Edexcel GCSE Physics

Your notes

Types of Forces

Contents

Your notes

Contact & Non-Contact Forces

Contact & Non-Contact Forces

- A force is defined as:

  A push or a pull that acts on an object due to the interaction with another object

- Forces can have an effect on bodies in several different ways:
  - They can change their **speed**
  - They can change their **direction**
  - They can change their **shape**
- Some examples of these changes are:
  - An engine can increase the **speed** of a vehicle due to a force called **thrust**
  - A comet's **direction** can be affected by **gravitational attraction**
  - A spring can have its **shape changed** by the force from a heavy **load**

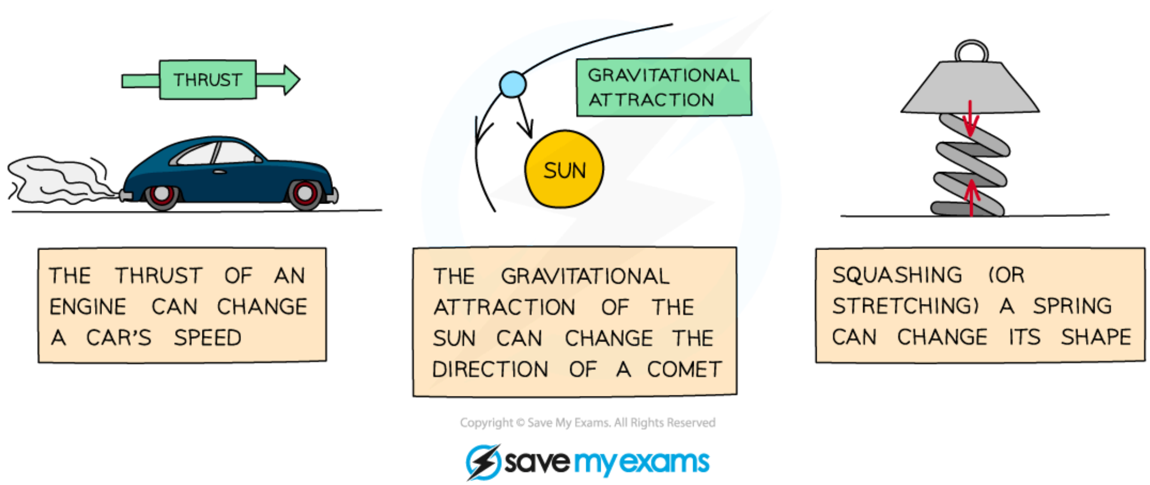
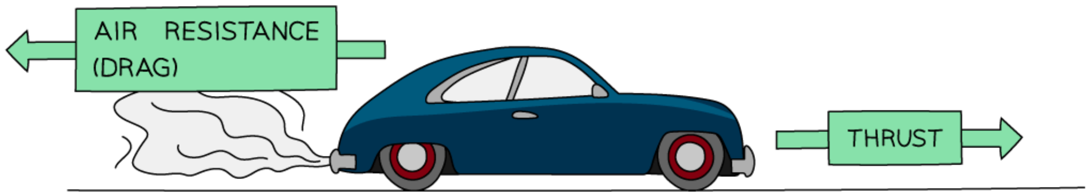


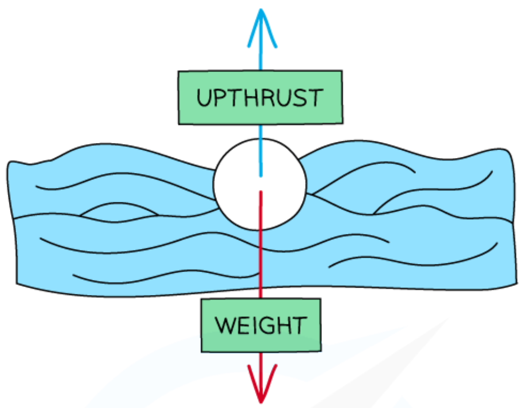
Diagram showing the effects of forces on different objects

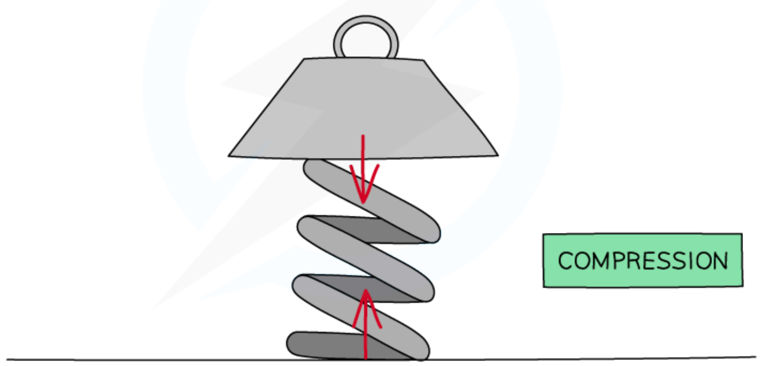
- Important forces to be familiar with:
  - **Weight** – the name given to the force of gravity on a mass
  - **Electrostatic force** – the force between two charged objects

- **Thrust** – the force causing an object to move (such as the force from a rocket engine)
- **Air resistance** (or **drag**) – the friction of the air on a moving object
- **Upthrust** – the force of a fluid (such as water) pushing an object upwards (making it float)
- **Compression** – forces that act inward on an object, squeezing it
- **Tension** – force transmitted through a cable or a string when pulled on by forces acting on its opposite ends
- **Reaction force** (or the **normal force**)– a force due to contact between two objects

