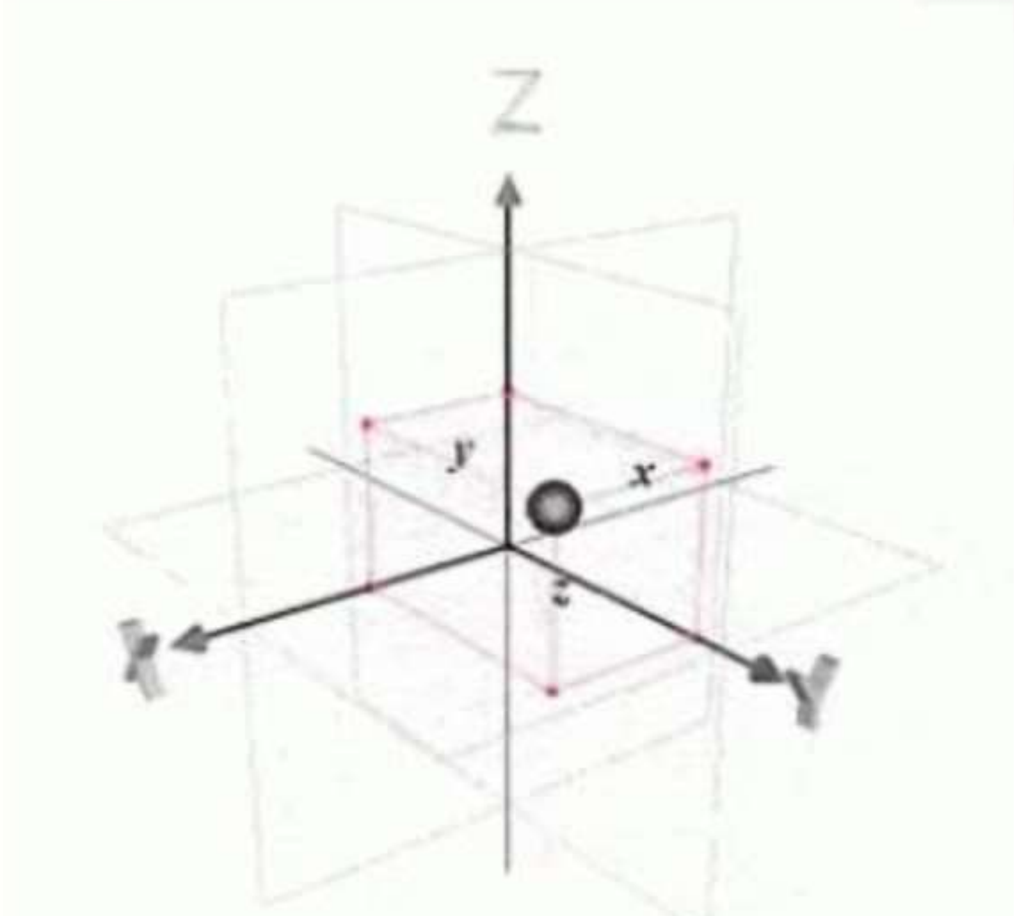
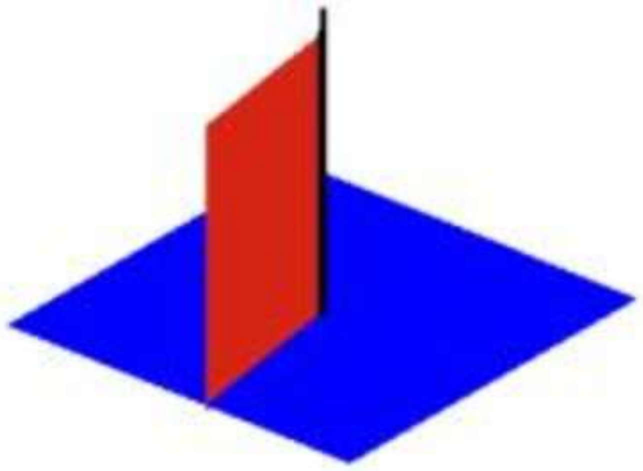
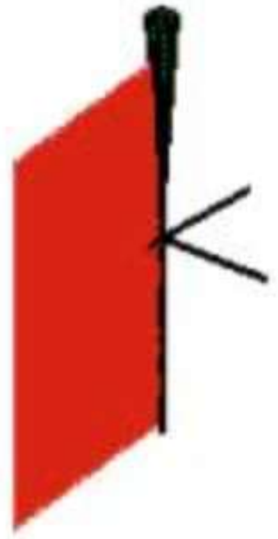
Coordinate systems

1. **Triple Products and its Applications**

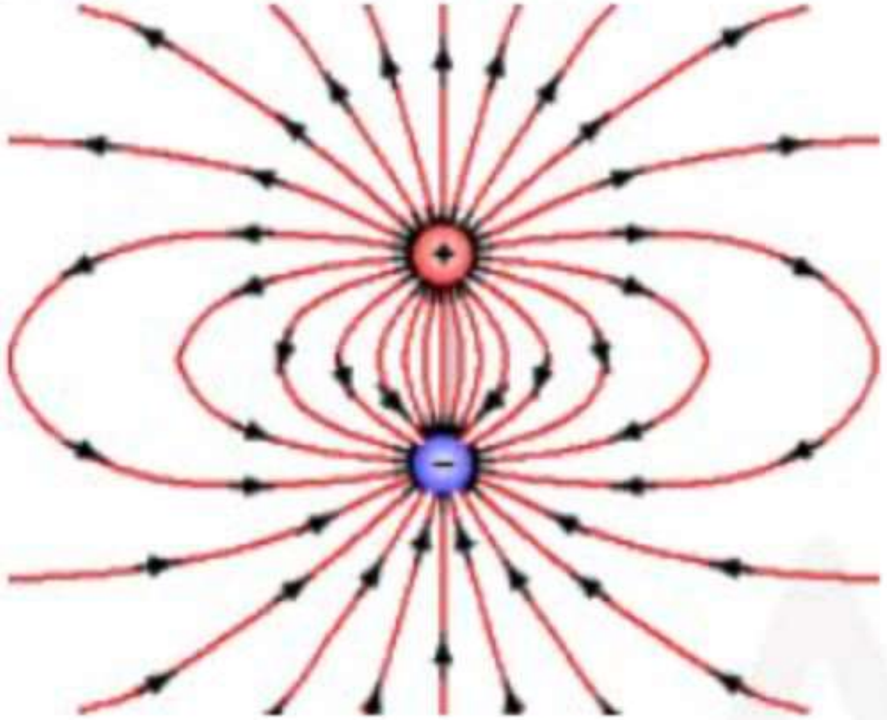
2. **Coordinate systems**

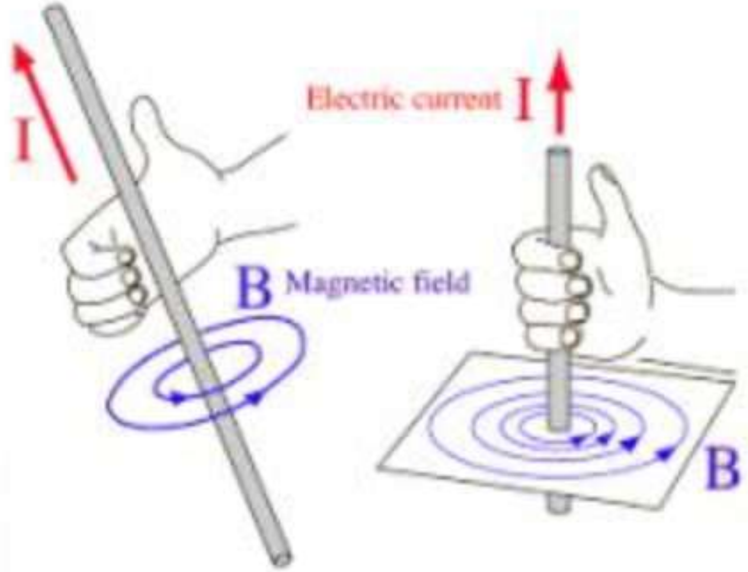


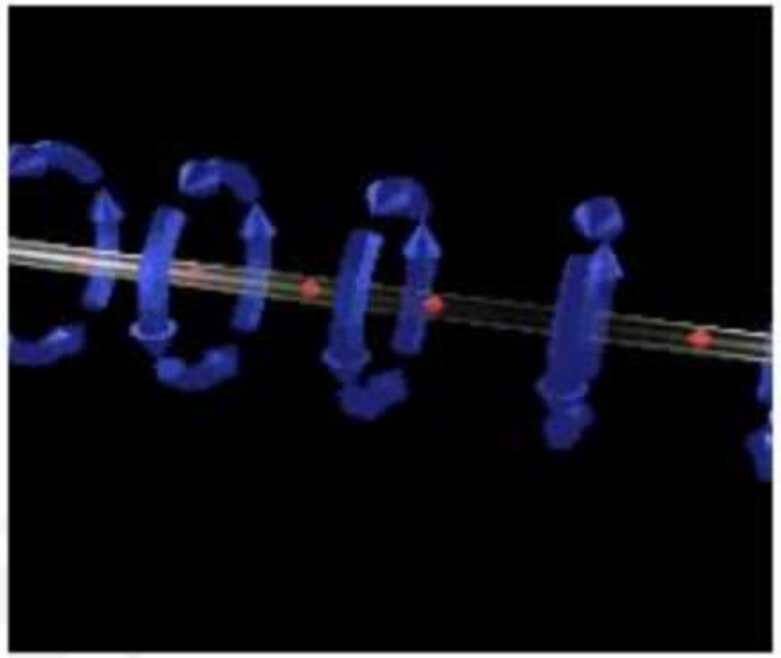


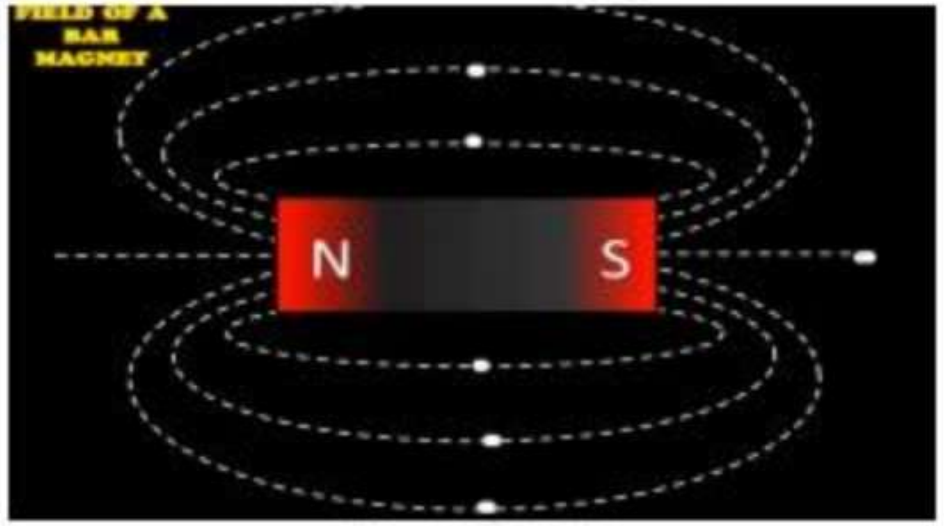


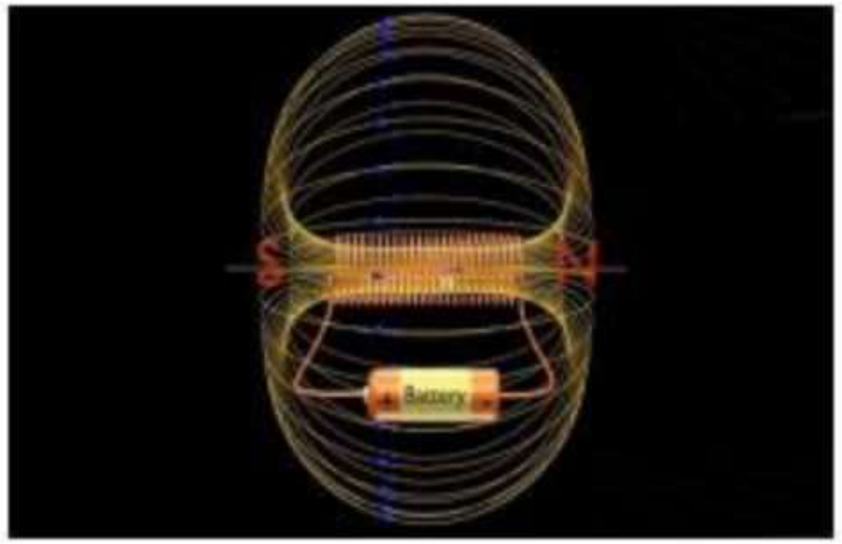
Recap

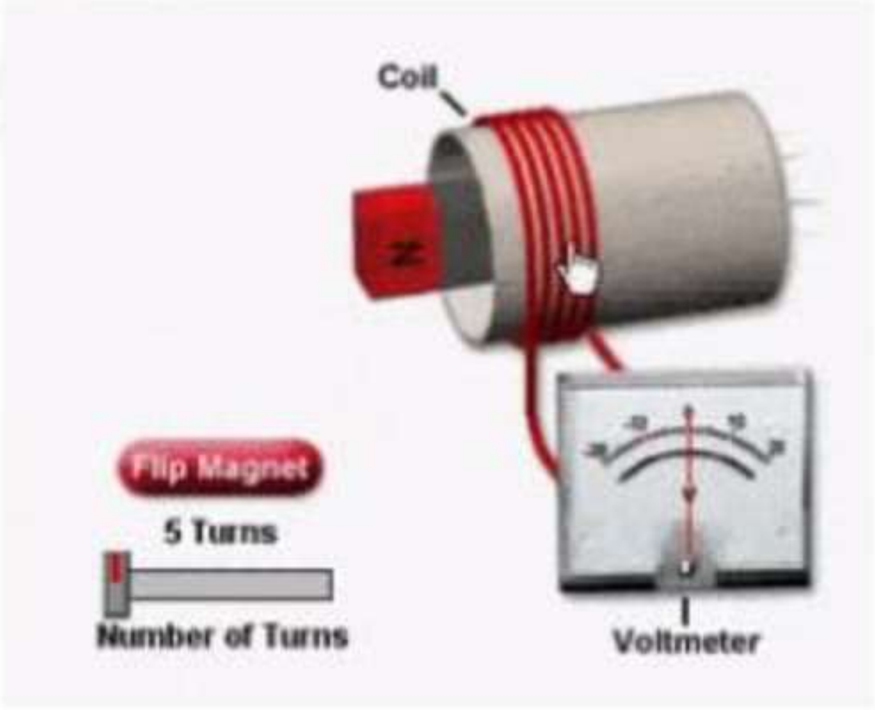



I
Electric current I
B Magnetic field
B

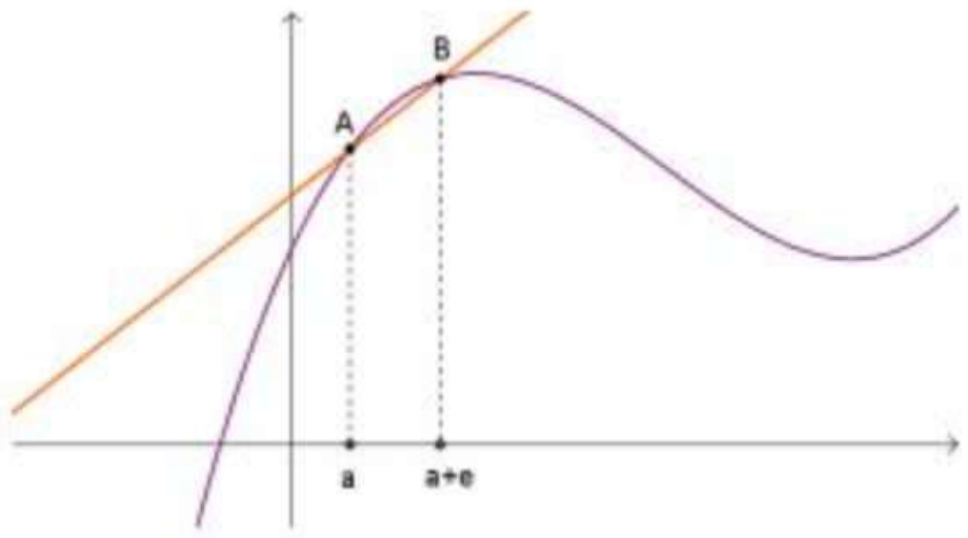



FIELD OF A BAR MAGNET
N
S




Coil
Flip Magnet
5 Turns
Number of Turns
Voltmeter

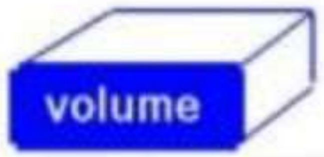
Recap



A scalar quantity has only magnitude.
A vector quantity has both magnitude and direction.

