Electrical Engineering
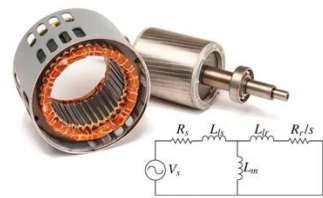
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Original material: Emmanuel BEURUAY
English version: Thomas TILLOCHER

Schedule

	M1 AEMS
Lectures	14 x 1,25 h dont 2 DS
Tutorials	8 x 1,25 h
Lab work	1 x 2,50 h + 6 x 3,75 h

Outline

Introduction

I)   Reminders (electricity)

II)   Power in sinusoidal regime (single-phase and 3-phase)

III) Transformers
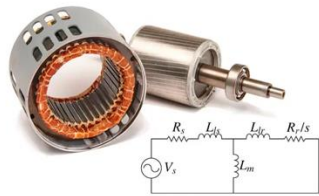
IV) Electric motors
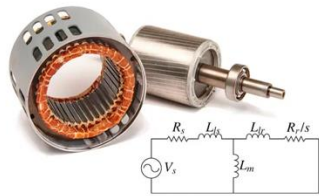
Introduction

- 3 main families:

DC Motor

DCM

Synchronous machine
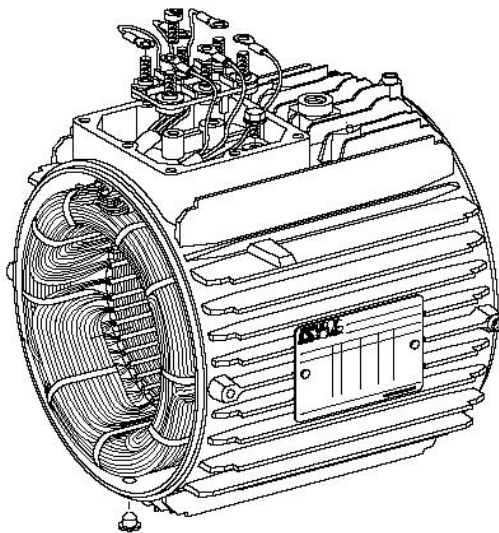
SM

Induction machine

/Asynchronous machine

ASM

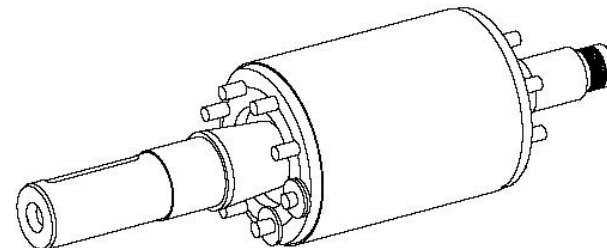## Introduction
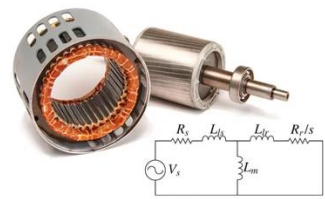
- Machine construction = 2 distinct parts for all 3 types of motors

Stator

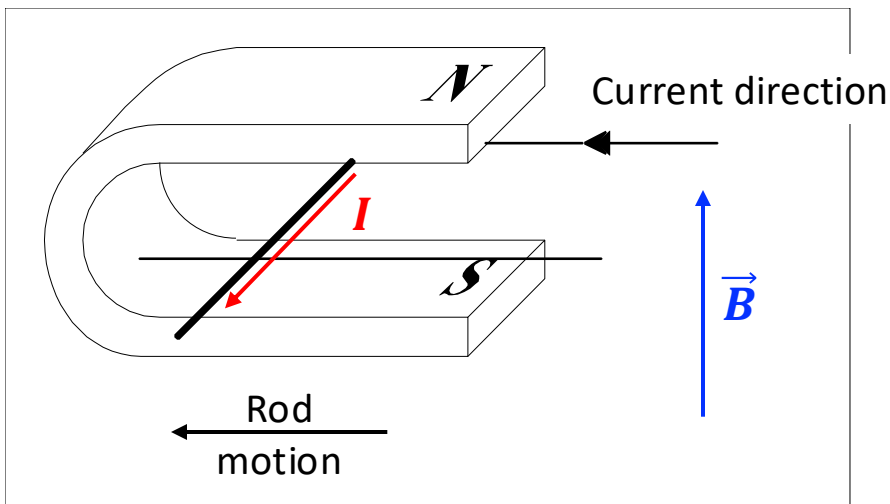Rotor

The DC motor

- <u>Laplace's force:</u>

"A moving conductor placed in a magnetic field is set in motion when a current flows through it"

