Magnetism and Electromagnetic Energy

Objective: Learning about magnetism, magnetic field and electromagnetism.

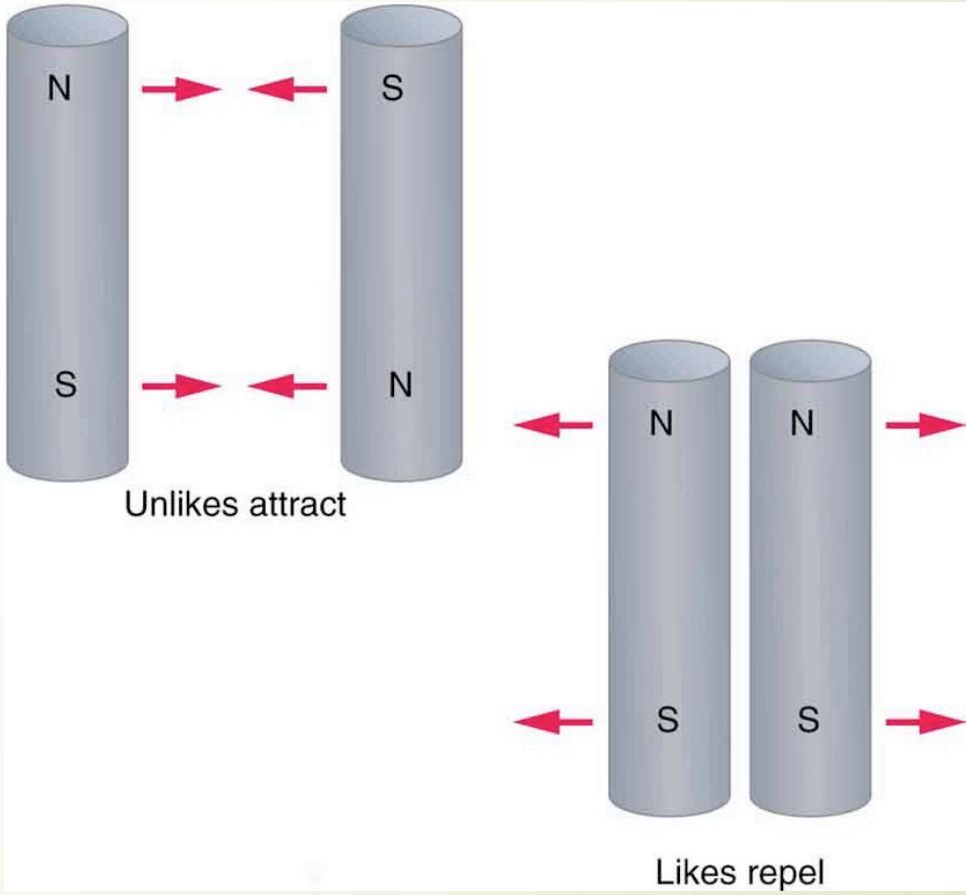
Key concepts:

- Magnetic poles
- Magnetic force and fields
- Electromagnets
- Electromagnetic induction- Faraday's Law
- Electric Motor and Generators
- Transformers

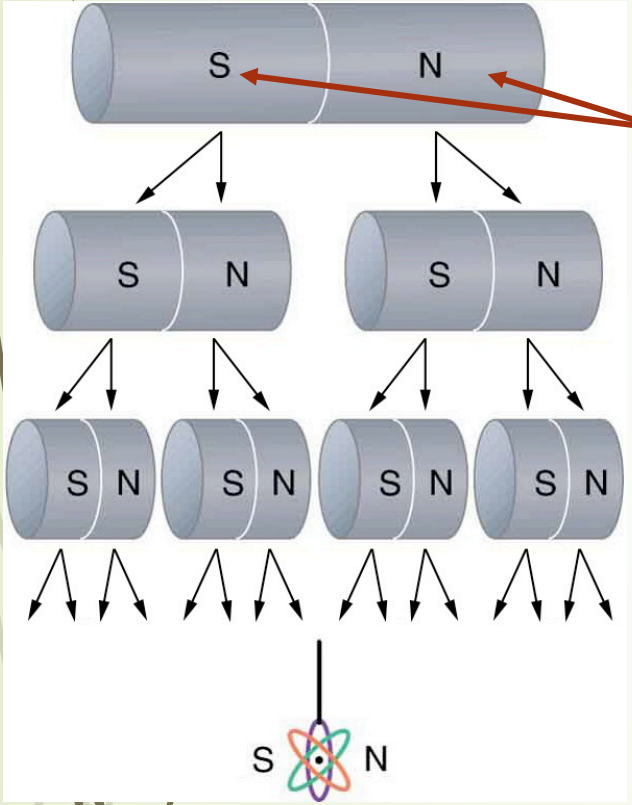
Magnetic Forces

Magnetic Force- is similar to electrical force

- Cause objects to attract or repel
- Strength decreases as distance increases between two magnets
- *Magnetic poles* produce magnetic forces (electric charges produce electric forces)

