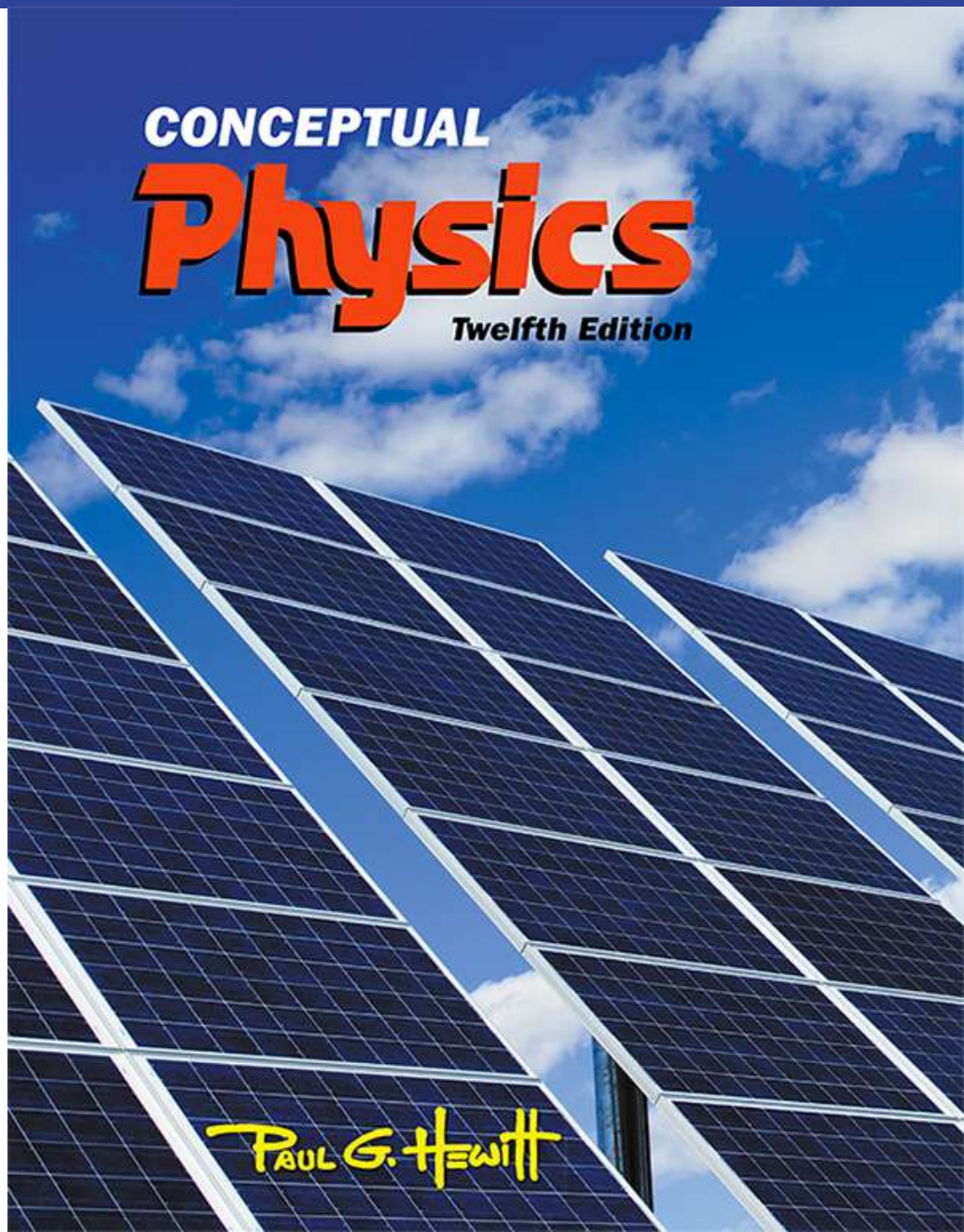
Lecture Outline

Chapter 24: Magnetism

Part 1: Sections 1-3

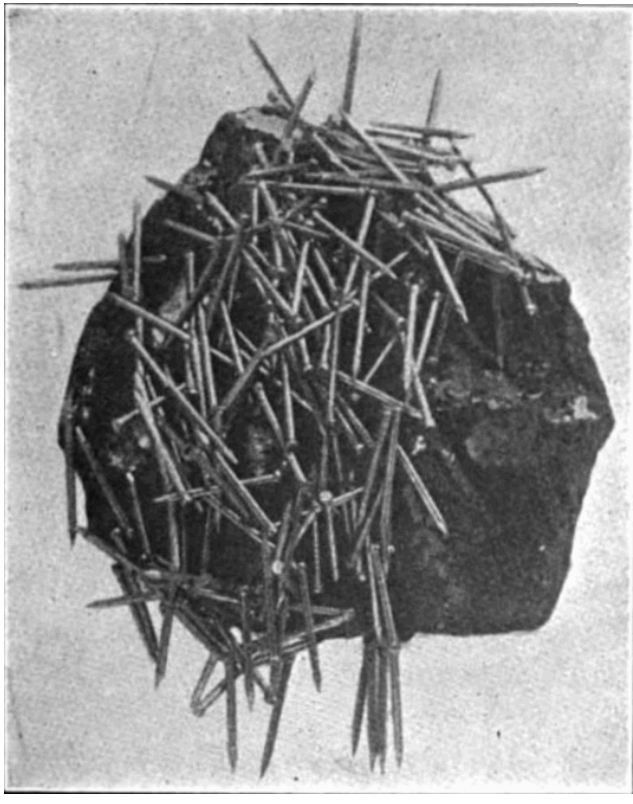


Magnetism

- The term *magnetism* comes from the name Magnesia, a coastal district of ancient Thessaly, Greece.

