1		mark	comment	sub
(i)	Continuous string: smooth ring: light string	E1 E1	One reason Another reason	2
(ii)	Resolve $\leftarrow$: $60\cos\alpha - 60\cos\beta = 0$ (so $\cos\alpha = \cos\beta$) and so $\alpha = \beta$	M1 E1	[(ii) and (iii) may be argued using Lami or triangle of forces] Resolution and an equation or equivalent. Accept $s \leftrightarrow c$. Accept a *correct* equation seen without method stated. Accept the use of '*T*' instead of '60'. Shown. Must have stated method (allow $\rightarrow$ seen).	2
(iii)	Resolve $\uparrow$ $2\times 60\times\sin\alpha - 8g = 0$ so α = 40.7933… so 40.8° (3 s. f.)	M1 B1 B1 A1 A1	Resolution and an equation. Accept $s \leftrightarrow c$. Do not award for resolution that cannot give solution (e.g. horizontal) Both strings used (accept use of half weight), seen in an equation $\sin\alpha$ or equivalent seen in an equation All correct	5
(iv)	Resolve $\rightarrow$ $10 + T_{QC}\cos 25 - T_{PC}\cos 45 = 0$ Resolve $\uparrow\ T_{PC}\sin 45 + T_{QC}\sin 25 - 8g = 0$ Solving $T_{CQ} = 51.4701...$ so 51.5 N (3 s. f.) $T_{CP} = 80.1120...$ so 80.1 N (3 s. f.)	M1 M1 A1 M1 A1 A1 F1	Recognise strings have different tensions. Resolution and an equation. Accept $s \leftrightarrow c$. No extra forces. All forces present. Allow sign errors. Correct. Any form. Resolution and an equation. Accept $s \leftrightarrow c$. No extra forces. All forces present. Allow sign errors. Correct. Any form. * method that leads to at least one solution of a pair of simultaneous equations. cao either tension other tension. Allow FT only if M1* awarded [Scale drawing: 1st M1 then A1, A1 for answers correct to 2 s.f.]	8
		17		

2	(i)		$v^2 - u^2 = 2as$ $0^2 - 40^2 = 2 \times a \times 125$ $\Rightarrow a = -6.4$ $F = ma$ $F = 800 \times (-)6.4 = (-)5120$	 M1 A1 M1 E1 **[4]**	 Substitution required. For *u v* interchange award up to M1 A0 Condone no – sign Allow +5120 or –5120	
	(ii)		$v = u + at$ $0 = 40 - 6.4 \times t$ $t = 6.25$ It takes 6.25 seconds to stop	 M1 A1 **[2]**	 FT for *a*	
			Alternative $s = \frac{1}{2}(u + v)t$ $125 = \frac{1}{2}(40 + 0) \times t$ $t = 6.25$ it takes 6.25 seconds to stop	 (M1) (A1) **[2]**		
			Alternative $s = ut + \frac{1}{2}at^2$ $125 = 40t + \frac{1}{2} \times (-6.4)t^2$ $3.2t^2 - 40t + 125 = 0$ $t = 6.25$	 (M1) (A1) **([2])**		

	(iii)		Reaction distance $< 155 - 125 = 30$ m Time taken to travel 30 m at 40 m s^{-1} is 0.75 s	M1 E1 **[2]**	30 must be seen and used	
	(iv)		Distance travelled before braking $= 20 \times 0.675 = 13.5\,\text{m}$ Distance travelled while braking $= \frac{20^2}{2 \times 6.4} = 31.25$ Stopping distance $= 13.5 + 31.25 = 44.75\,\text{m}$	B1 B1 B1 **[3]**	Cao	

