

# Module IV

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# 1 Maxwell's equations and EM waves

## 1.1 Topics to be covered.

### 1.1.1 Maxwell's equations

*Fundamentals of vector calculus, Divergence and Curl of  $\mathbf{E}$  and  $\mathbf{B}$  (static), Gauss' divergence theorem and **Stokes'theorem**. Description of laws of electrostatics, Faraday's laws of **EMI**. Current density  $\mathbf{J}$  and Equation of Continuity. Displacement current with derivation and Maxwell's equations in **vacuum***

### 1.1.2 EM Waves

*The wave equation in differential form in free space (derivation using Maxwell's equations), Plane EM waves( in vacuum), Transverse Nature and Polarization of EM waves*

# 2 Fundamentals of vector calculus

A *scalar* is a physical quantity with only magnitude.

A *vector* is a physical quantity with both magnitude and direction.

A *unit vector* like  $\hat{a}$  has a magnitude of 1

In *Cartesian coordinates*,  $\vec{a} = a_1\mathbf{e}_1 + a_2\mathbf{e}_2 + a_3\mathbf{e}_3$  where  $\mathbf{e}_1, \mathbf{e}_2$  and  $\mathbf{e}_3$  are unit vectors.

Magnitude  $|a| = \sqrt{a_1^2 + a_2^2 + a_3^2}$

## 2.1 Dot product (scalar product)

$a \cdot b = |a| \cdot |b| \cdot \cos(\theta) = a_1b_1 + a_2b_2 + a_3b_3$  is a scalar

## 2.2 Cross product (vector product)

$$a \times b = |a||b|\sin(\theta)\hat{n}$$

In terms of components  $a$  and  $b$

$$a \times b = \begin{vmatrix} \mathbf{e}_1 & \mathbf{e}_2 & \mathbf{e}_3 \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$$

