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New (9-1) AQA GCSE PHYSICS Paper 2

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4.5 FORCES

Forces

Waves

Magnetism and Electromagnetism

Space Physics

a) Scalar and Vector Quantites
b) Contact and Non-Contact Forces
c) Gravity
d) Resultant Forces
e) Work Done and Energy Transfer
f)Forces and Elasticity
g)Moments, Levers and Gears
h) Pressure in a Fluid
i) Atmospheric Pressure

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FORCES AND MOTION

Distance and Displacement
Speed, Velocity, Acceleration
Distance Time Graph
Velocity Time Graph

NEWTONS LAW OF MOTION

Newtons First Law
Newtons Second Law
Newtons Third Law
Forces and Breaking
Breaking Distance
Thinking Distance
Reaction Time

MOMENTUM

Momentun
Conservation of Momentum

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SCALARS AND VECTORS

SCALARS

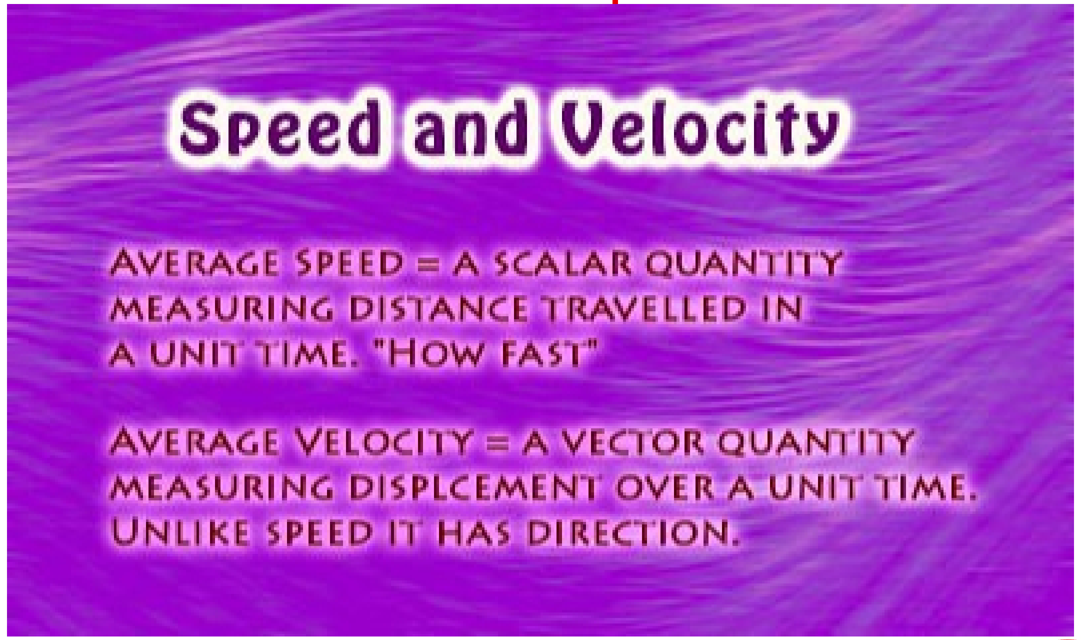
Quantity that has magnitude only

- Length
- Area
- Volume
- Temperature
- Speed
- Mass
- Density
- Pressure
- Work
- Energy
- Power

VECTORS

Quantity that has magnitude as well as direction

- Displacement
- Velocity
- Acceleration
- Momentum
- Force
- Weight
- Drag
- Thrust



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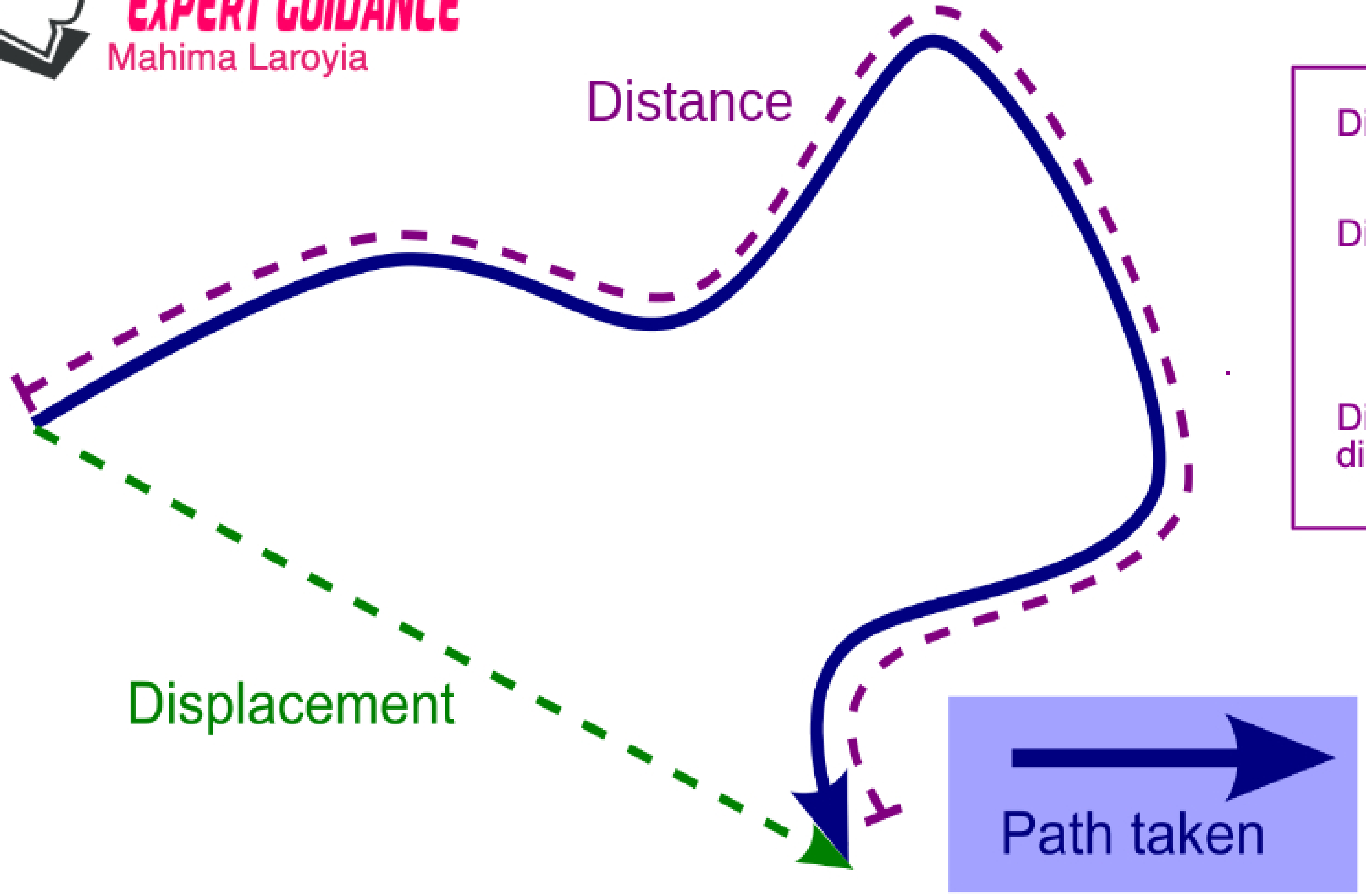
DISTANCE AND DISPLACEMENT



Distance is scalar Quantity

Displacement is a vector Quantity

Displacement is speed in a given direction

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CONTACT AND NON CONTACT FORCES

Force is push or pull on an object that causes an object due to interaction with another object that causes an object to:-
a) change speed
b) Change direction
c) change shape

CONTACT FORCES

Friction Force

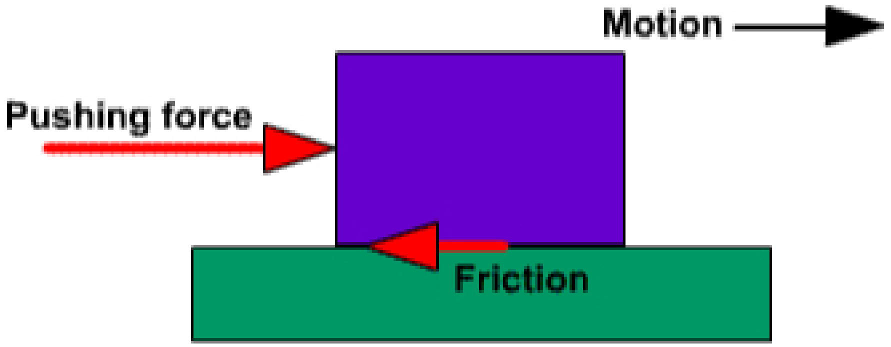
Tension

Air Resistance

Normal Contact Force

Drag Force

Force Experienced by the bodies when they are in physical contact



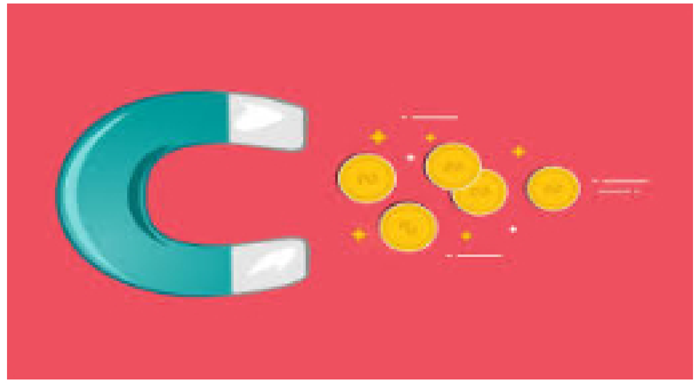
NON CONTACT FORCES

Gravitational Force

Electrostatic Force

Magnetic Force

Force experienced by the body without any physical contact



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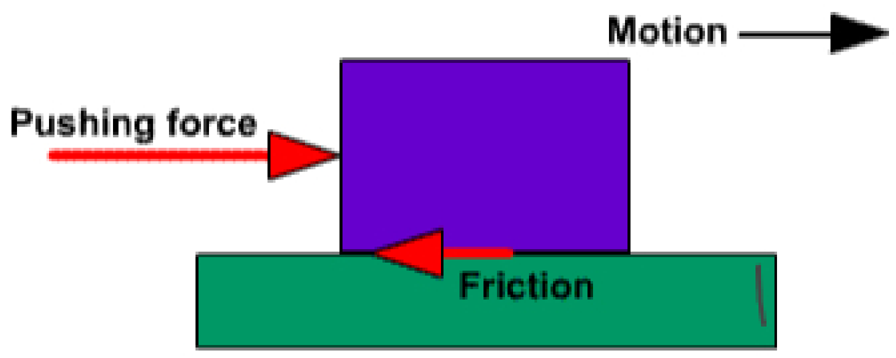
FRICTION FORCE



Friction is a contact force that opposed motion between the two surfaces that are in physical contact.

- It is a resistive force
- It happens in the opposite direction of motion.

It is a necessary evil

a) It helps to light a matchstick.

b) The friction between the tyres and the roads prevent the vehicle to slide.

a) It can cause wear and tear of machines

b) It can cause wear and tear of tyres

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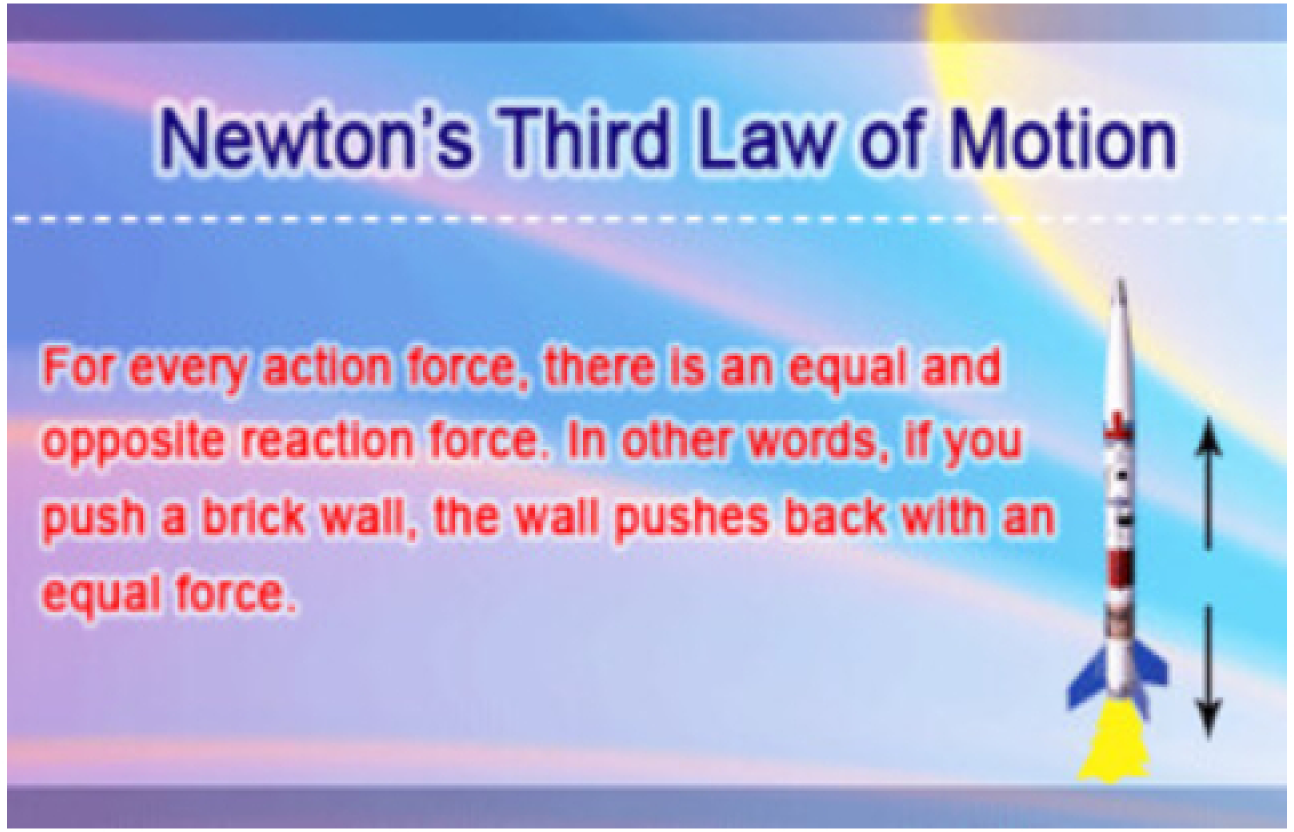
NEWTONS THIRD LAW OF MOTION



