KNOWLEDGE

Physics Topic P8
Forces in balance

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Section 1: Key terms

Scalar	A quantity with **magnitude (size) only,** e.g. speed, distance, time, area, volume.
Vector	A quantity that has both **magnitude (size)** and **direction,** e.g. all forces, displacement, velocity, weight, momentum.
Distance	How much ground an object has covered during its motion (scalar).
Displacement	Displacement is **distance** in a given **direction** (vector).
Magnitude	The value of a force in newtons.
Friction	The force **opposing** the **relative motion** of **two solid surfaces** in **contact**.
Contact force	Force between objects that are **touching** e.g. friction, air resistance.
Non-contact force	Force that acts on things **not touching** e.g. gravitational force, magnetic force.
Balanced forces	When forces are equal and opposite each other, also known as **equilibrium**.
Newton	Unit force is measured in.
Weight	The **force of gravity** acting **on an object's mass**. Measured using a **newtonmeter**.
Centre of mass	A **point** in the **middle** of an object where **all its mass acts**.
Resultant force	The **overall force** once all the forces have been considered.
Work done	Work is done when an **object is moved through a distance**. When work is done **against friction** there is a **temperature rise**.
Newton's first law	If the forces on an object are balanced the object will either: 1. Remain still 2. Keep moving with the same velocity
Newton's third law	When **two objects interact** they exert an **equal and opposite** force on each other.
Moment (HT)	**Turning effect** of a force
Load (HT)	Weight of an object

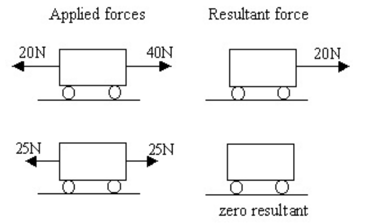
Section 2: Types of forces

Force	**Between**	**Contact or non-contact**	**Example**
Friction	Two moving surfaces	Contact	Brakes
Upthrust	An object & water	Contact	Boat
Reaction	Two stationary objects	Contact	Book on shelf
Air resistance	A moving object & air	Contact	Plane
Weight	Two masses	Non-contact	You and the earth
Tension	Two ends of an elastic material	Contact	Spring
Magnetic	Magnetic & magnetic materials	Non-contact	Magnet picking up a nail

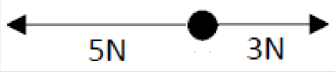
Section 3: Resultant forces

If the resultant force on an object **is zero**, then the object **stays at rest** or at the **same speed and direction.**
If the resultant force is **greater than zero**, the **speed or direction** of the object **will change**.

If two forces act on an object along the **same line**:
- the resultant force is **their sum** if the **forces act** in the **same direction.**
- the resultant force is their **difference** if the forces **act in opposite directions.**



A **free-body** force diagram of an object shows **the forces acting on it**.
Each force is shown on the diagram by a **vector** (an arrow pointing in direction of the force.)

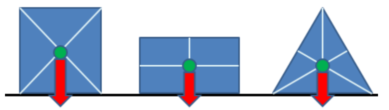


Free body force diagram (HT) showing forces in opposite directions.

Section 4: Centre of mass

Point at which mass of an object appears to be concentrated is known as its **centre of mass**. When an object is freely suspended, it comes to rest with its centre of mass **directly below the point of suspension.**

The centre of mass of a **regular shape** is at the **centre** (where the axes of symmetry meet.)

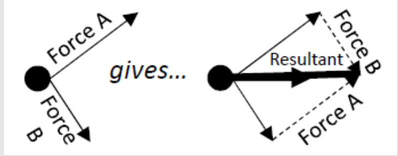


Section 5: The parallelogram of forces (HT)

The parallelogram of forces is a scale diagram of two force vectors which is used to find the **resultant of two forces** that are **not parallel** (don't act along the same line).

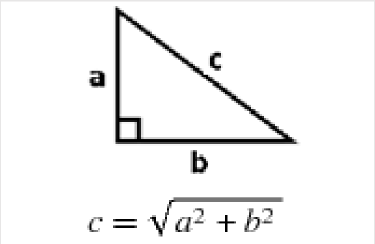
Force A and Force B are two forces that are **not parallel.**

The resultant is the **diagonal** of the parallelogram that **starts** at the **origin** of the two forces.