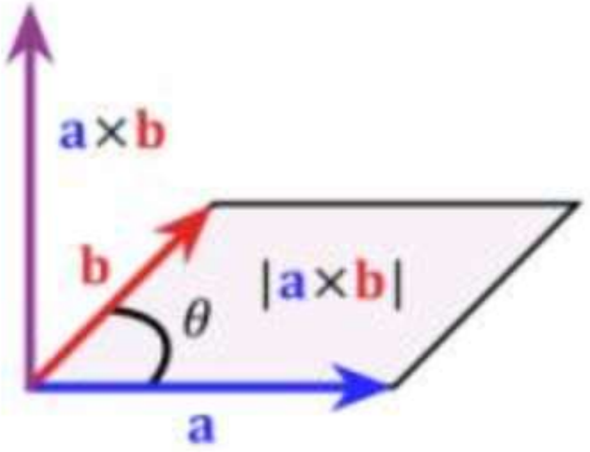
Scalar Quantities

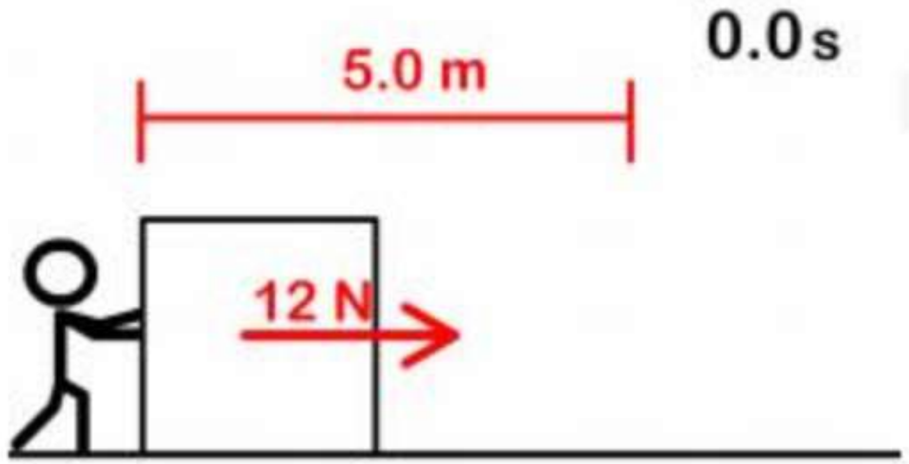
length, area, volume
speed
mass, density
pressure
temperature
energy, entropy
work, power

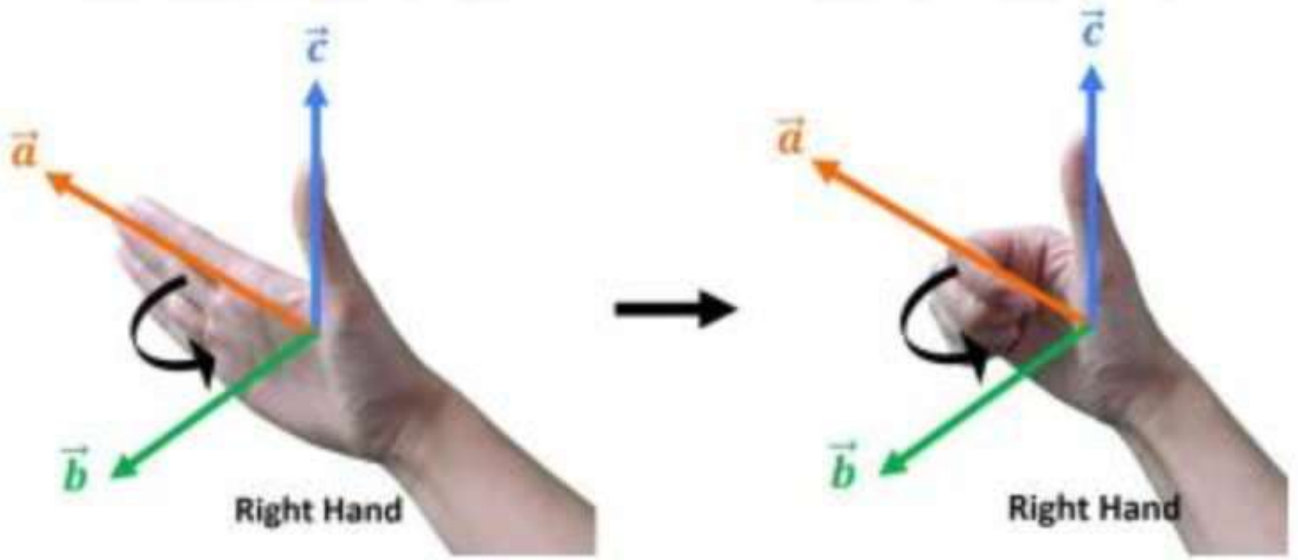


Vector Quantities

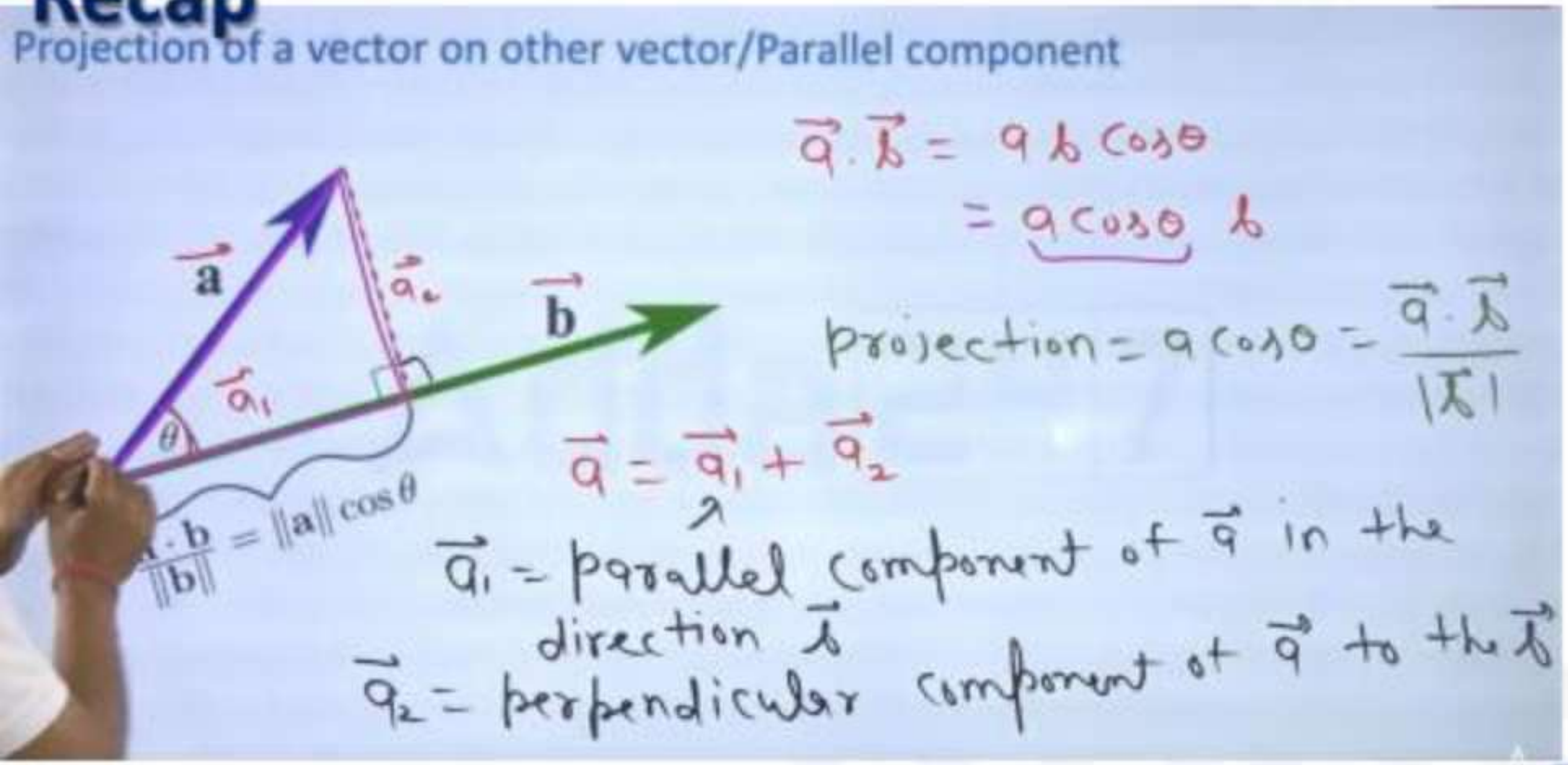
displacement
velocity
acceleration
momentum
force
lift, drag, thrust
weight





