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MADE EASY
ELECTRICAL ENGINEERING
D.C. Machine
By.Murli Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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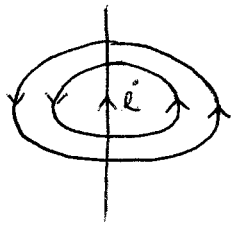
CHRISTIAN OERSTED 1820 Electro magnetism :-

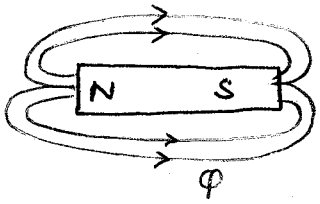
Relation b/w Electricity and magnetism

There is magnetic field around a current carrying conductor



current carrying conductor producing concentric flux line [Right hand Thumb rule] By using R-H thump rule fingure represent flux line direction and thumb in the current direction.

Every electrical machine is working because of flux.(φ) unit-weber



MICHAEL FARADAY (Father of Electricity) 1831 Electro Magnetic Induction :-

If current produce flux then why can't flux produce current?

NIKOLA TESLA 1880 RMF :- Rotating magnetic field

Induction & Synchronous machine is working on the bases of RMF

NIKOLA TESLA is behind AC power system.

ISSAC NEWTON 1687 Law's of motion

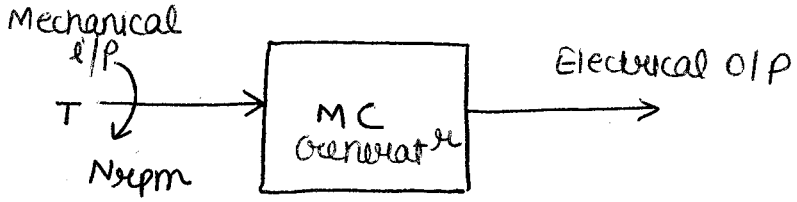
3rd law : Action ⟶ opposite reaction Len'z law -

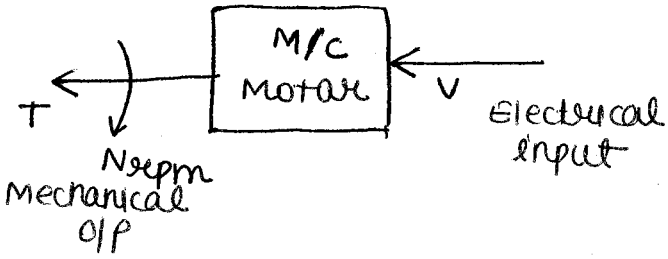
The result always the opposes the cause of it.

-: DC machine :-

Electrical Machine :-

Electro-Mechanical Energy conversion device

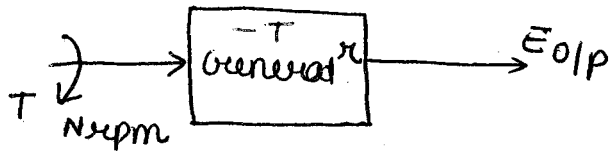




Electro mechanical : Reversible process [Pump storage Plant]

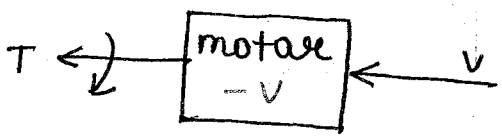
To maintaine the load factor, under light load condition acting like motor as well as making the water go back for ready the dam for peak load condition acting as generator.

Generator :-
we are supplying torque then generator is rotating in one direction, when the generator is giving electrical o/p then in the generator another torque is produce. so in the generator voltage is produced as well as torque is also produce this torque which is produce in generator is exactly oppose the torque what we are giving.



'-' sign denotes the opposite direction

Motor :- when m/c is working as motor, we are giving some voltage then in m/c another voltage is developed which is exactly opposite to supply voltage.



