P1: Forces

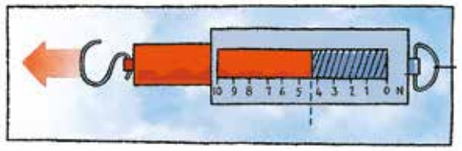
Knowledge organiser

What are forces?

A **force** can be a *push* or a *pull*.

Forces can be measured using a **newtonmeter**.

Forces are measured in **newtons** (N).



Contact forces occur when objects are touching, for example:

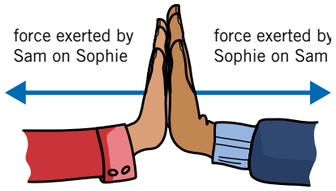
- **friction**
- **drag forces** (**air resistance** and **water resistance**)
- support forces (e.g., **reaction forces**)

Non-contact forces work at a distance, for example:

- **gravity**
- **magnetic force**
- **electrostatic force**

Forces always occur in pairs.

The pairs are called **interaction pairs**.



Balanced and unbalanced forces

When the forces acting on an object are the same size, but act in opposite directions, we say that they are **balanced**.

The balanced forces cancel out, and the object is in **equilibrium**.

If the forces are not the same size, and do not cancel each other out, we say they are **unbalanced**.

The larger the difference between unbalanced forces, the quicker the object will change speed.

Drag forces and friction

Friction is a contact force that occurs when two objects move against each other. It happens because all surfaces have some roughness – even ones that look smooth.

Friction can be reduced by adding **lubrication** (e.g., oil or grease).

Friction is often useful, for example:

- you need friction to walk across surfaces
- the brakes on a bike need friction to work.

A solid moving through a liquid or a gas has to push the liquid or gas particles out of the way. This produces a drag force on the solid object.

a solid moves through a gas

a solid moves through a liquid

Water resistance and air resistance are drag forces.

Drag forces can be useful if we need to slow something down, for example, by using parachutes.

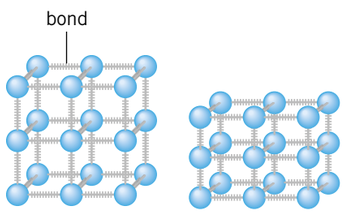
Making an object more **streamlined** will reduce the drag forces on it.

Reaction forces

When you stand on the floor:

- your weight pushes the particles in the floor together
- the bonds between the particles are **compressed**
- the compressed particles push back and support you.

A support force that balances the weight of an object is called the reaction force. **Upthrust** is another example of a support force.



Fields and non-contact forces

In physics, a **field** is a special region where certain objects experience a non-contact force. For example, when

- a mass experiences a force in a gravitational field
- a magnetic material (like iron) experiences a force in a magnetic field
- a charged object experiences a force in an electrostatic field.

As you get further away from a mass, a magnet, or a charged object, the field gets weaker.

Weight and mass

Mass is the amount of 'stuff' something is made of – it is measured in kilograms (kg).

Weight is a force so it is measured in newtons.

$$\text{weight (N)} = \text{mass (kg)} \times \text{gravitational field strength (N/kg)}$$

The **gravitational field strength** on Earth is about 10 N/kg.

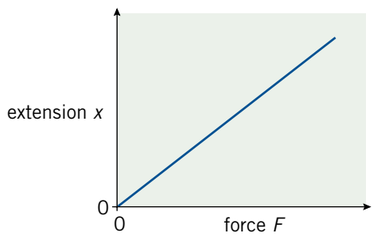
Your weight depends on the gravitational field strength but your mass is the same everywhere.

Hooke's law

Some objects – like springs – can be **stretched** when pulled. The amount they stretch by is called the **extension**.

A force called **tension** makes a spring return to its original length (unless it has gone beyond its **elastic limit**).

Hooke's law states that the extension of a spring doubles when you double the force. This means there is a **linear** relationship between force and extension.



Key terms

Make sure you can write definitions for these key terms.

air resistance, balanced, compress, contact force, drag force, elastic limit, electrostatic force, equilibrium, extension, field, friction, gravitational field strength, gravity, Hooke's law, interaction pair, linear, lubrication, magnetic force, mass, newton, newtonmeter, non-contact force, reaction force, stretch, streamlined, tension, unbalanced, upthrust, water resistance, weight