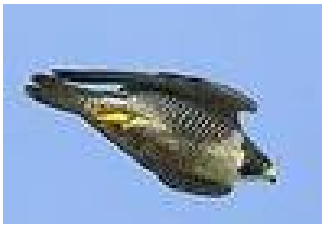
Usain Bolt—the fastest man

A jumbo jet cruises at 245 metres per second.



Peregrine falcons. The fastest animals in the world ?

Speed

The speed of any object is its distance travelled in a certain time. Think about a car travelling at 50 mph (miles per hour). This means the car may cover 50 miles in 1hour. A bus moving at 45 km/h (kilometres per hour) would travel 45 kilometres in 1 hour.

Speed can be calculated from :

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$v = \frac{d}{t}$$

In the class, speed is measured in metres per second (m/s or ms^{-1}). Since distance is measured in metres (m) and time is measured in seconds (s).

Average Speed

The **average speed** of a journey is the speed over the course of a journey.

Imagine your journey from home to school by car. You will not travel at the same speed for the duration of your journey. Your speed changes throughout the journey (at traffic lights, the approach to a roundabout, going over speed bumps etc.)

Average speed can be calculated from :

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{time for journey}}$$

Example

A girl cycles to a friend's house, which is 900m away, in a time of 3 minutes. Calculate her speed.

$$v = \frac{d}{t}$$

$$= \frac{900}{180}$$

$$= 5 \text{ m/s}$$

Measuring Average Speed

The measurement of average speed involves the measurement of
- the total **DISTANCE** travelled and
- the **TIME** taken to travel that distance

The total **DISTANCE** travelled is measured using a trundle wheel or measuring tape. The **TIME** taken to travel the distance is measured with a stopclock.

These measurements are then used in the formula to calculate the average speed

Average speed = total distance travelled / total time

A garden snail travels at an average speed of 0.03 mph.

Instantaneous Speed

The **instantaneous speed** is the speed you are travelling at a particular instant or moment of your journey.

Since the instantaneous speed is the speed at a moment, the time taken when calculating instantaneous speed is very small compared with the time for a whole journey. Hence devices have been developed to measure this small time interval (instantaneous speed) accurately, such as the RADAR gun, speed cameras or speedometers. In the class light gates are used to measure this small time interval required for instantaneous speed.

A RADAR gun used by the police to monitor speed.

Example

A laboratory trolley has a 5 cm mask attached to it. If the trolley runs down a slope and the mask on the trolley passes through a light gate at the bottom of a slope in 0.1 s, find the instantaneous speed of the trolley.

$$v = \frac{d}{t}$$

$$= \frac{0.05}{0.1}$$

$$= 0.5 \text{ m/s}$$

Speedometers help drivers to monitor their own speed.

A light gate attached to a TSA meter. Apparatus you should be familiar with.

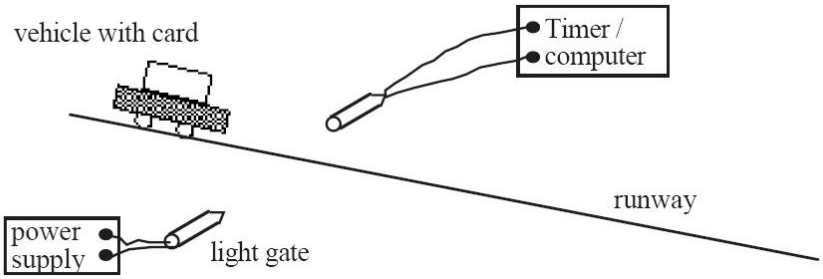
A bike speedometer which gives both average and instantaneous speed.

Thirty is ...

Measuring Instantaneous Speed

The measurement of instantaneous speed in the class requires the following apparatus

- a laboratory vehicle with mask (card)
- a runway
- a TSA meter or computer
- a light gate



Procedure for measuring instantaneous speed

- The **DISTANCE** which is the length of the mask (card) is measured with a ruler and entered into the TSA meter or the computer.
- The trolley is released from the top of the runway
- The trolley passes through the light gate at the bottom of the runway, the TSA meter will measure the **TIME** taken by the mask (card) to cut the light gate.
- The instantaneous speed is then calculated by the TSA meter or computer using the formula

Instantaneous speed = length of card / time taken to cut beam

Why Monitor Speed on the Roads

Speed is monitored by the law for a reason. The facts :

- Speed is one of the main factors in fatal road accidents.
- In 2009, 4,187 people were killed or seriously injured in crashes where speed was a factor.
- The risk of death is approximately four times higher when a pedestrian is hit at 40mph than at 30mph.

