SCHEME OF WORK SS2 SECOND TERM[

WK	TOPIC	CONTENT
1.	Sound waves	(i) Source of sound (ii) Transmission of sound (iii) Speed of sound in solid, liquid and gas.
2.	Sound waves	(i) Noise and music (ii) Force vibration and resonance (iii) Harmonics and overtones (iv) Stationary waves.
3. `	Application of sound waves	(i) Vibrations in strings and pipes (ii) Wind instrument (iii) Stringments (iv) Percussion instruments (v) Echoes and application (vi) Hearing aids
4.	Molecular theory of matter	Pressure in Fluids (i) Concept of pressure (ii) Pressure in liquids (iii) Atmospheric pressure (iv) Application of pressure and gas pressure (v) Pascal's Principle
5.	Electromagnetic Waves	Electromagnetic Spectrum
6.	Gravitational Force between two mass.	(i) Newton's law of gravitation (ii) "G" as Universal Constant (iii) Gravitational Potential (iv) Escape Velocity
7.	Gravitational Field	(i) Solar System (ii) Kepler's law (iii) Natural and artificial satellite
8.	Electric Fields	(i) Production of continuous charges – primary and secondary cells (ii) Electric Circuit: Series and parallel arrangement of cells and resistors
9.	Electric Fields	E.M.F of a Cell (i) Internal resistance of a cell (ii) Standard rheostats (iii) Resistivity and Conductivity
10.	Electric Fields	(i) Shunt and multipliers (Galvanometer conversion) (ii) Principles of the potentiometer (iii) Meter bridge

Week 1

SOUND WAVES

Definition

Sound can be defined as a wave motion which is conveyed through an elastic medium from a vibrating body to a listener. It is produced by vibrating bodies.

Transmission of Sounds

Any medium which has particles that can vibrate will transmit sound, but the nature of the medium will affect the speed of sound waves. In general, the speed of sound in liquid is five times that in gas, the speed of sound in solid is about fifteen times that in gases.

NB: Gases, liquids and sold can all transmit sound waves but a vacuum cannot.

The table below shows a typical speed of sound waves in different media.

Media	Approximate speed of sound (m/s)
Air	300m/s
Water	1500m/s
Iron	5000m/s

/

Characteristics of Sound

A musical note is a sound which originates from a source which is vibrating at certain frequencies.

A musical note possesses three characteristics which are **pitch, loudness** and **quality.**

(i) Pitch: the pitch of a musical note is its position on the musical scale. It is a characteristic of a note which enable one to differentiate high note from a low note. On a piano keyboard, the right-hand side keys produce note of high pitch while the left-hand side keys produce note of low pitch. Pitch depends on the frequency of the sound wave.

(ii) Loudness: Loudness is the magnitude of the sensation resulting from a sound reaching the ear. it depends on the intensity of the sound wave reaching the listener’s ear. It also depends on the square of the amplitude of the sound waves. A soft sound has a small amplitude but a loud sound has a large amplitude.

(iii) Quality or tone (Timbre): Quality is a characteristic of a musical note which distinguished it from another note of the same pitch and loudness produced by another instrument. The quality of a note depends on the overtones present in the note. Overtones haves to do with multiples of the fundamental frequency.

Week 2

Sound waves (Noise and music)

The difference between noise and music lies in the frequency of the sound waves (which is the physical quality associated with pitch)

Music is produced by vibration of regular frequencies while **noise** is produced by vibration of irregular frequencies. Common sources of noise include traffic, market places, amusement parks, exhibitions and construction sites.

Force Vibration and Resonance

Forced Vibration: This is a vibration that results from external periodic force acting on a system and setting the system vibrating at the same frequency as to the external periodic force. An example of force vibration is presented when a vibrating turning forks is placed in contact with the table top. The sound is observed to become louder because the vibrating fork forces a larger surface (the table top) to vibrate, setting in motion a greater mass of air in contact with it. Other examples of forced vibrations are:

(i) the vibration of the cone of a louder speaker caused by the fluctuations in the current flowing through the adjoining voice coil.

(ii) the vibrations of the diaphragm of a telephone, microphone or transmitter cause by the sound waves impinging on it

(iii) the vibrating body of a violin caused by the vibrations of the strings of the instrument.

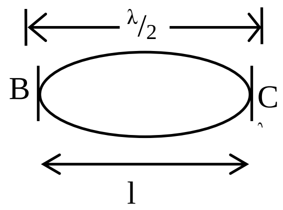
Resonance

Resonance: This is the phenomenon which occurs whenever a particular body or system is set into oscillation at its own natural frequency as a result of impulses or signals received from some other system or body which is vibrating with the same frequency. Resonance finds its application in the tuning of a radio set to a broadcasting station.

Harmonics and Overtones

The Lowest frequency obtained from a plucked string when the string vibrates in one loop is called the "fundamental frequency (f_o). Higher frequencies which are the integral or whole number multiples of fundamental frequency can be produced in the string. These are called the harmonic or overtones of the fundamental e.g. $2f_o$, $3f_o$, $4f_o$, etc.

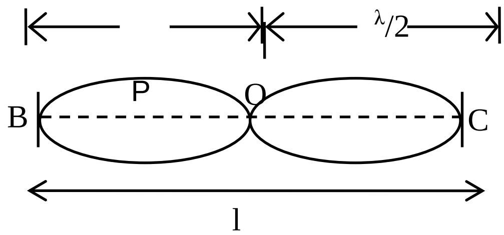
NB: F_o is the first harmonic
$F_1 = 2F_o$ is the second harmonic or 1st overtones
$F_2 = 3F_o$ is the third harmonic or 2nd overtones



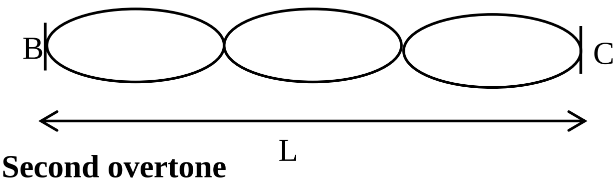
$l = {}^{\lambda}/_{2}$

$\lambda = 2l$

In the above diagram, a stretched wire or string is fixed at both ends B and C. To obtain the harmonic, we damp or touch the wire tightly with a finger at the center, 'O', and simultaneously pluck the wire at a point P such that BP = ¼ x L where 'L' is the length of the wire. The wire vibrates in two loops or segment as shown below



There are now three nodes (i.e. points that do not vibrate) at B, C, and O, and two antinodes (points of maximum displacement) at P and Q. since BO=OC = ${}^{\lambda}/_{2}$, we have that $L = {}^{\lambda}/_{2} + {}^{\lambda}/_{2} = \lambda$
The note produced in this mode is called the first overtone or second harmonic and the frequency, $F_1 = {}^{V}/_{\lambda} = {}^{V}/_{L}$
This is a higher note than the fundamental note.
The wire can be made to vibrate in three loops as shown below:



Second overtone

This produces the next higher note called the second overtone or 3rd harmonic as shown in the diagram above.

