Introduction to Electromagnetic Theory ← 12th Physics

Comprehensive Course on EMFT (EE)

EC EMFT: Sonal sir
EDC & Comm: Shushir sir
↳ 10th Oct

Mon - Fri
7:30pm - 9:30pm

5th Oct → PE
7am - 10:30 am

10th Oct → networks by UD sir

Ankit Goyal • Lesson 1 • Oct 3, 2022

ELECTROMAGNETIC THEORY

Topic Covered

- Coordinate Systems and Vector Calculus ✓
- Electrostatic Fields ✓
- Magnetostatic Fields ✓
- Time Varying Fields & Maxwell's Equations ✓

Syllabus EE - ESE / GATE

Electric Circuits and Fields:
Circuit elements, network graph, KCL, KVL, Node and Mesh analysis, ideal current and voltage sources, Thevenin's, Norton's, Superposition and Maximum Power Transfer theorems, transient response of DC and AC networks, Sinusoidal steady state analysis, basic filter concepts, two-port networks, three phase circuits, Magnetically coupled circuits; Gauss Theorem, electric field and potential due to point, line, plane and spherical charge distributions, Ampere's and Biot-Savart's laws; inductance, dielectrics, capacitance; Maxwell's equations.

→ GATE EMT syllabus for EE same as ESE

Syllabus ESE - EC

Electro Magnetics:
Elements of vector calculus, Maxwell's equations-basic concepts; Gauss', Stokes' theorems, Wave propagation through different media; Transmission Lines-different types, basics, Smith's chart, impedance matching/transformation, S-parameters, pulse excitation, uses; Waveguides-basics, rectangular types, modes, cut-off frequency, dispersion, dielectric types; Antennas-radiation pattern, monopoles/dipoles, gain, arrays-active/passive, theory, uses.

↳ extra portion by Sonal sir

ANALYSIS OF PREVIOUS GATE PAPER /EE

	1 Marks	2 Marks	TOTAL
2010	-	-	-
2011	-	1	2
2012	-	1	2
2013	1	1	3
2014 SET-1	1	1	3
2014 SET-2	1	1	3
2014 SET-3	1	1	3
2015 SET-1	3	1	5
2015 SET-2	3	1	5

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ANALYSIS OF PREVIOUS GATE PAPER

	1 Marks	2 Marks	TOTAL
2016 SET-1	2	1	4
2016 SET-2	2	2	6
2017 SET-1	2	1	4
2017 SET-2	2	1	4
2018	1	1	3
2019	1	-	1
2020	-	3	6
2021	2	2	6
2022	1	3	7

→ average: 5 marks
↳ 40-50 hrs

m/c : $\frac{12}{150} = 0.08$

emt: $5/40 = 0.125$

o/p/effort

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SYLLABUS

- Vector Algebra & Vector Calculus
- Coulom'b law, Electric Field Intensity
- Electric Flux Density, Gauss's Law, Divergence
- Electric Field and potential due to point
- Line, Plane and Spherical Charge Distributions
- Effect of Dielectric Medium
- Capacitance of simple Configurations, Biot Savart's law
- Ampere's Law, Curl, Faraday's Law, Lorentz force
- Magnetomotive Force, Reluctance, Magnetic Circuits ← machines
- Self and Mutual Inductance of Simple Configurations Maxwell's equations

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COURSE DURATION

40 TO 45 HOURS

WEIGHTAGE

4 - 6 MARKS

BOOK REFERENCE:

ELEMENTS OF ELECTROMAGNETIC FIELDS
by S.P. Seth

PRINCIPLES OF ELECTROMAGNETICS
by Matthew N.O. Sadiku

2nd/3rd year students

not for GATE-2023 students

Strategy

- attend live classes daily
- make short notes (hand written)
- practice DPP (end of class)
- practice PYQ
- every 4th session → doubts + DPP solution
- every Sunday Quiz

Mon-fri
Classes + SN + DPP

Sat: revise

Sun: test

Scalars & Vectors

① **Scalars**

Quantities that only have magnitude (& unit) but no direction.

eg: mass, time, charge, energy, potential, flux etc

5kg mass does not have any direction

② **Vectors**

Quantities that have both magnitude as well as direction

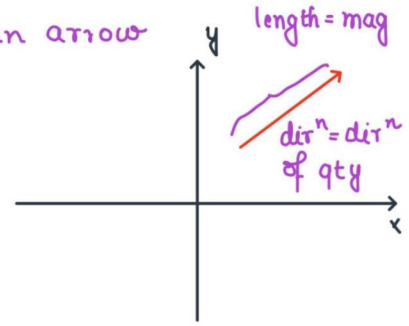
eg: Velocity, electric field, magnetic field, force, flux density, torque etc.

