PHY 104

ELECTRIC FIELD

It is a region where a charge experiences a force of electrical origin.

Electric line of force price are imaginary lines drawn is such a way that the direction at any point of the tangent is the same as the direction of the field at the same point.

Coulomb's Law

F $\propto \frac{q_1 q_2}{R^2}$

F $= \frac{k q_1 q_2}{R^2}$

Where k = constant

k = $^{1}/_{4\pi\varepsilon_o}$

$$\boldsymbol{F} = \frac{\boldsymbol{Qq}}{\boldsymbol{4\pi\varepsilon_o R^2}} \dots\dots\dots\dots\dots *$$

Where Q big/first charge

q small/second charge

ε_o = Permittivity of free space $(8.85x10^{-12}FM^{-1})$

R = distance apart

- **Electric Field Intensity**

  E = $^{F}/_{q}$ ………….. (i)

Recall, F = $\frac{Qq}{4\pi\varepsilon_o R^2}$ ………… (ii)

Put equ (ii) into (i);

E = $\frac{Qq}{4\pi\varepsilon_o R^2} \Big/ q$

E= $\frac{Q\cancel{q}}{4\pi\varepsilon_o R^2}$ x $^1/_{\cancel{q}}$

E = $\boldsymbol{\frac{Q}{4\pi\varepsilon_o R^2}}$ **…………. ***

- **Electric Potential**

V= ER …………..(i)

Recall, E = $\frac{Q}{4\pi\varepsilon_o R^2}$ …………..(ii)

Put equ (ii) into (i);

V = $\frac{Q}{4\pi\varepsilon_o R^2}$ x $^R/_1$

V = $\boldsymbol{\frac{Q}{4\pi\varepsilon_o R}}$ … … … … … *

- **Gauss's Law:** state that a d total flux passing normal through any closed surface, whatever its shaped is, it always equal to $\boldsymbol{Q/_{\varepsilon_o}}$.

- **Electric Field Intensity:** is the force experiment on a unit positive change placed at that point.

- **Electric dipole:** is to changed object with equal but positive electric charges that are separated by a distance.

- **Dipole moment;**

  P = $\boldsymbol{ql}$

  Where P = dipole moment

  q = charge magnitude

  l = dost between charges

- **Torque on a dipole in a uniform electric field;**

  t = P X E .... (i)

  Where t = torque

  P = dipole moment

  E = electric field intensify

Recall E = $\frac{Q}{4\pi\varepsilon_o R^2}$ .... (ii)

Put equ (ii) into (i);

$$t = {\text{P x } \frac{Q}{4\pi\varepsilon_o R^2}} \Big/ {\text{QC x } \frac{Q}{4\pi\varepsilon_o R^2}}$$

$$t = {\frac{PQ}{4\pi\varepsilon_o R^2}} \Big/ {\frac{Q^2}{4\pi\varepsilon_o R^2}}$$

N:B

❖ When $Q/_P$ lies on the axial line dipole of + q, then $\theta = 0^o$

Thus, V = $-\frac{Q}{4\pi\varepsilon_{oR^2}}$

- When $^{Q}/_{P}$ lies on the axial line dipole of – q, then = 180^{o}

  Thus, V = $-\frac{Q}{4\pi\varepsilon_{oR^2}}$

- **Application of Gauss's law**

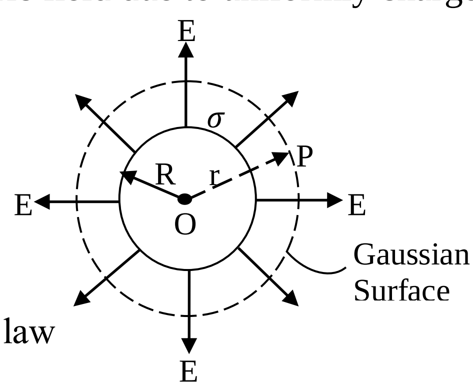
(a) Field due to an infinite long straight charged wire. $\left\{E = {}^{\chi}/_{2\pi\varepsilon_o r}\right\}$

(b) Electric field due to an infinite charged plane sheet. $\left\{E = {}^{\sigma}/_{2\varepsilon_o}\right\}$

(c) Electric field due to parallel charged sheets.

$E = E_1 - E_2 = 0$ and $E_1 + E_2 = {}^{\sigma}/_{2\varepsilon_o} + {}^{\sigma}/_{2\varepsilon_o} = {}^{\sigma}/_{\varepsilon_o}$

(d) Electric field due to uniformly charged spherical shell.



By Gauss's law

E = $\frac{Q}{4\pi\varepsilon_o r^2}$ ⟶ point outside the surface

E = $\frac{Q}{4\pi\varepsilon_o R^2}$ ⟶ point on the surface

When work is done

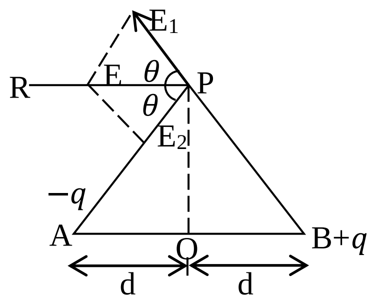
W = QV

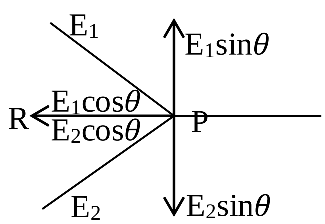
Recall V = $\frac{Q}{4\pi\varepsilon_o R}$

