Q	Solution	Marks	Total	Comments
1(a)	$\mathbf{v} = (6t^2 - 2t)\mathbf{i} + (1 - 12t^2)\mathbf{j}$	M1 A1 A1	3	differentiating both components one component correct second component correct
(b)	$\mathbf{v}\left(\frac{1}{3}\right) = \left(\frac{6}{9} - \frac{2}{3}\right)\mathbf{i} + \left(1 - \frac{12}{9}\right)\mathbf{j} = -\frac{1}{3}\mathbf{j}$	M1 A1	2	substituting the value for t into their $\mathbf{v}$ correct velocity
(c)	Travelling due south	A1ft	1	correct description (Follow through from $\mathbf{v} = \pm k\mathbf{j}$)
(d)	$\mathbf{a} = (12t - 2)\mathbf{i} - 24t\mathbf{j}$ $\mathbf{a}(4) = 46\mathbf{i} - 96\mathbf{j}$	M1 A1 A1	3	differentiating their velocity correct acceleration at time t correct acceleration at $t = 4$
(e)	$\mathbf{F} = 6(46\mathbf{i} - 96\mathbf{j}) = 276\mathbf{i} - 576\mathbf{j}$	M1		apply Newton's second law correctly
	$F = \sqrt{276^2 + 576^2} = 639$ N or $a = \sqrt{46^2 + 96^2} = 106.45$ $F = 6 \times 106.45 = 639$ N	M1 A1	3	finding magnitude correct magnitude

2(a)	$\mathbf{v} = \frac{\mathrm{d}r}{\mathrm{d}t}$			
	$\mathbf{v} = (3t^2 - 6t)\mathbf{i} + (4 + 2t)\mathbf{j}$	M1A1	2	
(b)	$\mathbf{a} = (6t - 6)\mathbf{i} + 2\mathbf{j}$	M1 A1ft		
	Using $\mathbf{F} = m\mathbf{a}$: $\mathbf{F} = (18t - 18)\mathbf{i} + 6\mathbf{j}$	A1ft	3	
(c)	When $t = 3$, $\mathbf{F} = 36\mathbf{i} + 6\mathbf{j}$			
	Magnitude is $\sqrt{36^2 + 6^2}$	M1		
	$= 36.5$	A1ft	2	Accept $6\sqrt{37}$; ft from (b)(i)
(d)	When **F** acts due north: Component of **F** in the **i** direction is 0	M1		
	$18t - 18 = 0$ $t = 1$	A1ft	2	ft from (b)(i)
	Total		**9**	

3 (a) $\rightarrow$ $30 = 2ut$ — B1

$\uparrow$ $-47.5 = 5ut - 4.9t^2$ — M1 A1

$-47.5 = 75 - 4.9\,t^2$ — eliminating u or t — DM1

$t^2 = \dfrac{75 + 47.5}{4.9} (= 25)$ — DM1

$t = 5$ ***** — cso — A1 — 6

(b) $30 = 2ut \Rightarrow 30 = 10u \Rightarrow u = 3$ — M1A1 — 2

(c) $\uparrow\ \dot{y} = 5u - 9.8t = -34$ — M1 requires both — M1A1

$\rightarrow\ \dot{x} = 2u = 6$ — $\dot{x}$ and $\dot{y}$ — A1

$v^2 = 6^2 + (-34)^2$ — DM1

$v \approx 34.5$ (m s^{-1}) — accept 35 — A1 — 5

Alternative

$\dfrac{1}{2}mv_B^2 - \dfrac{1}{2}mv_A^2 = m \times g \times 47.5$ with $v_A^2 = 6^2 + 15^2 = 261$ — M1A1(2,1,0)

$v_B^2 = 261 + 2 \times 9.8 \times 47.5\ (= 1192)$ — DM1

$v_B \approx 34.5$ (m s^{-1}) — accept 35 — A1 — 5

BEWARE : Watch out for incorrect use of $v^2 = u^2 + 2as$

[13]

Q	Solutio	Marks	Total	Comments
4(a)	Using $\mathbf{F} = m\mathbf{a}$,			
	$400 \cos \frac{\pi}{2} t\,\mathbf{i} + 600t^2\,\mathbf{j} = 200\,\mathbf{a}$	M1		
	$\mathbf{a} = 2 \cos \frac{\pi}{2} t\,\mathbf{i} + 3t^2\,\mathbf{j}$	A1	2	
(b)	$\mathbf{v} = \int a \, dt$	M1		M1 for either $\int a \, dt$ or 1 of 2 terms correct
	$= \frac{4}{\pi} \sin \frac{\pi}{2} t\,\mathbf{i} + t^3\mathbf{j} + \mathbf{c}$	A1m1		m1 for + **c**
	When $t = 4$, $\mathbf{r} = -3\mathbf{i} + 56\mathbf{j}$,			
	$64\mathbf{j} + \mathbf{c} = -3\mathbf{i} + 56\mathbf{j}$	m1		
	$\therefore \mathbf{c} = -3\mathbf{i} - 8\mathbf{j}$			
	$\therefore \mathbf{v} = (\frac{4}{\pi} \sin \frac{\pi}{2} t - 3)\mathbf{i} + (t^3 - 8)\mathbf{j}$	A1		Do not accept $\frac{2}{\frac{\pi}{2}}$ Accept 1.27 for $\frac{4}{\pi}$
(c)	When particle is moving due west,			
	northerly component is zero	M1		
	$\therefore t^3 - 8 = 0$	A1√		
	$t = 2$	A1	3	
(d)	When $t = 2$, $\mathbf{v} = -3\mathbf{i} + 0\mathbf{j}$	B1√		
	Speed of particle is 3 m s^{-1}	B1	2	B1 for change –3 to +3
	Total		**12**	

