Mark Scheme

Q1.

Question	Scheme	Marks	AOs
	Integrate **a** w.r.t. time	M1	1.1a
	$\mathbf{v} = \dfrac{5t^2}{2}\mathbf{i} - 10t^{\frac{3}{2}}\mathbf{j} + \mathbf{C}$ (allow omission of **C**)	A1	1.1b
	$\mathbf{v} = \dfrac{5t^2}{2}\mathbf{i} - 10t^{\frac{3}{2}}\mathbf{j} + 20\mathbf{i}$	A1	1.1b
	When $t = 4$, $\mathbf{v} = 60\mathbf{i} - 80\,\mathbf{j}$	M1	1.1b
	Attempt to find magnitude: $\sqrt{(60^2 + 80^2)}$	M1	3.1a
	Speed = 100 m s^{-1}	A1ft	1.1b
			(6 marks)

Notes:

1st **M1**: for integrating **a** w.r.t. time (powers of t increasing by 1)
1st **A1**: for a correct **v** expression without **C**
2nd **A1**: for a correct **v** expression including **C**
2nd **M1**: for putting $t = 4$ into their **v** expression
3rd **M1**: for finding magnitude of their **v**
3rd **A1**: **ft** for 100 m s^{-1}, follow through on an incorrect **v**

Q2.

Question	Scheme	Marks	AOs
(a)	$\mathbf{v}_B = (-16\mathbf{i} - 3\mathbf{j}) + 5(2.4\mathbf{i} + \mathbf{j})$	M1	3.4
	$\mathbf{v}_B = (-4\mathbf{i} + 2\mathbf{j})$	A1	1.1b
	$\sqrt{(-4)^2 + 2^2}$	M1	3.1a
	$\sqrt{20} = 2\sqrt{5}$, 4.5 or better ($\mathrm{m\ s^{-1}}$)	A1	1.1b
		(4)	
(b)	Using *A* as the initial position: $\mathbf{r}_C = \mathbf{v}_A t + \frac{1}{2}\mathbf{a}t^2 + \mathbf{r}_A$ where *t* = *T* $(4\mathbf{i} + c\mathbf{j}) = (-16\mathbf{i} - 3\mathbf{j})T + \frac{1}{2}(2.4\mathbf{i} + \mathbf{j})T^2 + (44\mathbf{i} - 10\mathbf{j})$ **OR** $\begin{pmatrix} 4 \\ c \end{pmatrix} = \begin{pmatrix} -16 \\ -3 \end{pmatrix} T + \frac{1}{2}\begin{pmatrix} 2.4 \\ 1 \end{pmatrix} T^2 + \begin{pmatrix} 44 \\ -10 \end{pmatrix}$ Equating **i**-components, to give a **quadratic** equation in *T* only. Allow *t* instead of *T*. **N.B.** Allow omission of 44 for this M mark. Also allow ± 4 but M0 if 4 is not used at all i.e. $4 = -16T + \frac{1}{2} \times 2.4T^2$ scores M1A0A0	M1	3.1a
	$4 = -16T + \frac{1}{2} \times 2.4T^2 + 44$	A1	1.1b
	(*T* =) 10	A1	1.1b

	ALTERNATIVE using *B* as the initial position: (The position vector of *B*, $\mathbf{r}_B$, should be $-6\mathbf{i} - 12.5\mathbf{j}$ but no credit for finding this) $\mathbf{r}_C = \mathbf{v}_B t + \frac{1}{2}\mathbf{a}t^2 + \mathbf{r}_B$ using **their** $\mathbf{v}_B$ from (a) and **their** $\mathbf{r}_B$ $(4\mathbf{i} + c\mathbf{j}) = (-4\mathbf{i} + 2\mathbf{j})t + \frac{1}{2}(2.4\mathbf{i} + \mathbf{j})t^2 + (-6\mathbf{i} - 12.5\mathbf{j})$ $\begin{pmatrix} 4 \\ c \end{pmatrix} = \begin{pmatrix} -4 \\ 2 \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} 2.4 \\ 1 \end{pmatrix} t^2 + \begin{pmatrix} -6 \\ -12.5 \end{pmatrix}$ Equating **i**-components, to give a **quadratic** equation in *t* only. Allow if they have *T* instead of *t*.	M1	3.1a

	N.B. Allow omission of their -6 or if they use 44 for this M mark. Also allow ± 4 but M0 if 4 is not used at all. e.g. $4 = -4t + \frac{1}{2}\times 2.4t^2$ scores M1A0A0		
	$4 = -4t + \frac{1}{2}\times 2.4t^2 - 6$	A1	1.1b
	t = 5 so (*T* =) 10	A1	1.1b
		(3)	
(c)	Equating **j**-components, with <u>their value of *T* or *t* substituted</u>, to give an equation, which must have a square term, in *c* only. **N.B.** Allow $\pm c$ in their equation. (**N.B.** Allow omission of -10 or their -12.5 for this M mark i.e. if using *A* as initial position $c = (-3\times 10) + \frac{1}{2}\times 1\times 10^2$ scores M1M0A0 **OR** if using *B* as initial position $c = (2\times 5) + \frac{1}{2}\times 1\times 5^2$ scores M1M0A0)	M1	2.1
	if using *A* as initial position $c = (-3\times 10) + \frac{1}{2}\times 1\times 10^2 + (-10)$ **N.B.** Allow $\pm c$ and/or $\pm(-10)$ in their equation **OR** if using *B* as initial position $c = (2\times 5) + \frac{1}{2}\times 1\times 5^2 + (-12.5)$ **N.B.** Allow $\pm c$ and/or $\pm(-12.5)$ in their equation	M1	1.1b
	c = 10	A1	1.1b
		(3)	

		(10 marks)
Notes: Accept column vectors throughout		
a	M1	Use of **v** = **u** + **a***t* with $t = 5$ to give an unsimplified $\mathbf{v}_B$ M0 if **u** = **0**
		N.B. If using integration, they must get to the same stage i.e. have found the constant and put $t = 5$ M0 if they omit the constant altogether
	A1	Correct $\mathbf{v}_B$ with **i**'s and **j**'s collected
	M1	Use of Pythagoras on *their* $\mathbf{v}_B$ to give a magnitude (need the root)
	A1	Must be positive
b	M1	Equating components of **i** to give an equation in *T* or *t* only. **N.B.** (they could use integration to get to the same stage) for this M mark, they **only** need to be equating the **i**-components, and receive no credit until they do so. M0 if **u** = **0**
	A1	A correct equation in *T* or *t* only (could be in $(T-5)$ if using *B* as initial position)
	A1	$T = 10$
c	M1	Equating components of **j** to give an equation in *c* only but allow omission of their initial position
	M1	With their value of *T* or *t* and **must include** ***t*** **= 0 position** (should be -10 if using *A* **OR** their -12.5 if using *B*)
	A1	cao

Q3.

