General Certificate of Education
Advanced Level Examination
June 2014

Mathematics MM03

Unit Mechanics 3

Friday 6 June 2014 1.30 pm to 3.00 pm

For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\ \text{m s}^{-2}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

1 A tennis ball is projected from a point O with a velocity of $(4\sqrt{3}\mathbf{i} + 4\mathbf{j})\,\mathrm{m\,s^{-1}}$, where $\mathbf{i}$ and $\mathbf{j}$ are horizontal and vertical unit vectors respectively. The ball travels in a vertical plane through O which is $30\,\mathrm{cm}$ above the horizontal surface of a tennis court. During its flight, the horizontal and upward vertical distances of the ball from O are x metres and y metres respectively.

Model the ball as a particle.

(a) Show that, during the flight, the equation of the trajectory of the ball is given by

$$y = \frac{x}{\sqrt{3}} - \frac{49x^2}{480}$$

[4 marks]

(b) The ball hits a vertical net at a point A. The net is at a horizontal distance of $4\,\mathrm{m}$ from O.

Determine the height of the point A, above the surface of the tennis court. Give your answer to the nearest centimetre.

[2 marks]

(c) State a modelling assumption, other than the ball being a particle, that you need to make to answer this question.

[1 mark]

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2 A rod, of length $x\,\mathrm{m}$ and moment of inertia $I\,\mathrm{kg\,m^2}$, is free to rotate in a vertical plane about a fixed smooth horizontal axis through one end.

When the rod is hanging at rest, its lower end receives an impulse of magnitude $J\,\mathrm{Ns}$, which is just sufficient for the rod to complete full revolutions.

It is thought that there is a relationship between J, x, I, the acceleration due to gravity $g\,\mathrm{m\,s^{-2}}$ and a dimensionless constant k, such that

$$J = kx^{\alpha}I^{\beta}g^{\gamma}$$

where α, β and γ are constants.

Find the values of α, β and γ for which this relationship is dimensionally consistent.

[6 marks]

3 A particle of mass $0.5\,\text{kg}$ is moving in a straight line on a smooth horizontal surface.

The particle is then acted on by a horizontal force for 3 seconds. This force acts in the direction of motion of the particle and at time t seconds has magnitude $(3t + 1)\ \text{N}$.

When $t = 0$, the velocity of the particle is $4\,\text{m s}^{-1}$.

(a) Find the magnitude of the impulse of the force on the particle between the times $t = 0$ and $t = 3$.

[3 marks]

(b) Hence find the velocity of the particle when $t = 3$.

[2 marks]

(c) Find the value of t when the velocity of the particle is $20\,\text{m s}^{-1}$.

[4 marks]

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4 Two boats, A and B, are moving on straight courses with constant speeds. At noon, A and B have position vectors $(\mathbf{i} + 2\mathbf{j})\,\text{km}$ and $(-\mathbf{i} + \mathbf{j})\,\text{km}$ respectively relative to a lighthouse. Thirty minutes later, the position vectors of A and B are $(-\mathbf{i} + 3\mathbf{j})\,\text{km}$ and $(2\mathbf{i} - \mathbf{j})\,\text{km}$ respectively relative to the lighthouse.

(a) Find the velocity of A relative to B in the form $(m\mathbf{i} + n\mathbf{j})\,\text{km h}^{-1}$, where m and n are integers.

[4 marks]

(b) The position vector of A relative to B at time t hours after noon is $\mathbf{r}\,\text{km}$.

Show that

$$\mathbf{r} = (2 - 10t)\mathbf{i} + (1 + 6t)\mathbf{j}$$

[3 marks]

(c) Determine the value of t when A and B are closest together.

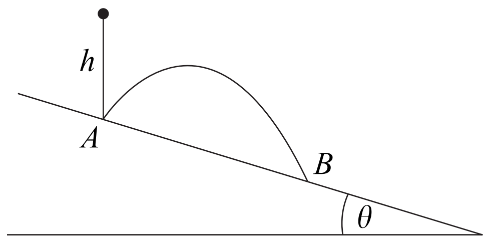
[5 marks]

(d) Find the shortest distance between A and B.