Your notes


AIR RESISTANCE
(DRAG)
THRUST


UPTHRUST
WEIGHT


COMPRESSION

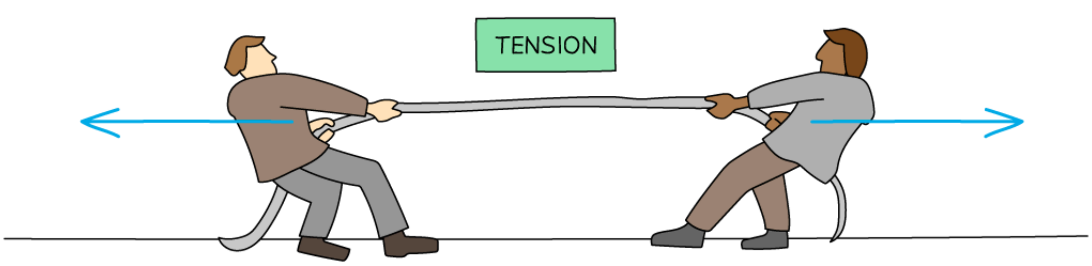

TENSION

Diagram showing several different types of forces acting on objects

Your notes

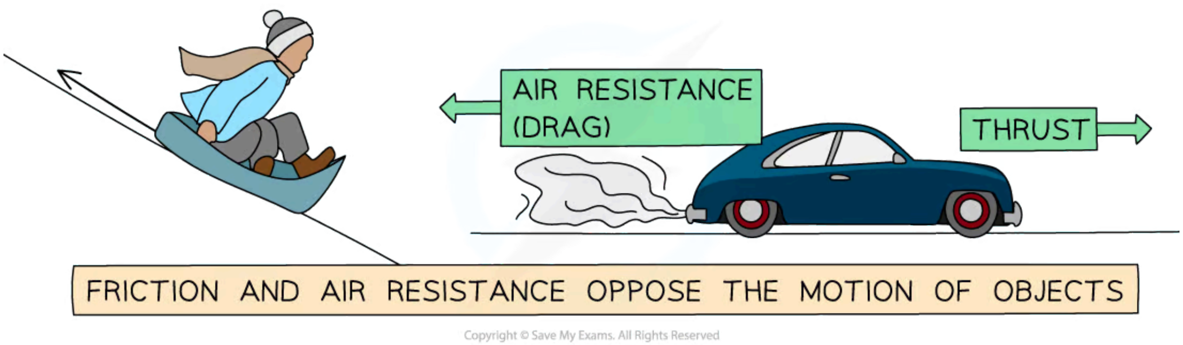
- All forces can be categorised into one of two types:
  - **Contact** forces
  - **Non-contact** forces

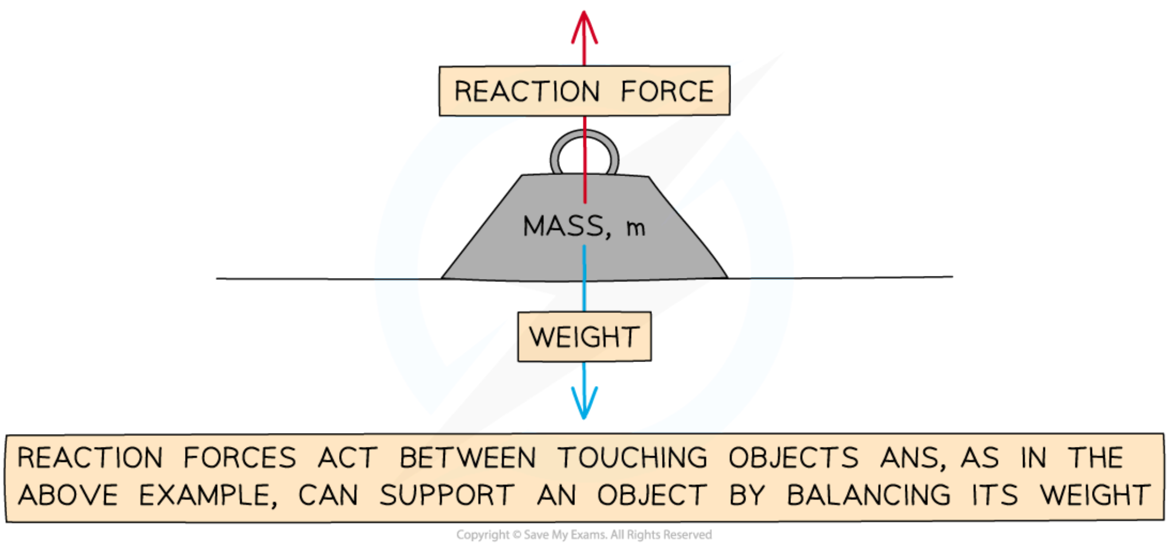
Contact Forces

- A contact force is defined as:

  A force which acts between objects that are physically touching

- Examples of contact forces include:
  - Friction
  - Air resistance
  - Tension
  - Reaction force / Normal force
- **Friction:**
  - Is a force that opposes motion
  - Occurs when objects rub against each
- **Air resistance:**
  - Is a type of friction
  - Occurs when an object moves through air
- **Tension:**
  - Is a force that pulls two objects connected by a length, such as a string or rope
  - Occurs when a force is applied to the length
- **Reaction force / Normal force:**
  - Is a force that pushes touching objects apart
  - Occurs when objects are supported by a surface





Examples of contact forces

Non-Contact Forces

- A non-contact force is defined as:

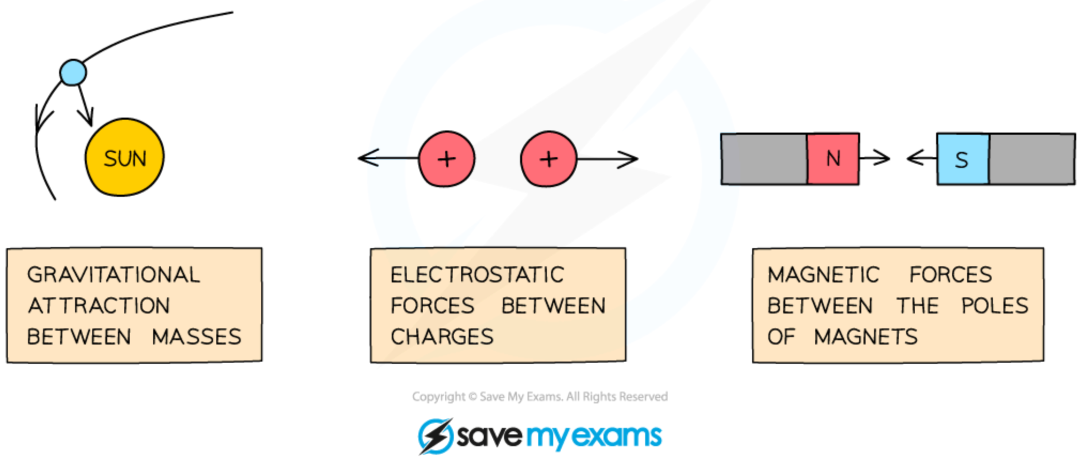
  A force which acts at a distance, without any contact between bodies, due to the action of a field

- Examples of non-contact forces include:
  - Gravitational force
  - Electrostatic force
  - Magnetic force
- **Gravitational attraction:**

Your notes

- The attractive force experienced by two objects with mass
- For example, the force between a planet and a comet

- **Electrostatic force:**
  - A force experienced by charged objects which can be attractive or repulsive
  - For example, the attraction between a proton and an electron
- **Magnetic force:**
  - A force experienced between magnetic poles that can be attractive or repulsive
  - For example, the attraction between the North and South poles of magnets



Examples of non-contact forces

Worked Example

Ben drags a sledge behind him as he climbs up a hill. Describe the contact and non-contact forces involved in this scenario.