Question	Scheme	Marks	AOs
(i)(a)	Integrate $\mathbf{a}$ wrt t to obtain velocity	M1	3.4
	$\mathbf{v} = (t - 2t^2)\mathbf{i} + \left(3t - \frac{1}{3}t^3\right)\mathbf{j}$ (+C)	A1	1.1b
	$8\mathbf{i} - \frac{28}{3}\mathbf{j}$ (m s^{-1})	A1	1.1b
		(3)	
(i)(b)	Equate $\mathbf{i}$ component of $\mathbf{v}$ to zero	M1	3.1a
	$t - 2t^2 + 36 = 0$	A1ft	1.1b
	$t = 4.5$ (ignore an incorrect second solution)	A1	1.1b
		(3)	
(ii)	Differentiate $\mathbf{r}$ wrt to t to obtain velocity	M1	3.4
	$\mathbf{v} = (2t - 1)\mathbf{i} + 3\mathbf{j}$	A1	1.1b
	Use magnitude to give an equation in t only	M1	2.1
	$(2t-1)^2 + 3^2 = 5^2$	A1	1.1b
	Solve problem by solving this equation for t	M1	3.1a
	$t = 2.5$	A1	1.1b
		(6)	
		(12 marks)	

Notes: Accept column vectors throughout		
(i)(a)	M1	At least 3 terms with powers increasing by 1 (but M0 if clearly just multiplying by t)
	A1	Correct expression
	A1	Accept $8\mathbf{i} - 9.3\mathbf{j}$ or better. Isw if speed found.
(i)(b)	M1	Must have an equation in t only (Must have integrated to find a velocity vector)
	A1 **ft**	Correct equation follow through on their v but must be a 3 term quadratic
	A1	cao
(ii)	M1	At least 2 terms with powers decreasing by 1 (but M0 if clearly just dividing by t)
	A1	Correct expression
	M1	Use magnitude to give an equation in t only, must have differentiated to find a velocity (M0 if they use $\sqrt{x^2 - y^2}$)
	A1	Correct equation $\sqrt{(2t-1)^2 + 3^2} = 5$
	M1	Solve a 3 term quadratic for t which has come from differentiating and using a magnitude. This M mark can be implied by a correct answer with no working.
	A1	2.5

Q4.

Question Number	Scheme	Marks	Notes
(a)	Integrate: $\boldsymbol{v} = \left(t^3 - 2t^2\right)\mathbf{i} + \left(3t^2 - 5t\right)\mathbf{j} + \mathbf{C}$	M1 A2	At least 3 powers going up. Condone errors in constants. Must be two separate component equations if not in vector form. Could be in column vector form. Allow with no "+ **C**" -1 each integration error. i.e. All correct A1A1 1 error A1A0, 2 or more errors A0A0 Allow with no "+ **C**"
	$t = 3: \mathbf{v} = 9\mathbf{i} + 12\mathbf{j} + \mathbf{C} = 11\mathbf{i} + 10\mathbf{j}$ $\mathbf{C} = 2\mathbf{i} - 2\mathbf{j}$	DM1	Substitute given values to find **C**. Dependent on the previous M mark
	$\mathbf{v} = \left(t^3 - 2t^2 + 2\right)\mathbf{i} + \left(3t^2 - 5t - 2\right)\mathbf{j}$	A1 (5)	Correct velocity (any equivalent form)
(b)	Parallel to **i** $\Rightarrow 3t^2 - 5t - 2 = 0$	M1	Set **j** component of their **v** equal to zero and solve for t Correct answers imply method, but incorrect answers need to show method clearly.
	$(3t+1)(t-2) = 0$, $t = 2$	A1	Correct only. Ignore $-\dfrac{1}{3}$ if present.
		DM1	Substitute their t to find **v**. Dependent on the previous M mark.
	$\lvert\mathrm{v}\rvert = 8 - 8 + 2 = 2$ (m s^{-1})	A1 (4)	The **answer must be a scalar** – the Q asks for speed. Results from negative t must be rejected.
		[9]	
	A candidate who has no "+C" can score at most M1A2M0A0 M1A0M1A0		

Q5.

Q	Scheme	Marks	
(a)	$t=\frac{5}{4}$	B1 M1	1.25
(b)	$\mathbf{r}=\left(2t^2-5t\right)\mathbf{i}+3t\mathbf{j}\left(+\mathbf{c}\right)$	A1	Integrate the velocity vector NB Also correct to use suvat with $\boldsymbol{a}$ = 4**i** and $\boldsymbol{u}$ = -5**i** + 3**j**.
	$t=0\quad 2\mathbf{i}+5\mathbf{j}=\mathbf{c}$ $\mathbf{r}=\left(2t^2-5t\right)\mathbf{i}+3t\mathbf{j}+\left(2\mathbf{i}+5\mathbf{j}\right)$ $(2t^2-5t+2)\mathbf{i}+(3t+5)\mathbf{j}$	DM1 A1 B1	Correct Use $\mathbf{r}_0$ to find C oe
(c)	$\mathbf{r}_Q=11\mathbf{i}+2\mathbf{j}-2t\mathbf{i}+ct\mathbf{j}$ $(11-2t)\mathbf{i}+(2+ct)\mathbf{j}$		Correct **j** component of $\mathbf{r}_Q$ Do not actually require the whole thing - can answer the Q by considering only the **j** component.
	$\mathbf{r}_P=\left(2t^2-5t+2\right)\mathbf{i}+\left(3t+5\right)\mathbf{j}$ $\mathbf{r}_Q=\mathbf{r}_P=d\mathbf{i}+14\mathbf{j}$	$2t^2-5t$	
	$3t+5=14$ | $2t^2-3t-9$ $(2t+3)(t-3)=0$ $t=3$ A1 ft	M1	Form an equation in t only
	$t=3$ $2+ct=14\Rightarrow c=4$ $d=11-2\times3=5$ or $d=2\times3^2-5\times3+2\Rightarrow d=5$	A1 A1 ft	Their t Their t
	Alt: $2t^2-5t+2=11-2t=d\Rightarrow t=\frac{11-d}{2}$ $2\left(\frac{11-d}{2}\right)^2-5\left(\frac{11-d}{2}\right)+2=d.$ $d^2-19d+70=0=(d-5)(d-14)$		

Q6.

