G.H. RAISONI INSTITUTE OF ENGINEERING & TECHNOLOGY, NAGPUR

(An Autonomous Institute)

Department of Electrical Engineering

Subject:- ELECTROMAGNETIC FIELDS
Subject Code:- UEEL206
4th Sem EE

Presented By,
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EE Department

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Introduction

- Electromagnetic field, a property of space caused by the motion of an electric charge. A stationary charge will produce only an electric field in the surrounding space. If the charge is moving, a magnetic field is also produced. An electric field can be produced also by a changing magnetic field.
- Electromagnetic fields are a combination of invisible electric and magnetic fields of force. They are generated by natural phenomena like the Earth's magnetic field but also by human activities, mainly through the use of electricity.

- In the 19th century it had become clear that electricity and magnetism were related, and their theories were unified: wherever charges are in motion electric current results, and magnetism is due to electric current. The source for electric field is electric charge, whereas that for magnetic field is electric current (charges in motion).

- The discovery of electromagnetic induction was made almost simultaneously, although independently, by **Michael Faraday**, who was first to make the discovery in 1831, and **Joseph Henry** in 1832.

COURSE OUTCOME

Upon successful completion of this course, student will be able to:

1] Define and recognize different co-ordinate systems. Apply different techniques of vector calculus to understand different concepts of electromagnetic field theory.
2] Explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.) in different media using the fundamental laws.
3]Describe static electric and magnetic fields, their behavior in different media, associated laws, and electromagnetic potentials and comprehend different Maxwell equations used to study time varying electromagnetic or dynamic fields.

SYLLABUS

No. of Subjects	Semester	Course Code	Name of Courses	Teaching Scheme			Credits	TAE	CAE	ESE	INT	EXT	TOTAL
				L	T	P							
3	4	BEEL222	Electromagnetic Fields	2	1		**3**	10	15	50			75

Unit 1:Vector Analysis

Idea of vector & scalars, Vector Algebra, vector addition, vector subtraction, dot product, scalar product in Cartesian coordinates system

Unit 2:

Cylindrical System , conversion of variables from Cartesian to cylindrical system and vice versa. Spherical co-ordinate system, transformation of Cartesian to spherical and vice versa

SYLLABUS

Unit 3: Coulomb's law

Coulomb's law, electric field intensity, field due to point charges, field due to continuous volume charge distribution, field of line charge, field of sheet charges, concept of flux density.

Unit 4: Gauss's law, Energy and Potential of charge system

Gauss's law, Application of Gauss's law, divergence theorem, definition of potential difference and potential, potential of a point charges, potential field of system of charge, potential gradient.

Unit 5:Steady Magnetic Field and Magnetic Forces

Biot Savarts law, Ampere's Circuital Law, Strokes theorem, Magnetic flux density, Scalar and Vector Magnetic potentials, force on moving charge, Magnetization and permeability, Magnetic circuit.Maxwell equations.

Text and Reference Books

Text Books:

1] William H. Hayt, Jr., John A. Buck, Engineering Electromagnetic, 7thEdition, Tata McGraw Hill Publishing Company Limited, 2006

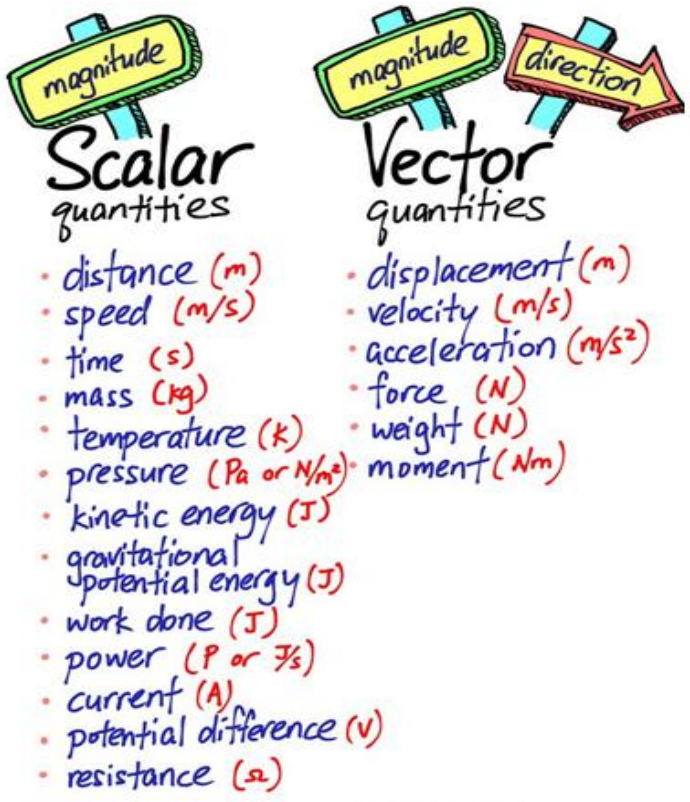
2] Matthew N. O. Sadiku, Elements of Electromagnetic, 5th Edition, Oxford University Press, 2010

