Lecture-28

On

INTRODUCTION TO ELECTRICAL ENGINEERING (ESO203)

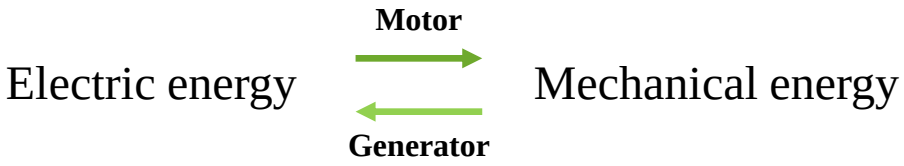
- Introduction to DC Machines.

Introduction to Machines

❑ Electromagnetic energy conversion:

- An electromagnetic machine is one that links an electrical energy system to another energy system by providing a reversible means of energy flow in its magnetic field.
- The magnetic field is therefore the coupling between the two systems and is the mutual link.
- The energy transferred from the one system to the other is temporarily stored in the field and then released to the other system.

Usually the energy system coupled to the electrical energy system is a mechanical one

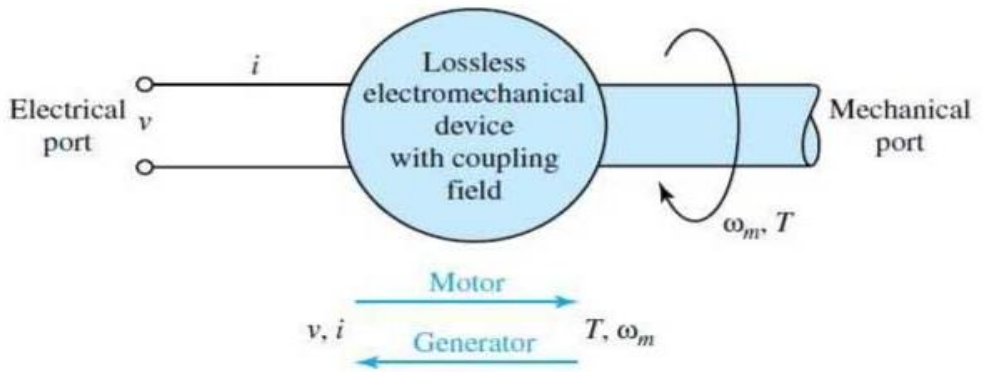


Usually, the energy system coupled to the electrical energy system is a mechanical one

Introduction to Machines (Cont...)

❑ Electromagnetic energy converters:

1. A mechanical system,
2. An electric system,
3. A coupling field.



Electric input(or output) energy $vi\Delta t = mechanical\ output\ (or\ input) energy\ T\omega_m\Delta t$

Both electric and magnetic fields store energy, from which useful mechanical forces and torques can be derived.

All industrial electric machines are magnetic field devices

Introduction to Machines (Cont...)

The change in flux linkage →

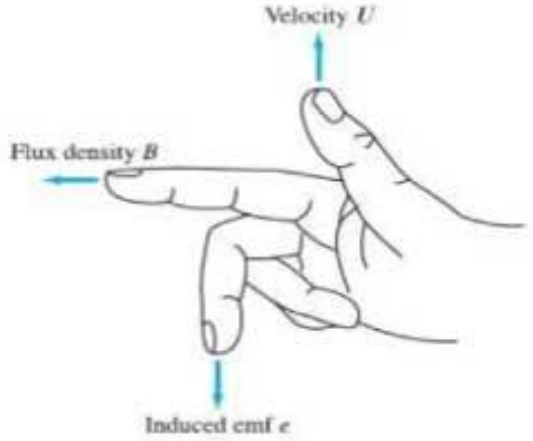
1. Transformer emf: The coil remaining stationary with respect to the flux, the flux varies in magnitude with time.

$$e = +\frac{d\lambda}{dt} = +N\frac{d\phi}{dt}$$

2. Motional emf : The flux remaining constant, the coil moves through it. A conductor or a coil moving through a magnetic field will have an induced voltage.

$$Motional\ EMF\ e = BlU$$

3. The coil may move through a time-varying flux

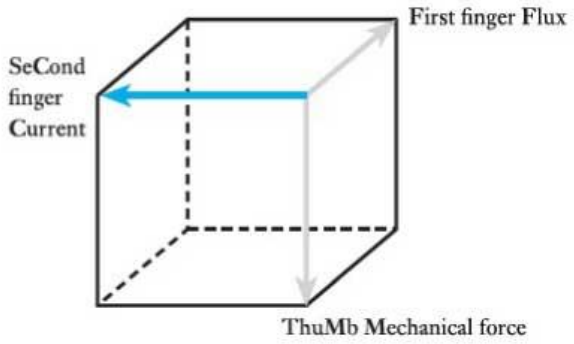


Both induce emfs are due to Faraday's law electromagnetism

Introduction to Machines (Cont...)

