Babul sir

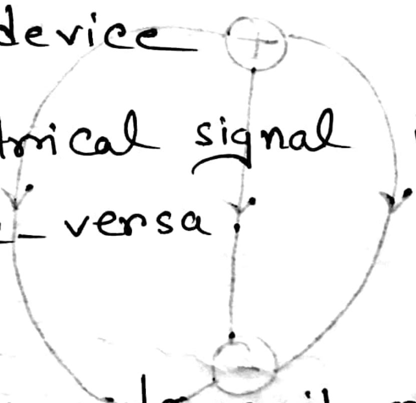
02-08-2023

* Antenna
* Transmission line
* Resonator
* How does Antenna work - Radiation mechanism
* Electromagnetic wave propagation

Antenna:

* structure associated with the region of transition between a guided wave and a free space wave or vice versa.

* A transition device
* Converts electrical signal into electromagnetic wave, or vice-versa.



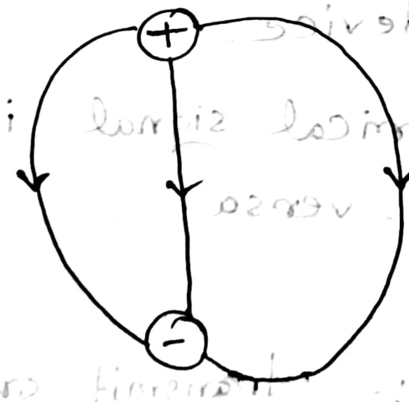
* Transmission line:- transmit or guide radio-frequency energy from one point to another with a minimum attenuation.

* Energy Concentration in pure standing wave oscillate from entirely electric to entirely magnetic and back twice per cycle. Such energy behaviour is characteristic of a resonant circuit.

***Antennas radiate (or recieve) energy; transmission lines guide energy, while resonators store energy.

** Electric charge oscillating harmonically with a frequency produces electromagnetic wave of the same frequency.

* Basic source of electromagnetic wave— electri dipole.



Dipole

Babul Sir

10-08-2023

Max well equation:

* Electric and magnetic field: move together.

* Antenna Parameters.
* Radiation resistance
* input impedance
* Radiation pattern

$$z = a + jb$$

$$\text{phase of } z = \tan^{-1}\left(\frac{b}{a}\right)$$

* Type of radiation patterns.

SMR Sir

13-08-2023

⇒ Electrical — force, field, potential

⇒ Coulomb law:

⇒ dirrection of electric field.

⇒ Electromagnetic wave.

$$\lambda = \frac{c}{f}$$

$$\boxed{f = 10\,KHz}$$

Maxwell's equation:

* Electric field lines originate on positive charges and terminate on negative charges.

* No magnetic monopoles are known to exist.

Gauss law for E field:

1st equation of maxwell $\longrightarrow$ $\nabla \cdot D = \rho_v$ | $\oint_S D \cdot dS = \int_V \rho_v \, dv$

D = electric flux density

ρ_v = Electric charge density per unit volume.

Gauss's law for H field. Non existence of mono pole:

2nd equation $\longrightarrow$ $\nabla \cdot B = 0$ | $\oint_S B \cdot dS = 0$

Faraday's Law:

A changing magnetic field induces an electromotive force (emf) and, hence, an electric field

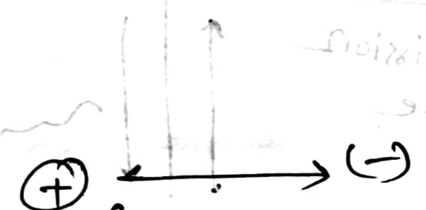
$$\nabla \times E = -\frac{\partial B}{\partial t} \quad \Big| \quad \oint_L E \cdot dl = -\frac{\partial}{\partial t} \int_S B \cdot dS$$

Ampere's Circuit law:

Magnetic fields are generated by moving charges or by changing electric fields.

$$\nabla \times H = J + \frac{\partial D}{\partial t} \qquad \oint_L H \cdot dl = \int_S \left(J + \frac{\partial D}{\partial t}\right) \cdot ds$$

H = magnetic field intensity
B = " flux density
E = Electric field intensity

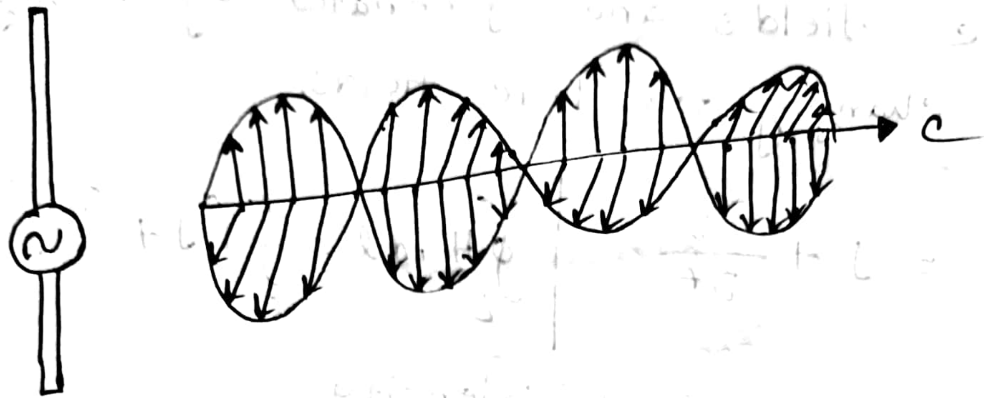


(dirrection of electric field)

* The current in the antenna produces the Circular magnetic field Lines. The current I produces the separation of charge along the wire, which in turn creates the electric field.

* The electric and magnetic fields E and B are perpedicular. to each other and the dirrection of propagation.

