1   **mark**   **Sub**

(i) $\sqrt{(-6)^2 + 13^2} = 14.31782...$ M1   Accept $\sqrt{-6^2 + 13^2}$

so 14.3 N (3 s. f.)   A1

                                                                                                    2

(ii)   Resultant is $\begin{pmatrix} -6 \\ 13 \end{pmatrix} - \begin{pmatrix} -3 \\ 5 \end{pmatrix} = \begin{pmatrix} -3 \\ 8 \end{pmatrix}$ B1   May not be explicit. If diagram used it must have

                                                                     correct orientation. Give if final angle correct.

Require $270 + \arctan\dfrac{8}{3}$ M1   Use of $\arctan\left(\pm\dfrac{8}{3}\right)$ or $\arctan\left(\pm\dfrac{3}{8}\right)$ ($\pm20.6°$ or

                                                                     $\pm69.4°$) or equivalent on **their** resultant

so 339.4439…° so 339°   A1   cao. Do not accept -21°.

                                                                                                     3

(iii) $\begin{pmatrix} -3 \\ 5 \end{pmatrix} = 5\mathbf{a}$ M1   Use of N2L with accn *used* in vector form

so ($-0.6\,\mathbf{i} + \mathbf{j}$) m s^{-2} A1   Any form. Units not required. isw.

change in velocity is ($-6\,\mathbf{i} + 10\,\mathbf{j}$) m s^{-1} F1   10**a** seen. Units not required. Must be a vector.

                                                               [SC1 for $a = \sqrt{3^2 + 5^2}/5 = 1.17$]

                                                                                                     3

                                                                                                     8

Question			Answer	Marks	Guidance
2	**(i)**	(*A*)	Distance travelled $=$ Area under the graph	M1	Attempt to find area
			$\frac{1}{2}\times 4 \times 8 + \frac{1}{2}\times 4 \times (8+12) + 4 \times 12$	M1	Splitting into suitable parts
			104 m	A1	Cao
					Allow all 3 marks for 104 without any working
	(i)	(*B*)	**Either**		
			Working backwards from distance when $t=12$	M1	
			$12 - \frac{(104-100)}{12}$	M1	Allow this mark for 0.33… Follow through from their total distance
			11.67 s	A1	Cao
			Or		
			Working forwards from when $t=8$	M1	
			$8 + \frac{(100-56)}{12}$	M1	Allow this mark for 3.67… Follow through from their distance at time 8s
			11.67 s	A1	Cao
				[6]	
	(ii)		Substituting $t=8$ gives $v = \frac{5}{2}\times 8 - \frac{1}{8}\times 8^2 = 12$	B1	
				[1]	

Question			Answer	Marks	Guidance
2	**(iii)**		Distance $= \int_{0}^{12} \left(\dfrac{5t}{2} - \dfrac{t^2}{8} \right) dt$	M1	Integratin v. Condone no limits.
			$\left[\dfrac{5t^2}{4} - \dfrac{t^3}{24} \right]_{0}^{12}$	A1	Condon no limits
			$[180 - 72]$ $(-[0])$	M1	Substituting $t = 12$
			108 m	A1	
				[4]	
	(iv)		Model P: distance at $t = 11.35$ is 96.2	B1	Ca
			Model Q: distance at $t = 11.35$ is		
			$\left[\dfrac{5t^2}{4} - \dfrac{t^3}{24} \right]_{0}^{11\,35} = 100.1$	M1	Substituting 11.35 in their expression from part **(iii)**
			Model Q places the runner closer	E1	Cao from correct previous working for both models
				[3]	
	(v)		Model P: Greatest acceleration $\dfrac{8}{4} = 2$ m s^{-2}	B1	
			Model Q: $a = \dfrac{dv}{dt} = \dfrac{5}{2} - \dfrac{t}{4}$	M1	Differentiating v
				A1	
			Model Q: Greatest acceleration is 2.5 m s^{-2}	B1	Award if correct answer seen
				[4]	

3		mark		
(i)	Area under curve $0.5 \times 2 \times 20 + 0.5 \times (20+10) \times 4 + 0.5 \times 10 \times 1$ $= 85$ m	M1 B1 A1	Attempt to find any area under curve or use const accn results Any area correct (Accept 20 or 60 or 5 without explanation) cao	3
(ii)	$\dfrac{20-10}{4} = 2.5$ upwards	M1 A1 B1	$\Delta v / \Delta t$ accept ± 2.5 Accept -2.5 downwards (allow direction specified by diagram etc). Accept 'opposite direction to motion'.	3
(iii)	$v = -2.5t + c$ $v = 20$ when $t = 2$ $v = -2.5t + 25$	M1 M1 A1	Allow **their** a in the form $v = \pm at + c$ or $v = \pm a(t-2) + c$ cao [Allow $v = 20 - 2.5(t-2)$] [Allow 2/3 for different variable to t used, e.g. x. Allow any variable name for speed]	3
(iv)	Falling with negligible resistance	E1	Accept 'zero resistance', or 'no resistance' seen.	1
(v)	$-1.5 \times 4 + 9.5 \times 2 + 7 = 20$ $-1.5 \times 36 + 9.5 \times 6 + 7 = 10$ $-1.5 \times 49 + 9.5 \times 7 + 7 = 0$	E1 E1	One of the results shown All three shown. Be generous about the 'show'.	2
(vi)	$\displaystyle\int_{2}^{7} (-1.5t^2 + 9.5t + 7)\,dt$ $= \left[-0.5t^3 + 4.75t^2 + 7t \right]_{2}^{7}$ $= \left(-\dfrac{343}{2} + \dfrac{19 \times 49}{4} + 49 \right) - \left(-4 + 19 + 14 \right)$ $= 81.25$ m	M1 A1 A1 A1 M1 A1 A1	Limits not required A1 for each term. Limits not required. Condone $+ c$ Attempt to use both limits on an integrated expression Correct substitution in **their** expression including subtraction (may be left as an expression). cao.	7
	total	19		

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