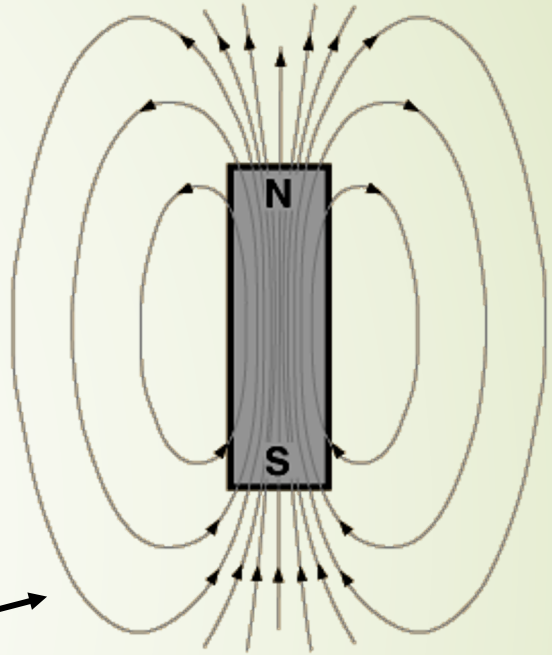


Magnetic Poles



Every magnet has a North and a South pole

Magnetic poles always exist in pairs, though electric charges can be separated

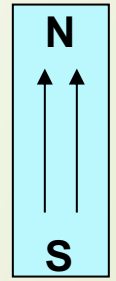


Rule:

- Like poles repel each other (N –N) or (S –S)
- Opposite poles attract (N – S)

➢ **Magnetic Fields** - Regions of Magnetic influence

- Direction of the magnetic field outside the magnet is from North pole to the South pole



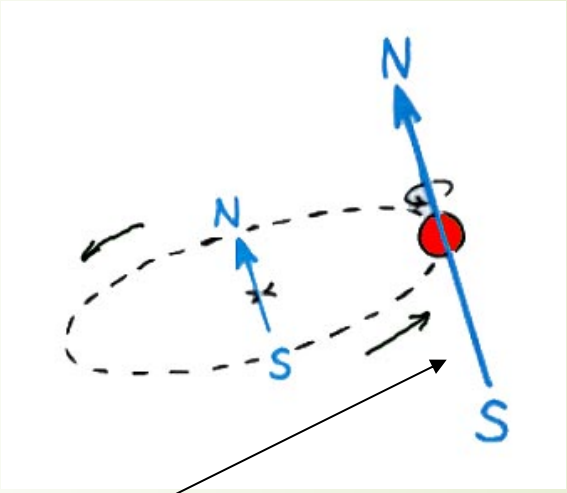
Inside the magnet

Magnetic Field

A magnetic field is produced by the motion of electric charges

Two kinds of electron motion **make magnetism**

1. **Electron revolution**
2. **Electron spin**



Electron spin produces a stronger magnetic filed

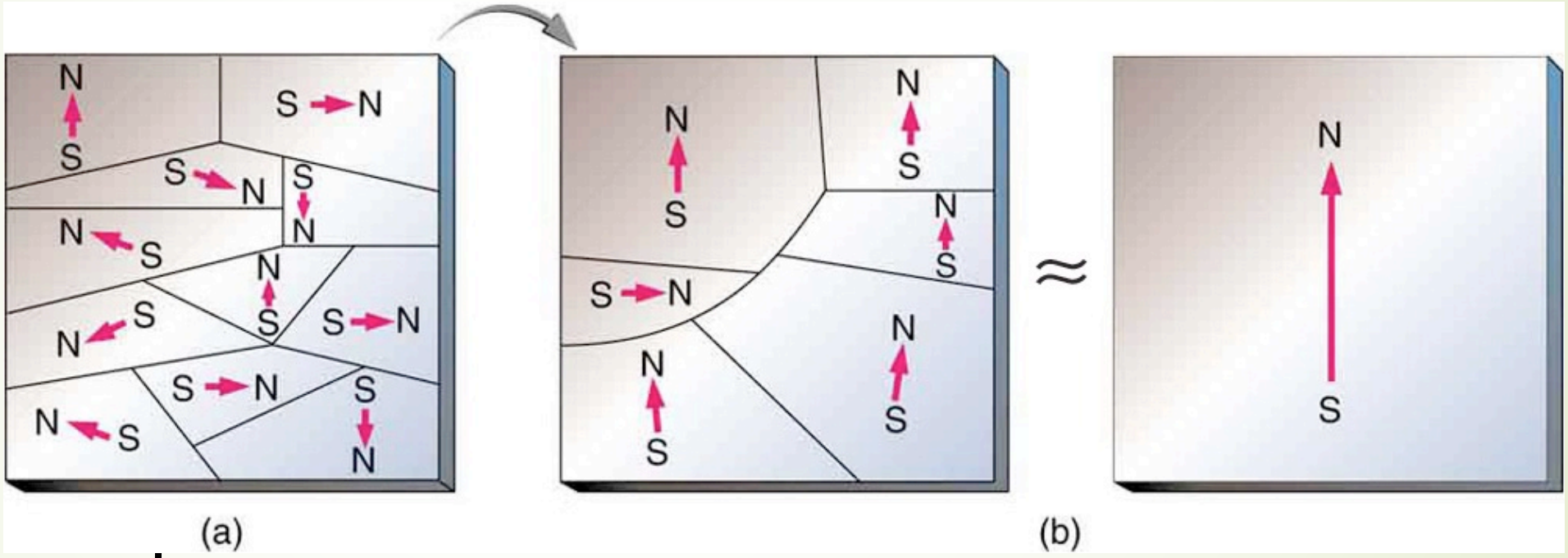
- Two electrons spinning in the same direction produce a strong magnetic field -*Iron, cobalt nickel make good magnets*

- Two electrons spinning in the opposite direction produce no magnetic field - *magnetic fields cancel each other*

