

Name: _____

Date: _____

Guided Learning: History of Electromagnetism

Learning goals

After completing this activity, you will be able to ...

- Identify major advances in the development of electromagnetic theory and technology.
- Describe and explain a major scientific advance in electromagnetism.
- Describe and explain a major technological advance in electromagnetism.

Vocabulary: amber, electromagnetism, electrostatic generator, Leyden jar, magnetic compass, static electricity

Warm-up question

Suppose you lived in ancient Egypt or Greece. What examples of electricity and magnetism would you have been able to observe in the natural world?

Early observations of electricity and magnetism

Electromagnetism is one of the four fundamental forces in nature, and influences a wide range of phenomena. Electromagnetism holds electrons to the nucleus of atoms and allows atoms to bond together to form chemical compounds. All solids and liquids are held together by electromagnetic forces. Light is an example of an electromagnetic wave. Humans have harnessed electromagnetism to power an enormous variety of technology, from compasses to computers and cell phones.

In spite of its importance, electromagnetism is not always easy to observe. Nevertheless, ancient peoples did observe several examples of electricity including lightning, and many also noted the powerful electric shocks that occurred when they touched certain animals such as electric catfish and electric eels. The ancient Greeks were the first to report on **static electricity**: Around 600 BCE Thales of Miletus noted that rubbing **amber**, a form of fossilized tree resin, with fur caused small objects such as feathers or hair to be attracted to the amber.



Lightning

The Chinese are credited with the invention of the **magnetic compass**, around 200 BCE. (It is possible that the Olmec culture of Mexico may have developed a compass 800 years earlier, but evidence is not conclusive.) The earliest Chinese compasses consisted of a spoon-shaped piece of lodestone balanced on a square tray. The Chinese were also the first to use compasses as a navigational aid.



Representation of an early Chinese compass

The first scientific experiments in electricity and magnetism were performed by William Gilbert, an English doctor, in the late 16th century. Gilbert discovered many substances capable of holding an electrical charge. He also discovered new ways of producing magnets. The first **electrostatic generators** were built in 17th century. These machines worked by friction—a leather pad was placed against a rotating glass globe, generating static electricity.



Benjamin Franklin flies a kite

The 17th century saw several major advances in electricity and magnetism. A major advance was the accidental invention of the **Leyden jar** by Ewald Georg von Kleist in 1744. Von Kleist was experimenting with an electrostatic generator while holding a jar with an iron nail in his hand. When he touched the nail, he received a nasty shock. The ability of the jar to store electrical charge was later improved by adding layers of foil to the inside and outside of the jar.

Benjamin Franklin (1706–1790) made two major contributions to the study of electricity. First, Franklin is generally credited as the first to describe electrical charge as “positive” and “negative,” a convention that lasts to this day. Second, Franklin was able to establish the link between electricity and lightning. Franklin did this famously by flying a kite in an electrical storm. As the kite floated near the storm clouds, a key tied near the bottom of the string became charged. Franklin observed a spark when he placed his hand near the key. (Contrary to popular belief, Franklin did not wait for the kite to be hit by lightning, as that probably would have caused his death.)



1. How were magnets first used? _____

2. Many of the early observations of electricity were of static electricity. How do you experience static electricity in everyday life? _____

Maturity of electromagnetism: 1780–present

In the 19th century, the study of electricity and magnetism developed from a curiosity to a central pillar of physics. Scientific discoveries were followed by commercial applications as people discovered the usefulness of these forms of energy in emerging technologies. The timelines below summarize some of the major scientific and technological advances of this period.

Scientific Advances			
Date	Discoverer(s)	Discovery	Description
1784	Charles-Augustin de Coulomb	Coulomb's law	Using a torsion balance, Coulomb finds the relationship between electrical force (F), charge (q), and distance (r).
1800	William Nicholson and Johann Wilhelm Ritter	Electrolysis	Water is first decomposed into hydrogen and oxygen by electrolysis. Electroplating is discovered soon after.
1820	Hans Ørsted and André-Marie Ampere	Electromagnetism	Ørsted finds that an electrical current produces a magnetic force. Ampere expresses these results mathematically.
1827	Georg Ohm	Ohm's law	Ohm discovers that the current in a circuit is proportional to voltage divided by resistance.
1831 to 1835	Michael Faraday and Joseph Henry	Electromagnetic induction	Henry and Faraday independently observe that a changing magnetic field can induce a current.
1861	James Clerk Maxwell	Maxwell's equations	Maxwell unites all knowledge of electromagnetism with four equations.
1864	James Clerk Maxwell	Electromagnetic theory of light	Maxwell proposes that light is an electromagnetic wave.
1887	Heinrich Hertz	Radio waves	Hertz discovers radio waves and proves the existence of electromagnetic waves.
1896	J.J. Thomson	Electron is discovered	Thomson's cathode ray tube experiments confirm the existence of the electron.
1905	Albert Einstein	Photoelectric effect	Einstein explains the photoelectric effect by stating that light is composed of "quanta."



Research project: Scientific advances

Research a topic from the "Scientific Advances" table above. Based on your research, create a poster that has the two sections:

- A clear and basic description of the scientific concept
- An account of how the concept was discovered

Collect information from sources that have reliable authors, and check your facts by consulting multiple sources. Use your own words, cite sources, and use pictures to demonstrate concepts.

Advances in Technology			
Date	Discoverer(s)	Discovery	Description
1800	Alessandro Volta	First battery	The first battery is a <i>voltaic pile</i> . It consists of alternating layers of zinc and copper separated by pieces of cardboard soaked in electrolyte.
1821	Michael Faraday	Electrical motor	Faraday invents the first motor that uses electricity to cause a wire to rotate in a magnetic field.
1837	Samuel Morse	Telegraph	Morse develops a practical system for instantly transmitting messages across great distances.
1876	Alexander Graham Bell	Telephone	Bell receives the first patent for the telephone.
1879	Thomas Edison	Incandescent light bulb	Edison files a patent for an incandescent light bulb.
1888	Nikola Tesla	Alternating current	Tesla popularizes the use of alternating current (AC) over the much less efficient direct current (DC).
1925	Julius Lilienfeld	Transistor	The transistor is an essential component of most electronic devices.
1926	John Logie Baird	Television	Baird, a Scottish inventor, demonstrates a primitive television that displays shadowy images.
1937	Alan Turing	Turing machine	Although only a theoretical device, the Turing machine provided the foundation of all modern computers.
1969	Willard Boyle and George E. Smith	CCD/Image sensor	The image sensor in digital cameras collects photons of light to form a digital image.
1991	CERN	World Wide Web	The Internet is launched, revolutionizing the way information is transmitted and shared.



Research project: Technology

Research a topic from the “Advances in Technology” table above. Based on your research, create a poster that has the two sections:

- A description of the technology and how it works.
- An account of how the technology was developed.

Collect information from sources that have reliable authors, and check your facts by consulting multiple sources. Use your own words, cite sources, and use pictures to demonstrate concepts.