PHYSICS NOTES FOR ‘O’ LEVEL

(S.1 WORK)

Physics- Is a branch of science concerned with the study of matter in relation to energy.

Certain properties of matter are measured in physics and the results are examined to see if there is any mathematical relationship between them. The equations that we meet in physics are a convenient way of expressing laws governing the behavior of matter.

Matter is anything that occupies space and has weight.

There are three fundamental quantities measured in physics, namely:

1. Length

2. Mass

3. Time

Measurement

INTERNATIONAL SYSTEM OF UNITS (S.I UNIT)

This is a metric system of measurements recommended in physics. S.I unit were derived from the M.K.S system. These first 3 basic units are the metre (m), kilogram (kg) and second (s)

LENGTH

Length is a distance between two fixed points or is a space between two points.

S.I unit of length is metres (m)

Other units

Kilometres (km), centimetres (cm), millimetres (mm), Inches, yards, miles etc.

Km = 1000m

1m = 1000cm = mm

1cm = 10mm.

Very small lengths are measured in micrometer and nanometers (nm).

1m = 1,000,000nm = 10^6 nm

1m = 1,000,000,000nm = 10^9 nm ***Example,*** Convert the following measurements.

(a) 20mm to metres.

1m = 1000mm = $\frac{1}{1000}$m

20mm = $(\frac{1}{1000} \times 20)$

= 0.02m

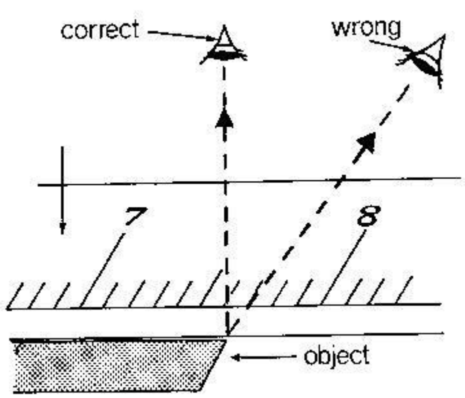
b) 0.8m to centimeters.

Length is measured using:

- Metre rule
- Tape measure
- Calipers
- Micrometer screw gauge
- Thread.

METRE RULE

Length measurement made with a metre rule should be correctly *read as shown below:*



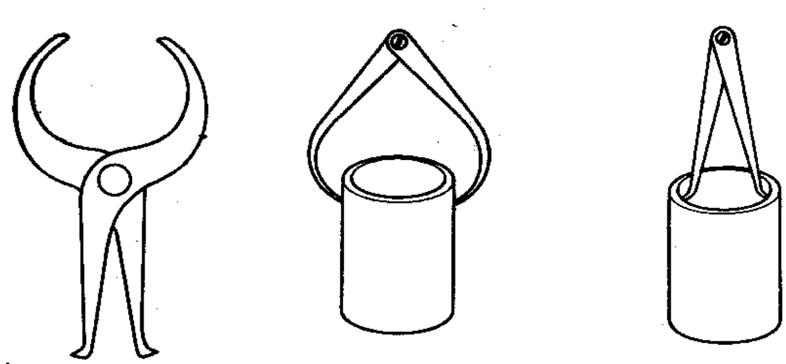
The eye must be right over the mark on the scale, and the reading should be to one decimal place i.e. 7.6cm.

CALIPERS: These are used to measure distance in solid objects where an ordinary metre rule cannot be applied. They are made out of pair of hinged steel jaws which are closed until they touch the object in the desired position.

Calipers are of two types namely:

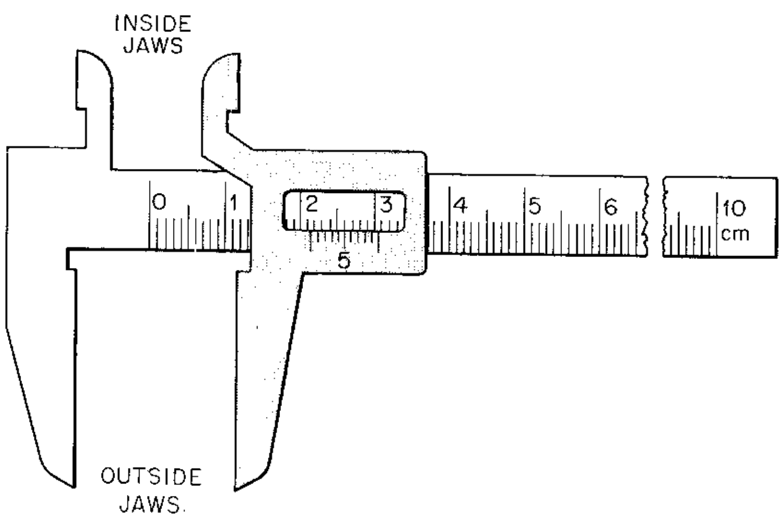
1. Engineer's calipers
2. Vernier calipers

ENGINEER'S CALIPERS



The distance between the jaws is after wards measured on an ordinary scale.

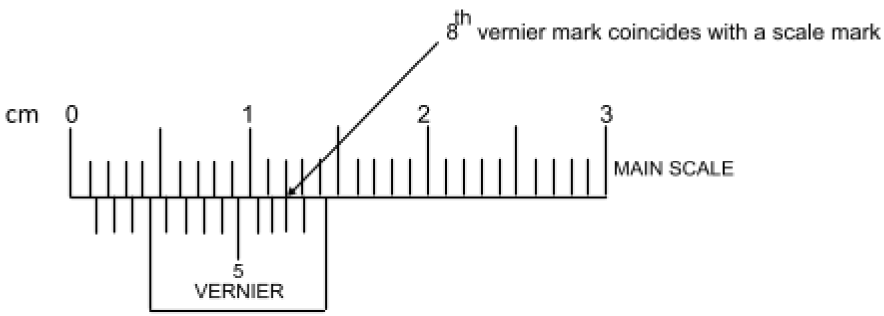
VERNIER CALIPERS OR SLIDE CALIPERS



This consists of steel scale with a fixed jaw at the end. The object whose diameter is to be measured is placed between the fixed jaws and the sliding jaws.

The inside jaw enables measurements such as internal diameter of tubes to be measured. It is used to measure diameter of objects like tins, cylinders, breakers etc. The Vernier scale enables the second decimal place to be measured accurately without having to estimate it

HOW TO READ A VERNIER



The main scale is in centimeters, 1cm has 10 divisions each division is

$\frac{1}{10}$ cm = 0.1cm.

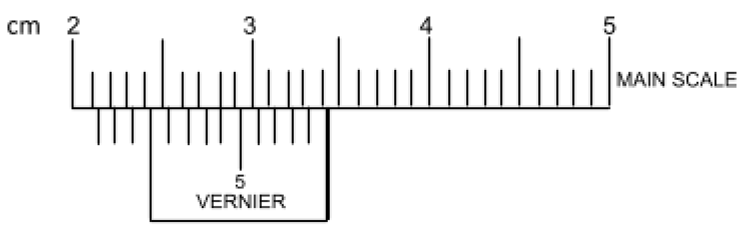
Vernier scale, each division is 0.01cm.

READING OF VERNIER CALIPERS,

1. Record the reading on the main scale to two places in cm.

2. Look along the Vernier scale carefully until you see division on it which coincides with the main scale, this gives the second decimal place.

Examples:

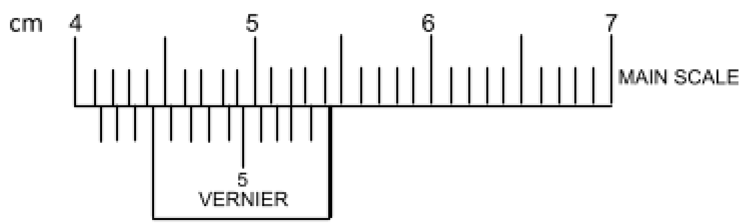


Main scale = 2.40cm

Vernier scale = 0.04cm

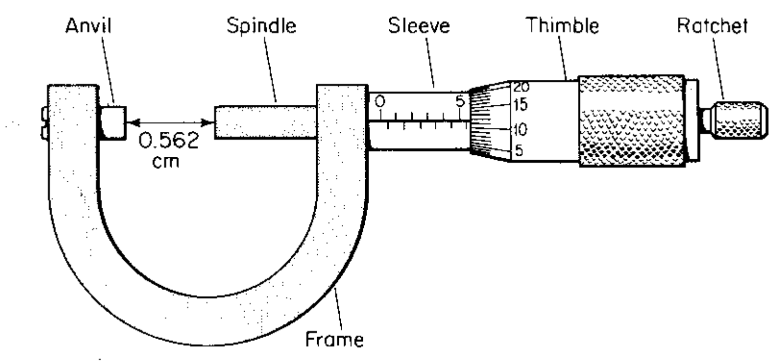
Final reading = 2.44cm

1. What readings are represented in the diagrams below:



MICROMETER SCREW GAUGE

This is used to measure small distance such as diameter of pieces of wire, bicycle spoke pins, needles etc.



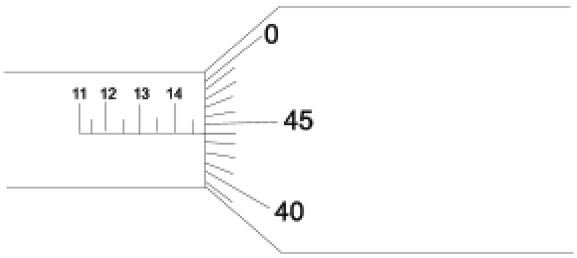
The instrument measures up to 2 decimal places in mm.It consists of a spindle which can be screwed and it is fitted with a scaled thimble.

For each turn the spindle moves through 0.5mm.The fraction each turn is indicated on the thimble. This has a scale of 50 divisions on the thimble represents $\frac{1}{50th}$ of half a millimeter i.e.

$\frac{1}{10}$ X 0.5mm = 0.01mm.

The sleeve-reading gives units to the 1st two decimal places and the thimble gives 2nd decimal place.

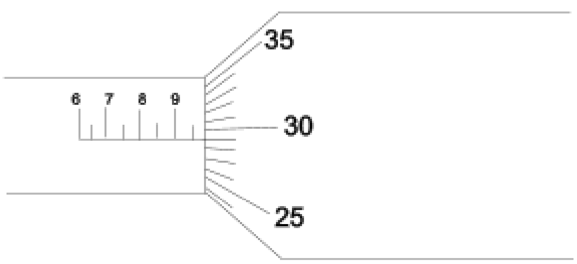
Example: 1.What readings are represented in the diagrams:



Sleeve scale reading = 14.50mm

Thimble scale reading = 0.44mm

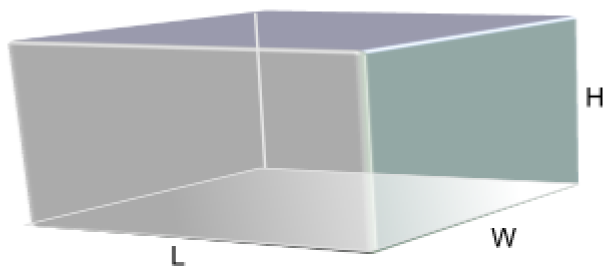
= 14.94mm



PRECAUTIONS TAKEN WHEN USING A MICROMETER SCREW GAUGE.

1. The faces of the anvil and the spindle must be cleaned to remove dust so as to get accurate readings.
2. The reading must be checked.
3. Measurement of area of object.

Cuboid



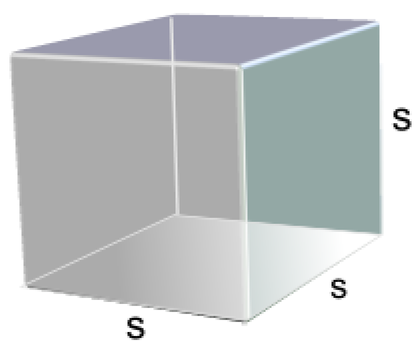
H = Height, L = Length, W = Width

Surface area = 2(L x W) + 2(L x h) + 2(W x h)

= 2Lw + 2Lh + 2Wh

= 2(LW + (h + Wh)

Cube



Surface area = 2(s x s) + 2(s x s) + 2(s x s)

= $2s^2 + 2s^2 + 2s^2$

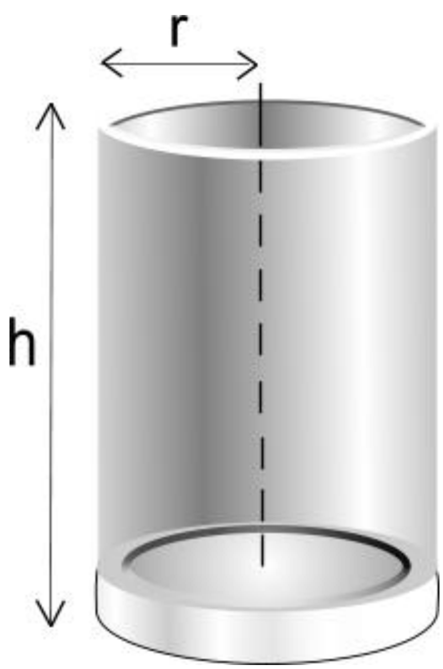
= $6s^2$

Cylinder:

(a) Open cylinder

h

Surface area = πr^2 + 2πr h

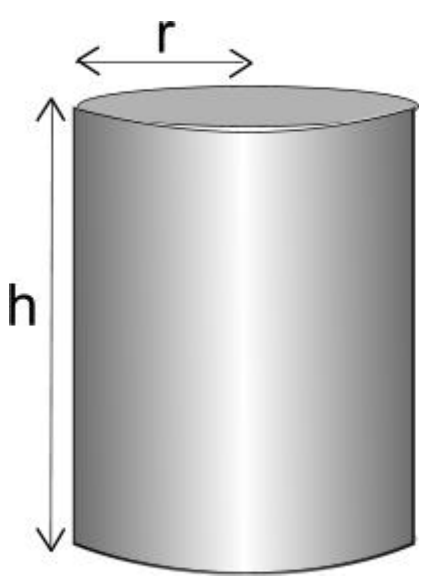


$= \pi r\ (r + 2h)$

Where r is the radius of the cylinder

h is the height of the cylinder

Closed Cylinder**.**



Surface area = $\pi r^2 + 2\pi rh$

$= 2\pi r\,(r + h)$

SI unit area; Square metre (m^2)

Other units mm^2, cm^2, dm^2, Dm^2, Hm^2, Km^2

NB: $1m^2$ = 100cm x 100cm

= $10,000cm^2$

$1m^2$ = 1,000,000mm

VOLUME:

Volume is space occupied by an object.SI unit is in metre cubed (m^3).

Other units mm^3, cm^3, dm^3, litre, milliliters.

NB: 1 Litre = $1000cm^3$

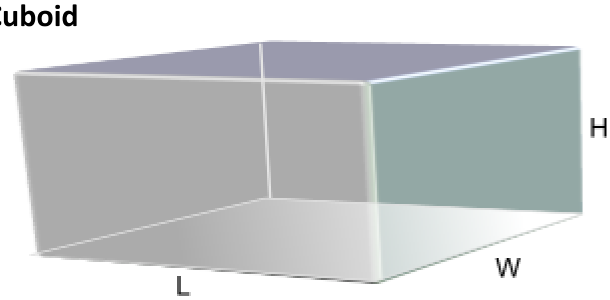
$1cm^3$ = $1000cm^3$

$1m^3$ = 100cm x 100cm x 100cm

=$1,000,000cm^3$

VOLUME OF REGULAR SHAPED OBJECTS

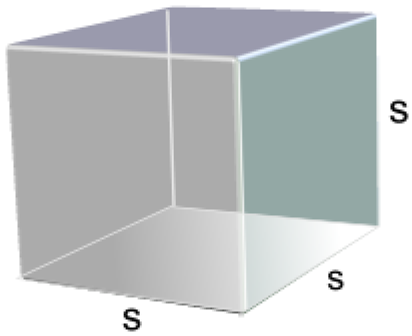
1. **Cuboid**



Volume = L x W x H

2. Cube

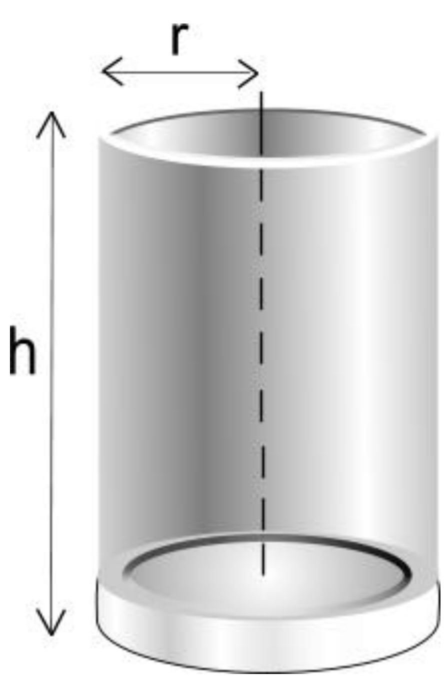
s Volume V **= s x s x s**



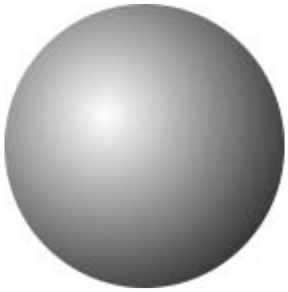
= s^3

3. Cylinder

Volume V = $2\pi r^2 h$



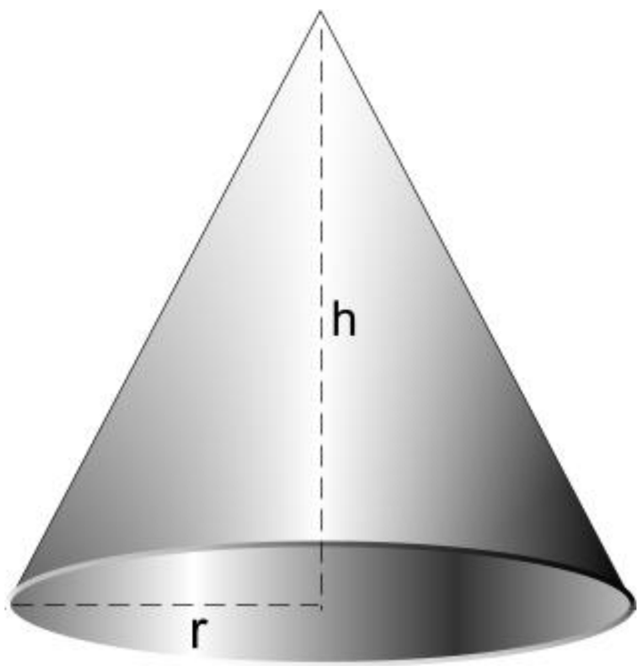
4. Sphere or circular object.



Volume V = $\frac{4}{3}2\pi r^3$

5. Cone

Volume V = $\frac{1}{3}\pi r^2 h$



VOLUME OF IRREGULAR SHAPED OBJECTS

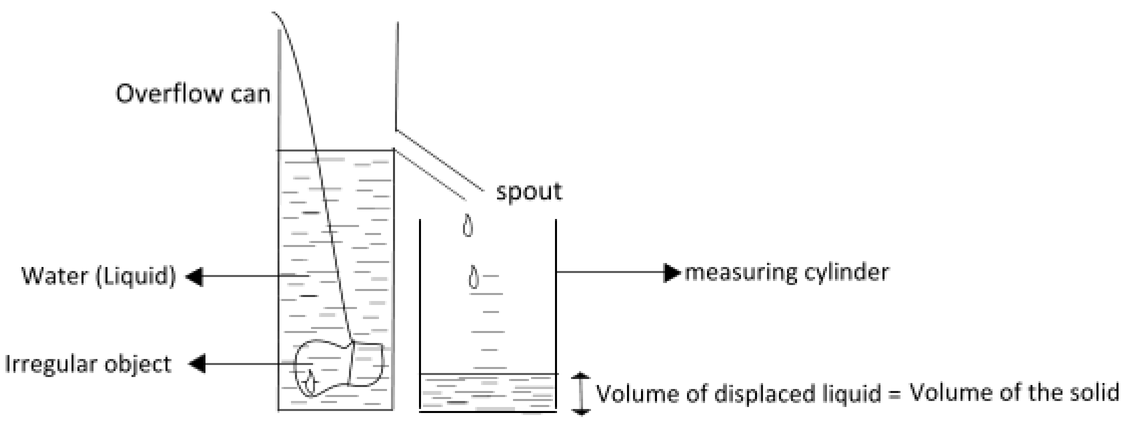
The volume of irregularly shaped objects is found by using the displacement method.

Procedure:

-An over flow can is filled with water or liquid.

-The irregular shaped object e.g a stone is tied onto a string and carefully lowered into the liquid in the overflow can. The liquid level is displaced.

The liquid flowing out of the can through the spout is collected using a measuring cylinder.It has a scale on it to measure the volume of the liquid.