***This is why most materials are not magnets

Magnetic Domains

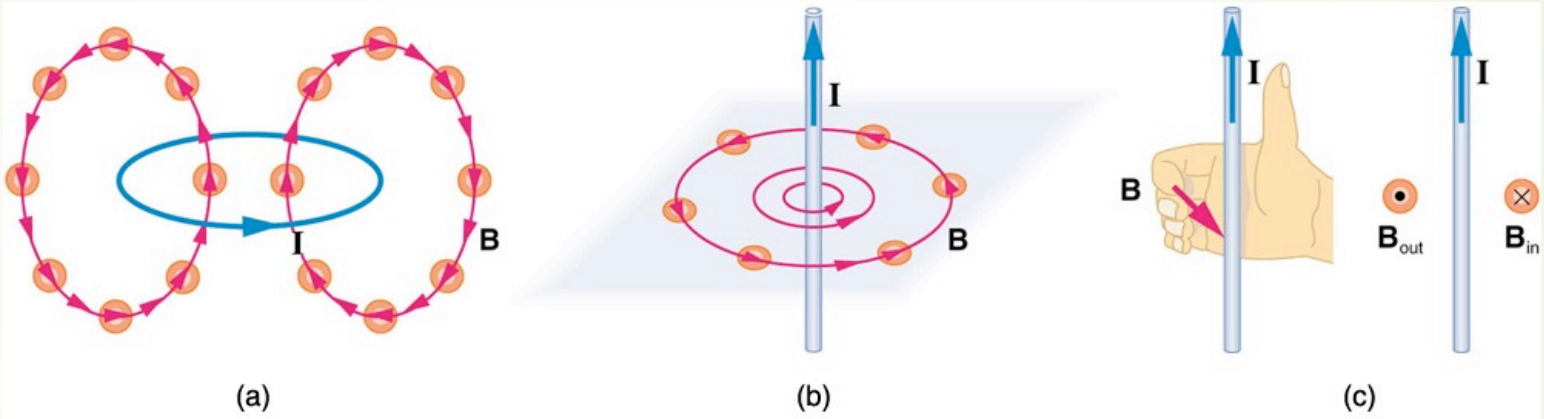
Magnetic Domains- clusters of aligned atoms
-only found in ferro-magnetic materials



Ordinary iron is not magnetized

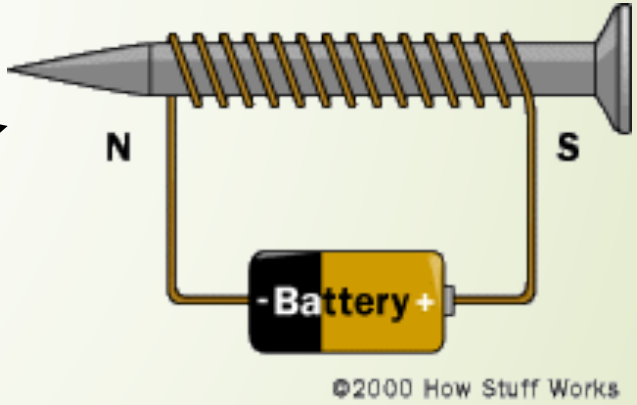
Electromagnet

A current carrying wire produces a magnetic field



If we insert a piece of iron inside a current carrying coil we can make a stronger magnet

