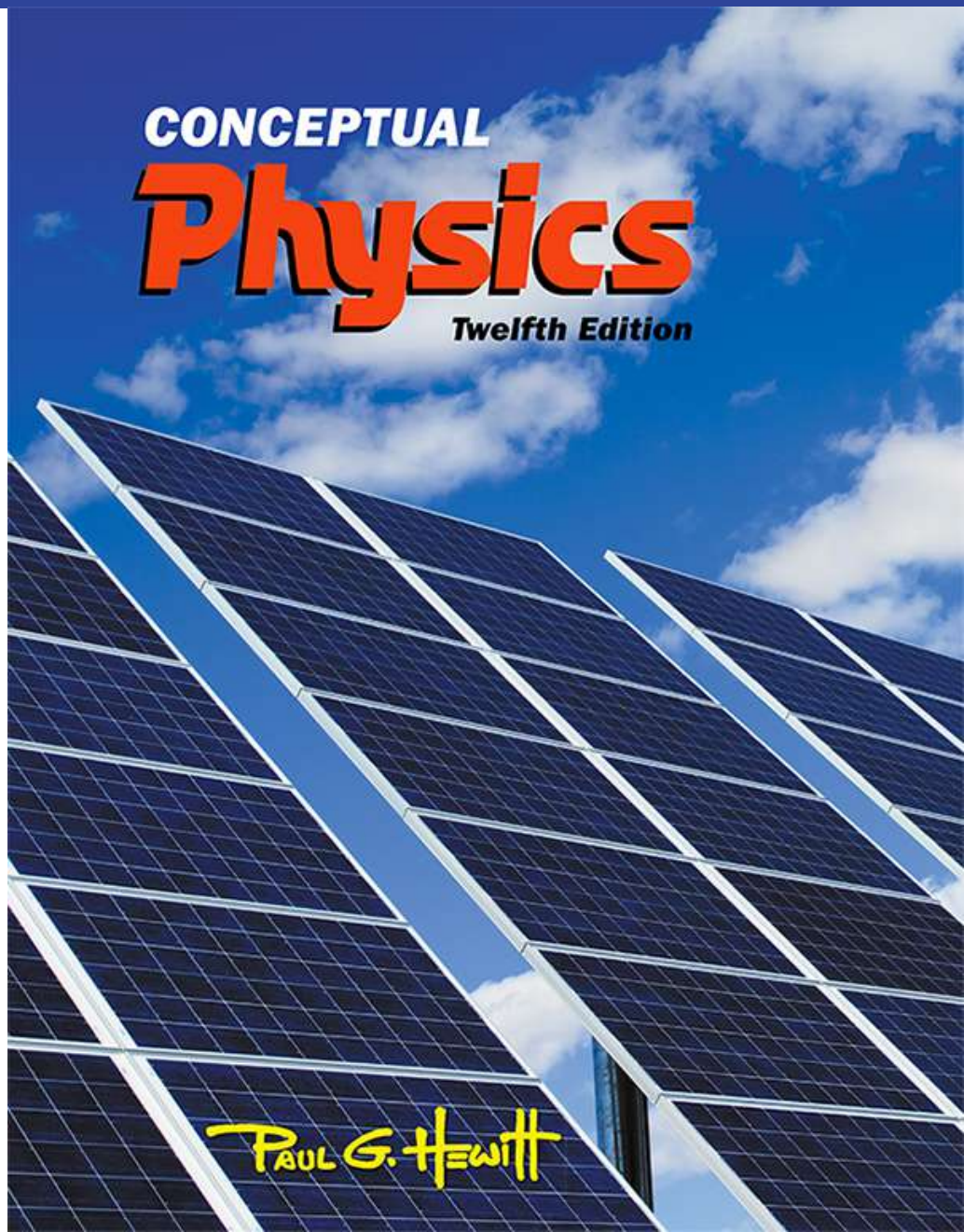
Lecture Outline

Chapter 24: Magnetism



Oersted's Experiment

A current exerts a force on a magnet.