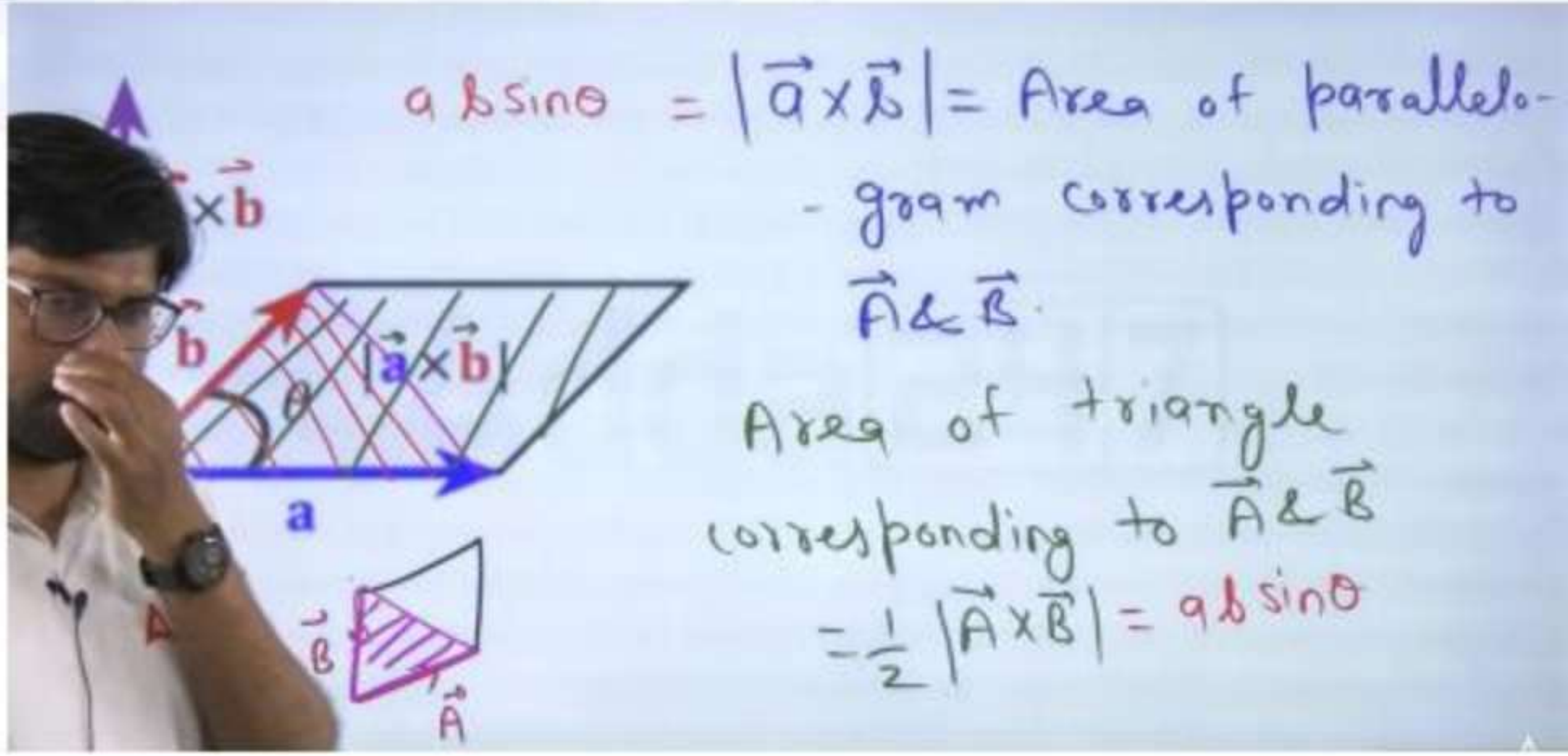


Recap



←Applications of DOT Product

Applications of DOT Product →



Recap

Dedicated batches available on **ADDA247** App, Use offer code **Y657**

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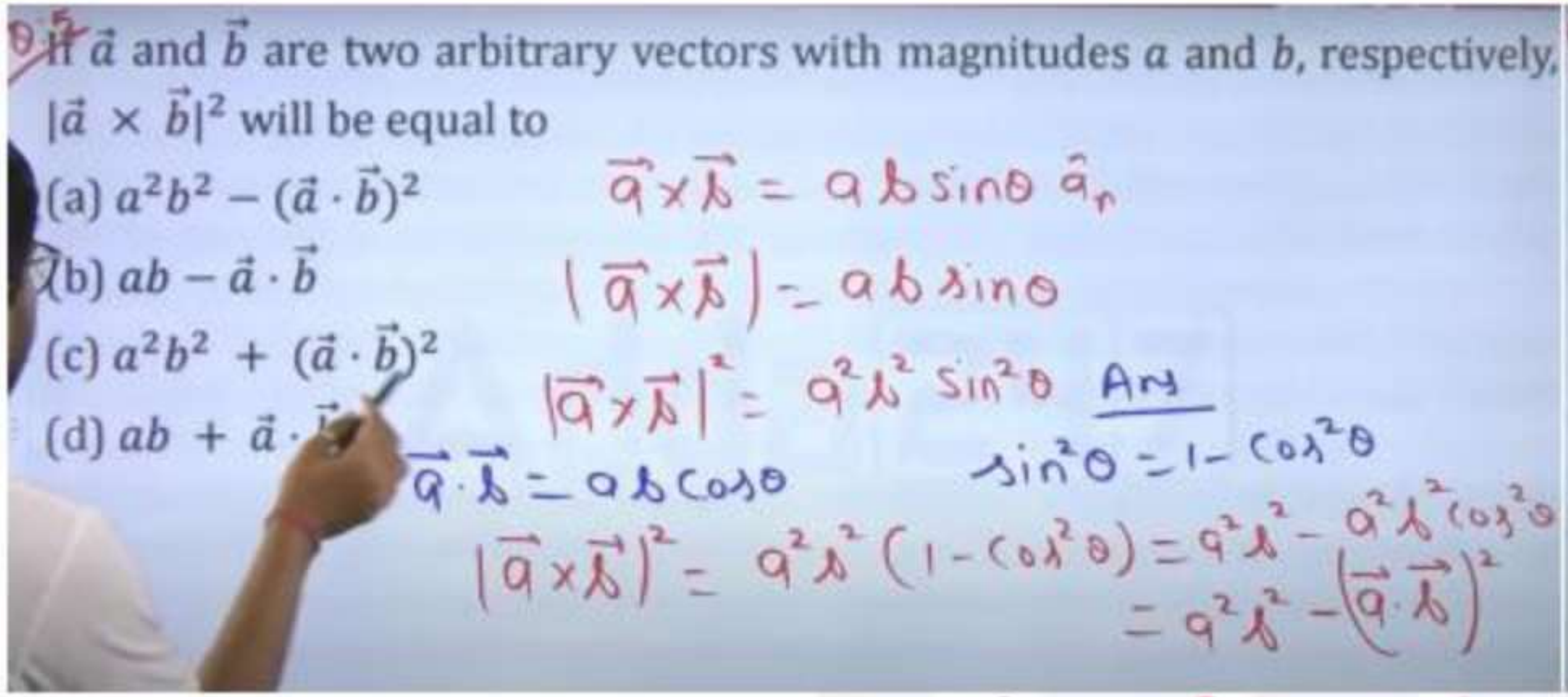
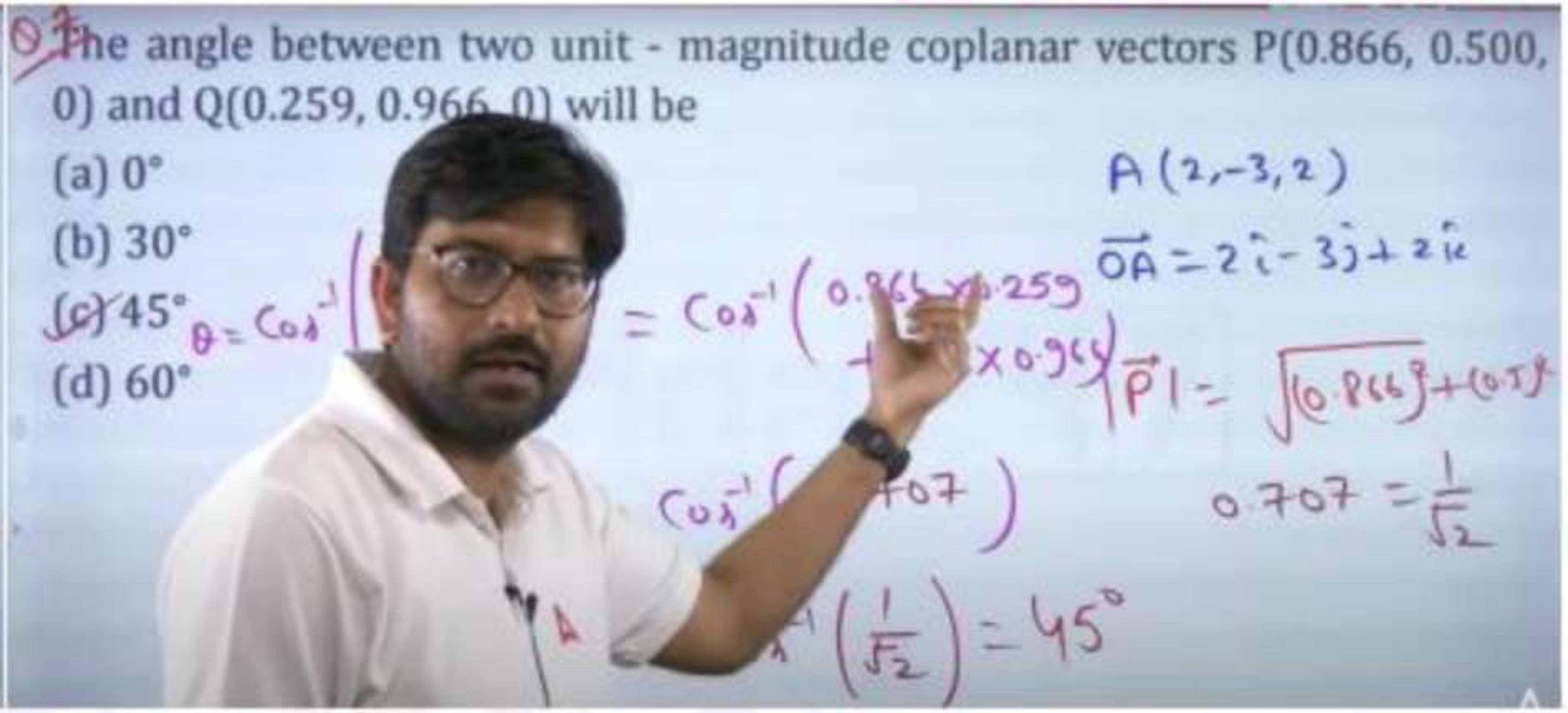
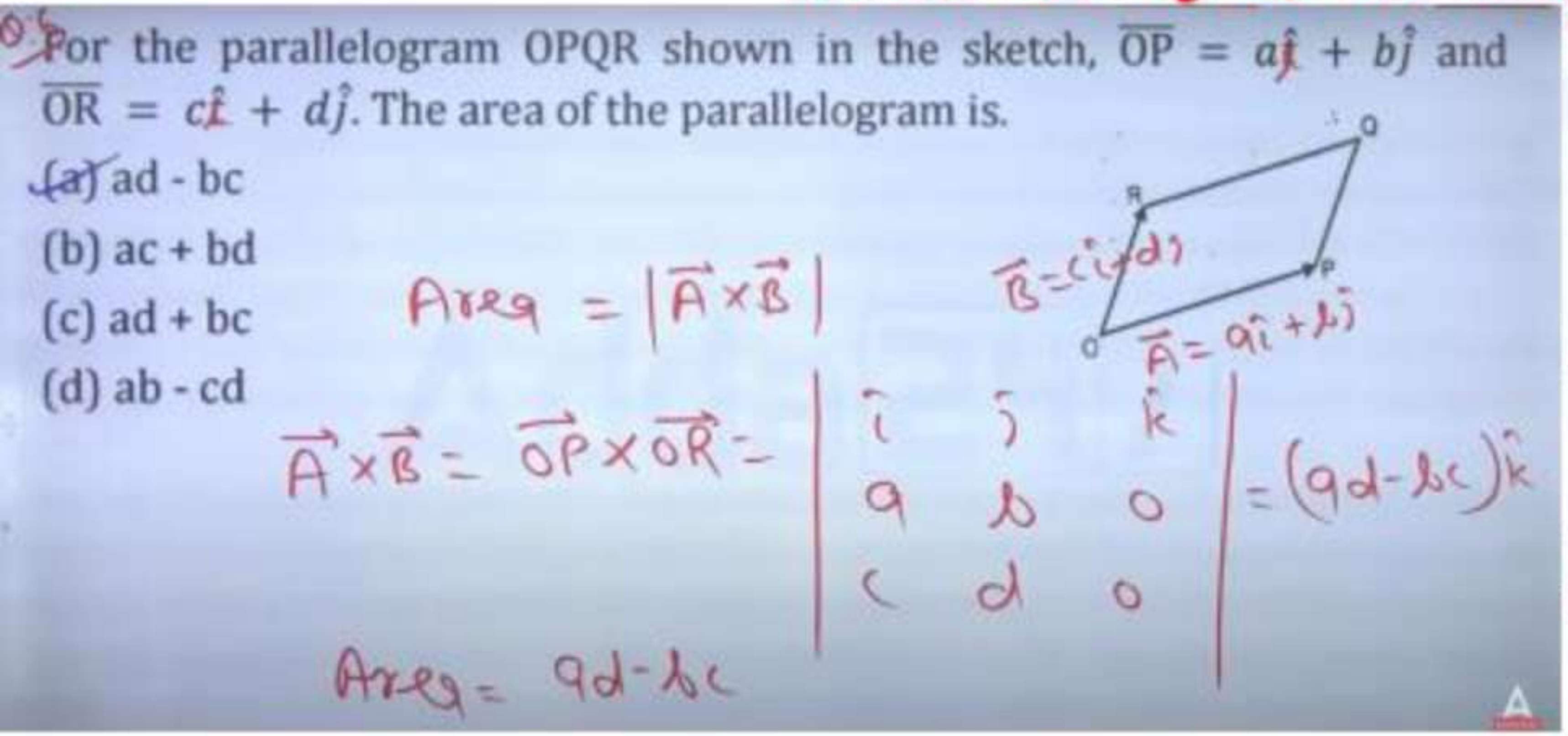
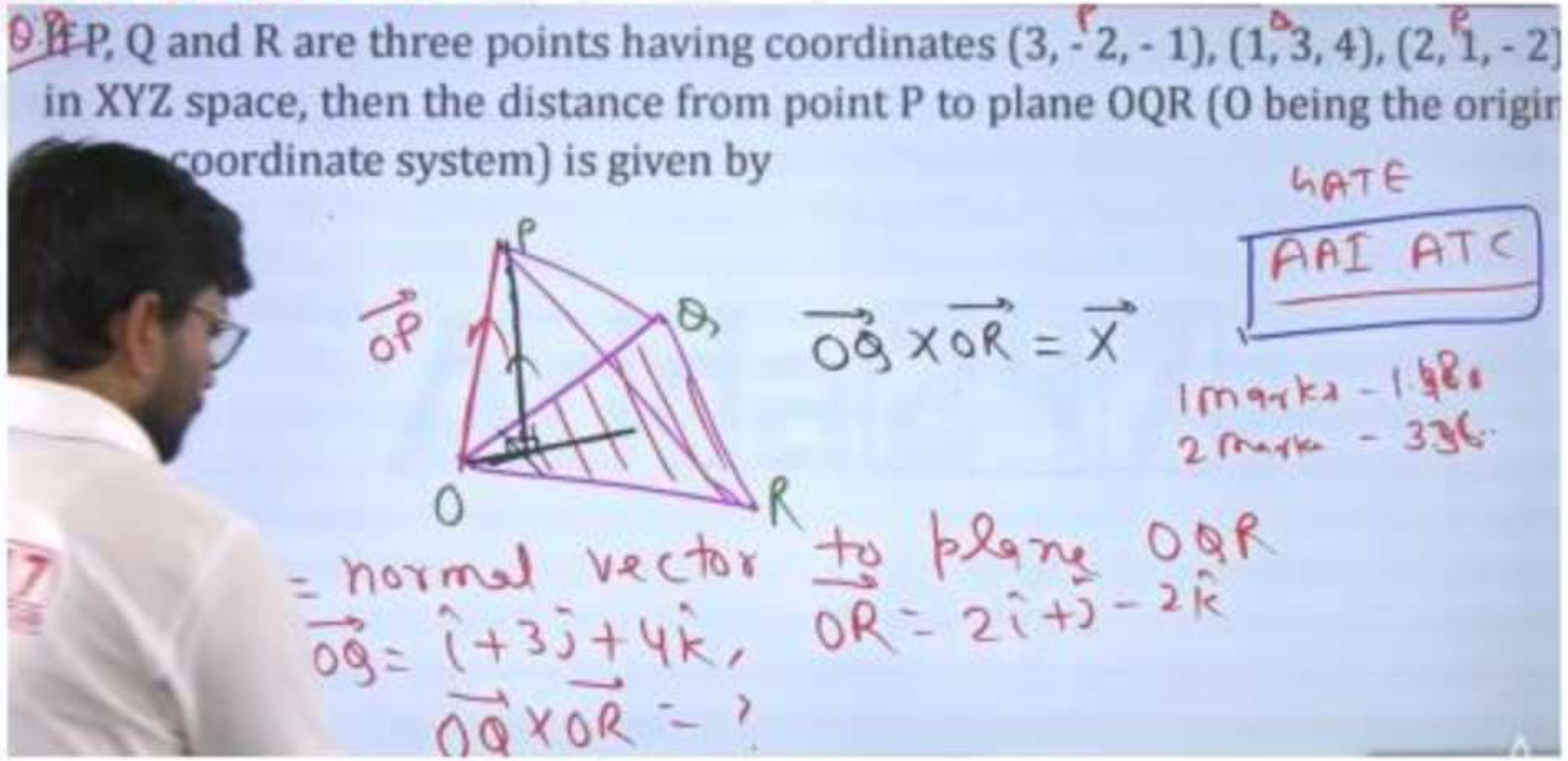




Number of Questions covered-9





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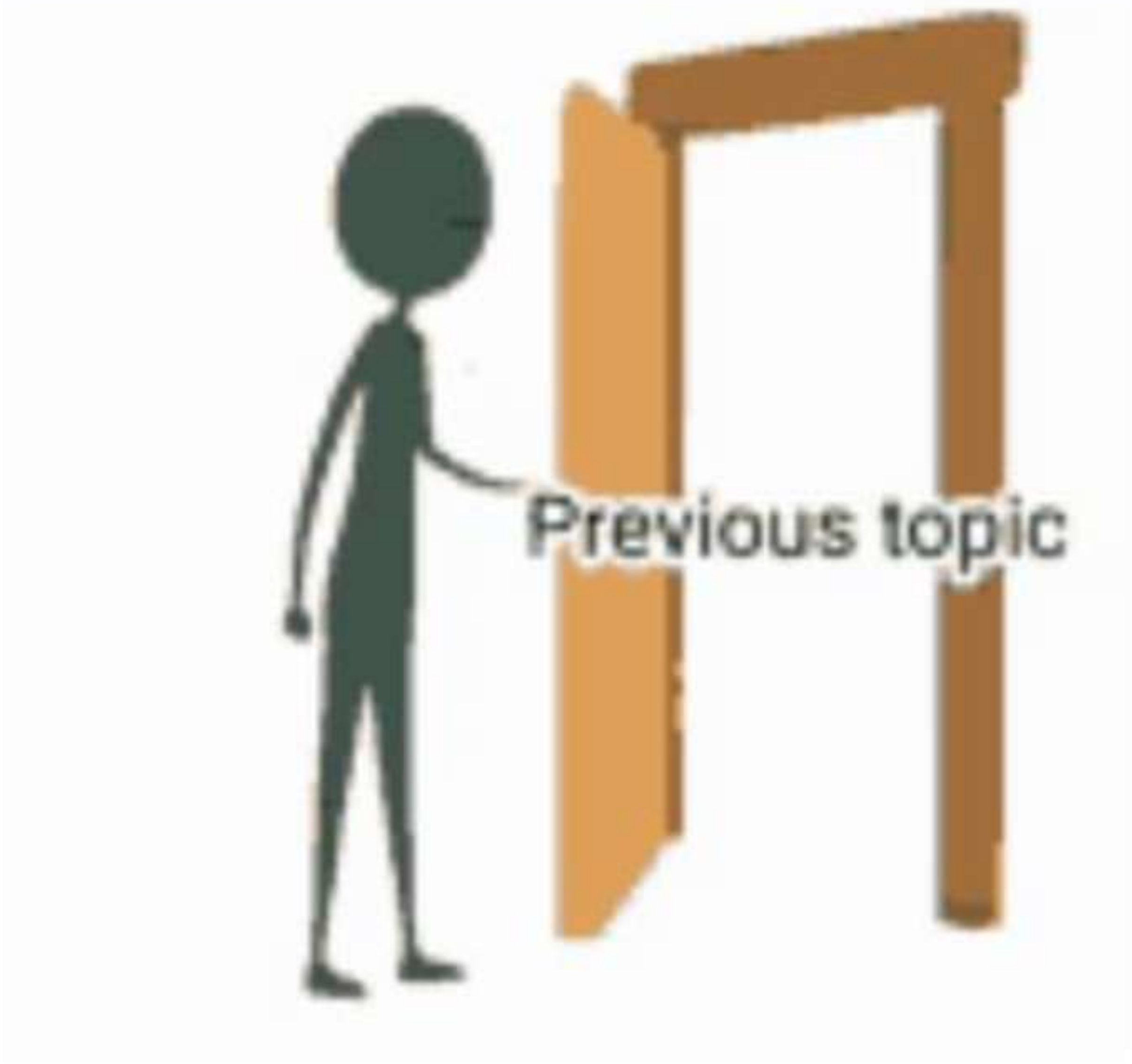
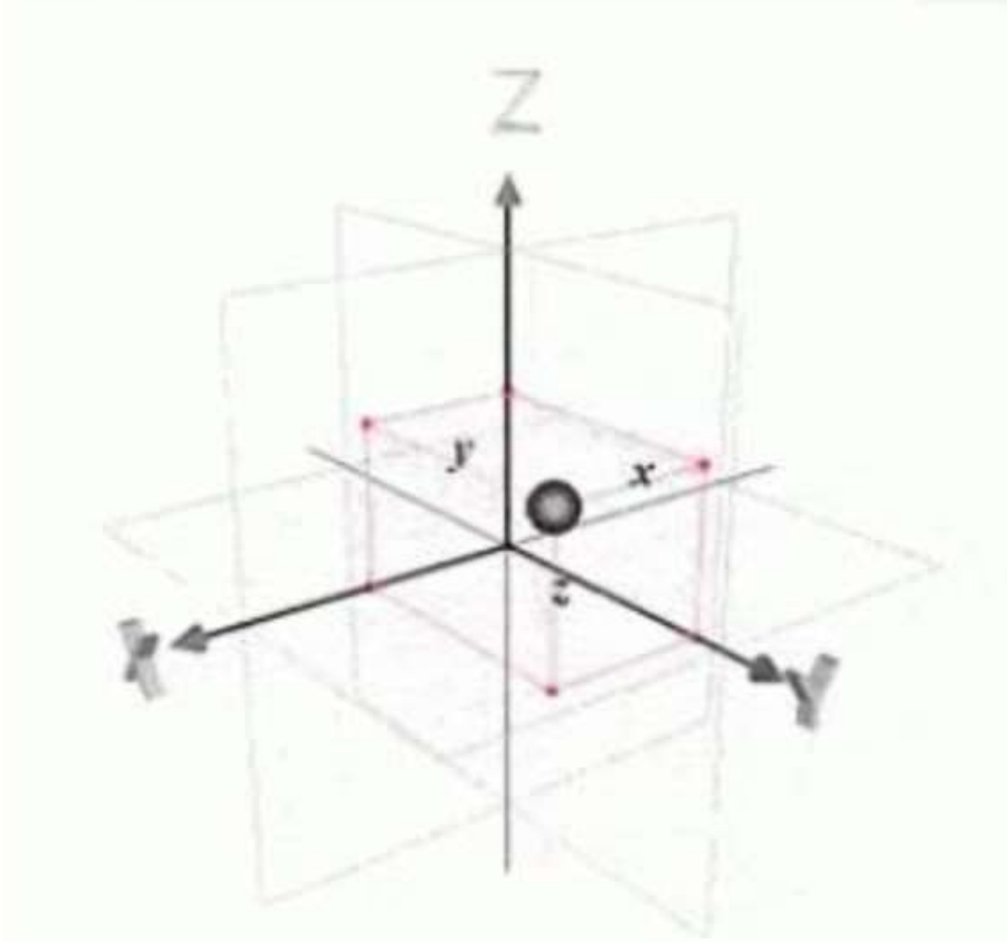
GATE 2024
GATE
प्रचण्ड Batch
Electromagnetic Field Theory
COORDINATE SYSTEMS
LEC-03
EE &ECE

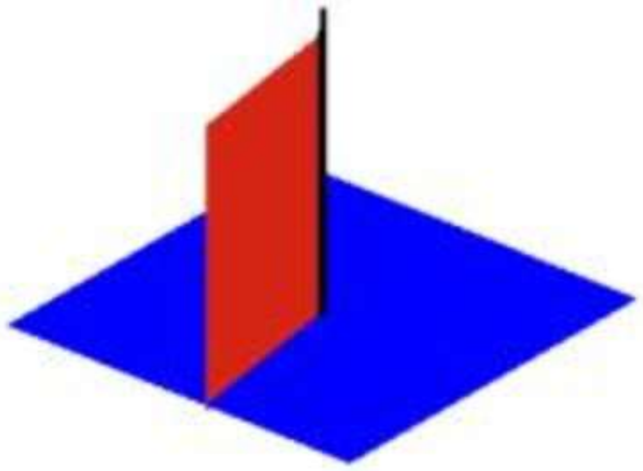


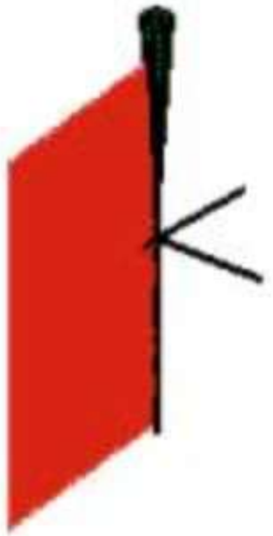
1. Basic introduction of Fields
2. Vectors, Scalars and Tensors
3. Position vector and vector between points
4. Magnitude and direction of vector
5. Dot and cross products and its applications

1. **Triple Products and its Applications**

2. **Coordinate systems**







Triple Product:- $\vec{A}, \vec{B}, \vec{C}$

$\vec{A} \cdot \vec{B} \rightarrow$ Scalor

1. $\vec{A} \cdot \vec{B} \cdot \vec{C} =$ invalid

2. $(\vec{A} \times \vec{B}) \times \vec{C} =$ Vector tripple product $5\vec{A}$

3. $(\vec{A} \cdot \vec{B}) \times \vec{C} =$ invalid

4. $(\vec{A} \times \vec{B}) \cdot \vec{C} =$ Scalar triple product.