W = $Q\left\{{}^{Q}/_{4\pi\varepsilon_o R}\right\}$

W = $\frac{Q}{4\pi\varepsilon_o R}$

Electric potential due to an electric dipole at a point on the equitorial line;





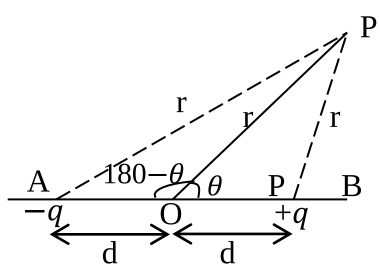
$E = E_1cos\theta + E_1cos\theta$

$E = 2Ecos\theta$

$= {}^{1}/_{4\pi\varepsilon_o} \quad . \quad {}^{q}/_{\langle r^2 + d^2\rangle^2} \;.\; 2cos\theta$

$E = \frac{P}{4\pi\varepsilon_o r^2}$

OR



P at charge $+q = {}^{1}\!/_{4\pi\varepsilon_o} \cdot \left({}^{q}\!/_{r^1}\right)$

P at charge $-q = {}^{1}\!/_{4\pi\varepsilon_o} \cdot \left({}^{-q}\!/_{r^2}\right)$

Total P due to dipole;

$$V = \frac{q}{4\pi\varepsilon_o}\left({}^{1}\!/_{r^1} - {}^{1}\!/_{r^2}\right)$$

Applying cosine rule by substituting and simplifying;

$$= \frac{q}{4\pi\varepsilon_o} \cdot {}^{1}\!/_{r}\left(\cancel{1 +}\, {}^{d}\!/_{r}\, cos\theta \;-\; \cancel{1 +}\, {}^{d}\!/_{r}\, cos\theta\right)$$

$$= \frac{q}{4\pi\varepsilon_o r}\left(\frac{2dcos\theta}{r}\right)$$

$$= \left(\frac{q2dcos\theta}{4\pi\varepsilon_o r^2}\right)$$

$$= \left(\frac{Pcos\theta}{4\pi\varepsilon_o r^2}\right)$$

- **Electrostatic Force Potential:** is a conservative force i.e. work done by the force in moving a unit test charge from one point to another.

Properties of Electrostatic force

- Scalar quantity
- Potential function satisfies superposition principle
- Gradient of potential gives the electric field
- Superposition principle states that “If there are many charges in space around a charges in space around a charge ‘Q’ then the total force and

charge is the sum of the forces on the charge due to the charges around it.

$$F_x = F_1 + F_2 + \ldots\ldots + F_n$$

Properties of electric charges:

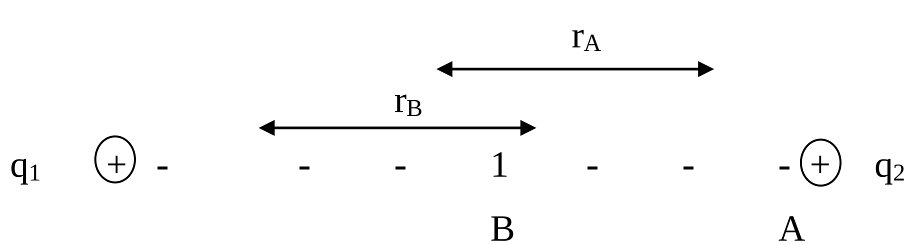
- Scalar quantity
- Repel (like charges) and attract (unlike charges)
- Additive
- Total charge of the universe is constant

Electric Potential Energy

Potential energy associated with a body placed in gravitational field. Also the gravitational potential energy of a body increases with the distance of the body from the centre of the earth i.e. work must be done for the body to move upwards against the earth's gravity.

This can also be applied to the charge placed in an electric field; a certain electric potential energy is associated with a charge.

Consideration to points A and B, with distance T_A and T_B from a positive charge.



W_{AB} = $E_{P.A}$ - $E_{P.B}$

W_{AB} = $\int_{r_A}^{r_B} Fdr = \int_{r_A}^{r_B} \frac{kQ^2}{r^2}\ dr$

W_{AB} = $\frac{kQ^2}{r_A}$ - $\frac{kQ^2}{r_B}$ (Joules)

Electric potential;

Recall = V = $\frac{kQ^2}{r}$

V = $\frac{Ep}{Q}$ (J/c)

Consideration total potential at a point due to n point charges Q_1, Q_2…… Q_n (algebraic sum)

= V = $\frac{KQ_1}{r_1} + \frac{KQ_2}{r_2}$ - - -+ $\frac{KQ_n}{r_3}$

V = k Σ $^{Q}/_{r}$

*also Ep between 2 points A and B

V_{AB} = V_A - V_B

= $\frac{KQ}{r_A}$ - $\frac{KQ}{r_B}$

V_A - V_B = $^{W_{AB}}/_{Q}$

*W_{AB} = Q{$V_A - V_B$ } …………. (V)

Recall W= $\frac{KQ^2}{r}$ …………….(I)

And V = $^{KQ}/_{r}$ ……………..(III)

So by dividing $^{W}/_{Q}$= V …………..(IV)

Also for small changes in recall equation (v)

V = $^{W}/_{Q}$ as W= QV

dv = -$^{dw}/_{Q}$

dv = -$\frac{Fdr}{Q}$ $\{V/M\}$

Thus E = $\frac{-dv}{dr}\begin{Bmatrix} potential \\ gradient \end{Bmatrix}$

Where electric field intensify is equal to the potential gradient.