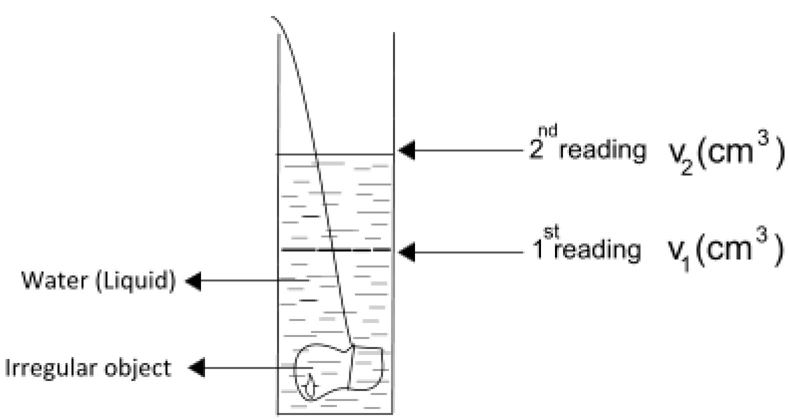


The volume of the liquid displaced is equal to the volume of the irregular object (stone).

METHOD II : Determining volume of irregular object

Procedure:

1. Liquid e.g. water is poured into a cylinder and the volume noted on its scale.



- A thread is tied around the irregular.
- The liquid flowing out of the can through the spout is collected using a measuring cylinder.
- Object leaving some of its thread loose.
- The solid (object) is lowered into the liquid in the cylinder and the 2nd reading noted.
- Volume of the solid is obtained from:
- volume 2nd reading - Volume 1st reading
- Therefore, $V = V_2 - V_1$

Volume of liquids

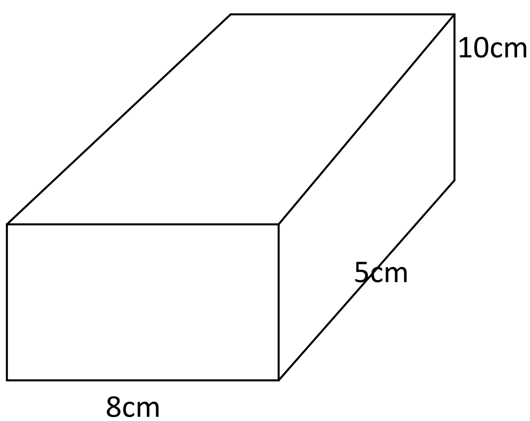
- To measure fixed volumes, the following vessels are used:

  Measuring flask, measuring cylinder, beaker, pipettes etc.

- To measure varying volumes use a burette.

Exercise:

1. Use the cuboid below to answer questions that follow.



Find the volume (i) in cm^3

Volume = L x W x H
= 8cm x 5cm x 10cm
= **$400cm^3$**

(ii) In m^3

Volume in cm^3 = L x W x H

= 8cm x 5cm x10cm

= $400cm^3$

Volume in m^3

$1m^3 = 1000,000\ cm^3$

$400cm^3$ $= \frac{400}{1,000,000} m^3$ = **$0.0004m^3$**

2. A cuboid has dimensions 2cm by 10cm. Find its width in metre if it occupies a volume of $80cm^3$.

solution

L x W x H = V

2cm x W x 10cm = $80cm^3$

W =4cm

Width in m

4cm $= \frac{4}{100}$ m

= **0.04m**

3(a) Find the volume of water in a cylinder of water radius 7cm if its height is 10cm.

Volume = $\pi r 2h$

= $\frac{22}{7}$ x 7cm x 7cm x10cm

= **$1540cm^3$**

(b) The volume of the cylinder was $120m^3$.When a stone was lowered in the cylinder filled with water the volume increased to $15cm^3$.

Find the

(i) Height of the cylinder of radius 7cm.

Volume v= $\pi r^2 h$

$12 = \frac{22}{7} x 7^2 x h$

$\therefore$ h = 0.078 cm

Mass

Mass is the quantity of matter a body contains. SI unit is the kilogram (kg).

Other units are milligrams (mg), grams (g), tones (t), micrograms (mg).

Note: 1 tonne = 1000kg

1 kg = 1000g

1 g = 1000mg

1g = 1,000,000Mg

Mass of the body is measured using the following instruments:

- Bean balance
- Lever – arm-balance
- Top-arm-balance

Example:

1. Convert : 400g to kg

1000g =1kg

400g = $\frac{400}{1000}$= **0.4kg**

Exercise:

(i) 0.84kg to g
(ii) 5000kg to tonnes
(iii) 0.84 tonnes to g

TIME:

This is the interval between events or is the duration between events.

SI unit is seconds (s)

Other units are:

- Minutes - Hours - weeks - years
- Micro seconds - Days - months - decades.
- Century - millennium

Time is measured using the following instruments.

- Watches - stop clocks.
- Clocks - stop watches.

NB.

- 1 Minute = 60 seconds
- 1 hour = 60 minutes = 360 seconds
- 1 day = 24 hours
- 1 week = 7 days
- 1year = twelve (12 months)

Example

1(a) Convert

(i) 2days to seconds

= 2 x 24 60 x 60

= 172800 seconds

(ii) 72 hours to seconds

1 hours= 3600seconds

72 hours = (72 x3600) seconds

= 259200 seconds

(iii) 20 minutes to hours

60 minutes = 3600 hours

20 minutes $= \frac{20}{360}$

$= \frac{1}{3}$ hours

(iv) 4days to seconds

4 x 24 x 60 x60 x 60 x 60 seconds

= 1244160000 seconds

Scientific notation and significant figures.

- A number is in scientific form, when it is written as a number between 1 and 9 which is multiplied by a power of 10.
- Scientific notation is used for writing down very large and very small measurements.

Example:

(i) 598,000,000m = 5.98×10^8m

(ii) 0.00000087m = 8.7×10^{-7}m

(iii) 60220m = 6.022×10^4m

Questions:

Convert the following to scientific form.

(a) 0.048 = 4.8×10^{-2}

(b) $\frac{3}{4}$ = 0.75

= 7.5×10^{-1}

(c) 1000 = 1.0×10^3

(d) 8.72 = 8.72×10^0

(e) $\frac{1}{8}$ = 0.125 = 1.25×10^{-1}

SIGNIFICANT FIGURES

All figures from 0-9 are significant figures except 0 (zero) at the beginning.

Eg a) 3 0 0 8

4^{th} sf

3^{rd} sf

2^{nd} sf

1^{st}

b) 0 2 3

3^{rd} sf

2^{nd} sf

1^{st} sf

c) 2.30 cm

3^{rd} sf

2^{nd} sf

1^{st} sf

Questions

Write the following to the stated significant figures

a) 28.8 to 3 s.f b) $\frac{2}{7}$ to 2 s.f c) 4.027×10^{-2} to 3 s.f

DENSITY

Density is the mass per unit volume of substance.

Density $= \frac{Mass}{Volume}$

The symbol for density ρ called *Rho.*

SI unit for density is kilogram per cubic metre (kg/m^3)

Other units for density:

g/cm^3 eg density of iron metal is 0.8g/cm3.This means that 8gm of iron have a volume of 1cm3.

Example:

Find the density of a substance of;

(i) Mass 100g and volume $10cm^3$
(ii) Mass 9kg and volume $3m^3$.

Solution:

(i) Density $= \frac{Mass}{Volume}$

$= \frac{9kg}{3m3}$

$= 3kg/m^3$

(ii) Density $= \frac{Mass}{Volume}$

$= \frac{100g}{10cm3}$

$= 10g/cm^3$

.

Converting density from g/cm^3 to kg/m^3

The density of the substance in g/cm^3 is multiplied by 1000 in order to convert to kg/m^3.And to convert from kgm^{-3} to $gcm^{-3,}$ divide by 1000.

Example:

The density to water is $1.0g/cm^3$. Find its density in kgm^{-3}.

Density $= 1.0gm^{-3}$

$= 1.0 \times 1000kgm^{-3}$

$= 1000kgm^{-3}$.

2. A piece of steel has a volume of 12cm^3 and a mass 96g.Find its density.

(a) In g/cm^3

Density = $\frac{Mass}{Volume}$ = $\frac{96g}{12cm3}$= **8g/cm^3**

(b) 8g/cm^3 to kg/m^3

= 8 x 1000

= 8000kg***/m³***

2. The oil level in a burette is 25cm^3.50 drops of oil fall from a burette. If the volume of one drop is 0.1cm^3.What is the final oil level in the burette.

Volume of one water drop = 0.1cm^3

Volume of 50 water drops = $\frac{1}{10}$ x 50cm^3 = 5cm^3

Final level = 25cm^3+5cm^3= *30cm^3*

Question

1.A measuring cylinder has water level of 13cm.What will be the new water level if 1.6g of a metallic block of density 0.8g/cm^3 is added.

EXPERIMENT TO DETERMINE DENSITY OF REGULAR OBJECT

The mass of the solid is found using a beam balance. The volume of the object is obtained by measuring the dimensions length, width and height using a ruler, Vernier calipers.

HOW TO GET DENSITY OF IRREGULAR SHAPED OBJECTS eg. a stone

- The mass of a solid is measured using a beam balance.
- Its volume is found using displacement methods.
- The density is then obtained from

Density = $\frac{Mass(M)}{Volume(v)}$

Density of liquids

- The volume is measured using a measuring cylinder.
- The liquid is poured into the beaker of known mass m,
- The mass M_2 of the beaker containing the liquid is found using a beam balance.
- The density of the liquid will be.

Density = $\frac{M}{V}$

Density = $\frac{M_2 - M_1}{V}$

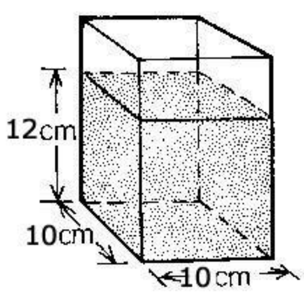
Density of Air

- A round bottomed flask is weight when full of air and its weighed again after removing air with a vacuum pump.
- The difference gives the mass of air.
- The volumes of air are obtained by putting water in the same flask and measure its volume using a measuring cylinder.
- The volume of water will be the volume of air.
- The density then calculated from;

Density = $\frac{Mass\ of\ Air}{Volume\ of\ Air}$

Examples

1. A Perspex box has a10cm square base containing water to a height of10 cm .a piece of rock of mass 600g is lowered into the water and the level rises to 12 cm.



a) What is the volume of water displaced by the rock ?

V = L x w x h

= 10 x10 x (12-10) = 200 cm^3

b) What is the volume of the rock ?

Volume of rock = volume of water displaced

= 200cm^3

Alternatively,

Volume of water before adding the rock V_1 = L x W x H

= (10 x 10 x 10) cm

= $1000cm^3$

Volume of water after adding the rock V_2 = L x W x H

= (10 x 10 x 12) cm^3

= $1200cm^3$

Volume of water displaced =$V_2 - V_1$

= (1200 – 1000) cm^3 = $200cm^3$

c) Calculate the density of the rock

Density = $\frac{Mass}{Volume}$

= $\frac{600g}{200cm3}$= $3g/cm^3$

2. A perspex box having 6cm square base contains water to a height of 10cm.
   a. Find the volume of water in the box.

      Volume of water in the box = L x w x h

      = 6cm x 6cm x 10cm

      = $360cm^3$

   b. A stone of mass 120g is lowered into the box and the level of water rises to 13cm.
      (i) Find the new volume of water?

      = L x w x h

      = 6cm x 6cm x 13cm

      = $468cm^3$

(i) Find the volume of the stone?

Volume of the stone = Volume of displaced water

= $V_2 - V_1$

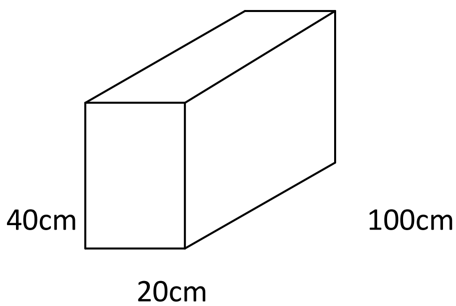
= 468 – $360cm^3$

= 108 cm^3

(ii) Calculate the density of the stone.

Density $= \frac{Mass}{Volume} = \frac{120g}{300cm3} = \frac{2}{5}$ g/cm^3

3. A steel C.P.U below, has a mass of 560g
   Find its density (i) in g/cm^3
   (ii) in kg/m^3



Volume $=$ L x W x H

$=$ (100 x 40 x 20) cm^3

$=$ 80,000cm^3

Density $= \frac{Mass}{Volume}$

$= \frac{560g}{80000cm3} =$ 0.007g/cm^3

(i) In kg/m3

Density = 0.007 x 1000

= 7kg/m^3

DENSITY OF MIXTURES

Suppose two substances are mixed as follows:

Substance	**Mass**	**Volume**	**Density**
X	M_1	V_1	$D_1 = \frac{M_1}{V_1}$
Y	M_2	V_2	$D_2 = \frac{M_2}{V_2}$

Then Density of the mixture = $\frac{Total\ mass\ of\ mixture}{Total\ volume\ of\ mixture}$

= $\frac{M_1+M_2}{V_1+V_2}$

Example;

Two liquids x and y mixed to form a solution. If the density of x = 0.8gcm^{-3} and volume = 100cm^3, y = 1.5cm^{-3} and volume = 300m^3.Find;

(i) The mass of liquid x

Density x Volume = 0.8 x 100gcm^3

= 80g

(ii) The mass of liquid

Density x Volume = 1.5 x 300 = 450g

(iii) Density of a mixture = $\frac{M1+M2}{V1+V2}$= $\frac{530}{400}$

= 1.325gcm^{-3}

RELATIVE DENSITY

This the ratio of the density of a substance to the density of water i.e

Relative density = $\frac{Density\ of\ substance}{Density\ of\ water}$

Example:

The density of aluminum is 2.7g/cm^3 and density of water is 1.0gcm^3.

Find the relative density of aluminum

Solution:

Relative density = $\frac{Density\ of\ Alminium}{Density\ of\ water}$

= $\frac{2.7g/cm3}{1.0g/cm3}$

Relative density of Aluminum = 2.7

Note:

(i) Relative density has no units.
(ii) It is numerically equal to the density of a substance expressed in g/cm^3.

(iii) Relative density measurements are in effect a density measurement.

Since relative density $= \frac{Density\ of\ a\ substance}{Density\ of\ water}$

And density of a substance $= \frac{Mass\ of\ substance}{Volume\ of\ substance}$

While density of Water $= \frac{Mass\ of\ water}{Volume\ of\ water}$

Relative density $= \frac{Mass\ of\ substance}{Volume\ of\ substance} \div \frac{Mass\ of\ water}{Volume\ of\ water}$

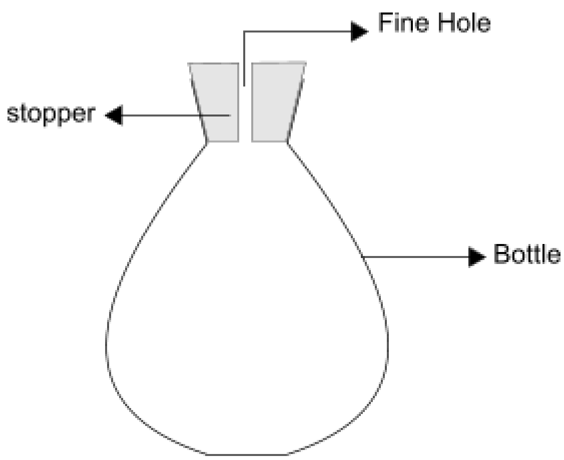
If volume of water = Volume of substance

Then; Relative density = $\frac{Mass\ of\ substance}{Volume\ of\ substance} \times \frac{Volume\ of\ water}{Mass\ of\ water}$

Finally, Relative density $= \frac{Mass\ of\ substance}{Mass\ of\ an\ equal\ volume\ of\ water}$

The relative density can be defined as the ratio of mass of a substance to the mass of an equal volume of water.

DETERMINATION OF REALTIVE DENSITY OF A LIQUID USING A DENSITY BOTTLE



To measure relative density of a liquid, we use a density bottle.
This bottle has a round glass stopper with a fine hole through it as shown below.

Procedure:

The bottle is weighed when empty and when full of a given liquid. The is then returned in the stock bottle.
After cleaning the bottle, it is filled with water and weighed again.

The results are set out as shown below.

Mass of the empty bottle = **a**
Mass of the bottle full of liquid = **b**
Mass of the bottle full of water = **c**
Mass of liquid = **b – a**

Mass of water = **c – a**

Relative density $= \frac{Mass\ of\ liquid}{Mass\ of\ water}$

Relative density $= \frac{(b-a)}{(c-a)}$

Relative density of liquid $= \frac{(b-a)}{(c-a)}$

Question;

1.A density bottle was used to measure the density of mercury. The following measurements were taken:

Mass of empty bottle = 20g
Mass of bottle full of mercury = 360g
Mass of bottle full of water = 45g

Calculate;

Relative density of mercury
Density of mercury

Solution

Relative density $= \frac{\text{Mass of mercury}}{\text{Mass of water}}$

$= \frac{b-a}{c-a}$

$= \frac{360-20}{45-20}$

$=$ 13.6g/cm^3

Relative density $= \frac{density\ of\ substance\ (mercury)}{density\ of\ water}$

$$13.6 = \frac{density\ of\ mercury}{1g/cm3}$$

Density of mercury = 13.6 x 1

= 13.6 x 1000

= $13.6gcm^{-3}$

= $136000kg/m^3$

2. Density bottle has a mass of 70g when empty, 90g when full of water and 94g when full of liquid.

Find the relative density of the liquid and its water.

Relative density $= \frac{Mass\ of\ the\ liquid}{Mas\ waters\ of}$

$= \frac{b-a}{c-a}$

$= \frac{94-70}{90-70} = \frac{24}{20} = 1\frac{1}{5}$ g/cm^3

Relative density $= \frac{Density\ of\ substance\ (liquid)}{density\ of\ water}$

$= \frac{1.2g/cm3x1}{1.2g/cm3x1} =$ $1.2g/cm^3$

ADVANTAGE OF USING DENSITY BOTTLE TO MEASURE RELATIVE DENSITY

It is fairly accurate way of obtaining relative density.

MEASUREMENT OF RELATIVE DENSITY OF A SOLID

This can be found by weighing the solid in air and when fully immersed in water. The solid immersed in water displaces an amount of water equal to its volume. The relative density is then calculated using;

Relative density = $\frac{Weight\ in\ \ air}{Weight\ in\ water}$

FORCE, MASS AND ACCELERATION

Force is a push or pulls that change a body's state or rest. If the force is applied on the body so that it moves,

It does so on in the direction of the force.

SI unit of force is a Newton (N)

Effects of force:

1. When force is applied on the body it may cause the following movement or motion.
2. The body accelerates
3. Change in shape.

Types of forces

They are various types of forces which exist in nature.
Some of these include:

(i) Gravitational force
(ii) Up thrust force
(iii) Friction force
(iv) Compression fore
(v) Tension force
(vi) Cohesion adhesion force.
(vii) Weight force.
(viii) Viscosity viscous force
(ix) Air resistance
(x) Centripetal force
(xi) Elastic force
(xii)Electoral static force.

GRAVITATIONAL FORCE

- Is the force that pulls an object toward the centre of the earth.
- When bodies fall under gravity, they have a constant acceleration due to gravity.
- On earth acceleration $g = 10m/s^2$
- The of the gravitational force on an object of mass m is given by $F = mg$

Example:

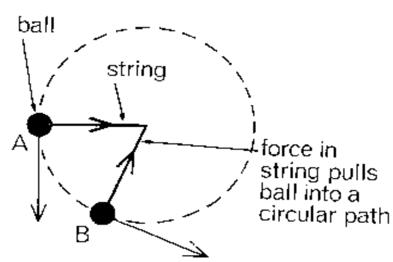
1. Find the gravitational force of a body of 2kg on earth.

Gravitational force $F = mg$

$= 2 \times 10 = 20N$

Centripetal force:

- Is a force which keeps bodies moving in circular path e.g vehicles on a roundabout, planets around the sun.
- Centripetal forces always act towards the centre of the path.



Weight:

Weight is a force exerted by a body on its free support. It is a pull of gravity on an object. The weight of a body of mass M is given by W = mg and its direction is always vertically downwards.SI unit is Newton (N).

Definition of a Newton.

A Newton is force required to give a mass of 1kg an acceleration of $1m/s^{2.}$

Example:

A piece of wood has mass of 2kg.Find its weight on earth ($g=10m/s^2$).

Solution

$W = mg = 2 \times 10 = 20N.$

Acceleration (g) varies slightly to the surface of the earth. Its value of the equator is slightly less than that at the poles. This implies that the weight of the body is slightly less at the poles.

Relationship between weight and mass;

Weight mass and for a body is got by multiplying mass and acceleration(g)   W = mg.