Newton's 3rd Law:

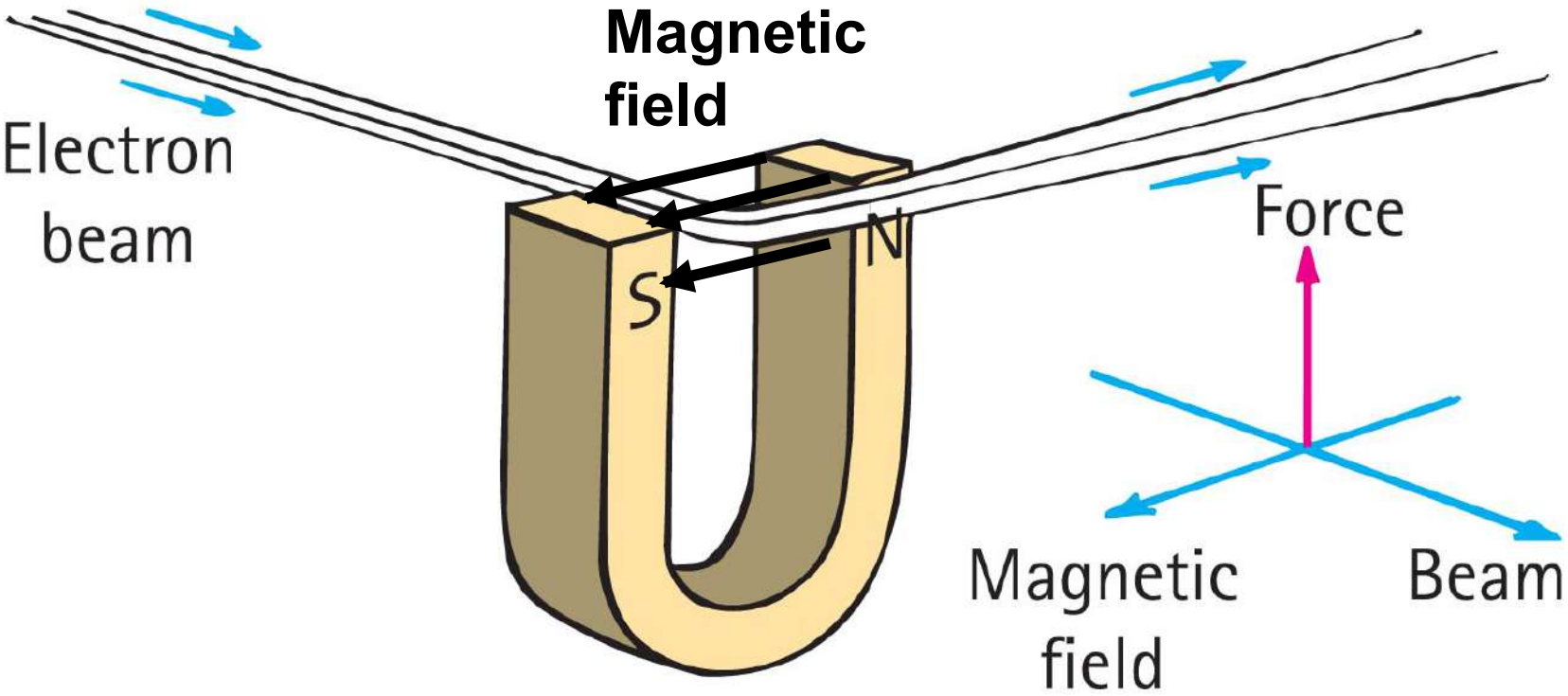
A magnet must exert a force on a current.

→ Current is moving charge.

→ No motion, no force.