Answer:

Step 1: Identify the contact forces

- Ben pulls on a rope attached to the sledge producing **tension** in the rope
- The ground supports Ben and the sledge with a **reaction** force
- There is **friction** between the sledge and the ground which opposes the motion

- There is also **friction** between Ben's shoes and the ground allowing Ben to climb the hill without slipping down
- A very small force due to **air resistance** slows Ben's motion up the hill

Step 2: Identify the non-contact forces

- The **gravitational attraction** between the Earth and Ben pulls Ben and the sledge downwards

Examiner Tips and Tricks

Getting the terminology correct in this topic is **key**! When talking about the force of gravity, make sure you refer to it as weight or gravitational attraction. Avoid calling it simply "gravity", as this term can mean several different things and will likely lose you a mark! Avoid using the terms wind resistance (there's no such thing) or air pressure (something entirely different) when you are talking about air resistance (or drag).

Your notes

Force as a Vector

Vector & Scalar Quantities

- All quantities can be one of two types:
  - A **scalar**
  - A **vector**

Scalars

- Scalars are quantities that have only a **magnitude**
  - For example, **mass** is a scalar quantity since it is a quantity that has no direction to it

Vectors

- Vectors have both a **magnitude** and a **direction**
- **Velocity** is a vector quantity since it is described with both a magnitude and a direction
  - When describing the velocity of a car it is necessary to mention both its speed and the direction in which it is travelling
  - For example, 60 km per hour in a Westerly direction
- **Distance** is a value describing only how long an object is or how far it is between two points - this means it is a **scalar** quantity
- **Displacement** on the other hand also describes the **direction** in which the distance is measured - this means it is a **vector** quantity
  - For example, 100 km in a Northern direction

Comparing Scalars & Vectors

- The table below lists some common examples of scalar and vector quantities:

Scalars & Vectors Table

Scalar	Vector
Distance	Displacement
Speed	Velocity
Mass	Weight
Energy	
Volume	
Density	
Temperature	
Power	
	Force
	Acceleration
	Momentum

Your notes

- Some vectors and scalars are similar to each other
  - For example, the scalar quantity **distance** corresponds to the vector quantity **displacement**
- Corresponding vectors and their scalar counterparts are aligned in the table where applicable

Examiner Tips and Tricks

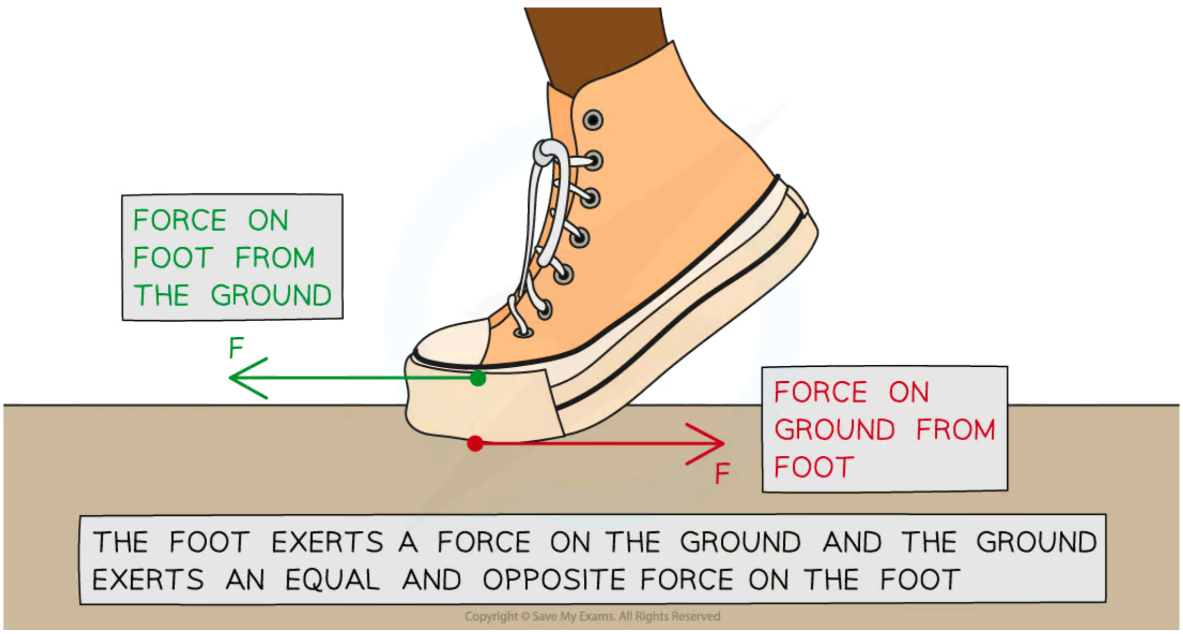
Do you have trouble figuring out if a quantity is a vector or a scalar? Just think – can this quantity have a minus sign? For example – can you have negative energy? No. Can you have negative displacement? Yes! Make sure you are comfortable with the differences between similar scalars and vectors, the most commonly confused pairings tend to be:

- Distance and displacement
- Speed and velocity
- Weight and mass

Force Pairs

Your notes

- When there is an interaction between **two objects**, the forces they exert **on each other** are equal in magnitude but opposite in direction
  - The **pair of forces** exerted by the interacting objects are known as **force pairs**
- Newton's third law explains the forces that enable someone to walk
  - The **foot** exerts a push force on the **ground**
  - The **ground** exerts a push force force on the **foot**
  - The forces are equal in magnitude and opposite in direction



