Motion, Motions & Forces and Conservation of Energy

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Unit 1 : Motion

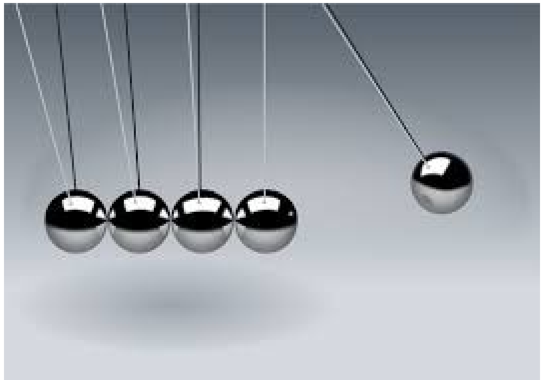
What is motion?

The dictionary definition is :

“The action or process of moving or being moved.”

But then you may ask, **“What is an action or process?”**

“An action or process is a thing that is done”



Vectors VS Scalars - Part 1

Velocity is speed in a particular direction.

Momentum is a combination of mass and velocity.

Vectors VS Scalars - Part 2

VECTORS

- Vectors have both **magnitude*** and direction.
- Forces are vectors, which is why they are shown on diagrams with arrows.
- **Displacement** is the distance covered in a straight line, and it has a direction.

  E.g. take a bathtub full of water, add more objects, the displacement increases north. If you reduce the objects, the displacement is higher south

SCALARS

- Scalars only have magnitude.
- Examples of scalars are : distance, speed, energy and time.
- **Distance** is the length of the space between two points.

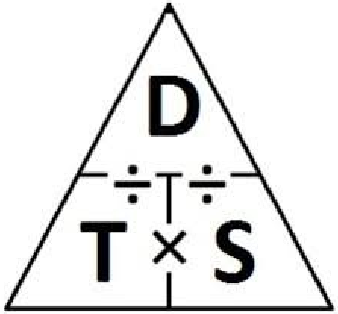
  For example, if Bob cycles from point A to point B, the space between A and B is the distance.

Distance/Time Graphs - Part 1

Speed can change during a journey, so the average speed is worked out.

Average speed is used to find the speed over the whole journey, but you can find the different speeds at different times of the journey in the graphs.

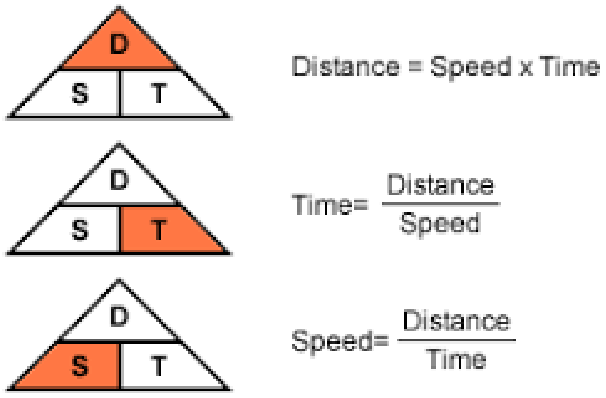
This equation is used to work out average speed :



$$\underline{\text{average speed}}\ (\text{m/s}) = \frac{\text{distance (m)}}{\text{time taken (s)}}$$

This equation can also be rearranged to find the distance :

distance travelled (m) = average speed (m/s) x time (s)

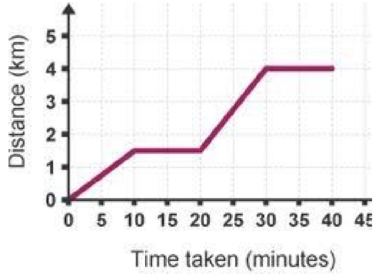


Distance/Time Graphs – Part 2

A journey can be shown on a distance/time graph. Since you use distance and time to work out speed, the graph gives infromation about the speed as well.

