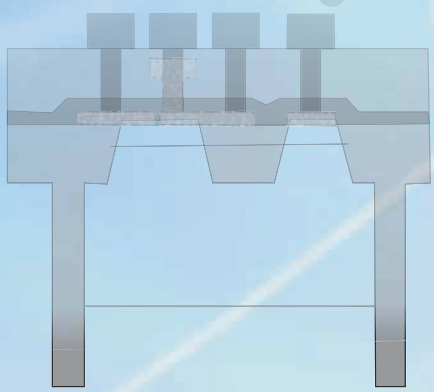
Pro-One

GATE

Graduate Aptitude Test in Engineering

Electronics and Communication Engineering

Eletromagnetic Waves & Trasmission Lines



btechguru.com

EMF THEORY

Physical interpretation of Maxwell's equations:

1. Net magnetic flux emerging through any close surface is zero.

2. Total electric flux density or total electric displacement (D) through the surface enclosing a volume V is equal to the total charge within the volume.

3. Electromagnetic force around a closed path is equal to the time derivative of the magnetic flux density displacement $\overline{B}$ through any surface bounded by the surface.

4. The magnetic motive force around a closed path is equal to the conduction current (J)plus the time derivative of the electric flux density or electric displacement $\overline{D}$ through any surface bounded by the path.

In free space, $\overline{J}=0 \; and \; \rho=0$

$$\because \nabla.\overline{B}=0$$
$$\nabla.\overline{B}=0$$
$$\nabla\times\overline{E}=-\frac{\partial\overline{B}}{\partial t}$$
$$\nabla\times\overline{H}=-\frac{\partial\overline{D}}{\partial t}$$

$$\oint_s \overline{B}\bullet d\overline{s}=0$$
$$\oint_s \overline{D}\bullet d\overline{s}=0$$
$$\oint_s \overline{E}\bullet d\overline{l}=\int_s \frac{\partial\overline{B}}{\partial t}\bullet d\overline{s}$$
$$\oint_s \overline{H}\bullet d\overline{l}=\int_s \frac{\partial\overline{D}}{\partial t}\bullet d\overline{s}$$

In case of harmonically varying fields

We can write

$$\overline{D}=D_0 e^{j\omega t}\Rightarrow\frac{\partial\overline{D}}{\partial t}=j\omega\overline{D}$$
$$\overline{B}=B_0 e^{j\omega t}\Rightarrow\frac{\partial\overline{B}}{\partial t}=j\omega\overline{B}$$

$$\nabla\bullet\overline{B}=0$$
$$\nabla\bullet D=\rho$$
$$\nabla\bullet\overline{E}=-j\omega\overline{\mu}H$$
$$\nabla\bullet\overline{H}=(\sigma+j\omega\varepsilon)\overline{E}$$

$$\oint_s \overline{B}\bullet ds=0$$
$$\oint_s \overline{D}\bullet ds=\int_{\rho v}\rho\; dv$$
$$\oint_s \overline{E}\bullet d\overline{l}=-j\omega\mu\int_s \overline{H}\bullet d\overline{s}$$
$$\oint \overline{H}\bullet d\overline{l}=(\sigma+j\omega t)\int_s \overline{E}\bullet ds$$

.

QUESTIONS

The length of a half wave dipole antenna to be used to receive a 10Mhz radio Signal=____________

Dipole antennas

(a) 15cm (b)30m (c)300m (d)km

---

2. A thunder cloud above the earth sets up a vertical electric field of 50 V/m. In this field a rain drop carrying a charge of $3\times10^{-7}C$ will experience an electromagnetic force of ____________N.

General

$(a)15\times10^{-6}$ $(b)12.66\times10^{-7}$ $(c)\frac{1}{4\pi\varepsilon_0}$ $(d)none$

---

3. Two α (alpha) particles are separated by a distance of $10^{-3}m$. Then the force of repulsion between them=__________

General

$(a)15\times10^{-6}$ $(b)12.66\times10^{-7}$ $(c)\frac{1}{4\pi\varepsilon_0}$ $(d)none$

4.The electric field intensity at point P, which is at a distance of r from a uniformly charged infinite plane with surface charge density ρ_s is=_________

General

(a) proportional to $\frac{1}{r^2}$ (b) proportional to $\frac{1}{r}$ (c) independent of r (d)proportional to r

---

The energy stored in the uniform electric field in a charged spherical shell of total charge Q with inner and outer radii R_1 *and* R_2 respectively is

General

$(a)Q^2\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ $(b)\frac{Q^2}{4\pi\varepsilon}\left(-\frac{1}{R_1}+\frac{1}{R_2}\right)$ $(c)\ 0$ $(d)\frac{Q^2}{8\pi\varepsilon}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

SOLUTIONS

1. Solution: (a)

$f = \frac{c}{\lambda} \Rightarrow \lambda = \frac{3\times 10^8}{10^7} = 30m$ **Length of half wave dipole antenna** $= \frac{\lambda}{2} = 15m$

---

2. Solution: (a)

$F = Eq = 50 \times 3 \times 10^{-7}\ N$

---

3. Solution: (b)

$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2} = \frac{9\times 10^9 \times (1.6\times 2\times 10^{-19})^2}{(10^{-3})^2} = 92.66\times 10^{-23} N$

---

4. Solution: (c)

If the infinite plane with surface charge density is in xy plane,

Then $\overline{E}$ will be in the direction of z-axis with a magnitude of

$\frac{\rho_s}{2\varepsilon_0}$, independent of distance

---

5. Solution: (d)

$$Energy = \frac{1}{2}\int_v \varepsilon E^2 \quad dv \ (dv \ \ is \ \ elemenental \ \ volume)$$

$$= \frac{\varepsilon}{2}\int_{R_1}^{R_2}\left(\frac{Q}{4\pi\varepsilon r^2}\right)^2 4\pi r^2 dr$$

.