S2 FORCES & MOTION
Speed & Acceleration

At the end of the section I can :

- ❑ 1 State that speed is the distance per unit time.
- ❑ 2 Describe how to measure average speed.
- ❑ 3 Carry out calculations involving the relationship between distance, time and average speed.
- ❑ 4 Describe how to measure instantaneous speed.
- ❑ 5 Carry out calculations involving the relationship between distance, time and instantaneous speed.
- ❑ 6 Identify situations when average and instantaneous speeds are different.
- ❑ 7 State that acceleration is the change in speed per unit time.
- ❑ 8 Describe the motions represented by a speed – time graph.

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 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

Average speed 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 throughout the journey. Your speed changes (at traffic lights, the approach to a roundabout, going over speed bumps etc.).

Average speed can be calculated from :

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

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

$$\textbf{average speed} = \frac{\textbf{total distance travelled}}{\textbf{total time}}$$

Instantaneous Speed

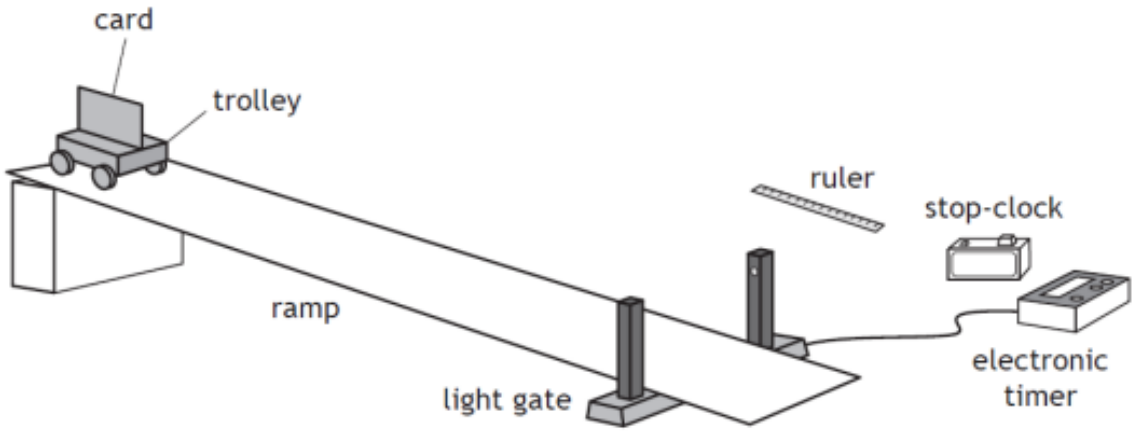
The instantaneous speed is the speed you are travelling at a particular instant or moment of your journey.

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. Devices have been developed to measure this small time interval (instantaneous speed) accurately, such as the RADAR gun, speed cameras or speedometers.

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 using the formula

$$\textbf{instantaneous speed} = \frac{\textbf{length of card}}{\textbf{time taken to cut beam}}$$

Instantaneous 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.

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

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

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

Acceleration

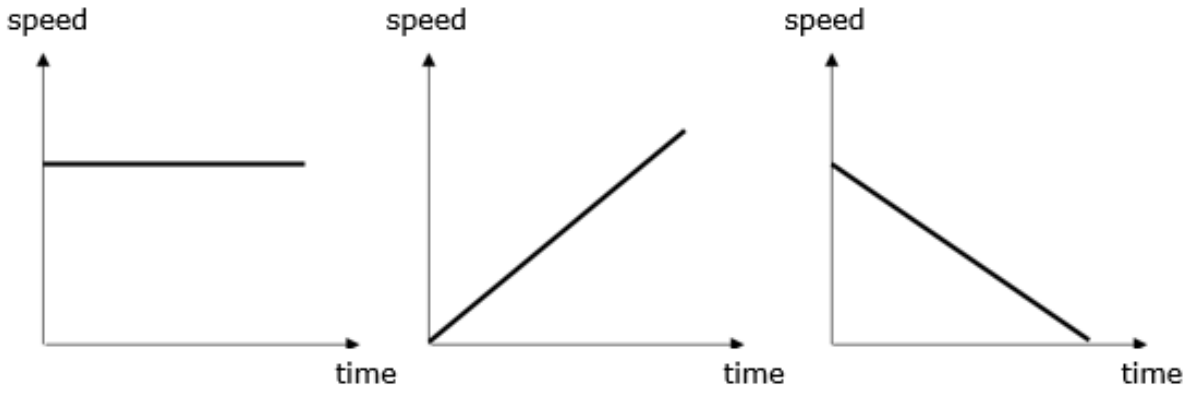
The speed of an object is how fast it is travelling and is the distance travelled in a second.