- Unusual stones were found by the Greeks more than 2000 years ago.

- These stones, called *lodestones*, had the intriguing property of attracting pieces of iron.
- Magnets were first fashioned into compasses and used for navigation by the Chinese in the 12th century.

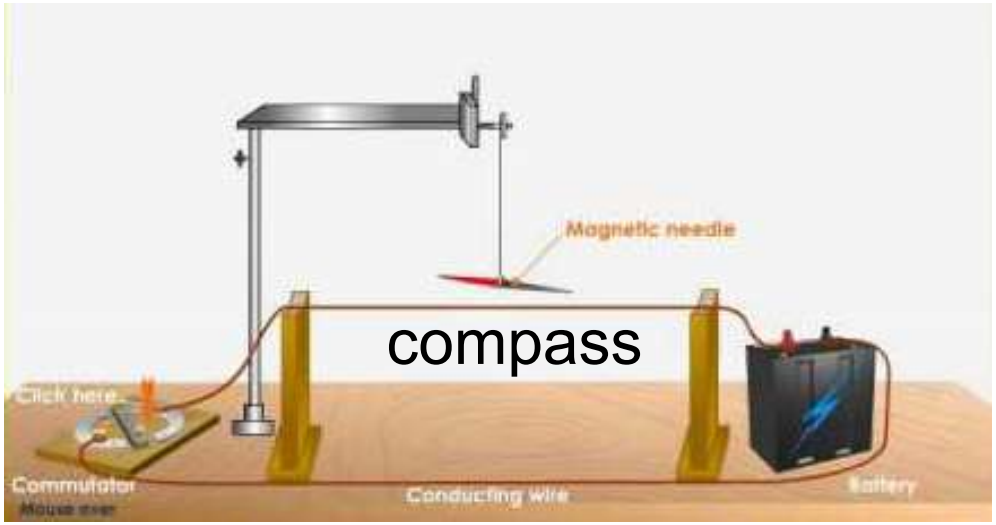


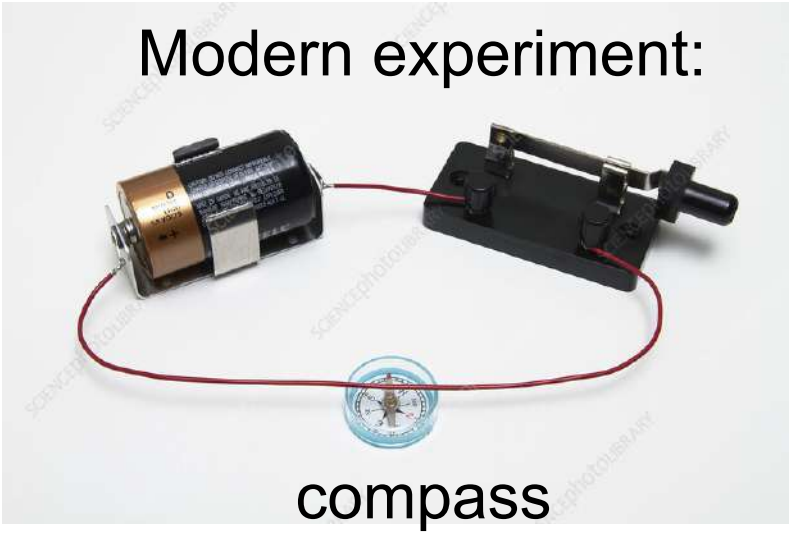
Magnetism and electricity seemed separate, until….

- During a classroom demonstration in 1820, Danish physicist Hans Oersted discovered:

An electric current makes a magnetic compass move!

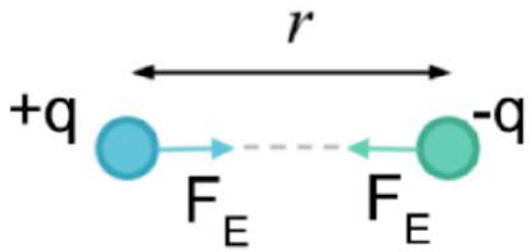
→ **Electromagnetism** was born.





Forces between 2 charged particles:

- The force between any two charged particles depends on the magnitude of the charge on each and their distance of separation, as specified in Coulomb's law.
- This force exists when charges are *at rest.*



- When the charged particles are *moving* with respect to each other, the force between electrically charged particles depends also, in a complicated way, on their motion.
- This force due to the *motion* of the charged particles is the **magnetic force**. It depends on **velocity.**

