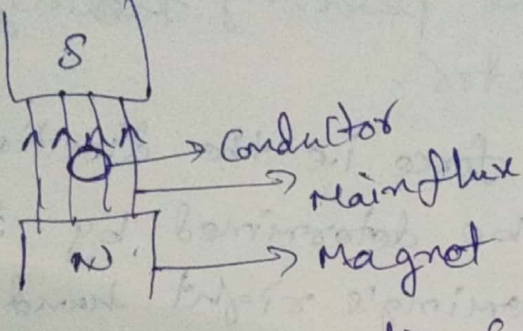
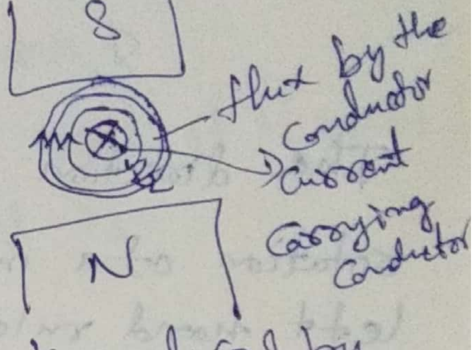
Principle of operation of D.C. Machine as a Motor:-

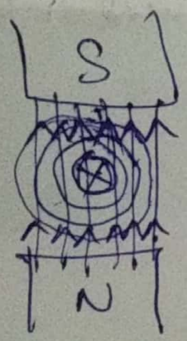
→ When a current carrying conductor is placed in a magnetic field, it experiences a mechanical force.



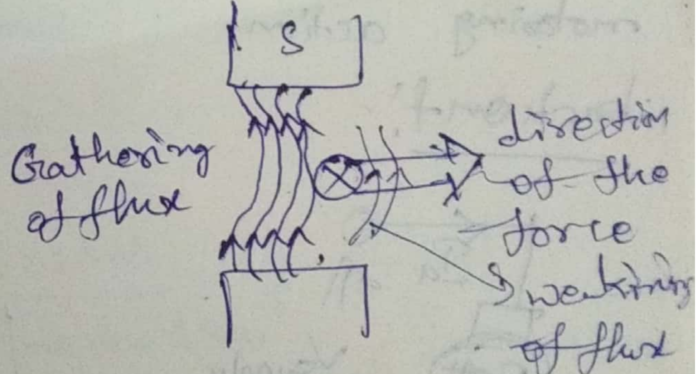
Conductor in a magnetic field



Flux produced by current carrying conductor.

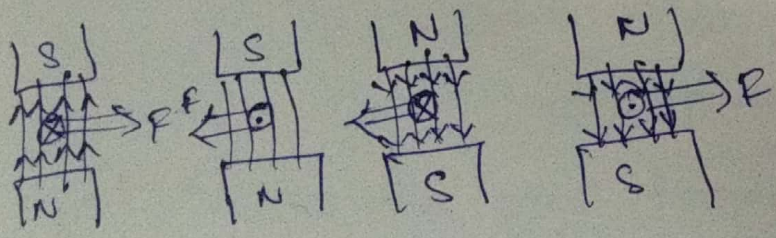


interaction of two fluxes

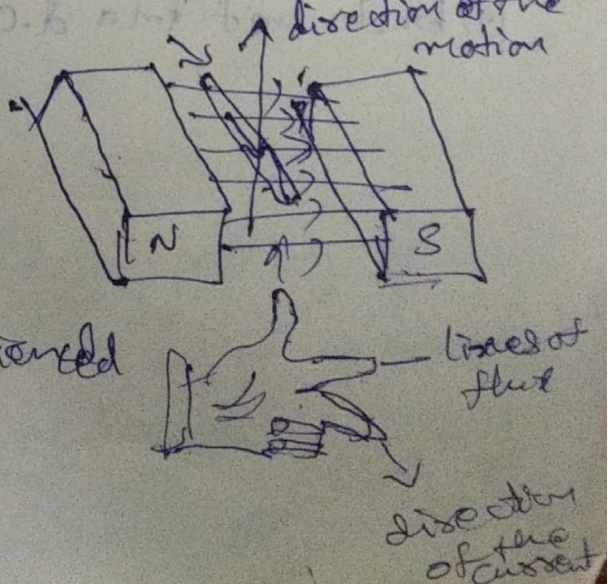


Force experienced by the conductor.