[2 marks]

Turn over ▶

5 A small smooth ball is dropped from a height of h above a point A on a fixed smooth plane inclined at an angle θ to the horizontal. The ball falls vertically and collides with the plane at the point A. The ball rebounds and strikes the plane again at a point B, as shown in the diagram. The points A and B lie on a line of greatest slope of the inclined plane.



(a) Explain whether or not the component of the velocity of the ball parallel to the plane is changed by the collision.

[2 marks]

(b) The coefficient of restitution between the ball and the plane is e.

Find, in terms of h, θ, e and g, the components of the velocity of the ball parallel to and perpendicular to the plane immediately after the collision.

[3 marks]

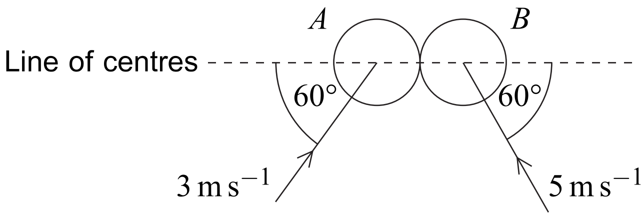
(c) Show that the distance AB is given by

$$4he(e+1)\sin\theta$$

[7 marks]

6 Two smooth spheres, A and B, have equal radii and masses $2\,\mathrm{kg}$ and $4\,\mathrm{kg}$ respectively.

The spheres are moving on a smooth horizontal surface and collide. As they collide, A has velocity $3\,\mathrm{m\,s^{-1}}$ at an angle of $60°$ to the line of centres of the spheres, and B has velocity $5\,\mathrm{m\,s^{-1}}$ at an angle of $60°$ to the line of centres, as shown in the diagram.



Just after the collision, B moves in a direction perpendicular to the line of centres.

(a) Find the speed of A immediately after the collision.

[6 marks]

(b) Find the acute angle, correct to the nearest degree, between the velocity of A and the line of centres immediately after the collision.

[2 marks]

(c) Find the coefficient of restitution between the spheres.

[2 marks]

(d) Find the magnitude of the impulse exerted on B during the collision.

[2 marks]

7 Two small smooth spheres, A and B, are the same size and have masses $2m$ and m respectively. Initially, the spheres are at rest on a smooth horizontal surface. The sphere A receives an impulse of magnitude J and moves with speed $2u$ directly towards B.

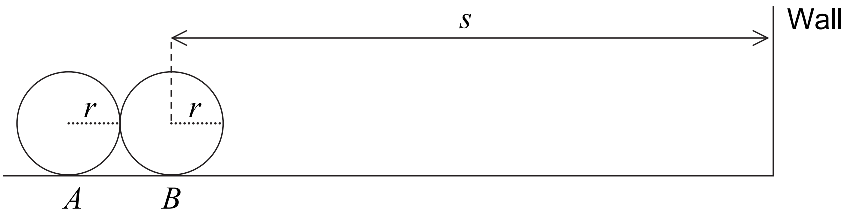
(a) Find J in terms of m and u.

[2 marks]

(b) The sphere A collides directly with B. The coefficient of restitution between A and B is $\frac{2}{3}$. Find, in terms of u, the speeds of A and B immediately after the collision.

[5 marks]

(c) At the instant of collision, the centre of B is at a distance s from a fixed smooth vertical wall which is at right angles to the direction of motion of A and B, as shown in the diagram.

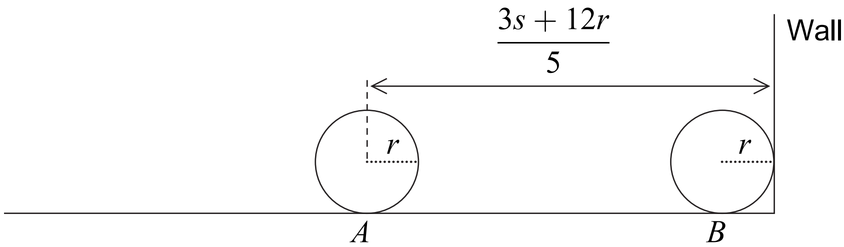


Subsequently, B collides with the wall. The radius of each sphere is r.