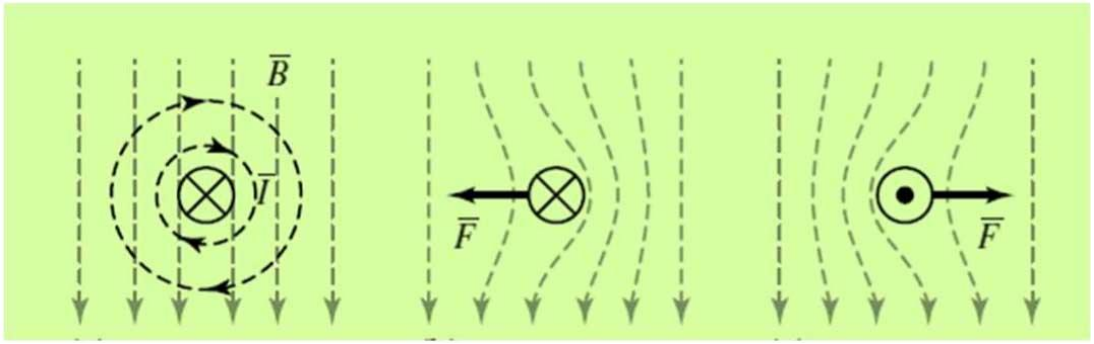
- Current-carrying conductors, when placed in magnetic fields, experience mechanical force.

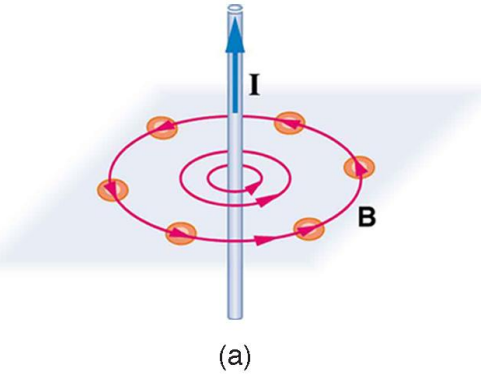
$$F = BlI \qquad Lorentz\ Force\ Equation$$



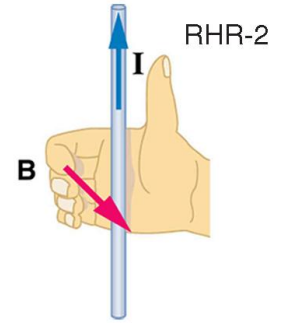
- If magnetic poles occur in pairs (north and south) and the movement of a conductor through a natural north– south sequence induces an emf that changes direction in accordance with the magnetic polarity (i.e., an alternating emf), the devices are inherently ac machines.

Introduction to Machines (Cont...)



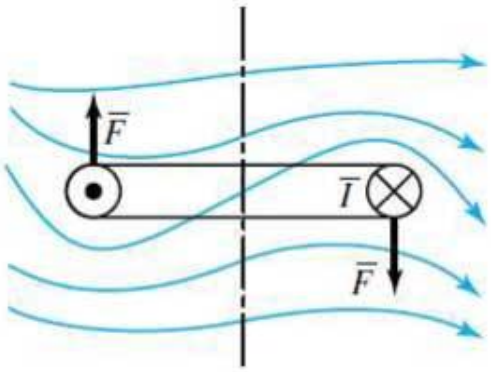


(a)



(b)

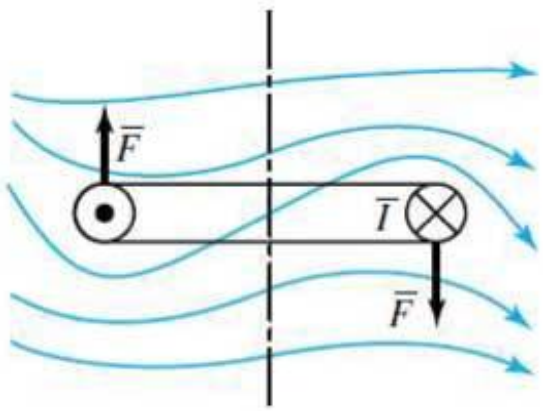
The force is always in such a direction that the energy stored in the magnetic field is minimized.

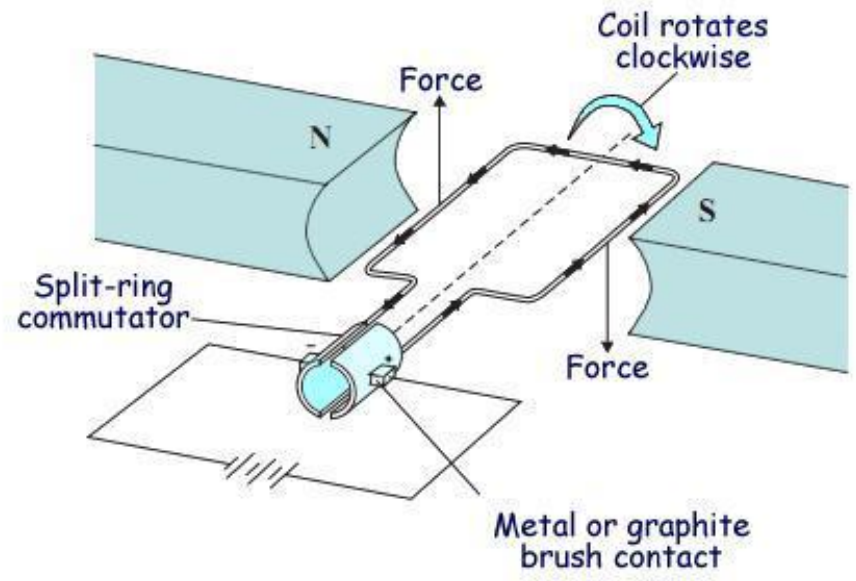


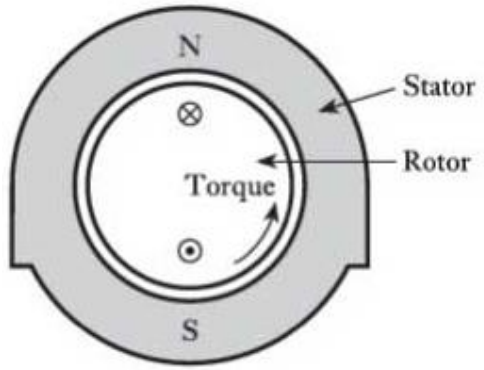
Torque produced by forces caused by interaction of current-carrying conductors and magnetic fields

Introduction to Machines (Cont...)

