1			M1		For using WD = Fdcos α
	WD = 45 × 25cos 14°		A1		
	Work done is 1090 J (1.09 kJ)		A1	3	
2	(i)	[0.6 = 0 + 0.3a]	M1		For using v = 0 + at
		Acceleration is 2 ms^{-2}	A1	2	
	(ii)	[mg – T = 2m, T – (1 – m)g = 2(1 – m)]	M1		For applying Newton's 2nd law to A or to B
		[m = T/8 ➔ T – (10 – 1.25T) = 2 – 0.25T or T = 8m ➔ 8m – (10 – 10m) = 2 – 2m]	M1		For eliminating or evaluating m
		T + 1.25T + 0.25T = 10 + 2 or m = 0.6 and T = 8m	A1		
		m = 0.6 and tension is 4.8 N	A1	4	
		Alternative for part **(ii)**			
		[{m + (1 – m)} × 2 = {m – (1 – m)} × g]	M1		For using $(m_A + m_B)a = (m_A - m_B)g$
		m = 0.6	A1		
		[mg – T = 2m or T – (1 – m)g = 2(1 – m)]	M1		For applying Newton's 2nd law to A or to B, substituting for m and solving for T
		Tension is 4.8 N	A1		

3			M1		For using $s = ut + \frac{1}{2}at^2$ for AB or AC
		$55 = 5u + 12.5a$	A1		
		$(55 + 65) = 10u + 50a$ or $65 = 5v_B + 12.5a$ and $v_B = u + 5a$	A1		
			M1		For solving for a or u
		$a = 0.4$ (or $u = 10$)	A1		
		$u = 10$ (or $a = 0.4$)	A1ft	6	
		Alternative			
		$v_B = (55 + 65) \div (5 + 5)$	M1		For calculating the speed at B as the mean speed for the motion from A to C.
		$v_B = 12\text{ms}^{-1}$	A1		
		For calculating the speed at X, where X is the point where the car passes 2.5 s after passing through A, as $55 \div 5 = 11\text{ms}^{-1}$	B1		
		$[a = (12 - 11) \div 2.5]$	M1		For using $a = (v_B - v_X) \div 2.5$
		$a = 0.4$	A1		
		$u = v_X - a \times 2.5 = 11 - 0.4 \times 2.5 = 10$	B1		
4	**(i)**	$[Y_1^2 = 68^2 - (-60)^2,\ Y_3^2 = 100^2 - 96^2.$ $Y_1 = 68\sin 28.1^\circ,\ Y_3 = 100\sin 16.3^\circ]$	M1		For using $Y^2 = F^2 - X^2$ or for finding the angles (say α and β) between the forces of magnitudes 68 and 100, respectively, and the x-axis. Then find the two relevant magnitudes from 68sinα and 100sinβ
		For correct magnitudes (32, 75, 28)	A1		Can be scored by implication if the final A1 is scored for the correct answer to part **(i)**
		Components are –32, 75 and –28	A1ft	3	
	(ii)	$[R^2 = (-60 + 0 + 96)^2 + (-32 + 75 - 28)^2]$	M1		For using $R^2 = X^2 + Y^2$
		Magnitude is 39 N	A1		
		$[\theta = \tan^{-1}\{(-32 + 75 - 28) \div (-60 + 0 + 96)\}]$	M1		For using $\theta = \tan^{-1}(Y/X)$
		Direction is 22.6° (or 0.395rad^c) anticlockwise from +ve x-axis.	A1	4	Accept just '22.6 from x-axis' or just '$\theta = 22.6$'

5	**(i)**	Acceleration for $t < 0.8$ is 4/0.8	B1		
		[$5 = 10\sin\theta$]	M1		For using $a = g\sin\theta$
		$\theta = 30°$	A1	3	
		Alternative for part **(i)**			
	(i)	[$mgh = ½ m4^2$ and $s = \{(0 + 4) \div 2\} \times 0.8$]	M1		For using PE loss = KE gain and $s \div t = (u + v) \div 2$ (A to B)
		$\sin\theta = 0.8/1.6$	A1		
		$\theta = 30°$	A1		
	(ii)	Acceleration for $0.8 < t < 4.8$ is			
		$-4/(4.8 - 0.8)$	B1		
		[$mg\sin30° - F = m(-1)$]	M1		For using Newton's second law
			M1		For using $\mu = F / R$
		$\mu = \dfrac{mg\sin 30° + m}{mg\cos 30°}$	A1ft		ft following a wrong answer for θ in part **(i)**
		Coefficient is 0.693	A1	5	Accept 0.69