Equipotential surface is an imaginary surface on which all points have the same potential

$Potential\ at\ c\ due\ to\ Q_1 = V_1 = \frac{KQ_1}{4}$

Potential at c due to Q_2= V_2= $\frac{KQ_2}{3}$

Total Potential at c = V_1 + V_2 = $\frac{KQ_1}{4}$ + $\frac{KQ_2}{3}$

W = $Q_3\left\{\frac{KQ_1}{4} + \frac{KQ_2}{3}\right\}$

W = $KQ_3\left\{\frac{Q_1}{4} - \frac{Q_2}{3}\right\}$

Recall W_{AB} = Q { $V_A - V_B$ }

*Nagative work done$\{-w\}$indicate work done by an electron as it moves from negative to the positive terminal.

*Positive work done $\{+w\}$ indicate work done on an electron as it moves from position to the negative terminal

CAPACITANCE

*Capacitance is defined as the amount of charge required to raise a potential diff by one unit.

C =$^{Q}/_{V}$ $\{Farad\}$

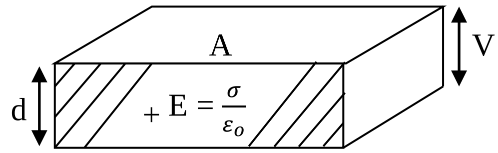
Where

C = Capacitances

Q = Change

V = potential

*Assuming the figure below is given;



Electric field strength, E = $\frac{\sigma}{\varepsilon_o}$ …………..(1)

N.B

Charge density σ = $^{Q}/_{A}$

N.B⇉ density = $\frac{mass}{volume}$

That equ (u) into (I)

E = $\frac{^{Q}/_{A}}{\varepsilon_o}$ = $^{Q}/_{A}$ X $^{1}/_{\varepsilon_o}$

E = $^{Q}/_{\varepsilon_o A}$- - - - -(III)

Also E = $^{V}/_{d}$ $\{potential\ gradient\}$

Electric field strength

Equate equ (v) and (iii)

$$^{V}/_{d} = \ ^{Q}/_{\varepsilon_o A}$$

$$^{Q}/_{V} = \ ^{\varepsilon_o A}/_{d}$$

recall C = $^{Q}/_{V}$

C = $\frac{\varepsilon_o A}{d}$

where, k is dielectric constant

C = $\frac{k\varepsilon_o A}{d}$

where C = Capacitance

k = dielectric constant

NOTE:

k for air = 1.0006

k for vacuum = 1

k for glass = 5

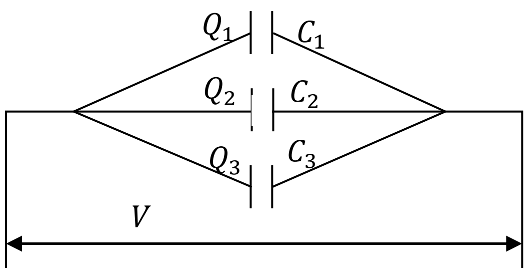
A = Area of overlap of plates

d = dist. between plates

ε_o = permittivity of vacuum $\{8.85 \text{x} 10^{-12} \text{fm}^{-1}\}$

- **Arrangement of Capacitors;**

(a) Parallel Arrangement;



$Q_A = Q_1 + Q_2 + Q_3 \ldots\ldots. + Q_n$

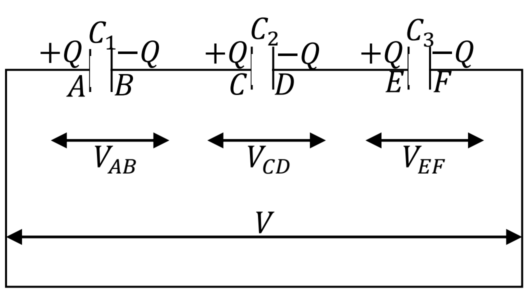
$CV = C_1V + C_2V + C_3V \ldots\ldots. + C_nV$

$CV = V\{C_1 + C_2 + C_3 \ldots\ldots. + C_n\}$

Divide both sides by V

$C = C_1 + C_2 + C_3 \ldots\ldots. + C_n$

(b) Series Arrangement;



C = Q/V

V = $^{Q}/_{C}$

V = $V_{AB} + V_{CD} + V_{EF}$

$Q/_C = Q/_{C_1} + Q/_{C_2} + Q/_{C_3} \ldots\ldots + Q/_{C_n}$

$Q/_C = Q/_{\langle C_1 + C_2 + C_3 \ldots\ldots + C_n \rangle}$

Multiply both sides by Q

$1/_C = 1/_{C_1} + 1/_{C_2} + 1/_{C_3} \ldots\ldots + 1/_{C_n}$

- Energy stored in a capacitor;

  W = $\int_0^2 dw$

  = $\int_0^Q \frac{Q.dQ}{C}$

Recall, V = $Q/_C$

  W = $1/_C \int_0^Q \frac{Q.dQ}{2}$

  W = $1/_C \langle Q^2/_2 \rangle_0^Q$

  W = $Q^2/_{2C}$

Recall, C = $Q/_V$

  Q = CV

  W = $\frac{C^2V^2}{2C}$ = $1/_2 \; \frac{C^{\cancel{2}}V^2}{2\cancel{C}}$

  W = $1/_2 \, CV^2$

Recall, Q = CV

  V = $1/_2 \, QV$

- **Electric Flux Density:** is the amount of flux passing through a deposit area that is perpendicular to the direction of the flux.