$L = {}^{3\lambda}/_{2}$ and from $V=f\lambda$, we have $F_2 = {}^{3V}/_{2L}$.

Thus, $F_0 = {}^{V}/_{2L}$, fundamental frequency or 1st harmonic or 2nd overtone and so on. The fundamental frequency is the lowest frequency but the strongest audible frequency. The overtones are higher frequencies but are quieter or softer than the fundamental waves.

Stationary waves

This is a wave that is produced when two waves with the same frequency, amplitude travelling in opposite directions are superposed.

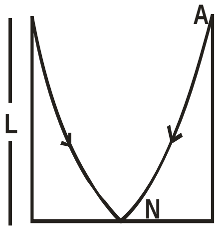
Nodes are points on a stationary wave which are at rest while antinodes are points where the amplitude of vibration is maximum.

Week 3

Sound waves (vibrations in strings and pipes)

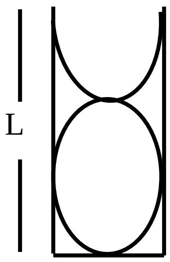
Closed Pipe

The simplest mode of vibration in a close pipe is shown in the diagrams below.



$\lambda = 4L$ (since $L = \lambda/4$)

Fundamental note (f_0 = first harmonic)



First overtone

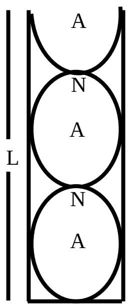
$L = 3\lambda/4$, $\therefore$ $\lambda = 4L/3$

$f_0 = V/\lambda = V/4L$ First overtone (2nd harmonic = $3f_0 = f_1$)

$V = f_1\lambda$. But $\lambda = 4L/3$

$f_1 = 3V/4L$ But $V/4L = f_0$

$\therefore$ fi=$3f_0$(3v/4L)



2nd Overtone

$L = 5\lambda/4$ $\lambda = 4L/5$

Fundamental frequency = f_0

The distance between the node and antinode is =$\lambda/4$

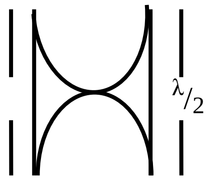
$F_2 = 5v/4L$ But $v/4L = F_0$

$F_2 = 5F_0\ (5v/4L)$ = 2nd overtone

It can be generally concluded that in closed pipes, only odd number of harmonics are present as overtones accompanying the fundamental notes. Therefore, the possible harmonics of a closed pipe are: f_0 $3f_0$, $5f_0$, $7f_0$ etc.

Opening Pipe

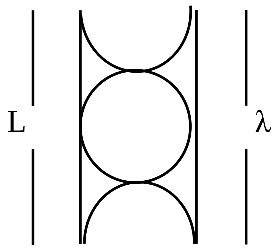
In open pipes, antinodes are observed at both ends while the length, $L = \lambda/2$. it therefore, follows that the frequency f_0 is i.e $f_0 = V/\lambda = V/2L$



$L = \lambda/2$ i.e $\lambda = 2L$

$F_0 = V/2L = V/\lambda$ (since $\lambda = 2L$)

Fundamental note (f_0 = 1st harmonic)



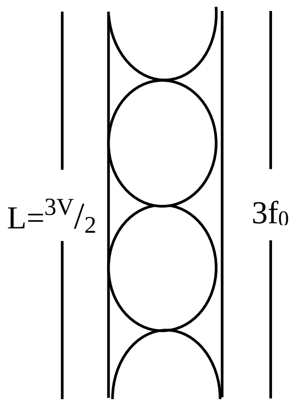
1st overtone

$f_1 = V/\lambda$ But $\lambda = L$

$f_1 = V/L = 2V/2L$

$f_1 = 2V/2L$, But $V/2L = f_0$

$f_1 = 2f_0\ (2V/2L)$



$L = \lambda/2$ i.e $\lambda = 2L$

$L = 3\lambda/2$, $\lambda = 2L/3$

$f_2 = V/\lambda = V/2L = 3V/2L$

But $V/2L = f_0$

$\therefore f_2 = 3f_0 = 3V/2L$

second overtone =3rd harmonic

It can be generally concluded that in an open pipe both odd and even harmonics are present as overtones. Example f_0, $2f_0$, $3f_0$, $4f_0$ etc.

Calculation

A pipe closed at one end has a length of 10cm. If the velocity in air of the pipe is 340m/s, calculate (a) the fundamental (b) the first overtone (c) Give reasons why the frequency of the fundamental may alter during the day.

Solution

V = 340m/s, L = 10cm = 0.1m

(a) $F_o = {}^{V}/_{4L} = {}^{340}/_{4 \times 0.1}$ = 850Hz

(b) $F_1 = 3F_o$ = 3 x 850 = 2550Hz

(c) If the temperature of the day changes, the velocity of sound 'V' changes since 'V' depends on the air temperature. So the frequency (f), which is ${}^{V}/_{\lambda}$, will change.

Musical Instrument

Musical instruments can be classified as follows: string instruments, wind instruments, percussion instruments.

Wind Instrument: These are instruments that produce sound because of vibrating air column. Examples are trumpets, pipe organ, clarinets, saxophones etc. In this instrument, a short column of air produces a high pitch note and a long column of air produces a low pitched note.

String Instruments: Examples of these instruments are the piano, the sonometer, the violin and the guitar. In this instrument, the frequency of the vibrating string depends on the length l, tension T, mass per unit length M, i.e. F = $½_L\sqrt{{}^{T}/_{M}}$.

A long thick and loose wire or string produces a low frequency note but a short, thin and taut string produces a high frequency note. The overtone of a stretched string are $2F_o$, $3F_o$, $4F_o$, etc.

Calculation

A metal wire of mass 1g and length 50cm is under tension of 80N. Compute (a) the fundamental frequency, (b) the first and second overtone (c) the speed of a transverse wave in the string.

