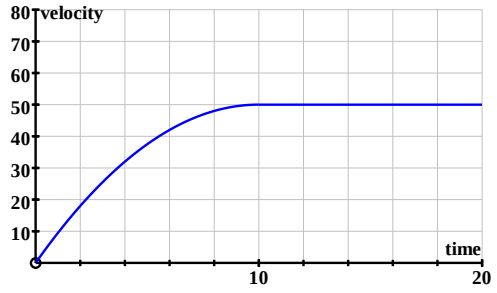
1	**(i)**		**Either** $-2+8t=7t$ **Or** $t=10-4t$ $\Rightarrow t=2$ Substituting $t=2$ in **both** expressions They meet at (14, 2)	**M1** **A1** **B1** **B1** **[4]**	Forming an equation for *t*. Accept vector equation for this mark. May be implied by a statement that *t* = 2. oe, eg showing $t=2$ satisfies both equations or a vector equation. Accept $\begin{pmatrix}14\\2\end{pmatrix}$	
	(ii)		Ashok's speed is $\sqrt{8^2+1^2}=\sqrt{65}$ Kumar's speed is $\sqrt{7^2+(-4)^2}=\sqrt{65}$ km h^{-1} They both walk at the same speed	**B1** **B1** **B1** **[3]**	CAO from correct speeds SC1 for finding both velocities correctly but neither speed	

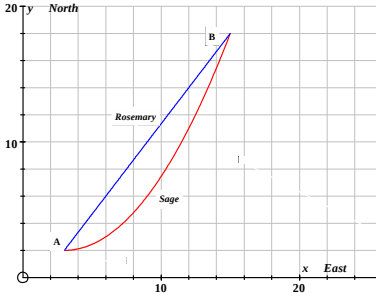
Follow through between parts of Question 2 should be allowed for the value of *h* (when *t* = 10) found in part (iii) if it is used in part (iv) or in part (v)(*A*).						
2	**(i)**		Integrate *a* to obtain *v* $v = 10t - \frac{1}{2}t^2 \quad (+c)$ $t = 10 \Rightarrow v = 100 - 50 = 50$ Since $a = 0$ for $t > 10$, $v = 50$ for $t > 10$	**M1** **A1** **M1** **A1** **[4]**	Attempt to integrate Substitution of $t = 10$ to find v Sound argument required for given answer. It must in some way refer to $a = 0$.	
2	**(ii)**		Continuous two part *v*-*t* graph  Curve for $0 \le t \le 10$ Horizontal straight line for $10 \le t \le 20$	**B1** **B1** **B1** **[3]**	The graph must cover $t = 0$ to $t = 20$ B0 if no vertical scale is given	

2	**(iii)**		Distance fallen = $\int\left(10t-\frac{1}{2}t^2\right)\mathrm{d}t$ $d=5t^2-\frac{1}{6}t^3+c \quad (c=0)$ Height = $1000-d$ Height = $1000-5t^2+\frac{1}{6}t^3$ When $t=10$, $h=667$	**M1** **A1** **A1** **B1** **[4]**	Attempt to integrate This mark should only be given if the signs are correctly obtained. oe	
	(iv)		Time at constant vel $=667\div 50=13.3$ Total time $t=10+13.3=23.3$	**B1** **B1** **[2]**	FT for *h* from part (iii) FT	
	(v)	***A***	Since $500>333$ The box will have reached terminal speed. So there is no improvement	**M1** **A1** **[2]**	For finding the height at which the crate reaches terminal velocity, eg $h = 167$, or equivalent relevant calculation. FT for *h* from part (iii) if used. Allow either one (or both) of these two statements.	
	(v)	***B***	$v=10t-t^2$ (for $t\le 5$) Terminal velocity is 25 $\mathrm{m\,s^{-1}}$ So better	**M1** **A1** **A1** **[3]**	Integration to find *v*	