  D = $Q/_A \langle c/m^2 \rangle$

  Where D = electric flux density

  OR charge density

  i.e D = σ

  Q = Charge

  A = Area

- Permittivity ε_o;

  ⟶ Electric flux

  ⟶ Voltage gradient

$\varepsilon_o = \frac{D}{E}$

- Relative permittivity ε_r;

  $D/E = \varepsilon_o \varepsilon_r$

- Absolute permittivity;

  $\varepsilon \quad = \varepsilon_o \varepsilon_r$

Thus;

Since $D/E = \varepsilon_o \varepsilon_r$

E = $\frac{D}{\varepsilon_o \varepsilon_r}$

N.B: D = $E\varepsilon_o \varepsilon_r$

k = ε_r

dielectric constant = relative permittivity

Since C = $\frac{k\varepsilon_o A}{d}$

So also C = $\frac{\varepsilon_o \varepsilon_r A}{d}$

* In a case, where a plate capacitor is interleaved;

C = $\frac{\varepsilon_o \varepsilon_r A\langle n-1\rangle}{d}$

Where $\varepsilon_o = permittivity\ of\ freespace$

$\varepsilon_r = real\ permittivity$

$A \ = Area$

$n \ = no. of\ interleaved\ plates$

$d \ = thickness\ of\ material$

- Electric Field Strength is equal to dielectric strength;

  E_m = ${V_m}/{d}$

  Where E_m = dielectric strength

  V = P.d

d = thickness of material

- **Types of Capacitors;**
  1. Variable air Capacitor
  2. Mica Capacitor
  3. Ceramic Capacitor
  4. Plastic Capacitor
  5. Electrolytic Capacitor
  6. Titanium oxide Capacitor
  7. Paper Capacitor
- **How to discharge a Capacitor;**

  It is done by connecting a high value resistor across the capacitor terminals.

ELECTRIC CURRENT

- Electric current is the net charge flow per unit time.

  I $= {}^{Q}/_{t}\ \langle Cs^{-1}\ or\ A\rangle$
- **Mechanism of metallic conduction;**

1. Conduction of electricity in metal due to free electrons.
2. When a battery is connected across the terminals, electric field is formed /set up
3. Electron drift constitutes in electric current;

- Current density (J);

  $\sigma = {}^{\mathrm{I}}/_{A} = nVe/nqV$

Where I $= Current$

A $= Area$

n $= Electrons\ per\ unit\ volume$

$\mathrm{V} = drift\ velocity$

$e = electron\ charge$

$\mathrm{q} = Charge$

Since; ${}^{\mathrm{I}}/_{A} = nVe/nqV$

$\therefore\ I = nAVe/nAqV$

Also; $A = {}^{I}/_{nVe} \Big/ {}^{I}/_{nVq}$

Also; $n = {}^{I}/_{AVe} \Big/ {}^{I}/_{AVq}$

Also; $V = {}^{I}/_{nAe} \Big/ {}^{I}/_{nAq}$

- Resistance is referred to the potential difference per unit current in a metallic conductor.
- Units law states that the current(I) in a metallic conductor i.e. a wire is directly proportional to the potential difference(V) and inversely proportional to the resistance(R).

$\mathrm{I} = {}^{V}/_{R} \ldots\ldots\ldots\ldots\ldots *$

$\therefore \mathrm{V} = \mathrm{IR} \ldots\ldots\ldots\ldots\ldots *$

$\mathrm{R} = {}^{V}/_{I} \ldots\ldots\ldots\ldots\ldots *$

Where I = Current

V = Potential difference

R = Resistance

Also; resistance;

$\mathrm{R} = \frac{\rho l}{A}$

Where R = resistance

ρ = resistivity of the material

l = length of material

A = Cross-sectional area

Since; $R = \frac{\rho l}{A}$

$\rho = \frac{RA}{l}$

* Also, ρ varies linearly with temperature;

Where ρ = resistivity

ρ_o = resistivity at a particular temperature

$\propto$ = temp. coefficient of resistivity

T & T_o = Temperature

$R = R_o \langle 1+\propto (T - T_o)\rangle \ldots \ldots \ldots \ldots *$

Also $R_o = \frac{R}{\langle 1+\propto(T-T_o)\rangle} \ldots \ldots \ldots \ldots *$

- **Internal Resistance of a cell;**

V = E – Ir ……….. (i)

Recall, V = IR …………… (ii)

Put equ (ii) into (i);

IR = E – Ir

Collect like terms

E = IR + Ir

$E = I\langle R + r\rangle \ldots \ldots \ldots \ldots *$

$I = \frac{E}{R+r}$

Where E = electromotive force

I = current

R = external resistance

r = internal resistance

Power is defined as the rate at which work is done. (J/s or watt)

P = IV … … … … (i)

Recall V = IR … … … … (ii)

Put (ii) into (i);

P = $I(IR)$

P = I^2R … … … … (iii)

Also, I = $^V/_R$ … … … … (iv)

Put equ (iv) into (i);

P = $(^V/_R)V$

P = $^{V^2}/_R$ … … … … (v)