$(\vec{A} \times \vec{B}) \cdot \vec{C}$

$\vec{A} = 2\hat{i} - \hat{j} + \hat{k}$

$\vec{B} = \hat{i} + 2\hat{j} + \hat{k}$

$\vec{C} = 3\hat{i} + \hat{j} - \hat{k}$

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -1 & 1 \\ 1 & 2 & 1 \end{vmatrix} = -3\hat{i} - \hat{j} + 5\hat{k}$$

$$(\vec{A} \times \vec{B}) \cdot \vec{C} = 9 - 1 - 5 = 3$$

* if $(\vec{A} \times \vec{B}) \cdot \vec{C} = 0$
then $\vec{A}, \vec{B}$ & $\vec{C}$ are called coplaner vector.

$(\vec{A} \times \vec{B}) \times \vec{C}$ = BAC-CAB rule

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

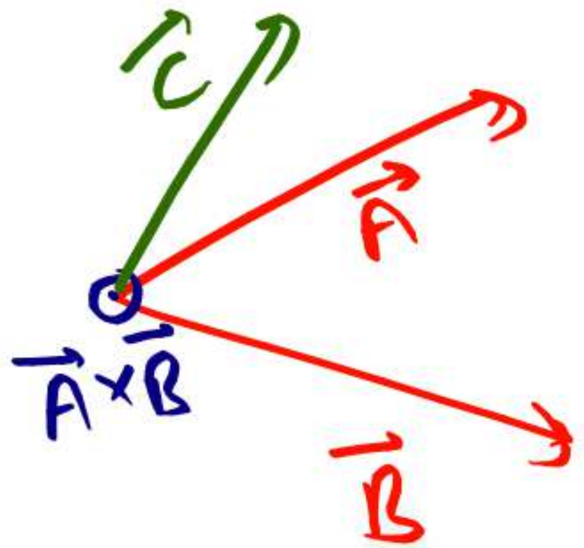
$$\vec{P} \times \vec{Q} \times \vec{R} = \vec{Q}(\vec{P} \cdot \vec{R}) - \vec{R}(\vec{P} \cdot \vec{Q})$$

$$\vec{X} \times \vec{m} \times \vec{D} = \vec{m}(\vec{X} \cdot \vec{D}) - \vec{D}(\vec{X} \cdot \vec{m})$$

Q: $\nabla \times \nabla \times \vec{P}$ is ...

$$\nabla(\nabla \cdot \vec{P}) - \vec{P}(\nabla \cdot \nabla) \Rightarrow \nabla(\nabla \cdot \vec{P}) - \nabla^2 P$$

Coplanar Vectors



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

if

$(\vec{A}\times\vec{B})\cdot\vec{C}=0$

$\Rightarrow$ $\vec{A}\times\vec{B}$ & $\vec{C}$ are normal to each other.

& $(\vec{A}\times\vec{B})$ is always normal to both $\vec{A}$ & $\vec{B}$.

$\Rightarrow$ $\vec{A},\vec{B}$ & $\vec{C}$ are in the same plane.

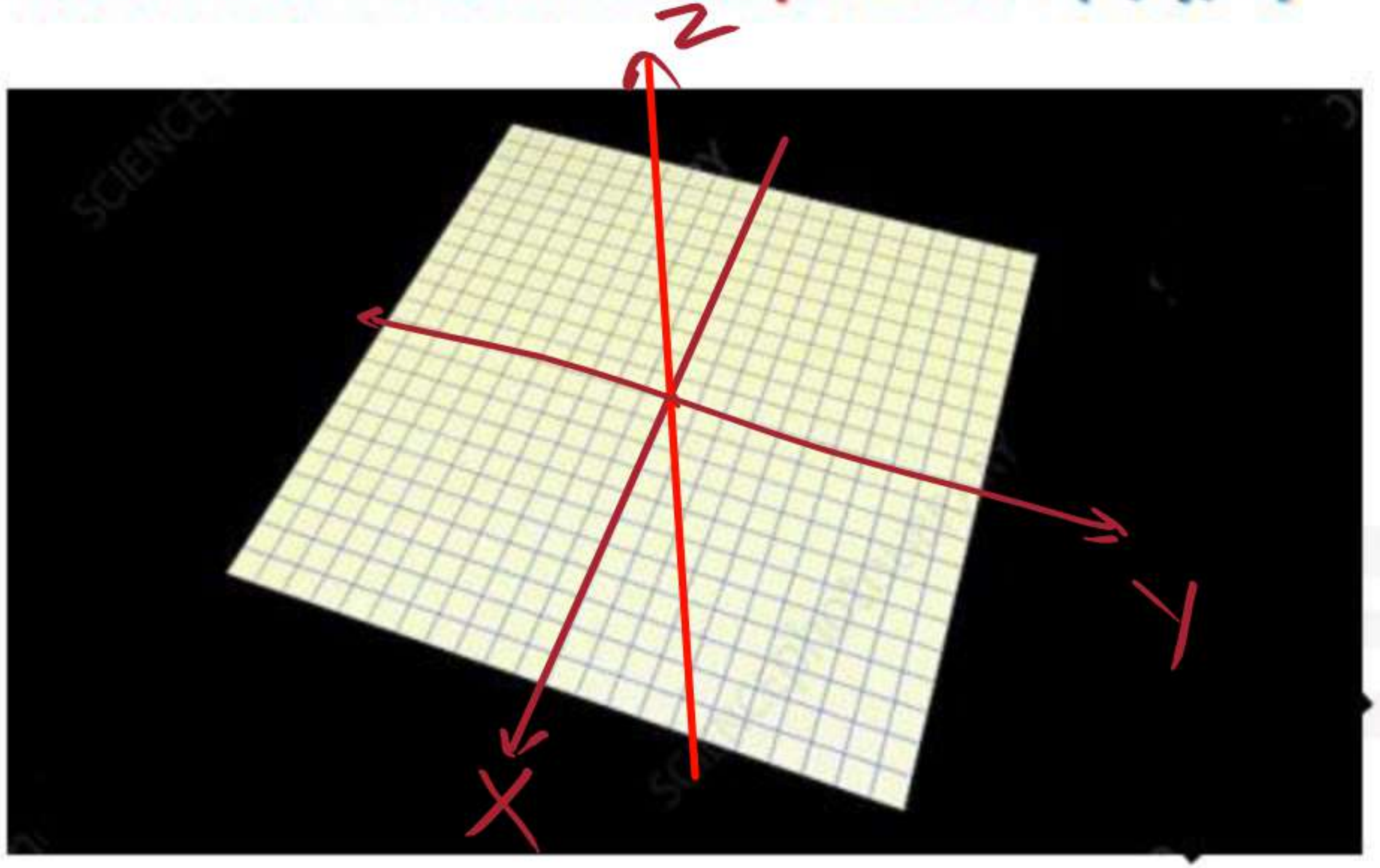
$(\vec{A}\times\vec{B})\cdot\vec{C}=0 \rightarrow$ coplaner vector.

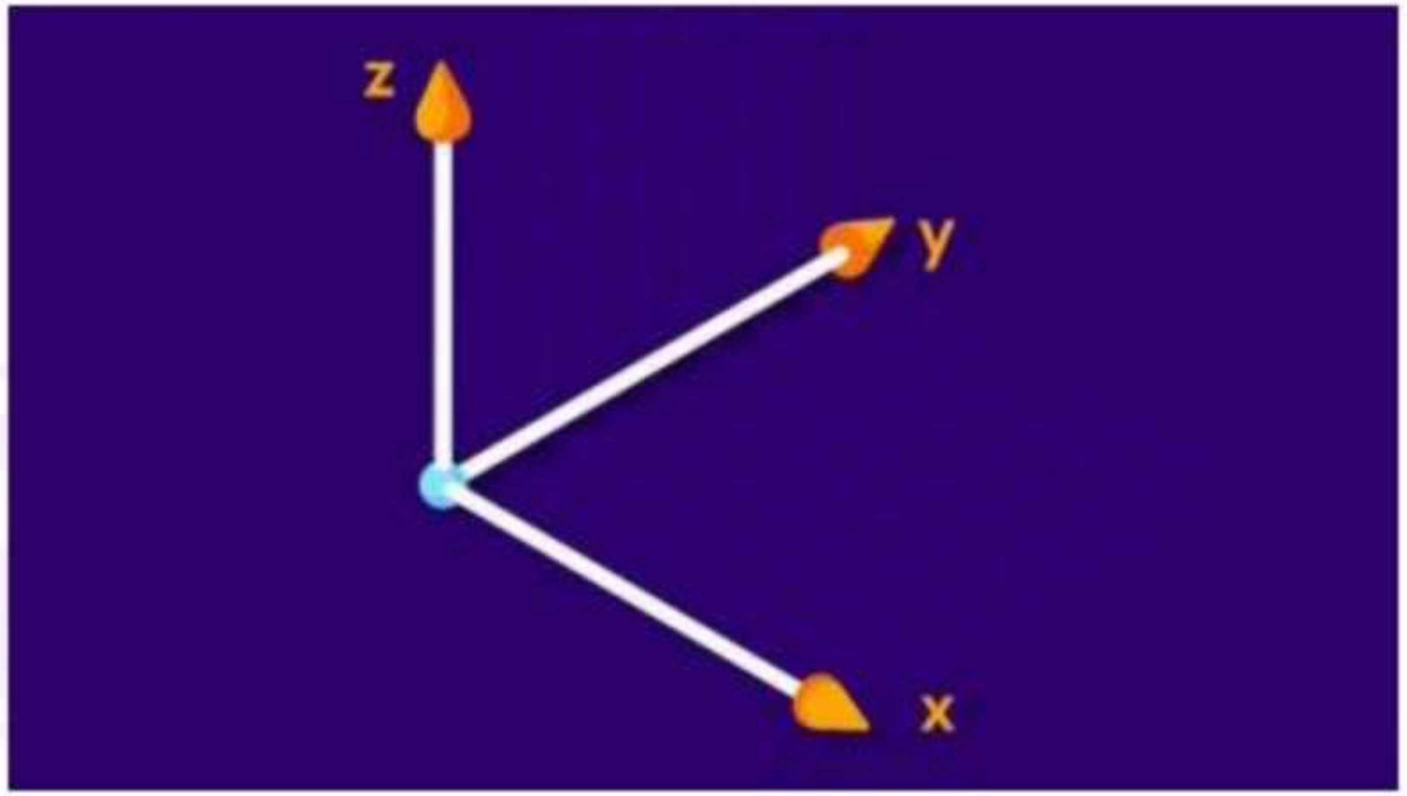
$\hookrightarrow$ scalar

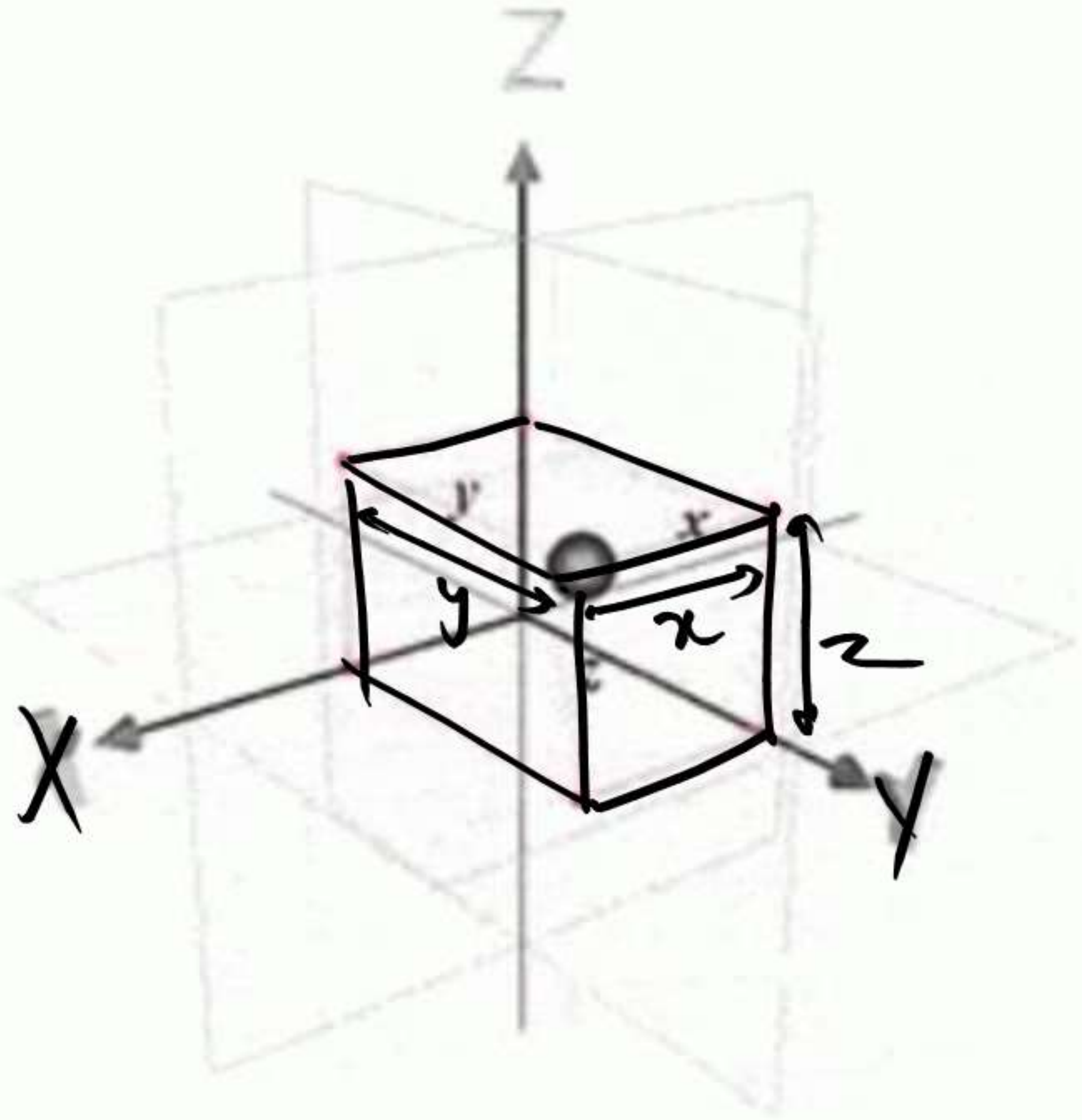
$(\vec{A}\times\vec{B})\times\vec{C} \rightarrow$ vector

$\vec{B}(\vec{A}\cdot\vec{C})-\vec{C}(\vec{A}\cdot\vec{B})$

Cartesian Coordinate systems P(x, y, z)