The nail becomes an electromagnet

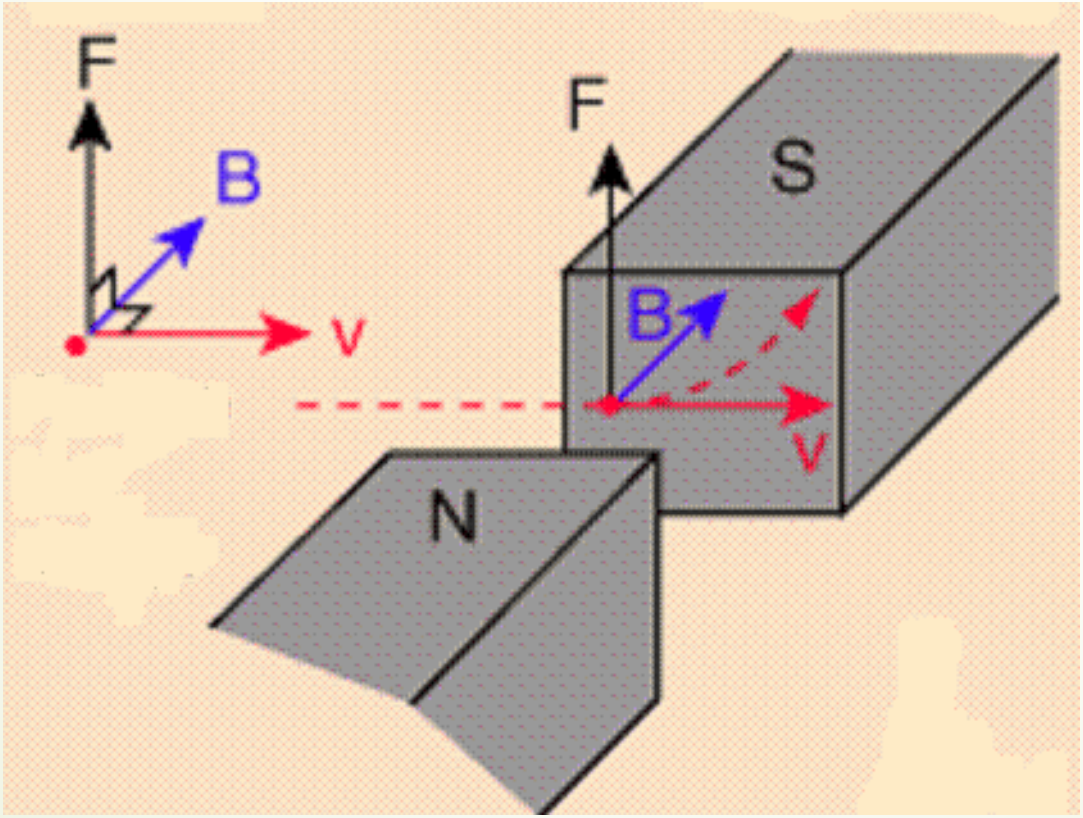


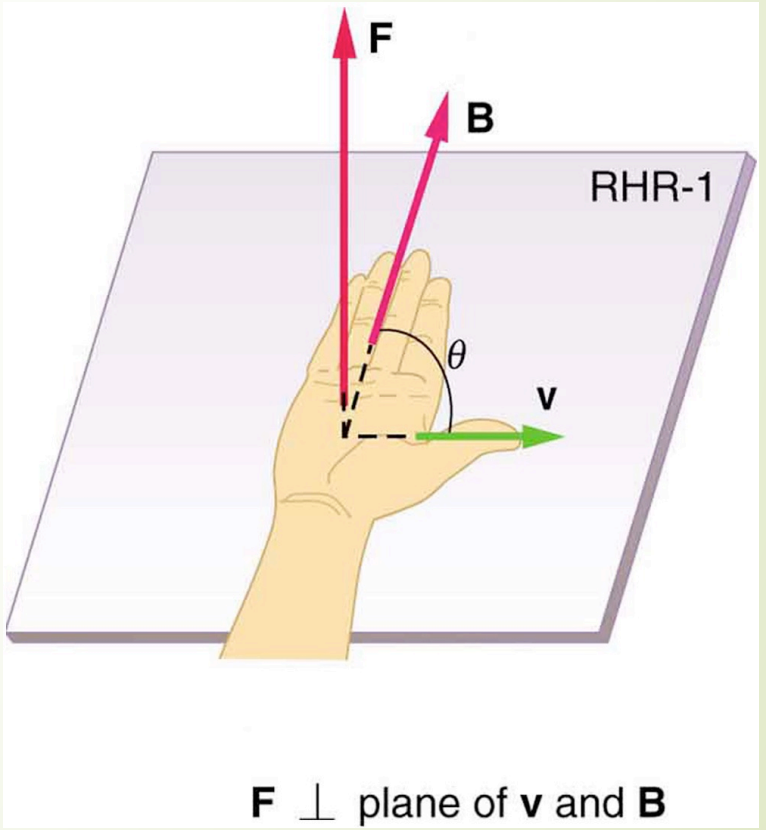
- Stays as a magnet as long as current flows through the coil.
- If we increase the current through the coil we can increase the strength of the electromagnet.

Magnetic forces on moving charges

If a charged particle is moving in a magnetic field it experiences a deflecting force.

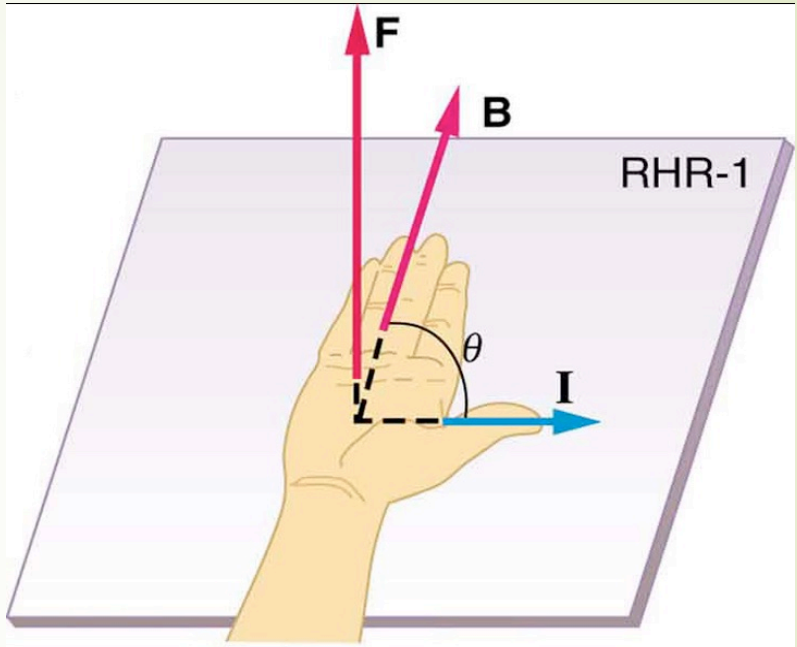
- For a positive charged particile, you point the thumb of the right hand in the direction of **v**, the fingers in the direction of ***B*** , and a perpendicular to the palm points in the direction of ***F***



