

Physics 2403

- Website: www.physics.umn.edu/~marshak
- No labs
- 3 large classes, 1 problem session/week
- 3 hour exams, optional final, grades on best 3 of 5
- Class: 10%, Problem Sets 40%, Exams 50%
- Michael DuVernois will teach some problem sessions

Topics

- Special Relativity: 3 weeks
- Quantum Mechanics: 3 weeks
- Atomic and Molecular Physics: 2 weeks
- Nuclear Physics: 1 week
- Solid State Physics: 2 weeks
- Elementary Particle Physics: 2 weeks
- Particle Astrophysics and Cosmology: 2 weeks

Development of Classical Physics

- Classical physics developed in parallel with the Renaissance and Reformation
- By the mid-19th Century, the Renaissance and Reformation were over and the political and social world moved on to the building of nation states and their transformation to liberal democracies

Development of Classical Physics

- Classical physics was essentially complete by the end of the 1800's
- Hertz's verification of electromagnetic waves completed Maxwell's exposition of electromagnetism
- Newtonian dynamics and Newtonian gravitation were tested by calculation of astronomical phenomena

Development of Classical Physics

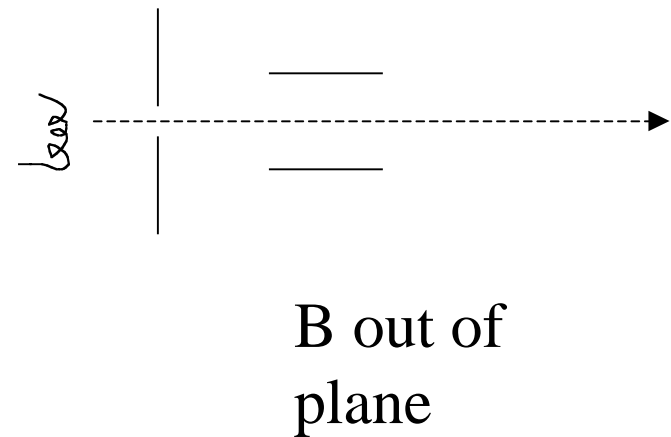
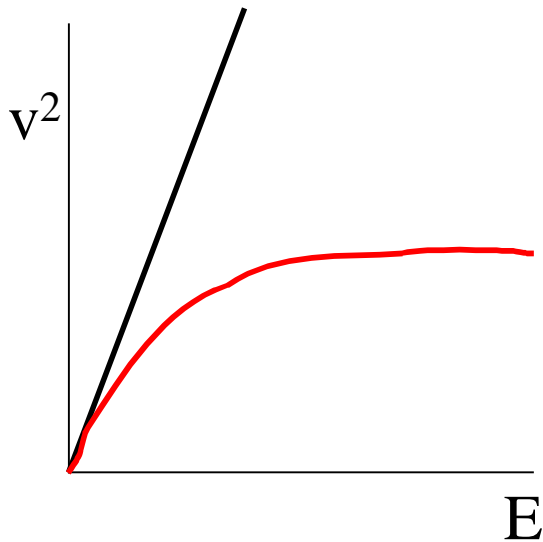
- Steam and internal combustion engines demonstrated thermodynamics, which itself could be derived from statistical mechanics

Problems With Classical Physics

- A few “small” problems with classical physics were recognized before 1900
- Ether and the Michaelson-Morley experiment
- Radioactivity
- Photoelectric effect

Motivations for Special Relativity

- Most straight-forward motivation for special relativity is the phenomenon of asymptotic velocity



What energy?

$$\frac{1}{2}mv^2 = qV$$

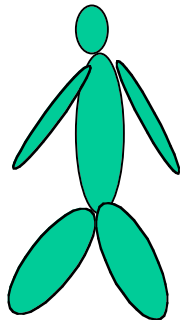
$$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2(1.6 \times 10^{-19})V}{9.1 \times 10^{-31}}} = 6 \times 10^5 \sqrt{V}$$

$$v = 2 \times 10^{-3} c \sqrt{V}$$

so for $v = 10\%$ of c , $V = 2500$ V

EM Motivation for Special Relativity

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Observer

Lorentz force appears to depend on observer

Historical Motivation for Special Relativity

- Historically, special relativity was motivated by concerns about light
- Conflict between particle and wave nature of light
- If light is a wave, what is the medium for its propagation and how can we measure the properties of that medium

Propagation of Light

- Propagation of light involves transport of energy away from a source
- The simplest mechanism for such transport is a stream of particles (proposed by Pythagoras in 6th Century B.C.)
- Accounts for propagation in straight lines (shadows) and propagation in vacuum

Propagation of Light

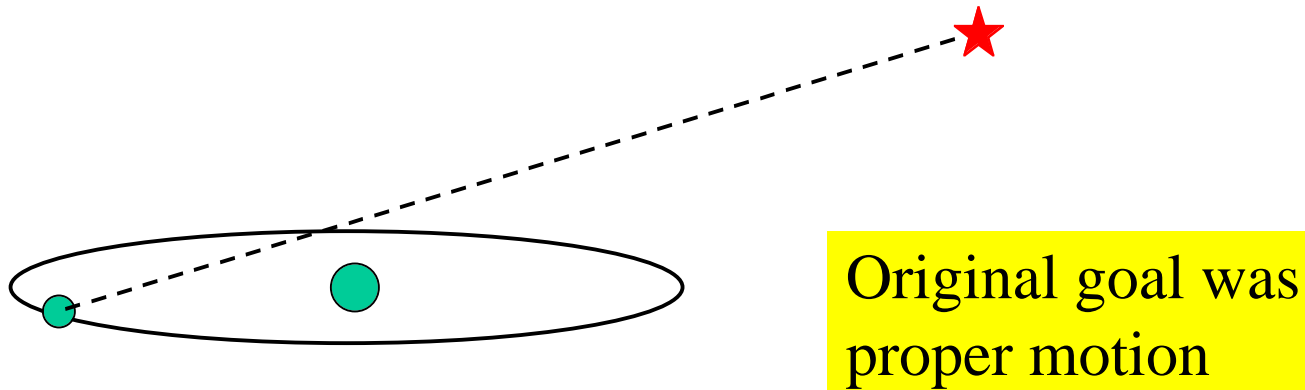
- In late 17th Century, Robert Hooke and Christian Huygens proposed wave theories of light
- Huygens showed in *Treatise on Light* (1690) that wave theory accounted for reflection and refraction
- Wave theory also accounts for diffraction, interference, polarization etc.

Propagation of Light

- Until mid-19th Century, light was viewed as a mechanical wave in luminiferous ether
- One problem is that light velocity is much larger than any known mechanical wave velocity (very high “T” but doesn’t interfere with planetary motion)

Stellar Aberration

- An early attempt to measure effect of ether was study of stellar aberration



Result was aberration depended on velocity

Stellar Aberration

- Implication of stellar aberration is that earth does not drag ether along with it