magnetic force

$$\vec{F} = q\vec{v} \times \vec{B}$$

velocity

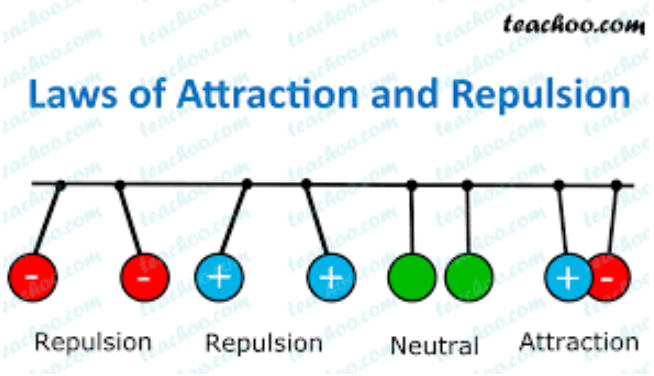
The sources of forces…

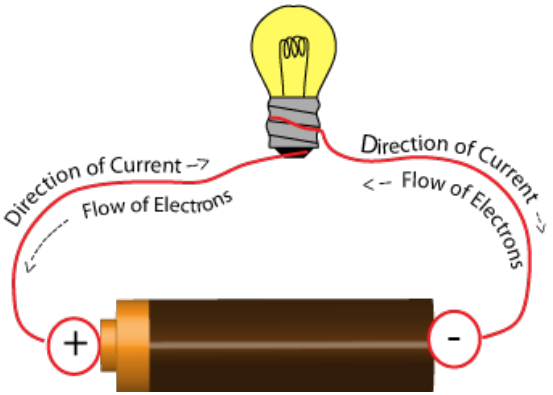
The source of the electric force is electric charge.

The source of the magnetic force is…

…moving charges….

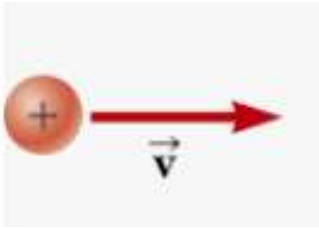
…also known as *current*.





The charge is usually made up of electrons, but protons will also experience the magnetic force.

→ Moving *neutrons* will not!



Start your classwork. Write answers out.

1. By whom, and in what setting, was the relationship between electricity and magnetism discovered?

2. The force between electrically charged particles depends on the magnitude of each charge, their separation distance, and what else?