Differences;

Mass	**Weight**
Measure using beam balance	Measured using spring balance
SI unit is kilogram (kg)	SI unit Newton (N)
It is constant	Varies from place to place
It is a scalar quantity	It is a vector quantity
Quantity of matter	Force

1. An object weighs 50N on earth. What is the weight of the same object on the moon? Gravitation acceleration on the moon is 8 m/s^2 while on earth g = 10m/s^2

W   = Mg

50 = m x 10

M = 5N

Weight on the moon W   = Mg

= 0.5 x 8= 4N.

3. A body of mass 5kg is acted on by a force in horizontal direction as shown below.

$\boxed{\text{Mass = 5kg}} \longrightarrow F$

If the force causes an acceleration of 4m/s^2.Find the force F.

Force   F = ma

= 5 x 4

= 20N.

4. Find acceleration of the body of mass 8kg when acted upon by a force of 16N.

Force   = ma

16N   = m x a

Acceleration =2m/s^2.

Exercise;

1. An object has a mass of 6kg.Find its weight?

   (i) On earth where g = $10m/s^2$

   Weight = $10m/s^2$ x 6kg

   = 60N

   (ii) On Jupiter where = g = $12m/s^2$

   Weight = Mg= $12m/s^2$ x 6kg

   = 72N

   (iii) On mars where g = $3m/s^2$

   Weight = $3m/s^2$ x 6kg

   = 18N.

2. The weight of a body on earth 1.5 times than that on the moon. Given the mass of the body is 0.4kg and acceleration g = $10m/s^2$ on earth. Calculate;

   (i) Weight on earth

   W = mg = 0.4 x 10 = 4N.

   (ii) Weight on the moon = $^4/_{1.5}$ = 2.67N

   (iii) Acceleration due to gravity on the moon;

   W = mg

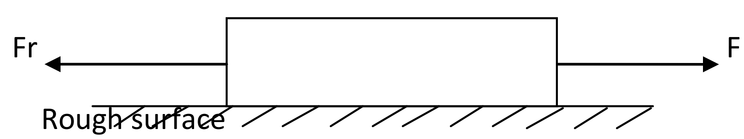
   2.67 = 0.4 x g

   a = $6.67m/s^2$

Friction:

Friction is a force that opposes relative motion of two bodies' contracts.

Friction acts in the direction opposite to that in which motion is taking place



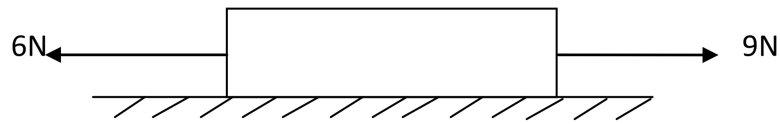
Where FR – Friction force

F – Force acting on the body

In the diagram above is force F moves the block to the right then friction acts with the block to the left.

Example:

A body of mass 3kg is acted on a horizontal force of 9N as shown below.



If the opposing friction is 6N. Find the acceleration of body.

Resultant force $F = (9 - 6) = 3N$

But force $F = ma$

$3 = 3a$

$a = 1m/s^2$

Question

A block of wood of mass 4kg acted upon by a horizontal force of 10N,if the block moves with an acceleration of $2mls^2$ .Find the friction ratio that opposes its motion.

Advantages of friction:

- Enables one to write.
- Enables one to light at a match box.
- Enables us to walk without sliding.
- Enables vehicles or bicycles to be brought to rest when brakes are applied.

Disadvantages of friction.

- Makes us un necessary noise.
- It delays work, retards movement.
- Bring about wear and tear.
- Produces un necessary heat.

Types of friction:

There are two types of friction met in practice namely:

- Static friction.
- Dynamic/kinetic or sliding friction.

Static friction presents motion where as dynamic friction slows down motion.

Ways of reducing friction:

- By lubricating.

Oil or grease is introduced between surfaces sliding over one another

The oil therefore keeps rough surface apart and friction is reduced.

- By using ball bearings
  Are used e.g. in axle and shaft of the bicycle, they do not slide but roll over one another.
  Rolling friction is less than sliding friction; therefore friction is reduced by the ball bearings.
  by using rollers between two rough surfaces.

VECTOR AND SCALAR QUANTITIES.
Vector quantity
Is the quantity which has magnitude and direction (size)
Examples include:
- Weight
- Acceleration, force, displacement, momentum, velocity, friction.

Scalar quantity.

It is a quantity which has only magnitude. Example includes:

Mass, speed, distance, time, density, volume, pressure, area, energy e.t.c.

Adding vectors and resultant forces.

When vector such a force are added their direction must be specified.

Resultant force

It is a single force which has the same effect as the two or more forces acting together at a point.

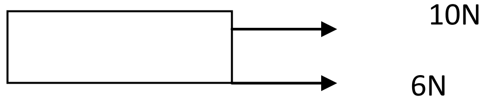
When two or more forces act on a body, the total force on the body is called the resultant force.

Adding force in the same direction.

When two or more forces act on the body in the same direction the resultant force is got by addition

Example:

(i)



Resultant force F = 10 + 6 = 16N

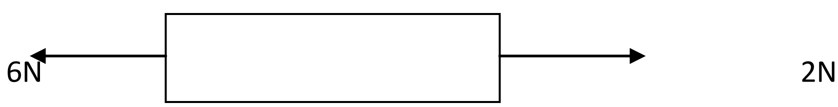
(ii)

Resultant force

F = (3 - 2) = 1N

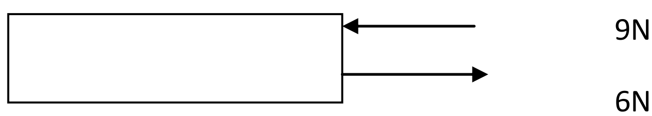
(a) When two or more forces act in opposite direction, the resultant force is got by subtraction.

(i)



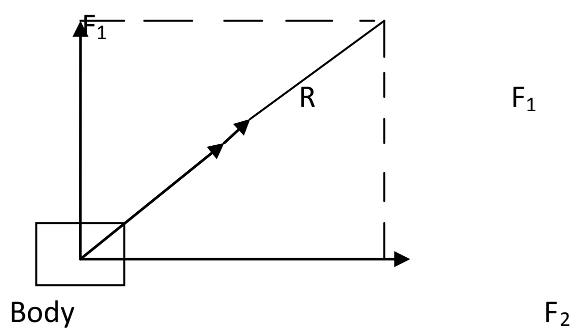
Resultant force

F = (6-2) = 4N to the left



(ii) Resultant force F = (9-6) N = 3N to the left

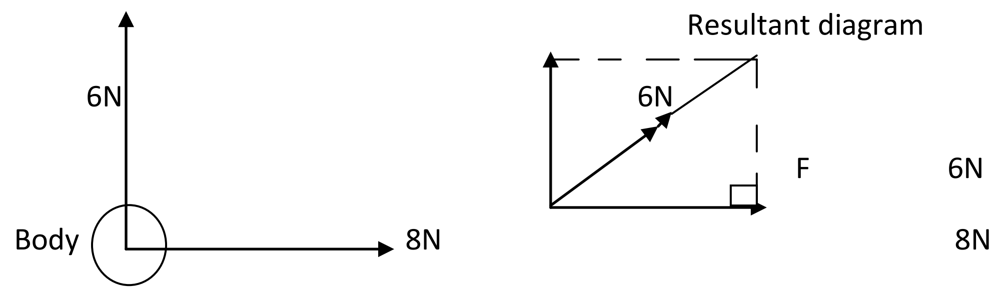
a. Forces of right angles.
   When two or more forces act on a body at right angles, the resultant force is obtained by use of Pythagoras theorem.



Resultant force R, $F^2 = F^2 + F^2$

F_2 $F = \sqrt{F^2_1 + F^2_2}$

E.g.1. Find the resultant force acting on the body shown.



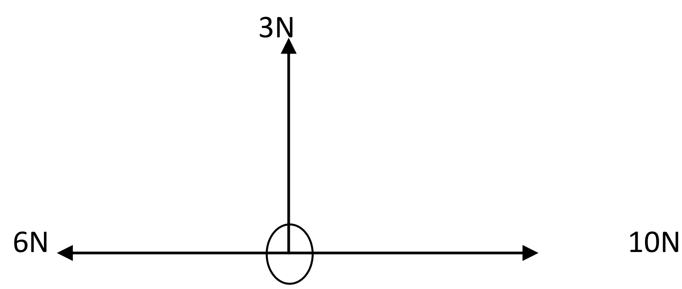
Resultant force F

$F^2 = 6^2 + 8^2$

$F^2 = 36 + 64$

F 10N

2. A body of mass 2kg is acted on by 3 forces of 10N, 6N and 3N as shown below.



Find the resultant force and acceleration of the body.

Resultant force = (10 - 6) N

= 4N to the right.

F = Ma

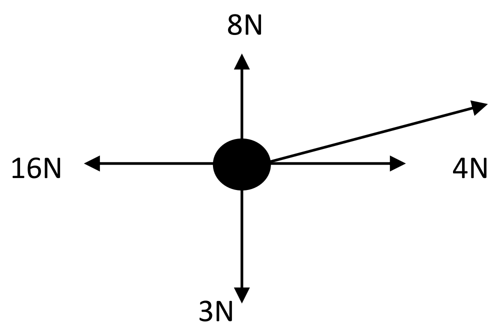
5N = 2a

$\frac{5N}{2} = \frac{2a}{2}$

$a = 2.5\ m/s^2$

Exercise:

1. Four forces act on a body as shown below;



Body of mass 2kg

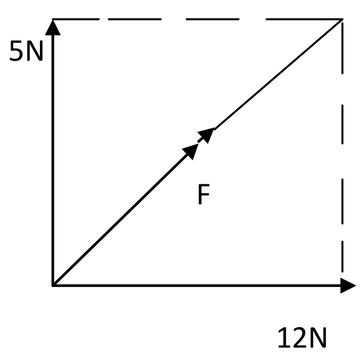
1.Find the resultant force and acceleration of the body.

Resultant force horizontally = (16N – 4N)

= 12N to the left

Resultant force vertically = (8N – 3N)

= 5N to the North



$F^2 = F^2 + F^2$

$= 12^2N + 5^2N$

$= 144N^2 + 25^2N$

$= \sqrt{169N}$

$= 13N$

$F = Ma$

$a = \frac{13}{2} = \frac{2a}{2} = 6.5m/s^2$

Force act on a body on a smooth ground as shown.

Find the resultant force and acceleration of the body.

WORK ,ENERGY,POWER.

Work

It is the product of force and distance moved in the direction of force.

Work = force x distance

SI units: Joules

A joule is the work done when force of one Newton moves a body through a distance of one metre in the direction of the force.

Other units include: kilo Joules, Mega joules e.t.c.

1 kilo Joule= 1,000joules

1megajoule =1,000,000joules

Example

1. A body of mass 5 kg is lifted through a distance of 6m .calculate the work done.

Force = mg

= 5 x 10

= 50N.

WD = F X D

= 50X6

= 300J.

2. Calculate the work done when a force of 30N moves through a distance of 9cm.

WD =FXD

= 30 x 0.09

= 2.7J

3. A man climbs a hill 300m high. If his weight is 50kg

Find the work he does to lift his body to the top of the hill

Force =mg = 50 x 10 = 500N

WD = F x d

= 500 x 300

= 150,000J.

4. A constant force of 10N acts on a body and moves it through 200cm. find the work done.

WD= F x d

= 10 x 2

= 20J

ENERGY

Energy is the ability to do work or it is the capacity to do work

S.I unit is joule.

Sources of energy

- The sun or the solar energy
- Chemical energy obtained from food, fuel e.t.c.
- Heat energy obtained from fuel , electric heaters and radiation from the sun.
- Light energy – obtained from conversion of other forms of energy
- Electrical energy – obtained from running water ,dynamos, generators e.t.c
- Nuclear energy- obtained from nuclear reactions
- Mechanical energy- obtained from conversion of other forms of energy.

Therefore main sources of energy are -:

- Food, Fuel (coal, gas, paraffin e.t.c), Wind, Sun, Running water.

Mechanical forms of energy

There are two namely

Potential energy

Kinetic energy

KINETIC ENE RGY

This is the energy possessed by a body in motion e.g. running water, moving bullet etc.

SI unit; joules

Kinetic energy is given by =KE = $\frac{1}{2}mv^2$ where M is the mass of the body, V is the speed or velocity.

Example;

1. Find the kinetic energy of a body mass 2kg moving with a speed of 4m/s

   KE = $\frac{1}{2}mv^2$

   KE = $\frac{1}{2} \times 2 \times 4^2$

   KE = 4^2

   KE = 16 J

2. Van persie of mass 60 kg is running at a speed of 10m/s. Find his kinetic energy.

   KE = $\frac{1}{2} mv^2$
   = $\frac{1}{2} \times 60 \times 10^2$
   = 30×10^2
   = 30×100
   = 3000J

3. Evra has a mass of 50kg moving with kinetic energy of 3125J.Calculate the speed with which he runs.

   KE = $\frac{1}{2} mv^2$
   3125 = $\frac{1}{2} \times 50\ v^2$
   3125 = $\frac{25v2}{25}$
   $\sqrt{125}$ = $\sqrt{v2}$
   = 11.2m/s
   Speed = 11.2m/s

PONTENTIAL ENERGY:

This is the energy possessed by a body due to its position above the ground. It lifts a body to some height above the ground. Work is done against gravitational force and it is stored in the body as potential energy.

When the body is allowed to fall, its potential energy reduces as it approaches the ground.

Potential energy = Work done

= F x d but F = mg and d = h

P.E = mgh

Where $g = 10m/s^2$ and h is the height above the ground.

Example1;

A stone of mass 8kg is lifted through a height of 2metres.Find the potential energy the stone develops (Take $g = 10m/s^2$)

P.E = mgh

= 8 x 10 x 2

= 160J

Question2;

A girl of mass 40kg is 15 metres above the ground. Find the potential energy she possesses.

P.E = mgh

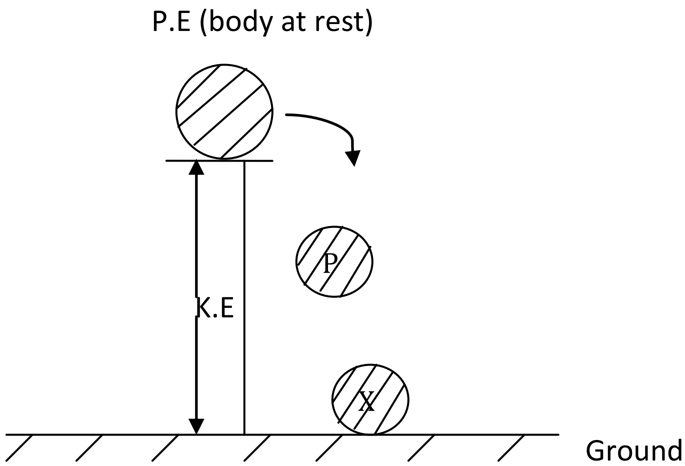
= 40 x 10 x 15

= 400 x 15

= 6000J

ENERGY INTER CHANGE

In the gravitational field energy changes from one form to another.



The stone has maximum potential energy at position y where it is at rest above the ground.

At P, the stone has both potential and kinetic energy and when it hits the ground at X it losses all the potential energy.

This potential energy is converted to kinetic energy which is maximum as it hits the ground.

P.E at Y = K.E at X

Mgh $= \frac{1}{2} mv^2$

2mgh = mv^2

2gh $= v^2$

V $= \sqrt{2gh}$

Where V is the speed which the stone lands on the ground

Example;

A stone of mass 1kg from rest at a h1kg falls from rest at height of 120m above the ground.

a. Find its potential ground energy before it begins to fall.
   P.E = mgh
   = 1 x 10 x120
   = 1200J

If the stone falls with a velocity of 2m/s, find its Kinetic energy.

$KE = \frac{1}{2} mv^2$

$= \frac{1}{2} 1 \times 2^2$

$= 2J$

C Find the velocity with which it hits the ground.

Gain I K.E = Loss in P.E

$\frac{1}{2} mv^2 \quad = mgh$

$\frac{1}{2} \times 1 \times v^2 = 1 \times 10 \times 20$

$V^2 \quad = 10 \times 12 \times 2$

$V \quad = 48.99m/s$

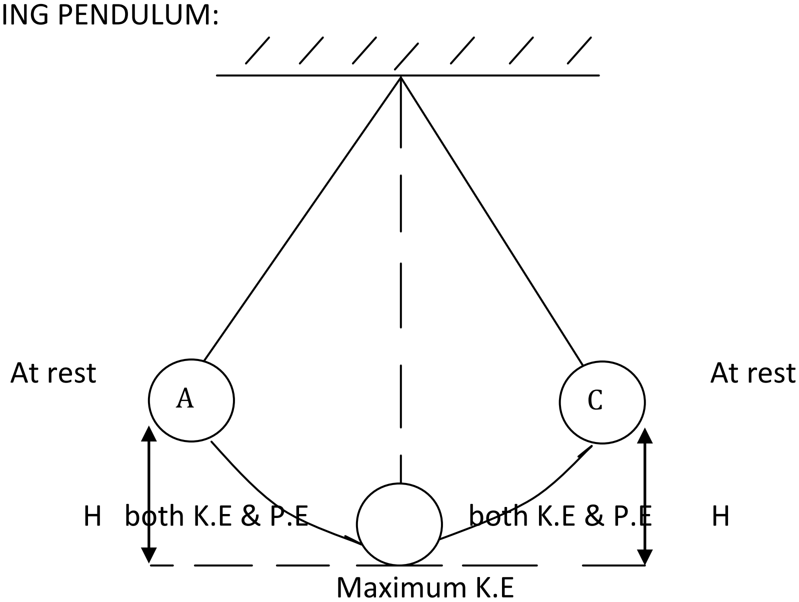
Or Simply $V = \sqrt{2gh}$

$V = \sqrt{2 \: x \: 10 \: x \: 120}$

$V = \sqrt{2400}$

$V = 48.99m/s$

SWINGING PENDULUM:



The swinging pendulum demonstrates inter conversion of energy.

At A and C the body has maximum potential energy.

At B the body has the highest speed and therefore maximum kinetic energy and zero potential energy because the height h = 0.

Along AB and BC the body possesses both potential and kinetic energy.

PRINCIPLES OF CONSERVATION OF ENERGY

It states that energy can neither be created nor destroyed but can be transformed from one form to another.

a. Explain why a swinging pendulum eventually stops after sometime? Due to the opposing friction air force.
b. (i)Describe the energy changes that occur at an instant the stone is released from a height h to the ground.

   (ii)Given that the height in b(i) was 20m.Calculate the speed with which the stone hits the ground.

   Answer;

   b.(i) At the height, the stone maximum P.E, as it falls, it gains K.E and shows loses P.E.

   On reaching the ground it attains maximum K.E and zero P.E.Sound and heat energy are given out.

Heat energy

Maximum P.E → P.E + K.E → Maximum .K.E → Heat energy, Light energy

Light energy

b.(ii) Gain K.E = Loss in P.E , $\frac{1}{2}mv^2 = mgh$

$V^2 = 2gh = 2 \times 10 \times 20$ $\quad V = 20m/s$

POWER:

This is the rate of doing work i.e.

Power $=\frac{Work\ done}{Time\ taken}$

Si unit of is the watt

Other units: Kilo watt (KW)

Mega watt (Mw)

Note; 1 kw = 1000w

1Mw = 1000,000w

1Mw = $\frac{1}{1000}$ w

Definition of a watt

A watt –is the power developed when one joule of work is done in one second.

I.e. 1W = 1J/s.

Examples

1. Boy climbs some stains .each step rise 20cm and there are 10 steps .if the boy has a mass of 50kg

a) How much work does he do in climb in the climbing the stains
b) Calculate the power developed if the took 10 seconds in climbing.

Force = mg

= 50 x10

= 500N

W = F x D

= 500 X 2 = 1000J

Power $=\frac{w}{t} = \frac{1000}{10}$ = 100W

2. A machine lifts a load of 2500N through a vertical height of 3m in 1.5s. Find

i) The power developed by a machine.

W = F X D = 2500 x 3 = 7500J.

P = $\frac{W}{T}$

= $\frac{7500}{1.5}$ = 5000W.

ii) Using the same power how long would it take to lift of 6000N through a vertical height of 5m.

W = d x F = 5 x 6000 = 30000

P $=\frac{w}{t}$

5000 =30000/t, Time t= 6 seconds.

3. A ball of 1 kg bounces off the ground to a height of 5m. Find the energy lost.

P.E before falling, P.E = Mgh = 1 x 10 x5 = 50J

P.E on the ground Mgh = 1x 10 x 2 = 20J

Energy lost = 50 - 20 = 30J.

Questions

1. A force of 500Ndisplaced a mass of 20kg through a distance of 4m in 5 seconds .find :

(i)The work done (ii) power developed

2. A pump is rated 400w. How many kilograms of water can it raise in one hour through a height of 72m?

MECHANICAL PROPERTIES OF MATTER

This deals with materials used in construction of structures like fridges, dams, tanks, motor vehicles, screw drivers etc.

