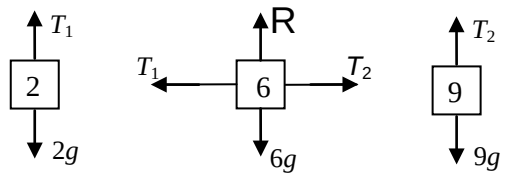
1	**(i)**			**B1** **B1** **B1** **[3]**	Diagrams for both 2 and 9 kg blocks. The tensions must be different from each other. No extra forces. Tensions on 6 kg block. The tensions must be different from each other. No extra forces. 6*g* and *R* on 6 kg block. No extra forces. **Special Case** When the tensions are given as T_1, T_2, T_3, T_4 (or equivalent) award up to SC1 SC0 for the first two marks.	
	(ii)		$9g - T_2 = 9a$ $T_2 - T_1 = 6a$ $T_1 - 2g = 2a$ $a = \frac{7}{17}g = 4.04$ (m s^{-2}) $T_1 = 27.7$ (N) $T_2 = 51.9$ (N)	**M1** **M1** **A1** **A1** **A1** **[5]**	First equation correct Both the remaining two equations correct. Do not give this mark if both tensions are shown as the same. The final three marks are dependent on both M marks *a*, T_1 and T_2 may be found in any order and FT should be allowed from the first of these found	
	(ii)		**Alternative: Whole system** $9g - 2g = 17a$ $a = \frac{7g}{17} = 4.04$ $T_1 - 2g = 2a$ and $9g - T_2 = 9a$ $T_1 = 27.7$ (N) $T_2 = 51.9$ (N)	 **M1** **A1** **M1** **A1** **A1**	 Both equations correct. Oe. The final two marks are dependent on both M marks. T_1 and T_2 may be found in either order and FT should be allowed from their value for *a*.	

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Follow through between parts of Question 2 should be allowed for values found in parts (ii) and (iii) providing the questions are not simplified.						
2	**(i)**		$F - R = ma$ $300 - R = (750 + 50) \times 0.25$ $R = 100$	**M1** **A1** **A1** **[3]**	Use of Newton's 2nd Law Correct elements present This is a given result	
	(ii)		**Carol in** Component of weight down slope $= 800g \sin 1.5° \ (= 205.2 \text{ N})$ Martin has to overcome 305.2 N $300 < 305.2$ Martin cannot manage	**M1** **A1** **A1**	Resolving down the slope. Accept use of 750 instead of 800. For this mark only condone no g and allow sin-cos interchange. Give M1 A1 for $800g\sin 15^o$ seen This mark may be awarded for an argument based on Newton's 2nd law leading towards a = -0.006	
			Carol out Martin has to overcome $750g \sin 1.5° + 100 = 292.4$N $300 > 292.4$ so Martin manages $300 - 292.4 = 7.6 = 750a$ The acceleration is 0.010 m s^{-2}	**B1** **M1** **A1** **[6]**	Explanation, based on correct working, that Martin can manage. This can be given retrospectively with a comment on a positive value for a. Use of Newton's 2nd Law Cao. Accept 0.01 or an answer that rounds to 0.01.	
	(iii)		Component of Carol's force parallel to the line of the car $= 150 \cos 30° \ (= 129.9)$ Resultant forward force $= 7.6 + 129.9 = 137.5$ $750a = 137.5$ The acceleration is 0.183 m s^{-2}	**M1** **A1** **M1** **A1** **[4]**	For attempt at resolution in the correct direction. For this mark only, condone sin-cos interchange. Give M1 A1 for $150\cos 30^o$ seen All forces parallel to the slope present and correct. Sign errors condoned. FT their force parallel to the slope from part (ii) (correct value 7.6 N)	

