- The product of E and H gives a new quantity which is expressed as watt per unit area. This quantity is called power density. P=E×H
- Time Varying fields

$$\frac{\partial D}{\partial t}=j\omega D_o e^{j\omega t}=j\omega D$$
$$\frac{\partial B}{\partial t}=j\omega Bo e^{j\omega t}=j\omega B$$

- Electromagnetic radiation is the means for many of our interactions with the world: light allows us to see; radio waves give us TV and radio; microwaves are used in radar communications; X-rays allow glimpses of our internal organs; and gamma rays let us eavesdrop on exploding stars thousands of light-years away.

TWO MARKS

1. Write the relations between Electrostatic and Magneto static fields

TERM	ELECTROSTATICS	MAGNETOSTATICS
Source Element	Stationary Electric Charge	Element carrying steady current
Force Law	Coulomb's Law	Biot and Savart's Law
Relation between Field & force	$E=\frac{F}{q}$	$F=q(VxB)$
Relation: Field & Potential	$E=-\nabla V$ $\varphi_E=-\int_L E.dl$	$B=\nabla xA$
Flux	$\varphi_E=-\int_S E.dS$	$\varphi_m=\iint_S B.dS$

2. Define Transformer E.m.f

A stationary conducting loop is in a time varying magnetic B field. Equation becomes

$$V_{emf}=\oint \bar{E}.dl=-\oint \frac{\partial B}{\partial t}.ds$$

This emf induced by the time-varying current (producing the time-varying B field) in a stationary loop is often referred to as *transformer emf* in power analysis since it is due to transformer action. By applying Stokes's theorem

$$\oint \nabla x\bar{E}.dl=-\oint \frac{\partial B}{\partial t}.ds$$

For the two integrals to be equal, their integrands must be equal; that is,

$$\nabla x\bar{E}.dl=-\frac{\partial B}{\partial t}.ds$$

This is one of the Maxwell's equations for time-varying fields. It shows that the time varying E field is not conservative ($\nabla \times E \neq 0$). This does not imply that the principles of energy conservation are violated.

3. Define Motional Electromotive forces

This type of emf is called motional emf or flux-cutting emf because it is due to motional action. It is the kind of emf found in electrical machines such as motors, generators, and alternators.

$$F_m = I l \, xB$$

$$F_m = IlB$$

4. Write the Differential form of Maxwell's equations

$$(\nabla \times E) = -\frac{\partial B}{\partial t}$$
$$\nabla \times H = J + \frac{\partial D}{\partial t}$$
$$(\nabla . D) = \rho$$
$$(\nabla . B) = 0$$

5. Write the Integral form of Maxwell's equations

$$\oint E.dL = -\int_s \frac{\partial B}{\partial t}.ds$$
$$\oint H.dl = J + \int_s \frac{\partial D}{\partial t}\, ds$$
$$\oint_s D.ds = \int_s \rho dv$$
$$\oint_s B.ds = 0$$

6. Define Faraday's law for Electromagnetic induction

The induced emf. V_{emf} (in volts), in any closed circuit is equal to the time rate of change of the magnetic flux linkage by the circuit. This is called Faraday's law, and it can be expressed as

$$\text{emf} = -N\frac{d\varphi}{dt} = -\frac{d\Psi}{dt}$$

where *N* is the number of turns in the circuit and ψ is the flux through each turn. The negative sign shows that the induced voltage acts in such a way as to oppose the flux producing it. This is known as *Lenz's law,2* and it emphasizes the fact that the direction of current flow in the circuit is such that the induced magnetic field produced by the induced current will oppose the original magnetic field.

7. Write the boundary condition for Electromagnetic fields

The boundary referring boundary conditions for static electric magnetic fields.

i, The tangential component of electric field intensity $\bar{E}$ is continuous at the surface.

$$E_{tan1}=E_{tan2}$$

ii. The tangential component of Magnetic field intensity $\bar{E}$ is continuous across the surface except for a perfect conductor.

$$H_{tan1}=H_{tan2}$$

At the surface of the perfect conductor the tangential component of the magnetic field intensity is discontinuous at the boundary.

$$H_{tan1}-H_{tan2} = K$$

iii. The normal component of the electric flux density is continuous at the boundary is the surface charge density is zero.

