

This effect was discovered by Edwin Hall 1879

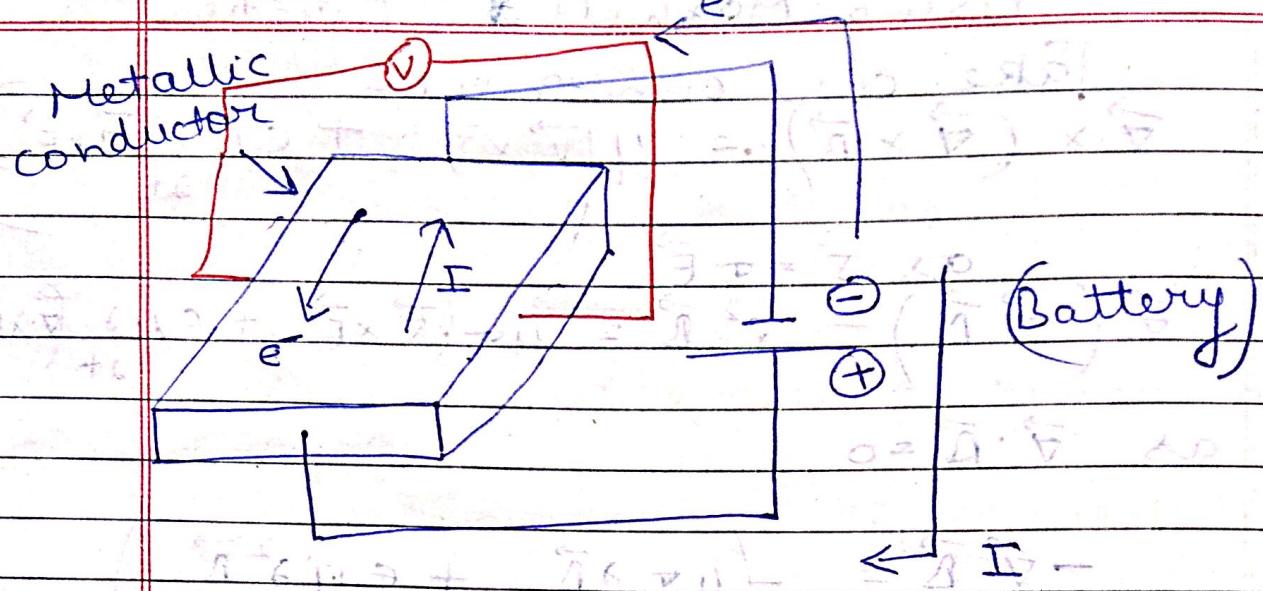
⇒ It is related to the behavior of moving charges in magnetic field

Hall effect

Let us consider a metallic conductor

Now the metallic conductor is connected to battery

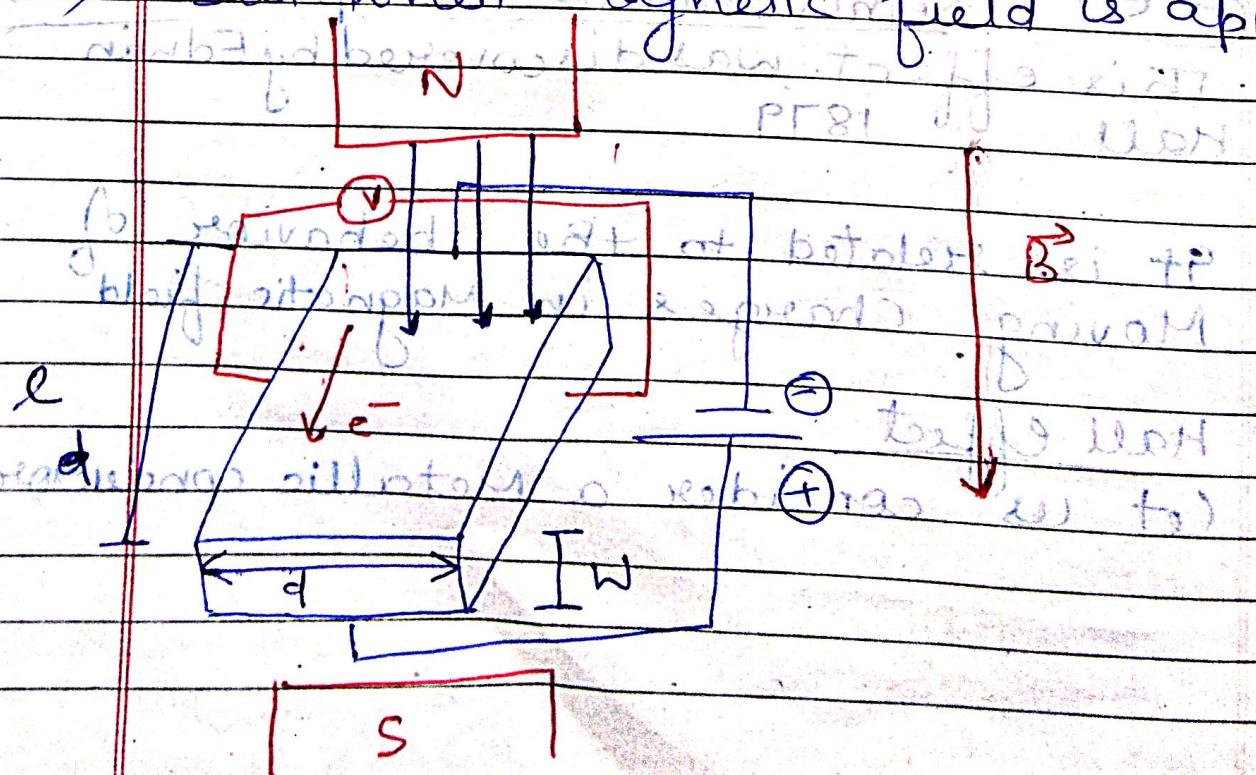
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⇒ When battery is connected to current starts flowing in the direction opposite to the flow of electrons