Question Number	Scheme	Marks	Notes
(a)	$\mathbf{a} = \frac{d\mathbf{v}}{dt} = 6t\mathbf{i} + (4-2t)\mathbf{j}$	M1	Differentiate **v** to obtain **a**.
		A1	Accept column vector or **i** and **j** components dealt with separately.
	When $t = 1$, $\mathbf{a} = 6\mathbf{i} + 2\mathbf{j}$	DM1	Substitute $t = 1$ into their **a**. Dependent on 1st M1
	$\lvert\mathbf{a}\rvert = \sqrt{6^2 + 2^2} = \sqrt{40} = 6.32$ (m s^{-2})	DM1	Use of Pythagoras to find the magnitude of their **a**. Allow with their t. Dependent on 1st M1
		A1 (5)	Accept awrt 6.32, 6.3 or exact equivalents.
(b)	$\mathbf{r} = \int (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}\, dt$	M1	Integrate **v** to obtain **r**
	$= (t^3 - t + C)\mathbf{i} + (2t^2 - \frac{1}{3}t^3 + D)\mathbf{j}$	A1	Condone C, D missing
	$t = 0, \mathbf{r} = \mathbf{i} \Rightarrow C = 1, D = 0$	DM1	Use $t = 0$, $\mathbf{r} = \mathbf{i}$ to find C & D
	When $t = 3, \mathbf{r} = 25\mathbf{i} + 9\mathbf{j}$ (m)	DM1	Substitute $t = 3$ with their C & D to find **r**. Dependent on both previous Ms.
		A1 (5) **10**	cao. Must be a vector.

Q7.

(a)	Speed $= \sqrt{8^2 + 48^2} = \sqrt{2368} = 48.7$ (ms^{-1})	M1 A1	(2)
(b)	$\mathbf{a} = 2\mathbf{i} - 6t\mathbf{j}$	M1 A1	
	When $t = 4$, $\mathbf{a} = 2\mathbf{i} - 24\mathbf{j}$ (ms^{-2})	A1	(3)
(c)	$\mathbf{r} = t^2\mathbf{i} - t^3\mathbf{j} + \mathbf{C}$	M1 A1	
	$t = 1$, $-4\mathbf{i} + \mathbf{j} = \mathbf{i} - \mathbf{j} + \mathbf{C}$, $\mathbf{C} = -5\mathbf{i} + 2\mathbf{j}$	DM1	
	$\mathbf{r} = (t^2 - 5)\mathbf{i} + \left(-t^3 + 2\right)\mathbf{j}$		
	When $t = 4$, $\mathbf{r} = (16-5)\mathbf{i} + (-64 + 2)\mathbf{j} = 11\mathbf{i} - 62\mathbf{j}$	DM1 A1	(5) **10**

Q8.

Question Number	Scheme	Marks
(a)	$\mathbf{a} = d\mathbf{v}/dt = 6t\mathbf{i} - 4\mathbf{j}$	M1 A1
(b)	Using $\mathbf{F} = \frac{1}{2}\mathbf{a}$, sub $t = 2$, finding modulus e.g. at $t = 2$, $\mathbf{a} = 12\mathbf{i} - 4\mathbf{j}$ $\mathbf{F} = 6\mathbf{i} - 2\mathbf{j}$ $\lvert\mathbf{F}\rvert = \sqrt{(6^2 + 2^2)} \approx \underline{6.32\text{ N}}$	M1, M1, M1 A1(CSO)
	M1 Clear attempt to differentiate. Condone **i** or **j** missing. A1 both terms correct (column vectors are OK) The 3 method marks can be tackled in any order, but for consistency on epen grid please enter as: M1 **F**=m**a** (their **a**, (correct **a** or following from (a)), not **v**. $\mathbf{F}=\frac{1}{2}\mathbf{a}$). Condone **a** not a vector for this mark. M1 subst t = 2 into candidate's vector **F** or **a** (**a** correct or following from (a), not **v**) M1 Modulus of candidate's **F** or **a** (not **v**) A1 CSO All correct (beware fortuitous answers e.g. from 6t**i**+4**j**)) Accept 6.3, awrt 6.32, any exact equivalent e.g. $2\sqrt{10}$, $\sqrt{40}$, $\frac{\sqrt{160}}{2}$	

Q9.

Question	Scheme	Marks	AOs
(a)	$(4\mathbf{i}-\mathbf{j})+(\lambda\mathbf{i}+\mu\mathbf{j})=(4+\lambda)\mathbf{i}+(-1+\mu)\mathbf{j}$	M1	3.4
	Use ratios to obtain an equation in λ and μ *only*	M1	2.1
	$\frac{(4+\lambda)}{(-1+\mu)}=\frac{3}{1}$ or $\frac{\frac{1}{4}(4+\lambda)}{\frac{1}{4}(-1+\mu)}=\frac{3}{1}$	A1	1.1b
	$\lambda-3\mu+7=0$ * Allow $0=\lambda-3\mu+7$ but nothing else.	A1*	1.1b
		(4)	
(b)	$\lambda=2 \Rightarrow \mu=3$; Resultant force $=(6\mathbf{i}+2\mathbf{j})$ (N)	M1	3.1a
	$(6\mathbf{i}+2\mathbf{j})=4\mathbf{a}$ OR $\lvert(6\mathbf{i}+2\mathbf{j})\rvert=4a$	M1	1.1b
	Use of $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ with $\mathbf{u}=0$, their $\mathbf{a}$ and $t=4$: Or they may integrate their $\mathbf{a}$ twice with $\mathbf{u}=0$ and put $t=4$: $\mathbf{r}=\frac{1}{2}\times\frac{(6\mathbf{i}+2\mathbf{j})}{4}4^2=(12\mathbf{i}+4\mathbf{j})$	DM1	2.1
	$\sqrt{12^2+4^2}$	M1	1.1b
	ALTERNATIVE 1 for last two M marks: Use of $s=ut+\frac{1}{2}at^2$, with $u=0$, their a and $t=4$: DM1 $s=\frac{1}{2}\times\sqrt{1.5^2+0.5^2}\times4^2$ Use of Pythagoras to find mag of $\mathbf{a}$: $a=\sqrt{1.5^2+0.5^2}$ M1		
	ALTERNATIVE 2 for last two M marks: Use of $s=ut+\frac{1}{2}at^2$, with $u=0$, their a and $t=4$: DM1 $s=\frac{1}{2}\times\left(\frac{\sqrt{6^2+2^2}}{4}\right)\times4^2$ Use of Pythagoras to find $\lvert(6\mathbf{i}+2\mathbf{j})\rvert$: $=\sqrt{6^2+2^2}$ M1		
	$\sqrt{160}$, $2\sqrt{40}$, $4\sqrt{10}$ oe or 13 or better (m)	A1	1.1b
		(5)	
		(9 marks)	

