\cos\theta\left(5g - \dfrac{F\cos\theta}{\sin\theta}\right)$	DM1	Eliminate one variable to find F or R Dependent on both previous M marks
	$4F\left(\sin\theta + \dfrac{\cos^2\theta}{\sin\theta}\right) = 20g\cos\theta - 20g\cos\theta + 5gd\cos\theta$		
	$F = \dfrac{5gd\cos\theta\sin\theta}{4}$	A1	One force correct
	$R = 5g - \dfrac{5gd\cos^2\theta}{4}$	A1	Both forces correct
			See next page for part (b)

5b	$\mu = \dfrac{\dfrac{5gd\cos\theta\sin\theta}{4}}{5g - \dfrac{5gd\cos^2\theta}{4}}$	M1	Use of $F = \mu R$
	$\dfrac{1}{2}\left(5g - \dfrac{5gd\cos^2\theta}{4}\right) = \dfrac{5gd\cos\theta\sin\theta}{4}$	A1	$\left(4 - d\cos^2\theta = 2d\cos\theta\sin\theta\right)$
	$4\times169 = 120d + 144d$	M1	Use $\tan\theta = \dfrac{5}{12}$ and solve for d
	$d = \dfrac{169}{66}$	A1	(= 2.6 m or better)
		(4)	
5balt	$F = 5gd\times\dfrac{12}{13}\times\dfrac{5}{13}\times\dfrac{1}{4}\left(=\dfrac{75gd}{169}\right)$	M1	Use $\tan\theta = \dfrac{5}{12}$
	$R = 5g - \dfrac{5gd}{4}\times\dfrac{144}{169}$	A1	Both unsimplified expressions
	$75gd = \dfrac{1}{2}\left(5\times169g - 180gd\right)$	M1	Use of $F = \mu R$ and solve for d
	$150gd + 180gd = 845g$, $d = \dfrac{169}{66}$	A1	(= 2.6 m or better)
		(4)	
5balt	$R = 5g - \dfrac{12}{13}P$, $F = \dfrac{5}{13}P$	M1	Substitute trig in their equations from resolving.
	$\dfrac{5}{13}P = \dfrac{1}{2}\left(5g - \dfrac{12}{13}P\right)$	M1	use $F = \mu R$ and solve for d
	$\Rightarrow P = \dfrac{65}{22}g$	A1	
	$d = \dfrac{4P}{5g\cos\theta} = \dfrac{169}{66}$	A1	
		[12]	

Q	Scheme	Marks	Notes
6a	Horizontal motion: $x = 3t$	B1	
	Vertical motion: $y = 4t - \frac{g}{2}t^2$	M1	Correct use of *suvat*. Condone sign error(s)
		A1	
	$\left(y = 4\times\frac{x}{3} - \frac{g}{2}\times\frac{x^2}{9}\right),\quad \lambda = -\left(\frac{4\lambda}{3} - \frac{g\lambda^2}{18}\right)$	M1	Use $y = -x$ and form an equation in one variable
	, $\frac{7\lambda}{3} = \frac{g\lambda^2}{18}$	M1	solve for λ
	$\lambda = \frac{42}{g}$ or 4.3 (4.29)	A1 (6)	Not $\frac{30}{7}$
alta	Horizontal motion: $x = 3t$	B1	
	Vertical motion: $y = 4t - \frac{g}{2}t^2$	M1	Correct use of *suvat*. Condone sign error(s)
		A1	
	$\Rightarrow -3t = 4t - \frac{1}{2}gt^2,\ \left(t = \frac{14}{g}\right)$	M1	Use $y = -x$ and form an equation in one variable
	$\lambda = 3t$	M1	Solve for λ
	$\lambda = 4.3$ (4.29)	A1 (6)	
6b	At A: $v \rightarrow 3$ (m s^{-1})	B1	
	$v\uparrow \quad 4 - g\times\frac{14}{g}$	M1	Complete method using *suvat* to find $v\uparrow$ with their t or λ
	$= -10$ (m s^{-1})	A1	Accept +10 with direction confirmed by diagram
	Speed $= \sqrt{(\text{their } 10)^2 + (3)^2}$	DM1	Dependent on the first M1 in (b)
	$= \sqrt{109}$ (m s^{-1})	A1	(10.4) Allow for $v\uparrow$=10
	$\tan^{-1}\left(\frac{\text{their } 10}{3}\right)$ or $\tan^{-1}\left(\frac{3}{\text{their } 10}\right)$	DM1	Use trig to find a relevant angle. Dependent on the first M1 in (b)
	Direction $= 73.3°$ below the horizontal	A1	(1.28 radians) Accept direction $3\mathbf{i} - 10\mathbf{j}$ Do not accept a bearing
		(7)	
Alt 6b	Loss in GPE : $mg\lambda = 42m$	B1	
	Gain in KE : $\frac{1}{2}mv^2 - \frac{1}{2}m\times 25$	M1	Terms must be dimensionally correct. Condone sign error.
		A1	
	Solve for v: $42 = \frac{1}{2}v^2 - \frac{25}{2}$	M1	
	$v = \sqrt{109}$	A1	
	$v\cos\theta = 3$	M1	Use trig. to find a relevant angle
	$\theta = 73.3°$ below the horizontal	A1 (7)	Accept correct angle marked correctly on a diagram.
		[13]	

Q	Scheme	Marks	Notes
7a			
	CLM: $6mu = 2mv + 3mw$	M1	Requires all 3 terms. Must be dimensionally correct. Condone sign error(s)
	$(6u = 2v + 3w)$	A1	This equation defines their directions
	Impact: $w - v = \frac{3}{4} \times 3u \left(= \frac{9}{4}u \right)$	M1	Must be used with e on the correct side
		A1	Penalise inconsistent directions here
	$6u = 2w - \frac{9}{2}u + 3w$	DM1	Solve simultaneous equations for v or w Dependent on the 2 previous M marks
	$w = \frac{21}{10}u = v_B$	A1	One correct
	$v = w - \frac{9}{4}u = \left(\frac{21}{10} - \frac{9}{4}\right)u = -\frac{3}{20}u$, $v_A = \frac{3}{20}u$	A1	Both correct
		(7)	
7b	Speed of B after hitting wall $= \frac{21}{10}ue$	M1(B1)	$e \times$ their w
	Impulse $= \frac{27}{4}mu = 3m\left(\frac{21}{10}u + \frac{21}{10}ue\right)$	M1	for their w. Must be trying to use the correct equation with $3m$.
	$\frac{9}{4} = \frac{21}{10}(1+e)$, $e = \frac{1}{14}$	A1 (3)	
7b alt	Impulse $= \frac{27}{4}mu = 3m\left(\frac{21}{10}u + V\right)$, $\left(V = \frac{3u}{20}\right)$	M1(B1)	Use impulse to find V. Must be trying to use the correct equation with $3m$.
	$\frac{21u}{10}e = \frac{3u}{20}$,	M1	$V = e \times$ their w.
	$e = \frac{1}{14}$	A1 (3)	
7c	Speed of B after second impact = $\frac{1}{14} \times \frac{21}{10}u = \frac{3}{20}u$	B1ft	Compare two relevant speeds. (ft on their V or their e x their w)
	Same velocity (and A has a head start), so no collision.	B1 (2)	From correct work only
		[12]	