Current direction

Rod
motion

$$\vec{F} = I\,d\vec{l} \wedge \vec{B}$$

$$F = B \times I \times l$$

B : induction magnetic field (T)

I : current intensity (A)

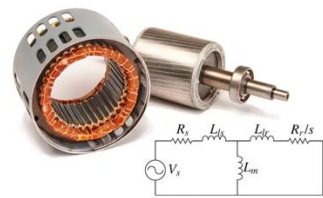**l** : length (m)

Right hand rule :

        Thumb => Thrust
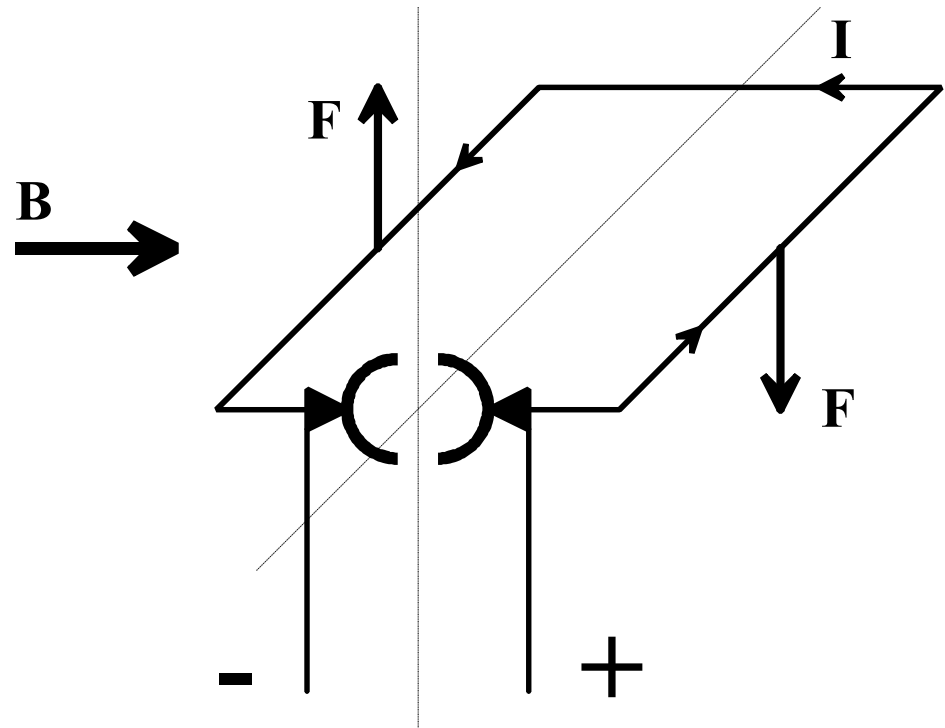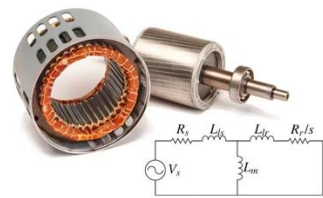   Index => Intensity
        Major => Magnetism

The DC motor

- First approach of the principle: Moving frame with current flowing through it

- Two diametrically opposed conductors:

