1		M1		For using Newton's 2nd law with three terms
	DF – R = 800 × 1.2	A1		
	DF = 22500/18 [= 1250]	B1		
	Resistance is 290 N	A1	4	
2		M1		For a triangle of forces with sides 18, R and W for A or for B – or – for resolving forces acting on A or on B parallel to line of greatest slope
	For A: right angle between 18 and R **and** 30° opposite 18 **or** $W_A$sin30° = 18 **or** For B: right angle between 18 and W **and** 30° opposite 18 **or** W_B sin30° = 18cos 30°	A1		
	For B: right angle between 18 and W **and** 30° opposite 18 **or** W_B sin30° = 18cos 30° **or** For A: right angle between 18 and R **and** 30° opposite 18 **or** $W_A$sin30° = 18	B1		
	Weight of A is 36 N and weight of B is 31.2 N	A1	4	
3 (i)		M1		For resolving forces parallel to slope with three terms
	$F + W\sin\alpha = 7.2$	A1		
	[$\mu \times 7.5\cos\alpha \geqslant 7.2 - 7.5\sin\alpha$]	M1		For using $F \leqslant \mu R$
	$\mu \geqslant 17/24$	A1	4	**AG**
(ii)	[$7.2 + 7.5 \times (7/25) - \mu(7.5 \times 24/25) > 0$]	M1		For using 'resultant force down the plane is > 0' and $F = \mu R$
	$\mu < 31/24$	A1	2	**AG**
4 (i)	End speed = 1.3 + 0.1 × 20	B1		
	$v_Q(t) = 0.008t^2 + v_Q(0)$	B1		
	[$3.3 = 0.008 \times 20^2 + v_Q(0)$]	M1		For substituting end speed and t = 20
	Speed of Q when t = 0 is 0.1 ms^{-1}	A1	4	

(ii)	Distance $AO = (3.3^2 - 1.3^2) \div (2 \times 0.1)$ or $20 \times ½ (1.3 + 3.3)$ [= 46]	B1		or $AO = 1.3(20) + ½(0.1) \times 20^2$
	Distance $OB = 0.008 \times 20^3 \div 3 + 0.1 \times 20$ [= 70/3 = 23.3]	B1		
	Distance AB is 69.3 m	B1	3	
5 (i)		M1		For resolving forces horizontally on B, including the frictional force and using tensions in PB and BQ being equal to the weights of P and Q respectively.
	Frictional force = $\mu \times 0.25g$	B1		
	$0.3g = 0.2g + \mu 0.25g$ ➔ Coefficient of friction is 0.4	A1	3	
(ii)		M1		For applying Newton's 2nd law to P or to B
	$0.2g - T = 0.2a$ **or** $T - 0.4 \times 0.25g = 0.25a$	A1		
	$T - 0.4 \times 0.25g = 0.25a$ **or** $0.2g - T = 0.2a$ **or** $0.2g - \mu 0.25g = (0.2 + 0.25)a$	B1		
		M1		For solving for a and for T
	Acceleration is 2.22 ms^{-2}	B1		
	Tension is 1.56 N	A1	6	
6 (i)	[$3g - R = 3 \times 5.5$]	M1		For using Newton's 2nd law
	Resistance is 13.5 N	A1	2	
(ii)	Graph consists of two line segments; the first starts at the origin and has a positive gradient.	B1		
	The second starts where first one ends and has positive but less steep gradient.	B1	2	

(iii)	$[v_S^2 = 2 \times 10 \times 5 = 100$ **or** $v_B^2 = v_T^2 + 2 \times 5.5 \times 4]$	M1		For using $v^2 = u^2 + 2as$ (for either stage)
	$v_S = 10$ ms^{-1} at surface **and** $v_B = 12$ ms^{-1} at bottom – both shown on sketch	A1		
	$[10 = 0 + 10t_1$ or $12 = 10 + 5.5(t_2 - t_1)]$	M1		For using $v = u + at$ (for either stage)
	$t_1 = 1$ s at surface and shown on sketch	A1		
	$t_2 = 1.36$ s at bottom and shown on sketch.	A1	5	
7		M1		To obtain PE change or KE change
	PE change $= 60g \times 17.5$ **or** KE change $= \frac{1}{2} 60(8.5^2 - 3.5^2)$	A1		[PE = 10500]
	KE change $= \frac{1}{2} 60(8.5^2 - 3.5^2)$ **or** PE change $= 60g \times 17.5$	B1		[KE = 1800]
	WD against resistance $= 6 \times 250$	B1		[= 1500]
	WD by pulling force $= 50\cos\alpha \times 250$	B1		
		M1		For using 'WD by the pulling force is a linear combination of PE change, KE change and WD against resistance.'
	WD $= 10500 - 1800 + 1500$	A1√		
	WD by the pulling force is 10200 J or 10.2 kJ	A1		
	For using WD $= Fd\cos\alpha$	M1		
	$10200 = 50 \times 250 \cos\alpha$	A1		
	$\alpha = 35.3$	A1	11	

Alternative solution				
		M1		Using $v^2 = u^2 + 2as$
	$(3.5)^2 = (8.5)^2 + 2a(250)$	A1		
	$a = -3/25 = -0.12$	A1		
		M2		Applying Newton's 2nd law with 4 relevant terms [Allow M1 with 3 relevant terms]
	$50 \cos \alpha - 6 - 60g(17.5/250) = 60(-0.12)$	A4		One mark for each correct term
	$[\cos \alpha = 102/125]$	M1		Solve for cos α
	$\alpha = 35.3$	A1	11	