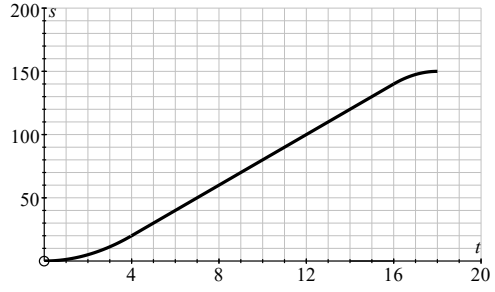
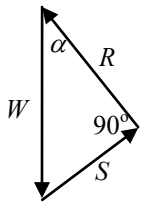
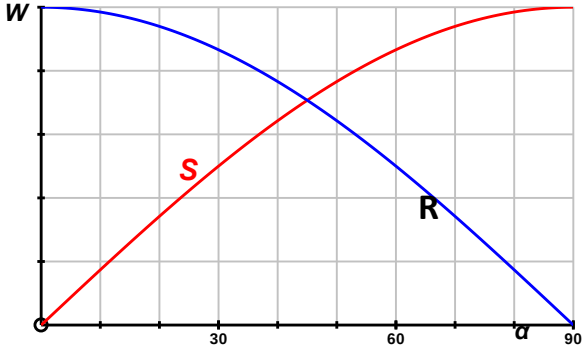
Question			Answer	Marks	Guidance	
1	(i)		When $t = 4$, $s = \frac{1}{2} \times 4 \times 10$		Finding the area of the triangle or equivalent.	
			$s = 20$	B1		
			When $t = 18$, $s = \frac{1}{2} \times (18 + 12) \times 10$	M1	A complete method of finding the area of the trapezium or equivalent.	
			$s = 150$	A1	CAO	
				[3]		
1	(ii)					
			Graph joining (0,0), (4,20) and (18, 150)	B1	Allow FT for their (4,20) and (18, 150) Condone extension to (20, 150) with a horizontal line.	
			The graph goes through (16, 140)	B1		
					Allow SC1 for the first two marks if there is a consistent displacement from a correct scale, eg plotting (18,150) at (19, 150)	
			Curves at both ends	B1	The sections from $t = 0$ to $t = 4$ and from $t = 16$ to $t = 18$ are both curves	
				[3]		

Question			Answer	Marks	Guidance	
2	(i)			B1 B1 B1 **[3]**	Closed triangle with cycling arrows. Accept any consistent orientation. All forces labelled. Correct angles. The 90° may be implied. α may be shown between S and the horizontal (ie outside the triangle). SC1 Award for a force diagram with no extra forces and all labels and directions correct.	
	(ii)		$R = W\cos\alpha$ $S = W\sin\alpha$	B1 B1 **[2]**	Allow FT for sin-cos interchange following the wrong angle in the triangle being marked α in part (i) for both marks. SC1 if both S and R are given negative signs	
	(iii)		 Sketch graph of R against α Correct sketch graph of S against α $45° < \alpha \ (\leq 90°)$	 B1 B1 B1 **[3]**	The answers in part (iii) must - either be fully correct - or they must all be consistent with those in part (ii) where the marks in part (ii) are FT from part (i). No credit should be given to forms other than $W\cos\alpha$ and $W\sin\alpha$. The curves must have the correct end points and lie within the correct range; no credit should be given for straight lines. Graphs must be correctly labelled. Unlabelled graphs get B0 B0. Condone no explicit vertical scale. Do not accept straight lines. Must be consistent with graph of R Condone $45° \leq \alpha$	

Question			Answer	Marks	Guidance
3	*(A)*		False This is a speed-time graph not one for displacement-time	M1 A1	**Notice** that the runner may have returned to his starting place or may not; the graph does not contain the information to tell you which is the case. **Accept** statements only if they are true and relevant, e.g.: There is no information about direction of travel There is no evidence to suggest he has turned round Distance is given by the area under the graph but this is not the same as displacement Speed is not a vector and so the area under the graph says nothing about the direction travelled It just (or only) shows speed-time **Do not accept** statements that are, or may be, untrue: eg The particle moves only in the positive direction **Do not accept** statements that are true but irrelevant: eg The distance travelled is the area under the graph **Condone** This is a speed time graph not one for distance-time
	(B)		True	B1	Ignore subsequent working
	(C)		True	B1	Ignore subsequent working
	(D)		False The area under the graph is 420 not 400 **[6]**	M1 A1	Accept area up to time 55 s is 400 m The calculation in the false example must be correct