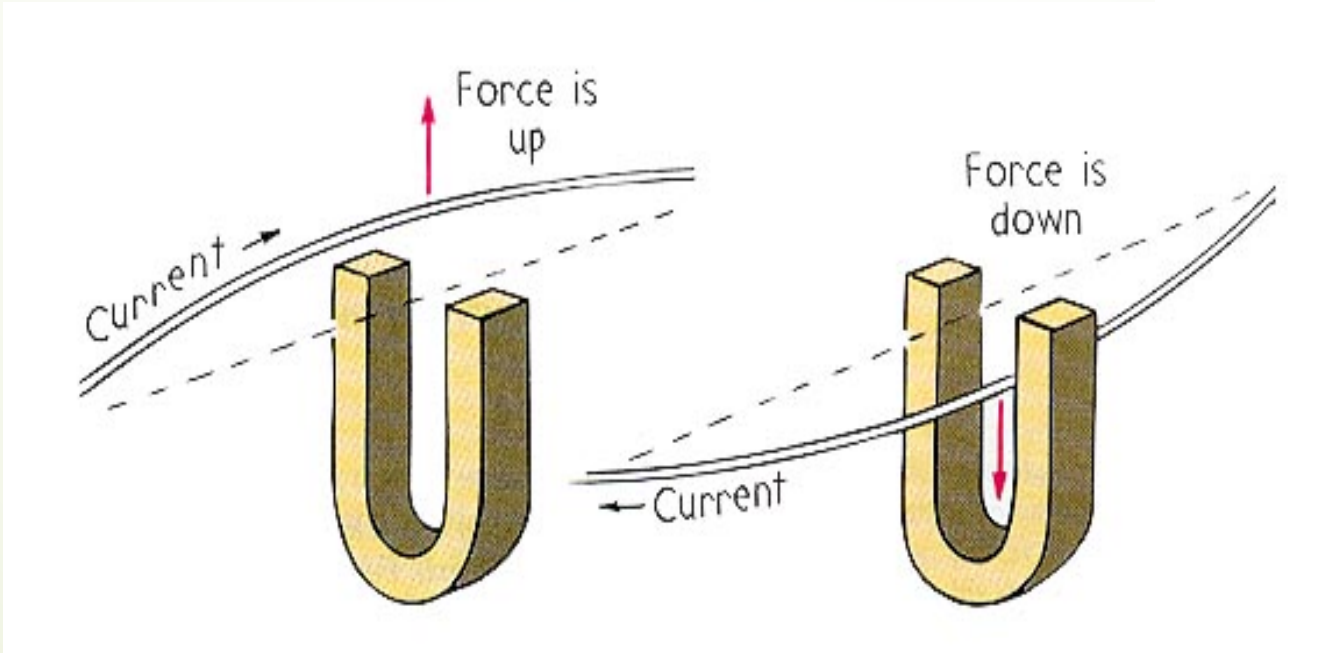


Magnetic forces on a current-carrying wire

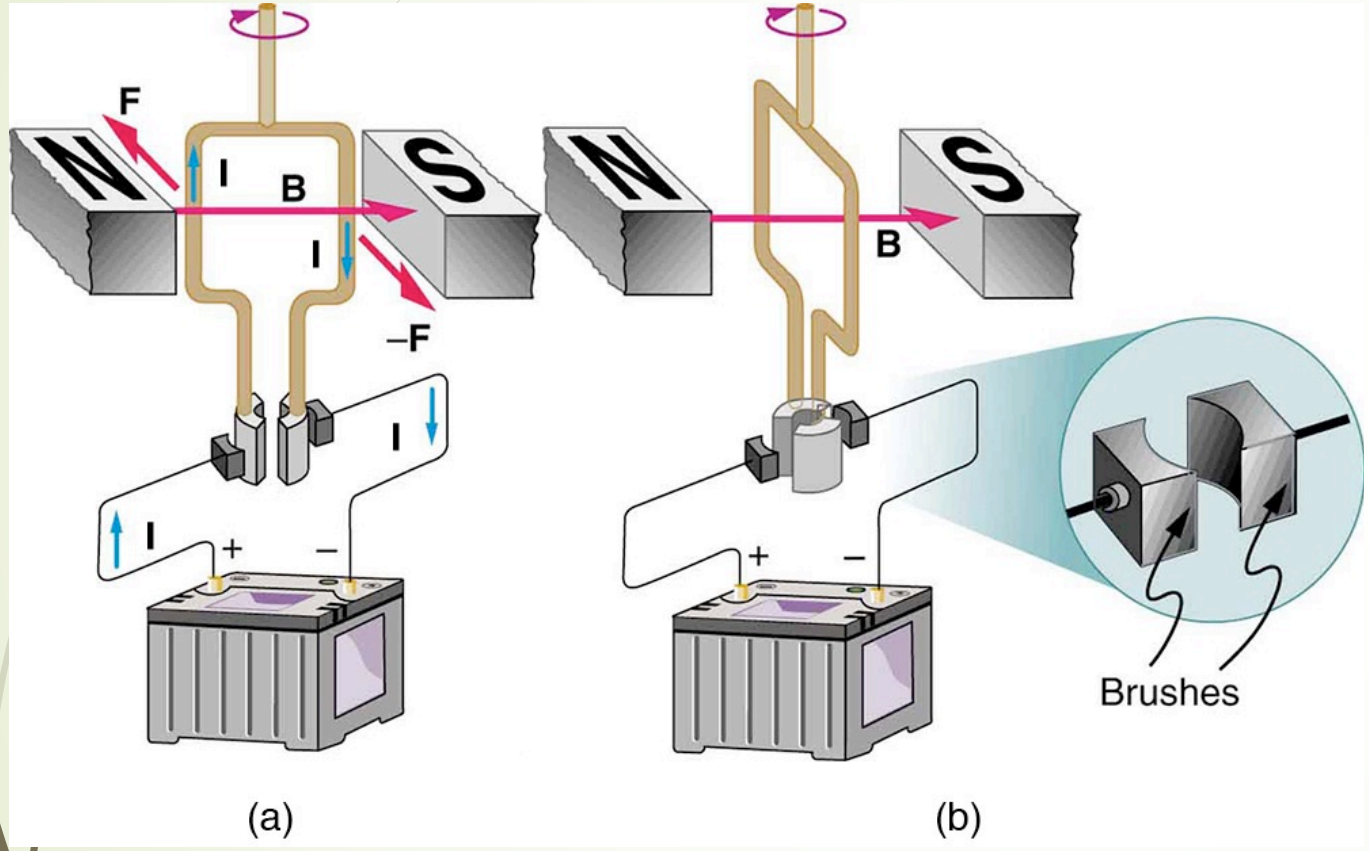
Charges ordinarily cannot escape a conductor, the magnetic force on charges moving in a conductor is transmitted to the conductor itself.



