In ΔAPC, we have,

$$\cos\alpha = \frac{PC}{PA} = \frac{a}{r} \qquad \left(\because \cos\theta = \frac{b}{h}\right)$$

$$\therefore r = \frac{a}{\cos\alpha}$$

With the value 'r' equation (iv) becomes,

$$\Delta B = \frac{\mu_0}{4\pi}\,\frac{I d\alpha}{(a/\cos\alpha)}$$

$$\therefore \Delta B = \frac{\mu_0 I}{4\pi a}\cos\alpha\, d\alpha \text{ ——— (v).}$$

Now, the total magnetic field intensity due to finite straight conductor XY is,

$$B = \int_{-\alpha_1}^{\alpha_2} dB = \int_{-\alpha_1}^{\alpha_2} \frac{\mu_0 I \cos\alpha\, d\alpha}{4\pi a}$$

$$= \frac{\mu_0 I}{4\pi a}\int_{-\alpha_1}^{\alpha_2} \cos\alpha\, d\alpha$$

$$= \frac{\mu_0 I}{4\pi a}\left[\sin\alpha\right]_{-\alpha_1}^{\alpha_2}$$

$$= \frac{\mu_0 I}{4\pi a}\left[\sin\alpha_2 - \sin(-\alpha_1)\right]$$

$$= \frac{\mu_0}{4\pi a}\left[\sin\alpha_2 + \sin\alpha_1\right]$$

$$\therefore B = \frac{\mu_0 I}{4\pi a}\left(\sin\alpha_1 + \sin\alpha_2\right) \text{ --- (vi)}$$

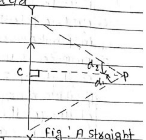

Fig: A straight wire.

This is the value of magnetic field due to a finite straight conductor.

Where, k is proportionality constant and $\mu_0 = 4\pi\times10^{-7}$ H/m is called the permeability of the free space or vaccum.

The total magnetic field 'B' due to current flowing through a conductor at any point 'p' is given by,

$$B = \int \Delta B = \int \frac{\mu_0}{4\pi}\,\frac{I\Delta l \sin\alpha}{r^2}$$

$$\therefore B = \frac{\mu_0}{4\pi}\int \frac{I\Delta l\sin\alpha}{r^2} \text{ ---- (ii)}$$

#. Application of Boit and savart law:

a) Magnetic field at the centre of narrow circular coil?

⇒ Suppose a narrow circular coil of radius 'r' having N-turns. The magnetic flux density 'ΔB' at the centre 'O' of the circular coil due to its small element 'Δl' is given by

$$\Delta B = \frac{\mu_0}{4\pi}\,\frac{I\Delta l\sin\alpha}{r^2}$$

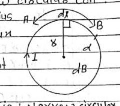

Fig: Narrow circular coil.

Since, $\alpha = 90^\circ$

$$\Delta B = \frac{\mu_0 I \Delta l}{4\pi r^2} \qquad (\because \sin\alpha = \sin 90 = 1)$$

Thus, the total magnetic field 'B' at the centre 'O' of narrow circular coil is,

$$B = \int dB = \int_0^{2\pi r N} \frac{\mu_0}{4\pi}\,\frac{I dl}{r^2} \qquad \boxed{\Delta B = dB,\ \Delta l = dl,\ \Delta B = B}$$

$$= \frac{\mu_0}{4\pi}\int_0^{2\pi r N}\frac{I dl}{r^2}$$

$$= \frac{\mu_0}{4\pi}\,\frac{I}{r^2}\int_0^{2\pi r N} dl$$

$$= \frac{\mu_0}{2\pi}\,\frac{I}{r^{2}}\, \pi r N$$

$$\therefore B = \frac{\mu_0 I N}{2r} \text{ ———— (i)}$$

current flowing through the resistance 'R' and 'Ig' be the current flowing through the galvanometer 'G'.

Applying kirchhoff's current law at the juction 'A' we have, $\therefore I = I_1 + I_2$ ......(iii)

In closed mesh ABDA, Applying kirchhoff's voltage law, we have, $\therefore I_1P + I_gG - I_2R = 0$ --- (iv)

Similarly, in closed mesh BCDB Applying KVL, we have,

$$\therefore (I_1 - I_g)Q - (I_2 + I_g)S - I_gG = 0 \text{ --- (v)}$$

If the resistance in the circuit are suitably adjusted the current following through the galvanometer can be made zero, i.e. $I_g = 0$. This is the balancing condition of wheatstone bridge. For this potential difference across B and D must be zero.

