Chapter 8: Forces in balance

Knowledge organiser

Scalars and vectors

Scalar quantities only have a magnitude (e.g., distance and speed).

Vector quantities have a magnitude *and* a direction (e.g., velocity and displacement).

Forces

A **force** can be a push or pull on an object caused by an interaction with another object. Forces are vector quantities.

Contact forces occur when two objects are touching each other.

For example, friction, air-resistance, tension, and normal contact force.

Non-contact forces act at a distance (without the two objects touching).

For example, gravitational force, electrostatic force, and magnetic force.

Resultant forces

If two or more forces act on an object along the same line, their effect is the same as if they were replaced with a single **resultant force**. The resultant force is

- the sum of the magnitudes of the forces if they act in the same direction
- the difference between the magnitudes of the forces if they act in opposite directions.

If the resultant force on an object is zero, the forces are said to be **balanced**.

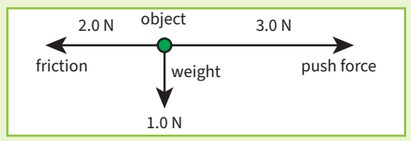
Newton's First law

Newton's First Law states that the velocity, speed, and/or direction of an object will only change if a resultant force is acting on it. This means that:

- if the resultant force on a stationary object is zero, the object will remain stationary
- if the resultant force on a moving object is zero, it will continue moving at the same velocity, in a straight line.

Drawing forces

Free body diagrams use arrows to show all of the forces acting on a single object. For example:



A dot or circle represents the object, with the forces drawn as arrows:

- the arrow length represents the magnitude of the force
- the arrow direction shows the direction of the force.

Newton's Third Law

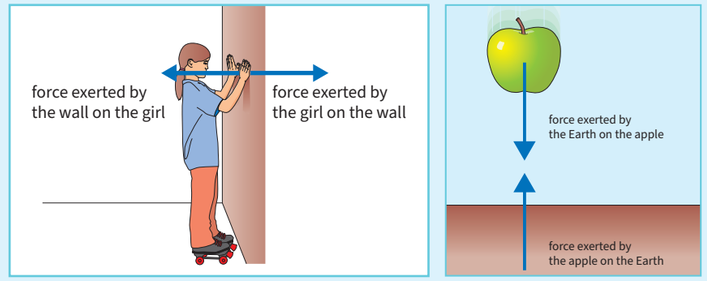
Newton's Third Law states that whenever two objects interact with each other, they exert *equal and opposite* forces on each other.

This means that forces always occur in pairs.

Each pair of forces:

- act on separate objects
- are the same size as each other
- act in opposite directions along the same line
- are of the same type, for example, two gravitational forces or two electrostatic forces.

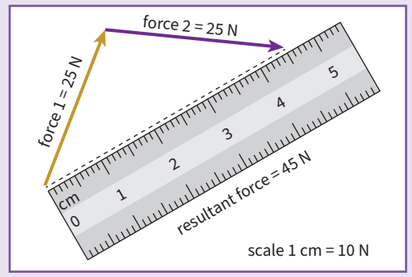
Force pairs



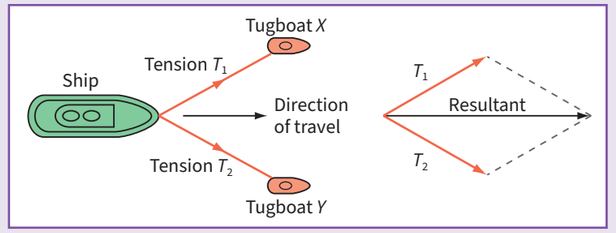
Scale drawings (HT only)

Scale drawings can be used to find the resultant of two forces which are not acting along the same line.

The forces are drawn end to end. The resultant can then be drawn between the two ends, forming a triangle.

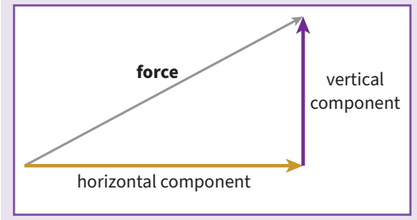


You can use the parallelogram of forces where the two forces are drawn to scale as sides of a parallelogram.



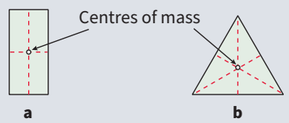
Resolving forces

A single force can always be resolved (split) into two component forces at right angles to each other:



The two component forces added together give the same effect as the single force.

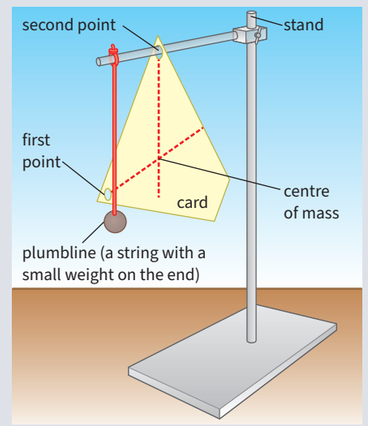
Centre of mass



For a flat symmetrical object, the centre of mass is where the axes of symmetry meet.

The point through which the weight of an object can be considered to act.

For a flat irregularly shaped object, find the centre of mass by suspending the object from different points. The centre of mass always lies beneath the point of suspension.



Moments

A force or system of forces can cause an object to rotate.

The turning effect of a force is called the **moment** of the force, and its size can be calculated using the equation:

L *moment of a force* (Nm) = *force* (N) × *distance* (m)

$$M = F\,d$$

If an object is balanced, the sum of the clockwise moments equals the sum of the anticlockwise moments.

Levers and gears

Levers and **gears** can be used to increase the moment of a force, making it easier to lift or rotate an object.

If a small gear drives a large gear, the moment of the applied force is *increased* but the large gear moves slower (and vice versa).

A lever allows a large moment of force to be produced by allowing force to be applied further from the pivot.

Key terms

Make sure you can write a definition for these key terms.

balanced · centre of mass · contact force · free body diagram · force pair · force · gear · lever · moment · Newton's First Law · non-contact force · resultant · scalar · vector

Chapter 8: Forces in balance

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P8 questions	Answers
1	What is a scalar quantity?	only has a size (magnitude)
2	What is a vector quantity?	has both a size and direction
3	What is a force?	a push or pull that acts on an object due to the interaction with another object
4	Is force a vector or scalar quantity?	vector
5	What is a contact force?	when objects are physically touching (e.g., friction, air-resistance, tension, normal contact force)
6	What is a non-contact force?	when objects are physically separated (e.g., gravitational, electrostatic, magnetic)
7	What is the same about the interaction pair of forces when two objects interact with each other?	the forces are the same size
8	What is different about the interaction pair of forces when two objects interact with each other?	forces are in opposite directions
9	What is the size of the resultant force on an object if the forces on it are balanced?	zero
10	What is the centre of mass?	the point through which the weight of an object can be considered to act
11	What is the turning effect of a force called?	a moment
12	What can you say about clockwise and anticlockwise moments on a balanced object?	sum of all the clockwise moments about any point = sum of all the anticlockwise moments about that point
13	How does a lever reduce the amount of force needed to create a particular sized moment?	by increasing the distance from the pivot
14	What happens to the moment of a force when a small gear drives a large gear?	moment is increased
15	What does Newton's First Law say?	the valocity of an object will only change if a resultant force is acting on it
16	What is the resultant force on a stationary object?	zero
17	What is the resultant force on an object moving at a steady speed in a straight line?	zero
18	What does Newton's Third Law say?	when two objects interact they exert equal and opposite forces on each other

Put paper here