*** The electric and magnetic fields are in phase.



*

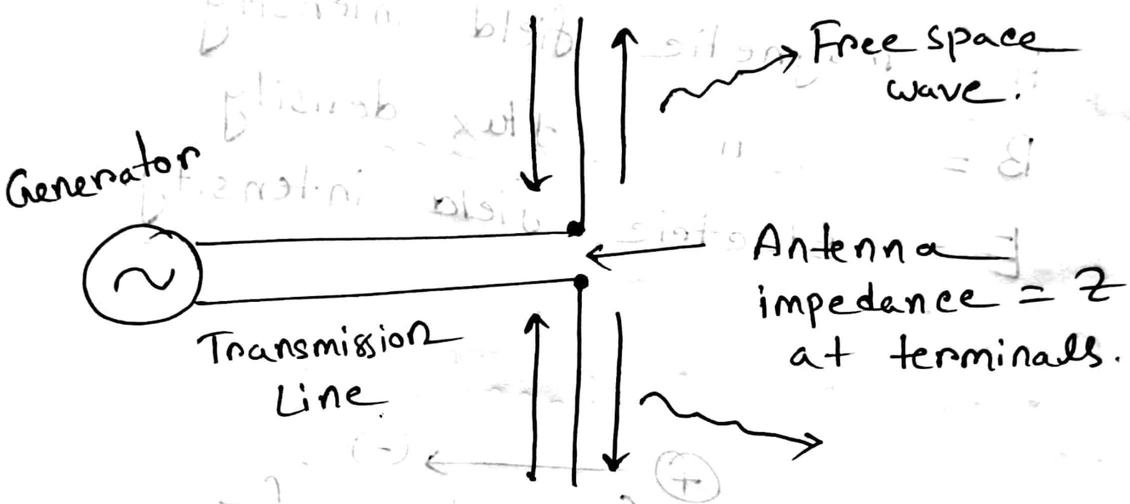
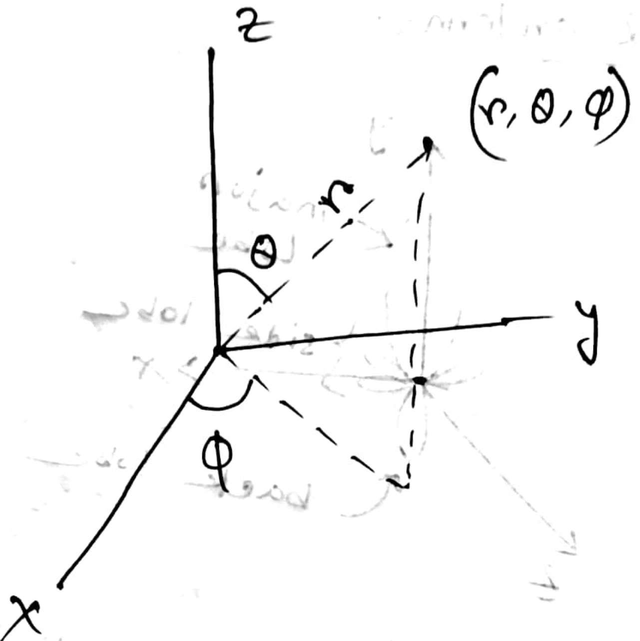


Fig: Dipole Antenna

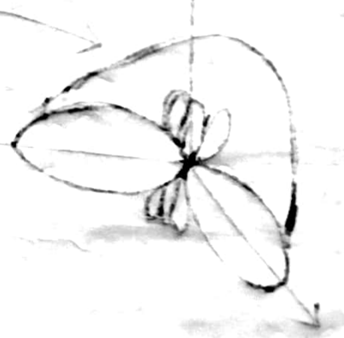
Radiation pattern:

Radiation pattern provides information that describe how an antenna directs the energy it radiates.

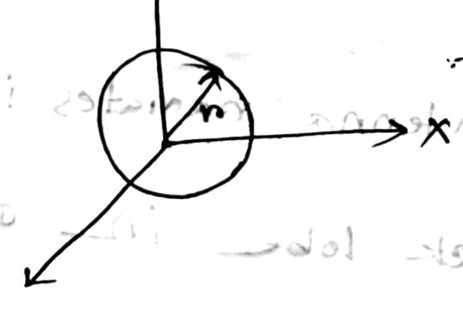
It shows the relative distribution of radiated power as a function of direction in space (θ, ϕ)



* Radiation is the term used to represent the emission or reception of wave front at the antenna, specifying its strength.
* The sketch drawn to represent the radiation of an antenna is its radiation pattern.

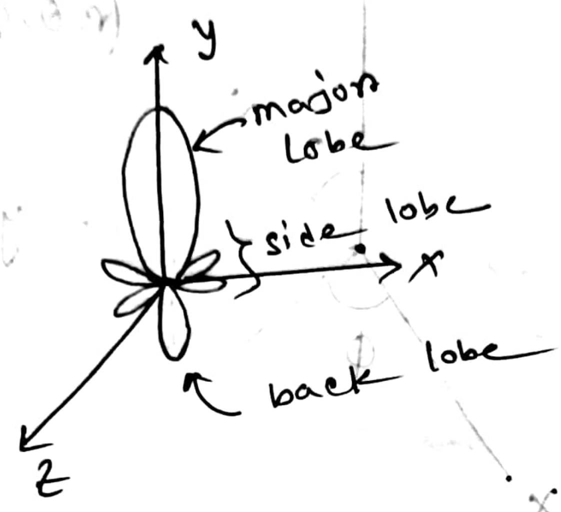


Iso-tropic Antenna :



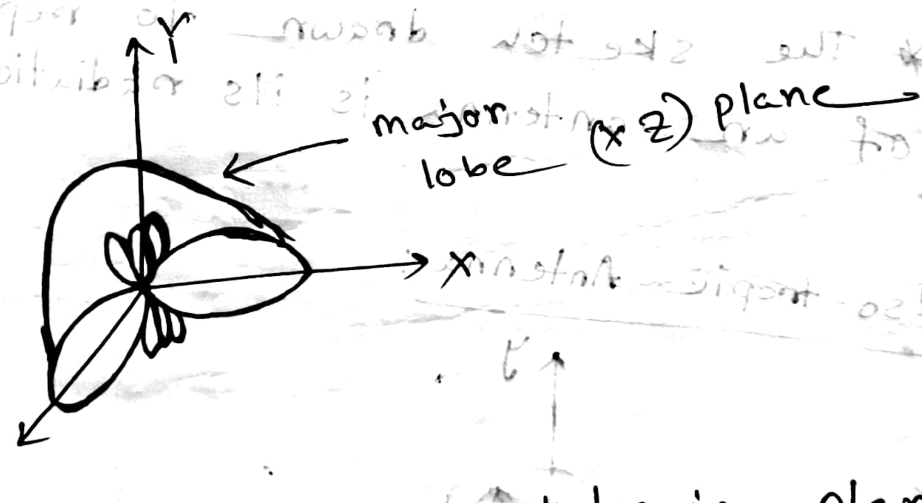
* Radiates equally in All the dirrection
  Radiation pattirn will be sphere.

Dirrectional antenna:



- Directional antenna radiates in particular dirrection.

Omni dirrectional Antenna:

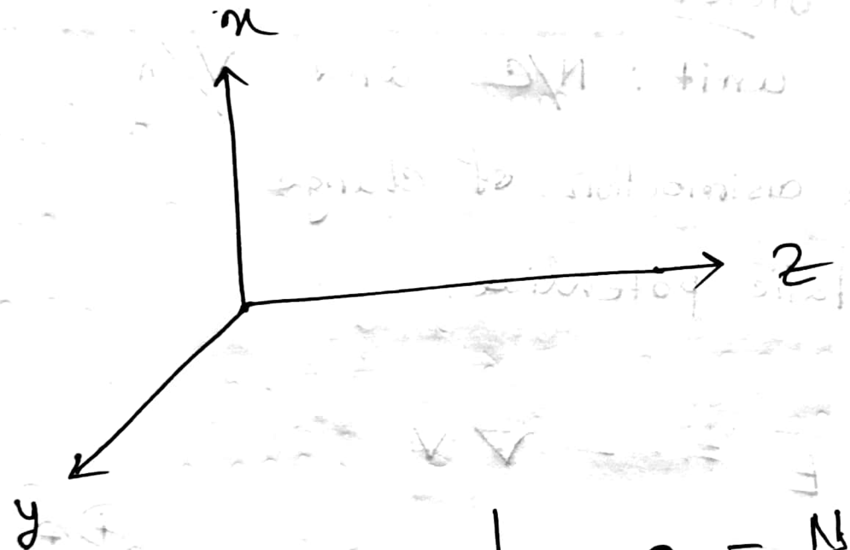


- Omni directional antenna radiates in plane.
- There is no back lobe in omni dirrectional antenna.

