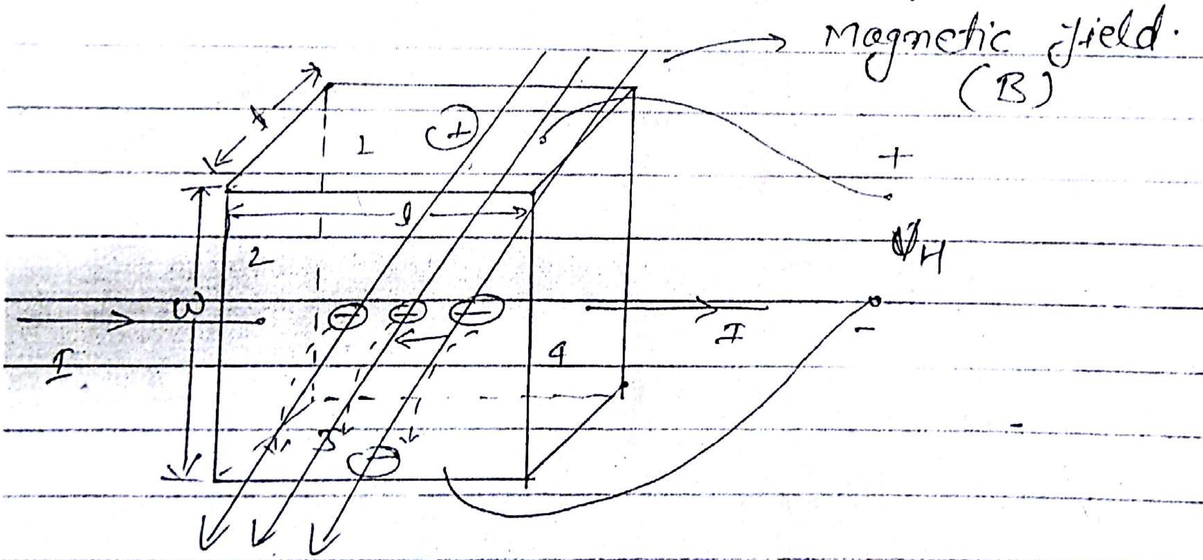
HALL SENSOR :-

Hall sensors works on the principale Hall effect.

Hall Effect :-

If a charged particle is placed in a magnetic field, it deviates from its original path and acquires a new path.



Consider a conducting block as shown above.

current density :-

$$J = \frac{I}{A} = \frac{N \cdot e}{A \cdot t}$$

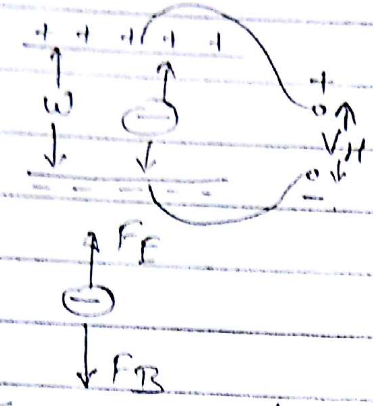
$$= \frac{N e \times l}{A \cdot l \times t} = \frac{N \cdot e}{V} \times v$$

$$J = \frac{I}{A} = n e v \longrightarrow (1)$$

velocity

Force acting on charged Particle :-

(Magnetic force) $F = e V B \longrightarrow (2)$ $\quad V \times B \rightarrow \theta = 90°$ here.



at steady state :

$$F_E = F_B$$

$$\not{e}\left(\frac{V_H}{\omega}\right) = \not{e} V B$$

$$V_H = \omega \cdot V \cdot B$$

Force Acting on charged Particle :-

$$V_H = \not{\omega} \times \frac{I}{\not{\omega} \cdot t \cdot n q} \times B$$

$A \leftarrow \omega \cdot t$

(Electric force) $F = eE$

$$F = e\left(\frac{V_H}{\omega}\right) \longrightarrow (3)$$

$$V_H = \frac{1}{nq} \cdot \frac{IB}{t}$$

$$V_H = K_H \cdot \frac{IB}{t}$$

☆ $$V_H = K_H \cdot \frac{\vec{I} \times \vec{B}}{t}$$

K_H = hall Coeff.

t = dimension of the conductor which is ||el to the magnetic field.

In case of Hall sensors the dir^n of current and magnetic field both are ⊥r to each other.
The developed Hall voltage will be always ⊥r to both current as well as magnetic field.
Hall effect can be observed both in conductors as well as semi-conductor.