Reference Books:

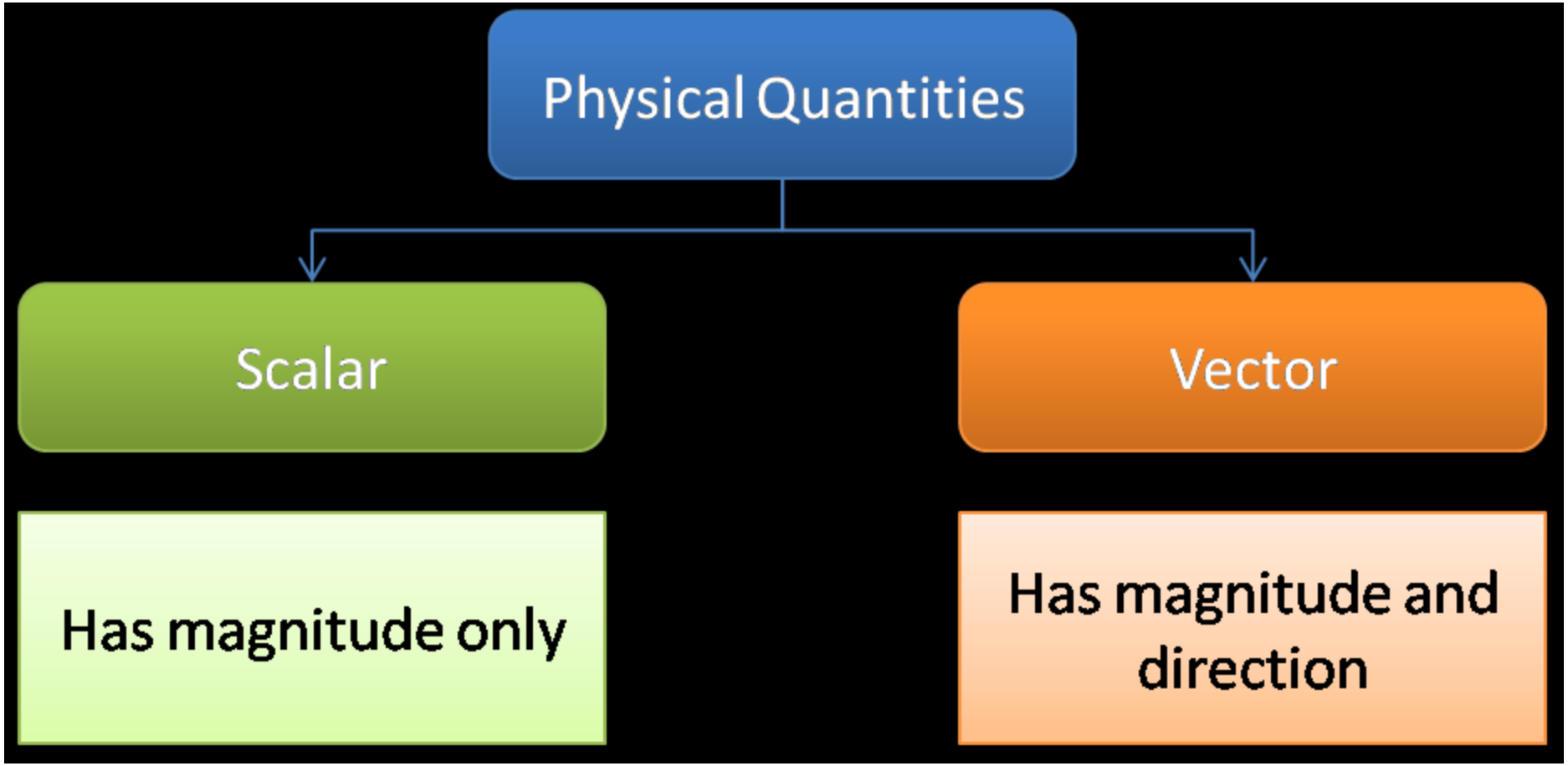
1] A Tinguria, Fundamentals Of Electromagnetic Fields, 2ndEdition, Denett & Co, 2006

