Parallel Forces acting together

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In leaflet 2.3 several types of force were introduced, one at a time. However, in practice it is more likely that more than one force will be acting on an object at any given time.

Here the idea of a **net** or **resultant force** is considered. This is the sum of forces acting in one direction minus the sum of forces acting in the opposite direction, given that all the forces act parallel to a given direction. For non-parallel forces, see leaflet 2.6.

Equilibrium is the term used to describe a **zero** net or resultant force.
In such a case, the object will either:
1. Move with a constant velocity (Newton's 1st Law) or
2. Remain at rest.

Worked Example 1.
A car, of mass 1100 kg, is being towed by a truck, along a straight horizontal road. The only horizontal forces acting on the car are the tension in the tow bar and a resistive force. Given the acceleration of the car is 0.7 m s $^{-2}$ and the resistive force is 125 N, what is the tension in the tow bar?

Solution
Modelling the car as a particle and constructing the diagram with horizontal forces on, as in Figure 1, it can be seen that the resultant force is $T-125$.

Applying Newton's Second Law of Motion:

$$\begin{aligned} F &= ma \\ T-125 &= 1100\times 0.7 \\ \Rightarrow T &= 770+125 \quad = 895 \text{ N} \quad = 900 \text{ N (2 s.f.)} \end{aligned}$$

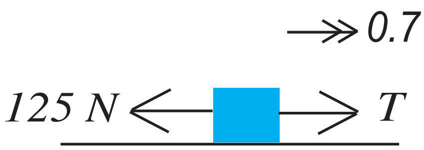

Figure 1

Worked Example 2.
A newsagent pushes a box of magazines, of mass 6 kg, across a horizontal floor in a straight line. If he pushes with a force of 75 N and the box moves with a constant speed, what is the size of the resistive force, R_f?

Solution
Modelling the box of magazines as a particle and constructing the diagram with horizontal forces on, as in Figure 2, it can be seen that the resultant force is $75 - R_f$. It is also important to recognise that the acceleration is 0 m s^{-2}, because the speed is constant.

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Applying Newton's Second Law of Motion:

$$\begin{aligned} F &= ma \\ 75 - R_f &= 6 \times 0 \\ \Rightarrow R_f &= 75 \text{ N} \end{aligned}$$

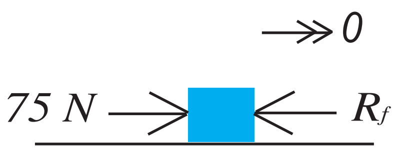

Figure 2

Worked Example 3.

A small boat of mass 8500 kg is cruising near shore in a straight line and has a driving force of 8000 N. If there is a horizontal resistive force of 1200 N, opposing the motion, what is the acceleration of the boat?

Solution

Modelling the boat as a particle and constructing the diagram with horizontal forces on, as in Figure 3, it can be seen that the resultant force is 8000 − 1200.

Using Newton's Second Law of Motion:

$$\begin{aligned} F &= ma \\ 8000 - 1200 &= 8500a \\ \Rightarrow a &= \frac{6800}{8500} = 0.8 \text{ m s}^{-2} \end{aligned}$$

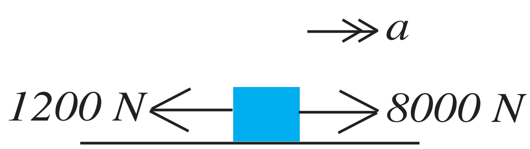

Figure 3

Exercises

1. A car, of mass 1400 kg, is being towed by a truck, along a straight horizontal road. The only horizontal forces acting on the car are the tension in the tow bar, 790 N, and a resistive force of 230 N. What is the acceleration of the car?

2. A newsagent pushes a box of magazines, of mass 4 kg, across the horizontal floor in a straight line. If he/she pushes with a force of 8.9 N and the box moves with an acceleration of 0.9 m s $^{-2}$, what is the size of the resistive force?

3. A speed boat of mass 5750 kg is cruising near shore in a straight line and has a driving force of 11500 N. If there is a horizontal resistive force of 1150 N, opposing the motion, what is the acceleration of the boat?

4. A motorbike and its rider have a combined mass of 570 kg. If the motorbike travels along a straight horizontal road with an acceleration of 3 m s $^{-2}$, whilst experiencing a resistive force of 135N, what is the driving force of the engine?

5. Two men have constructed a shed but now need to move it a short distance into position. They decide to push it across the garden. They both push horizontally, with the same force, so that the shed moves at a slow but constant speed. Given there is a resistance of 540 N, what force does each man push with?

6. A car of mass 1250 kg accelerates from rest to 28 m s^{-1} in a straight line along a horizontal road in 8 seconds. Given there is a constant resistive force of 225 N, find the driving force of the car.

Answers (all to 2 s.f.)

1. 0.40 m s $^{-2}$ 2. 5.3 N 3. 1.8 m s $^{-2}$ 4. 1800 N 5. 270 N 6. 4600 N

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