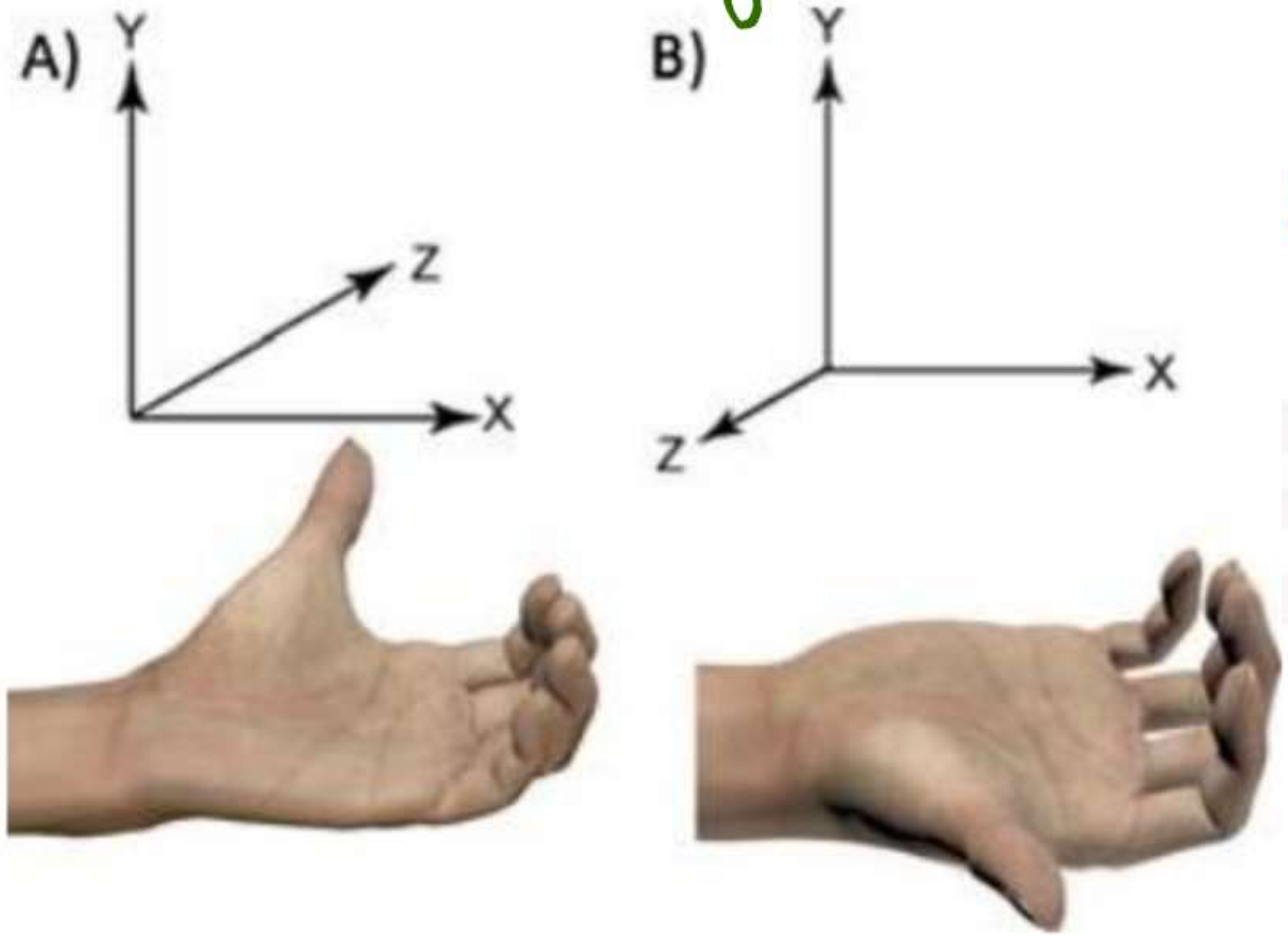
$$-\infty < x < \infty$$

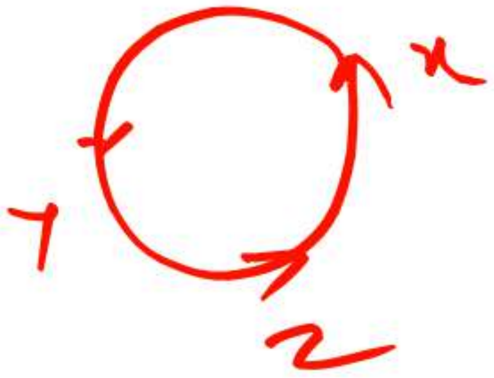
$$-\infty < y < \infty$$

$$-\infty < z < \infty$$

Left hand and right hand cartesian coordinate systems

By default





Righ hand co-ordinate system

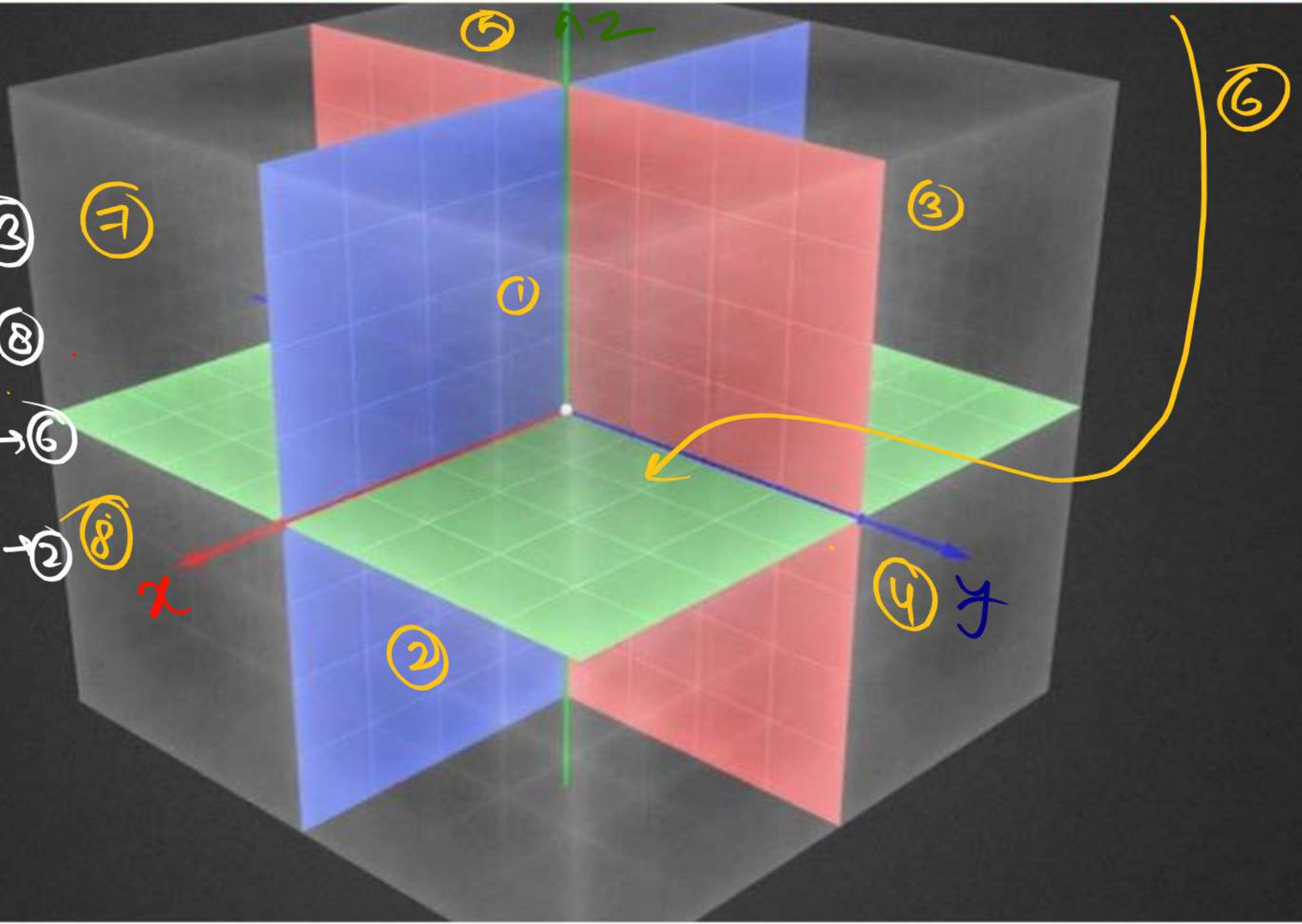
Points

A(-3, 1, 5) → 3

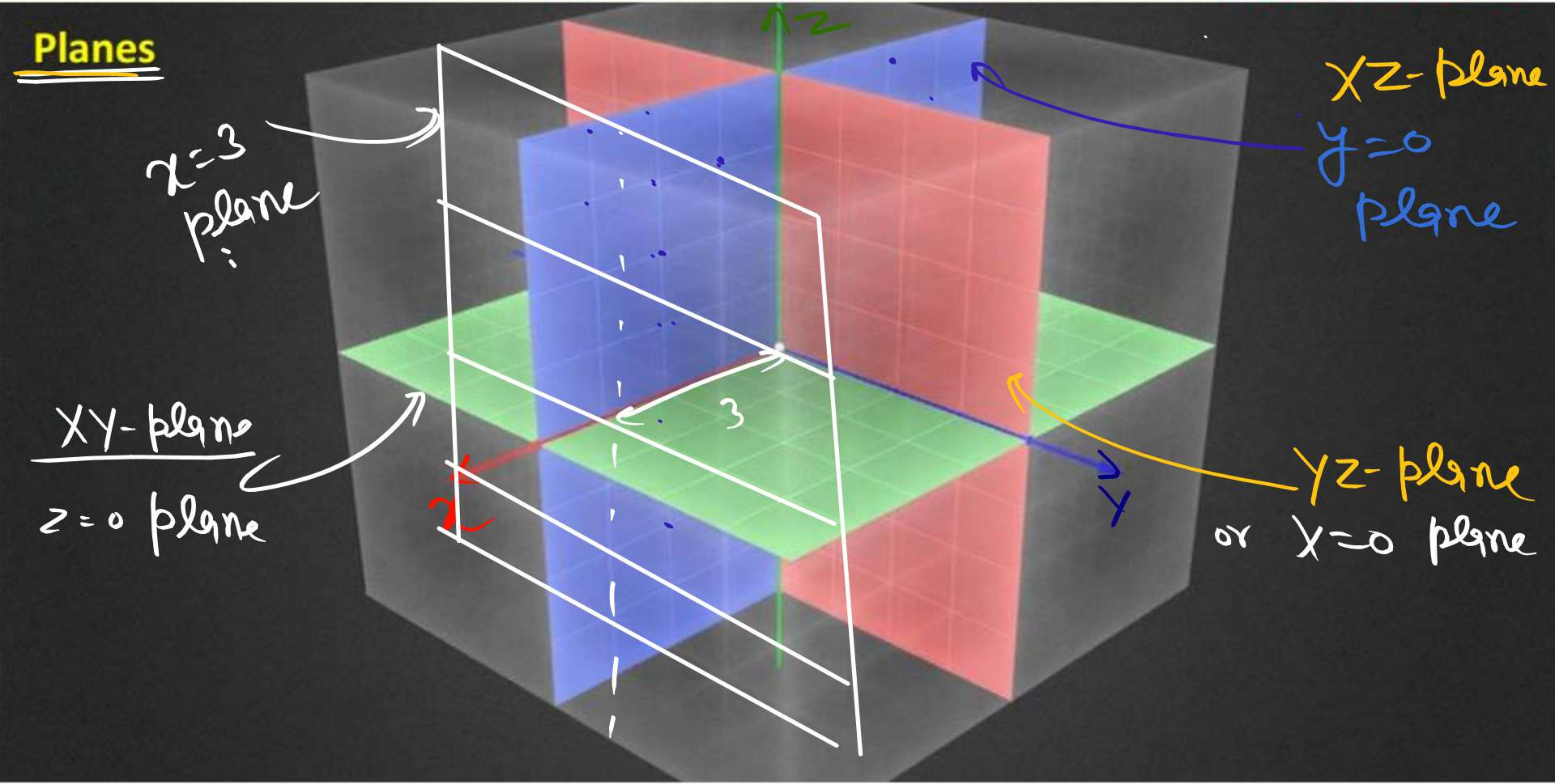
B(2, -1, -3) → 8

C(-2, -4, -1) → 6

D(2, 1, -4) → 2



Planes


Z
XZ-plane
y=0
plane
x=3
plane
3
XY-plane
z=0 plane
x
Y
YZ-plane
or X=0 plane

X = Constant

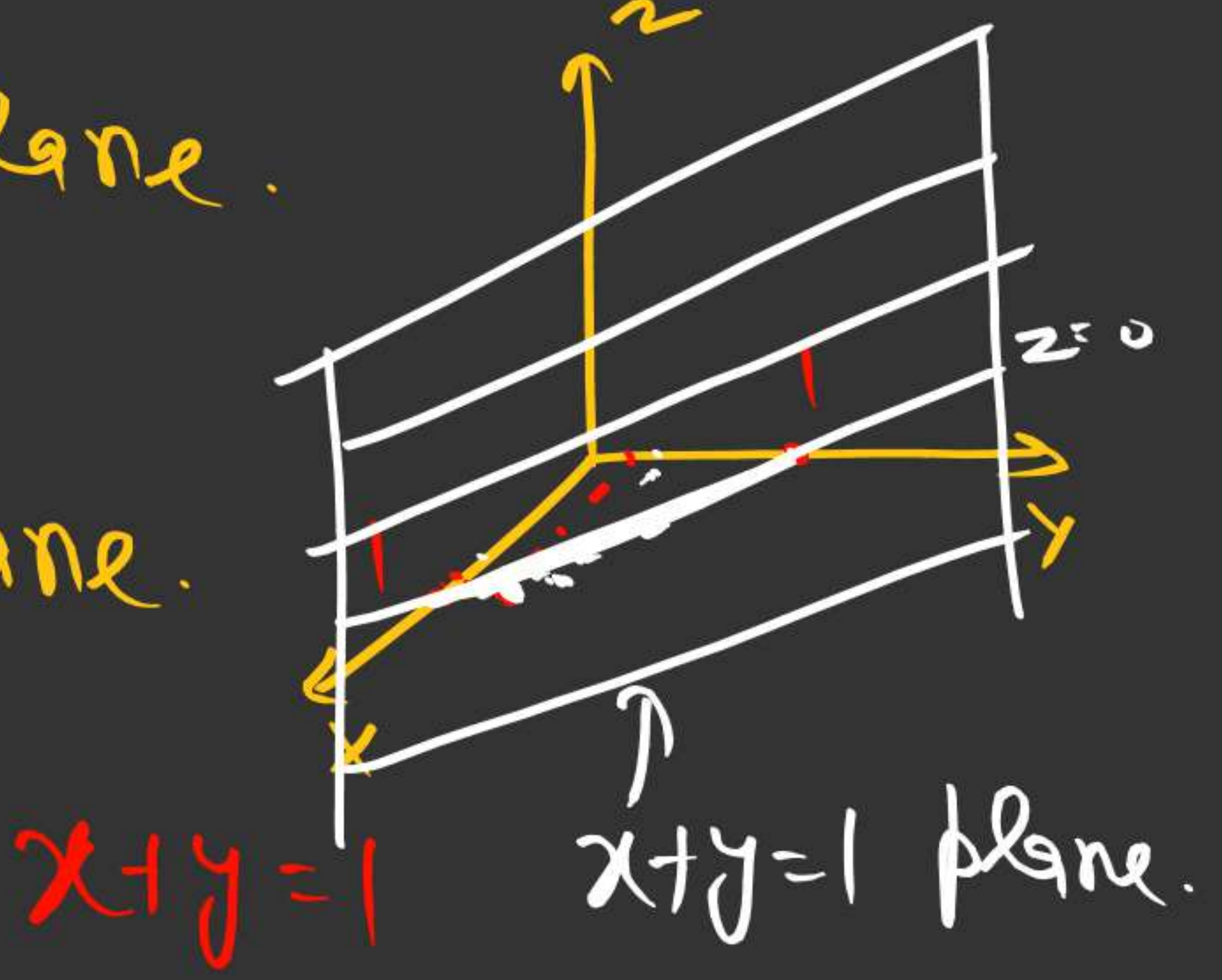
plane parallel to YZ - plane (X = 0) plane.

Y = Constant

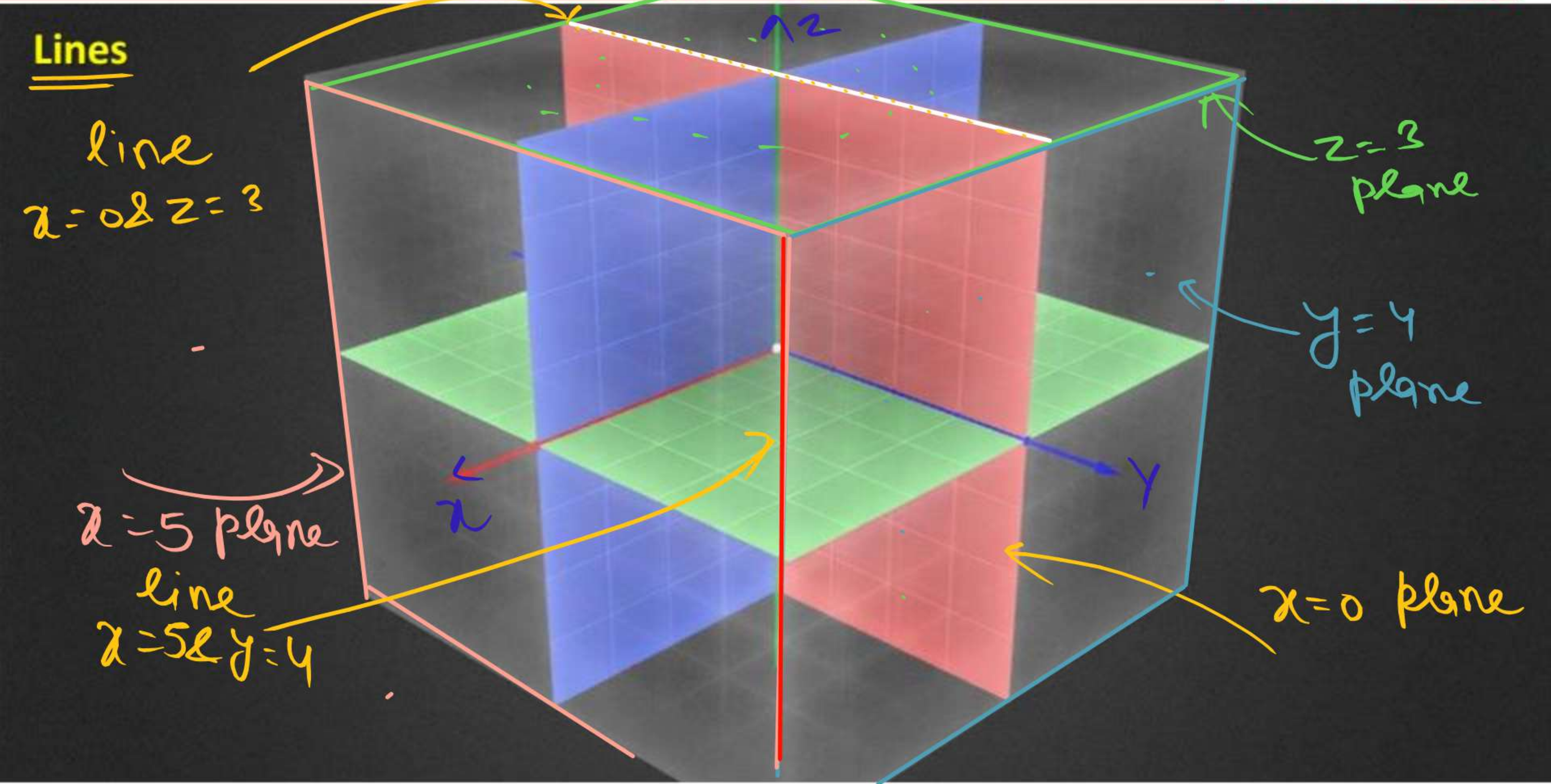
plane parallel to XZ - plane.