$\Rightarrow$ current flowing through them in opposite directions

$\Rightarrow$ placed in a magnetic field

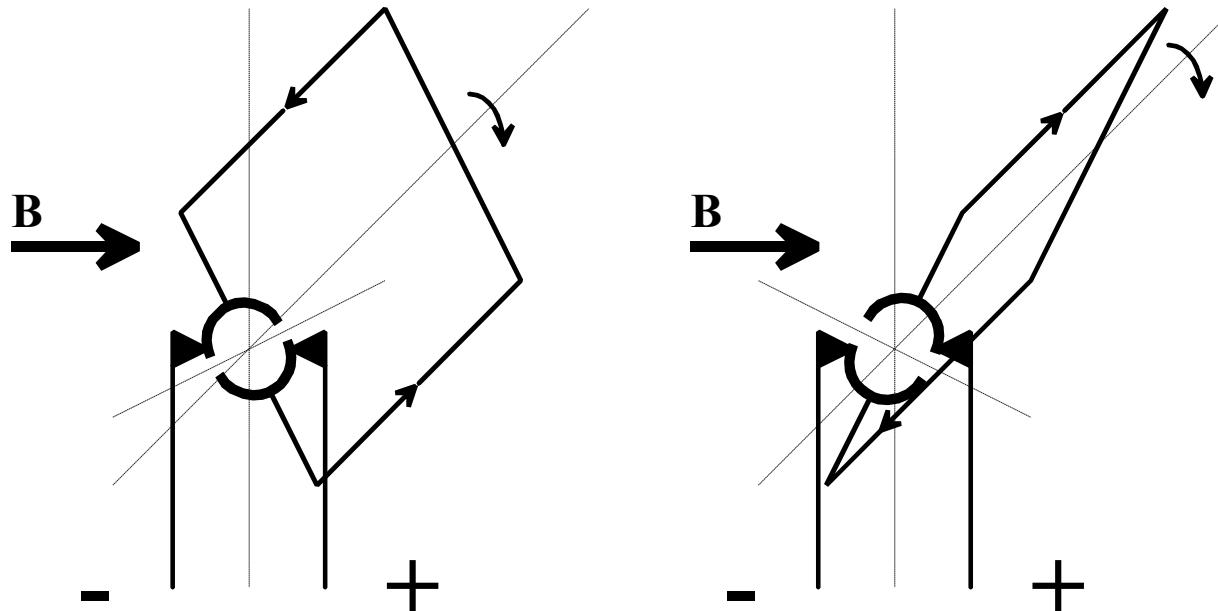- Will be subjected to two forces in opposite directions:

=> Turn in the same direction.

The DC motor

- <u>First approach of the principle:</u> Current reversal

- When the two conductors reach the "neutral" line, the direction of the forces is reversed.
⟹ the direction of the current in each conductor must change

- Thanks to the collector, even though the voltage is DC, the current in the winding made up of the two conductors will reverse under the switching axis, and rotation will continue.
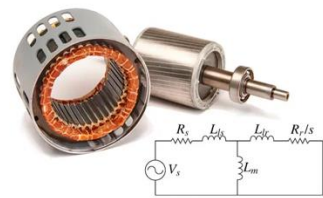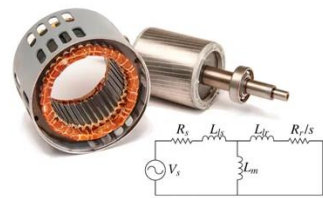
The DC motor