Solution

(a) $F_o = ½_L\sqrt{{}^{T}/_{M}}$

L = 50cm = 0.5m, T = 80N, Mass = 1g = 0.001kg,

m = $\frac{0.001}{0.5}$ = 0.002kg/m

$F_o = \frac{1}{2(0.5)}\sqrt{\frac{80}{0.002}}$ = 200Hz

∴ F_o = 200Hz

(b) F_1 = 1st overtone = $2F_o$ = 2 x 200 = 400H

F_2 = 2nd overtone = $3F_o$ = 3 x 200 = 600Hz

(c) From V = Fλ

λ = 2L for open pipe or string

Thus, V = 2FL = 2 x 0.5 x 200 = 200m/s

Percussion Instrument: Percussion instrument produces sound when struck. The note produced is usually of short duration. Example of percussion instrument are the talking drums, bell, gong, xylophone, turning fork, etc.

Echoes

A sound head after the reflection of sound waves from a plane surface is called echo. An echo can sometimes be a nuisance but in other cases, echoes are very useful and have important applications.

Application of Echo

(1) **Determination of the depth of sea:** Echoes are used in the determination of the depth of a sea. If the depth of a sea is denoted by 'd', and 'v' is the speed while 't' is the time taken. Since the wave is reflected back after striking the sea bed, the distance is twice and it is given by d = ${}^{Vt}/_{2}$.

(2) **Determination of speed of sound in air:** Echo is used in the determination of speed of sound in air. By directing a sound signal to a wall and measuring the time taken by the echo produced to reach us. The speed of the sound is given by V = ${}^{2d}/_{t}$.

(3) **Exploration of Oil and Gas:** Echo is used in oil and gas exploration.

Calculation

A man standing 99m from the foot of a high cliff claps his hand and hears the echo in 0.60s later. Calculate the speed of the sound waves.

Solution

v=? d=99m t=0.65 v=2d/t

$$v = \frac{2x99}{0.6} = 330ml$$

Hearing Aids

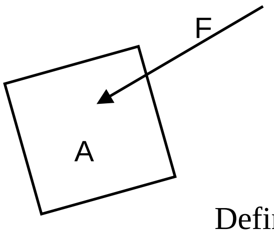
Hearing aids are used to compensate for hearing loss (as in case of the elderly). Hearing aids work by amplifying the sound entering the ear such that they can be heard by the wearer. Hearing aids usually consists of a microphone, an amplifier, a receiver (or speaker) and a battery. The battery is used to power the hearing aids. The microphones receives the sound waves from the environment and convert them into electrical signals which then passes into the amplifier. The amplifier amplifies the signals. The amplified electrical signals enter the receiver or speaker, which then, converts them into sound waves that are loud (than those received from the environment). In this way, the wearer of the hearing aids is able to hear sounds that would otherwise be inaudible.

Different types of hearing aids are used for different types of hearing loss.

Week 4

Pressure in Fluid

Suppose we apply a force “f” perpendicularly on an area “A” of a wall as shown below, we say that a pressure “P” is exerted on the will by a force “F”



Definition:

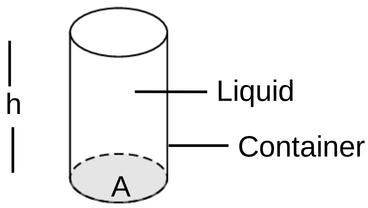
Pressure is defined as perpendicularly force per unit area acting on a surface. Symbolically, P=F/A. It is measured in Newton per meter square (N/M^2). Another unit of pressure is Pascal.

NB: 1 N/M^2 = 1 Pascal. A third unit of pressure is “bar”
1 bar = 10^5 NM^{-2} = 10^5 Pa

Pressure is a scalar quantity.

Pressure In Liquids

The pressure due to liquid is called hydrostatic pressure



Consider an area A of a liquid at a depth “h” below the surface of the liquid. The pressure at that level is due to the weight (force) of water above it. i.e P= Weight/Area

But weight = Mg and Area = A ………….(i)
P = mg/A – (ii)

Multiplying (i) by h, we have

P = mgh/Ah $^{-(2)}$ = mgh/v (volume = Area x height)

P = mgh/v = m/v

But m/v = ρ (density)

p = ρgh

Pressure in a liquid can be calculate using the above formula where ρ is density of liquid in kg/m^3

‘g’ is acceleration due to gravity in m/s^2 and h is the depth of the weight of water below the water level.

Characteristics of liquid pressure:

(i) The pressure of liquid increases with depth.

(ii) The pressure is the same at the same level and acts in all direction

(iii) At a particular depth pressure increase when the density of the liquid increase.

Atmosphere Pressure:

This is the pressure due to the atmosphere or air pressure. Using mercury, one atmosphere can support a height of 0.76m or 76cm or 760cm of mercury at sea level.The instrument for measuring atmosphere pressure is the barometer. We have simple barometer and aneroid barometer.

Gas pressure:

This is the pressure that arises from any gaseous substance. The instrument used for measuring gas pressure is called manometer.

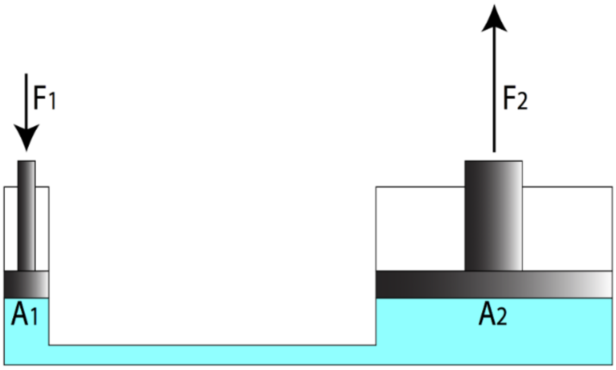
Pascal Principles

Pascal principles deal with transmission of pressure in fluids. This principles states that the pressure applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and the containing vessels.
Thus, when we apply an air pressure at a point in a bicycle tyre, the pressure in the tyre is increased equally at every other point along the tyre.

Application of Pascal Principles

it has its application in (i) car breaking system (ii) hydraulic press

Hydraulic Press

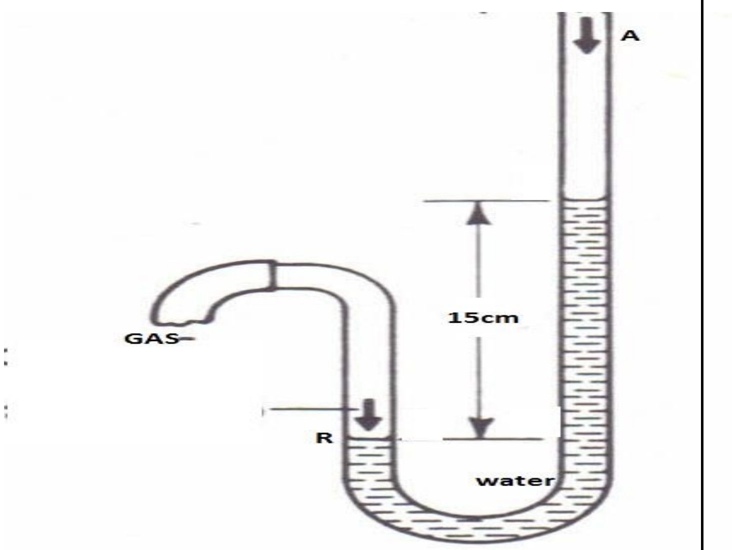


From Pascal Principles

$\frac{F1}{A1} = \frac{F2}{A2}$ i.e. $P_1 = P_2$ where $P_1 = F_1/A_1$ and

$P_2 = F_2/A_2$

Calculation



1

(a) Calculate the gas pressure of the given diagram if atmosphere is 760 monthly
(b) What is the difference in atmospheric pressure and gas pressure?