Materials used in common are;

- Timber
- Metals
- Glass
- Plastics
- Rubber
- Concrete
- Bricks

Before materials are put to use, it is necessary to whether they will stand the condition of finished structure and tools which they will be subjected to.

These conditions are known as by tests called ***Mechanical properties***.

Some mechanical properties include:

- Strength
- Stiffness
- Ductility
- Brittleness
- Elasticity
- Plasticity
- Hardness

Strength;

It is the property of material that makes it require a large force to break. The material which has this property is said to strong e.g concrete, metals etc.

Stiffness;

It is the property of material that makes it resist being bent. Materials with this property are said to be stiff e.g steel, iron and concrete.

Ductility;

It is a property of materials that makes it possible to be molded in different shapes and sizes or rolled into sheets, wires or useful shapes without breaking. Materials which have this property are called ***ductile materials e.g.***

Copper wire, Soft iron wire etc.

Brittleness;

This is the materials that break suddenly when force is applied on it. Materials which have this property are called brittle materials e.g. bricks, chalks, glass, charcoal etc.

Elasticity;

This is property that makes material stretch when force is applied on it and regains original size and shape when the force is removed. Materials with this property are called elastic materials e.g rubber, copper spring etc.

Plasticity;

This is the property which makes materials stretched (deformed) permanently even when the applied force is removed materials which have this property are called plastic materials e.g. plasticine, clay, putty or tar etc.

Hardness;

This is a measure of how difficult it is to scratch a surface of a material. Hard materials include; metals, stones etc.

Timber as a building material;

It is used for making furniture, walls, bodies of vehicles, bridges, making ceilings etc.

Advantages	**Disadvantages**
It is cheap	Can get rotten
It is durable when seasoned and treated	Not fire resistant
They are easier to work with	Needs treating and seasoning

Mechanical properties;

It is strong, stiff and somehow hard.

Bricks and blocks as building materials.

These are stony materials.

Uses; For construction of bridges, walls, floors etc.

Mechanical properties;

- It is hard
- It is strong under compression
- It is stiff.

Advantages;-They are cheap, durable, and easy to work with.

Disadvantages;-They are brittle

- They need firing, and it turn out to be expensive.
- Not suitable under wet conditions i.e can soften and weaken.

Glass as a building material;

Glass is used as a building material because it has a number of desirable properties which include;

- It is transparent
- Few chemicals react with it
- It can be melted and formed into various shapes
- Its surface is hard and difficult to scratch
- It can be re-enforced (strengthened)

Construction materials;

These include concrete, bricks, glass, timber, iron bars, iron sheets etc.

Concrete;

A concrete is a mixture of cement, sand and gravel of small stones and water.

Concrete is strong under compression but weak under tension. It can with stand tension of forces when it is

re-in forced.

Re- in forced concrete;

- Pour wet concrete on steel rods when it dries; it gets stuck on the rods which is strong under tension. This forms a re-in forced concrete.
- It can also be re-in forced by putting fibre in concrete when it is wet and leave it to harden.

Other re-in forcing materials include;

- Bamboo stripes
- Wood stands
- Metal rods and wire mesh.

Advantages of re-in forcing concrete;

- It is weather resistant
- It does not need firing and it is fire safety.
- It is ductile when still wet
- It is durable
- It has a high tensile strength
- It is stiff or tough

Advantages of concrete over bricks;

- Concrete can be molded in various shapes
- Concrete does not need firing
- Concrete is weather resistant
- Concrete can have a range of properties depending on the proportion of the mixture.
- Concrete can used to fill holes of different shapes.

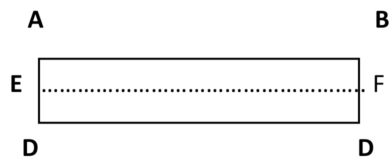
BEAMS:

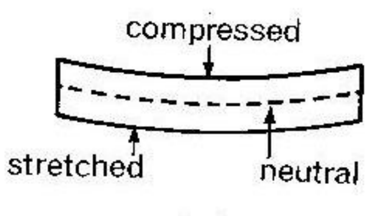
A beam is along piece of materials e.g. wood, metal, concrete etc. It is usually horizontal and supported at both ends. It carries the weight of the part of the building or other structures.

When a force is applied on a beam it bends on one side of the beam in compressed (under compression), the other side is stretched (under tension) and its centre is un stretched (neutral).

Beam before bending:

Beam after bending





EF – is the neutral axis

AB – Under compression

DC – Under tension

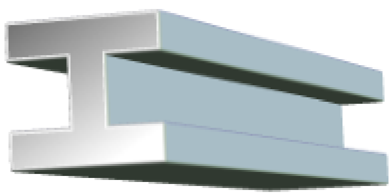
EF – Un stretched ie it neither under tension nor compression.

The neutral axis of beam does not resist any forces and can therefore be removed without weakening the stretch of the beam.

GIRDERS: A girder is a beam in which the material's neutral axis can be removed.

Examples of Girders;

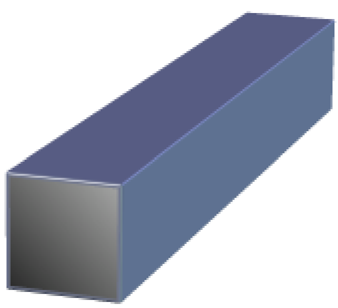
(i) I – Shape girders



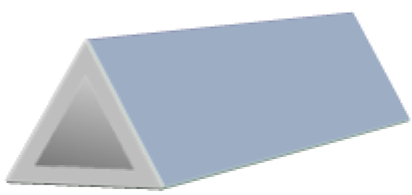
This I – shaped girder is used in construction of large structures like bridges.

(ii) Hollow tube/girder (hollow cylinder)

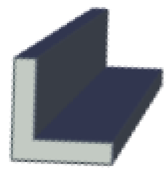
(iii) Square beam/girder



(iv) Triangular beam/girder



(v) L – Shaped girder.



Advantages of hollow beams

- It is light
- Economically cheap
- It is strong than solid beam.

Disadvantages of solid beams

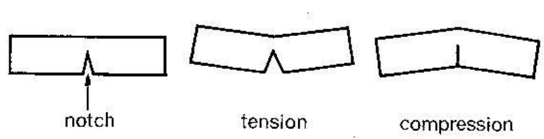
-They are heavier

-They are economically expensive -They are weak.

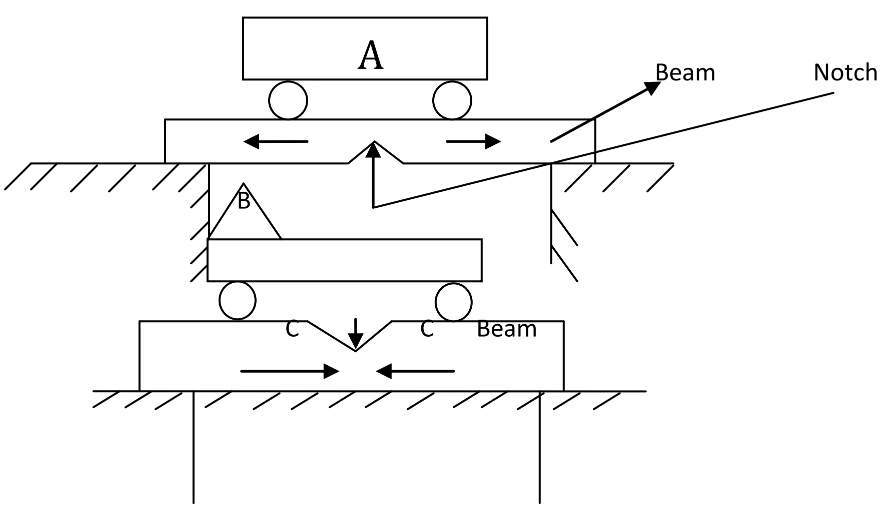
Disadvantages of a material used in the neutral axis: It is a wastage and un necessary.

NOTCH AND NOTCH EFFECTS

A notch is a cut on a weak point on a material. It is either a cratch or scratch on the surface of the material.



A notch weakens the strength of a material when it is the region of tension than when it is under compression.



In ‘A’ the beam breaks easily when the car crosses the bridge because the notch is the region of tension and therefore weakens the beam.

In ‘B’ the beam does not break easily when the car crosses.

Notch effect: This is the effect that the notch has on the strength of the material ie the notch weakens the strength of the material.

WAYS OF REDUCING NOTCH EFFECTS

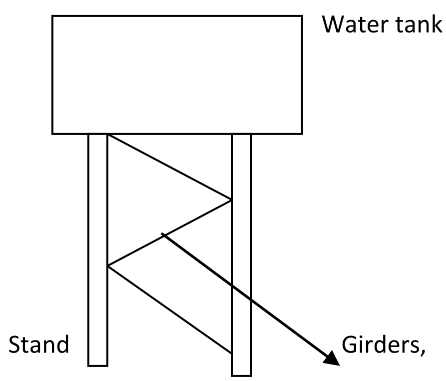
- Designing the structures in such way that all its parts are under compression.
- Making the surface of the construction material smooth.
- Use of laminated rather solid materials in construction.
- Making the notch blunt.

Structures;

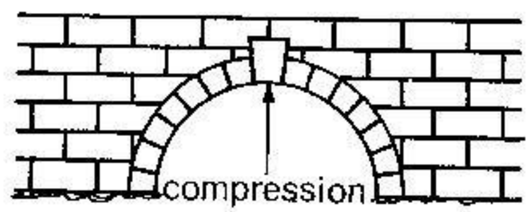
A structure consists of pieces of materials joined together .in a particular way. The pieces of materials used to strengthen structures are called girders.

Examples of structures;

(i) Stands of water tank.

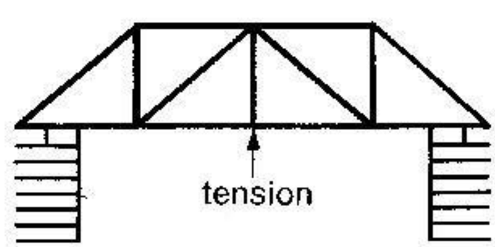


(ii)Arched bridge



-Both the upper and lower parts of the bridge are under compression. The bridge is weak under tension.

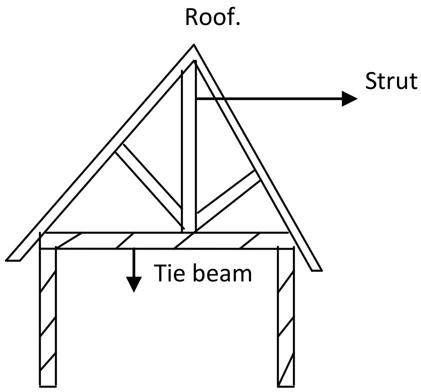
(iii)Girder Bridge;



STRUTS AND TIES:

Tie: A tie is a girder under tension and can be replaced by a string.

Strut: A strut is a girder under compression.

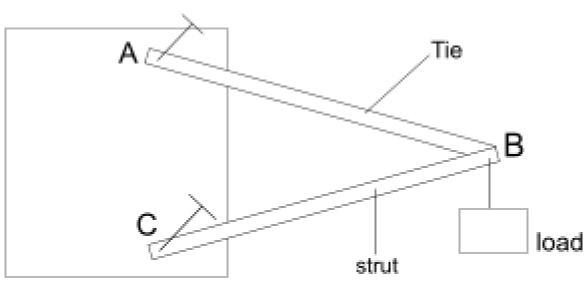


HOW TO IDENTIFY SHUTS AND TIES IN A STRUCTURE.

- Remove each of the girder one at a time from the structure of the frame work and the effect it causes on the frame work is noted.
- If the frame work moves further apart the girder is a tie otherwise the girder is a strut

Experiment to distinguish between a tie and a strut.

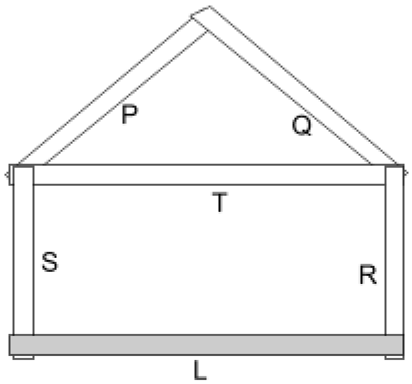
- Two straws are fixed on the side of a piece of soft board.
- A small load is added at the end B. The structure supports the load.
- The straw AB is now replaced by the string of the same length.
- If the structure still supports the load, then AB is under tension hence it is a tie.
- Similarly straw AB is then replaced with the string of the same length. If the structure does not support the load and it collapses then AB was under compression and it is a strut.



Example;

In the frame work below, identify the struts and ties.

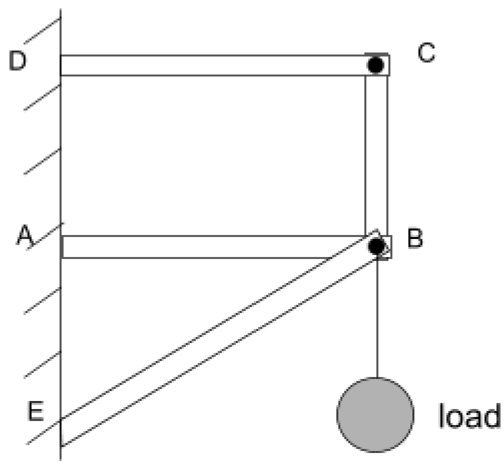
(a)



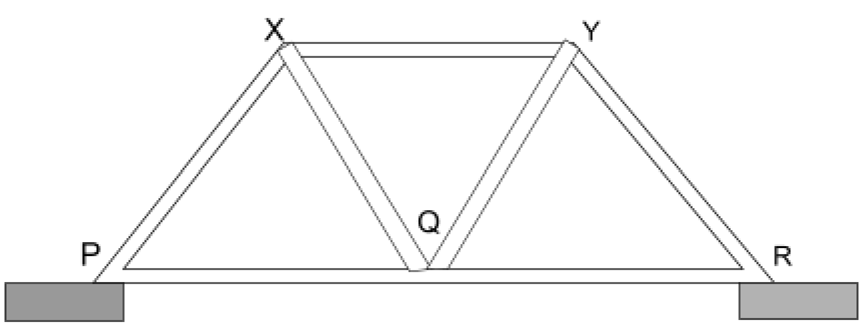
T – Tie P – Strut S- Strut

Q – Strut L – Tie R- Strut

(b)



(C)



HOOKE'S LAW OF ELASTICITY.

It states that the extension of an elastic material is directly proportional to the applied force provided the elastic limit is not exceeded.

I.e. applied force $F \alpha e$ where e-extension or

$F = k e$ k- Elastic constant of material. and F- Applied force.

Example

1. An elastic wire of length 10cm has force applied on it of 3neutons.if its

a) Extension e.

b) Elastic constant k.

Extension $e = l - l_0$ =12 -10 = 2cm. = 0.02m

Using F =K e.

3= k x 0.02 There fore $K = 150Nm^{-1}$

2. A spring extends by 0.5 cm when a load of o.4N hangs on it.

a) Find the load required to cause an extension of 1.5cm.

b) What additional load causes the extension of 1.5cm?

Method 1

Using F =K e

$0.4 = k \times 0.5 = \frac{0.4}{0.5} = 0.8N/cm$

$F_2 = ke_2 = 0.8 \times 1.5 = 1.2N.$

Method 2.

$\frac{F1}{F2} = \frac{e1}{e2} = \frac{0.4}{F2} = \frac{0.5cm}{1.5cm}$

$F_2 = \frac{0.4 \ x \ 1.5}{0.5} = 1.2N$

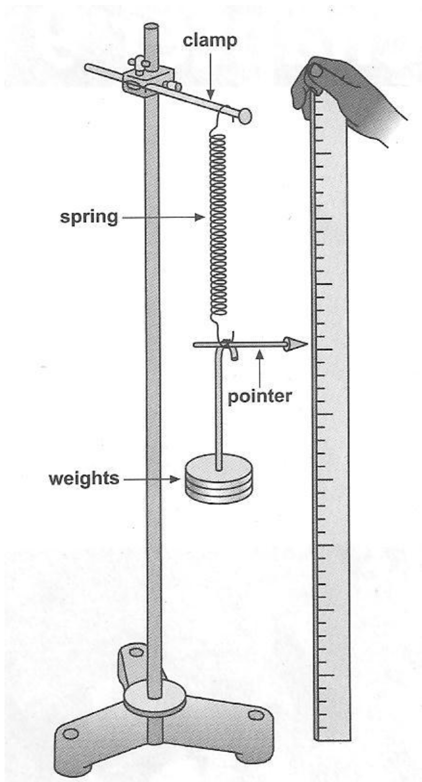
Additional load required = (1.2 – 0.4) = 0.8N

Exercise;

1. A spring has an un stretched length of 12 cm when a force of 8N is attached to its length becomes 16cm.
    a. Extension produced
    b. The constant of the spring,
    c. Extension which will be produced by a force of 12N,

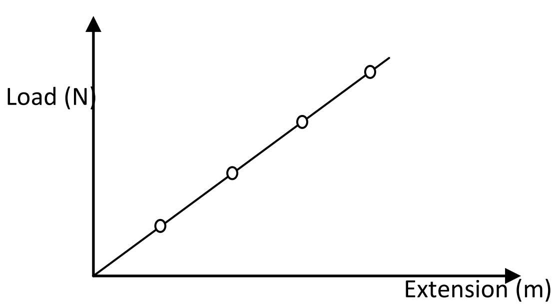
Experiment to verify (prove) Hooke's law

A spring is suspended next to the metre rule with a pointer at the bottom end used to obtain a reading on a scale as shown below.



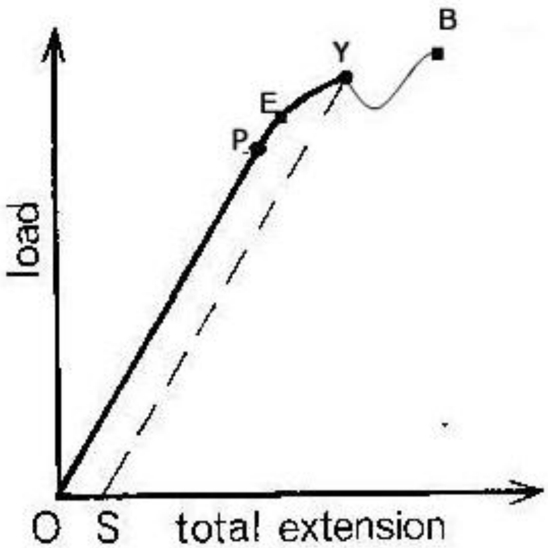
- The initial position X_0 on the pointer is read and recorded.
- Uniformly load the spring by adding standard masses on the mass hanger.
- The new position X of the pointer whenever the spring is loaded is recorded.
- The extension for each load added is recorded from

  $e = X – X_0$.
- A graph of load against extension is plotted as shown.



A straight line passing through the origin verified hook's law.

A graph load against, extension for a ductile wire



Points;

P- Proportional limit

E- Elastic limit

Y- Yield point

B- Breaking point.

Lines/ regions

OP – Region where hook's law is obeyed or region of proportionality, the materials under goes elastic deformation.

OS – materials undergoes permanent extension.

SY – Material undergoes plastic deformation.

Definitions;

Elastic deformation;

This is the deformation which occurs before the elastic limit. The wire regions its shape and size. After deformation energy is stored as potential energy.

Plastic deformation;

This occurs after the elastic limit. The wire fails to recover its original shape and size fully. Permanent extension is made and part of the energy is stored as elastic potential energy and the rest is converted into heat in the wire as it stretches. The wire recovers along YS and not OE.

STRESS, STRAIN AND YOUNG'S MODULUS

Consider a force F acting on a material e.g. a wire of length l and cross section area A so that it extends by length e.

Stress for the wire is defined as the ratio of applied force on a material to its cross section area i.e. stress is equal to force over area.

Stress = $\frac{Force}{Area}$

SI unit N/m^2

Strain is a ratio of extension of a material of its original length i.e.

Strain $\frac{Extension}{Original\ length}$ or Strain = $\frac{e}{L}$

Strain has no units.

Young's modulus is defined as the ratio of stress to strain.

Y = $\frac{Stress}{Strain}$

SI unit = N/m^2

Young's modulus is defined when the elastic limit is not exceeded and its value is constant.

Example;

1. A force of 20N acting on a wire of cross sectional area $10cm^2$ = makes its length to increase from 3m to 5m. Find stress?

a). Stress = $\frac{Force}{Area}$ = $\frac{20}{10}$ = $2Nm^{-2}$

b). e = $L - L_0$ = (5 – 3) = 2m

Strain = $\frac{e}{Lo}$ = $\frac{21}{3}$ = 0.67

Y = $\frac{Stress}{Strain}$ = $\frac{2\ 3}{2}$ = $3Nm^{-2}$

2. A copper wire of length 10cm is subjected to a force of 2N if the cross section area is $5cm^2$ and a force causes an extension of 0.2cm.