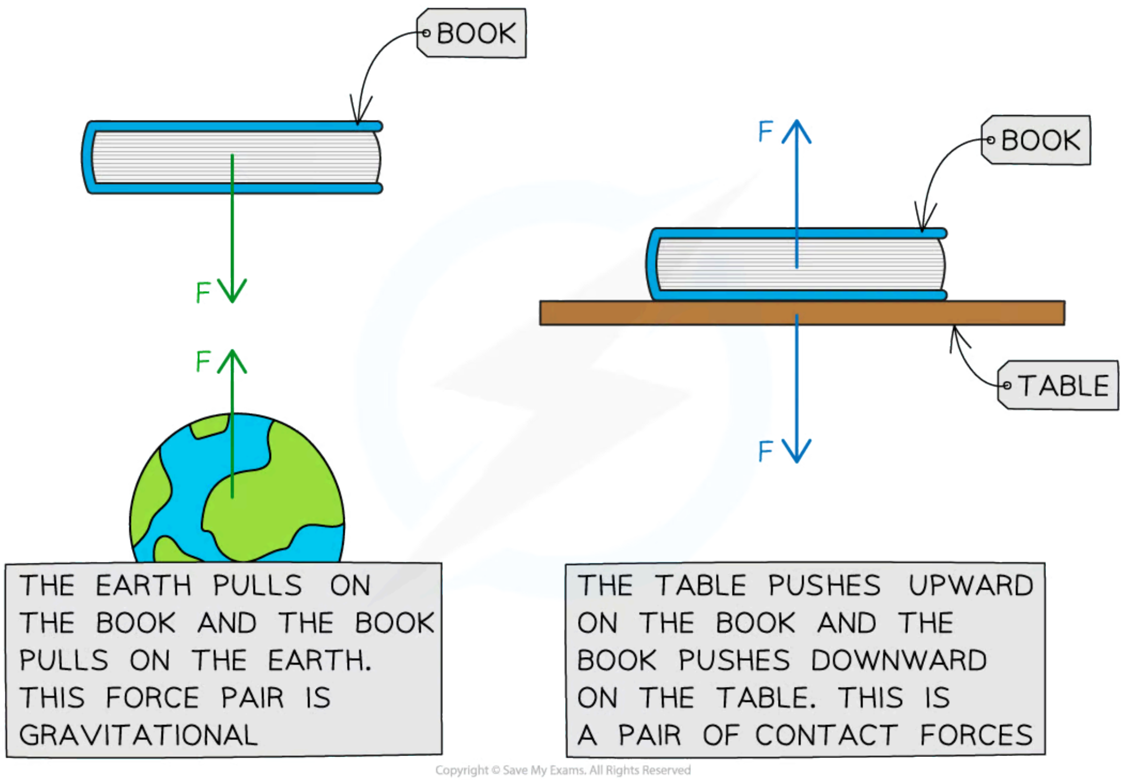
The force pairs are the foot and the ground: The foot pushes backwards on the ground, and the ground pushes the foot forwards

- Vector diagrams can be used to represent Newton's third law
- Use the following three rules to help you identify a third law pair:

1. The two forces in a third law pair act on **different objects**
2. The two forces in a third law pair always are equal in size but act in opposite directions

Your notes

3. The two forces are always the **same type**: weight, normal contact force, etc.



Scenario 1: The gravitational pull of the Earth acts on the book (weight) and the normal contact force of the table acts on the book. Scenario 2: The gravitational pull of the Earth acts on the book (weight) and the gravitational pull of the book acts on the Earth (weight)

- The diagram above shows:
  - The gravitational pull of the Earth on the book (weight) and the gravitational pull of the book on the Earth (weight)
    - Both forces are the same **type** (weight)
    - Both forces act on **different** objects (Earth on book, and book on Earth)
    - Both forces are **equal** and **opposite**
    - This is a **third law pair**
  - The gravitational pull of the Earth on the book (weight) and the push force of the table on the book (normal contact force)
    - These forces are not the same **type** (weight and normal contact force)

- Both forces act on the **same** object (the book)
- Both forces are **equal** and **opposite**
- This is not a third law pair, this is an example of **Newton's first law**; the forces are balanced so there is no resultant force acting on the book

Your notes

Your notes

Scale Drawings

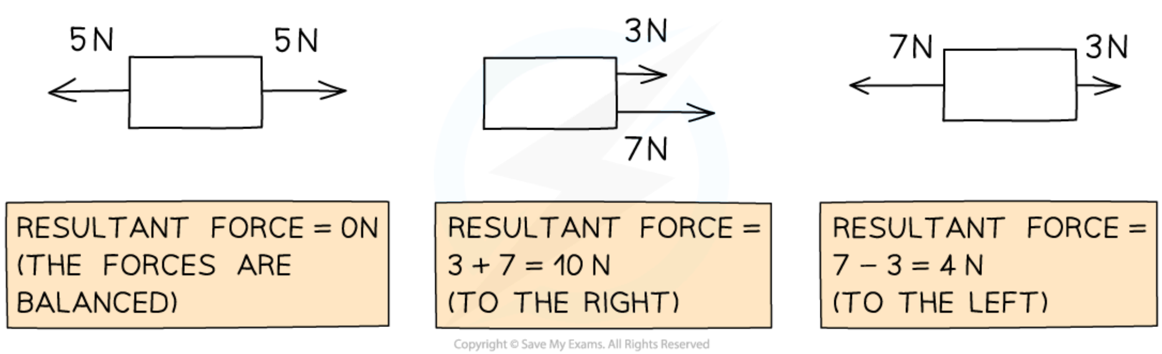
Using Scale Drawings

Higher Tier Only

- Resolving vectors into components allows for more **accurate** calculations of resultant forces
- By resolving all of the involved forces into their horizontal and vertical components and then adding or subtracting as required, a final resultant force vector can be **constructed** using a **scale diagram**
- Vector diagrams can also be used to illustrate net (or resultant) forces and equilibrium situations

Net Force

- Vector diagrams include arrows in a particular direction which represent the different forces on an object
- The size of the arrow corresponds to the size of the force
- Net, or resultant, forces can be calculated by adding or subtracting all of the forces acting on the object
  - Forces working in opposite directions are **subtracted** from each other
  - Forces working in the same direction are **added** together
- If the forces acting in opposite directions are equal in size, then there will be no resultant force – the forces are said to be **balanced**

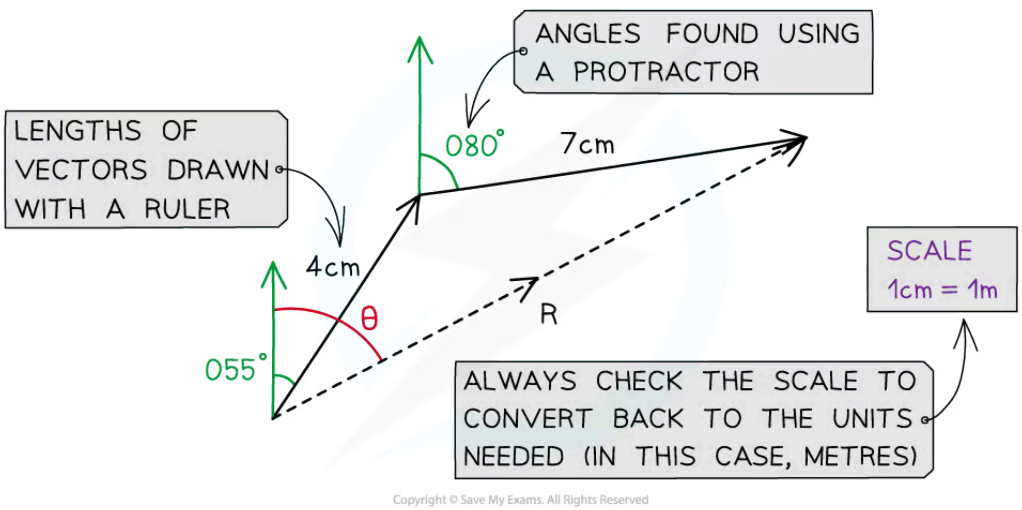


Resultant forces on an object

Resolution of Forces

Your notes

- Two forces can be added together to find the **resultant** force
- When two vectors are not at right angles, the resultant vector can be calculated using a scale drawing
  - **Step 1:** Link the vectors head-to-tail if they aren't already
  - **Step 2:** Draw the resultant vector using the triangle or parallelogram method
  - **Step 3:** Measure the length of the resultant vector using a ruler
  - **Step 4:** Measure the angle of the resultant vector (from North if it is a bearing) using a protractor

