Preview of Period 16: Motors and Generators

16.1 DC Electric Motors

What causes the rotor of a motor to spin?

16.2 Simple DC Motors

What causes a changing magnetic field in the simple coil motor?

16.3 St. Louis DC Motor

What causes a changing magnetic field in the St. Louis motor?

16.4 AC Electric Motors

Do alternating current motors need commutators?

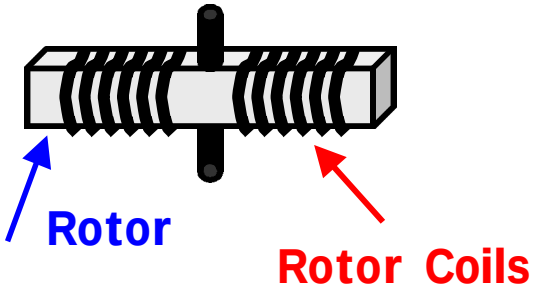
16.5 Building a Buzzer

What causes a changing magnetic field in the buzzer?

Act 16.1: Electric Motors

Motors convert electrical energy into kinetic energy using the forces between magnetic fields to spin a rotor.

The rotor consists of a metal rod wrapped in a coil of wire and mounted on a pivot, which allows the rotor to spin.

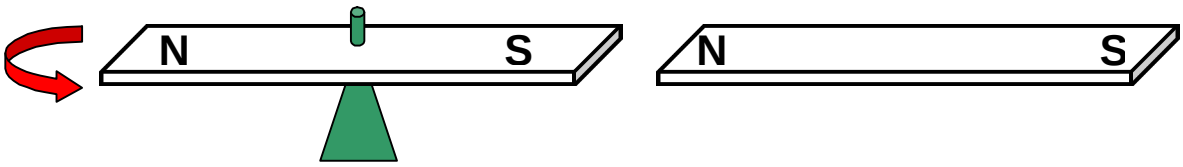


Current in the wires makes the rotor an electromagnet (a solenoid).

The ends of the rotor (the poles of its electromagnet) are attracted to and repelled by the poles of nearby magnet(s).

To keep the rotor spinning, its poles must reverse their polarity. This requires a changing current in the coil of the rotor.

Act 16.1: Spinning a Permanent Magnet with Another Permanent Magnet



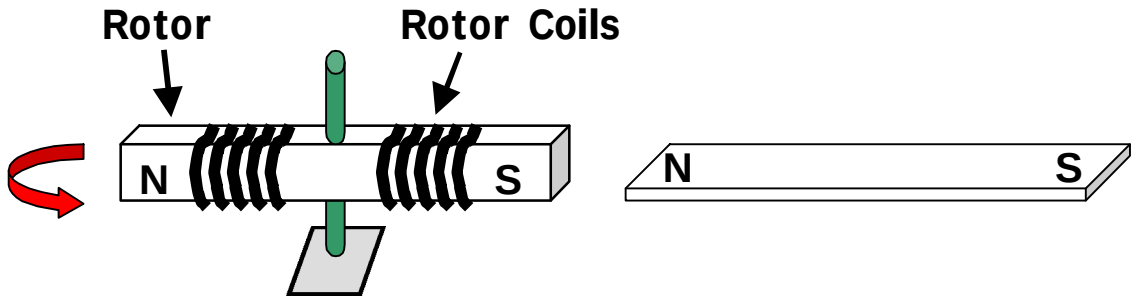
Magnet on a pivot Magnet in your hand

- The magnet spins until its south end is aligned with the north end of the magnet in your hand.
- If you remove the magnet in your hand just as the south pole of the spinning magnet approaches it, the spinning magnet's motion causes it to continue to spin.
- If you flip and replace the magnet in your hand at the appropriate time, the spinning magnet again rotates to align its south pole with the north pole of that magnet.

Replace the permanent magnet in your hand with an electromagnet (a solenoid).

Why must you turn the current on and off to make the magnet spin?