M/C → G : V & T generated
M/C → M : T & V generated

Energy is never generated, so, Generator can't generate any by itself unless we rotate the generator

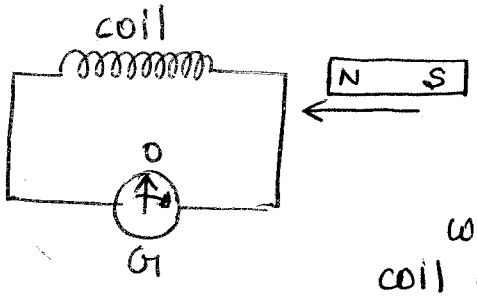
When a m/c is acting like generator mode or motor mode two things are commonly happen (V & I) that's why DC machi can be used as motor as well as Generator

Transformer is not a electrical machine because there is no electro-mechanical Energy conversion happens in it. In transfor mer electro-magnetic conversion takes place. internally.

DC Generator :-

construction details of DC Generator is exactly similar to DC motor., difference in characteristic and application.
DC Generator, is Rotating electrical m/c which is designed to take the advantage of electromagnetic induction in ord er to convert mechanical energy into DC electrical energy.

Faraday's law of Electro magnetic Induction :-
The phenomen of producing induced emf in a conductor through a change in magnetic field.



when the magnet is stationary then [near the coil] galvanometer is deflecting zero.

when the magnet is moved near to the coil or inside the coil then galvanometer is deflecting in one direction If movement is fast then more deflection, if it is slow then less deflection. i.e; there will be change in the magnetic field due to movement now change in magnetic field is responsible to produce induced emf in the coil.

whenever a conductor cuts a magnetic flux, a dynamically induced emf in the conductor

IInd law: The magnitude of induced emf is directly proportional to rate of change of flux linkages.

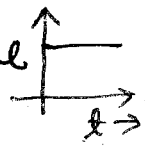
Flux: φ webers conductor: N Flux linkage $(\lambda) = \varphi \cdot N$

Flux linkage means the interaction between flux and conductor
↓ magnet ↓ cu wire

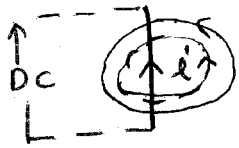
Induced emf
- Dynamically (AC in nature) (involved with motion or speed) flux cutting voltage
- Statically (AC in nature) (NO motion) i.e, stationary

Flux:-
- (a) Time invarying flux / steady magnetic field
- (b) Time varying flux

In time invarying flux, the flux is not varying w.r.t time



Ex-: Permanet magnet



when we give AC supply to conductor then we get continuously time varying current which is obviously produce time varying flux in it.

$$e = \frac{d\lambda}{dt} \text{ volts}$$

$$= \frac{d(N\varphi)}{dt} = N\frac{d\varphi}{dt}$$

$$\boxed{e = N\frac{d\varphi}{dt} \text{ volts}} \qquad \boxed{e = -N\frac{d\varphi}{dt} \text{ volts}}$$

'-' sign represent lenz's law

$$e = \left(N\frac{d\varphi}{di}\right) \times \frac{di}{dt} \qquad (L) \qquad e = -L\frac{di}{dt} \text{ volts}$$

conductor behaves like inductor.

when there is rate of change of flux linkages conductor behaves as an inductor. Inductor will opposes the change in current so to communicate the opposition factor we put negative sign This negative sign doesn't represent any polarity or motion in DC m/c.

→ If the flux is time invarying in nature, it requires relative motion between flux and conductor for effective rate of change of flux linkages (one should rotate w.r.t other)

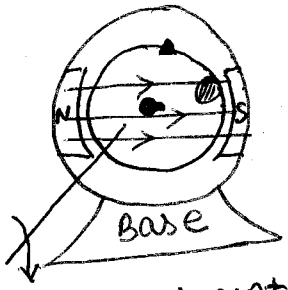
→ If the flux is time varying then it automatically produces voltages with stationary conductor because of inherent rate of change (No need of relative motion)

Three mode of flux linking :-

① Flux : Flux is stationary and nature is time invarying.

conductor : Rotating

magnet : stationary then flux will be stationary & having time invarying nature



Place a conductor on rotating part & don't rotate the rotating part then there is flux and conductor but missing the rate of change of flux linkage

If we want to create rate of change of flux linkage in time invarying flux then we require one should rotate w.r.t to other. i.e. either flux or conductor any one should rotate w.r.t. other then relative motion occurs → rate of change of flux linkage occurs produce induced emf.