Calculate;

(i) Tensile stress

Stress =Force/area but A = $5cm^2$ = $0.0005m^2$

= 2/0.0005

= 4000 Nm^{-2}

(ii) Strain =extension/ original length = $\frac{0.0002}{0.1}$ = 0.002m = 2.0 x 10^{-4} m

(iii) **Young's modulus**

Y = stress/strain = 4000/ 0.002 = 20,000,000 Nm^{-2} = 2.0 x $10^7 Nm^{-2}$

Questions

3. A mass of 200kg is placed at the end of the wire 15cm long and cross sectional $0.2cm^2$ if the mass causes an extension of 1.5cm

Calculate.

i. Tensile stress
ii. Tensile stress.

4. A mass of 200g is placed at the end of a wire 15cm long are cross sectional area 0.2m .if the mass causes an extension of 1.5 calculate

(i)Tensile stress

(ii)Tensile strain

(iii)Young modulus

PRESSURE

Pressure is defined as force acting normally per unit area.

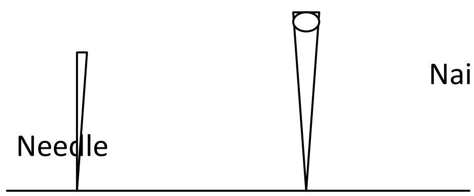
SI unit is Nm^{-2} or Newton per square metre or Pascal.

$P = \frac{Force}{Area}$ Note: $1Nm^{-2} = 1pa$

Other units: Kilo Pascal (Kpa) or Kilo Newton per metre squared (KNm^{-2})

Note: 1Kpa =1000pa and $1KNm^{-2} = 1000Nm^{-2}$

The pressure increases when the surface area is decreased. This can be demonstrated using a needle and a nail as shown



When the same force is applied at the end of the needle and nail. One tends to feel more pain from the needle than the nail.

This is because surface area of the top of the needle is smaller therefore the pressure is high.

The increase in pressure when the surface area is decreased explains the tractor can easily move in a muddy area than the bicycle.

Example;

1.A car piston exerts a force of 200N on a cross sectional area of $40cm^2$.Find the pressure exerted by the piston

P $= \frac{Force}{Area}$ and Area $= \frac{40}{10,000}$ $= 0.004\ m^2$

$= \frac{200}{0.004}$ $= 50,000N/m^2$

2.The pressure exerted on foot pedal of cross sectional area $5cm^2$ is $200Nm^{-2}$.Calculate the force.

Force = pressure xarea

= 200 x 0.0005 = 0.1N

Minimum and maximum pressure;

Pressure is always minimum (smallest) the area largest

Pressure is always maximum (largest) when the area is smallest.

Therefore minimum pressure = $\frac{Force}{maximum\ area}$

Pressure (maximum) = $\frac{Force}{minimum\ area}$

Example;

1.A box measures 5m by 1m by 2m and has weight of 60N while resting on the surface. What is the minimum pressure.

Maximum area = 5 x 2 = 10 m^2

Minimum p. = $\frac{Force}{maximum\ area}$ = $\frac{60}{10}$ = 60N/m^2

Minimum.Area = 2 x 1 = 2m^2

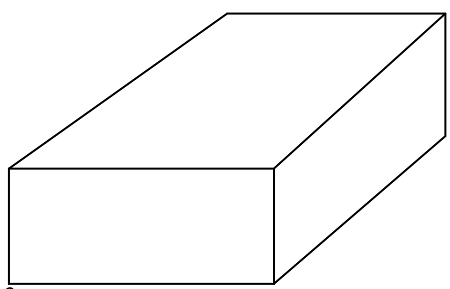
Maximum pressure = $\frac{Force}{minimum\ area}$ = $\frac{60}{2}$ = 30N/m^2

2. A box of dimension of 6m x 2m x 4m is exerted on the floor by a force of 400N.Determine its density.

Maximum pressure;

Minimumarea = 4 x 2 = 8m^2

Maximum pressure = $\frac{Force}{min}$ = 400/8 = 50N/m^2



2m

Maximum area = 6 x 4 = 24m^2

.minimum pressure = $\frac{Force}{Area}$ =400/24 = 16.67Nm^{-2}

6m

Density

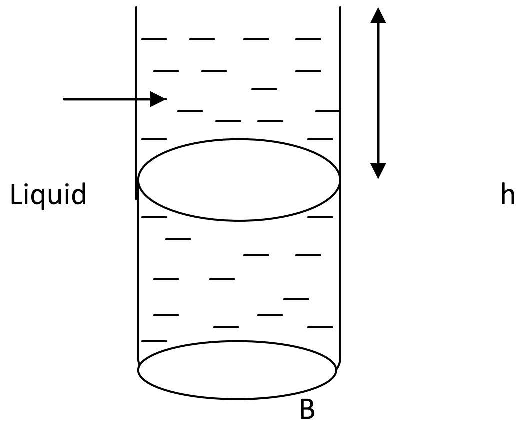
4m

V = L x W x H = 6 x 2 x 4 = 48m3

P = $\frac{m}{v}$ =40/48 = 0.833kg/m^3

PRESSURE LIQUIDS

Consider a column of liquid h above B in a cylinder as shown below;



The pressure on the surface of the liquid in a container of cross sectional area A is due to weight W of the liquid above it.

But weight W = mg but also m =p x v

= p x v x g but v = A x h

= p x A x h x g but pressure p. = $\frac{w}{A}$

P = $\frac{p \, x \, A \, x \, h \, x \, g}{A}$ = p x h x g

Hence p = hpg Where h - depth of the liquid

P – density of liquid gravitational acceleration.

If follows that pressure is the same in all directions are depends on.

(i) Depth (h) of the liquid
(ii) Density (p) of the liquid

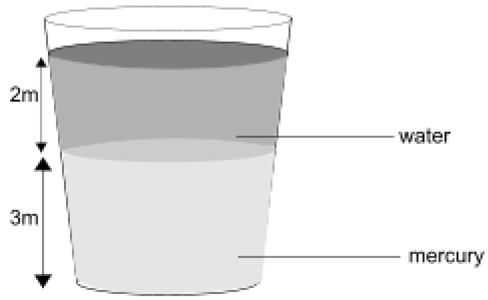
Example I

The density of liquid X is 800kgm^{-3}.It was poured in a container to a depth of 400cm.Calculate the pressure it exerts at the bottom of the container.

Pressure p = hpg

= $\frac{400}{100}$ x 800 x 10 = 32,000Nm^{-2}

2.



The tank contains mercury and water. The density of mercury is $13600kgm^{-3}$ and that of water is $1000kgm^{-3}$.Find the total pressure exerted at the bottom.

Pressure due to water

P = hpg = 2m x 1000 x 10 = $20000Nm^{-2}$

Pressure due to mercury = hpg = 3 x 13600 x 10 = $408000Nm^{-2}$

Total Pressure = 408000 + 20000 = $428000Nm^{-2}$

3. A cylinder vessel of cross section area $50cm^2$ contains mercury to a depth of 2 cm .calculate

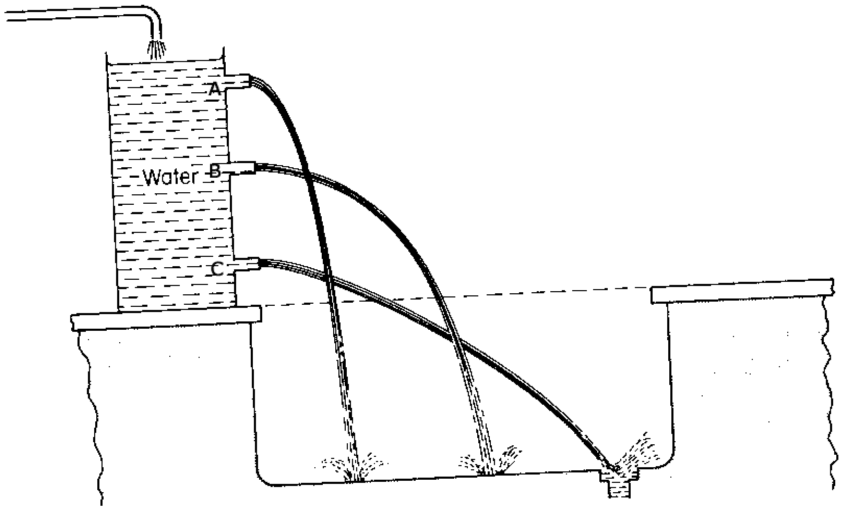
i) The pressure that mercury exerts on the vessel
P = hpg
= 2 x 13600 x 10 = 2720Nm-^{2}

ii)The weight of water in the vessel (density of mercury)=$13600kgm^{-3}$)

w = P x A and A = 50/10000 m^2

= 2720 x $\frac{5}{10000}$ = 1.36N

Experiment to show that pressure in liquids increase with increase in depth (h)



Use a long can with three equally sized holes A, B, C blocked by the corks at different depths h_1, h_2 and h_3 respectively as shown above.

Water is filled in the can so that it just remains full and the three holes opened at once.The size of water jets coming out

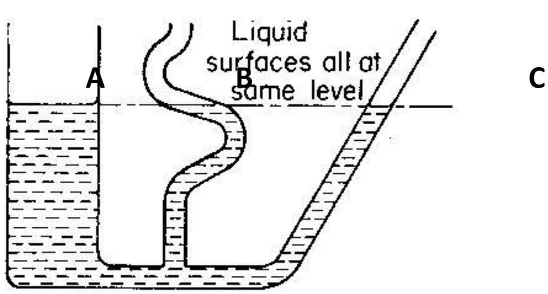
Of the holes is noted.

Observation;

The speed with which water spurts out is greatest for the lowest jet, showing that pressure increases with depth.

NB pressure does not depend on shape and cross sectional area of the container. This can be illustrated using communication tube.

Experiment to show that pressure is independent of cross section area and shape of container



The liquid is allowed into the tubes A, B, C and D as shown above.

The liquid reaches the same height h in all the tubes.

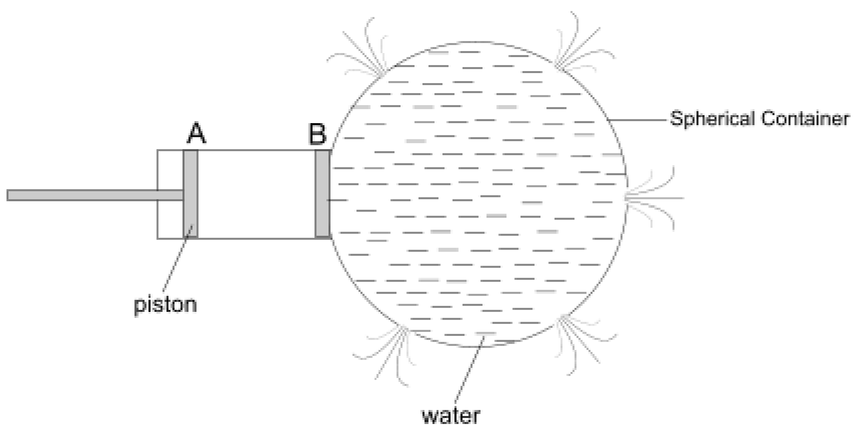
Since the tubes are of different cross sectional area and shape. It follow that pressure does not depend on shape and cross sectional area.

PRINCIPAL OF TRANSMISSION OF PRESSURE IN LIQUIDS

(Pascal's principal) or (Law of liquid pressure)

The principal states that "pressure at a point of liquid is equally transmitted through out the liquid. The principl assumes that the liquid is incompressible.

Experiment to verify the principal of transmission of pressure in liquids



A spherical container pinched at different points around it. When piston is moved in such way that it pushes "B" to compress the liquid

The pressure caused is transmitted equally throughout the liquid. This can be observed by having all holes pouring out the liquid at the same rate when the piston is pushed in hence pressure in liquid is equally transmitted.

Summary;

Experiment above show that pressure in liquids;

1. Depends on depth and density.
2. Equally transmitted through out the liquids.
3. Is independent of shape or cross sectional area of the container in which the liquid is placed.

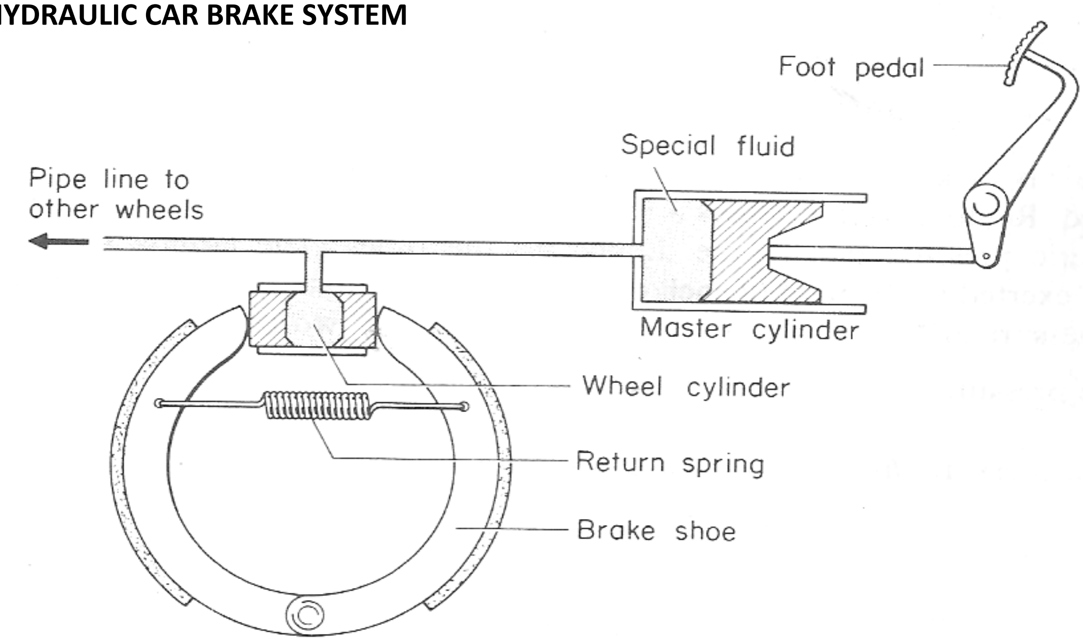
Application of the Pascal's principle:

Some machines where the Pascal's

Principle is used include;

1. Hydraulic car brakes
2. Hydraulic press
3. Hydraulic lifts.

THE HYDRAULIC CAR BRAKE SYSTEM

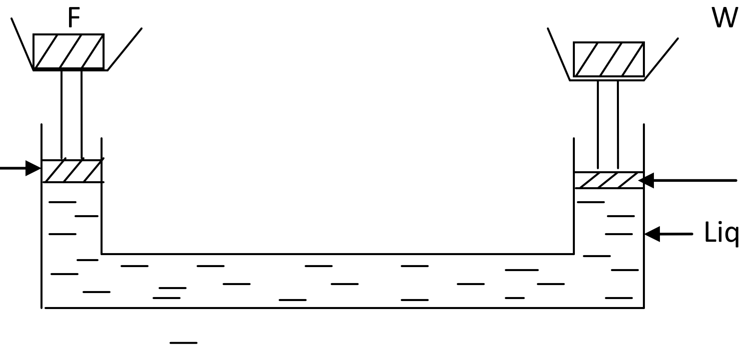


Mode of action:

- When a foot is applied on a foot pedal, the piston in the master cylinder exerts a force on the brake fluid.
- The resulting pressure is transmitted to the wheel cylinder of each wheel.
- The force caused, then moves the wheel piston which push against the break pad, making them squeezed against the car wheel, hence the wheel stops rotating and the car stops.

HYDRAULIC PRESS;

A hydraulic press consists of two connected cylinders of different bores, filled with water or any other incompressible liquid and fitted with piston shown in the figure below.



- When the force F is exerted on the liquid via piston A, the pressure produced is transmitted equally through out to piston B, which supports a load W.
- The force created at B raises the load squeezing a hard substance.

Example;

1.The cross sectional area of the piston A = $2m^2$ and the force applied at piston A is 10N.Calculate the force on B, given the cross section area as $150m^2$.

Pressure at A, $P = \frac{Force}{Area} = \frac{10}{2} = 5N/m^2$

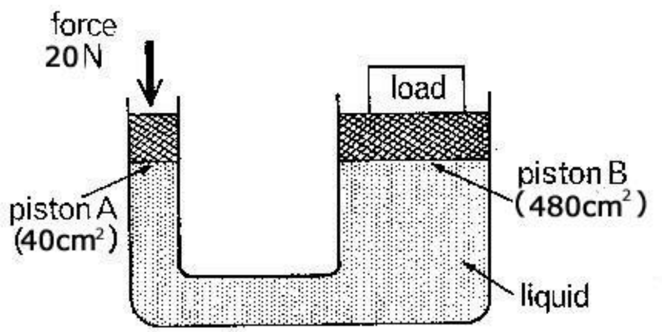
Pressure at A, = Pressure at B

$5 = \frac{W}{150}$ Therefore, Force W = 5 x 150 = 750N

Hence a small force of 10N applied on a big of 750N.

2. Calculate the weight B, lifted by the H.P of piston area $48cm^2$ with a force of 20N whose piston area is $400cm^2$ as shown

below:



Pressure at B, = pressure at A

=20/0.004

= 5000 Nm^{-2}

Weight W =pressure at B xpiston area B

=5000 x0.048

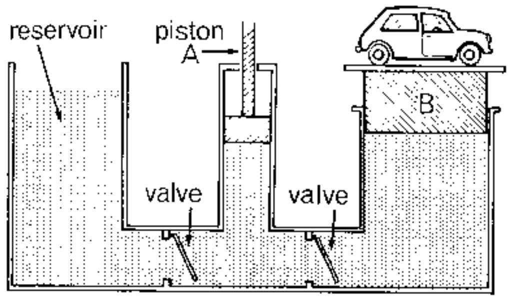
= 240N

Questions

1. Calculate the weight W raised by a force of 56N applied on a small piston area of $14m^2$.take the area of the large piston to be $42m^2$.

2.A force of 32N applied on a piston of area $8cm^2$ is used to lift a load W acting on large area of $640cm^2$.Determine the value of W.

Hydraulic lift



This is commonly used in garages; it lifts cars so that repairs and service on them can be done easily under neath the car.

A force applied to the small piston, raises the large piston, which lifts the car.One valve allows the liquid to pass from

The small cylinder to the widr one, a second valve allows more liquid (usually oil) to pass from oil reservoir on the left

To the small cylinder.When one valve is open, the other must be shut.

ATMOSPHERIC PRESSURE:

The earth is surrounded by a sea of air called atmosphere. air has weight therefore it exerts pressure at the surface of the earth. The pressure this air exerts on the earth's surface is called atmospheric pressure.

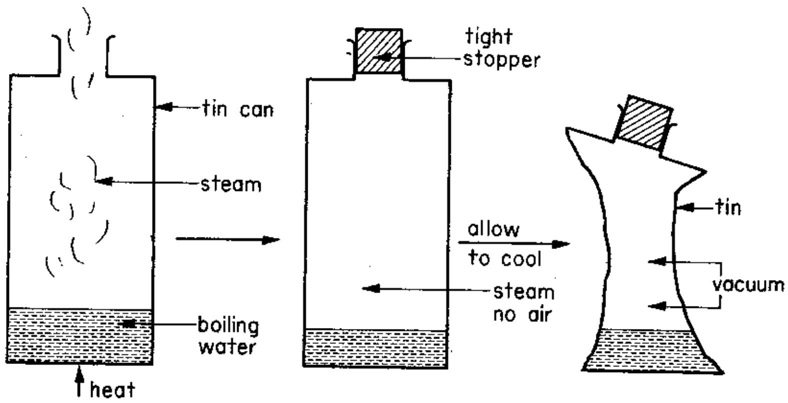
Atmospheric pressure is the pressure exerted by the weight of air on all objects on earth's surface.

The higher you go the less dense the atmosphere and therefore atmospheric pressure decrease at high altitude and increase at low altitude.

The value of atmospheric pressure is about 101325N/m.