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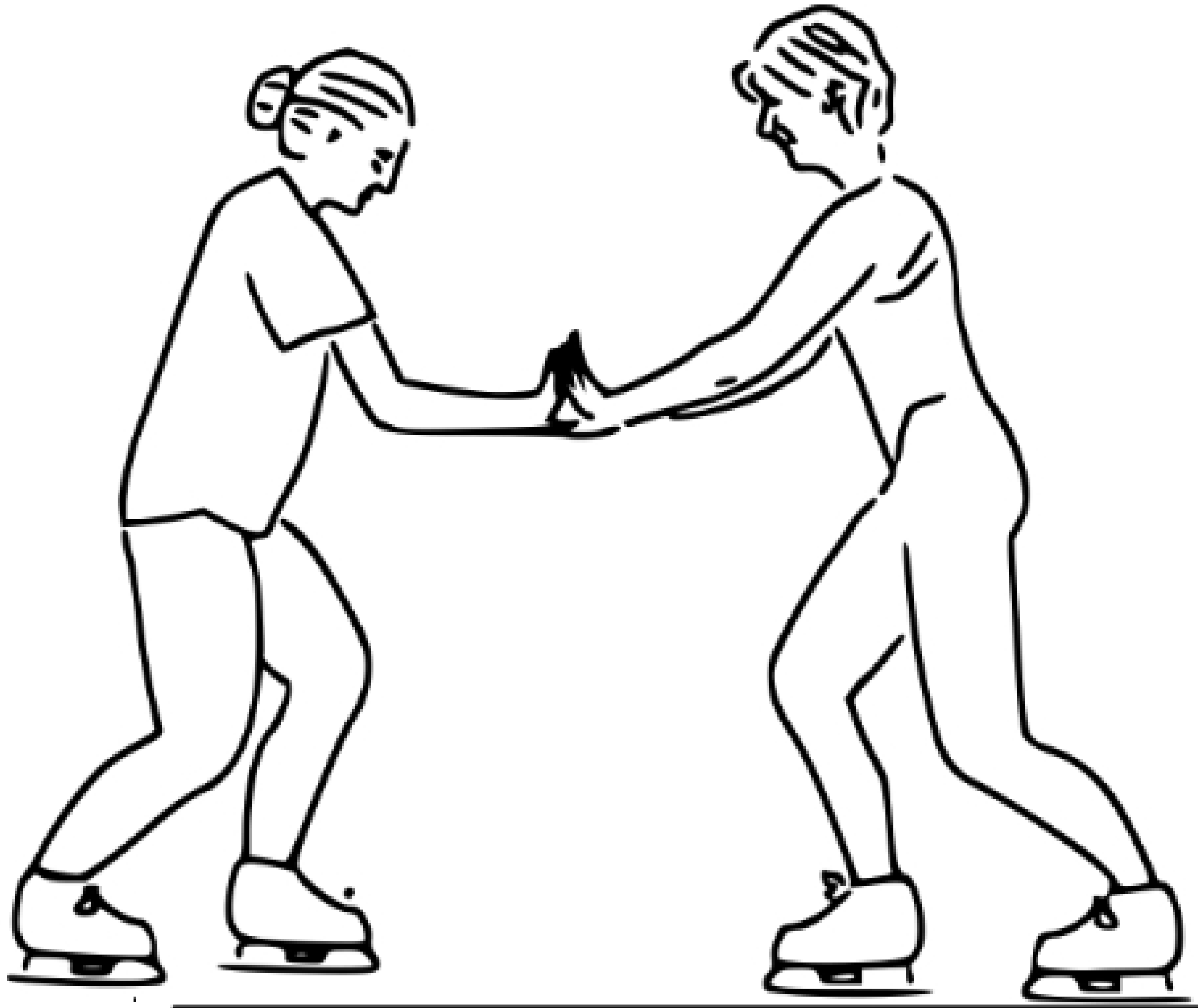

THE SKATERS MOVE TOWARDS EACH OTHER AS THEY PULL ON EACH OTHER WITH EQUAL AND OPPOSITE FORCE

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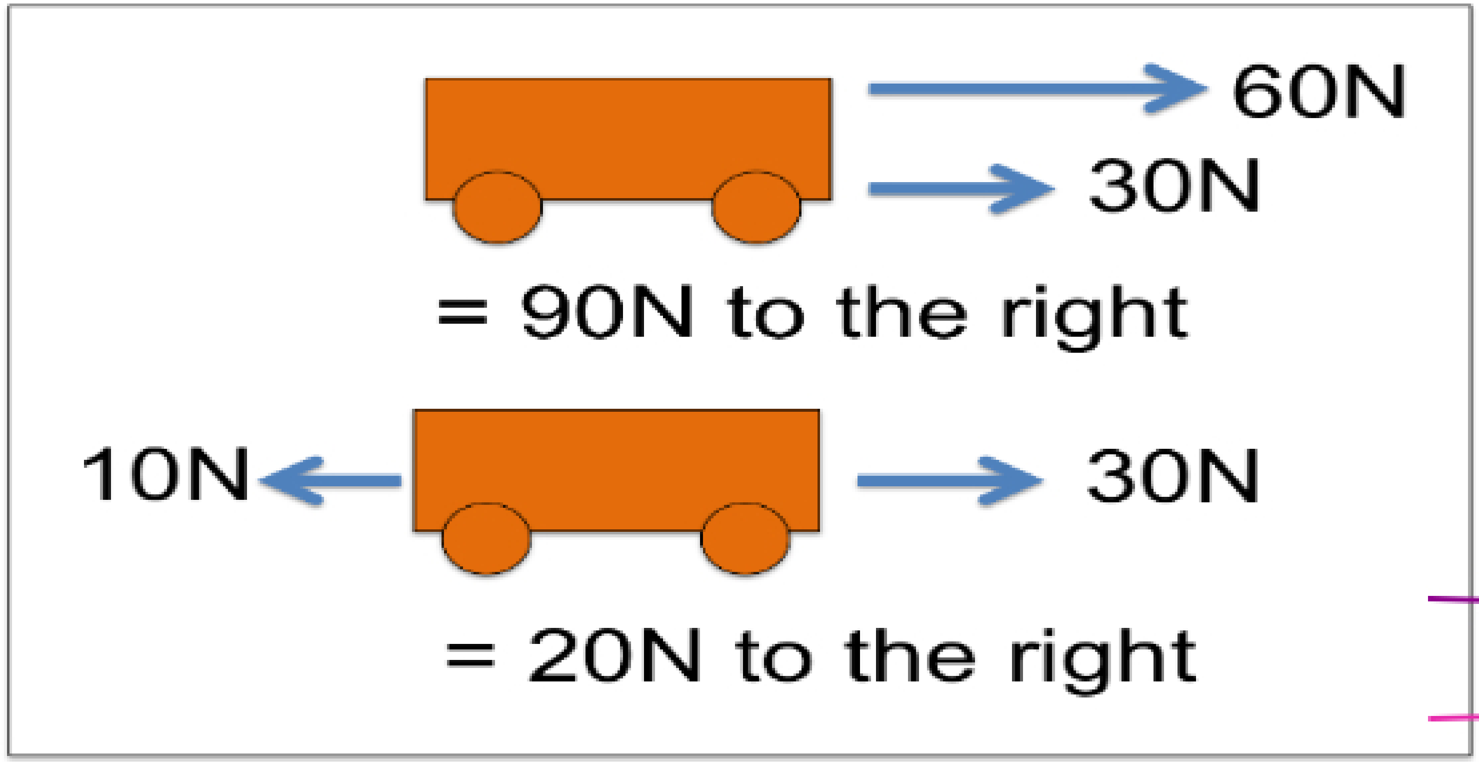
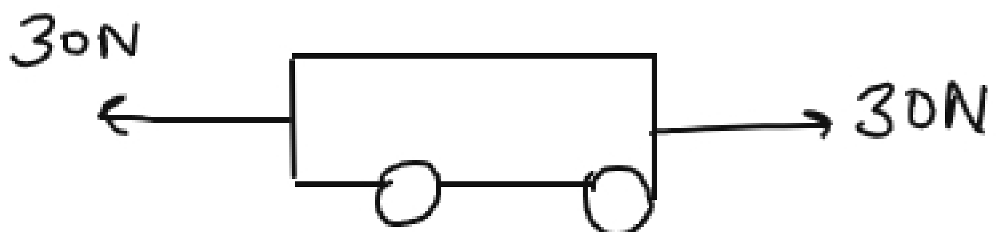
RESULTANT FORCES

It is the total force that acts on the body. It is the sum of all the forces that acts on the body .





Net force = 0 N (forces are balanced)
The body will stay at rest

The resultant force decides the speed and the direction of the body.

BALANCED

- If the resultant force is zero
- If the forces are balanced and the body is at rest then it will stay at rest.

If the forces are balanced and the body is moving it will keep on moving with the same speed and direction

UNBALANCED

- If the resultant force is non zero
- The body will move in the direction of resultant force

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NEWTONS FIRST LAW OF MOTION

NEWTONS FIRST LAW OF MOTION

Inertia = the resistance of an object to a change in its state of motion or rest

Newton's First Law of Motion = objects will continue in their state of motion or rest unless acted upon by an unbalanced force.

Source: Flickr.com

If an object is at rest it will remain at rest
If an object is in motion it will continue to move with the same speed and direction unless no resultant force acts on it.

If the resultant force is non zero or unbalance the object will move or change speed or direction.

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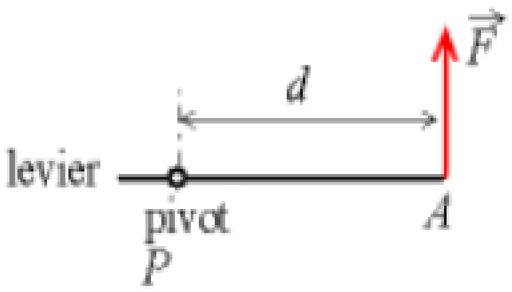
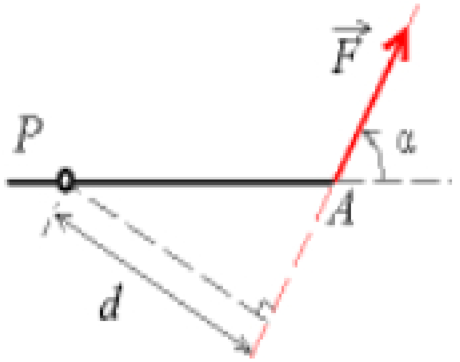
MOMENTS

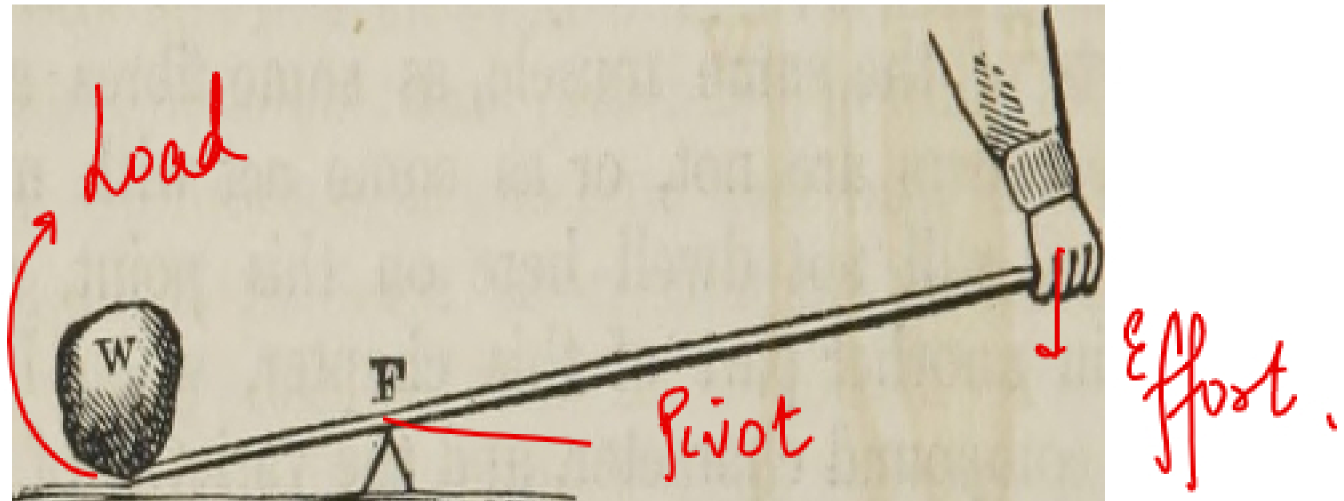
It is the turning effect of force.





MOMENT =. Force. X Perpendicular distance from the pivot

$$Nm = N \times m$$



A crowbar as a force multiplier

Greater distance from the pivot increases the moment or the turning effort so a small effor can lift a heavy load.

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MOMENT QUESTIONS

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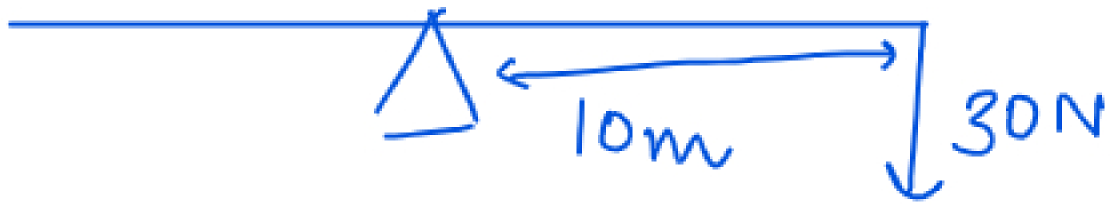
Q1



Calculate the moment

Moment = Force X distance
= 30 X 10
= 300 Nm

Q2 The moment of a spanner is 50 Nm. Calculate the force acting at a distance of 10m from the pivot.

Moment = Force X Distance

$$\text{Force} = \frac{\text{Moment}}{\text{Distance}}$$

$$= \frac{50\,\text{Nm}}{10\,\text{m}}$$

$$= 5\,\text{N}.$$

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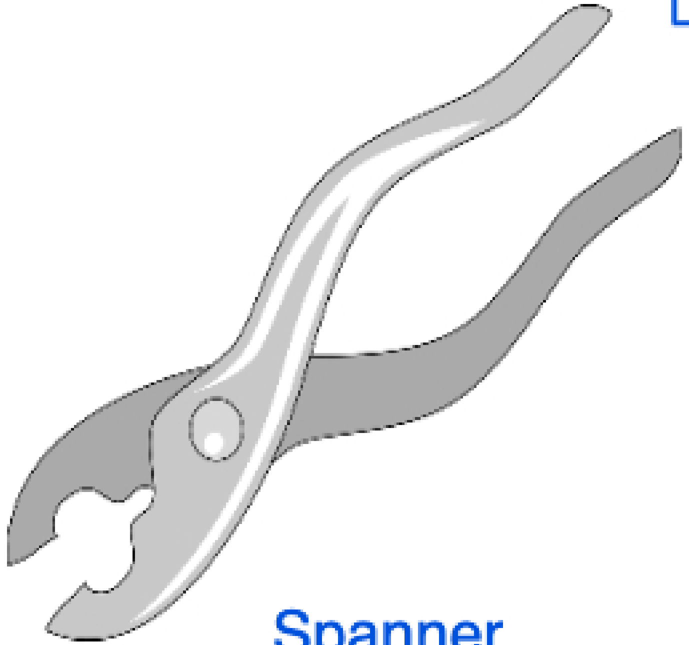
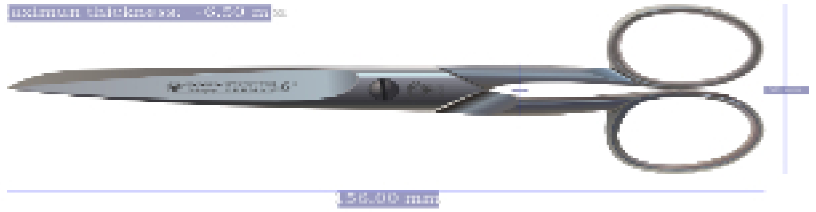
LEVERS AND GEARS

Simple Lever and Force Multipliers


bottle Opener


Spanner


Scissor

In all these levers, the turning effect of force is greater by increasing the distance of effort further away from the pivot. It increases the turning effect and multiply the force with a small effort.

