### THE NATURE OF LIGHT

### Prof. Stephen Sekula 11/15/2010 Supplementary Material for PHY1308 (General Physics -Electricity and Magnetism)

## ANNOLINCEMENTS

- Homework 11:
  - Due today by 5pm (covers remainder of CH27)
- Next Exam
  - Friday, in class (Chapters 26-27)
  - I will be away next week on Thur. and Fri. (substitute exam proctors will be here on Friday)
  - Extra Office Hours! Mon: 2-4, Tue: 1-2:30, Wed: 1-2:30
  - . Review Session: Tuesday Night, 7pm, FS157

## GALILEO GALILEI



1564-1642

Considered the first "modern scientist," Galileo combined mathematics with observation and argued that this was the way to understand the natural world.

He perfected the telescope and observed that the earth could not be the center of the universe. He was tried and convicted by the Inquisition for heresy and was placed under house arrest for the remainder of his life. *He died the* year before Isaac Newton was born.

## SPEED OF SOUND

Make measurements of the round trip that sound takes from Dallas Hall to points 100m and 200m south of Dallas Hall.

(Don't get shut down by the cops)



## SPEED OF LIGHT



Ole Roemer First to measure speed of light to be finite (1676)



Roemer estimated the speed of light to be 220,000 km/s by observing Earth-seasonal variations in lo's orbit.





## GAUSS'S LAW FOR ELECTRIC FIELDS

$$\int \vec{E} \cdot d\vec{A} = q/\epsilon_0$$

- · electric charge is the source of electric field
- Coulomb's Law is actually a consequence of Gauss's Law, though a proof of this is outside the scope of this course. It's enough to know that this is true, and that this means Gauss's Law tells us how charges respond to electric fields
- All the business about electric potential derives from this equation, and combined with conservation of energy we can recover Ohm's Law, Kirchoff's Laws, etc.

## GAUSS'S LAW FOR MAGNETIC FIELDS

$$\int \vec{B} \cdot d\vec{A} = 0$$

- there are no magnetic charges (at least, none discovered yet)
- magnetic fields equally enter and leave a closed volume of space through the area surrounding that volume

## AMPERE'S LAW

$$\int \vec{B} \cdot d\vec{r} = \mu_0 I$$

moving electric charge is the source of magnetic field

•The Biot-Savart law is a consequence of Ampere's Law, a proof outside the scope of this course. However, this means that Ampere's Law also encapsulates how electric charges respond to magnetic fields

# **FARADAY'S LAW** $\varepsilon = -\frac{d \Phi_B}{dt}$

•changing magnetic flux induces an electromotive force (an electric potential difference) that resists the change

## FARADAY'S LAW REVISITED $\int \vec{E} \cdot d\vec{r} = -\frac{d\Phi_B}{dt}$

•what Faraday's Law REALLY says: changing magnetic flux induces an electric field

### THE FOUR EQUATIONS OF ELECTRICITY AND MAGNETISM

$$\int \vec{E} \cdot d \vec{A} = q/\epsilon_0$$

$$\int \vec{B} \cdot d \vec{A} = 0$$

$$\int \vec{B} \cdot d \vec{r} = \mu_0 I$$

$$\int \vec{E} \cdot d \vec{r} = -\frac{d \Phi_B}{dt}$$

### ELECTRICITY AND MAGNETISM IN FREE SPACE

$$\int \vec{E} \cdot d\vec{A} = 0$$

$$\int \vec{B} \cdot d\vec{A} = 0$$

$$\int \vec{B} \cdot d\vec{r} = 0$$

$$\int \vec{E} \cdot d\vec{r} = -\frac{d\Phi_B}{dt}$$

## JAMES CLERK MAXWELL



### 1831-1879

Brilliant scientist working in Britain.

- United electricity and magnetism into a single "force"
- Developed a theory of large numbers of particles
- Made the first true color photograph

Published in 1864 "A Dynamical Theory of the Electromagnetic Field," which was seen by Faraday before his death in 1867.

### MAXWELL'S EQUATIONS IN FREE SPACE

$$\int \vec{E} \cdot d\vec{A} = 0$$

$$\int \vec{B} \cdot d\vec{A} = 0$$

$$\int \vec{B} \cdot d\vec{r} = \mu_0 \epsilon_0 \frac{d\Phi_E}{t}$$
$$\int \vec{E} \cdot d\vec{r} = -\frac{d\Phi_B}{dt}$$



Heinrich Hertz (1857-1894) First to satisfactorily demonstrate the existence of EM waves Guglielmo Marconi (1874-1937) Italian inventor who developed the radio telegraph system (first demonstrated in 1894) Robert Hyer (1860-1929) Physicist, First President of SMU First American to communicate using EM waves (1894)











#### **Chart of the Electromagnetic Spectrum**





Albert Einstein (1879-1955)

In 1905, published three papers on atomic theory, the nature of light, and the re-interpretation of space and time based on the theory of electromagnetism ("relativity").