Electromagnetic Field and Wave

[redacted] SMR sir (12-08-2023)

Electromagnetic wave.



$$\frac{dH}{dx} = \frac{dE}{dt}$$

$$e = N.\mu \frac{dH}{dt}$$

$\lambda = 4$ cm

$f = c/\lambda$ Hz

$= 3\times10^{8} / 4\times10^{-2}$

displacement currents,

$\boxed{D = \epsilon E}$

* Wave guide.

Optimum

Logical Explanation

SMR sir

[20-08-2023]

* Electro magnetic Theory:

Eletctro statics:

Magnetostatics:

Colombs Law:

$$F_{12} = \hat{a}_{R_{12}} \frac{Q_1 Q_2}{4\pi\epsilon_0 r_{12}^2}$$

Electric field.

↳ unit : N/C and V/m

* Continuous distribution of charge

* Electrostatic potential.

$$\bar{E} = -\nabla V$$

$$\boxed{V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}}$$

$$W_{a\to b} = -\int_a^b \bar{F}\cdot \bar{dl} = -q\int_a^b \bar{E}\cdot \bar{dl}$$

$$\oint_c \bar{E}\cdot \bar{dl} = 0$$

* Book ⟶ JK Rider.

Babul sir
(22-08-2023)

1 sr = 1 rad.

* Directivity
* Effective aperture. (Expression of gain)

Q. Find the gain of antenna?

Find and stablish relationship among Directivity, wave length,

* Friis Transmission Formula.

G_t

$T \rightarrow P_t$ $\qquad$ R

P_t $\qquad$ P_r

Q. Derive the Friss transmission formula?

Q. mathematical problem.

SMR

24-08-2023

$$\frac{\partial E}{\partial x} \neq 0 \Rightarrow \frac{\partial H}{\partial t}$$

$$\boxed{H(t) = A \sin \omega t}$$

$$\frac{\partial E}{\partial t}$$

Dipol, Dipole moment.

Electrostatic Potential due to charge dipole.

* Spherical Co-ordinate.
* Electrostatic potential due to charge dipole in the Far-Field.

$$\boxed{V(r, \theta) = \frac{Q\, d \cos\theta}{4\pi\epsilon_0 r^2}}$$

$$V \approx \frac{1}{4\pi\epsilon_0} \frac{\bar{P} \cdot \hat{a}_r}{r^2}$$

Babul Sir

24-08-2022

$1\ GHz = ?\ Hz$

$10^9\ Hz.$

Problem:

We know,

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi r}\right)^2$$

Given,

$P_t = 160W$

$G_t = 25\ dB = 10^{\frac{25}{10}} = 10^{2.4}$

$G_r = 20\ dB = 10^{\frac{20}{10}}$

$\lambda = \frac{c}{f}$

$= \frac{3\times10^8}{1\times10^9}$

$= 0.3m$

$r = 1Km = 10^3 m$

$$= 160\times316.23\times100 \times \left(\frac{0.3}{4\times\pi\times10^3}\right)^2$$

$$= 2.88\times10^{-3}$$

Types of Antenna and their application.

Thin Linear antenna.

The fields of short dipole.

$\mu_0 = 4\pi\times10^{-7}\ Hm^{-1}$

Q. Bio-savart law and Amperes law. (H.W.)

Self

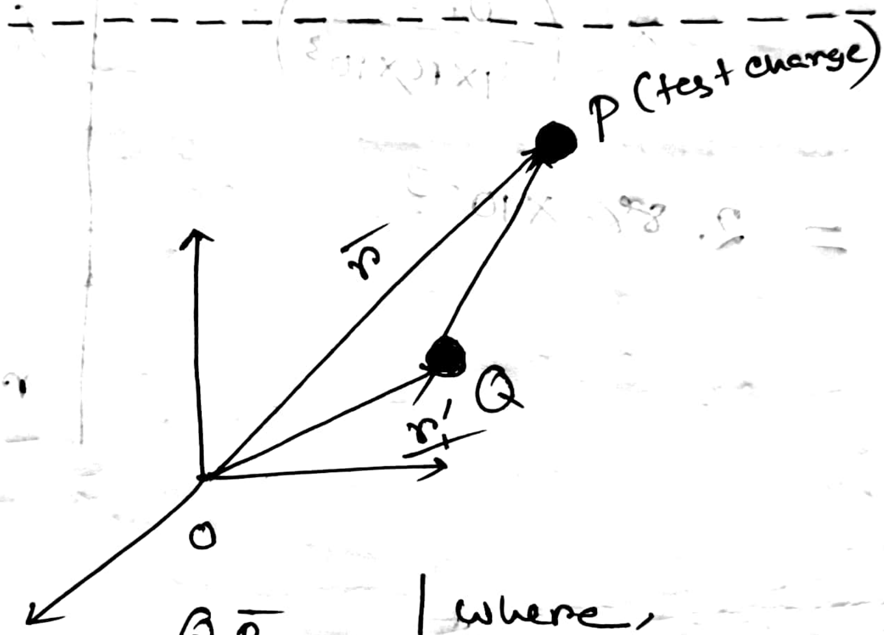
* Electric field ⟶ force per unit charge.

$$\overline{E} = \lim_{Q_t \to 0} \frac{\overline{F}_{Q_t}}{Q_t} \quad \Bigg\} \begin{array}{l} \text{basic unit} \to N/C \\ \text{also, } V/m \end{array}$$

(For a point charge at origin)

$$\overline{E}(r) = \hat{a}_r \frac{Q}{4\pi\epsilon_0 r^2} = \frac{Q\overline{r}}{4\pi\epsilon_0 r^3}$$

* The directions of E and F are same.



$$\overline{E}(\overline{r}) = \frac{Q\overline{R}}{4\pi\epsilon_0 R^3}$$

where,
$\overline{R} = \overline{r} - \overline{r}'$
$R = |\overline{r} - \overline{r}'|$

* Source ⟵ primed co-ordinates

Observation point ⟵ unprimed coordinates.