With $I_g = 0$, the equation (iv) becomes,

$$I_1P - 0 - I_2R$$

$$\therefore I_1P = I_2R \text{ ······ (vi)}$$

With $I_g = 0$, the equation (v) becomes,

$$(I_1 - 0)Q - (I_2 + 0)S - 0.G = 0$$

$$\therefore I_1Q - I_2S = 0 \text{ ------ (vii)}$$

From equation (vi) & (vii) we get,

$$\frac{I_1P}{I_1Q} = \frac{I_2R}{I_2S}$$

$$\therefore \frac{P}{Q} = \frac{R}{S} \text{ ------ (viii)}$$

this is the blancing condition of the wheatstone bridge.

If 'F_0' be the theshould frequency of light for a given metal, the work function 'ϕ' becomes.

$$\phi = hF_0$$

thus, above equation (iii) can be written as,

$$hF = \frac{1}{2}mv^2 + \phi$$

$$hF - \phi = \frac{1}{2}mv^2$$

$$hF - hF_0 = \frac{1}{2}mv^2$$

$$h(F - F_0) = \frac{1}{2}mv^2 \text{ ···· ——— (iv)}$$

If λ and λ_0 be the wave length of the incidient photon and the wave length corresponding to the theshold frequency respectively then,

$$F = \frac{c}{\lambda}$$

and, $$F = \frac{c}{\lambda_0}$$

where, 'c' is the velocity of light in vaccum.

Hence, $$\frac{1}{2}mv^2 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) \text{ ——— (v).}$$

This is another form of Einsten's photoelectric equation this equation also gives the maximum k.E of the photoelectric equation

$$\text{i.e. } (k.E.)_{max} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda}\right) \text{ ---- (vi)}$$

Therefore, the total work done in moving a unit positive charge from point Q to p is.

$$W_{Qp} = \int_R^r dw.$$

$$= -\int_R^r \frac{1}{4\pi\varepsilon_0}\,\frac{q}{x^2}\times dx$$

$$= -\frac{q}{4\pi\varepsilon_0}\int_R^r x^{-2}\,dx$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[\frac{x^{-2+1}}{-2+1}\right]_R^r$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[\frac{x^{-1}}{-1}\right]_R^r$$

$$= -\frac{q}{4\pi\varepsilon_0}\left[-\frac{1}{x}\right]_R^r$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{R}\right]$$

$$\therefore W_{Qp} = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r} - \frac{1}{R}\right)$$

By the difinition, the potential difference between two points p and Q is,

$$\Delta V = V_{pQ} = W_{Qp}$$

$$\therefore \Delta V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r} - \frac{1}{R}\right)$$

This gives the value of potential difference between two points p and Q.

Now, the total work done in moving a unit positive charge from infinity to that point 'p' is.

$$W_{\infty p} = \int_\infty^r dw.$$

$$= -\int_\infty^r \frac{1}{4\pi\varepsilon_0}\,\frac{q}{x^2}\,dx$$

$$= -\frac{q}{4\pi\varepsilon_0}\int_\infty^r \frac{1}{x^2}\,dx$$

$$= \frac{-q}{4\pi\varepsilon_0}\int_\infty^r x^{-2}\,dx$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[\frac{x^{-2+1}}{-2+1}\right]_\infty^r$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[\frac{x^{-1}}{-1}\right]_\infty^r$$

$$= \frac{-q}{4\pi\varepsilon_0}\left[-\frac{1}{x}\right]_\infty^r$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{r} - \frac{1}{\infty}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\,\frac{1}{r}$$

$$\therefore W_{\infty p} = \frac{1}{4\pi\varepsilon_0}\,\frac{q}{r} \text{ ———— (ii).}$$

By definition, the value of electric potential at the point 'p' is

$$V = W_{\infty p}$$

$$\therefore V = \frac{1}{4\pi\varepsilon_0}\,\frac{q}{r} \text{ ——— (iii)}$$

This gives the value of electric potential due to a point charge at the point 'p'.

$$\frac{dN}{N} = -\lambda dt$$

On integrating, we get,

$$\int\frac{dN}{N} = -\lambda\int dt$$

$$\text{or, } \ln N = -\lambda t + c \text{ ———— (ii)}$$

Where, c is the constant of integration.

