PHYSICS
FORM THREE
NOTES

APPLICATIONS OF VECTORS

Scalar and Vector Quantities

Difference between Scalar and Vector Quantities

Distinguish between scalar and vector quantities

Scalar Quantities

These are physical quantities which have magnitude only. Examples of scalar quantities include mass, length, time, area, volume, density, distance, speed, electric current and specific heat capacity.

Vector Quantities

These are physical quantities which have both magnitude and direction. Examples of vector quantities include displacement, velocity, acceleration, force, pressure, retardation, and momentum.

Addition of Vectors Using Graphical Method

Add vectors using graphical method

Scalar physical quantities have magnitude only. Thus, they can be added, multiplied, divided, or subtracted from each other.

Example 1

If you add a volume of $40cm^3$ of water to a volume of $60cm^3$ of water, then you will get $100cm^3$ of water.

Vectors can be added, subtracted or multiplied conveniently with the help of a diagram.

Vectors Representation

A vector quantity can be represented on paper by a direct line segment.

1. The length of the line segment represents the magnitude of a vector.
2. The arrow head at the end represents the direction.

Methods of Vector Addition

There are two methods that are used to sum up two vectors:

1. Triangle method
2. Parallelogram method.

Triangle Method

A step-by-step method for applying the head-to-tail method to determine the sum of two or more vectors is given below.

1. Choose a scale and indicate it on a sheet of paper. The best choice of scale is one that will result in a diagram that is as large as possible, yet fits on the sheet of paper.

2. Pick a starting location and draw the first vector*to scale*in the indicated direction. Label the magnitude and direction of the scale on the diagram (e.g., SCALE: 1 cm = 20 m).

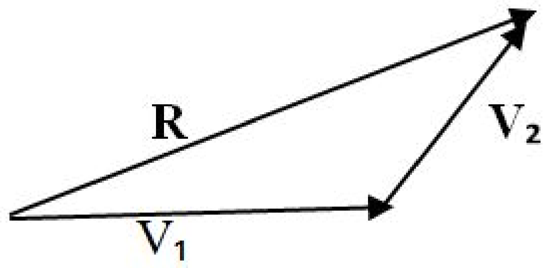
3. Starting from where the head of the first vector ends, draw the second vector*to scale*in the indicated direction. Label the magnitude and direction of this vector on the diagram.

4. Draw the resultant from the tail of the first vector to the head of the last vector. Label this vector as **Resultant**or simply**R**.

5. Using a ruler, measure the length of the resultant and determine its magnitude by converting to real units using the scale (4.4 cm x 20 m/1 cm = 88 m).

6.Measure the direction of the resultant using the counterclockwise convention.

Resultant vector: This is the vector drawn from the starting point of the first vector to the end point of the second vector which is the sum of two vectors.



Where:

- Vi - First vector
- V2 - Second vector
- R - Resultant vector

Example 2

Suppose a man walks starting from point A, a distance of 20m due North, and then 15m due East. Find his new position from A.

Solution

Use scale

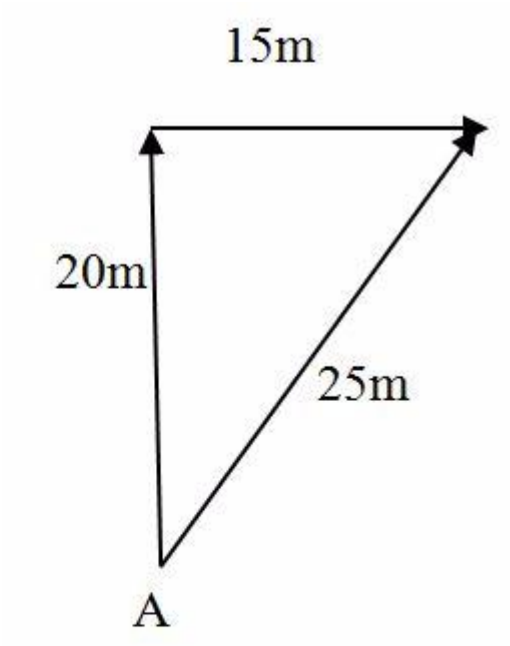
1CM Represents 5m

Thus

20m due to North Indicates 4 cm

15m due to East Indicates 3cm.

Demonstration



The position of D is represented by Vector AD of magnitude 25M or 5CM at angle of $36^0 51$”

Since

- Tan Q = (Opposite /Adjacent)
- Tan Q = 3cm /4cm
- Q = Tan^{-1} (3/4)
- Q = Tan^{-1}(0.75)
- Q = 35º51”

The Resultant displacement is 25m ad direction Q = 36º51”

The Triangle and Parallelogram Laws of Forces

State the triangle and parallelogram laws of forces

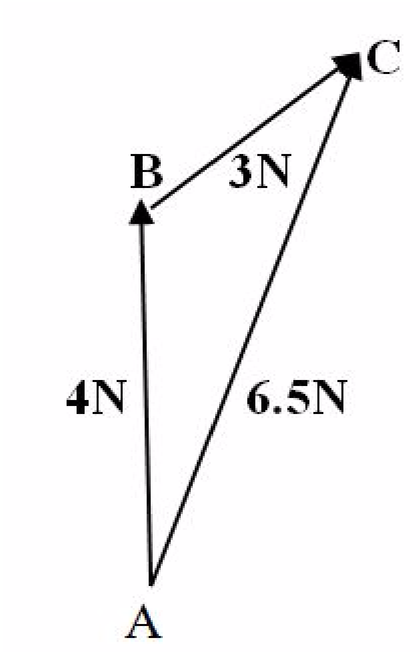
Triangle Law of Forces

Triangle Law of Forces states that “If three forces are in equilibrium and two of the forces are represented in magnitude and direction by two sides of a triangle, then the third side of the triangle represents the third force called resultant force.”

Example 3

A block is pulled by a force of 4 N acting North wards and another force 3N acting North-East. Find resultant of these two forces.

Demonstration



Scale

1Cm Represents **1**N

Draw a line AB of 4cm to the North. Then, starting from B, the top vectorofAB, draw a line BC of 3 CM at 45^{o}East of North.

Join the line AC and measure the length (AC = 6.5 cm) which represents 6.5N. Hence, AC is the Resultant force of two forces 3N and 4N.

Parallelogram Method

In this method, the two Vectors are drawn (usually to scale) with a common starting point , If the lines representing the two vectors are made to be sides of s parallelogram, then the sum of the two vectors will be the diagonal of the parallelogram starting from the common point.

The Parallelogram Law states that “If two vectors are represented by the two sides given and the inclined angle between them, then the resultant of the two vectors will be represented by the diagonal from their common point of parallelogram formed by the two vectors”.

Example 4

Two forces AB and AD of magnitude 40N and 60N respectively, are pulling a body on a horizontal table. If the two forces make an angle of 30^o between them find the resultant force on the body.

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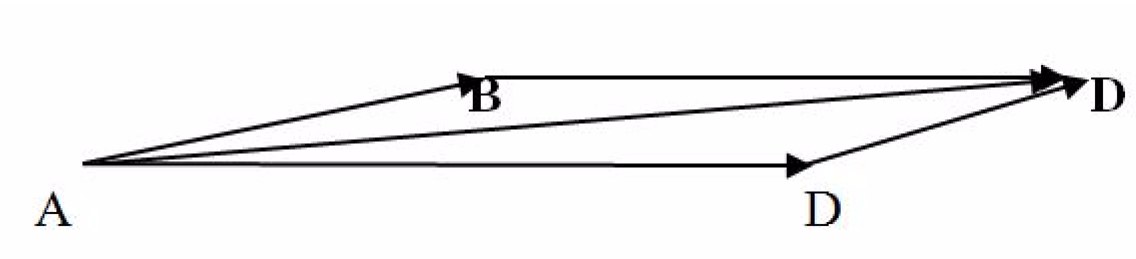


Choose a scale.

1cm represents10N

Draw a line AB of 4cm

Draw a line AD of 6cm.

Make an angle of 30^o between AB and AD. Complete the parallelogram ABCD using the two sides AB and include angle 30^O.

Draw the lineAC with a length of9.7 cm, which is equivalent to 97 N.

The lineAC of the parallelogram ABCD represents the resultant force of AB and AD in magnitude and direction.

Example 5

Two ropes, one 3m long and the other and 6m long, are tied to the ceiling and their free ends are pulled by a force of 100N. Find the tension in each rope if they make an angle of 30^{o}between them.

Solution

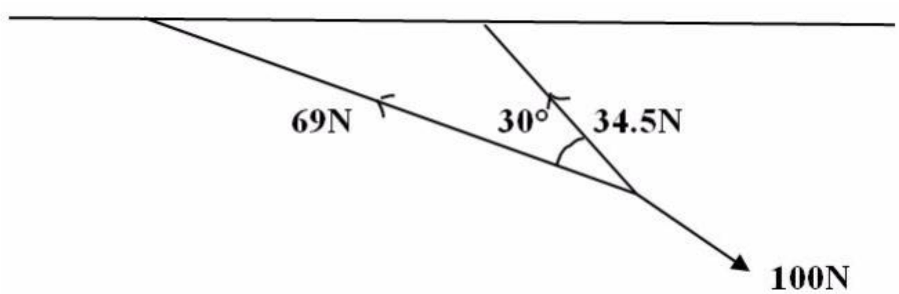
1cm represents 1N

Thus

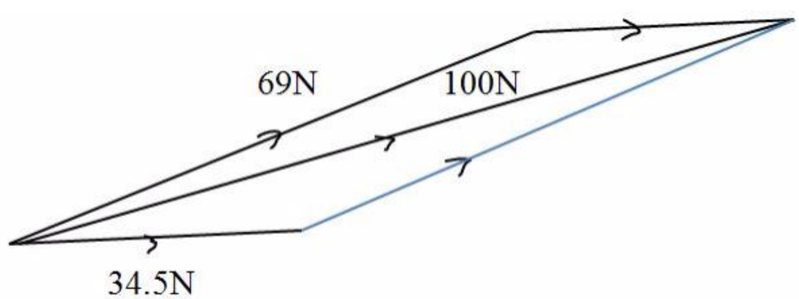
3cm = represent 3m

6cm = represents 6m

Demonstration



By using parallelogram method



Tension, determined by parallelogram method, the length of diagonal using scale is 8.7 cm, which represents 100N force.

Thus.

Tension in 3m rope = 3 X 100 / 8.7 = 34.5N

Tension in 6m rope = 6 x 100 / 8.7 =69N

Tension force in 3m rope is 34.5N and in 6m rope is 69N.

Note: **Equilibrant forces**are those that act on a body at rest and counteract the force pushing or pulling the body in the opposite direction.

Relative Motion

The Concept of Relative Motion

Explain the concept of relative motion

Relative motion is the motion of the body relative to the moving observer.

The Relative Velocity of two Bodies

Calculate the relative velocity of two bodies

Relative velocity (Vr) is the velocity relative to the moving observer.

CASE 1: If a bus in overtaking another a passenger in the slower bus sees the overtaking bus as moving with a very small velocity.

CASE 2: If the passenger was in a stationary bus, then the velocity of the overtaking bus would appear to be greater.

CASE 3: If the observer is not stationary, then to find the velocity of a body B relative to body A add velocity of B to A.

Example 6

If velocity of body B is VB and that of body A is VA, then the velocity of B with respect to A , the relative velocity VBA is Given by:

VBA = VB + (-VA)

That is

VBA = VB – VA

NOTE:The relative velocity can be obtained Graphically by applying the Triangle or parallelogram method.

For same direction

$V_{rBA} = V_B - (+V_A)$

$= V_B - V_A$ ____________________ (I)

For different direction

$V_{rBA} = V_B - (-V_A)$

$V_{rBA} = V_B + V_A$ ________________________ (II)

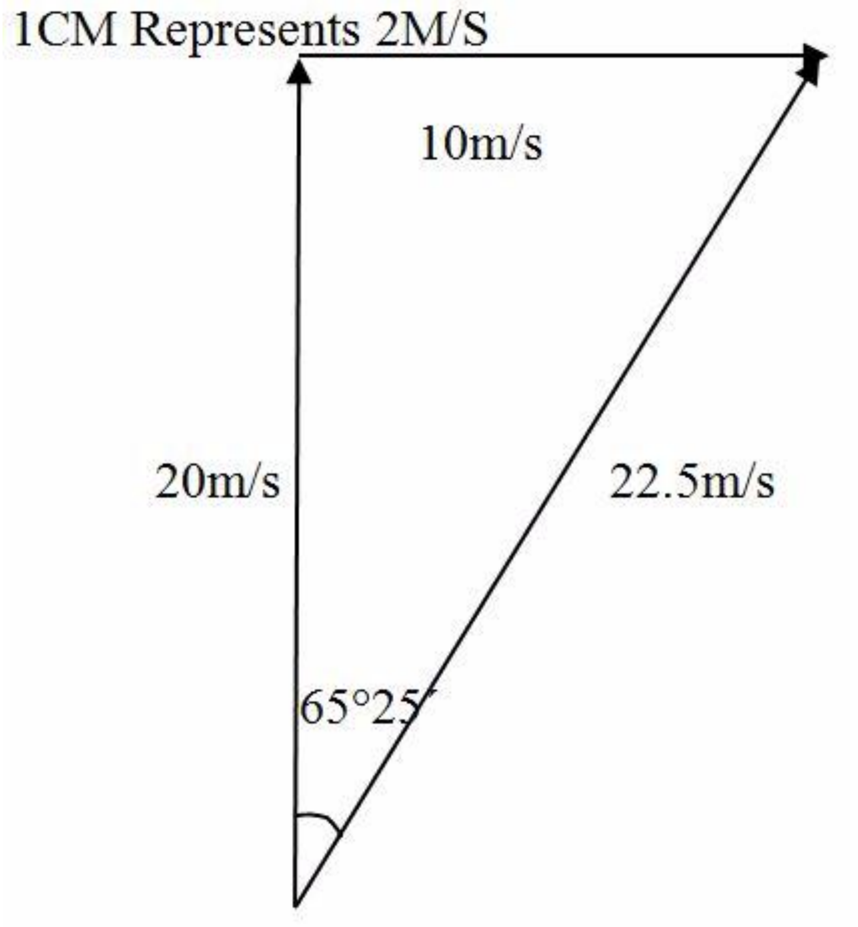
Example 7

A man is swimming at 20 m/s across a river which is flowing at 10 m/s. Find the resultant velocity of the man and his course if the man attempted to swim perpendicular to the water current.

Solution

Scale

1cmrepresents 2m/s



- The length of AC is 11.25 cm which is 22.5 m/s making a angle of 65º25’ with the water current.
- The diagonal AC represent (in magnitude and direction) the resultant velocity of the man.

The Concept of Relative Motion in Daily Life

Apply the concept of relative motion in daily life

Knowledge of relative motion is applied in many areas. In the Doppler effect, the received frequency depends on the relative velocity between the source and receiver. Friction force is determined by the relative motion between the surfaces in contact. Relative motions of the planets around the Sun cause the outer planets to appear as if they are moving backwards relative to stars in universe.

Resolution of Vectors

The Concept of Components of a Vector

Explain the concept of components of a vector

Is the Splits or separates single vector into two vectors (component vectors) which when compounded, provides the resolved vector.

Resolved vector is asingle vector which can be split up into component vectors.

Component vectorsare vectors obtained after spliting up or dividing a single vector.

Resolution of a Vector into two Perpendicular Components

Resolve a vector into two perpendicular components

Components of a vector are divided into two parts:

1. Horizontal component
2. Vertical component

Take angle OAC

Case 1

SinQ = FX/F

Thus

FX = F SinQ

Horizontal component, FX = FSinQ

Case 2

Cos Q = Fy/F

Thus:

Fy = FCosQ

Vertical component: Fy = FCosQ

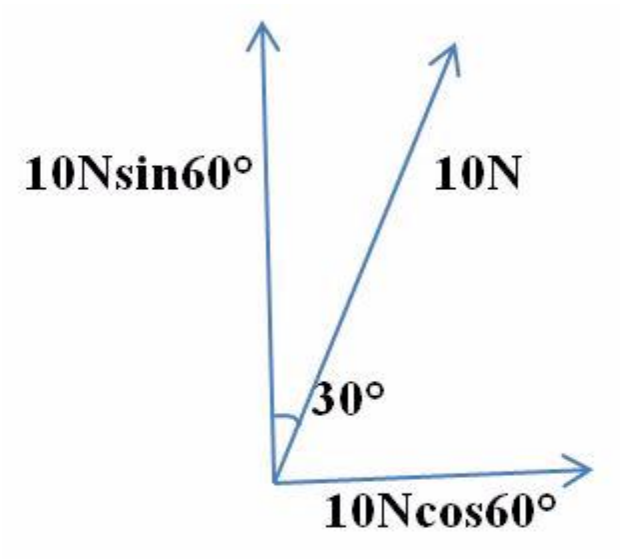
Resolution of Vectors in Solving Problems

Apply resolution of vectors in solving problems

Example 8

Find the horizontal and vertical components of a force of 10N acting at 30^0 to the vertical.

Solution



FX = FCOS 60º

Since

Cos 60º /F =(FX)

FX = F CoS60º ____________________(1)

FX = 10NCos 60º

Fy = ?

Sinq = Fy

Fy =F SinQ ______________________________ (ii)

Fy= 10N Sin 60º

FRICTION

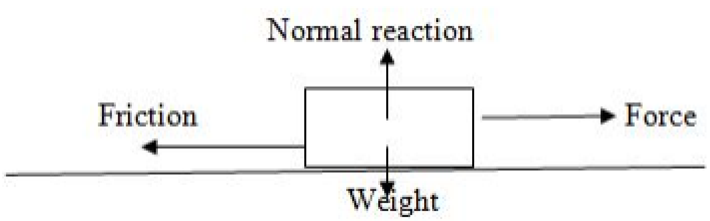
Concept of Friction

The Concept of Friction

Explain the concept for friction

Friction is the force which opposes (resists) motion of the body for example: If a block of wood is placed on a table it remains at rest Unless it is acted upon by an external force.

The applied force must exceed the maximum friction force between the block of wood and the table if the block is to be moved along the table.



Friction force between two surface in contact exists only when there is relative motion between the two contacting surface.

The friction between two surfaces exists because of the nature of the surface of the bodies in contact. (Strictly speaking all surfaces are rough because they are made up of peaks and valleys)

Demonstration

The peak and valleys on the surfaces of bodies may be due to a random arrangement of coarse particles, for example the surface of a gridding stones.

Smooth surfaces exert almost no friction. What happens when two objects are pushed?

When one body is pushed against another, the peaks of one surface have to rise up over the peaks of the other surface. Hence opposition to motion or friction occurs the force acting to restore the bodies to their original position.

The Advantages and Disadvantages of Friction in Daily Life

Realize the advantages and disadvantages of friction in daily life

Advantages of Friction

Thefriction force has several advantages which includes the following:

1. It helps in walking process (because friction force stop us from slipping over).

2. It helps cars to move onroads easily due to friction between car tyres and road (makesa car stay on road) NOTE: Most car tyres have deep dreads to increase friction between the tyres and the road surface.

3. it helps in car braking system. Brakes rely on friction between the brake drum or pads and the wheels. In a bicycle, there are brake pads which clamp onto the wheel to slow it down.

Disadvantages of friction

Frictional force has several dis-advantages which includes the following:

1. Cause machinery to heat up and can cause wear and tear.

2. Cause machinery to be less efficient.

3. Cause machinery to produce noise.

Methods of Reducing Friction

Describe methods of reducing friction

Thedifferent methods ofreducing friction between surfaces includes the following:

1. Polishing:Polishing the surface, reduces the irregularities and hence, reduces friction.

2. Lubrication:It provides a layer of the lubricant on which the bodies can easily slide.

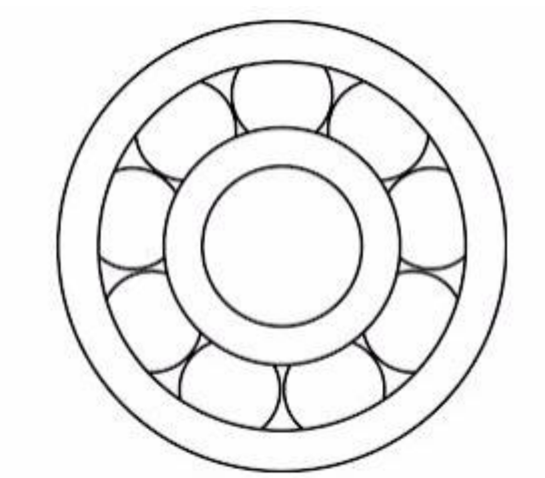
3. Use of ball-bearing or roller bearing:Roller bearing help to convert sliding friction into a milder form-rolling friction. Rolling friction is lesser than sliding friction.

4. Streamlining:Fast cars, boats, planes etc., have a streamlined body. This is to allow air (or water in the case of boats) to easily flow by, without offering much resistance. Flying birds have streamlined bodies.

5. Use of correct combination of surfaces in contact:Use of alloys on moving and sliding parts reduces friction because alloys have a low coefficient of friction.

Roller

- It is a simple cylinder on which a body to be pulled RESTS.
- It is used to eliminates sliding friction.
- Conveyor belts use metal rollers.



Wheels

- These arerollers that are fixed to a moving body, held in place by cylinders or axles which are threaded in their centers. Example; a trailer towed by vehicle.
- Wheels are used to eliminate sliding friction.
- They are used to reduce friction (the friction between surfaces can be reduced by smoothing and polishing the surfaces in contact).

- In order to make surfaces slippery, a lubricant such as oil or graphite is used. Oil and Grease are commonly used invehicles and machines to reduce friction between moving parts. In engines, differential air is also an effective lubricant in machine.

Types of Friction

Types of Friction

Identify types of friction

There are three main types of friction in daily life which include the following:

1. Static friction: an opposing forcebetween two solid objectsat rest.In simple words, when there is no relative motion between two solid objects in contact with each other, we describe the frictional force between them asstatic.
2. Limiting friction: numerically equal to the minimum external force required to make a body just move over another.
3. Dynamic friction: numerically equal to the force of opposition when a body is moving over the rough surface.

Limiting Friction

Determine limiting friction

Limiting friction is equal to the minimum external force required to make a body just move over one another. Is the maximum possible value of static friction. It is the frictional force that must be overcome before an object starts moving. The coefficient of friction will be the same for all masses. The limiting frictional forces is independent of applied force but depends on nature of surface.

Example 1

A block of mass 20 kg is pulled along a horizontal surface. If the coefficient of friction is 0.4, what force is acting on the block?

Solution

Force = coefficient of friction ×mass × acceleration due to gravity

F = 0.420×10 = 80N.

Laws of Friction

Laws of Friction

State laws of friction

The five laws of friction

1. When an object is moving, the friction is proportional and perpendicular to the normal force (N).

2. Friction is independent of the area of contact.

3. The coefficient of static friction is slightly greater than the coefficient of kinetic friction.

4. Within rather large limits, kinetic friction is independent of velocity.

5. Friction depends upon the nature of the surfaces in contact.

The Coefficient of Friction

Determine the coefficient of friction

Coefficient of friction is the ratio of the frictional force that acts between two objectsin contact to the normal reaction, R.

$$U = \frac{Fr}{R}$$

Types of Coefficient of friction

There are three main types of coefficient of frictions which includes the following:

Coefficient of static friction is the ratio of the static friction to the normal reaction.

$Us = Fr_s/R$

Coefficient of dynamic friction U_S

Is the ratio of the dynamic friction to the normal reaction that acts onthe body.

Ud = Frd/R

Laws of Friction in Solving Problems

Apply laws of friction in solving problems

Demonstration to determine coefficient of dynamic friction.

Method of calculation

The coefficient of dynamic friction U is

U = Frictional force, Fr/Normal Reaction, R

U= Fr/R________________________________ (I)

By Resolving forces we get

Fr = W SinQ ___________________________(II)

R= W CosQ _________________________(III)

Put Eqn (iii) ad (ii) into eqn (i)

U =W SinQ/Wc osQ

U =W SinQ/WCosQ

But SinQ/CosQ=TanQ

U=TanQ

Thus

TanQ = (AB/CB) FROM Angle ABC

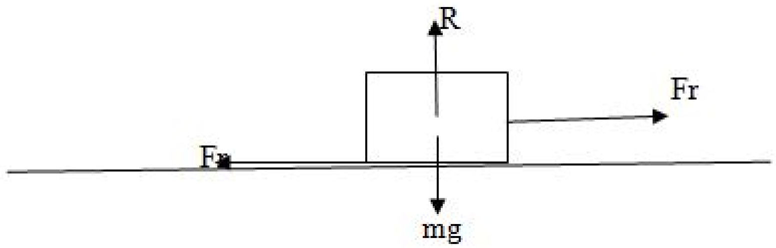
But

U = TanQ

u = (ab/cb)

Example 2

Find the static friction between a block of wood of mass 10kg and the table on which it rests. A minimum force of 50N is required to make the block just move on the table top.



Solution

Limiting Friction, Fr = 50N

Normal Reaction, r =(10 X 10) = 100N

Coefficient of static friction; Us

Us = (Fr/ R)

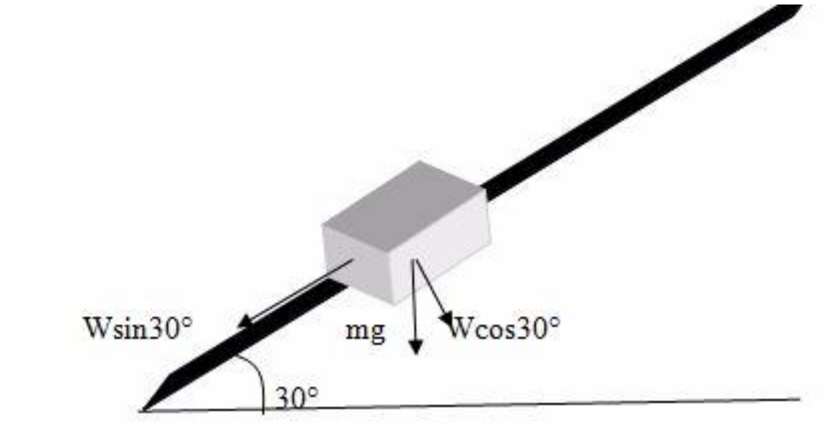
Us = (50/100)

Us = 0.5

Therefore,coefficient of static friction, Us = 0.5

Example 3

A mass is placed on an Inclined plane such that it moves at a constant speed when tapped tightly. If the angle the plane makes with the horizontal is 30º. Find the coefficient of dynamic friction.



The Coefficient of friction U =Fr/R

Fr = WSinQ/R = WCosQ

At Equilibrium

U =WSinQ/wCosQ

U = (W/W) (SinQ/CosQ)

But (SinQ/CosQ) = TanQ

U = Tan 30º

U = 0.56

Coefficient of friction, U = 0.56

LIGHT

Light is a form of energy which controls the sense of vision.

Reflection of Light from Curved Mirrors

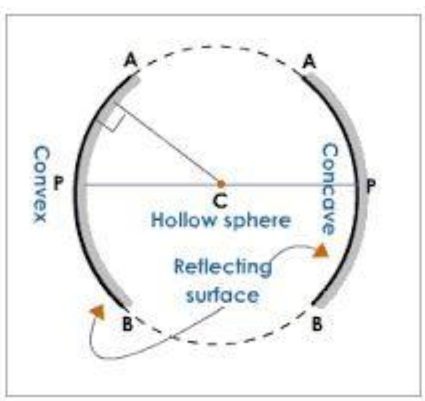
Difference between Concave and Convex Mirrors

Distinguish between concave and convex mirrors

Concave mirror is a spherical mirror whose reflecting surface is curved inwards. A Good example is the driving mirror of a car.

