Forces

Printable revision sheet — Galaxscia

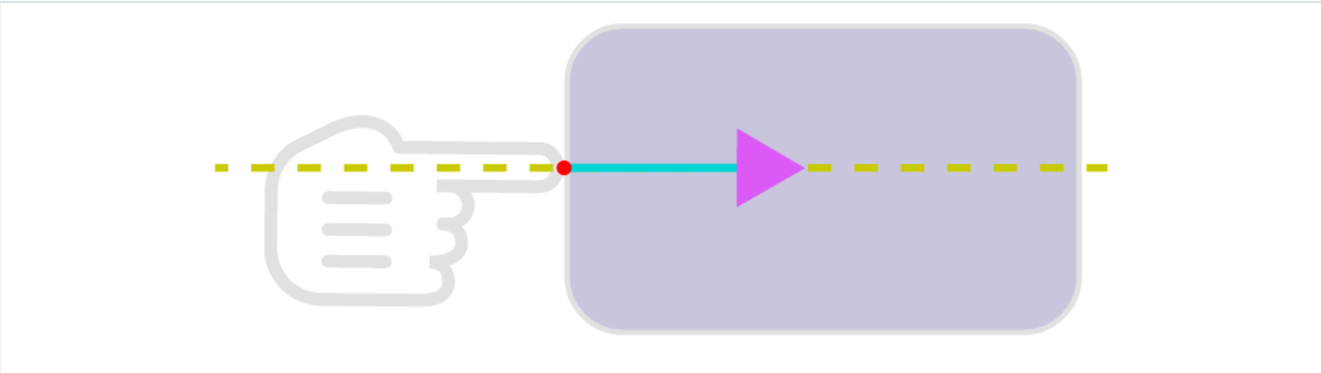
LEVEL 1

Discovering the idea of a force

In everyday life, many actions on objects are described by the word **force**: you push a door, the wind pushes a leaf, the Earth pulls an apple. In physics we use the force model to represent and analyse these actions.

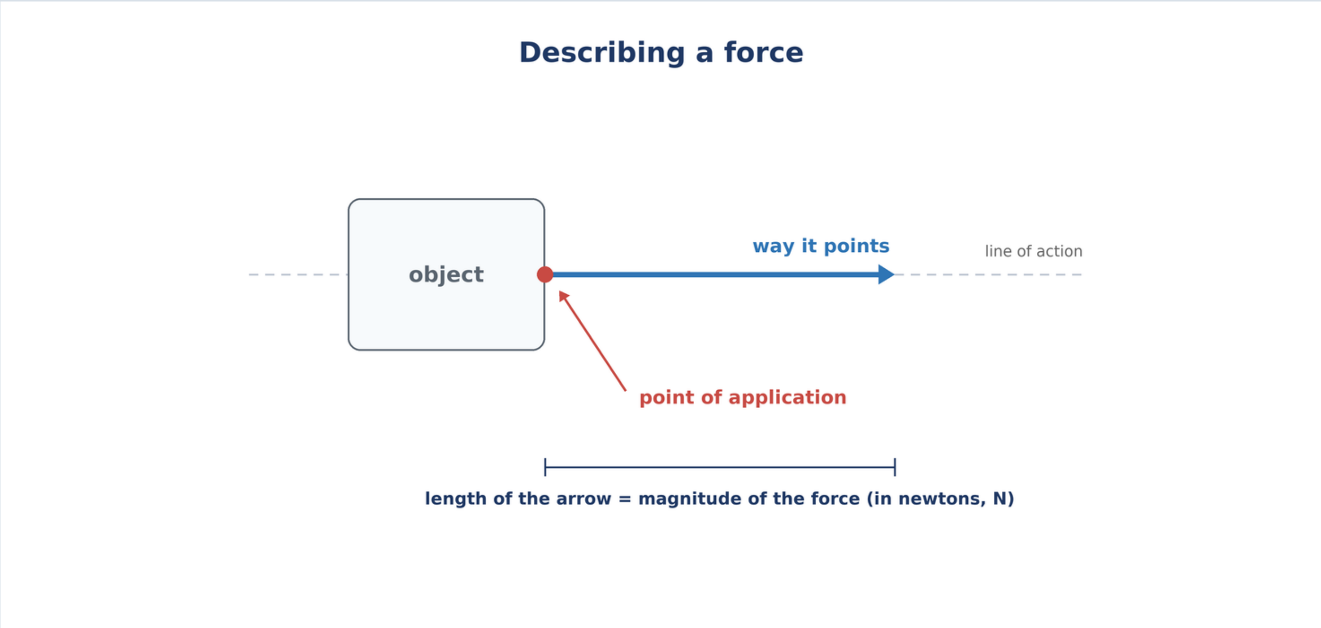
A force is like the **identity card** of an action: it does not show the "real" action, but it gives all the information needed to describe it and to compare it.