Magnetic Forces on Moving Charges

- **Moving** charges in a magnetic field experience a deflecting force. (continued)



Magnetic Forces on Moving Charges

- Moving charges in a magnetic field experience a deflecting (sideways) force.
  - Greatest force if:
    - particle movement in direction **perpendicular** to the magnetic field lines
    - → **Changes direction of motion only.**
  - Less force if:
    - particle movement other than perpendicular to the magnetic field lines
  - No force if:
    - particle movement *parallel* to the magnetic field lines

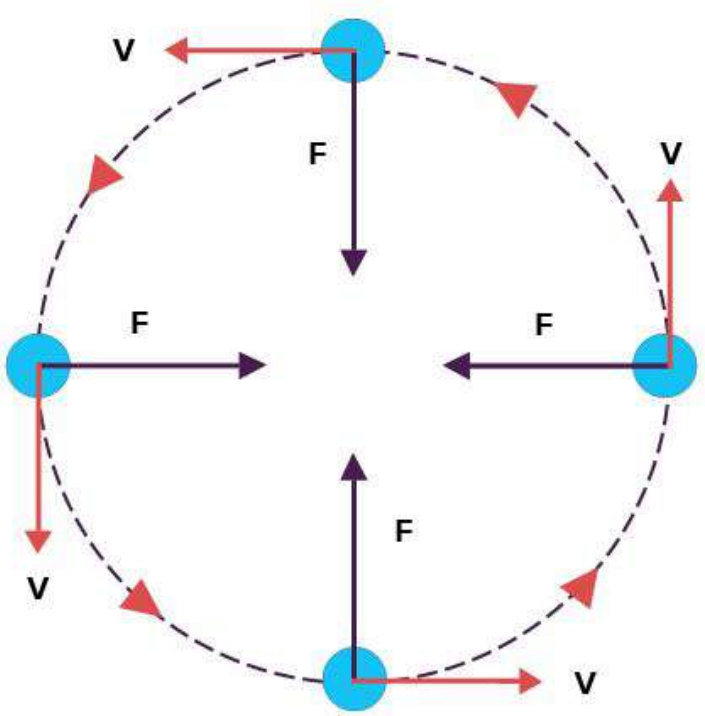
A force perpendicular to velocity…

…only changes the *direction* of motion!

…and not your speed.

Example:

Uniform circular motion:



Centripetal force F inward.

Velocity tangent.

Direction changes.

Speed doesn't.

Magnetic Force on Moving Charges CHECK YOUR NEIGHBOR

The reason that an electron moving in a magnetic field doesn't pick up speed is

A. magnets only divert them.
B. only electric fields can change the speed of a charged particle.
C. the magnetic force is always perpendicular to its motion.
D. All of the above.

Magnetic Force on Moving Charges CHECK YOUR ANSWER

The reason that an electron moving in a magnetic field doesn't pick up speed is

C. the magnetic force is always perpendicular to its motion.

Explanation:

Although all statements are true, the reason is given only by C. With no component of force in the direction of motion, speed doesn't change.