Convex mirror is a spherical mirror whose reflective surface is curved outwards. A good example of a convex mirror is a shaving mirror.

General demonstrations of convex and concave mirrors (curved mirrors:

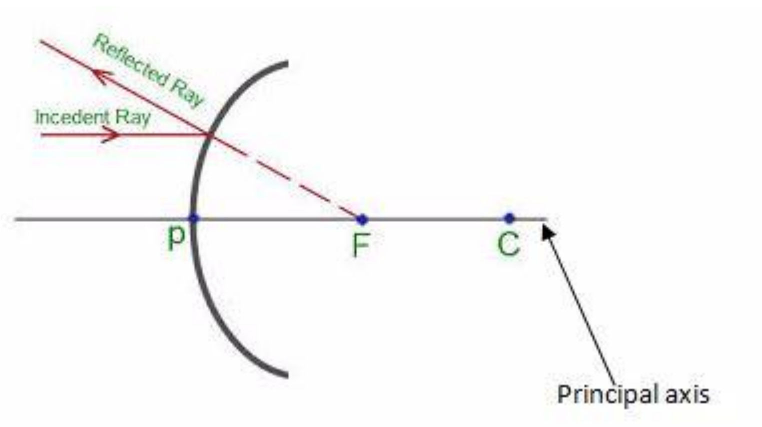


The Terms Principle, Axis, Pole, Principle Focus and Radius of Curvature as Applied to Curved Mirrors

Explain the terms principle, axis, pole, principle focus and radius of curvature as applied to curved mirrors

Terms used in studying curved mirrors

- **Centre of curvature (C):**the centre of the sphere of which a mirror is a part of.
- **Radius of curvature (R)**: the radius of sphere of which a mirror is a part of.
- **Pole (P)**: the central point of the reflecting surface of spherical mirror (curved or convex mirror).



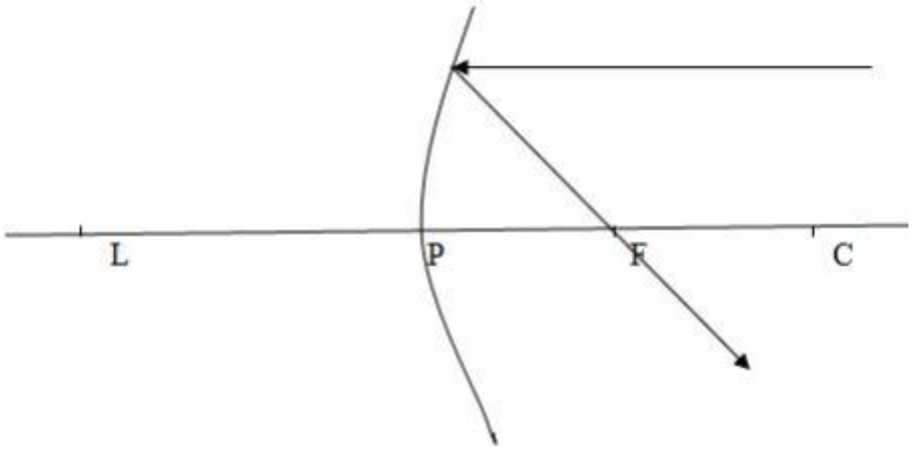
- **Principal axis:**the straight line joining the centre of curvature (C) and the pole (P).
- **Principal focus (F):**the point o the principal axis where light rays tend to intersect. This point is between centre of curvature and the pole.
- **Principal axis:**the straight line joining the centre of curvature (C) and the pole (P).
- **Principal focus (F):**the point on the principal axis where light rays tend to intersect. This point is between centre of curvature and the pole.

The Images Formed by a Curved Mirror

Locate the images formed by a curved mirror

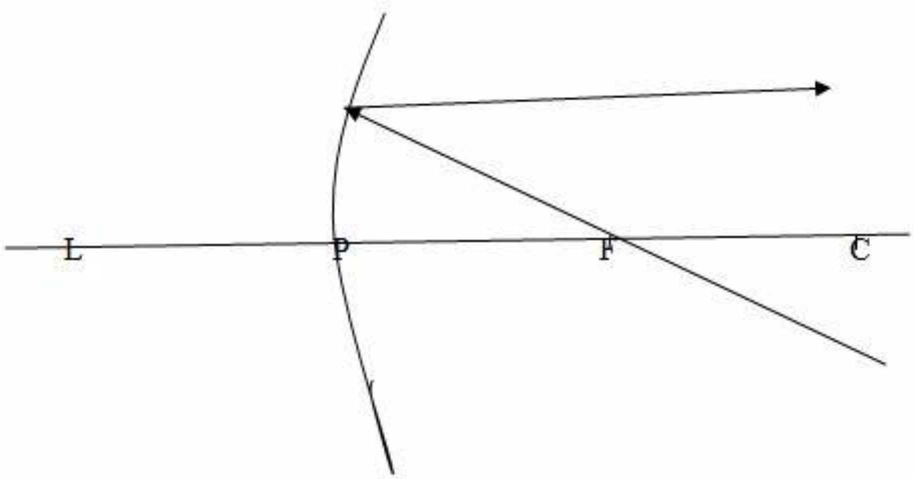
Case (1)

When a beam of light parallel and very close to the principal axis, CL, is reflected from a concave mirror, it converges to a point, F, on the principal axis called the principal focus.



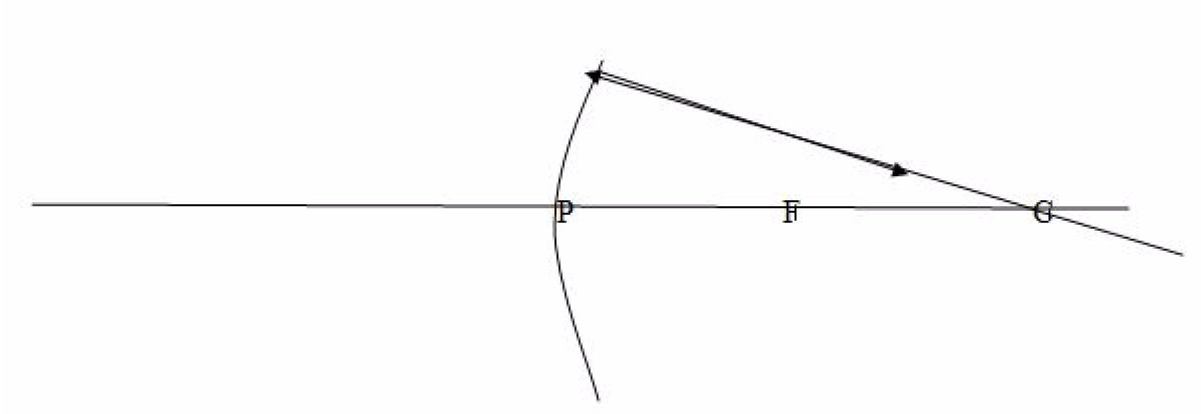
Case 2

When a ray passes through the principal focus, F, it is reflected parallel to the principal axis.



Case 3

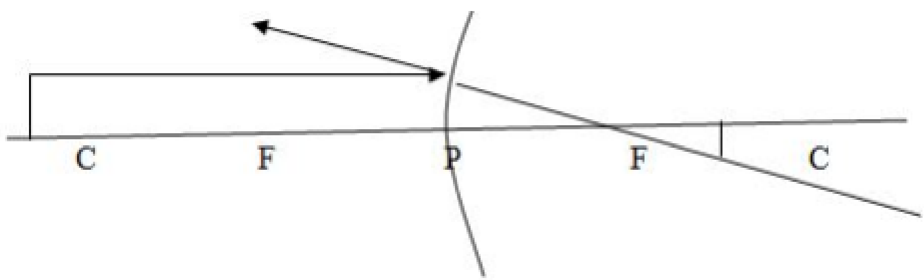
When a ray passes through the centre of curvature, C, which therefore strikes the mirror at normal incidence, it is reflected back along its original path.



Note: Concave mirrors have a real focus because light passes through the focus.

The formation of images by concave mirror tends to change as the position of object changes.

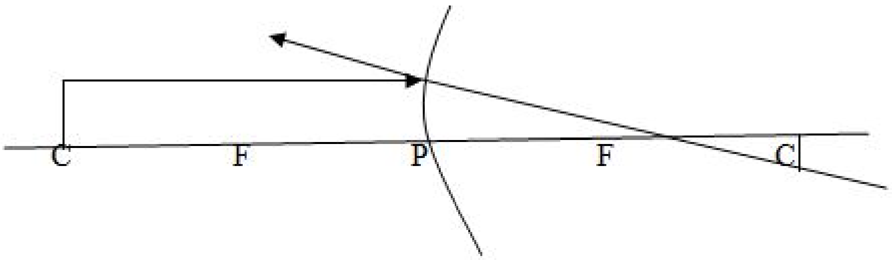
Case 1: Image (I) formed by a concave mirror when the object is beyond C.



Properties of images formed:

1. The image is between C and F
2. The image is smaller than the object
3. The image is inverted (upside down)
4. The image is real

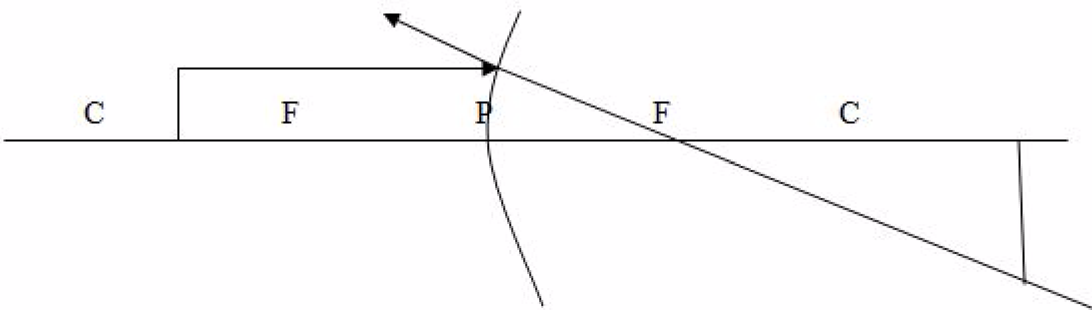
Case 2: The object is placed at C



Properties of image

1. The image is formed at C
2. The image has the same size as object
3. The image is inverted (upside down)
4. The image is real.

Case 3: The object is placed between C and F

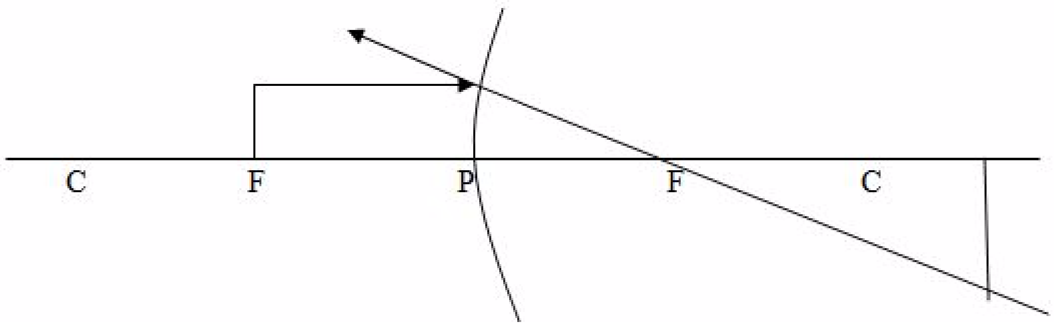


Properties of image formed

1. The image is real
2. The image is large than object
3. The image is formed beyond C
4. The image is inverted (upside down)
5. The image is real
6. The image is large than object
7. The image is formed beyond

8. The image is inverted (upside down)

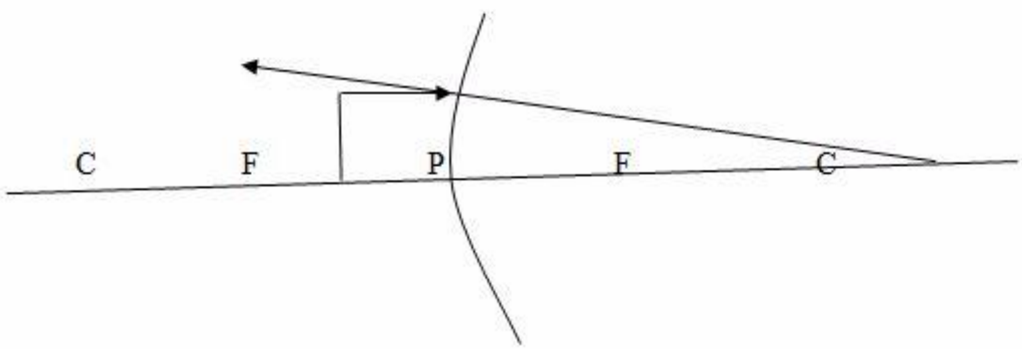
Case 4:The object is placed at F



Properties of image:

1. The image is formed at infinity (x)
2. The image is formed beyond C
3. The image is large than object
4. The image is Real

Case 5:The object is placed between F and P.



Properties of image formed:

1. The image is virtual
2. The images is upright
3. The image is formed behind the mirror

4. The image is large than the object

Formation of images in a convex mirror:

Obviously,there isonly one kind of image formed when an object is placed at any position.

Properties of image formed by convex mirror:

1. the image is virtual
2. the image is upright
3. The image is smaller than object (diminished)
4. The image is formed behind the mirror.

Example 1

An object 2cm long is erected 8cm infront of a concave mirror of radius of curvature 10cm. By using a scale drawing, determine the position, size and nature of image formed.

Data given

- Height of object, Ho = 2cm
- Object distance, U= 8cm
- Radius of curvature, r = 10cm
- Focal length,f =8cm
- Choose suitable scale.
- Say 1cm represents 5cm

From this scale then

- Height of object, Ho = 2cm
- Object distance, U= 2cm
- Focal length, F = 2.5cm

Thus,

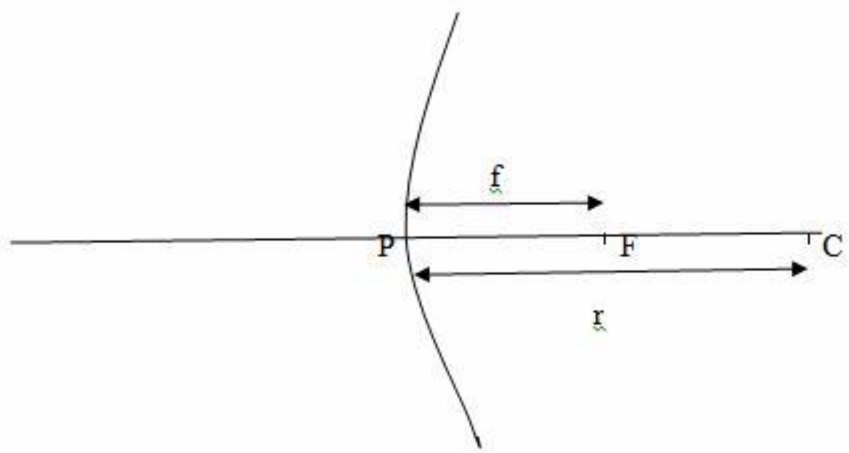
Image distance, V = X

Image Height, H_1=Y

The Focal Length of a Concave Mirror

Determine practically the focal length of a concave mirror

Focal length (f) is the distance between the principal focus and the pole.



Convex and Concave Mirrors in Daily Life

Use Convex and concave mirrors in daily life

Curved mirrors are used as:

1. Driving mirrors
2. Shaving mirrors
3. Reflectors

Question Time 1

Why is convex mirror used as driving mirror?

The convex mirror is used as driving mirror because it provides the wider field of view.

Question Time 2

Why concave mirror used as shaving mirror?

Concave mirrors are used as shaving mirrors because they form an enlarged image when held close up.

Refraction of Light

The Concept of Refraction of Light

Explain the concept of refraction of light

Refraction of light refers tothe bending of light as it passes through two different medium because the speed of light tends to change when travelling from one medium to another.

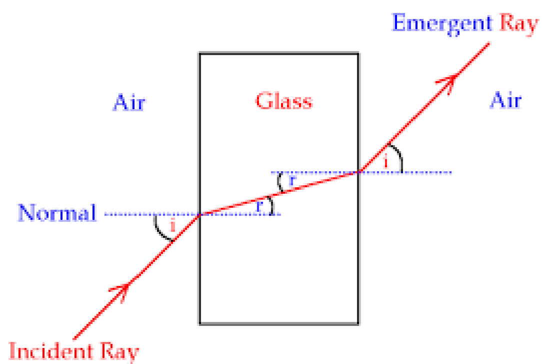


Figure showing refraction of light as it passes from air to glass.

The Angle of Incidence and Angle of Refraction

Measure the angle of incidence and angle of refraction

The angle of incidence (i)is the angle between the incident ray of light and the normal at the point of incidence.

The angle of Refraction (r)is the angle between the refracted ray and the normal at the point of incidence.

The Laws of Refraction

State the laws of refraction

First law of refraction

The First Law of refraction states that "the incident ray, the refracted ray and the normal at the point of incident are located in the same plane.”

Second law of refraction

Second Law of refraction states that “when a light ray passes from one medium into another medium, the angle of incidence (i) and corresponding angle of refraction(r) are such that the ratio of sine of the angle of incidence to the sine of the angle of refraction (sini/sinr) is a constant value called the refractive index."

Note: The Second Law of Refraction is called Snell's Law in honour of a Dutch scientist named Snell (1591 – 1626) who first described it.

The Refraction Index of a Material

Determine the refraction index of a material

Refractive index (n) is the ratio of the sine of the angle of incidence to the sine of the angle of refraction.

n = Sini/Sinr OR

Refractive index (n) is the ratio of the velocity of light in air to the velocity of light in glass.

n = Velocity of light in air (Va)/Velocity of light in glass (Vg)

Or

Refractive index, n is the constant number which expresses how many times or to what extent a light ray bends when passing through different medium.

Absolute refractive index (n_a) is the refractive index between vacuum or air and any other medium.

The refractive indices between air and some common media is given below:

Medium	Refractive index (n)
Diamond	2.417
Ethanol	1.360

Glass (Crown)	1.520
Quartz	1.553
Water (at 20ºC0	1.333
Air (at stp)	1.00029

Example 2

The refractive index for light passing from air to water is equal to 1.333 find the refractive index for light travelling from water to air.

Data given:

Refractive index an_w of air to water = 1.333

Required: To find refractive index from water to air

Since

anw = 1.333

wna = (1/anw)

= (i/1.333)

: wna = 0.75

Real and Apparent Depth

Real depthis the actual height measured without taking account any refraction of light

Apparent depth is the virtual height measured when viewed by observer.

The Concept of Critical Angle and Total Internal Reflection of Light

Explain the concept of critical angle and total internal reflection of light

Critical angle

Critical angleis the angle of incidence (i) for which the angle of refraction (r) is equal to 90º . It is obtained when light rays moves from a dense medium to a less dense medium.

For refractive index

n=Sini/sinr

But i= Critical angle, C

r = 90º

Thus n= sinC/sin 90º

n=SinC/1

n = Sin C

c= Sin -1 (n)

Total Internal Refraction

This occurs when a light ray from a less dense medium is reflected into the denser medium at the boundary separating the two media.

Conditions for total internal reflection to occur include the following:

1. Light must be travelling from a more dense to less dense medium.
2. Light must incident at the boundary at an angle greater than the critical angle (C).

Optical fibres

These are very thin tubes of plastic or glass and because they are so thin they can bend without breaking, so they can carry light around the corners.

Uses of optical fibres

- Used in telecommunications to carry telephone calls over vast distance, without loss of intensity and without interference.

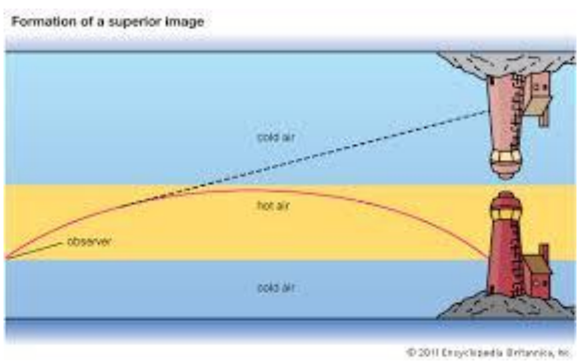
- Used in endoscope to view inside a patient body for example inside stomach. Light is carried into the stomach through a bunch of fibres and is reflected into small camera, which then displays a picture on a screen.

The Occurance of Mirage

Explain the occurrence of mirage

This is the phenomenon inwhich an object appears to be at an incorrect position due to the bending of light rays from the object.

Mirages occur during hot days.



Refraction of Light by Rectangular Prism

The Passage of Light through a Triangular Prism

Trace the passage of light through a triangular prism

Deviation of light in a prism is the changing in direction of the incident ray when it enters/hits a triangular glass prism.

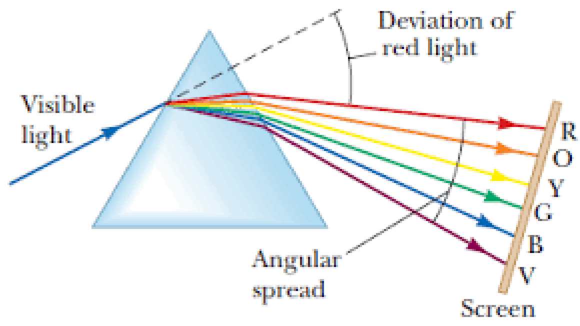
Where i

is the angle of incidence

s is the angle of deviation

The minimum angle of deviation (qm)

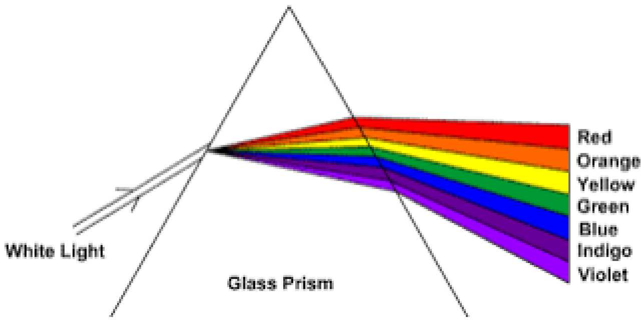
In order to determine the minimum angle deviating (Qm) then we must set triangular Glass prism as follows.



The Dispersion of White Light

Demonstrate the dispersion of white light

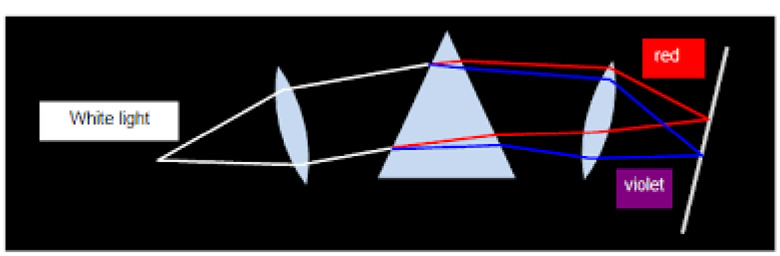
Dispersion of light is the splitting up of light beam (white light) into its seven components of colour by a prism.



Spectrum is the patch or band of colours which comprise / constitute seven component of white light.

Pure section is the patch or band of colours in which the colours are clearly separated.

In order to produce pure spectrum then we must use two converging lenses (convex lenses).



When colours of spectrum are combined, they form white light.

In order to combine colours of the spectrum, weneed two triangular glass prisms and one lens.

Impure spectrum:the band/patch of colours which overlap and are not seen clearly.

The rainbow:a bow-shaped spectrum of seven colours of white light formed when white light undergoes dispersion within the rain drops because water is denser than air, so has a large refractive index.

Activity 1

A rainbow can be demonstrated as follows:

Spray some water into the air in a direction opposite to that of the sun.

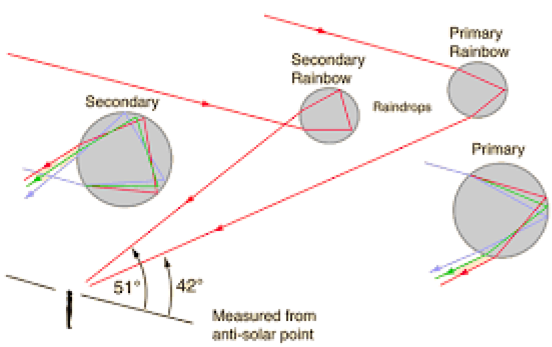
Look at the water shower while you face away from the sun. You will see the colour of the spectrum of white light in the falling drops of water. The spectrum so formed hasthe shape like a bow. So it is called rainbow.

There are two main types of rainbow:

1. Primary rainbow
2. Secondary rainbow

Primary rainbow

This is formed when light undergoes one or single total internal reflection in the water droplets. In this type of the rainbow the violet colour is on the inside of the bow while the red colour is on the outside.



The Angles of Deviation and Minimum Deviation

Determine the angles of deviation and minimum deviation

Finding the refractive index (n) of glass by using the deviation of light in a prism:

Refracting angle of prism is A

Snell's law

S in i/Sin r = N

Sin i= n sin r

Sin e' = nsin i

From Geometry of figure

I = A- r

The total angle of deviation (s) is the angle between the direction orf the incident ray and the emergent ray.

Again from the Geometry Q is given by:

S= i+r'- A

When the deviation is a minimum (Sm) the passage of light through the prism will be symmetrical so:

I = r 'and r = I'

This means that;

A + Smin = 2i = 2r'

Therefore;

Refractive index, n = Sin (A + Smin)/2

Sin (A/2)

Where

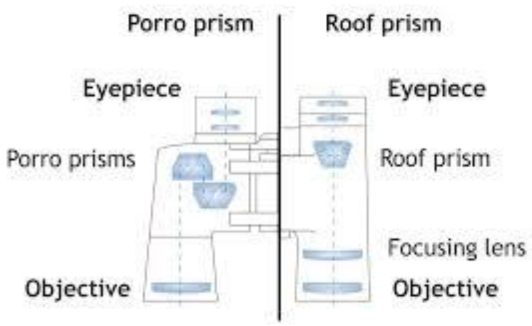
A = Apex angle (angle of prism)

Smin – The angle of minimum deviation

A Simple Prism Binocular

Construct a simple prism binocular

Simple prism binocular



Colours of Light

The Component of White Light

Explain the component of white light

There are two types of colour of light

1. Primary colour of light
2. Secondary colour of light

Primary colour of light

These are basic (fundamental) Colour of light to which the eye is most sensitive.Primary Colour of light Include the following

1. Red
2. Green
3. Blue

Secondary colours of light

These are colour of light obtained after mixing primary colours of light

Colour mixing by Addition

This is the process of combining primary colours of light without loss any colour to form secondary colours of light.

	Primary color	Secondary color
	Red + Blue	Magenta
	Red + Green	Yellow
	Blue + Green	Cyan

Colours of White Light

Recombine colours of white light

When all white light (Red , Blue and Green)Combineforms WHITE LIGHT.