* Electric field at a point arising from multiple point charge,

$$\overline{E}(\overline{r}) = \sum_{k=1}^{n} \frac{Q_k \overline{R}_k}{4\pi\epsilon_0 R_k^3}$$

Volume charge $\longrightarrow C/m^3$

$\hookrightarrow dQ = \rho_v \, dv \longrightarrow Q = \int_v \rho_v \, dv$

$dQ = \rho_L \, dl \longrightarrow Q = \int_L \rho_L \, dl$ (Line charge)

$dQ = \rho_s \, ds \longrightarrow Q = \int_s \rho_s \, ds$ (surface charge)

Electric field due to,

Volume charge density $\rightarrow \bar{E}(\bar{r}) = \frac{1}{4\pi\epsilon_0} \int_{V'} \frac{\rho_{ev}(\bar{r}')\bar{R}}{R^3} dv'$

surface charge density,

$$\bar{E}(\bar{r}) = \frac{1}{4\pi\epsilon_0} \int_{S'} \frac{\rho_{es}(\bar{r}')\,\bar{R}}{R^3} ds'$$

Line charge density,

$$\bar{E}(\bar{r}) = \frac{1}{4\pi\epsilon_0} \int_{L'} \frac{\rho_{el}(\bar{r}')\,\bar{R}}{R^3} dl'$$

* An electric field is a force field.

→ Test charge q_0 moving from A to B

Work done, W_{AB}

$W_{AB} \rightarrow$ Positive (B has higher potential)

- Negative (B has lower potential)
- Zero (B has same potential as A)

* Electrostatic field is conservative.

- The value of the line integral around any closed path is zero.

$$\oint_c \bar{E} \cdot d\bar{l} = 0$$

$$V_{ab} = \frac{W_{a \to b}}{q} = \int_a^b \bar{E} \cdot d\bar{l}$$

$$V_{ab} = (-) \int_a^b \bar{E} \cdot d\bar{l} = \int_a^{P_0} \bar{E} \cdot d\bar{l} - \int_{P_0}^b \bar{E} \cdot d\bar{l}$$

$$= -\int_{P_0}^b \bar{E} \cdot d\bar{l} - \left(-\int_{P_0}^a \bar{E} \cdot d\bar{l}\right)$$

$$= V(b) - V(a)$$

* Electrostatic potential $V \longrightarrow$ Scalar field.

$$V(\bar{r}) = -\int_{P_0}^{P} \bar{E} \cdot d\bar{l}$$

P_0 ← reference point.

*The reference point (P_0) is where the potential is zero.

$$W_{ab} = Q V_{ab}$$

Along a short path of length Δl we have,

$$\Delta W = Q \Delta V = - Q . \bar{E} . \Delta \bar{l}$$

$$\text{or} \quad \Delta V = - \bar{E} . \Delta \bar{l}$$

$$\boxed{\bar{E} = - \nabla V}$$

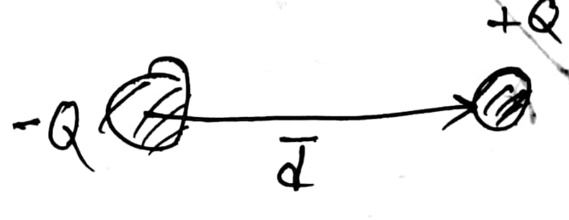
$$V(r) = \frac{1}{4\pi\epsilon_0} \frac{Q}{R}$$

Electro static potential Resulting from multiple point charges,

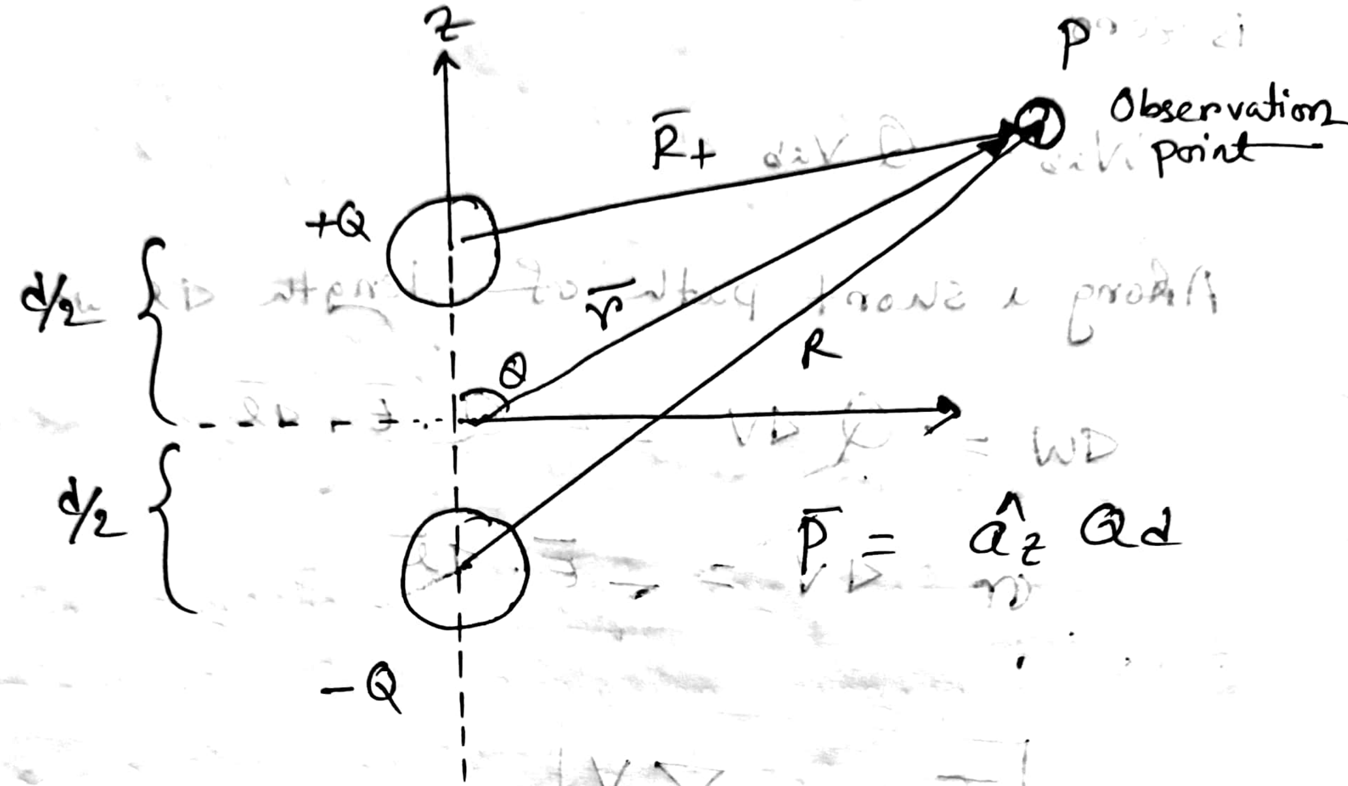
$$V(\bar{r}) = \sum_{K=1}^{n} \frac{Q_K}{4\pi\epsilon_0 R_K}$$