Facts about distance/time graphs:

- **If the line is horizontal, it means the object is stationary (not moving)**
- **Straight, sloping lines means the object is travelling at a constant speed**
- **The steeper the line, the faster the object is travelling**
- **Speed is calculated from the gradient of the line.**



Acceleration – Part 1

A change in velocity is called acceleration. Acceleration is a vector quantity, meaning it has both size and direction.

Acceleration tell you the change in velocity each second.

The following equation is used to calculate acceleration:

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

It can also be written as :

$$a = \frac{v - u}{t}$$

a = acceleration
v = final velocity
u = initial velocity
t = time taken for change in velocity

Acceleration – Part 2

If an object is slowing down, the **acceleration will have a negative value.**

Acceleration can also be related to initial velocity.

(final velocity)^2 - (initial velocity) = 2 x acceleration x distance

(m/s)^2 (m/s)^2 (m/s^2) (m)

- This can also be written as :

$v^2 - u^2 = 2 \times a \times d$

Deceleration occurs when $v < u$ according to the previous equation

An object in free fall is moving downwards because of gravity. If there are no other forces acting upon it (air resistance), the acceleration due to gravity is 9.8 m/s2.

Velocity/Time Graphs – Part 1

The changing velocity of a dragster can be shown in a **velocity/ time graph·**

Facts about a velocity/time graph :

- **A horizontal line means the object is moving at a constant speed.**
- **A sloping line upwards means that an object is accelerating. The higher the gradient*, the higher the acceleration. If the line slopes down to the right, the object is decelerating.**
- **You can find the acceleration of an object from the gradient of the line in a velocity/time graph.**

Key Concepts of Topic 1

- Vectors have magnitude and direction, scalars only have magnitude.
- Speed = distance x time
- In a distance/time graph, the speed is the gradient of the line.
- Acceleration is a change in velocity a specific time.

  $$\textbf{Acceleration} = \frac{\textbf{change in velocity}}{\textbf{time taken}}$$

- Acceleration is the gradient of the line on a velocity/time graph.

UNIT 2 STARTS HERE:

MOTION

&

FORCES

Resultant Forces - Part 1

- **What is the resultant force?**

  A resultant force is a force equal to the sum of all forces acting on an object.

  If 10N and another 10N are applied to the right, the resultant force is 20N. But if 40N is applied to the left, and 30N applied to the right, the resultant force is 10N left.

  Why do this?

  The rules of resultant forces are simple:

- **If the forces are acting in the same direction, add them**
- **If they are acting in opposite direction, subtract the smaller force from the larger force.**

Resultant Forces - Part 2

- If the resultant of all forces are 0, the forces are called **balanced.** If there in a non-0 resultant force on the object, the object is now called **non-balanced.**

Newton's First Law - Part 1

- Newton's first law is :
- **A moving object will continue to move at the same speed and direction unless an external force acts on it.**
- **A stationary object will also remain stationary unless an external force acts upon it.**

E.g. if you kick a ball, it will keep flying until another force acts upon it. This may sound weird, but there are other forces acting upon it the second you kick it.

Newton's First Law - Part 2

What is circular motion?

An object that moves around in has a changing velocity, but the speed stays the same.

The resultant force that causes the change in direction is called the **centripetal force,** and that acts towards the centre of the circle.

Mass & Weight

- A lot of people get the definitions of **mass** and **weight** confused.
- **Mass** **=** the quantity of matter there is in an object.
- **Weight** **=** a measure of the pull of gravity on an object.

The unit for mass is **Kg (kilograms)**, and because weight is a force, it can be measured in **N (newtons)**.

On Earth, the **gravitational field strength,** is 9.8 newtons per kilogram (N/kg), but most scientists round it up to 10 N.