Magnetic Force on Moving Charges CHECK YOUR NEIGHBOR, Continued

The magnetic force on a moving charged particle can change the particle's

A. speed.
B. direction.
C. Both A and B.
D. Neither A nor B.

Magnetic Force on Moving Charges CHECK YOUR ANSWER, Continued

The magnetic force on a moving charged particle can change the particle's

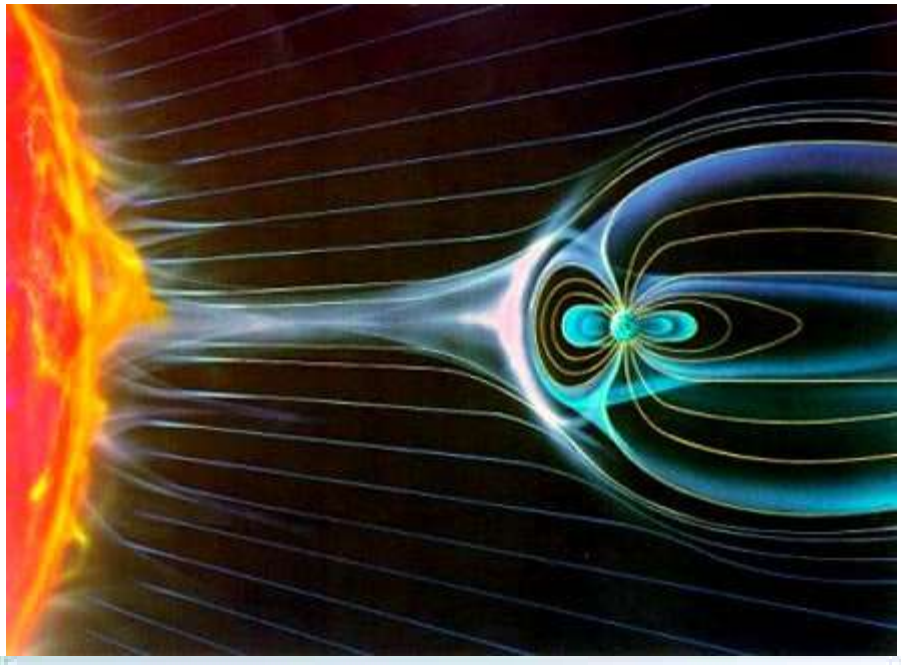
B. direction.

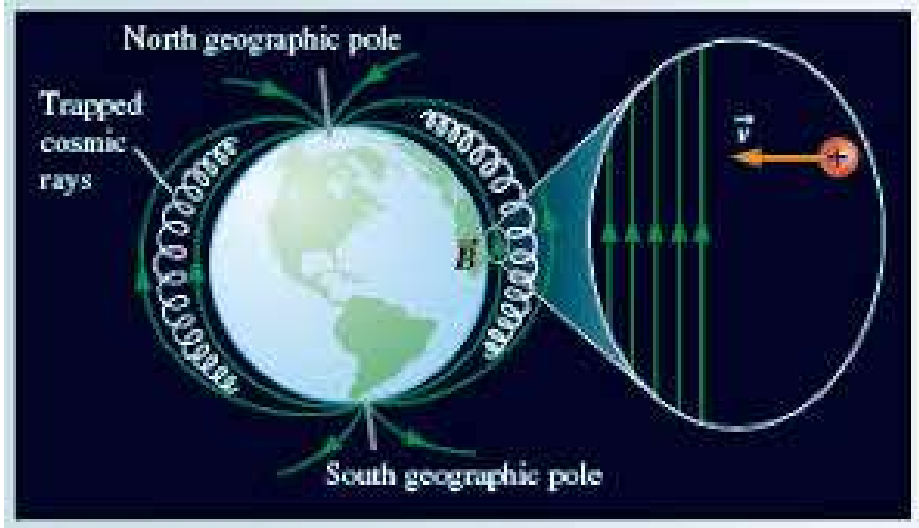
A magnetic “cocoon.”

Cosmic rays are charged particles from the Sun and outer space.

They are deflected by Earth’s magnetic field.

This reduces the amount that reaches Earth’s surface, and so protects us.