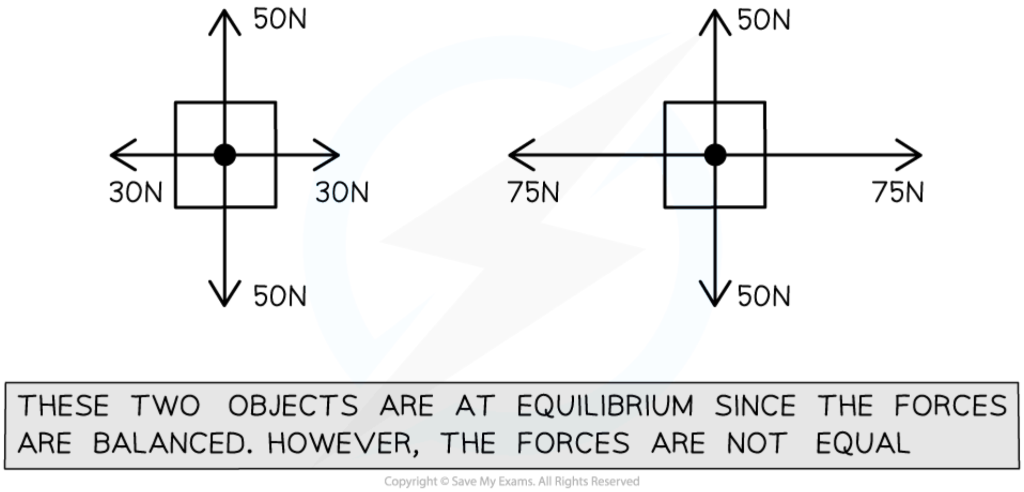


A scale drawing of two vector additions. The magnitude of resultant vector R is found using a rule and its direction is found using a protractor

- Note that with scale drawings, a scale may be given for the diagram such as 1 cm = 1 km since only limited lengths can be measured using a ruler
- The final answer is always converted back to the units needed in the diagram
  - Eg. For a scale of 1 cm = 2 km, a resultant vector with a length of 5 cm measured on your ruler is actually 10 km in the scenario

Equilibrium

- A system is in equilibrium when all the forces are balanced. This means:
  - There is **no** resultant force
- An object in equilibrium will therefore remain at rest, or at a constant velocity, and not rotate or move



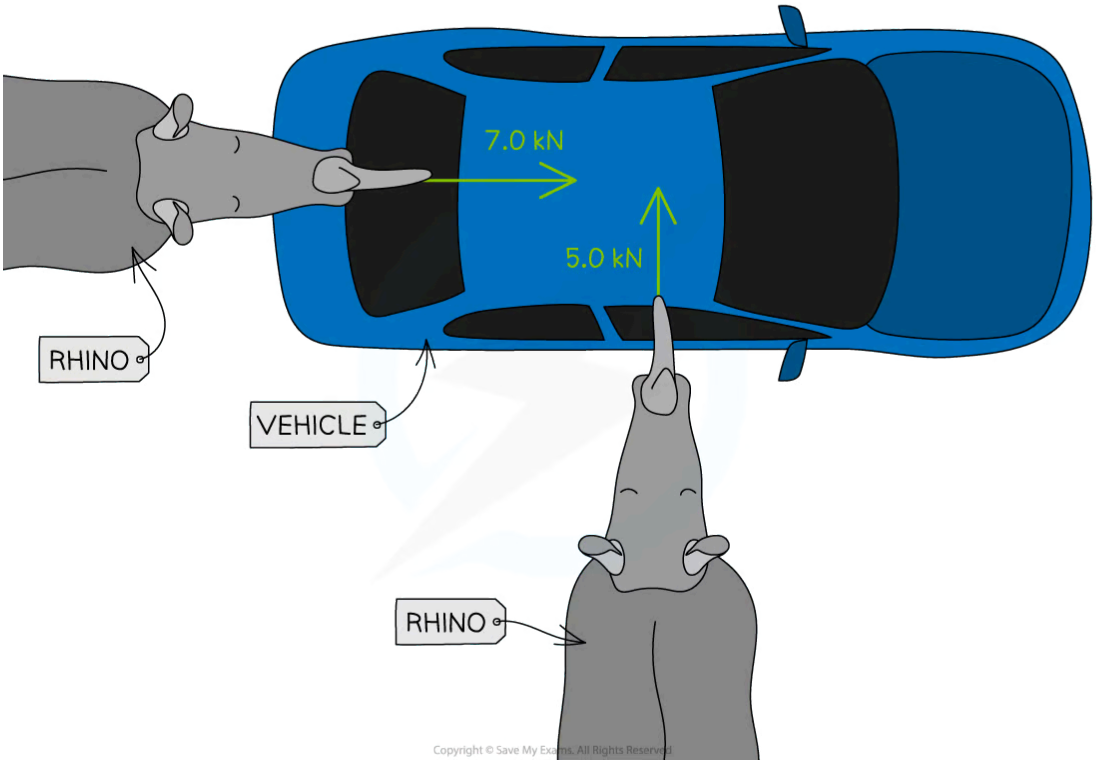
An object is in equilibrium if the horizontal forces on it are equal and vertical forces on it are also equal

Your notes

Worked Example

The diagram below shows two rhinos pushing against a vehicle. The two forces are at right angles to each other.

Your notes



Draw a scale vector diagram to determine the magnitude of the resultant force. Label the two forces applied and the resultant, and clearly state the scale used.