(8) A constant magnetic field of 0.1 wb/m² is passed through a current carrying conductor in ⊥r dirⁿ, produces a voltage of 10 volt at steady state. If the thickness of the conductor is 0.1 m and magnitude of the current is 10 Amp then the Hall coeff. of the sensor is ____?

Solⁿ:→ $B = 0.1\ wb/m^2$ $V_H = 10V$, $t = 0.1m$, $I = 10A$

$K_H = ?$

$\because V = K_H \cdot \frac{IB}{t} \Rightarrow 10 = K_H \cdot \frac{10 \times 0.1}{0.1}$

$\Rightarrow K_H = 1$ unit Ans.

$\frac{V-m}{A \cdot \left(\frac{wb}{m^2}\right)}$

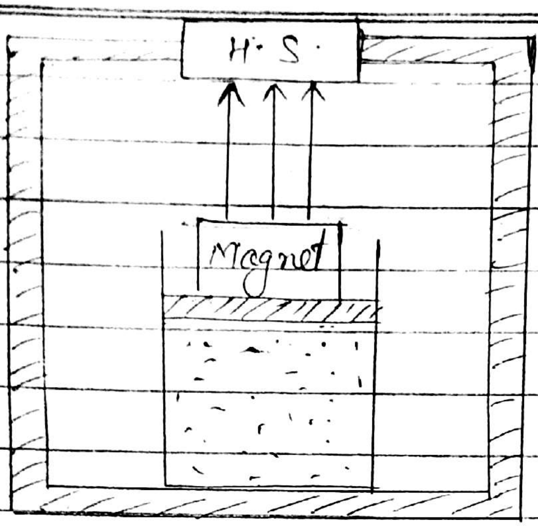
speed of shaft
↑ → Br. load

$V_H = f(I, B, t)$

(8) For the liq. level measurement Hall sensor set up is used as shown below. The sensor carries a current of 2 Amp. ⊥r to the magnetic field. The magnetic field associated with sensor changes with the water level (h) as $B(h) = (0.2h + 0.1)\ wb/m^2$. If the output voltage of the Hall sensor is ⊥r to both applied magnetic field and current then find the magnitude of hall voltage if the water level ↑sed to 2 m from 0 m. Given that the thickness of the sensor is 0.1 m & the Hall coeff. is 1 unit?

Solⁿ:→ $B(h) = (0.2h + 0.1)\ wb/m^2$

$I = 2A$, $t = 0.1\ m$, $K_H = 1$ unit



@ $h = 0m$ (tank is empty)

$B(0) = 0.1 \ wb/m^2$

$V_H(0) = K_H \cdot \frac{I \cdot B(0)}{t}$

$V_H(0) = 1 \times \frac{2 \times 0.1}{0.1}$

$V_H(0) = 2V$ } ⇒ offset voltage.

i.e. when there is no input → still some voltage as output.

@ $h = 2m$

$B(2) = 0.2 \times 2 + 0.1$

$= 0.5 \ wb/m^2$

$V_H(2) = K_H \cdot \frac{I \times B(2)}{t} = 1 \times \frac{2 \times 0.5}{0.1}$

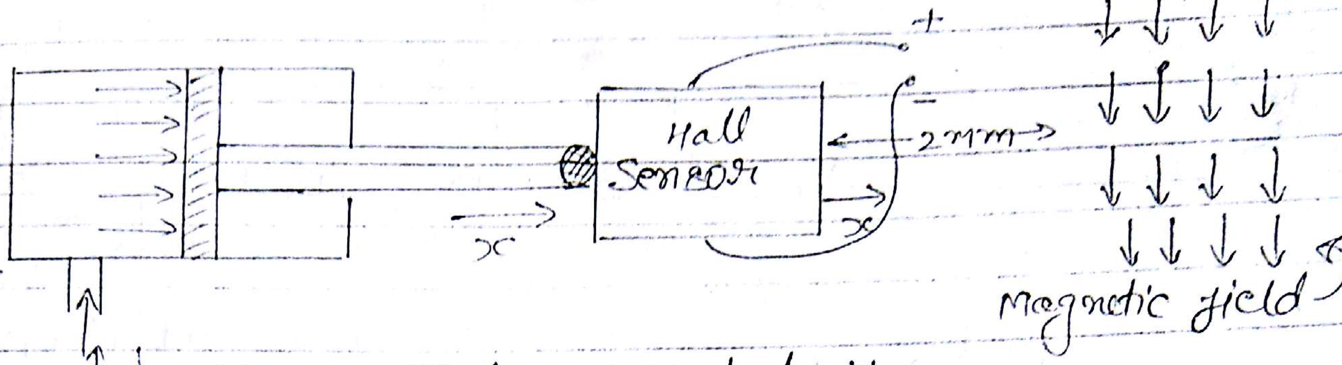
$V_H(2) = 10 V$

$h \propto B(h) \propto V_H$ → output is voltage → sensor.