*** An electric charge dipole consists of a pair of equal and opposite charges separated by a small distance.

dipole moment,



*** Electric field lines are everywhere normal to the equipotential surfaces.

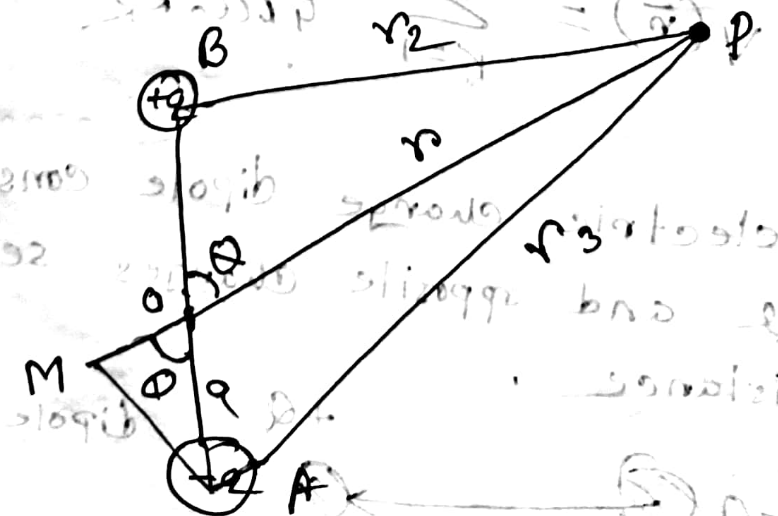


$\bar{P} = \hat{a}_z Qd$

$$R_+ = \sqrt{r^2 + \left(\frac{d}{2}\right)^2 - rd\cos\theta}$$

$$R_- = \sqrt{r^2 + \left(\frac{d}{2}\right)^2 + rd\cos\theta}$$

Potential Due to an electric Dipole:



" Founding piller"

$$V = \frac{1}{4\pi\epsilon_0} \times \left[\frac{q}{PB} - \frac{q}{PA} \right]$$

$$PA = PM = PO + OM$$

$$= r + a\cos\theta$$

$$\therefore PB = r - a\cos\theta$$

$$\therefore V = \frac{1}{4\pi\epsilon_0} q \left(\frac{1}{r - a\cos\theta} - \frac{1}{r + a\cos\theta} \right)$$

$P = q \times 2a$

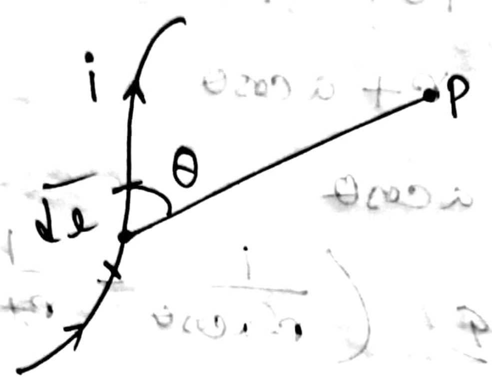
$$= \frac{1}{4\pi\epsilon_0} \frac{q (2a\cos\theta)}{r^2 - a^2\cos^2\theta} = \frac{1}{4\pi\epsilon_0} \frac{p\cos\theta}{r^2 - a^2\cos^2\theta}$$

when, $r >> a$

$$V = \frac{1}{4\pi\epsilon_0} \frac{p\cos\theta}{r^2}$$

* An electric field can be visualized using flux lines. (lines of force)/ lines of force.
* flux line is tangent to the electric field.
* The scalar electric potential can be visualized using equipotential surfaces.
* Equipotential surface → (V constant)

Bio-savart law:



The magnetic field at any point due to an element of a conductor carrying current is → (1) directly proportional to

(a) the strength of the current i

(b) length of the element dl

(c) sine of the angle θ between the element in the direction of current and the line joining the element to the point p.

(2) Inversely proportion to the square of the distance r of the point p from the centre of element.

$$\boxed{dB = \frac{\mu_0}{4\pi} \times \frac{I\,dl \sin\theta}{r^2}}$$

Amperes law:

The line integral of magnetic field (B) around a close loop is proportional to the electric current (I) passing through the loop.

$$\boxed{\oint \vec{B} \cdot \vec{dl} = \mu_0 I}$$

(sadiku chapter)

Babul sir

29-08-2023

H.W. → Magnetic scalar and vector potential. (7.7)

A → line current (only)

Chapter 2: Various co-ordinate system.

" 3: Vector calculas ***

Q. Find the expression of field for short dipole (Magnetic / Electric / Both)

Q. Find the radiation resistance for a short dipole. (For air)

$*\quad \nabla \cdot \bar{B} = 0$

$\nabla \cdot (\nabla \times \bar{A}) = 0$

so, $\boxed{\bar{B} = \nabla \times \bar{A}}$

$\nabla \times (\nabla V) = 0$

$\nabla \cdot (\nabla \times A) = 0$

$\boxed{H = -\nabla V_m}$

$$\boxed{D = \epsilon_0 E}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2}$$

$$\boxed{D = \frac{Q}{4\pi r^2}}$$

Gauss law:

$$\epsilon_0 \oint E \cdot ds = q$$

$$\boxed{\oint_s D \cdot ds = Q_{enc}}$$

* Electric Flux density of a spherical shell of charge using gauss's law.

Differential form of Gauss's law:

$$\boxed{\nabla \cdot D = q_{ev}}$$

Babul Sir

05-09-2023

Field

Q. $L = \frac{\lambda}{10}$

$$R_r = 80\pi^2 \left(\frac{L}{\lambda}\right)^2$$

$$= 80\pi^2 \left(\frac{\cancel{\lambda}/10}{\cancel{\lambda}}\right)^2$$

$$= 80\pi^2 \times \frac{1}{100}$$

$$= 0.8\pi^2$$

The thin linear Antenna (Field pattern)

Q. Find the far field expression for a symetrical, center-fed, thin linear antenna.

(Book Page: 222)

↳ Cases 5-5a / 5-5b / 5-5c

Not for ct

$1\,GHz = 10^3 (MHz)$

Aperture Antenna:

Horn Antenna

CT → 19/09/2023

Up to field of equation.

SMR Sir

07 — 08 — 2023.

* Vector magnetic potential.

$$\boxed{B = \nabla \times A}$$

Magnetic flux density

$$F = I \oint_C d\bar{l} \times \bar{B}$$

* Lorentz force.

* Amperes Circuital law!

* Stokes theorem to Ampere's law.

$$\nabla \times \bar{B} = \mu_0 \bar{J}$$

Differential form of Ampere's Law.

→ Magnetic dipole → magnetic field.

Direction of magnetic field.

Babul sir

02-09-2023

Directivity of a Rectangular Horn Antenna:

Q. Find the expression for the directivity of a horn Antena.

$D = ?$

Problem (2.1) ← (Antenna book.)

(2.2)

(2.4) (2.5) → loss দেওয়া থাকলে Input থেকে বাদ দিয়ে math করতে হবে।

Change densit.

Pattern ⟶ from book (Problem [illegible])

SMR Sir ⟶ Thursday exam.