Show that the distance of the centre of A from the wall at the instant that B hits the wall is $\dfrac{3s + 12r}{5}$.

[4 marks]

(d) The diagram below shows the positions of A and B when B hits the wall.



The sphere B collides with A again after rebounding from the wall. The coefficient of restitution between B and the wall is $\frac{2}{5}$.

Find the distance of the **centre of** $\boldsymbol{B}$ from the wall at the instant when A and B collide again.

[4 marks]

Key to mark scheme abbreviations

M	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
√or ft or F	follow through from previous incorrect result
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
$-x$ EE	deduct x marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Q	Solution	Mark	Total	Comment
1 (a)	$x = 4\sqrt{3}t$	B1		
	$y = 4t - \frac{1}{2}gt^2$	B1		
	$t = \frac{x}{4\sqrt{3}}$			
	$y = 4 \times \frac{x}{4\sqrt{3}} - \frac{1}{2}(9.8)\left(\frac{x}{4\sqrt{3}}\right)^2$	M1		
	$y = \frac{x}{\sqrt{3}} - \frac{49x^2}{480}$	A1	4	AG
(b)	$y = \frac{4}{\sqrt{3}} - \frac{49(4)^2}{480}$	M1		PI by correct answer
	(The height is $0.676 + 0.3$) 0.98 m or 98 cm	A1	2	CAO
(c)	No air resistance or The ball does not spin **or** No loss of energy	B1	1	
	Total		**7**	

Q	Solution	Mark	Total	Comment
2	$[J] \equiv \text{MLT}^{-1}$ $[g] \equiv \text{LT}^{-2}$	B1		Dimensions of J and g, PI
	$\text{MLT}^{-1} = L^{\alpha}\left(\text{ML}^2\right)^{\beta}\left(\text{LT}^{-2}\right)^{\gamma}$	M1		FT from B1
	$\text{MLT}^{-1} = \text{M}^{\beta}\text{L}^{\alpha+2\beta+\gamma}\text{T}^{-2\gamma}$	A1		PI
	$\beta = 1$	B1		
	$-2\gamma = -1$ $\alpha + 2\beta + \gamma = 1$	m1		Correctly solving **their** two equations **involving three unknowns,** PI by the answers
	$\gamma = \frac{1}{2}$ $\alpha = -\frac{3}{2}$	A1		
	Total		**6**	

(a) Only quoting the formula and substituting scores M1 A1.

Q	Solution	Mark	Total	Comment
3 (a)	$I = \int_0^3 (3t+1)\,dt$	M1		Condone missing limits and missing dt
	$= \left[\frac{3}{2}t^2 + t\right]_0^3$	m1		For correct integration only
	$= \frac{33}{2}$ or 16.5 Ns	A1	3	Condone missing units
(b)	$\frac{33}{2} = 0.5v - 0.5(4)$	M1		Impulse/momentum equation for correct terms, FT on their impulse from part (a)
	$v = 37$ ms^{-1}	A1F	2	
(c)	$\int_0^T (3t+1)\,dt = 0.5(20) - 0.5(4)$	M1		Correct impulse-momentum equation, condone missing limits
	$\left[\frac{3}{2}t^2 + t\right]_0^T = 0.5(20) - 0.5(4)$			
	$3T^2 + 2T - 16 = 0$	A1		Correct quadratic equation
	$(3T+8)(T-2) = 0$ or $T = \frac{-2 \pm \sqrt{(-2)^2 - 4(3)(-16)}}{2(3)}$	m1		Correct solution of their equation, PI
	$T = 2$ s	A1		Rejecting impossible time PI
	$\left(T = -\frac{8}{3} \text{ s impossible}\right)$		4	
	Total		**9**	

(a)

Alternative (non-calculus): Attempt at finding the area under force-time graph M1

$= \frac{1+10}{2} \times 3$ OE A1

= 33/2 or 16.5 (NS) A1

(c)

Alternative:

$a = \frac{3t+1}{0.5}$

$v = \int \frac{3t+1}{0.5}(dt)$ Attempt at integrating the acceleration M1

$v = 3t^2 + 2t + 4$

$20 = 3T^2 + 2T + 4$

$3T^2 + 2T - 16 = 0$ A1 , etc.

