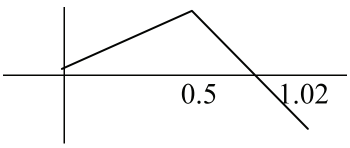
1			M1		For using WD = Fdcosα
		WD = 6 × (0.5 × 8)cos24°	A1		
		Work done is 21.9 J	A1	[3]	
2	(i)		M1		For resolving forces horizontally or vertically
		Tcosθ + Tsinθ = 11.2 (or – Tcosθ + Tsinθ = 0.16g)	A1		
		– Tcosθ + Tsinθ = 0.16g (or Tcosθ + Tsinθ = 11.2)	A1	[3]	
	(ii)	[Tcosθ = 4.8 and Tsinθ = 6.4 and $T^2 = 4.8^2 + 6.4^2$ or tanθ = 6.4/4.8] [$4T^2(\cos^2\theta + \sin^2\theta) =$ $(11.2 - 1.6)^2 + (11.2 + 1.6)^2$ or 2Tsinθ ÷ 2Tcosθ = (11.2 + 1.6) ÷ (11.2 – 1.6) or (Tcosθ + Tsinθ) ÷ (– Tcosθ + Tsinθ) = 11.2 ÷ 1.6]	M1		For finding Tcosθ and Tsinθ and hence finding T or θ, OR for finding the value of $4T^2(\cos^2\theta + \sin^2\theta)$ or of 2Tsinθ ÷ 2Tcosθ or of (Tcosθ + Tsinθ) ÷ (– Tcosθ + Tsinθ)
		T = 8 (or θ = 53.1)	A1		
		θ = 53.1 or T = 8	A1	[3]	
3	(i)		M1		For using s = $\int v\,dt$
		$s = 0.027(10t^3/3 - t^4/4)$ (+C)	A1		
		s = 0.027[10 000/3 – 10000/4]	DM1		For finding the value of *t* at A and using limits or equivalent
		Distance is 22.5 m	A1	[4]	
	(ii)	[$0.027(20t - 3t^2) = 0 \rightarrow t = 20/3$]]	M1		For using d*v*/d*t* = 0
		v_{max} = 0.027(4000/9 – 8000/27)	A1ft		ft incorrect t in $0.027(10t^2 - t^3)$
		Maximum speed is 4 ms^{-1}	A1	[3]	

4	(i)	[When $4 < v < 6$, $a_{ave} = (6 – 4)/(0.5 – 0)$; when $19 < v < 21$ $a_{ave} = (21 – 19)/(24.5 – 16.3)$]	M1		For using $a \approx \frac{\Delta v}{\Delta t}$
		Average accelerations are 4 ms^{-2} and 0.244 ms^{-2}	A1	[2]	
	(ii)	DF(5) = P/5 and DF(20) = P/20	B1		
		[DF – R = ma]	M1		For using Newton's 2nd law
		P/5 – R = 1230 × 4 and P/20 – R = 1230 × 0.244	A1ft		ft incorrect average a values
		P = 30800 (or R = 1240)	B1		
		R = 1240 (or P = 30800)	B1ft	[5]	ft P/5 – $1230a_1$ or P/20 – $1230a_2$ or $5(1230a_1 + R)$ or $20(1230a_2 + R)$
5	(i)	WD against resistance = 800 × 500	B1		
		[2 800 000 = PE gain + 400 000]	M1		For using WD by the driving force = PE gain + WD against resistance
		[2 400 000 = 16000g × 500sin α]	M1		For using PE gain = mgLsin α
		α = 1.7	A1	[4]	
	(ii)	[KE gain = 2 400 000 + 2 400 000 – 800 000]	M1		For using KE gain = WD by the driving force + PE loss – WD against resistance
		4000 000 J	A1ft		ft PE gain
		[½ 16000($v^2 – 20^2$) = 4 000 000]	M1		For KE gain = ½ m($v^2 – 20^2$) and attempting to solve for v
		Speed is 30 ms^{-1}	A1	[4]	

SR (max 2/4) for candidates who assume constant driving force and constant resistance without justification
Uses Newton's Second Law and $v^2 = u^2 + 2as$ [4800 + 16000gsin α – 1600 = 16000a, $v^2 = 20^2 + 2a \times 500$)] M1
Speed is 30 ms^{-1} A1

Alternative Method for Part (i)

(i)	Driving force = 2800 000 ÷ 500	B1	
	[DF – mgsinα – R = m × 0] For using Newton's second law	M1	
	[16000 × 10sinα = 5600 – 800] For solving the resultant equation for α	DM1	
	α = 1.7	A1	[4]

6	(i)		M1		For resolving forces parallel to the plane
		$F = 5.9 - 6.1 \sin\alpha$	A1		
		$R = 6.1\cos\alpha$	B1		
		$[5.9 - 6.1 \sin\alpha \leq \mu (6.1\cos\alpha)]$	M1		For using $F \leq \mu R$
		$\mu > \frac{4}{5}$	A1	[5]	AG
	(ii)	$[6.1 \times (11/61) + 5.9 - \mu 6.1 \times (60/61) > 0]$	M1		For using $F = \mu R$ and 'net downward force > 0'
		$\mu < \frac{7}{6}$	A1	[2]	AG
	(iii)	$[6.1 \times (11/61) + 5.9 - \mu\, 6.1 \times (60/61) = 0.61 \times 1.7]$	M1		For using Newton's 2nd law and $F = \mu R$
		$\mu = 0.994$	A1	[2]	
7	(i)	$[T - 0.12g = 0.12a$ & $0.38g - T = 0.38a$; $a = \frac{0.38 - 0.12}{0.38 + 0.12} g]$	M1		For using Newton's second law for A and B or for using $a = \frac{M - m}{M + m} g$
		Acceleration is 5.2 ms^{-2}	A1	[2]	
	(ii)	$[v^2 = 2 \times 5.2 \times 0.65;\ 0.65 = ½\, 5.2T_B^2]$	M1		For using $v^2 = 2ah$ or $s = ½ at^2$
		Speed of B is $2.6ms^{-1}$ or $T_B = 0.5$	A1ft		ft incorrect a
		$T_B = 0.5$ or Speed of B is $2.6ms^{-1}$	B1	[3]	
	(iii)	$[-2.6 = 2.6 - 10(T - 0.5)]$	M1		For using $-V = V - g(T - T_B)$ or equivalent
		$T = 1.02$	A1ft		ft incorrect V and/or T_B
		Correct graph for $0 < t < 1.02$ ft incorrect values of V, T and T_B	B1ft	[3]	
	(iv)	$[0.65 + 0.5(1.02 - 0.5)2.6]$	M1		For using 'total distance $= ½ (VT_B) + 2 \times ½ \frac{T_A - T_B}{2} V$
		Total distance is 1.326 m (accept 1.33)	A1	[2]	