Complementary colours of light: These are the colours which produce white light when combined.

- Red + Blue+ Green - White light
- Red + Cyan - White light
- Blue + Yellow - White light
- Green + Magenta - White light

The Appearances of Coloured Object under White Light

Explain the appearances of coloured object under white light

There are two types of coloured paints (pigments) which Include the following

1. Primary coloured pigment (paints)
2. Secondary coloured pigment (paints)

Primary, Secondary and Complementary Colours of Light

Identify primary, secondary and complementary colours of light

Primary Coloured pigments

These are basic coloured pigments which form secondary coloured pigment when combined.

The primary coloured pigments include:Yellow, Cyan and Magenta

Secondary colour pigments

These are coloured pigments which are formed when two primary colours combine, whichis always accompanied with the removal of other colours.

Difference between Additive and Subtractive Combination of Colours

Distinguish between additive and subtractive combination of colours

Colour Mixing by Substration

Is the process of mixing two primary coloured paints (pigments) to form secondary colour white.

Example 3

- Magenta + Cyan
- Magenta = (Blue) + (Red)
- Cyan = (Blue) + (green)

The colour which is common to Blue will appear while red and green disappear.

Magenta + Cyan = Blue

Example 4

- Magenta + yellow
- Magenta = (Blue) + (Red)
- Yellow = (Green) + (Red)

The colour which is common to both red will appear while blue and green will disappear.

Hence

Magenta + Yellow = Red

Example 5

- Cyan + yellow
- Cyan = (Blue) + (Green)
- Yellow = (Red) + (Green)

The colour which is common to both green will appearwhile Blue and Red will disappear

Hence

Cyan + Yellow = Green

Refraction of Light by Lenses

Difference between Convex and Concave Lenses

Distinguish between convex and concave lenses

A lens is a transparent medium bounded by two surfaces of regular shape. There are two major categories of lenses which include:

The Terms Focal Length, Principle Focus, Principle Axis and Optical Centre as Applied to Lenses

Explain the terms focal length, principle focus, principle axis and optical centre as applied to lenses

Optical center is a geometric center of a lens. **Center of curvature** is the center of the sphere in which a lens is a part. **Principal axis** is an imaginary line which passes through the optical center of the lens at right angle to the lens. **Principle focus** is a point through which all rays traveling close and parallel to the principal axis pass through.

The Focal Length of a Lens

Determine practically the focal length of a lens

Focal length is a distance between between optical centre and the principal focus. It is important to note that the the principal focus is not the halfway between the optical centre and the centre of curvature in lenses as it is in mirrors. The plane through the principal focus which is at right angles with the principal axis is called the focal plane.

Example 6

An object is 2 cm high and placed 24cm from a convex lens. An image formed 72 cm. find the focal length of the lens.

Solution

i/f = 1/u + 1/v

1/f =1/24 + 1/72

1/f = 4/72

f = 18cm.

The Immage Formed by a Lens

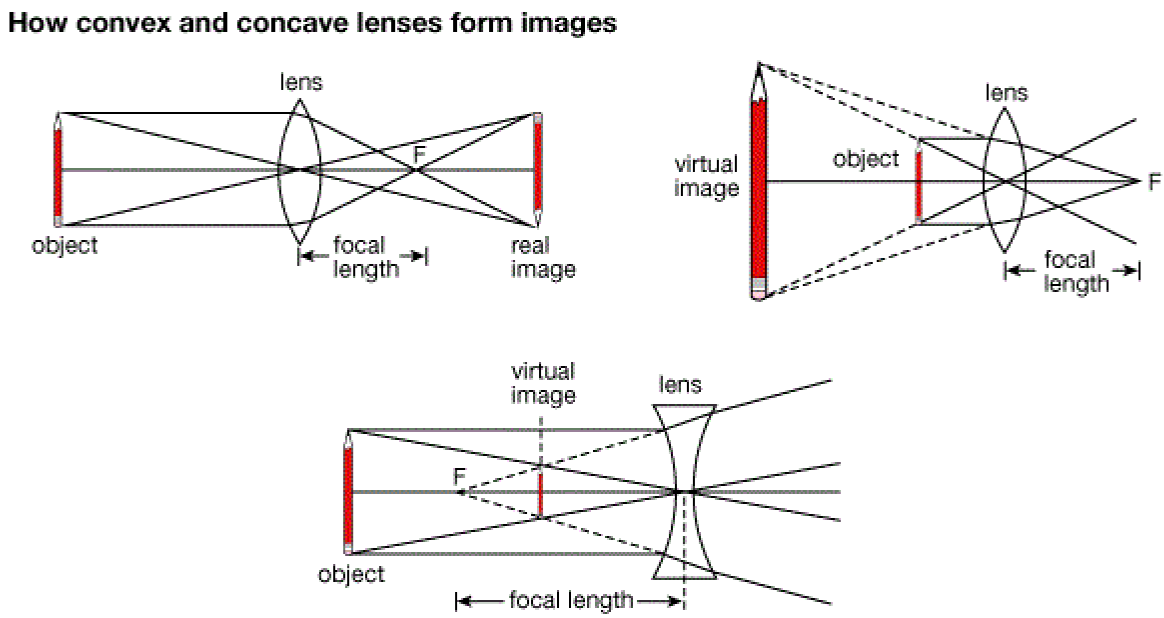
Locate the image formed by a lens

Rays diagrams are normally used toillustratesthe formation of images by lenses.

1. A ray parallel to the principal axis passes through or appears to diverge from the principal focus after refraction.

2. A ray of light passing through the principal focus of a lens is refracted parallel to the principal axis of the lens.

3. A ray of light through the optical center of the lens continues throughundeviated(Not change direction)



The position, Size and Nature of the Image formed by Lens

Determine the position, size and nature of the image formed by lens

The nature, position and size of the image formed by a lens depends on the position of the object in relation to the type of lens. For example in converging lens when the object is between the lens and principal focus the image will be formed at the same side as the object but further from the lens. It is virtual, erect, and magnified. The image by concave lens is erect, virtual and reduced.

Activity 2

1. Take a convex lens. Find its approximate focal length in a way described in Activity 11.

2. Draw five parallel straight lines, using chalk, on a long Table such that the distance between the successive lines is equal to the focal length of the lens.

3. Place the lens on a lens stand. Place it on the central line such that the optical centre of the lens lies just over the line.

4. The two lines on either side of the lens correspond to F and 2F of the lens respectively. Mark them with appropriate letters such as $2F_1$, F_1, $F_2$and $2F_2$, respectively.

5. Place a burning candle, far beyond $2F_1$to the left. Obtain a clear sharp image on a screen on the opposite side of the lens.

6. Note down the nature, position and relative size of the image.

7. Repeat this Activity by placing object just behind $2F_1$, between F_1 and $2F_1$ at F_1, between F_1 and O. Note down and tabulate your observations.

The nature, position and relative size of the image formed by convex lens for various positions of the object is summarized in the table below:

Position of the object	**Position of the image**	**Relative size of the image**	**Nature of the image**
At infinity	At focus F_2	Highly diminished, point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Infinitely large or highly enlarged	Real and inverted
Between focus F_1 and optical centre O	On the same side of the lens as the object	Enlarged	Virtual and erect

Activity 3

1. Take a concave lens. Place it on a lens stand.

2. Place a burning candle on one side of the lens.

3. Look through the lens from the other side and observe the image. Try to get the image on a screen, if possible. If not, observe the image directly through the lens.

4. Note down the nature, relative size and approximate position of the image.

5. Move the candle away from the lens. Note the change in the size of the image. What happens to the size of the image when the candle is placed too far away from the lens.

Nature, position and relative size of the image formed by a concave lens for various positions of the object

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished, point-sized	Virtual and erect
Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect

The Magnification of the Lens Camera

Determine the magnification of the lens camera

As we have a formula for spherical mirrors, we also have formula for spherical lenses. This formula gives the relationship between object distance (u), image-distance (ν) and the focal length (f). The lens formula is expressed as$1/\nu - 1/u = 1/f$(8)

The lens formula given above is general and is valid in all situations for any spherical lens. Take proper care of the signs of different quantities, while putting numerical values for solving problems relating to lenses.

The magnification produced by a lens, similar to that for spherical mirrors, is defined as the ratio of the height of the image and the height of the object. It is represented by the letter m. If h is the height of the object and h′ is the height of the image given by a lens, then the magnification produced by the lens is given by,m = Height of the Image / Height of the object = h' / h(9)

Magnification produced by a lens is also related to the object-distance u, and the image-distance ν. This relationship is given byMagnification (m) = h' / h = ν / u(10)

Example 7

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also, find the magnification produced by the lens.

Solution

A concave lens always forms a virtual, erect image on the same side of the object.

Image-distance v = –10 cm;

Focal length f = –15 cm;

Object-distance u = ?

Since, $1 /v - 1 / u = 1 / f$

or, $1 / u = 1 / v - 1 / f$

$1 / u = 1 / -10 - 1 / (-15) = - 1 / 10 + 1 / 15$

$1 / u = (-3+2) / 30 = 1 / (-30)$

or, u = - 30 cm.

Thus, the object-distance is 30 cm.

Magnification $m = v/ u$

$m = -10 \text{ cm} / -30 \text{ cm} = 1 / 3 = +0.33$

The positive sign shows that the image is erect and virtual. The image is one-third of the size of the object.

The Relationship between Focal Length (f) Object Distance (u) and Image Distance (v) as Applied to Lenses

Determine the relationship between focal length (f) object distance (u) and image distance (v) as applied to Lenses

The lens equation is given as $1/f =1/u + 1/v$, if sign convection is used for u, v and f the equation applies to both converging and diverging lenses for all cases of object and image.

Example 8

An object is placed 12 cm from converging lens of focal length 18 cm. Find the position of the image.

Solution

Since the lens is converging f = +18 cm. 1/v = 1/18 -1/12, v = -36.

The image is virtual.

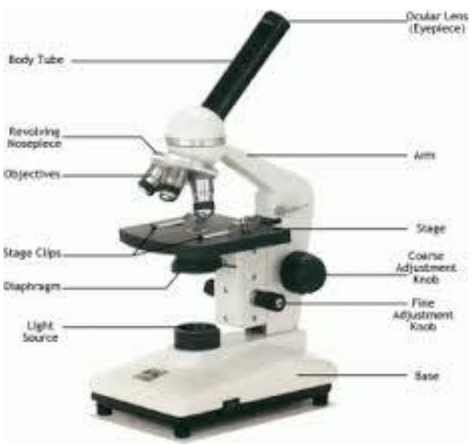
OPTICAL INSTRUMENTS

Simple Microscope

The Structure of the Simple Microscope

Describe the structure of the simple microscope

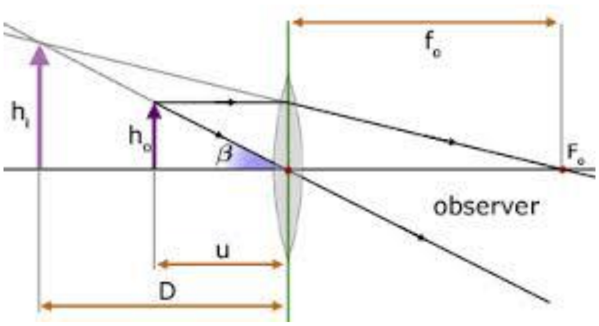
A magnifying glass, an ordinary double convex lens with a short focal length, is a simple microscope. The reading lens and hand lens are instruments of this type. When an object is placed nearer such a lens than its principal focus, i.e., within its focal length, an image is produced that is erect and larger than the original object. The image is also virtual; i.e., it cannot be projected on a screen as can a real image.



The Mode of Action of a Simple Microscope

Describe the mode of action of a simple microscope

The image formed by magnifying glass or simple microscope is virtual and erect object place between principal focus (f) and convex lens.



- The normal district vision
- The position of the lens is usually adjusted so that V is about 25cm, which is the shortest distance of distinct vision.

Using the equation of lens (Lens formula).

I/U + I/V = I/F

Adopting the 'real is positive' sign convention we obtain:

V = (-Ve) since the image is virtual.

I/U – I/V = I/F

V= 25 –(Normal district vision)

I/U – I/25 =I/F

I/U = I/F + I/25

(I/U)=-1 (25 + F)

25F

U = 25F/F+25

The above formula shows the means of obtaining the distance of object, U.

Magnication (*M)* of simple microscope

Magnification is the ratio of the image distance to the object distance.

M = Image distance, V

Object distance, U

Hence

M = v/u …………………..(i)

From $V = 25cm$ (distance of district vision)

From $U = 25f/(f+25)$ ……………………… (ii)

Insert eqn (ii) into (i)

$M = V/ (25f/(f+25)$

$M = 25/(25f/f+25)$

$M = 25/f + 1$

Example 1

A simple microscope with lens of focal length 5cm is used to read division of a scale 0.5mm in size. How large will the division be seen through the simple microscope?

Data given

- Focal length, $f = 5cm$
- Required to find magnification, M

Soln:

From

$M = (25/f + 1)$

$= (25/5+1)$

$=(5+1)$

$= 6$

The magnification of lens = 6

Let the size of the object be ho and that of the image be hi. Then:

$M = h1/H$ ……………(i)

$H1 = 6h$

The Height , h = (0.5mm)

H1 = 6 (0.5mm)

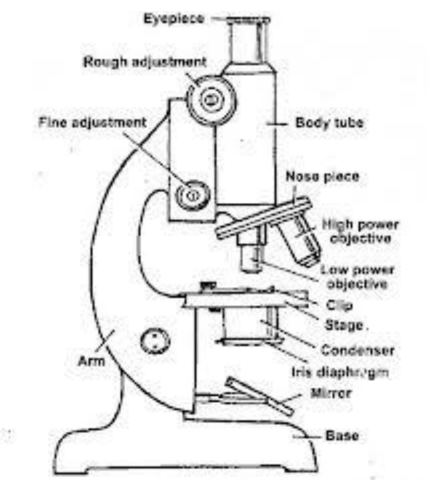
HI = 3mm

Hence, each division will appear to have a size of 3.0mm viewed through the simple microscope.

A Simple Microscope

Construct a simple microscope

Parts of simple microscope



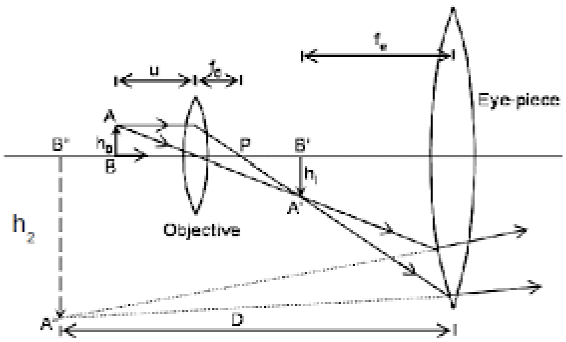
Compound Microscope

The Structure of a Compound Microscope

Describe the structure of a compound microscope

A compound microscope is an optical instrument used to produce much greater magnification than that produced by simple microscope. The main features of a compound microscope includes two short-focus convex lenses, the objective lens, and the eyepiece.

Demonstration



The Mode of Action of a Compound Microscope

Describe the mode of action of a compound microscope

The most commonly used microscope for general purposes is the standard compound microscope. It magnifies the size of the object by a complex system of lens arrangement.

It has a series of two lenses; (i) the objective lens close to the object to be observed and (ii) the ocular lens or eyepiece, through which the image is viewed by eye. Light from a light source (mirror or electric lamp) passes through a thin transparent object.

The objective lens produces a magnified 'real image' (first image of the object). This image is again magnified by the ocular lens (eyepiece) to obtain a magnified 'virtual image' (final image), which can be seen by eye through the eyepiece. As light passes directly from the source to the eye through the two lenses, the field of vision is brightly illuminated. That is why it is a bright-field microscope.

The Magnification of a Compound Microscope

Determine the magnification of a compound microscope

The object lens forms a real and inverted image $I_I$of the object O (the image is slightly magnified). The eyepiece lens acts as a magnifying glass for the first image II and produces a magnifical virtual image.

The object is placed just beyond the principal (fo) of the objective lens so that that the real image I, is formed inside the principal focus (F) of the eye piece. The eyepiece treats the real image I, as an object and then forms its magnified virtual image I2.

Magnification of a compound microscope: This isthe ratio of the image distance produced by a compound microscope to the object distance. The magnification produced by objective lens is v/u.

Where

V is the image distance

U is the object distance

The magnification given by the eyepiece is given by;

Me = 25/fe + 1

If the final image is formed at the least distance of distinct vision (V = 25cm).

Mc = $M_o m_e$

Combine eqn (i) and (ii)

Then

Mc = (v/u) (25/fe+1)

The above formula shows that the final virtual image is formed at the least distance of distinct vision.

Uses of a Compound Microscope

Mention uses of a compound microscope

The uses of a compound microscope includes the following:

- Used to magnify microorganism such as bacteria which cannot be seen by naked eyes.
- Used in hospitals widely to detect microorganisms in specimens provided by patients. A specimen is a small amount that is taken for testing. Blood is an example of specimens. In hospitals microscopes can detect parasites such as plasmodium ssp (a causative agent for malaria) in blood specimen.

Example 2

A certain microscope consists of two converging lenses of focal length 10cm and 4cm for the objective and eyepiece, respectively. The two lenses are separated by a distance of 30cm. The instrument is focused so that the final image is at infinity. Calculate the position of the object and the magnification of the objective lens.

For the objective lens

$I/U + I/V = I/Fo$

Where

$Fo = 10cm$

The objective lens forms a real image of the object at the principal focus of the eyepiece.

Thus

$V = (30 – 4)$

$= 26cm$

Thus $I/U + I/V = I/10$

$I/U + 1/26 = 1/10$

$1/U = (1/10 – I/26)$

$(I/U) -1 = (4/65)$

$(1/U) -1 = (4/65)-1$

$U = (65/4)$

The distance of object, $U= 16.25cm$

The magnification given by the objective lense is given by:

Whereas:

$V = 26cm$

U= 16.25cm

Mo = (26cm/16.25cm)

The magnificent given by objective lens, Mo = 1.6.

Astronomical Telescope

The Structure of an Astronomical Telescope

Describe the structure of an astronomical telescope

An Astronomical Telescope is used for observing heavenly bodies like stars and planets (generally bodies which are very far away from normal vision of human eyes). Like compound microscope, it consists of two convex lenses, objective lens and the eyepiece.

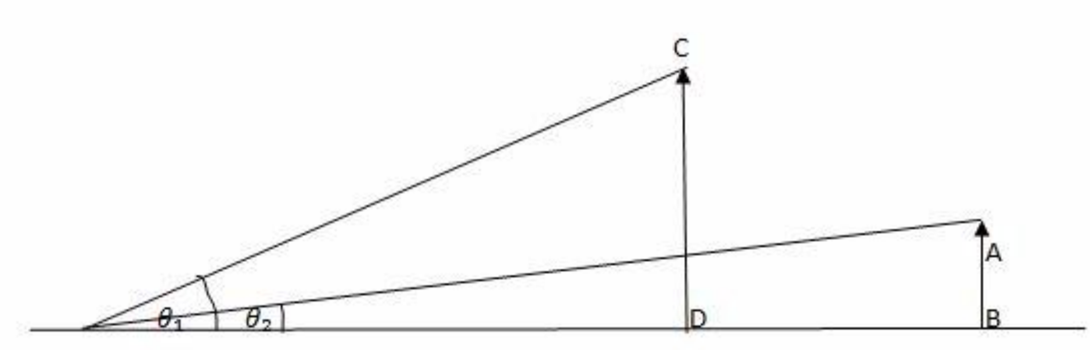
The focal length Fb of the objective lens is longer than the focal length Fe of the eye piece lens.Rays of light from a distant object are nearly parallel when they strike the objective lens of the Telescope.The objective lens forms a real image, inverted and diminished image IQ of a distant object is in the focal plane.The eye piece forms the final magnified image at infinity

When the telescope is adjusted in such a way that the final image is at infinity it is said to be in normal adjustment.In this case the distance between objective lens and eyepiece is (Fb + Fe) This is the maximum separation between the objective lens and the eyepiece lens.

The Mode of Action of an Astronomical Telescope

Describe the mode of action of an astronomical telescope

The main reason for a distant object to be smaller is that the two objects subtend different angles at the eye. In other words, we can say that different angles substended by the eye causes a distant object to appear smaller.



The object AB and CD are of the Same height.The object CD is closer to the eye than AB.

The object CD appears to be taller than AB because angle B that CD subtends at the eye is greater than the angle x subtended by AB at the eye. Images there can be made to appear large by bringing them closer to the eye.

In a telescope the final image is magnified because it subtends a much greater angle at the eye than does a distant object observed without a telescope. B is the angle subtended by the final image at the eye and X is the angle subtended by a distant object.

The Magnification of an Astronomical Telescope

Determine the magnification of an astronomical telescope

The magnification of a telescope is defined as the ratio of the angel B (in radians) subtended by the final image at the eye to the angle X subtended by a distant object at the eye.

Thus, for telescope the magnification is given by:

M = B/x …………………………………i

From figure B= IQ/ID ……………………..ii

X = IQ/IA ………………………………………..iii

But Insert eqn (ii) and (iii) into eqn (i)

M = (12/ID)

(IQ/IA)

M = (IA/ID)

But IA = fo and IF =fe

M = fo/fe……………………………….(x)

Where

Example 3

fois the focal length of two thin converging lenses of focal lengths 25cm and 4cm respectively. It is focused on the moon which subtends an angle of 0.6° at the objective lens. The final image is formed at the observers least distance of distinct vision (25cm in front of the eyepiece). Find the diameter of this image.

In the previous figure:

X = h/fo

Where fo is the focal length of the objective lens

X = h/25

Where X is the angle in radians subtended at the objective lens by the moon.

H = 25x

H = 25 (6/10 x 11/180)

H = 25 (6/10 x 22/7 x 1/80)

H = 0.2619m

The height of the image, h = 0.2619m

The distance of this image from the eyepiece is obtained from the relation:

- I/U + I/V = I/fe = 4cm
- V= -25cmV = -25cm
- I/U – I/25 = ¼

- I/U = (1/4 + 1/25)
- (I/U)-1 = (25 +4) -1/100
- 100U= (100/29)

The magnification, m of the lens:

- M = V/u
- M = (25CM/100/29)
- M = 29/4

Let the height of the final image of the moon be h:

- M = Hi/h
- hI = mh
- HI = (29/4) (0.2619)
- HI= 1.90cm

The Height of image Hi = 1.9cm

Hence

The diameter of the final image of the moon will be 1.90cm

Observation of the universe today are best made from the Hubble Telescope. Outside the Earth's atmosphere, this telescope suffer from less interference.

Uses of an Astronomical Telescope

Mention uses of an astronomical telescope

Astronomers use telescopes because they're much better than our eyes. Here are a few reasons:

1. Telescopes see lots of colours - telescopes can collect light that our eyes are unable to: radio, microwave, infrared, ultraviolet, x-rays and gamma rays.

2. Telescopes collect lots of light - our pupils are only a few millimeters across, so we can only collect photons over a tiny area whereas telescopes can collect photons of huge areas (e.g. a football fields worth for radio telescopes).

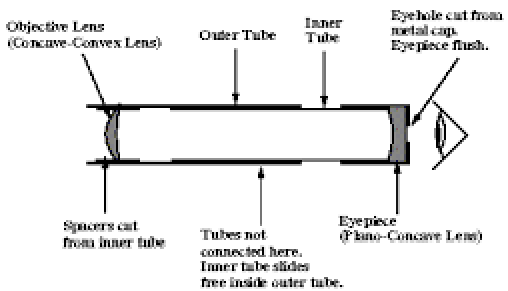
3. Telescopes see fine details because of the wave nature of light and the nerves in our eyes, we can only see details about the same angular size as Jupiter's width. Telescopes can allow us to resolve fine details - like Jupiter's Great Red Spot.

4. Telescopes can record observations with cameras - You can see things with your eye and draw them, but telescopes can share observations with the world! This is especially important for convincing skeptics that what you saw was real!

A Simple Astronomical Telescope

Construct a simple astronomical telescope

A simple telescope



Projection Lantern

The Structure of the Projection Lantern

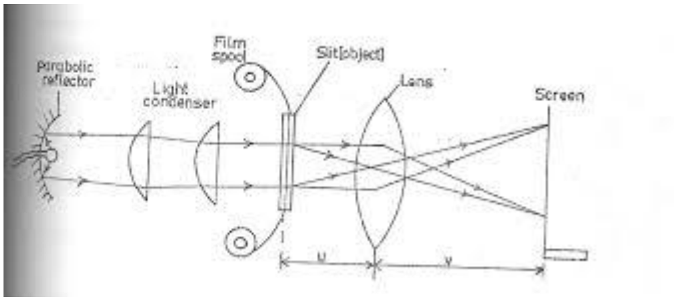
Describe the structure of the projection lantern

The projection lantern forms images of slides or camera film onto a distant screen. The film or slide to be projected is inverted and highly illuminated.

The Mode of Action of a Projection Lantern

Describe the mode of action of a projection lantern

Optical arrangement of projection lantern.



- The slice or film to be projected is inverted and highly illuminated.
- The concave mirror helps to concentrate the light which would otherwise be partly wasted.
- The lamp is placed at the principal focus of the concave mirror.
- The heat filter reduces the heat at falling on the slide or film so as to avoid it overheating.
- Since the image of the projection lantern is Highly magnified, it would not be very bright if there was not enough illumination.
- The condenser directs a maximum amount of light from the source of the slide and produce uniform illumination the screen. (The condenser is a double in order to reduce chromatic aberration).
- The projection lens forms the image of the slide on the screen.
- The light source is usually located at a distance of 2f from a condenser and invited so that the image on the screen is upright (erect).
- The focal length of the projection lens is ABOUT TWICE THE FOCAL length of the condenser since the screen is usually far from the lens.

The Magnification of a Projection Lantern

Determine the magnification of a projection lantern

Example 4

A lantern projector using a slide of (2cm x 2cm) projects a picture (1cm x 1cm) onto a screen 12m from the projection lens. How far from the lens must the slide be? Find the approximate focal length of the projection lens.

Solution

The magnification m is given by;

M = V/U …………………………………….i

Where

- H^I is the size of image
- H is the size of object
- U object distance
- V image distance

Thus

M = Hi …………………. ii

Then eqn (i) = eqn ii

- v/u =hi/h
- (1200/u)-1 = (100/2) -1
- (u/1200) = (2/100)
- U = (2/100) (1200)
- U = 24cm

The object distance, U = 24cm

Uses of a Projection Lantern

Mention uses of a projection lantern

Projection lantern are used in various areas. These include:

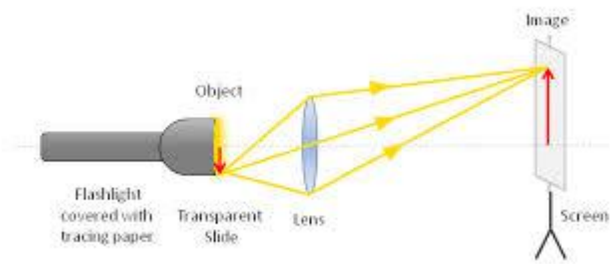
- Projection of films, slides and transparencies,
- projection of opaque objects, i.e. episcopic projection,

- used in searchlights and headlights,
- used in projection apparatus in industry for gauge and screw thread testing,
- used in physical experiments such as projection of a spectrum,
- used in polarisation experiments and interference experiments.