- <u>Construction:</u> basic schematic
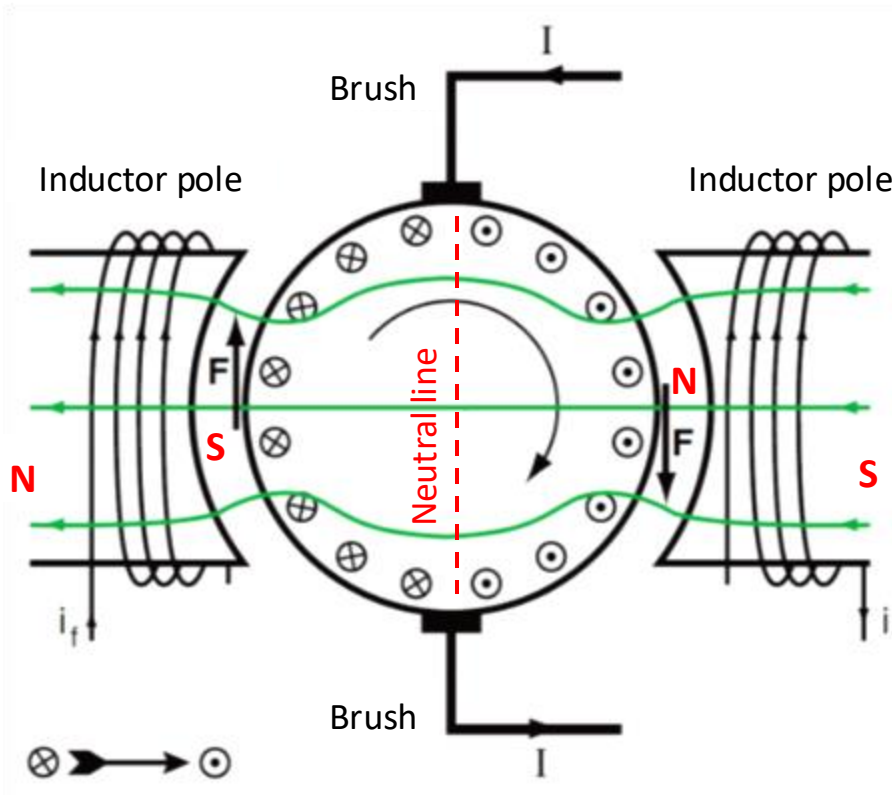
The motor is made up of two main parts:

- The stator (fixed)

=> Acts as an electromagnet

=> Usually called "inductor",

- The rotor (moving),

=> Rotating part where Laplace forces are applied

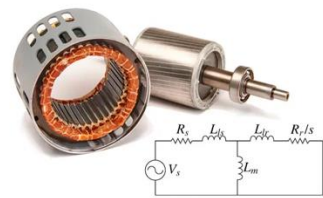=> Also acts as an electromagnet

=> Usually called "armature".

