Connected particles Badge Challenge

Challenge 1

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 $0.88\,\text{m}\,\text{s}^{-2}$,

(a) show that $R = 860$,

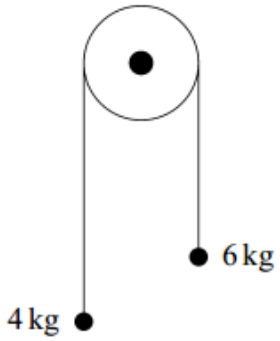
(3)

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

(3)

Challenge 2

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.

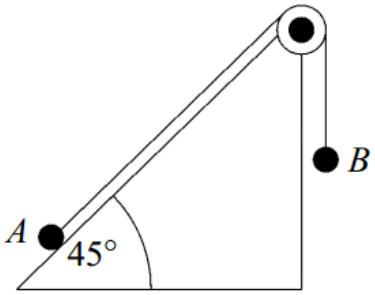


(a) Show that the acceleration of each particle is $1.96\,\text{m s}^{-2}$. *(5 marks)*

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

Challenge 3

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.



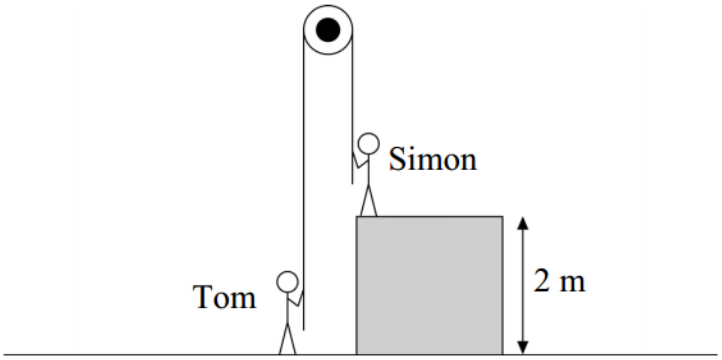
The mass of A is 14 kg and the mass of B is 6 kg.

(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)*

Final Challenge

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)*