CfE Forces — B. McMULLEN

What can forces do to objects?

They can change the :

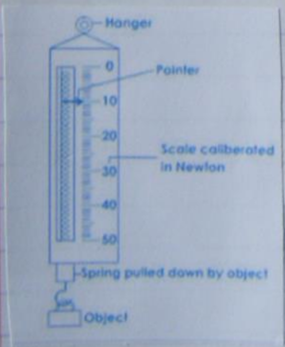
- Speed
- shape
- Direction of the object

Which unit is used to measure force?

Newtons. This is named after the famous English Physicist Sir Isaac Newton (1643-1727)

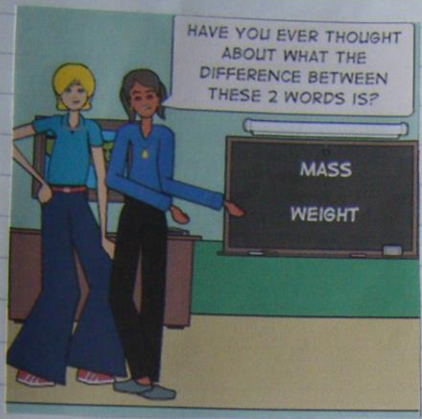
Which instrument is used to measure force?

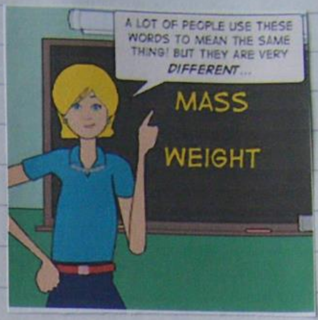
A Newton Balance (sometimes called a spring balance)



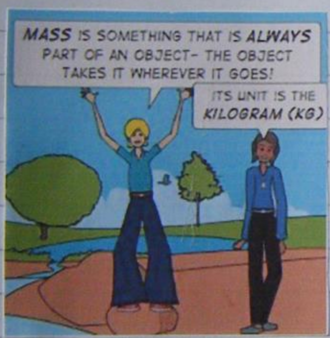
The greater the force exerted, the greater the length of the spring.

MASS AND WEIGHT



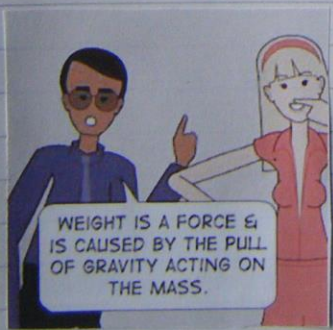


• MASS



mass is a measure of the matter contained in an object and it is measured in kilograms (Kg).

• WEIGHT



Weight is the force due to gravity acting on an object and it is measured in Newtons (N).

Equation linking mass and Weight.

* Weight = mass x gravitational field strength *

Weight → Newtons

mass → Kilograms

gravitational field strength → Newtons per kilogram.

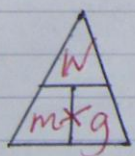
* Sometimes acceleration due to gravity measured in metres per second squared is used instead of gravitational field strength. *

$$W = mg$$

W → Weight (N)

m → mass (Kg)

g → Gravitational field strength (NKg^{-1})



1. $W = mg$
2. $m = \frac{W}{g}$
3. $g = \frac{W}{m}$

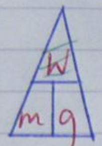
* Gravitational field strength (g) is defined as the force or weight per unit mass acting on an object ie $g = \frac{W}{m}$ *

Ex1

Q Calculate the weight of your Physics teacher if he has a mass of 95 kg.

(g on Earth $= 9.8\,NKg^{-1}$)

A $W = ?$
$m = 95Kg$
$g = 9.8NKg^{-1}$



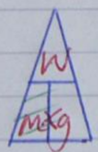
$W = mg = 95 \times 9.8$

$\Rightarrow W = 931N$

Ex2

Q Calculate the mass of an object of weight 588N.

A $W = 588N$
$m = ?$
$g = 9.8NKg^{-1}$



$m = \frac{W}{g} = \frac{588}{9.8} = 60Kg$

Ex3

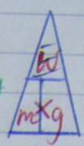
A person of mass 65Kg walks through the jungle with a rucksack containing a total mass of 4.9Kg.

Q Calculate the weight of the person when:

a) wearing a rucksack

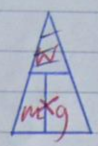
b) when the rucksack is taken off.

A) a) $W = ?$
$m = 65kg + 4.9kg = 69.9kg$
$g = 9.8NKg^{-1}$



$W = mg$
$\Rightarrow W = 69.9 \times 9.8$
$\Rightarrow W = 685N$

b) $W = ?$
$m = 65kg$
$g = 9.8NKg^{-1}$



$W = mg$
$\Rightarrow W = 65 \times 9.8$
$\Rightarrow W = 637N$

Gravitational field strength (g)

* Do not write a capital G for gravitational field strength.