The DC motor

- <u>Construction:</u> basic schematic

The DC motor

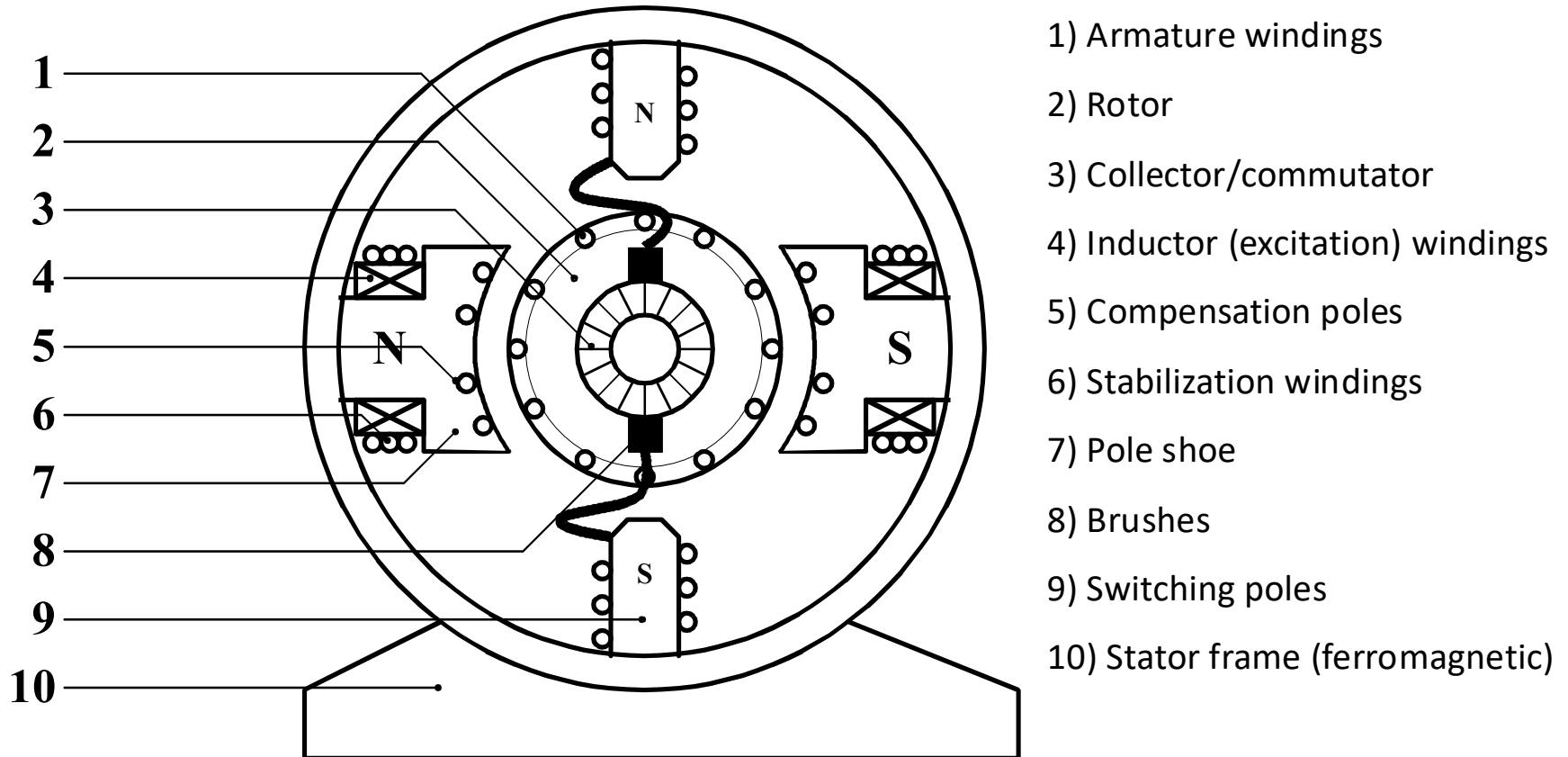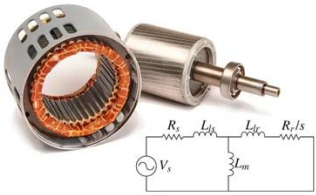- Construction:

1) Armature windings

2) Rotor

3) Collector/commutator

4) Inductor (excitation) windings

5) Compensation poles

6) Stabilization windings

7) Pole shoe

8) Brushes

9) Switching poles

10) Stator frame (ferromagnetic)

The DC motor

- <u>The inductor (4):</u>
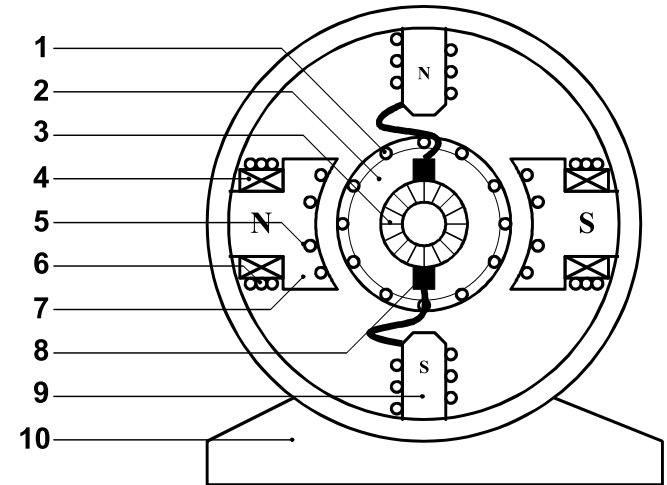
⇒ Coils wound around polar cores arranged around the periphery of the stator

⇒ Excitation current I_e flows through it, producing a magnetic flux ϕ.

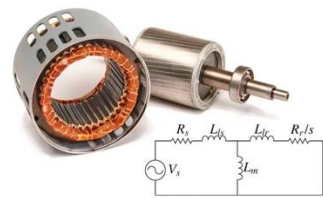⇒ On small machines, the inductor is replaced by permanent magnets.

