Tanmay Singh

Date : ....

E20CSE035

Experiment - 10

Hall Effect

Aim →

* To study hall effect in semiconductor sample and determine the hall coefficient and density of charge carriers. This experiment demonstrates the effect of Lorentz force.

Apparatus :- Two solenoids, constant source of power to maintain magnetic field, Hall probe with semiconductor sample, constant current supply with ammeter and voltmeter, Gauss meter.

Formula Used →

$$R_H = \frac{E_y}{IB} = \frac{V_H d}{IB} \quad \text{—} (1)$$

$$V_H = \frac{R_H B I}{d} \quad \text{—} (2)$$

$$\boxed{\begin{aligned} m &= R_H B/d \\ R_H &= md/B \end{aligned}} \quad \text{—} (3)$$

$$\boxed{R_H = \frac{1}{qn}} \quad \text{—} (4)$$

$n \rightarrow$ carrier density in the semiconductor

$V_H \rightarrow$ Hall Voltage

$R_H \rightarrow$ Hall coefficient

$I \rightarrow$ current

$E_y \rightarrow$ Electric field (transverse)

$q \rightarrow$ charge of the carrier

$m \rightarrow$ slope

Table 1:-

* Data for calculating R_H and density of charge carrier for Ge subjected to a fixed mag. field.

* Parameters →

(a) Current through the solenoid = 1 A
(b) Resultant magnetic field (B) = 0.1482 T
(c) Thickness of the material (d) = 0.0001 m
(d) Charge of the carrier (|q|) = 1.602×10^{-19} C

S.No.	Hall Current I_1 (mA)	Hall Voltage V_H (mV)	Hall coefficient (R_H) $\left(\frac{\Omega m}{T} \text{ or } \frac{m^3}{C}\right)$ (from eqn 3)	Density of Charge n ($1/m^3$) [from eqn (4)]
1	1.0	28.756		
2	1.5	43.133		
3	2.0	57.511	0.0194	3.21763
4	2.5	71.889		×
5	3.0	86.267		10^{20}
6	3.5	100.645		
7	4.0	115.023		

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Table 2:-

Current through the solenoid = 2.5 A

Resultant magnetic field (B) = 0.3706 T

Thickness of the material (d) = 0.0003 m

Charge of the carrier (|q|) = 1.602×10^{-19} C

S. No.	Hall Current I (mA)	Hall Voltage V_H (mV)	Hall coefficient, R_H ($\frac{\Omega m}{T}$ or $\frac{m^3}{C}$) (from slope, eqn ③)	Density of charge n ($1/m^3$) from eqn ④
1	1.0	23.963		
2	1.5	35.945	0.0194	3.2176 × 10^{20}
3	2.0	47.926		
4	2.5	59.908		
5	3.0	71.889		
6	3.5	83.871		
7	4.0	95.852		

Calculations →

Table 1 →

$x_1 = 1.0 \times 10^{-3} A$ $\quad$ $y_1 = 28.76 \times 10^{-3} V$

$x_2 = 2.0 \times 10^{-3} A$ $\quad$ $y_2 = 57.51 \times 10^{-3} V$

$$\text{Slope } (m) = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{(57.51 - 28.76) \times 10^{-3}}{(2.0 - 1.0) \times 10^{-3}}$$

$$\boxed{m = 28.75}$$

Hall Coefficient (R_H):

$$R_H = \frac{md}{B}$$

$$= \frac{28.75 \times 0.001}{0.1482}$$

$$R_H = 0.0194 \ \Omega m/T$$

Density of Charge Carrier (n):

$$n = \frac{1}{R_H q} = \frac{1}{0.0194 \times 1.602 \times 10^{-19}}$$

$$n = 3.21763 \times 10^{20} \ m^{-3}$$

Calculation for Table 2 →

$x_1 = 1.0 \times 10^{-3}$ A ; $y_1 = 23.96 \times 10^{-3}$ V
$x_2 = 2.0 \times 10^{-3}$ A ; $y_2 = 47.93 \times 10^{-3}$ V

$$\text{Slope } (m) = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{47.93 - 23.96}{2.0 - 1.0} \times \frac{\cancel{10^{-3}}}{\cancel{10^{-3}}}$$

$$\boxed{m = 23.97}$$

Hall coefficient (R_H):

$$R_H = \frac{md}{B} = \frac{23.97 \times 0.0003}{0.3706}$$

$$R_H = 0.0194 \ \Omega m / T$$

Density of charge carrier (n):

