PHYSICS 12

ELECTROMAGNETISM

and its applications

(Electrical) CONDUCTOR = material that allows the flow of electric charges.

- Silver, copper, aluminum, graphite, gold, dissolved salts, some polymers

(Electrical) INSULATOR = material that does not permit the flow of significant amount of charges.

- Rubber, glass, plastic, ceramics, paper

FERROMAGNETIC MATERIAL = material that can be magnetized by exposure to an external magnetic field

- Iron, nickel, cobalt, gadolinium, and dysprosium

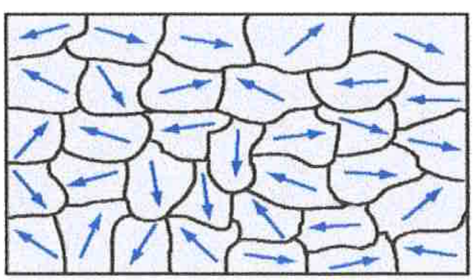
ELECTROMAGNETIC INDUCTION = process during which magnetic field is used to generate electric current

FARADAY'S LAW = the law of electromagnetic induction

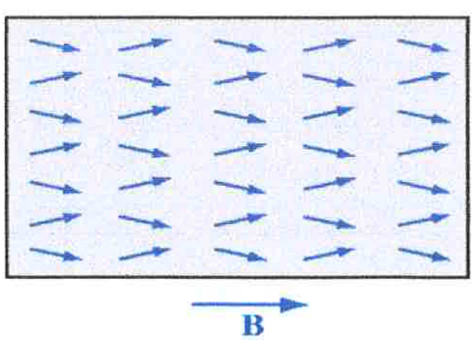
= a continuously changing magnetic field will induce electric current in a closed conducting loop. The continuously changing electric field can be achieved either by moving the magnet or by moving the wire. The amount of the induced current can be increased by moving the magnet/wire more quickly or by using a stronger magnet.