- <u>Compensation poles (5):</u>

⇒ Compensate for the armature magnetic reaction

⇒ Placed in the notches of the pole shoes

⇒ The current flowing in the armature flows through them

⇒ Ensures compensation for any load.

- <u>The switching poles (9):</u>

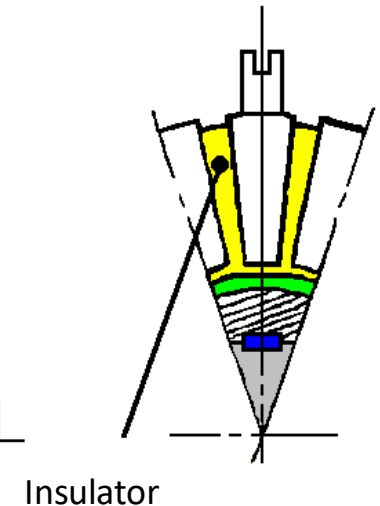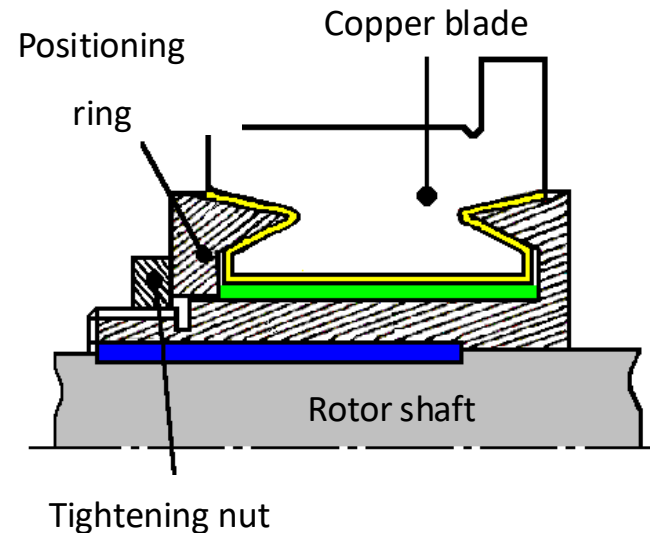⇒ Ease current switching in conductors by separating the neutral line from the switching axis (prevent shortcut)
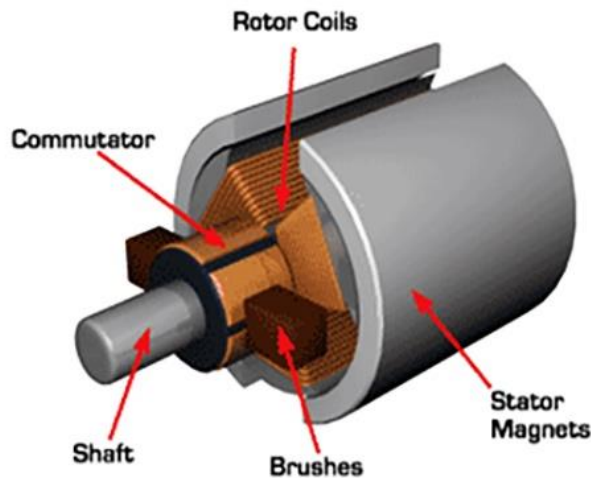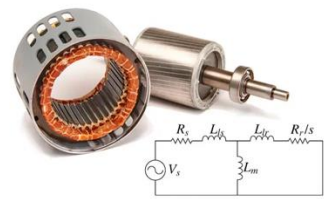
The DC motor

- <u>Collector and brushes (8):</u>

Rotor Coils

Commutator

Shaft

Brushes

Stator Magnets

Positioning ring

Copper blade

Rotor shaft

Tightening nut

Insulator

⟹ The commutator is a set of copper blades, laterally insulated from each other, and arranged in a cylinder at the end of the rotor.