Alternative (non-calculus): Attempt at finding the area under force-time graph for impulse

$$\frac{1+(3T+1)}{2}\times T = 0.5(20) - 0.5(4)$$ OE M1

Q	Solution	Mark	Total	Comment
4 (a)	$\boldsymbol{v}_A = \dfrac{(-\mathbf{i}+3\mathbf{j})-(\mathbf{i}+2\mathbf{j})}{\frac{1}{2}} = -4\mathbf{i}+2\mathbf{j}$ $\boldsymbol{v}_B = \dfrac{(2\mathbf{i}-\mathbf{j})-(-\mathbf{i}+\mathbf{j})}{\frac{1}{2}} = 6\mathbf{i}-4\mathbf{j}$	M1 A1		M1 for a difference of two corresponding position vectors divided by $\frac{1}{2}$, A1 for all correct
	${}_A\boldsymbol{v}_B = (-4\mathbf{i}+2\mathbf{j})-(6\mathbf{i}-4\mathbf{j})$ ${}_A\boldsymbol{v}_B = -10\mathbf{i}+6\mathbf{j}$	m1 A1	4	Accept any difference of their velocities NMS scores 0/4
(b)	$\mathbf{r_0} = (\mathbf{i}+2\mathbf{j})-(-\mathbf{i}+\mathbf{j})$	B1		
	$\mathbf{r} = (\mathbf{i}+2\mathbf{j})-(-\mathbf{i}+\mathbf{j})+(-10\mathbf{i}+6\mathbf{j})t$	M1		M1 for using $\mathbf{r} = \mathbf{r}_0 + {}_A\boldsymbol{v}_B t$ with their ${}_A\boldsymbol{v}_B$.
	$\mathbf{r} = (2-10t)\mathbf{i}+(1+6t)\mathbf{j}$	A1	3	AG
(c)	$AB^2 = (2-10t)^2+(1+6t)^2$	M1		Or $AB = \sqrt{(2-10t)^2+(1+6t)^2}$
	A and B are closest when $\dfrac{\mathrm{d}AB^2}{\mathrm{d}t}\left(\text{or } \dfrac{\mathrm{d}AB}{\mathrm{d}t}\right)=0$	B1		PI
	$\dfrac{\mathrm{d}AB^2}{\mathrm{d}t} = 2(2-10t)(-10)+2(1+6t)6=0$	m1 A1		Condone one sign error **or** one coefficient error All correct
	$t = \dfrac{7}{68}$ or 0.103	A1	5	At least 3 s.f. required if decimal. Accept equivalent fractions
(d)	$AB = \sqrt{(2-10\times 0.103)^2+(1+6\times 0.103)^2}$ **or** $\sqrt{\left(\dfrac{33}{34}\right)^2+\left(\dfrac{55}{34}\right)^2}$	m1		Dependent on M1 and m1 in part (c)
	$AB = 1.89$ or $1.886...$	A1	2	At least 3 s.f. required
	Total		**14**	

4 (c) *Alternative 1*:

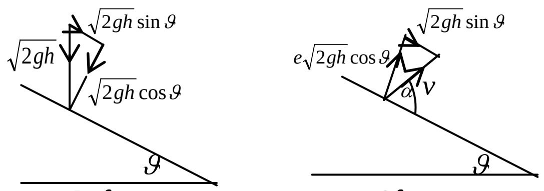
$AB^2 = (2-10t)^2 + (1+6t)^2$	M1
$AB^2 = 4 - 40t + 100t^2 + 1 + 12t + 36t^2$	A1
A and B are closest when $\frac{dAB^2}{dt}\left(\text{or } \frac{dAB}{dt}\right) = 0$	B1
$-40 + 200t + 12 + 72t = 0$	m1
$t = \frac{7}{68}$ or 0.103	A1

