Electromagnetic field theory -

Antenna

Network A. Ec/w

Device

Analog. Semicond.

Course outcomes -

Bounded media & ~~Unbounded~~ media

free space

① Transmission line -

② waveguides

Unit I

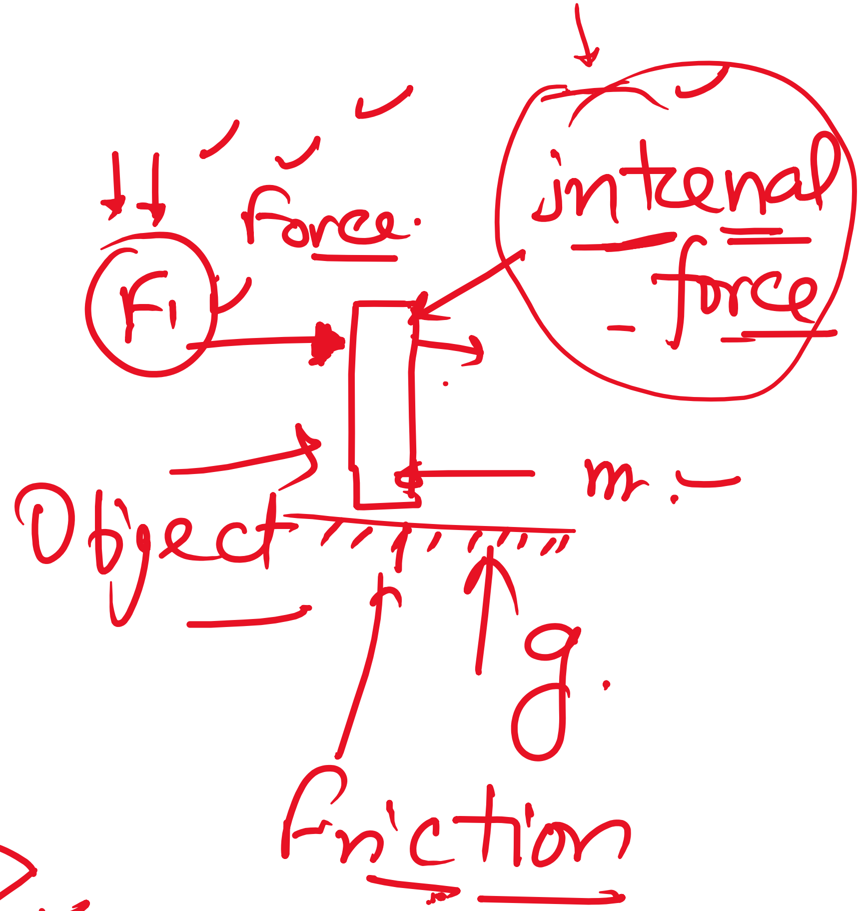
① Vectors & Scalars -

Vectors → magnitude & direction.

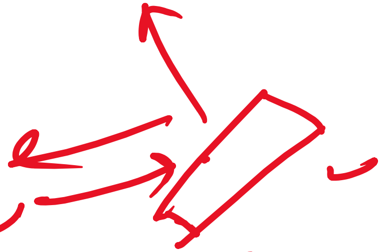
ex - force, field etc.

Scalars → manitude

ex - mass



→ **Unit vector**



$$\vec{A} = A_x \hat{x} + A_y \hat{y} + A_z \hat{z}$$

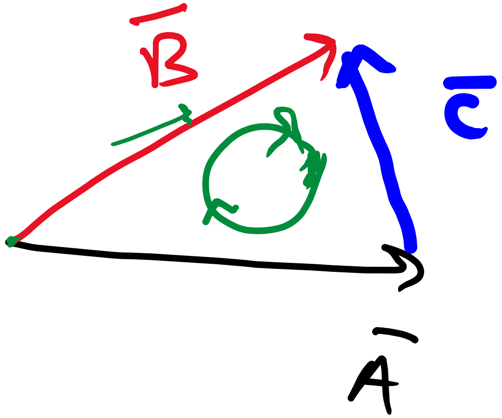
unit vector

$$\hat{a} = \frac{\bar{A}}{|\bar{A}|} = \frac{A_x \hat{x} + A_y \hat{y} + A_z \hat{z}}{\sqrt{A_x^2 + A_y^2 + A_z^2}}$$

unit vectors tells about the direction of a vector.

