Section 2: Newton's second law

Notes and examples

These notes contain subsections on

- Using Newton's second law in two dimensions

Using Newton's second law in two dimensions

In a situation where there are forces acting on an object in two dimensions, and there is motion, then you should consider the components of the forces in the direction of motion, and in the direction perpendicular to the motion.

This makes the calculations simpler: in the direction of motion you can apply Newton's 2nd law $F = ma$, and in the direction perpendicular to the motion there is no motion and therefore no resultant force (this is a special case of Newton's 2nd law).

Always start by drawing a good-sized diagram showing all the forces and angles.

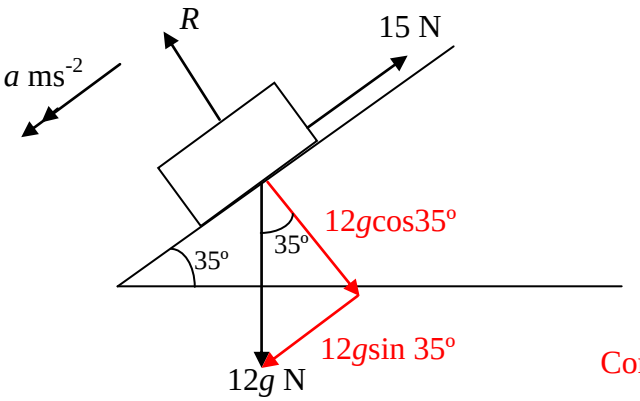
Example 1

A block of mass 12 kg is on a slope of angle 35°. It experiences a resistance force of 15 N as it slides down the slope. Find

(i) the reaction force

(ii) the acceleration of the block.

Solution



Components in red

(i) Using Newton's second law perpendicular to the slope:

$$R - 12g\cos 35° = 0$$

$$R = 12 \times 9.8 \cos 35° = 96.3 \text{ (3 s.f.)}$$

There is no acceleration in the direction perpendicular to the slope.

The reaction force is 96.3 N (3 s.f.).

(ii) Using Newton's second law down the slope:

$$12g\sin 35° - 15 = 12a$$

$$a = \frac{12\times 9.8\sin 35° - 15}{12} = 4.37 \text{ (3 s.f.)}$$

The acceleration in the direction parallel to the slope is a ms^{-2}.

So the acceleration is 4.37 ms^{-2} down the slope.

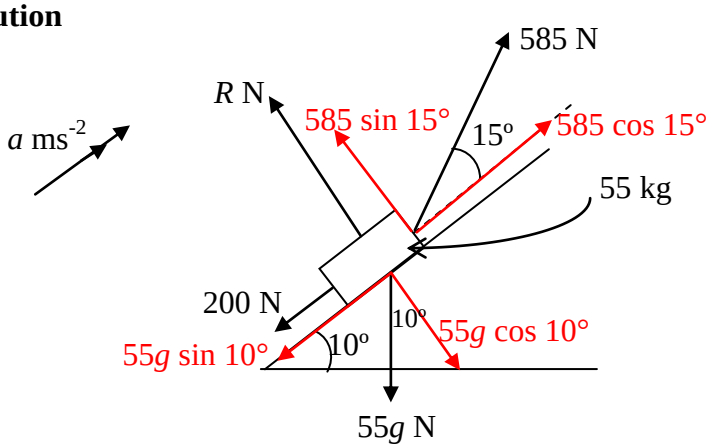
Example 2

An arctic explorer is pulling a sledge containing her provisions, a total mass of 55 kg, up a slight incline of 10º. The rope she is pulling with makes an angle of 15º with the slope, and she pulls with a force of 585 N. The ice causes a resistance to motion of 200 N.

(i) Calculate the acceleration of the sledge.

(ii) If she starts from rest, how long does it take her to reach a speed of 2 ms^{-1}?

Solution



Components in red

(i) Using Newton's second law parallel to the slope:

$$585\cos 15° - 55g\sin 10° - 200 = 55a$$

$$a = \frac{585\cos 15° - 55\times 9.8\sin 10° - 200}{55} = 4.936 \text{ (4 s.f.)}$$

The acceleration is 4.94 ms^{-2} (3 s.f.)

(ii)

$u = 0$	$v = u + at$
$a = 4.936$	$2 = 4.936t$
$v = 2$	$t = 0.405$ (3 s.f.)
$t = ?$	

She takes 0.405 s (3 s.f.) to reach a speed of 2 ms^{-1}.