4 (c) *Alternative 2*:

$AB^2 = (2-10t)^2 + (1+6t)^2$	M1	
$AB^2 = 4 - 40t + 100t^2 + 1 + 12t + 36t^2$	A1	
$AB^2 = 136t^2 - 28t + 5$		
$AB^2 = 136\left(\left(t - \frac{7}{68}\right)^2 + \ldots\right)$	m1 A1	m1 for attempt at completing the square of <u>their</u> quadratic
$t = \frac{7}{68}$ or 0.103	A1	

4(c) *Alternative 3 (Not in the specification)*:

$[(2-10t)\mathbf{i} + (1+6t)\mathbf{j}].[-10\mathbf{i} + 6\mathbf{j}]$ $(=0)$	M1 for the scalar product of the r with <u>their</u> ${}_Av_B$ A1 for all correct
$-20 + 100t + 6 + 36t$ $(=0)$	A1
$-20 + 100t + 6 + 36t = 0$	m1 for correctly solving <u>their</u> equation
$t = \frac{7}{68}$ or 0.103	A1

Q	Solution	Mark	Total	Comment
5 (a)	'No change' with an attempt to explain Explanation referring to smoothness or lack of friction parallel to the plane	B1 B1	 2	
(b)	Before After Speed before impact $=\sqrt{2gh}$ PI Parrallel component after impact $=\sqrt{2gh}\sin\vartheta$ Perpendicular component after impact $=e\sqrt{2gh}\cos\vartheta$	M1 A1 A1	3	Allow $\pm$ expressions
(c)	At B,) $0=\mathrm{e}\sqrt{2gh}\cos\vartheta^{*}\,t-\frac{1}{2}g\cos\vartheta\,t^{2}$ $t=\frac{2\mathrm{e}\sqrt{2gh}\cos\vartheta}{g\cos\vartheta}$ or $\frac{2\mathrm{e}\sqrt{2gh}}{g}$ $x=\sqrt{2gh}\sin\vartheta^{*}\,t+\frac{1}{2}g\sin\vartheta\,t^{2}$ $AB=\frac{\sqrt{2gh}\sin\vartheta 2\mathrm{e}\sqrt{2gh}}{g}+\frac{g\sin\vartheta 4\mathrm{e}^{2}2gh}{2g^{2}}$ $AB=\frac{4gh\mathrm{e}\sin\vartheta}{g}+\frac{8g^{2}h\mathrm{e}^{2}\sin\vartheta}{2g^{2}}$ $AB=4h\mathrm{e}\sin\vartheta+4h\mathrm{e}^{2}\sin\vartheta$ $AB=4h\mathrm{e}(\mathrm{e}+1)\sin\vartheta$	M1 A1 A1 M1 A1 m1 A1	 7	Allow M1 for using $\sin\vartheta$ instead of $\cos\vartheta^{*}$ and + instead of – Allow M1 for using $\cos\vartheta$ instead of $\sin\vartheta^{*}$ and – instead of + Elimination of t. OE AG, must be convinced
	Total		**12**	

(a) The minimum statement for 2 marks is: 'No friction, so no change to velocity parallel to the plane'

Allow numerical value of 9.8 for g in part (c), but deduct one A1 mark in part (b) if they have used numerical value.