⇒ and when voltmeter is connected across the two ends of the conductor the Potential difference comes out to be zero

⇒ But when Magnetic field is applied



As we know that magnetic field lines goes from North Pole to South Pole

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In that case we find a certain potential difference.

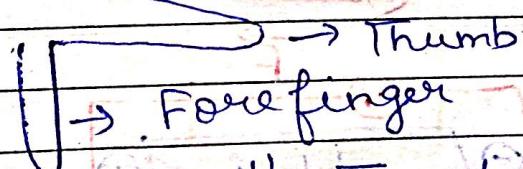
This voltage is called Hall voltage
This is Hall effect

Reason

when charge particle moves in a magnetic field a force will act on it
This force is called Lorentz Force

Direction of Lorentz Force

The direction of Lorentz Force is given by Fleming's left hand rule



If your left hand's thumb, forefinger and middle finger all are \perp to each other.

If forefinger represent Magnetic field

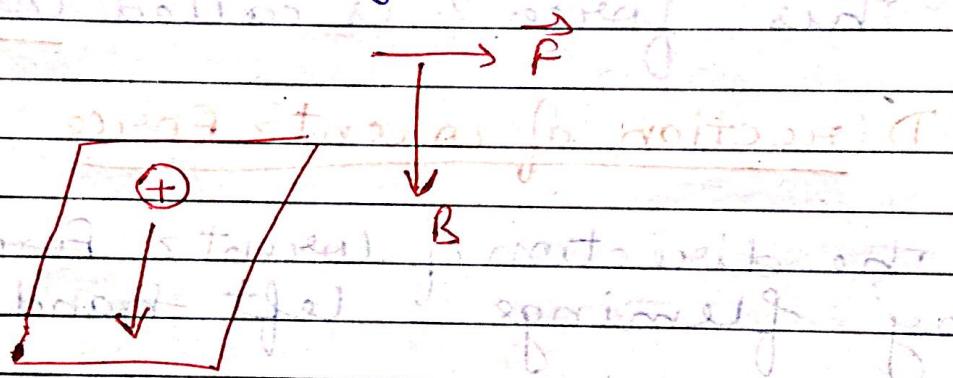
and middle finger represent the velocity (direction) of charge