(Q) Consider the following fig. where the gap b/w the cylinder & Hall sensor is assumed to be zero. If the cylindrical rod mechanism has a sensitivity of 1 mm / 10N, then find the minimum input pr. of the oil which acts on the Piston can generate the output voltage. The dia. of the Piston is 100 mm and the thickness of the hall sensor is 0.1 mm & Hall coeff. of the sensor is 10 units.

(i) Hall sensor carries a constant current of 2 Amp. and strength of the magnetic field is 5 wb/m² & the dirⁿ of the magnetic field is ⊥r to the dirⁿ of current?

Solⁿ:



$\frac{1mm}{10N}$

Voltage will be generated if

$x = 2mm$

$F = 20N$ ← force for 2mm.

$= \frac{F}{A_P}$

$= \frac{20}{\frac{\pi}{4}(100\times10^{-3})^2}$

$P = 2.546\ KPa$.

(ii) ~~To generate~~ In the above set up if the volumetric flow rate of the oil which enters into cylindrical chamber is 10 mm/sec, then find the minimum time after which voltage will be generated?

Sol^n:→ $Q = 10\ mm/sec$

$velocity = Q/A_P = \frac{10\times10^{-3}\times10^{-3}m^3}{\frac{\pi}{4}(100\times10^{-3})^2} = 1.27\times10^{-3}\ m/sec$

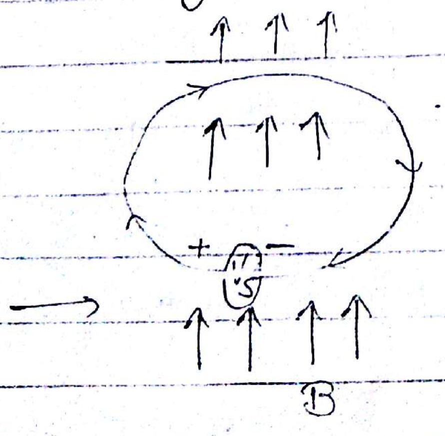
1 sec → 1.27 × mm

1.57 sec ← 2 mm

(or) $\frac{\pi}{4}(0.1)^2\times2 = 10\times mL\times10^{-3}\times t$

$t = 1.57\ sec$.

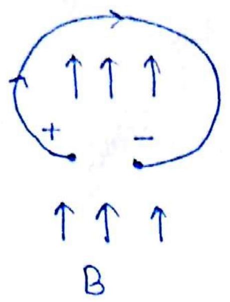
Electro-Magnetic Induction :-



$V_s(t) = -\frac{d\phi(t)}{dt}$

↑ Induced voltage. (ϕ → Magnetic field/Flux)

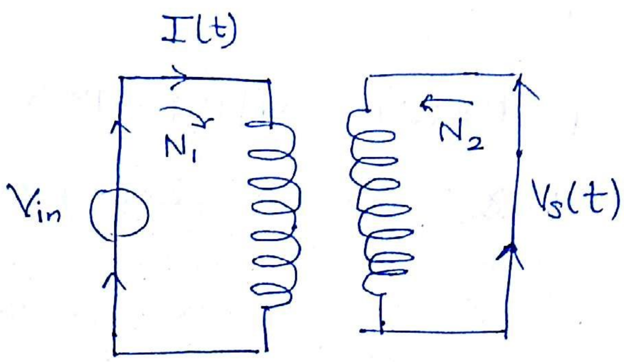
Electro - magnetic Induction



$$V_s(t) = -\frac{d\phi(t)}{dt}$$

↑ Induced Voltage

Transformer :-



$$V_s(t) \propto V_{in}(t)$$

$$V_s(t) = K\, V_{in}(t)$$

$$\frac{V_s(t)}{V_{in}(t)} = K = \frac{N_2}{N_1}$$

$N_2 < N_1$, $K < 1$ → Step down

$N_1 > N_2$, $K > 1$ → step up.