5(c) *Alternative*

(At B,) $0 = v\sin\alpha\, t - \frac{1}{2}gt^2\cos\vartheta$	M1
$t = \frac{2v\sin\alpha}{g\cos\vartheta}$	m1
$x = v\cos\alpha t + \frac{1}{2}gt^2\sin\vartheta$	M1
$AB = v\cos\alpha\left(\frac{2v\sin\alpha}{g\cos\vartheta}\right) + \frac{1}{2}g\left(\frac{2v\sin\alpha}{g\cos\vartheta}\right)^2\sin\vartheta$	A1
$AB = \frac{2v^2\sin\alpha\cos\alpha}{g\cos\vartheta} + \frac{2v^2\sin^2\alpha\sin\vartheta}{g\cos^2\vartheta}$	
$\left.\begin{array}{l}\sin\alpha = \frac{\sqrt{2gh}\, e\cos\vartheta}{v} \\ \cos\alpha = \frac{\sqrt{2gh}\,\sin\vartheta}{v}\end{array}\right\}$	B1 (for both)
$AB = \frac{2v^2 \times \frac{\sqrt{2gh}\, e\cos\vartheta}{v} \times \frac{\sqrt{2gh}\,\sin\vartheta}{v}}{g\cos\vartheta} + \frac{2v^2\left(\frac{\sqrt{2gh}\, e\cos\vartheta}{v}\right)^2\sin\vartheta}{g\cos^2\vartheta}$	m1
$AB = 4he\sin\vartheta + 4he^2\sin\vartheta$	
$AB = 4he(e+1)\sin\vartheta$	A1 AG, must be convinced

Q	Solution	Mark	Total	Comment
6 (a)	Conservation of linear momentum along the line of centres:			
	$2\times 3\cos 60^\circ - 4\times 5\cos 60^\circ = 2\times v$	M1		Condone sign errors
		A1		Correct with $2v$ or $-2v$
	$v = -3.5$	A1		Or $\frac{7}{2}$, accept 3.5 from consistent working
	Velocity of $A \perp$ to line of centres : $3\sin 60^\circ$	B1		Possibly seen on a diagram
	$V = \sqrt{(3.5)^2 + (3\sin 60^\circ)^2}$	M1		FT their v from above
	$V = 4.36$ or $\sqrt{19}$ ms^{-1}	A1	6	AWRT 4.36, condone missing units
(b)	$\tan^{-1}\frac{3\sin 60^\circ}{3.5}$ *	M1		For correct expression, FT their v from part (a)
	$= 37^\circ$	A1	2	CAO
(c)	$e = \frac{3.5}{3\cos 60^\circ + 5\cos 60^\circ}$	M1		For correct expression, FT their v from part (a)
	$e = 0.875$ or $\frac{7}{8}$	A1	2	CAO
(d)	$I = 4\times 5\cos 60^\circ - 4\times 0$ or $2\times 3\cos 60^\circ - -2\times 3.5$	M1		OE, condone the missing zero term, **FT**
	$I = 10$ Ns	A1	2	CAO, condone missing units
	Total		**12**	

(b) * or $\sin^{-1}\frac{3\sin 60^\circ}{4.36}$ or $\cos^{-1}\frac{3.5}{4.36}$

Q	Solution	Mark	Total	Comment
7 (a)	$J = 2m(2u) - 2m(0)$	M1		
	$= 4mu$	A1	2	A0 for sign error or $-4mu$ as answer
(b)	$2m(2u) = 2mv_A + mv_B$ $4u = 2v_A + v_B$	M1		CLM
	$\dfrac{v_B - v_A}{2u - 0} = \dfrac{2}{3}$	M1		Restitution, condone sign error
	$4u = 3v_B - 3v_A$	A1		All correct
	$v_A = \dfrac{8}{9}u$	A1		
	$v_B = \dfrac{20}{9}u$	A1	5	
(c)	$t = \dfrac{s-r}{\frac{20u}{9}}$ or $\dfrac{9(s-r)}{20u}$	M1		$(s-r)$ divided by their v_B from (b)
	Distance travelled by A is $\dfrac{8u}{9} \times \dfrac{9(s-r)}{20u}$	m1		Their $v_A \times$ their time from the line above
	$= \dfrac{2(s-r)}{5}$	A1		OE
	Distance of centre of A from the wall is $s + 2r - \dfrac{2(s-r)}{5} = \dfrac{3s+12r}{5}$	A1	4	AG
(d)	$w_B = \dfrac{20u}{9} \times \dfrac{2}{5}$	M1		Their v_B from (b) $\times \dfrac{2}{5}$
	$= \dfrac{8}{9}u$	A1		
	A and B have the same speed $\Rightarrow$ The distance between them will be halved to $\dfrac{1}{2}\left(\dfrac{3s+12r}{5} - 3r\right)$ or $\dfrac{3s-3r}{10}$	M1		Explanation not needed
	$\therefore$ The required distance is $\dfrac{1}{2}\left(\dfrac{3s+12r}{5} - 3r\right) + r = \dfrac{3s+7r}{10}$	A1	4	Simplification not required
	Total		**15**	

(a) Condone omission of $-2m(0)$.