A Simple Projection Lantern

Construct a simple projection lantern

Projection Lantern



The Lense Camera

The Structure of the Lens Camera

Describe the structure of the lens camera

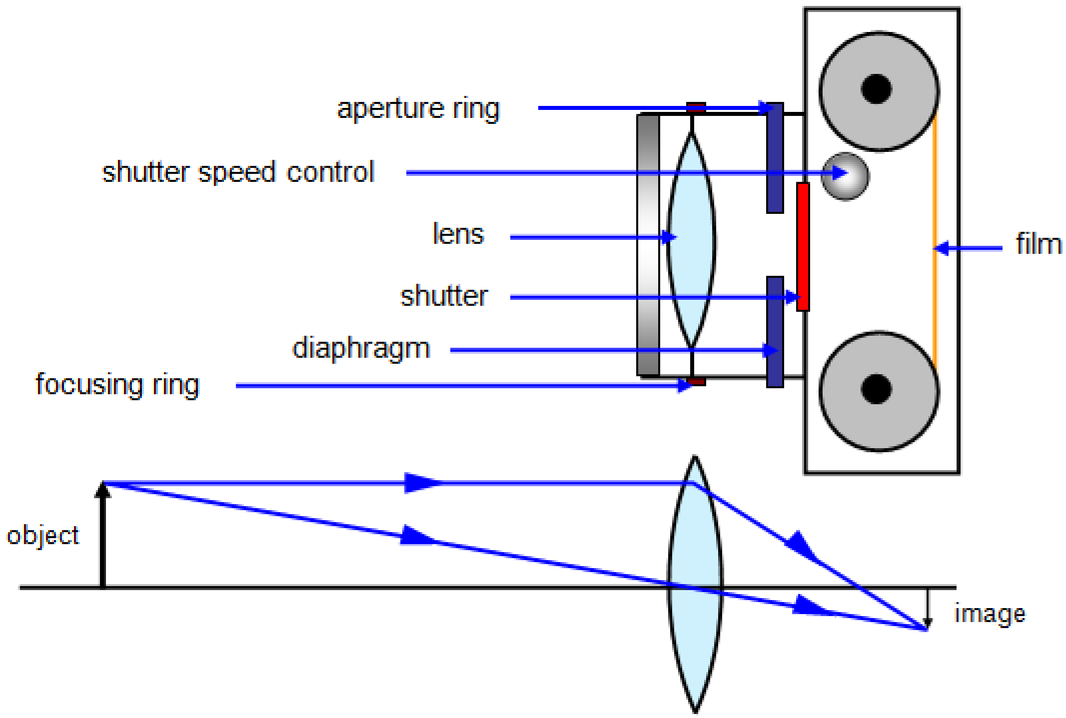
Lens camera is an instrument which produces an image of object on the screen using light. The basic physical principle of all camera is the same in spite of the variation in the design of cameras.

The optical system of the camera are very similar to that of the lantern projector but with the direction of light reversed.The converging lens forms a real image of the object to be photographed.(This image is diminished (smaller than the object and inverted)

The lens can be moved back and forward with the help of focusing any so that objects at different distances can be brought to the focus.A forced image is locate on the film or plate when the shuttled is open for a suitable amount of time as determined by the shutter speed.

Light enters the camera Box and makes a picture of the object on the film “(The film is sensitive to light)

The camera is equipped with a diagram or light entering the camera.It ensures that is incident centrally on the lens so that the distortion of the image formed is reduced



The Mode of Action of the Lens Camera

Describe the mode of action of the lens camera

The aperture stop, which is the limiting diameter of the aperture thought which light enters the camera (given as fraction of focal length F of lens) is also called F Number.

This F Number; is the fraction of focal length of the lens given as focal length divide by lens diameter.

F number = Focal length, F/Lens diameter, d

FN = F/d

Where d = is lens diameter.

- The Number Indicates the Number of times the focal length F of times the focal length F of the lens diameter (or stop)

- The smaller the F - Number for a given focal length the larger the lens diameter
- The lens with a larger diameter has a greater light- gathering power or speed
- This for such a lens the shutter allows light in the camera for a short interval of time.

The Magnification of the Lens Camera

Determine the magnification of the lens camera

Magnification of a lens camerais obtained as the ratio of the Image distance and the object distance.

But from the lens formula:

Thus M = v/U

I/U + I/V = I/F

I/V = I/F - I/U

$(I/V)^{-I} = (U - F / FU)^{-I}$

V = FU/ (U - F)

Example 5

A lens camera is to be used to take a picture of a man 2m tall if the lens of the camera Has a focal length of 10cm, calculate the minimum size of the film frame required, given that the man is 20.1m from the camera.

Solution:

Magnification is given by:

M = f/ (u-f)

Where

F= 10cm U = 201/m / 2010cm

M = (10/2010 – 10)

M = 1/20 i

Let the size of the frame be h when the height of man is 2m.

Then

M = 1/200

But h1/h = 1/200

h1 = (1/200) 2

h1 = (1/200)2

h1 (2/200)

h1 = (1/100) m

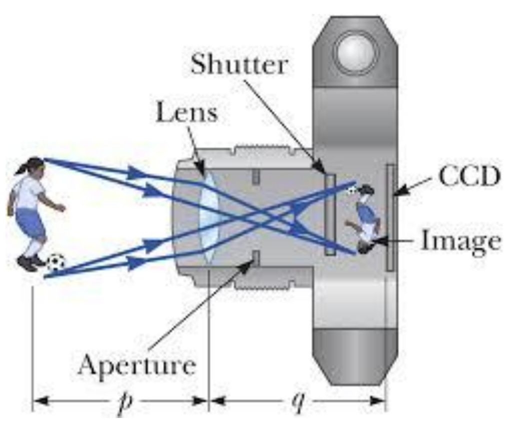
h1 = 1cm or 10mm

The film frame should be at least 10mm square.

Simple Lens Camera

Construct a simple lens camera

A simple lens camera



The Human Eye

The Structure of the Human Eye

Describe the structure of the human eye

The eyeball approximately spherical in shape.The wall of this sphere consist of two layers, the outer layer or sclera and the inner layer or choroid.The front portion of the SCLERA FORMS A TRANSPARENT CURVED section called the camera.The choroid layer is balance in order to prevent internal reflection and also to protect the light sensitive parts of the eye.

The aqueous and vitreous hum our are jelly – like substance that fills the spaces within the eyeball.The aqueous humour is the salt solution of refractive index n, 1.38.Vitrous hurmour is a watery , Jelly substance of refractive index 1.34.Behind the cornea there is a colored diagram called the iris.

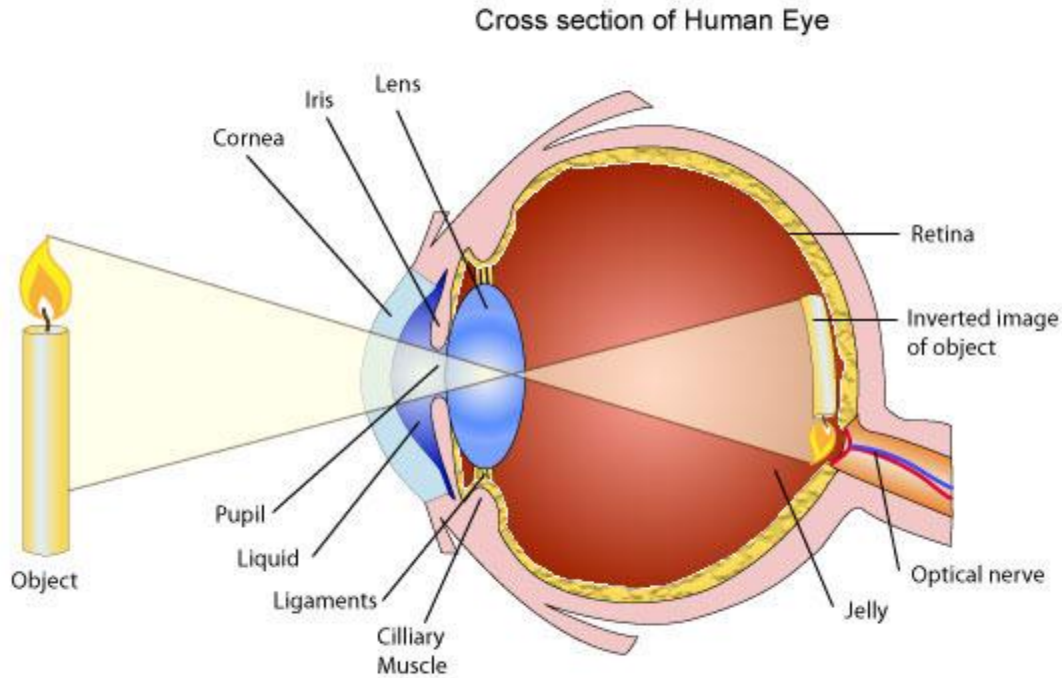
The iris has the central hole called the pupil. The iris contains muscles which control the size of the pupil. The size of the pupil decreased in the bright light and increased in the dim light.

Behind the pupil and there is a crystalline lens held in position by suspensory ligaments that are attached to the choroid layer.Near the suspensory ligaments are the ciliary muscles.The function of the suspensor ligaments there are the cilliary muscles.

The function of cillary muscles is to control the thickness of the lens. The lens become thick when the ciliary muscles contract and thin when the ciliary muscles are relaxed.

At the back of the eye there is a retina (This is the part of the eye which is sensitive to light).Image formed is inverted formed on the Retina (This is the part of the eye which is sensitive to light.)

Image formed is inverted formed on the retina by successive refraction of light at the corner, the aqueous hurmour the crystalline lens and the Vitreous hurmour.Electrical signals are then transmitted to the Brain through the topic nerve. Finally, the brain interprets these signals.



Accommodation Power of the Human Eye

Explain accommodation power of the human eye

Accommodation is the process whereby the eye alters its focal length in order to form images of objects at different distances.

(Thickening or Thinning of the lens causes a change in its focal length).

The thickening or thinning of the crystalline lens is made possible by the action of the ciliary muscles.To view neare object t, ciliuary muscles contract, this makes the lens thicker.

In the relaxed state of ciliary muscles, the crystalline lens become thinner and enables the eye to see (view) distant objects. The farthest point which can be seen clearly is called the far point of the eye and the nearest point is called the near point of the eye.

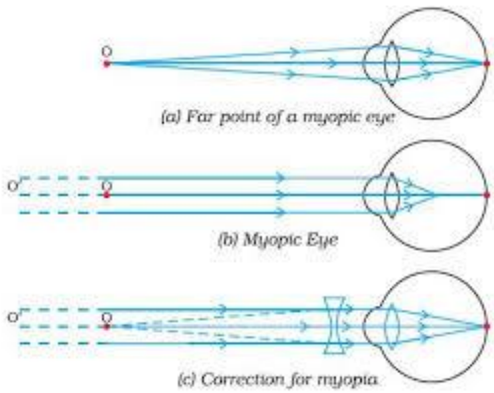
The corresponding distance from these points to the eye are referred to as the maximum and least distance of district vision respectively.A normal eye (i.e. without defects of vision) has a far point at infinity and near point at a distance of 25cm from the eye.Structure of lens " view distant object"

The Defects of the Human Eye

Identify the defects of the human eye

Myopia or near-sightedness

- This defect causes person to see near object clearly while distant objects are not seen clearly.
- The strength of the cornea and the eye lens combination is too great even when muscles of the eye are completely relaxed.
- The focal length of the cornea and the eye – lens combination is always less than the distance to the retina.
- Images of distant object are formed in front of the retina even when eye is totally relaxed. However, an object that is closer can be brought into focus.
- In this situation the focal length of the cornea and the eye lens is so short that objects closer than the conventional (near point of 25cm) can be brought into focus. That's why this condition is called Short sightedness (near sightedness).
- Since the problem is that the strength of the eye – lens and the cornea combination is too great, the solution is to provide eye glasses (or contract lenses) with negative lens.
- The negative lens weakens the strength of the cornea and eye – lens just enough so that the resulting focal length when the eye muscles are relaxed matches the distance back to the retina so that distant images are now in focused.
- The eye glass lenses are negative lenses that means they are thinner in the middle than at the edges.
- It is easy to identify this kind of eye glass lenses since acting by themselves they do not form a real image of an object at any distance.

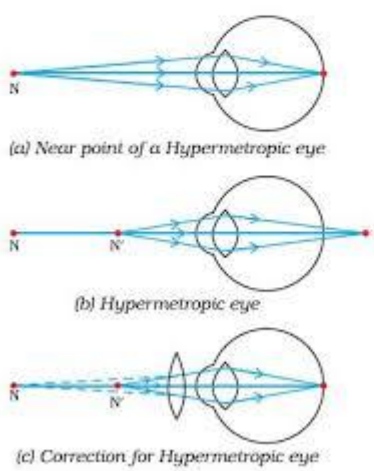


Hyperopia or far-sightedness

- This defect causes a person to see distant objects only and short-distance objects are not seen clearly.

- In the person with this condition, the strength of the cornea and the eye-lens combination is too weak when the eye muscles are totally relaxed. So the image of a distant object is formed behind the retina.

- The solution in the opposite of myopia. Victims should wear positive eye lenses which strengthen the corner and the eye lens just enough so that the resulting focal length when the eye is relaxed matches the distance to the back of the retina.



Astigmatism

- This occurs when the focal length for the cornea and the eye's lens for an object oriented in some direction is not the same as for another located in a perpendicular direction.

- The eye can not bring the vertical and horizontal lines in a '+' symbol in sharp focus at the same time. (The axis of differing focal length need not be exactly horizontal and vertical).
- The problem is that the cornea of the eye lens is not symmetrical. The solution is to use eye glasses whose lenses are not symmetrical in a complementary way.
- The cylindrical lens may be combined with an additional positive or negative lenses.

Decreased accommodation

- This condition typically occurs in middle-aged people.
- The eye muscles gradually weaken with age, so that the range or accommodation is decreased.
- People with this condition cannot bring both near objects and far objects into focus.
- The weakening of the eye muscles often causes the focal length of the eye lens to increase as well so that many people of middle age tend to become far sighted.
- Since the problem is adequate accommodation, no single lens can correct it and people with this problem usual needs bifocals.
- Bifocals are glasses with two different lens strengths, one for near and one for distant objects.
- The usual arrangement is that the bottom half of the lens is the near strength and the top half is the far strength.

The Correction of the Defects of Human Eye

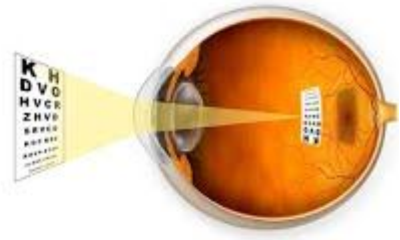
Describe the correction of the defects of human eye

Myopia is common name for impaired vision in which a person sees near objects clearly while distant objects appear blurred. In such a defective eye, the image of a distantobject is formed in front of the retina and not at the retina itself. Consequently, a nearsighted person cannot focus clearly on an object farther away thanthe far point for the defective eye.

This defect arises because the power of the eye is too great due to the decrease in focal length of the crystalline lens. This may arise due to either

1. excessive curvature of the cornea, or

2. elongation of the eyeball.



Correction: This*defect*can be*corrected*by using a*concave (diverging*) lens. A concave lens of appropriate power or focal length is able to bring the image of the object back on the retina itself.

Farsightedness, also called hypermetropia, common name for a defect in vision in which a person sees near objects with blurred vision, while distant objects appear in sharp focus. In this case, the image is formed behind the retina.

This defect arises because either

1. the focal length of the eyelens is too great, or

2. the eyeball becomes too short, so that light rays from the nearby object, say at point N, cannot be brought to focus on the retina to give a distinct image.

Correction: This defect can be corrected by using a*convex*(*converging*) l*ens*of appropriate focal length. When the object is at N', the eye exerts its maximum power of accommodation. Eyeglasses with converginglenses supply the additional focussing power required for forming the image on the retina.

The Human Eye and the Lens Camera

Compare the human eye and the lens camera

The camera

1. The eye and the camera has a have a convex lens which form a real and inverted image of an object.

2. The eye and the camera are blackened inside to prevent internal reflection. Rays of light which are not received on the retina or camera film are absorbed by the choroid layer of the eye or the black surface inside the camera.

3. The eye can regulate the amount of light that passes through the crystalline lens by using pupil while in a camera the diaphragm regulates light.

4. In the eye the image is formed in the retina while in the camera the image is formed on the photographic plate.

5. The eye can change the focal length of its lens by the contraction and relaxation of the ciliary muscles. In this way the eye can focus objects at different distance. In a camera objects at different distance are focused on by moving the lens forwards and backwards.

THERMAL EXPANSION

Thermal Energy

The Concept of Heat

Explain the concept of heat

Heat – Is the transfer of energy due to temperature differences.

Temperature – Is the degree of hotness or coldness of a body.

Or heat is a form of energy which raises the temperature of the substance.

SI Unit of Temperature is Kelvin (K).Conversion of centigrade into fahrerinheit given by:f = 9/5ºC + 32

Conversion of Fahrenheit into centigrade given by C = 5/9/ (F – 32). Thermometer used for measurement of temperature. Maximum thermometer is the one which is used to measure the highest temperature obviously filled with mercury.

A Minimum thermometer is used to measure the lowest temperature and it is filled with alcohol. Combined maximum and minimum thermometer (Six's thermometer) is used to measure highest and lowest temperature at the same time.

SI Unit of Heat is Joule (J) mathematically heat energy given by:

- $H = MC (Q_2 – Q_1)$
- M = Mass of substance
- C = Specific heat capacity
- Q_2 = Final Temperature
- Q_1 = Initial Temperature

Source of Thermal Energy in Everyday Life

State the source of thermal energy in everyday life

There are numerous sources of energy such as the sun, fuels, nuclear sources, geothermal, electricity among others. The most important source of thermal energy is the sun. The sun generates its energy by a process called thermonuclear fusion. Most sources of thermal energy derive their energy from the sun. Thermal energy from the sun makes life on earth possible.

Difference between Heat and Temperature

Distinguish between heat and temperature

Heatand**temperature**are related and often confused. More heat usually means a higher temperature.

Heat(symbol:*Q*) is energy. It is the total amount of energy (both kinetic and potential) possessed by the molecules in a piece of matter. Heat is measured in Joules.

Temperature(symbol:*T*) is not energy. It relates to the average (kinetic) energy of microscopic motions of a single particle in the system per degree of freedom. It is measured inKelvin (K), Celsius (C) or Fahrenheit (F).

When you heat a substance, either of two things can happen: the temperature of the substance can rise or thestateof substance can change.

Heat	**Temperature**	
Definition	Heat is energy that is transferred from one body to another as the result of a difference in temperature.	Temperature is a measure of hotness or coldness expressed in terms of any of several arbitrary scales like Celsius and Fahrenheit.
Symbol	Q	T
Unit	Joules	Kelvin, Celsius or Fahrenheit
SI unit	Joule	Kelvin
Particles	Heat is a measure of how many atoms there are in a substance multiplied by how much energy each atom possesses.	Temperature is related to how fast the atoms within a substance are moving. The ‘temperature’ of an object is like the water level – it determines the direction in which ‘heat’

		will flow.
Ability to do work	Heat has the ability to do work.	Temperature can only be used to measure the degree of hea

Thermal Expansion of Solids

Expansion of Solids

Demonstrate expansion of solids

When a solid is heated one or more of the following may occur:

- Its temperature may rise
- Its state may change
- It may Expand

Expansion of solids is the increase in dimensions of a solid when heated.

Contraction of solids is the decrease in dimensions of a solid when is cooled.

DEMONSTRATION OF EXPANSION OF SOLIDS

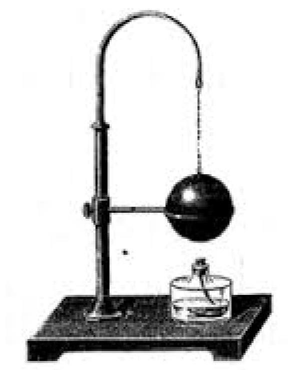
In order to demonstrate the expansion of solid we can use following method

1. The ball and Ring Experiment
2. The Bar and Gap Experiment

The ball and Ring Experiment

1st Case: When the ball is not heated then it will pass through the ring very easily because it has a small volume.

2nd Case: When the ball is heated, it will expand and increase in volume, so itwill not pass through the ring.



The Bar and Gap experiment

1stCase: When the Bar not heated (Not raised with temperature) then the dimension will remain constant.

2nd Case: When the Bar is heated (raised with temperature) then the dimension of the Bar will increase and eventually will not pass thought the Gap.

Expansion of Solids in terms of Kinetic Theory of Matter

Explain expansion of solids in terms of kinetic theory of matter

When a**solid**is heated, its atoms vibrate faster about their fixed points. The relative increase in the size of solids when heated is therefore small. Metal railway tracks have small gaps so that when the sun heats them, the tracks expand into these gaps and don't buckle.

Forces due toexpansion

Normally Expansion and contraction is accompanied by tremendous forces; The presence of force indicates the expansion and contraction is Resisted.

Bar breaker

- Consists a strong metal blocker with a pair of vertical jaws J and a strong metal Bar R. The metal bar has a wing nut N at one end and an eye at the other end.
- The bar is placed between the two pair of Jaws
- A short cast iron C is inserted in the eye of the bar.
- The bar is then heated it expands and the wing not screwed to tighten the bar R against the jaws.
- The bar is then allowed to cool as it cools, it contracts the short cast Iron rod C which presses against the jaws of the bar breaker, Resists the contraction of the Metal bar R.
- The resistance to the contraction of the bar sets up very large forces which breaks the short cast Iron rod C in the eye of metal bar, Because the contracting bar is trying to pull itself through the small gap in the frame.

Expansivity of Different Solids

Identify expansivity of different solids

The coefficient of linear expansion or linear expansivity (x)

The amount by which the linear dimension of a given solid expands depends on:

- The length of the solid
- The temperature to which the solid is heated
- The nature of solid

Coefficient of linear Expansivity (x) is the fractional increase in length of the solids per original length per degree rise in temperature.

Mathematical formula

$$X = \frac{\triangle L}{Lo \triangle Q}$$

Where

$\triangle l$ - Change in length (l-lo)

lo - Original length

$\triangle Q$ – Change in Temperature ($Q_2 - Q_1$)

L - Final length

Q_2 – Final Temperature

Q_1 – Initial Temperature

Thus

$$X = \frac{L - Lo}{Lo\,(Q_2 - Q_1)}$$

SI Unit of coefficient of linear expansivity (X) is per degree centigrade $^oC^{-1}$

Example 1

A copper rod has a length of 40cm on a day when the temperature of the room is 22.3ºC. What will be its length become on a day when the temperature of the room is 30ºC ? The linear expansivity of copper is 0. 000017/ºC

Solution

The increase in length $\triangle L$ is given by

$$X = \frac{\triangle L}{L_o \triangle Q} \quad \ldots\ldots 1$$

$$\triangle L = X L_o \triangle Q$$

$$L_o = 40cm$$

$$Q_2 = 30^{\circ}C$$

$$Q_1 = 22.3^{\circ}C$$

$$X = 0.000017/^{\circ}C$$

$$\triangle L = XL_o (Q_2 - Q_1)$$

Table which shows the coefficient of Expansivity Constant.

Substance	Linear Expasivity (PerºC)
Aluminum (Al)	0.000026
Brass	0.000019
Copper	0.000017
Iron	0.000012
Steel	0.000012
Concrete	0.000011
Glass	0.0000085
Invar (Alloy of Iron and Nickel)	0.000001

The Application of Expansion of Solids in Daily Life

Explain the applications of expansion of solids in daily life

There is a large number of important practical applications of thermal expansion of solids; While laying the railway tracks, a small gap is left between the successive lengths of the rails. This will allow expansion during a hot day. The iron tyre is to be put on a wheel, the tyre is first heated until its diameter becomes more than that of the wheel and is then slipped over the wheel.

Thermal Expansion of Liquids

The Apparent Expansion of Liquids

Explain the apparent expansion of liquids

Liquids expands when heated and contracts when cooled. It is easier to observe expansion in liquids than in solids. Different liquids expand at different rates in response to the same temperature change. Liquids expand much more than solids for equal changes of temperature. Apparent expansion of liquids is always less than the true expansion of the liquid.

Demonstrate the Effects of Heat on Liquids

Demonstrate the effect of heat on liquids

Liquids unlike solids can be poured. If a liquid is poured into a vessel, it takes the shape of the vessel. For this reason a liquid can't have linear and aerial expansivity, thus liquids have only volume expansivity. Liquids molecules have kinetic energy. This energy increases if the temperature of the liquid is raised by heating. Heating causes the molecules of liquid to move faster.

Activity 1

Items Needed

- Large heat safe glass bowl
- Cooking Oil
- Food Coloring
- Two 2×4 blocks
- Candle

- Match or Lighter

Instructions

1. Begin by filling a large glass bowl with cooking oil.
2. Next, add between 5-10 drops of food coloring into the oil. Helpful Tip: Place the drops near the center of the bowl.
3. Prop the bowl up off the table using two 2×4 blocks.
4. Light a candle and carefully place it under the bowl. The flame of the candle should touch the bottom of the glass bowl.
5. Look through the side of the glass bowl and watch carefully to observe what happens. Helpful Tip: It will likely take 5 minutes before you see anything happen to the liquid/food coloring.

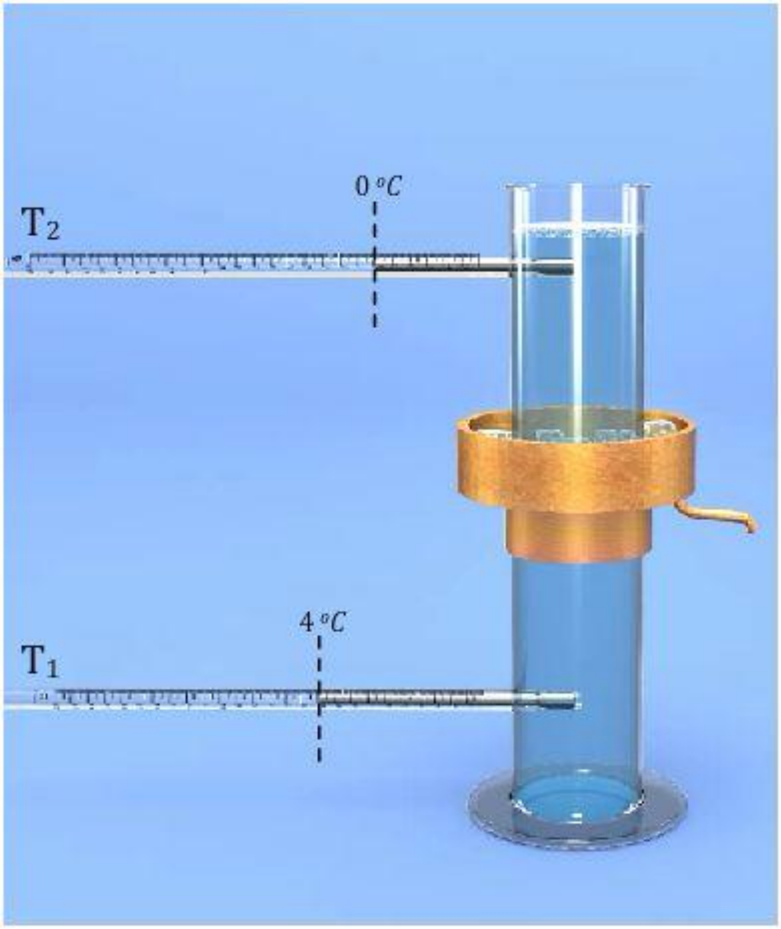
You can alternatively follow the experiment through the following vedio

Verification of Anomalous of Water

Verify the anomalous expansion of water

The instrument used to demonstrate anomalous expansion of water is called hope's apparatus. it consists of a brass cylinder, jacket J with a mixture of ice and salt and two thermometers A and B at regular intervals upward and at the bottom.The hope's experiment shows that water contracts as it cools down to 4 degree centigrade and then expands as it cooled further below 4 degree centigrade.