Where P = power

V = voltage

R = resistance

I = current

- **Heat Law/Joule's Law:** states that the heat product per second is proportional to the square of the current and the resistance of the wire;

  H $\propto I^2R$

i.e H $\propto P$

Since P = IV, then

H = IVT

Thus; $IVT = mc\Delta T$

$I = \frac{mc\Delta T}{Vt}$ … … … … $*$

$V = \frac{mc\Delta T}{It}$ … … … … $*$

$t = \frac{mc\Delta T}{IV}$ … … … … $*$

$m = \frac{IVt}{c\Delta T}$ … … … … $*$

$$\Delta T = \frac{IVt}{mc} \ldots \ldots \ldots \ldots *$$

Where

$I = Current$

$V = Potential\ difference$

$t = time\ required$

$m = mass\ of\ substance$

$\Delta T = change\ in\ Temp.$

From Internal resistance of a cell;

V = E – Ir

Thus $Ir = E - V \ldots \ldots \ldots \ldots (i)$

$r = \frac{E-V}{I} \ldots \ldots \ldots \ldots (ii)$

I = $\frac{E-V}{r} \ldots \ldots \ldots \ldots (iii)$

For Calculating terminal Voltage;

$V = E + Ir$

Note: As the temperature coefficient of resistance falls, temperature increases.

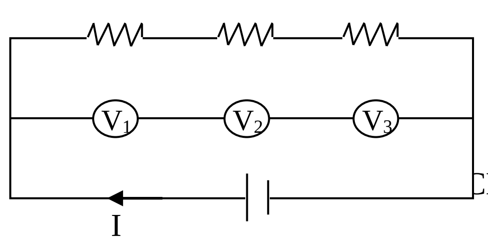
e.g -0.00048 for carbon.

* Since, $R_o = R_\theta[1+\propto (T - T_o)]$

$$\frac{R_1}{R_2} = \frac{1+\propto\theta_1}{1+\propto\theta_2}$$

DIRECT CURRENT CIRCUITS

- Series Connection



CE*Dept*#

Recall V = IR

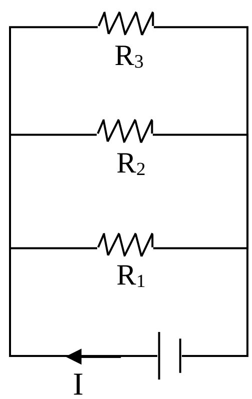
$$V = V_1 + V_2 + V_3 + \dots\dots\dots + V_n$$

$$IR = IR_1 + IR_2 + IR_3$$

Divide through by I

$$R = R_1 + R_2 + R_3 + \dots\dots\dots + R_n$$

- Parallel Connection



Recall V = IR

$$I = V/R$$

$$I = I_1 + I_2 + I_3 + \dots\dots\dots + I_n$$

$$V/R = V/R_1 + V/R_2 + V/R_3 + \dots\dots\dots + V/R_n$$

Multiply through by $1/V$

$$1/R = 1/R_1 + 1/R_2 + 1/R_3 + \dots\dots\dots + 1/R_n$$

- **Kirchoff's Law**;
  - Point Law/Current Law states that the algebraic sum of all currents entering a junction must be equal to zero.

$$\sum_{i=1}^{n} I = 0$$

- Loop Law/Voltage Law states that the algebraic sum of all the p.d changes across the various elements in any closed loop is zero.

$$\sum_{i=1}^{n} V = 0$$

OR

It states that the algebraic sum of the e.m.f is equal to the algebraic from all p.d in that circuit.

$$\therefore \quad -E_1 + I_1R_1 - I_2R_2 + E_2 = 0$$

$$E_1 - E_2 = I_1R_1 - I_2R_2$$

- **Potential Divider;**

  Voltage Distributor Circuit

  $$V_1 = \left(\frac{R_1}{R_1+R_2}\right)V$$

  $$V_2 = \left(\frac{R_2}{R_1+R_2}\right)V$$

  $$V_{out} = \left(\frac{R_2}{R_1+R_2}\right)V_{in}$$

- **Current Divider;**

  $$I_1 = \left(\frac{R_1}{R_1+R_2}\right)I$$

  $$I_2 = \left(\frac{R_2}{R_1+R_2}\right)I$$

N.B: $cm^2 \longrightarrow m^2$

* $\frac{xcm}{1000} \longrightarrow$ m

* mm $\longrightarrow$ m

$\frac{xcm}{10{,}000} \longrightarrow$ m

- All analogue electrical indicating instruments require some essential devices;

1. Operating device/deflecting

2. Controlling device
3. Dumping device

MAGNETIC FIELD

- **Law of Magnetism:** states that "like poles repel while unlike poles attract"
- **Application of Temporary Magnet;**

1. Electric bells
2. Earpiece
3. Induction coil
4. Magnetic relay

- **Application of Permanent Magnet;**

1. Electric motor
2. D.C dynamo
3. Radio loud speaker
4. Transistor's aerials

- **Why steel is most prepared for making permanent magnet;**
  Steel cannot be easily magnetized because it takes time for it magnetic molecules to be arranged
- **Methods of making magnet;**

1. Single touch method
2. Double stroke
3. Hammering the earth's field
4. Electrical method (best way of making magnet)

- **Keepers**; are used to retain magnetic properties of a magnet when placed across the ends of the bar magnet.
- When the moment of electrons tends to cancel out themselves, the material is said to be **NON-MAGNETIC.**