2. Calculate the pressure in a water at a depth of 5m if density of water is $1000kg/m^3$ ($g = 9\text{-}8m/s^2$) ($Pw = 1000kg/m^5$)

3. A pressure of 1.013 x 105 Pa using mercury will support a height of? ($\rho_m = 13600kg/m^3$, $g = 9.8m/s^2$).

(4) A hydraulic press has a large circular piston of radius 0.4m and a circular plunger of radius 0.05m. A force of 100N is exerted by the plunger. Find the force exerted on the piston.

Solution

Gas pressure at R = A+h

(1a)

A = 760mmhg
H = 15cm of water.
Converting cm of water to cm of mercury,

$\frac{\rho w}{\rho m} = \frac{h\ of\ mecury}{h\ of\ water}$

$\frac{1}{13.6} = \frac{h}{15}$

Length = 15/13.6

= 1.1029cm of Hg
= 11.03mm Hg

R = 760 + 11.03
= 771.03mmHg

(1b)

R = A + h

h = R – A

h = 771.03 – 760

h= 11.03mmHg

(2)

P = ρgh

$\rho = 1000kg/m^3$

$G = 9.8m/s^2$, h = 5m

P = 1000 x 98 x 5

= 49,000 Pa

= 49Kpa

(3)

$P = 1.013 \times 10^5 Pa$

= 101300Pa

$\rho m = 13600kg/m^3$

$g = 9.8m/s^2$, h =?

P = ρgh

$h = {}^{P}/_{\rho g}$

$h = \frac{101300}{9.8 \ x \ 13600}$

h = 0.7600mHg

h = 760mmthg

(4)

$\frac{F1}{A1} = \frac{F2}{A2}$ $r_2 = 0.05m$ $r_1 = 0.4m$

$F_1 = 100N$, F2 = ?

$A^2 = \pi r^2 = \frac{22}{7}(0.05)^2 = 0.00786m^2$ $A1 = \pi r^2 = \frac{22}{7}(0.4)^2 = 0.50286$

$F_1 = \frac{F2A1}{A2} = \frac{100 \ x \ 0.00786}{0.50286}$

$F_2 = \frac{F1A2}{A1} = \frac{100 \ x \ 0.50286}{0.00786} = 639.8N$

∴ 639.8N

Week 5

Electromagnetic Spectrum

There are two classes of waves. These are mechanical and electromagnetic waves. **Mechanical** waves are waves that requires material medium for their propagation. Examples are sound waves, water waves and waves on a rope.

Electromagnetic waves are waves that do not require material medium for their propagation. They arise from the vibration of electrical "E" and magnetic "M" field. The combination if electric field waves and magnetic field waves are called electromagnetic {E-M} waves. They vibrate at right angel to each other.

Differences

Mechanical waves differs from electromagnetic waves from the point of view that they require material medium and travel at a speed below that of light but electromagnetic waves required not material medium and travel at the speed of light i.e. $c = 3.0 \times 10^8$m/s. In addition mechanical waves can be transverse or longitudinal but electromagnetic waves is a transverse waves.

Types of Electromagnetic Waves

There are different types of radiation and each radiation has a different wave length and frequency. Examples of electromagnetic radiations are radio waves, infra-red rays, visible light, ultra-violet rays, x-rays and gamma rays. Since all electromagnetic waves travelled at the speed of light, they are related in terms of speed of light, C, the wavelength, λ and frequency f, of radiation by the equation $C = f\lambda$,

Where C is velocity in m/s
f is frequency in Hertz (Hz)
λ is wavelength in metre (m).

Electromagnetic Spectrum

The arrangement of electromagnetic waves in order of decreasing wavelengths and increasing frequency or vice-versa is known as electromagnetic spectrum.

Wavelength (λ)	**Radiation**	**Detected by**
$10^5 – 10^{-5}$m	Radio Waves	Radio receiving circuit
10^{-6}m	Infra-red	Thermocouple
1.2×10^{-7}m – 3.8×10^{-7}m	Visible light	Eye
3.8×10^{-2} – 10^{-8}m	Ultra-violet	
10^{-8}m	x-ray	
10-^{11}m	Gamma rays	

Uses of Electromagnetic Waves

(i) Radio waves are used in radio transmission and radar.

(ii) Visible light makes object visible and also provide radiant energy

(iii) Ultra-violet rays are used in fluorescent light

(iv) X-rays are used in the study of crystals, the structure and properties of atoms and molecules and the arrangement in matter. X-rays are used in the hospital to make x-rays pictures or radiograph of bones and internal organs of the body. X-rays are used in airports as scanners to detect concealed weapons in luggage's. It is also used to detect flaws in various kinds of material used in heavy industries.

(v) Gamma rays are used in medical field to sterilize surgical equipment, bandages, drugs. It is also used in the treatment of cancer due to their penetrating power (100 times greater than that of x-rays).

Week 6

Gravitational Field

Definition of Gravitational Field

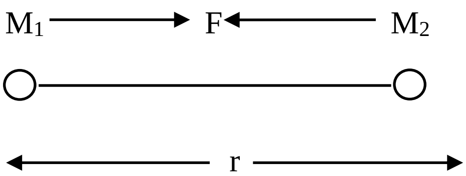
Force fields are forces whose source do not require contact with the body they affects.
A field is a concept used in physics to explain or describe the region, space or area where the effect of an object is felt or experienced by another object. We have gravitational, electric and magnetic field.

Gravitational field is a region or space around a mass in which the gravitational force of the mass can be felt. Gravitational force is the force of attraction exerted by a body on another body in the universe.

Universal Law

Sir Isaac Newton proposed a Universal Law. This law states that the gravitational force of attraction between two masses M_1 and M_2 is directly proportional to the product of the two masses and inversely proportional to the square of their distance apart.

