Circuit Theory	Field Theory.
1. Deals with Voltage (V) & Current (I).	Deals with Electric Field (E) & Magnetic Field (H).
2. V & I are Scalars	$\vec{E}$ & $\vec{H}$ are Vectors.
3. V & I are produced from E & H	E & H are produced from V & I.
4. V & I are functions of time	E & H are functions of time & space (x, y, z) (or) (ρ, ϕ, z) (or) (r, θ, ϕ).
5. Cannot be applied in free space (∴ Radiation effects are neglected)	Applicable in free space. (Radiation effects are Considered).
6. Basic Laws are Ohms Law, Kirchoffs Law	Coulomb's Law, Gauss Law, Amperes Circuital Law.
7. Basic Theorems are Thevenin's, Norton's, Reciprocity, Superposition, MPT Theorems.	Reciprocity, Helmholtz, Stokes, Divergence & Poynting Theorems.

Electromagnetics → Study of fields & Waves.

$\vec{E}$	$\vec{H}$
① $\vec{E}$ → Electric field Intensity Electric Field E – Field Electric field strength Unit → V/m (or) Newton/C. (Belongs to Voltage)	$\vec{H}$ → Magnetic field Intensity. → Magnetic Field → H – Field → Magnetic Field strength Unit → A/m. (Belongs to Current).
② $\vec{D}$	$\vec{B}$
$\vec{D}$ → Electric Flux Density Electric Displacement Vector Electric charge Density → D – Field. Unit → Coulomb/m^2 C/m^2.	$\vec{B}$ → Magnetic Flux Density. → Magnetic Displacement Vector. → Magnetic charge Density → B – Field. Unit → Weber/m^2 (or) Tesla A/m^2.
Gauss Law :- Surface Integral of Electric flux density = charge enclosed by the surface $\iint_S \vec{D}\cdot\vec{ds} = Q.$	$\iint_S \vec{B}\cdot\vec{ds} = 0.$

$\vec{E}$

(3) $\vec{D} = \varepsilon E$.

$\varepsilon \rightarrow$ Total permitivity of the medium.

$\varepsilon = \varepsilon_0 \varepsilon_r$.

$\varepsilon_r \rightarrow$ Relative permitivity of the medium.

$\varepsilon_0 \rightarrow$ permitivity in free space.

8.854×10^{-12} Fd/m.

(4) Capacitance

Capacitance/unit Length.

5. $Q \rightarrow$ Charge.

Unit $\rightarrow$ Coulomb.

$\psi \rightarrow$ Electric flux (or) Electric charge

Unit $\rightarrow$ Coulomb.

6. $Q = C.V.$

7 EMF unit $\rightarrow$ Volts.

$\vec{H}$

$\vec{B} = \mu \vec{H}$

$\mu \rightarrow$ Total permeability of the medium.

$\mu = \mu_0 \mu_r$

$\mu_0 \rightarrow 4\pi \times 10^{-7}$ H/m.

H $\rightarrow$ Henry.

Inductance

Inductance/unit Length.

$\phi \rightarrow$ Magnetic Flux

Unit $\rightarrow$ Weber.

$\phi = LI$.

{If more than one turn then use Capa $\boxed{\Lambda = N\phi}$

N $\rightarrow$ No. of Turns.

MMF unit $\rightarrow$ Amp Turns

$\vec{E}$	$\vec{H}$
Electric Field Intensity (V/m)	Magnetic Field Intensity (A/m).

$\frac{C}{m}$ $\downarrow$ Line charge Density

$\frac{C}{m^2}$ $\downarrow$ Surface charge Density.

$\frac{C}{m^3}$ $\downarrow$ Volume charge density.

$\frac{A}{m}$ $\downarrow$ Line Current Density

$\frac{A}{m^2}$ $\downarrow$ Surface Current Density

$\frac{A}{m^3}$. $\downarrow$ Volume Current Density.