- When the moment of electrons cancellation is not complete, the material is said to be **PARA-MAGNETIC**.
- When the moment of electrons are produced, and material is said to be **DIA-MAGNETIC.**
- **Magnetic Field:** is a region around a magnet/current carrying a conductor, where a magnetic force is been felt/experienced.
- **Magnetic Flux:** refers to the number of magnetic lines of force in a given magnetic field. It is a Vector quantity and measured in Weber(wb). ϕ
- **Magnetic Flux Density;**

  $B = \frac{Magnetic\ Flux}{Area}$

  $B = {}^{\phi}/_{A} \longrightarrow$ Magnetic flux density

  $\phi = BA$
- **Magnetic Force, F;**

  $F \propto B$ … … … … (i)

  $F \propto I$ … … … … (ii)

  $F \propto l$ … … … … (iii)

  Sum equ (i), (ii) and (iii);

  $\boldsymbol{F = BIl}$ … … … … … $*$

  at angle θ

  $\boldsymbol{F = BIlsin\theta}$ … … … … … $*$
- Consider a charge of an electron, $\boldsymbol{e}$ (**Lorenz Force**)

  $\boldsymbol{F = BeVsin\theta}$ … … … … … $*$
- Consider a charge of an electron, $\boldsymbol{Q}$ (**Lorenz Force**)

  $\boldsymbol{F = BQVsin\theta}$ … … … … … $*$

- **Electromagnetic Induction:** is a phenomenon in which electricity could be produced using magnets/magnetic field.
- **From Faraday's Law;**

1. Whenever there is a change in direction of magnetic flux an induced current, I is produced.
2. Induced e.m.f. is produced as a result of the magnetic flux linking a coil.

- **Faraday's Law;**

➢ **First Law:** It states that the induced e.m.f in a circuit is directly proportional to the rate of change of magnetic flux;

$$\mathcal{E} = {}^{\phi}/_{t}$$

For N-turns of coil;

$$\mathcal{E} = \frac{\mathrm{Nd}\,\phi_B}{\mathrm{d}t} \ldots\ldots\ldots\ldots\ldots *$$

$$\mathcal{E} = \frac{\mathrm{N}\,\phi_B}{t} \ldots\ldots\ldots\ldots\ldots *$$

➢ **Second Law (Lenz's Law):** It states that the induced current flows in such a direction so as to oppose the motion producing it.

- **Factors affecting the induced e.m.f**;

✓ Strength of magnet
✓ No. of turns of the coil (solenoid)
✓ Surface area of the coil.
✓ Distance between the magnet and coil

- **Uses of Induction Coil;**

✓ X-ray tubes operation
✓ Coil-ignition system of motor
✓ Radio transmitters

- ✓ Investigation of high voltages and study of discharge through gases.
- **From a moving coil;**

  T = BAIN … … … … … ∗

  at angle θ

  T = BAINcos$\boldsymbol{\theta}$ … … … … … ∗
- **Magnetic flux density;**

  $B = \frac{N_o I}{2\pi R}$

  Where $N_o = permeability$ $(4\pi \text{x} 10^{-7})$

  For Closely spaced loops

  $B = \frac{N_o NI}{2\pi R}$

  For a solenoid (N-turns of coil)

  $B = \frac{N_o NI}{l} \; / \; \frac{N_o NI}{2R}$
- **Force between two parallel conductors**

  $F = \frac{N_o I_1 I_2 l}{2\pi R}$

ELECTRICAL MEASURING INSTRUMENT AND MEASUREMENTS

- **Types of Instrument;**

  i. Analogue Instrument

  ii. Digital Instrument
- **Essential device required analogue electrical indication instrument;**

  a. Depleting/Operating device

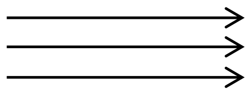
  b. Controlling device

  c. Damping device

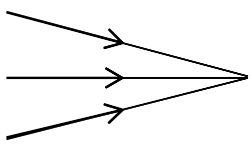
- **Types of controlling device;**
  i. Spring control
  ii. Gravity control
- **Types of dumping;**
  i. Eddy – current
  ii. Air – friction
  iii. Fluid – friction
- Moving coil Instrument measures D.C and can be used in conjunction with a bridge rectifier to provide an alternating current/voltage.
- **Ammeter;** measures current, posses low resistance and must be connected in series.
- **Voltmeter;** measures P.d, posses high resistance and must be connected in parallel.

- A source of light is referred to as the origin of sensation in vision.
- A ray of light is the direction path through which light energy travels.
- A beam of light is the collection of rays of light. We have 3 types;

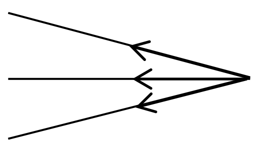
1. Parallel Beam



2. Convergence Beam



3. Divergence Beam

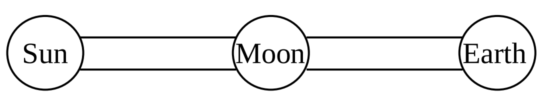


- Natural effects of rectilinear propagation of light;

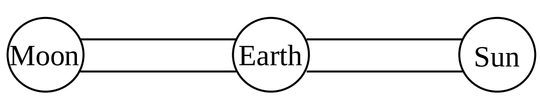
1. Sun as the point source
2. Shadow; (a) Umbra