Acceleration

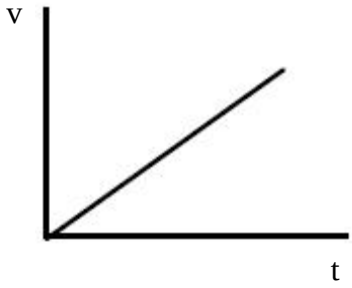
The speed of an object is how fast it is travelling and is the distance travelled in 1 second.

The acceleration of an object is the **increase** in speed in 1 second i.e. by how much the speed **increases** in 1 second

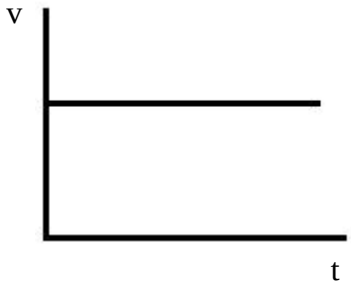
If an object is accelerating the value of its speed will be getting bigger after each second.

Speed-Time Graphs

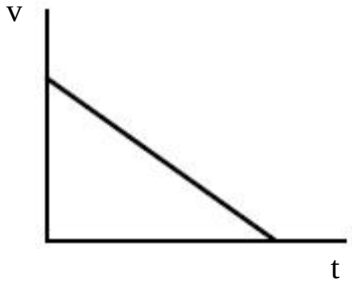
Graphs are a good way of displaying information as relevant information can be taken from them easily. Hence graphs are used in a number of subjects (or situations). Speed-time graphs are no different. The shape of a speed-time graph clearly displays the motion of an object and the instantaneous speed of an object may be read from the graph. The speed-time graphs below are used often.



This graph displays the speed increasing over time— **ACCELERATION**.

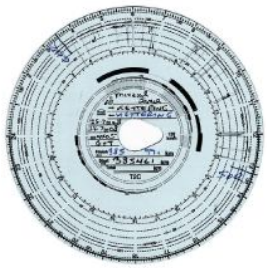


This graph displays the speed Remaining constant over time— **STEADY SPEED**.



This graph displays the speed decreasing over time— **DECELERATION**.

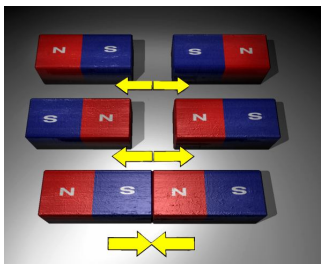
Cheetahs can accelerate from 0 to 60 mph in 3 seconds.



Tacographs are used to monitor long distance drivers.

How do dragsters decelerate quickly ?

A skydiver being pulled towards the ground by the force of gravity.



Magnetic forces at work.

Sir Isaac Newton, the greatest scientist of his era.

Forces

Forces are normally considered to be a **push** or a **pull** from one object to another.
For example,

- You can use a **pushing** force to move a shopping trolley.
- In a tug of war both teams use a **pulling** force.
- You use a **push** and a **pull** when you turn the handlebars of a bike.

You cannot see a force but the effects of a force are clearly seen. They will cause a change in the

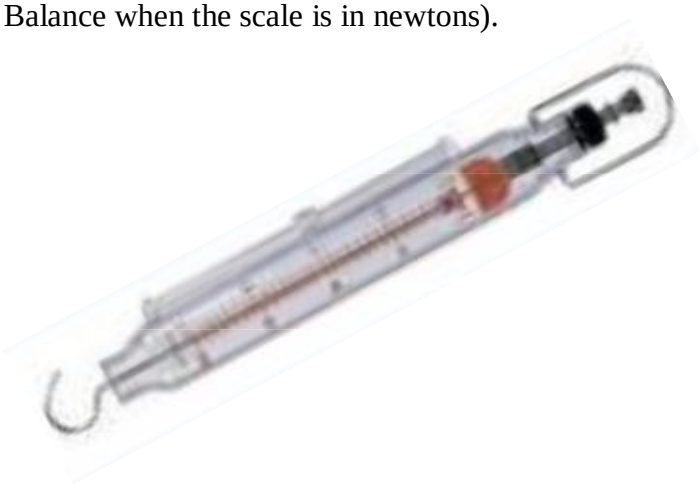
- Shape of an object
- Speed of an object
- Direction of movement of an object