Power Density & Energy Density.

power Density $\rightarrow$ Power / Unit surface area (W/m²)

$$\boxed{\vec{P} = \vec{E} \times \vec{H} = \frac{V}{m} \times \frac{A}{m} = \frac{VA}{m^2} = \frac{W}{m^2}}$$

$\rightarrow$ power flow thro' plane (or) area.

$\rightarrow$ It is a Scalar Quantity.

[Related Vector Quantity is Poynting Vector]

Energy Density $\rightarrow$ Energy / Unit volume $\Rightarrow$ (J/m^3).

$\rightarrow$ Energy flow through Volume.

Field Parameter → Circuit Parameter → (5) Density function (or) Point function

1. E → $V = \oint E \cdot dl$ V/m.

Eletric field Intensity.

2. D → $\Psi_e = \iint_S D \cdot ds$ C/m^2.

Eletric Flux Density

3. ρ_v → $Q = \iiint_v \rho_v \cdot dv$ Coulomb/m^3.

Total charge Volume

4. H → $I = \oint H \cdot dl$ Amp/m.

Magnetic Field Intensity

5. B → $\Psi_m = \iint_S B \cdot ds$ Wb/m^2.

Magnetic flux density.

6. J → $I = \iint_S J \cdot ds$ Amp/m^2.

J_d → Displacement Current Density $\left(\frac{\partial D}{\partial t}\right)$

&

J_c → Conduction Current Density

[Current Density]

(i) Line charge distribution

$$Q = \int \rho_l \cdot dl \rightarrow \text{Wire Antenna.}$$

(ii) Surface charge distribution.

$$Q = \iint \rho_s \, ds \rightarrow \text{plate (or) sheet.}$$

(iii) Volume charge distribution.

$$Q = \iiint \rho_v \cdot dv. \rightarrow \text{Parabolic Antenna.}$$

Three Constitutive relations in Field Theory Analysis :-

$$\vec{D} = \varepsilon_e \vec{E}. \rightarrow (1)$$

Electric flux density

$$\vec{B} = \mu \vec{H}. \rightarrow (2)$$

Magnetic flux Density

Current density, $\vec{J} = \sigma \vec{E}. \rightarrow (3).$

1. Dot product of two Vectors is a Scalar Quantity.

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}.$$

$$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}.$$

$$y = \vec{A}\cdot\vec{B} = |\vec{A}|.|\vec{B}|.\cos\theta.$$

$$\boxed{y = A_x B_x + A_y B_y + A_z B_z}.$$

2. Cross product of two Vectors is a Vector Quantity.

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$$

$$\vec{B} = B_x\hat{i} + B_y\hat{j} + B_z\hat{k}.$$

$$\vec{Y} = \vec{A}\times\vec{B} = |\vec{A}|.|\vec{B}|.\sin(\theta).\hat{n}.$$

$\hat{n}$ → Resultant Direction.

$$\Rightarrow \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$\Rightarrow \hat{i}(A_y B_z - B_y A_z) - \hat{j}(A_x B_z - A_z B_x) + \hat{k}(A_x B_y - A_y B_x).$$

Dot Product :-

1. $\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$.

2. $\vec{i} \cdot \vec{i} = \vec{j} \cdot \vec{j} = \vec{k} \cdot \vec{k} = 1$.

3. $\vec{i} \cdot \vec{j} = \vec{j} \cdot \vec{k} = \vec{k} \cdot \vec{i} = 0$.

Cross Product :-

1. $\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$.

2. $\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$.

3. $\vec{i} \times \vec{i} = \vec{j} \times \vec{j} = \vec{k} \times \vec{k} = 0$.

4. $\vec{i} \times \vec{j} = \vec{k}$. $\quad\|\quad \vec{j} \times \vec{i} = -\vec{k}$

   $\vec{j} \times \vec{k} = \vec{i} \quad\|\quad \vec{k} \times \vec{j} = -\vec{i}$

   $\vec{k} \times \vec{i} = \vec{j} \quad\|\quad \vec{i} \times \vec{k} = -\vec{j}$