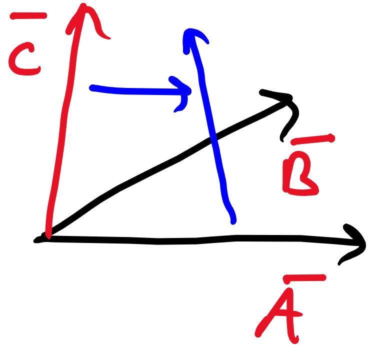
[* unit vector tells about the propagation, the direction of increment, the direction of expension of a vector]

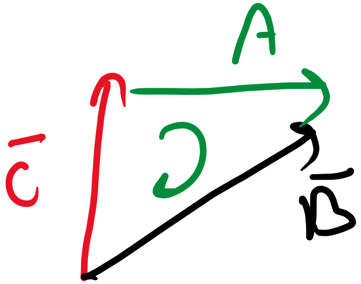
Addition & subtraction of vectors -

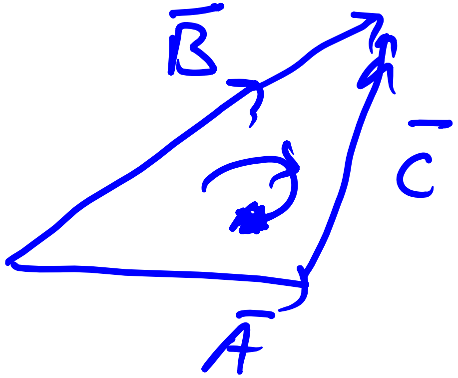


$$\bar{B} - \bar{C} - \bar{A} = 0$$

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







$$\bar{B} - \bar{C} - \bar{A} = 0$$

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

$$\bar{C} + \bar{A} - B = 0$$

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

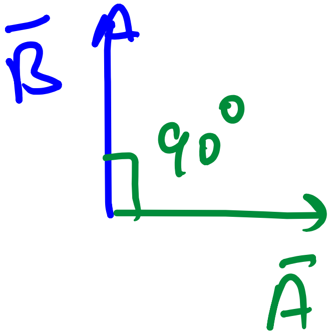
Vector multiplication -

① Dot product

② Cross product.

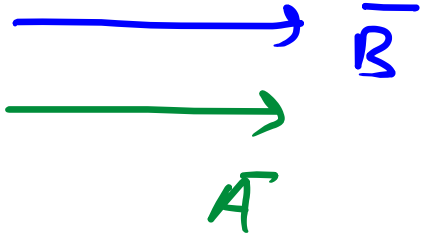
$$\bar{A} \cdot \bar{B} = |\bar{A}|\,|\bar{B}|\cos\theta$$

