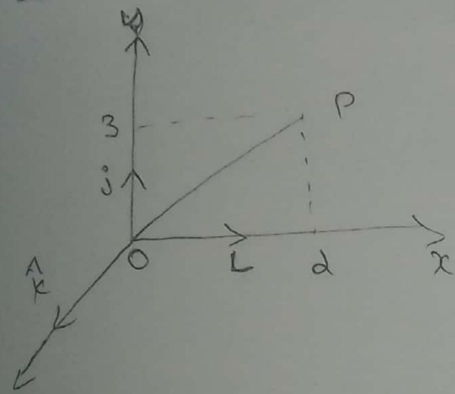
ELECTROMAGNETIC WAVES

Reference Books :- /materials : William Hayt

Ganesh Rao

→ vector Algebra

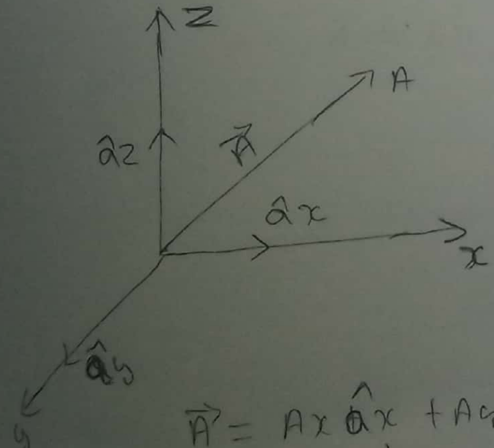


vector → it has both magnitude and direction

scalar → it has only magnitude.

$\vec{OP}$ → position vector

$\vec{OP} = 2\hat{i} + 3j$ $\hat{i}, \hat{j}$ → unit vector



magnitude $\vec{A}$

$j = \sqrt{-1}$

$i = \sqrt{-1}$

$\vec{B} = Bx\hat{a}x + By\hat{a}y + Bz\hat{a}z$

$\vec{A} = Ax\hat{a}x + Ay\hat{a}y + Az\hat{a}z$

Ax → Amplitude, âx → vector unit

$\vec{A} = \sqrt{Ax^2 + Ay^2 + Az^2}$ → magnitude

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Dot product of 'v'

$\vec{A}.\vec{B} = |\vec{A}||\vec{B}| \cos\theta$

Scalar Quantity

	$\hat{a}_x$	$\hat{a}_y$	$\hat{a}_z$
$\hat{a}_x$	1	0	0
$\hat{a}_y$	0	1	0
$\hat{a}_z$	0	0	1

$\hat{a_x}.\hat{a_x} = |\hat{a_x}||\hat{a_x}| \cos\theta$

$\cos(0) = 1$

$\hat{a_x}.\hat{a_y} = |\hat{a}_x||\hat{a_y}| \cos\theta$

$\cos 90 = 0$

$\hat{a_x}\,\hat{a_z} = |\hat{a}_x||\hat{a}_z| \cos\theta$

$\cos 90 = 0$

$\vec{A}.\vec{B} \Rightarrow$ Commulative & $A(B+C) = AB+AC \rightarrow$ distributive.

$\vec{A}.\vec{B} = (A_x\hat{a_x} + A_y\hat{a_y} + A_z\hat{a_z}).(B_x\hat{a_x} + B_y\hat{a_y} + B_z\hat{a_z})$

$$\boxed{\vec{A}.\vec{B} = A_xB_x + A_yB_y + A_zB_z}$$

distributive property $A(B+C) = A.B + A.C$

Fields and waves

09/09/2020

Vector algebra

Dot Product

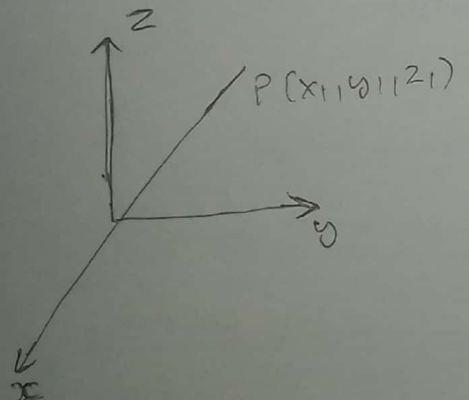
•	ax	ay	az
ax	ax	0	0
ay	0	ay	0
az	0	0	az