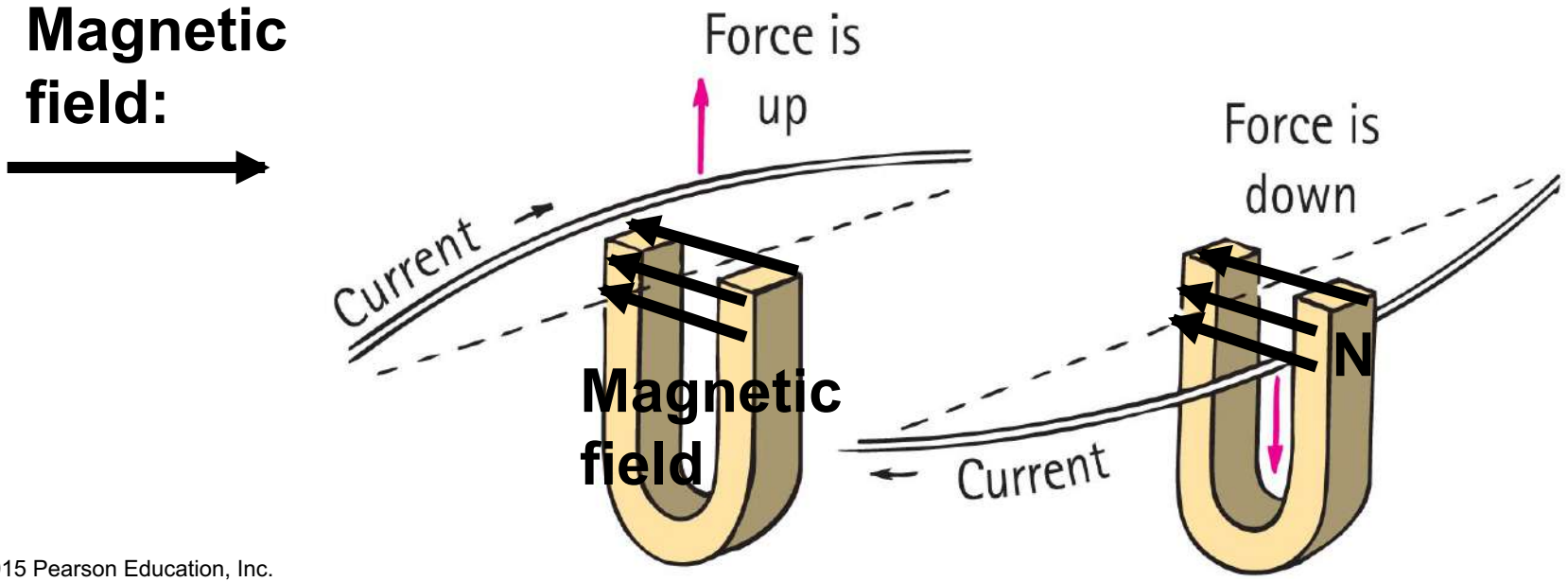
Classwork: answer on separate sheet.

18. True or false: A charged particle must move in a stationary magnetic field in order that a force due to the field act on it.

19. In what direction relative to a magnetic field does a charged particle move in order to experience maximum deflecting force? Minimum deflecting force?

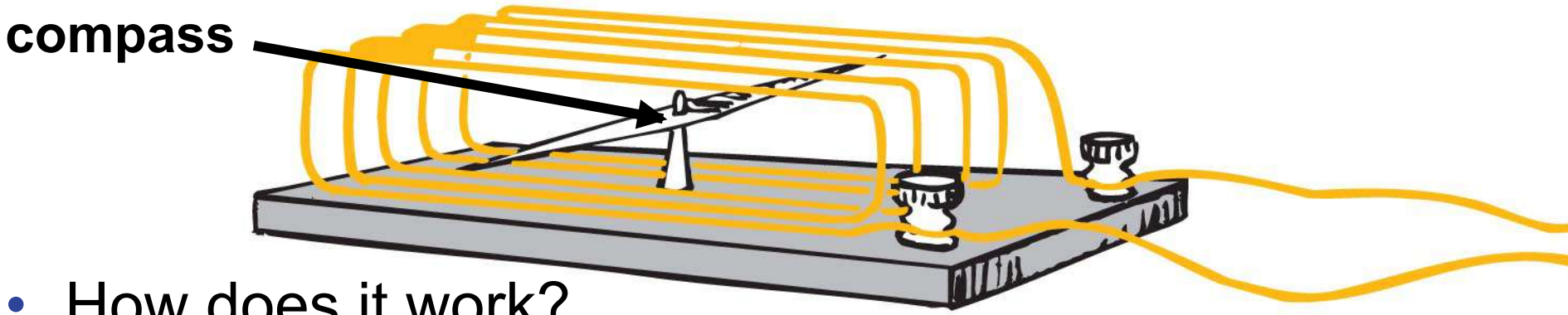
20. What effect does Earth's magnetic field have on the intensity of cosmic rays striking Earth's surface?