   (b) Penumbra
3. Eclipse

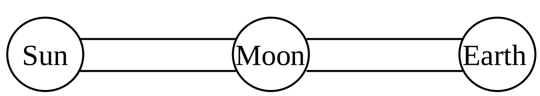
   (a) Eclipse of the sun



   (b) Eclipse of the sun



   (c) Eclipse of the sun



- Propagation of Light

1. It can be polarized
2. It can be diffracted
3. It can be refracted
4. It can be reflected
5. It can travel in a straight line

- **Magnification**: is dep. As the ratio of image distance/height to object distance/height.

$$M = \frac{Image\ distance}{Object\ distance} = \frac{Image\ height}{Object\ height}$$

$$M = \frac{V}{U}\ \langle no\ unit \rangle$$

$$M = \frac{D_i}{D_o} = \frac{H_i}{H_o}$$

D_i = Image distant

D_o = Object distant

H_i = Image height

H_o = Object height

- **Reflection:** can be referred to as re-propagation of light waves when incidented at a particular angle on a plane surface. We have two types;

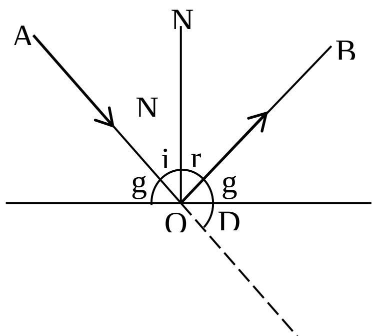
1. Smooth/Regular reflection
2. Rough/Irregular reflection

- **Laws of Reflection:**

First Law; States that “the incident ray, reflected ray and the normal all lie on the same plane”.

Second Law; States that “ the angle of incidents is equal to the angle of reflection”. i = r.

- Consider the fig. below



i = Angle of incidence

r = Angle of reflection

N = Normal

g = Angle of glance

D = Angle of deviation

Thus, Angle of deviation;

$$D = 2g$$

Also, angle of glance

$$g = (90 - r)$$

- **Image formed on a plane mirror;**
    - Image is the same size as that of object
    - Image distance is the same in front of the mirror and behind the mirror.
    - Image is laterally inverted
    - It is virtual i.e. cannot be formed on a photographic screen
- **No of images formed;**

$$n = \frac{360}{\theta} - 1$$

Where n = number of images

O = indirect angle

- **Applications of plane mirror**

i. Viewing glass/dressing mirror

ii. Sextant device

iii. Periscope

iv. Kaleidoscope

- **There are 2 types of curved mirror;**

1. Concave mirror produces real image and has its right and side coated outwards.

2. Convex mirror: produces virtual image and has its left hand side coated inward

- **Aperture;** is the point where rays of light been propagated can be incidented (i.e. cut out section from the curved surface.
- **Focus;** It is the point where light incidented on a curved surface is been reflected (i.e. the converging point) It helps to defense whether an image is real/virtual.
- **Curvature;** It is an imaginary centre assumed to be the centre of the curved surface.
- **Principal axis:** It is the line joining the pole P and the centre of curvature C. It is the distance between the pole P and the centre of curvature C.
- **Pole:** It is the centre point produced an on aperture.
- **Focal length:** It is the distance between the focus and the pole P.

  Focal length = $\frac{radius\ of\ curpature}{2}$

Thus F = $^{r}/_{2}$

Also, $r = 2$F

- **Principle of reversibility:** for every surface the light incidented and perpendicular to plane surface is reflected on the same line of its incident.
- **Nature of images formed by a concave mirror;**

1. Virtual
2. Diminished
3. Erect/upright

- F of Concave(converging) mirror;

F = +

- F of Concave(converging) mirror;

F = −

- Application of curved mirror;

(a) Convex mirror

(i) Cardium mirror

(ii) Security mirror

(b) Concave mirror

(i) Dentist mirror

(ii) Shaving mirror

- Mirror formular;

Consider general formular of mirror;

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad \text{---------------} \qquad (1)$$

Where V = image of distance

U = object distance

F = Focal length;

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Multiply 2ru by V;

$\frac{1}{v}(V) + \frac{1}{u}(V) = \frac{1}{f} \quad (V)$

$1 + \frac{V}{u} = \frac{V}{f}$

Recall: m = $\frac{V}{u}$

1 + m = $\frac{V}{f}$

$\therefore$ m = $\frac{V}{f}$ - 1 ----- (1b)

Also, recall F = $\frac{r}{2}$ - - - - - (1b)

Put eqn (11b) into (11a)

$M = \frac{V}{\frac{r}{2}} - 1$

$M = \left(\frac{V}{1} \ x \ \frac{2}{r}\right) - 1$

$M = \frac{2V}{r} - 1$ - - - - (111)

Refraction is refer to as a property of change in the direction of light, when it passes from one medium to another.

Laws of refraction;

1st law states that the incidence ray, normal at the point of incidence and the refracted ray all lie on the same plane".

2nd law states that "the ratio of the sine of angle of incidence to the sine of angle of refraction is constant all rays passing from one medium to another". (Snell's law).

i.e. $\frac{\sin i}{\sin r} = n$

This sin i = n sin r

i = $\sin^{-1}$ [nsin r]

Also, sin r = $\frac{\sin i}{n}$

∴ r = $\sin^{-1}\left(\frac{\sin i}{n}\right)$

Where n = refractive index

Sin i = angle of incidence

Sin r = angle of refraction

Refraction for denser medium (glass) to less dense medium; glass to air

μ = gμa = $\frac{1}{a\mu g}$

Water to air;

μ = Wμa = $\frac{1}{a\mu g}$

Refraction index helps to determine the extent of permeability at which ray travels through a medium.