- **Rotating Machines:** The force of interaction can be made to give rise to rotary motion

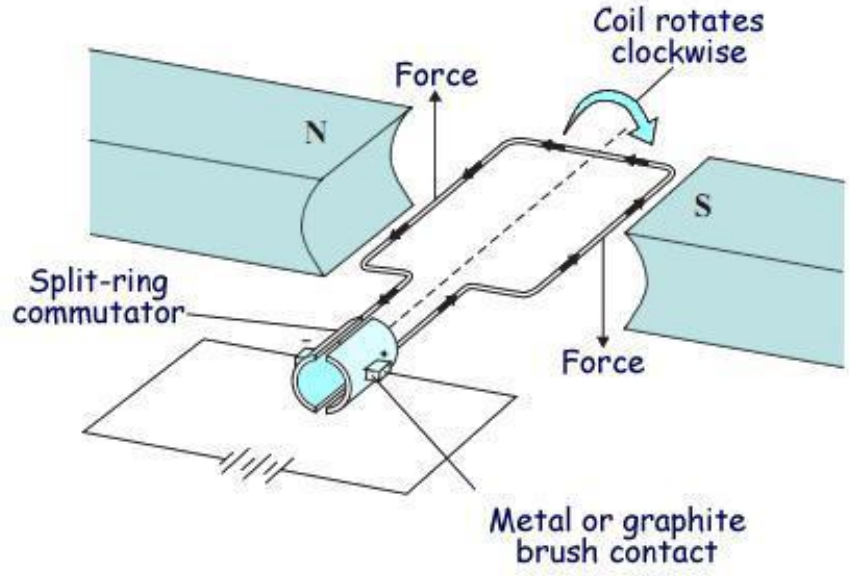






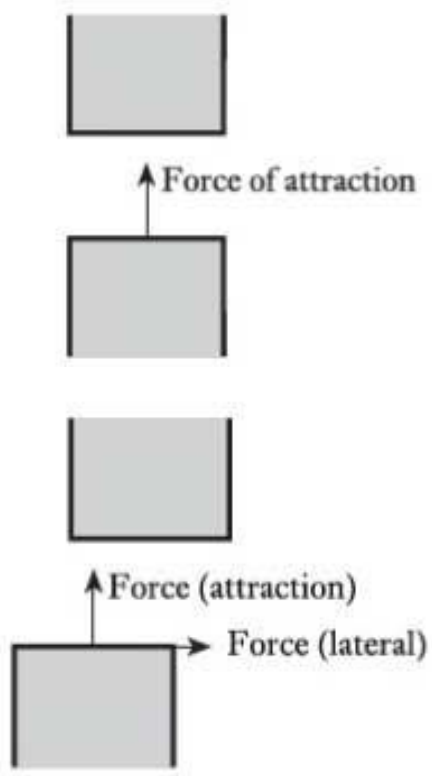
By passing a current through the coil, it experiences a force on each of the coil sides resulting in a torque about the axis of rotation.

Introduction to Machines (Cont...)



Introduction to Machines (Cont...)

❑ Force of Alignment:



- The force of alignment acts in any direction that will increase the magnetic energy stored in the arrangement. When the poles are brought together , the reluctance of the airgap in the magnetic circuit decreases, flux increases, consequently the stored energy.
- If the poles move laterally, the cross-sectional area of the airgap is increased and the reluctance is reduced with consequent increase in the stored magnetic energy as before.
- In motor and generator action, the magnetic fields tend to line up, pole to pole.
- When their complete alignment is prevented by the need to furnish torque to a mechanical shaft load, motor action results. When the alignment is prevented by the application of a mechanical torque to the rotor from a source of mechanical energy, generator action results.

Introduction to Machines (Cont...)

- Electromagnetic energy conversion occurs when changes in the flux linkage result from mechanical motion