This stands for the Universal Constant of Gravitation studied in Higher Physics, where
$G = 6.67 \times 10^{-11} Nm^2Kg^{-2}$ *

The gravitational field strength varies on different planets.

1) mass of an object is constant on different planets

2) Weight of an object would change on different planets due to each planet having unique gravitational field strengths

$W = mg$ $\therefore$ $g\uparrow$ then $W\uparrow$ and if $g\downarrow$ then $W\downarrow$

m is constant.

Ex4

Complete the table below when applied to an 80kg Astronaut.

Planet	g (NKg^{-1})	Weight (N) $W=mg$
Mercury	3·7	80 x 3·7 = 269N
Venus	8·8	80 x 8·8 = 704N
Earth	9·8	80 x 9·8 = 784N
*Moon	1·6	80 x 1·6 = 128N
Mars	3·8	80 x 3·8 = 304N
Jupiter	26·4	80 x 26·4 = 2112N
Saturn	11·5	80 x 11·5 = 920N
Uranus	11·7	80 x 11·7 = 936N
Neptune	11·8	80 x 11·8 = 944N
**Pluto	4·2	80 x 4·2 = 336N

* The Moon is not a planet though it is a natural satellite of the Earth

** Pluto is no longer classified as a planet and is now known as a Dwarf Planet.

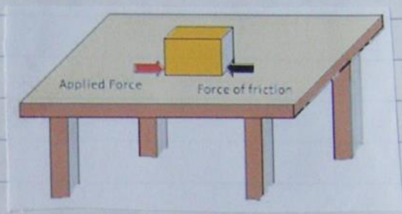
These 8 planets in our Solar System are listed in order of how far they are away from the Sun.

My Very Easy Method Just Speeds Up Naming Planets.

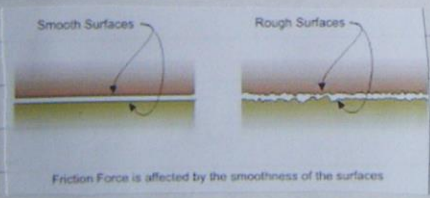
Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto.
(Made before Pluto was re-classified)

The force of friction

This is the force that opposes the motion of an object ie it acts in the opposite direction to the motion of the object.



Frictional forces are caused by two surfaces coming into contact with one another. eg Rubbing your hands together.



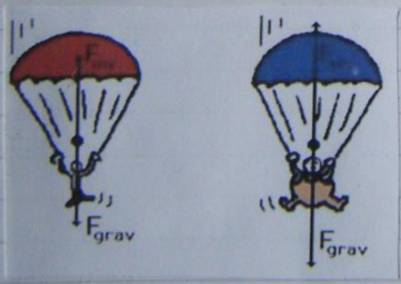
The smoother a surface the smaller the force of friction and vice-versa.

Obviously the force of friction on this floor surface is very low. This shows the 'banana skin effect'.

Air Resistance

This is the force of friction caused by the air on the motion of an object. Air Resistance will also act in the opposite direction to the objects motion.

Two pupils jumped out of an aeroplane at the same time. There is air resistance acting against both boys but this is not enough to slow them down.



Pupil 2 has a larger mass than pupil 1.

When they open their parachutes the air resistance acting on each pupil increases markedly.

As Air Resistance = F_{GRAV} (Weight), then the air resistance experienced by pupil 2 is greater than that experienced by pupil 1.

Balanced forces

• Car

• DRAG FORCE
+
• FORCE OF FRICTION BETWEEN THE TYRES AND THE ROAD SURFACE

• ENGINE FORCE

The car is moving with a constant speed of $48 \, km h^{-1}$ (30mph).

The forces acting on the car are balanced which means that car could be either stationary or moving with a constant speed.

* The pair of forces are balanced ie equal in magnitude and opposite in direction. *.

• Aeroplane

↑ Lift Force

Engine Force (Thrust) ←

→ Drag Force (Air Resistance)

↓ Weight

If the aeroplane is travelling with a constant speed at a constant altitude, then the horizontal and vertical pairs of forces are equal and opposite.

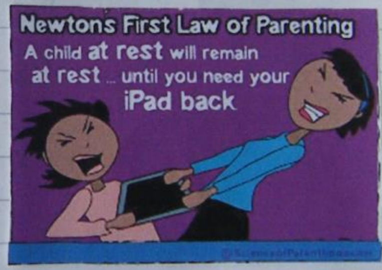
↑ Lift force = ↓ Weight and Engine Force ← = Drag Force →

Newtons 3 Laws of motion.

Newton devised his three laws of motion over 300 years ago and he was known then and is still known now as the founder of Classical Physics.

- Newton's First law of motion.

An object will remain at rest or will continue to move at a constant speed in a straight line unless acted upon by an Unbalanced force.



- Newton's Second Law of motion.

An object will accelerate (or decelerate) if an Unbalanced force acts on it.

The magnitude of the acceleration will be determined by:

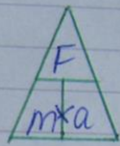
1) Unbalanced force acting on the object
2) mass of the object.

Equation.

