Lesson 3

A-Level Applied Mathematics
Mechanics : Dynamics I : Year 1

3.1 Connected Particles (A first taste)

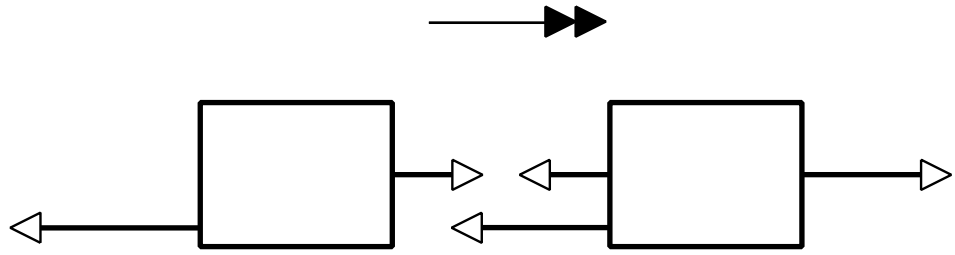
The Car and the Caravan Example

A car of mass 1200 kg tows a caravan of mass 900 kg along a horizontal road.
The engine of the car exerts a forward force of 2800 N.
The resistance to the motion of the car and caravan, in Newtons, are 1200*k* and 900*k*.
(*k is an unknown constant that will need to be found*)
The car accelerates at 0.8 m s^{-2}.

(i) Complete the diagram below by marking on

- ◇ The 1200 kg and 900 kg masses.
- ◇ The 1200*k* N and 900*k* N resistances.
- ◇ The 2800 N driving force.
- ◇ The 0.8 m s^{-2} acceleration.
- ◇ The tension in the tow-bar, *T*.

(ii) Find the tension, in Newtons, in the tow-bar.



(iii) Where, in the solution, was Newton's 3rd Law applied ?

3.2 Exercise

Question 1

A car of mass 1500 kg is towing a trailer of mass 500 kg along a straight horizontal road. The car and the trailer are connected by a light inextensible tow-bar. The engine of the car exerts a driving force of magnitude 10000 N. The car and trailer experience resistance of magnitudes 3000 N and 1000 N respectively.

(a) Draw a diagram showing the significant forces and question information.

(b) Find **(i)** The acceleration of the car.

(ii) The tension in the tow-bar.

Question 2

A car of mass 900 kg tows a caravan of mass 500 kg against resistance totalling 700 N. The resistance on the car and caravan are proportional to their masses (in other words, the resistances are $900k$ and $500k$ for some constant k).

The car is accelerating at 0.8 m s^{-2} along a horizontal road.

(a) Draw a diagram showing the significant forces and question information.

(b) Find **(i)** The driving force exerted by the engine.

(ii) The tension in the tow-bar.

Question 3

M1 Examination Question from June 2006, Q6.

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 marks]

(b) the tension in the tow-rope

[3 marks]

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) How far does the car move in the first 4 s after the tow-rope breaks ?

[6 marks]

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

[1 mark]

Question 4

M1 Examination Question from May 2003, Q8

A car which has run out of petrol is being towed by a breakdown truck along a straight horizontal road. The truck has mass 1200 kg and the car has mass 800 kg. The truck is connected to the car by a horizontal rope which is modelled as light and inextensible. The truck's engine provides a constant driving force of 2400 N. The resistances to motion of the truck and the car are modelled as constant and of magnitude 600 N and 400 N respectively.

Find

(a) the acceleration of the truck and the car

[3 marks]

(b) the tension in the rope

[3 marks]

When the truck and car are moving at 20 m s^{-1} the rope breaks. The engine of the truck provides the same driving force as before. The magnitude of the resistance to the motion of the truck remains 600 N.

(c) Show that the truck reaches a speed of 28 m s^{-1} approximately 6 s earlier than it would have done if the rope had not broken.

[7 marks]

Q1 from Mechanics 1 by Hebborn, Littlewood & Norton, Q2 from M1 by Hooker, Jennings, Moran & Pateman