Sometimes objects experience a force without contact from another object. These are known as **NON CONTACT** forces. The following are examples of this :-

- Magnetic forces
- The force of gravity

Measuring Forces

Forces can be measured using an instrument called a spring balance (a Newton Balance when the scale is in newtons).



When a pulling force is applied to the Newton Balance the spring stretches (changes shape). The pointer on the spring moves over the scale as the spring stretches. When the pointer stops moving the size of the force can be read from the scale.

All forces are measured in Newtons (N).

Weight and Mass

What is the difference ? Well…

Mass is the amount of matter an object has and is measured in **kilograms** (**kg**). **Mass does not change it remains the same**.

Weight is the force of gravity working upon an object and is the Earths pull on the mass. Since weight is a force it is measured in **Newtons** (**N**).

e.g. sitting on couch - the couch will experience a force (<u>your weight</u>) resulting in a change of shape.

e.g. throwing a ball up - the <u>weight of the ball</u> will cause the ball to change speed & direction and fall towards the Earth.

Weight can be calculated using the formula

Weight = mass x gravitational field strength

W = m x g

Gravitational field strength (**g**) is measured in N/kg.
On Earth a mass of one kilogram has a weight of ten Newtons.
This means the gravitational field strength on Earth is 10 N/kg.

Example

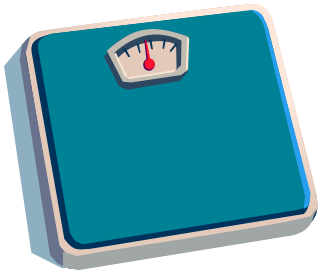
A man has a mass of 80kg. Calculate his weight on Earth.

W = m x g
= 80 x 10
= <u>800N</u>

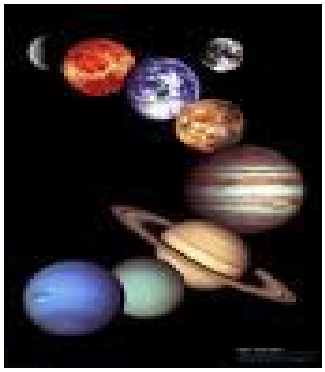
If the man visited other planets in the Solar System his weight would change as a result of their different gravitational field strengths.

His mass, however, would stay the same.

The weight of the car is changing the shape of the tyre.



Bathroom scales measure mass in kilograms - not weight.



The Solar System

Striking a match relies upon friction.

Hydrofoils on a boat reduce contact (friction) between the hull and the water.

Parachutists use their chute to increase air resistance.

Friction

No surface when examined with a powerful microscope will ever appear perfectly smooth. So when two surfaces rub against one another some very tiny high points on both surfaces catch onto each other – this causes **friction**.

Friction is a resistive force which opposes the motion of an object. It is a force which always acts in the opposite direction to the movement of an object. Friction, also, causes **kinetic energy** to change to **heat energy**.

Reducing Friction

Friction is greater when there is a good contact between two surfaces. Thus, to reduce friction we must reduce the contact between the surfaces. In the table below the ways of reducing contact, and examples, are given.

Separate the surfaces (with an air cushion)	**Air Hockey** air between puck & table **Hovercraft** air between hovercraft & sea
Lubricate the surfaces (with oil, water, grease)	**Door Hinge** oil the hinge **Water Park** water on the slides
Reduce the area of contact (making the surfaces rubbing together smaller)	**Wheel Axle** ball bearings around the axle **Ice Skating** the blades of ice skates
Streamline to reduce air resistance (air friction)	**Shape of a Car** aerodynamic shape **Cycling** change your **body shape** to go faster (head down)

To increase friction you must improve contact between the surfaces. Doing the opposite of what is in the table above would help you do that.