Point to be Remember

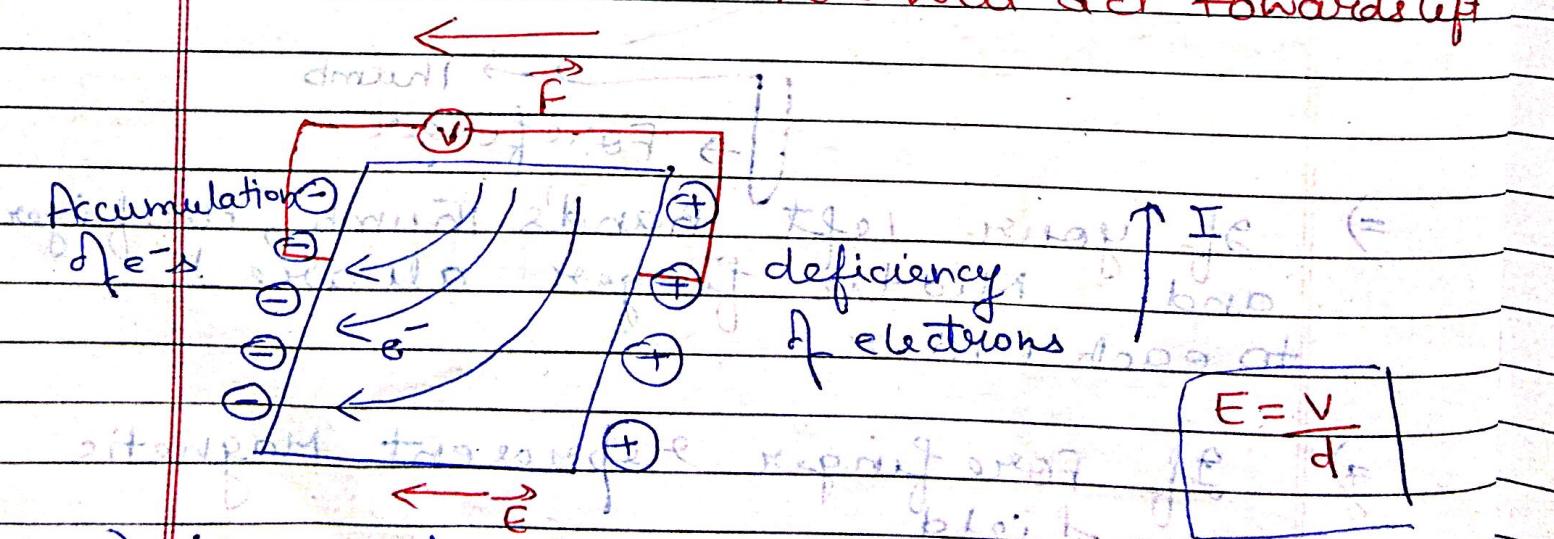
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But here is one imp thing to Notice

that Flemings left hand rule
the Middle finger gives the direction of velocity of +ve charge
So here in the Hall effect we are dealing with the movement of electrons
Therefore the direction given by the Middle finger will be for +ve charge
So we will consider the opposite direction automatically in order to find the direction of -ve charge.



But for electron for will act towards up



\Rightarrow Hence if we attach a voltmeter across Two end then it will give some Potential difference

Hall Effect

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The Production of Potential difference across the electrical conductor transverse to electric current in the conductor and to the applied Magnetic field

Force acting on electron

$$\vec{F} = q(\vec{v} \times \vec{B}) \quad \text{--- (1)}$$

$$\vec{E} = \frac{\vec{F}}{q} \quad \text{--- (2)}$$

→ We know that

$\Rightarrow \vec{F} = q\vec{E}$ (relationship between force and electric field)

$$q\vec{E}_H = -e(\vec{v} \times \vec{B})$$

$$\vec{E}_H = \vec{v} \times \vec{B} \quad \text{--- (2)}$$

$$\begin{cases} \vec{A} \times \vec{B} = AB \sin \theta \\ \vec{v} \times \vec{B} = vB \sin \theta \end{cases}$$

θ is angle b/w \vec{v} and \vec{B}

Here $\theta = 90^\circ$

$$\Rightarrow \sin 90^\circ = 1$$

Eq (2) will become

$$E_H = vB = \frac{V}{d} \quad \text{--- (3)}$$

$$E_H = \nu B = \frac{V_H}{d}$$

$$V_H = \nu B d \rightarrow \text{Hall effect} \quad - (4)$$

$$\text{we know that } I = q/t \quad - (5)$$

$$\text{Now } q = Ne$$

N = No. of electrons in a conductor

e = charge of each electron

$$\text{Now we know that } n = \frac{N}{V}$$

where n = no. density of e^- (No. of e^- s per unit volume)

$$\Rightarrow N = nv \quad (\text{Explain})$$

Put all the values in eqn (5)