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2	**(iv)**		Component of weight down the slope $=(750+50+80)\times 9.8\times \sin 3°$			
			$880a = 451.3 - 100$	**M1**	Newton's 2nd law with correct elements present. No sin-cos interchange. The same mass must be used in both places.	
			$a = 0.399$	**A1**		
			$v^2 - u^2 = 2as$			
			When $v = 8$, $s = 8^2 \div (2\times 0.399)$	**M1**	Selection and use of an appropriate formula (unless with $a = g$)	
			$s = 80.1$	**A1**	FT their value of a	
			$80.1 < 100$ so Yes they get the car started	**A1**	FT their value of a	
				[5]		
	(iv)		**Alternative: Finding the speed after 100 m** Component of weight down the slope			
			$=(750+50+80)\times 9.8\times \sin 3°$	**M1**	Newton's 2nd law with correct elements present. No sin-cos interchange	
			$880a = 451.3 - 100$			
			$a = 0.399$	**A1**		
			$v^2 - u^2 = 2as$			
			$v^2 = (0^2) + 2\times 0.399\times 100$	**M1**	Selection and use of an appropriate formula (unless with $a = g$)	
			$v = (\sqrt{79.8}) = 8.93...$	**A1**	FT their value of a	
			($v > 8$) so they get the car started	**A1**	FT their value of a	

Question			Answer	Marks	Guidance	
3	(i)		Whole train: mass = 150 tonnes Total Resistance = 3000 N	B1	Both totals required.	
			$12000 - 3000 = 150000a$	M1	Correct elements must be present	
			$a = 0.06$ The acceleration is 0.06 m s^{-2}	A1 **[3]**	CAO. Errors with units (eg not converting tonnes to kilograms) are penalised here but condoned where possible for the remainder of the question.	
	(ii)		Truck B: $T - 500 = 30000a$	M1	Correct elements must be present	
			$T - 500 = 30000 \times 0.06$	A1	Allow FT for a from part (i) if units are used consistently, for all the marks in this part	
			$T = 2300$ Between A and B, tension of 2300 N	A1 **[3]**		
			Alternative			
			Rest of train: 12 000 – 2500 – T = 120 000a	M1	Correct elements must be present	
			T = 12 000 –2500-120 000 × 0.06	A1		
			T = 2300	A1		
	(iii)		Treating the train as a whole - 2000 – 5000 – 500 = 150 000a	M1		
			$a = -0.05$	A1	Allow FT for the remaining A marks in part (iii) from an error in a	
			$v^2 - u^2 = 2as$ $0^2 - 10^2 = 2 \times (-0.05) \times s$	M1		
			$s = 1000$ Stopping distance is 1000 m	A1		
			B: $T - 500 = 30000a$	M1	Correct elements must be present. Alternative for rest of train: -T – 5000 –2000 = 120 000 × -0.05	
			$T = -1000$	A1	The sign of 1000 must be consistent with the direction of T.	
			Between A and B, thrust of 1000 N	A1 **[7]**	Dependent on previous M and A marks. Accept "compression".	

Question			Answer	Marks	Guidance	
3	(iv)		Equilibrium parallel to the slope $150000 \times 9.8 \times \sin\alpha + 3000 = 12000$ $\alpha = 0.35°$	M1 A1 A1 **[3]**	Correct elements must be present and there must be an attempt to resolve the weight. Condone omission of *g* for this mark. CAO	
	(v)		B: $T_2 - 500 - 30000 \times 9.8 \times \sin 0.35...° = 0$ $T_2 = 2300$ Between A and B, tension of 2300 N, as in part (ii) **[2]**	M1 A1 **[2]**	Correct elements must be present. Condone omission of g for this mark. Do not accept 1800 N for the component of the weight without justification. Alternative for rest of train: $12\,000 = T + 2500 + 120\,000 \times 9.8 \times \sin 0.35^{o}$ This mark can only be awarded if the angle found in (iv) is correct.	