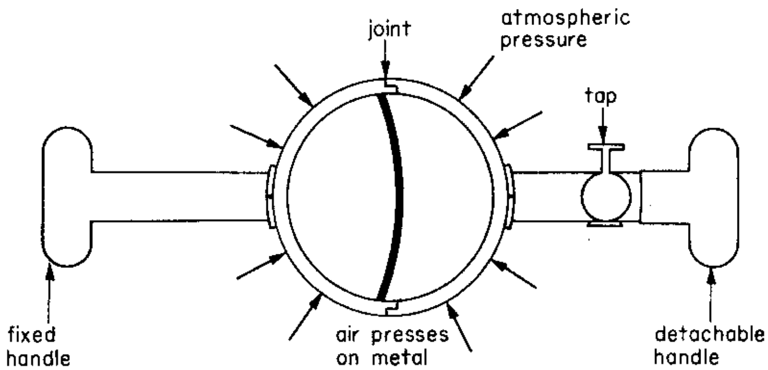
Experiment to demonstrate the existence of pressure;

a. Crushing can experiment or collapsing can experiment;



- A metal can with its tight stopper removed, is heated until the small quantity of water in boils.
- When the steam has driven out all the air, the cork is tightly replaced and the heat removed at the sometime.
- Cold water is poured over the can. This causes the steam inside to condense reducing air pressure inside
  the can
- The can collapses in wards. This is because the excess atmospheric pressure outweighs the reduced pressure inside the can.

b**. The Magdeburg's hemisphere**



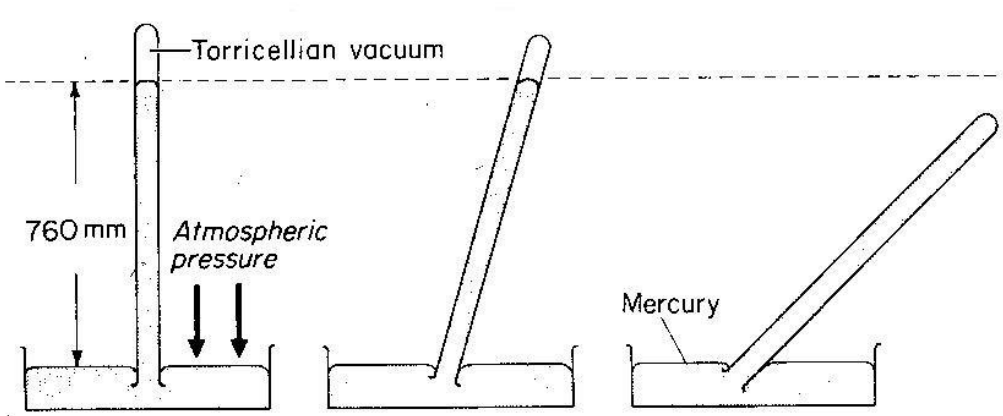
The hemisphere is made of two hollow bronze with a stop cork on onside. The rims are placed together with grease tightening between them to form an air tight joint. The air is pumped out and the stop cork closed. It becomes impossible for even eight horses to separate them. When air is re admitted in the sphere they are easily separable. This indicates the existence of atmosphere pressure.

MEASUREMENT OF ATMOSPHERIC PRESSURE:

Atmospheric pressure is measured using an instrument called Barometer.

Types of barometers	Units of pressure
1. Simple barometer	Nm^{-2}
2. Fortin barometer	Pa
3. Aneroid barometer	atmospheres

Simple barometer



A simple barometer is made by filling completely a thick walled glass tube of about 1m long with mercury.

The tube should have uniform bore, the tube is tapped from time to time to expel any air bubbles trapped in mercury.

It is inverted over a dish containing mercury as shown in the diagram.

The mercury level falls leaving a column “h” of about 76 cmHg.

The height “h” gives the atmospheric pressure 76cm Hg.The empty space created above the mercury in the tube vacuum called Torricellian vacuum.

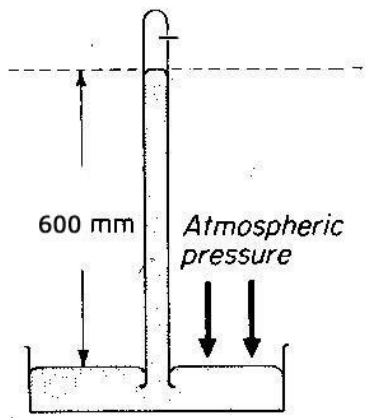
NB;The vertical height of the mercury will remain constant if the tube is lifted as in (2) provided the top of the tube is not less than 76cm above the level of mercury in the dish.

If it is fitted so that “h” is less than 76cm.The mercury completely fills the tube. This shows that vacuum was a trice vacuum and a column of mercury is supported by atmospheric pressure.

Generally, Atmospheric pressure = Barometer height x Density of liquid x gravity

Example;1. Determine the atmospheric pressure (i) in cmHg and in (ii) Pascal's (Nm^{-2}) using the following barometer.

(a)



(i) Height = 600mmHg p = 60cmHg

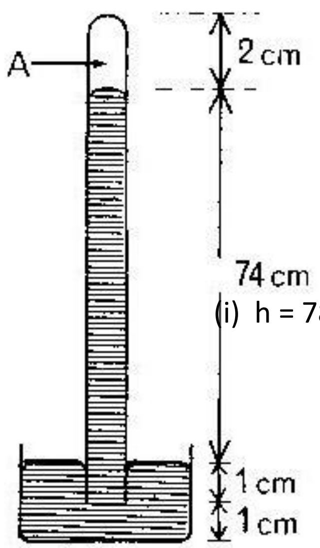
(ii) P = hpg

= 600mm x 13600 x 10

= $\frac{600}{100}$ x 13600 x 10

= 81600pa or $81600Nm^{-2}$

(b)



(i) h = 78– 4 = 76cmHg

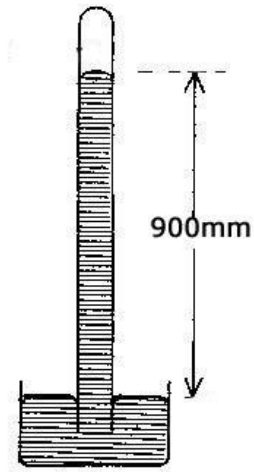
(ii) p = hpg = 0.76 x

13600 x10

=105,

$53Nm^{-2}$

(c)



(i) P=h=900mmhg= 90cmHg

ii) P= hρg = 0.9 x13600 x10

= 122400 Nm^{-2}

2. Express (i) 76cm Hg in Nm^{-2} (density = 13600kgm^{-2})

P= hρg

$= \frac{76}{100}$ x 13600 x 10 = 103360 Pascals

(ii) 540mmHg in pa

P = hρg $= \frac{540}{1000}$ x 13600 x 10 = 73440N/m^2

3. The column of mercury supported by by the atmospheric pressure is 76cm.Find column of water that the atmosphere pressure in the same place. Comment on your answer.

P = hρg $= \frac{76}{100}$ x 13600 x 10

= 103360 Nm^{-2}

In the same place atmosphere pressure is the same as using water;

P = hρg

103360 = h x 1000 x 10

h = 103360/ 1000 X 10

h= 1034m

The answer to the question a above, explains why water is not used in a barometer because the column will be too long.

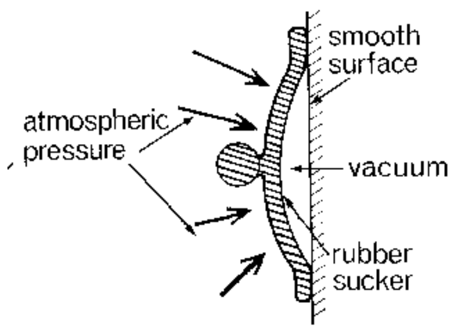
Applications of Atmospheric pressure

Atmospheric pressure may be made useful in

a. Rubber suckers
b. Bicycle pump
c. Lift pump
d. Force pump
e. Siphon
f. Water supply system
g. Drinking straw

Rubber Sucker

This is circular hollow rubber cap before it is put to use it is moisturized to get a good air seal and firmly pressed against a small flat surface so that air inside in pushed out then atmospheric pressure will hold it firmly against surface as shown below



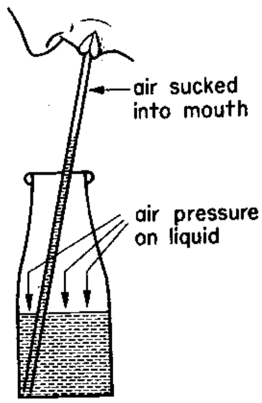
Uses of rubber sucker;

-**It** is in kitchens and toilets to clear blocked sinks and drainage system.

-It is used in industries for lifting metal sheets.

-It is used printing machines for lifting papers to be fed into the printer.

Drinking straw;

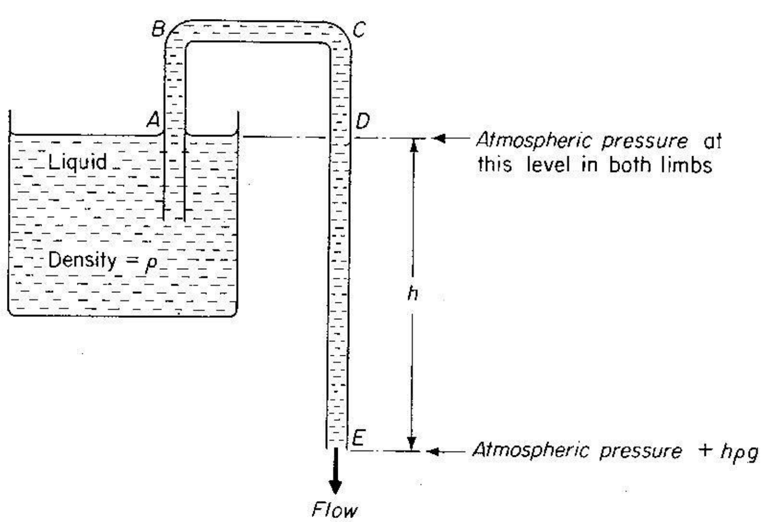


-When drinking using a straw some of the air in the straw goes into the lungs once sucked.

-This leaves space in the straw partially evacuated and atmospheric pressure pushing down the liquid becomes greater than the pressure of the air in the straw.

The siphon;

This is used to take the liquid out of vessels (eg. Aquarium, petrol tank)



How a siphon works

The pressure at A and D is atmospheric, therefore the pressure at E is atmospheric pressure plus pressure due to

The column of water DE. Hence, the water at E can push its way out against atmospheric pressure..

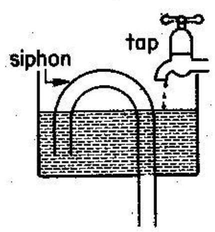
NB: To start the siphon it must be full of liquid and end A must be below the liquid level in the tank.

Applications of siphon principle

1. Automatic flushing tank: This uses siphon principle.

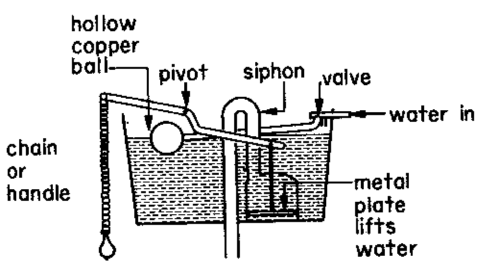
Water drips slowly from a tap into the tank.The water therefore rises up the tube until it reaches and fills the bend

In the pipe.the siphon action starts and the tank empties (the water level falls to the end of the tube).The action Is then repeated again and again.



2**. Flushing tank of water closet:** This also uses the siphon principle.

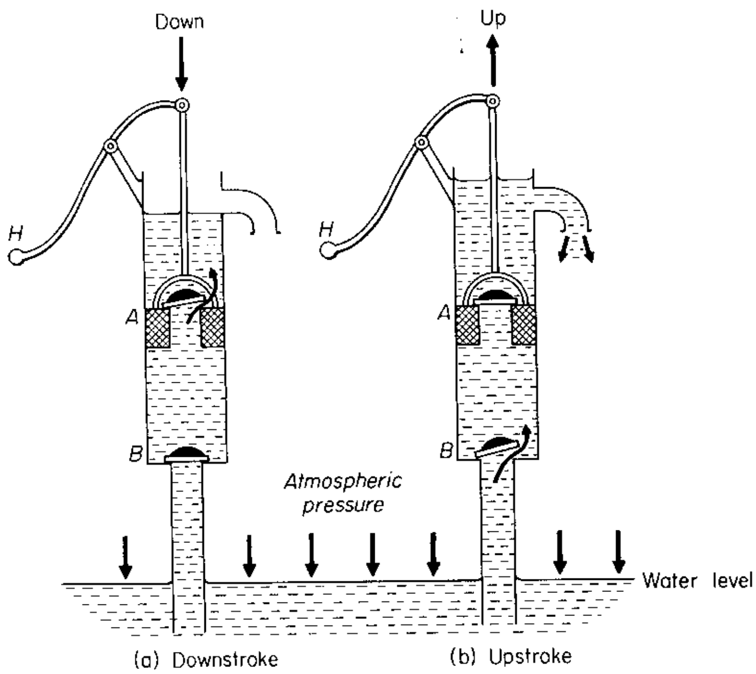
When the chain or handle is pulled, water is raised to fill the bend in the tube as shown below:



The siphon action at once starts and the tank empties.

Lift pump or common pump;

Pumps are used to raise water from walls. They consist of cylindrical metal barrel with side tubes near the top to act as spouts.



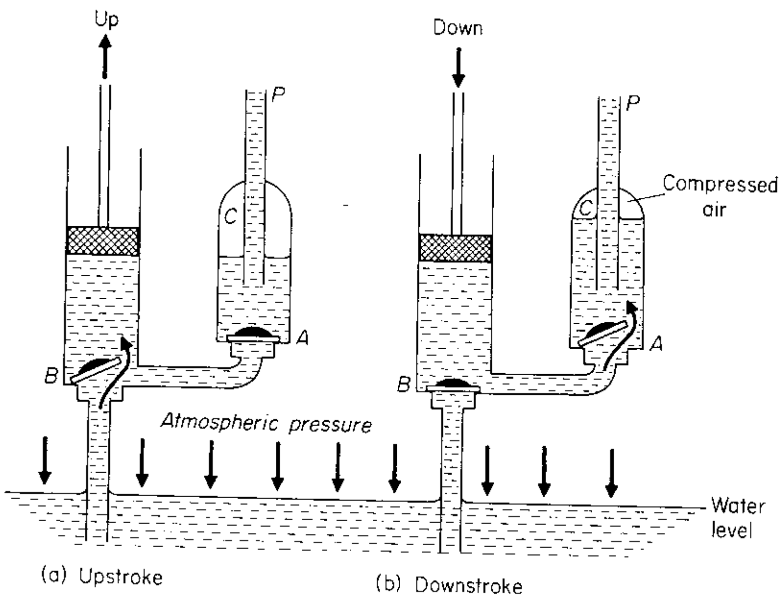
Down stroke;

When the plunger moves down wards valve B closes due to force of gravity on it and weight of water above it.

At the same time water inside the barrel passes upwards through A into the space above the plunger.

The upstroke;

- Valve A closes due to the force of gravity on it and weight of water above it.
- As the plunger rises water is pushed up the pipe through valve B by atmospheric pressure the surface of the use in the well.
- At the same time, the water above it is raised and fall out at the spout.



A force pump is used to raise water from a deep well or reservoir to a storage tank.

It is first primed to make it air tight.

On the upstroke, valve A closes and atmospheric pressure forces the water up the barrel through valve B.

On the down stroke valve B closes, water is forced into the reservoir through valve A and also out of the spout D.

The air in the spout is compressed and on the next up stroke, it expands so keeping the supply of water at B.

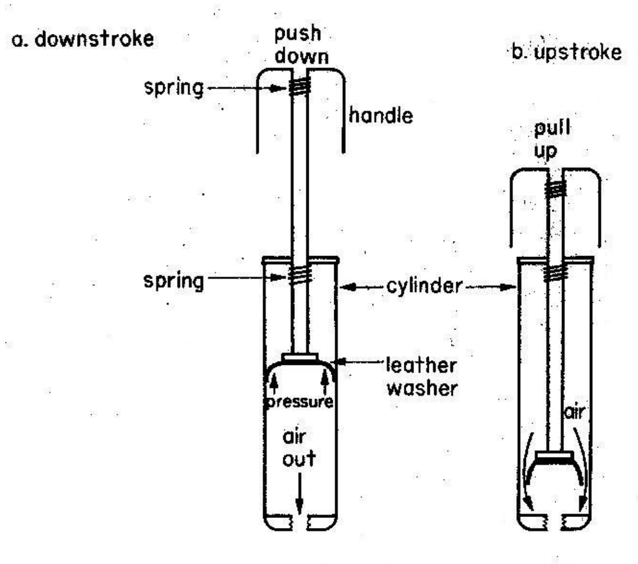
BICYCLE PUMP:

Principle and action of a pump

-The air in the pump barrel is compressed.

-The high pressure of the air in barrel presses the leather washer against the inside of the barrel closing the pump valve.

-When the pressure of compressed air becomes greater than that of air already in the tyre, air is force past the tyre valve in the tyre.



When the handle is pulled out, the pressure of the air in the barrel is reduced.

The high pressure of air in the tyre closes the tyre valve preventing the air escaping.

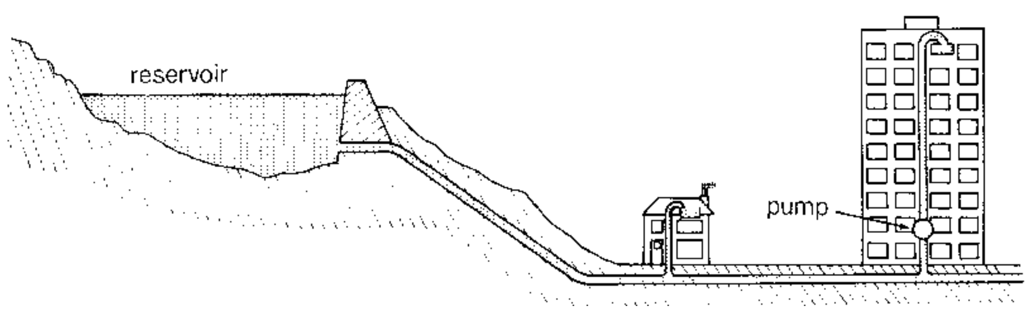
The atmospheric pressure being greater than the reduced pressure in the barrel, forces the air past the leather washer opening the valve refilling the barrel with air.

Water supply system:

Water supply in towns often comes from a reservoir on a high groundwater flows from it through a pipe to any tap or storage tank that is below the water reservoir.

In very tall building it may be necessary to first pump water to a large tank on a roof. Reservoirs of water supply in hydro electric power stations are often made in mountainous.

The dam must be thicker at the bottom than at the top to with stand large water pressure at the bottom.

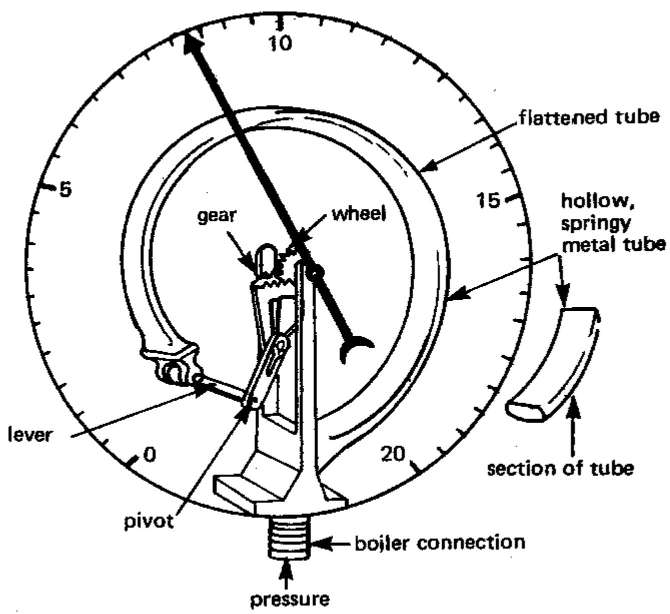


Variation of the atmospheric pressure with altitude at sea level, the atmospheric pressure is 760mmHg.When you move, on the top of the mountain, the pressure reduces to about 600mmHg.This shows that pressure reduces with increase in altitude.

Measurement of fluid pressure:

a. **Bourdon gauge**

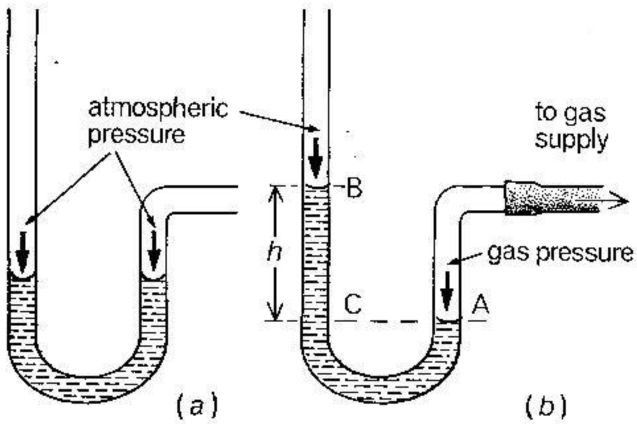
This gauge measures the very high pressures of liquids or gases, e.g. the pressure of steam in boilers.It is a hollow
Curved tube of springy metal closed at one end.The tube straightens slightly when pressure acts on the inside.
The closed end of the tube is joined to a series of levers and gear wheels which magnify the slight movement.
A pointer moving over a scale(usually graduated in 10^5 pa, which is about 1 atmosphere pressure) records
The pressure.the reorded pressure is the excess pressure of liquid or gas over atmospheric pressure, but some gauges can record the actual pressure.



Bourdon gauges are commonly used at filling stations.

b. **Manometer;**

It is a U – shaped tube containing mercury,



Action;

One limb is connected to the gas or air cylinder whose pressure P, is required.

