1		M1		For resolving forces parallel to the line of greatest slope
	Applying T cos β = W sin α	A1		T (24/25) = 5.1 (8/17) or T cos 16.26 = 5.1 sin 28.07
	Tension is 2.5 N	A1	3	
First Alternative Marking Scheme				
		M1		For resolving forces vertically or horizontally
	Applying R cos α + T sin (α + β) = W and R sin α = T cos (α + β)	A1		R cos 28.07 + T sin 44.33 = 5.1 and R sin 28.07 = T cos 44.33
	Tension is 2.5 N	A1	3	
Second Alternative Marking Scheme				
		M1		Using Triangle of forces
	Applying T / sin α = 5.1 / sin (90 + β)	A1		T / sin 28.07 = 5.1 / sin 106.26
	Tension is 2.5 N	A1	3	

2		M1		For using KE = ½ m v^2 or WD = F d cos α
	Gain in KE = ½ 25 × 3^2 or WD by pulling force = 220 × 15 cos α	A1		
	WD by pulling force = 220 × 15 cos α or Gain in KE = ½ 25 × 3^2	B1		
	[3300 cos α = 112.5 + 3000]	M1		For using WD by pulling force = KE gain + WD against resistance
	α = 19.4	A1	5	

3 **(i)**		M1		For using F = P/v and Newton's 2nd law with a = 0
	100/4 – 4k = 0 → k = 6.25	A1	2	AG
(ii)		M1		For using Newton's 2nd law with a = 0 uphill → 3 term equation
	100/v – 70g × 0.05 – 6.25v = 0	A1		
	[$6.25v^2 + 35v - 100 = 0$] or [$v^2 + 5.6v - 16 = 0$]	M1		For solving a 3-term quadratic for v
	Maximum speed is 2.08 ms^{-1}	A1	4	

4		M1		For resolving three forces parallel to the plane
	0.6g sin α = F + P cos α	A1		Value of α used or values of sin α and cos α used
		M1		For resolving three forces perpendicular to the plane
	R = 0.6g cos α + P sin α	A1		Value of α used or values of sin α and cos α used
		M1		For using F = μR
	0.6g sin α – P cos α = 0.4 (0.6g cos α + P sin α)	A1		Value of α used or values of sin α and cos α used
	6(12/13) – P(5/13) = 2.4(5/13) + 0.4P(12/13)	M1		For solving the resultant equation for P
	P = 6.12	A1	8	

Alternative Marking Scheme

		M1		For resolving three forces vertically
	$W = R\cos\alpha + F\sin\alpha$	A1		Value of α used or values of sin α and cos α used
		M1		For resolving three forces horizontally
	$P = R\sin\alpha - F\cos\alpha$	A1		Value of α used or values of sin α and cos α used
		M1		For using $F = \mu R$ in both equations
	$0.6g = R(5/13) + 0.4R(12/13)$ and $P = R(12/13) - 0.4R(5/13)$	A1		Value of α used or values of sin α and cos α used
	$78 = R(5 + 4.8)$ and $13P = R(12 - 2)$ $\rightarrow 13P = (78 \div 9.8) \times 10$	M1		For finding R and substituting into an expression for P
	$P = 6.12$	A1	8	

5 (i)	[$s = t^2/2 - 0.1t^3/3$]	M1*		For integrating to find s for $0 \leqslant t \leqslant 5$
	[$s_1 = 25/2 - 0.1 \times 125/3$]	DM1*		For obtaining s_1 by using limits 0 to 5 or having zero for constant of integration (can be implied) and substituting t = 5
	$s_1 = 8.33$	A1	3	
(ii)			M1	For using $s = v(5) \times (45 - 5)$ for $5 \leqslant t \leqslant 45$
	$s_2 = 2.5 \times 40$	A1		
	[$s = 9t^2/2 - 0.1t^3/3 - 200t$ for $45 \leqslant t \leqslant 50$]	M1		For integrating to find s for $45 \leqslant t \leqslant 50$ and implying the use of limits 45 and 50 or equivalent via constant of integration
	$s_3 = [9(50)^2/2 - 0.1(50)^3/3 - 200(50)] - [9(45)^2/2 - 0.1(45)^3/3 - 200(45)]$	A1		For applying the limits at 45 and 50 correctly or equivalent via constant of integration
	[= 8.33]			