Resulting displacement (HT)

The resulting displacement (c) is **measured** using a **ruler** on a scale diagram or calculated using **Pythagoras.**



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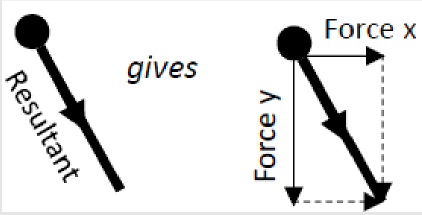
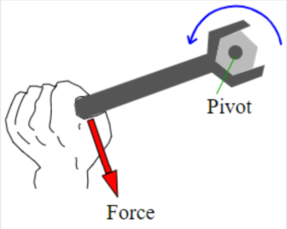
Section 6: Resolution of forces (HT)

Resolving a force means finding perpendicular components that have a resultant force that is equal to the force.	
Drawing two forces at **right angles** to represent a **single resultant force**.	
Equilibrium	For an object in **equilibrium**, the resultant force is zero. For e.g. an object at rest has a resultant force of zero so is in equilibrium.

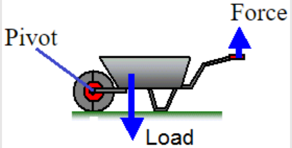
Section 7: Moments at work (Triple)

The **moment** of a force is **a measure** of the **turning effect** of the force on an object.

Moment of a force (turning effect) can be **increased** by: • Increasing the **size** of the force. • Using a spanner with a **longer** handle (**distance** the force is applied is further from the pivot.)	
To calculate a moment you need to know:	• How much **force** is being applied (Newtons, N) • The **distance** from the pivot that the force is being applied (Meters, m) **Moment = force x distance**
Unit for moment	(newton metre Nm)

A **small force** over a **large distance** can generate the **same moment** as a **large force** over a **small distance**.

Examples of levers include **scissors** and **wheelbarrows**.



Section 8: Levers and gears (Triple)

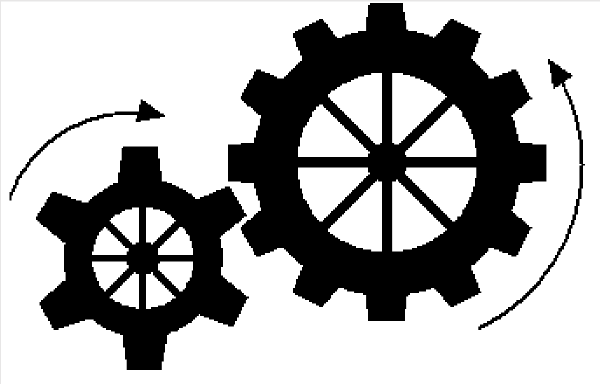
Levers use the idea of **balanced moments** to make it **easier** for us to do **work**. Levers **increase the distance** from the **pivot** at which the **force is applied**. Levers act as **force multipliers** as less force is required to get the same moment by increasing the distance.

Gears are like levers because they can **multiply the effect** of a **turning force**.

Gears are wheels with toothed edges that rotate on an axle or shaft. When one gear turns, it causes the other gear to rotate in the opposite direction.

If you want to **increase the moment of a turning force**, you need a **small gear** wheel to **drive** a **large gear** wheel. We see this in cars.

When a car is in **low gear**, a **small gear wheel** turns (effort) a **large gear wheel** (load.) The load force is larger than the effort force hence it is acting as a **force multiplier**.



Changing gears (Triple)

Low gear to high gear	A low gear ratio gives low speed and a high turning effect. A high gear ratio gives high speed and a low turning effect.

Section 9: Moments and equilibrium (Triple)

If an object at rest doesn't turn, the sum of the anticlockwise moments about any point = the sum of the clockwise moments about any point. This is the **principle of moments**.

Applying the principle of moments gives the equation

$$W_1d_1 = W_2d_2$$

W = Weight in newtons, N
d = distance in metres, m