Fleming's left hand rule:-



direction of the force experienced by conductor.



the direction of Rotation of Motor:-

the magnitude of force experienced by the conductor in motor is $F = BlI$ Newtons

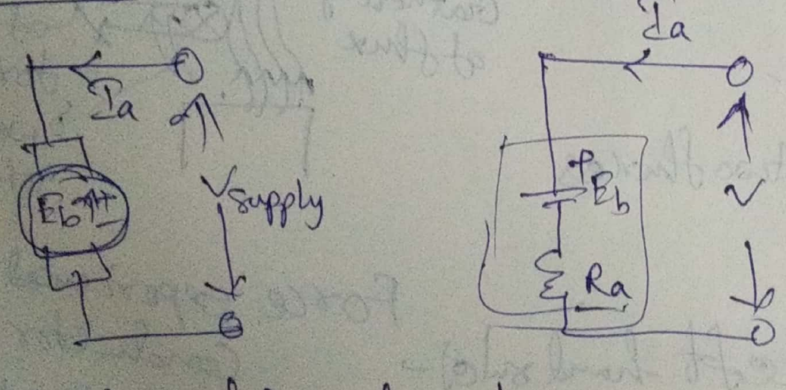
B = flux density due to the flux production by the field winding

l = A length of the conductor

I = current passing through the conductor.

The direction of such force i.e the direction of rotation of a motor can be determined by Flemings left hand rule. So Fleming's right hand rule. is to determine direction of induced emf i.e for generating action while Fleming's left hand rule is to determine direction of force experienced i.e for motoring action.

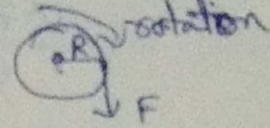
back emf:-



(a) back emf in a d.c motor

→ Torque equation of D.C. Motor:-

It is seen that the turning (or) twisting force about an axis is called torque.



Consider a wheel of radius 'R' meters acted upon the by a circumferential force 'F' newtons

the wheel is rotating at a speed of 'N' r.p.m then angular speed of the wheel is

$$\omega = \frac{2\pi N}{60} \text{ rad/sec}$$

So workdone in one revolution is

'W' = F × distance travelled in one revolution (perimeter)

$$W = F \times 2\pi R \text{ Jouls}$$

$$P = \text{Power developed} = \frac{\text{Workdone}}{\text{time}}$$

$$= \frac{F \times 2\pi R}{\text{time for 1 rev}} = \frac{F \times 2\pi R}{\frac{60}{N}}$$

$$= (F \times R)\left(\frac{2\pi N}{60}\right)$$

$$P = T \times \omega \text{ watts}$$

T = Torque in N-m

ω = Angular speed in rad/sec

Let T_a be the gross torque developed by the armature of the motor. It is also called armature torque. The gross mechanical power developed in the armature is $E_b I_a$.

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$$P = T \times \omega$$

$$E_b I_a = T_a \times \frac{2\pi N}{60}$$

$$E_b = \frac{\phi Z N}{60} \cdot \frac{P}{A}$$

$$\frac{\phi Z N}{60} \frac{P}{A} \times I_a = T_a \times \frac{2\pi N}{60}$$

$$T_a = \frac{1}{2\pi} \phi I_a \frac{PZ}{A}$$

$$\boxed{\therefore T_a = 0.159 I_a \phi \cdot \frac{PZ}{A}} \text{ N-m}$$