2] Rajeev Bansal, Handbook of Engineering Electromagnetic, 1st Edition, CRC Press, 2004

Vector Analysis



Idea of vector & scalars



What Is SCALAR???

Length of a car is 4.5 m

Physical Quantity

Magnitude

Time is 2:00hrs

Physical Quantity

Magnitude

A scalar is a physical quantity that has only a magnitude.

Examples:

- Mass
- Length
- Time
- Temperature
- Volume
- Density

What Is VECTOR???

Force of 20 N is exerted on a table in east direction

Physical Quantity Magnitude Direction

A train is travelling from nagpur to the north with a velocity of 1500m/sec

Physical Quantity Magnitude Direction

A vector is a physical quantity that has both a magnitude and a direction.

Examples:

- Position
- Displacement
- Velocity
- Acceleration
- Momentum
- Force

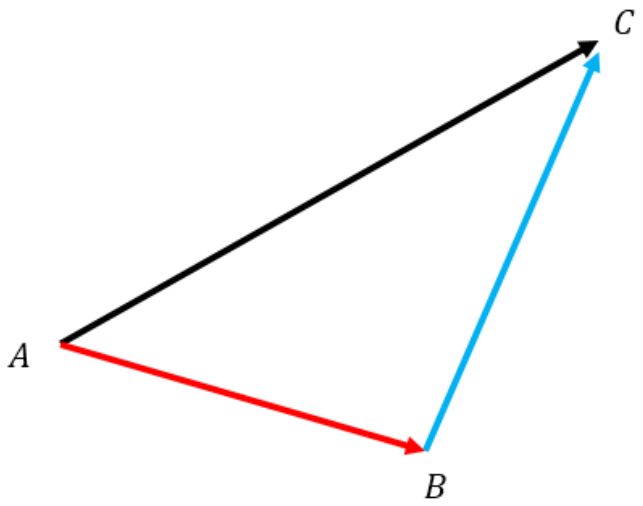
Representation of a Vector Quantity



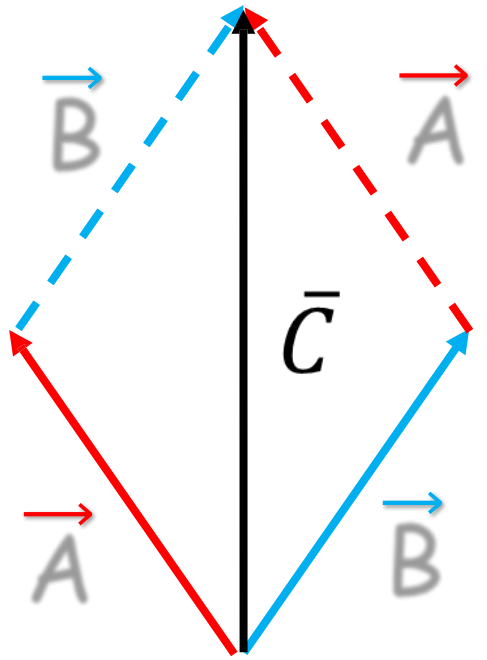
Here AB is a Vector Quantity and it is represented with a horizontal line on AB as $\overline{AB}$