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.

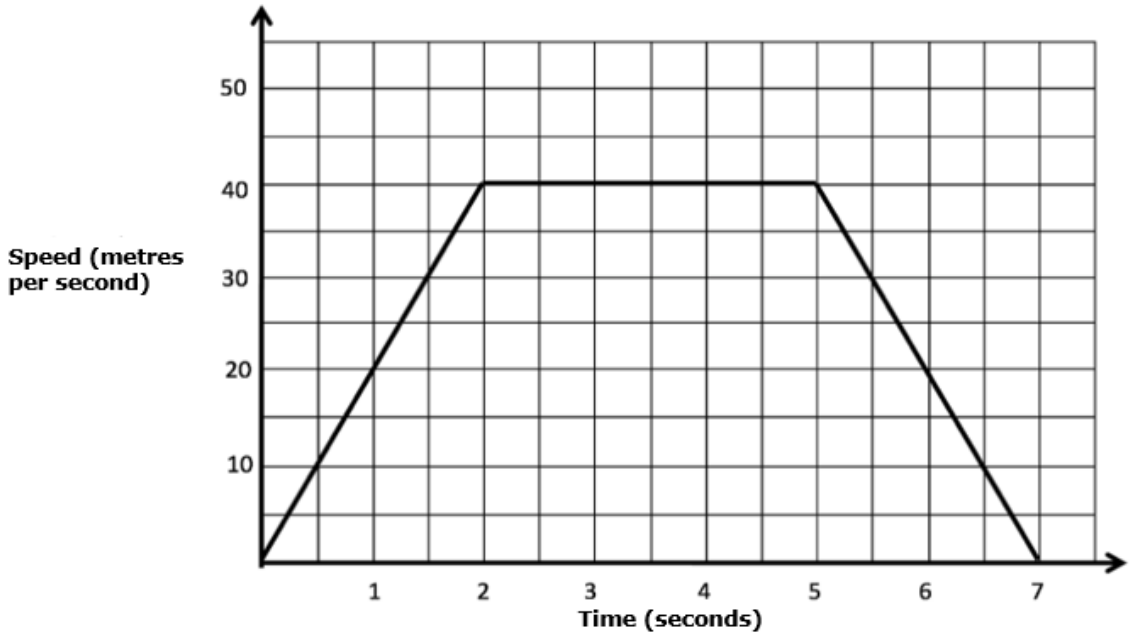
Speed-Time Graphs

Speed-time graphs are a good way of displaying information. The shape of a speed-time graph clearly displays the motion of an object. The speed-time graphs below are used often.



CONSTANT SPEED **ACCELERATION** **DECELERATION**

The instantaneous speed of an object can be read from a speed-time graph.



In the graph above, the object **accelerates** from 0 m/s to 40 m/s in 2 seconds, maintains a **constant speed** of 40 m/s from 2 to 5 seconds and **decelerates** from 40 m/s to 0 m/s between 5 and 7 seconds.