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Question			Answer	Marks	Guidance
4	(i)		If the acceleration is to the right		
			Overall $30 - F = (4 + 6) \times 2$	M1	Newton's 2nd Law in one direction. No extra forces allowed and signs must be correct.
			$F = 10$	A1	
			If the acceleration is to the left	M1	For considering second direction. No extra forces allowed and signs must be correct.
			$F = 50$	A1	
				[4]	
	(ii)		6 kg block $30 - T = 6 \times 2$	M1	Newton's 2nd law with correct elements on either block
			$\Rightarrow T = 18$	A1	CAO No follow through from part (i)
			In the other case $T = 42$	A1	CAO No follow through from part (i)
				[3]	

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Question			Answer	Marks	Guidance
5	**(i)**		$v = u + at$	M1	Use of a suitable constant acceleration formula
			$5 = 0 + a \times 10 \Rightarrow a = 0.5$	A1	Notice The value of a is not required by the question so may be implied by subsequent working
			$F = ma \Rightarrow 120 - R = 40 \times 0.5$	M1	Use of Newton's 2nd Law with correct elements
			$R = 100$ N	E1	
				[4]	
	(ii)	(*A*)	$F = ma \Rightarrow -100 = 40a$	M1	Equation to find a using Newton's 2nd Law
			$\Rightarrow a = -2.5$	A1	
			When $t = 1.6$ $v = 5 + (-2.5) \times 1.6 = 1$ ms^{-1}	A1	CAO
				[3]	
	(ii)	(*B*)	When $t = 6$, it is stationary. $v = 0$ ms^{-1}	B1	
				[1]	

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Question			Answer	Marks	Guidance
5	(iii)		Motion parallel to the slope:	B1	Component of the weight down the slope, ie $40g\sin 15°$ (= 101.457…)
			$200 - 40g\sin 15° = 40a$	M1	Equation of motion with the correct elements present. No extra forces.
			$a = 2.463...$		This result is not asked for in the question
			$v^2 - u^2 = 2as \Rightarrow 8^2 = 2 \times 2.46... \times s$	M1	Use of a suitable constant acceleration formula, or combination of formulae. Dependent on previous M1.
			$\Rightarrow s = 12.989...$ rounding to 13.0 m	E1	Note If the rounding is not shown for s the acceleration must satisfy $2.452... < a < 2.471...$
				[4]	
	(iv)		Let a be acceleration up the slope		
			$-40 \times 9.8 \times \sin 15° = 40a$	M1	Use of Newton's 2nd Law parallel to the slope
			$a = -2.536...$, ie 2.536 m s^{-2} down the slope	A1	Condone sign error
			$s = ut + \frac{1}{2}at^2$		
			$-12.989... = 8t + \frac{1}{2} \times (-2.536...)t^2$	M1	Dependent on previous M1. Use of a suitable constant acceleration formula (or combination of formulae) in a relevant manner.
			$1.268...t^2 - 8t - 12.989... = 0$	A1	Signs must be correct
			$t = \dfrac{8 \pm \sqrt{64 - 4 \times 1.268... \times (-12.989...)}}{2 \times 1.268...}$	M1	Attempt to solve a relevant three-term quadratic equation
			$t = -1.339...$ or $7.647...$, so 7.65 seconds	A1	
				[6]	

Question			Answer	Marks	Guidance
5	(iv)		**Alternative 2-stage motion**		
			Let a be acceleration up the slope		
			$-40\times 9.8\times \sin 15° = 40a$	M1	Use of Newton's 2nd Law parallel to the slope
			$a = -2.536...$, ie 2.536 m s^{-2} down the slope	A1	Condone sign error
			Motion to highest point		
			$v = u + at \quad \Rightarrow \quad 0 = 8 - 2.536...t$	M1	Dependent on previous M1. Use of a suitable constant acceleration formula, for either t or s, in a relevant manner.
			$t = 3.154...$	A1	For either t or s
			$s = ut + \frac{1}{2}at^2 \Rightarrow s = 8\times 3.154... - \frac{1}{2}\times 2.536...\times 3.154...^2$		
			$s = 12.616...$		
			Distance to bottom = 12.989.. + 12. 616... = 25.605...		
			$s = ut + \frac{1}{2}at^2 \Rightarrow 25.605... = \frac{1}{2}\times 2.536...\times t^2$	M1	Use of a suitable constant acceleration formula
			$t = 4.493...$		
			Total time = 3.154... + 4.493... = 7.647 ... s	A1	