Vector Addition

Triangle Law



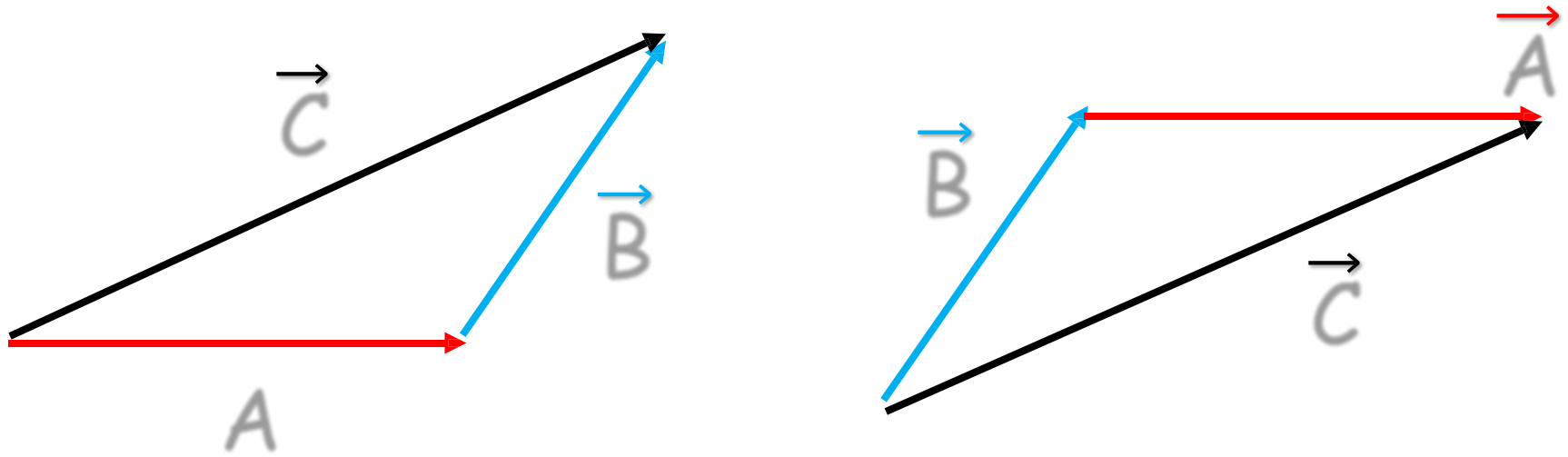
Parallelogram Law



$$\overline{C} = \overline{A} + \overline{B}$$

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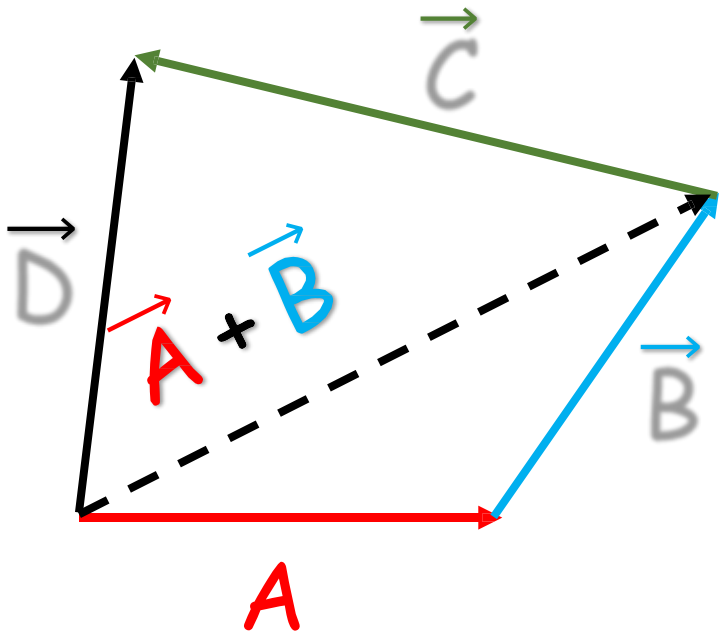
Commutative Property