Z = Constant

plane parallel to XY - plane.



Lines



$x = r$ & $y = k$

$\rightarrow$ line parallel to z-axis.

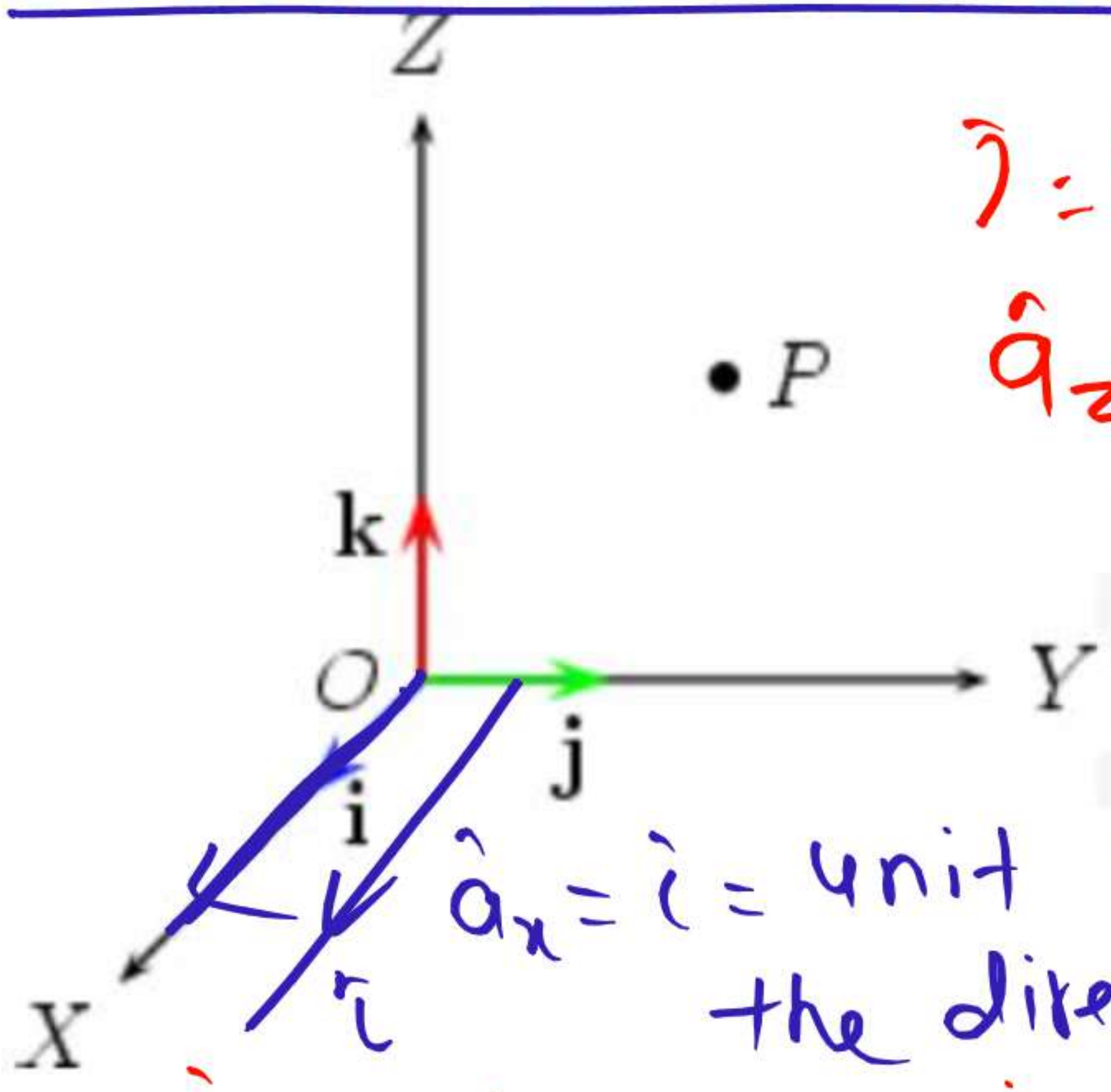
$x = p$ & $z = m$

$\rightarrow$ line parallel to y-axis.

$y = q$, $z = n$

$\Rightarrow$ line parallel to x-axis.

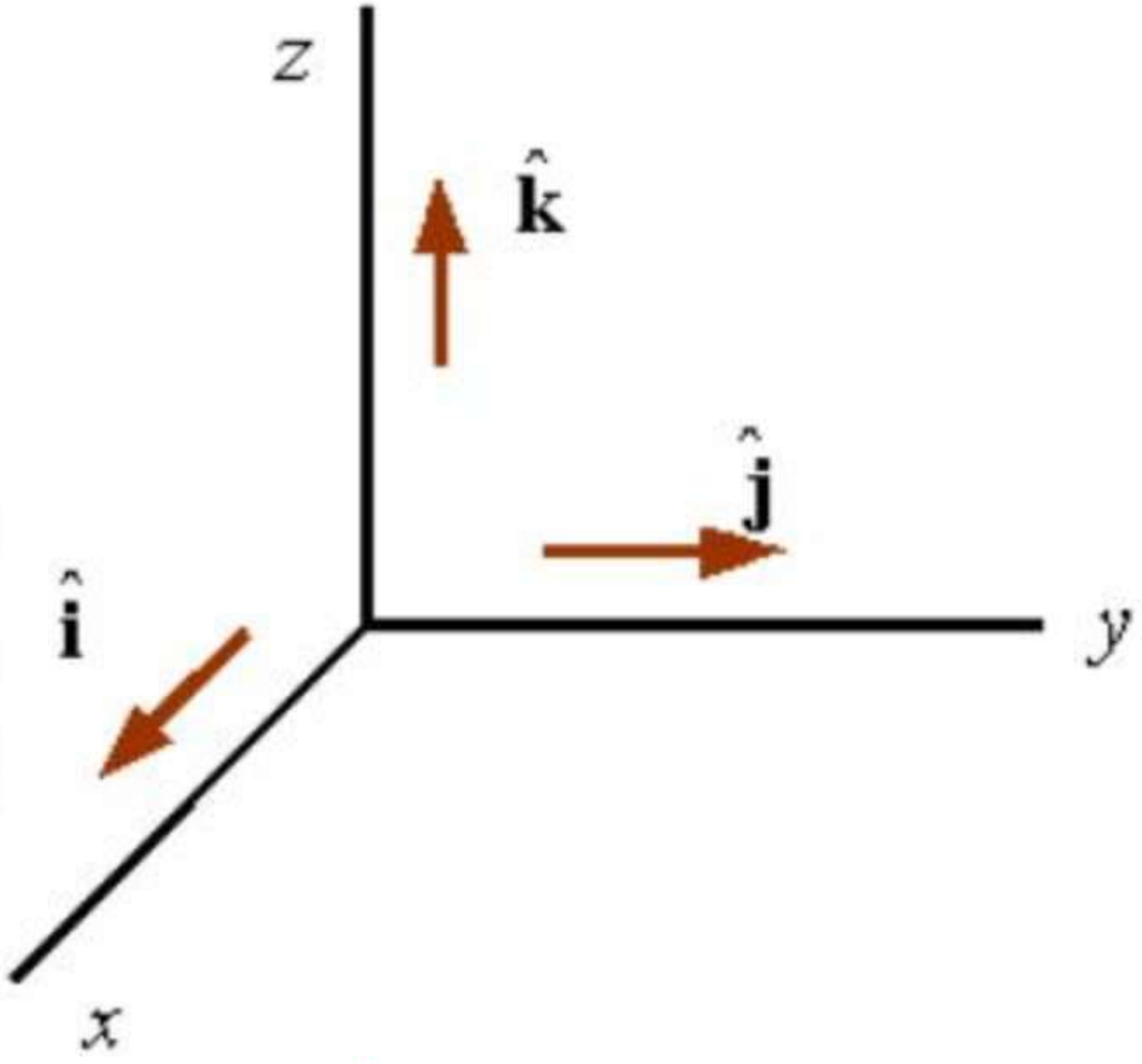
Unit vectors in cartesian coordinate systems



$\hat{j} = \hat{a}_y$

$\hat{a}_z = \hat{k}$

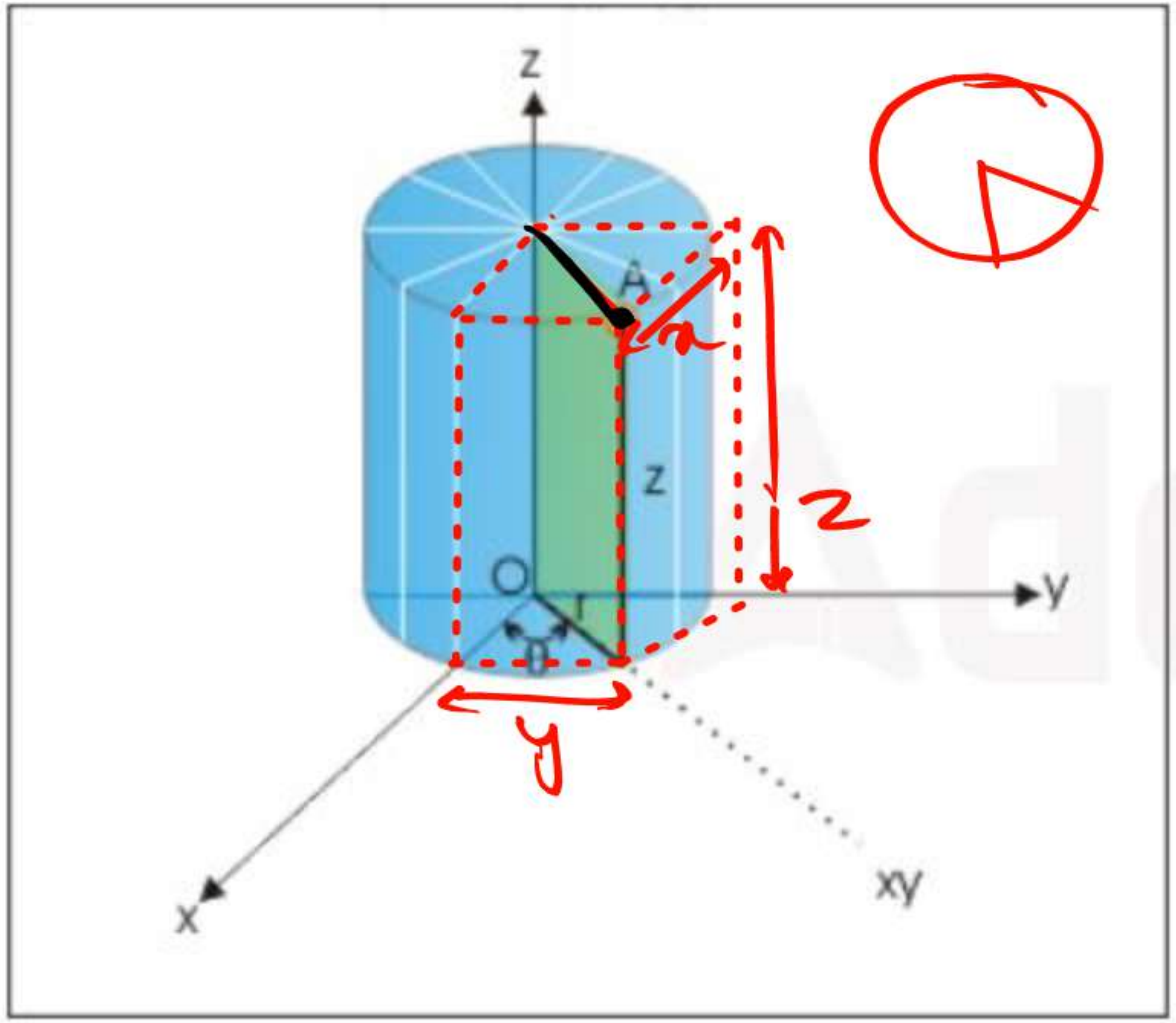
$\hat{a}_x = \hat{i}$ = unit vector in the direction of 'x'



$\hat{a}_x \rightarrow$ unit vector in the direction of increment of x with y & z fixed.

Cylindrical Coordinate systems P(ρ, ϕ, z)

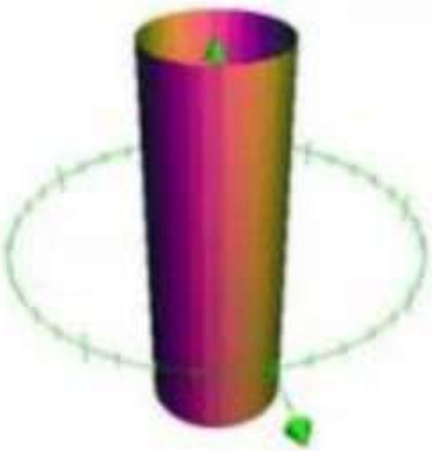
or 'r'



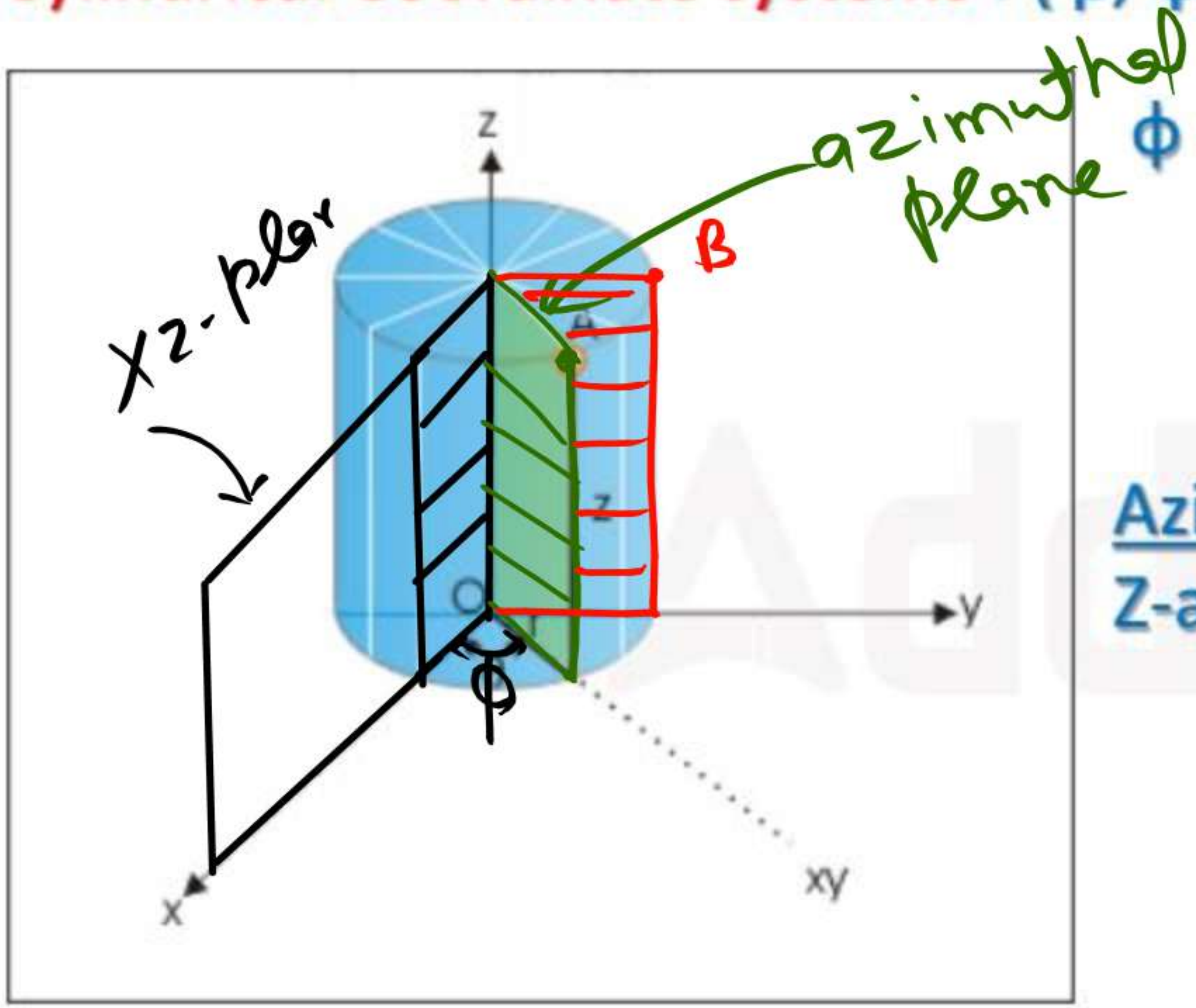
ρ = radius of cylinder passing through the point and centered around z axis

It is perpendicular distance of point from z-axis.