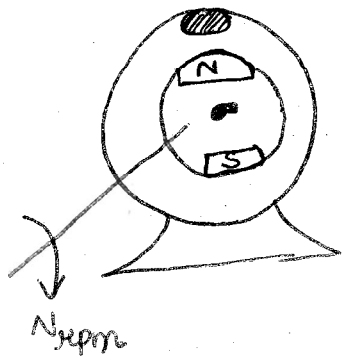
Ex : DC machine (Dynamically induced emf)

↳ Rotation is involved

② Flux: Flux is Rotating and nature is Time invarying

conductor : Stationary

in this when we start rotating then magnet is also rotate due to which flux is rotating but flux is time invarying only.



Rate of change of flux linkage occurs in conductor which produces dynamically induced emf.

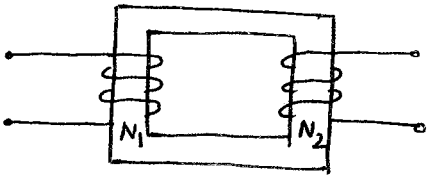
Ex:- Synchronous machines

To collect the current from stationary part is so easy.

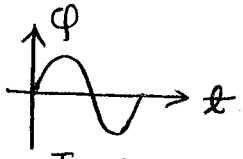
(2) Flux : Stionary & Time varying

conductor : stationary

DC voltage :→ ϕ ↑ & conductor



is @ stationary there is no rate of change of flux linkage. Never work on DC.

AC supply → 

Time varying → natural rate of change of flux linkage ↓ enough to produce induced emf

Ex:- Transformer (Induction m/c is nothing but rotating X-mer) (statically induced emf)

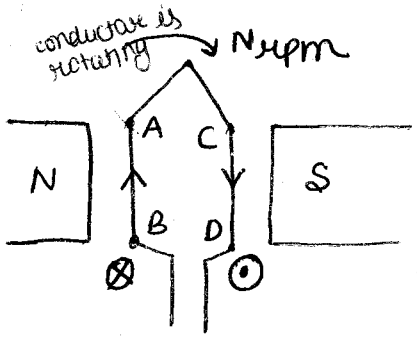
↳ NO motion require

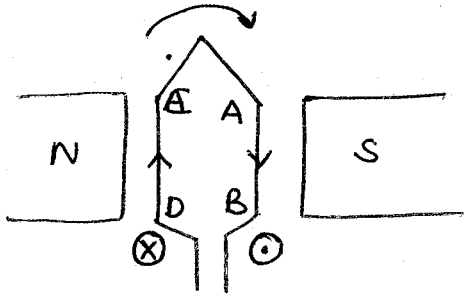
<u>working of a simple loop generator</u> :-

In order to produce induced emf in a conductor, require

(a) flux (b) conductor (c) prime mover According to FLEMI

Rotate the conductor b/w magnetic field.





is ↑AB CD↓ CD is moving down

[0°-180°] mechanical degree

↑CD AB↓

[180°-360°] mechanical degree

we use Fleming's right hand rule in order to know dynamically induced emf.

$e = Blv\sin\theta$

B = flux density (Tesla)