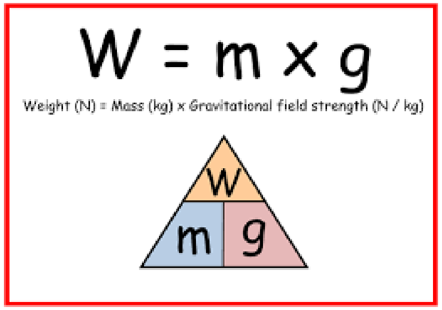
The **weight** of an object can be found using this equation:

weight = mass x gravitational field strength

(N) (Kg) (N/Kg)

- This can also be written as :

W = m x g



Mass & Weight - Part 2

Forces on falling bodies:

On Earth, a falling object has air resistance acting upon it too.

0.5 seconds after jumping.
speed = 5 m/s

Air resistance increases with speed, so the air resistance is smaller than her weight. The larger resultant force makes her accelerate downwards.

3 seconds after jumping.
speed = 25 m/s

Her air resistance is larger, but her weight starys the same. The resultant force is still smaller, so she is still accelerating, but not as fast.

12 seconds after jumping.
speed = 55 m/s

She is moving so fast that the air resistance balances her weight. She continues to fall at same speed.

Newton’s Second Law - Part 1

What is Newton’s second law?

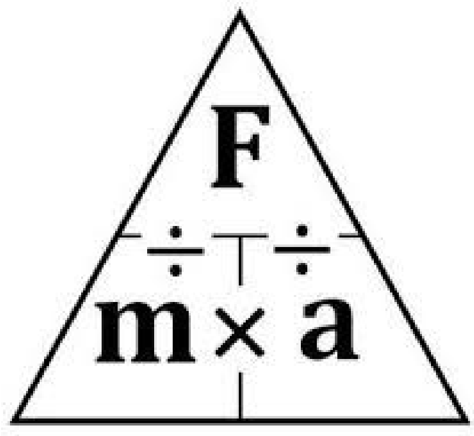
- **Newton's second law states that when you push an object with more force it will move faster and farther away.**

E.g. hit a cricket ball lightly and it can travel 5m at 2 m/ph, but his it harder and it can travel 20m at 10 m/ph.

Newton's Second Law - Part 2

The force needed to accelerate a particular object can be calculated with this equation:

force = mass x acceleration
(N) (Kg) (m/s$_2$)



This can also be written as :

F = m x a

Inertial Mass:

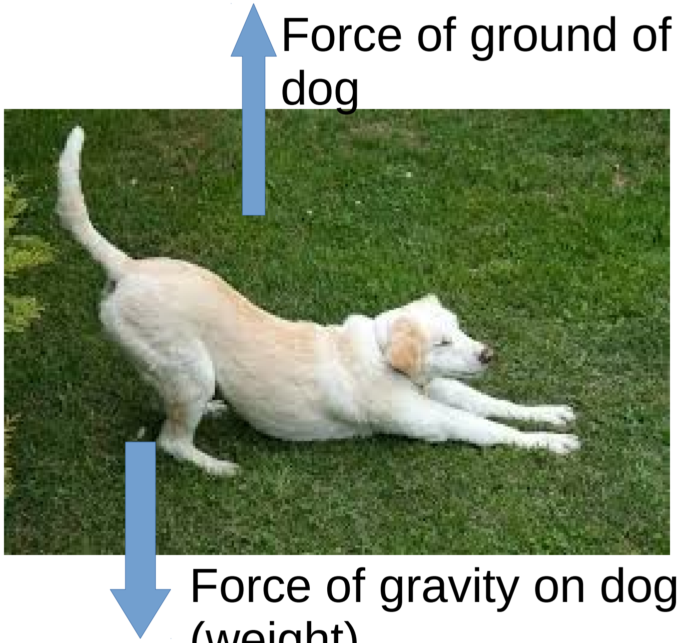
The inertial mass of an object is the force on it divided by the by the acceleration the force produces.

Newton's Third Law - Part 1

What is Newton's third law?

The forces on 2 different objects when they interact with eacth other.