Mathematically $F – m_1m_2/r^2$ – $F= \frac{GM1M2}{r2}$



Where F is force in Newton.

M_1 and M_2 are masses in kilogram (kg) r is the distance of separation in metre (m), G is gravitational constant in Nm^2/kg^2 and its value is $6.67x10^{-11}$ Nm^2/kg^2

Gravitational Field Strength or Intensity (G)

Gravitational field strength or intensity (g) at any point is defined as force per kilogram at that point. Recall that F=mg – (1) from (1) above, g = f/m, which is force kilogram mass. Hence ‘g’ is the gravitational field strength.

<u>Relationship Between Universal constant (G) and Gravitational field strength (g).</u>

The gravitational force of attraction of the earth on any mass on the earth’s surface is given by $F=GMm/r^2$
Recall that force of gravity or weight of a body is given by F=Mg, thus $F= \frac{GMm}{r2}$ = mg
The force per unit mass is given by i.e. $g = GM/r^2$ = F/m

Hence,

$$g = GM/r^2$$

From the above equation, another unit for “g” is N/kg.

Gravitational Potential (V)

Point in any gravitational field possess gravitational potential. If free to move, a body will move from a point of higher potential to a point of lower potential.
Gravitational potential (v) is the work done in taking a unit mass or 1kg from infinity to that point. It is a scalar quantity. It has a unit of 1kg.

Mathematically

$$v = - Gm/r$$

Calculation

(i) Calculate the gravitational force of attraction between the earth and a mass of 5kg on the surface of the earth.
(ii) Show that the result obtained is the same using f=mg (take mass of earth = 6.0x10-11 Nm^2/kg^2)

Solution

(i)

$F = GMm/r^2$

$G = 6.7 \times 10^{-11}$ Nm^2/kg^2

$M = 6.0 \times 10^{24}kg$

m = 5kg

r = 6.4×10^6m

F = $\frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 5}{(6.4 \times 10^6)^2}$

F = 49.07N = 49N

(ii)

Recall that F = mg

m = 5kg

g = $9.8m/s^2$

f = 5 x 9.8

= 49N

Hence,

F = GMm/r^2 = mg

2) Determine the mass of the earth if the radius of the earth is approximately 6.38×10^6m,

G = 6.67×10^{-11} Nm^2/kg^2 and g = $9.8m/s^2$

Solution

g = GM/r^2

M = gr^2/G

M = $\frac{9.8 \times (6.38 \times 10^6)^2}{6.64 \times 10^{-11}}$ = 5.98×10^{24}kg

3) Find the gravitational potential of a point on the earth's surface. (Take mass of earth as 5.98×10^{24}kg, its radius as 6.38×10^6m)

G = 6.67×10^{-11} Nm^2/kg^2

Solution

V = Gm/R = $\frac{6.64 \times 10^{-11} \times 5.558 \times 10^{24}}{6.38 \times 10^6}$

greater than 11km/s.

Escape Velocity

Any object thrown up comes down quickly to the earth. But there is a certain velocity upon which an object or body will be projected upward and it will never come down that velocity is called escape velocity.

Escape velocity is the minimum velocity required for an object (e.g. satellite or rocket) to just escape or leave the gravitational influence or field of an astronomical body (e.g. the earth) permanently.

The work-done in carrying a mass from a point at a distance r from the center of the earth to a distance is so great that the gravitational field is negligibly weak and is given by

W = f x r = $\frac{M_{eM}}{r^2}$ x r = $\frac{GMeM}{r}$

The work done = kinetic energy

$\frac{GMeM}{r}$ = ½ Mv^2

$^{2Me}/_{r} = v^2$

$^{2GMe}/_{r} = V^2$

But g = GMe/r^2

Or gr = $\frac{GMeM}{r}$

2gr = v^2

v=$\sqrt{2gr}$

Ve = $\sqrt{2gr}$

Thus

Ve is the velocity of escape

If we take g = $9.8m/s^2$ and the radius of the earth to be 6.4×10^6m, then,

Ve = $\sqrt{2 \, x \, 9.8 \, x \, 6.4 \, x \, 106}$ = 11 x 10^3 m/s or 11km/s

this means that for an object to escape the gravitational influence, it must be projected with a velocity

Week 7

Gravitational Field

Definition of Solar System

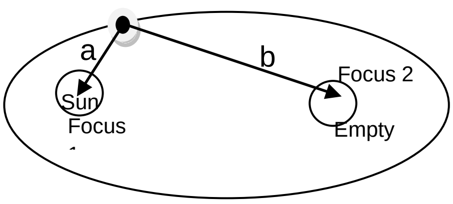
The sun and eight planets constitute our solar system. The planet revolved round the sun in elliptical or near-circular orbits. These planets are held in their respective orbits by the gravitational force exerted by the sun. The gravitational force exerted on a planet is always directed towards the sun and the center of the planet's circular motion. This model of the solar system and planetary motion was developed after many years of research and hypotheses.

In the 2nd century, Ptolemy postulated that the earth was stationary and at the center of the universe. The other planets, the sun and the stars revolved round it in a perfectly circular orbit. This theory was known as Geocentric theory. It was later replaced by the Heliocentric theory of the universe devised by Nicolaus Copernicus in 1543. According to the Heliocentric theory, the earth and other planets revolved in a circular orbit round the sun.

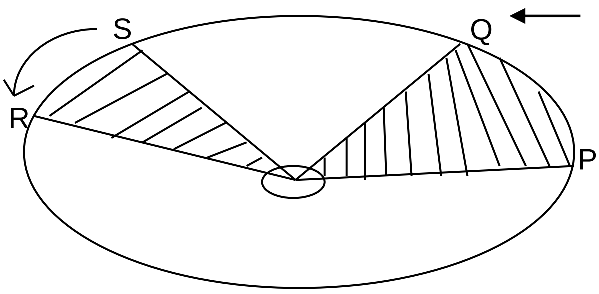
In the 17th century, a German astronomer, Johannes Kepler made use of Tycho's Brahe's (Danish astronomer) detailed observations of Mar's movement around the sun and discovered that the planet actually revolved in an elliptical orbit around the sun rather than a circular orbit. Kepler went on to formulate three empirical laws of planetary motion based on his and Brahe's observations. Isaac Newton later demonstrated that Kepler's law was a consequence of gravitational force that exist between two objects.