Question			Answer	Marks	Guidance	
3	(i)		Speed $= \sqrt{(-5)^2 + 0^2 + (-10)^2}$ $= 11.2 \text{ m s}^{-1}$ (11.18)	M1 A1	For use of Pythagoras. Accept $\sqrt{5^2 + 10^2}$. Accept $\sqrt{125}$ or $5\sqrt{5}$	
			$\tan\theta = \frac{5}{10}$ $\theta = 26.6°$	M1 A1 **[4]**	Complete method for correct angle; may use $\sin\theta = \frac{5}{11.2}$, $\cos\theta = \frac{10}{11.2}$. Allow 153.4°, 206.6°	
3	(ii)		$\begin{pmatrix} 0 \\ 0 \\ -980 \end{pmatrix}$ her weight $\begin{pmatrix} 0 \\ 0 \\ 880 \end{pmatrix}$ resistance to her vertical motion $\begin{pmatrix} 50 \\ -20 \\ 0 \end{pmatrix}$ force from the power unit	B1 B1 B1 **[3]**	The descriptions should be linked to the forces, either by the layout of the answer or by suitable text. If not, assume that the forces they refer to are in the order given here (which is the same as the question). Accept "Air resistance", "Arms stretched out" and similar statements. Condone mention of a parachute.	
3	(iii)		Resultant force $= \begin{pmatrix} 50 \\ -20 \\ -100 \end{pmatrix}$ Acceleration $= \begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix}$ Magnitude $= \sqrt{0.5^2 + (-0.2)^2 + 1^2} = 1.1357...$ So 1.14 to 3 s.f.	B1 B1 B1 **[3]**	May be implied Newton's 2nd Law Answer given. Allow FT from sign errors. Accept $\lvert\mathbf{F}\rvert \div 100$	

Question			Answer	Marks	Guidance	
3	(iv)		$\mathbf{v} = \mathbf{u} + \mathbf{a}t$	M1	FT their **a** for the first 5 marks of this part. Vectors must be seen or implied. Accept valid integration.	
			$\mathbf{v} = \begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix} + \begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix} t$	A1		
			$\mathbf{r} = \mathbf{r_0} + \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$	M1	Vectors must be seen or implied. Accept valid integration. Condone no $\mathbf{r_0}$ for this M mark	
			$\mathbf{r} = \begin{pmatrix} -75 \\ 90 \\ 750 \end{pmatrix} + \begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix} t^2$	A1		
			When $t = 30$	M1	Vectors must be seen or implied.	
			$\mathbf{r} = \begin{pmatrix} -75 - 150 + 225 \\ 90 + 0 - 90 \\ 750 - 300 - 450 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$, as required	E1	CAO	
					SC1 to replace the first 4 marks of this section if the acceleration is taken to be **g** but the answer is otherwise correct.	
				[6]		
3	(v)		When $t = 30$, $\mathbf{v} = \begin{pmatrix} 10 \\ -6 \\ -40 \end{pmatrix}$	M1	There must be an attempt to work out at least the vertical component of the velocity at t = 30. This mark is not dependent on a correct answer.	
			The vertical component of the velocity is too fast for a safe landing	A1	Accept an argument based on speed derived from a vector.	
				[2]		

Question			Answer	Marks	Guidance
4	(i)		$v = 0 \Rightarrow 3(t-2)(t-4) = 0$	M1	Setting $v = 0$ (may be implied)
			$T_1 = 2,\ T_2 = 4$	A1	Accept $t = 2$ and $t = 4$
				[2]	
4	(ii)		$x = \int v\,dt$	M1	Use of integration
			$x = 24t - 9t^2 + t^3 + c:\ c = 0$	A1	Condone omission of c
			$t = 2 \Rightarrow x = 48 - 36 + 8 = 20$	E1	CAO
			$t = 4 \Rightarrow x = 96 - 144 + 64 = 16$	A1	CAO
				[4]	

5	(i)		A: $t = 0$, $\mathbf{r} = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$, B: $t = 2$, $\mathbf{r} = \begin{pmatrix} 15 \\ 18 \end{pmatrix}$ $\begin{pmatrix} 15 \\ 18 \end{pmatrix} - \begin{pmatrix} 3 \\ 2 \end{pmatrix} = \begin{pmatrix} 12 \\ 16 \end{pmatrix}$ $\sqrt{12^2 + 16^2} = 20$ The distance AB is 20 km.	B1 B1 B1 **[3]**	Award this mark automatically if the displacement is correct Finding the displacement. Follow through from position vectors for A and B Cao
5	(ii)		$\mathbf{v} = \frac{d\mathbf{r}}{dt} = \begin{pmatrix} 6 \\ 8 \end{pmatrix}$ which is constant	B1 **[1]**	Any valid argument. Accept $\begin{pmatrix} 6 \\ 8 \end{pmatrix}$ with no comment. Do not accept $a = 0$ without explanation.
5	(iii)			B1 B1 B1 **[3]**	Points A and B plotted correctly, with no FT from part (i), and the line segment AB for the *Rosemary*. No extra lines or curves. For the *Sage*, a curve between A and B. B0 for two line segments. Nothing extra. No FT from part (i). Passes through (9, 6) Condone no labels