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

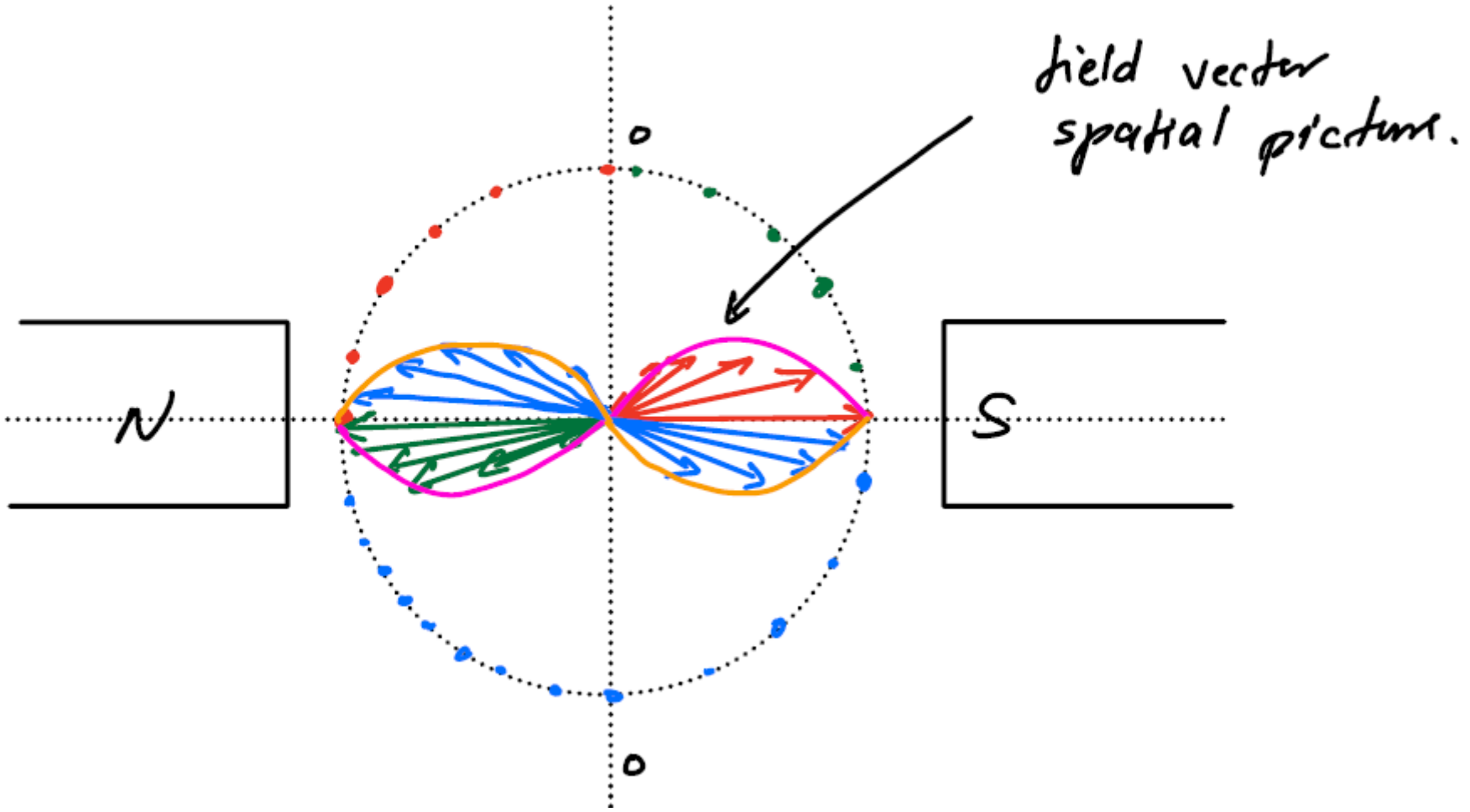
- Voltages are generated in windings or groups of coils by
  i. Rotating these windings mechanically through a magnetic field.
  ii. By mechanically rotating a magnetic field past the winding.
  iii. Or by designing the magnetic circuit so that the reluctance varies with rotation of the rotor.

- A set of such coils connected together is typically referred to as an ***Armature winding*****.**
- In a DC machine, the armature winding is found on the rotating member, referred to as the rotor. In ***AC machines,*** the armature winding is typically on the stationary portion of the motor referred to as the ***stator***, in which case these windings may also be referred to as stator windings.

Introduction to Machines (Cont...)

- Field Winding: FA second winding (or set of windings) which carry DC current, and which are used to produce the main operating flux in the machine.
- In most rotating machines, the stator and rotor are made of electrical steel, and the windings are installed in slots on these structures. The use of such high-permeability material maximizes the coupling between the coils and increases the magnetic energy density associated with the electromechanical interaction.

Introduction to Machines (Cont...)