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GEARS

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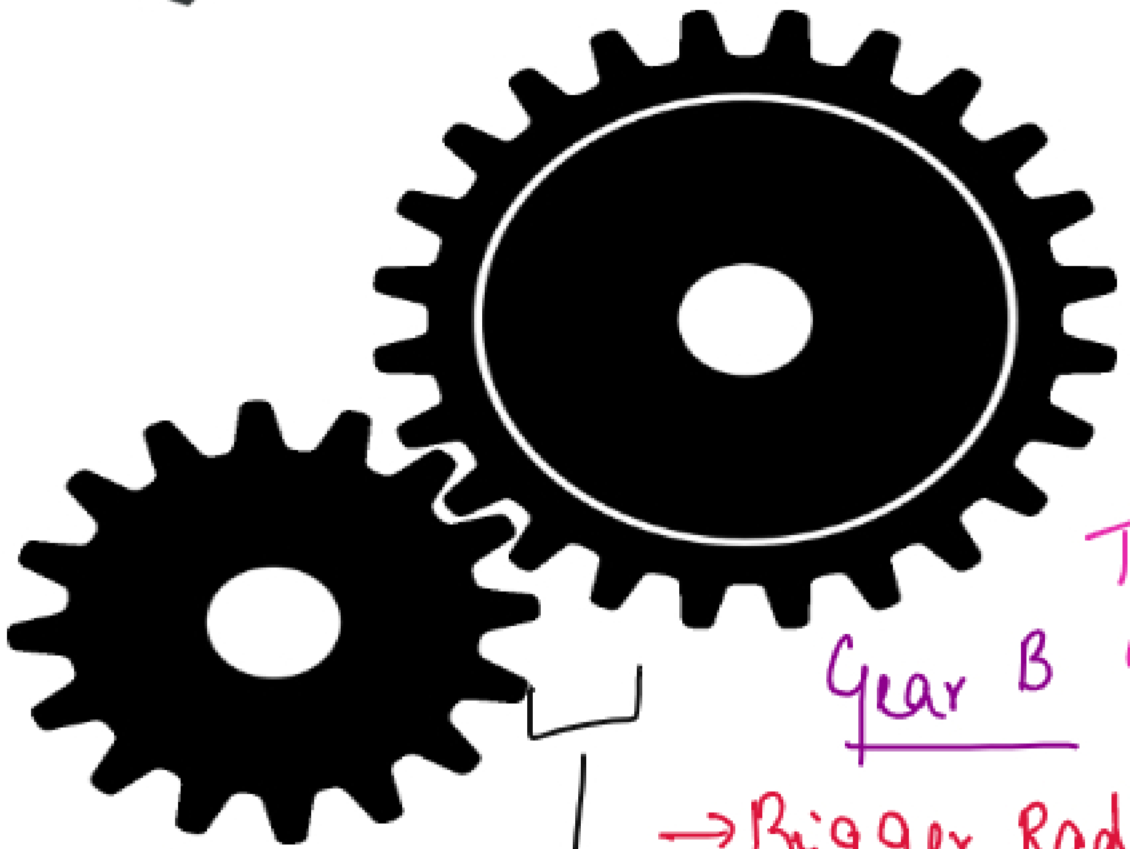
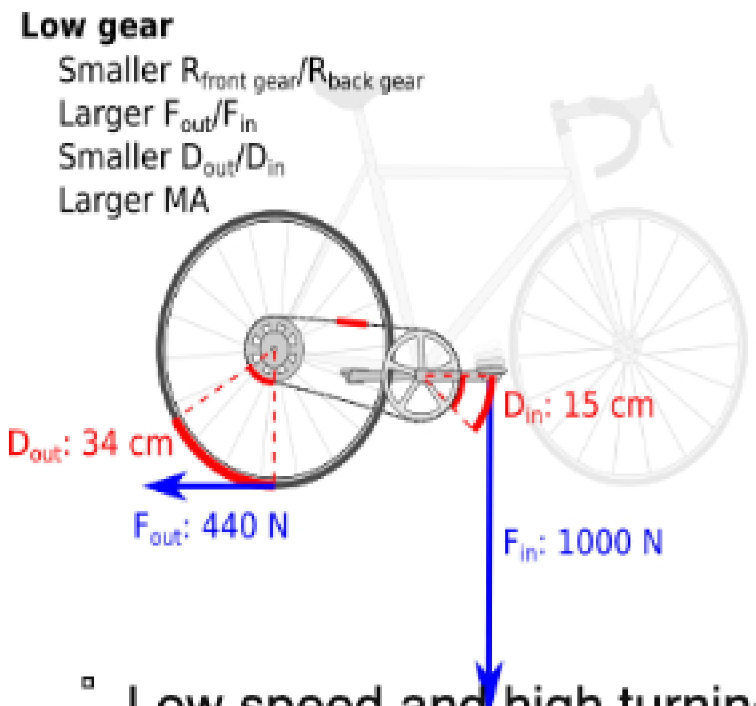


Gear B is greater due to greater radius.
Turning effect
→ Bigger Radius!
→ connected to wheels.

→ Gear A connected to engine
→ smaller radius.

at point of contact they exert equal and opposite force



- Low speed and high turning effect

small gear wheel run a bigger gear wheel

bigger wheel has greater turning effect but slow speed

High speed and low turning effect

large gear wheel run a smaller gear wheel

small gear wheel force acts near to the shaft it run faster with a high speed but lower turning effect

GEARS TRANSMIT TURNING EFFECT OF FORCE

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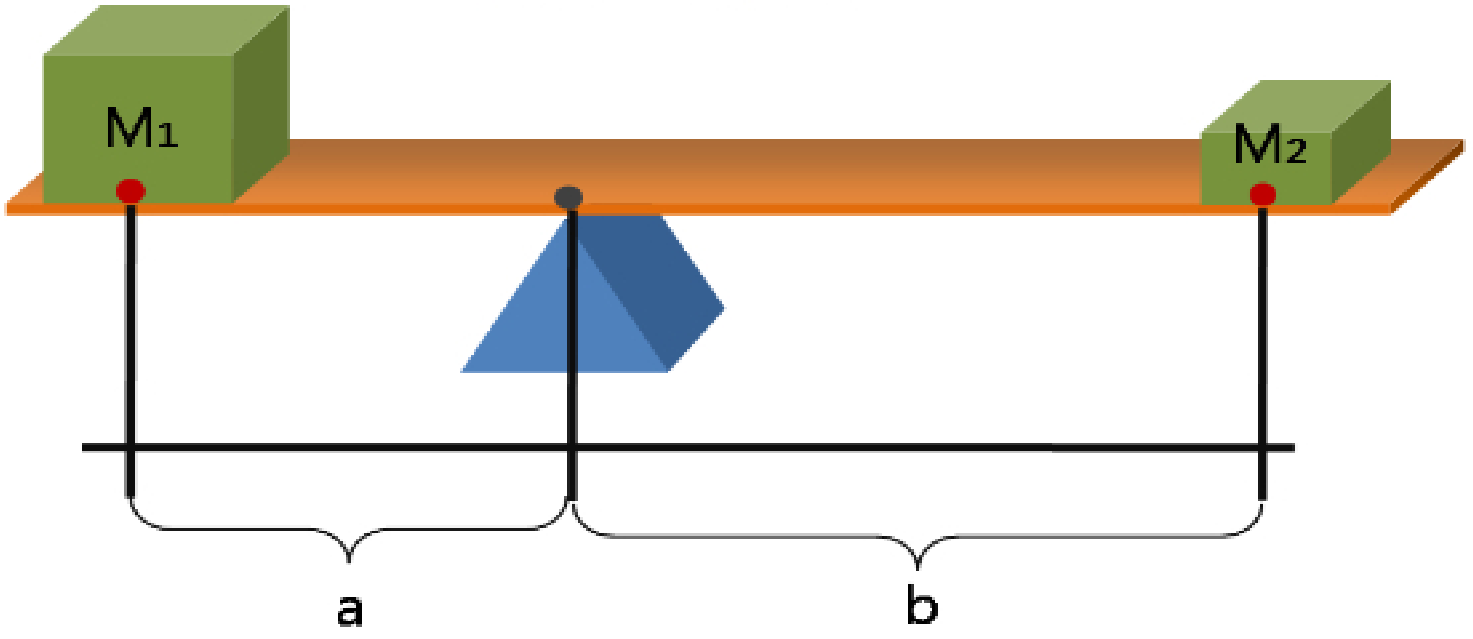
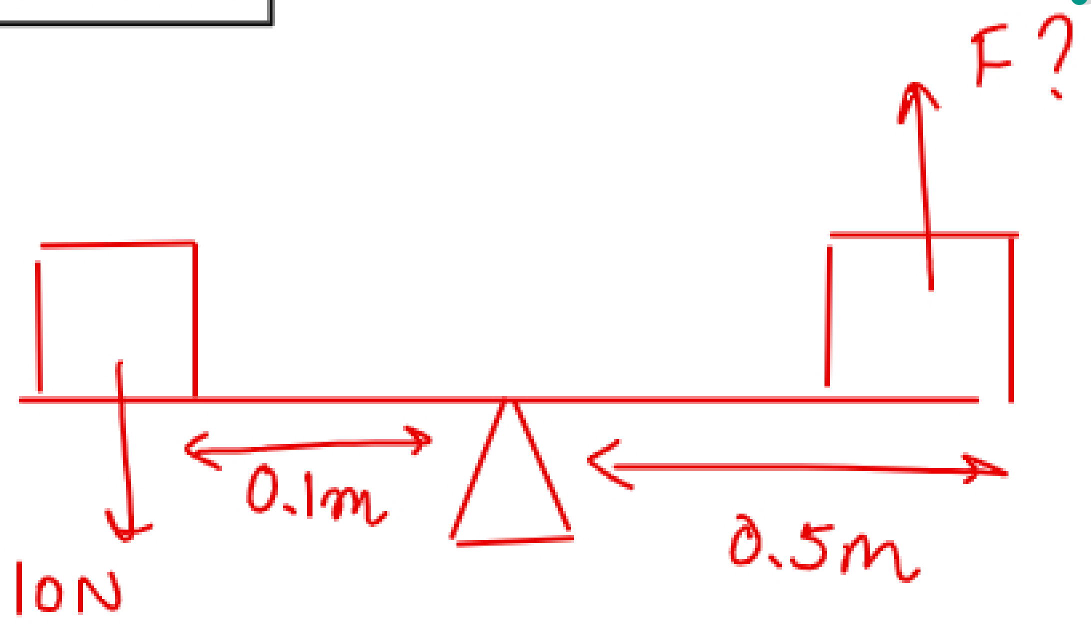
MOMENTS AND EQUILBRIUM

$M_1 \times a = M_2 \times b$



The sum of clockwise moments=
The sum of anticlockwise moments



Moment = 10×0.1
= 1Nm

$\frac{1}{0.5} = F$

= 2N

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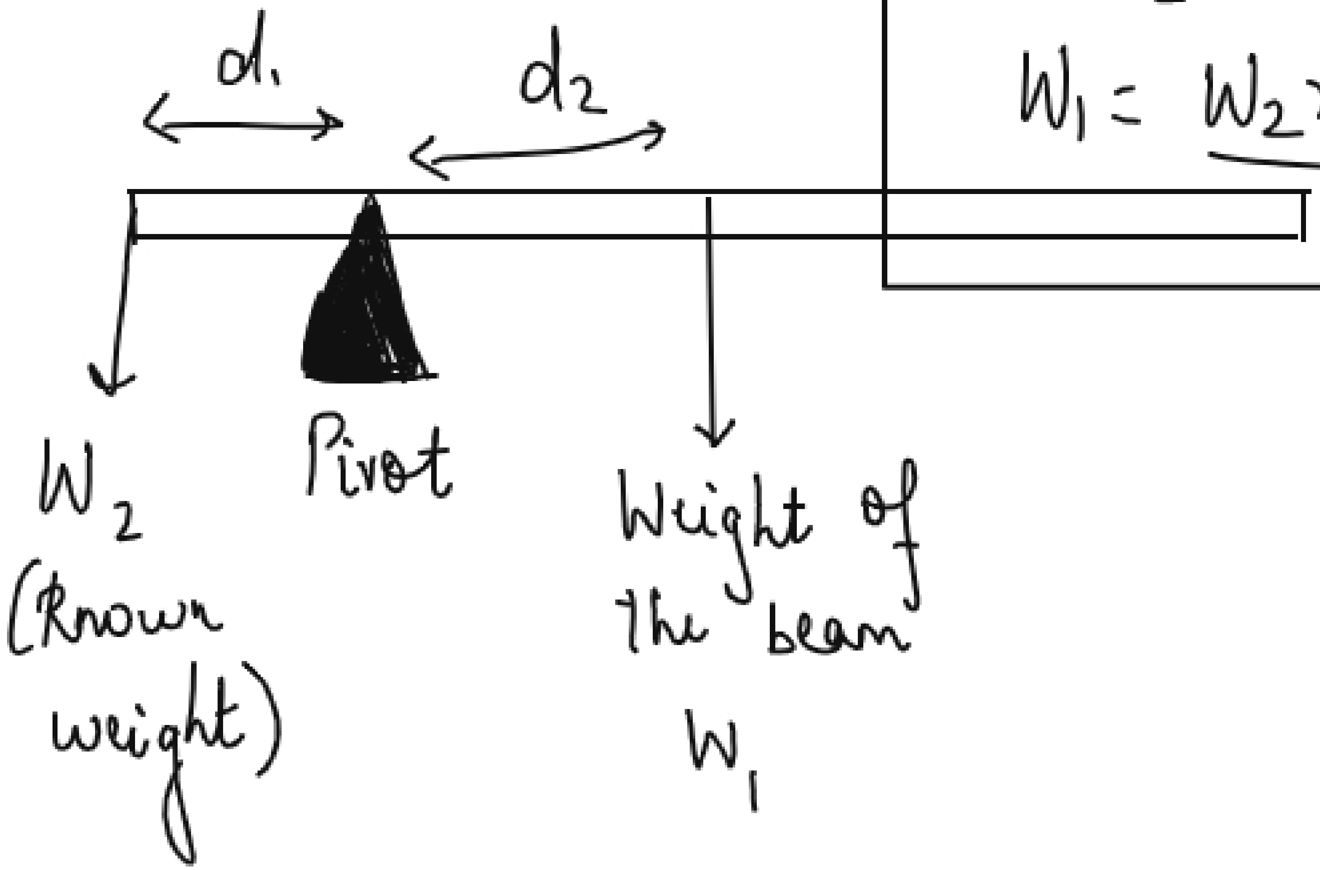
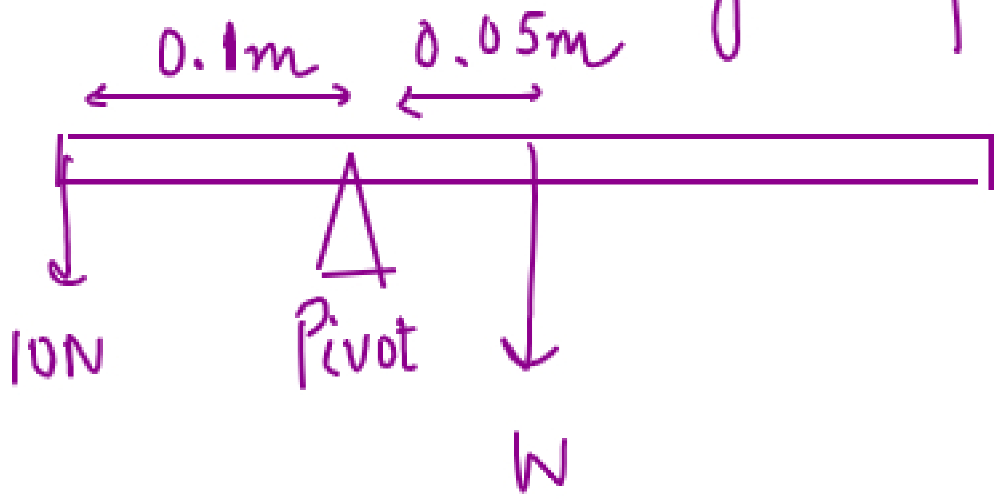
WEIGHT OF THE BEAM