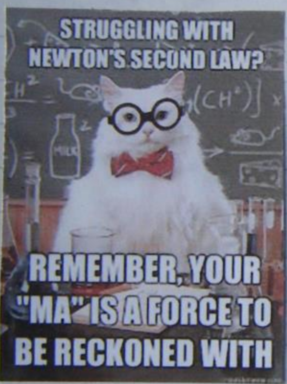
- Unbalanced Force = mass x acceleration
  - Unbalanced Force ↓ Newtons
  - mass ↓ kilograms
  - acceleration ↓ metres per second squared.

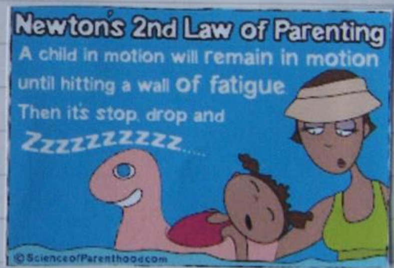
$$F = ma$$

(N) (kg) (ms^{-2})



1. $F = ma$
2. $a = \frac{F}{m}$
3. $m = \frac{F}{a}$

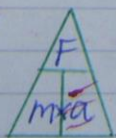




Ex5

A 6kg mass has an unbalanced force of 21N exerted on it.
Calculate the acceleration of the mass.

$F = 21N$
$m = 6kg$
$a = ?$

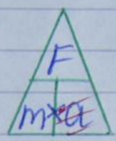


$$a = \frac{F}{m} = \frac{21}{6} = 3{\cdot}5ms^{-2}$$

Ex6

Q/ A trolley is pulled with a force of 20N. If a force of friction of 6N acts against the direction of movement of the trolley then calculate its acceleration if its mass is 7Kg.

$F = 20N - 6N = 14N$
$m = 7Kg$
$a = ?$



$a = \frac{F}{m} = \frac{14}{7} = 2ms^{-2}$

Ex7

A toy car accelerates from $8ms^{-1}$ to $14ms^{-1}$ in 4 seconds. If the mass of the toy car is 800g then calculate:

Q a) Acceleration of the toy car.

b) Unbalanced force on the toy car.

A/ a) $u = 8ms^{-1}$
$v = 14ms^{-1}$
$a = ?$
$t = 4s.$

$a = \frac{v-u}{t} = \frac{14-8}{4} = \frac{6}{4} = 1.5ms^{-2}$

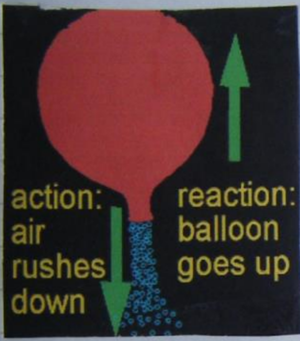
b) $F = ?$
$m = 800g = 0.8Kg$
$a = 1.5ms^{-2}$
↑
From part a).

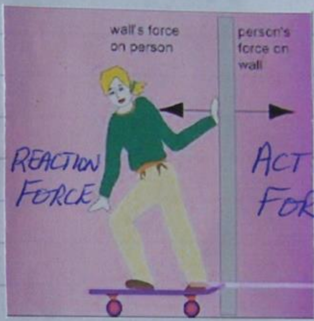
$F = ma$
$\Rightarrow F = 0.8 \times 1.5$
$\Rightarrow F = 1.2N$

• Newton's Third Law of motion

For every action force there is an equal and opposite reaction force.

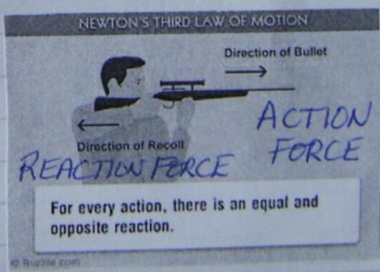
* The action force and the reaction force are equal in magnitude and opposite in direction.





REACTION (Ball on boot) FORCE

ACTION FORCE (Boot on ball)

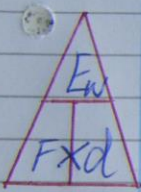


Work Done

This is the energy required or transfered to an object when moving it from one point to another.

eg When moving your pencilcase from one point to another on your desk.

This requires a force to be applied on your pencilcase multiplied by the distance that the pencil case moves.



$$E_W = F \times d$$

- d → distance travelled (metres).
- E_W → Work Done (Joules)
- F → Force Exerted (Newtons)

1/ $E_W = F \times d$ 2/ $F = E_W / d$ 3/ $d = E_W / F$

Ex 8

A person exerts a force of 30N on a trolley to push it 50m.
Calculate the work done on the trolley.

$E_W = ?$
$F = 30N$
$d = 50m$

$E_W = F \times d = 30 \times 50 = \underline{1500J}$

Ex 9

A dog does 1200J of work done pulling a sledge 20m.
Calculate the force exerted on the sledge.

$E_W = 1200J$
$F = ?$
$d = 20m$

$F = \frac{E_W}{d} = \frac{1200}{20} = \underline{60N}$