Q1

Question	Scheme	Marks	AOs
1 (a)	For P Differentiate $\mathbf{r}_p$ with respect to t to form vector	M1	1.1a
	$(\mathbf{v}_P =) -6t^2\mathbf{i} + (4t - 5)\mathbf{j}$	A1	1.1b
	$\frac{-6t^2}{4t-5} = \frac{-15}{2}$	M1	3.1a
	$4t^2 - 20t + 25 = 0$	M1	1.1b
	$t = 2.5$	A1	1.1b
		(5)	
(b)	Differentiate $\mathbf{v}_P$ with respect to t $((\mathbf{a}_p=) -12t\,\mathbf{i} + 4\,\mathbf{j})$	M1	1.1a
	Substitute $t = 2.5$ into $((\mathbf{a}_p=) -30\,\mathbf{i} + 4\,\mathbf{j})$ (ms^{-2})	A1	1.1b
		(2)	
(c)	For Q Integrate $\mathbf{v}$ with respect to t to get $\mathbf{q}$	M1	1.1a
	$\mathbf{q} = \frac{6t^{\frac{3}{2}}}{\frac{3}{2}}\mathbf{i} + \left(5t - \frac{3t^2}{2}\right)\mathbf{j}$	A1	1.1b
	Substitute $t = 1$ and use Pythagoras $(\mathbf{p} = \mathbf{i} - 3\mathbf{j}, \quad \mathbf{q} = 4\mathbf{i} + 3.5\mathbf{j})$	M1	1.1b
	Distance $= \frac{\sqrt{205}}{2}$ (m)	A1	1.1b
		(4)	
			(11 marks)

Notes Question 1 (a)

M1: Differentiate $\mathbf{r}_P$ with respect to t to form vector. Evidence of powers being decreased by one on at least two terms and in form $c\mathbf{i} + d\mathbf{j}$

A1: Correct answer

M1: Correct ratio used on their calculated $\mathbf{v}_P$ to form quadratic equation in t

M1: Obtaining a 3 term quadratic and solving for t

A1: $t = 2.5$

(b)

M1: Differentiate $\mathbf{v}_P$ with respect to t

A1: Substitute $t = 2.5$ into $\mathbf{a}_P$ to get correct answer from correct working

(c)

M1: Integrate $\mathbf{v}_Q$ with respect to t to get $\mathbf{r}_Q$. Must be a vector.

A1: Correct vector expression.

M1: Pythagoras must include square root

A1: $\mathrm{d} = \frac{\sqrt{205}}{2} (\mathrm{m})$

Q2

Question	Scheme	Marks	AOs
2(a)	Moments about *B*	M1	3.3
	$W \times \frac{2a}{3} = Ta\sin\alpha$	A1	1.1b
	$T = \frac{5}{6}W$ *	A1*	2.2a
		(3)	
2(b)	Moments about *A* $\left(aS\sin\beta = \frac{1}{3}aW\right)$ OR Moments about *G* $\left(\frac{2}{3}aS\sin\beta = \frac{1}{3}aT\sin\alpha\right)$ OR Resolve vertically $(T\sin\alpha + S\sin\beta = W)$	M1	3.4
	$S\sin\beta = \frac{1}{3}W$ *	A1*	2.2a
		(2)	
2(c)	Resolve horizontally	M1	3.3
	$S\cos\beta = T\cos\alpha$	A1	1.1b
	$S\cos\beta = \frac{1}{2}W$	A1	1.1b
	$S = \sqrt{\left(\frac{1}{2}W\right)^2 + \left(\frac{1}{3}W\right)^2}$	M1	2.1
	$S = \frac{\sqrt{13}}{6}W$ oe, 0.6*W* or better	A1	1.1b
		(5)	
			(10 marks)

Notes:

2a	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors
	A1	Correct equation
	A1*	Given answer correctly obtained
2b	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion

	A1*	Given answer correctly obtained
2c	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors
	A1	Correct equation
	A1	Correct equation in *S*, *W* and β only
	M1	Complete method to find *S* in terms of *W* only e.g. Divide to obtain $\tan\beta = \frac{2}{3}$ and use it to find *S*
	A1	cao