Alternative mark scheme for previous 2 marks				
	Recognising the symmetry of the velocity distribution due to the correspondence of the points (0,0) → (50,0) and (5,2.5) → (45,2.5)	(M1)		
	Complete the idea of symmetry with one further property and hence State $s_3 = s_1 = 8.33$	(A1)		Property is any one of a(0) = – a(50) a(5) = a(45) v(2.5) = v(47.5) oe
	Distance from O to A is 117m	A1		
	Average speed is 2.33 ms^{-1}	B1ft	6	ft answer for total distance

6 (i)		M1		For applying Newton's 2nd law to A or B
	T – 0.4g = 0.4a or 1.6g – T = 1.6a	A1		
	1.6g – T = 1.6a or T – 0.4g = 0.4a or 1.6g – 0.4g = (1.6 + 0.4)a	B1		
	T = 6.4	A1		
	Work done by tension is 7.68 J	B1ft	5	
Alternative mark scheme for 6 (i)				
		M1		For applying Newton's 2nd law to A or B
	T – 0.4g = 0.4a or 1.6g – T = 1.6a	A1		
	1.6g – T = 1.6a or T – 0.4g = 0.4a or 1.6g – 0.4g = (1.6 + 0.4)a	B1		
	WD by T = initial PE – final KE = 1.6 × g × 1.2 – ½ × 1.6 × 14.4	M1		For finding v^2 and applying Work/Energy equation to B
	WD by T = 19.2 – 11.52 = 7.68	A1	5	

6	(ii)	[$1.6 \times 10 \times 1.2 = ½\ 1.6\ v^2 + 7.68$]	M1		For using PE loss = KE gain + WD by T to find v^2
		$v^2 = 14.4$	A1		
		$14.4 = 2 \times 10 \times h$ $h = 0.72$ $H = 2 \times 1.2 + h$	M1		For using PCE for A's motion after B reaches the ground or $0 = u^2 - 2gh$ and $H = 2 \times 1.2 + h$
		Greatest height is 3.12 m	A1	4	
First Alternative Marking Scheme for 6 (ii)					
		[$v^2 = 2 \times 6 \times 1.2$]	M1		For using $v^2 = 2as$ to find v^2
		$v^2 = 14.4$	A1		
		$14.4 = 2 \times 10 \times h$ $h = 0.72$ $H = 2 \times 1.2 + h$	M1		For using PCE for A's motion after B reaches the ground or $0 = u^2 - 2gh$ and $H = 2 \times 1.2 + h$
		Greatest height is 3.12 m	A1	4	
Second Alternative Marking Scheme for 6 (ii)					
		WD by T = Increase in PE $7.68 = 0.4 \times g \times s$	M1		For applying WD by T to particle A's complete motion
		$s = 1.92$	A1		
		$H = 1.2 + s$	M1		For adding 1.2 to s
		$H = 1.2 + 1.92 = 3.12$ Height = 3.12 m	A1	4	

7 (i)	[s = ½ 5 × 0.4 + 19 × 0.4 + ½ 4 × 0.4] Distance = 9.4	M1 A1	 2	For using the area property for distance
(ii)	Acceleration is 0.08 ms^{-2} Deceleration is 0.1ms^{-2}	B1 B1	 2	
(iii)	[T – (800 + 100) g = (800 +100)a] T – 900g = 900a T = 9072 N in 1st stage T = 9000 N in 2nd stage T = 8910 N in 3rd stage	M1 A1 A1	 3	For applying Newton's 2nd law to the elevator and box
(iv)	[R – 100g = 100a] R = 1008 N R = 990 N	M1 A1 A1	 3	For applying Newton's 2nd law to the box For obtaining the greatest value of the force on the box For obtaining the least value of the force on the box