F ⊥ plane of **I** and **B**



Electric Motor



The force on the current carrying coil makes it to rotate

↓

Rotation can be used to run clocks, lift objects, etc.

Input – Electrical energy

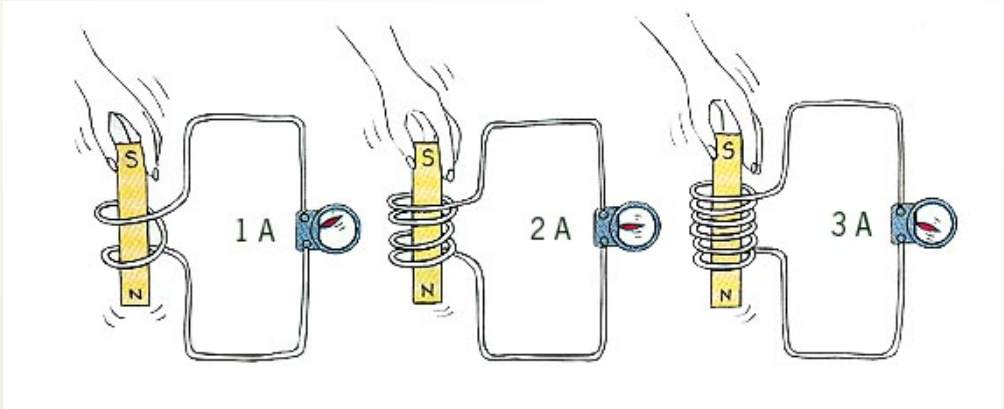
Output – Mechanical energy

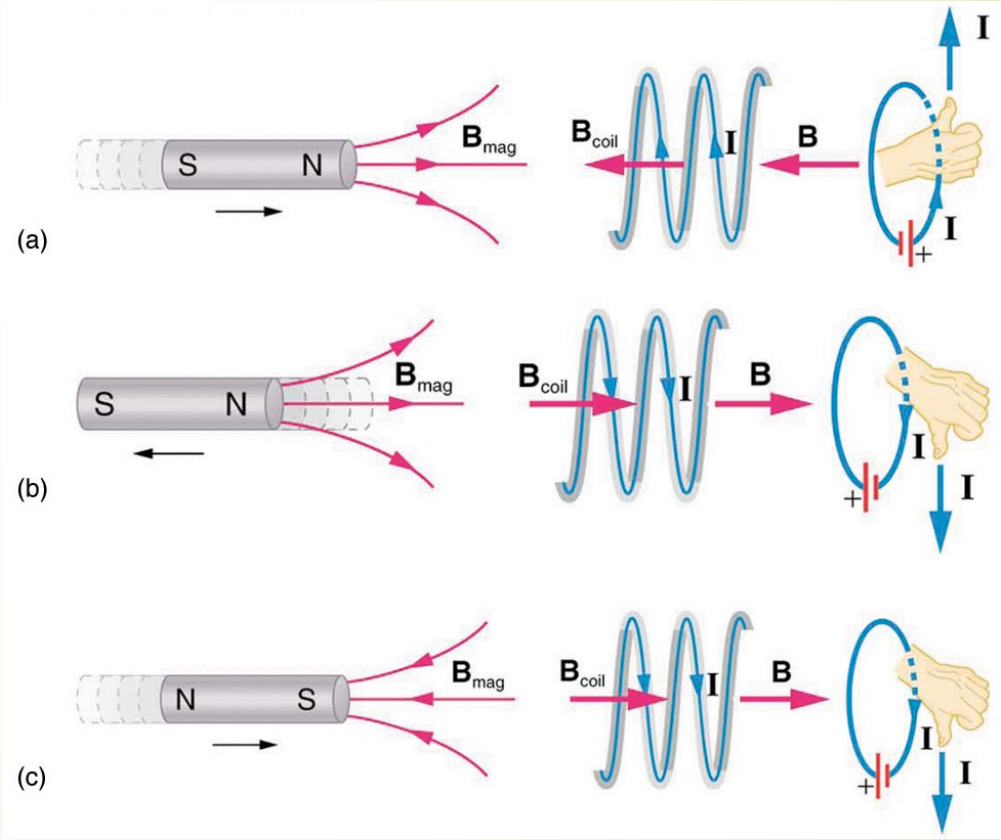
Electromagnetic Induction

- Faraday's Law of induction: (Lenz's Law)
  The induced voltage in a coil is proportional to the number of loops multiplied by the rate at which the magnetic field changes within those loops.

$$V = -N\frac{\Delta\Phi}{\Delta t}.$$

- More number of loops induce more voltage or more current
- The induced voltage also depend on how fast the magnet is entering or leaving the coil





Connections between Electricity and Magnetism

Complete the relationships. List at least one example of each relationship from everyday applications.