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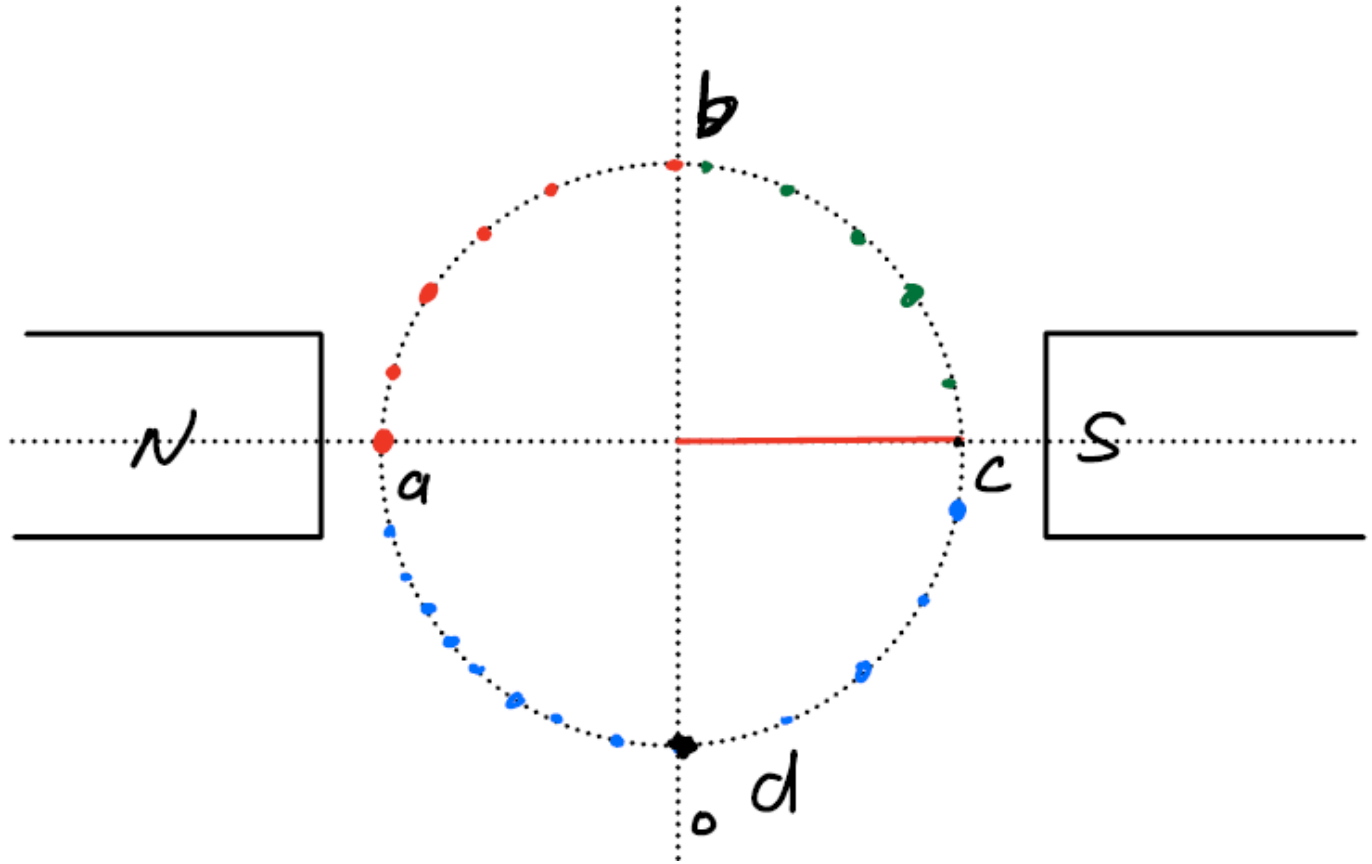