$$W_1 \times d_2 = W_2 \times d_1$$

$$W_1 = \frac{W_2 \times d_1}{d_2}$$

Calculate the weight of beam



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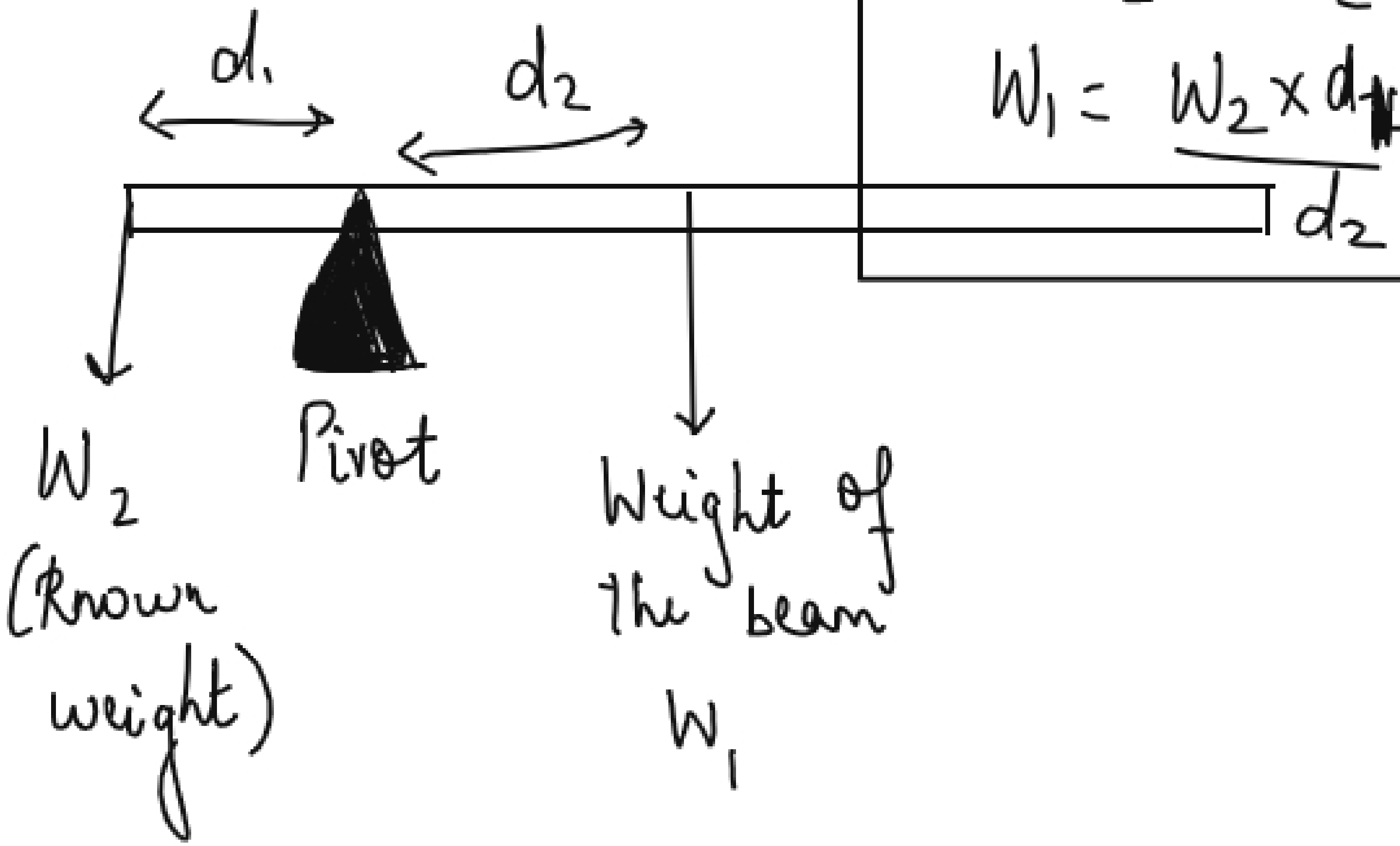
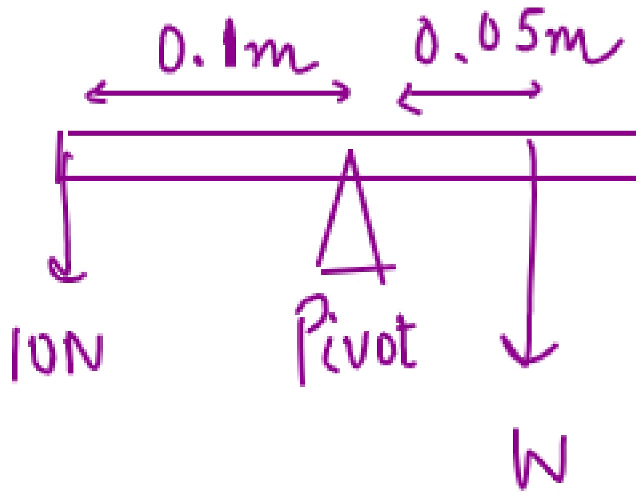
WEIGHT OF THE BEAM

$$W_1 \times d_2 = W_2 \times d_1$$

$$W_1 = \frac{W_2 \times d_1}{d_2}$$



Calculate the weight of beam



$$W \times 0.05 = 10 \times 0.1$$

$$W = \frac{10 \times 0.1}{0.05} = 20N$$

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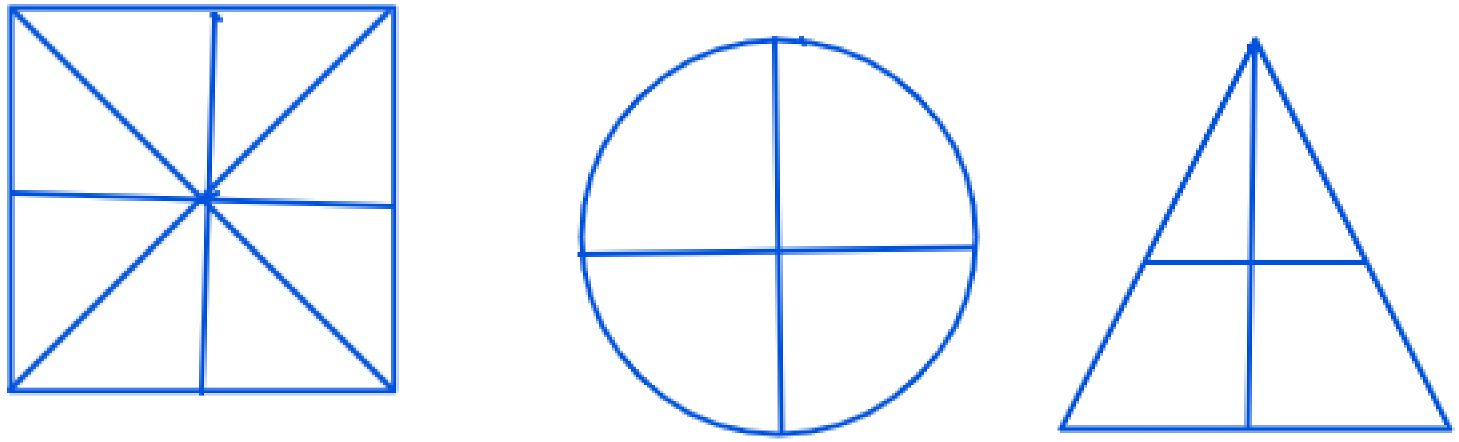
CENTRE OF MASS

It is the point at which the entire mass of the object can be thought as being concentrated.

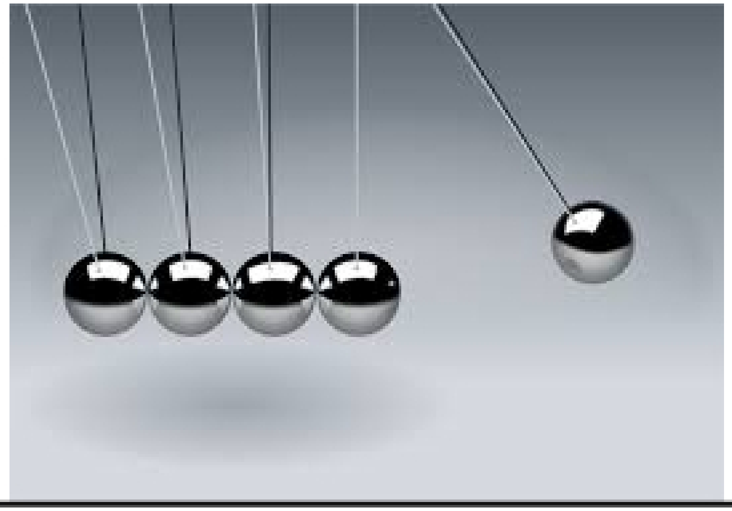
CENTRE OF MASS FOR SYMMETRIC OBJECTS



It is along the point of symmetry

If there more line of symmetry the centre of mass is at the intersection of lines of symmetry

SUSPENDED OBJECT



- The center of mass is directly below the point of suspension.
- When suspended, the weight will give the turning effect and it will come back to its equilbrium position

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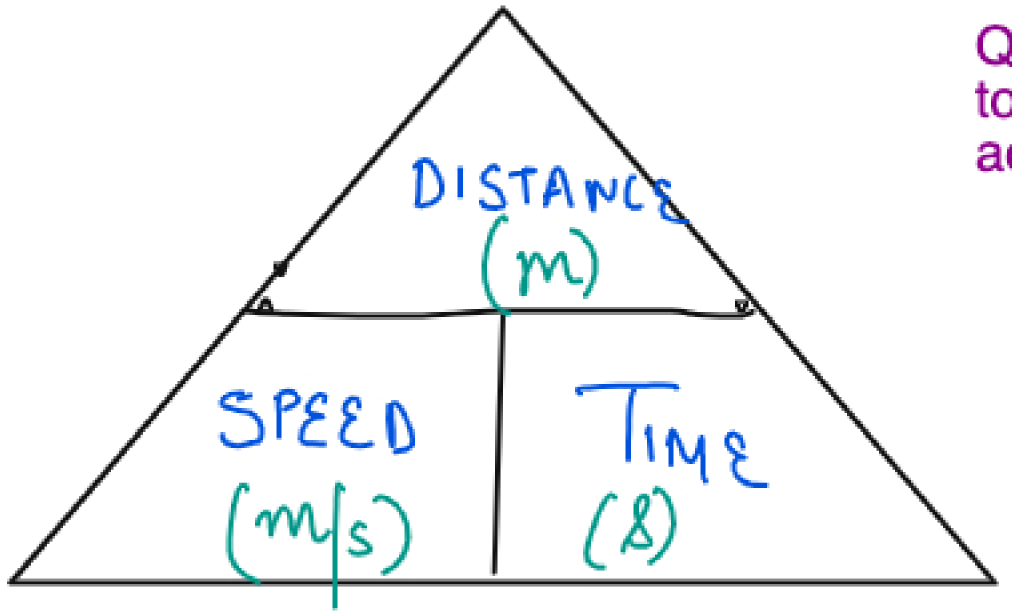
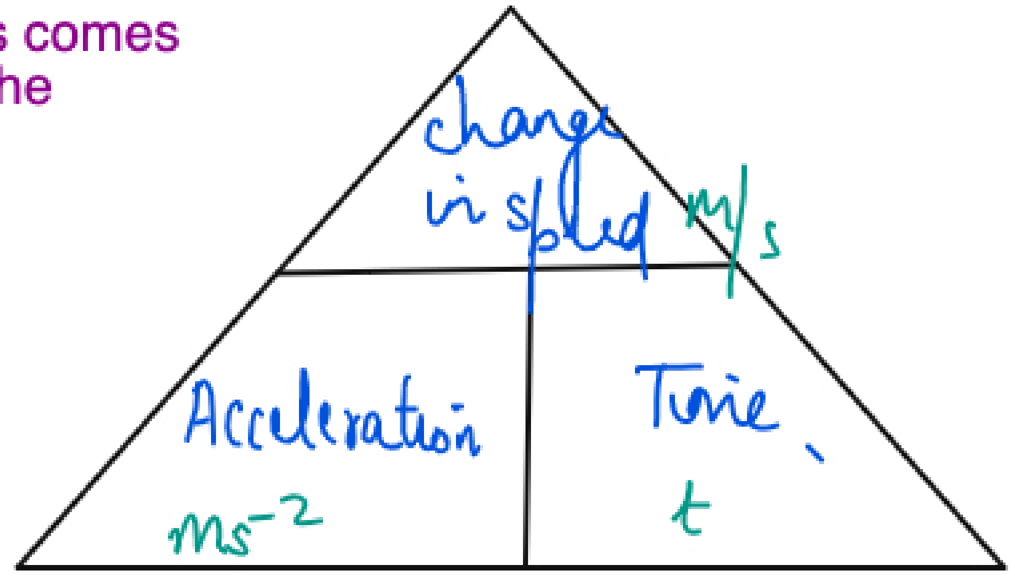
SPEED, VELOCITY AND ACCELERATION



Q1 A Body travelling at 20 m/s comes to rest in 1 minute. Calculate the acceleration ?