	(v)		The distance travelled during the reaction time is not affected by the slope. It is $20 \times 0.675 = 13.5\,\text{m}$		13.5 is rewarded later	
			Component of the car's weight down the slope	M1	Allow cos for sin for M1 Allow omission of *g* for this mark only	
			$= mg\sin\alpha = 800 \times 9.8 \times \sin 5^\circ\ (= 683.3\ \text{N})$	A1	Cao	
			Force opposing motion when the brakes are applied $= 5120 - 683.3 = 4436.9$	M1	The resistance (5120) and their weight component (683.3) must have opposite signs.	
			Acceleration $= (-)\dfrac{4436.7}{800} = (-)5.546\ \text{ms}^{-2}$	A1		
			Distance travelled while braking $= -\dfrac{u^2}{2a} = -\dfrac{400}{2 \times (-)5.546} = 36.06\,\text{m}$	A1		
			Stopping distance $= 13.5 + 36.06 = 49.56\,\text{m}$	F1	Allow FT for 36.06 from previous answer. Allow FT of 13.5 from part (iv)	
				[6]		
	(vi)		Increase in stopping distance on account of slope $= 49.56 - 44.75 = 4.81\,\text{m}$			
			Percentage increase $= \dfrac{4.81}{44.75} \times 100 = 11\%$	B1	Cao This mark is dependent on a correct final answer to part (v)	
				[1]		

3		mark	notes
(i)	25 N	B1 1	Condone no units. Do not accept -25 N.
(ii)	50 cos25 = 45.31538… so 45.3 N (3 s. f.)	M1 A1 2	Attempt to resolve 50 N. Accept s ↔ c . No extra forces. cao but accept – 45.3.
(iii)	Resolving vertically $R + 50 \sin 25 - 8 \times 9.8 = 0$ R = 57.26908… so 57.3 N (3 s. f.)	M1 A1 A1 3	All relevant forces with resolution of 50 N. No extras. Accept s ↔ c . All correct.
(iv)	Newton's 2nd Law in direction DC $50\cos 25 - 20 = 18a$ a = 1.4064105… so 1.41 m s^{-2} (3 s. f.)	M1 A1 A1 3	Newton's 2nd Law with m = 18. Accept $F = mga$. Attempt at resolving 50 N. Allow 20 N omitted and s ↔ c . No extra forces. Allow only sign error and s ↔ c . cao
Q8 (v)	continued Resolution of weight down the slope	 B1	 mgsin5° where m = 8 or 10 or 18, wherever first seen
	either Newton's 2nd Law down slope overall $18 \times 9.8 \times \sin 5 - 20 = 18a$ a = – 0.2569… Newton's 2nd Law down slope. Force in rod can be taken as tension or thrust. Taking it as tension T gives For D: $10 \times 9.8 \times \sin 5 - 15 - T = 10a$ (For C: $8 \times 9.8 \times \sin 5 - 5 + T = 8a$) T = – 3.888… = - 3.89 N (3 s. f.) The force is a thrust	 M1 A1 M1 F1 A1 A1	 $F = ma$. Must have 20 N and m = 18. Allow weight not resolved and use of mass. Accept s ↔ c and sign errors (including inconsistency between the 15 N and the 5 N). cao $F = ma$. Must consider the motion of either C or D and include: component of weight, resistance and T. No extra forces. Condone sign errors and s ↔ c . Do not condone inconsistent value of mass. FT only applies to a, and only if direction is consistent. '+T' if T taken as a thrust '-T' if T taken as a thrust If T taken as thrust, then T = +3.89. Dependent on T correct

	or Newton's 2nd Law down slope. Force in rod can be taken as tension or thrust. Taking it as tension T gives For C: $8\times 9.8\times \sin 5 - 5 + T = 8a$ For D: $10\times 9.8\times \sin 5 - 15 - T = 10a$ a = – 0.2569… T = – 3.888… = - 3.89 N (3s.f.) The force is a thrust	M1 M1 A1 A1 F1 A1	$F = ma$. Must consider the motion of C and include: component of weight, resistance and T. No extra forces. Condone sign errors and s ↔ c. Do not condone inconsistent value of mass. $F = ma$. Must consider the motion of D and include: component of weight, resistance and T. No extra forces. Condone sign errors and s ↔ c. Do not condone inconsistent value of mass. Award for either the equation for C or the equation for D correct. '-T' if T taken as a thrust '+T' if T taken as a thrust First of a and T found is correct. If T taken as thrust, then T = +3.89. The second of a and T found is FT Dependent on T correct
	then After 2 s: $v = 3 + 2 \times a$ v = 2.4860303.. so 2.49 m s^{-1} (3 s. f.) 9	M1 F1	Allow sign of a not followed. FT their value of a. Allow change to correct sign of a at this stage. FT from magnitude of **their** a but must be consistent with its direction.
		18	