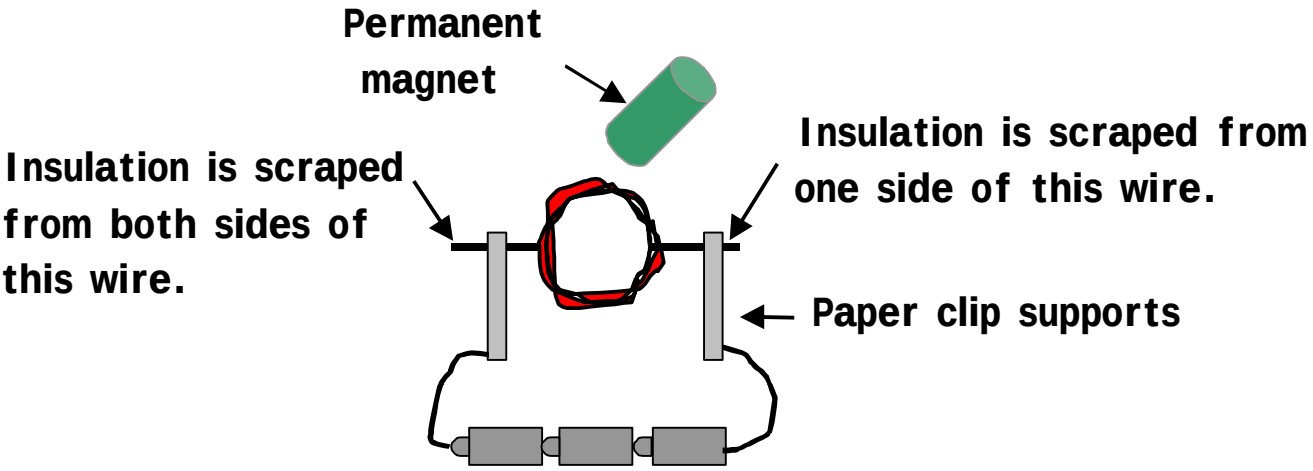
Act 16.1: Spinning an Electromagnet



Spinning Electromagnet Permanent Magnet

- The electromagnet spins until its south pole is aligned with the north pole of the magnet.
- If the current in the electromagnet is turned off just as its south pole approaches the north pole of the permanent magnet, the electromagnet's motion causes it to continue to spin.
- If the current in the electromagnet is turned on at the appropriate time, the electromagnet again rotates to align its south pole with the north pole of the permanent magnet.

Act 16.2: Building a Simple Motor



End view of a wire with insulation scraped from one side of one end.

How does the motor work?

- Current flowing through the coil creates a magnetic field around the coil that causes the coil to be attracted to the permanent magnet.
- Because one wire has one bare side and one side with insulation, as the wire spins the current turns off and on at the appropriate times to keep the coil spinning.

Direct Current (DC) Electric Motors

Motors require a changing magnetic field.

- **Direct electric current (DC) is a steady flow of current in one direction. Direct current produces an unchanging magnetic field around the wire.**

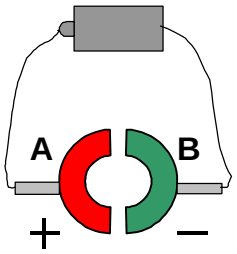
How can DC current from batteries, etc. be turned into a changing current?

- **A commutator turns the DC current into a changing current by repeatedly switching the current on and off or by changing its direction.**

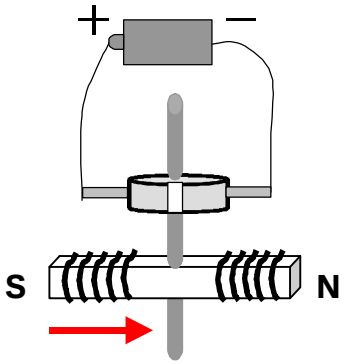
- **The St. Louis motor uses a commutator to repeatedly change the direction of the DC current.**

Split Ring Commutator in a DC Motor

The positive end of the battery is connected to half A of the commutator ring. Current flows from left to right through the rotor coil.

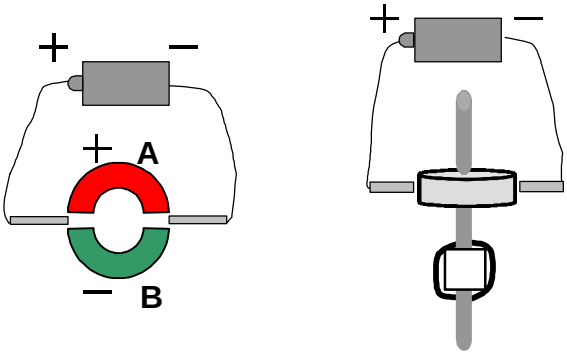


Top view of commutator

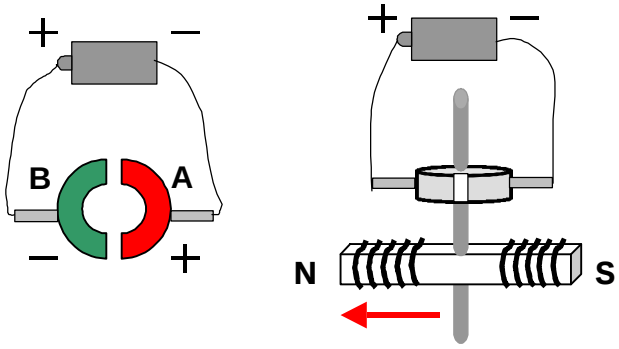


Side view of commutator and rotor.