Kepler's Laws

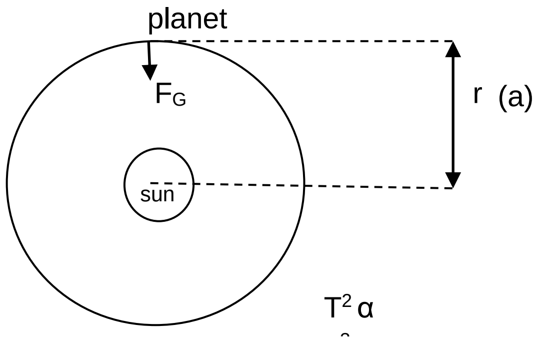
(i) First Law: This states that the orbit of a planet is an ellipse with the sun at one focus of the ellipse. This law is also known as the law of ellipse.



(ii) 2nd Law: This law states that an imaginary line drawn from the center of the planet to that of the sun sweeps areas in equal interval of time.



(iii) 3rd Law: This states that the square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbits. The orbital period of a planet is the time it takes the planet to revolve round the sun. The semi-major axis of a planet is the distance from the center of its elliptical orbit, through one focus, to the ellipse. It is comparable to the radius of a circular orbit.



Kepler's third law is known as the law of Harmonics.

Also, $T^2 = \frac{4\pi^2}{GM_{sun}} r^3$

Where G is gravitational constant;

M_{sun} is mass of the sun.

r is radius of the elliptical orbit or the semi major axis of the elliptical orbit.

T is period of the planet.

Geostationary Orbits

A satellite is said to be in a geostational orbit (as known as geosynchronous or parking orbit) if it appears stationary to an observer on the earth's surface.
This means that the satellite is always found directly above a particular location from the earth's surface.

The conditions for a satellite to be geostationary are as follows:

(a) the satellite revolves in the same direction as the earth (from West to East)
(b) the satellite orbited period is the same as the earth's rotational period (24 hours)
(c) the satellite moves directly above the earth's equator.

Electric Field (Primary and secondary cells, parallel and series arrangement of cells and resistor)

What is cell? A cell is a device that converts chemical energy into electrical energy. A series of cells connected together is called a battery.

TYPES OF CELL

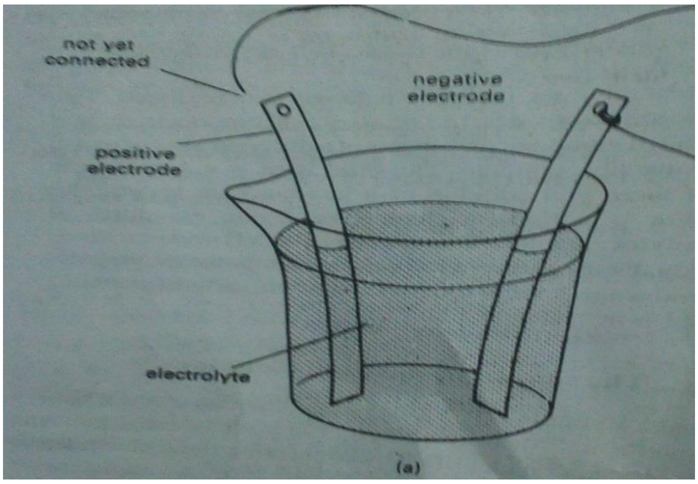
There are basically two types of cells

(i) Primary cells
(ii) Secondary cells

Primary cells:

A primary cell is cell that produces current as a result of irreversible chemical change. Examples of primary cells are simple cell (voltaic cell), Daniel cell and leclanche cell.

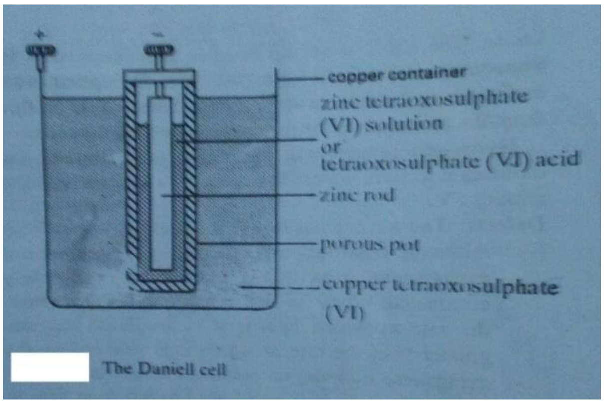
Simple cell (voltaic cell): A simple cell is composed of two electrodes (copper and zinc).Copper is the positive electrode and zinc is the negative electrode. These electrodes are contained in a container with dilute tetraoxosulphate VI acid (H_2SO_4). The voltage of a simple cell is 1 volt



Defects of a simple cell: The two defects of a simple cell are polarization and local action.

Polarization occurs when hydrogen bubbles insulate the copper electrodes (anode +ve) and prevent it from having a good contact with the electrolyte.
Polarization can be prevented by occasionally brushing the copper electrode or by using a depolarizer such as manganese dioxides which oxidize hydrogen to form water.
Local action is as a result of not using pure zinc electrodes and this introduces impurities into the electrolytes and wears away the zinc electrodes. This can be prevented by cleaning the zinc plate with tetraoxosulphate(vi) acid and then rubbing it with some mercury. This process is known as amalgamation. The mercury amalgam prevents the impurities from having contacts with the electrolyte.

Daniel cell: The Daniel cell is made up of zinc plate (-) and copper plate (+) which is the container. The electrolyte is dilute H_2SO_4 (aq). It counters the problem of polarization. the depolarizer is $CuSO_4$ (aq). The voltage production of Daniel cell is 1.08 volt. It is no longer in use today.

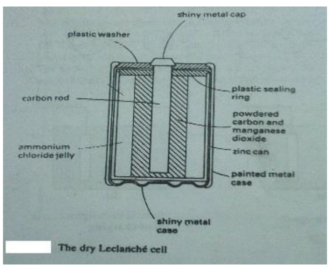


The Daniell cell

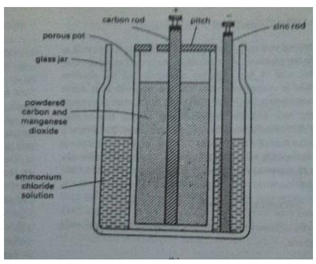
Leclanche cell: Ieclanche cell is another primary cell that is of two types. The wet and dry Ieclanche cells.

For the dry leclanche cell, the positive pole is a carbon rod, the negative (-ve) pole is zinc which is the containing vessels, on electrolyte of NH_4Cl in a jelly or paste form with flour and gum to make it reasonable dry and a depolarizer of magnese dioxide ($Mn0_2$) mixed with powdered carbon. Local action sets in after some time the e.m.f of this cell is about 1.5v.

For the wet leclanche cell, the positive pole is carbon, while the negative pole is the zinc plate the electrolyte is liquid NH_4Cl in a glass vessels. The positive pole is the carbon rod and it is inside a porous pot surrounded by magnese dioxide as a depolarizer,
Defects of wet leclanche cell are polarization and it is comber some to carry.



