1	(i)	$F = 720/12$	B1		
		$[F – R = 75 \times 0.16]$	M1		For use of Newton's second law
		$R = 48$	A1	3	
	(ii)	$[720/v > 48]$	M1		For using $P/v – R = ma$ and $a > 0 \rightarrow P/v > R$
		$v < 15$ i.e. speed is less than 15 ms^{-1}	A1	2	
2	(i)	$F = 0.2 \times 6g \cos 8$	B1		
		$[6g \sin 8 – F = 6a]$	M1		For use of Newton's second law
		Deceleration is 0.589 ms^{-2}	A1	3	Accept $a = –0.589$
	(ii)		M1		For use of $0 = u^2 + 2as$
		Distance is 7.64 m	A1	2	
3			M1		For using $v = \int a\,dt$
	$v = (0.8/0.25)\ t^{0.25} + (C)$		A1		
	$C = 1.8$		B1		
			M1		For using $s = \int v\,dt$
	$s = (3.2/1.25)t^{1.25} + 1.8t + (K)$		A1ft		ft only from an incorrect non-zero value of C
	Distance is 111 m		A1	6	
4	(i)	For triangle of forces with 60° shown correctly, or $C\cos\phi = 4\cos 30$ and $C\sin\phi = 10 – 4\sin 30$, or $F = 4\cos 30$ and $R = 10 – 4\sin 30$	B1		
		$[C^2 = 4^2 + 10^2 – 2 \times 4 \times 10\cos 60$ or $C^2 = (4\cos 30)^2 + (10 – 4\sin 30)^2]$	M1		For using cosine rule or for using $C^2 = (C\cos\phi)^2 + (C\sin\phi)^2$ or $C^2 = F^2 + R^2$
		$C = 8.72$	A1	3	
	(ii)	$[\mu = 4\cos 30/(10 – 4\sin 30)]$	M1		For using $\mu = F/R = C\cos\phi/C\sin\phi$
		Coefficient is 0.433 (accept 0.43)	A1	2	
4	Alternative Method				
	(i)	For obtaining $\phi = 66.6°$ or $\tan\phi = 4 \div \sqrt{3}$ from $4 \div \sin(90° + \phi) = 10 \div \sin(150° – \phi)$	B1		
		For using C N and (4 N or 10 N) in Lami's theorem to find C $[C \div \sin 120° = (4 \div \sin 156.6°$ or $10 \div \sin 83.4°)]$	M1		
		$C = 8.72$	A1	3	
	(ii)	$[\mu = \sqrt{3} \div 4$ or $\mu = \cos 66.6° \div \sin 66.6°]$	M1		For using $\mu = F/R = C\cos\phi / C\sin\phi$
		Coefficient is 0.433 (accept 0.43)	A1	2	

5	(i)		M1		For applying Newton's second law to A or to B
		$0.9g - T = 0.9a$ or $T - 0.6g = 0.6a$	A1		
		$T - 0.6g = 0.6a$ or $0.9g - T = 0.9a$ or $(0.9 - 0.6)g = (0.9 + 0.6)a$	B1		
		Acceleration is 2 ms^{-2} and tension is 7.2 N	A1	4	
	(ii)		M1		For using $0 = u - gt$
		$u = 3$	A1		
		$[3^2 = 2 \times 2\ h]$ $[½\ (0.9 + 0.6)3^2 = (0.9 - 0.6)gh]$	M1		For using $v^2 = 0^2 + 2ah$ with $v_{taut} = u_{slack}$ or for using KE gain = PE loss while the string is in tension
		Height is 2.25 m	A1	4	
6	(i)	KE loss = $½\ 16000(15^2 - 12^2)$	B1		
		PE gain = 16000g(AB/20)	B1		
			M1		For using WD by DF = PE gain + WD against resistance – KE loss
		1200 = 0.8g(AB) + 1.24(AB) – 648	A1		
		Distance AB is 200m	A1	5	
	(ii)	Distance BD is 300m	B1	1	
	(iii)	WD against resistance =			
		1240(BC) + 1860(300 – BC)	B1ft		ft distance BD
			M1		For using KE loss = PE gain + WD against res'ce – WD by DF
		$½\ 16000(12^2 - 7^2) =$ 2400000 + (558000 – 620BC) – 7200 × 300	A1		
		Distance BC is 61.3 m	A1	4	

Alternative for Q6 part **(iii)**.

For BC16000a = 7200 – 1240 – 8000 and for CD 16000a = 7200 – 1860 – 8000	B1
For using $v^2 = u^2 + 2as$ for both BC and CD	M1
$v_C^2 = 144 - 2 \times 0.1275(BC)$ and $49 = v_c^2 - 2 \times 0.16625(300 - BC)$	A1
For eliminating v_c^2 and obtaining BC = 61.3 m	A1

SR for candidates who assume that the acceleration is constant in part **(i)**, although there is no justification for the assumption (max. 3/5)

For appropriate use of Newton's second law and $v^2 = u^2 + 2as$	M1
$[1200000 \div AB - 1240 - 160000/20 = 16000a$ and $a = (12^2 - 15^2)/2(AB)]$	
For eliminating a and attempting to solve for AB	M1
Distance AB is 200m	A1

7	(i)	(a)	$[2 \times \frac{1}{2}(1 + 9)400]$	M1		For using area property for distance
			Approximation is 4000 m	A1	2	
		(b)		M1		For using the gradient property for acceleration
			Accelerations are 0.02 ms^{-2} and – 0.02 ms^{-2}	A1	2	Accept deceleration is 0.02 ms^{-2}
	(ii)	(a)		M1		For using a = dv/dt and attempting to solve a= 0.02 or a = –0.02.
			$0.04 - 0.0001t = \pm 0.02$	A1ft		
			Values of t are 200 and 600	A1	3	
		(b)	$v_1 - v = 0.02t + 1 - 0.04t + 0.00005t^2$	B1		
			$v_1 - v = [0.00005t^2 - 0.02t + 2 - 1]$ $= 0.00005(t^2 - 400t + 40000) - 1$ $= 0.00005(t - 200)^2 - 1$	B1	2	AG
		(c)	For using $(v_1 - v)_{min}$ occurs when			
			$t = 200 \rightarrow -1 \le v_1 - v$	B1		
			For using $(v_1 - v)_{max}$ occurs when t = 0 and when $t = 400 \rightarrow v_1 - v \le 1$	B1	2	