$\vec{A} = A_x \hat{a}_x + A_y \hat{a}_y + A_z \hat{a}_z$

$\vec{B} = B_x \hat{a}_x + B_y \hat{a}_y + B_z \hat{a}_z$

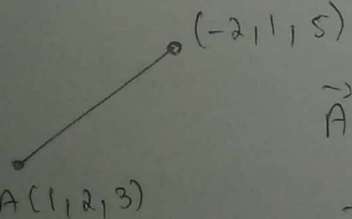
$$\vec{A}\times\vec{B} \quad \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$\vec{A}\times\vec{B} = \hat{a}_x\,[A_y B_z - B_y A_z] - \hat{a}_y\,[A_x B_z - B_x A_z] + \hat{a}_z\,[A_x B_y - B_x A_y]$$



$\vec{OP} = x_1 \hat{a}_x + y_1 \hat{a}_y + z_1 \hat{a}_z$

ex:-



$\vec{A}\cdot\vec{B} = (-2-1)\hat{a}_x + (1-2)\hat{a}_y + (5-3)\hat{a}_z$

$\vec{AB} = -3\hat{a}_x - \hat{a}_y + 2\hat{a}_z$

Amplitude

$|\vec{AB}| = \sqrt{3^2+1^2+2^2}$

$= \sqrt{9+1+4}$

$|\vec{AB}| = \sqrt{14}$

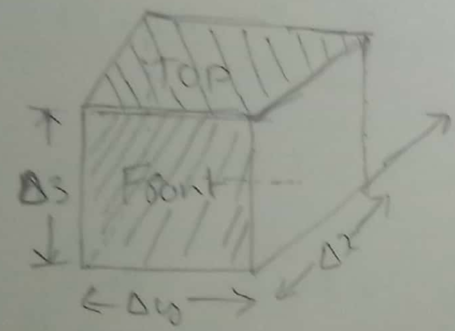
* To calculate unit vector in $\overrightarrow{AB}$

$$\boxed{\hat{a}_{AB} = \frac{\overrightarrow{AB}}{|AB|}}$$

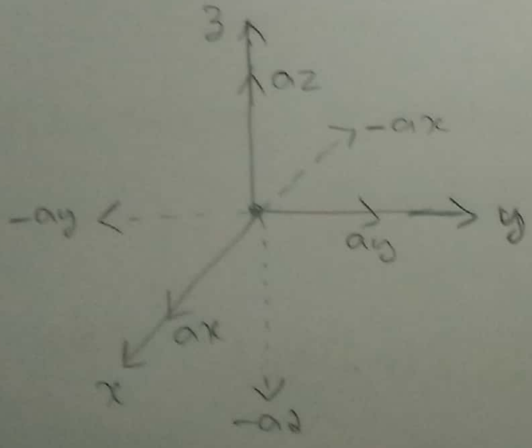
$$\hat{a}_{AB} = \frac{-3\hat{a}_x - \hat{a}_y + 2\hat{a}_z}{\sqrt{14}}$$

$$\boxed{\hat{a}_{AB} = \frac{-3}{\sqrt{14}}\hat{a}_x - \frac{1}{\sqrt{14}}\hat{a}_y + \frac{2}{\sqrt{14}}\hat{a}_z}$$

Surface area



incremental volume of cube = ΔV



Surface area of front surface.