Q1 A car is travelling at the speed of 20 m/s. Calculate the distance covered in 10 minutes

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

v = final velocity
u = initial velocity
t = time

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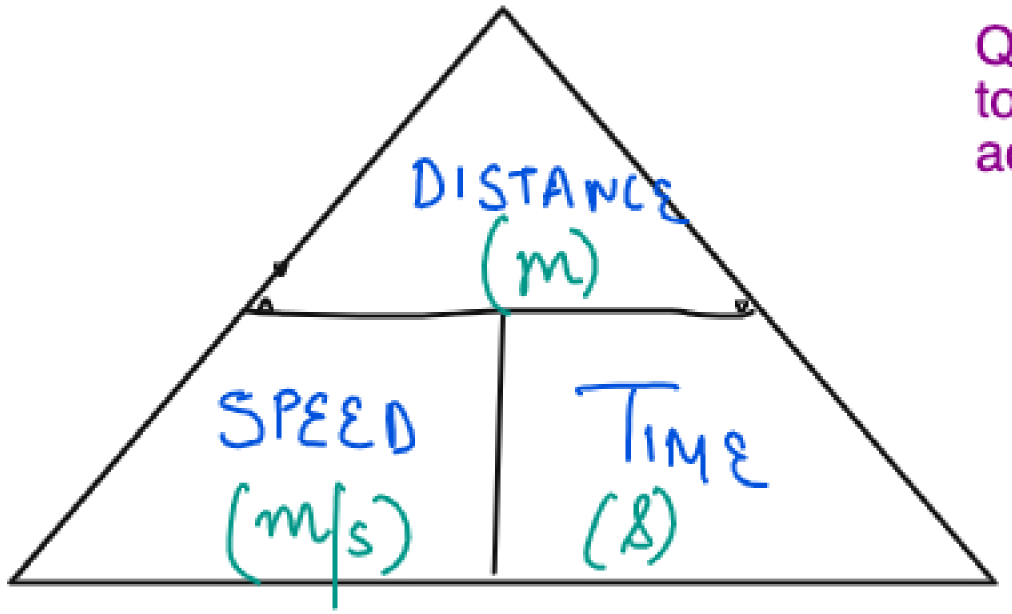
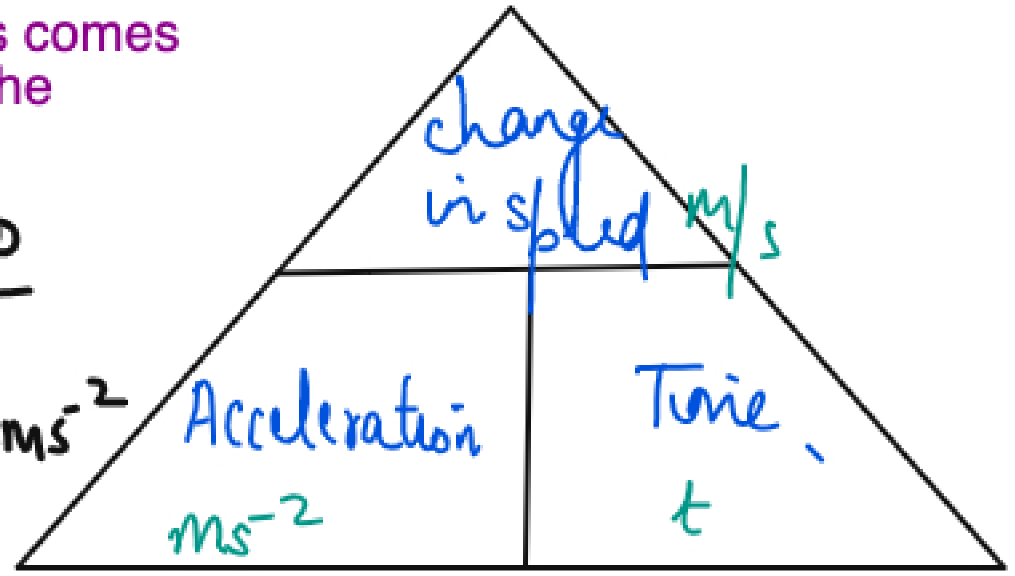
SPEED, VELOCITY AND ACCELERATION



Q1 A Body travelling at 20 m/s comes to rest in 1 minute. Calculate the acceleration ?

$$a = \frac{v-u}{t} = \frac{0-20}{60}$$

$$= \frac{-20}{60} = -0.33\,ms^{-2}$$



Q1 A car is travelling at the speed of 20 m/s. Calculate the distance covered in 10 minutes

$$D = S \times t$$

$$= 20 \times 10 \times 60$$

$$= 12000\,m$$

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

v= final velocity

u= initial velocity

t= time

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DISTANCE TIME GRAPHS

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SLOPE OF DISTANCE TIME GRAPH GIVES SPEED

Q1 Calculate the speed in

a) 0-6 second

b) 6-11 seconds

c) 11 to 17 seconds

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DISTANCE TIME GRAPHS

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SLOPE OF DISTANCE TIME GRAPH GIVES SPEED

Q1 Calculate the speed in

a) 0-6 second

$$\frac{10-0}{6-0} = \frac{\not{10}\,5}{\not{6}\,3} = 1.6\,ms^{-1}$$

b) 6-11 seconds

$$0$$

c) 11 to 17 seconds

$$\frac{10-2}{6} = \frac{\not{8}\,4}{\not{6}\,3} = 1.3\,ms^{-1}$$

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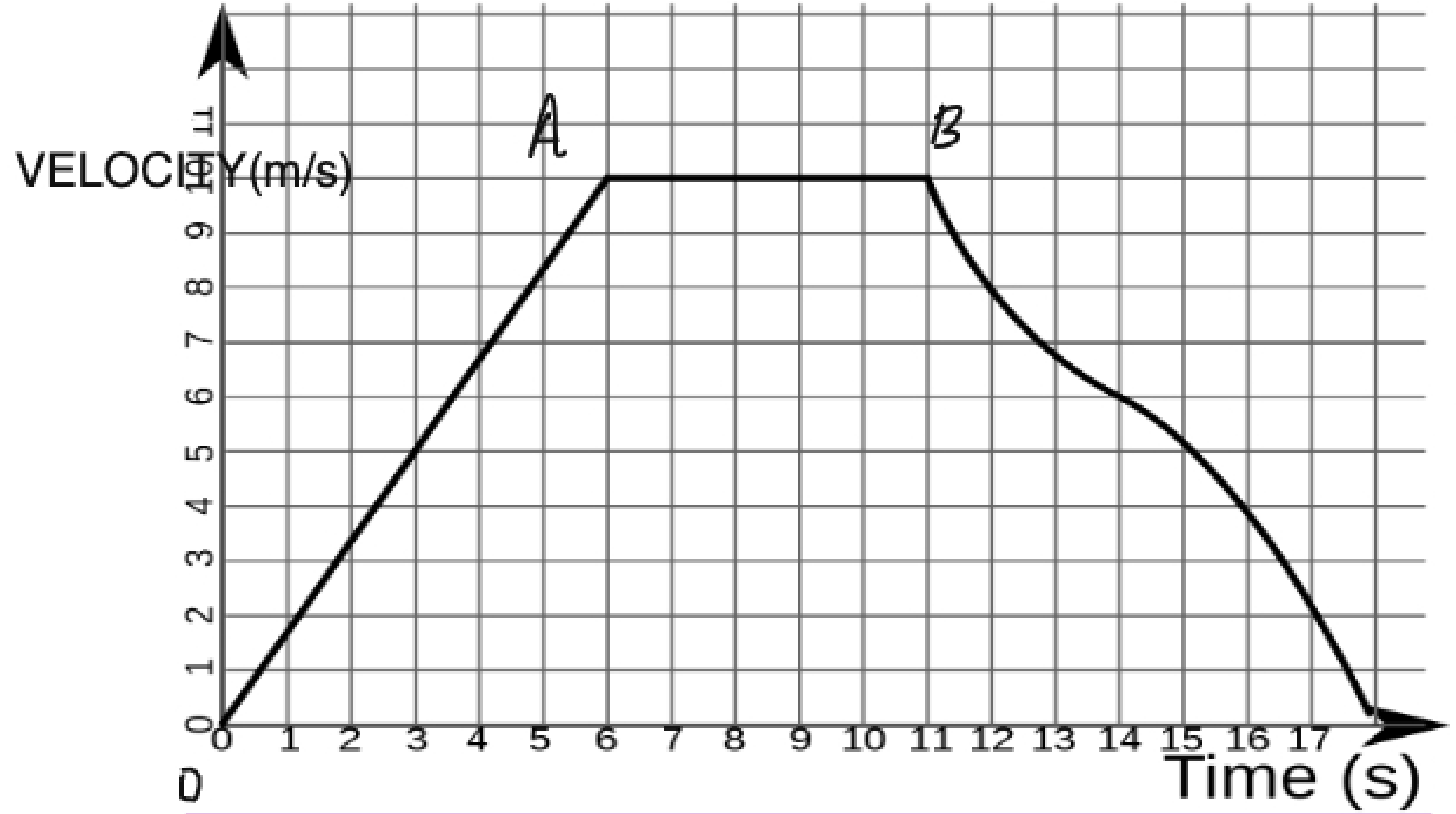
VELOCITY TIME GRAPHS



Calculate the acceleration and distance travelled from

a) O to A

b) A to B

SLOPE OF VELOCITY TIME GRAPH= ACCELERATION

AREA UNDER THE GRAPH = DISTANCE

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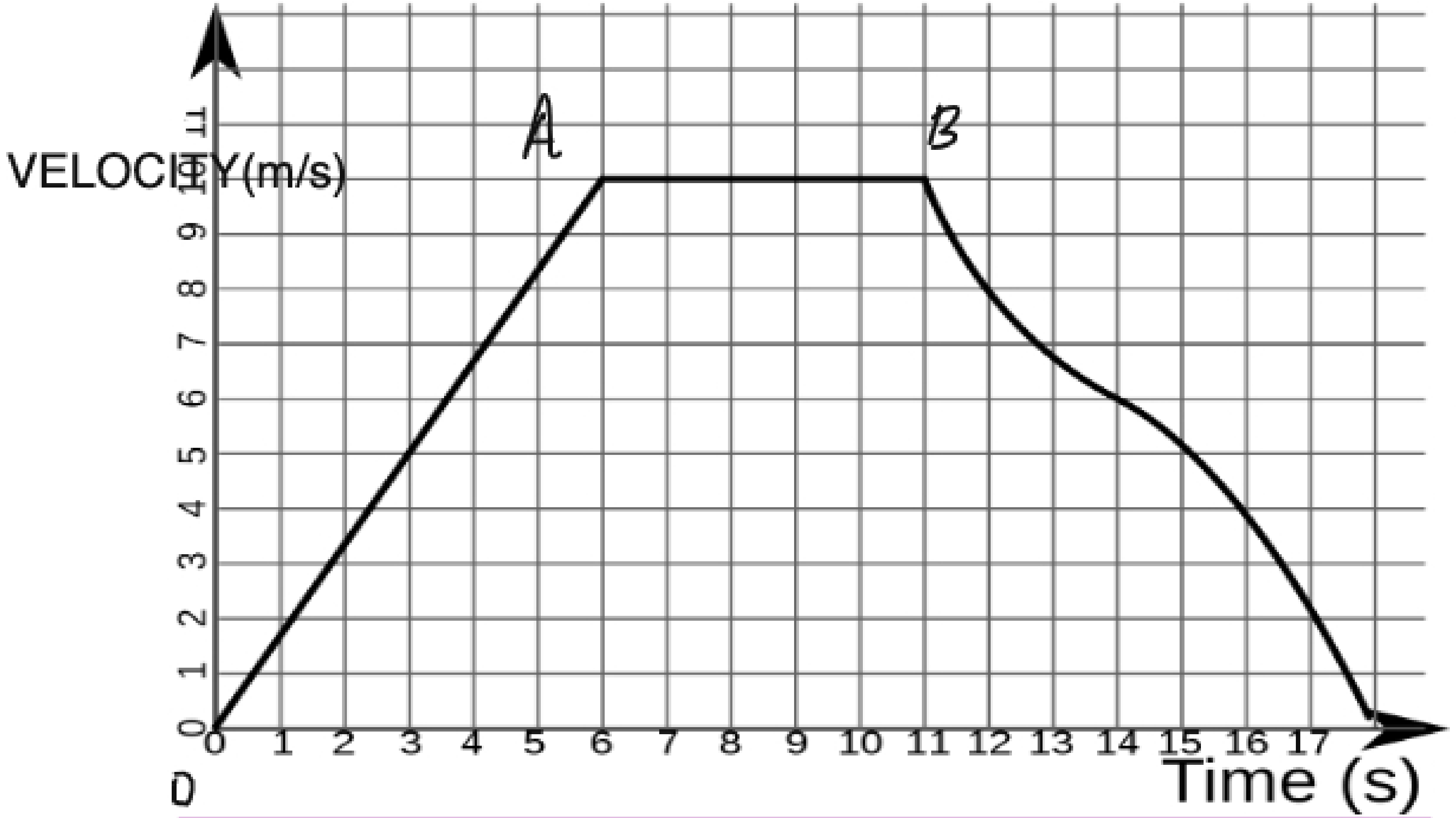
VELOCITY TIME GRAPHS



SLOPE OF VELOCITY TIME GRAPH= ACCELERATION

AREA UNDER THE GRAPH = DISTANCE

Calculate the acceleration and distance travelled from

a) O to A

$$\frac{10-0}{6} = 1.6\ m/s^2$$

b) A to B

0

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EQUATIONS OF MOTION

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$$v = u + at$$

Q1 Calculate the final velocity when the body at rest accelearates to 10 m/s2 in 20 seconds.

$$v^2 - u^2 = 2as$$

v = final velocity (ms^{-1})
u = initial velocity (ms^{-1})
a = acceleration (ms^{-2})
s = distance (m)
t = time (s)

Q2 Calculate the distance travelled when the body moving at 5m/s accelerates to 10 m/s with the accleration of 5m/s2.

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EQUATIONS OF MOTION

$$v = u + at$$

$$v^2 - u^2 = 2as$$

v = final velocity (ms^{-1})
u = initial velocity (ms^{-1})
a = acceleration (ms^{-2})
s = distance (m)
t = time (s)

Q1 Calculate the final velocity when the body at rest accelearates to 10 m/s2 in 20 seconds.

