Electromagnetics Theory

INTRODUCTION

Outline:

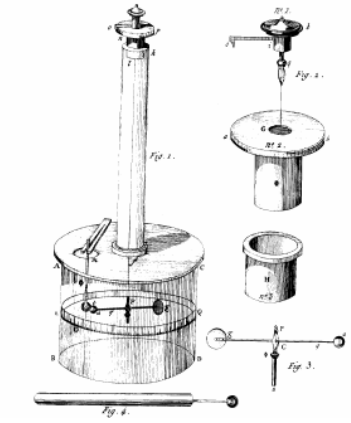
1. **Brief History of Electromagnetics**
2. **Historical Timeline**
3. **Dimensions, Units and Notation**
4. **The Electromagnetic Spectrum**
5. **Some Engineering Applications**

1.0 Brief History of Electromagnetics

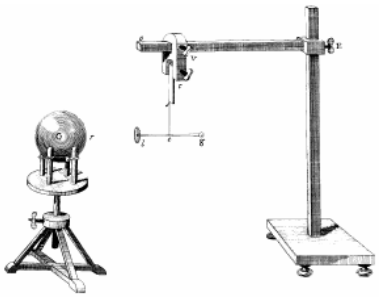
- John Mitchell (1724-1793) : Inverse square law

$$f \alpha \frac{qq'}{r^2}$$

- Charles de Coulomb (1736-1806) : Coulomb's law



Coulomb's apparatus



Coulomb's apparatus for unlike charges

Brief History of Electromagnetics (Cont'd)

- Oersted (1777-1851) : A wire carrying a current could deflect the needle of a compass.
- Andre Ampere (1775-1836) : Two current-carrying wires would create forces on each other of either repulsion or attraction.
- J.B Biot (1774-1855) and F. Savart (1791-1841) : A system of steady currents *I* creates a magnetic field at point *(x,y,z)* given by

$$\boldsymbol{B}(x,y,z)\,\alpha\,\int\frac{\boldsymbol{I}dl\times\boldsymbol{r}}{r^3}$$

Biot-Savart law

Brief History of Electromagnetics (Cont'd)

- K.F Gauss (1777-1855) : Discovered **Gauss's law** of electrostatic, which provides that knowing the number of electric flux lines leaving a closed surface allows one to determine the net positive charge enclosed by that surface.
- M. Faraday (1791-1867): A *time-changing* magnetic field would produce an electric field which produces a current in a closed loop. **Faraday's law**.
- J.C Maxwell (1831-1879) : Unify the previous discoveries, he predicted the existence of EM waves, which H. Hertz (1857-1894) demonstrated, experimentally in 1887.

2.0 Historical Timeline

Classical Era

- Magnus (900 BC) : experiences a pull on the iron nails by the block rock. The rock became known as *magnetite* (permanent magnet)
- Willian Gilbert (1600): published *electric* term.
- Isaac Newton (1671): demonstrates that *white light* is a mixture of all the colors.
- Benjamin Franklin (1752):demonstrates that *lightning* is electricity

Historical Timeline

Modern Era

- Telecommunications
  - Thomas Edison (1872) : electric typewriter
  - Alexander Bell(1876): telephone
  - Heinrich Hertz(1887): radio waves
- Computer Technology
  - Vannevar Bush (1930): analog computer
  - Konrad Zuze (1941): programmable digital computer
  - Yoshiro Nakama (1950) floppy

3.0 Dimensions, Units and Notation

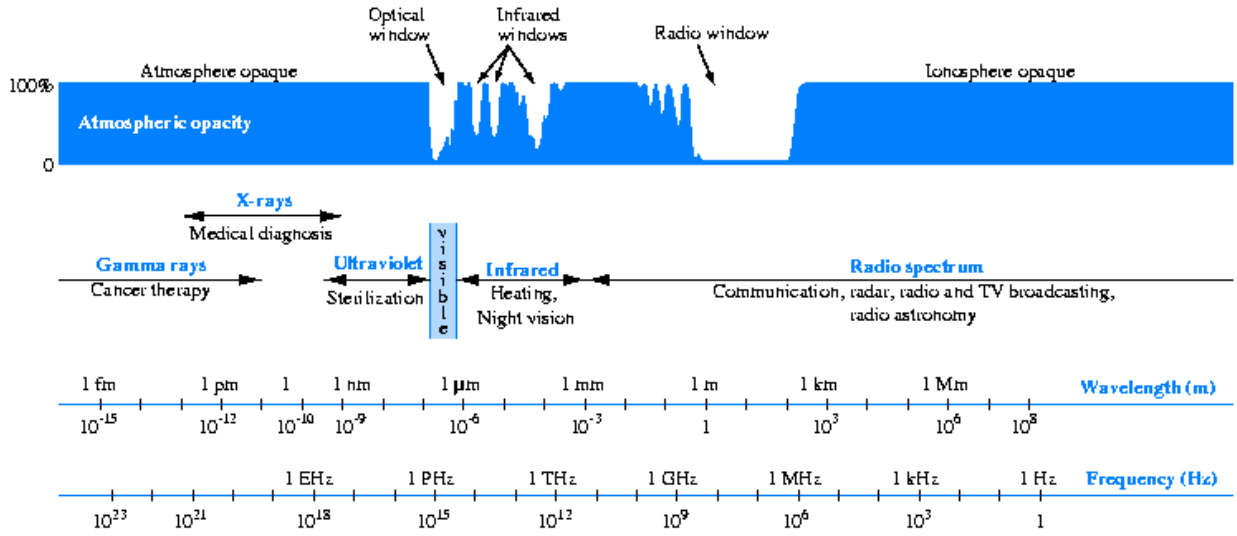
Dimension	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	Ampere	A
Temperature	Kelvin	K
Amount of substance	mole	mol