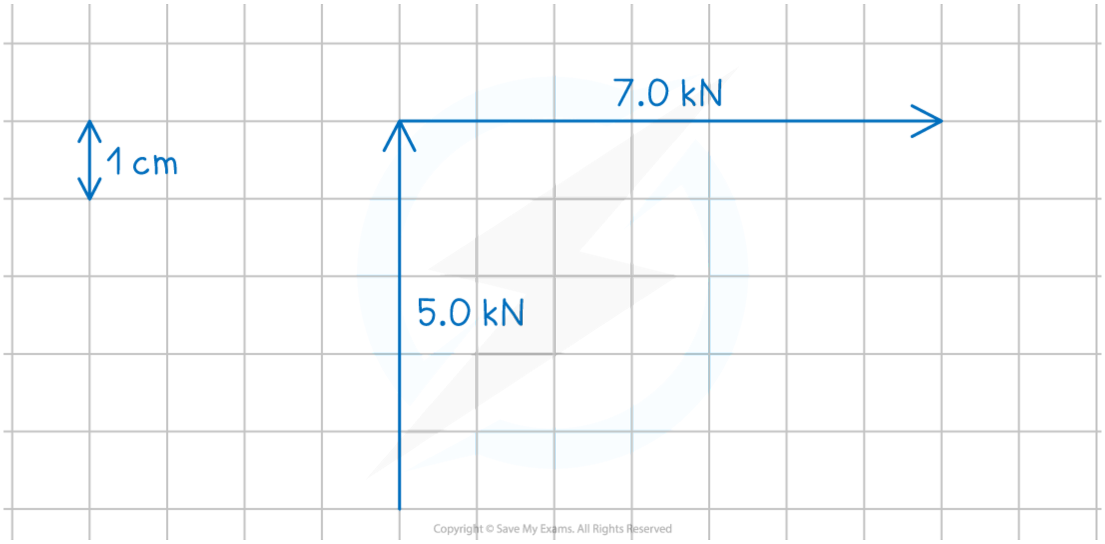
Answer:

Step 1: Decide on a suitable scale

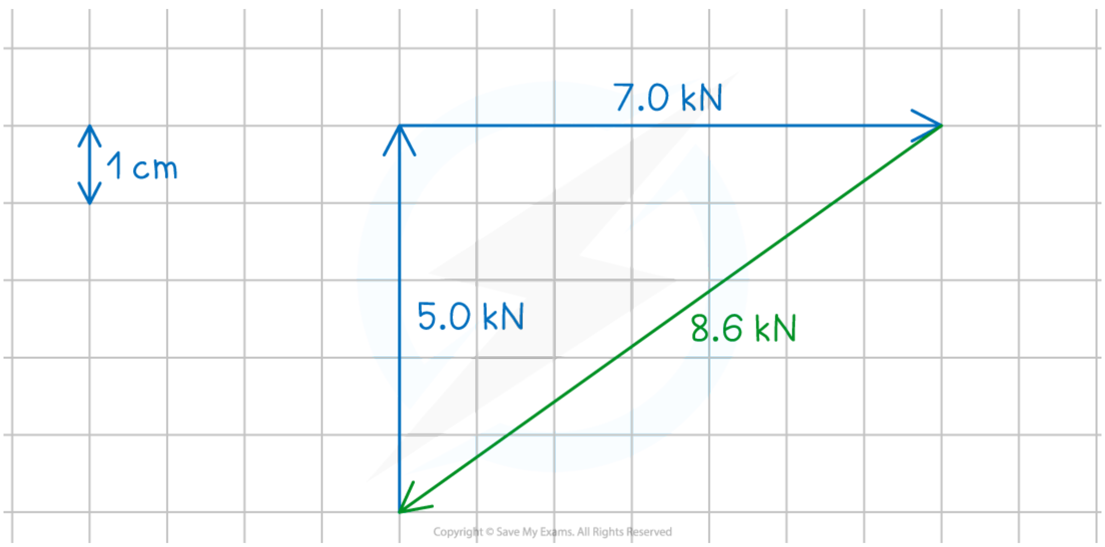
- A scale of 1 cm to 1.0 kN is the most suitable for this scenario

Step 2: Use grid paper to draw the vectors top to tail and to scale

Your notes



Step 3: Draw the resultant vector and measure its length



Step 4: Use the scale to convert the length to kN

- The resultant force is 8.6 cm, meaning the resultant force is equal to **8.6 kN**

Examiner Tips and Tricks

> When constructing scale drawings, always use a ruler and a sharp pencil and double check the **scale** (e.g. is 1 square = 1 cm)

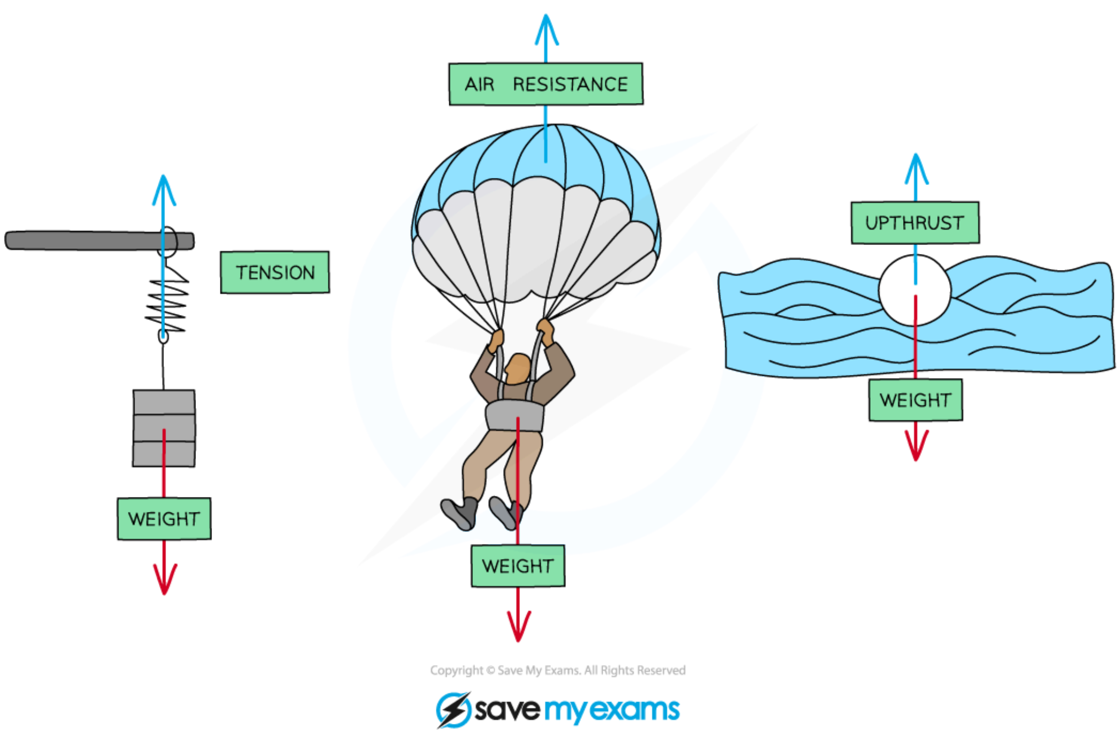
Your notes

Free Body Diagrams

Free Body Diagrams

Higher Tier Only

- Free body diagrams are useful for modelling the forces that are acting on an object
- Each force is represented as a **vector** arrow, where each arrow:
  - Is scaled to the **magnitude** of the force it represents
  - Points in the **direction** that the force acts
  - Is **labelled** with the name of the force it represents
- Free body diagrams can be used:
  - To identify which forces act in which plane
  - To resolve the net force in a particular direction