In the year 1805, the scientist T. C. Hope devised a simple arrangement, known as Hope’s apparatus, to demonstrate the anomalous behaviour of water.



Hope's apparatus consists of a long cylindrical jar with two openings on the side, one near the top and the other near the bottom to fit thermometers in each of these openings. A metallic cylindrical air-tight trough with an outlet is also fitted onto the jar, on its central portion. Two thermometers are fitted air-tight in the two openings of the cylindrical jar. The thermometer near the bottom of the jar is T_1, and the one near the top of the jar is T_2. Now the cylindrical jar is filled with water. The cylindrical trough at the central portion of the jar is filled with a freezing mixture of ice and common salt.

The Application of Expansion of Liquids in Everyday Life

Explain the applications of expansion of liquids in everyday life

Water in lakes and ponds usually freezes in winter. Ice, being less dense floats on the water. This insulates the water below against heat loss to the cold air above. Water at 4 degree centigrade being most dense, remains at the bottom of the lake, while ice, being less dense than water floats on the layers of water. This enables aquatic animals to survive in the water below the ice.

Thermal Expansion of Gases

The Concept of Thermal Expansion of Gases

Explain the concept of thermal expansion of gases

Gases expand when heated just like solids and liquids. This is because the average kinetic energy of the molecules in a gas is directly proportional to the absolute temperature of the gas. Heating the gas increases the kinetic energy of its molecules, making them vibrate more vigorously and occupy more space.

The Relationship between Volume and Temperature of Fixed Mass of Air at Constant Pressure

Investigate the relationship between volume and temperature of fixed mass of air at constant pressure

Three properties are important when studying the expansion of gases. These are; pressure, volume and temperature. Charles law states that the volume of a fixed mass of gas is directly proportional to the absolute (Kelvin) temperature provided the pressure remains constant. Mathematically $V_1T_2= V_2T_1$.

Example 2

the volume of gas at the start is recorded as 30 cm3with a temperature of 30°C. The cylinder is heated further till the thermometer records 60°C. What is the volume of gas?

Solution:

We know,V/T = constant

therefore,

$V_1/T_1=V_2/T_2$

V_1 =30 cm^3

T1 =30°C = 30+273 = 303K*(remember to convert from Celsius to Kelvin)*

T2 =60°C = 60+273 = 333K

V2 =?

V1/T1=V2/T2

$V_2=V_1xT_2/T_1$

V_2=30x333/303

= 32.97 cm^3

The Relationship between Pressure and Volume of a Fixed Mass of Air at Constant Temperature

Investigate the relationship between pressure and volume of a fixed mass of air at constant temperature

The relationship obtained when the temperature of a gas is held constant while the volume and pressure are varied is known as Boyle’s law. Mathematically, P1V1 = P2V2. Boyle's law states that the volume of a fixed mass of gas is inversely proportional to its pressure if the temperature is kept constant.

PressurexVolume = constant

pxV = constant

Example 3

The volume of gas at the start is 50 $cm^3$with a pressure of 1.2 x 10^5Pascals. The piston is pushed slowly into the syringe until the pressure on the gauge reads 2.0 x 10^5Pascals. What is the volume of gas?

Solution:

We know

p x V = constant

therefore,

$p_1xV_1= p_2xV_2$

p_1=1.2 x 10^5Pascals

V_1=50 cm^3

p_2=2.0 x 10^5Pascals

V_2=?

p1xV1= p2xV2

$V_2=p_1xV_1/p_2$

$V_2=1.2x10^5x50/2.0 \times 10^5$

V_2= 30 cm^3

The Relationship between Pressure and Temperature of a Fixed Mass of Air at Constant Volume

Investigate the relationship between pressure and temperature of a fixed mass of air at constant volume

To investigate the relationship between the pressure and the temperature of a fixed mass, the volume of the gas is kept constant. The pressure is then measured as the temperature is varied. P1/T1 = P2/T2 ,this is called pressure law. The pressure law states that the pressure of a fixed mass of a gas is directly proportional to the absolute temperature if the volume is kept constant

Example 4

Pressure of gas is recorded as 1.0 x 10^5N/m^2at a temperature of 0°C. The cylinder is heated further till the thermometer records 150°C. What is the pressure of the gas?

Solution:

We know,p/T = constant

therefore,

$p_1/T_1= p_2/T_2$

p_1=1.0 x 10_5N/m^2

$T_1 = 0^{\circ}C = 0+273 = 273K$*(remember to convert from Celsius to Kelvin)*

$T_2 = 150^{\circ}C = 150+273 = 423K$

$p2 = ?$

$p1/T1 = p2/T2$

$p_2 = p_1 x T_2 / T_1$

$p_2 = 1.0x10^5 x423/273$

$= 1.54 \text{ x } 10^5 N/m^2$

The General Gas Equation from the Gas Laws

Identify the general gas equation from the gas laws

The three gas laws give the following equations:

1. pV = **constant***(when T is kept constant)*
2. V/T = **constant***(when p is kept constant)*
3. P/T= **constant***(when V is kept constant)*

These 3 equations are combined to give the ideal gas equation:

$$\frac{pV}{T} = \text{constant}$$

Where,

- *p = the pressure of the gas*
- *V = the volume the gas occupies*
- *T = the gas temperature on the Kelvin scale*

From this equation we know that if a fix mass of gas has starting values of p1, V1 and T1, and then some time later has value p2, V2 and T2, the equation can be written as:

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

Exercise 1

Sabah pumps up her front bicycle tyre to 1.7 x 105Pa. The volume of air in the tyre at this pressure is 300 cm3. She takes her bike for a long ride during which the temperature of the air in the tyre increases from 20°C to 30°C. Calculate the new front tyre pressure assuming the tyre had no leaks and so the volume remained constant?

Absolute Scale of Temperature

Explain absolute scale of temperature

Absolute zero is the lowest temperature that can be attained theoretically. It is not possible to attain this temperature because all gases liquefy before attaining it. The kelvin scale of temperature is obtained by shifting the vertical axis to -273 degrees Celsius and renaming it 0 K. On the scale 0 degrees Celsius becomes 273 K and 100 degrees Celsius corresponds with 373 K.

Convertion of Temperature in Degrees Centigrade (Celsius) to Kelvin

Convert temperature in degrees centigrade (celsius) to kelvin

The Kelvin temperature scale takes its name after Lord Kelvin who developed it in the mid 1800s. It takes absolute zero as the starting point and temperature measurements are given the symbol K (which stands for "Kelvin"). Temperature differences on the Kelvin scale are no different to those on the Celsius (°C) scale. The two scales differ in their starting points. Thus, 0°C is 273K.

Converting from Celsius to Kelvin

- Temperature in °C + 273 = Temperature in K

Converting from Kelvin to Celsius

- Temperature in K – 273 = Temperature in °C

Example 5

The temperature of a gas is 65 degrees Celsius. Change it to the kelvin scale.

Solution

T(K) = degrees Celsius + 273, T(K) = 65+273

therefore T(K) = 338 K.

Standard Temperature and Pressure (S.T.P)

Explain standard temperature and pressure (S.T.P)

The standard temperature and pressure (S.T.P) is a set of conditions for experimental measurements to enable comparisons to be made between sets of data. The standard temperature is 0 degrees Celsius (273 K) while the standard pressure is 1 atmosphere (101300 Pa or 760 mm of mercury).

Expansion of Gas in Daily Life

Apply expansion of gas in daily life

Land and sea breezes are the result of expansion of air caused by unequal heating and cooling of adjacent land and sea surfaces. The piston engine and firing bullets from guns work under principles of expansion of gases.

TRANSFER OF THERMAL ENERGY

Conduction

The Concept of Conduction of Heat

Explain the concept of conduction of Heat

Conduction is the transfer of heat energy through solids, for example, metals. Generally solid substances contain particles which are close together. Each particle vibrates at one position but cannot move to another position.

Solid materials differ greatly in their ability to conduct HEAT.

Good and Bad Conductors of Heat

Identify good and bad Conductors of Heat

Solid materials differ greatly in their ability to conduct HEAT.

Good conductors

These are the substances which allows the passage of heat energy easily example all metals.

Metals contain tiny particles called electrons (particles that carry electricity through metals) which are free to move inside the metal and carry energy from hotter places to colder places.

Bad conductors

These are materials which does not allow the passage of heat and electricity e.g Non – metals, woods.

GOOD CONDUCTOR	BAD CONDUCTOR
• Silver • Aluminum • Brass	• Glass • Wood • Asbestos

• Iron • Copper • Steel	• Water • Air

How to Minimize Heat Losses due to Conduction

Explain how to minimise Heat losses due to Conduction

There are some simple ways to reduce heat loss, including fitting carpets, curtains and draught excluders.

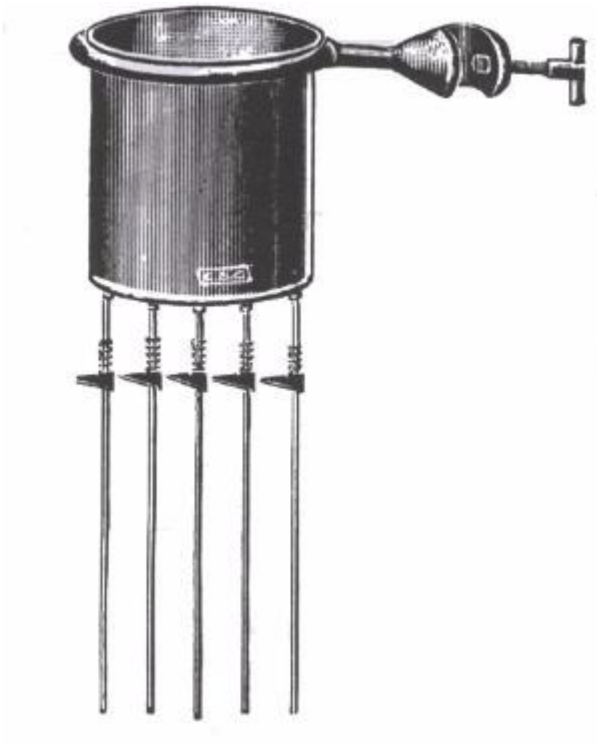
Heat loss through windows can be reduced using double glazing. The gap between the two panes of glass is filled with air. Heat loss through conduction is reduced, as air is a poor conductor of heat. Heat transfer by convection currents is also reduced by making the gap is very narrow.

Heat loss through walls can be reduced using cavity wall insulation. This involves blowing insulating an material into the gap between the brick and the inside wall, which reduces the heat loss by conduction. The material also prevents air circulating inside the cavity, therefore reducing heat loss by convection.

Knowledge of Conduction in Daily Life

Apply knowledge of conduction in daily life

The difference in conductivity of various materials can be demonstrated using Edser’s apparatus



The apparatus consists of copper can with identical rods of aluminum, copper, lead and iron fixed to the bottom of the can.

The can is supported by a metal ring which is clamped to a retort stand. When hot water is poured inside the copper can, heat will be passed along the rods by conduction.

After some time, it will be observed that wax coatedon the rods will melt and move down the rods. Note how far along the rods the wax has melted when the apparatus reaches a steady state.

This indicates that the materials from which the rods are made have different thermal conductivities. Of the four metal rods, the copper rod is observed to conduct heat more quickly than the rest.

Conduction of Heat Energy through Liquids

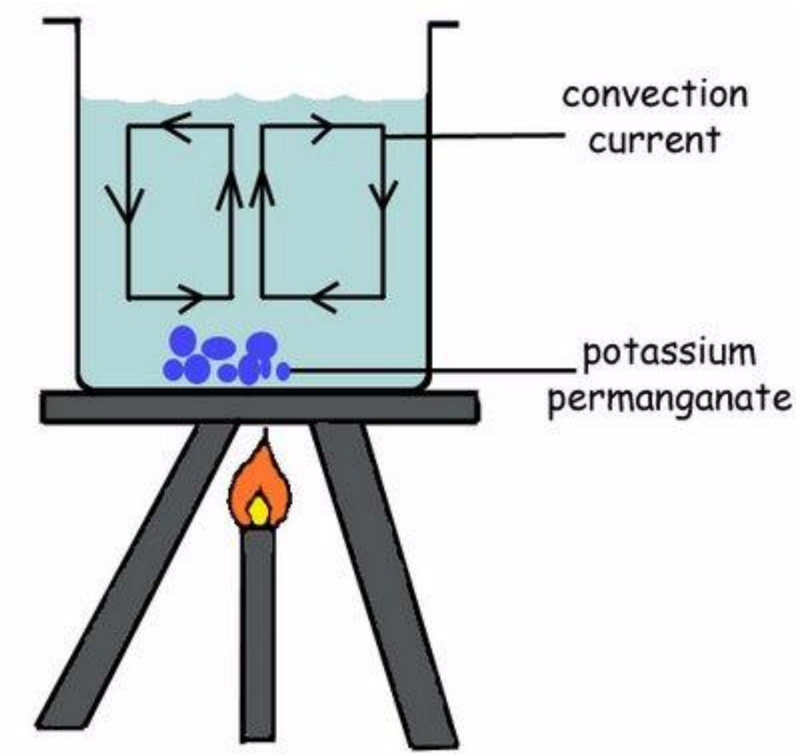
- All liquids expect mercury and gases are poor conductors of heat.
- Gases are far worse conductors of heat than liquids.
- Fluids are bad conductors of heat. They transfer heat by means of convection.

Convection

The Concept of Convection of Heat

Explain the concept of convection of heat

Convection is the transfer of Heat through the fluids (Liquids or Gases)

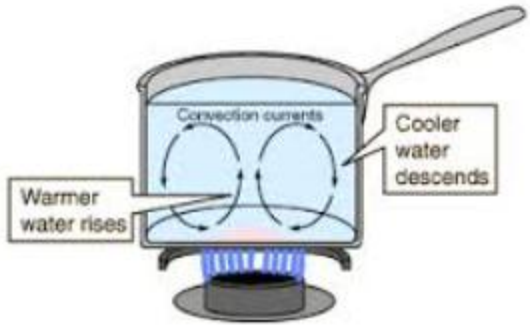


Convection in Fluids in Terms of Kinetic Theory of Matter

Explain convection in fluids in terms of kinetic theory of matter

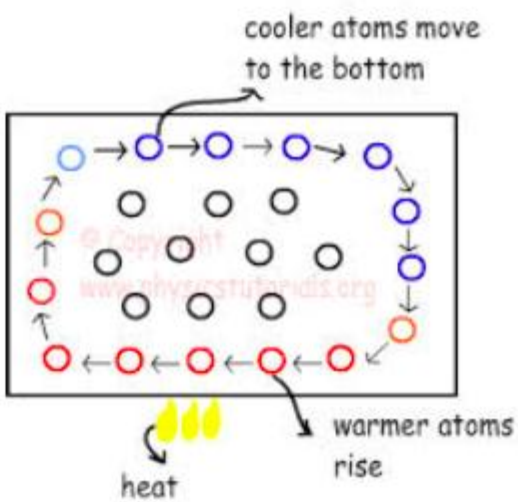
Convection currents are the currents of a liquid that move from the bottom to the top of the liquid container when the liquid is heated.

The heated liquid expands and becomes less denser and so can float upwards and replaced by colder denser liquids that sinks.



Convection in gases.

Convection air current occurs due to the unequal Heating of the Earth's atmosphere by the sum. (Thus current called strong convection current).



How to Minimize Heat Losses due to Convection in Daily Life

Explain how to minimise heat losses due to convection to daily life

When you understand the effects of cold water on the body, and how the body responds, you are far more prepared to make life-saving decisions, either for yourself or in a rescue situation.

It's actually quite simple: the body attempts to maintain a constant core temperature (h*omeostasis*) through a balance of heat loss and heat gain. Body heat is normally gained through activities such as exercise and shivering, and also with the application of external heat sources such as heat packs.

Convection is the process of air or water flowing by the skin and carrying away body heat. It's convective heat loss that you try to prevent by staying as still as possible in the water. Staying still, the boundary layer of water next to the skin is heated by the body and remains undisturbed. If you move around in the water, you disrupt that boundary layer of warmer water, and that increases heat loss.

Once a body has been in cold water for an extended period of time, most of the skin is cool with little blood flow. However, there are critical areas that are lighter (warmer) than the surrounding tissue. This is because blood is flowing through major blood vessels, which are near the skin surface. These areas in the neck, armpits and groin are areas of high heat transfer. That means that these areas have high heat loss in the cold but allow heat gain in the heat. This is why, in a rescue scenario, the most effective rewarming often consists ofapplying external heat directly to the armpits as well as the chest.

As a final note, it's important to realize that the activity of swimming (which is naturally thought of as producing a heat GAIN), in cold water conditions will result in increasing the blood flow to blood vessels close to the skin, and because of conduction and convection, it can actually increase the rate of heat LOSS and expedite the onset of hypothermia.

Knowledge of Convection to Daily Life

Apply knowledge of convection to daily life

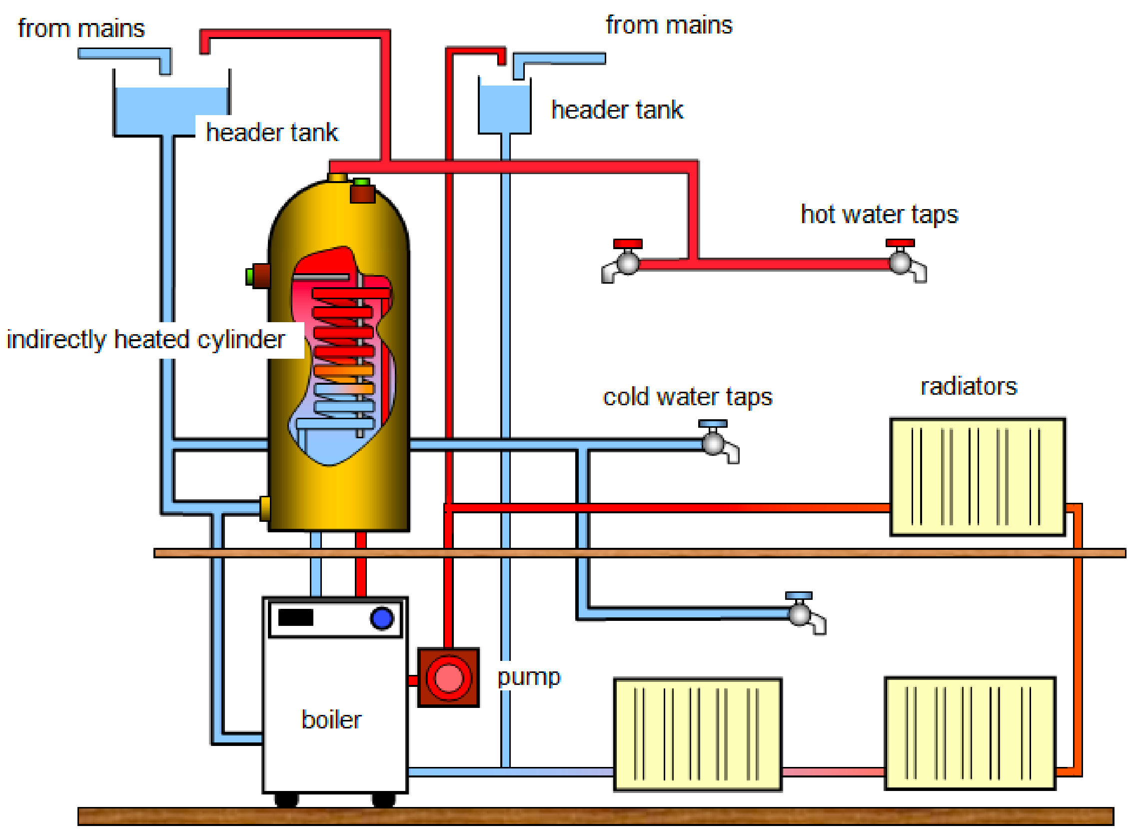
Domestic hot water system

- Convection currents are used to circulate hot water from a boiler in a domestic hot water system. The system consists of aboiler B, a hot water storage tank, H and cold water supply tank (cistern) C all connected by pipes.

- When water is heated (electrically or by fire) at the button of the boiler, it expands and become less dense, and so rises to the top.

- The hot water in the boiler passes through the outlets at the top of the boiler into the upper part of the hot water storage tank.

- The lower portion of the storage tank is filled with cold water from the cistern, which is high enough to drive the hot water out when the hot water tap T is open.
- The cistern is fitted with a ball-cock which maintains the level of water in the cistern by allowing water in when the level falls.



Radiation

The Concept of Radiation

Explain the concept of radiation

Radiation is transfer of heat energy from one point to another without the requirement of any material medium.

The stars including the sum illuminate the world by radiation.

Radiant energy from the sun Reaches the Earth through the Vast empty space ?(vacuum) existing between the atmosphere and the sun.

This energy travels with the speed of light and has similar properties to light i.e. Radiant energy can be reflected absorbed and Transmitted.

The body which absorbs radiant energy becomes heated up and its temperature rises.

Good Absorbers and Emitters of Radiant Heat

Identify good absorbers and emitters of radiant heat

Radiant energy can be detected by means of a thermopile.

Thermopile is an instrument which convents radiant energy (radiant heat energy) into electrical energy.

If the terminals of the thermocouple are connect to a galvanometer by connecting wires, a current flows in the galvanometer G when the thermopile is directed towards a hot body, such as an electric lamp.

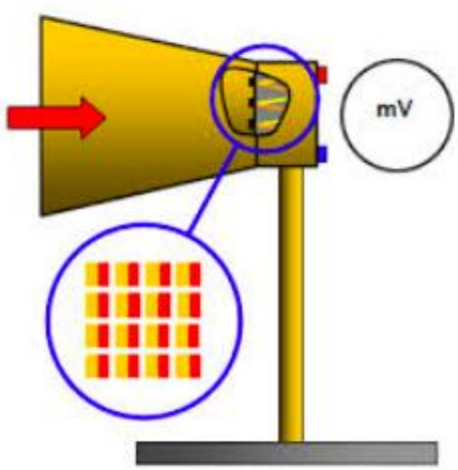
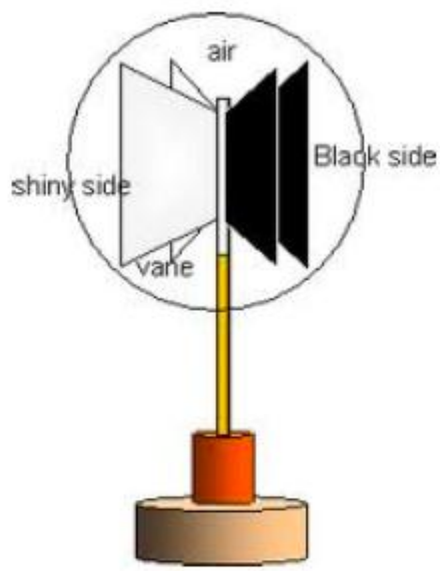


Figure 3



An increase in deflection of Galvanometer G is observed when the current thought the electric lamp is increased. Comparison of Radiant energy

The amount of Heat energy radiated by a body depends on:

1. The Temperature of the body.

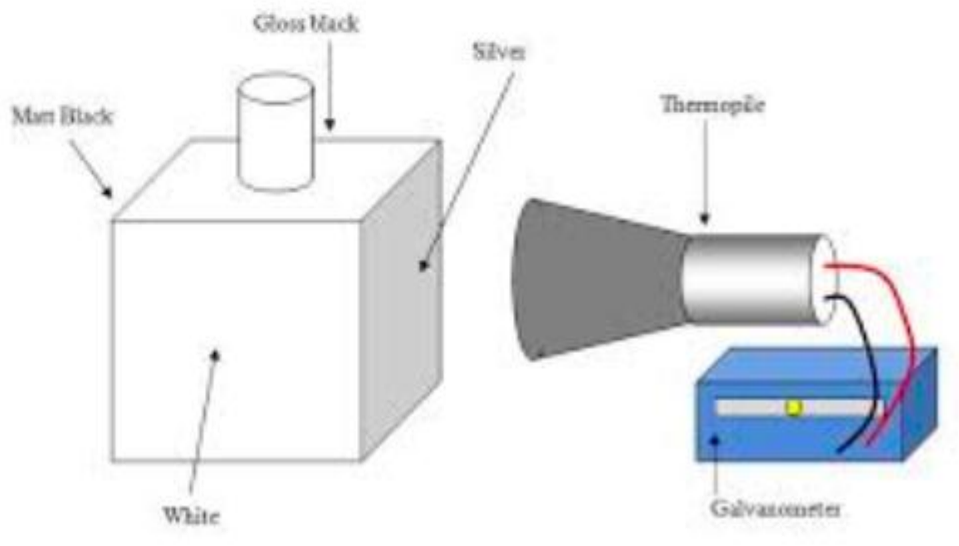
2. The Nature of surface the body.

3. The surface area for the body

To demonstrate the fact that the amount of Heat energy radiated from a body depends on the nature and area of its surface (Leslie's cube) can be used.

The figure below shows Comparison son of Radiant energy from different – substance.

- Leshe's cube is a cube – shaped metal Box which has Three of its sides painted with different colours e.g Green, Black and Grey.
- One side is highly polished serve as a reflecting surface.
- The cube is placed on a Turn table R and Maintained Hot by Running steam into it.
- Thermopile, T connected to a galvanometer G is placed at a fixed distance from the cube by Turning the Turn table.
- The black side of the cube will produce the largest deflection of the Galvanometer G, While the polished surface will produces the leats deflection.
- The alternative demonstration of the absorption of radiant Heat by a surface can be per formed by using two tiny plates and Ban sern burner.