10-09-2023

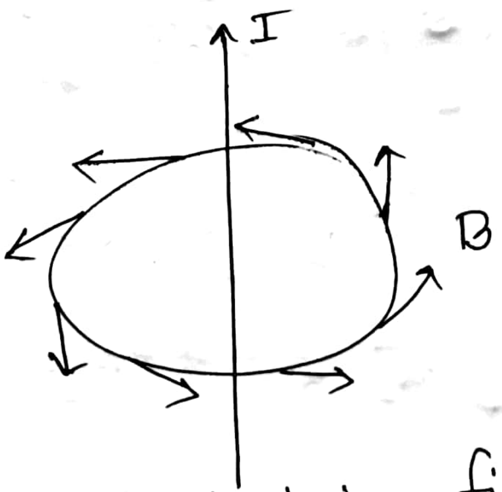
Maxwell's Equation.

$$\nabla \cdot E = \frac{q}{\epsilon_0}$$

$$\nabla \cdot B = 0$$

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

$$\nabla \times B = \mu_0 J + \epsilon_0 \mu_0 \frac{\partial E}{\partial t}$$



← Curl of B.

displacement of electric field produces time varying magnetic field.

EOF

EFW

10, 11 + 12, 13, 14} Sadiku books

$$\nabla \times (\nabla \times E) = -j\omega\mu H_s$$

$$\nabla^2 E_s - \gamma^2 E_s = 0$$

Q. Show that a rectangular wave-guide can not support TEM mode.

Q. TM mode এর field pattern কেমন হবে?

Q. What is quiver plot? ⇒ (visualization of electric field) ⇐

Section A

Self.

Electric displacement flux density,

$$\boxed{\bar{D} = \epsilon_0 \bar{E}}$$

* An Isolated magnetic north pole or an isolated magnetic south pole do not exist practically. But an isolated positively charged body and isolated negatively charged body can exist.

* Electric flux density is defined as the amount of flux passes through unit surface area in the space imagined at right angle to the direction of electric field.

We know,

$$E = \frac{Q}{4\pi \epsilon_0 \epsilon_r r^2}$$

$Q = \psi$ = electric flux lines.

$$\therefore E = \frac{\psi}{4\pi \epsilon_0 \epsilon_r r^2}$$

$$\Rightarrow \frac{\psi}{4\pi r^2} = E \times \epsilon_0 \epsilon_r$$

$$\therefore D = E \times \epsilon_0 \epsilon_r$$

$$\therefore \overline{D} = \epsilon \overline{E}$$

$$\boxed{\epsilon = \epsilon_0 \epsilon_r}$$

*** The number of electric lines of force emanated from a charge body is equal to the quantity of charge of the body measured in Coulombs.

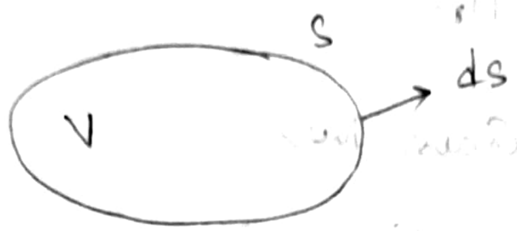
Gauss's Law

"The net electric flux emanating from a close surface S is equal to the total charge contained within the volume V bounded by that surface."

$$\boxed{\oint \overline{D} \cdot \overline{ds} = Q_{encl}}$$

$$Q_{encl} = \int_V q_v \, dv$$

q_v = volume charge Density

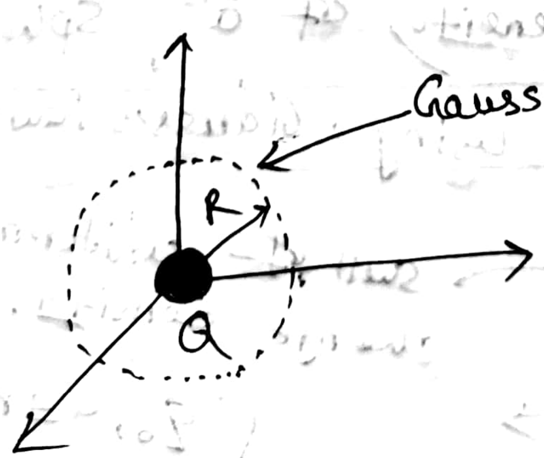


* Gauss law determines unknown electric flux density resulting from a given charge distribution.

Gaussian Surface:

A Gaussian surface is a surface to which the electric flux density is normal and over which equal to a constant value.

Electric flux density of a point charge using Gauss's Law.



$$Q_{encl} = Q$$

D is everywhere normal to the Gaussian surface.

$\therefore \overline{D} = \overline{a}_r D_r$

$D_r \rightarrow$ magnitude of $\vec{D}$ on Gaussian surface.

$\therefore$ Applying Gauss law,

$$Q_{enc} = \oint_S \overline{D} \cdot \overline{ds}$$

$$= D_r \oint_S ds$$

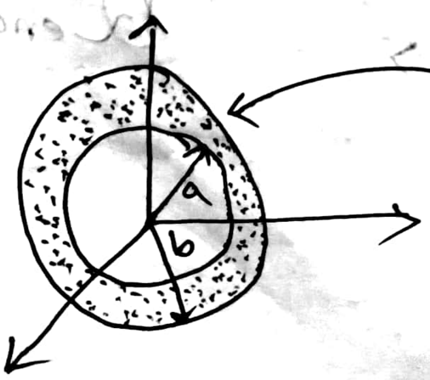
$$= D_r \cdot 4\pi r^2$$

where, $\oint ds = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} r^2 \sin\theta \, d\theta \, d\phi = 4\pi r^2$

is the surface area of the Gaussian surface. Thus,

$$\overline{D} = \frac{Q}{4\pi r^2} \overline{a_r}$$

Electric flux density of a spherical shell of charge using Gauss's law:



shell of uniform charge density.

$$q_{ev} = \begin{cases} q_0, & a \le r \le b \\ 0, & \text{otherwise} \end{cases}$$

3 Gausian surface $\longrightarrow$ 1. $0 \le r \le a$

2. $a < r \le b$

3. $r > b$

$$Q_{enc} = \int_v q_{ev}\, dv$$

For Case 1: $0 \le r \le a$, $Q_{enc} = 0$

For Case 2: $a < r \le b$,

$$Q_{encl} = \int_a^r q_o\, dv$$

$$= q_o \frac{4}{3}\pi r^3 - q_o \frac{4}{3}\pi a^3$$

$$= q_o \frac{4}{3}\pi (r^3 - a^3)$$

For Case - 3: $r > b$

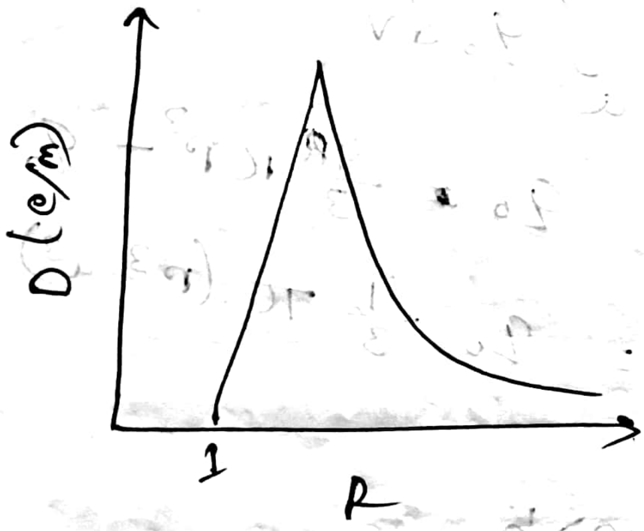
$$Q_{encl} = \int_a^b q_{ev}\, dv = q_o \frac{4}{3}\pi (b^3 - a^3)$$