angle between $\bar{A}$ & $\bar{B}$



$\Rightarrow \theta = 90^\circ$

$\bar{A} \cdot \bar{B} = 0$



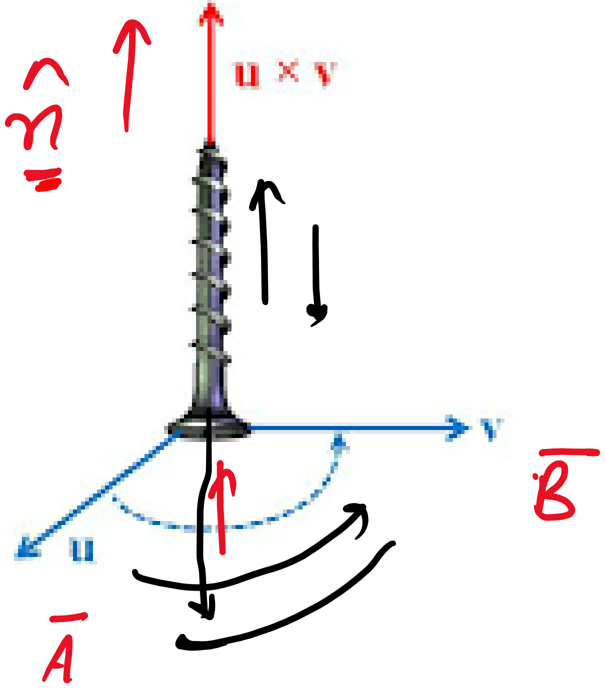
$\bar{A} \parallel \bar{B}$

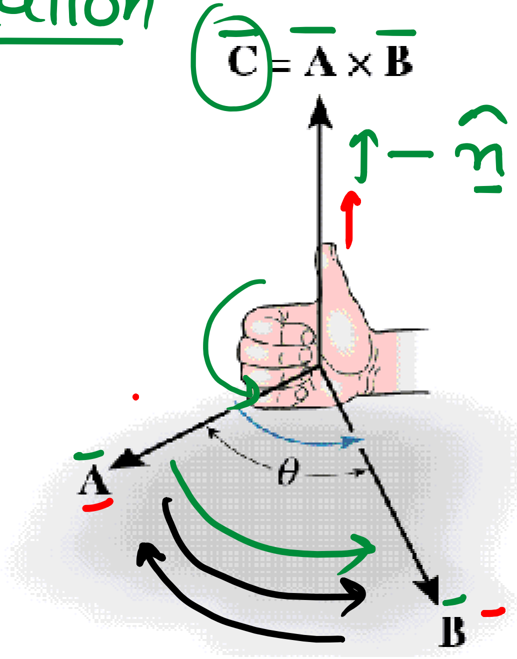
$\theta = 0^\circ$

$\bar{A} \cdot \bar{B} = A \cdot B$

Cross product - $\bar{A} \times \bar{B} = |A|\,|B| \sin\theta \, \hat{n}$

rotation





① $\theta = 0^\circ$

$\vec{A}$, $\vec{B}$ $\Rightarrow \bar{A} \times \bar{B} = 0$

② $\theta = 90^\circ$

$\Rightarrow \bar{A} \times \bar{B} = AB\,\hat{n} = \bar{C}$

Elements of Electromagnetics by Sadiku. (3rd Edition)

5th, 6th, 7th

$\Rightarrow \vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$

① Commutative law : $\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$

② Distributive law = $\vec{A}\cdot(\vec{B}+\vec{C}) = \vec{A}\cdot\vec{B} + \vec{A}\cdot\vec{C}$.

$\Rightarrow \vec{A}\times\vec{B} = AB\sin\theta\,\hat{n}$

① It is not commutative. $\rightarrow$ $\vec{A}\times\vec{B} \neq \vec{B}\times\vec{A}$

it is "anti commutative" $\Rightarrow$ $\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$

② Associative law - $\vec{A}\times(\vec{B}\times\vec{C}) \neq (\vec{A}\times\vec{B})\times\vec{C}$.

③ Distributive law - $\vec{A}\times(\vec{B}+\vec{C}) = \vec{A}\times\vec{B} + \vec{A}\times\vec{C}$

$$\bar{A}\times\bar{B} \Rightarrow \quad \bar{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$$

$$\bar{B} = B_x\hat{x} + B_y\hat{y} + B_z\hat{z}$$

$$\bar{A}\times\bar{B} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$\underline{\bar{A}\times\bar{B}} = \hat{x}(A_yB_z - A_zB_y) - \hat{y}(B_xA_z - A_xB_z) + \hat{z}(A_xB_y - B_xA_y$$

Q. $\bar{A} = 3\hat{x} + 4\hat{y} + \hat{z}$ & $\bar{B} = 2\hat{y} - 5\hat{z}$

find the angle between $\bar{A}$ & $\bar{B}$.

Sol-

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

$\bar{A}\cdot\bar{B} = (3\hat{x} + 4\hat{y} + \hat{z})\cdot(2\hat{y} - 5\hat{z}).$

$= 0\ \cancel{x} + 8 - 5\cdot(\hat{z}\cdot\hat{z}) = 8 - 5 = 3$

Dot Product of two vectors.

"A Scalar quantity"

Note:-

$\hat{x}\cdot\hat{x} = |\hat{x}||\hat{x}|\cos\theta = 1\cdot 1\cos 0^\circ = 1$

Parallel

$\hat{x}\cdot\hat{y} = |\hat{x}||\hat{y}|\cos 90^\circ = 1\cdot 1\cdot 0 = 0$

normal.

$$\cos\theta = \frac{\bar{A}\cdot\bar{B}}{|\bar{A}|\cdot|\bar{B}|} = \frac{3}{\sqrt{9+16+1}\cdot\sqrt{4+25}} = \frac{3}{\sqrt{26}\sqrt{29}}.$$

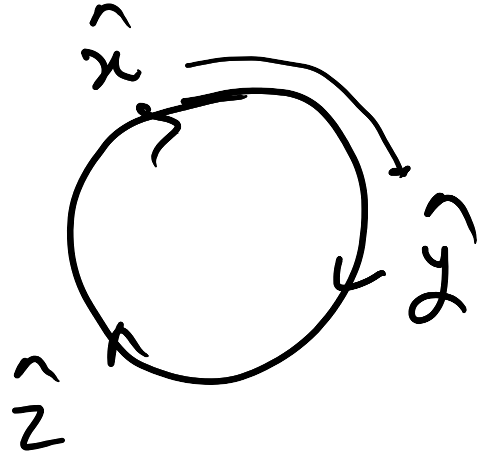
$$\theta = \cos^{-1}\left(\frac{3}{\sqrt{26}\sqrt{29}}\right) \rightarrow \text{Ans.}$$

Cross product →

$\hat{x} \times \hat{y} = \hat{z}$ | $\hat{y} \times \hat{x} = -\hat{z}$

$\hat{y} \times \hat{z} = \hat{x}$ | $\hat{z} \times \hat{y} = -\hat{x}$

$\hat{z} \times \hat{x} = \hat{y}$ | $\hat{x} \times \hat{z} = -\hat{y}.$



Scalar triple product -

$$\bar{A}\cdot(\bar{B}\times\bar{C}) = \bar{B}\cdot(\bar{C}\times\bar{A}) = \bar{C}\cdot(\bar{A}\times\bar{B})$$