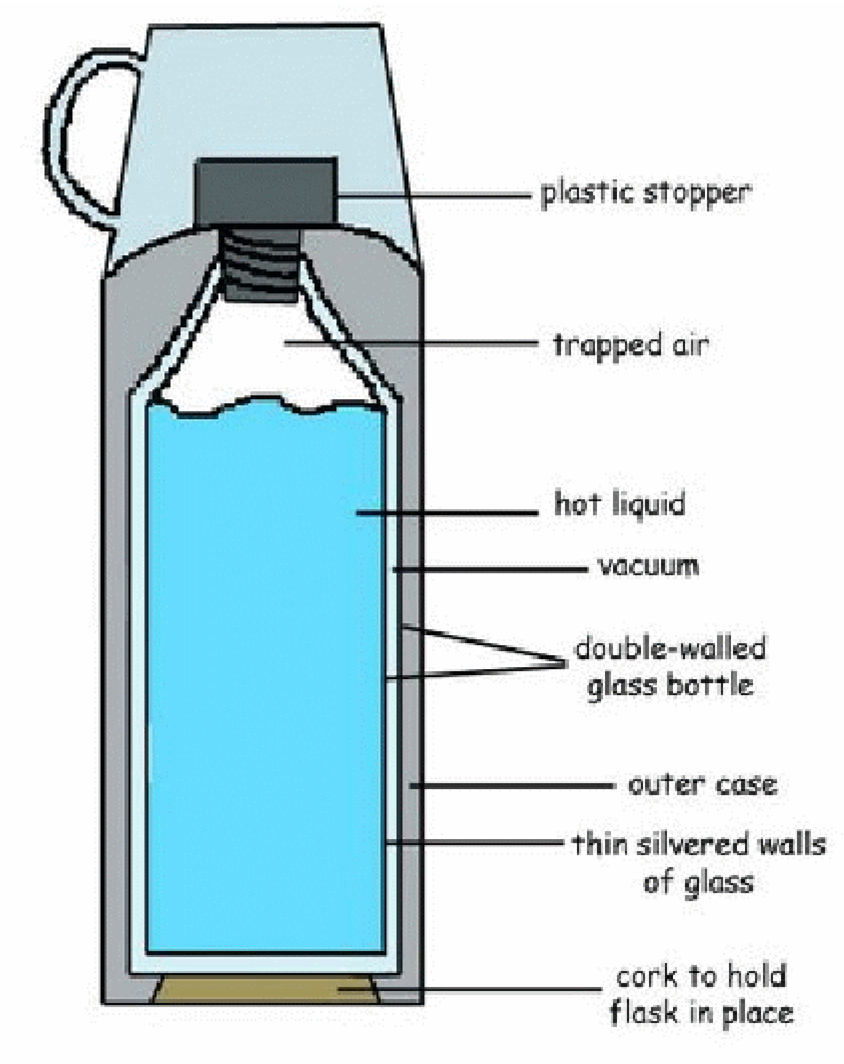


Heat Losses due to Radiation

Minimize heat losses due to radiation

The vacuum flask was designed by sir James Dewar for purpose of stoning condenser air in the liquid state.

Now days used for keeping liquids hot over a period of Time. It would also keep liquids Cold for a long time.



The vacuum flask consists of the double walled glass vessed with a vacuum between the walls.

The walls are silvered on the vacuum side. The flask controls convection, conduction and radiation of Heat energy.

Convection is prevented by the vacuum space between the walls and by closing the flask at the top.

Conduction is reduced by having the container made of glass, which is a bad conductor of heat. The stopper is made of a bad conductor e.g. cork or rubber.

The vacuum is also a non – conducting space. The outer glass wall is supported by a pad of felt or cork attached to a plastic case.

Radiation is minimized by the of silvered surfaces. The silvered surface reflects any Radiant heat energy coming from the outside or inside the flank.

MEASUREMENT OF THERMAL ENERGY

Heat Capacity

Heat capacity is the amount of **heat** required to raise the temperature of an object or substance by one degree. The temperature change is the difference between the final temperature (T_f) and the initial temperature (T_i).

The Factors which Determine Heat Quality of a Substance

Explain the factors which determine heat quality of a substance

Heat is a form of energy transferred between bodies due to difference in temperature between them. The energy possessed by the body due to its temperature is called the internal thermal energy. The heat content is due to the random motion of the particles that make up the body. The heat content is determined by its mass, temperature change and the specific heat capacity of the substance.

The Heat Capacity

Determine the heat capacity

Heat capacity is the quantity of heat required to raise the temperature of a substance by one degree Celsius.

Heat capacity = mass of the substance X specific heat capacity

Thus H.C = MC

Also

$$\text{Heat energy, } H = MC(\triangle Q) \text{ .... (i)}$$

$$\triangle Q = (Qf - Qi) \text{ .... (ii)}$$

$$H = MC(Qf - Qi)$$

Example 1

Find the heat capacity of a lump of copper of mass 50kg. The specific heat capacity of copper is 420 J/ Kg ^{o}c.

Data Given

Mass of copper, M= 50kg

The specific heat capacity of copper, C = 420J/Kg^{o}C

Required: To calculate heat capacity, H.C.

H.C = MC

= 50Kg x 420J/Kg^{o}C

= 21600J

=21KJ

Calculating a quantity of heat

- The quantity of heat required to change the temperature of a body with mass, M Kg by Q degree Celsius is MCQ joules.
- In order to raise the temperature of a body, heat must be supplied to it.
- In order to lower its temperature, heat must be removed from it.

The Heat Equation is therefore written:

Heat Gained or Heat Lost = Mass X specific heat capacity X change in temperature

Change in temperature:

H =MCQ

Where

H=Heat gained / lost

M= Mass of the body

Q= change (Rise or fall) In Temperature of the body.

Example 2

Water of mass 3kg is heated from 26ºc to 96ºC. Find the amount of heat supplied to the water given that the specific heat capacity of water is 4.2×10^3 J / Kg ºc

Data Given

Mass of water, M = 3Kg

Specific Heat capacity, C = 4.2×10^3 j / Kgº C

Initial temperature, Qi= 26 ºC

Final Temperature, Qf = 96ºC

Required

The amount of heat, H

H= MCQ

C = H/MQ

H = MCQ

H = 3Kg x 4.2×10^3 (96-26) ºC

C= 882000J= 882KJ

The Specific Heat Capacity

Determine the specific heat capacity

Specific heat capacity is the quantity of heat required to raise the temperature of a unit mass of a substance by one degree Celsius.

The quantity of heat supplied to or taken away from a body depends on:

1. The mass of the body, M
2. The temperature different, ΔT
3. The thermal properties of the body.

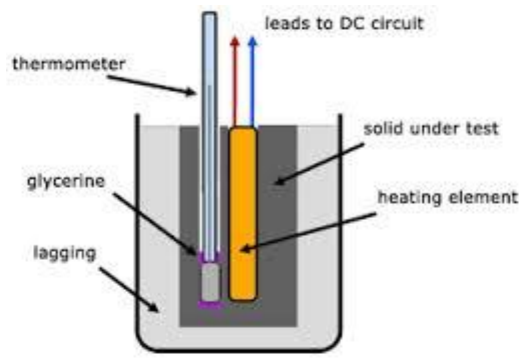
Transfer of Heat

Heat energy tends to flow from High temperatures to Low temperatures

If you pick up a warm object, heat energy transfers from the object to your hands and your hands feel warm. If you pick up a cool object, heat energy transfers from hands to the object and your hands feel cold.

Determining specific Heat capacity

- Calorimeter – Is the special instrument or vessel used for measurement of Heat.
- Calorimeter is highly polished metal can usually made of copper or aluminium.
- It is flitted with an insulating cover in which there are two holes.
- Two holes allow a thermometer and a stirrer to be inserted.
- The stirrer is made of the same metal as that of the calorimeter.



Demonstration of the specific Heat capacity of a solid

Determining specific Heat capacity by Method of Calculation.

Heat lost by solid, $Hs = Ms \times Cs\ (Qs - Qf)$

Heat Gained by Calorimeterand stirrer, $Hc = Mc \times Cc\ (Qf - Qi)$

Heat Gained by Water, $HW = Mw \times Cw\ (Qf - Qi)$

But the heat lost by the solid is equal to heat gained by the calorimeter and stirrer plus the heat gained by the water in the calorimeter.

$Hs = Hc + Hw$

But

Heat gained by a calorimeter and content equal to heat lost by the solid.

Thus $Hc + Hl = Hs$

$Mc\ Cc\ (Qf - Qi) + Mi\ Ci\ (Qf-Qi) = Ms\ Cs\ (Qs-Qs)$

$$Cl = \frac{Ms\ Cs\ (Qs-Qf) - Mc\ Cc\ (Qf-Qi)}{Mi\ Cl\ (Qf-Qi)}$$

Example 3

A piece of metal with a mass of 200g at a temperature of 100ºC is quickly transferred into 50g of water at 20ºC find the final temperature of the system (specific Heat capacity of water Cw = 4200J/ Kg ºC specific Heat capacity of the metal Cm = 400J/KgºC.

Ms Cs (Qs-Qf) = Mc Cc (Qf-Q) Mm Cw (Qf-Ql)

$$Cs = Mc\ Cc\ (Qf-Qi) + Mw\ Cw\ \frac{(Qf - Qi)}{Ms\ (Qs-Qf)}$$

Where:

Cs. Is the specific Heat capacity of the solids.

Determining the specific heat capacity of liquid, Cl

By calculation method;

Heat Gained by calorimeter and stirrer

Hc = Mc Cc (Qf – Qi)

Heat Gained by liquid

Hi = M_L C_L (Qf – Qi)

Heat lost by the solid

Hs = Ms Cs (Qs-Qf)

Let

Q be the final Temperature of the system

$$\text{Heat Gained by water} = \frac{0.50\text{Kg} \times 4200\text{J}}{(Q-20)}$$

$$= 210\ (Q-20)\ \text{J}$$

$$\text{Heat lost by metals} = \frac{0.2\text{Kg} \times 400\text{J}}{(100-Q)}$$

$$= 80\ (100-Q)\ \text{J}$$

If there are no heat Losses to the surroundings, then.

(Heat gained by water) = (Heat lost by metal)

210 (Q-20) = 80(100 – Q)

21(Q-20) = 8 (100-Q)

21Q – 420 = 800 – 8Q

21Q +8Q = (800+420)

29Q = 1220

Q = (1220/29)

Q = 42.1°C

Change of State

Change of state is the transformation of the condition of matter from one (state) to another caused by the change In temperature.

The Behaviour of Particles of Matter by Applying Kinetic Theory

Explain the behaviour of particles of matter by applying kinetic theory

The kinetic theory of matter (particle theory) says that all matter consists of many, very small particles which are constantly moving or in a continual state of motion. The degree to which the particles move is determined by the amount of energy they have and their relationship to other particles. The particles might be atoms, molecules or ions. Use of the general term 'particle' means the precise nature of the particles does not have to be specified.

Particle theory helps to explain properties and behaviour of materials by providing a model which enable us to visualise what is happening on a very small scale inside those materials. As a model, it is useful because it appears to explain many phenomena but as with all models it does have limitations.

In solids the particles	**In liquids the particles**	**In gases the particles**
• are held tightly and packed fairly close together - they are strongly attracted to each other • o are in fixed positions but they do vibrate	• are fairly close together with some attraction between them • are able to move around in all directions but movement is limited by attractions between particles	• have little attraction between them • are free to move in all directions and collide with each other and with the walls of a container and are widely spaced out •

Solids, liquids and gases

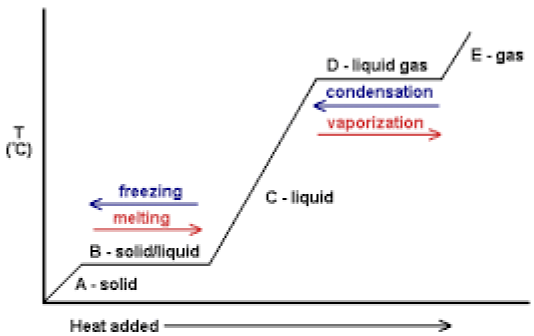
The model can be used to help explain:

1. the properties of matter
2. what happens during physical changes such as melting, boiling and evaporating

The properties of matter

Solids	**Liquids**	**Gases**
• have a definite shape • maintain that shape • are difficult to compress as the particles are already packed closely together • are often dense as there are	• do not have a definite shape • flow and fill the bottom of a container. They maintain the same volume unless the temperature changes • are difficult to compress because there are quite a lot of particles in a small	• do not have a definite shape • expand to fill any container • are easily compressed because there are only a few particles in a large volume • are often low density as there

many particles packed closely together	volume • are often dense because there are quite a lot of particles in a small volume	are not many particles in a large space



The graph of temperature versus temperature for a Heated.

The Melting Point of a Substance from its Cooling Curve

Determine experimentally the melting point of a substance from its cooling curve

Melting is the process of change of the state of matter from solid into liquid e.g ice into water.

Melting point (M.P): Itis the temperature at which solid substance tends to change into liquid.

Freezing: It is the process of change of the state of matter from liquid to solid e.g water into ice.

Freezing point: Is the temperature at which liquid change into solid. E.g water change into ice at $O^{o}C$.

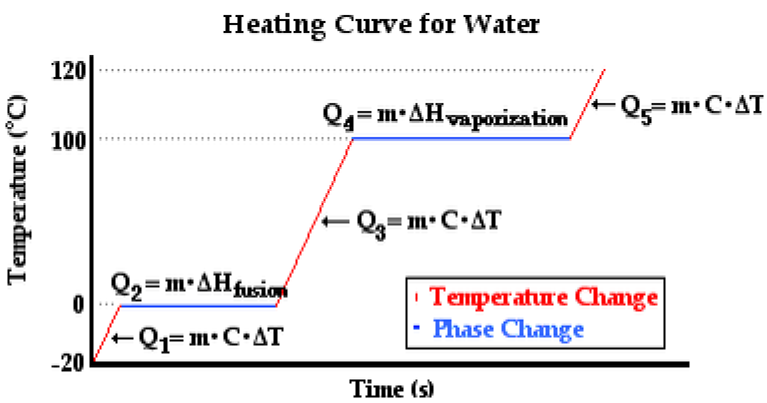
Evaporation:Is the process of change liquid substance into vapour (gas)

Sublimation: It is the change of state of matter from solid to gas and vice versa without passing through the liquid phase.e.g. ammonium Chlonde (NH_4CL) and Iodine tends to sublime.

Sublimation point is the temperature at which a solid tends to change into gas and vice versa without passing through liquid state.

Condensation:Is the change of state of gaseous state of matter into liquid state.e.g steam into water.

Deposition: Is the change of the state matter from gas into solid. e.g. Ammonium chloride vapour and Iodine vapour into solid (NH_4CI) and (Iodine).



Demonstration of cooling and melting curves for (octadecanoic acid).

Melting point (m.p) table

Substance	Melting point (ºC)
Copper	1083
Glass	1000 – 1400
Iron	1450
Lead	327
Pitch	40 – 80
Mercury	- 39
Platinum	1775
Tin	232
Tungsten	3377

The Effect of Impurities on the Freezing Point and the Boiling Point of a Substance

Demonstrate the effect of impurities on the freezing point and the boiling point of a substance

The effect of dissolved substances on the boiling point and melting point (M.P) means that the additional of impurities will result in increased (B.P) and (M.P).

Effect of impurities on Boiling Point

When an impurity is added to a substance its boiling point is elevated, i.e., its boiling point is increased.

The elevation in boiling point increases with increase in concentration of the solute because when adding the solute vapour pressure of the solution becomes lower than pure solvent. Thus the solution has to be heated more to make the vapour pressure equal to atmospheric pressure. Thus the boiling point gets elevated.

For example boiling point of water is 100^oC under normal atmospheric pressure. If we add sugar or salt to this water its vapour pressure becomes lower and boiling point increases.

Generally, when 1 mole of any non electrolyte is dissolved in 1 litre of water the elevation of boiling point is 0.53^0.

Effect of impurities on freezing point

When an impurity is added its freezing point is lowered i.e. its freezing point decreases.

The depression in freezing point increases with the increase in concentration of the solute because on adding the solute the vapour pressure of solution becomes lower than that of pure solvent. Since freezing point is the temperature at which vapour pressure of liquid and solid phase are equal, therefore, for the solution, this will occur at a lower-temperature.

For example the freezing point of water is O^oC under normal atmospheric pressure. If we add sugar or salt to this water its vapour pressure lowers and freezing point decreases.

Generally, when 1 mole of any non-electrolyte is dissolved in 1 litre of water the depression in freezing point of water is 1.86^0C.

Conclusion

1. The impurities present in a liquid pull its two fixed points away from each other i.e. the freezing point is lowered while the boiling point is raised.

2. The depression in freezing point and the elevation in boiling point increases with increase in the concentration of the solute or impurity i.e. these are the colligative properties that depends only on the no. of moles of the solute. They are independent of the nature of the solute.

The Effect of Pressure on the Boiling Point and Freezing Point of a Substance

Demonstrate the effect of pressure on the boiling point and freezing point of a substance

If a substance expands on solidifying, e.g., water, then the application of pressure lowers its melting point.

If a substance contracts on freezing, the pressure raises its melting point, e.g., paraffin wax.

The freezing point of water is lowered by 0 .007 ºC per atmosphere increase in pressure, whereas that of paraffin wax increases by 0.04 ºC per atmosphere increase in pressure.

When a is liquid heated, its temperature rises and eventually remains constant.

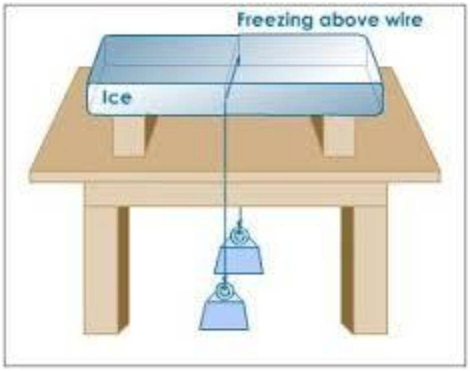
Boiling is the process of forming bubbles of vapour inside the body of a liquid. It rises to the surface of liquid. The process usually depends onexternal pressure above the liquid.

The Phenomenon of Regelation

Explain the phenomenon of regulation

Regelation is the Refreezing process which takes place when copper wire is passed through the Ice BLOCK

Regelation is the Refreezing process which takes place when the wire is observed to Cuts right through the ice block and falls on the floor.



The Concept of Boiling and Evaporation in Respect to the Kinetic Theory of Matter

Give the concept of boiling and evaporation in respect to the kinetic theory of matter

If a liquid is heated, the particles are given more energy and move faster and faster expanding the liquid. The most energetic particles at the surface escape from the surface of the liquid as a vapour as it gets warmer. Liquids evaporate faster as they heat up and more particles have enough energy to break away. The particles need energy to overcome the attractions between them. As the liquid gets warmer more particles have sufficient energy to escape from the liquid. Eventually, even particles in the middle of the liquid form bubbles of gas in the liquid. At this point the liquid is boiling and turning to gas. The particles in the gas are the same as they were in the liquid except that theyhave more energy. At normal atmospheric pressure, all materials have a specific temperature at which boiling occurs. This is called the "boiling point" or boiling temperature. As with the melting point, the boiling point of materials vary widely, e.g., nitrogen -210°C, alcohol 78°C, and aluminium 459°C.

Any material with a boiling temperature below 20°C is likely to be a gas at room temperature. When liquids boil the particles must have sufficient energy to break away from the liquid and to diffuse through the surrounding air particles. As these particles cool down and lose energy they will condense and turn back to liquid. When steam is formed by water boiling at 100°C the particles quickly condense as the surrounding air temperature is likely to be much less that 100°C so the particles cool rapidly. In fact the "steam" coming out of a boiling kettle can only be seen because some of the gas particles have condensed to form small droplets of water.

Evaporating

Within a liquid some particles have more energy than others. These "more energetic particles" may have sufficient energy to escape from the surface of the liquid as gas or vapour. This process is called evaporation and the result of evaporation is commonly observed when puddles or clothes dry. Evaporation takes place at room temperature which is often well below the boiling point of the liquid. Evaporation happens from the surface of the liquid. As the temperature increases, the rate of evaporation increases. Evaporation is also assisted by windy conditions which help to remove the vapour particles from the liquid so that more escape.

Evaporation is a complex idea for children for a number of reasons. The process involves the apparent disappearance of a liquid which makes the process difficult for them to understand. It is not easy to see the water particles in the air. Also, evaporation occurs in a number of quite differing situations - such as from a puddle or bowl of water where the amount of liquid obviously changes, to situations where the liquid is less obvious - such as clothes drying or even those where there is no obvious liquid at all to start with - such as bread drying out. A further complication is that evaporation may be of a solvent from a solution e.g. water evaporating from salt water to leave salt. These situations are quite different yet all involve evaporation.

Evaporation may also involve liquids other than water e.g. perfume, petrol, air fresheners. The particle model can be used to explain how it is possible to detect smells some distance away from the source.

Latent Heat of Fusion and Vaporisation

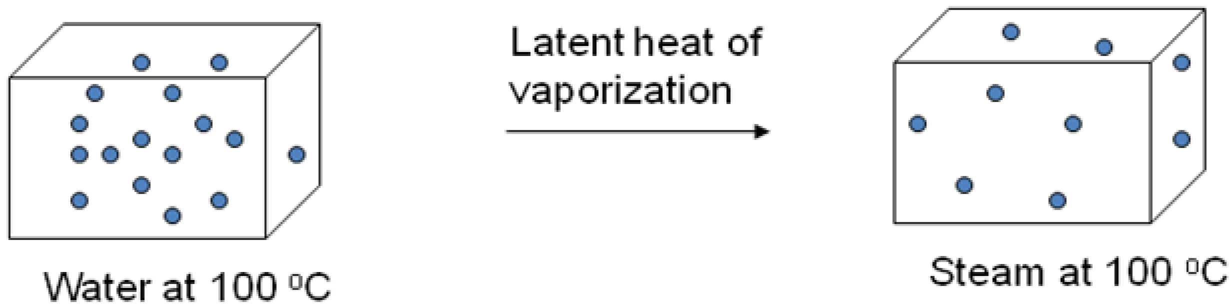
Demonstrate latent heat of fusion and vaporisation

Latent Heat is the energy when is supplied in form of heat required to change the state of the Matter from one form into another.

Latent heat is not determined (detected) by using a thermometer. So latent heat is also called hidden heat.

Specific latent Heat is the energy supplied to a unit Mass and change Its state from one state of Matter to another state of matter.

Latent heat of Vaporization is the heat required to change a liquid into a gaseous state at constant temperature.



- Mass of Beaker = M_1 kg
- Mass of Beaker + Water = M_2 kg
- Time taken to Boil =t_1 Minutes
- Time taken to Boil away = t_2 Minutes
- Specific latent heat of = L J / kg Vapor
- Heat gained by steam = $(M_2 - M_1)L$

Generally

$$\frac{\text{Heat gained by steam}}{\text{Heat gained by Water}} = t_2/t_1$$

$$\frac{(M_2 - M_1)}{(M_2 - M_1)\, CW \times 100} = t_2/t_1$$

$T_{1\ time}$ taken to evaporate

T2 time taken to boil

In this experiment , the Heat gained by the Beaker may be Neglected.

Latent heat of fusion is the amount of heat required to change a substance from solid to liquid at constant temperature.

Example 4

Calculate the amount of Heat required to melts 800g of Ice at 0ºC The specific Latent of fusion of Ice 33400J/kg

Data given:

Mass of Ice , M = 800g (0.8kg)

Specific Heat of fusion, L = 33400 J/kg

Heat gained, H = ML

H= (0.8 x 33400J/ kg)

H = 267520J

Determination of the specific Latent Heat of fusion of Ice.

- Mass of Calorimeter + stirrer = M_1
- Mass of calorimeter +Water =M_2
- Mass of Calorimeter +Water = M_3
- Initial Temperature of Water = Q_1
- Final temperature of Water =Q_f
- Mass of Water = ($M_2 - M_1$)
- Mass of Ice = ($M_3 - M_2$)

The Ice melts and forms Water at 0ºC .The Water formed warm up to Temperature Qf.Heat gained by ice during melting at 0ºC = $(M_3 - M_2)L$ where L is the specific latent Heat of fussion.

Heat gained by the water formed = $(M_3 - M_2)\, C_W\, Q_F$

Where

- CW is the specific heat capacity of water.
- Heat lost by the original water in the calorimeter = $(M_2 - M_1)\, (Q_1 - Q_F)\, C_{w.}$
- heat lost by calorimeter and stirrer = $M1\, C_C\, (Q_i - Q_f)$.
- Cc is the specific heat capacity of the material of the calorimeter.

Applying the heat equation:

(Heat gained by ice in Melting + Heat gained by the Water formed) =(Heat lost by calorimeter and stirrer + Heat lost by original Water)

$(M_3 - M_2) L + (M3- M2) CW QF= M1 C_C (Q_1 - Q_F)+ (M2- M1 CW Q1 - QF)$

$$L = \frac{[M_2 C_C + (M_2 - M_1) C_W][Q_i - Q_f] - (M_3 - M_2) C_W Q_f}{M_3 - M_2}$$

Specific Latent heat of Vaporisation is the amount of heat required to change a unit Mass of liquid into gaseous state (Vapour) at constant temperature.

Specific latent Heat of fusion is the amount of heat required to change a unit Mass of solid substance into liquid at constant temperature

SUBSTANCE	SPECIFIC LATENT HEATOF FUSSION J/ kg
Ice	334400
Naphthalene	146300
Lead	24662
Copper	179740
Aluminum	317680
Gold	66880

Example 5

0.6 kg of ice at - 10ºC is dropped into 2kg of Water 49ºC contained in a Copper calorimeter of mass 0. 15kg . If the final temperature of the Mixture is 20ºC fin d the specific latent Heat of fusion of ice.
Where

- Specific Heat capacity of ice = 2.1 x 103 J/ KgºC
- Specific Heat capacity of copper = 420 J/ Kg ºC

- Specific Heat Capacity of Water = 4200 j/ Kg º C

Solution

Heat gained by ice during warming up form - 10 ºC to 0ºC

= (0 . 6 ×2 . 1 X 103 ×10)

= 12600J

Heat gained when ice at 0ºC changes to water at 0ºC = 0.6L; where L is the latent heat of fusion of ice

Heat gained by cold Water in warming up from 0ºC to 20ºC

=(0 . 6 ×4 . 2 × 103 × 20)

=50400 J

Heat lost by Water during cooling from 49ºC to 20ºC

= 0 . 15 ×420 ×29

= 1827 J

But

Total Heat gained = Total Heat lost

12600 + 0.6 L + 50400 = 243600 + 1827

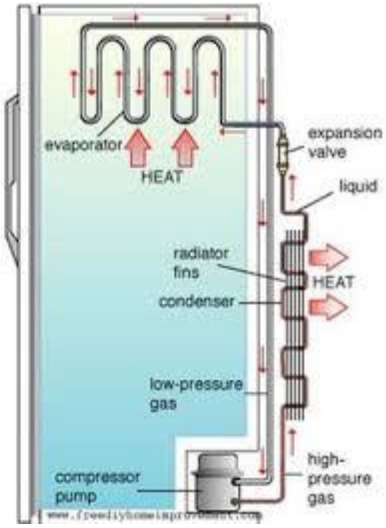
L = 245427 - 6300\ O.6

L = 304045J/ Kg

The Mechanism of Refrigeration

Describe the mechanism of refrigeration

Refrigerator is a machine which can enable Heat to flow from a cold Region to a Hot region.The Basic principle used in Refrigeration is Cooling by absorption of latent Heat



How it Works

A volatile liquid such as freon, evaporates inside the copper coils **A** surrounding the freezing cabinet or the refrigeration.

- The latent heat of Vaporization comes from the air surrounding the coil i.e. from the inside of the freezing g cabinet
- An eclectically driven pump **P** remove the vapor from **A** and force it into the heat exchanger**C, w**hich is made of copper coils.
- The coils of the heat exchanger are filled with cool fins ***F***
- In the heat exchanger, vapor is compressed by the pump and condensed back to liquid.
- The conversion of vapour into liquid in (c) gives out the latent heat of vaporization, which is conducted away by the fins.
- The condensed liquid is then returned to the evaporator coil (A) through avalve (V) (in this way a continuous circulation of vapour and liquid is set up).
- The rate of evaporation and the degree of cooling is controlled by a thermostat, which switches the pumps motor on and off at intervals.
- The thermostat can be adjusted to give the desired low temperature inside the freezing cabinet where food is preserved.

