Hall effect ~~in~~ in metals

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* **Hall effect:-** When a magnetic field is applied perpendicular to a conductor carrying current, a voltage is developed accross the specimen in a direction perpendicular to both current and magnetic field. This phenomena is known as Hall effect.

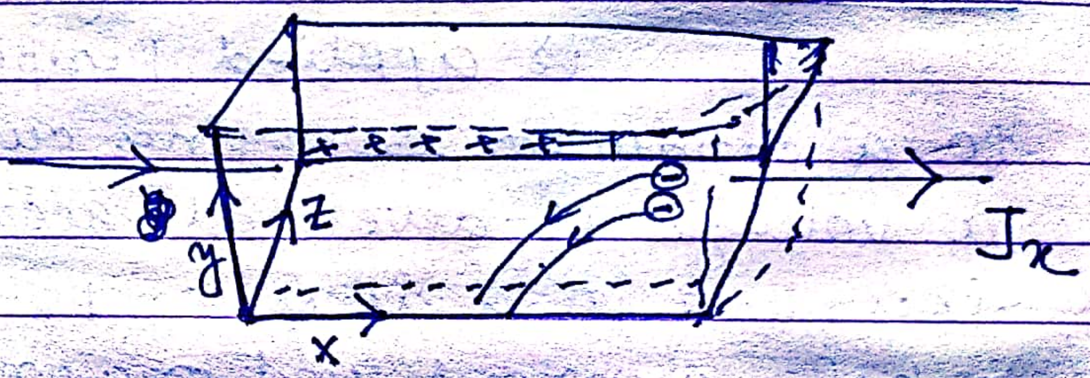
This developed voltage in Hall effect is known as Hall voltage.

* **Hall coefficient:-** Hall ~~effect~~ Coefficient is defined as the ratio of the electric field strength produced per unit current density to the transverse magnetic field

i.e $$R_H = \frac{E_H / J_x}{B_z} = \frac{E_H}{J_x B_z}$$

So unit of R_H is $\frac{\text{Volt.meter}}{\text{Amp. web/m}^2} = \text{Volt.m}^3 / \text{Amp} / \text{wb}$

Derivation of R_H :-



Let The current is flowing along x-direction

magnetic field is along Z-direction so a Hall field must be developed along "-y" direction

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Let the charge carrier is electron so the force on it (electric)

$$\vec{F} = -e\vec{E}$$

and magnetic force

$$\vec{F} = -e(\bar{v} \times \bar{B})$$

∴ Total force

$$\vec{F} = -e\bar{E} - e(\bar{v} \times \bar{B})$$

now $\vec{v} = -\hat{i} v_x$

and $\vec{B} = \hat{k} B_z$

at steady state, net force on electron should be zero.

at this situation electric field is called as Hall field

$$\therefore 0 = -e\vec{E}_H - e(-\hat{i} v_x \times \hat{k} B_z)$$

$$\therefore \vec{E}_H = v_x B_z (\hat{j})$$

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$$\vec{E}_H = v_x B_z (-\hat{j})$$

$$\therefore E_H = v_x B_z$$ → and its direction is along '-y' direction

Now $\vec{J}_x = n(-e)\vec{v}$

$$\vec{J}_x = n(-e)\, v_x (-\hat{i})$$

$$= n e v_x \hat{i}$$

$$\therefore J_x = n e v_x$$ → along +x direction

$$\therefore \frac{E_H}{J_x} = \frac{-v_x B_z}{n e v_x}$$

$$\therefore R_H = -\frac{1}{ne}$$ → For electron

Similarly if the charge carrier be hole Then $R_H = \frac{1}{ne}$

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Hall mobility :-

The drift velocity produced per unit electric field due to Hall effect is called Hall mobility

Expression :

$$J_x = ne v_x$$

Now conductivity

$$\sigma = \frac{-J_x}{E_x}$$ as

- ve sign arises ~~due to~~ (as) the charge carrier is electron

$$\sigma = -\frac{ne v_x}{E_x}$$

$$\sigma = -ne\mu$$

$$\therefore \mu = \left(-\frac{1}{ne}\right)\sigma = R_H \sigma$$

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Importance of the Hall effect :-

1. The sign of the current carrying charge is determined.

2. From the magnitude of the Hall ~~co~~ coefficient the number of charge carrier per unit volume can be calculated.

3. The mobility is measured directly.

4. It can be decided whether the material is metal, semiconductor or insulator.