$$\oint_s \overline{D} \cdot \overline{ds} = DS$$

$$\therefore D = \frac{Q_{encl}}{S}$$

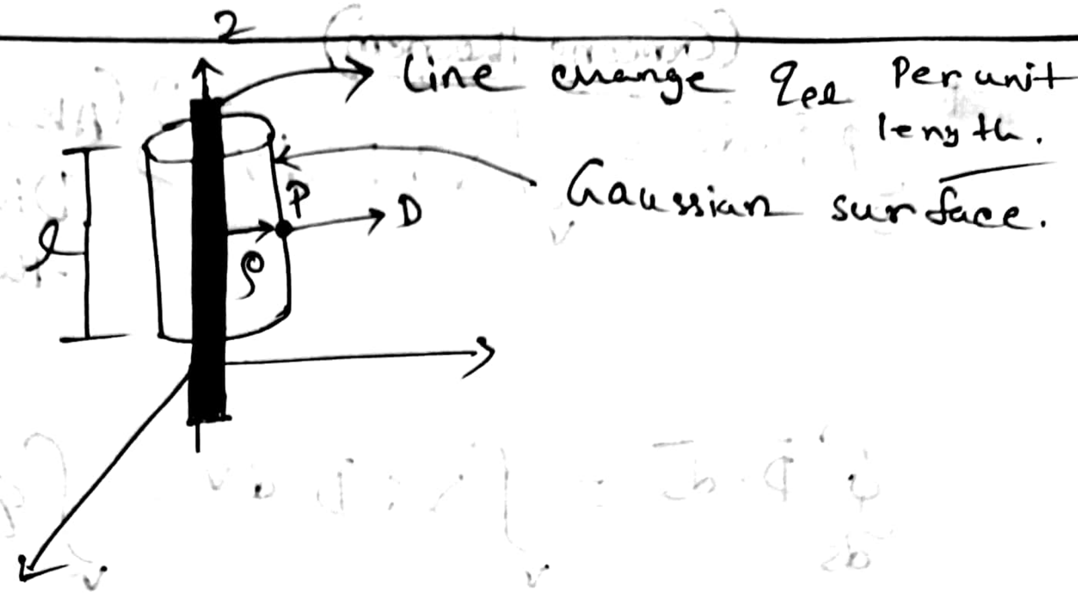
So,
electric flux density,

$$\bar{D} = \begin{cases} 0, & 0 \le r \le a \\ \hat{a}_r \dfrac{q_0 \frac{4}{3}\pi (r^3 - a^3)}{4\pi r^2} = \hat{a}_r \dfrac{q_0}{3}\left(r - a^3/r^2\right), & a < r \le b \\ \hat{a}_r \dfrac{q_0 \, 4/3 \, \pi (b^3 - a^3)}{4\pi r^2} = \hat{a}_r \dfrac{q_0}{3} \dfrac{(b^3 - a^3)}{r^2}, & r > b \end{cases}$$



Electric flux density of an Infinite Line charge using Gauss law:

Consider a infinite line charge carrying charge per unit length of q_l :



* Consider cylinder of radius ρ.

$$\overline{D} = \hat{a}_\rho D_\rho$$

Total charge within the volume enclosed by each Gaussian surface.

$$Q_{encl} = \int_L q_{el}\, dl$$

$$Q_{encl} = q_{el}\, l$$

$$l \times q_{el} = Q_{encl} = \oint_S \overline{D} \cdot \overline{ds} = D_\rho \oint_S ds = D_\rho 2\pi\rho l$$

where, $\oint ds = 2\pi\rho l$ is the surface area of the Gaussian surface.

$$\boxed{\therefore \overline{D} = \frac{q_{el}}{2\pi\rho}\, \hat{a}_\rho}$$

(Greens theorem)

* $$\oint_S \bar{D}\cdot \bar{ds} = \int_V \nabla\cdot \bar{D}\, dV$$ } (Also called Divergence theorem)

$$\oint_{ds} \bar{D}\cdot \bar{ds} = \int_V \nabla\cdot \bar{D}\, dV = \int_V q_{ev}\, dV$$

$$\therefore \boxed{\nabla\cdot \bar{D} = q_{ev}}$$ ← (Differential form of Gauss law)

Magneto statics

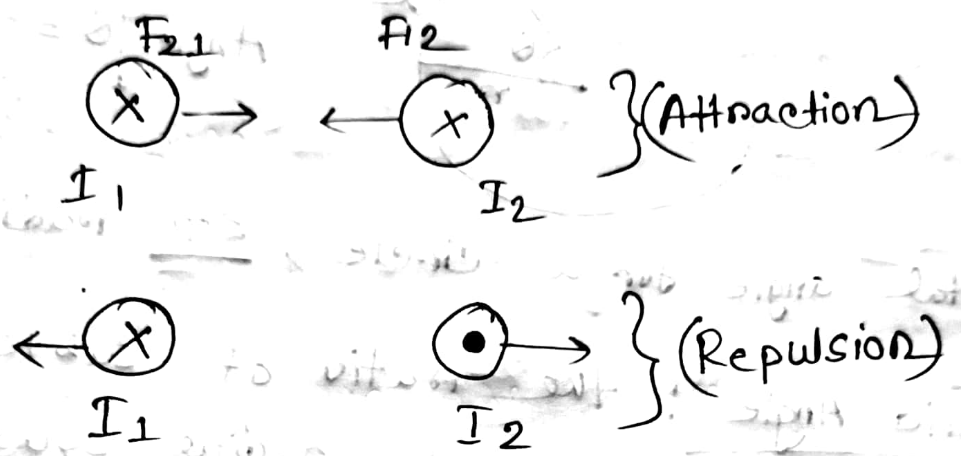
* Deals with the effects of electric charges in steady motion. (i.e. steady current or DC)

* Fundamental law → Ampere's law of force

(Analogous to Coulomb's law)

Ampere's law of force

*** Ampere's law of force gives the magnetic force between two current carrying circuits in an otherwise empty space.



** The force acting on a current element $I_2 dl_2$ by a current element $I_1 dl_1$ is given by,

$$\boxed{\bar{F}_{12} = \frac{\mu_0}{4\pi} \frac{I_2 d\bar{l}_2 \times (I_1 d\bar{l}_1 \times \hat{a}_{R_{12}})}{R_{12}^2}}$$

Total force,

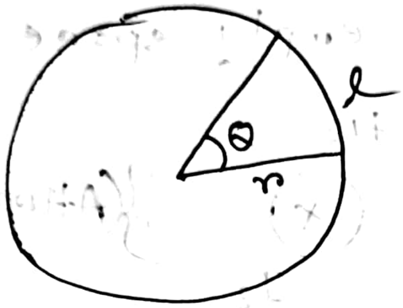
$$\bar{F}_{12} = \frac{\mu_0 I_1 I_2}{4\pi} \oint_{C_2} \oint_{C_1} \frac{d\bar{l}_2 \times (d\bar{l}_1 \times \hat{a}_{R_{12}})}{R_{12}^2}$$

$$\boxed{\bar{F}_{21} = -\bar{F}_{12}}$$

(Equal in magnitude but opposite in direction)

Section - B
self

* Radiation can be plotted as a function of angular position and radial distance from the antenna.