⟹ The brushes, carried by the stator, rub against the commutator blades. The commutator assembly reverses the direction of current in the rotor conductors as they cross the machine neutral line.
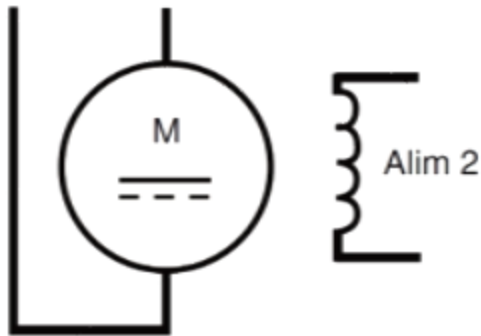
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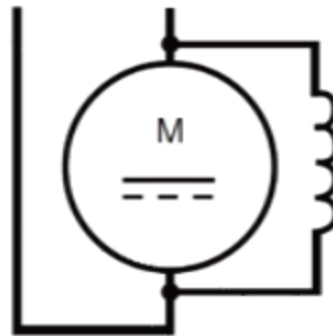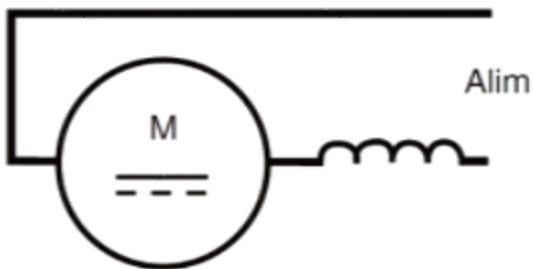
The DC motor

- <u>Connections of the DC motor:</u>

Separately excited DC motor

Shunt excited DC motor
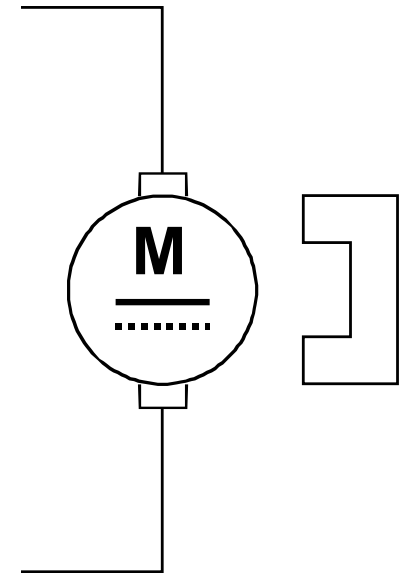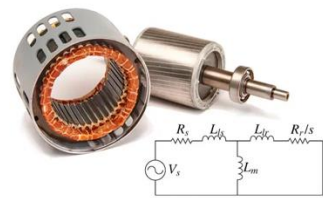
Alim 2