$u = 0$ $a = 10\,ms^{-2}$
$v = ?$ $t = 20s$

$v = u + at$
$= 0 + 200 = 200\,m/s$

Q2 Calculate the distance travelled when the body moving at 5m/s accelerates to 10 m/s with the accleration of 5m/s2.

$u = 5\,m/s$
$v = 10\,m/s$
$a = 5\,ms^{-2}$

$v^2 - u^2 = 2as$, $s = \frac{v^2 - u^2}{2a}$

$\frac{100 - 25}{10} = 7.5\,m$

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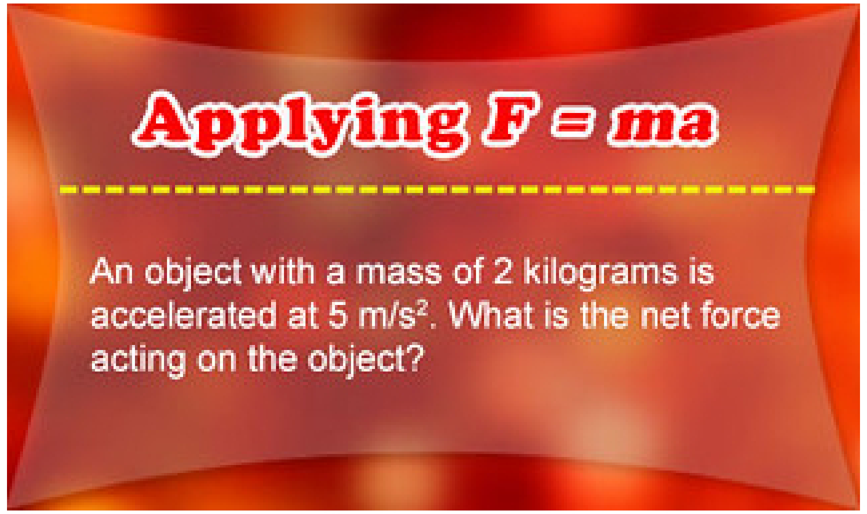
NEWTONS SECOND LAW OF MOTION



The acceleration of a body is

a) directly proportional to the resultant force
b) inversely proportional to the mass of an object

Calculate the accleration of a body of mass 10 Kg falling downwards on the ground with the resultant force of 50 N ?

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NEWTONS SECOND LAW OF MOTION

F = mass x acceleration

SPEED UP	SPEED DOWN
The velocity of the object increases.	The velocity of the object decreases
The object accelerated.	The object is decelerated
The resultant force is in the direction of motion	The resultant force is opposite to the direction of motion.

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WEIGHT AND TERMINAL VELOCITY

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Mass	Weight
Measurement of amount of matter in an object.	It is the force acting on the body due to gravity
Measured in Kg	Measured in N
It is always constant	It is variable and changes with change in gravity
It is scalar	It is vector
Measured by beam balance	Measured by newton-meter

WEIGHT =. MASS. X. GRAVITATIONAL FIELD STRENGTH
(N) (kg) (N/kg)

g on earth = 9.8 N/kg
or 10. N/kg

Calculate the weight of the object of mass 10 Kg ?

Calculate the gravitation field strength of the same body in moon if it weights 16N on moon ?

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WEIGHT AND TERMINAL VELOCITY

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WEIGHT =. MASS. X. GRAVITATIONAL FIELD STRENGTH
(N) (kg) (N/kg)

g on earth = 9.8 N/kg or 10. N/kg

Calculate the weight of the object of mass 10 Kg ?

$W = 10 \times 10$
$= 100N$

Calculate the gravitation field strength of the same body in moon if it weights 16N on moon ?

$g = \frac{W}{M} = \frac{16}{10} = 1.6\ ms^{-2}$

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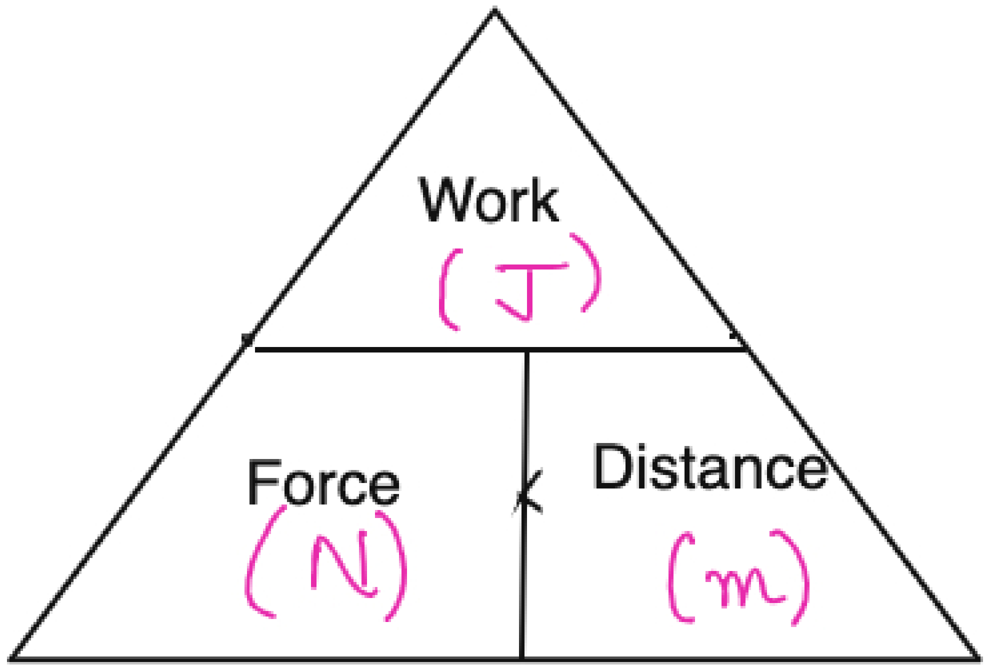
FORCE AND WORK RELATIONSHIP



Energy transferred = Work Done

Q1 Calculate the work done when the force of 100 N moves the object to a distance of 2m ?

Q2 Calculate the force applied when 100 J of work is done to move an object to a distance of 5 m ?

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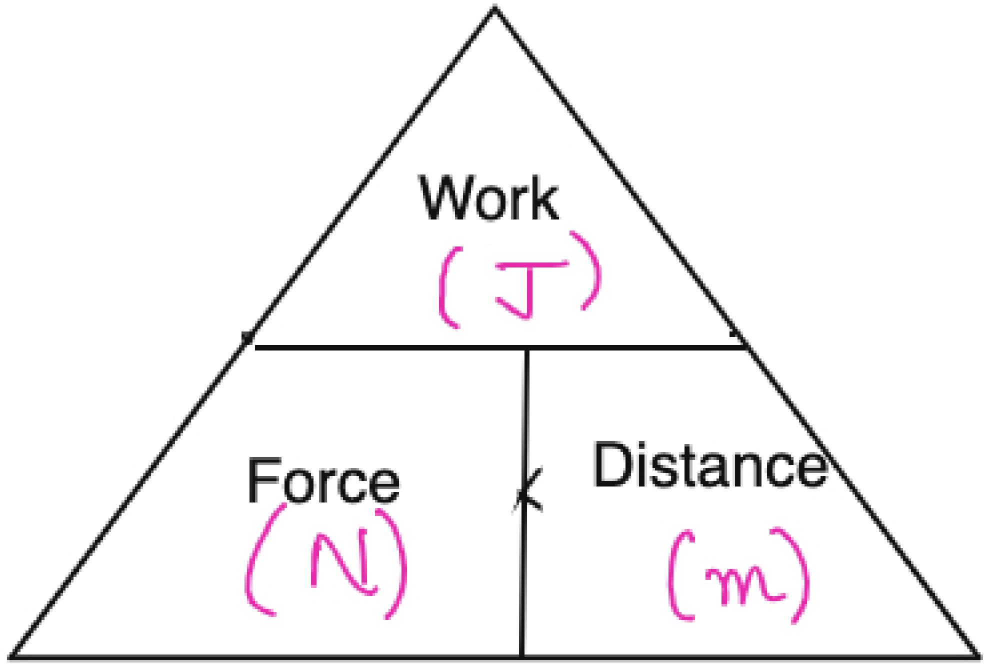
FORCE AND WORK RELATIONSHIP



Energy transferred = Work Done

Q1 Calculate the work done when the force of 100 N moves the object to a distance of 2m ?

$$W = F \times s$$
$$= 100 \times 2$$
$$= 200 J$$

Q2 Calculate the force applied when 100 J of work is done to move an object to a distance of 5 m ?

$$F = \frac{W}{D} = \frac{100}{5} = 20 N$$

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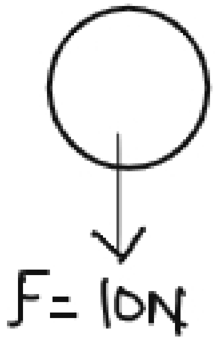
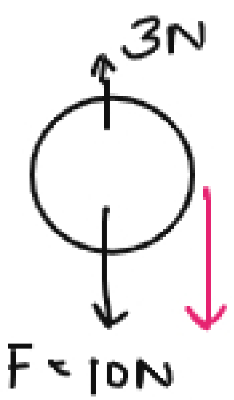
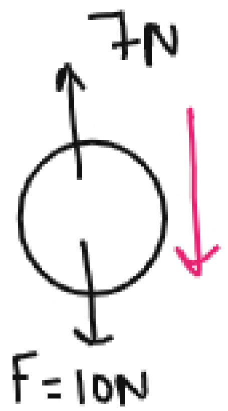
FREE FALL



(air resistance)

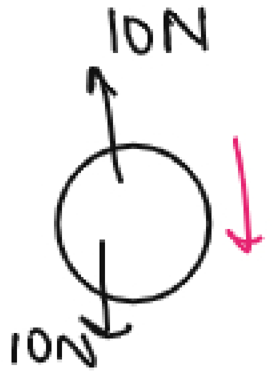


Resultant force = 7N, downwards.



(air resistance)

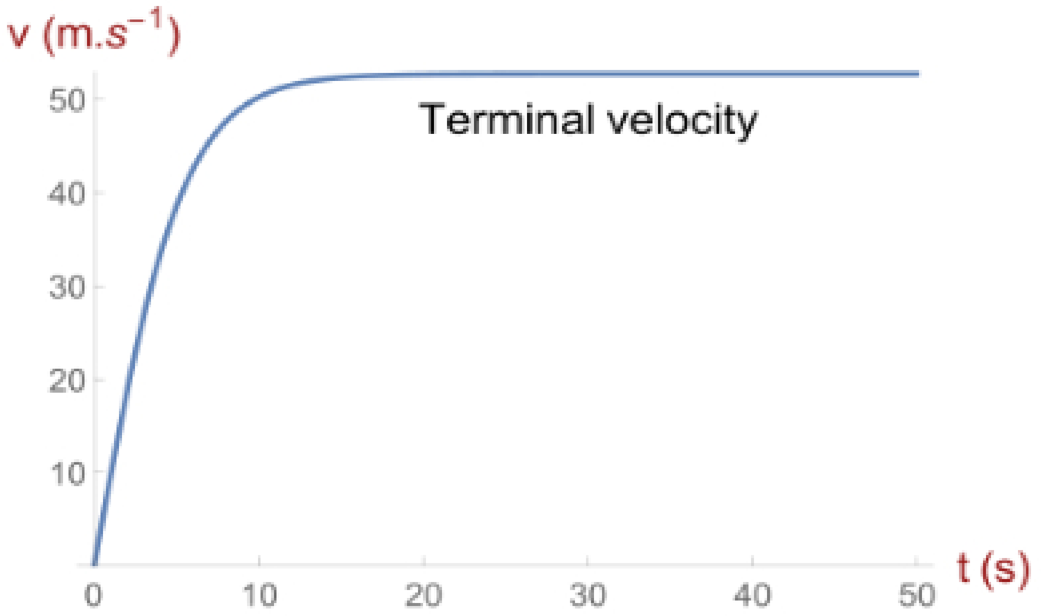
Resultant force = 3N (downwards)



Resultant force = 0.
Acceleration zero
constant velocity.

TERMINAL VELOCITY

It is the constant velocity of an object when the resultant force is zero and the weight of the body is balanced by the drag and body has zero acceleration.



Terminal Velocity.

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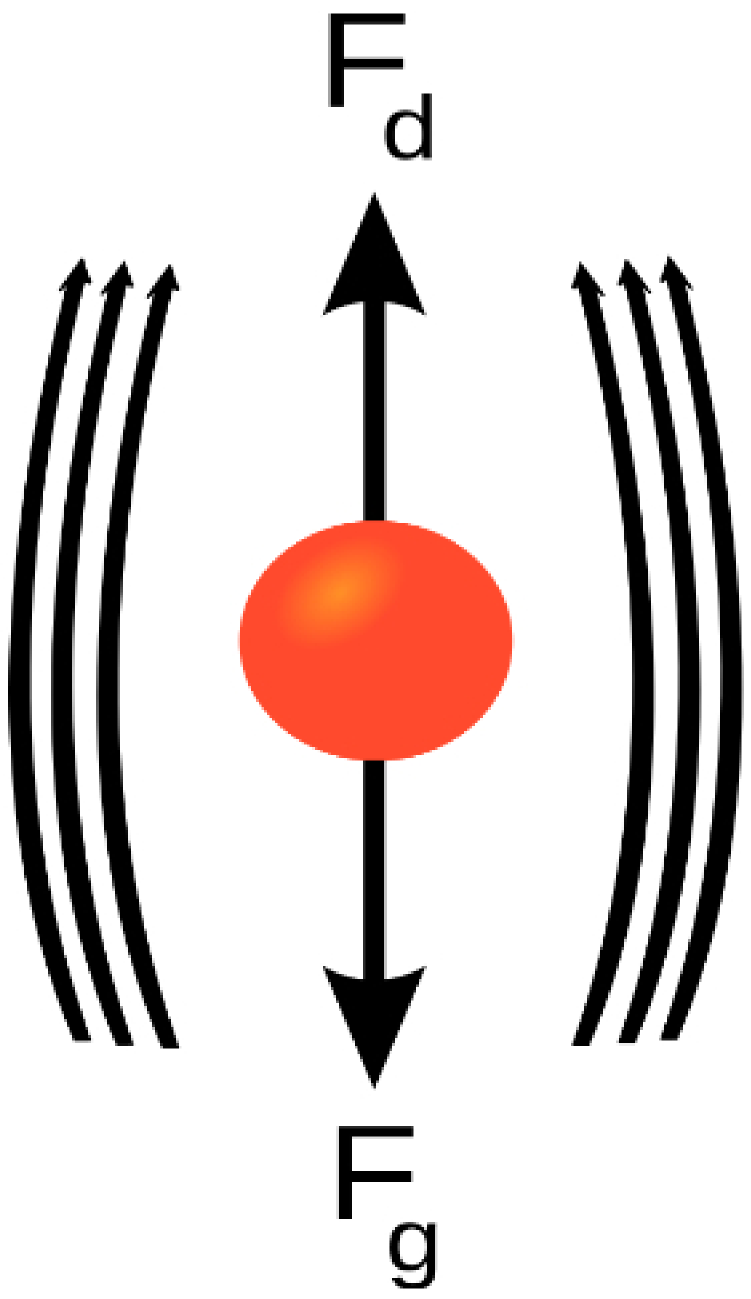
TERMINAL VELOCITY IN FLUIDS



In fluids, weight of the object is balanced by frictional force acting upwards.

