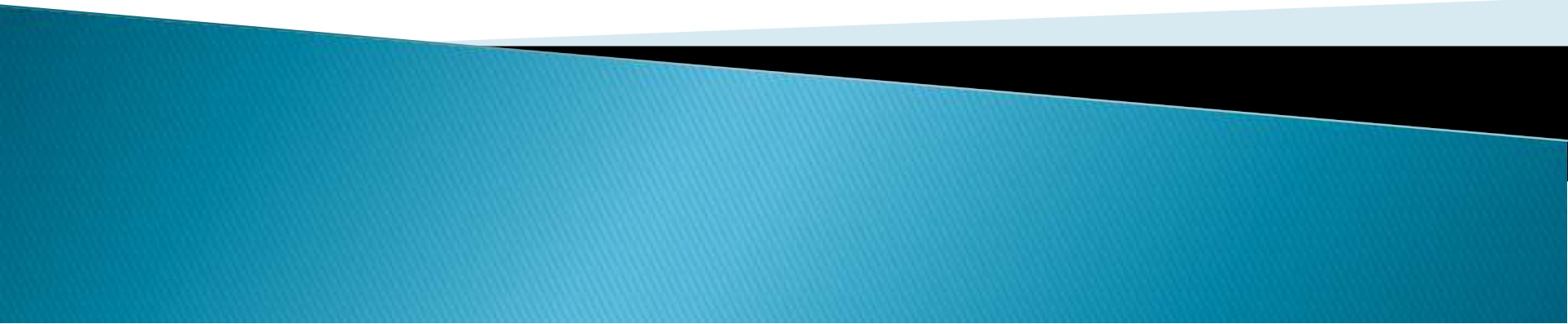


# ELECTROMAGNETIC THEORY



- ▶ Electro magnetic Theory covers the basic principles, of electro magnetism: experimental basis, electrostatics, magnetic fields of steady currents, motional e.m.f and electromagnetic induction, Maxwell's equations, propagation and radiation of electromagnetic waves, electric and magnetic properties of matter and conservation laws.

# Why electromagnetic theory is needed?

- ▶ EM Theory is an essential basis for understanding the devices, methods and systems used for electrical energy both electric and magnetic fields are defined in terms of the forces they produce.

# Who created electromagnetic waves?

- ▶ Heinrich Rudolf Hertz was a German Physicist who first conclusively proved the existence of the electromagnetic waves theorized by James Clerk Maxwell's electromagnetic theory of light.

# How was electromagnetic radiation discovered?

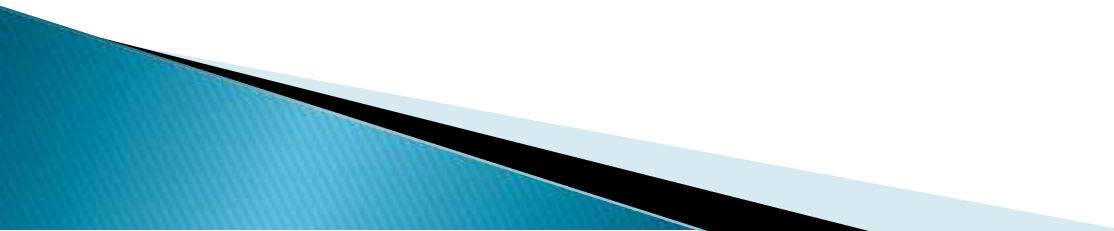
- ▶ In 1887 Heinrich Hertz demonstrated the existence of the waves predicted by Maxwell by producing radio waves in his laboratory. It took a bit longer for scientists to discover the high energy light in the electromagnetic spectrum.

# GAUSS'S LAW

- It states that , the divergence of the electric field intensity at any point is equal to  $1/\epsilon_0$  times the volume charge density at the points .

$$\nabla \cdot \mathbf{E} = \rho / \epsilon_0$$

# APPLICATION OF GUASS LAW:

- ▶ Guass law is useful in calculating the electric field for a given charge distribution only for cases involving a high degree of symmetry since the unknown quantity  $E$  appears in the integrand.
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# ENERGY OF A CONTINUOUS CHARGE DISTRIBUTION

- ▶ Work done on a continuous charge distribution =  $\frac{1}{2} \int \rho V \, d\tau$
- ▶ The quantity  $\frac{1}{2} \epsilon_0 \mathbf{E}^2$  is the energy density in the electric field.