Notes: Accept column vectors throughout

a	M1	Adding the two forces, **i**'s and **j**'s must be collected (or must be a single column vector) seen or implied
	M1	Must be using ratios; Ignore an equation e.g. $(4+\lambda)\mathbf{i}+(-1+\mu)\mathbf{j}=3\mathbf{i}+\mathbf{j}$ if they go on to use ratios.

		However, if they write $4+\lambda=3$ and $-1+\mu=1$ then $3(-1+\mu)=3$ so $4+\lambda=3(-1+\mu)$ with no use of a constant, it's M0 They may use the acceleration, with a factor of $\frac{1}{4}$ top and bottom, see alternative **Allow one side of the equation to be inverted**
	A1	Correct equation
	A1*	Given answer correctly obtained. Must see at least one line of working, with the LH fraction 'removed'.
b	M1	Adding $\mathbf{F}_1$ and $\mathbf{F}_2$ to find the resultant force, λ and μ must be substituted **N.B.** M0 if they use $\mu=2$ coming from $-1+\mu=1$ in part (a).
	M1	Use of $\mathbf{F}=4\mathbf{a}$ Or $\lvert\mathbf{F}\rvert=4a$, where **F** is <u>their</u> resultant. (including $3\mathbf{i}+\mathbf{j}$) This is an independent mark, so could be earned, for example, if they have subtracted the forces to find the 'resultant' **N.B.** M0 if only using $\mathbf{F}_1$ or $\mathbf{F}_2$
	DM 1	Dependent on previous M mark for **Either**: use of $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ with $\mathbf{u}=0$, their **a** and $t=4$ to produce a displacement vector **Or** : integrate twice, with $\mathbf{u}=0$, their **a** and $t=4$ to produce a displacement Vector **Or**: use of $s=ut+\frac{1}{2}at^2$ with $u=0$, their a and $t=4$ to produce a length
	M1	Use of Pythagoras, with square root, to find the magnitude of their displacement vector, **a** or **F** (M0 if only using $\mathbf{F}_1$ or $\mathbf{F}_2$) depending on which method they have used.
	A1	cao

Q10.

Question	Scheme	Marks	AO
(a)	Differentiate **v**	M1	1.1a
	$(\mathbf{a} =)6\mathbf{i} - \frac{15}{2}t^{\frac{1}{2}}\mathbf{j}$	A1	1.1b
	$= 6\mathbf{i} - 15\mathbf{j}$ (m s^{-2})	A1	1.1b
		(3)	
(b)	Integrate **v**	M1	1.1a
	$(\mathbf{r} =)(\mathbf{r}_0) + 3t^2\mathbf{i} - 2t^{\frac{5}{2}}\mathbf{j}$	A1	1.1b
	$=(-20\mathbf{i}+20\mathbf{j})+(48\mathbf{i}-64\mathbf{j})=28\mathbf{i}-44\mathbf{j}$ (m)	A1	2.2a
		(3)	
		(6)	

Marks		Notes
		N.B. Accept column vectors throughout and condone missing brackets in working but they must be there in final answers
a	M1	Use of $\mathbf{a} = \frac{d\mathbf{v}}{dt}$ with attempt to differentiate (both powers decreasing by 1) M0 if **i**'s and **j**'s omitted and they don't recover
	A1	Correct differentiation in any form
	A1	Correct and simplified. Ignore subsequent working (ISW) if they go on and find the magnitude.
b	M1	Use of $\mathbf{r} = \int \mathbf{v}\,dt$ with attempt to integrate (both powers increasing by 1) M0 if **i**'s and **j**'s omitted and they don't recover
	A1	Correct integration in any form. Condone $\mathbf{r}_0$ not present
	A1	Correct and simplified.

Q11.

Question	Scheme	Marks	AOs
	Allow column vectors throughout this question		
(a)	Differentiate v wrt t	M1	3.1a
	$\frac{3}{2}t^{-\frac{1}{2}}\mathbf{i}-2\mathbf{j}$ isw	A1	1.1b
		(2)	
(b)	$3t^{\frac{1}{2}}=2t$	M1	2.1
	Solve for t	DM1	1.1b
	$t=\frac{9}{4}$	A1	1.1b
		(3)	
(c)	Integrate v wrt t	M1	3.1a
	$\mathbf{r}=2t^{\frac{3}{2}}\mathbf{i}-t^2\mathbf{j}(+\mathbf{C})$	A1	1.1b
	$t=1$, $\mathbf{r}=-\mathbf{j} \Rightarrow \mathbf{C}=-2\mathbf{i}$ so $\mathbf{r}=2t^{\frac{3}{2}}\mathbf{i}-t^2\mathbf{j}-2\mathbf{i}$	A1	2.2a
		(3)	
(d)	$\sqrt{(3t^{\frac{1}{2}})^2+(2t)^2}=10$ or $(3t^{\frac{1}{2}})^2+(2t)^2=10^2$	M1	2.1
	$9t+4t^2=100$	M(A)1	1.1b
	$t=4$	A1	1.1b
	$\mathbf{r}=14\mathbf{i}-16\mathbf{j}$	M1	1.1b
	$\sqrt{14^2+(-16)^2}$	M1	3.1a
	$\sqrt{452}$ $(2\sqrt{113})$ (m)	A1	1.1b
		(6)	
			(14 marks)

Notes:		
a	M1	Both powers decreasing by 1 (M0 if vector(s) disappear but allow recovery)
	A1	cao
b	M1	Complete method, using **v**, to obtain an equation in t only, allow a sign error
	DM1	Dependent on M1,solve for t
	A1	cao
c	M1	Both powers increasing by 1 (M0 if vectors disappear but allow recovery)
	A1	Correct expression without **C**
	A1	cao
d	M1	Use of Pythagoras on **v** and 10 to set up equation in t
	M(A)1	Correct 3 term quadratic in t
	A1	cao
	M1	Substitute their numerical t value into their **r**
	M1	Use of Pythagoras to find the magnitude of their **r**
	A1	cso

Q12.