l = Active length of conductor
i.e, length who cut the flux

V = peripheral velocity = $\frac{\pi DN}{60}$

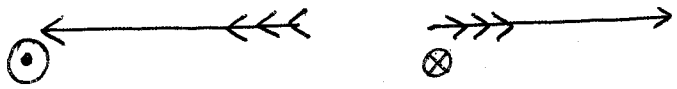
θ = angle between flux & conducto

D = Diameter of armature

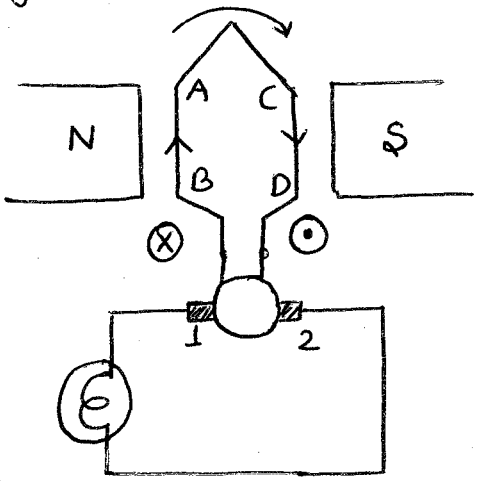
Fleming right han's rule :-

Forefinger → Flux Thumb → Motion force

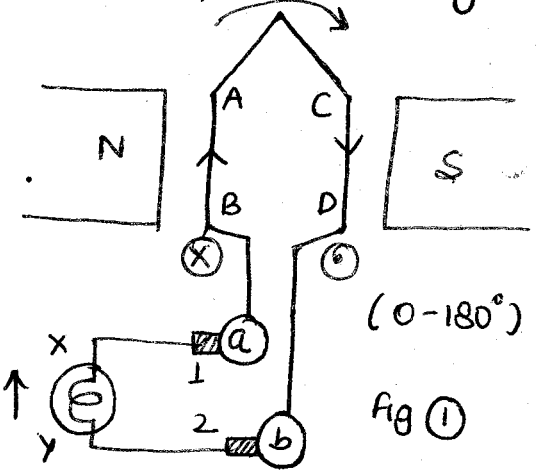
middle finger → Direction of current or induced voltage in conductor [To know]



when blub is connecting to it then bulb is also get rotated which is problem for the designing purpose. For to be stationary the load we need idea which is sliding contact. But if we use one ring then it short circuit the coil.



So, we go for two ring concept



(0-180°)

Fig ①

current direction : B A C D b 2 y x 1 a B

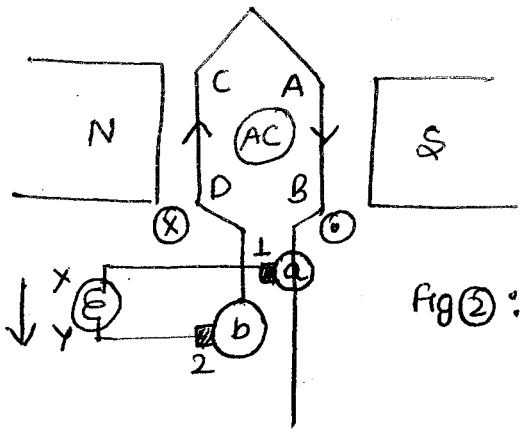


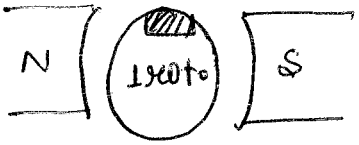
Fig ②:

current direction: DCABA 1 X Y 2 b D

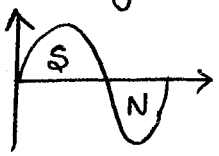
Bidirectional current in coil i.e; AC

in the coil: AC | in the bulb: AC | i.e; thus is AC generator.

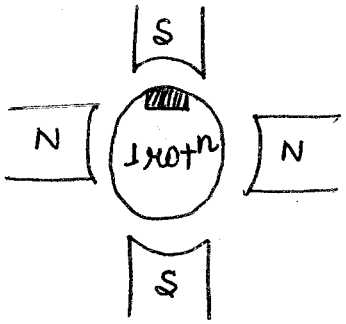
AC is collected as AC when connect two ring or slip ring

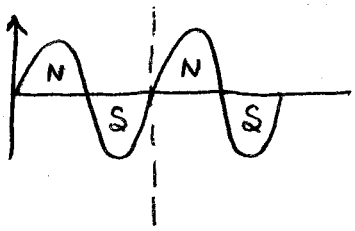


when conductor make one rotation then conductor will pass south pole and then also north pole. so, if south pole produce one pulse then north pole produce opposite. [There is no rule is south pole producing + or -ve & North pole producing +ve or -ve]



with 2 pole: 1 cycle in one rotation





with 4 pole: 2 cycle in one rotn

with P pole: P/2 cycle/rotn

No. of cycles/rotation = $P/2$

No. of Rotation/sec = $N/60$ N is in rpm.

$$\frac{\text{cycles}}{\text{rotation}} \times \frac{\text{rotation}}{\text{sec}} = \frac{P}{2} \times \frac{N}{60}$$

$$f = \frac{\text{cycle}}{\text{sec}} = \frac{PN}{120} \quad \text{or} \quad N = \frac{120f}{P}$$