$\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$

Also, where displacement of pin occurs on an experiment; [lateral displacement]

D = $t[1- \frac{1}{\mu}]$

Where D = pin displacement

T = tickness

N = Refractive idex

Since, d = t $[1 - \frac{1}{\mu}]$ ------- (1)

D = $(t - \frac{t}{\mu})$

Lcm = μ

D = $[\frac{\mu t\ -\ t}{\mu}]$

D = $\mu t \quad - \quad t$ ------ (ii)

Collect like terms

D μ - μ t = - t

Factorise;

μ {D – t} = - t

Thus, μ = $\frac{-\,t}{D\ -\ t}$ ------ (iii)

Recall eqn. (iii);

D μ = ut - t

Factorise

D μ = t[u – 1]

T = $\frac{D\mu}{\mu - 1}$ ------ (iv)

Critical angle is the angle of incidence in the denser medium when the angle of refraction in the less dense medium is 90^{o}

Recall; μ = $\frac{\sin i}{\sin r}$ = n

sin i = sin C, sin r = 90^{o}

Consideration medium to $g\mu$g = $\frac{\sin c}{\sin 90}$

$a\mu$g = $\frac{\sin 90}{\sin C}$

Also, sin 90^{o} = 1

$a\mu$g = $\frac{1}{\sin C}$

Where sin c = critical angle.

Total internal reflection occurs when the incidence angle exceeds the critical angle, and there exists no refraction.

Conditions under which total internal reflection occurs;

(i) Light rays must travel from a denser medium to a less denser medium.

(ii) Critical angle must be exceeded by the angle of incidence.

Application of total internal reflection;

(1) Mirage;

(2) Binoculars

(3) Optical fibres

(4) Refractometer

(5) Cameras

(1) They are used in conveying informations

(2) Used in medical labs to see deep inside the throat.

A mirage is an optical illusion caused by total internal reflection of light separating two layers of air of different densities.

A consideration the n of equilateral triangular prism;

$a\mu g = \frac{\sin i}{\sin r}$

$i = \frac{A+D}{2}$ - - - (I)

$r = \frac{A}{r}$ - - - (II)

$\therefore \; a\mu g = \frac{\sin\{A+D\}}{\sin\{\frac{A}{2}\}}$

Where A = equilateral angle

B = minimum deviation

Deviation is defined as the change in the direction of a ray of light when it passes through a glass prism.

Lenses are transparent medium which could be glass, plastic and nylon which are bounded by non –coated curved surfaces.

*Type ;

(1)Concave lens $\{diverging\}$

(2)Convex lens $\{converging\}$

*Focal length

Concave lens =-

Convex lens =+

*Different between real image & virtual image

	Real	virtual
(1)	Inverted	Erect/upright
(2)	Formed on photographic screen	Cannot be formed on the screen
(3)	Formation is by true rays	Formation is by apparent rays

*Power lens of a lens

P = $\frac{1}{f} \rightarrow \frac{dioptre}{focal\ length}$

*Deviation by angle prism

D = A $\{n - 1\}$

Where A = refracting angle

N =refracting index

*M =$\frac{f_{o\rightarrow}}{f_{e}\rightarrow}\frac{objective\ focal\ length}{eyepiece\ pocal\ length}$

Also M = ${F_o}/{F_e}\langle 1 + {F_e}/{D}\rangle$

Where

M = linear magnification

F_o= objective focal length

F_e =eye piece focal length

D= lateral displacement

W $\frac{KQ^2}{r/Q} = \frac{KQ^2}{r}$ x$\frac{1}{Q}$

V = $\frac{KQ}{r}$

$\frac{KQ^2}{r^2}$ x $\frac{1}{Q}$

$\frac{KQ}{r}$

v_A - v_B = $\frac{KQ^2}{r}$

v_A - v_B = $\frac{W_{AB}}{Q}$

V = $\frac{KQ}{r}$

Recall Ep = $\frac{KQ^2}{r}$

V = $\frac{KQ^2}{r/Q}$

V = $\frac{KQ}{r}$

This v = $\frac{EP}{Q}$

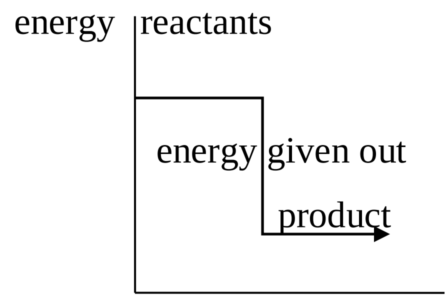
Broken bonds;

Energy is absorbed.

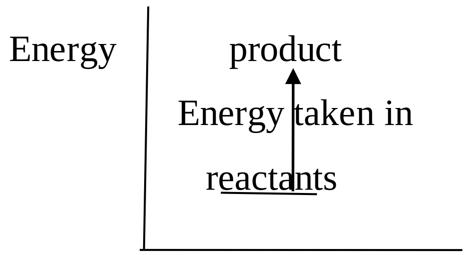
-Bond made

Energy is evolved

Exothermised;



*Endothermole



*An enthalpy changes is a heat change that takes place at constant pleasure.