Question	Scheme	Marks	AOs
(a)	$7\mathbf{i} - 3\mathbf{j}$ seen or implied by Pythagoras	B1	1.1b
	Use Pythagoras: $\sqrt{7^2 + (-3)^2}$	M1	3.1a
	$\sqrt{58}$, 7.6 or better ($\mathrm{m\ s^{-1}}$)	A1	1.1b
		(3)	
(b)	$t^2 - 3t + 7 = 2t^2 - 3$ OR $\frac{t^2 - 3t + 7}{2t^2 - 3} = \frac{1}{1} = 1$	M1	2.1
	$t = 2$ only	A1	1.1b
		(2)	
(c)	Differentiate **v** wrt t to give a vector.	M1	3.1a
	$(2t - 3)\mathbf{i} + 4t\mathbf{j}$	A1	1.1b
		(2)	
(d)	$2t - 3 = 0$	M1	3.1a
	$t = 1.5$	A1	1.1b
		(2)	
			(9 marks)

Notes: Allow column vectors throughout.		
a	B1	cao
	M1	Use of Pythagoras, including the square root, on a **velocity** vector at $t = 0$
	A1	cao. Must come from a correct **v**.
b	M1	Equating **i** and **j** components of **v** or a ratio of 1:1 to obtain a quadratic in t only. If they use a constant, e.g. $t^2 - 3t + 7 = k$ and $2t^2 - 3 = k$, k must be eliminated to earn this mark. **N.B.** M0 (since wrong working seen) if they write down $\mathbf{i} + \mathbf{j} = (t^2 - 3t + 7)\mathbf{i} + (2t^2 - 3)\mathbf{j}$ **OR** $\begin{pmatrix} 1 \\ 1 \end{pmatrix} = \begin{pmatrix} t^2 - 3t + 7 \\ 2t^2 - 3 \end{pmatrix}$ **OR** $t^2 - 3t + 7 = 1$ and $2t^2 - 3 = 1$
		and then $t^2 - 3t + 7 = 2t^2 - 3$
	A1	$t = 2$
		N.B. Allow M1A1 for a **correct** trial and error method where they obtain $\mathbf{v} = 5\mathbf{i} + 5\mathbf{j}$ when $t = 2$ but M0 if they don't get $t = 2$
c	M1	At least one power decreasing by 1 in **each** component in their **v** (M0 if clearly dividing by t) **Both i** and **j** needed in their answer or a column vector Allow recovery if the **i** and **j** disappear and then reappear.
	A1	cao (must be a vector) isw e.g. if they find the magnitude or put $t = 0$ or differentiate again **i**'s and **j**'s do not need to be collected. **N.B.** Allow M1A0 for $2t - 3\mathbf{i} + 4t\mathbf{j}$
d	M1	$2t - 3 = 0$ or (their **derivative** of the **i**-component of **v**) = 0 **N.B.** M0 if they equate the derivative of both components of **v** to zero.
	A1	cao **N.B.** Correct answer, with no working, can score both marks.

Q13.

Question	Scheme	Marks	AOs
(a)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ or integrate to give: $\mathbf{v} = (-2\mathbf{i} + 2\mathbf{j}) + 2(4\mathbf{i} - 5\mathbf{j})$	M1	3.1a
	$(6\mathbf{i} - 8\mathbf{j})$ (m s^{-1})	A1	1.1b
		(2)	
(b)	Solve problem through use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ or integration (M0 if $\mathbf{u} = 0$) Or any other complete method e.g use $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ and $\mathbf{r} = \frac{(\mathbf{u}+\mathbf{v})T}{2}$;	M1	3.1a
	$-4.5\mathbf{j} = 2t\mathbf{j} - \frac{1}{2}t^2 5\mathbf{j}$ (j terms only)	A1	1.1b
	The first two marks could be implied if they go straight to an algebraic equation.		
	Attempt to equate **j** components to give equation in T only $(-4.5 = 2T - \frac{5}{2}T^2)$	M1	2.1
	$T = 1.8$	A1	1.1b
		(4)	
(c)	Solve problem by substituting <u>their</u> T value (M0 if $T < 0$) into the **i** component equation to give an equation in λ only: $\lambda = -2T + \frac{1}{2}T^2 \times 4$	M1	3.1a
	$\lambda = 2.9$ or 2.88 or $\frac{72}{25}$ oe	A1	1.1b
		(2)	
Notes: Accept column vectors throughout		**(8 marks)**	

Notes: Accept column vectors throughout		(8 marks)
2a	M1	For any complete method to give a **v** expression with correct no. of terms with $t = 2$ used, so if integrating, must see the initial velocity as the constant. Allow sign errors.
	A1	Cao isw if they go on to find the speed.
2b	M1	For any complete method to give a vector expression for **j** component of displacement in t (or T) only, using $\mathbf{a} = (4\mathbf{i} - 5\mathbf{j})$, so if integrating, RHS of equation must have the correct structure. Allow sign errors.
	A1	Correct **j** vector equation in t or T. Ignore **i** terms.
	M1	Must have earned 1st M mark. Equate **j** components to give equation in T (allow t) only (no **j**'s) which has come from a displacement. Equation must be a 3 term quadratic in T.
	A1	cao
2c	M1	Must have earned 1st M mark in (b) Complete method - must have an equation in λ only (no **i**'s) which has come from an appropriate displacement.. (e.g M0 if $\mathbf{a} = \mathbf{0}$ has been used) Expression for λ must be a quadratic in T
	A1	cao

Q14.