Representation of a vector

- we show an arrow over a symbol to indicate quantity is a vector.

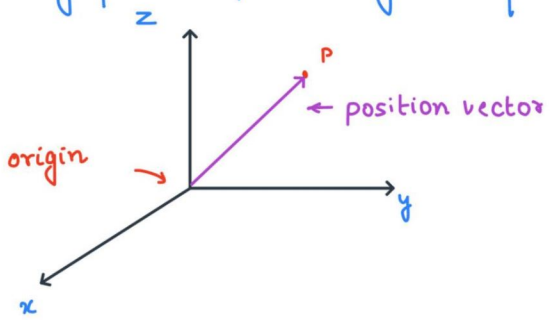
  eg $\vec{v}$: represents velocity vector

- graphically, a vector is shown as an arrow
  - ↳ magnitude → length of arrow
  - ↳ direction → dir^n of arrow



Position Vector

- position of a particle always depends on reference or observer.
- We first define co-ordinate system with origin.
- The vector joining particle from origin is position vector.



Unit vector

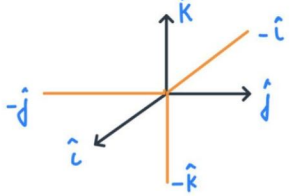
- A vector whose length or magnitude is unity (= 1) is called as Unit Vector.
- represented by cap over symbol
- $\hat{A}$: represents a unit vector in dir^n of $\vec{A}$

$$\hat{A} = \frac{\vec{A}}{|\vec{A}|}$$ ← unitless

↳ magnitude of $\vec{A}$

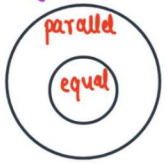
$$\vec{A} = |\vec{A}|\,\hat{A}$$

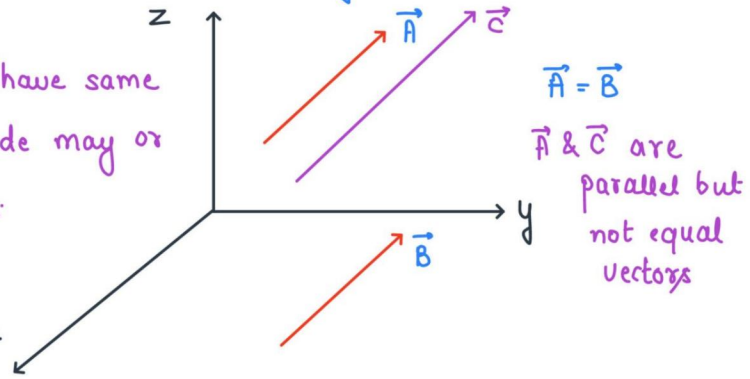
- unit vector in x-dir^n = $\hat{i}$ or $\hat{a}_x$
  y-dir^n = $\hat{j}$ or $\hat{a}_y$
  z-dir^n = $\hat{k}$ or $\hat{a}_z$



Equality of Vectors

- If two vectors have same length & same direction irrespective of their starting & ending point, they are said to be equal vector.
- parallel vectors have same dir^n but magnitude may or may not be equal.





$\vec{A} = \vec{B}$

$\vec{A}$ & $\vec{C}$ are parallel but not equal vectors

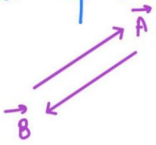
Some special vectors

① Zero vector or null vector

- zero vector has zero length or magnitude but a certain direction.

② Negative vector

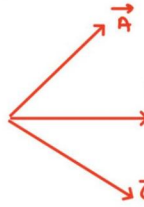
- when we use negative sign in front of a vector then we need to reverse the dir^n of the vector but keeping length same.



$\vec{B} = -\vec{A}$

③ Concurrent vectors

- when multiple vectors originate at same point, they are said to be concurrent.