3. What is the source of magnetic force?

Types of Magnets

BAR

RING

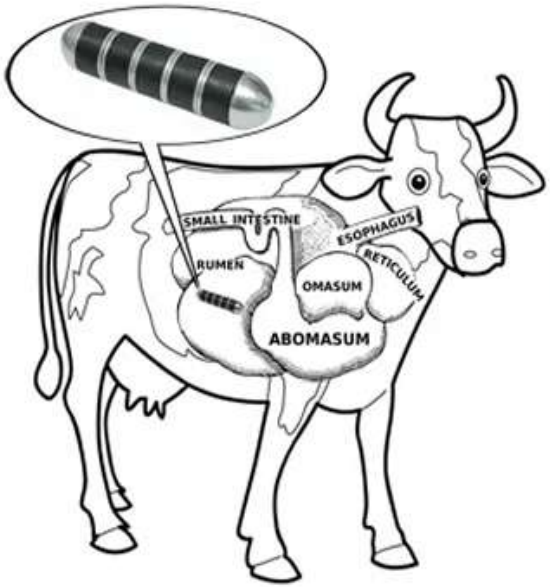
NEODYMIUM

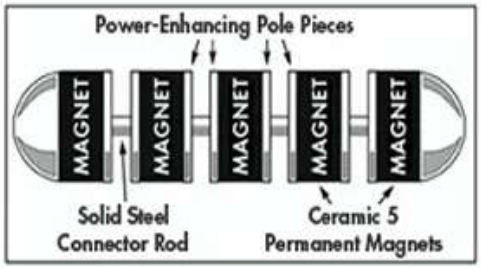
COW

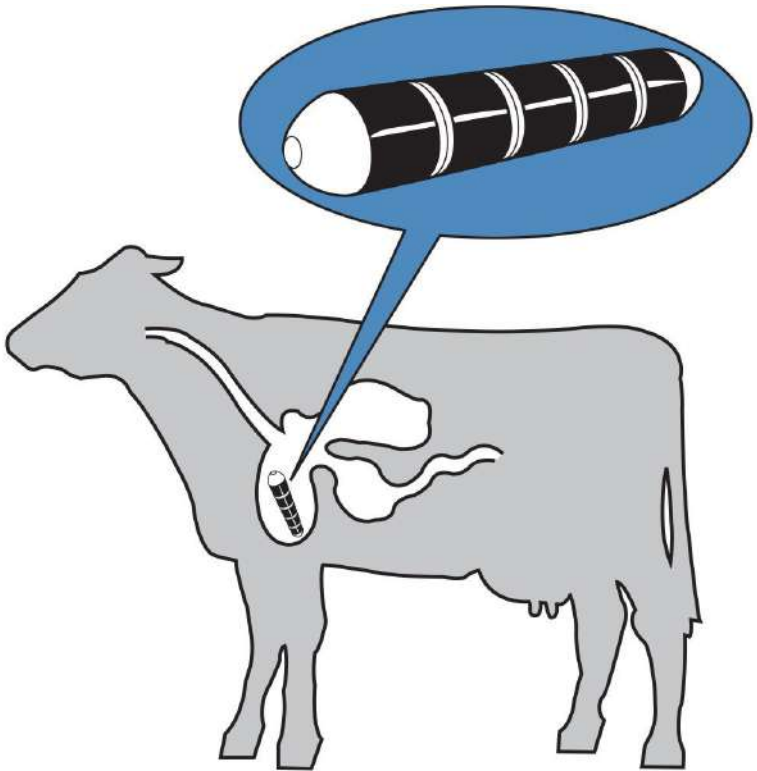
HORSESHOE

WAND

Cow magnets







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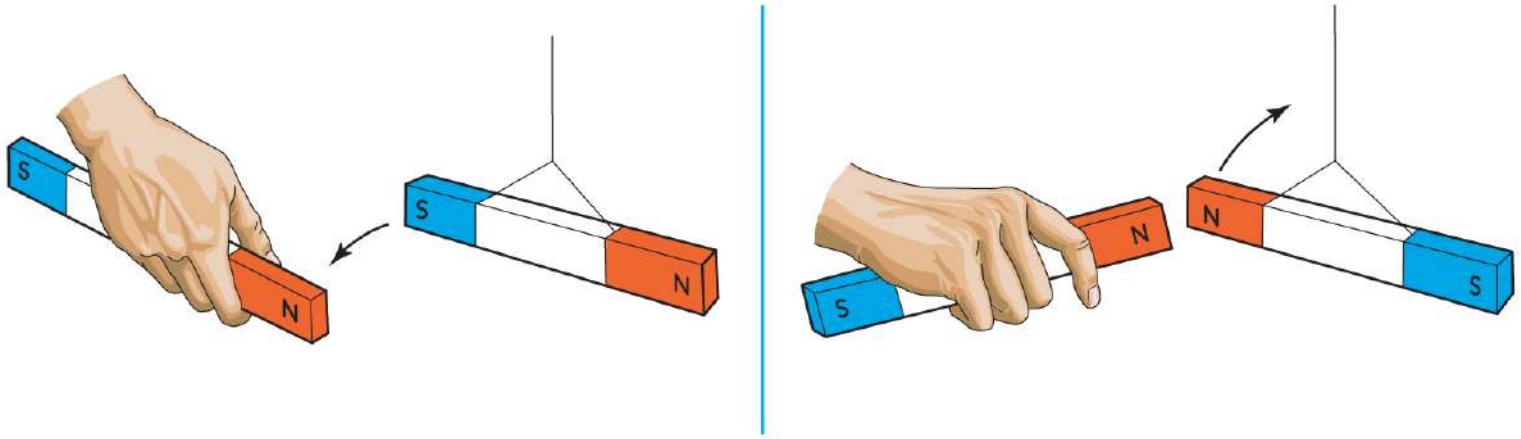
- Magnetic force between a pair of magnets
  - Force of attraction or repulsion between a pair of magnets depends on which end of the magnet is held near the other.



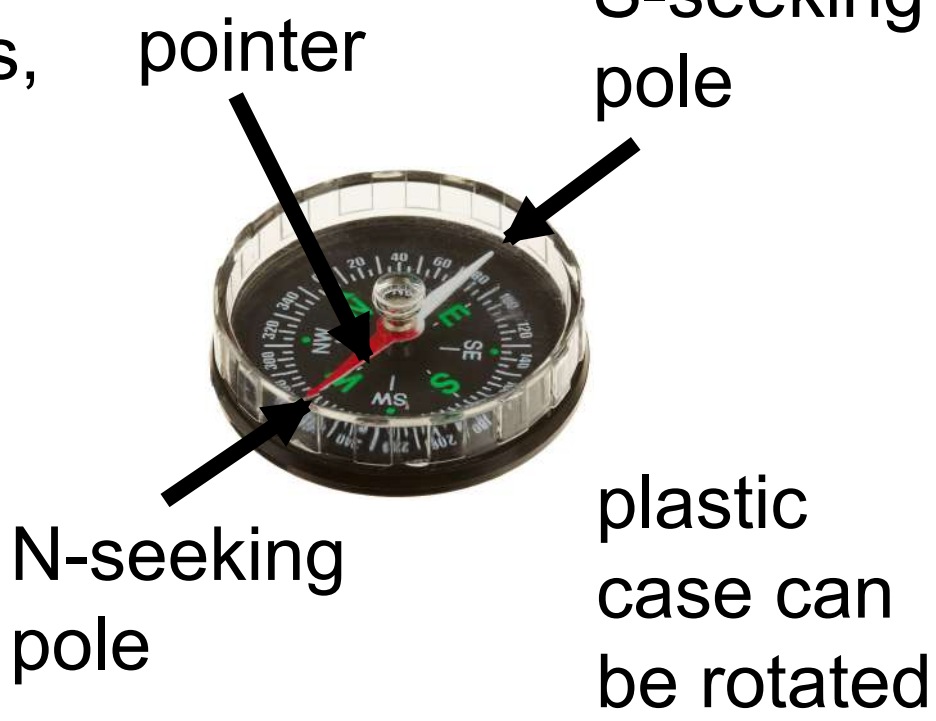
Behavior similar to electrical forces.

  - Strength of interaction depends on the ***distance*** between the two magnets (closer → stronger).

- Magnetic poles…
  - …give rise to magnetic force
  - …have 2 types interacting with each other:
    - north pole (north-seeking pole), N
    - south pole (south-seeking pole), S

Ex: In a magnetic compass, the pointer is a magnet balanced on a pin so that it can move freely..

It's poles line up with Earth's magnetic field.