(A) Wire with **electric current** flowing interacting with a magnetic field generates:

Example:_____

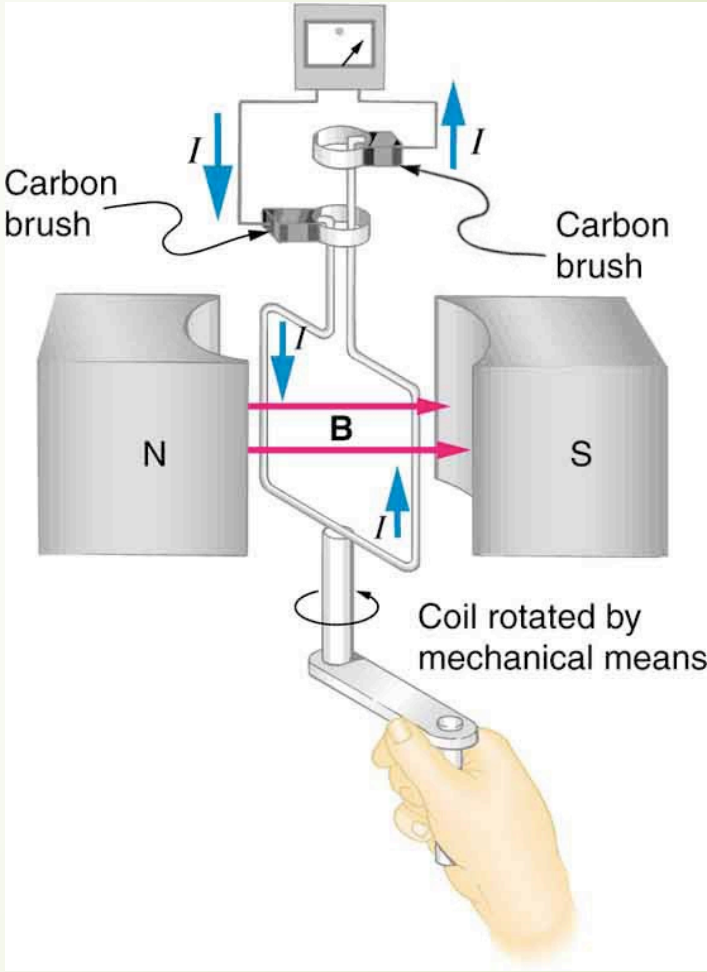
(B) Electric (charge) field in motion generates:

Example:_____

Connections between Electricity and Magnetism

(C) Magnetic field in motion relative to a coil of wire (or coil of wire in motion relative to magnetic field) generates:

Example:_____



Electromagnetism

A coherent description of electromagnetism was formulated by James Clerk Maxwell

Maxwell's Laws:

Law 1: Coulomb's Law - like charges repel, unlike attract; inverse square force

Law 2: There are no magnetic monopoles in nature.

Law 3: Magnetic phenomena can be produced by electrical effects.

Law 4: Electrical phenomena can be produced by magnetic effects.

Transformers

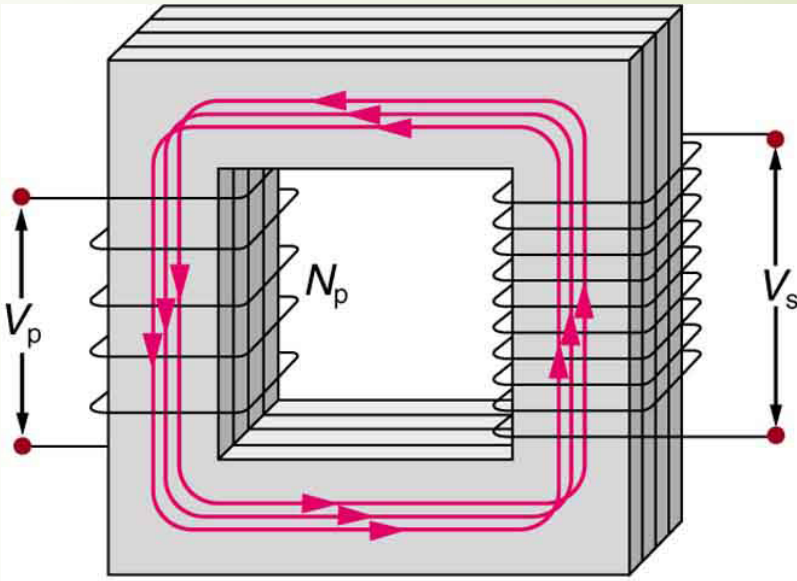
Transformers are used to increase or decrease voltage.

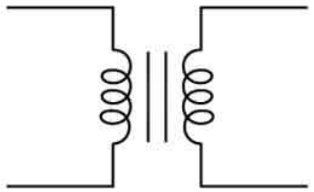
What is required for transformers to function?

_____

The number of windings is _____ related to the voltage.

The power (P = V × I) must remain constant so the current is _____ related to the voltage.