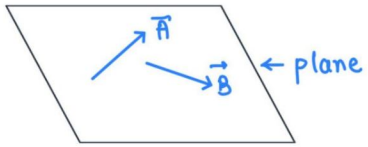


concurrent vector

④ Coplanar vector

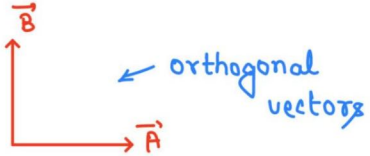
- if multiple vectors lie on a single plane, they are said to be co-planar.

eg $\vec{A} = 2\hat{i} - 3\hat{j}$ (xy plane)
$\vec{B} = 3\hat{i} + 2\hat{j}$ (xy plane)
} co-planar



⑤ Orthogonal vector

- if 2 vectors lie at 90° to each other, they are said to be orthogonal.



Q If $\vec{A} = 0.5\hat{i} + 0.8\hat{j} + c\hat{k}$ represents a unit vector. find value of c.

unit vector $|\vec{A}| = 1$

$$\left[0.5^2 + 0.8^2 + c^2\right]^{1/2} = 1$$

$$c = \sqrt{0.11}$$

$$= 0.3316$$

Operations on a vectors

① Multiplication & Division by a Scalar

- product of $\vec{A}$ with scalar m has magnitude $|m||\vec{A}|$ & dir^n same or opposite to $\vec{A}$ depending on whether $m > 0$ or $m < 0$ respectively.
- $\vec{A}/m$: magnitude $\frac{|\vec{A}|}{|m|}$

dir^n: same as $\vec{A}$, $m > 0$
opp. to $\vec{A}$, $m < 0$

Vector Algebra

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Addition and Subtraction of Vector

- Suppose we have 2 vectors $\vec{A}$ & $\vec{B}$

$\vec{C} = \vec{A} + \vec{B}$: addition

$\vec{D} = \vec{A} - \vec{B}$: subtraction

- vector addition is commutative

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

- vector addition is associative

$\vec{A} + (\vec{B} + \vec{C}) = (\vec{A} + \vec{B}) + \vec{C}$

$= (\vec{A} + \vec{C}) + \vec{B}$

subtraction is not commutative

$\vec{A} - \vec{B} = -(\vec{B} - \vec{A})$

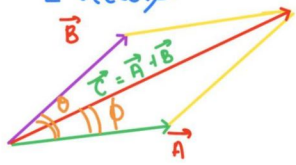
anti-commutative

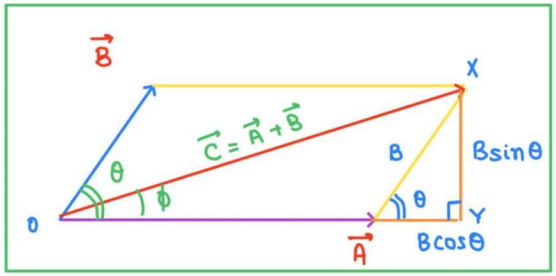
Parallelogram law of Vector Addition

Step-1: draw the 2 vectors with their tail at same point

Step-2: Complete a parallelogram with 2 vectors as its 2 sides.

Step-3: main diagonal of parallelogram represents sum of 2 vectors.





in Δ OXY

$OY = A + B\cos\theta$

$XY = B\sin\theta$

$\tan\phi = \frac{XY}{OY} = \frac{B\sin\theta}{A + B\cos\theta}$

$OX = |\vec{C}| = C = \left[(A + B\cos\theta)^2 + (B\sin\theta)^2\right]^{1/2}$

$C = \left[A^2 + B^2 + 2AB\cos\theta\right]^{1/2}$

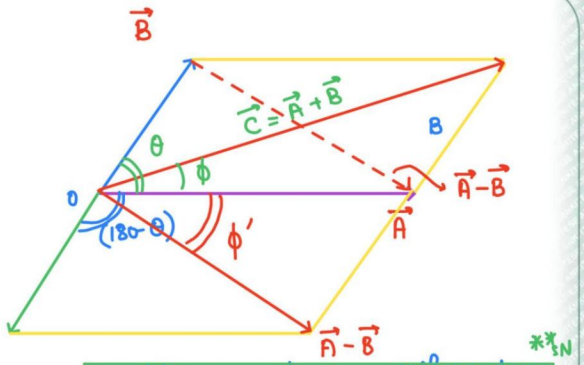
Subtraction of Vector

$\vec{D} = \vec{A} - \vec{B}$

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

$-\vec{B}$: has equal magnitude as $\vec{B}$ but opposite dirⁿ

- main diagonal of parallelogram represents sum while other diagonal difference.



- while considering diff replace θ by (180-θ)