There is a pair of forces acting on the two interactive objects, often called **action-reaction forces.**



Newton's Third Law - Part 2

Collision!

You can apply the idea of action-reaction to what happens when things collide.

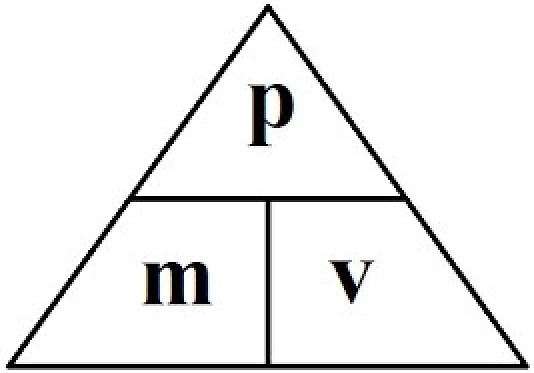
Momentum - Part 1

Momentum is a measure of an object to keep moving or how hard it is to stop it moving.

Momentum can be using this equation :

momentum = mass x velocity   **or**   **p = m x v**

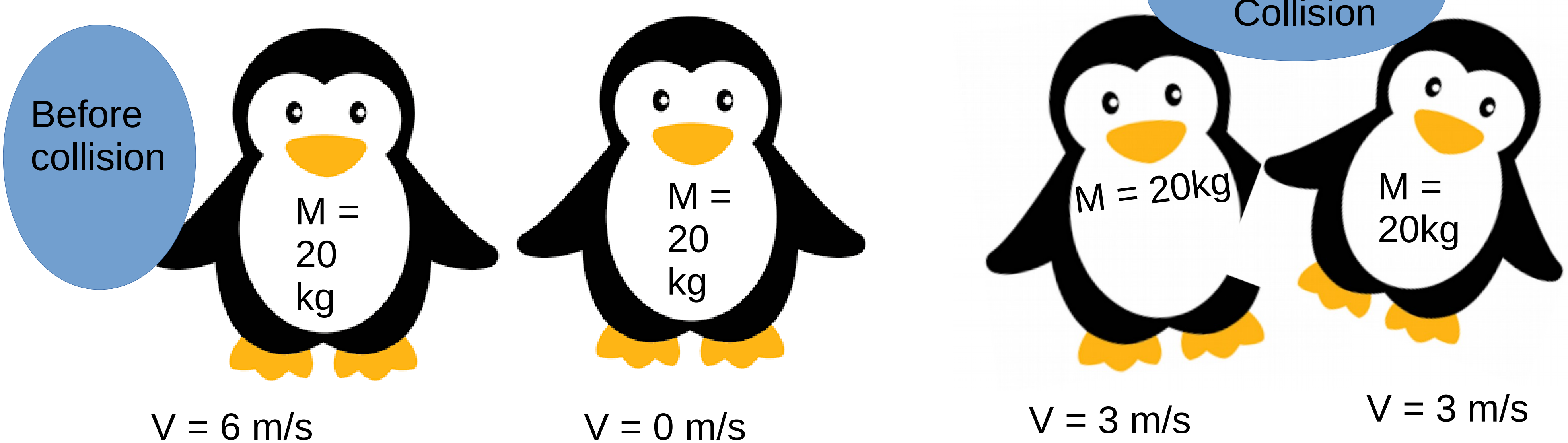
(Kg m/s)   (Kg)   (m/s)



Momentum - Part 2

Momentum and collisions

When moving objects collide, the total momentum of both objects is the same before and after the collision, as long as there are no external forces acting on them. This is known as **conservation of momentum**.



Stopping Distance

When a driver sees a probem ahead, their vehicle will travel a bit while the driver reacts. This is called the **thinking distance.**

The vehicel will then travel a bit more while the brakes are working to stop the car. This is called the **braking distance.**

To find out stopping distance, you use this equation:

stopping distance = thinking distance + braking distance

Reaction times

A reaction time is the time between a person detecting a **stimulus** and their **response**.

