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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.

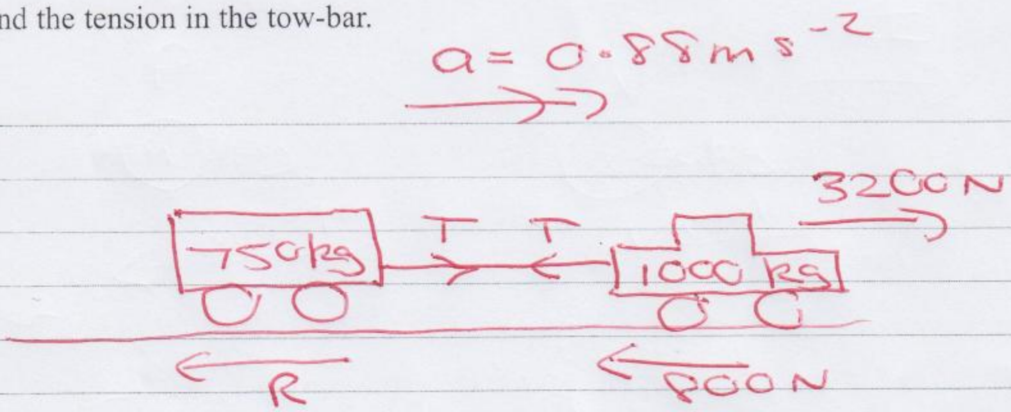
Given that the acceleration of the car and the caravan is $0.88\,\mathrm{m\,s^{-2}}$,

(a) show that $R = 860$,

(3)

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

(3)



a) Whole system ($\rightarrow$)

$(1000+750) \times 0.88 = 3200 + T - T - 800 - R$

$R = 2400 - 1750 \times 0.88$

$R = 860\text{ N}$ (as required)

b) For Car only R ($\rightarrow$)

$1000 \times 0.88 = 3200 - 800 - T$

$T = 2400 - 1000 \times 0.88$

$= 1520\text{ N}$

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6. A car is towing a trailer along a straight horizontal road by means of a horizontal tow-rope. The mass of the car is 1400 kg. The mass of the trailer is 700 kg. The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The resistances to motion of the car and the trailer are assumed to be constant and of magnitude 630 N and 280 N respectively. The driving force on the car, due to its engine, is 2380 N. Find

(a) the acceleration of the car,

(3)

(b) the tension in the tow-rope.

(3)

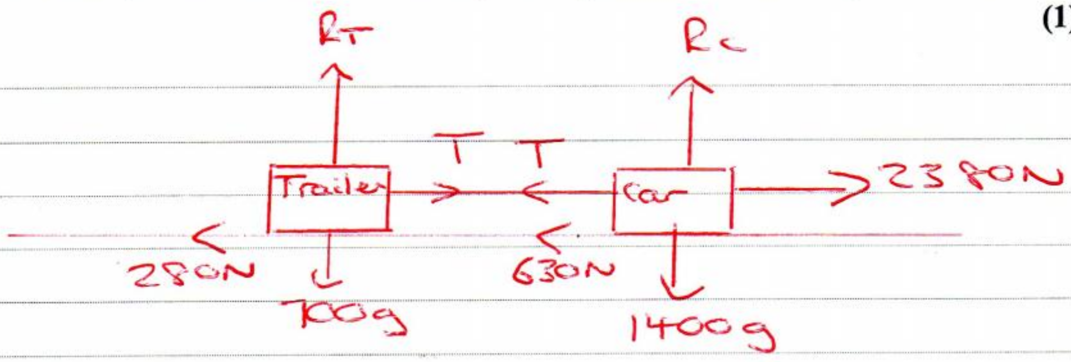
When the car and trailer are moving at 12 m s^{-1}, the tow-rope breaks. Assuming that the driving force on the car and the resistances to motion are unchanged,

(c) find the distance moved by the car in the first 4 s after the tow-rope breaks.

(6)

(d) State how you have used the modelling assumption that the tow-rope is inextensible.