Transformer symbol

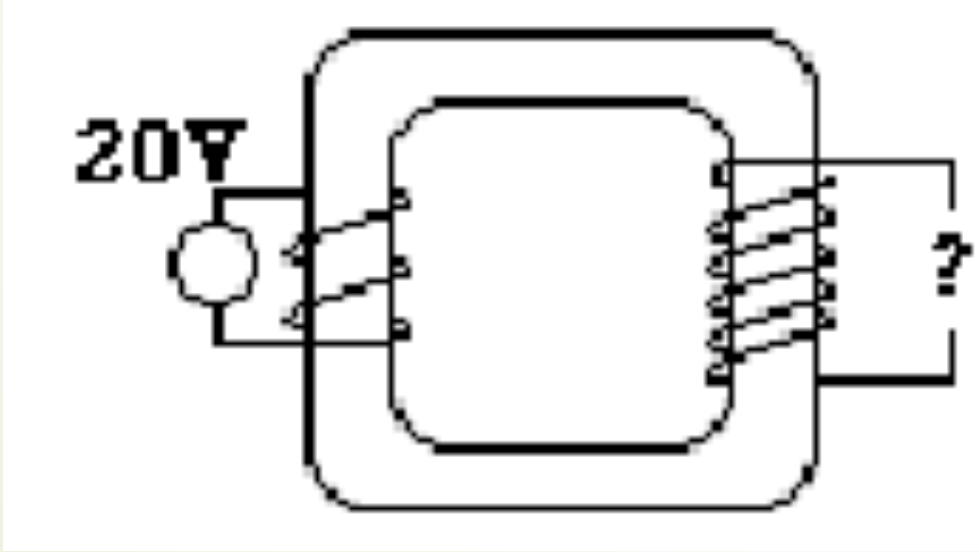
$$\frac{V_s}{V_p} = \frac{N_s}{N_p}.$$

$$P_p = I_p V_p = I_s V_s = P_s.$$

Transformers

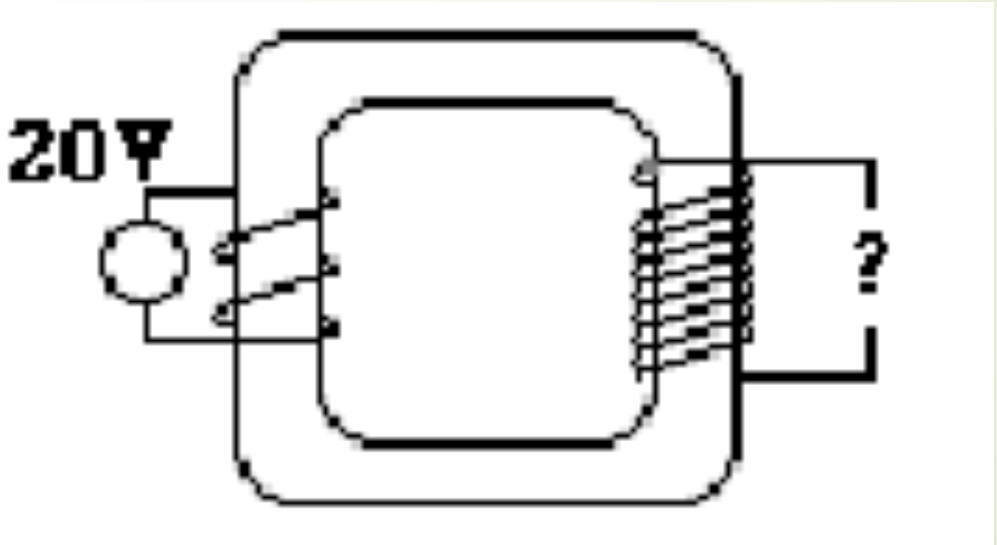
STEP UP TRANSFORMERS

3 coils	6 coils
20 V	40 V
6 A	3 A



STEP UP TRANSFORMERS

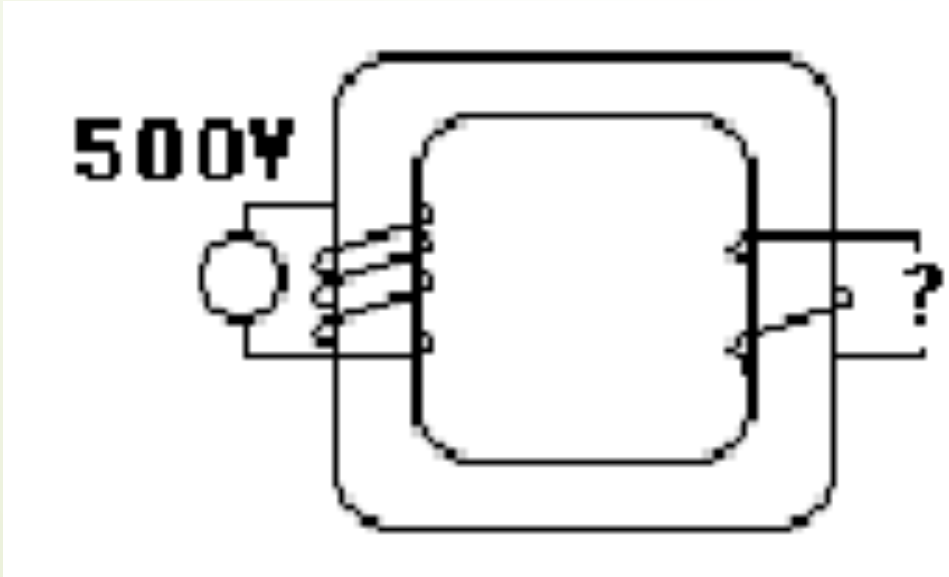
3 windings	9 windings
20 V	____ V
6 A	____ A



Transformers

STEP DOWN TRANSFORMERS

4 coils	2 coils
500 V	250V
5 A	10 A



STEP DOWN TRANSFORMERS

10 coils	2 coils
240 V	____V
6 A	____ A