Stopping Distances -Part 2

Braking Distances

Car brakes use **friction** to slow the car down. There are many factors that can affect the braking distance of the car. E.g. if the tyres are worn then they create less friction. Also, if the road is **wet or icey**, it creates less friction as well.

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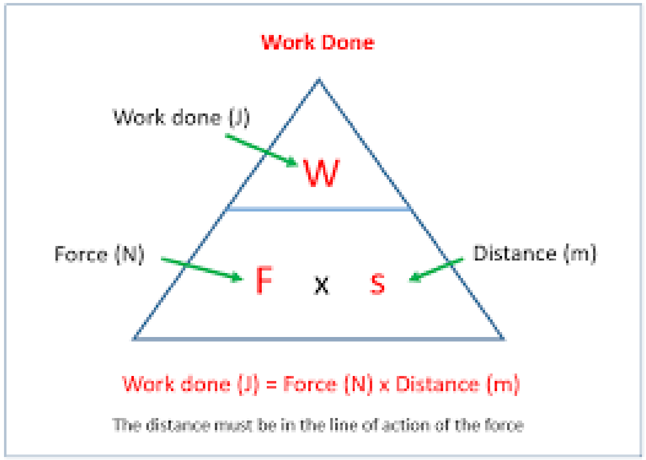
Braking Distance & Energy - Part 1

The energy transferred by a force acting over a distance is called **work done**.

You calculate the work done using this equation:

work done = force x distance moved in direction of force
(J) (N) (m)



Braking Distance & Energy - Part 2

The energy stored in a moving object is called **kinetic energy**.

The amount of kinetic energy depends on the mass of an object and its velocity.

The equation to work out kinetic energy is :

kinetic energy = ½ x mass x speed2
(J) (Kg) (m/s2)

Crash Hazards

Slowing down in deceleration. The force needed for any acceleration depends on the size of the acceleration and the mass.

Most cars have many safety features built in to them. Crumple zones are built into the front (and sometimes at the back) of the car. With the crumple zone, the deceleration is less and the force is also less.

Also, when the car stops, the passengers don’t stop with the car. Seat belts hold the passengers from flying into the window.

Key Concepts of Unit 2

- **Newton's first law** = a moving object wil continue to move unless an external factor acts on it
- **Newton's second law** = the acceleration in the direction of a resultant force depends on the size of the force and the mass of the object.
- **Newton's third law** = the forces on 2 different objects when they onteract with eachother.
- **Momentum** = a measure of how hard it is to stop an object moving.

UNIT 3 STARTS HERE:

C O N S E R V A T I O N O F E N E R G Y

Energy Stores & Transfers

Energy is stored in 7 different ways:

- Chemical Energy
- Kinetic Energy
- Thermal Energy
- Elastic Potential Energy
- Gravitational Potential Energy
- Atomic Energy
- Nuclear Energy

Energy can also be transferred between two stores.

Energy Efficiency

- When some machines are turned on, some of their energy is **dissipated*** into its surroundings.

  Friction between moving parts can be reduced through **lubrication**. Oil or other liquids can be used as lubricants.

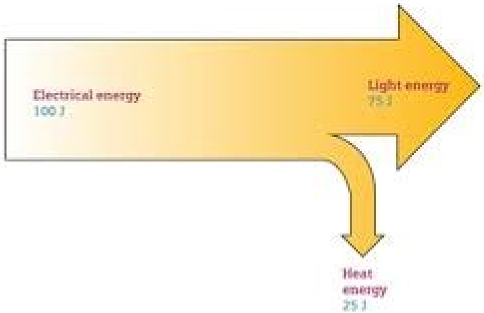
  Efficiency is a way of describing how good a machine is at tranferring energy into useful froms.

Sankey Diagrams

A sankey diagram is a simple representation of energy efficiency.