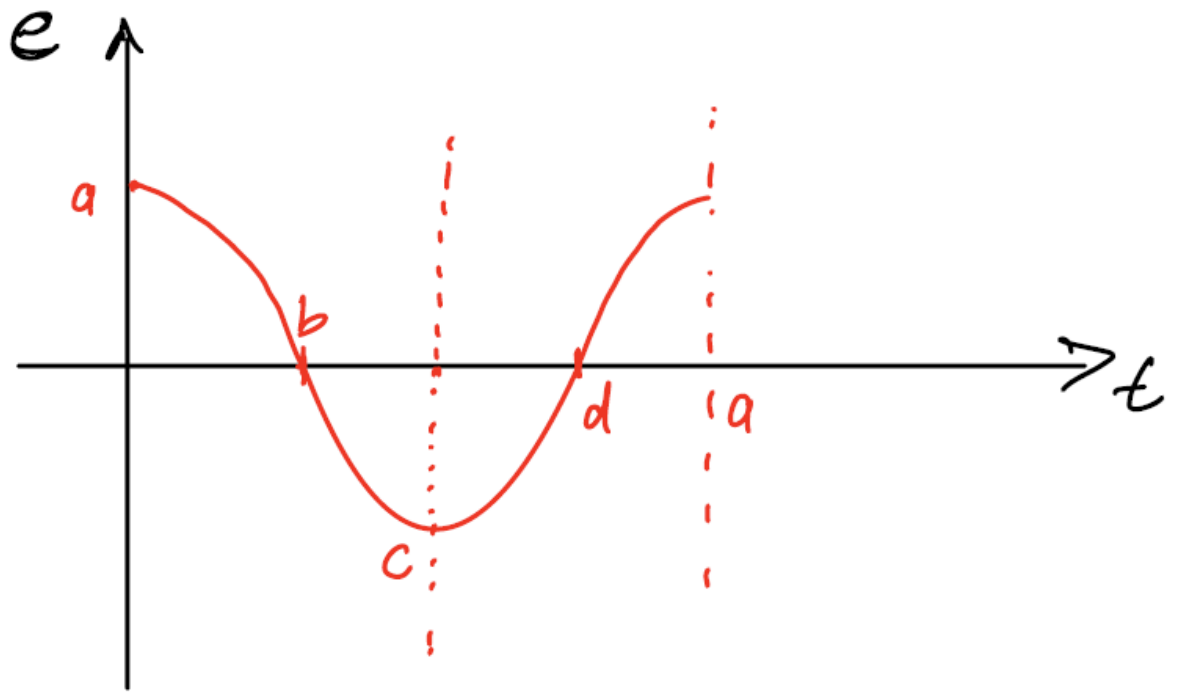
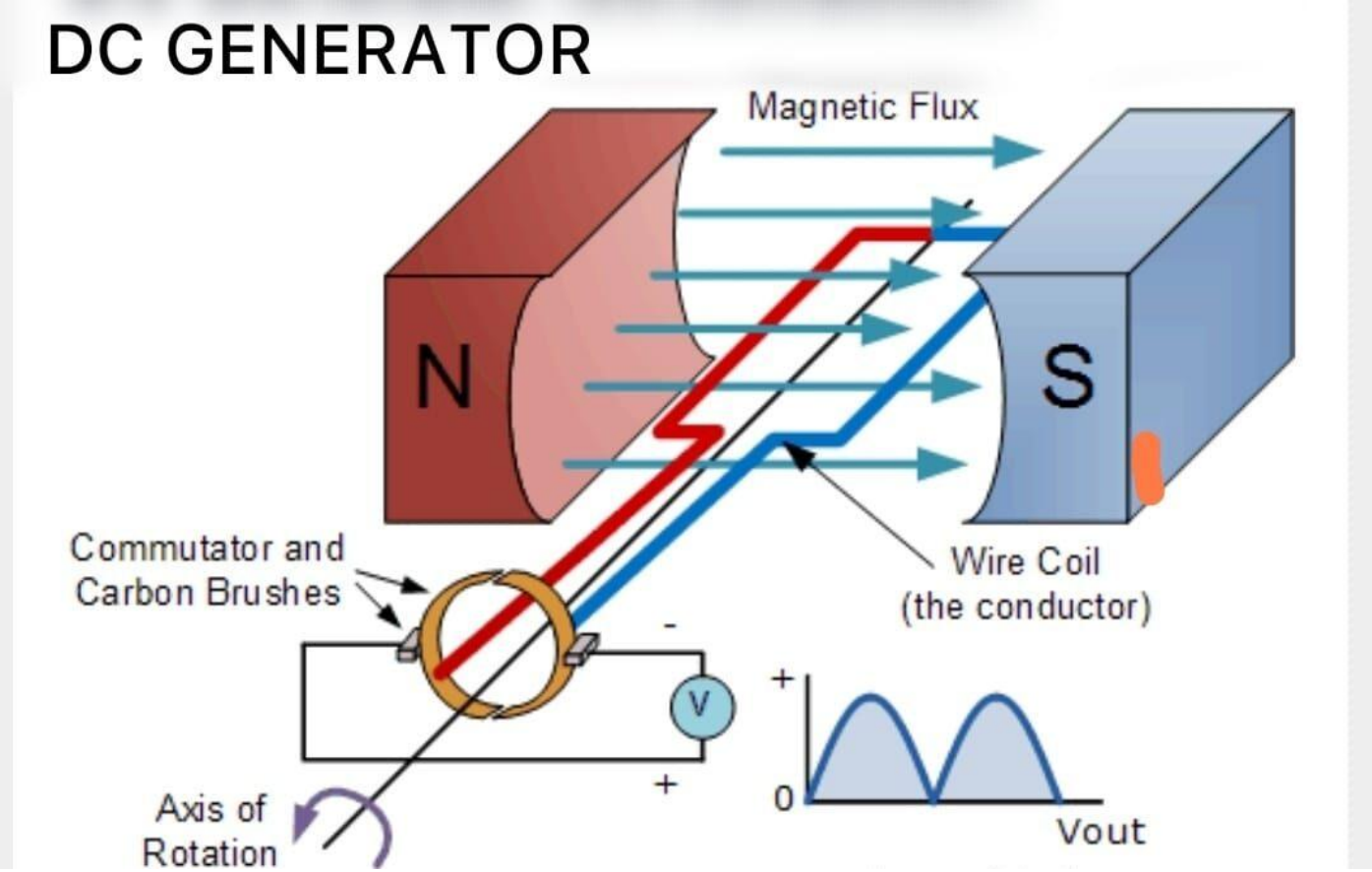
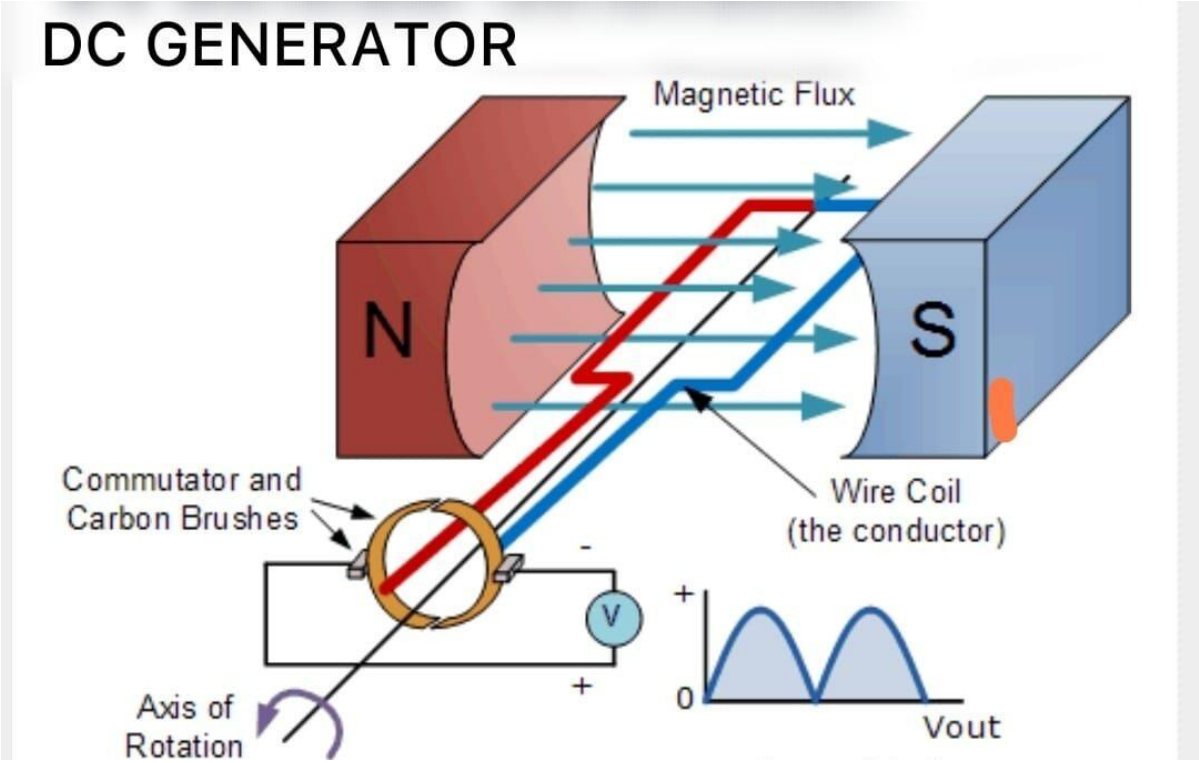