The four characteristics of a force



Example : the weight of a 10 kg object

- **Point of application** : the centre of gravity of the object.
- **Direction** : vertical, passing through the object and the centre of the Earth.
- **Way it points** : downwards (towards the centre of the Earth).
- **Magnitude** : worked out with the formula $P = m \times g$, with $g \approx 9.81$ N/kg (often rounded to 10 N/kg, a unit also written m/s²), so $P = 10 \times 9.81 \approx 98.1$ N



Key points — revision questions

What are the four things needed to describe a force?

What is the point of application of the weight of an object?

What is the unit used to measure a force?

LEVEL 2

Representing a force with a diagram

In physics, every force is represented by an **arrow**. Each property of the arrow matches one characteristic of the force:

The **point of application** is the place where the **arrow starts.** The direction and the way it points are shown by the arrow itself. The **magnitude** is shown by the **length of the arrow.**

Method for drawing a force

Identify the 4 characteristics of the force.

Choose a scale (e.g. 1 cm = 10 N).

Place the point of application on the drawing of the object.

Draw the arrow along the right direction and pointing the right way.

The length of the arrow matches the magnitude of the force. (e.g. the force is 50 N. With that scale, the arrow will be 5 cm long.)

Important rules: use the same scale for every force in a diagram, name each force (P, R, F, ...), write the value if it is known, and be precise about the point of application.

Key points — revision questions

What does the length of an arrow represent on a diagram?

How do you draw a force?

If the scale is 1 cm = 20 N, what magnitude does a 3 cm arrow correspond to?

LEVEL 3

Forces in real situations, and balance

Often several forces act on the same object at the same time. To know what happens to the object, we look at the **resultant force** (the vector sum of the forces).

If the resultant is zero, the motion of the object does not change.

If not, the motion changes (speeding up or slowing down depending on the way the resultant points).

Balanced and unbalanced forces

Balanced: the forces cancel out, so the resultant is zero, so the object is still or moving at constant speed.

Unbalanced: the forces do not cancel out, the resultant is not zero, so the object speeds up or slows down.

Examples of analysis

1) A book resting on a table:

Forces:

weight P (downwards, at the centre of the book),

reaction of the table R (upwards, at the point of contact).

If P = R then

the object is balanced (it does not move).

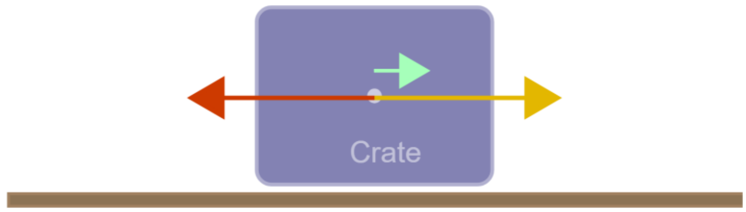
2) A crate pulled at constant speed:

Horizontal forces:

pull towards the front

friction towards the back.

If pull = friction then the speed is constant.



Key points — revision questions

What is the condition for an object to be balanced? Draw a simple situation.

What happens if the forces do not cancel out? Draw a simple situation.

LEVEL 4

Going further: Newton's laws

Isaac Newton (1643-1727) set out three simple but powerful laws to describe the motion of bodies. These laws are still used today to understand mechanics.

1. First law: the principle of inertia

With no resultant force, an object at rest stays at rest and a moving object keeps a constant velocity (same direction, same way).

Example: a marble rolls on a perfectly smooth, horizontal table; it would carry on for ever if nothing slowed it down.

2. Second law: the link between force and motion

The resultant force $\vec{F}$ acting on an object is proportional to its mass m and to its acceleration $\vec{a}$:

$$\vec{F} = m \times \vec{a}$$

This means that with the same force, a light object speeds up more than a heavy one.

3. Third law: action and reaction

If an object A exerts a force on an object B, then B exerts a force of the same size but in the opposite direction on A.

Example: when you push a wall, the wall "pushes back" with an equal force in the opposite direction, even though it does not move.