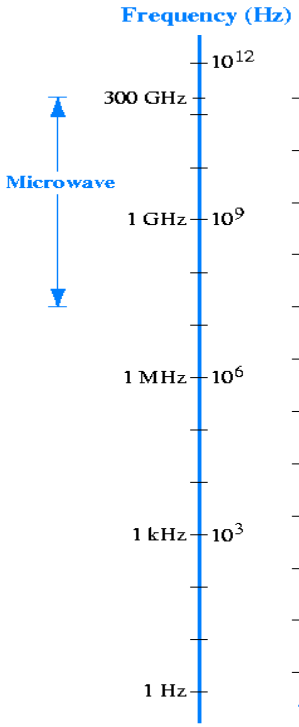
- SI – Systeme Internationale
- All other dimensions are regarded as secondary

Scalar and Vector Quantities

- *Medium weight Italic font* for scalar quantities, e.g. R for resistance
- **Boldface roman font** for vector quantities, e.g. $\mathbf{E}$ for electric field vector
- A vector consists of a magnitude (scalar) and a direction (usually denote by a unit vector), e.g. $\mathbf{E} = \hat{\mathbf{x}}E$
- Unit vector is printed in boldface with a circumflex (^) above the letter
- Phasors is represented with a tilde (~) over the letter, e.g. $\tilde{\mathbf{E}}$

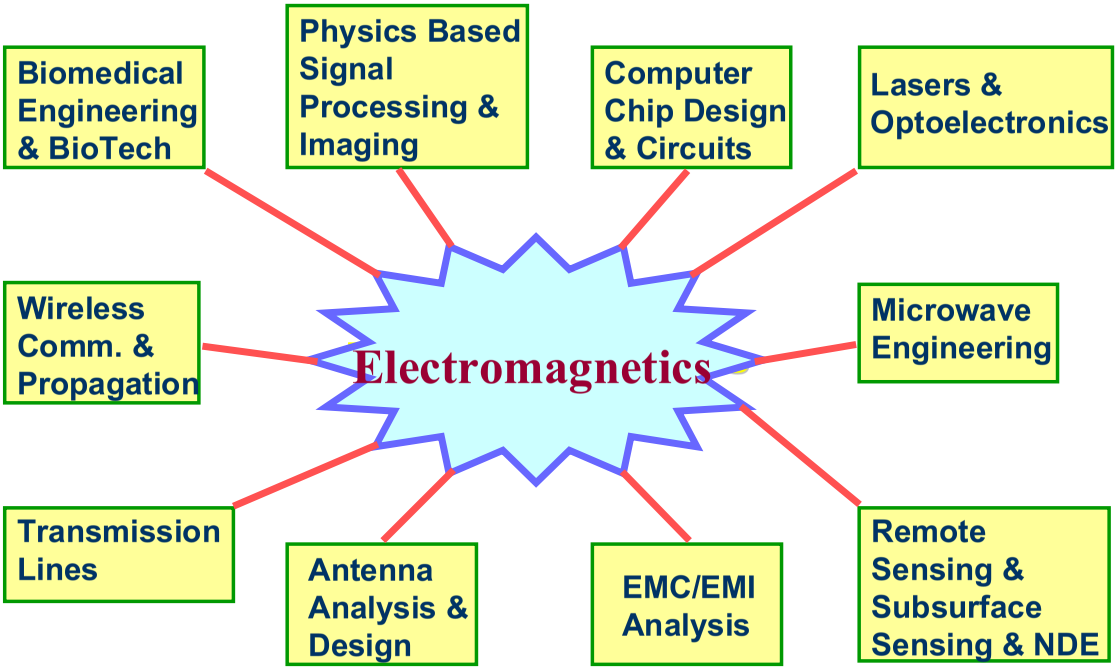
4.0 The Electromagnetic Spectrum





Band	Applications
Extremely High Frequency EHF (30 - 300 GHz)	Radar, advanced communication systems, remote sensing, radio astronomy
Super High Frequency SHF (3 - 30 GHz)	Radar, satellite communication systems, aircraft navigation, radio astronomy, remote sensing
Ultra High Frequency UHF (300 MHz - 3 GHz)	TV broadcasting, radar, radio astronomy, microwave ovens, cellular telephone
Very High Frequency VHF (30 - 300 MHz)	TV and FM broadcasting, mobile radio communication, air traffic control
High Frequency HF (3 - 30 MHz)	Short wave broadcasting
Medium Frequency MF (300 kHz - 3 MHz)	AM broadcasting
Low Frequency LF (30 - 300 kHz)	Radio beacons, weather broadcast stations for air navigation
Very Low Frequency VLF (3 - 30 kHz)	Navigation and position location
Ultra Low Frequency ULF (300 Hz - 3 kHz)	Audio signals on telephone
Super Low Frequency SLF (30 - 300 Hz)	Ionospheric sensing, electric power distribution, submarine communication
Extremely Low Frequency ELF (3 - 30 Hz)	Detection of buried metal objects
$f < 3$ Hz	Magnetotelluric sensing of the earth's structure

5.0 Some Engineering Applications



Thank You