- Magnetic force on current-carrying wires
  - Current of charged particles moving through a magnetic field experiences a deflecting force.
    - Direction is **perpendicular** to both magnetic field lines and current (perpendicular to wire).
    - Strongest when current is **perpendicular** to the magnetic field lines.



Magnetic Force on Current-Carrying Wires

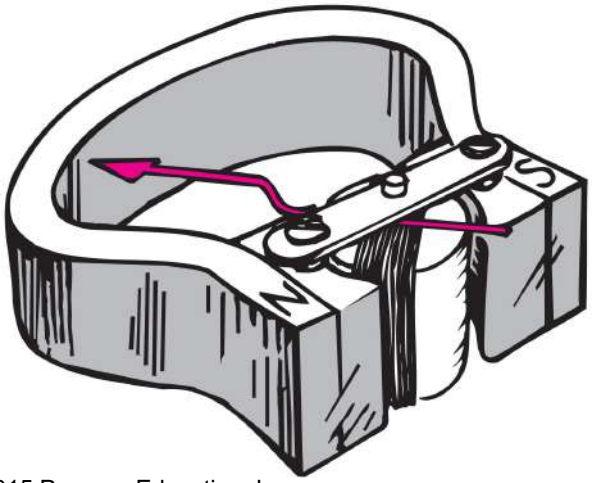
- Electric meters detect electric current
  - Simplest way to build:
    - magnetic compass next to a single wire (Oersted)
    - compass in a coil of wires (stronger field)



- How does it work?
- The currents causes a magnetic field.
- Magnetic field exerts a force on the magnet.

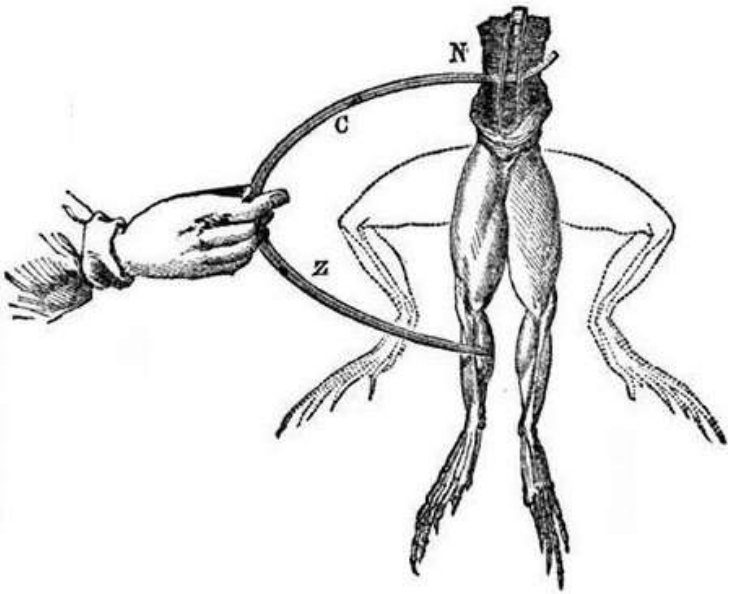
Better: Hold magnet still. Let coils move.

- **Galvan**ometer
  - Current-indicating device named after Luigi **Galvan**i
  - Called *ammeter* when calibrated to measure current (amperes)
  - Called *voltmeter* when calibrated to measure electric potential (volts)



Luis Galvani

Discovered that frog legs twitched when touched with two different metals (a simple battery).