At first $t = 0$

$N = N^0$ (intial number of atom).

$$\ln N^0 = 0 + c$$

$$\ln N^0 = c$$

On substitution, equation (ii) becomes.

$$\ln N = -\lambda t + \ln N^0$$

$$\ln N - \ln N^0 = -\lambda t \qquad \left(\because \log x - \log y = \log\frac{x}{y}\right)$$

Taking antilog on both side we get,

$$\text{or, } \frac{N}{N_0} = e^{-\lambda t}$$

$$\therefore N = N^0 e^{-\lambda t} \text{ ———— (III)}$$

This equation gives the radioactive disintegration law and indicates that radioactive substance decreses with time.

#. Types of radioactivity are given below:

i) Natural Radioactivity:

⇒ The radioactivity exhibited by elements found in nature is called natural radioactivity.

⇒ The heavier elements found in periodic table always show this types of radioactivity.

b) Artificial Radioactivity:

⇒ The radioactivity induced in an element by means of external agency is called artificial radioactivity.

$$W = \frac{YA}{L}\cdot\left(\frac{e^2}{2}\right)$$

$$\therefore W = \frac{YA}{L}\cdot\frac{e^2}{2}$$

This is equavalent to the elastic potential energy stored in the stretched wire. this may be written as,

$$E = W = \frac{YA}{L}\cdot\frac{e^2}{2}$$

$$\text{or, } E = \frac{1}{2}\left(\frac{YAe}{L}\right)\times e$$

$$\therefore E = \frac{1}{2}\times F\times e \text{ ———— (i)}$$

$$E = \frac{1}{2}\text{ maximum stretching force} \times \text{extension}$$

$$E = \text{average force} \times \text{extension.}$$

Again, equation (i) can be writen as,

$$E = \frac{1}{2}\times\frac{F}{A}\times\frac{e}{L}\times AL$$

$$\therefore E = \frac{1}{2}\times \text{stress} \times \text{strain} \times \text{volume of the wire.}$$

Energy density (Ed):

⇒ The energy stored per unit volume of wire is called energy density (Ed). and is given by.

$$Ed = \frac{\text{elastic potential energy}}{\text{volume}}$$

$$\therefore Ed = \frac{1}{2}\times \text{stress} \times \text{strain.}$$

What do you mean by elastic limit?

⇒ Elastic limit is the maximum extent to which a solid may be stretched withouth permanent alternation of shape or size. In other words, elastic limit is maximum stress or force per unit area within a solid material that can arise before the onset of permanent deformation.

Ans: Laplace correction:

⇒ While deriving the above Newton's formula, Newton assumed that the propagation of sound take a place in the isothermal condiction. However according to Laplace the propagation of sound should take place in the adiabatic condition. since the adiabatic equation of state is,

$$PV^\gamma = \text{constant.}$$

$$\text{or, } d(PV^\gamma) = d(k)$$

$$\text{or, } Pd(V^\gamma) + V^\gamma dP = 0$$

$$\text{or, } P\gamma V^{\gamma-1}\cdot dV + V^\gamma dP = 0$$

$$\text{or, } P\gamma V^{\gamma-1}\cdot dV = -V^\gamma dP$$

$$\text{or, } P\gamma = \frac{-V^\gamma dP}{V^{\gamma-1}\cdot dV}$$

$$\text{or, } P\gamma = -\frac{\cancel{V^\gamma}\, dP}{\cancel{V^\gamma}\cdot V^{-1} dV}$$

$$\text{or, } P\gamma = \frac{-dP}{V^{-1}dV}$$

$$\therefore P\gamma = \frac{-dP}{dV/V} = \frac{\text{stress}}{\text{strain}} = -k_{adi} \text{ ···· (II)}$$

where, k_{adi} is the adiabatic bulk modelus of elasticity Negative sign indicates that as the pressure is increases it's volume is decreases or vice-versa.

Hence, the Laplace equation for velocity of sound is given by,

$$V = \sqrt{\frac{k_{adi}}{\rho}} = \sqrt{\frac{P\gamma}{\rho}} \text{ ——— (II)}$$

$\gamma = 1.4$ and is called ratio of specific heat.

Now, these value equation (II) be-comes.

$$V = \sqrt{\frac{1.013\times10^5\times1.4}{1.293}} \Leftarrow \sqrt{\frac{P\gamma}{\rho}}$$

$$\therefore V = 331\text{ ms}^{-1}$$

This value agree with experimental value.