5.5. MAXWELL'S EQUATIONS

In the absence of any dielectric or magnetic material, the four Maxwell's equations are given below:

(*i*) $\oint_S \vec{E}.d\vec{s} = q/\epsilon_0$. This equation is **Gauss's Law in electrostatics.** This gives the value of total electric flux in terms of the charge enclosed by surface *S*. This equation gives an *electric field due to* *discrete charge or due to certain charge distribution* and tells that the electric lines of force start from some positive charge and end at some other negative charge, *i.e.*, ***the electric lines of force do not form continuous closed path.*** This law predicts that isolated charge exists.

(*ii*) $\oint_S \vec{B}.d\vec{s} = 0$. This equation is **Gauss's Law in magnetostatics,** where $\oint_S \vec{B}.d\vec{s}$ represents the surface integral of $\vec{B}$ over a closed surface. This law shows that the number of magnetic lines of force entering a closed surface is equal to number of magnetic lines of force leaving it. It means, there is no starting or end point of magnetic lines of force. Thus, the ***magnetic lines of force always form closed paths.*** If it were not so, then the isolated magnetic monopoles would have existed. Thus, the Maxwell's equation (*ii*) confirms the ***absence of magnetic monopole.***

(*iii*) $\oint \vec{E}.d\vec{l} = -\frac{d}{dt}\int_s \vec{B}.d\vec{s}$. This equation is **Faraday's law of electromagnetic induction** where, $\int_S \vec{B}.d\vec{s}$ represents the surface integral of $\vec{B}$ over a surface bounded by a closed curve over which the line integral for electric field is taken. This law gives a relation between electric field and a changing magnetic flux. This law shows that ***the line integral of electric field around any closed path (i.e. the emf) is equal to the time rate of change of magnetic flux through the surface bounded by the closed path.***

(*iv*) $\oint \vec{B}.d\vec{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{d}{dt}\int_s \vec{E}.d\vec{s}$. This equation is generalised form of **Ampere's law as Modified by Maxwell** and is also known as ***Ampere-Maxwell law.*** This law shows that the line integral of the magnetic field around any closed path is related to the conduction current (I) and displacement current $\left(I_D = \epsilon_0 \frac{d}{dt}\int_s \vec{E}.d\vec{s}\right)$ through that path. This law predicts that the magnetic field can be produced by a conduction current as well as by displacement current.