The body falls with constant velocity as net force or resultant force acting on the object is zero, so the body falls at constant velocity called the terminal velocity.

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FORCES AND BREAKING

STOPPING DISTANCE

The shortest distance a vehicle can safely stop in.

It is the sum of thinking distance and braking distance

THINKING DISTANCE

The distance travelled by the body during its reaction time.

= Speed x reaction time

Affected by tiredness, drug, alcohols as all these affects the reaction time.

BRAKING DISTANCE

Distance travelled by the body when the braking force is applied.

Poor weather conditions, road conditions, poorly maintained vehicles, speed of the vehicle and the mass of the vehicle affects the same.

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MOMENTUM

Momentum =. Mass. X Velocity
kgms^{-1} (kg) (ms^{-1})

Momentum is a vector quantity

It has a magnitude as well as direction

Greater the speed, greater the momentum

Higher the velocity, higher the momentum

Principle of conservation of momentum

In a closed system, the momentum before the collission and after the collission remains unchanged.

$$m_1 v_1 = m_2 v_2$$

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CONSERVATION OF MOMENTUM

An object with the mass of 100 Kg moving with the velocity of 10 m/s collided with the mass of 20 kg object which is at rest.
After collission both the objects move together.
Calculate the speed after the collission.

Calculate the speed after collisions

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CONSERVATION OF MOMENTUM

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An object with the mass of 100 Kg moving with the velocity of 10 m/s collided with the mass of 20 kg object which is at rest.
After collission both the objects move together.
Calculate the speed after the collission.

Calculate the speed after collisions

Before Collission

$m_1 = 100kg \quad m_2 = 20kg$

$v_1 = 10m/s \quad v_2 = 0$

Momentum before collission

$100 \times 10 + 20 \times 0$

$1000 \, kgms^{-1}$

After Collission

$m_1 + m_2 = 120kg$

$v = ?$

$1000 = 120 \times v$

$v = \frac{1000}{120} = 8.33ms^{-1}$

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IMPACT FORCES

Relationship between force and momentum

Force is change in momentum over time.

$$F = \frac{\text{change in momentum}}{\text{Time}}$$

$$= \frac{mv - mu}{t} = m\left(\frac{v-u}{t}\right)$$

$$F = ma$$

If we increase the time and the momentum is conserved, the impact force can be decreased.

So greater impact time = reduced impact force

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CAR SAFETY FEATURES

All these features increases the impact time, decreasing the momentum and thus reduced the impact force.

SEAT BELTS

They spread the force across the person's body and increases the impact time which decreases the decelerting force

AIRBAGS

Airbags also spread the force, increases the impact time decreasing the impact force minimizing the injury.

CRUMPLE ZONES

They increases the impact time which changes the momentum of the passengers. As time is increased, impact force is decreased.

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FORCES AND ELASTICITY

Effect of force on elastic objects

Change shape or deformation by :-

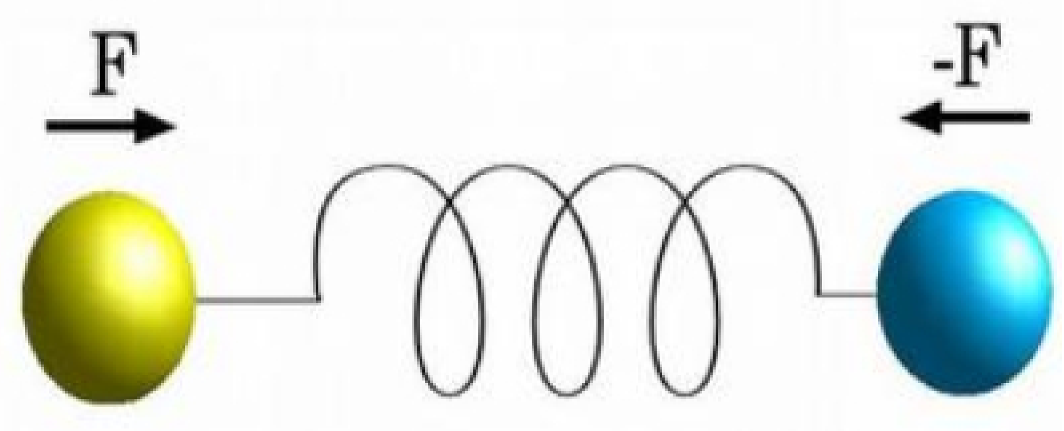
Bending
Stretching
Compressing

Elastic Deformation

Object regains its original shape when the force is removed like stretched rubber band

Inelastic Deformation

Object that does not gain its original shape and changes shape permanently.
Example: overly stretched rubber



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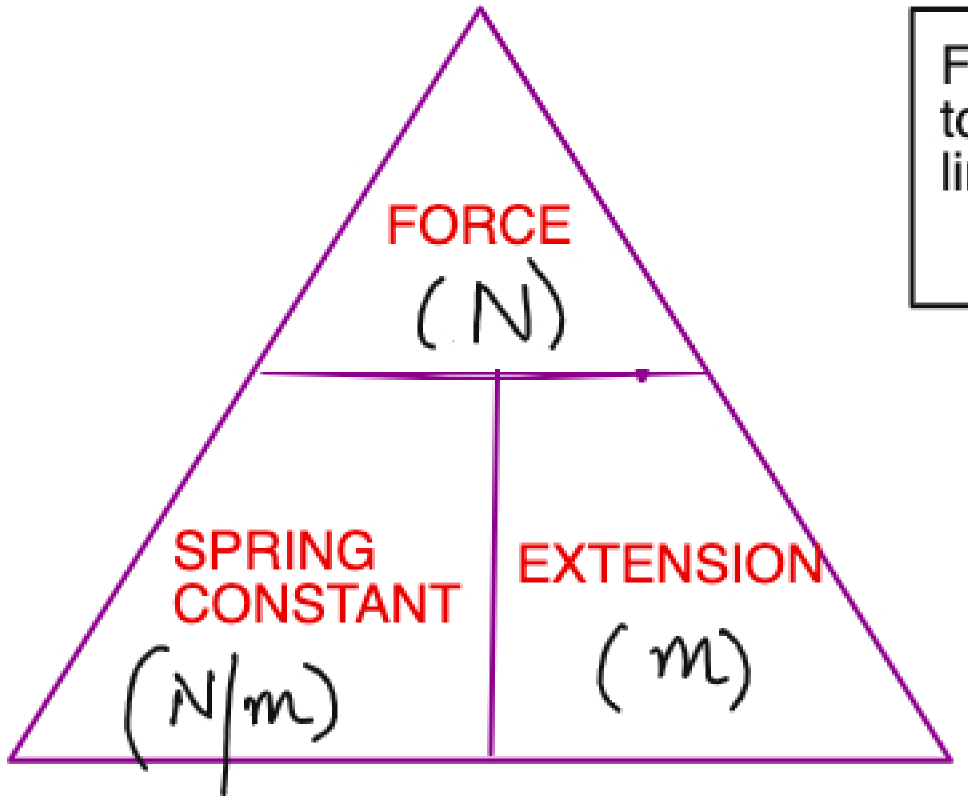
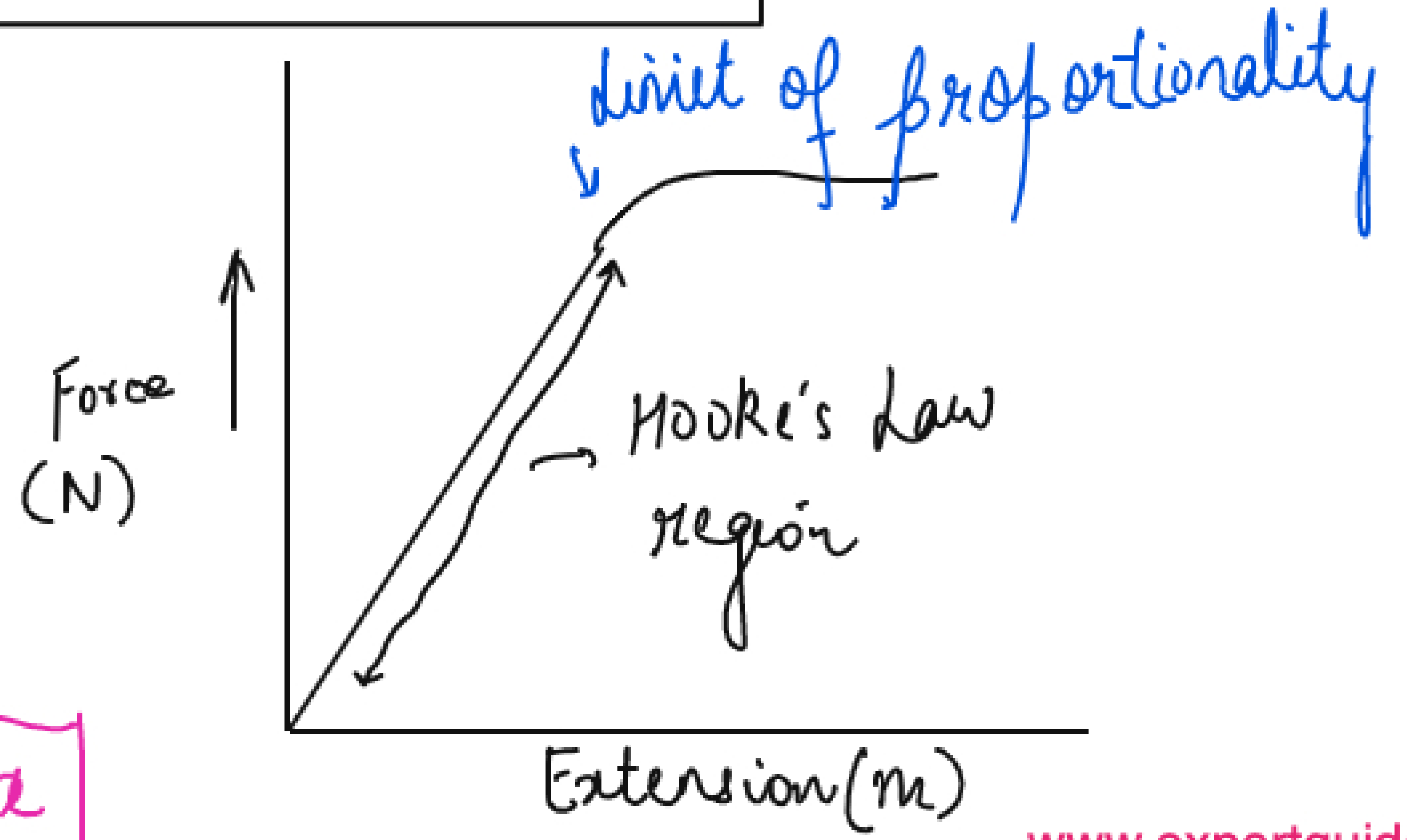
FORCES AND ELASTICITY

HOOKE's LAW

Force on a spring is directly proportional to the extension until it reaches its limit of proportionality.





$F \propto x$

$F = kx$

$F = -kx$

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FORCES AND ELASTICITY

SPRING CONTSTANT

It is the measure of the stiffness of the spring.
Greater the spring constant stiffer is the object.

$$k\ (N/m) = \frac{F\ (N)}{e\ (m)}$$

LIMIT OF PROPORTIONALITY

It is the point upto which the springs obeys Hooke's law. Beyond this point, the object comes in the plastic region and no longer obeys the Hooke's law.

Q1 Calculate the force applied on the spring when it is extended by 2m. The spring constant is 5N/m

Q2 Calculate the spring constant of a spring when a force of 50N extends the spring by 5 m.

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FORCES AND ELASTICITY

SPRING CONSTANT

It is the measure of the stiffness of the spring.
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$$k\,(N/m) = \frac{F\,(N)}{l\,(m)}$$

LIMIT OF PROPORTIONALITY

It is the point upto which the springs obeys Hooke's law. Beyond this point, the object comes in the plastic region and no longer obeys the Hooke's law.

Q1 Calculate the force applied on the spring when it is extended by 2m. The spring constant is 5N/m

$$F = kl$$
$$= 5 \times 2$$
$$= 10N$$

Q2 Calculate the spring constant of a spring when a force of 50N extends the spring by 5 m.

$$k = \frac{F}{l} \cdot \frac{50}{5} = 10N/m$$

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ELASTIC POTENTIAL ENERGY

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$$E = \frac{1}{2} k e^2$$

E = Elastic potential energy (J)
k = spring constant (N/m)
e= extention in the spring (m)

Elastic potential energy is the energy stored in the spring when it is stretched or compressed

Q1 Calculate the elastic potential energy of an object when a spring of spring constant 2 N/m is stretched by 20 cm.

Q2 Calculate the extension produced when 10 J of energy is transferred to a spring with a spring constant of 5N/m.

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ELASTIC POTENTIAL ENERGY

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k = spring constant (N/m)
e = extention in the spring (m)

Elastic potential energy is the energy stored in the spring when it is stretched or compressed

Q1 Calculate the elastic potential energy of an object when a spring of spring constant 2 N/m is stretched by 20 cm.

$$E = \frac{1}{2} \times 2 \times 0.2 \times 0.2$$
$$= 0.04 J$$

Q2 Calculate the extension produced when 10 J of energy is transferred to a spring with a spring constant of 5N/m.

$$10 = \frac{1}{2} \times 5 \times e^2$$
$$e^2 = 4$$
$$e = \sqrt{4}$$

$$e = 2 m$$

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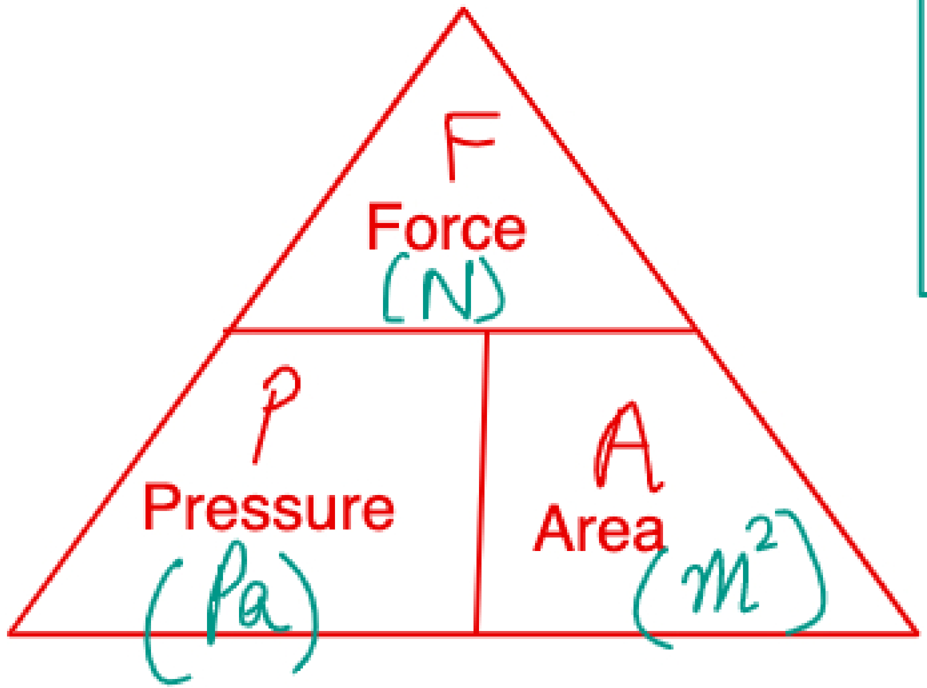
PRESSURE



Greater the force greater the pressure

Smaller the area more will be the pressure exerted

Q1 Calculate the pressure exerted when the force of 10 N acts on an area of 2 cm^2 ?