$$I = nAve \quad - (6)$$

Now ve is velocity

so eqn (6) will become

$$I = nAve$$

$$I = nAdve$$

$$vd = \frac{I}{nAe} \quad - (7)$$

By putting eqn ① in eqn ④

we get

$$V_H = \frac{IB}{ne}$$

$$V_H = \frac{IB}{w} \quad (1)$$

where $\frac{1}{w} = R_H = \text{Hall coefficient}$

$$\boxed{V_H = \frac{IBR_H}{w}} \quad (8)$$

Mobility of moving e^- inside conductor

\Rightarrow As e^- is moving inside the conductor so mobility define how easily it can move

$$M = ne \mu$$

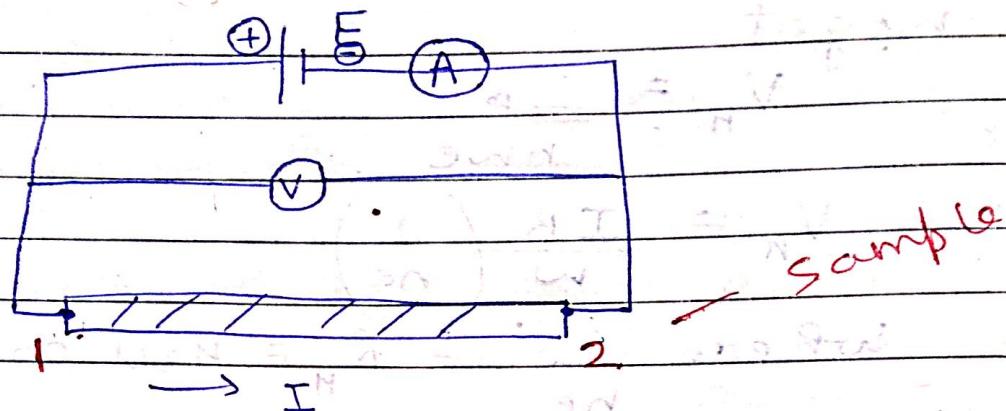
$$\mu = ne(R_H)$$

$$\boxed{\mu = ne + R_H}$$

Resistivity $\rho = \frac{1}{\mu}$

Four Probe MethodTwo Probe Method

Probe → A Point metal tip for making electrical contact with circuit



A be the cross sectional area

l be the length of wire

$$V = IR \rightarrow \text{Ohm's Law}$$

$$R = \frac{fl}{A}$$

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

⇒ Two Probe Method is used to find the resistivity of the material

⇒ Here we have a long thin wire of uniform cross sectional area connected to a battery E such that I be the current flowing through the wire

Drawbacks of two Probe Method

Major Problem in this Method is error due to contact Resistance of Measuring wire

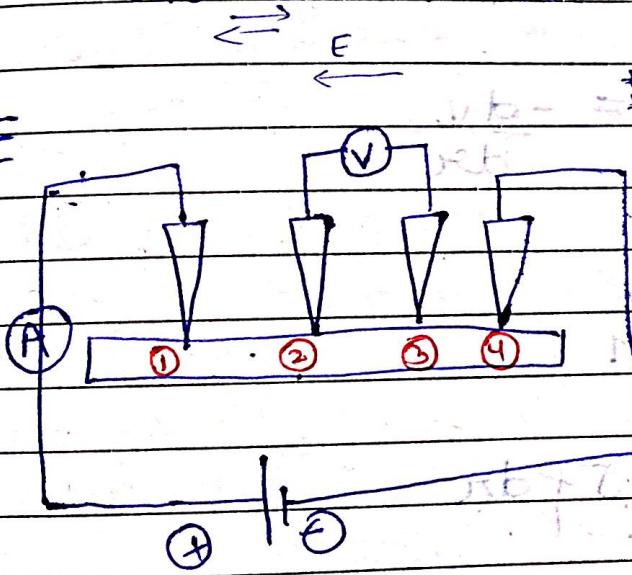
This Method cannot be used for

Material having random shapes.

(3) The heating of sample due to soldering results in injection of impurities into the material thereby affecting its resistivity.

Four Probe Method

Here we consider four equally spaced tungsten metal tip. Each tip is supported by spring at the back to minimize the sample damage.