$0 \leq \rho < \infty$



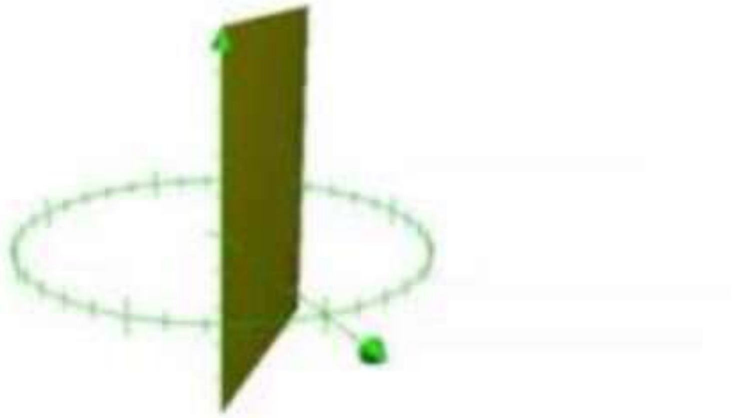
Cylindrical Coordinate systems P(ρ, $\bar{\phi}$, z)



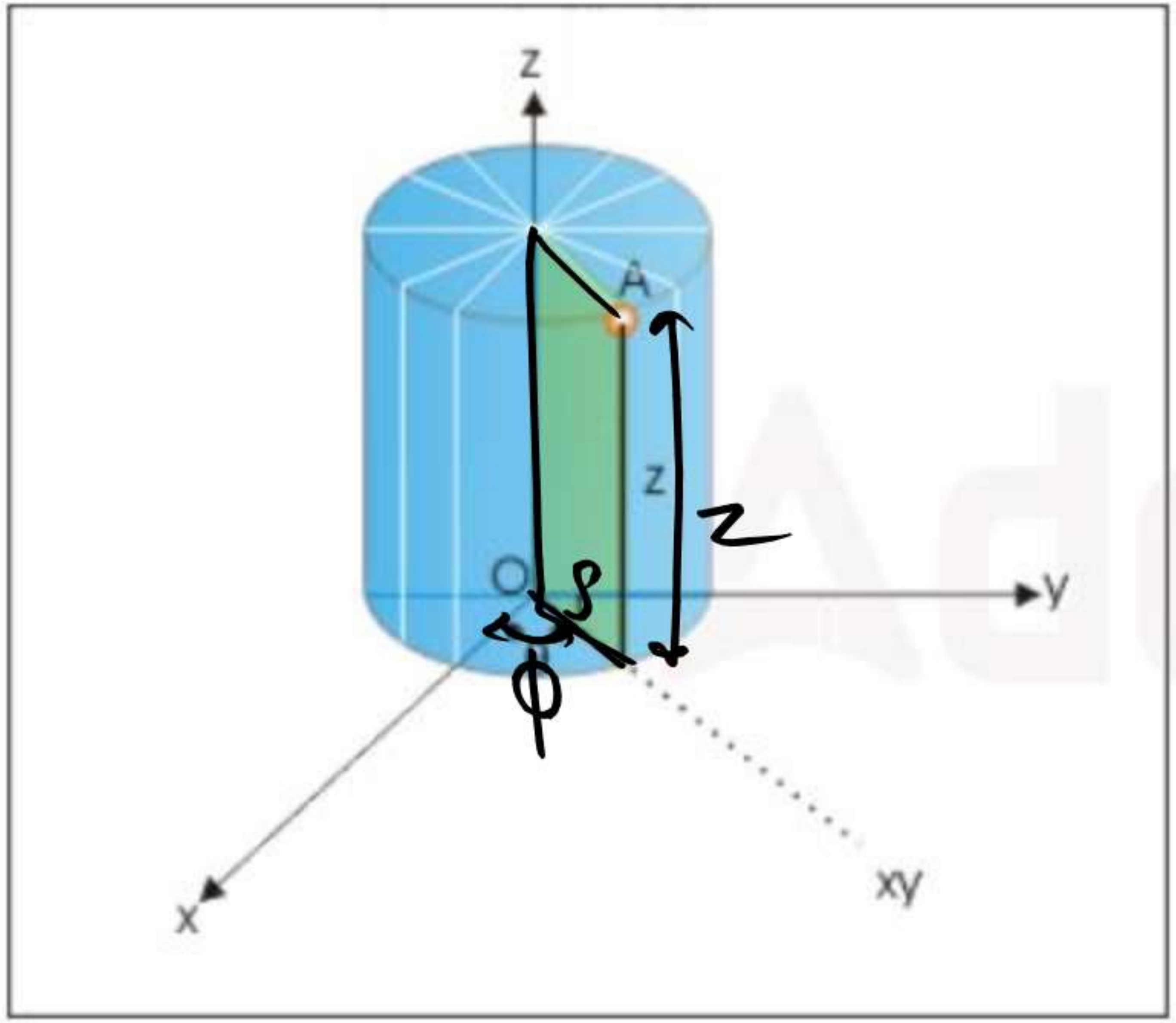
ϕ =Azimuthal angle

Angle of the azimuthal plane from XZ-plane

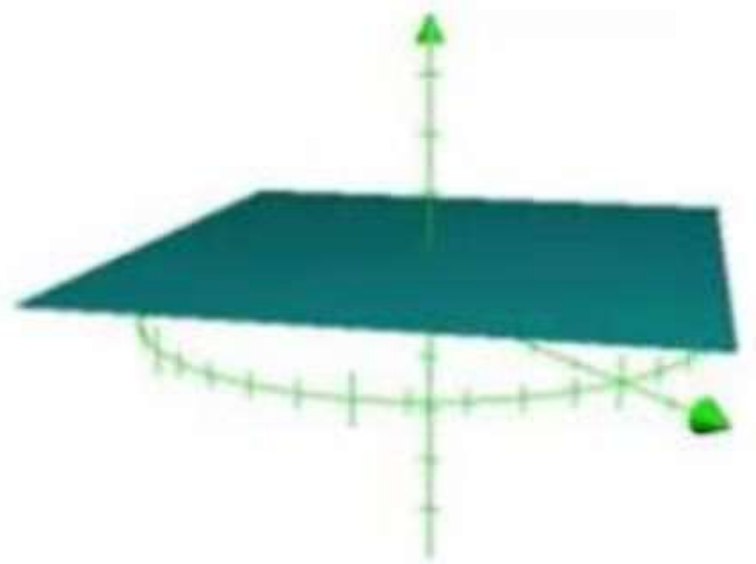
<u>Azimuthal plane</u>:- Imaginary plane passing from Z-axis and point of observation



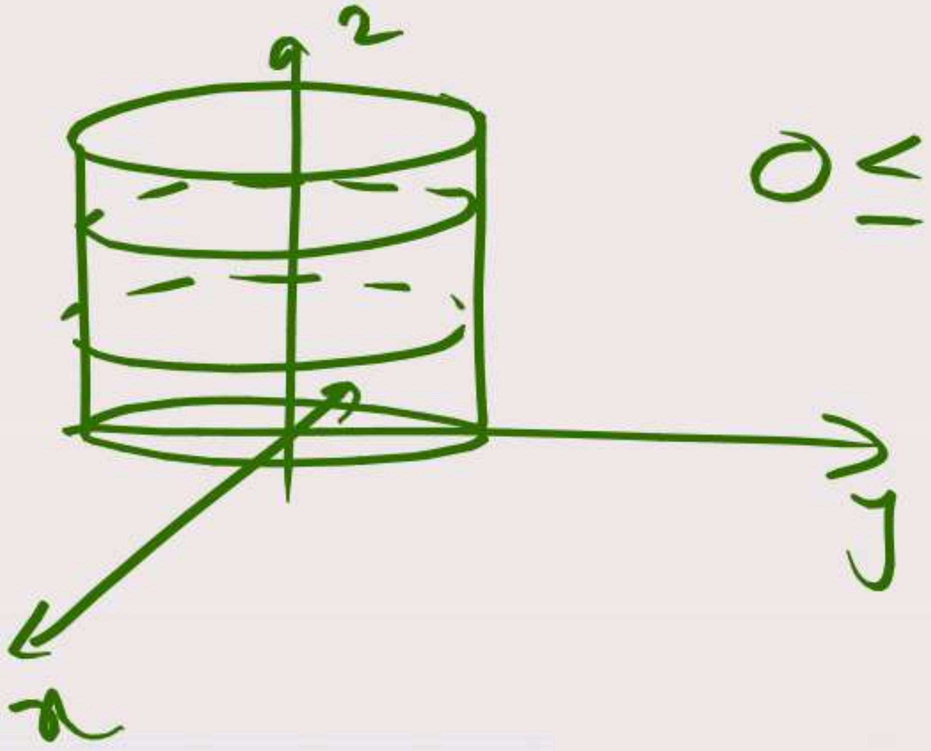
Cylindrical Coordinate systems P(ρ, ϕ, z)