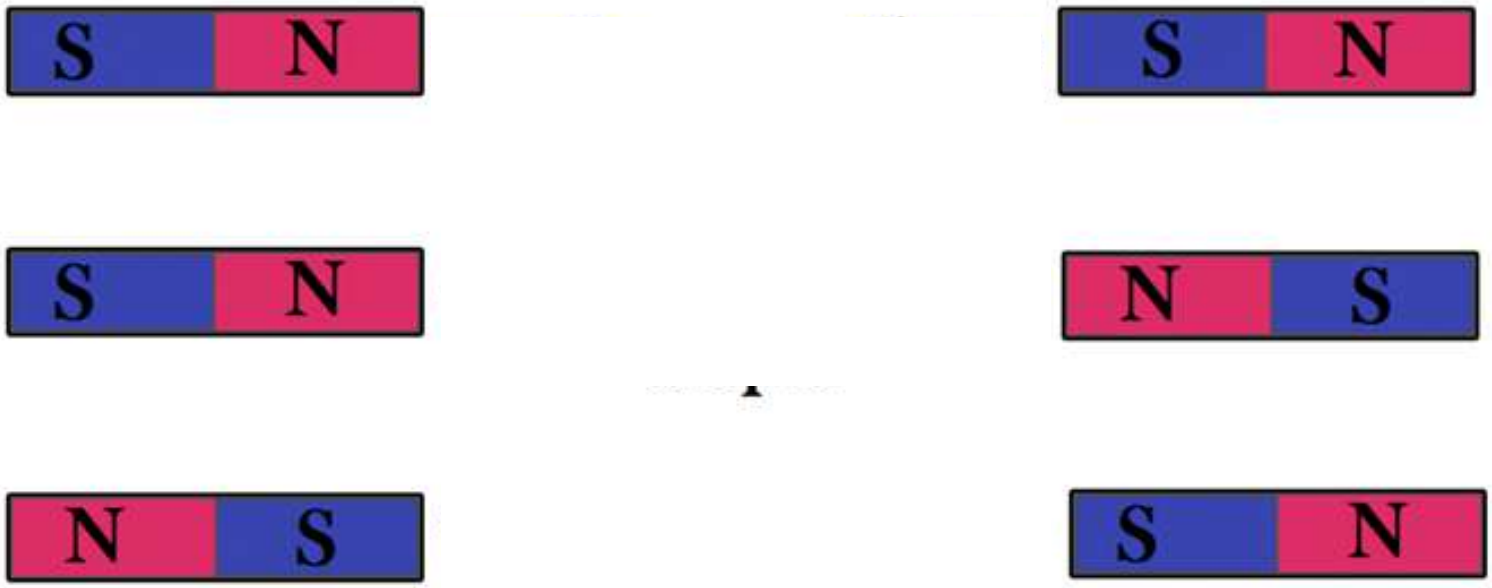


Rule for magnetic forces between poles:

Like poles (N and N or S and S) repel;

Opposite poles (N and S) attract.

Ex. Do they attract and repel?



- In all magnets—can't have one pole without the other
- No single pole (a *mono*pole) known to exist

Bar magnet:

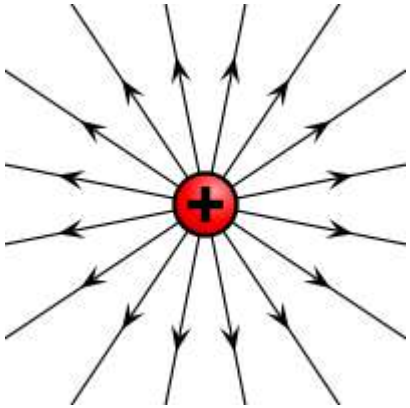
…broken:

…and broken:

…and broken:

…etc.

This is not true for electric charges. They can be found “alone.”



Add to classwork

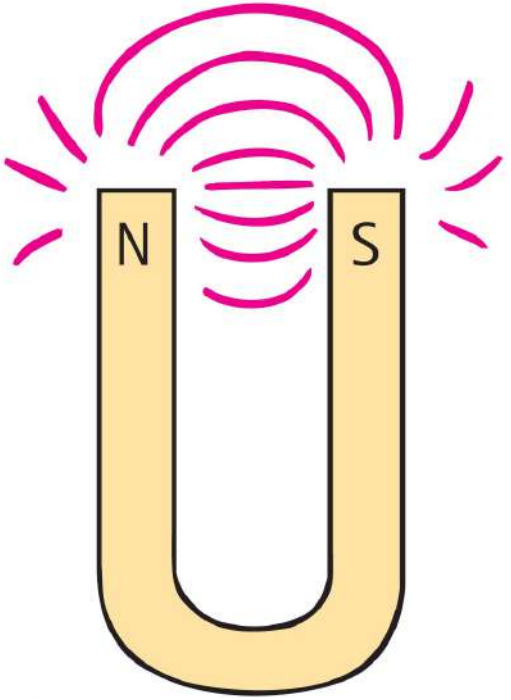
4. Is the rule for the interaction between magnetic poles similar to the rule for the interaction between electrically charged particles?

5. In what way are magnetic poles very different from electric charges?

Magnetic Poles, Continued-1

- Examples:
  - simple bar magnet—poles at the two ends

  - horseshoe magnet: bent U shape—poles at ends



Magnetic Poles
CHECK YOUR NEIGHBOR

A weak and strong magnet repel each other. The greater repelling force is by the

A. stronger magnet.
B. weaker magnet.
C. Both the same.
D. None of the above.

Magnetic Poles
CHECK YOUR ANSWER

A weak and strong magnet repel each other. The greater repelling force is by the

C. Both the same.

Explanation:

Remember Newton's third law!