Q3

7(a) (i)	$T - 2mg\sin\alpha - F = 2ma$	M1A1
(ii)	$3mg - T = 3ma$	M1A1
	N.B. Ignore the labelling (i) and (ii)	(4)
7(b)	$R = 2mg\cos\alpha$ Allow if this appears in (a).	M1A1
	$F = \frac{1}{2}R$	B1
	Substitute for trig. and solve for a,	DM1
	$a = \frac{1}{5}g$	A1
		(5)
7(c)	$T = \frac{12mg}{5}$ $(23.52m)$	DM1
	$2T\cos\left(\frac{90^o - \alpha}{2}\right)$ **OR** $\sqrt{T^2 + T^2 - 2T^2\cos(90^o + \alpha)}$ **OR** $\sqrt{(T\cos\alpha)^2 + (T + T\sin\alpha)^2}$	M1
	Substitute for trig and T to obtain an expression in m or mg	DM1
	$\frac{48\sqrt{5}mg}{25}$; Accept $4.3mg$ or better, $42m$ or $42.1m$	A1
		(4)
7(d)	Tension is the same on **either side of the pulley**, tension across the pulley is the same.	B1
	B0 for tension is same for A and B or is the same for both strings etc	(1)
		(14)

	Notes for question 7	
	N.B. If m's are consistently missing, mark (a) and (b) as a MR	
7(a)	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation	
	M1 Correct no. of terms, condone sign errors	
	A1 Correct equation **N.B.** Could have a replaced by $(-a)$ in both	
7(b)	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation	
	B1 Seen, possibly on a diagram or in (a)	
	DM1, dependent on the two M's in (a), for solving 2 simultaneous equations or using a whole system equation to find a	
	A1 cao	
7(c)	DM1, dependent on the relevant 1st or 2nd M1 in (a), for attempt to find their T, must be of form km or kmg. Apply isw if they 'cancel' m's.	
	M1 for a **correct** expression in terms of T and α only; α does not need to be substituted	
	DM1, dependent on previous M, for substituting in their T **and** for trig, to give an expression of form km or kmg	
	A1 cao	
7(d)	B1 for any equivalent statement. B0 for incorrect extras.	

Question	Scheme	Marks	AOs
4 (a)	Horizontal motion: $x = 5t$	B1	3.3
	Vertical motion: $s = ut + \frac{1}{2}at^2$	M1	3.4
	$y = 8t - \frac{1}{2} \times 10 \times t^2$	A1	1.1b
	$y = 1.6x - 0.2x^2$ *	A1*	2.2a
		(4)	
(b)	$0 = 1.6x - 0.2x^2$	M1	1.1b
	$OA = 8$ (m)	A1	1.1b
		(2)	
(c)	$\dot{x} = 5$	B1	3.4
	When $x = 6$, $y = 1.6\times6 - 0.2\times36$ (= 2.4) **OR** When $x = 6$, $t = 6\div5$ (= 1.2)	M1	1.1b
	$\dot{y}^2 = 8^2 - 2\times10\times2.4$ **OR** $\dot{y} = 8 - 10\times1.2$	M1	3.4
	Speed ($= \sqrt{5^2 + (-4)^2}$) = 6.4 (m s^{-1})	A1	1.1b
	Angle (with horizontal) = $\tan^{-1}\left(\frac{4}{5}\right)$	M1	1.1b
	Direction at angle 39° below the horizontal (oe)	A1	2.2a
		(6)	
(d)	It would **increase** the value of OA predicted by the model	B1	2.2a
	Smaller value of g $\Rightarrow$ smaller magnitude of coefficient of x^2 in equation $0 = 1.6x - 0.2x^2 \Rightarrow$ larger value of x	B1	2.4
		(2)	
(e)	Take account of one factor such as • air resistance • spin • wind • size of ball	B1	3.5c
		(1)	
			(15 marks)

Notes Question 4:

(a)

B1: Correct expression for horizontal distance in terms of t

M1: Use of $s = ut + \frac{1}{2}at^2$ using $u = 8$

A1: Correct unsimplified equation

A1*: Eliminates t to reach given answer from fully correct working

(b)

M1: Substitutes $y = 0$ in given equation (must be using part (a))

A1: Correct answer

(c)

B1: Correct horizontal velocity component seen or implied

M1: **Either** finds y when $x = 6$ **or** finds t when $x = 6$

M1: Complete method to find vertical component of velocity (or square of vertical component)

A1: Correct speed (to 2 sig figs as directed by question)

M1: Correct use of trig to find a relevant angle for the direction, using horizontal and vertical velocity components

A1: Correct angle (to 2 sig figs as directed by question, but 'over-accuracy' only penalised once per question), including indication that the direction is downwards (could be on a diagram).

(d)

B1: Correct statement

B1: Correct reasoning

(e)

B1: Any one factor related to the model