Your notes

Free body diagrams can be used to show the various forces acting on objects

Your notes

Worked Example

Draw free-body diagrams for the following scenarios:

a) A picture frame hanging from a nail

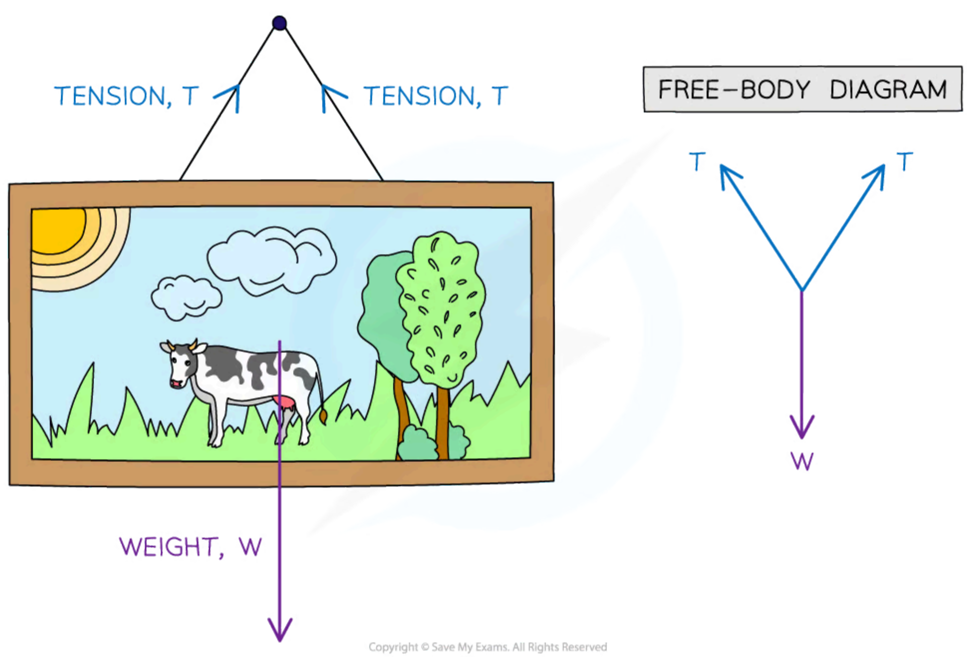
b) A box sliding down a slope

c) A man fishing in a stationary boat

d) A car accelerating along a road

Answer:

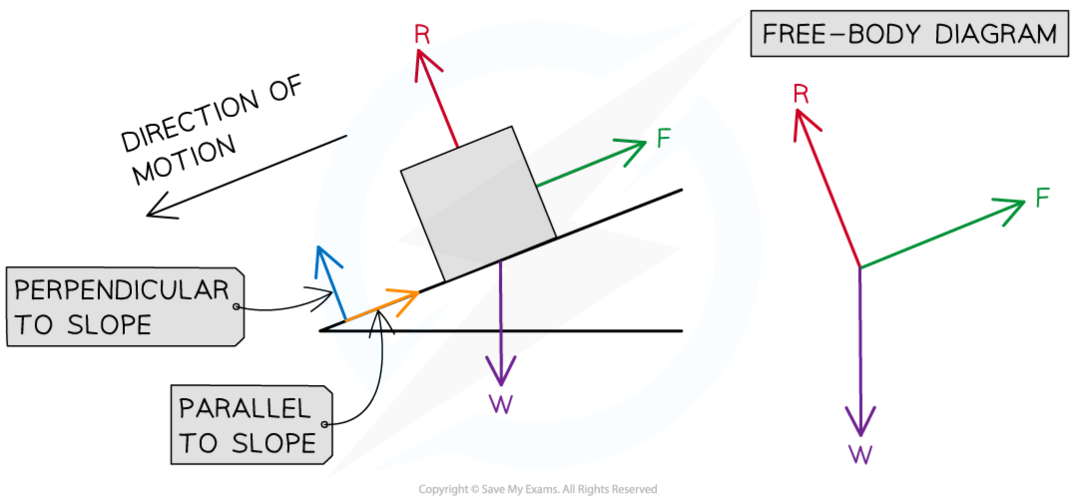
Part (a)



- The size of the arrows should be such that the 3 forces would make a closed triangle as they are **balanced**

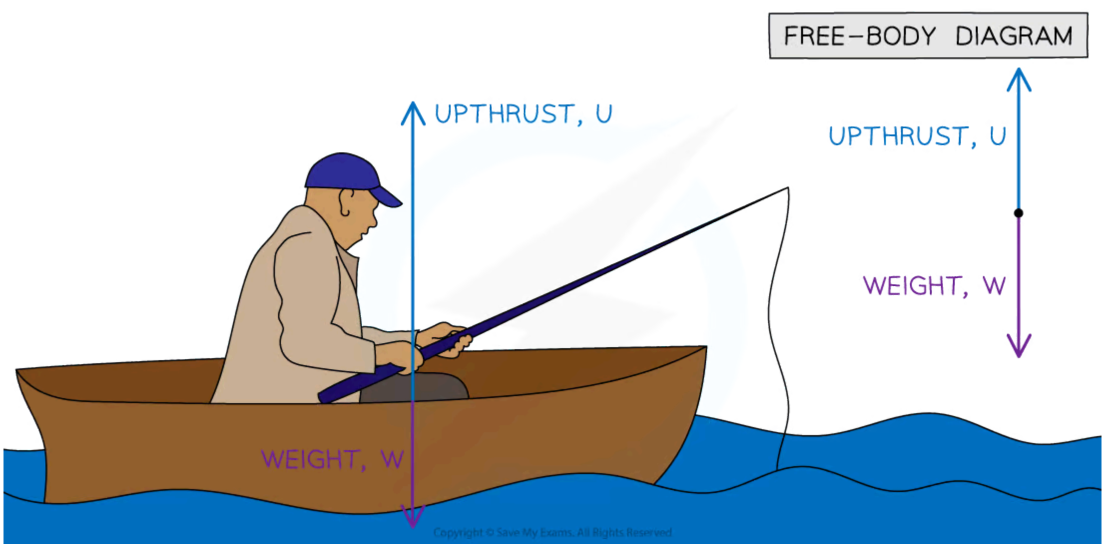
Part (b)