# GUASS LAW IN THE PRESENCE OF DIELECTRICS

- ▶ The flux of the electric displacement vector across an arbitrary closed surface is equal to the free charge enclosed by the surface.
- ▶  $\nabla \cdot \mathbf{D} = \rho$

# BIOT-SAVART LAW

- ▶ The force between two current elements  $dl_1$  and  $dl_2$  carrying steady current  $I_1$  and  $I_2$  respectively.
- ▶ It varies directly as the product of the magnitudes of currents.
- ▶ Varies inversely as the square of the distance between the two elements.
- ▶  $B = \frac{\mu_0}{4\pi} \int \frac{I \cdot dl}{r^2}$

# AMPERE'S LAW

- ▶ It states that the line integral of magnetic induction vector  $B$  around a closed path is equal to  $\mu_0$  times the total current crossing any surface bounded by the line integral path.
- ▶  $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$

# FARADAY'S LAW

- ▶ Faraday's law states that the absolute value or the magnitude of the circulation of the electric field  $E$  around a closed loop is equal to the rate of change of the magnetic flux through the area enclosed by the loop.

$$\nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$$

# MAXWELL'S EQUATION

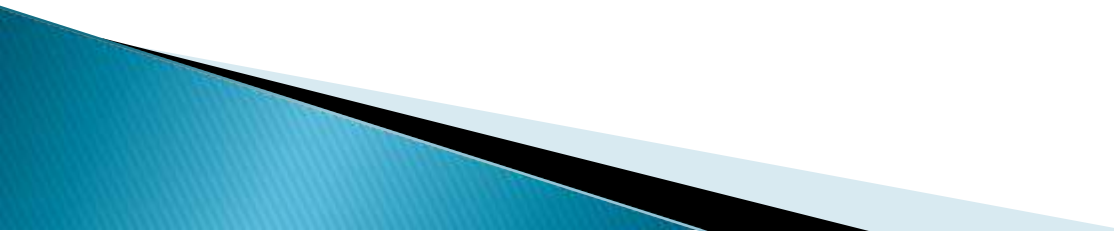
- ▶ There are four fundamental equations of electromagnetism known as Maxwell's equations. These equations correspond to a generalisation of certain experimental observations regarding electricity and magnetism.

- ▶  $\nabla \cdot \mathbf{D} = \rho$

- ▶  $\nabla \cdot \mathbf{B} = 0$

- ▶  $\nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$

- ▶  $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathbf{D} / \partial t$

- ▶ Maxwell's equations are a set of four differential equations that form the theoretical basis for describing classical electromagnetism.
  - ▶ Gauss's law:– Electric charges produce an electric field. The electric flux across a closed surface is proportional to the charge enclosed.
  - ▶ Gauss's law for magnetism:– There are no magnetic monopoles. The magnetic flux across a closed surface is zero.
  - ▶ Faraday's law:– Time varying magnetic fields produce an electric field.
  - ▶ Ampere's law:– Steady currents and time varying electric fields produce a magnetic fields.
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# BOUNDARY CONDITIONS ON E,B,D,H

- ▶ The fields E,B,D,H will be discontinuous at a boundary between two different media or at a surface which carries charge density  $\sigma$  or current density K .
- ▶  $D1_{\perp} - D2_{\perp} = \sigma$
- ▶  $B1_{\perp} - B2_{\perp} = 0$
- ▶  $E1_{\parallel} - E2_{\parallel} = 0$
- ▶  $H1_{\parallel} - H2_{\parallel} = K$

# SCALAR AND VECTOR POTENTIALS

- ▶  $\mathbf{B} = \nabla \times \mathbf{A}$
- ▶  $\mathbf{E} = -\nabla V - \partial \mathbf{A} / \partial t$
- ▶ Where  $\mathbf{A}$  is called the vector potential ,  $V$  is called the scalar potential.
- ▶ They are mathematical functions which are not physically measurable.
- ▶ They are not independent of each other .
- ▶ These define the field vectors  $\mathbf{E}$  and  $\mathbf{B}$  uniquely, though they themselves are non-unique.
- ▶ They play an important role in relativistic electrodynamics.



# ENERGY IN ELECTRODYNAMICS

- ▶  $\frac{dw}{dt} = -\int \frac{1}{2} (\epsilon_0 \mathbf{E}^2 + \frac{1}{\mu_0} \mathbf{B}^2) d\tau - \frac{1}{\mu_0} \int (\mathbf{E} \times \mathbf{B}) \cdot d\mathbf{a}$
- ▶ The first integral of the equation is the total energy stored in the field  $W_{EB}$ .
- ▶ The second term represents the rate at which energy is carried out of  $V$  across its boundary surface by the electromagnetic field

Thank You