1 (i)	[N + component of X = Weight of B]	M1		For resolving forces acting on the block vertically (3 terms required)
	Normal component is (70 – Xcos15°) N	A1	[2]	
(ii)	F = Xsin15°	B1		
	[Xsin15° = 0.4(70 – Xcos15°)]	M1		For using F = μR
	Value of X is 43.4	A1	[3]	
2		M1		For using Newton's 2nd law
	DF – 600 – 1250 × 0.02g = 1250 × 0.5	A1		
		M1		For using DF = 23000/v
	v = 23000 ÷ (625 + 600 + 250)	A1ft		ft error in one term for DF above (1st A mark)
	Speed of car is 15.6 ms^{-1}	A1	[5]	
Alternative Method				
		M1		For using WD by driving force = KE gain + PE gain + WD against resistance
	WD = 1250 × 0.5s + 1250g × 0.02s + 600s	A1		
		M1		For using WD by driving force = DF × s and DF=23000/v
	v = 23000 ÷ (625 + 600 + 250)	A1ft		ft error in one term for WD above (1st A mark)
	Speed of car is 15.6 ms^{-1}	A1	[5]	
3		M1		For resolving forces acting on *P* horizontally.
	$0.8T_1 + 12T_2/13 = 2.24$	A1		
		M1		For resolving forces acting on *P* vertically.
	$0.6T_1 – 5T_2/13 = 1.4$	A1		
		M1		For solving for T_1 and T_2
	$T_1 = 2.5$ <u>and</u> $T_2 = 0.26$	A1	[6]	
				SR for using Lami's Rule for T_1, T_2 and 2.24 N (weight missing) (max 3/6) T_1/sin157.38 = 2.24/sin59.49 B1 T_2/sin143.13 = 2.24/sin59.49 B1 T_1 = 1(.00) and T_2 = 1.56 B1

4 (i)	PE loss = $0.4g \times 5$ J = 20 J	B1		
	Initial $KE_{up} = 0.4g \times 5 - 12.8 = 7.2$ J	B1		
	$[0.4gh = 2g - 12.8]$	M1		Uses PE gain = KE loss to form equation in h
	Height reached is 1.8 m	A1	[4]	AG
(ii)	$5 = 0 + \frac{1}{2} gt_{down}^2 \quad (t_{down} = 1)$	B1		
	$0 = 6 - gt_{up}$ or $1.8 = \frac{1}{2} gt_{up}^2 \ (t_{up} = 0.6)$	B1		
	Total time is 1.6 s	B1	[3]	
	First Alternative for part (i)			
	$v^2 = 2 \times 10 \times 5 \rightarrow \quad (v = 10)$	B1		
	KE loss = $\frac{1}{2} 0.4(10^2 - v_{up}^2) = 12.8$	B1		
	$[v_{up} = 60, \quad 0 = 6^2 - 2gh]$	M1		Uses $v^2 = u^2 - 2gs$ to form equation in h
	Height reached is 1.8 m	A1	[4]	AG
	Second Alternative for part (i)			
	$0.4gh = 12.8$	M1		Uses PE gain = KE loss
	h = 3.2 m	A1		
	[Height reached = 5 – 12.8/0.4g]	M1		Uses height reached = 5 – 'height not reached'
	Height reached is 1.8 m	A1	[4]	AG
	Third Alternative for part (i)			
	$\frac{1}{2} \times 0.4v^2 = 12.8 \quad (v=8)$ and $[8^2 = 0^2 + 2gh]$	M1		Uses KE loss = 12.8 and $v^2=u^2+2gs$
	h = 3.2 m	A1		
	[Height reached = 5 – 3.2]	M1		Uses height reached = 5 – 'height not reached'
	Height reached is 1.8 m	A1	[4]	AG

5 (i)		M1		For using WD by driving force = Gain in PE + WD against resistance
	WD against resistance $= 4500 \times 1200 - 16000g \times 18$	A1		
	WD against resistance $= 2.52 \times 10^6$ J	A1	[3]	
Alternative Method for part (i)				
	$[R + 16000g \times 18/1200 = 4500]$	M1		For resolving along the plane
	$[WD = (4500 - 16000g \times 18/1200) \times 1200]$	M1		For using WD against resistance = Rs
	WD against resistance $= 2.52 \times 10^6$ J	A1	[3]	
(ii)	KE gain $= \frac{1}{2}\,16000(21^2 - 9^2)$ J	B1		
		M1		For using F = (KE gain + 2000 × 2400) ÷ 2400
	F = 7680000 ÷ 2400 = 3200	A1	[3]	
				SR (max 1/3) for using $v^2=u^2+2as$ and Newton's 2nd law $21^2 - 9^2 = 2a \times 2400$, $a = 0.075$ $F - 2000 = 16000 \times 0.075$ $F = 3200$ B1
(iii)	$[P_A = (3200 + 1280) \times 9$ and $P_B = (3200 - 1280) \times 21]$	M1		For using P = Fv to find P_A and P_B
	$P_A = P_B = 40320$ W	A1	[2]	
6 (i)	Velocity immediately before is 1.2 ms^{-1}	B1		
	Velocity immediately after is – 1 ms^{-1}	B1	[2]	
(ii)		M1		For using distance OW = ∫vdt with limits 0 to 60 (W is wall) or For using distance WA = – ∫vdt with limits 60 to 100
	Distance OW $= 0.025 \times 60^2 - 0.0005 \times 60^3 \div 3$	A1		
	Distance WA $= -[(0.0125 \times 100^2 - 2.5 \times 100) - (0.0125 \times 60^2 - 2.5 \times 60)]$	A1		
	Distance is 54 + 20 = 74 m	A1	[4]	

(iii)	[$dv/dt = 0.05 - 0.001t = 0$ or $0.0005t(100 - t) = 0 \rightarrow t = 0$ or 100]	M1		For using v_{max} occurs when $dv/dt = 0$ or when t = the midpoint of the roots of the quadratic equation $v = 0$.
	Maximum speed ($= 0.05 \times 50 - 0.0005 \times 50^2$) is $1.25\,ms^{-1}$	A1		
	Plausible quadratic curve starting at (0,0), with max. at (50, 1.25) and terminating at (60, 1.2)	B1		
	Straight line segment from (60,–1) to (100,0)	B1	[4]	
7 (i)		M1		For applying Newton's 2nd law to P or to Q
	For $T - (40 \div 160) \times 0.76g = 0.76a$ <u>or</u> $0.49g - T = 0.49a$	A1		
	For $0.49g - T = 0.49a$ <u>or</u> $T - (40 \div 160) \times 0.76g = 0.76a$ <u>or</u> $0.49g - (400 \div 160) \times 0.76g = (0.49 + 0.76)a$	B1		
	Acceleration is $2.4\,ms^{-2}$ and tension is 3.72 N (3.724 exact)	A1	[4]	
(ii)	[$v^2 = 2 \times 2.4 \times 0.3$]	M1		For using $v^2 = 0 + 2as$
	Speed is $1.20\,ms^{-1}$	A1ft	[2]	ft a from (i) ($a \neq \pm g$)
(iii)		M1		For using $v^2 = u^2 + 2as$ with $v = 0$ and $a = -(40 \div 160)g$
	Distance while Q is on the ground $= (2 \times 2.4 \times 0.3) \div 2(40g \div 160)$ ($= 0.288\,m$)	A1ft		ft a from (i) and/or s = 30
	Distance travelled is 0.588 m	A1	[3]	