AC = Alternating current

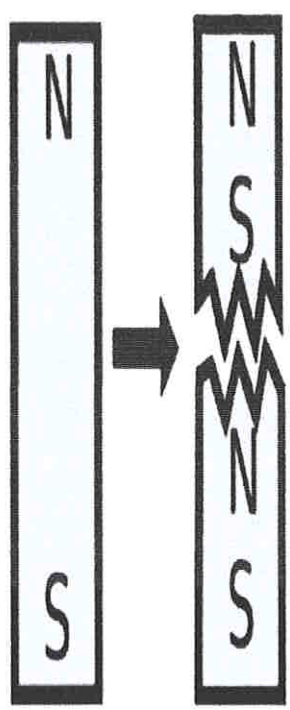
DC = Direct current



(a) Unmagnetized domains



(b) Magnetized domains

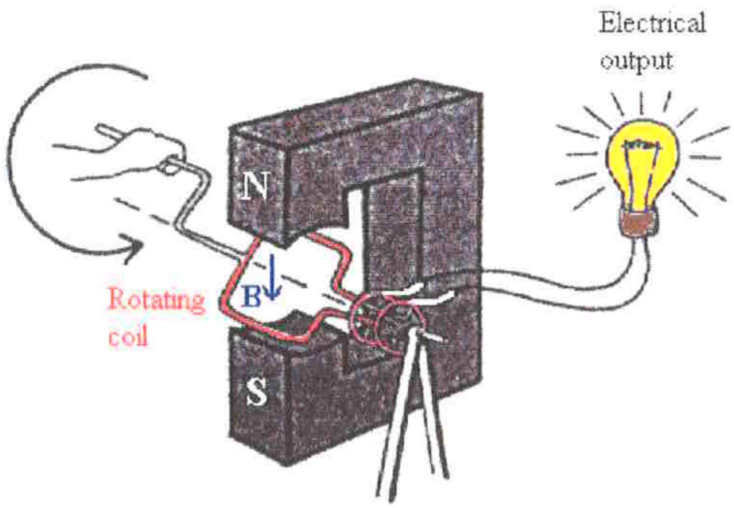


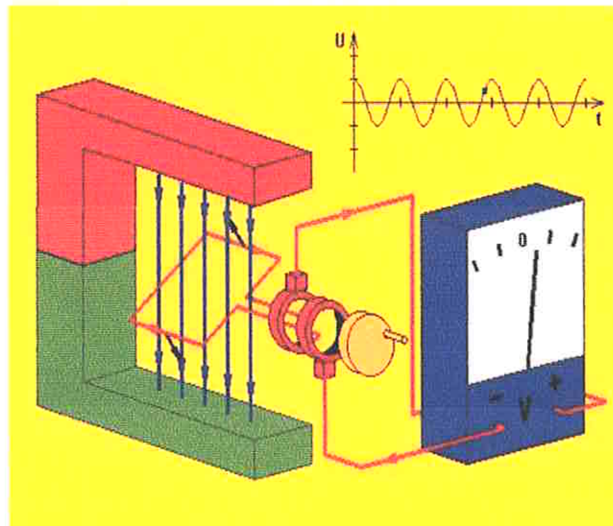
Material	Conductivity (Siemens/meter)
Copper	59.88×10^6
Silver	62.89×10^6
Gold	42.55×10^6
Aluminum	36.74×10^6
Iron	10.3×10^6
Graphite	71.4×10^5

ELECTRIC GENERATORS

= devices that convert mechanical energy into electrical energy

Electric generators consist of multiple wire loops placed in a strong magnetic field. When a generator is connected to a closed circuit, the induced emf produces electric current.





- The greatest current is generated when the velocity is perpendicular to the magnetic field
- When the wire is parallel with the magnetic field the induced current is **zero**
- The current changes direction every 180°
- Current is not induced where the wire is in the same plane as the magnetic field

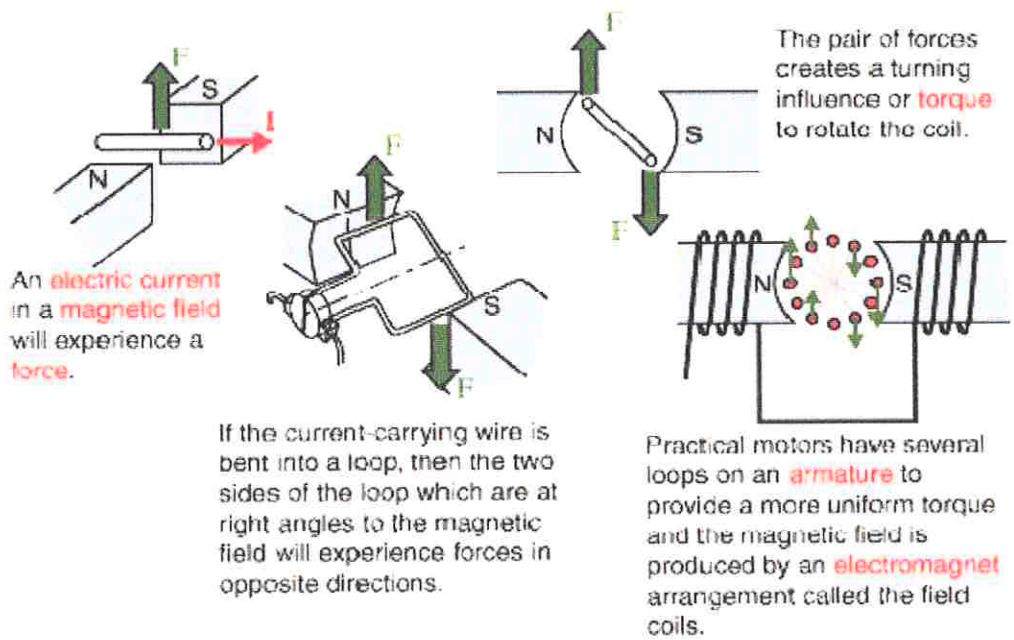
Application: potential energy form water in a dam is converted into kinetic energy of falling water that spins turbines. Turbines turn coils of conductor in a magnetic field and induces an emf (=voltage)