Question	Scheme	Marks	AOs
(a)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$: $(10.5\mathbf{i} - 0.9\mathbf{j}) = 0.6\mathbf{j} + 15\mathbf{a}$	M1	3.1b
	$\mathbf{a} = (0.7\mathbf{i} - 0.1\mathbf{j})$ m s^{-2} Given answer	A1	1.1b
		(2)	
(b)	Use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$	M1	3.1b
	$\mathbf{r} = 0.6\mathbf{j}\,t + \frac{1}{2}(0.7\mathbf{i} - 0.1\mathbf{j})\,t^2$	A1	1.1b
		(2)	
(c)	Equating the **i** and **j** components of **r**	M1	3.1b
	$\frac{1}{2} \leftarrow 0.7\,t^2 = 0.6\,t - \frac{1}{2} \leftarrow 0.1\,t^2$	A1ft	1.1b
	$t = 1.5$	A1	1.1b
		(3)	
(d)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$: $\mathbf{v} = 0.6\mathbf{j} + (0.7\mathbf{i} - 0.1\mathbf{j})\,t$	M1	3.1b
	Equating the **i** and **j** components of **v**	M1	3.1b
	$t = 0.75$	A1 ft	1.1b
		(3)	
			(10 marks)

Notes:

(a)

M1: for use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$

A1: for given answer correctly obtained

(b)

M1: for use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$

A1: for a correct expression for **r** in terms of t

(c)

M1: for equating the **i** and **j** components of their **r**

A1ft: for a correct equation following their **r**

A1: for $t = 1.5$

(d)

M1: for use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ for a general t

M1: for equating the **i** and **j** components of their **v**

A1ft: for $t = 0.75$, or a correct follow through answer from an incorrect equation

Q15.

Question Number	Scheme	Marks
(a)	$\tan\theta = \frac{2}{9}$ $\theta = 12.5^\circ$ bearing 103°	M1 A1 A1 (3)
(b) (i) (ii)	$\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$ $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$	M1 A1 A1 (3)
(c)	$\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$	M1 A1 (2)
(d)	$D^2 = (8 + 5t)^2 + (6 - 10t)^2$ $= 125t^2 - 40t + 100$ $100 = 125t^2 - 40t + 100$ $0 = 5t(25t - 8)$ $t = 0$ or 0.32	M1 A1 M1 M1 A1 A1 (6) **14**
	Notes	
(a)	M1 for $\tan\theta = \pm\frac{2}{9}$ or $\pm\frac{9}{2}$ or use $\sin\theta$ or $\cos\theta$	
	First A1 for $\theta = \pm 13^\circ$ or $\pm 77^\circ$ or $\pm 12.5^\circ$ or $\pm 77.5^\circ$ or better	
	Second A1 for 103°	
(b)	M1 for clear attempt at $\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$ or $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$ (Allow slips but must be a '+' sign and $\mathbf{r} + t\,\mathbf{v}$)	
(i)	First A1 for $\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$oe	
(ii)	Second A1 for $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$oe	
(c)	M1 for $\mathbf{p} - \mathbf{q}$ or $\mathbf{q} - \mathbf{p}$ with their $\mathbf{p}$ and $\mathbf{q}$ substituted A1 for correct answer $\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$ (don't need $\overrightarrow{QP}$ but on R.H.S must be **identical** coefficients of **i** and **j** but allow column vectors)	
(d)	First M1 for attempt to find QP or QP^2 in terms of *t only*, using correct formula First A1 for a correct expression (with or without √) $125t^2 - 40t + 100$ Second M1 for √ (3 term quadratic) = 10 or (3 term quadratic) =100. Third M1 for quadratic expression = 0 and attempt to solve (e.g. factorising or using formula) Second A1 for $t = 0$ (if they divide by t and lose this value but get 0.32, M1A0A1) Third A1 for $t = 0.32$ oe	

Q16.

Question Number	Scheme	Marks
(a)	$\tan\theta = \frac{5}{20}$ $\theta = 14.036..^{0}$ $\theta = 104^{0}$ nearest degree	M1 A1 A1 (3)
(b)	$\mathbf{p} = 400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$ $\mathbf{q} = 800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$	M1 A1 A1 (3)
(c)	Equate their **j** components: $20t(\mathbf{j}) = (800 - 5t)(\mathbf{j})$ $t = 32$ $\mathbf{s} = 800\mathbf{j} + 32(20\mathbf{i} - 5\mathbf{j})$ $= 640\mathbf{i} + 640\mathbf{j}$	M1 A1 M1 A1 (4) **10**
(a)	**Notes** **Allow column vectors throughout** M1 for $\tan\theta = \pm\frac{5}{20}$ or $\pm\frac{20}{5}$ (or any other complete method) First A1 for $\pm 14.04°$ or $\pm 75.96°$ Second A1 for $104°$	
(b) (i) (ii)	M1 for clear attempt at either **p** or **q** (allow slip but t <u>must</u> be attached to the velocity vector and position vector and velocity vector must be paired up correctly) First A1 $400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$ "**p** =" not needed but must be clear it's P Second A1 $800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$ "**q** =" not needed but must be clear it's Q	
(c)	First M1 for equating their **j** components; allow **j**'s on both sides First A1 for $t = 32$ Second M1 <u>independent</u> for substituting their t value into their **q** from (b) Second A1 for $640\mathbf{i} + 640\mathbf{j}$	

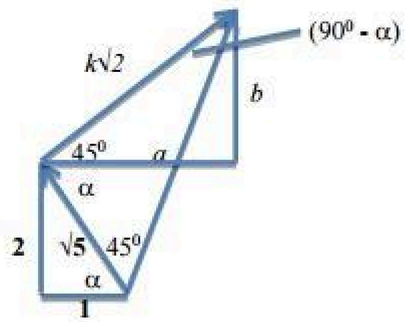
Q17.

Question Number	Scheme	Marks
(a)	$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$	B1
	$(-1+a)\mathbf{i} + (2+b)\mathbf{j}$	M1
	$\dfrac{-1+a}{2+b} = \dfrac{1}{3}$	**DM**1 A1
	$a = b = k = 2.5$; $\mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$	**DM**1 A1; A1 (7)
	ALTERNATIVE:	
	$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$	B1
	$(-1+a)\mathbf{i} + (2+b)\mathbf{j} = p(\mathbf{i} + 3\mathbf{j})$	M1 for LHS
	$-1 + a = p$ $2 + b = 3p$	**DM**1 A1
	$a = b = k = 2.5$; $\mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$	**DM**1 A1; A1 (7)
(b)	$\mathbf{v} = 3\mathbf{i} - 22\mathbf{j} + 3(3\mathbf{i} + 9\mathbf{j})$ $= 12\mathbf{i} + 5\mathbf{j}$	M1 A1
	$\lvert\mathbf{v}\rvert = \sqrt{12^2 + 5^2} = 13 \text{ ms}^{-1}$	M1 A1 **cso** (4)
		11
	Notes	
(a)	B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(k \neq 1)$ seen or implied in working, including for an incorrect final answer, with the wrong k value. First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with $\mathbf{i}$'s and $\mathbf{j}$'s collected (which can be implied by later working) but allow a slip. <u>(M0 if *a* and *b* both assumed to be 1)</u> Second M1, dependent on first M1, for ratio of their cpts = 1/3 or 3/1 (Must be correct way up for the M mark) First A1 for a correct equation which may involve two unknowns Third M1, dependent on first and second M1, for solving for *k* oe Second A1 for a correct k value Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$	

