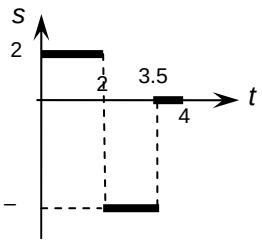
1	**(i)**	(*A*)	Distance travelled = Area under the graph $\frac{1}{2}\times 4\times 8+\frac{1}{2}\times 4\times(8+12)+4\times 12$ 104 m	M1 M1 A1	Attempt to find area Splitting into suitable parts Cao **Allow all 3 marks for 104 without any working**
	(i)	(*B*)	**Either** Working backwards from distance when $t=12$ $12-\frac{(104-100)}{12}$ 11.67 s	 M1 M1 A1	 Allow this mark for 0.33… Follow through from their total distance Cao
			Or Working forwards from when $t=8$ $8+\frac{(100-56)}{12}$ 11.67 s	 M1 M1 A1	 Allow this mark for 3.67… Follow through from their distance at time 8s 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
1	(iii)		Distance $= \int_0^{12}\left(\frac{5t}{2}-\frac{t^2}{8}\right)\mathrm{d}t$	M1	Integratin v. Condone no limits.
			$\left[\frac{5t^2}{4}-\frac{t^3}{24}\right]_0^{12}$	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 $\left[\frac{5t^2}{4}-\frac{t^3}{24}\right]_0^{11\ 35}=100.1$	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 $\frac{8}{4}=2$ m s^{-2}	B1	
			Model Q: $a=\frac{\mathrm{d}v}{\mathrm{d}t}=\frac{5}{2}-\frac{t}{4}$	M1	Differentiating v
				A1	
			Model Q: Greatest acceleration is 2.5 m s^{-2}	B1	Award if correct answer seen
				[4]	

		mark	note
2(i)		B1 B1 2	Section from $t = 10$ to $t = 15$ Section from $t = 15$ to $t = 20$. FT connecting from their point when $t = 15$. Ignore graph outside $0 \le t \le 20$.
(ii)	$\frac{-6-14}{10} = -2$ so -2 m s^{-2}	M1 A1 2	Attempt at $\frac{\Delta v}{\Delta t}$
(iii)	**either** Displacement is $\frac{14}{2}\times 7 - \frac{13+5}{2}\times 6$ or $\frac{14}{2}\times 7 - \frac{3\times 6}{2} - 5\times 6 - \frac{5\times 6}{2}$ $= -5$ so 5 m downwards	M1 B1 B1 A1	FT misread from graph or graphing error to all but final A1 cao Attempt at whole area. Condone 'overlap' but not 'gaps'. 'Positive' area expression correct. Condone sign error. 'Negative' area expression correct. Condone overall sign error. Accept –5 m cao

	or Displacement is $14\times10+\frac{1}{2}\times(-2)\times10^2-\ 5\times 6+\ \frac{-6+0}{2}\times5$ $= 140 – 100 – 30 –15 = –5$ so 5 m downwards	 M1 A1 B1 A1 4	 Using *suvat* from 0 to 10 or 15 to 20. Condone ‘overlap’ but not ‘gaps’ Subtracting 30 or 15 or 45 Accept –5 m cao
		8	

3 (i)	$0 < t < 2$, $v = 2$ $2 < t < 3.5$ $v = -5$	B1 B1	Condone '5 downwards' and ' – 5 downwards'	2
(ii)		B1 B1	Condone intent – e.g. straight lines free-hand and scales not labelled; accept non-vertical sections at $t = 2$ & 3.5. Only horizontal lines used and 1st two parts present. BOD t-axis section. One of 1st 2 sections correct. FT (i) and allow if answer correct with (i) wrong All correct. Accept correct answer with (i) wrong. FT (i) only if 2nd section –ve in (i)	2
(iii)	(A) upwards; (B) and (C) downwa	E1	All correct. Accept +/- ve but not towards/away from O Accept forwards/backwards. Condone additional wrong statements about position.	1
				5

		Mark	Comment	Sub
4(i)	When $t = 2$, velocity is $6 + 4 \times 2 = 14$	M1 A1	Recognising that areas under graph represent changes in velocity in (i) or (ii) or equivalent *uvast.*	2
(ii)	Require velocity of – 6 so must inc by – 20 $-8 \times (t - 2) = -20$ so $t = 4.5$	M1 F1	FT ±(6 + **their** 14) used in any attempt at area/ *uvast* FT **their** 14 [Award SC2 for 4.5 WW and SC1 for 2.5 WW]	2
		4		