The dry Leclanché cell



Secondary cell (Accumulator):

Secondary cells are those cells that can be recharged when they run down, by passing current backward through them. Examples of secondary cells are the lead-acid accumulators and the alkaline or NIFE accumulator (nickel-iron).

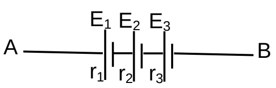
Lead-acid accumulator: The positive pole is lead peroxide (chocolate or dark brown in colour. The negative pole is lead plate (Grey in colour).

The electrolyte is sulphric acid. When a cell is giving out current, it is discharging. When fully charged its voltage is 2.2 volts and relative density of `1.25 when it is discharged the relative density is 1.15 and its voltage is slightly less than 2.0 volts. The relative density should not be allowed to fall below 1.15 before charging.

Maintenance of Lead-acid accumulator

(i) The liquid level should be maintained by using distilled water
(ii) Very large current should not be taken from the cell
(iii) If an accumulator is not to be use for a very long time the acid should be removed and kept dry or it should be recharged from time to time
(iv) The battery should be kept clean so that current does not leak away.
(v) The cell should not charged for a longtime if the relative density falls blow 1.15

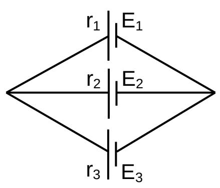
Arrangement of cells: Cells can be arranged in series or parallel. When cells are arranged in series, the effective e.m.f is the sum of the total number of cell.



$E = E_1 + E_2 + E_3$

$r = r_1 = r_2 = r_3$

Cells in parallel: When identical cells are arranged in parallel, the effective e.m.f is that of one cell.

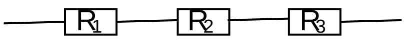


$E = E_1 = E_2 = E_3$

$1/r = 1/r_1 + 1/r_2 + 1/r_3$

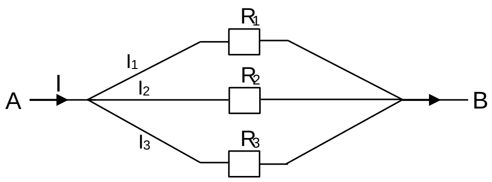
Advantage of parallel connection over series connection is that a steadier current is produced. While advantage of series connection over parallel is that a higher current is produced.

Arrangement of resistors: Resistors can be arranged in series and in parallel when resistors are arranged in series, the equivalent resistance is $R = R_1+R_2+R_3$ - - +Rn



$R = R_1 + R_2 + R_3$

S



$1/R + 1/R_1 + 1/R_2 + 1/R_3$

Parallel connection

Examples

(a) five resistance of values 0.1Ω, 1.7Ω, 2.0Ω, 1.0Ω and 0.9Ω are connected in series. Calculate the value of the combined resistors. (b) Four resistors of resistances 1Ω, 5Ω, 3Ω and 4Ω are connected in parallel. Calculate the value of the effective resistance

Solution

(a) $R = R_1 + R_2 + R_3 + R_4 + R_5$

$R = 0.1 + 1.7 + 2.0 + 1.0 + 0.9$

$R = 5.7$

(b) $1/R = 1/R_1 + 1/R_2 + 1/R_3 + 1/R_4$

$1/R = 1/1 + 1/5 + 1/3 + 1/4$

$1/R = (60+12+20+15)/60$

$1/R = 107/60$

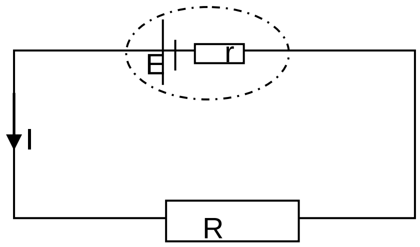
$R = 60/107$

$R = 0.56\Omega$

Electricity

The e.m.f of a cell is the potential difference across its terminal whenever it is connected to an open circuit i.e. it is not supplying current to an external circuit.

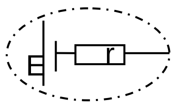
Terminal potential difference is the potential difference across the terminals of the cells when its delivering current to an external circuit. The potential drop across the internal resistance of a cell is known as lost voltage.



Internal Resistance (r)

The internal resistance of a cell (r) is the resistance offered by the electrolyte or chemicals to the motion of the current between the two poles.. It is denoted by the symbol (r) closed to the cell. The internal resistance of a cell determines the maximum current that can be supplied by a cell of given E.M.F.

Diagram showing the position of internal resistor.



Relationship between E, R. r and I

The relationship between Electromotive Force (E), external resistance (R), internal resistance (r) and current (t) is given by

$I = \frac{E}{R+r} = V/_R$

Using ohm's law

$I = \frac{E}{R+r} \Longrightarrow$ I(R+r) =E or IR +Ir = E

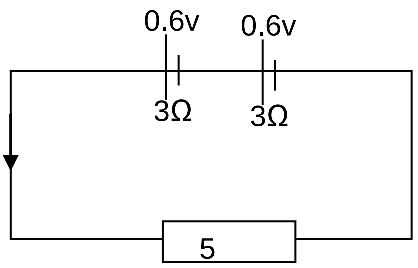
The term Ir is called the lost voltage and it is equal to E-V, i.e. the potential drop across the internal resistance

But, IR =V from ohm's law

Therefore, V+Ir = E

E.g. A battery made up of two cells joined in series supplies current to an external resistance of 5Ω. If the e.m.f, and internal resistance of each cell are 0.6v and 3Ω respectively, calculate the (a) the current flowing in the external resistor (b) the terminal P.d and (c) the lost voltage

Solution



(a)r_{total} = 3+3 = 6Ω

Total resistance in the circuit is =6+5 = 11Ω

Total e.m.f =0.6v +0.6v =1.2v

$I = E/(R + r) = 1.2/11 = 0.11A$

(b) Terminal P.d , V =IR = 0.11 X 5 =0.55v

(c) lost voltage =1.2 – 0.55 =0.65v

Resistivity:

All electric conductor has a certain measure of resistance. This resistance (R) of the material in form of a wire is directly proportional to the length and inversely proportional to cross-sectional area mathematically

$$R \propto \frac{L}{A}$$

Hence R = pL/A - - (1)

ρ is the constant of proportionality known as resistivity. The unit of resistivity is ohm meter (Ωm)

ρ = RA/L - (2)

The surface of wire is circular in shape. Thence, A = πr^2

from R = ρL/A

$$R = \rho L/\pi d^2/4 = \frac{4\rho l}{\pi d^2}$$ ---------(3)

.: from (3), ρ = $\pi d^2 R/4L$ --------------(4)

Where d is the diameter of the wire in meter (m)

L is the length of the wire in metre (m)

R is the resistance in ohm (Ω)

Conductivity: Conductivity is the reciprocal of resistivity. It is measure of the conduction of electrical/current on a material.

$$\text{Conductivity} = \frac{I}{\text{Resistivity}}$$

The resistance of wire 0f length 100cm and of diameter 0.3mm is found to be 3.0Ω Calculate the (a) the resistivity and (b) the conductivity of the wire.