		mark	notes
4(i)	$\frac{-20}{2} = -10$ -10 m s^{-2}	M1 A1 2	Use of a suitable triangle to attempt at $\Delta v / \Delta t$ for suitable interval. Accept wrong sign. cao. Allow both marks if correct answer seen.
(ii) (A) **(B)**	Signed area under graph $\frac{1}{2} \times 2 \times 20 = 20$	M1 A1	Using the relevant area or other complete method
	either using areas Signed area $2 \le t \le 5$ is $\frac{1}{2} \times ((5-2)+(4.5-2.4)) \times (-4) = -10.2$ Signed area $5 \le t \le 6$ is $\frac{1}{2} \times 1 \times 8 = 4$ Total displacement is 13.8 m	 B1 B1 B1	 Allow + 10.2. cao but FT from their 20 in part (A)
	or using *suvat* From $t = 0$ to $t = 2.4$: 19.2 From $t = 4.5$ to $t = 6$: 3.0 From $t = 2.4$ to $t = 4.5$: -8.4 Total : 13.8	 B1 B1 B1	 Both required and both must be correct.
		5	
(iii)	$a = 4t - 14$ $a(0.5) = -12$ so -12 m s^{-2}	M1 A1 A1 3	Differentiate. Do not award for division by t.
(iv)	Model A gives -4 m s^{-1} For model B we need v when $a = 0$ $v\left(\frac{7}{2}\right) = -4.5$ so model B is 0.5 m s^{-1} less	B1 M1 A1 F1 4	May be implied by other working Using (iii) or an argument based on symmetry or sketch graph that $a = 0$ when $t = 3.5$ Accept values without more or less

(v)			Do not penalise poor notation
	Displacement is $\int_0^6 \left(2t^2 - 14t + 20\right) \mathrm{d}t$	M1	Limits not required.
	$= \left[\frac{2t^3}{3} - 7t^2 + 20t\right]_0^6$	A1	Limits not required. Accept 2 terms correct.
		M1	Substitute limits
	= 12 so 12 m.	A1	cao. Accept bottom limit not substituted.
		4	
		18	

		mark	notes
5(i) (A)	4 m	B1	
(B)	$12 - (-4) = 16$ m	M1	Looking for distance. Need evidence of taking account of +ve and –ve displacements.
		A1	
(C)	$1 < t < 3.5$	B1	The values 1 and 3.5
		B1	Strict inequality
(D)	$t = 1$, $t = 3.5$	B1	Do not award if extra values given.
		6	
(ii)	$v = -8t + 8$	M1	Differentiating
		A1	
	$a = -8$	F1	
		3	
(iii)	$8t + 8 = 4$ so $t = 0.5$ so 0.5 s	B1	FT **their** v.
	$-8t + 8 = -4$ so $t = 1.5$ so 1.5 s	B1	FT **their** v.
		2	
(iv)	**method 1**		
	Need velocity at $t = 3$		
	$v(3) = -8 \times 3 + 8 = -16$	B1	FT **their** v from (ii)
	either		
	$v = \int 32 \, dt = 32t + C$	M1	Accept $32t + C$ or $32t$. SC1 if $\int_3^4 32 dt$ attempted.
	$v = -16$ when $t = 3$ gives $v = 32t - 112$	A1	Use of **their** -16 from an attempt at v when t=3
	$y = \int (32t - 112) dt = 16t^2 - 112t + D$	M1	FT **their** v of the form $pt + q$ with $p \neq 0$ and $q \neq 0$.
			Accept if at least 1 term correct. Accept no D.
	$y = 0$ when $t = 3$		
	gives $y = 16t^2 - 112t + 192$	A1	cao
	or		
	$y = -16 \times (t-3) + \frac{1}{2} \times 32 \times (t-3)^2$	M1	Use of $s = ut + \frac{1}{2}at^2$
		A1	Use of **their** -16 (not 0) from an attempt at v when t=3 and 32. Condone use of just t
		M1	Use of $t \pm 3$
		A1	cao
	(so $y = 16t^2 - 112t + 192$)		
	method 2		
	Since accn is constant, the displacement y is a quadratic function. Since we have $y = 0$ at $t = 3$ and $t = 4$		
	$y = k(t - 3)(t - 4)$	M1	Use of a quadratic function (condone no k)
		A1	Correct use of roots
		B1	k present
	When $t = 3.5$, $y = -4$		
	so $-4 = k \times \frac{1}{2} \times -\frac{1}{2}$	M1	Or consider velocity at $t = 3$
	so $k = 16$ (and $y = 16t^2 - 112t + 192$)	A1	cao Accept k without y simplified.
		5	
		16	

		mark	comment	sub
6(i)	$0.5\times8\times10=40$ m	M1	Attempt to find whole area or … If *suvat* used in 2 parts, accept any *t* value $0\le t\le 8$ for max.	2
(ii)		A1	cao	
	$0.5\times5\times(T-8)=10$	M1	$0.5\times5\times k=10$ seen. Accept ±5 and ±10 only. If *suvat* used need whole area; if in 2 parts, accept any *t* value $8\le t\le T$ for min.	
		B1	Attempt to use $k = T - 8$.	
	$T = 12$	A1	cao. [Award 3 if $T = 12$ seen]	3
(iii)				
	40 – 10 = 30 m	B1	FT **their** 40.	1
		6		