Series excited DC motor
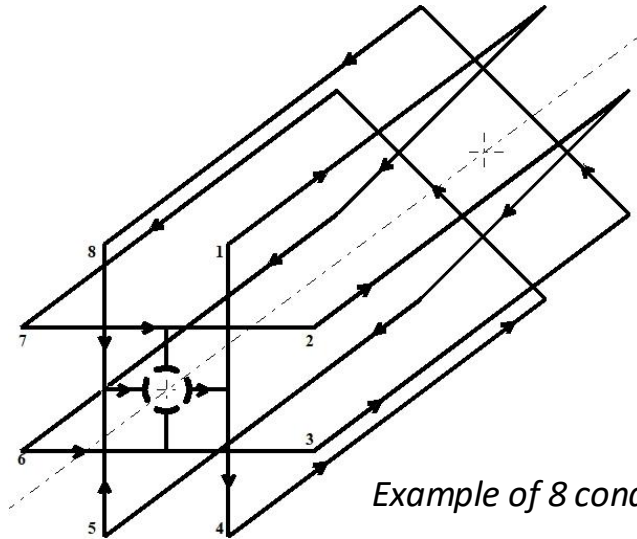
Alim

=> High torque at start

Compound excited DC motor

Alim

Magnet excited DC motor
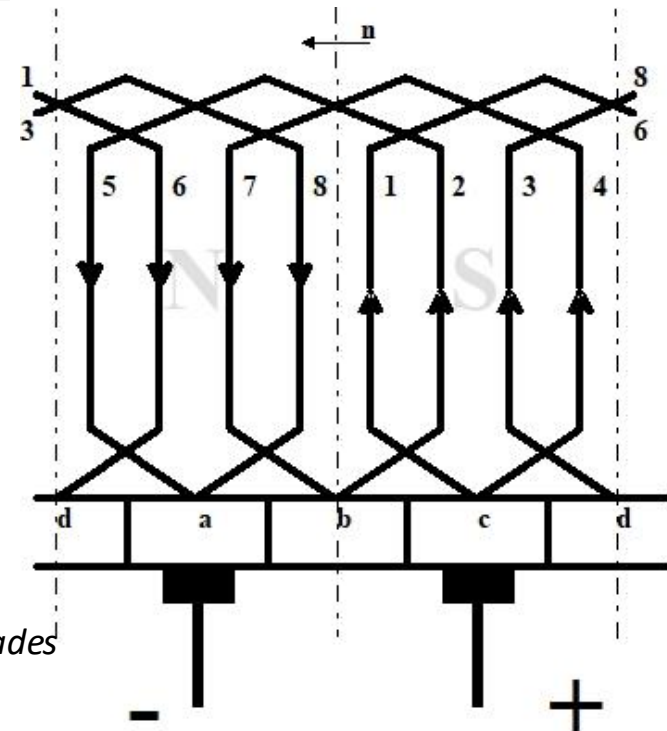
The DC motor

- <u>The electric circuit at the armature (1):</u>
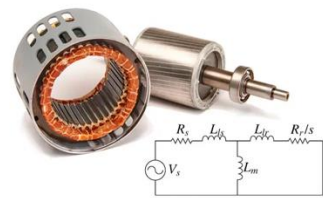

Example of 8 conductors, 4 blades

- <u>Windings:</u>

⇒ Each individual wire is called a "conductor", two conductors form a "turn", turns are grouped by "section" (one section is between 2 blades) and sections by coil.

⇒ The two halves of a section are located in almost diametrically opposed slots. The section input and output conductors are soldered to two adjacent switch blades.
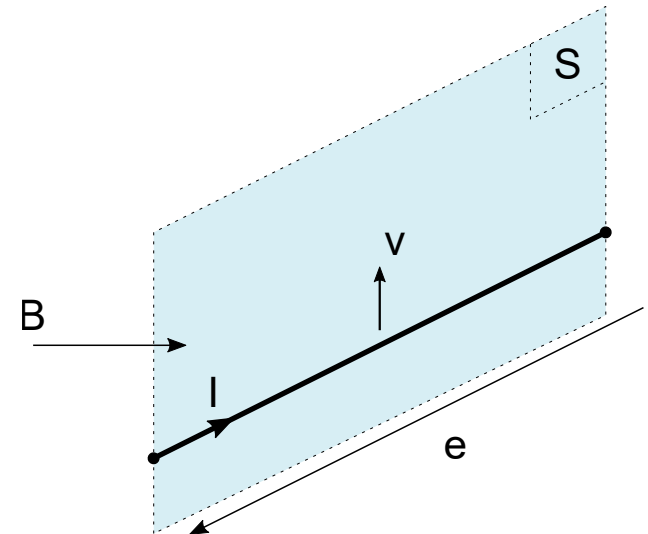
The DC motor

- <u>Electromechanic relations:</u> counter electromotive force

- The machine rotates at a speed "n" expressed in rpm

"Φ" is the flux produced by the inductor in Wb.

- By considering "p" the number of pole pairs in the machine stator:

=> During one revolution, an active armature conductor crosses "p" times the "+ Φ" flux and "p" times the "- Φ" flux.

- The flux variation seen by a conductor is written:
$$\Delta\Phi = +p.(+\phi) - p.(-\phi) = 2.p.\phi$$

- At each conductor is created a counter electromotive force e:
$$e = \frac{\Delta\phi}{\Delta t} = \frac{2.p.\phi}{1/n} = 2p.n.\phi$$

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