S2 FORCES & MOTION

Forces

At the end of the section I can :

- ❑ 1 State that objects can experience a force without contact from other objects.
- ❑ 2 Describe the effects of forces in terms of their ability to change the shape, speed and direction of travel of an object.
- ❑ 3 Describe how to the use a newton balance to measure force.
- ❑ 4 State that weight is a force and is the Earth's pull on an object.
- ❑ 5 Distinguish between mass and weight.
- ❑ 6 State that the force of friction can oppose the motion of an object.
- ❑ 7 Describe the methods used to decrease or increase friction.
- ❑ 8 Identify situations where friction is useful and where it is a nuisance.
- ❑ 9 State that equal forces acting in opposite directions are called balanced forces.
- ❑ 10 State that balanced forces are equivalent to no force at all.
- ❑ 11 State that when balanced forces or no forces act on an object it remains stationary or its speed remains constant.
- ❑ 12 State that when the forces acting upon an object are unbalanced the object accelerates.
- ❑ 13 Explain, in terms of forces, why seatbelts are used in cars.

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.

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**

The Effects of a Force

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**

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.

Weight and Mass

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 acting upon an object and is the Earths pull on an object. 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 and direction and fall towards the Earth.

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 two 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

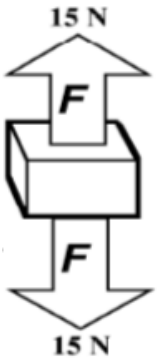
Friction is a Nuisance

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

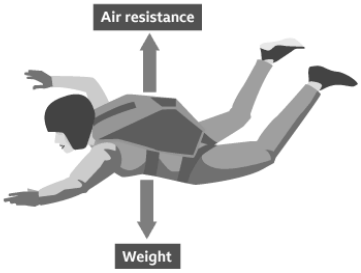
Two forces of the same size pulling in the opposite direction acting upon an object, balance each other. The forces are called **balanced forces**.



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.

Examples of Balanced Forces

· 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 car travelling at its maximum speed. The engine force is equal and opposite to the forces of friction acting upon the car.

· 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**).
This is Newton's second law of motion.

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.

S2 FORCES & MOTION
Projectiles

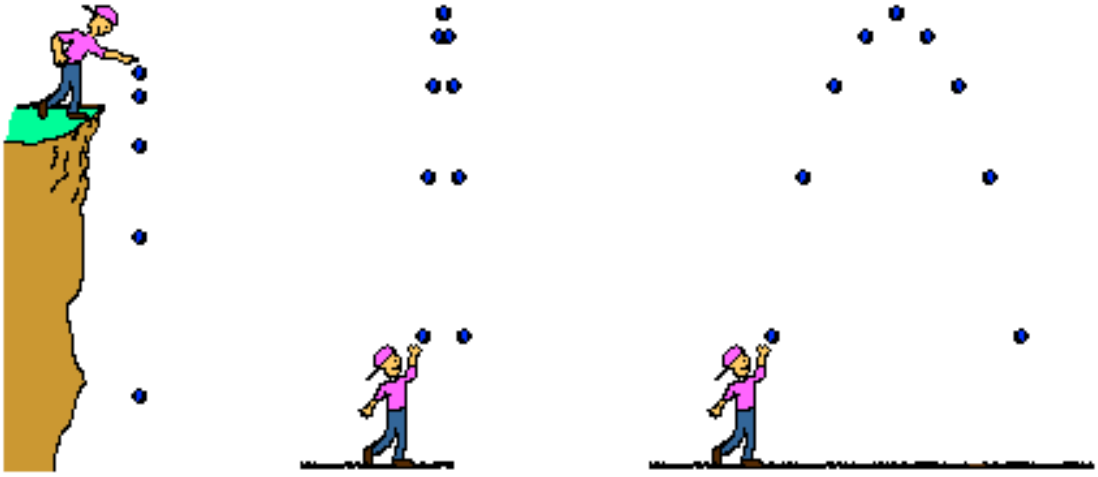
At the end of the section I can :

- ❑ 1 State that a projectile is an object which moves under the influence of gravity.
- ❑ 2 Describe the horizontal distance a projectile travels as the range.
- ❑ 3 Describe how the angle of launch and the speed at launch effects the range of a projectile.

Projectiles

When an object is thrown or fired, it travels a distance horizontally through the air before hitting the ground. Eventually even the fastest thrown or fired object hits the ground due to the effects of the force of gravity. Any object moving in this way is called a projectile.

A projectile is an object moving under the influence of gravity.



The horizontal distance travelled by a projectile 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

Earth wire