Q	Solution	Marks	Total	Comments
5(a)	$\mathbf{v} = \frac{d\mathbf{r}}{dt}$	M1		
		A1		**i** terms
	$\mathbf{v} = (e^{\frac{1}{2}t} - 8)\mathbf{i} + (2t - 6)\mathbf{j}$	A1	3	**j** terms
(b)	When $t = 3$, $\mathbf{v} = -3.52\mathbf{i}$	B1		Accept $(e^{\frac{3}{2}} - 8)\mathbf{i}$
	Speed is 3.52 m s $^{-1}$	B1	2	3.5 does not give 2nd B mark
(c)	West	**B1**		
(d)	$\mathbf{a} = \frac{1}{2}e^{\frac{1}{2}t}\mathbf{i} + 2\mathbf{j}$	M1A1		
	When $t = 3$, $\mathbf{a} = \frac{1}{2}e^{\frac{3}{2}}\mathbf{i} + 2\mathbf{j}$ or $2.24\mathbf{i} + 2\mathbf{j}$	A1	3	
(e)	Using $\mathbf{F} = m\mathbf{a}$:	M1		Accept $\mathbf{F} = 7\mathbf{a}$
	$\mathbf{F} = 7(\frac{1}{2}e^{\frac{3}{2}}\mathbf{i} + 2\mathbf{j})$			
	$\therefore$ Magnitude of force is			
	$7\left((\frac{1}{2}e^{\frac{3}{2}})^2 + 2^2\right)^{\frac{1}{2}}$	M1		
	$\mathbf{F} = 21.025$			
	$\mathbf{F} = 21.0$	A1	3	Accept 21
	Total		**12**	

Q	Solutio	Marks	Total	Comments
6(a)	$\mathbf{a} = \frac{\mathrm{d}v}{\mathrm{d}t}$			
	$\mathbf{a} = -8\mathrm{e}^{-2t}\mathbf{i} + (6-6t)\mathbf{j}$	M1 A1 A1	3	M1: Differentiating with either of the two components correct. Do not need to see **i** or **j**. A1: Correct **i** component. A1: Correct **j** component.
(b)	Using $\mathbf{F} = m\mathbf{a}$			
	$\mathbf{F} = 5\times\{-8\mathrm{e}^{-2t}\mathbf{i} + (6-6t)\mathbf{j}\}$	M1 A1	2	M1: Multiplying their acceleration by 5, even if not a vector. A1: Correct expression.
	$= -40\mathrm{e}^{-2t}\mathbf{i} + (30-30t)\mathbf{j}$			
(c)	Magnitude of $\mathbf{F}$ is			
	$\{(-40)^2 + (30)^2\}^{\frac{1}{2}}$	M1		M1: Finding magnitude from two non-zero terms. Must add terms and square root. Condone $\{(40)^2 + (30)^2\}^{\frac{1}{2}}$
	$= 50$	A1	2	A1: Correct answer only. In this part, condone lack of negative signs in expression for force in (b) (i).
(d)	When **F** acts due west, **j** component is zero	M1		M1: Putting **j** component equal to zero.
	$30 - 30t = 0$ $t = 1$	A1	2	A1: Correct time.
(e)	$\mathbf{r} = -2\mathrm{e}^{-2t}\mathbf{i} + (3t^2 - t^3)\mathbf{j} + \mathbf{c}$	M1 A1 A1		M1: Integration with either of the two components correct. Do not need to see **i** or **j**. A1: Correct **i** component. A1: Correct **j** component. Condone lack of + **c**
	When $t = 0$, $\mathbf{r} = 6\mathbf{i} + 5\mathbf{j}$ $\therefore$ $\mathbf{c} = 8\mathbf{i} + 5\mathbf{j}$	dM1		dM1: Finding **c** using $6\mathbf{i} + 5\mathbf{j}$ and $\mathrm{e}^0 = 1$.
	$\therefore$ $\mathbf{r} = (8 - 2\mathrm{e}^{-2t})\mathbf{i} + (5 + 3t^2 - t^3)\mathbf{j}$	A1	5	A1: Correct position vector.
	Total		**14**	

7 (a) $\mathbf{I} = 0.4(15\mathbf{i} + 16\mathbf{j} + 20\mathbf{i} - 4\mathbf{j})$ $(= 0.4(35\mathbf{i} + 12\mathbf{j}) = 14\mathbf{i} + 4.8\mathbf{j})$ M1

$|\mathbf{I}| = \sqrt{(14^2 + 4.8^2)}$ *or* $0.4\sqrt{(35^2 + 12^2)}$ M1 A1

M1 for any magnitude

$= 14.8$ (Ns) A1 4

(b) Initial K.E. $= \frac{1}{2} m(15^2 + 16^2)$ $(= 240.5m = 96.2$ J) M1

$\frac{1}{2} mv^2 = \frac{1}{2} m(15^2 + 16^2) = m \times 9.8 \times 1.2$ M1 A2, 1,0

–1 each incorrect term

$v^2 = 504.52$ M1

$v = 22$ (m s^{-1})

accept 22.5 A1 6

(c) $\arccos \dfrac{15}{22.5} = 48°$ M1 A1 A1 A1 4

accept 48.1 °

(d) Air resistance B1, B1 2

Wind (problem not 2 dimensional)

Rotation of ball (ball is not a particle)

any 2

[16]