VAPOUR AND HUMIDITY

Vapour

The Process of Evaporation of Liquid

Explain the process of evaporation of liquid

Vapours

- These are molecules which escape into the atmosphere after liquids are heated.
- When a liquid is heated strongly then molecules tends to escape (those molecules are called vapour).
- Most liquids evaporates at any temperature however liquids may vary in the rate at which they evaporate at ordinary temperature.
- Alcohol and ether evaporate rapidly but lubricating oil and mercury hardly evaporate.
- Evaporation of a liquids result in the formation of vapour.

Factors Affecting Evaporation of a Liquid

Identify factors affecting evaporation of a liquid

There are several factors which affect evaporation of liquids when heated which include the following:

a. **Nature of the liquid:** Normally liquids evaporation differs depending on the nature of liquid. Example; Volatile liquids evaporate faster than non-volatile liquids, which evaporate slowly. Alcohol evaporates faster than other liquids like water. The boiling point of alcohol is 78^0C while that of water is 100^oC.

b. **Pressure above the liquid (atmospheric pressure):** When the atmospheric pressure is high, the rate of evaporation may be reduced.

c. **Surface energy of the liquid:** This forms a boundary or skin between the liquid and the atmosphere. The surface energy prevents molecules with lower kinetic energy from escaping into the atmosphere. Some liquids such as alcohol have low surface energy , hence they evaporate rapidly.

Question Time 1

Why do molecules escapes when the liquid is heated?

When the liquid is heated, the molecules tend to gain (absorb) kinetic energy hence the random speed of the moleculesincreases.

The process of evaporation of liquid can be explained using Kinetic Theory.When a liquid is left to evaporate in a closed container, the pressure of the vapour in the container gradually increases.

Difference between Saturated and Evaporation of a Liquid

Distinguish between saturated and evaporation of a liquid

Vapours

The molecules in a liquid are in a state of continuous motion and some of those at the liquid surface will gain sufficient energy to escape from the surface altogether. The molecules that have left the surface are said to be in the vapour state. The difference between a vapour and a gas is purely one of temperature, a vapour being a gas below its critical temperature.

This phenomenon is known as evaporation. The number of molecules leaving the surface, and hence the rate of evaporation, will increase with temperature as the liquid contains more energy at a higher temperature. The effect of the evaporation of a liquid can be shown clearly by the following experiment.

Some ether is run into the flask, as shown in the figure below. It will evaporate in the enclosed space and the pressure that it exerts on the water will force a jet of water out of the tube. Warming the liquid will increase this evaporation and give a more powerful jet.

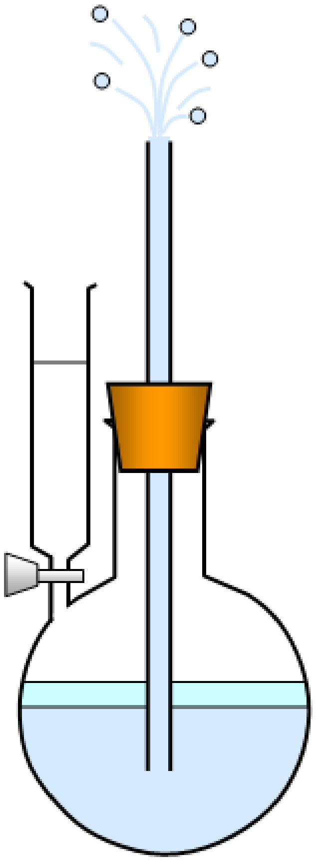


Figure 1

You can show that the rate of evaporation may be increased by:

a. Warming the flask gently.

b. Increasing the area of the liquid surface.

c. Blowing a stream of air across the surface.

d. Reducing the pressure above the liquid surface.

Saturated vapours

When a liquid is in a closed container the space above the liquid is full of vapour, and the vapour is then described as a saturated vapour - this means that the density of the liquid molecules in the air is a maximum. This is due to molecules continually escaping and reentering the liquid. At any moment the number of molecules leaving the surface will be equal to the number returning to it and so a dynamic equilibrium is set up.

The properties of saturated vapours were first investigated by Dalton around 1800. This is shown in Figure 2(a), which shows a state before saturation has been reached (when there will be more molecules leaving the surface than returning to it) and Figure 2(b), which shows the saturated state. A dynamic equilibrium exits here.

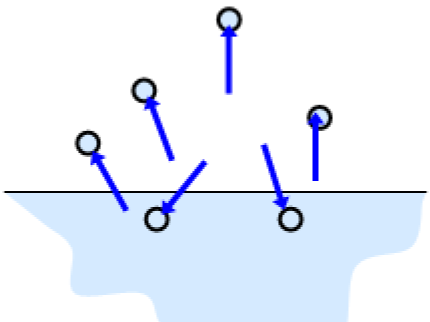


Figure 2(a)

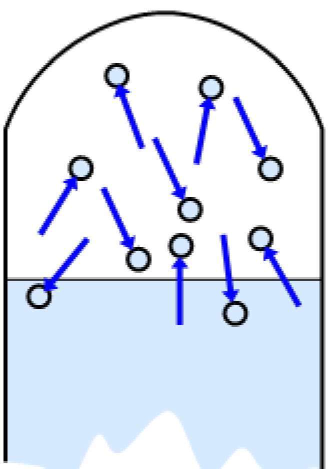


Figure 2(b)

This vapour will exert a pressure and if there is sufficient liquid the air above the liquid surface will be saturated with vapour; the pressure that this saturated vapour exerts is known as the saturated vapour pressure (s.v.p.) of the liquid at that temperature.

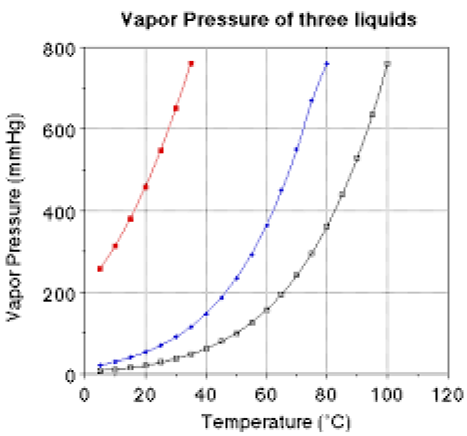
Notice that since the velocity of the molecules increases with temperature the saturated vapour pressure also increases with temperature, and therefore the temperature of the vapour must be specified when quoting its saturated vapour pressure (s.v.p.)

The Effect of Temperature on Saturated Vapour Pressure (S.V.P) of a Liquid

Explain the effect of temperature on saturated vapour pressure (S.V.P) of a liquid

Saturated vapour pressure (S.V.P): Is the pressure exerted by vapour when a liquid is heated and reaches a state of Equilibrium where eventually the rate at which the molecules leave the liquid is equal to the rate at which others return to it.

The Height, of mercury represents the saturated vapour pressure of the liquid in the flask. Saturated vapour pressure increases with the increase in Temperature (Ti) and the increased with decrease in Temperature (Td).



The graph of saturated vapour pressure (svp) against Temperature

The graph shows as saturated vapour pressure (s.v.p) increases then the temperature will increase and vice versa for decrease of temperature.

Boiling point (B.P):Is the temperature reached where the saturated vapour pressure (S.V.P) is equal to external atmospheric pressure.

The Boiling point of alcohol is $78^{O}C$ water is $100^{O}C$ and pressure of the atmosphere as 76cm of mercury.The intersection of the normal atmosphere pressure line with the liquids S.V.P curve.

Humidity

The Concept of Humidity

Explain the concept of humidity

HUMIDITY is the measure of the extent to which the atmosphere contains water vapour (moisture).

The Formation of Dew

Explain the formation of dew

DEW:These are deposits formed when the temperature fall slowly in the drops of water vapour.

Dew point (D.P): Is the temperature to which air must be cooled to become saturated. For example in an air container, if water vapour at pressure of 8mm of mercury were to be cooled , dew would form at 7.9^0C.

Measurement of Relative Humidity

Measure relative humidity

Absolute humidity is the mass of water vapour present in a unit volume of it and is usually expressed in grams per cubic metre (g/m^3). The absolute humidity is not very frequently used since in practice we're more often concerned with the degree of wetness of the air.

Relative Humidity (R.H) is the ratio of the mass of water vapour actually in a unit volume of air to that is required to saturate it at the same temperature.

R.H = Mass of water vapour/Volume of air required to saturate the air at the same temperature

It is common practice to quote relative Humidity as a fraction or a percentage.

Thus

R.H = m/M X 100%

Where

M = mass of water vapour actually present in a unit of given volume of air.

M= mass of water vapour required to saturate the air at the same temperature.

Relative Humidity is also defined as the saturation vapour pressure of water at the dew point divided by the saturation vapour pressure of water at the original air temperature.

R.H = s.v.p at dew point/s.v.p at air Temperature

Note: The low value of relative humidity of air means that evaporation takes place readily from the surface of water.The high value of relative Humidity then evaporation does not take place readily from the surface of water.

Humid atmosphereis saturated with water vapour.

Perspiration: Is the evaporation of sweat from the skin, is not so effective at cooling the body in humid atmosphere.

Note:

- Cotton manufacturing industries are constructed on sites where the relative Humidity (R.H) Is High.
- Cotton fibres must not become too dry, otherwise they become Brittle and hence cause difficulties in spinning.
- In contrast, a dry atmosphere is required by ware House for the storage of food, Tobacco and assembling of certain electrical components.
- Air – conditioning plants are installed in ships and buildings for the purpose of moderating Humidity.

MEASURING RELATIVE HUMIDITY

Hygrometers are instruments used for finding relative humidity at a given place. With most hygrometers, the relative humidity is determined by first finding the dew point and then using vapour pressure tables.

A very common type of Hygrometer (often known as Mason’s hydrometer). A piece of muslin wick is wrapped round the bulb of one the thermometer and its lower and dipped into water capillary action keeps the Muslin wrapped around the bulb wet.

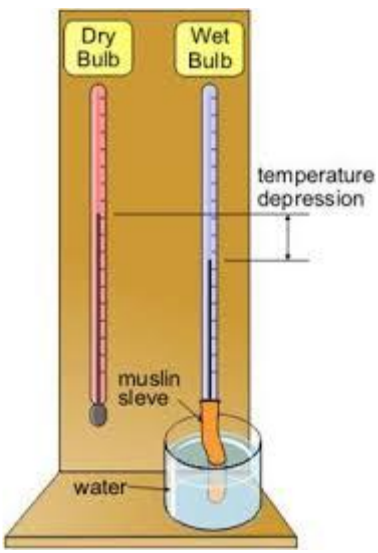
- Evaporation of water surrounding the wet bulb absorbs heat from the bulb, consequently the temperature of the wet bulb falls.

- The reading of the wet bulb thermometer is normally found to be several degrees below that of the dry bulb Thermometer is known as the wet bulb depression.

Example 1

If the dry the temperature is 30^0C when the wet bulb temperature is 20^OC then the wet bulb depression is 10^oC the rate Evaporation depends on the amount of water Vapour present in the air.

The less moisture the air has the greater the difference between the two thermometer reading.The difference is therefore greatest for dry air and zero for saturated air.

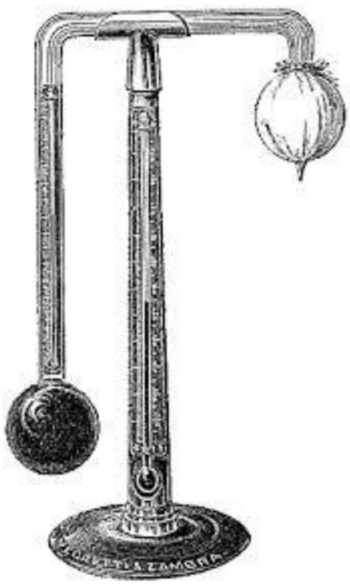


REGNAULT'S HYGROMETER: Is used to determine dew point and relative Humidity.Simplified form of regnault's hygrometer consist of two test – tubes A and B with silvered ends C and D Respectively.

- Test tube A contains ether and it is fitted with rubber stopper which carries a thermometer T and two narrow tubes E and F.

- Test tube B. is empty and serves as comparison.

- Air is bubbled through ether via the narrow tube E by applying a fitted pump at the end of the Narrow tube F. This causes the rapid evaporation which results in the absorption of latent heat from ether and the container.
- Air surrounding the tube cools to temperature at which the water vapour present is sufficient to saturate it.
- Consequently is seen to form on C while D appears unchanged.



Above show Regnault (dew point) hygrometer.

- The reading of the thermometer T is then noted.
- The flow of air through the ether is then stopped and the apparatus allowed warming up.
- The temperature at which the dew on C disappears is noted.
- The dew point is then taken as the mean of the two temperatures.
- Suppose the dew pint is Q1 and the actual air temperature is Q2 if the tables the value of S.V.P for water at Q1 and Q2 are X and Y millimeters of mercury Respectively.
- R.H = S.V. Pat Q1 x 100%/S.V.P at Q2

Example 2

The dew point in a room at a temperature of 10^0c is 12,55C if the saturated vapor pressure if saturated vapor pressures at these two temperatures are 15.5mm and 10.9mm of mercury respectively calculate the Relative Humidity.

Solution

Required: To find relative humidity, RH.

RH = S.V.P at dew pointx 100%/S.V.P at air temperature

RH= 10.9/15.5× 100%

Relative Humidity, RH = 71%

The Knowledge of Humidity in Daily Life

Apply the knowledge of humidity in daily life

Water in the atmosphere exists in different forms example: Clouds, Rain, Snow, Hail stones, Mist, Fog and Smog.

Clouds.

- Consist of the tiny droplets of water or Ice floating in the sky formed by condensation of water vapor in the upper atmosphere.
- Clouds formation occurs when temperature falls below the dew point and small particles of dust or salt crystals are present to act as nuclei on which condensation can begin.
- Cooling is due to upward movement of air accompanied by example.
- Clouds may also formed when a warm moist air current meets a cold one if the drops become big enough by joining together they may fall as rain.

Rain: These are drops of water that fall on the grounds when cooling occurs in the clouds.

Snow: Formed when the dew points is below the freezing point (F.P) 0^OC.Under these conditions, the atmospheric vapour condenses directly into ice crystal.

Hail stones

- Formed due to super cooling of water droplets in such a way that the droplets are cooling below 0^oC without freezing.
- When these droplets are carried upwards by ascending air currents, they solidify upon coming into contact with ice crystals in the upper atmosphere.
- Hail stones are dangerous to air craft and human beings.

Mist: Is the condensation of vapour Iito water droplets occurring near the ground.

Fog: Is a mist In which Visibility does not extend beyond 1km.

Smog: This is dense fog, where visibility is reducing to a few metres.

THERMAL CURRENT ELECTRICITY

Electromotive force (emf) and potential difference (pd)

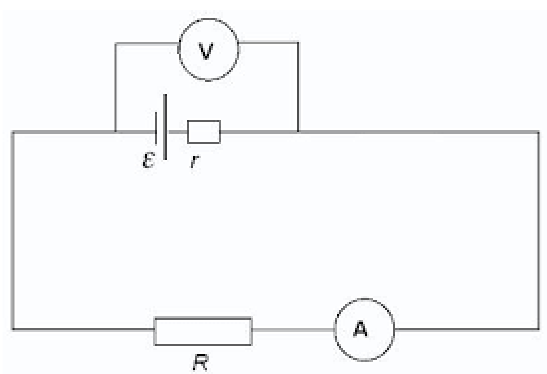
The Concept of Electromotive Force (emf) and Potential Difference (PD)

Explain the concept of electromotive force (emf) and potential difference (pd)

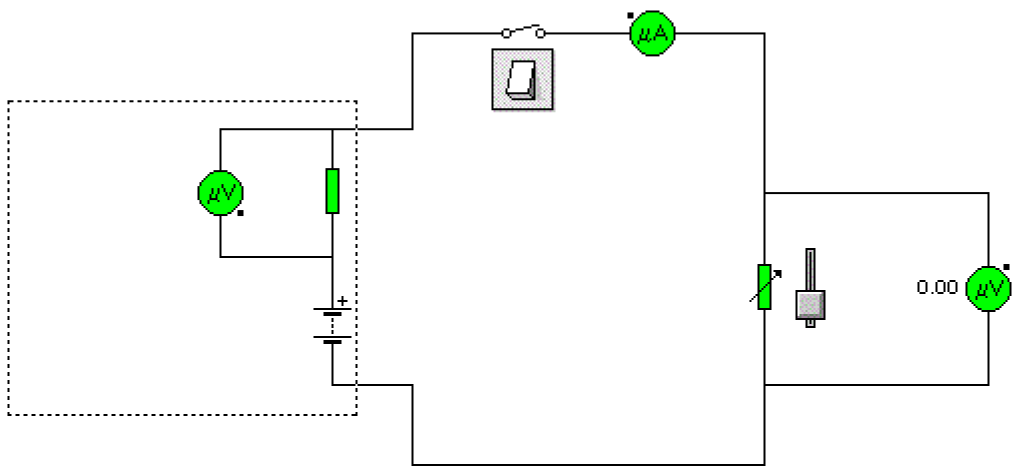
Potential difference (P.d) is the difference in potential between two charged points of conductor. It is measured in volts with the unit V.

Electromotive force (e.m.f) is the voltage developed by any source of electrical energy such as a battery or dynamo. It is generally defined as the electrical potential for a source in a circui. It is measured in volt with the unit V.

Internal Resistance (r)is an opposition offered in the batteries or power supplies which have the effect of reducing the output potential difference as the current supplied increases.



The voltmeter in the following figure shows the 'lost volts'.



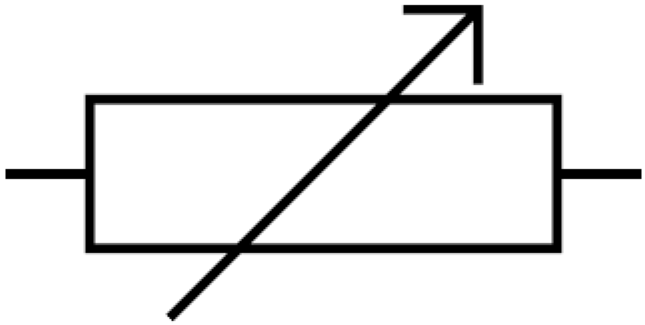
- Set the variable resistor in the circuit to 10Ω.
- Close the switch and note the values of the p.d across the internal resistance and the load resistance.
- Suppose the result shows a p.d across 10Ω load resistance of 7.5V and a p.d across the
- 2Ω internal resistance of 1.5V the e.m.f of battery is 9V.
- The p.d actually available at the battery terminals is called the terminal p.d. If the e.m.f of the battery is V_{tpd} = Terminal, p.d across the internal resistance = $V_{lost.}$Thus E = $V_{tpd} – V_{lost.}$
- The Electromotive force (e.m.f) can be regarded as the total potential difference including the potential difference lost across the internal resistance of the battery.
- The SI unit of potential difference or electromotive force is the Volt (Symbol V).

Resistance (R)is an opposition offered by resistor to the flow of an electric current.

From Ohm’s law, R = (V/I)

Resistor is a component that has resistance or is an instrument used to opposes the flow of current.

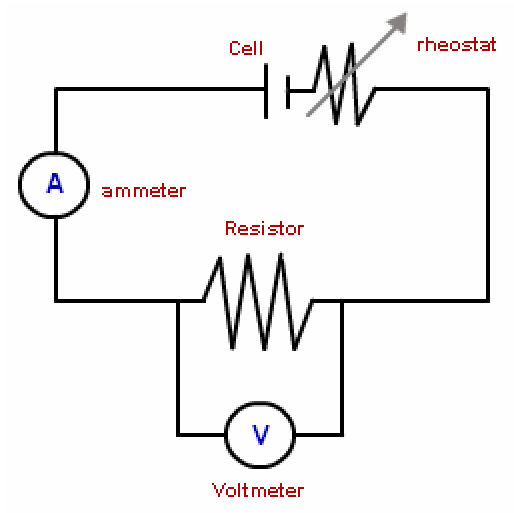
Variable resistor (rheostat) is a resistor whose resistance can be changed smoothly in order to change the current flowing.



Resistance box consists of a number of resistors connect in series through thick brass blocks (any of the resistors may be short-circuited by putting a plug into the associated socket).

Wire resistorsare lengths of wire of known resistance. The resistors used in electronic circuits are made from carbon or metal film and the value of resistance is shown by colour coded rings.

Resistanceis measured inohms. The resistance of a conductor may be determined by passing a steady current (I) through it and at the same time recording the corresponding voltage across it.



The SI Units of Electromotive Force and Potential Difference

State the SI units of electromotive force and potential difference

Electromotive Force (e.m.f.) of a source is the energy converted from non-electrical to electrical form when one coulomb of positive charge passes through the source.

SI unit: Volt (V)

E=W/Q, where E = e.m.f., W = work done by source, Q = amount of positive charges

The potential difference between two points is defined as the energy converted from electrical to other forms when a current of positive charge passes between the two points.

TheSI unit: Volt (V)

V=W/Q, where V = potential difference, W = work done in driving the charge between the two points, Q = amount of positive charge.

IMPORTANT: There can be e.m.f. without a closed circuit. BUT there cannot be a potential difference without a closed circuit.

Electromotive Force of a Cell and Potential Difference

Measure electromotive force of a cell and potential difference across a conductor

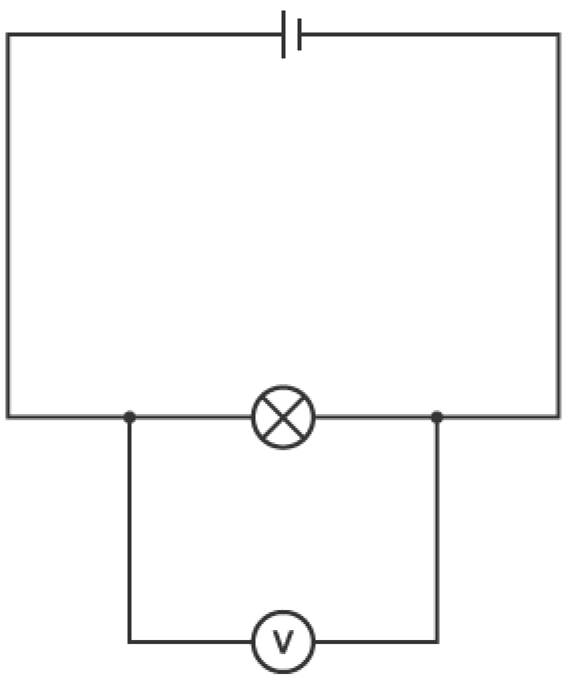
Potentiometer is a device used to compare the e.m.f. (electromotive force) of two cells, to measure the internal resistance of a cell, and potential difference across a resistor. It consists of a long wire of uniform cross-sectional area and of 10 m in length. The material of wire should have a high resistivity and low temperature coefficient. The wires are stretched parallel to each other on a wooden board. The wires are joined in series by using thick copper strips. A metre scale is also attached on the wooden board.

The **potentiometer** works on the principle that when a constant current flows through a wire of uniform cross sectional area, potential difference between its two points is directly proportional to the length of the wire between the two points.

Electromotive force (emf) is a measurement of the energy that causes current to flow through a circuit. It is the energy provided by a cell or battery per coulomb of charge passing through it. It can also be defined as the potential difference across the terminals of a cell, when no current flows through it. Electromotive force is also known as voltage, and it is measured in volts. Electromotive force is not truly a force; rather, it is a measurement of energy per unit charge.

Measuring potential difference

Potential difference is measured using a device called a voltmeter. Just like ammeters, some types have a pointer on a dial, but most have a digital display. However, unlike an ammeter, you must connect the voltmeter in parallel to measure the potential difference across a component in a circuit.



A circuit diagram showing a voltmeter in parallel with a lamp

When two components are connected in parallel, you cannot follow the circuit through both components from one side to the other without lifting your finger or going back over the path you have already taken.

Resistance to Electric Current

The Concept of Electric Current in a Conductor

Explain the concept of electric current in a conductor

Resistance of a wire: The resistance of a wire depends on the length (L) and cross sectional area of the conductor. R is directly proportional to L.

Also

R = L/A

Combine eqn (I) and (II)

R = L/A

R = K. L/A

K = Constant called Resistivity (J)

R = JL/A

J = RA/L

Resistivity (J) is the resistance of a 1metre length of a piece of a conductor whose cross – sectional area is equal to 1 meter square (m2).

Example 1

The resistance of copper wire is found to be 10Ω. Calculate the resistance of a copper wire of the same length but whose radius is twice that of the first wire.
Solution:

Let, r and J be the radius, length and resistivity of the wire whose resistance is 10Ω.

Thus

R = JL/A

But

Cross – sectional area, A = IId2/4r or IIr_2

R = JL/A........................... (i)

Let 2r, L and J be the radius length and Resistivity of the wire of Resistance (R)

$R = JL/II(2r)^2$ ....(ii)

Divide Eqn (ii) / (i)

$$R/10\Omega = JL/IIr^2 / JL/4IIr^{2V}$$

$$R/10\Omega = (JL/IIr^2)\ °\ (¼)$$

$$(R/10\Omega) = (¼)$$

$$R = 2.5\Omega$$

Resistance, RE of the conductor 2.5Ω

Factors which Determine the Resistance of a Conductor

Describe factors which determine the resistance of a conductor

There are three external factors that influence the resistance in a conductor. Thickness (cross sectional area of the wire), length, and temperature all have some effect on the amount of resistance created in a conductor. The fourth factor is the conductivity of the material we are using. Some metals are just more electrically conductive than others. This however, is considered an internal factor rather than an external one.

1. **Cross Sectional Area:**The cross-sectional area of a conductor (thickness) is similar to the cross section of a hallway. If the hall is very wide, it will allow a high current through it, while a narrow hall would be difficult to get through due to it's restriction to a high rate of flow. The animation at the left demonstrates the comparison between a wire with a small cross sectional area (**A**) and a larger one (**A**). Notice that the electrons seem to be moving at the same speed in each one but there are many more electrons in the larger wire. This results in a larger current which leads us to say that the resistance is less in a wire with a larger cross sectional area.
2. **Length of the Conductor:**The length of a conductor is similar to the length of a hallway. A shorter hallway would allow people to move through at a higher rate than a longer one.
3. **Temperature:**The temperature of a conductor has a less obvious effect on the resistance of the conductor. It would be as hard to apply the hallway analogy as it is hard to say whether a hot hallway would make us move faster or slower than a cold hallway. To truly understand the effect you must picture what happens in a conductor as it is heated. Remember, heat on the

atomic or molecular scale is a direct representation of the vibration of the atoms or molecules. Higher temperature means more vibrations. Imagine a hallway full of people. Half of the people (the electrons) are trying to move in the same direction you are and the other half (the protons) are evenly spaced but stationary in the hallway. This would represent a cold wire. Since the wire is cold the protons are not vibrating much so the electrons can run between them fairly rapidly. As the conductor (hallway) heats up, the protons start vibrating and moving slightly out of position. As their motion becomes more erratic they are more likely to get in the way and disrupt the flow of the electrons. As a result, the higher the temperature, the higher the resistance. A prime example of this is when you turn on a light bulb. The first instant, the wire (filament) is cold and has a low resistance but as the wire heats up and gives off light it increases in resistance. As a result we can say that Ohm's law holds true unless temperature changes.At extremely low temperatures, some materials have no measurable resistance. This is called superconductivity. The materials are known as superconductors. Gradually, we are creating materials that become superconductors at higher temperatures and the race is on to find or create materials that superconduct at room temperature. We are painfully far away from the finish line.