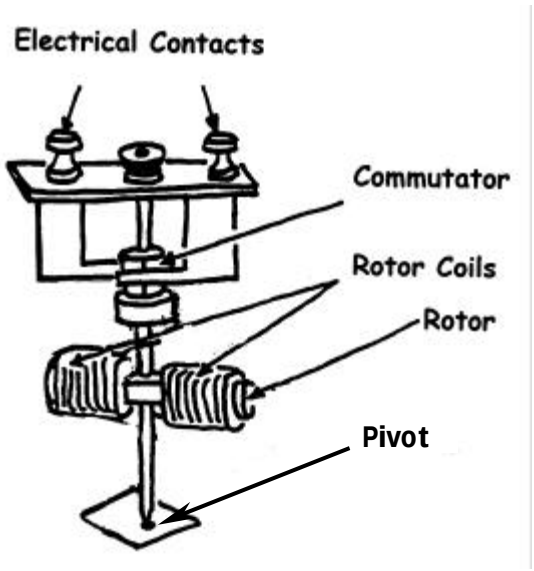
After the commutator turns ¼ of a turn to the right, the brushes do not touch the commutator ring. No current flows.



After another ¼ turn to the right, the positive end of the battery is connected to half B of the ring. Current flows from right to left through the rotor coils. The poles of the rotor reverse.



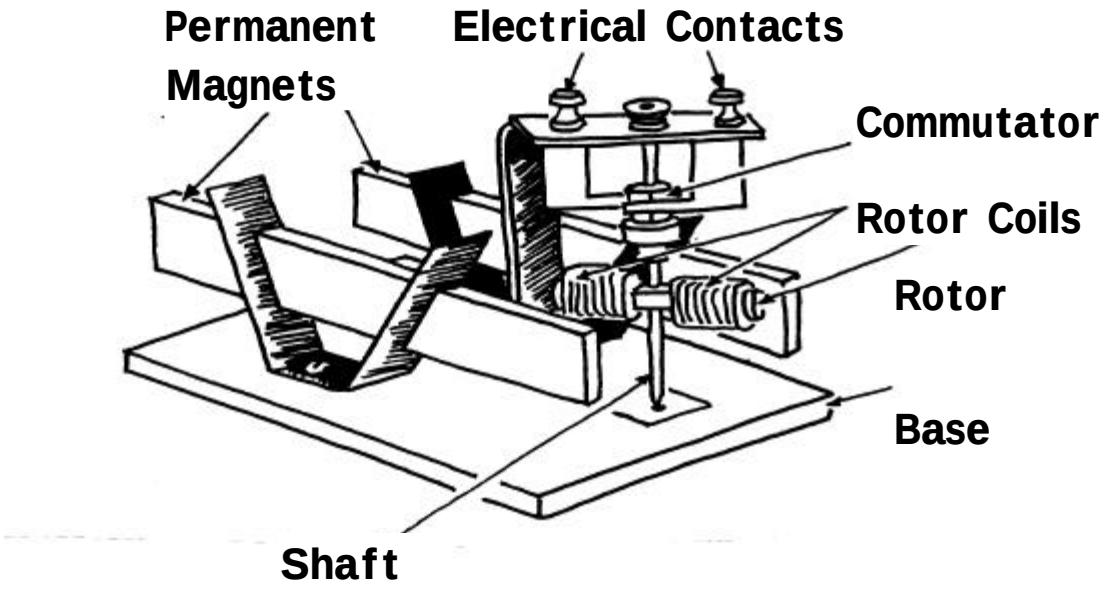
Act. 16.3 St. Louis Motor Rotor and Commutator



- The commutator is a rotating ring of conducting material with two slits.

- When the two halves of the commutator ring are aligned with the connectors (brushes) that lead to the electromagnet, a complete circuit is formed and current flows from the battery, through the commutator, and to the rotor coils.

Act. 16.3 St. Louis DC Motor



- Direct current motors, such as the St. Louis motor, use a commutator to create a changing magnetic field.
- The split ring commutator changes the direction of the current flowing through the rotor coils.
- Each time the current reverses, the poles of the electromagnet reverse.
- The magnetic fields of the ends of the electromagnet are attracted to and repelled by the magnetic fields of the permanent magnets, causing the rotor to spin.

Act. 16.4.a: Alternating Current Motors

- Alternating Current (AC) reverses direction 120 times per second.
- These reversals produce a changing magnetic field around a current-carrying wire.
- This changing magnetic field can be used to spin a rotor.

Synchronous Motors

Synchronous motors use the current reversals of alternating current to provide a changing magnetic field to spin the rotor.

Thus, synchronous motors do not need a commutator.

Since the rotors of synchronous motors spin in synch with the changing AC current, synchronous motors have a fixed rotational speed.