Q2 Calculate the force applied when 100 Kpa of Pressure is applied to an area of 4 cm^2 ?

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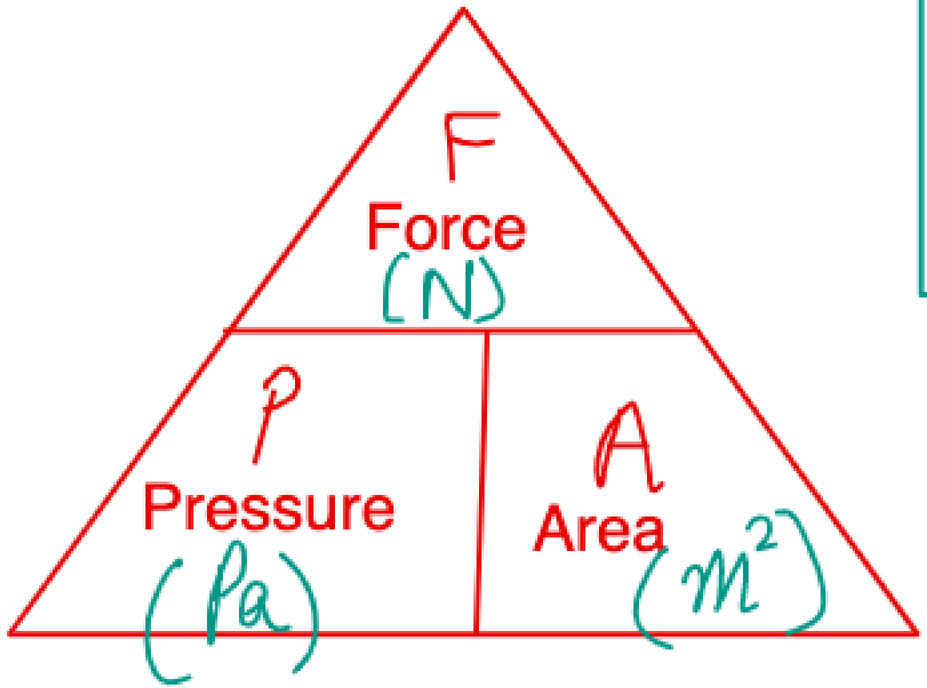
PRESSURE



Greater the force greater the pressure

Smaller the area more will be the pressure exerted

Q1 Calculate the pressure exerted when the force of 10 N acts on an area of 2 cm^2 ?

$$P = \frac{F}{A} = \frac{10}{0.02} = 500\ Pa$$

Q2 Calculate the force applied when 100 Kpa of Pressure is applied to an area of 4 cm^2 ?

$$F = P \times A = \frac{100 \times 10^3 \times 4\ m}{10^4}$$

$$= 40N$$

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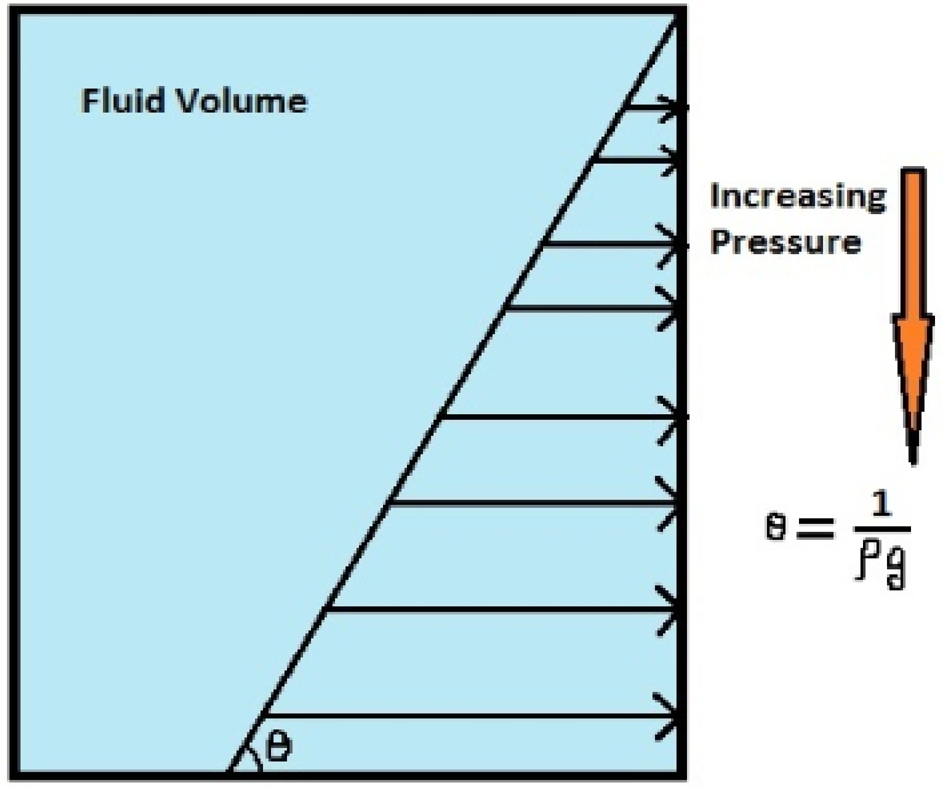
PRESSURE IN LIQUIDS



Pressure in liquids increases with depth.

The weight of the column above exerts the pressure.

$p = h \times \rho \times g$

- p: Pressure in a liquid (Pa)
- h: height of the column (m)
- ρ: density of the liquid ($kg\,m^{-3}$)
- g: gravitational field strength (N/kg)

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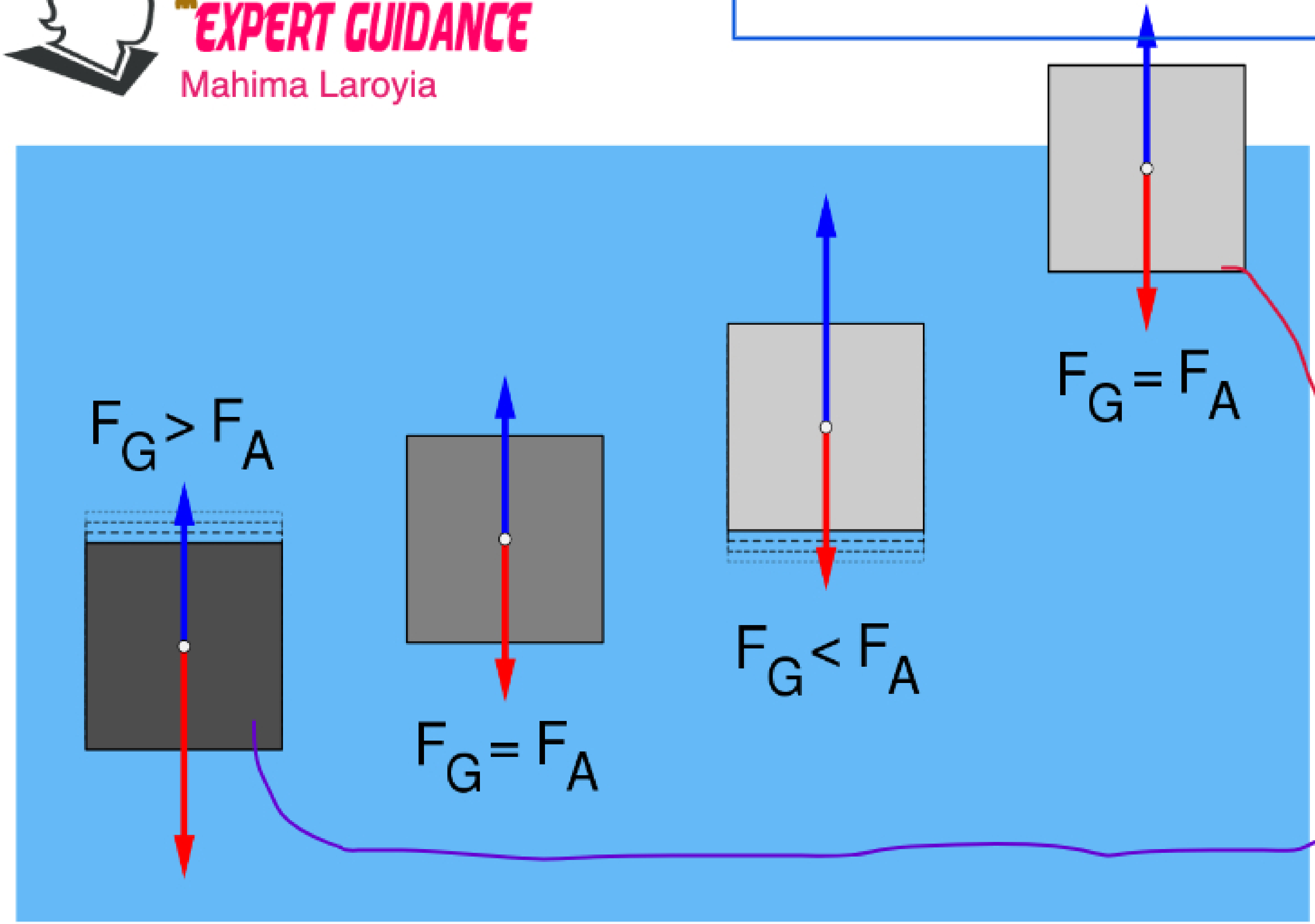
SINKING AND FLOATING



UPTHRUST

The upward force experienced by an object when it is submerged in water due to the pressure at the depth.

FLOATING

When the weight of an object is balanced by the upthrust.

SINKING

When weight is greater than upthrust.

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ATMOSPHERIC PRESSURE

Atmospheric pressure arises due to collission of the airparticles with the Earth's surface

It decreases with altitude as the number of particles decreases with height causing decrease in weight.

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KEY TERMS

a) Force
b) Scalar
c) Vector
d) Friction
e) Newton First Law
f) Newton Second Law
g) Newton Third Law
h) Resultant Force
i) Free Body Diagram
j) Moments
k) Levers
l) Gears
m)Centre of Mass

n) Speed
o) Velocity
p) Acceleration
q)Weight
r) Terminal Velocity
s) Thinking Distance
t) Breaking Distance
u)Momentum
v) Collissions
w) Hooke's Law

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KEY TERMS

a) Force

Force is push or pull on an object that causes an object due to
interaction with another object that causes an object to:-
a) change speed
b) Change direction
c) change shape

b) Scalar

Quantity that has magnitude only.
eg Length, Area, Volume etc

c) Vector

Quantity that has magnitude as well as direction. eg Displacement, velocity, acceleration, momentum

d) Friction

Friction is a contact force that opposed motion between the
two surfaces that are in physical contact.

e) Newton First Law of Motion

If an object is at rest it will remain at rest
If an object is in motion it will continue to move with the same
speed and direction unless no resultant force acts on it.

f) Newton Second Law of Motion

The acceleration of a body is
a) directly proportional to the resultant force
b) inversely proportional to the mass of an object

g) Newton Third Law of Motion

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

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KEY TERMS

h) Resultant Force It is the total force that acts on the body. It is the sum of all the forces that acts on the body .The resultant force decides the speed and the direction of the body

i) Free Body digrams are the graphical illustration to represent all the forces acting on a body.

j) Moments: It is the turning effect of force. It is calculated by force multiplied by the perpendicular distance from the pivot.

Moment: It is the turning effect of force.

q)Weight: It is the force acting on the body due to gravity

k) Levers : In all these levers, the turning effect of force is greater by increasing the distance of effort further away from the pivot. It increases the turning effect and multiply the force with a small effort.

l) Gears : GEARS TRANSMIT TURNING EFFECT OF FORCE

m)Centre of Mass: It is the point at which the entire mass of the object can be thought as being concentrated.

n) Speed: It is the distance travelled divided by the time taken.

o) Velocity: Speed in a given direction

p) Acceleration: It is the change in speed over time taken.

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KEY TERMS !!!!

r) Terminal Velocity: It is the constant velocity of an object when
the resultant force is zero and the weight of the body is balanced by the drag and body has zero acceleration.

s) Thinking Distance: The distance travelled by the body during its reaction time.

t) Breaking Distance: Distance travelled by the body when the braking force is applied.

u)Momentum: It is the product of mass and velocity.

v) Conservation of Momentum: In a closed system, the momentum before
the collission and after the collission remains unchanged.

w) Hooke's Law: Force on a spring is directly proportional
to the extension until it reaches its limit of proportionality.

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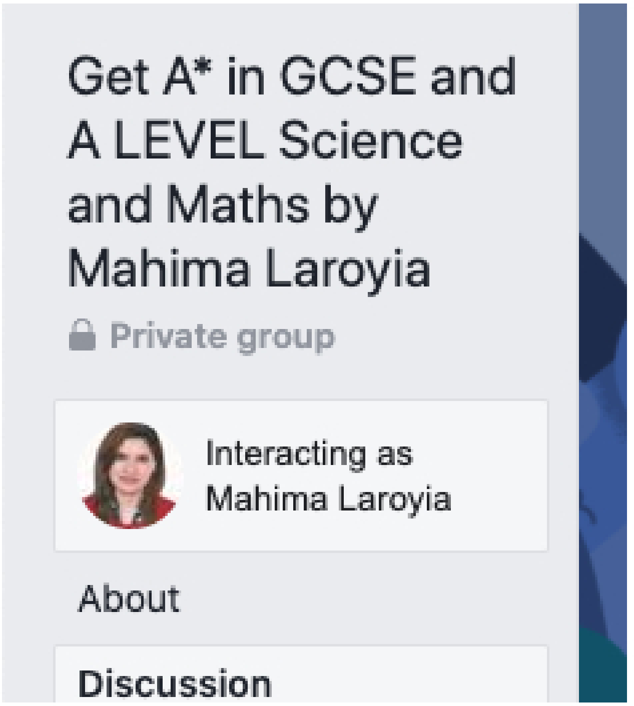
NEXT STEP !!!!

Check the Specification

Exam Questions on this topic



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