

Assignment

Readings (Articles):

- (1) Robert S. Elliott, "The History of Electromagnetics as Hertz Would Have Known It," IEEE Trans. Microwave Theory Tech., vol. 36, no. 5, pp. 806–823, 1988
(Available on the course BLACKBOARD site)
- (2) Jeff Biggins, "Sketches of a History of Classical Electromagnetism," URL: <http://history.hyperjeff.net/electromagnetism.html>
- (3) Leonard Taylor, "Gallery of Electromagnetic Personalities: A Vignette History of Electromagnetics," URL: <http://www.ee.umd.edu/~taylor/frame1.htm>
[For information on L. Taylor, see <http://www.eee.umd.edu/~taylor>]

Readings (Books):

- (1) D. Bodanis, *Electric Universe*, Crown: New York, NY, 2005
- (2) R. S. Elliott, *Electromagnetics*, IEEE: Piscataway, NJ, 1993.

(The books are available on reserve at the library.)



10.1

Electromagnetic History: Why Study It?

- Helps fulfill ABET requirements
 - Outcome: [An ability to communicate effectively](#)
 - Outcome: [A recognition of the need for, and the ability to engage in lifelong learning](#)
 - But why does ABET care?
...their industrial advisory board told them they should care
 - Okay, so why should industry or government care?
- Engineering jobs don't just involve engineering!
 - Communication skills are critical in making things happen
 - Technology is already changing and engineers must keep abreast
- ***Fields are hard to understand!***



Thinking about where these ideas came from is useful...

10.2

Early Work (Before the 19-th Century)

Electricity and magnetism were thought to be unrelated phenomena!

- Electricity

- Before 1700: Static electricity was known without understanding
- Stephen Gray discovered that electricity could be conducted (1729)
- Franklin proposes two types of electricity (1747)
- Coulomb demonstrates Coulomb's law (1785)

Coulomb's law is consistent with action at a distance and analogous to gravitational interactions!

Franklin, Priestley, Coulomb



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10.3

Early Work (Before the 19-th Century)

Electricity and magnetism were thought to be unrelated phenomena!

- Magnetism

- Before 1200: Lodestones are known from ancient times
Compasses are known to the Chinese before 300 and in Europe by 1200
- Peregrinus introduces the two poles of a magnet (1269)
- Gilbert shows that Earth can be considered a magnet (1600)
- Mitchell proposes that the two poles exert opposite forces (1750)

No quantitative theory up to 1800!

Gilbert



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10.4

Early 19-th Century

Theoretical Advances

- Laplace introduces a potential field whose derivative yields the gravitational force (1777) [*First introduction of the field concept*]
- Poisson extends this idea to electrical forces (1811) and introduces Poisson's equation (1813)
- Gauss introduces Gauss's theorem and Gauss's equation (1813)
- Poisson shows that the field concept can be extended to magnetic systems through use of a "magnetic potential" (1824)

Laplace, Poisson, Gauss



Early 19-th Century

Engineering advances

- Volta invents the first chemical battery (1800)
- Davy characterizes the conductivity of many metals (1821)
- Ohm discovers Ohm's law (1827)
- Kirchhoff discovers Kirchhoff's laws (1845)

The importance of the development of reliable, controllable current sources cannot be exaggerated!

Volta, Davy, Ohm, Kirchhoff



Early 19-th Century

Magnetostatics

- Ampere, Biot, and Savart demonstrate forces between currents (1820)
- Ampere formulates Ampere's law (1825)
- Biot formulates the Biot-Savart law (1826)

This work was inspired by Oersted's work showing that a changing current deflects a compass needle

Ampere, Biot



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10.7

Early 19-th Century

Electrodynamics

- Oersted shows that a current deflects a compass needle; speculates that a changing electric field produces a magnetic field (1820)
- Faraday shows that a changing magnetic field produces an electric field, which in turn produces a remote magnetic field... (1831)
- Henry makes the same discovery as Faraday, **but does not publish** (1830)
- In a series of experiments, Faraday develops the electrical generator and the electrical motor (1831–1851) [as do Henry and others]

Oersted, Faraday, Henry



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10.8

Maxwell's Equations

Lines of force; field equations; electromagnetic radiation

- Faraday develops the line of force concept over many years; publishes (1852)
- Maxwell develops the line of force concept mathematically (1855)
- Maxwell modifies Ampere's law to include displacement current (1861), *leading to the first full formulation of Maxwell's equations*
- Maxwell predicts the existence of electromagnetic radiation; speculates that light is electromagnetic radiation (1865)

Maxwell



Electromagnetic Waves

Creation and detection of radio waves

- Hertz demonstrates transmission of electromagnetic waves (1888)
- Marconi demonstrates and later commercializes the first practical radio wave transmitter (1895); wins 1909 Nobel prize

I should mention: *Fourier invents the Fourier transform (1807)*

Hertz, Marconi, Fourier