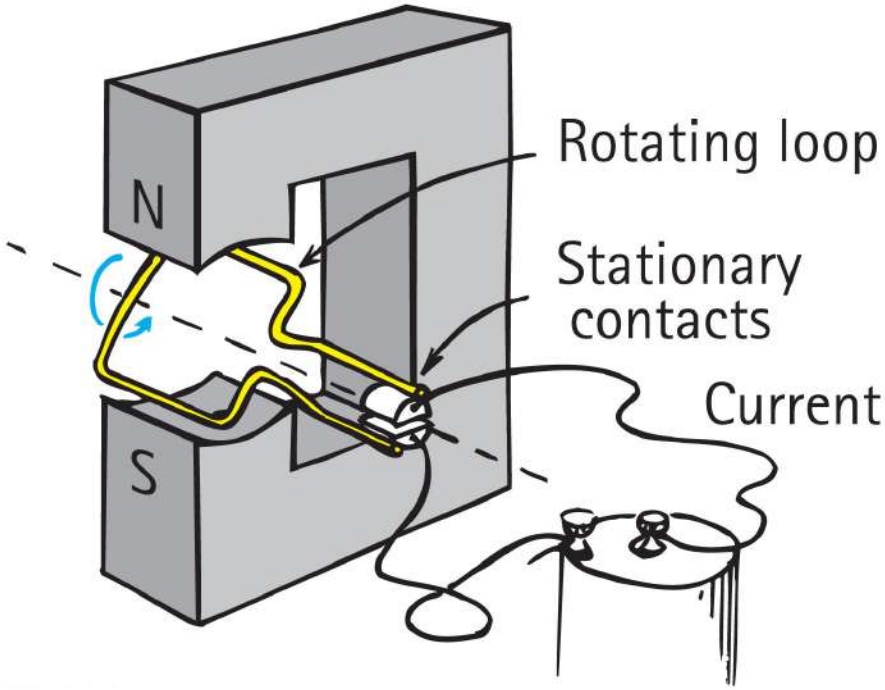
More Classwork:

21. What relative direction between a magnetic field and a current-carrying wire results in the greatest force?

22. How does a galvanometer detect electric current?

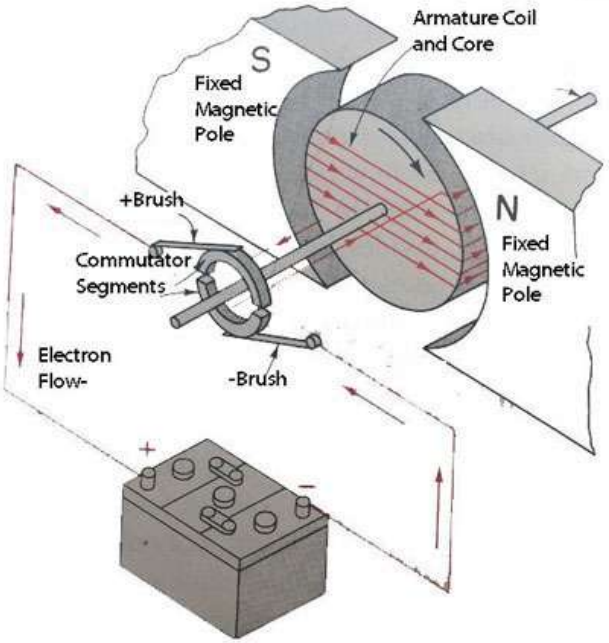
23. What is a galvanometer called when it has been calibrated to read current? When it has been calibrated to read voltage?

- Electric motor
  - Different from galvanometer in that each time the coil makes **a half rotation**, the direction of the current changes in cyclic fashion to produce continuous rotation
  - The galvanometer idea is extended to produce continuous motion.