ALTERNATIVE: Using two simultaneous equations

B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(k \neq 1)$ seen or implied in working.
First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with **i**'s and **j**'s collected (LHS of equation) (M0 if <u>*a* and *b* both</u> assumed to be 1) but allow a slip
Second M1, dependent on first M1, for equating coeffs to produce *two* equations in 2 or 3 unknowns. Must have p and $3p$ <u>(M0 if *p* is assumed to be 1 or *k*</u>)
First A1 for two correct equations
Third M1, dependent on first and second M1, for solving for k oe
Second A1 for a correct k value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

ALTERNATIVE: Using magnitudes and directions



$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$, seen or implied	B1
Correct vector triangle	M1
$\dfrac{k\sqrt{2}}{\sin 45^0} = \dfrac{\sqrt{5}}{\sin(90^0 - \alpha)}$, $\alpha = \arctan 2$	**DM**1 A1
$2k = 5$	
$k = 2.5$; $\mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$	**DM**1 A1; A1 (7)

ALTERNATIVE: Using magnitudes and directions
B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ seen or implied in working.
First M1 for a correct vector triangle (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$). (M0 if <u>*a* and *b* both</u> assumed to be 1 and/or longest side is assumed to be $\sqrt{10}$)
Second M1, dependent on first M1, for using sine rule on vector triangle
First A1 for a correct equation. 45^0 may not appear exactly.
Third M1, dependent on first and second M1, for solving for k oe
Second A1 for a correct k value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

(b)	First M1 for use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ with $t = 3$ First A1 for $12\mathbf{i} + 5\mathbf{j}$ seen or implied. However, if a wrong $\mathbf{v}$ is seen A0 Second M1 for finding magnitude of their $\mathbf{v}$ Second A1 for 13	

Q18.

Question Number	Scheme	Marks
a	$\mathbf{F} = ma$: $3\mathbf{i} - 2\mathbf{j} = 0.5a$	M1
	$a = 6\mathbf{i} - 4\mathbf{j}$	A1
	$\lvert a \rvert = \sqrt{6^2 + (-4)^2} = 2\sqrt{13}$ (m s^{-2}) **	M1A1 (4)
b	$v = u + at$: $v = (\mathbf{i} + 3\mathbf{j}) + 2(6\mathbf{i} - 4\mathbf{j})$	M1A1 ft
	$= 13\mathbf{i} - 5\mathbf{j}$ m s^{-1}	A1 (3)
c	Distance = $2\lvert\mathbf{v}\rvert = 2\sqrt{4+1} = 2\sqrt{5} = 4.47$ (m)	M1A1
		(2)
d	When $t = 3.5$, velocity of P is $(\mathbf{i} + 3\mathbf{j}) + 3.5(6\mathbf{i} - 4\mathbf{j}) = 22\mathbf{i} - 11\mathbf{j}$	M1A1 ft
	Given conclusion reached correctly. E.g. $22\mathbf{i} - 11\mathbf{j} = 11(2\mathbf{i} - \mathbf{j})$	A1 **(3)**
		[12]

Notes for Question

Question (a)

Either:
First M1 for use of $\mathbf{F} = m\,\mathbf{a}$
First A1 for $\mathbf{a} = 6\mathbf{i} - 4\mathbf{j}$
Second M1 for $a = \sqrt{(6^2 + (-4)^2)}$ (Allow $\sqrt{(6^2 + 4^2)}$)
Second A1 for $a = 2\sqrt{13}$ (ms^{-2}) **Given answer**

Or:
First M1 for $F = \sqrt{(3^2 + (-2)^2)}$ (Allow $\sqrt{(3^2 + 2^2)}$)
First A1 $F = \sqrt{13}$
Second M1 for $\sqrt{13} = 0.5\,a$
Second A1 for $a = 2\sqrt{13}$ (ms^{-2}) **Given answer**

Question (b)
M1 for $(\mathbf{i} + 3\mathbf{j})$ + (2 x their $\mathbf{a}$)
First A1 **ft** for a correct expression
Second A1 for $13\mathbf{i} - 5\mathbf{j}$; isw if they go on to find the speed

Question (c)
M1 for $2\sqrt{(2^2 + (-1)^2)}$ or $\sqrt{(4^2 + (-2)^2)}$
A1 for $2\sqrt{5}$ or $\sqrt{20}$ or 4.5 or 4.47 or better

Question (d)
M1 for $(\mathbf{i} + 3\mathbf{j})$ + (3.5 x their $\mathbf{a}$) ,or possibly, their (b) + (1.5 x their $\mathbf{a}$)
First A1 ft for a correct expression *of form* $a\mathbf{i} + b\mathbf{j}$
Second A1 for given conclusion reached correctly *e.g.* $22\mathbf{i} - 11\mathbf{j} = 11(2\mathbf{i} - \mathbf{j})$ oe **Given answer**

Q19.

Question Number	Scheme	Marks
(a)	$(4\mathbf{i} - 2\mathbf{j}) + (2\mathbf{i} + q\mathbf{j}) = (6\mathbf{i} + (q-2)\mathbf{j})$ $6 = 2(q-2)$ ratio 2:1 $q = 5$	M1A1 **DM1** A1 (4)
(b)	$6\mathbf{i} + 3\mathbf{j} = 1.5\mathbf{a}$ $\mathbf{a} = (4\mathbf{i} + 2\mathbf{j})$ m s^{-2} $\mathbf{v} = \mathbf{u} + \mathbf{a}t = (-2\mathbf{i} + 4\mathbf{j}) + 2(4\mathbf{i} + 2\mathbf{j})$ $= 6\mathbf{i} + 8\mathbf{j}$ speed $= \sqrt{6^2 + 8^2}$ $= 10$ m s^{-1}	M1 A1 M1 A1ft **M1** A1 (6) **[10]**

Notes for Question

Question (a)
First M1 for $(4\mathbf{i} - 2\mathbf{j}) + (2\mathbf{i} + q\mathbf{j})$
First A1 for $(6\mathbf{i} + (q-2)\mathbf{j})$ (seen or implied)
Second M1, **dependent on first M1**, for using 'parallel to $(2\mathbf{i} + \mathbf{j})$' to obtain an equation in q *only*.
Second A1 for $q = 5$

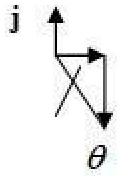
Question (b)
First M1 for their **resultant force** $= 1.5\mathbf{a}$
First A1 for $\mathbf{a} = 4\mathbf{i} + 2\mathbf{j}$
Second M1 for $(-2\mathbf{i} + 4\mathbf{j}) + 2$ x (their **a**) **(M0 if force is used instead of a)**
Second A1 **ft** for their velocity at $t = 2$
Third M1for finding the magnitude of their velocity at $t = 2$
Third A1 for 10 (ms^{-1})

N.B. In (b), if they use scalars throughout, M0A0M0A0M0A0

Q20.