Act. 16.4.b: Alternating Current Motors

Universal Motors:
AC Motors with Commutators

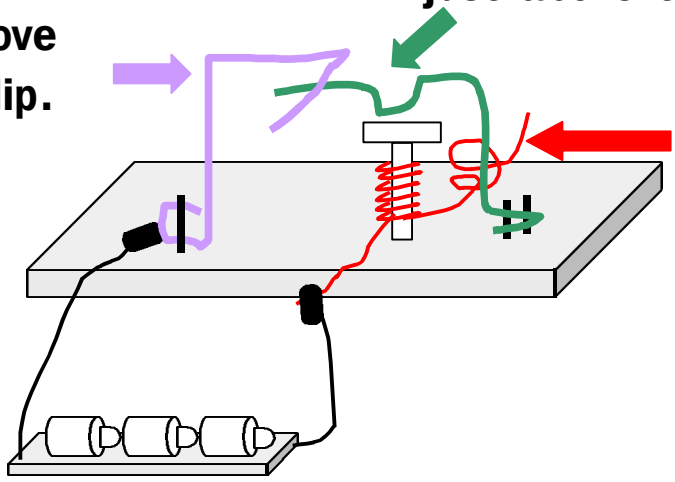
- A DC motor can be converted into an AC universal motor by replacing the permanent magnets with electromagnets.
- The alternating current through each electromagnet reverses direction at the same time. Therefore, the poles of each electromagnet reverse at the same time.
- A commutator is used to reverse the current direction in the rotor coils at the proper time to spin the rotor.
- The amount of current reaching the electromagnets can be varied to produce different rotational speeds.
- Therefore, universal motors are used when various motor speeds are desired, as in an electric mixer.

Act. 16.5 Building a Buzzer

Follow the directions in your activity sheet. Refer to the model on your table.

Make a bend in the paper clip that lies horizontally just above the nail head.

The non-magnetic wire lies above the paper clip.



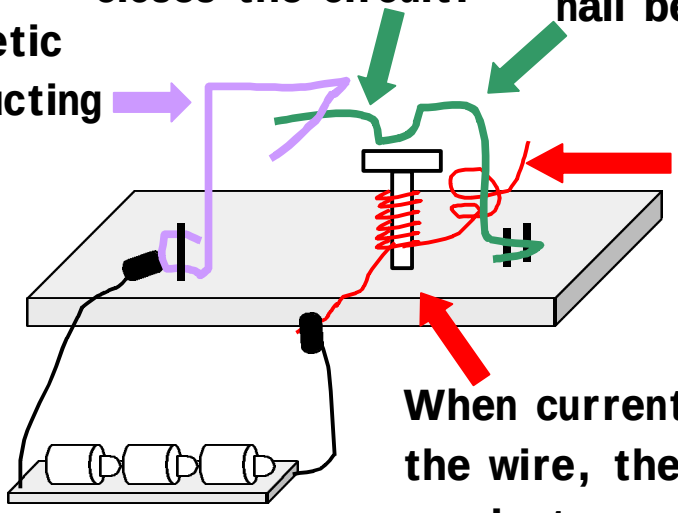
Strip insulation from both sides of both ends of the wire. Wrap the wire around the nail.

How Does the Buzzer Work?

The motion of the paper clip opens and closes the circuit.

The steel paper clip is attracted to the nail when the nail becomes an electromagnet.

The non-magnetic wire is a conducting pathway.



Wire stripped of insulation provides an electrical connection to the paper clip.

When current flows through the wire, the nail becomes an electromagnet.

Period 16 Summary

16.1: Electric motors convert electrical energy into kinetic energy using the forces between magnetic fields.

At least one of the magnetic fields must be a changing magnetic field.

16.2: A direct current motor, such as the St. Louis motor, uses a commutator to produce a changing magnetic field.

The changing current induces a changing magnetic field in the motor's rotor.

The permanent magnet exerts a force on the changing magnetic field of the electromagnet, spinning the rotor.

16.3: The rotors of synchronous AC motors spin in synch with the 120 reversals per second of alternating current. Synchronous motors have a fixed rotational speed.

Universal AC motors use a commutator to synchronize the change in magnetic fields of the rotor coils with the rotational speed of the rotor. Universal motors have varying rotational speeds.

Period 16 Review Questions

R.1 Can you make a practical motor using only permanent magnets? Why or why not?

R.2 Why do you scrape insulation from only one side of one end of the wire in the simple electric motor seen in class?

R.3 What causes the rotor in a DC motor, such as the St. Louis motor, to spin?

R.4 What causes the rotor in a synchronous AC motor to spin?

R.5 What causes the rotor in a universal AC motor to spin? How does a universal motor differ from a synchronous motor?