12	**(a)**		$\mathbf{v} = (1-2t)\mathbf{i} + (2t^2 + t - 13)\mathbf{j}$ If P is stationary, then $1-2t=0$ and $2t^2+t-13=0$ $\mathbf{i}: 1-2t=0 \Rightarrow t=\frac{1}{2}$ $\mathbf{j}: 2t^2+t-13=0 \Rightarrow t=2.3117..., -2.8117...$ No value of t is common to both components, so P is never stationary	**M1** **A1** **[2]**	**3.1b** **2.2a**	Considers **either** the **i or j** component equal to zero **or** forms a five-term quartic equation for $\lvert\mathbf{v}\rvert^2 = 0$ (oe) $(4t^4 + 4t^3 - 47t^2 - 30t + 170 = 0)$ **BC** – need not see the negative value of t **or** for substituting t = 0.5 into quadratic expression for **j** and showing this gives a non-zero answer (oe) with correct working **and** conclusion	**A1** for the **correct** quartic equation with roots stated as $2.3 \pm 0.35i$, $-2.8 \pm 0.65i$ + correct conclusion
12	**(b)**		$\Rightarrow \mathbf{a} = -2\mathbf{i} + (4t+1)\mathbf{j}$ (m s^{-2})	**B1** **[1]**	**1.1**	Correct derivative **–** or as a column vector	Brackets must be around the $4t + 1$

12	**(c)**		$-2\left(2t^2+t-13\right)=1\left(1-2t\right)$	**M1***	**3.1b**	Setting up a quadratic equation in t only – allow sign errors (including on the 1 and 2) and the 1 and –2 on the wrong side	Or multiples of 1 and –2
			$4t^2-25=0 \Rightarrow t=2.5$	**M1dep***	**1.1**	Solves their (two or three term) quadratic and selects their positive value of t	**Check unsupported solutions if incorrect quadratic equation**
			$\mathbf{F}=m\mathbf{a} \Rightarrow \mathbf{F}=0.5\left\{-2\mathbf{i}+\left(4t+1\right)\mathbf{j}\right\}$	**M1***	**3.4**	Substitute their **a** into $\mathbf{F} = 0.5\mathbf{a}$ or their $\lvert\mathbf{a}\rvert$ into $\lvert\mathbf{F}\rvert = 0.5\lvert\mathbf{a}\rvert$. If **F** not stated in terms of t then one component must be correct following through from their **a** (and possibly t)	Must use correct value of 0.5 for m but can be in terms of t
			$\lvert\mathbf{F}\rvert=\sqrt{\left(-1\right)^2+5.5^2}$	**M1dep***	**1.1**	Dependent on previous **M** mark only	From a value of $t > 0$
			$\lvert\mathbf{F}\rvert=5.59$ (N)	**A1** **[5]**	**1.1**	awrt 5.59 (exact: $\frac{5\sqrt{5}}{2}$)	5.590169…

12	**(d)**		$\mathbf{s} = \left(t - t^2\right)\mathbf{i} + \left(\frac{2}{3}t^3 + \frac{1}{2}t^2 - 13t\right)\mathbf{j}(+\mathbf{c})$	**M1***	**1.1**	Integrates **v** wrt t – at least three terms correct	Allow without +**c**
			$t = 1, \mathbf{s} = \frac{1}{6}\mathbf{j} \Rightarrow \mathbf{c} = (0\mathbf{i} +)12\mathbf{j}$	**A1**	**3.4**	Uses given conditions to find correct **c** – dependent on a completely correct integrated expression for **s**	www
			When t = 1.5, $\mathbf{s} = -\frac{3}{4}\mathbf{i} - \frac{33}{8}\mathbf{j}$	**M1dep***	**1.1**	Substitute t = 1.5 into their **s**	
			$tan^{-1}\left(\frac{\pm 3/4}{\pm 33/8}\right)$ or $tan^{-1}\left(\frac{\pm 33/8}{\pm 3/4}\right)$	**M1**	**3.1b**	Attempt to find a relevant angle using the components of their **s** (allow use of sin/cos with the magnitude of **s**)	**Dependent on both previous M marks.** Written in terms of arctan is sufficient
			Bearing = $180 + \tan^{-1}\left(\frac{3/4}{33/8}\right)$ = 190°	**A1**	**3.2a**	awrt 190 (or from $270 - tan^{-1}\left(\frac{33/8}{3/4}\right)$)	190.3048465…
				[5]			