6	(i)				For using DF = $30000/v$
		[$30000/v - 1000 - 1250g \times 30/500 = 1250a$]	M1		For using Newton's 2nd law
		$v_{bottom} = 30000/(1250 \times 4 + 1000 + 750)$ and	M1		
		$v_{top} = 30000/(1250 \times 0.2 + 1000 + 750)$	A1		
		[½ $1250(15^2 - 4.44....^2)$]	M1		For using KE gain = ½ $m(v_{top}^2 - v_{bottom}^2)$
		Increase in KE is 128000 J (128 kJ)	A1	5	
		Alternative for part **(i)**			
	(i)	[$F - 1000 - 1250g \times 30/500 = 1250a$]	M1		For using Newton's second law to find the driving force at the bottom and the top
		$F_{bottom} = 1250 \times 4 + 1000 + 750 = 6750$ and $F_{top} = 1250 \times 0.2 + 1000 + 750 = 2000$	A1		
		[$v_{bottom} = 30000/6750$ and $v_{top} = 30000/2000$]	M1		For using DF = 30000/v to find v_{bottom} and v_{top}
		[½ $1250(15^2 - 4.44....^2)$]	M1		For using KE gain = ½ $m(v_{top}^2 - v_{bottom}^2)$
		Increase in KE is 128000 J (128 kJ)	A1		
	(ii)	PE gain = $1250g \times 30$ and			
		WD against resistance = 1000×500	B1		
		[$WD_{car} = 128000 + 375000 + 500000$]	M1		For using WD by car's engine = KE gain + PE gain + WD against resistance
		Work done is 1000 000 J (1000 kJ)	A1ft	3	ft incorrect answer in **(i)**

Special Ruling applying to part **(i)** for candidates who omit the weight component in applying Newton's second law. (Max 3 out of 5)

	(i)	$v_{bottom} = 30000/(1250 \times 4 + 1000)$ and $v_{top} = 30000/(1250 \times 0.2 + 1000)$	B1		
		[½ $1250(24^2 - 5^2)$]	M1		For using KE gain = ½ $m(v_{top}^2 - v_{bottom}^2)$
		Increase in KE is 344000 J (344 kJ)	A1		

7	(i)	$dv/dt = k(120t - 3t^2)$	B1		
		$[v(40) = k(60 \times 40^2 - 40^3) = 6.4]$	M1		For finding v_{max} as the value of v when $dv/dt = 0$ and $t \neq 0$ and equating with 6.4
		$k = 0.0002$	A1	3	AG
	(ii)	$t = 60$ at A	B1		
			M1		For integrating $v(t)$ to find $s(t)$
		$s(t) = 0.0002(20t^3 - t^4/4) \quad (+ C)$	A1		
		$[OA = 0.0002 \times (20 \times 60^3 - 60^4/4)]$	M1		For using limits 0 to 60 or evaluating $s(t)$ when $t = 60$ with $C = 0$ (which may be implied by its absence)
		Distance is 216 m	A1	5	
	(iii)	$[dv/dt = 0.0002(120 \times 60 - 3 \times 60^2)]$	M1		For evaluating dv/dt when $t = 60$
		Magnitude of acceleration is 0.72 ms^{-2}	A1	2	Accept $a = -0.72$ ms^{-2}
	(iv)	$[20t^3 - 0.25\,t^4 = 0,$ $v = 0.0002(60 \times 80^2 - 80^3)]$	M1		For attempting to solve $s(t) = 0$ for non-zero t and substituting into $v(t)$.
		Speed is 25.6 ms^{-1}	A1	2	