The beginning is the total amount of energy going in, and the end 2 arrows are useful and wasted enefgy. The arrow pointing downwards is the inefficient energy and the straight arrow is the efficient energy.

Sankey diagrams are useful when comparing the efficiency of two items when wanting to purchase an item



Keeping Warm - Part 1

Energy can be passed in different ways:

- Conduction – vibrations are passed on within a solid.
  metals are good thermal conductors, and wood is a bad thermal conductor
- Convection – part of a fluid that is warmer than the rest rises and sets up a convection current
- Radiation – the only way energy is transferred through a vacuum

Keeping Warm - Part 2

What is thermal conductivity?

This is when energy is not transferred through them very easily bu heating.

Modern brick walls are built with a cavity between them which inculates the house. This is because the air is trapped inbetween the walls and can’t escape.

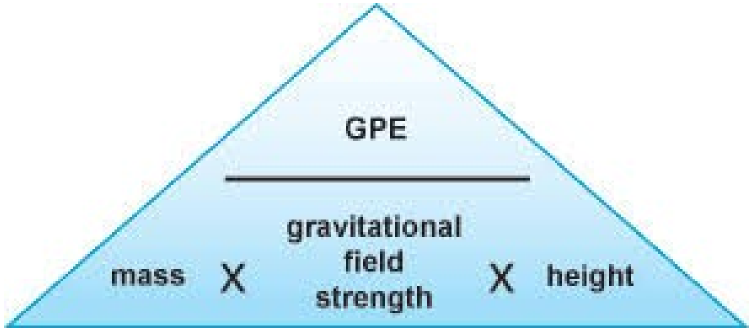
Stored Energies - Part 1

Gravitational potential energy is energy that is stored because an object's position in a gravitational field.

The amount of GPE stored depends on the mass of the object, the strength of gravity and how far is moved upwards.

GPE is worked out using this equation:

- **change in gravitational potential energy (j) = mass (kg) x gravitational field strength (N/kg) x change in vertical height (m)**

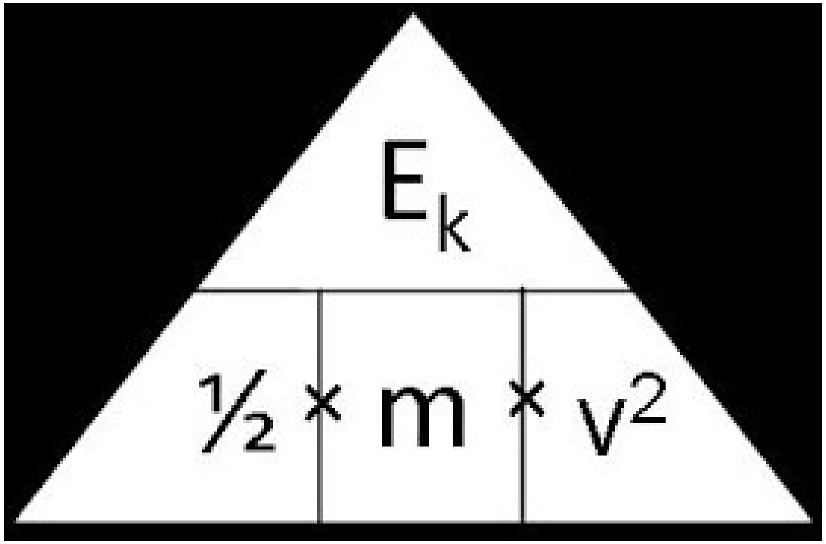


Stored Energies - Part 2

When energy is stored in moving objects, we call this kinetic energy.

We work out kinetic energy with this equation:

kinetic energy = ½ x mass x (speed)^2
(J) (Kg) (m/s)^2



Non-renewable resources

Non-renewable means that they will **one day run out**.

Examples of non-renewable energy sources are:

- Coal
- Oil
- Natural Gases