(1)



a) For car + trailer R(→)

$(700+1400)\times a = 2380-630-280$

$2100a = 1470$

$a = 0.7\ ms^{-2}$

b) For trailer R(→)

$700\times 0.7 = T - 280$

$T = 700\times 0.7 + 280$

$T = 770N$

6c) First, find acceleration of car when the rope breaks

R ($\rightarrow$)

$1400 \times a = 2380 - 630$

$a = \frac{2380 - 630}{1400}$

$a = 1.25 \ ms^{-2}$

$s = ?, u = 12 ms^{-1}, v = ?, a = 1.25 ms^{-2}, t = 4s$

$s = ut + \frac{1}{2}at^2$

$s = 12 \times 4 + \frac{1}{2} \times 1.25 \times 4^2$

$s = 48 + 10$

$s = 58m$

d) Same acceleration for car and trailer

Leave blank

6. A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(a) the acceleration of the car and trailer,

(3)

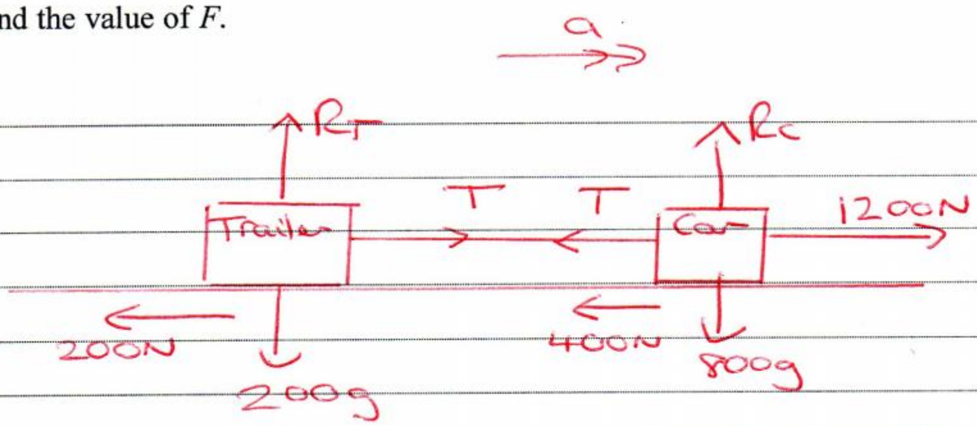
(b) the magnitude of the tension in the towbar.

(3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(c) find the value of F.

(7)