Second limb is left open to the atmosphere using a metre rule.

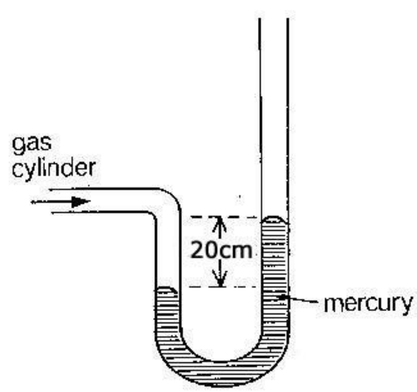
Pressure P, of the gas is calculated as

Pressure at B, = Pressure at C

= H + h (when A is above C)

= H – h (when A is below C)

Example;



1.Find the gas pressure given atmospheric pressure H = 760cmHg

(i) In cmHg

(ii) In Nm^{-2}

Solution

Gas pressure P = H + h = 76 + 20 = 96 cmHg

$P = h\rho g = \frac{96}{100} \times 13600 \times 10 = 130560\ Nm^{-2}$

2. Express a pressure of 75cm Hg into Nm^{-2}

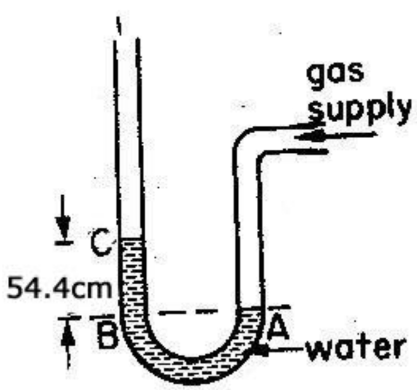
$P = h\rho g = \frac{75}{100} \times 13600 \times 10 = 102000Nm^{-2}$

3. A man blows in one end of a water U – tube manometer until the level differ by 40.0cm.If the atmospheric pressure is $1.0 \times 10^5\ N/m^2$ and density of water is $1000kgm^{-3}$.calculate his lung pressure.

Pressure of air = $H + h\rho g$

$= 1.01 \times 10^5 + \frac{40}{100} \times 1000 \times 10 = 105{,}000Nm^{-2}$

Therefore lung pressure = $105{,}000Nm^{-2}$



4. The manometer contains water, when the tap is opened, the difference in the level of water is 54.4cm. The height of mercury column in the barometer was recorded at 76cm.What is the pressure in cm Hg at points A, B, and C.

Pressure at A = pressure C

= H + h

Pressure using mercury = pressure of water

$h_1 p_1 g_1 = h_2 p_2 g_2$

$= h \times 13600 \times 10 = 54.4 \times 1000 \times 10$

$= \frac{h1 \ x\ 136000}{13600} = \frac{54.4\ x\ 1000}{13600}$

h = 4 cm

Therefore at B, P = h + 4

P = 4 +76 = 80cm Hg

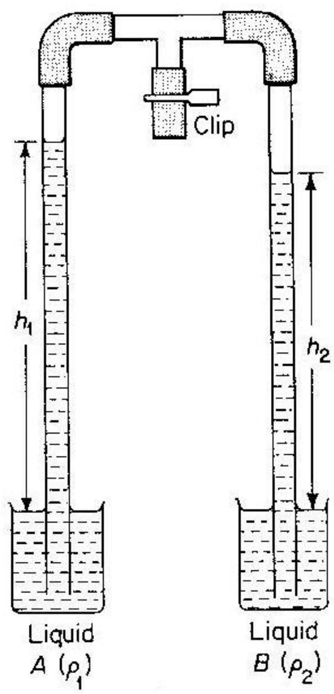
5. The difference in pressure at the peak of the mountain and the foot of the mountain is

5.0 x 104Nm^{-2}.Given that the density of air is 1.3kgm^{-3},Calculate the height of the mountain.

Difference of P = hpg → 1.0 x 10^4 = h x 1.3 x 1.0

h = 7846.15m or 7.85km

Comparison of densities of liquids using Hare's apparatus



Liquids of different densities are placed in glass pots as shown above.

When the gas tap is opened each liquid rises to different height h_1 and h_2.Since they are subjected to the same gas supply,

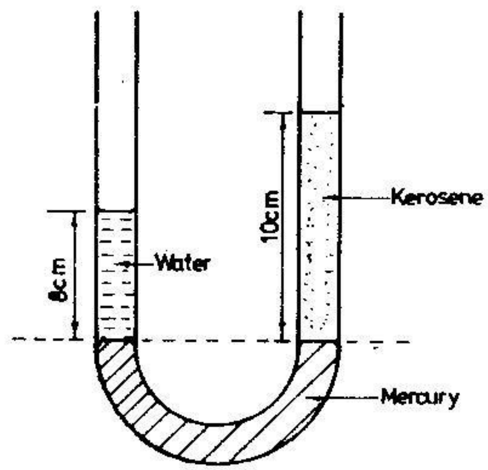
Pressure on liquid 1 = pressure on liquid 2

$$h_1 \ p_1 \ g = h_2 \ p_2 \ g$$

$$h_1 \ p_1 = h_2 \ p_2$$

$$\frac{p1}{p2} = \frac{h2}{h1}$$

Example;



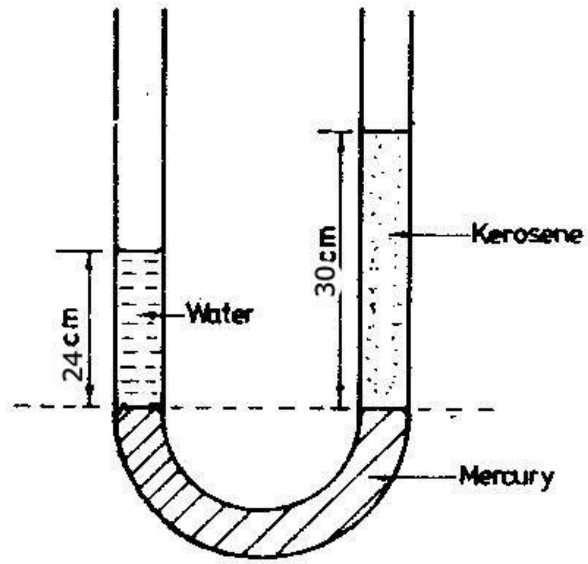
1. Water and kerosene are placed in U-tube containing mercury as shown above.

Determine the density of kerosene

Pressure of kerosene= Pressure of water (since both tube are open to the atmosphere)

$$h_x \ \rho_x \ g = h_w \ \rho_w \ g$$

$$h_x \rho_x = h_w \ p_w \qquad \rho_x = \frac{hw\ pw}{hX} = \frac{18\ X\ 1000}{20}$$



2. The level of the mercury in arms of the manometer shown below is equal. Determine

(i) Density kerosene

(ii) Relative density of kerosene

$h_1\, p_1\, g = h_2\, p_2\, g$

$24 \times 1000 = 30 \times p_2$

$\frac{24000}{30} = \frac{30P2}{30}$

Density $\rho = 800 kgm^{-3}$

Relative density of kerosene

R.d $= \frac{P\ of\ alcohol}{P\ of\ water}$

$= \frac{800}{1000}$

$= 0.8$

MACHINES

A machine is a device which allows the supply of energy at one point to do work at another point.
A force called effort is applied on a machine to over come a resisting force called load.

A machine is used to

- Covert energy from one form to another.
- It amplifies a force.
- Magnifies movements.

Terms used

1. **Work in put**

This is a work done by the effort and is equal to the effort and distance moved by the effort.

Work in put = effort x distance moved by effort

W input = E XDE

2. **Work out put**

This is the work done by the machine to over come the load.
$Work\ output\ =\ load\ x\ distance\ moved\ by\ load.$

W output L x d L

3. **Mechanical advantage (M.A)**

Is the ratio of load to effort i.e.

MA = $\frac{Load}{effort}$

It has no unit because it is a ratio of forces (quantity with the same units)

4. **Velocity ratio**

This is the ratio of distance moved by effort to the distance moved by the load in the same time interval. It has no unit.

VR = $\frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load}$

5. **Efficiency**

This is the ratio of work output to the in put expressed as a percentage.

$\tau = \frac{work\ output\ x100}{work\ output}$

The ratio of mechanical advantage to velocity ratio also fives efficiency $= \tau = \frac{M.A}{VR}$ X100

Proof for $\tau = \frac{M.A}{VR}$ X100

From $\tau = \frac{work\ output}{work\ in\ put}$ x 100

$$\tau = \frac{L\ \ X\ dL}{E\ \ X\ dE}\ X100$$

$$\tau = \text{M.A X} \frac{1}{VR}\ X100$$

$$\tau = \frac{M.A}{V.R} \text{X100.}$$

Types of simple machines

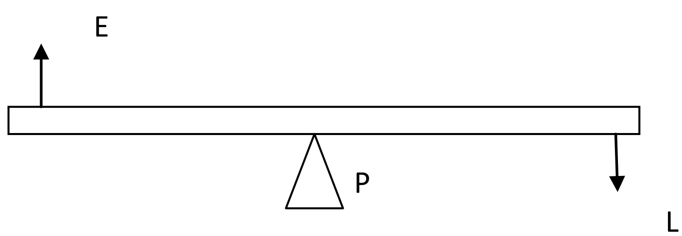
These include lever, pullys inclined planes, wages screws, wheels and axle, gears.

a) LEVERS

A lever is a simple machine which has a turning point called fulcrum/pivot. There are 3 classes of levers

1st class levers

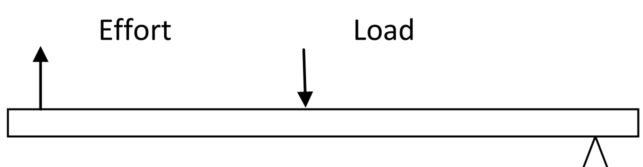
These are levers that have pivot between and effort.



E.g. pair of scissors, sea saws pair of pliers bottle opener etc.

2nd class lever

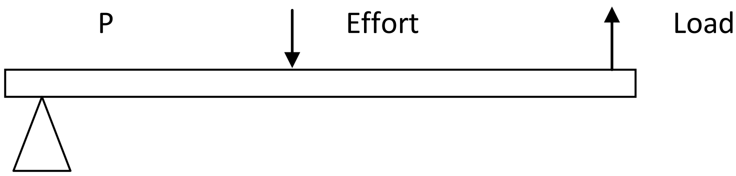
This is the lever that has a load between the pivot and the effort.



E.g. wheelbarrow, Nut cracker, axe etc.

3rd class lever

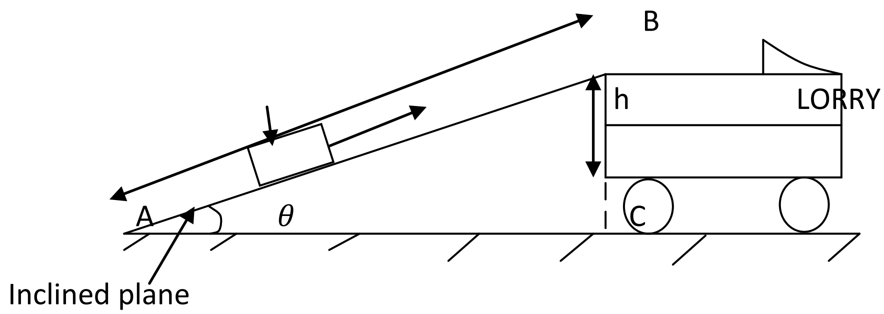
This is when the effort is between the pivot and load



E.g. Fore arm, spade, pair of tongs, forceps.

b) INCLINED PLANE

It is a wooden plunk which is inclined to the ground



The effort raises the load (box) through a vertical height BC by pulling it along the inclined from point A at the ground to point B at the required height

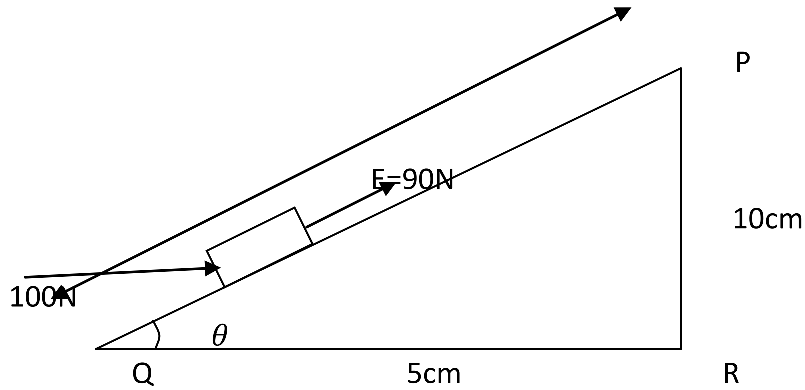
AB – length of inclined plane
L – Load / weight
E – Effort (pull / push)
θ - Angle of inclination to the ground
BC –vertical height

V.R = $\frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load} = \frac{x}{h}$

V.R = $\frac{1}{sin\theta}$

Question

1. Below is an inclined plane used to lift a load from R to p as shown?



QR = 5m QP = 10m

a) Determine
   i) mechanical advantage
   ii) angle of inclination
   iii) velocity ratio
   iv) Efficiency of the machine.

b) i) What is meant by first class lever?

ii) By means of a lever, an effort of 50N moves a load of 200N through a distance of 200N through 3M. If the effort moves a distance of 16m; calculate

- The mechanical advantage
- The efficiency.

SOLUTION

(a)i) $\text{M.A} = \frac{Load}{effort} = \frac{100}{90} = 1.11$

ii) $\text{Cos}\,\theta = \frac{Adjucent}{hypotenues}$

$= \frac{QR}{QP} = \frac{5}{10} = 0.5$

$\theta = \cos^{-1}(0.5) = 60^0$

iii) $\text{V.R} = \frac{1}{\sin\theta} = \frac{\mathbf{1}}{\mathbf{sin\ 60}} = \frac{\mathbf{1}}{\mathbf{0.866}} = 1.155$

(iv) $\tau = \frac{M.A}{V.R}$ X100

$= \frac{1.11}{1.155}$ X100

= 96.6%

(b) This is where the pivot is in between the load and effort.

M.A = $\frac{load}{effort} = \frac{200}{150} = 4$

$\tau = \frac{M.A}{V.R}$ X 100 but V.R = $\frac{d}{dL}$

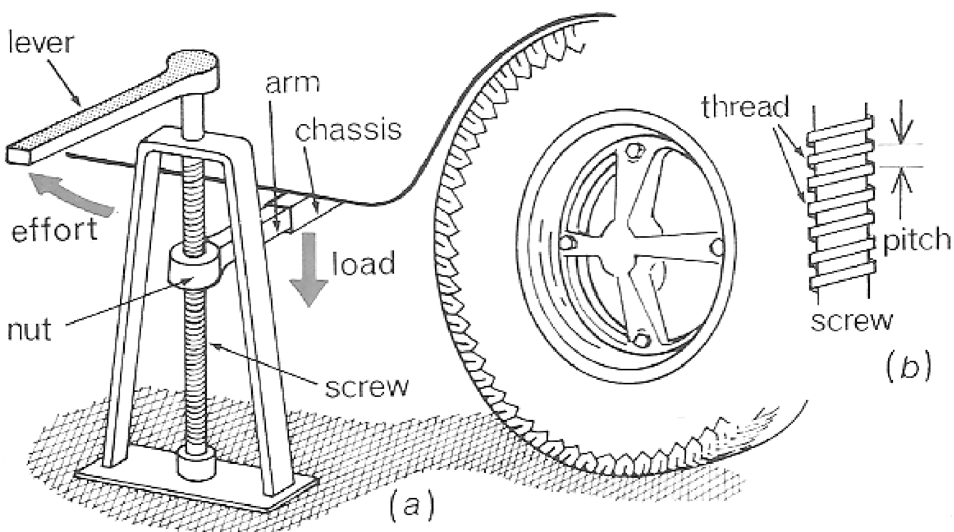
$= \frac{4}{16/3}\ X\ 100$

= 75%

SCREWS

Pitch is the distance between one thread and the next measured along the axis of the screw. it is equal to the distance moved by the load when the screw is rotated through one complete turn.

Examples of a screw jack



P – Pitch

a –radius of rotation (effort distance)

V.R of the screw = $\frac{dE\ in\ one\ rotation}{dL\ in\ one\ rotation.}$

$= \frac{2\pi a}{p}$

Example

Given that the pitch of a screw is 5mm when an effort is rotated to lift a load of 750N in one turn. Calculate

i) M.A

ii) V.R

iii) Efficiency

Solution:

(i) M.A = $\frac{Load}{Effort} = \frac{750}{30}$ = 25

(ii)V.R = $\frac{2\pi a}{p}$

= $\frac{2\ x 3.14\ x\ 50}{0.5}$

= 628

iii) $\tau = \frac{M.A}{V.R}$ X100 = 3.98%

Questions

2. A machine of velocity ratio 5 is used to raise a load whose weight is 200N. The effort required is 50N. calculate its M.A
3. A trolley of weight 10N is pulled from the bottom to the top of the inclined plane by a steady force of 2N.If the height and distance moved by the force are2m and 20m respectively. calculate

i) M.A

ii) V.R

iii) Efficiency

PULLEYS

A pulley is a grooved wheel mounted on a block. A string or rope passes around the pulley and it is held in place by the groove. An effort E is applied on the rope to reduce tension T in the rope such that effort = tension.

A tension in the rope is constant or uniform and acts in both directions along the rope. The load L is supported by the total tension in the sections of the rope attached to the pulley on which the load is fixed.

The tension in the section of the rope attached to the load directly is equal to the number of sections of the rope attached to the load by tension.

Load L = n t where n is number of sections of the rope attached to the load.

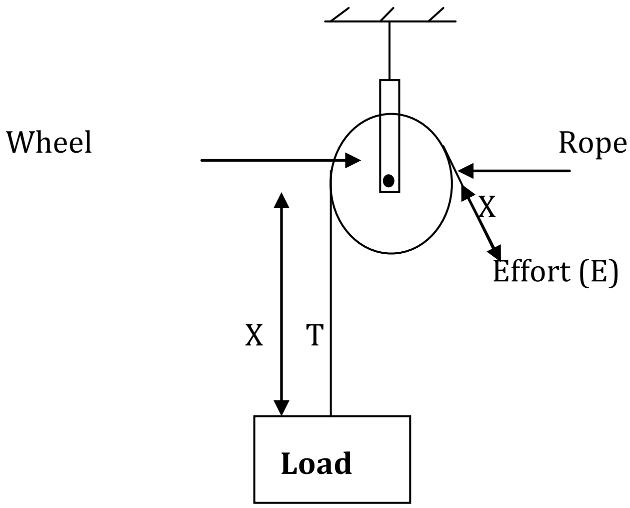
L can be less than n T ($L < nT$) due to the weight of the pulleys

L + W = nT where W is weight of the pulleys.

Types of pulley systems

Single fixed pulley.

It consists of only one pulley which is fixed.



Tension T = E

At equilibrium L =T

M.A = $\frac{Load}{effort}$ =$\frac{L}{E}$ but L=E

= $\frac{E}{E}$

= 1

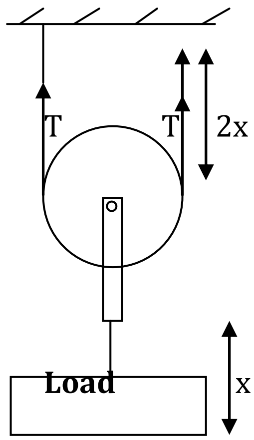
V.R = $\frac{Distance\ moved\ by\ effort}{Distance\ moved\ by\ load}$

= $\frac{x}{x}$

= 1

Single movable pulley

Consist of one moving pulley.