7(d) *Alternative1*:

$w_B = \frac{20u}{9} \times \frac{2}{5}$ M1

$= \frac{8}{9}u$ A1

Time taken by B to collide again $= \frac{x}{\frac{8}{9}u}$

Time taken by A to collide again $= \frac{\frac{3s+12r}{5} - 3r - x}{\frac{8}{9}u}$

$x = \frac{3s+12r}{5} - 3r - x$ or $\frac{3s-3r}{10}$

The distance of the centre of B from the wall $= \frac{3s-3r}{10} + r = \frac{3s+7r}{10}$ A1

Alternative 2:

$w_B = \frac{20u}{9} \times \frac{2}{5}$ M1

$= \frac{8}{9}u$ A1

Velocity of A relative to B $= \frac{16u}{9}$

Distance to collision $= \frac{3s+12r}{5} - 3r$

Time to collision $= \frac{\frac{3s+12r}{5} - 3r}{\frac{16u}{9}}$

$= \frac{27s-27r}{80u}$

Distance moved by B $= \frac{8u}{9}\left(\frac{27s-27r}{80u}\right)$ M1

The required distance $= \frac{8u}{9}\left(\frac{27s-27r}{80u}\right) + r = \frac{3s+7r}{10}$ A1

Scaled mark unit grade boundaries - June 2014 exams

A-level

Code	Title	Maximum Scaled Mark	Scaled Mark Grade Boundaries and A* Conversion Points A*	A	B	C	D	E
LAW01	LAW UNIT 1	96	-	77	69	62	55	48
LAW02	LAW UNIT 2	94	-	72	63	54	45	37
LAW03	LAW UNIT 3	80	69	63	58	53	48	43
LAW04	LAW UNIT 4	85	71	64	58	53	48	43
MD01	MATHEMATICS UNIT MD01	75	-	61	55	50	45	40
MD02	MATHEMATICS UNIT MD02	75	69	63	57	52	47	42
MFP1	MATHEMATICS UNIT MFP1	75	-	55	48	41	35	29
MFP2	MATHEMATICS UNIT MFP2	75	63	56	49	43	37	31
MFP3	MATHEMATICS UNIT MFP3	75	65	60	55	50	45	41
MFP4	MATHEMATICS UNIT MFP4	75	70	66	59	53	47	41
MM03	MATHEMATICS UNIT MM03	75	71	68	61	54	47	40
MM04	MATHEMATICS UNIT MM04	75	68	61	53	45	38	31
MM05	MATHEMATICS UNIT MM05	75	67	59	51	43	35	27
MM1B	MATHEMATICS UNIT MM1B	75	-	53	46	40	34	28
MM2B	MATHEMATICS UNIT MM2B	75	68	62	55	48	41	35
MPC1	MATHEMATICS UNIT MPC1	75	-	62	56	50	44	38
MPC2	MATHEMATICS UNIT MPC2	75	-	55	49	43	37	32
MPC3	MATHEMATICS UNIT MPC3	75	65	59	53	47	41	36
MPC4	MATHEMATICS UNIT MPC4	75	59	54	49	44	39	34
MS03	MATHEMATICS UNIT MS03	75	68	62	55	48	41	35
MS04	MATHEMATICS UNIT MS04	75	67	60	52	44	37	30
MS1A	MATHEMATICS UNIT MS1A	100	-	85	75	66	57	48
MS1A/W	*MATHEMATICS UNIT MS1A - WRITTEN*	*75*		*65*				*38*
MS1A/C	*MATHEMATICS UNIT MS1A - COURSEWORK*	*25*		*20*				*10*