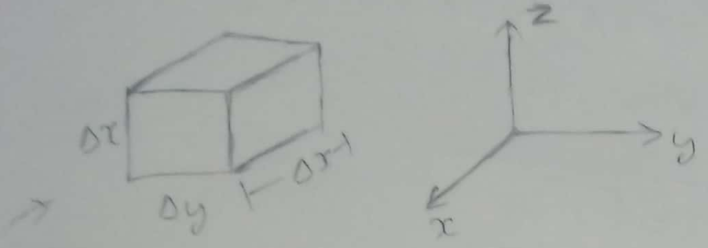
$$\Delta S_{Front} = \Delta y \, \Delta z \, \hat{a}_x$$

$$\Delta S_{Top} = \Delta y \, \Delta x \, \hat{a}_z$$

$$\Delta S_{right} = \Delta x \, \Delta z \, \hat{a}_y$$

$$\left.\begin{aligned} \Delta S_{back} &= -\Delta y \, \Delta z \, \hat{a}_x \\ \Delta S_{bottom} &= -\Delta y \, \Delta x \, \hat{a}_z \\ \Delta S_{left} &= -\Delta x \, \Delta z \, \hat{a}_y \end{aligned}\right\} \text{opposite direction}$$

area / differential surface area



③ Differential volume / incremental volume

$\boxed{\Delta V = \Delta x \; \Delta y \; \Delta z}$ → differential volume of cube.

① linear co-ordinate system

② Cylindrical co-ordinate system

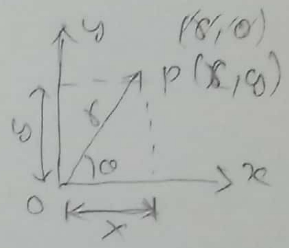
Cylindrical co-ordinate system is extension of polar co-ordinate system

Polar co-ordinate

(r, θ)

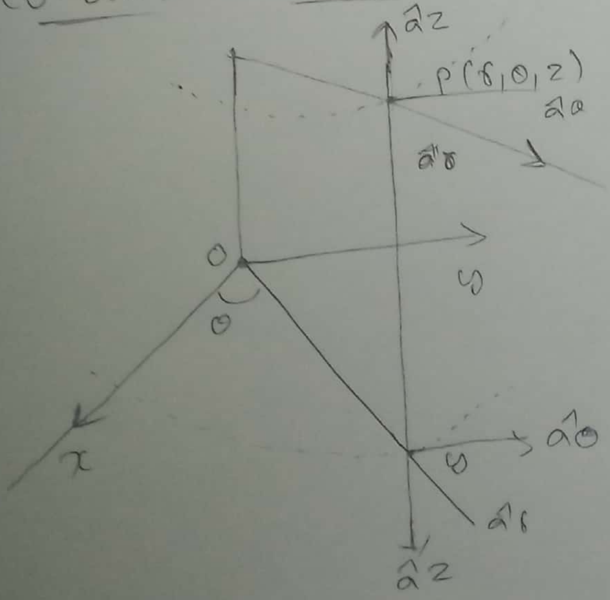
↓

radial component



θ = angular component

Co-ordinate system



$(\hat{a}_r, \hat{a}_\theta, \hat{a}_z)$

$(a\hat{r}, a\hat{\theta}, a\hat{z})$

Considering $P:(r, \theta, z)$

$x = r\cos\theta$

$y = r\cos\theta$

$z = z$

$x^2+y^2 = r^2\cos^2\theta + r^2\sin^2\theta$

$x^2+y^2 = r^2$

$\boxed{r = \sqrt{x^2+y^2}}$

$\boxed{\theta = \tan^{-1}\left(\frac{y}{x}\right)}$

ex: $P:(1,2,3)$

$= (\underbrace{\sqrt{5}}_{r}, \tan^{-1}(2), 3)$

$= (\sqrt{5}, 63.434, 3)$

$P_{cc3} = (\underset{r}{4}, \underset{\theta}{\frac{\pi}{6}}, \underset{z}{2}) \Rightarrow \underline{(2\sqrt{3}, 2, 2)}$

(r, θ, z)

$x = r\cos\theta$

$x = 4\cos\pi/6$

$\boxed{x = (2\sqrt{3})}$

$y = r\sin\theta$

$= 4\sin(\pi/6)$

$\boxed{y = 2}$

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