- Current enters through Probe 1 and leaves through Probe 4
- Pointed Tip of Metal is used in order to avoid contact resistance

$S \rightarrow$ Distance b/w Probe 1 and 2

$S_1 \rightarrow$ Distance b/w Probe 2 and 3

$S_2 \rightarrow$ Distance b/w Probe 3 and 4

$$\textcircled{1} \quad V = \frac{I}{2\pi r}$$

\Rightarrow Current starting spreading Radially

$$J = \frac{I}{\text{Area}} = \frac{I}{2\pi r^2}$$

(Area of ring $2\pi r^2 \Delta r$ (Area) Half sphere

Radius r)

$$E = J_f = -\frac{dv}{dr}$$

$$J_f = -\frac{dv}{dr}$$

$$v \frac{dv}{dr} = -J_f dr$$

$$\int_0^r dv = - \int \frac{I_f}{2\pi r^2} dr$$

$$\int_0^r dv = - \frac{I_f}{2\pi} \int \frac{dr}{r^2}$$

$$V_b = -\frac{I_f}{2\pi} \left(-\frac{1}{r} \right)$$

$$V = \frac{I_f}{2\pi r}$$

Voltage across Probe 2

$$V_2 = \frac{I_f}{2\pi} \left[\frac{1}{s_1} - \frac{1}{s_1+s_2} \right]$$

Voltage across Probe 3

$$V_3 = \frac{I_f}{2\pi} \left[\frac{1}{s_1+s_2} - \frac{1}{s_3} \right]$$

Voltage drop across Probe 2 and 3

$$V = V_2 - V_3 = \frac{I_f}{2\pi} \left[\frac{1}{s_1} - \frac{1}{s_1+s_2} - \frac{1}{s_1+s_2} + \frac{1}{s_3} \right]$$

Since Probes are at Equal distance

$$s_1 = s_2 = s_3 = s_4 \text{ ss}$$

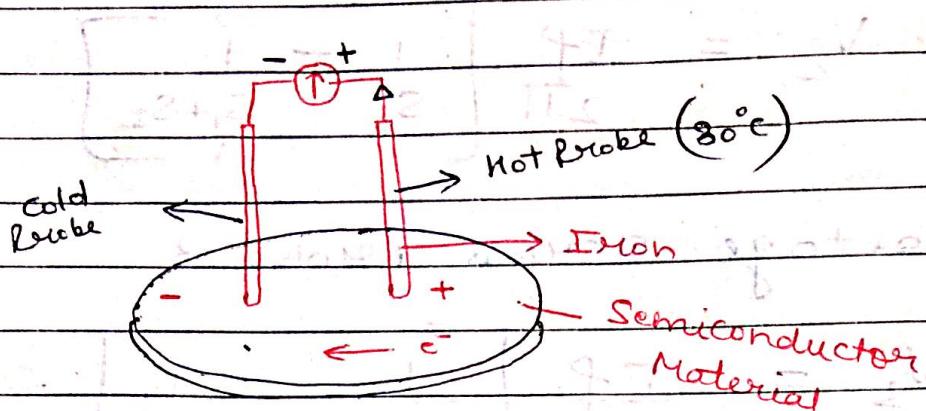
$$V = \frac{I_f}{2\pi} \left[\frac{1}{s} - \frac{1}{2s} - \frac{1}{2s} + \frac{1}{s} \right]$$

$$V = \frac{I_f}{2\pi} \left[\frac{\frac{2}{s}}{s} - \frac{1}{s} \right]$$

$$V = \frac{I_f}{2\pi s}$$

$$P = \frac{V \times 2\pi s}{I}$$

Hot Point Probe Method



- ① This is simple method used to determine the type of semiconductor (whether n-type or p-type).
- ② Two fine Metal (Iron) Probes are placed on the Semiconductor and a galvanometer of Multimeter is placed between them.
- ③ One probe is kept at room Temperature that is cold end and the other is heated to about 80°C (Hot end).
- ④ The Probe heats the Semiconductor thus the K.E of the carriers increase and the charge carrier will start diffusing.
- ⑤ All the produces deflection in galvanometer or give +ve reading / -ve reading on the Multimeter depending on the Type of Semiconductor.
- ⑥ The voltage produced is called Thermo voltage and the current flows is called thermo-current.
- ⑦ If the Semiconductor is n-type, electrons will move away from the hot probe towards the cold probe so that the hot probe acquires positive charge w.r.t the cold probe and the current flows in the

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counter clockwise direction i.e galvanometer deflects towards left. In a p-type Semiconductor the holes move away from the hot probe towards the cold probe so that the hot probe acquires negative charge w.r.t the cold probe and the current flows in the circuit in the clockwise direction in the direction of current flow.