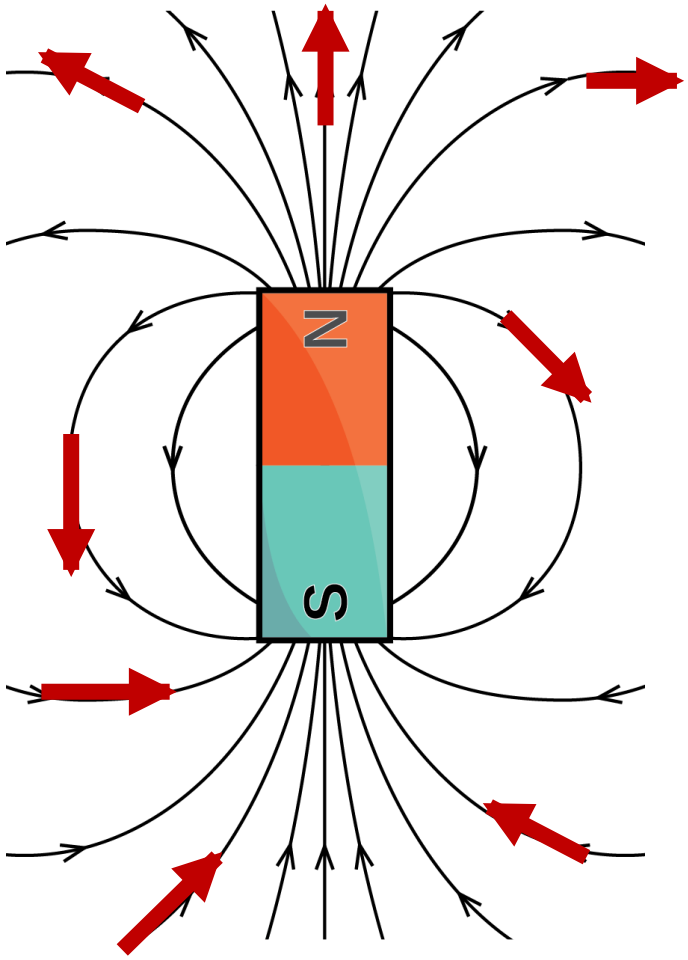
CHECK POINT

Do both electrical forces and magnetic forces depend on motion?

CHECK POINT

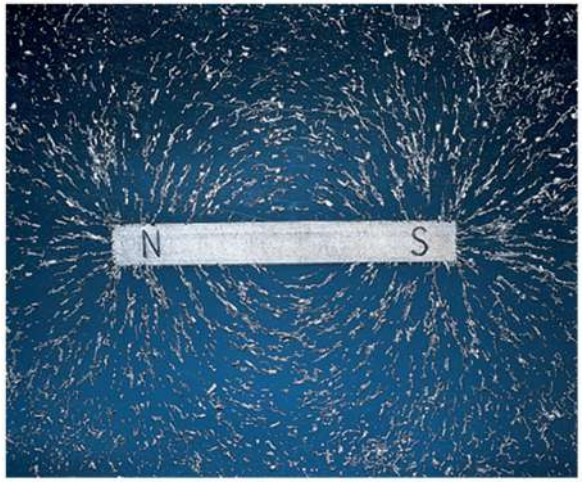
Does every magnet necessarily have a north and a south pole?

- Magnetic fields
  - Region of magnetic influence surrounding magnetic poles
  - Shape revealed by force lines that spread from one pole to the other
  - Direction is **from the north pole to the south pole**,
  - If a magnetic compass is placed anywhere, its N pole will point in the direction of the lines (see the arrows).

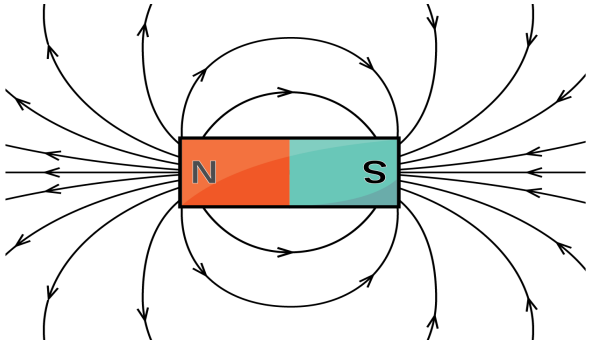


Sprinkle iron filings near a magnet:

The filings act like little magnets…they line up with the field.



The field idea explains how magnets can exert forces without touching!



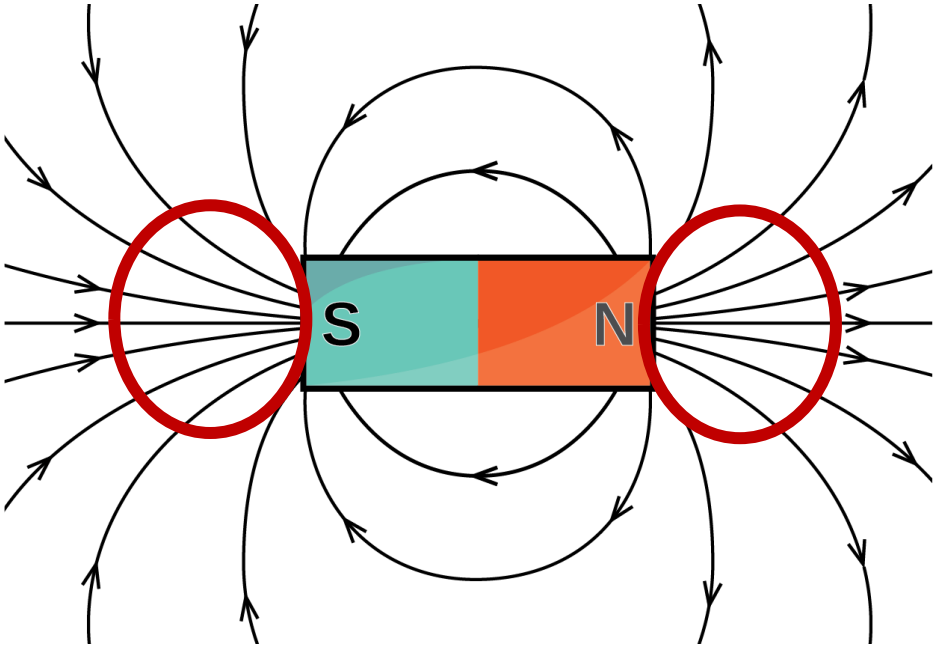
Strength of the Magnetic field:

- If lines are:

…close together → strong magnetic field

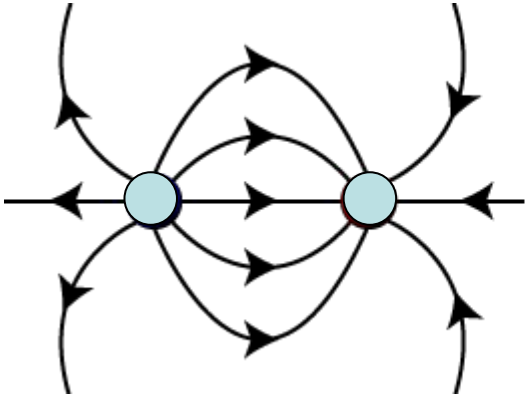
…farther apart → weak magnetic field

Where is the magnetic field the strongest?

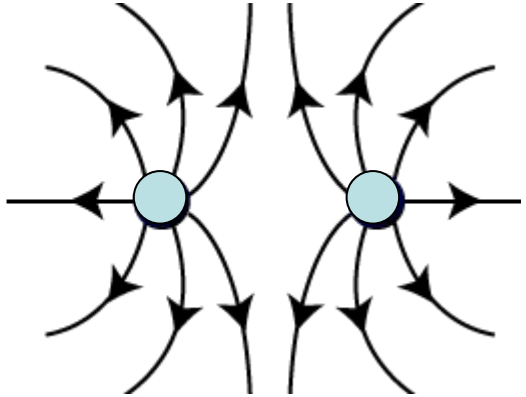


Which charge (and pole) is which?

charges:
(out of +,
into -)

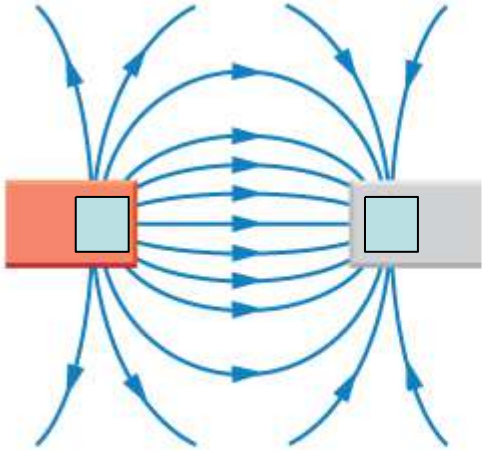


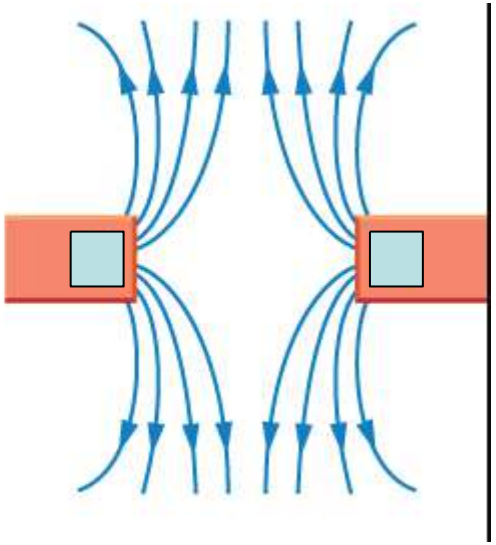
attraction



repulsion

poles:
(out of N,
into S)