a) For whole system

$R(\rightarrow)$

$(200+800)\times a = 1200-400-200$

$1000\,a = 600$

$a = \frac{600}{1000}$

$a = 0.6\ \text{m s}^{-2}$

b) For Trailer $R(\rightarrow)$

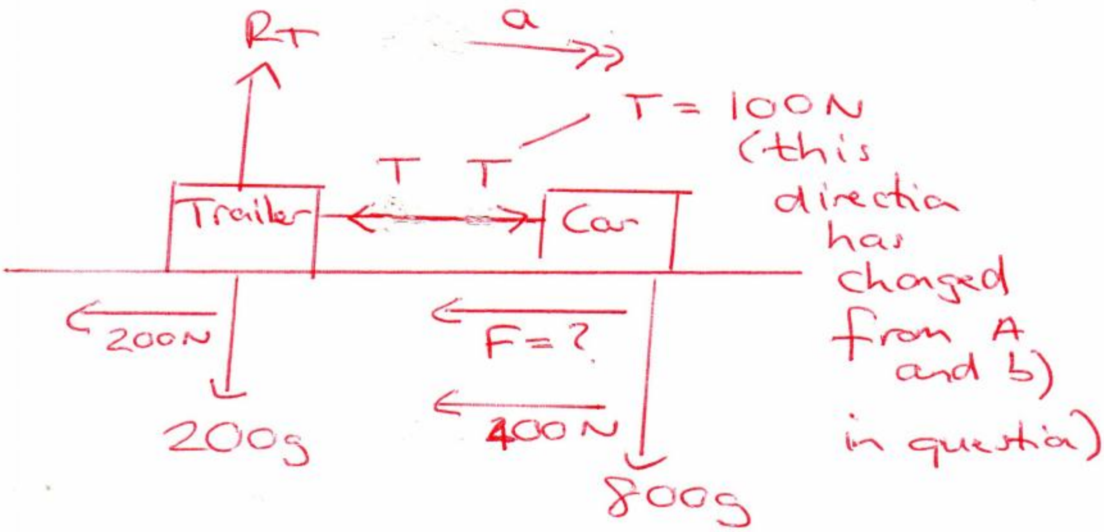
$200\times 0.6 = T - 200$

$120 = T - 200$

$T = 200+120$

$T = 320\ \text{N}$

6c)



For trailer + car $R(\rightarrow)$

$(200+800)\times a = -200-400-F$

$1000a = -600 - F$ (1)

For trailer

$R(\rightarrow)$

$200a = -T - 200$

$200a = -100 - 200$

$200a = -300$

$a = -\frac{300}{200} = -1.5 \, ms^{-2}$

Put $a = -1.5 \, ms^{-2}$ in (1)

$1000 \times (-1.5) = -600 - F$

$F = -600 + (1000 \times 1.5)$

$F = 900 \, N$

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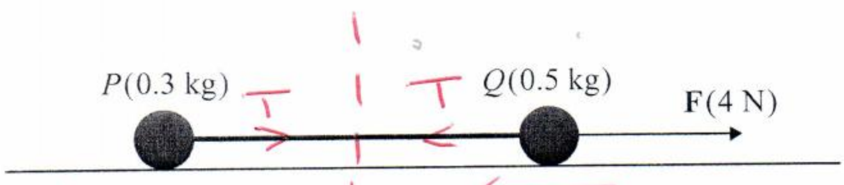
7.



1N **Figure 3** 2N

Two particles P and Q, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane. At time $t = 0$, a constant force **F** of magnitude 4 N is applied to Q in the direction PQ, as shown in Figure 3. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of P has constant magnitude 1 N and the resistance to the motion of Q has constant magnitude 2 N.

Find

(a) the acceleration of the particles as the system moves under the action of **F**, **(3)**

(b) the speed of the particles at $t = 6$ s, **(2)**

(c) the tension in the rod as the system moves under the action of **F**. **(3)**

At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(d) the distance moved by P as the system decelerates, **(4)**

(e) the thrust in the rod as the system decelerates. **(3)**

a) Equation of motion for whole system

$R\ (\rightarrow)$

$(0.3+0.5)a = 4 - 1 - 2 + T - T$

$0.8a = 1$

$a = \frac{1}{0.8} = 1.25\ ms^{-2}$

b) $s = ?$
$u = 0\ ms^{-1}$
$v = ?$
$a = 1.25\ ms^{-2}$
$t = 6$

$v = u + at$
$v = 0 + 1.25 \times 6$
$v = 7.5\ ms^{-1}$

Speed is $7.5\ ms^{-1}$ at $t = 6$ s

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Q7c) Equation of motion for Particle P only

R $(\rightarrow)$

$T - 1 = 0.3 \times 1.25$

$T = 1 + 0.3 \times 1.25$

$T = 1.375$ N

d) Equation of motion for whole system

R $(\rightarrow)$ $0.8a = -2 - 1$

$a = \frac{-3}{0.8} = -3.75 \text{ ms}^{-2}$

$s = ?$

$u = 7.5 \text{ ms}^{-1}$

$v = 0 \text{ ms}^{-1}$

$a = -3.75 \text{ ms}^{-2}$

$t = ?$

$v^2 = u^2 + 2as$

$s = \frac{v^2 - u^2}{2a}$

$s = \frac{0^2 - 7.5^2}{2 \times -3.75} = 7.5 \text{ m}$

e) Equation of motion for P only

$0.3 \times -3.75 = T - 1$

$T = 1 - 0.3 \times 3.75$

$T = -0.125$ N

So thrust is 0.125 N

(opposite direction to T on diagram)