Solution

(a)

P =RA/L

Given R= 3.0Ω, L =100cm = 1m

r = 0.3/2 X 10^{-3} = 1.5 X 10^{-4}m

Area(A) = π (1.5 X $10^{-4})^2$ = 2.12 X 10^{-7} Ωm

(b) σ =1/ρ = 1/(2.12 X 10^{-7}) = 4.7 X 10^6 $(\Omega m)^-$

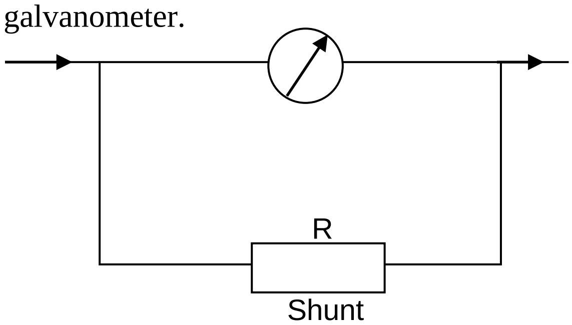
Week 10

SHUNT AND MULTIPLIER, RESISTIVITY AND CONDUCTIVITY

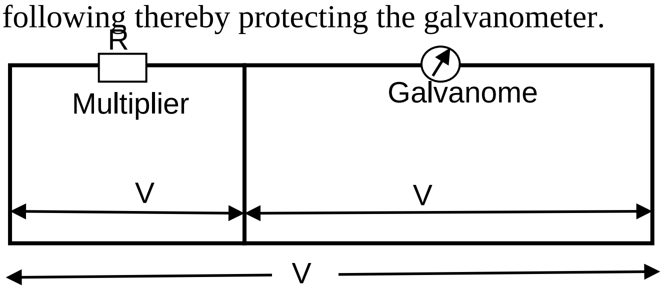
INTRODUCTION

Galvanometer is a device that is used to detect and measure small amount of current.
Passage of large current destroys it.

Shunt: A shunt is a low resistance resistor that is connected in parallel to a galvanometer so as to measure large current by the galvanometer. When this connection is made, the galvanometer will then function as an ammeter. The shunt diverts a large amount of current flowing thereby allowing small amount of current to pass through the galvanometer.



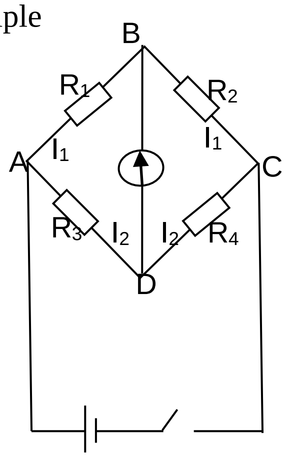
Multiplier: A multiplier is a high resistance resistor that is connected in series to a galvanometer so as to measure a high voltage when this connection is made, the galvanometer will then function as a voltmeter. The multiplier resists a good amount of the current that is following thereby protecting the galvanometer.



Measurement of resistance by wheatstone bridge

The diagram below is called a wheat stone bridge

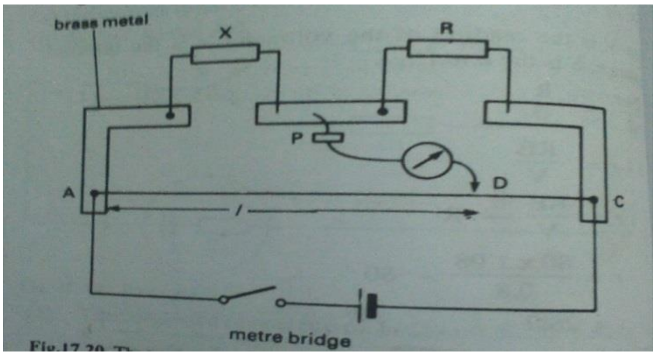
Working principle



The Wheatstone bridge consist of four resistors of resistance R_1,R_2,R_3 and R_4 connected as shown in the diagram. The current in the cells splits through ABC and ADC by adjusting one or more of the resistors, a balance point is reached i.e Where there is no deflection in the galvanometer. The condition at balance point is

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

Meter Bridge: The Wheatstone Bridge is time consuming method of finding resistances. The metre bridge is a practical way of finding resistance. It consist of a uniform across sectional area of wire on a 100cm (1m) metre rule. The diagram is shown below



The unknown resistance is labeled R. The jockey is connected via the galvanometer and it is gently tap on the wire until a balance point is reached as indicated by the galvanometer (when there is no deflection) at balance point,

$$\frac{X}{R} = \frac{L_1}{L_2}.$$

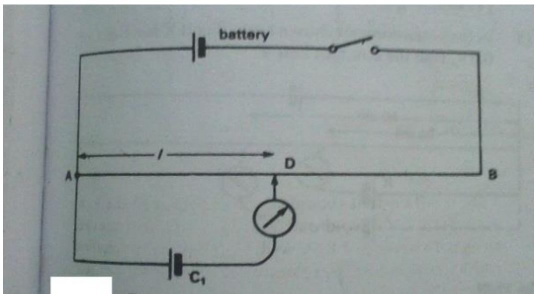
Also, $L_1 + L_2 = 100$
or $L_2 = 100 - L_1$

$$\frac{X}{R} = \frac{l_1}{100 - L_1}$$ (since $L_2 = 100 - L_1$)

$$X = \frac{RL_1}{100 - L_1}$$

Potentiometer:

Potentiometer is an instrument for comparing and measuring electromotive force (e.m.f) of a cell. The diagram is shown below



Comparison of e.m.f.s

It consists of a uniform across-sectional area resistance wire of length 100cm.

Battery Z provides a constant current through the wire. The cell with unknown e.m.f, E_1, is connected as shown and the jockey is adjusted until a balance point is reached, the length is noted as L_1. it is removed and the other cell of known e.m.f E_2 connected the process is repeated until a balance point is reach. The length is noted as L_2.

E_1 is related to E_2 by the following equation

$$\frac{E_1}{E_2} = \frac{L_1}{L_2}$$

$$E_1 = \frac{L_1 E_2}{L_2}$$