Magnetic Fields
CHECK YOUR NEIGHBOR, Continued

Where magnetic field lines are more dense, the field there is

A. weaker.
B. stronger.
C. Both A and B.
D. Neither A nor B.

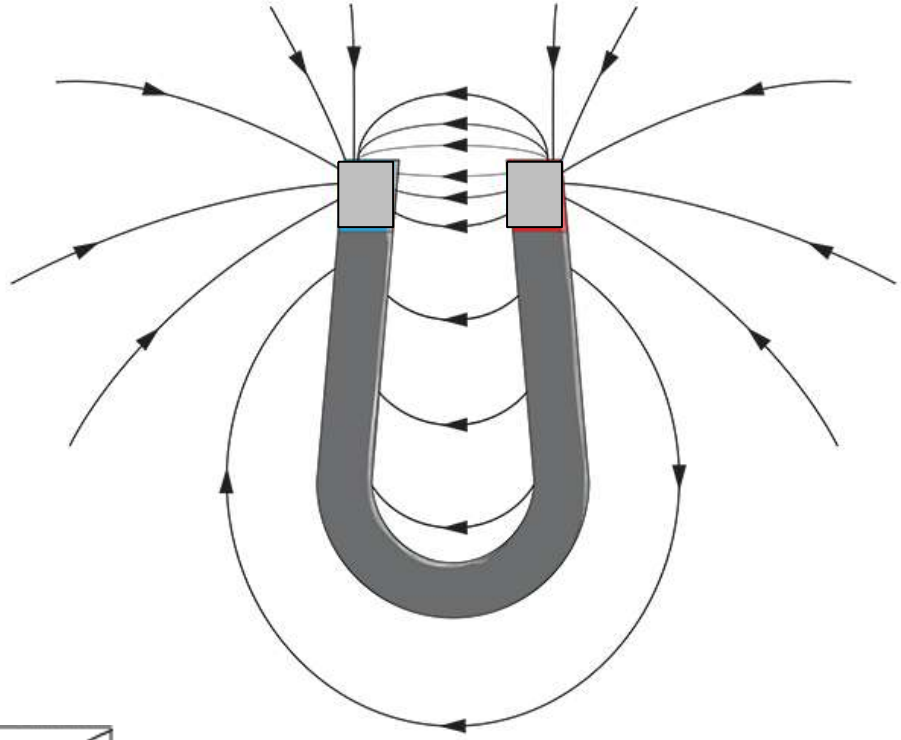
Magnetic Fields
CHECK YOUR ANSWER, Continued

Where magnetic field lines are more dense, the field there is

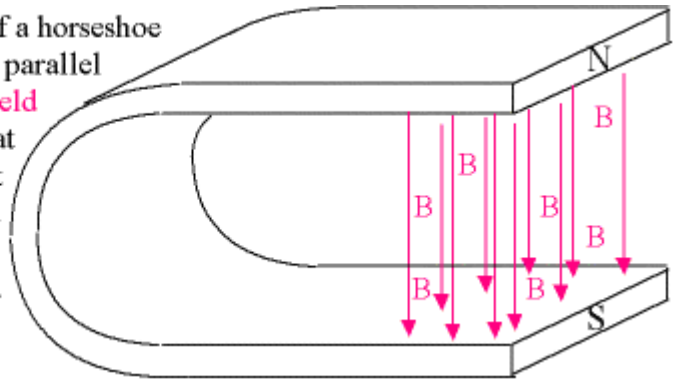
B. stronger.

Magnetic field of a horseshoe magnet:

Which pole is N?



In between the poles of a horseshoe magnet, field lines are parallel and therefore, B, the field strength, is uniform that means it is independent of position. This is not true for the outside space around the poles.



How can you tell field is constant between the poles?

- Einstein discovered that the motion of an electric charge distorts its electric field into a magnetic field!
- → Moving charges produces magnetism.
- Q: What is "moving' inside a solid bar magnet?

A: The electrons are moving in 2 ways!

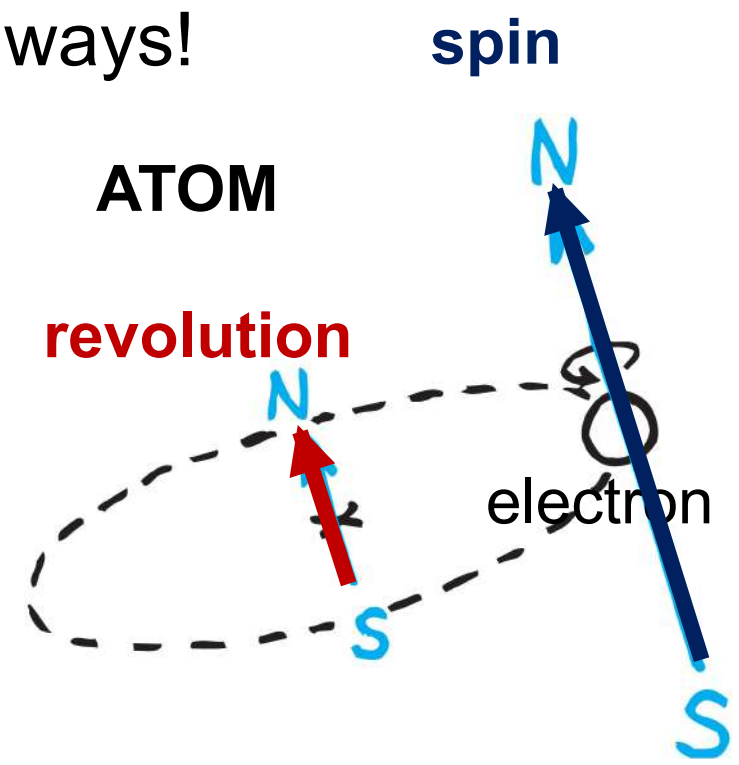
1. electron **spin** (rotation)

a) main contributor to magnetism

b) pair of electrons spinning in same direction creates a stronger magnet

c) pair of electrons spinning in opposite direction cancels magnetic field of the other

2. **electron revolution**



Magnetic Fields
CHECK YOUR NEIGHBOR

The source of all magnetism is

A. electrons rotating around an atomic nucleus.
B. electrons spinning around internal axes.
C. either or both A and B.
D. tiny bits of iron.

Magnetic Fields
CHECK YOUR ANSWER

The source of all magnetism is

C. either or both A and B.

Classwork:

6. How does magnetic field strength relate to the closeness of magnetic field lines about a bar magnet?

7. What produces a magnetic field?

8. What two kinds of rotational motion do electrons in an atom appear to have?