The Relationship between Potential Difference across the Conductor and Current

Determine the relationship between potential difference across the conductor and current

The relationship between voltage, V and current ,I in a metal conductor was discovered by George Ohm and formulated in a law called as Ohm’s law.

Ohm’s law state: The potential across a metal conductor is directly proportional to the current flowing through the conductor, provided that its temperature remains constant.

Or VaI , if T remains constant

Types of Resistors

Identify types of resistors

Resistors can be classified on various types based on various factors.Some of the classification of resistors are:

Based on the conductive properties of a resistor resistors can be classified as:

1. **Linear Resistor**: A linear resistor is the type of resistor whose resistance remains constant with increase in the potential difference or voltage applied to it. Or the Resistance or Current passed through the resistor does not changes as the applied voltage (P.D) changes. The V-I characteristics of such resistor is a straight line as shown on the figure below or in other words these types of resistors followsOhm's Law very strictly.

2. **Non Linear Resistor**: Non-Linear Resistor are those types of resistors in which the Current passedthroughit is not exactly directly proportional to the Potential Difference applied to it. These types of resistors have non-liner V-Icharacteristicsand does not strictly follows ohm's Law

Based on the resistance value of the resistor the resistors can be classified into following groups:

- **Fixed Value Resistor:** Fixed value resistors are those types of resistors whose value is fixed already during manufacturing and cannot be changed during its usage.

Fixed resistor

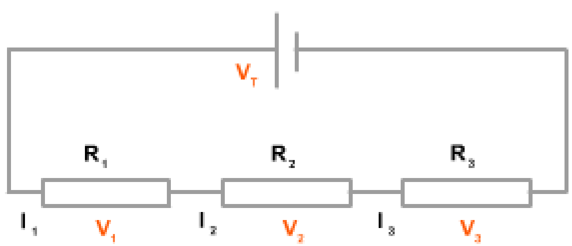
- **Variable Resistor or Potentiometer:** Variable Resistors or Potentiometers are those types of resistors whose value can be changed during its usage.

Variable Resistors

The Equivalent Resistance of more than two Resistors in Series and Parallel

Determine the equivalent resistance of more than two resistors in series and parallel

Resistor in series: To connect two or more resistors in series is to joins the resistors one to another in succession. Consider a total of N Resistors connected in series.



Let a current I flow through each of the Resistor R1, R2, R3 .... RN let their total resistance be represented by only one resistor R called the Equivalent Resistance.

According to Ohm’s law, the voltage across each Resistor will be:VI = IRI V2 = IR2 V3 = 1R3 ....Vn = IRN

The voltage V across the set of Resistor is the sum of the voltages a cross each resistor.

Thus

V = VI + V2 + V3 ....VN

V = (IRI + IR2 + IR3 ....IRN)

V = I (RI + R2 + R3 .... RN)

V/I = (RI + R2 + R3 .... RN)

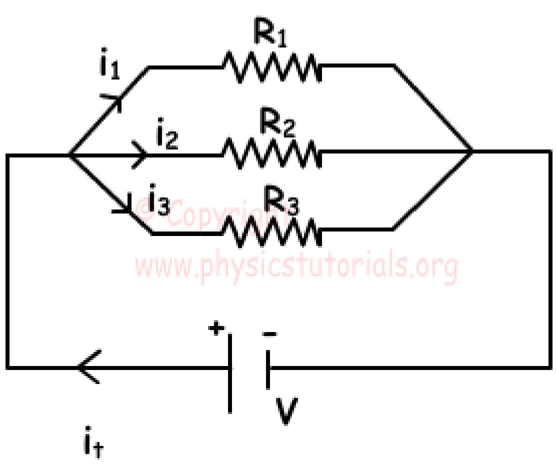
But

V/I = R = (Equivalent Resistor)

R = (RI + R2 +R3 ....RN)

Hence equivalent resistance of resistors connected in series is resistor connected in parallel.

Now let us consider the case where a total of N RESISTORS connected in parallel to each other as illustrated.



Let;The current I, I2, I3 ... In flow in the resistor RI, R2 , R3 ....RN Respectively

I = 1, 12+13 .... IN

The potential different across each Resistor is the same.Suppose the P.D a cross the Resistor is V and equivalent Resistances R

Then

$I = I1 + I2 + I3$ ....IN

$V/R = V/RI + V/R2 + V/R3$ .... VN/RN

$V/V (I/R) = V/V (IR1 + 1/R2 + 1/R3$ ....I/RN)

Hence the reciprocal of the equivalent Resistance in parallel is equal to the sum of the reciprocals of the individual Resistors.

Example 2

Two resistor of 3Ω and 5Ω are connected in series and then in parallel. Find the equivalent resistance when they are in series and parallel.

Solution

Equivalent resistance in series, R

$R = RI + R2$

$R = (3\Omega + 5\Omega)$

$R = 8\Omega$

Equivalent Resistance in parallel, R

$I/R = I/R1 + I/R2$ ....I/RN

$I/R = I/3 + I/5$

$(I/R) = (5+3)/15$

$(I/R) = (8/15)$

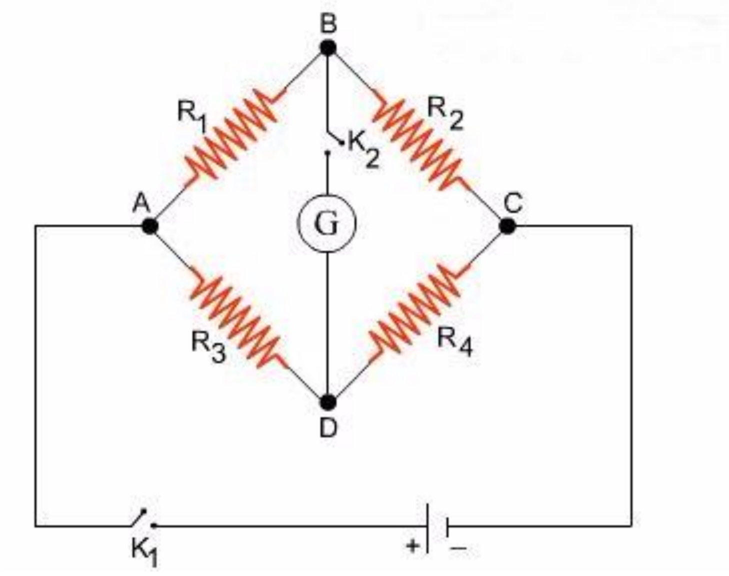
$R = (15/8)$

$r = 1.875\Omega$

The Mode of Action of a Wheatstone Bridge

Explain the mode of action of a Wheatstone bridge.

Wheat stone bridge is an electrical circuit . In wheat-stone bridge four resistance R_1, R_2, $R_3$and $R_4$are connected end to end with each other to form a closed loop. A sensitive galvanometer "G" is connected between their junctions as shown. The circuit is provided with two keys 'K_1' and 'K_2'. Generally wheat-stone bridge is used to determine unknown resistances.



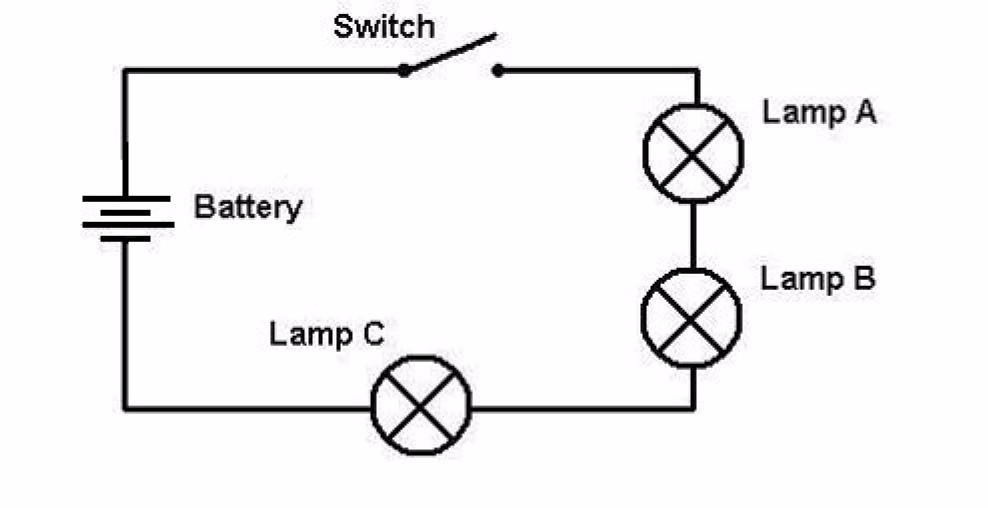
Simple Electric Circuit

Connect and analyse a simple electric circuit

A collection of devices such as resistors and sources in which terminals are connected together by connecting wires is called an *electric circuit.*These wires converge in *nodes*, and the devices are called *branches* of the circuit, as shown in figure below.

The general circuit problem is to find all currents and voltages in the branches of the circuit when the intensities of the sources are known. Such a problem is usually referred to as *circuit analysis.*

Remarks-- While the current in a resistor has a fixed relationship with the voltage across it, the current flowing in a voltage source, or the voltage across a current source, is theoretically unrestricted and can assume whatever value governed by the external circuit.

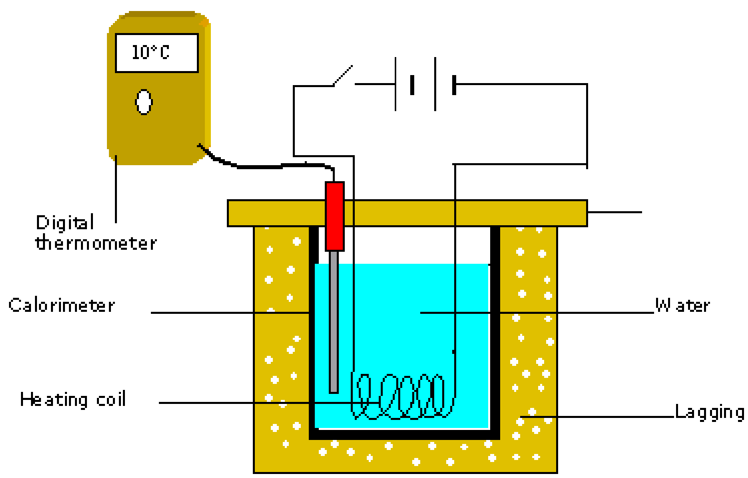


Effects of an Electric Current

The Mechanism of Heating by Electric Current

Explain the mechanism of heating by electric current

Electricity is the form of energy, and it can be demonstrated as follows:



When you close key K an electric current flows thought the wire resistor and the water heats up, showing that the electrical energy is being converted to heat. Suppose the increase in temperature of the water is Q. Then, the heat gained by the water is given by:

H = MCQ

Factors which determines the Quality of Heat Generated in a Conductor due to a Current

Describe factors which determine the quality of heat generated in a conductor due to a current

H is directly proportional to Q.

- Heat absorbed by the water is proportional to the increase in its temperature.
- The arrangement used in experiment can be also used to investigate how the heat (or temperature) varies with current and resistance of the wire.
- H is directly proportional to Q.
- Heat is directly proportional to the temperature.
- H is directly proportional to $I^{2.}$
- Also Heat is directly proportional to the time (t).
- H is directly proportional to t.
- Also Heat is directly proportional to the Resistance, R.
- H is directly proportional to R.

When we combine the equations, wefind that

H is proportional to I^2Rt

Hence

- $H = KI^2Rt$
- $H = (IR)\ It$
- $V = IRH = VIt$
- $H = ItV$

By Ohm's law

- $I = (V/R)$

- $H = (V/R)(tV)$
- $H = V^2t/R$

SI Unit of energy is Joule (J).

Equation: $H = (V^2t)$ is joule's law of heating.

Joule is the work done when a change of one coulomb flows through a conductor with a potential difference (p.d) of 1 volt a cross it in one second.

Example 3

An electric Kettle has a wire of Resistance 5Ω. 1kg of water is to be heated from room temperature (300k) up to its boiling point (373k). Using the kettle, if we ignore the thermal capacity of the kettle, what current must flow in the resistance wire if the water is to be heated in 10 minutes?
(Specific Heat capacity of water = 4200J/Kgk)

Data Given

- Specific Heat capacity, C = 4200 J/Kgk
- Change in Temperature = (373 – 300) K=73K
- Mass of water, M = 1Kg
- Resistance of wire, R = 5Ω
- Time of the current to flow, t = 10min = 600s

Solution

The thermal energy Gained by water

H = MCQ

= (Ikg x 4200J/Kgk x 73K)

= 3.066 x 105 J

Electrical energy delivered by a current I flowing is

$H = I^2Rt$

$= 3 \times 10^3 I^2 J$

Thermal energy gained = Electrical energy delivered.

$$3.0 \times 10^3 I^2 = 3.066 \times 10^5$$

$$\sqrt{I^2} = \sqrt{\frac{3.066 \times 10^5}{3 \times 10^3}}$$

$$I = 10.1A$$

Electrical Power

Determine electrical power

Electrical power (P): Is the electrical energy delivered per Unit time taken to deliver the energy.

$$P = \frac{(\text{Electrical energy})}{\text{Time taken}}$$

$$P = \frac{(I^2Rt)}{t}$$

$$P = 1^2R$$

$$P = (IR)I$$

$$IR = V$$

$$P = VI$$

$$\boxed{P = IV}$$

Every electrical appliance should Cary a label starting with the potential difference for which it is designed and the power it can convert when operating at the stated potential difference.

Example 4

Calculate (a) the current taken and (b) the resistance of the plate of an electric iron rated 240v, 2000W.

(a) Since

$P = IV$

$I = (P/V)$

$I = \frac{(2000W)}{240V}$

$I = 8.33A$

Current Electricity, $I = 8.33A$

(b) Since

$P = V^2/R$

$R = V^2/P$

$R = (240)^2/2000$

$R = 28.8\ \Omega$

Resistance of wire, $R = 28.8\Omega$

The Power Rating of Electrical Appliances

Interpret the power rating of electrical appliances

The commercial Unit of Electrical energy is the Kilowatt – Hour, abbreviated as KWh.I Kwh is the energy supplied in one Hour by an appliance working at the rate of 1000 watts.

IKwh = 1000 W X I hour

= (1000 x 3600)

3.6×10^6J

Example 5

What is the cost of using an electric Iron rated 240V, 2000W for 10 Hours if the Electrical energy costs Tshs 100 per Unit (1 Unit = 1 Kwh).Total energy used for 10hrs = (2000W X 10hr). = 2000Wh=20Kwh

The cost of using the appliance

1Kwh = 100Tsh

20 Kwh = X

x = (20Kwh x 100Tsh)/IKwh

x = 2000 Tsh

The cost of using appliance = 2000Tsh

Electric Installation

The Meaning of the Letter E (Earthing) L (Live) and N (Neutral) in Electrical Wiring

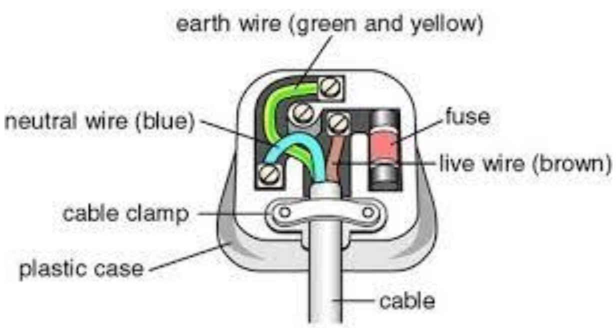
Explain the meaning of the letter E (Earthing) L (Live) and N (Neutral) in Electrical Wiring

Domestic Electricity:Is the form of electricity which is wired in the house.

LIVE WIRE (L): Is connected to one of the lower holes using a pin Brown / Red in colour.

NEUTRAL WIRE (N): Is connected to one of the lower holes using a pin is blue in colour.

EARTH (E): The upper hole is connected to the Earth wire with stripes of green and yellow lines or just green.



The Function of a Fuse and a Circuit Breaker

Describe the function of a fuse and a circuit breaker

Fuse is an electrical instrument which is composed of the thin wire of aluminum or copper insulated with rubber or plastic which melts when current exceeds its normal value. Fuse can also be described as a short piece of special wire which melts when more than a rated amount of current passes thought it.

Circuit Breakers:These are sensitive switches that turn off the current when there is a surge of current following a fault they can be reset simply by flicking the switch to the ‘on’ position.

Wiring on a Board

Perform wiring on a board

The plug; Is the device that is connected to the cable that supplies electricity to the appliance on one side and is pushed into a socket connected to the source of the mains electricity supply on the other.

Elecrical Faults in Domestic Appliances

Check and rectify electrical faults in domestic appliances

Most faults you will encounter are from a fairly simple cause. Sometimes these are easy to track down sometimes not. The key to success is to use a logical and systematic approach when trying to pinpoint the cause.

A good stating point is to get familiar with your consumer unit whether it is a fuse type or a circuit breaker type.

Identify what circuits you have and what they do:You'll probably have several lighting circuits, probably one on each floor and several socket circuits (ring circuits) one on each floor. Additionally you may have several circuits for individual applianceslike cookers, electric showers, alarms, out-door power, etc.

In the event of a fault you may find a fuse blows or a circuit breaker trips on one of these circuits. Clearly the problem is limited to that one circuit. You can try to reset the breaker or change the fuse. This may well solve the problem if it has been caused by a temporary overload.If the fuse blows again or the breaker trips you still have a fault and need to investigate that circuit.

Either, the circuit is drawing too much current(which could be the result of a faulty appliance or you've got too many appliances for the rating of that circuit),Or, there is a short circuit which means somewhere you have a live wire touching something it shouldn't, which will be due to one of several possible causes.

Appliances not working?

1. Try them in another socket.

2. Check the fuse in the plug (see using a continuity checker).

3. If other appliances works on the socket and you've checked the fuse then the appliance is broken! Replace it or try and get it repaired by a specialist.

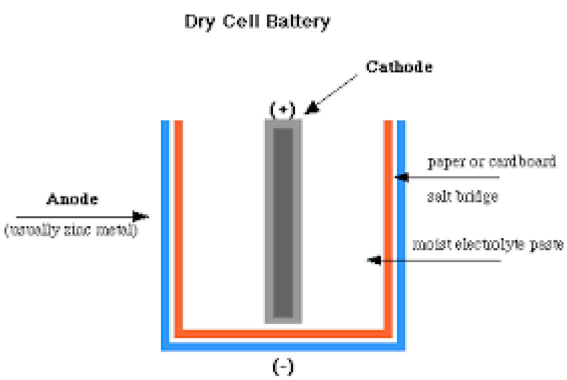
Cells

Simple cellis the cell consists of copper and zinc cathode with dilute sulphuric acid as Electrolyte.

The Mode of Action of a Dry Cell (Leclanche)

Describe the mode of action of a dry cell (Leclanche)

Action of simple cells;



a. **At cathode:** The zinc plate dissolves in the sulphuric acid solution and liberates electrons into the external circuit. The metal discus had to be of different material Volta used copper and zinc discs sand witched by cloth soaked in salt water. The combined device was called a voltaic pile. Volta also obtained the same effects by using copper and zinc plates dipped in dilute sulphunic acid. Volta called these devices, arranged in series. The " Crown of cups" zn - 2e - Zn 2+ The 2n $^{2+}$ ions go into solution.

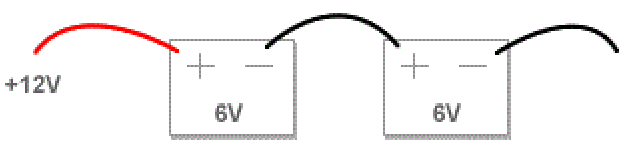
b. **At anode:** Positively charged hydrogen lons (H+) are attracted towards the negatively charged copper plate2H $^{+}$ + 2e ----- H_2.The chemical reaction in the cell creates a potential different between plates, causing electrons to flow when the two plates are joined with a wire. The electrons flow is maintained by the chemical change that occurs when the zinc dissolves in the sulphuric acid. Since simple cell, which is able to adrive an electric current through a circuit, is said to be a source of electromotive force (e.m.f)

Voltage of Combination of Cells in Series and Parallel

Determine voltage of combination of cells in series and parallel

Connecting in Series

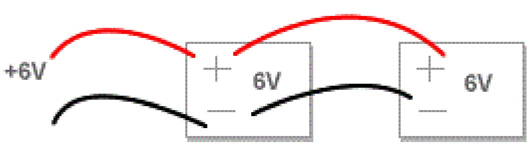
When connecting your batteries in Series you are doubling the voltage while maintaining the same capacity rating (amp hours). This might be used in a scooter, Power Wheels kids vehicle, or other applications. Just use a jumper wire between the negative of the first battery and the positive of the second battery. Run your negative wire off of the open connector from the first battery and your positive off of the open connector on your second battery.



Connecting in series (double voltage, same capacity [ah]

Connecting in parallel

When connecting cells in parallel, you are doubling the capacity (amp hours) of the battery while maintaining the voltage of one of the individual batteries. This would be used in applications such as laptop batteries, some scooters, some ups backups, etc. Use a jumper wire between the positives of both batteries and another jumper wire between the negatives of both batteries. Connect your positive and negative wires to the same battery to run to your application.



Connecting in parallel (double voltage, same capacity [ah]

The Cell Defects

Identify the cell defects

Simple Have two main defects which cause the current to diminish quickly when the cell is being used.

Two defects of simple cell are:

a. Polarisation

b. Local Action

Polarisation

Polarisation is the defect occurs in simple cell caused by the formation of hydrogen bubbles around the copper plate.These bubbles insulate the copper plate and prevent other positive hydrogen ions from receiving electrons from the copper plate to become neutral.

Also hydrogen ions accumulating at the copper plate repels other Hydrogen ions (This defect is called Back e.m.f and opposes or weakens the main e.m.f of the cell).

How to minimize polarisation

- Polarisation can be minimised by using suitable oxidising agents, called depolarisers, to remove the hydrogen. An example of depolarisers for hydrogen is potassium dichromate. The dichromate oxidizes the hydrogen to form water.

Local Action

Local action is the process by which a cell is used up when no external current is flowing.Commercial zinc normally contains atoms of Iron, lead, carbon, etc called impurities.

When commercially zinc is used in a simple cell, bubbles of hydrogen are seen escaping from the zinc plate (evidence of local Action).The Impurities on the surface of the Zinc act as a second plate of a cell. As a result, Zinc dissolves in the acid even when the cell is not in use (This process wastes the zinc)

How to minimize local action

The problem of local action can be overcome by using amalgamated zinc plate (zinc coated with mercury).

Pure zinc in mercury form zinc amalgam. This is done by rubbing some mercury on the zinc plate.

The leclanche cell: Is the cell uses an aqueous solution of ammonium chloride (sal ammoniac) as the electrolyte, amalgamated zinc rod as cathode. The carbon rod as anode fixed in a porous pot, containing a powdered mixture of carbon and manganese (iv) oxide.

The carbon makes the mixture more conducting, and the manganese (IV) oxide (manganese dioxide,MnO_2) acts as a depolarizer.

The Dry cell

Is a modified leclanche cell in which the main electrolyte is a paste of starch and ammonium chloride. The action of the cell is similar to that of the wet leclanche cell.

The paste is prevented from drying by sealing the top of cell with some insulating materials. This type of cell gives a larger current and have a shorter recovery (demoralising time) than the 'wet' type;

Hence it is useful for a greater variety of applications.However, Local action cannot be eliminated completely in these cells, so that the cells have a storage (or shelf) life ranging from a few months to up to several years if stored in a cool place

The leclanche cell is called a primary cell and this type of cell current is produced from a non recoverable or irreversible chemical reaction.

Example:When all the zinc has been dissolved in the simple cell it can never be recovered to its original form by passing a current thought the cell in the opposite direction.

Secondary cell

This is the cell which can be recharged after it hasrun down (used). This is done by passing a d.c current from a dynamo or similar device through the cell in the opposite direction to that in which the cell usually supplies current in an external circuit.

Also called storage cells or accumulator some common accumulators are:

1. Lead Acid accumulators
2. Nickel – Cadmium accumulators
3. Alkaline and chloride accumulators

The main advantage of this type of cell is that it has a very low internal resistance and can therefore give a large current with very little drop in the terminal potential difference.

The Mode of Action of Lead-acid accumulator

Describe the mode of action of lead-acid accumulator

The lead – acid accumulator cell consists of two plates of lead immersed in sulphuric acid.The acid is in a plastic container.Two or more cells may be connected to forms battery

The positive terminal is lead (iv) oxide and the negative terminal is lead.

Wood / rubber/ separator/Insulator

Cathode electrode: Lead plate (–)

Anode Electrode:lead (iv) oxide (+)

Before the accumulator is use it has to be charged

The Charging and Discharging Phenomenon of an Accumulator

Explain the charging and discharging phenomenon of an accumulator

Charging is done by connecting across its plates as source of direct current. If the current of 2A may be allowed to flow across the terminal of the cell. The positive terminals of the cell and the source of current (dynamo) must be connected together similar the negative terminal must be connected together.

If the cell is now fully charged the p.d across its terminals on open circuit is 2v, and the cell is ready for use.It can light says a2v electric lamp connected across its terminals. The currents will flow in the reverse direction to the charging current.

Discharging Accumulator

- Is the process of using charges stored in the lead – Acid Accumulator.
- When the accumulator is discharged after long use both plate become coated with lead sulphate.
- The relative density (R.D) of Acid also become less and the P.d of cell falls.
- Recharging will restore the plate of lead (iv) oxide and lead, and the relative density of acid will rise to 1.25
- The accumulator must not allowed to discharge below the stated values of p.d and Relative density, or it will not be possible to recover it on recharging.
- The capacity of an accumulator is the amount of current in amperes that the cell can send thought a circuit is measured in ampere – Hour (Ah)
- The charging rate an Accumulator is a current in amperes, numerically equal to one – tenth (1/10) of the capacity required in Recharging.
- Lead-acid accumulators have high e.m.f (2v per cell) and allow internal Resistance.
- Accumulators are best cared for by a regular check of the level of the sulphuric acid.
- Any loss due to evaporation must be replenished with distilled water only.
- No acid should be added unless there has been same spillage from the cell.
- Accumulators must be recharged regularly using the charging current recommended by the manufactures.
- They should not left in discharged condition for a long time.
- When not in use they should be recharged at least once every month.
- An accumulator should never be short-circuited.
- Shorting the cell may cause swelling and buckling of the plates due to excessive heat developed in the cell, leading to permanent damage (A cell in this condition is said to be sulphated).

Cells and Accumulators in Daily Life

Use cells and accumulators in daily life

Uses of electric cells

- Electric cells are very useful when no mains supply of electricity is available or when connecting to a main supply of electricity would be inconvenient.
- Portable radios, torches, calculators and watches are example of devices that use primary cells.
- It is possible to buy rechargeable batteries for these devices.These are secondary cells to start the engine and to run all the electrical circuits.
- This cell is recharged by the alternator when the car is in use.