At equilibrium

Load L = 2 T

M.A = $\frac{L}{E} = \frac{2T}{T} = 2$

V.R = $\frac{Distance\ moved\ by\ effort}{Distance\ moved\ by\ load}$

$= \frac{2x}{x} = 2$

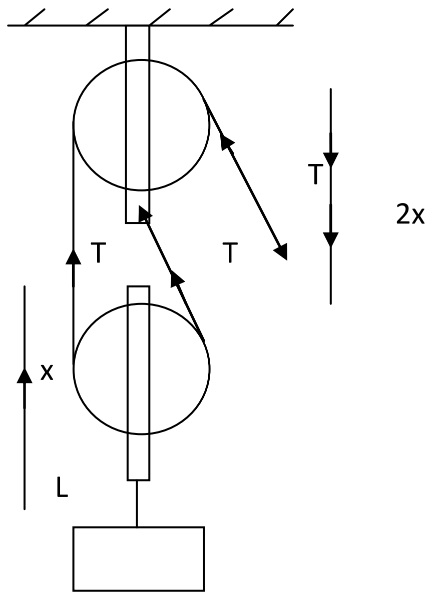
Block and tackle single pulley system

It consists of one or more pulleys in two blocks mounted independently on the same axle. One block is fixed and the other is moving. The load is fixed on the lower moving block, the upper fixed block has a number of pulleys as stated below in comparison with the lower block

1. For total even number of pulleys -:
   Number of pulleys in the upper block = number of pulleys in the lower block.
2. For total odd numbers of pulleys

Number of pulleys in the upper block exceeds number of pulleys in the lower block by 1

System of 2 pulleys

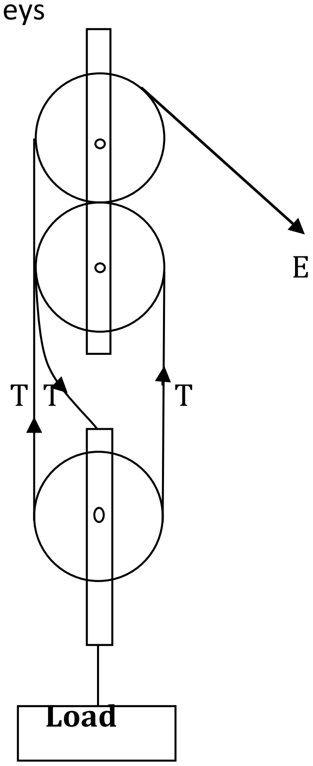


At Equilibrium , L = 2T,   E = T

M.A $= \frac{L}{E} = \frac{2T}{T} = 2$

V.R $= \frac{dE}{dL} = \frac{2X}{X} = 2$

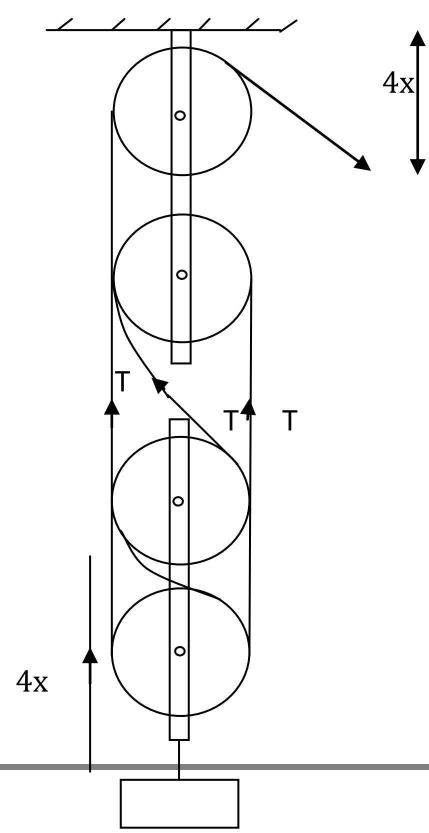
System of 3 pulleys



At equilibrium L = 3T, E = T

M.A = $\frac{L}{E} = \frac{3T}{T} = \frac{\mathbf{3X}}{\mathbf{X}} = \mathbf{3}$

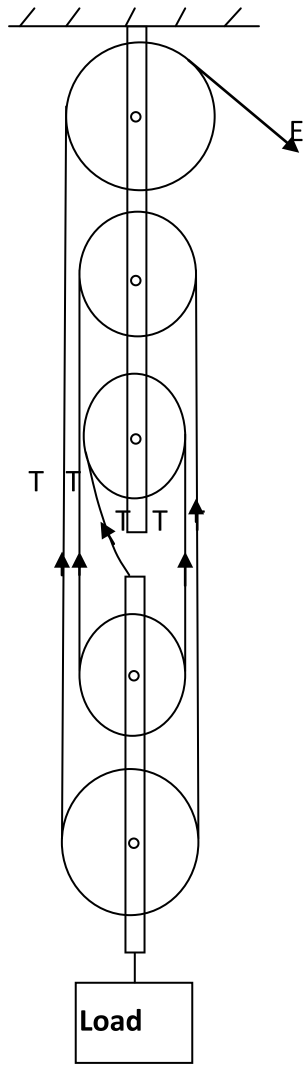
System of 4 pulleys



At equilibrium ≡m
Load L = 4T and E = T

M.A $= \frac{L}{E} = \frac{4T}{T} = 4$

System of 5 pulleys



At equilibrium ≡ m, L = 5T and E = T

M.A $= \frac{L}{E} = \frac{5T}{T} = 5$

V.R $= \frac{dE}{dL} = \frac{5X}{X} = 5$

1. Example

A pulley system of V.R = 3 Supports a load of 20N given that the tension in each string is 8N. Calculate

i) The effort required to raise a load
ii) The mechanical advantage.
iii) The distance moved by the effort. if the load moves thru a distance of 2m
iv) The weight of a pulley.

SOLUTION

i) $E = T = 8N$

$3E = L + W$

$3 \times 8 = 20 + W$

Therefore weight of the pulley $W = 24 - 20 = 4$

Weight of each pulley = 2N

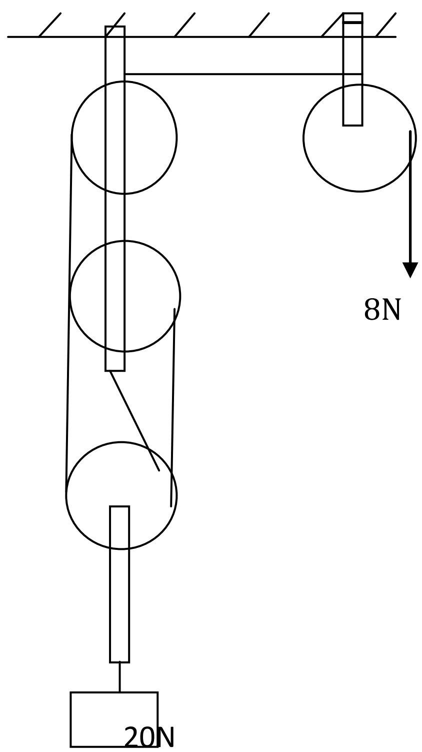
ii) $M.A = \frac{L}{E} = \frac{20}{8} = 2.5$

iii) $V.R = \frac{dE}{dL}$

$3 = \frac{dE}{2}$ $\qquad$ $dE = 3 \times 2 = 6m$

Efficiency $\tau = \frac{M.A}{V.R} \times 100 = \frac{2.5}{3.0} \times 100 = 83⅓\%$

2. A single stringed pulley system shown below.



A load of 20N raised by an effort of 8N, If the system is friction less find the mass of the lower pulley.

Upward forces = down ward forces

$3T = 20 + W$

$3 \times 8 = 20 + W$

$W = (24 - 20)$

$W = 4N$

3. Mass of the lower pulley = $\frac{w}{g} = \frac{4}{10}$ =0.4kg An effort of 50N is required to raise a load of 200N using a pulley system of Velocity 5
   a) Draw a diagram to show the pulley system.
      i) Find the efficiency of the system.
      ii) Calculate the work wasted when the load is raised thru 120cm.
   b) Give 2 reasons why efficiency of your pulley system is always less than 100%.

   Solution

   i) $\tau = \frac{M.A}{V.R} X100 = \frac{4}{15} X100 = 80\%$

   ii) dL = 120cm = 1.2m

   Work in put = E X dE = 50 X 6 = 300J

   Work output = L X dL= 200 x 1.2 = 240J

   Work wasted = work in put – work output
   = 300 – 240
   = 60J

N.B

Number of strings supporting a movable load velocity ratio.

Efficiency of a pulley system is always less than 100%

(i) work is wasted when overcoming friction force
(ii) work is wasted in raising moving parts of the machine.

Work wasted = work input – work output.

Ways of improving on the efficiency on the machine

- By lubricating moving parts of the machine
- By reducing on the weight of moving parts using light alloys

Uses of pulleys

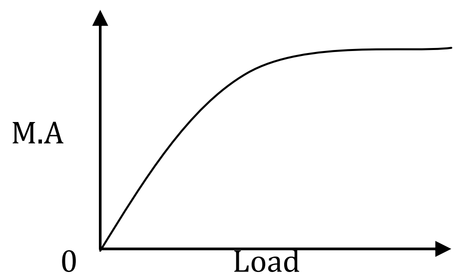
- Used in hasting flags
- Used in cranes in building.

Explain how a flag is hoisted.

A string is attached on the wheel of the pulley up the pole and the flag which acts as the load is attached to the string and pulled to the hoist the flag.

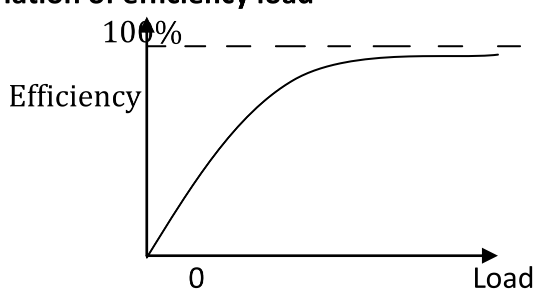
The flag is tied on a string and the string is then post over the pulley running. The rope is pulled down and the flag is hoisted.

Variation of M.A with load



- When the load is small, friction and unnecessary weight are also small. Therefore M.A is significant
- When the load is increased friction and unnecessary weights are increased, decrease the efficiency and M.A of the machine.

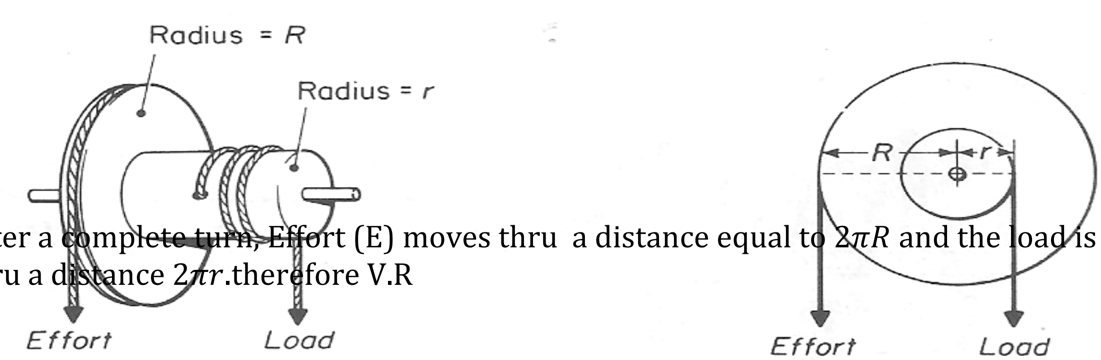
Variation of efficiency load



- When the load is small, friction and other necessary weights are significant compared to the load. This makes both M.A and efficiency small.
- When the load becomes big friction and efficiency necessary weights become insignificant (very small) compared the load. This increases the M.A and efficiency of the system.

WHEEL AND AXLE

It consists of a large diameter wheel and axle both of which are firmly attached to one another.

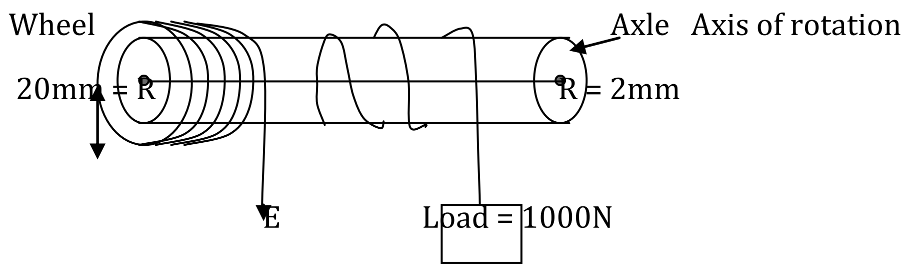


(a) (b)

After a complete turn, Effort (E) moves thru a distance equal to $2\pi R$ and the load is raised thru a distance $2\pi r$.therefore V.R

$$V.R = \frac{Distance\ moved\ by\ effort}{distance\ moved\ by\ load}$$

$$V.R = \frac{2\pi R}{2\pi r} = \frac{R}{r}$$



Example

1. Assuming that the efficiency of the above system is 45%. Find
   a) The effort required to raise the load.
   b) The energy wasted when the effort moves thru one 1760cm

Solution

a) $V.R = \frac{R}{r} = \frac{20mm}{2mm} = 10$

$$\text{Efficiency} = \frac{M.A}{V.R} X100$$

$$45 = \frac{M.A}{10} X100$$

$$M.A = \frac{45\ X10}{100} = 4.5$$

$$M.A = \frac{Load}{effort} = \frac{1000}{E} = 4.5$$

$$\text{Effort } E = \frac{1000}{4.5} = 222.2N.$$

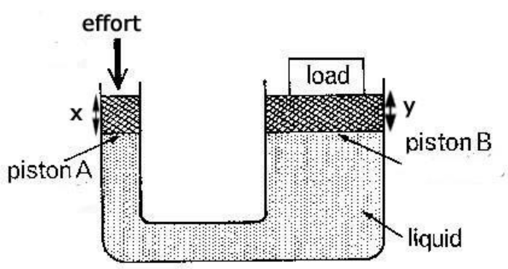
b) Work input = E x dE = $222.2\ X\ 2\pi\ X\ \frac{20}{1000} = 8.88\pi J$

Work output = L X dE = $1000\ x 2\pi\ x\ \frac{2}{1000} = 4\pi J$

Work wasted = $(8.88 - 4)\pi = 4.88\pi J = 15.34J$

HYDRAULIC PRESS

It works on the principle that pressure transmitted thru an incompressible liquid/ fluid is the same every where in the fluid.



Pressure p = $\frac{force(F)}{area(A)}$

F = P X A

Therefore E = P X A_1= P X πr^2

And load L = P X A_2 = P X πR^2

M.A = $\frac{load}{effort}$ = $\frac{P\pi R2}{P\pi r2}$

M.A = $\frac{R2}{r2}$

When E and L move through a distance x and y respectively, the volumes are pressed by small piston is equal to volume raised up in the; large piston.

A_1 x = A_2 y = $\pi r^2 x = \pi R^2$ = $\frac{x}{y} = \frac{\pi R2}{\pi r2}$

V.R = $\frac{R2}{r2}$

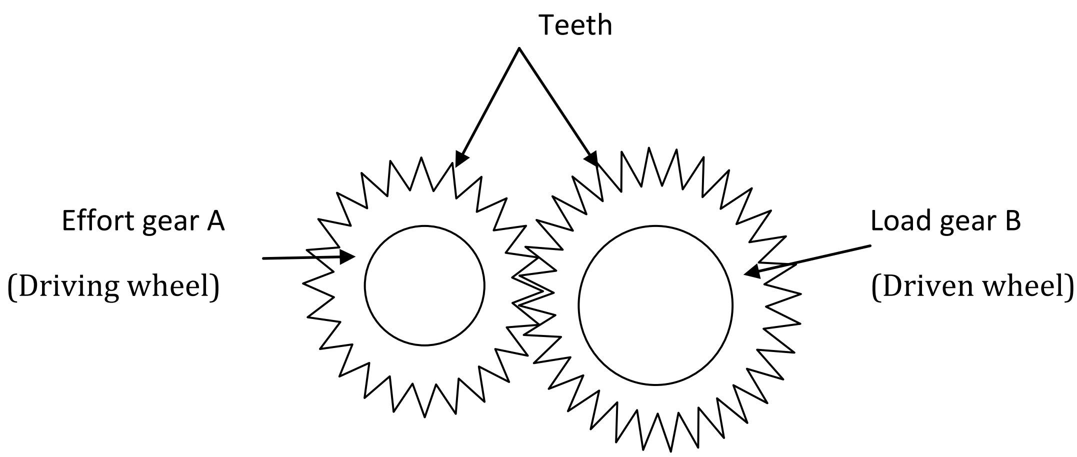
Questions

1. A hydraulic hoist has a main cylinder diameter of 30cm and a pump cylinder diameter of 1cm.
   Calculate
   a) V.R
   b) The maximum load it can raise
   c) M.A (given that the force applied on the piston pump 70N and efficiency equal 80%)
2. The efficiency of the hydraulic press is 60 %. Find the load raised if an effort of 200 NIS applied on a piston of radius 5cm and the load is pressed on the piston of radius 30cm.

GEARS

In gears, the effort is applied to one wheel which is called the driving wheel. The other wheel to which the load is connected is called the driven wheel.

For two gears is contact, observed speed of rotation is inversely proportional to the number of teeth.



Velocity ratio = $\frac{speed\ of\ rotation\ of\ driving\ wheel}{speed\ of\ rotation\ of\ driven\ wheel.}$

V.R = $\frac{Number\ of\ teeth\ in\ a\ driven\ wheel}{number\ of\ teeth\ in\ driving\ wheel.}$

If gear A turns its teeth it interlocks with those of B and make it turn in the opposite direction.

N.B

The fastest turning gear is that with the smallest number of teeth.

Example

A hydraulic machine has 120 teeth in the driven gears and 40 teeth in the driven gear. Calculate

i) It's V.R.
ii) Its M.A(if the machine is 80% efficient)

Solution

i) V.R = $\frac{number\ ot\ teeth\ in\ driven\ gear}{over\ number\ of\ teeth\ in\ driving\ gear.}$

$= \frac{120}{40} = 3$

ii) Efficiency $\tau = \frac{M.A}{V.R}$ X100

$80 = \frac{M.A}{3}$ X100

$$M.A = \frac{80\ X3}{100} = 2.4$$

HEAT ENGINES

These are simple machine which turns chemical energy to kinetic energy and heat. There are two types of heat energies

i) Petrol engine
ii) Diesel engine

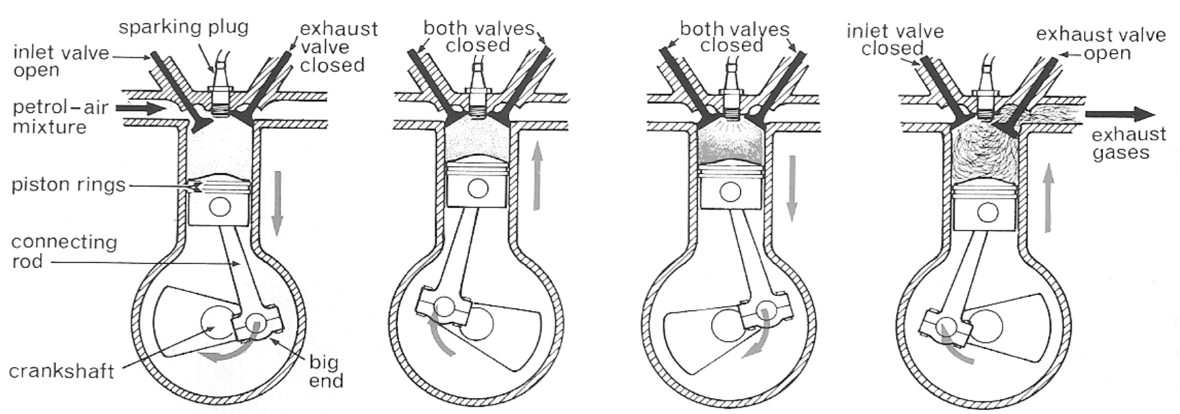
Petrol engine

These are used to power cars, motor, bikes, vans etc.

Petrol is mixed with air and exploded inside the engine cylinder. The explosion is used to force down a closely fitting piston.

The crank shaft is used to turn the up and down movement of the piston into kinetic energy that drives the valve forward; in this way engine energy is abstained as a results of burning petrol inside it.

The four stroke petrol engine.



1. INTAKE 2.COMPRESSION 3. POWER 4. EXHAUST

1. Intake stroke.

Air and petrol mixture enters the cylinder and the piston goes down as the exhausted valve closes hence pressure within decreases.

2. Compression and power stroke

-spark plug produces a spark which ignites the mixture. After very high compression an explosion occurs and the position is pushed down. Power s obtained plus some energy (chemical $\rightarrow mechanical\ \rightarrow heat$).

3. Exhaust stroke

The exhausted valve opens and unwanted gases are taken out while the in let valve is closed, after the piston has moved upwards.

N.B- four cylinders are used in four stroke engine for continuous power production. in every quarter of the cycle.

Diesel engine

These are used to carry heavy Lorries, trailers etc. they are efficient in pulling very heavy loads e.g. ships. The main difference between diesel and petrol engine is the way in which the fuel is burnt. The injector pump is compressed so much that it becomes hot enough to ignite the diesel fuel. The diesel engine must be made stronger than engine in order

The diesel engine has no spark plug instead has a fuel injector. In the diesel engine air is compressed to withstand extra compression required.

Differences between petrol engine

PETROL ENGINE	DIESEL ENGINE
-fuel is ignited on /in the engine by electric spark plug.	- fuel is ignited by compression
-Has a car burretor for mixing air and petrol	Lack a car burrettor
Has spark plugs	Lacks spark plugs
-operates at lower compression ratio of 8:1and therefore less powerful	Operates at higher compression and therefore ratio of 16:1 and therefore more powerful
Power occurs when petrol and air mixture is ignited	Only diesel is ignited
Has no injector pump	Has injectors which atomize diesel
Petrol engine is lighter	Its heavier
Produces less noise	Produces a lot of noise
Maintenance is more frequent and usually have problems in starting.	Maintenance is less frequent and causes no problem in starting.

END