Your notes



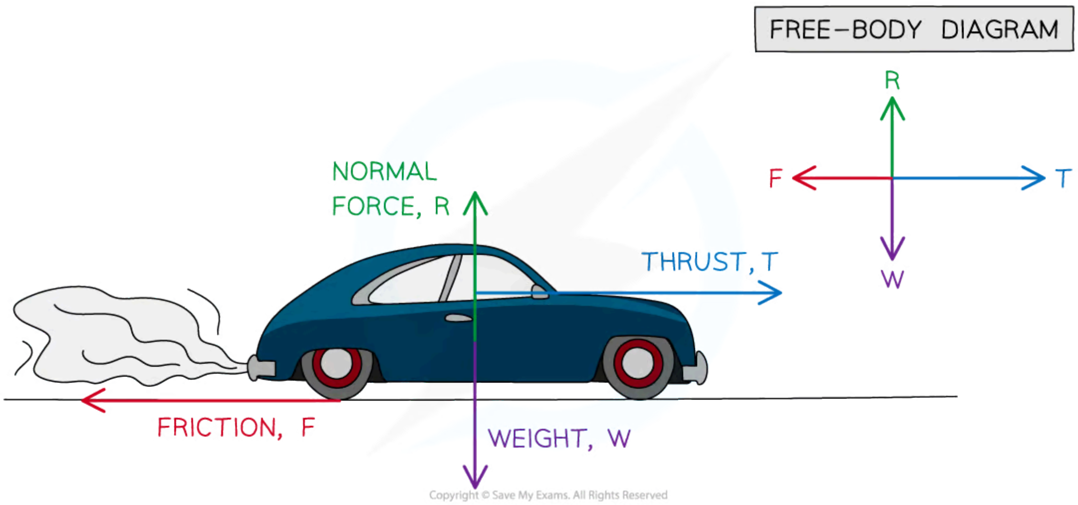
- There are three forces acting on the box
- The **normal contact force**, *R*, acts perpendicular to the slope
- **Friction**, *F*, acts parallel to the slope and in the opposite direction to the direction of motion
- **Weight**, *W*, acts down towards the Earth

Part (c)



- As the boat is not moving, the size of both arrows must be the **same**

Part (d)



- As the car is accelerating, the size of the thrust must be **larger** than the size of the friction force
- As in part (c), the upwards and downwards forces must be **equal**

Your notes

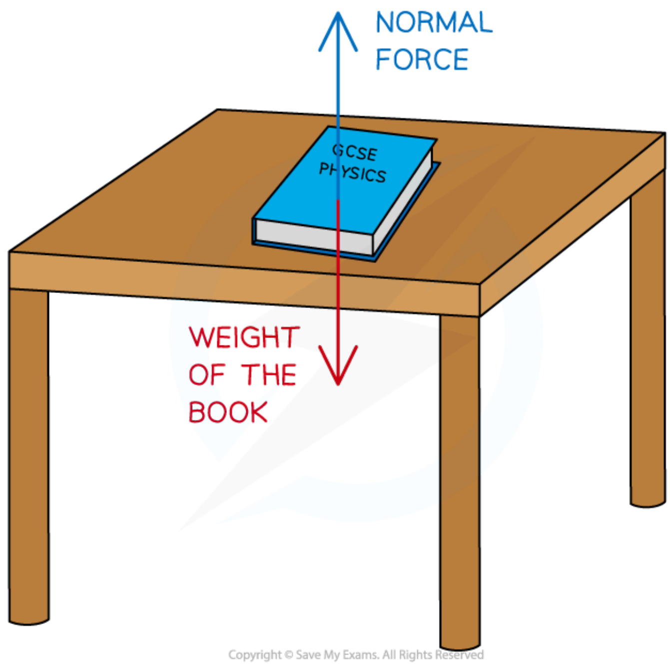
Your notes

Balanced Forces

Balanced Forces

Higher Tier Only

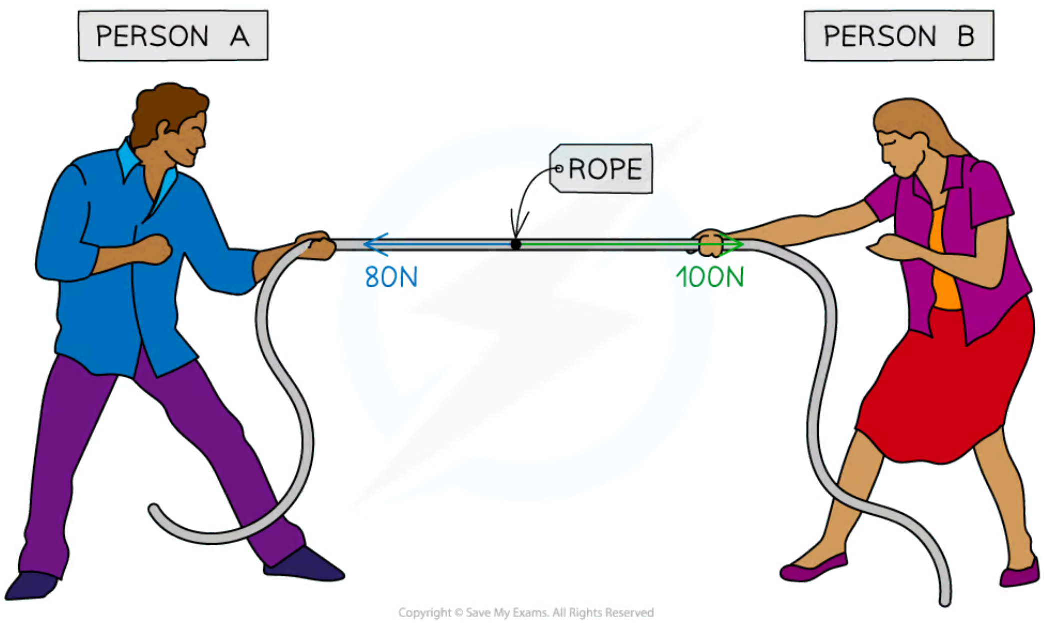
- A **resultant force** is a single force that describes all of the forces operating on a body
- When many forces are applied to an object they can be combined (added) to produce one final force which describes the **combined action** of all of the forces
- This single resultant force determines:
  - The **direction** in which the object will move as a result of all of the forces
  - The **magnitude** of the final force experienced by the object
- The resultant force is sometimes called the **net force**
- Forces can combine to produce
  - **Balanced** forces
  - **Unbalanced** forces
- **Balanced** forces mean that the forces have combined in such a way that they cancel each other out and no resultant force acts on the body
  - For example, the **weight** of a book on a desk is balanced by the **normal** force of the desk
  - As a result, **no resultant force** is experienced by the book, the book and the table are **equal** and **balanced**



A book resting on a table is an example of balanced forces

- **Unbalanced** forces mean that the forces have combined in such a way that they do not cancel out completely and there is a **resultant force** on the object
  - For example, imagine two people playing a game of tug-of-war, working against each other on opposite sides of the rope
  - If person **A** pulls with 80 N to the left and person **B** pulls with 100 N to the right, these forces do not cancel each other out completely
  - Since person **B** pulled with more force than person **A** the forces will be unbalanced and the rope will experience a resultant force of 20 N to the right

Your notes



A tug-of-war is an example of when forces can become unbalanced