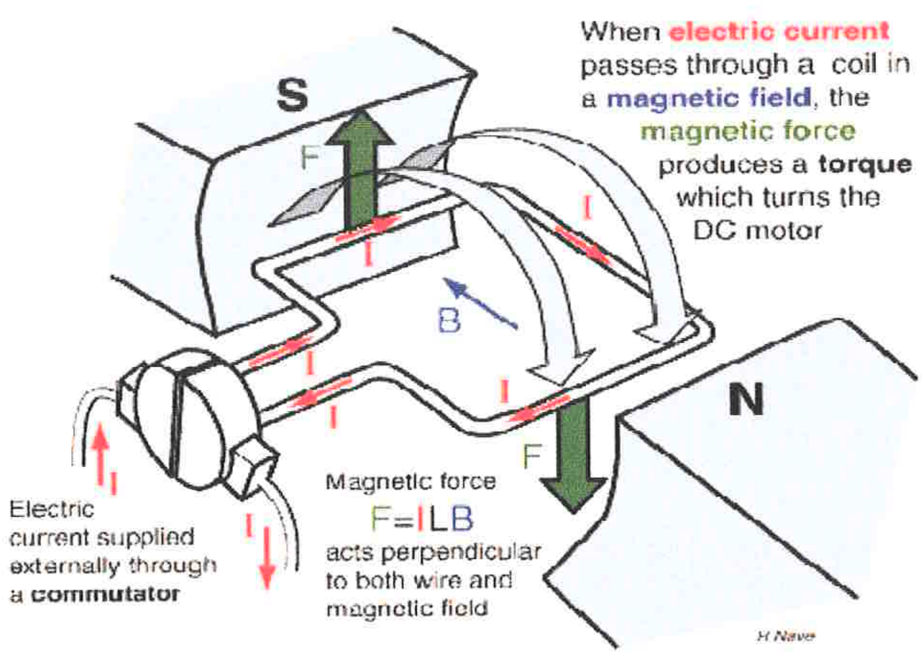
Generators and motors are almost identical in construction but convert energy in opposite directions

ELECTRIC MOTORS

= devices that convert electric energy into mechanical energy

- emf is generated when a current-carrying wire moves in a magnetic field. This emf is reffered to as **back emf**
- **Back emf** opposes the current





$$V_{circuit} = V_{source} - \varepsilon_{ind}$$

$$\varepsilon_{back} = \varepsilon_{source} - Ir$$

Example1: When a motor with a stationary coil is connected to a 4.5V power supply, there is current of 3.0A through it. When the coil is released, the current drops to 1.8A.

a) What is the coil's resistance?

b)What is the back emf in the motor at this rate of rotation?

c) The load on the motor is reduced allowing the speed of the motor to double what is the current through the motor?

Example 2. When a motor is prevented from rotating while 6.0V is applied to the motor, the current through the wire is 8.0A. When the motor is allowed to rotate the current drops to 2.0A. What is the back emf when the motor is rotating?

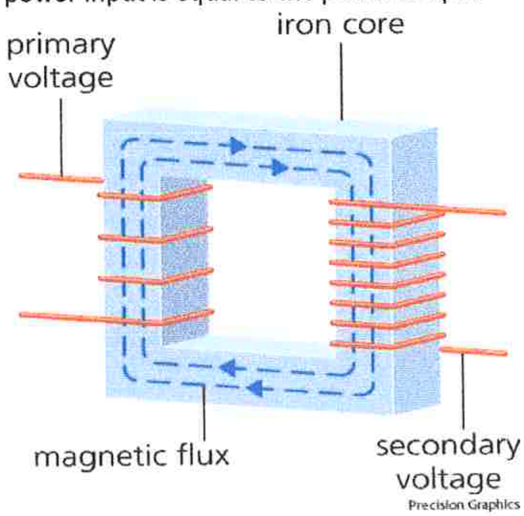
Back emf

- Emf that tends to reduce the applied current
- Increases in magnitude as the rotational speed of the coil increases
- When there is no back emf, the current is larger as it is limited only by the resistance of the coil
- When the coil rotates, the induced back emf opposes the applied voltage and the current in the coil is reduced

TRANSFORMERS

= devices that increases or decrease AC voltage.

- Widely used as they are efficient = little energy is lost during voltage changes
- Ideal transformer = 100% efficient, that is the power input is equal to the power output



A transformer consists of two coils that are electrically insulated from each other and wound around the same iron core.

- **Step-Up Transformer** increases voltage, decreases current, increases number of turns, power is constant
- **Step-Down Transformer** decreases voltage, increases current, decreases number of turns, power is constant

Secondary voltage is proportional to the primary voltage. The secondary voltage depends on the ratio of the number of turns in the secondary coil to the number of turns in the primary coil.

TRANSFOMER EQUATION:

Example: A step-up transformer has a primary coil consisting of 200 turns and a secondary coil consisting of 3000 turns. The primary coil is supplied with voltage of 90V.

a) Sketch a diagram of the transformer.

b) Find the voltage in the secondary coil.

c) If the current in the secondary coil is 2.0A, what is the current in the primary coil?