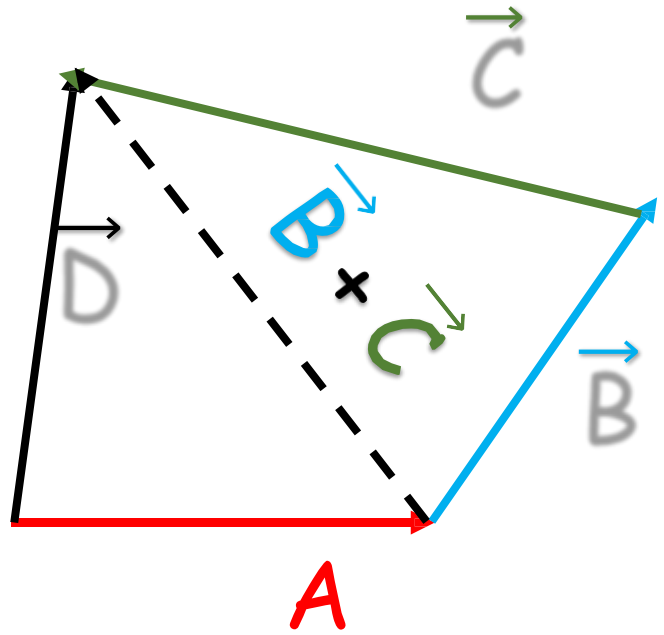


$$\overline{C} = \overline{A} + \overline{B} = \overline{B} + \overline{A}$$

Therefore, addition of vectors obey commutative law

Associative Property



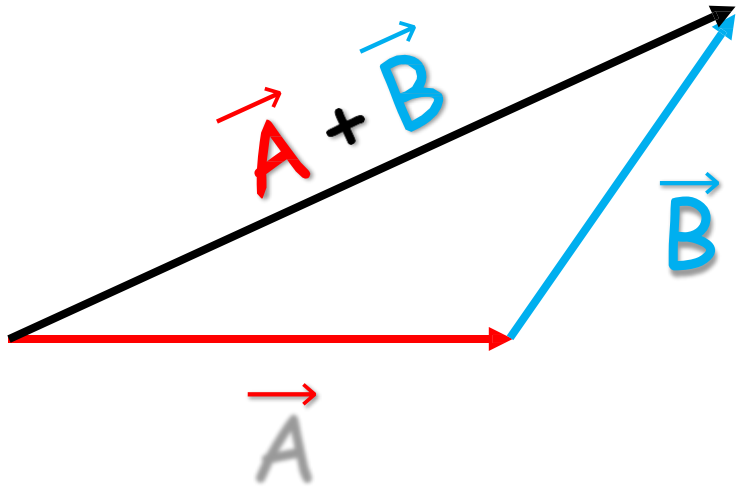


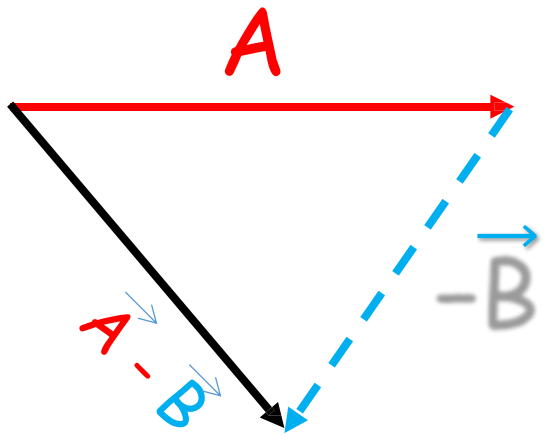
$$\overline{D} = (\overline{A} + \overline{B}) + \overline{C} = \overline{A} + (\overline{B} + \overline{C})$$

Therefore, addition of vectors obey associative law.

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Subtraction of Vectors





The subtraction of B from vector A is defined as the addition of vector −B to vector A.

$$\bar{A} - \bar{B} = \bar{A} + (-\bar{B})$$

Multiplication of Vectors

• **Dot Product** – also known as the "scalar product", an operation that takes two vectors and returns a scalar quantity.

•The dot product of two vectors can be defined as the product of the magnitudes of the two vectors and the cosine of the angle between the two vectors.

•Alternatively, it is defined as the product of the projection of the first vector onto the second vector and the magnitude of the second vector.

•Thus,

$$\bar{A} \cdot \bar{B} = |\bar{A}|\,|\bar{B}| \cos\theta$$

Cross product – also known as the "vector product", a binary operation on two vectors that results in another vector.

- The cross product of two vectors in 3-space is defined as the vector perpendicular to the plane determined by the two vectors whose magnitude is the product of the magnitudes of the two vectors and the sine of the angle between the two vectors.
- So, if $\hat{n}$ is the unit vector perpendicular to the plane determined by vectors A and B,

$$\bar{A} \times \bar{B} = |\bar{A}|\,|\bar{B}| \sin\theta\, \hat{an}$$