Question Number	Scheme	Marks
	$-6\mathbf{i} + \mathbf{j} = \mathbf{u} + 3(2\mathbf{i} - 5\mathbf{j})$ $\Rightarrow \mathbf{u} = -12\mathbf{i} + 16\mathbf{j}$ $\Rightarrow u = \sqrt{(-12)^2 + 16^2} = 20$	M1 A1 A1 cso M1 A1 **[5]**

Q21.

Question Number	Scheme	Marks
(a)	 $\tan\theta = \dfrac{2}{1} \Rightarrow \theta = 63.4^{\circ}$	M1 A1
	angle is 153.4°	A1 (3)
(b)	$(4+p)\mathbf{i} + (q-5)\mathbf{j}$	B1
	$(q-5) = -2(4+p)$	M1 A1
	$2p + q + 3 = 0$ *	A1 (4)
(c)	$q = 1 \Rightarrow p = -2$	B1
	$\Rightarrow\ \mathbf{R} = 2\mathbf{i} - 4\mathbf{j}$	M1
	$\Rightarrow \lvert\mathbf{R}\rvert = \sqrt{2^2 + (-4)^2} = \sqrt{20}$	M1 A1 f.t.
	$\sqrt{20} = m8\sqrt{5}$	M1 A1 f.t.
	$\Rightarrow m = \dfrac{1}{4}$	A1 cao (7)
		[14]

Q22.

Question Number	Scheme	Marks
(a)	$\tan\theta = \dfrac{8}{6}$	M1
	$\theta \approx 53°$	A1 (2)
(b)	$\mathbf{F} = 0.4(6\mathbf{i}+8\mathbf{j})\ (= 2.4\mathbf{i}+3.2\mathbf{j})$	M1
	$\lvert\mathbf{F}\rvert = \sqrt{(2.4^2+3.2^2)} = 4$	M1 A1 (3)
(c)	$\mathbf{v} = 9\mathbf{i}-10\mathbf{j}+5(6\mathbf{i}+8\mathbf{j})$	M1 A1
	$= 39\mathbf{i}+30\mathbf{j}\ \left(\text{ms}^{-1}\right)$	A1 (3)
		(8 marks)

Q23.

Question Number	Scheme	Marks
(a)	speed $= \sqrt{2^2+(-5)^2}$ $= \sqrt{29} = 5.4$ or better	M1 A1 **(2)**
(b)	$((7\mathbf{i}+10\mathbf{j})-(2\mathbf{i}-5\mathbf{j}))/5$ $=(5\mathbf{i}+15\mathbf{j})/5 = \mathbf{i}+3\mathbf{j}$ $\mathbf{F} = m\mathbf{a} = 2(\mathbf{i}+3\mathbf{j}) = 2\mathbf{i}+6\mathbf{j}$	M1 A1 A1 DM1 A1ft **(5)**
(c)	$\mathbf{v} = \mathbf{u}+\mathbf{a}t = (2\mathbf{i}-5\mathbf{j})+(\mathbf{i}+3\mathbf{j})t$ $(-5+3t)\mathbf{j}$ Parallel to $\mathbf{i} \Rightarrow -5+3t=0$ $t = 5/3$	M1 A1 M1 A1 **(4)** **[11]**

Q24.

Question	Scheme	Marks	AOs
(a)	Put $t = 2$ in $\mathbf{v}$ and use Pythagoras: $\sqrt{12^2 + (-6\sqrt{2})^2}$	M1	3.1a
	$\sqrt{216}, 6\sqrt{6}$ or 15 or better $(\mathrm{m\,s^{-1}})$	A1	1.1b
		(2)	
(b)	Differentiate $\mathbf{v}$ wrt t to obtain $\mathbf{a}$	M1	3.4
	$6t\mathbf{i} - 3t^{-\frac{1}{2}}\mathbf{j}$ oe $(\mathrm{m\,s^{-2}})$ isw	A1	1.1b
		(2)	
(c)	Integrate $\mathbf{v}$ wrt t to obtain $\mathbf{r}$	M1	3.4
	$\mathbf{r} = t^3\mathbf{i} - 4t^{\frac{3}{2}}\mathbf{j}\ (+\mathbf{C})$	A1	1.1b
	$(\mathbf{i} - 4\mathbf{j}) = 4^3\mathbf{i} - 4 \times 4^{\frac{3}{2}}\mathbf{j} + \mathbf{C}$	M1	3.1a
	$(-62\mathbf{i} + 24\mathbf{j})$ (m) isw e.g. if they go on to find the distance.	A1	1.1b
		(4)	
			(8 marks)

Notes: Accept column vectors throughout apart from the answer to (b).		
a	M1	Need square root but -ve sign not required. Allow $\mathbf{i}$'s and/or $\mathbf{j}$'s to go missing from their $\mathbf{v}$ at $t = 2$, provided they have applied Pythagoras correctly.
	A1	cao N.B. Correct answer with no working can score 2 marks.
b	M1	Both powers decreasing by 1. Allow a column vector. M0 if $\mathbf{i}$ or $\mathbf{j}$ is missing but allow recovery in (b).
	A1	cao. Do not accept a column vector.
c	M1	Both powers increasing by 1 M0 if $\mathbf{i}$ or $\mathbf{j}$ is missing but allow recovery.
	A1	($\mathbf{r}$ =) not required
	M1	Putting $\mathbf{r} = (\mathbf{i} - 4\mathbf{j})$ and $t = 4$ into their displacement **vector** expression which must have $\mathbf{C}$ (allow C) to give an equation in $\mathbf{C}$ only, seen or implied. Must have attempted to integrate $\mathbf{v}$ for this mark to be available. N.B. $\mathbf{C}$ does not need to be found and this is a method mark, so allow slips.
	A1	cao