Angle, $\boxed{\theta = l/r}$

Total angle for a circle, $\underline{2\pi}$ radians

It is amount of area per square of radius.

(Angle measurement in three dimension)

Solid Angle: the ratio of subtended area on sphere to radius squared.

$$\boxed{\Omega = \frac{A}{r^2}}$$ steradians (sr) or rad^2

Solid angle of sphere $= \frac{4\pi r^2}{r^2} = 4\pi$ sr

Beam efficiency:

Ω_M = solid angle for major lobe

Ω_m = " " " minor lobe

total solid angle (Also can be said Area)

$$\Omega_A = \Omega_m + \Omega_M$$

Beam efficiency, $\boxed{\varepsilon_M = \frac{\Omega_M}{\Omega_A}}$

⇒ Stray factor :

$$\boxed{\varepsilon_m = \frac{\Omega_m}{\Omega_A}}$$

$$\boxed{\varepsilon_m + \varepsilon_M = 1}$$

Relation between Radian and Steradian:

$$1 \text{ steredian} = 1 \text{ rad} \times 1 \text{ rad}$$
$$= 1 \text{ rad}^2$$
$$= \left(\frac{180}{\pi}\right)^2 (\text{deg})^2$$
$$= 3282.8 \text{ deg}^2$$

* For complete sphere,

$$\text{Solid Angle} = 4\pi \text{ Sr}$$
$$= 4\pi \times 3282.8$$
$$= 41252.8 \text{ deg}^2$$

Radiation Intensity:

The power radiated from an antenna per unit solid angle is called the radiation intensity.

$$\Omega_A = \int_0^{2\pi}\int_0^{\pi} P_n(\theta,\phi)\, d\Omega$$

Directivity:

The directivity D of an antenna is given by the ratio of the maximum radiation intensity to the average radiation intensity.

- The directivity,

$$D = \frac{U_{\text{given direction}}}{U_{avg}}$$

- Average radiation intensity,

$$U_{avg} = \frac{P_{rad}}{4\pi}$$

- Directivity, $\boxed{D = \frac{4\pi U}{P_{rad}}}$

* Maximum Directivity has to be calculated in case of direction is not given.

→ Maximum directivity is defined as the ratio of radiation intensity in max.

direction to the radiation intensity of Isotropic source.

(Average radiation)

maximum poynting

$$D = \frac{U(\theta, \phi)_{max}}{U_{av}} = \frac{S(\theta, \phi)_{max}}{S_{av}}$$

(Average Poynting vector)

*

Poynting vector describes the energy of a EM wave per unit time per unit area at any given instant of time.

Average pointyang vector over a sphere is given by,

$$S(\theta, \phi)_{av} = \frac{1}{4\pi} \int_0^{2\pi} \int_0^{\pi} S(\theta, \phi) \, d\Omega \, (Wm^{-2})$$

Thus the directivity

$$D = \frac{1}{\frac{1}{4\pi} \iint \frac{S(\theta, \phi)}{S(\theta, \phi)_{max}} \, d\Omega}$$

$$= \frac{1}{\frac{1}{4\pi} \iint P_n(\theta, \phi) \, d\Omega}$$

$$\therefore \boxed{D = \frac{4\pi}{\Omega_A}}$$

** The smaller the beam solid Angle, the greater the directivity.

Gain:

The antenna gain is defined as the ratio of maximum radiated power in a specific direction to the maximum radiated power in the same direction by an isotropic antenna.

$$G = \overset{\text{Efficiency}}{\eta}\, \underset{\text{Directivity}}{D}$$

Effective Aperture:

* Describes the effectiveness of an antenna in the recieving mode.

$$\text{Effective aperture} = \frac{\text{Power delivered to the load}}{\text{incident power density}}$$

Relationship between Effective Aperture, Gain and Directivity:

The radiated power,

$$P = \frac{|E_a|^2}{Z} A \quad \text{---(1)}$$

In terms of field intensity E_r at a distance r,

$$P = \frac{|E_r|^2}{Z} r^2 \Omega_A \quad \text{---(2)}$$

$$|E_r| = \frac{|E_a| A}{r \lambda} \quad \text{---(3)}$$

Substituting (3) into (2) we get,

$$P = \frac{|E_a|^2 A^2}{r^2 \lambda^2 Z} r^2 \Omega_A$$

$$= \frac{|E_a|^2 A^2}{\lambda^2 Z} \Omega_A \quad \text{---(4)}$$

equating (4) and (1) we get,

$$\lambda^2 = A \Omega_A$$

we know, $\boxed{D = \frac{4\pi}{\Omega_A}}$

$$\therefore \lambda^2 = A \times \frac{4\pi}{D}$$

$$\therefore \boxed{D = \frac{4\pi}{\lambda^2} A_{em}}$$

$$\eta = \frac{A_e}{A_{em}}$$

$$\therefore G = \eta D$$
$$= \frac{4\pi}{\lambda^2} A_e$$

Ae = Effective aperture of the antenna.

Aem = maximum effective aperture of the antenna.

SMR sir

(14-09-2023)

(John D Ryder
Book)

$$\nabla \times (\nabla \times E) = -\frac{\partial(\nabla \times B)}{\partial t}$$

$$\bar{\nabla} \times (\bar{\nabla} \times \bar{E}) = -\mu \epsilon \frac{\partial^2 \bar{E}}{\partial t^2}$$

$\nabla \cdot E = 0$ in free space.

$$\nabla^2 \bar{E} = \mu \epsilon_0 \frac{\partial^2 \bar{E}}{\partial t^2} \qquad \nabla^2 \bar{B} = \mu \epsilon \frac{\partial^2 \bar{B}}{\partial t^2}$$

* EM wave free space → Light এর velocity তে Propagate করে।

* First electromagnetic field equation.

* The second Electromagnetic field.

EFW - (Babul) Sir

14-09-2023

Q. Show that for a rectangular wave guide TM_{00} mode will not support.

→ Sadiku book → 554 Page, ex

Q. Find the expression of cutoff frequency of rectangular wave guide in TM mode.

Q. For a Rec. wave guide in TM mode show the cut off frequency expression and wave length.

Example: 12.1

Excercise: 12.1

12.2 → example

12.2 → exercise

Example → 12.3 + 12.3 excercise.

12.13 → excercise.