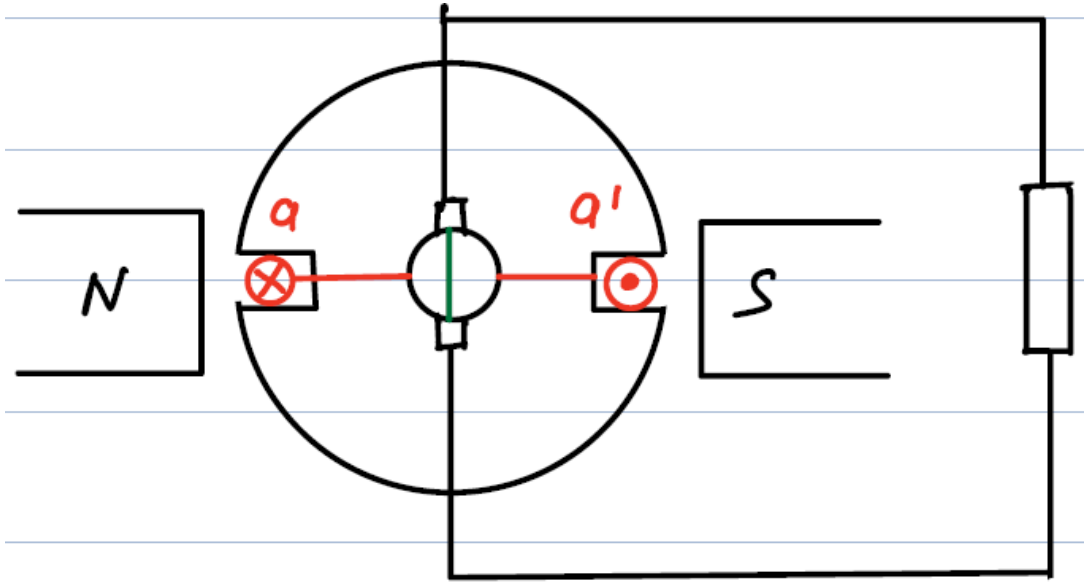


Introduction to Machines (Cont...)



Introduction to Machines (Cont...)





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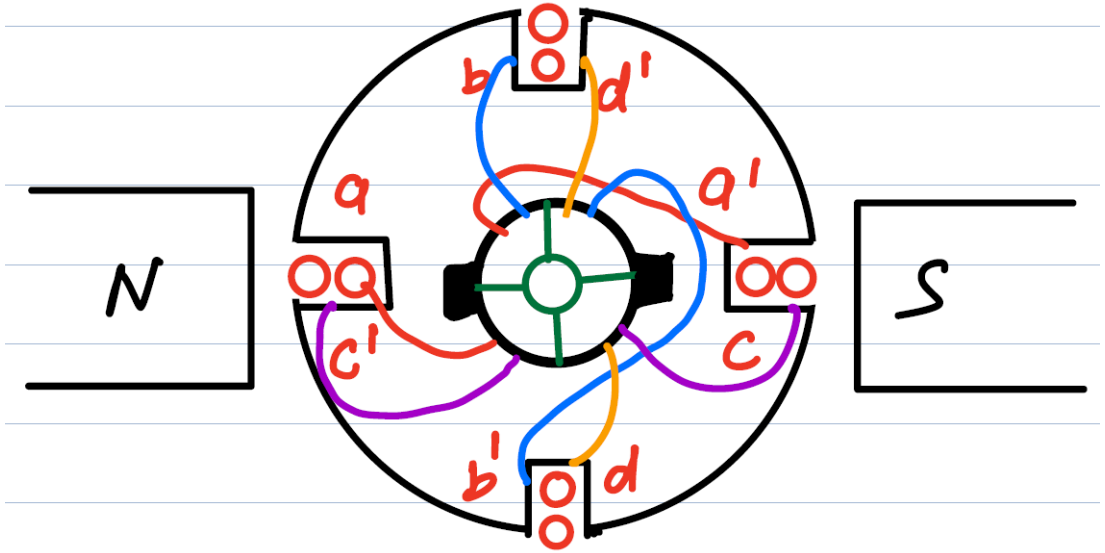