$$DN_1=DN_2$$

If ths surface charge density is non zero, then the normal component of the electric flux density is discontinuous at the boundary.

$$D_{N1}-D_{N2}=\rho s$$

iv. The normal component of the magnetic flux density is continuous at the boundary.

$$B_{N1}=B_{N2}$$

8. Write the wave equation

$$\nabla^2 E= \mu\,\sigma\frac{\partial E}{\partial t}+\mu\,\varepsilon\frac{\partial^2 E}{\partial t^2}$$
$$\nabla^2 D= \mu\,\sigma\frac{\partial D}{\partial t}+\mu\,\varepsilon\frac{\partial^2 D}{\partial t^2}$$
$$\nabla^2 H= \mu\,\sigma\frac{\partial H}{\partial t}+\mu\,\varepsilon\frac{\partial^2 H}{\partial t^2}$$
$$\nabla^2 B= \mu\,\sigma\frac{\partial B}{\partial t}+\mu\,\varepsilon\frac{\partial^2 B}{\partial t^2}$$

In general,

$$\nabla^2\begin{bmatrix}\bar{E}\\ \bar{D}\\ \bar{H}\\ \bar{B}\end{bmatrix}=\mu\,\sigma\frac{\partial}{\partial t}\begin{bmatrix}\bar{E}\\ \bar{D}\\ \bar{H}\\ \bar{B}\end{bmatrix}+\mu\,\varepsilon\frac{\partial^2}{\partial t^2}\begin{bmatrix}\bar{E}\\ \bar{D}\\ \bar{H}\\ \bar{B}\end{bmatrix}$$

9. Define Poynting Vector

The product of E and H gives a new quantity which is expressed as watt per unit area. This quantity is called power density.

$$P=E\times H$$

Where P is called Poynting vector.

10. Define Poynting's theorem

Poynting theorem states that the net power flowing out of a given volume is equal to the time rate of decrease in the energy stored within the volume V minus the ohmic power dissipated.

11. What is Time harmonic fields

A time-harmonic field is one that varies periodically or sinusoidal with time. Not only is sinusoidal analysis of practical value, it can be extended to most waveforms by Fourier transform techniques. Sinusoids are easily expressed in phasors, which are more convenient to work with.

12. Define Electromagnetic Spectrum

Electromagnetic radiation is the means for many of our interactions with the world: light allows us to see; radio waves give us TV and radio; microwaves are used in radar communications; X-rays allow glimpses of our internal organs; and gamma rays let us eavesdrop on exploding stars thousands of light-years away. Electromagnetic radiation is the messenger, or the signal from sender to receiver. The sender could be a TV station, a star, or the burner on a stove. The receiver could be a TV set, an eye, or an X-ray film. In each case, the sender gives off or reflects some kind of electromagnetic radiation. All these different kinds of electromagnetic radiation actually differ only in a single property their *wavelength*. When electromagnetic radiation is spread out according to its wavelength, the result is a spectrum

13. Define a wave?

If a physical phenomenon that occurs at one place at a given time is reproduced at other places at later times, the time delay being proportional to the space separation from the first location, then the group of phenomena constitute a wave.

14. Write short notes on imperfect dielectrics.
    A material is classified as an imperfect dielectrics for $\sigma<<1$, that is conduction current density is small in magnitude compared to the displacement current density.
15. What is mean by skin depth?
    The distance through which the amplitude of the travelling wave decreases to 37% of the original amplitude is called skin depth or depth of penetration.
16. What is called skin effect?
    For the frequencies in the microwave range, the skin depth or depth of penetration is very small for good conductors and all the fields and currents may be considered as confined to a thin layer near the surface of the conductor. This thin layer is nothing but the skin of the conductor and hence it is called skin effect

QUESTION BANK

1. Explain about Faraday's law for Electromagnetic induction
2. Write the Fundamental relations for Electrostatic and Magneto static fields.
3. Explain about Differential form of Maxwell's equations and Integral form of Maxwell's equations.
4. Derive the Expression for Potential functions.
5. Explain about the Electromagnetic boundary conditions
6. Derive the expression for Wave equations and their solutions.
7. Short notes about Poynting's theorem and also explain power flow in a coaxial cable.
8. What is Time harmonic fields
9. Explain about Electromagnetic Spectrum.