Vector triple product -

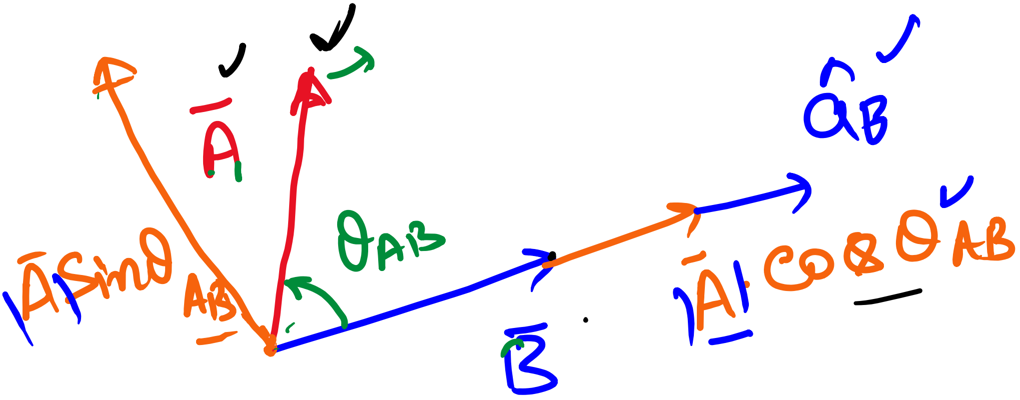
$$\bar{A}\times(\bar{B}\times\bar{C}) = \bar{B}(\bar{A}\cdot C) - \bar{C}(\bar{A}\cdot\bar{B})$$

$$BAC - CAB$$

Projection of a vector →

① find the scalar component of vector $\bar{A}$ along $\bar{B}$.

② find the vector component of $\bar{A}$ along vector $\bar{B}$.



① Component of $\bar{A}$ along $\bar{B}$ ⇒ $\underline{A_{AB}} = |\bar{A}|\cos\theta$

$$A_{AB} = |A|\,|\hat{a}_{AB}|\cos\theta = \bar{A}\cdot\hat{a}_{AB} \rightarrow \text{Scalar}$$

$$\bar{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z} \Rightarrow \hat{a}_{AB} = \frac{\bar{B}}{|\bar{B}|} = \frac{B_x\hat{x} + B_y\hat{y} + B_z\hat{z}}{\sqrt{B_x^2 + B_y^2 + B_z^2}}$$

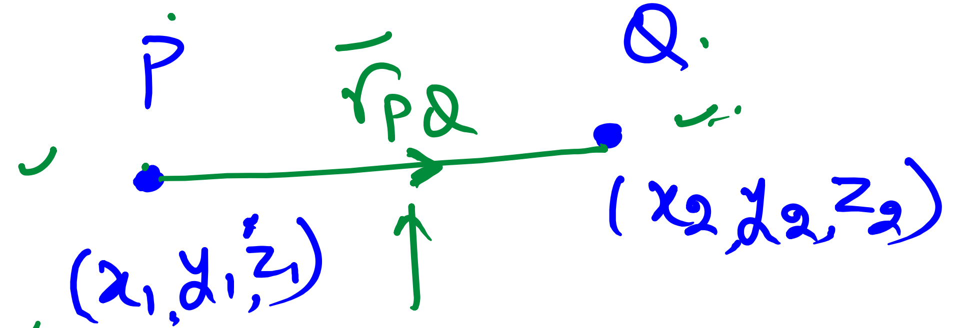
(2) The vector component of $\bar{A}$ along $\bar{B}$ –

$$\underline{\bar{A}_{AB}} = A_{AB} \cdot \hat{a}_B = \underbrace{\underbrace{(\bar{A} \cdot \hat{a}_B)}_{\text{Scalar comp.}} \cdot \hat{a}_B}_{\text{Vector Comp.}}$$

⇒ Position & distance –

vector

scalar



Position vector from P to Q

$$\bar{r}_{PQ} = (x_2 - x_1)\hat{x} + (y_2 - y_1)\hat{y} + (z_2 - z_1)\hat{z}$$

Distance $= |\bar{r}_{PQ}|$ → between P & Q

$= \sqrt{\quad}$

Solved example - 1.3

Assignment vector calculus -

Solve all the unsolved problems of chapter 1

Book - Elements of Electromagnetics by Sadiku

(3rd edition) or any other too :

Time limit : - Two day up to 21/08/2021

Review Questions