$$n = \frac{1}{R_H q}$$

$$= \frac{1}{0.0194 \times 1.602 \times 10^{-19}}$$

$$n = 3.21763 \times 10^{20} \ m^{-3}$$

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Result →

Mean $R_H = 0.0194 \ \Omega m/T$

Mean $n = 3.21763 \times 10^{20} \ m^{-3}$

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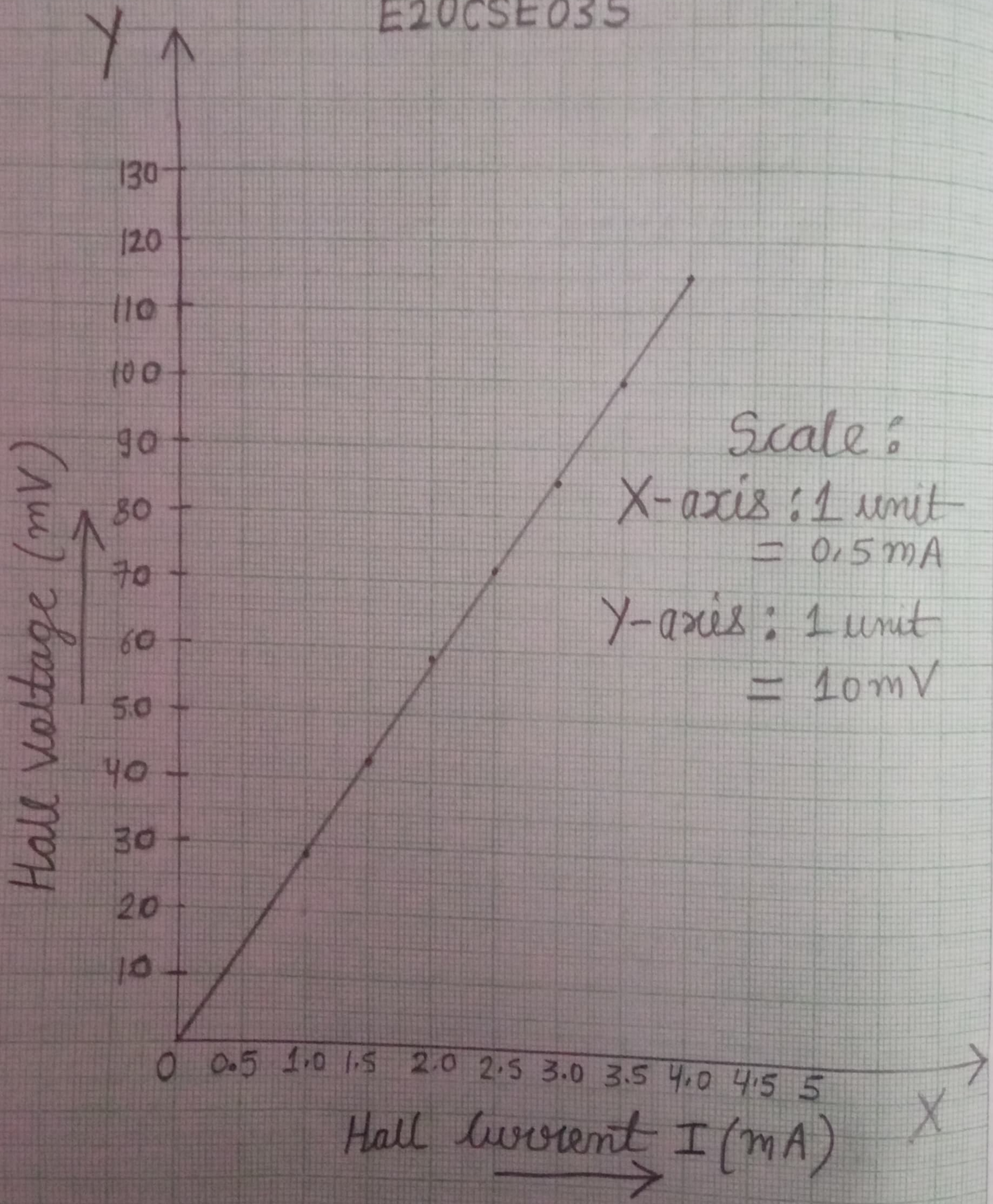

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Scale:

X axis : 1 unit : 0.5 mA

Y axis : 1 unit : 10 mV