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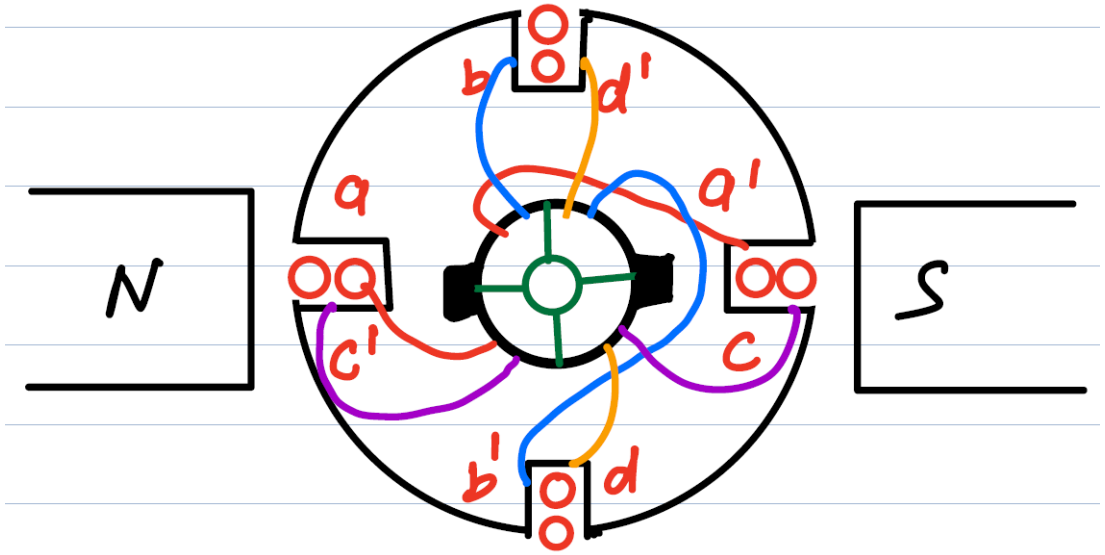

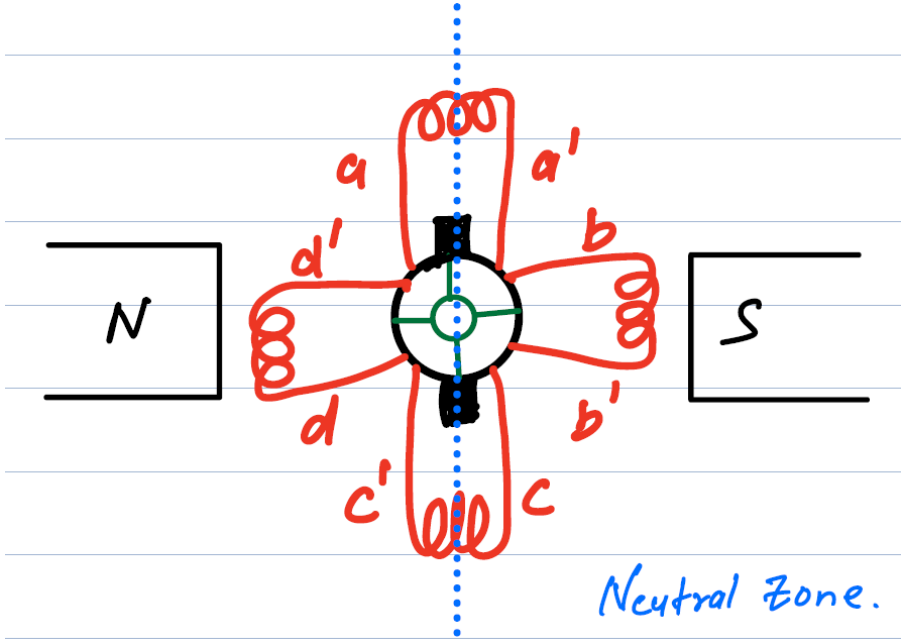

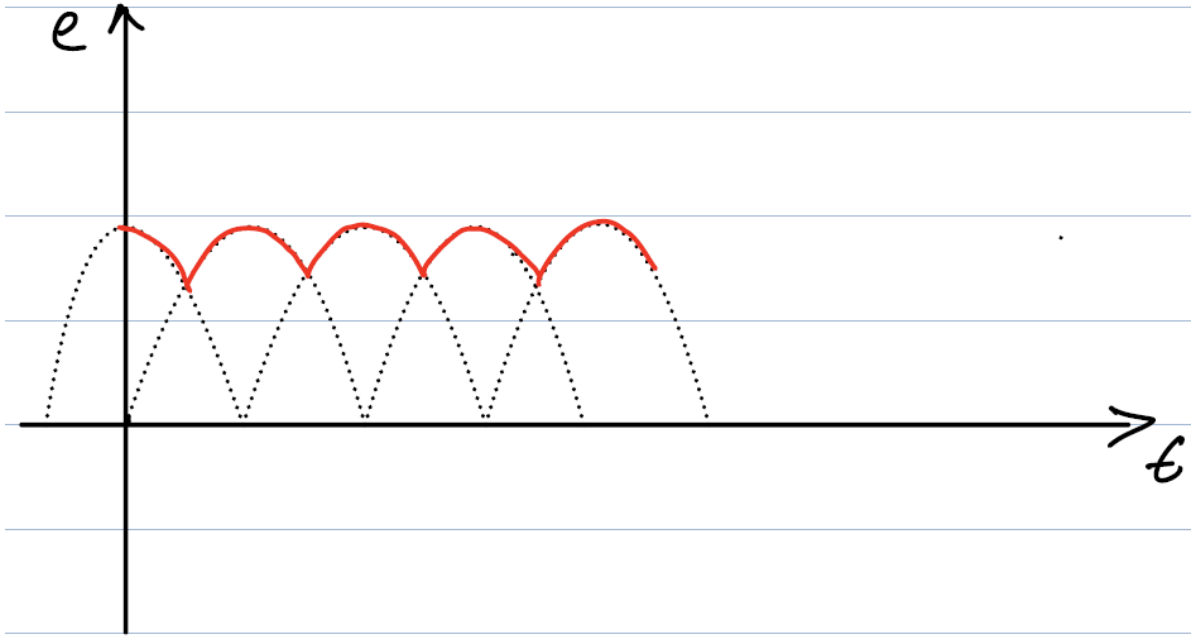


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