2. A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N. The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and R newtons respectively.

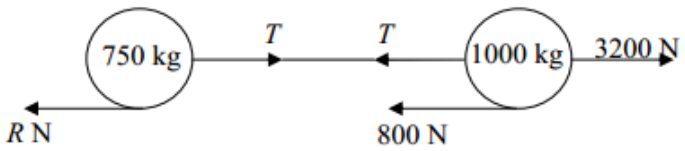
Given that the acceleration of the car and the caravan is $0.88\,\text{m s}^{-2}$,

(a) show that $R = 860$,

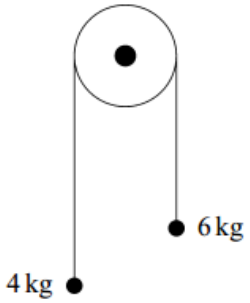
(3)

(b) find the tension in the tow-bar.

(3)

Question Number	Scheme	Marks
2 (a)		
	For the whole system	
	$R(\rightarrow)$ $\quad 3200-800-R=1750\times0.88$	M1 A1
	Leading to $\quad R=860$ *	A1
		(3)
(b)	For the caravan	
	$R(\rightarrow)$ $\quad T-860=750\times0.88$	M1 A1
	Leading to $\quad T=1520\ (\text{N})$	A1
		(3)
		6
	Alternative for (b)	
	For the car	
	$R(\rightarrow)$ $\quad 3200-800-T=1000\times0.88$	M1 A1
	Leading to $\quad T=1520\ (\text{N})$	A1
		(3)

3 Two particles, of masses 4 kg and 6 kg, are connected by a light, inextensible string that passes over a smooth, light pulley. The two particles are released from rest, with the string taut, as shown in the diagram.

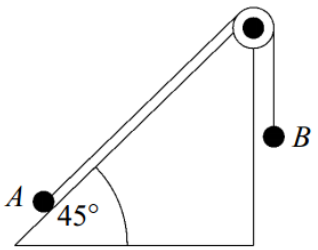


(a) Show that the acceleration of each particle is $1.96\,\text{m s}^{-2}$. *(5 marks)*

(b) Calculate the tension in the string. *(2 marks)*

3(a)	$T - 4g = 4a$	M1		Forms two equations of motion
	$6g - T = 6a$	A1 A1		First equation correct Second equation correct
	$6g - (4a + 4g) = 6a$			
	$a = \frac{2g}{10} = 1.96\,\text{m s}^{-2}$	m1 A1	 5	Solves for a Correct a from correct working
(b)	$T = 4 \times 1.96 + 4 \times 9.8 = 47.0\,\text{N}$	M1 A1	 2	Uses one equation to find T Correct T
	Total		**7**	

4 Two particles, A and B, are connected by a light inextensible string, which passes over a smooth light pulley. Particle A is on a smooth slope, at 45° to the horizontal, and particle B hangs with the string vertical, as shown in the diagram.



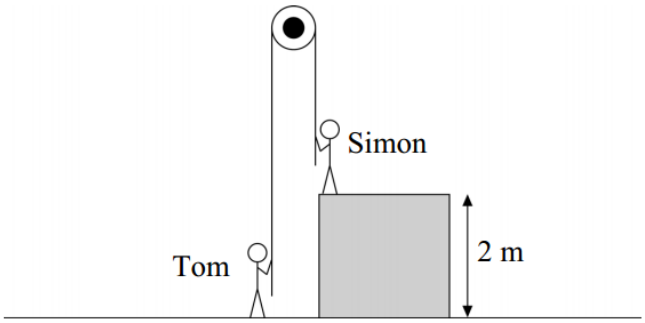
The mass of A is 14 kg and the mass of B is 6 kg.

(a) Using two equations of motion, show that the acceleration of the particles is $1.91\ \text{m s}^{-2}$, correct to three significant figures. *(6 marks)*

(b) Particle B is replaced by a particle C of mass m kg. After the particles have been set in motion, they move with a constant speed. Find m. *(4 marks)*

Question Number and Part	Solution	Marks	Total	Comments
4(a)	$14a = 14g\sin 45° - T$	M1		Equation of motion for one particle
	$6a = T - 6g$	A1		Correct equation
	$14a = 14g\sin 45° - (6a + 6g)$	M1		Equation of motion for other particle
		A1		Correct equation
	$a = \dfrac{14g\sin 45° - 6g}{20} = 1.91\ \text{ms}^{-2}$	M1		Solving for a
		A1	6	Correct a from correct working
(b)	$T = mg$	M1		Equation for one particle
	$T = 14g\cos 45°$	M1		Equation for other particle
		A1		Correct m
	$m = 14\cos 45° = 9.90\ \text{kg}$	A1	4	
	Total		**10**	

6 Two children are holding the ends of a light, inextensible rope, which passes over a light, smooth pulley. Initially Tom, who has a mass of 40 kg, is standing at ground level and Simon, who has a mass of 60 kg, is on the edge of a fixed platform 2 metres above ground level. Model the two boys as particles, one initially at ground level, and the other initially at a height of 2 metres. The rope is taut.



Simon steps off the platform and as he falls vertically, Tom rises vertically.

(a) Assume that the rope remains taut while the boys are moving.

(i) Show that the acceleration of each boy is 1.96 m s^{-2}. *(5 marks)*

(ii) Find the tension in the rope. *(2 marks)*

(b) Find the total distance that Tom travels upwards. *(7 marks)*

Question Number and part	Solution	Marks	Total	Comments
6(a)(i)	$60\times9.8-T=60a$	M1		Equation of motion for one boy
		A1		Correct equation
	$T-40\times9.8=40a$	M1		Equation of motion for other boy
		A1		Correct equation
	$588-(40a+392)=60a$			
	$a=1.96$ m s^{-2}	A1	5	**ag** Correct answer from correct working
(ii)	$T=40\times1.96+392=470$ N (to 3 sf)	M1		Substituting for a and solving for T
		A1	2	awrt 470
6(b)	$v^2=0^2+2\times1.96\times2=7.84$	M1		Finding v^2 using $s=2$, $u=0$ and $a=1.96$
		A1		Correct v or v^2
	$0^2=7.84+2\times(-9.8)s$	m1		Equation for s with $v=0$ and $a=\pm g$
		A1		
	$s=0.4$	m1		Solving for s
	$h_{max}=2+0.4=2.4$ m	A1		Obtaining 0.4
		A1	7	Adding 2 to get 2.4
	Total		**14**	