electric motors

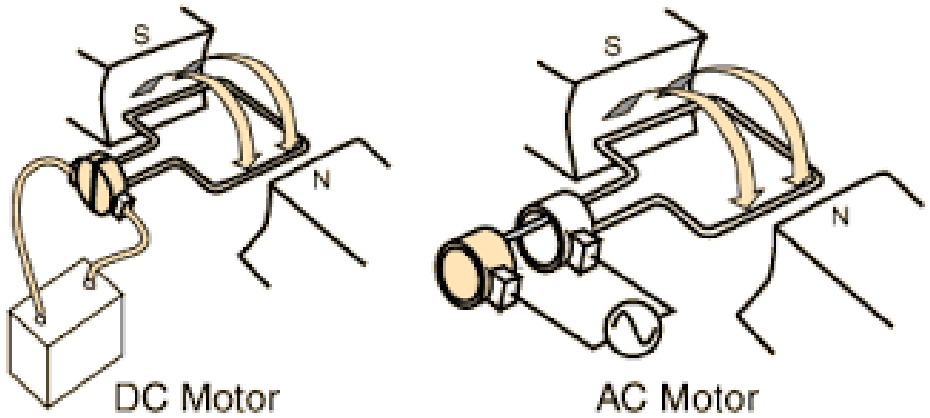
Convert electric energy to mechanical (kinetic energy)



If one coil works, try many coils!

DC motor:

brushes reverse current

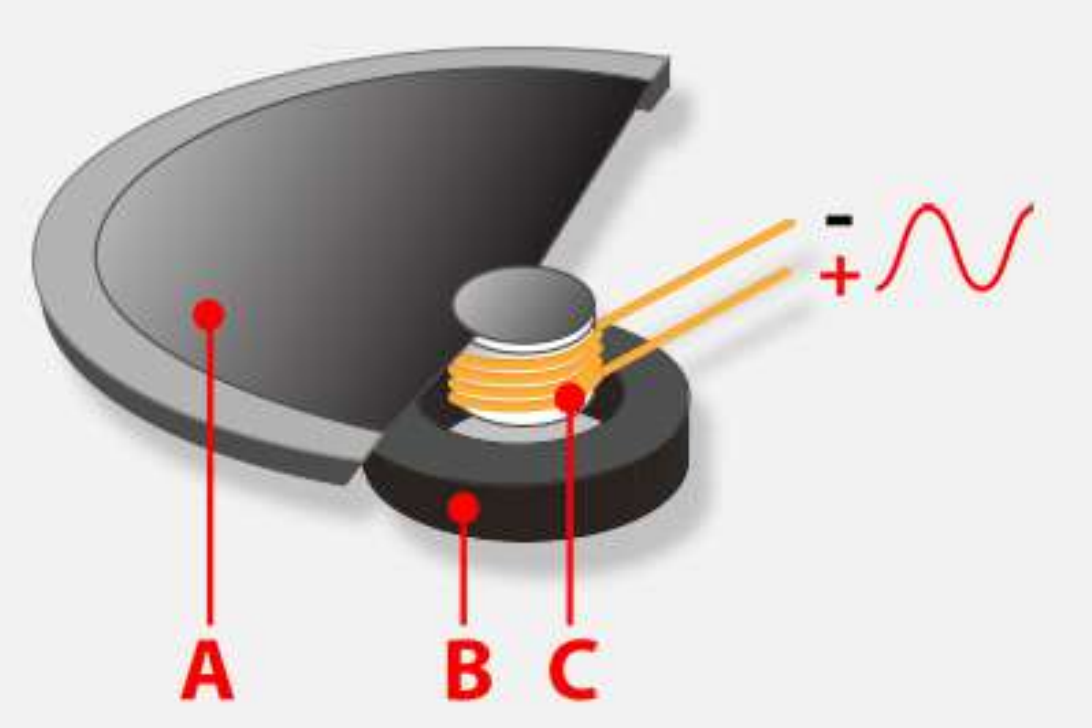


AC motor:

current naturally reverses

How speakers work

1. Current flows in coil
2. Magnetic field exerts force on coil
3. Coil moves cone one way
4. Current reverses direction
5. Coil moves coin other way
6. etc.



More Classwork:

24. How often is current reversed in the loops of an electric motor?

25. Is it correct to say that an electric motor extends the physics that underlies a galvanometer?