Physics 208 E&M History Outline

Part I - Static Electricity and Static Magnetism (Magnets)

1. First electrical effect ("amber effect") discovered ~2500 years ago. Rub amber or related material, and it attracts bits of dust. Much amber was yellow as the sun (helios "elios" in Greek), and the Greek name for amber was "electron". No explanation for the effect. **You already should know a bit about static electricity. I will show you a piece of bright yellow amber.**

2. First magnetic effects discovered ~2500 years ago. Greeks noticed the loadstone in a region named "magnesia". Loadstone was permanent magnet, iron was non-permanent magnet. Compass needle (a permanent magnet) was invented ~1500 years ago in China. Compass needle could be attracted or repelled by another magnet, according to which end was nearest. Likes repel, unlikes attract. **You already should know a bit about magnets and compass needles.**

3. ~1600 Gilbert (England) wrote De Magnete, on magnetism and the earth as a huge magnet. Called magnet poles north and south. One chapter was devoted to electricity, where he discusses a measuring instrument he called a versorium (like a compass needle but involving no permanent electricity). Versorium always was attracted to (no repulsion from) a rubbed object. **I will show you a versorium, and you can easily make one.**

4. ~1680 onward (Europe), better sources of static electricity by rubbing were discovered. (Fur rubbed on glass tubes, etc.) **You already should know a bit about how to make static electricity.**

5. ~1729 Gray (England) discovered the distinction between conductors and insulators. To prevent electricity from escaping, did experiments on insulating surfaces. Permitted improved static electricity storage devices (e.g., metal cannon on wax surface). **You should know the distinction between conductors (metals, like copper) and insulators (like glass and plastic). See Fig.21.6.**

6. ~1755 Dufay (France) discovered that there were two and only two classes of electrical materials, which he called vitreous (glassy) and resinous (amber-like; same class as plastics). He found that likes repel and unlikes attract. See Fig. 21.1. But both kinds of electricity attract the versorium! **You should know about the two types of electricity.**

7. ~1745 (Poland, Holland) a very effective means of storing electricity was discovered (called a condensor, now a capacitor): the Leyden jar. **These are now known as condensors (of electricity) or capacitors (because of their capacity to store electricity).**

8. ~1748 Benjamin Franklin (British colonies) developed the fluid model of electricity to explain the operation of the Leyden jar. This electric fluid could transfer from one material to another, but was conserved -- the first conservation law. He argued that lightning was electrical in nature, and developed the lightning rod as an application of his ideas -- to draw off atmospheric electricity before it could damage a building. An excess (deficit) of electric fluid was positive (negative). He called vitreous electricity positive and resinous electricity negative. **Law of Charge Conservation: sum of initial charges = sum of final charges (was it an accident that Franklin also said "A penny saved is a penny earned?" We will study charge conservation.**

Franklin also placed Leyden jars in series and in parallel (a "battery" of them), to increase their effect. 9. ~1750 (Europe) the operation of the versorium was understood, using the idea of charge separation (electrical polarization for insulators, electrostatic induction for conductors) and an electric force between two charges that weakened with separation. **We will study this.**

10. ~1775 Coulomb (France) used a torsion balance and studied static electricity and magnets. Discovered the inverse square law for electric charges q, q' and also for magnetic poles q*, q*':

\[ F \sim \frac{qq'}{r^2} \]

\[ F \sim \frac{q^*q^*'}{r^2} \]

**We will study this in detail.**

End of material for Exam 1.

11. ~1780 Volta (Italy) established the law of capacitance between two objects with charges Q and -Q, that Q=CV. (Here V is the voltage difference between the two objects.) **Volta's Law for Capacitance**

Series and Parallel Capacitors

**We will study this.**
Part II - Dynamic Electricity (Electric Currents), Electromagnetism, Induced Electric Currents, Field Concept
12. ~1790 Galvani (Italy) made a source of constantly flowing electricity.
13. ~1800 Volta (Italy) invented the battery by piling up many of Galvani's cells (aka voltaic cells), so they are in series.
   series and parallel voltaic cells
14. ~1825 Ohm (Germany) related current flow (I) through a wire to the voltage difference (V) across its ends
   Ohm's Law: I=V/R.
   End of material for Exam 2.
15. ~1819 Oersted (Denmark) showed that a wire carrying an electric current can deflect a compass needle -- the birth of electromagnetism. The magnetic field circulates around the wire.
   Oersted's Right-Hand Rule for magnetism of a long wire carrying electric current (qualitative)
16. ~1821 Ampere (France) showed how an electricity-carrying circuit can be thought of as a magnet. Related current through a wire and applied magnetic field to the force on the wire.
   Ampere's Right-Hand Rule for magnetism of a wire loop carrying electric current (quantitative)
   Ampere's Law of Force on a current-carrying wire
17. ~1829 Henry (USA) and Faraday (England) discovered that a time-varying magnetic field can produce a circulating electric field.
   Faraday's Law of Electromagnetic Induction
18. ~1830 Faraday (England) discovered how voltaic cells operate, and (in electroplating) the proportionality between the electroplated mass and the charge that flowed through the voltaic cell.
   Faraday's Law of Electrolysis
19. ~1840 Faraday (England) studied insulators and their dielectric properties. Faraday cage for electrical screening. Developed field concept (electric field, magnetic field). Gauss's Law.
   End of material for Exam 3.

Part III - Induced Magnetic Fields, Electromagnetic Radiation
20. ~1865 Maxwell (England) proposed that a time-varying electric field (called a displacement current) can produce a circulating magnetic field, and that this leads to electromagnetic radiation, one form of which is light. Wrote the standard treatise on Electricity and Magnetism.
   Ampere's Law of Circulation and Generalized Ampere's Law of Circulation
   Maxwell's Equations, EM Radiation (radio, TV, cell phones, wifi, etc.)
21. Light as EM Radiation, properties.
22. Light as Particle (short wavelength): Geometrical Optics and Image Formation.
23. Light as Wave (long wavelength): Interference.
   End of material for Final.

Just as Newton with universal gravity (sun acts on earth, earth acts on apple) unified astronomy (physical science of the heavens) and physics (physical science on the earth), so Maxwell, by completely integrating electricity and magnetism, unified these subjects with light.

With Einstein, who helped bring on the revolution in modern physics (quantum physics, gravity at the scale of the universe, the mechanics of objects moving near the speed of light, the relation between mass and energy), Newton and Maxwell are the physicists whose work I most admire.