Friction is Useful

Any movement that relies on one surface pushing against another would be impossible without FRICTION.

We need friction – we need **very good contact** between 2 surfaces when

Walking or running	Soles of shoes & ground
Braking	Brake pads & wheel
Driving (steering, accelerating)	Tyres & road
Using ladders	Base of ladders & ground

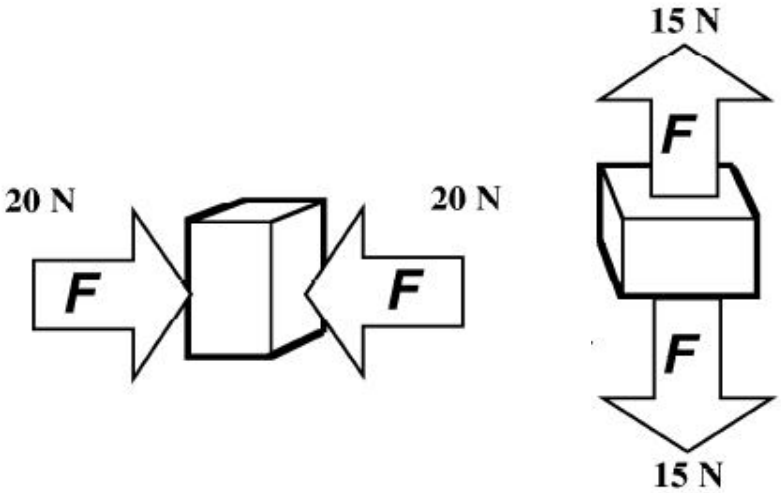
Friction is a Nuisance

We do not want friction - we want **poor contact** between surfaces when

Skiing	Ski & snow
Skating	Blade & ice
Cycling	Chain & cog
Surfing	Surf board & sea water

Balanced Forces

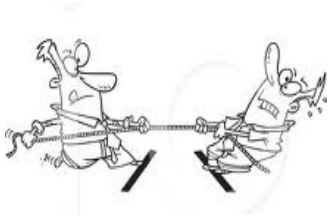
When two forces are the same size as each other and act on the same object but in opposite directions, they balance each other. The forces are called **balanced forces**.



The forces that are acting on the objects above are balanced forces. In each case the overall force is 0N. This means the object will **remain stationary** or will travel at a **constant speed**.
This is Newton's first law of motion.

Do you find your bicycle brakes useful ?

Why is friction a nuisance in car engines ?



In a tug of war when neither team moves, the forces are balanced.

A helicopter hovering.

The distance a golf ball travels depends on the speed of the club and loft (angle) of the club.

Examples of Balanced Forces

- A car travelling at its maximum speed. The engine force is equal and opposite to the forces of friction acting upon the car.
- A skydiver falling through the air at a constant speed. This is because their weight is balanced by the air resistance acting on their body.
- A helicopter hovering. The weight of the helicopter is balanced by the lift provided by the blades.

Unbalanced Forces

When unbalanced forces act upon an object, the object will **accelerate** (or **decelerate**).

Seat Belts

A **seat belt**, sometimes called a **safety belt**, is a safety harness which is designed to secure the occupant of a vehicle against harmful movement that may result from a collision or a sudden stop. The seat belt restrains the driver (or passenger) and provides an unbalanced force which decelerates the driver at the same rate as the car. This reduces the likelihood and severity of injury in a traffic collision.

Without a seat belt the occupant of the car would continue to travel at the speed of the car, before the collision, until they strike the windscreen or dashboard.

Seat belts are used in cars to provide a **backwards force** to prevent the passenger continuing to move forward if the car stops suddenly.

The Range of a Ball

When an object is thrown or fired (it is called a **projectile**), it travels a distance horizontally before hitting the ground. Eventually even the fastest thrown or fired object hits the ground due to the force of gravity pulling it down. This horizontal distance travelled is called the **range**. The range of a ball thrown or hit is changed by :

- the speed the ball is launched at
- the angle of the ball as the launch