z = Height

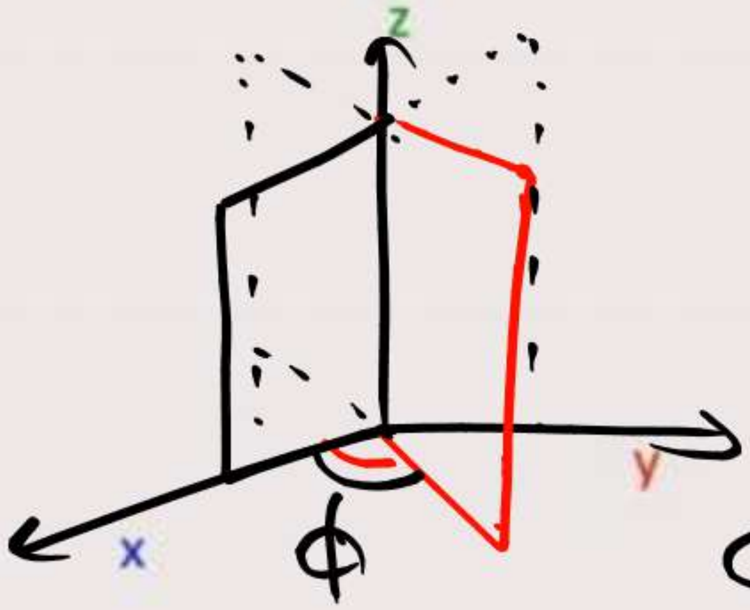


Cylindrical Coordinate System



$0 \le \rho < \infty$

Cylindrical Coordinate System

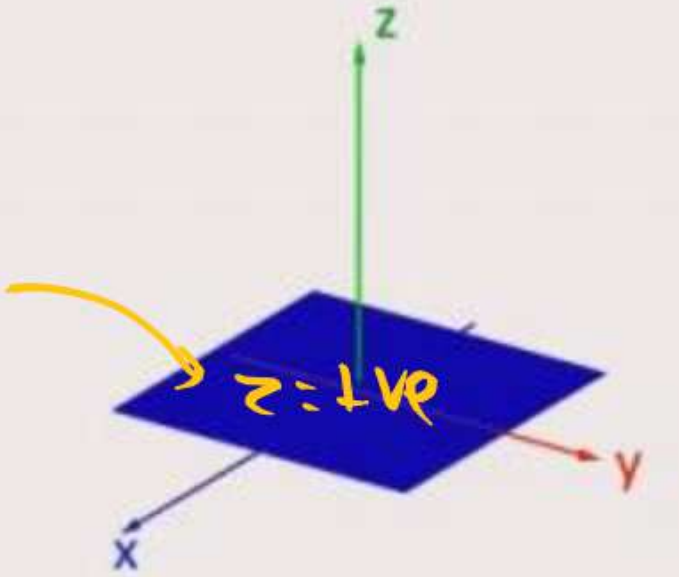


~~Constant r surface~~

~~R ≥ 0°~~

$0 \le \phi \le 2\pi$

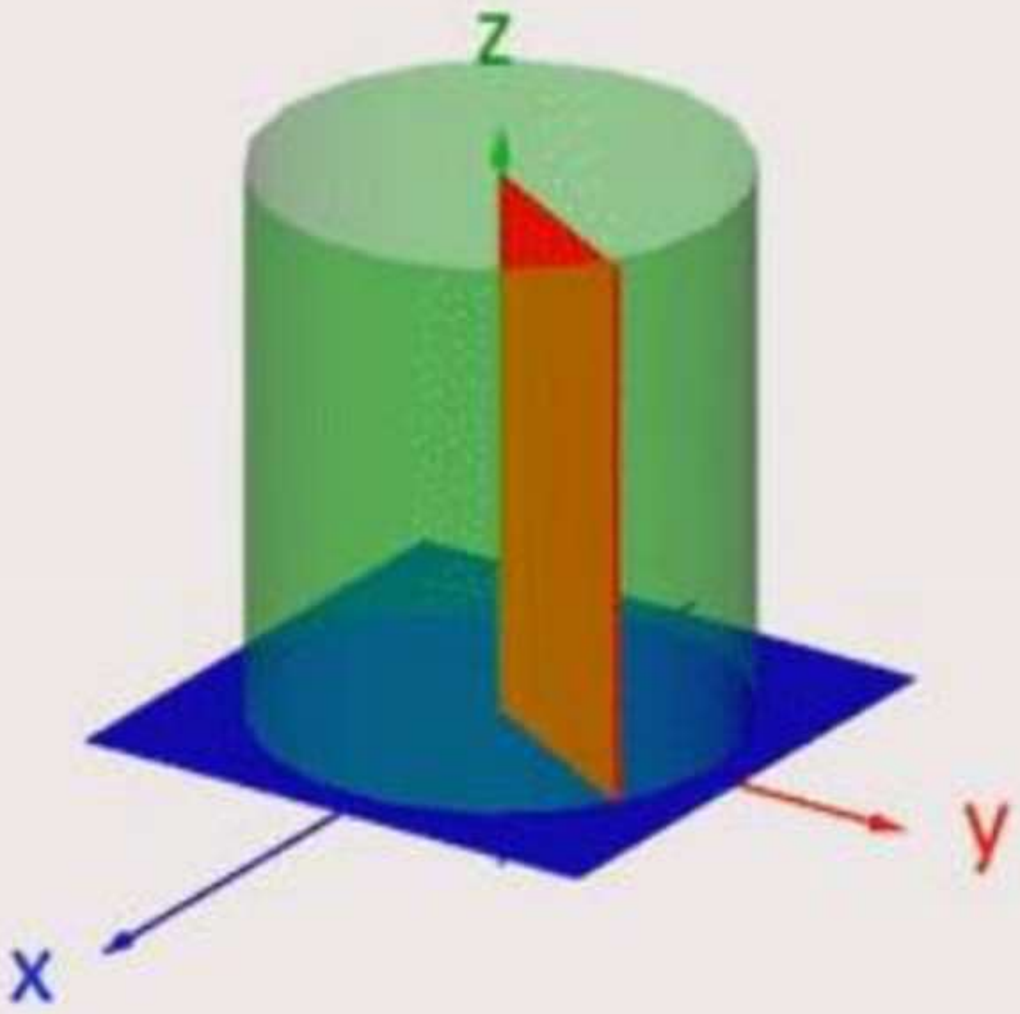
Cylindrical Coordinate System



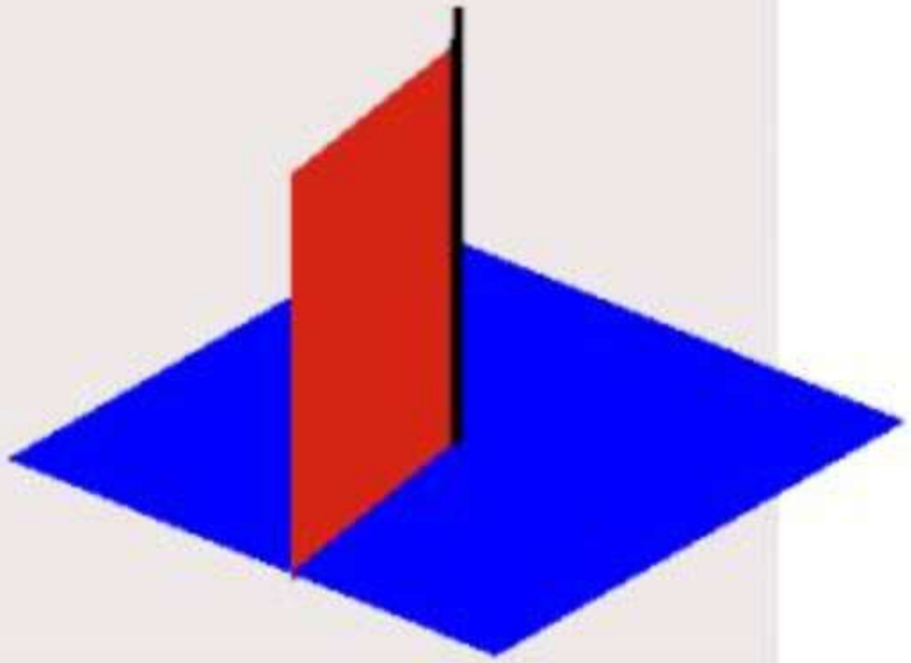
Constant z surface

$-\infty \le z \le +\infty$

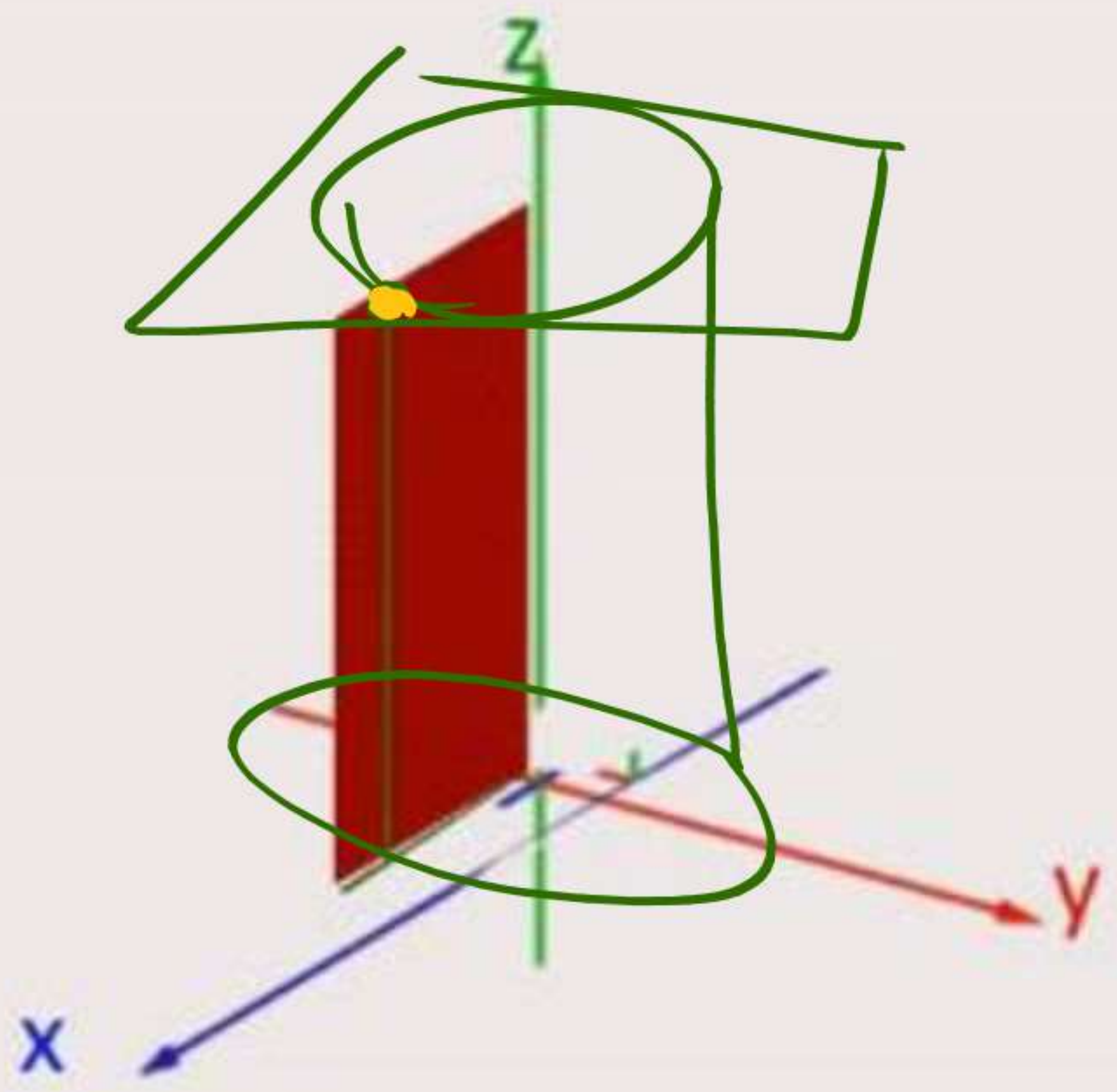
Cylindrical Coordinate System



Cylindrical coordinate system planes



Cylindrical Coordinate System



Point P

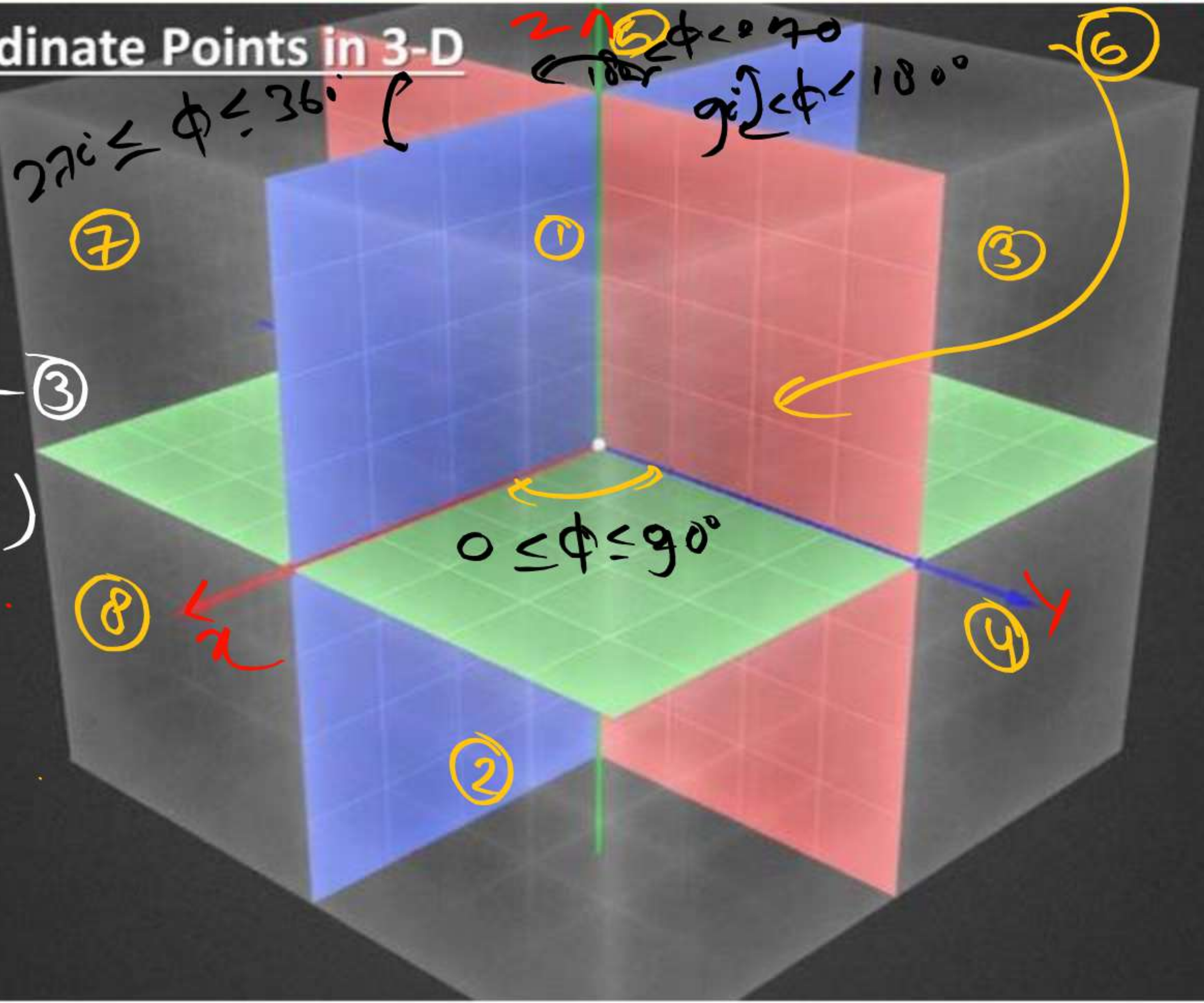
p(p, ϕ, z)

Cylindrical Coordinate Points in 3-D

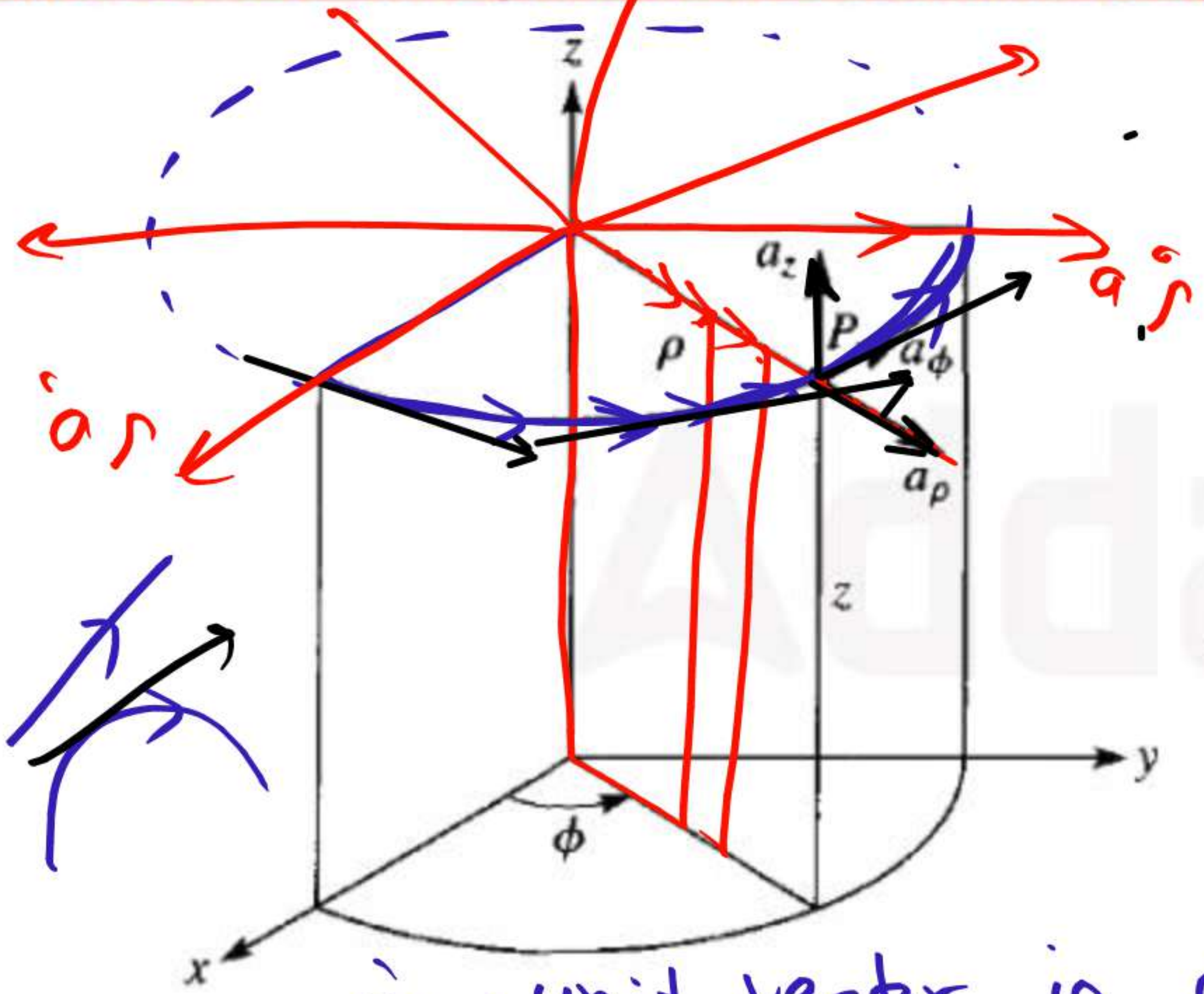
$A(3, 70°, -2) \rightarrow ②$

$B(2, 143°, 1) - ③$

$C(2, 315°, -7) \rightarrow ⑧$



Unit Vectors in cylindrical Coordinate systems

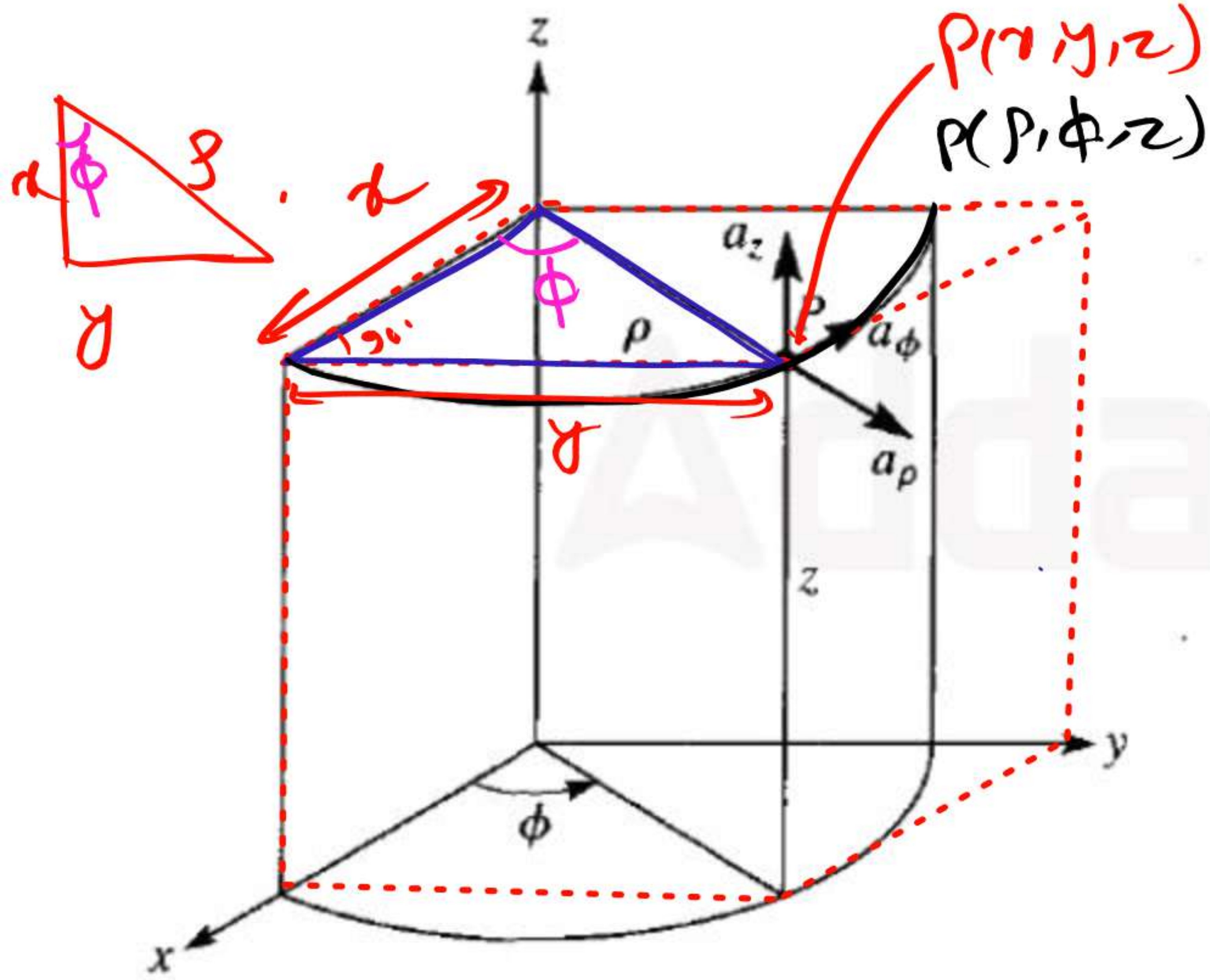


$\hat{a}_\rho$ = unit vector in the direction in which ρ increases & ϕ & z fixed.

$\hat{a}_\rho \rightarrow$ unit vector in radially outward direction from z-axis.

$\hat{a}_\phi \rightarrow$ unit vector in circular rotation around z-axis.

Interconversion of Coordinates in Cylindrical and cartesian



Cartesian to Cylindrical

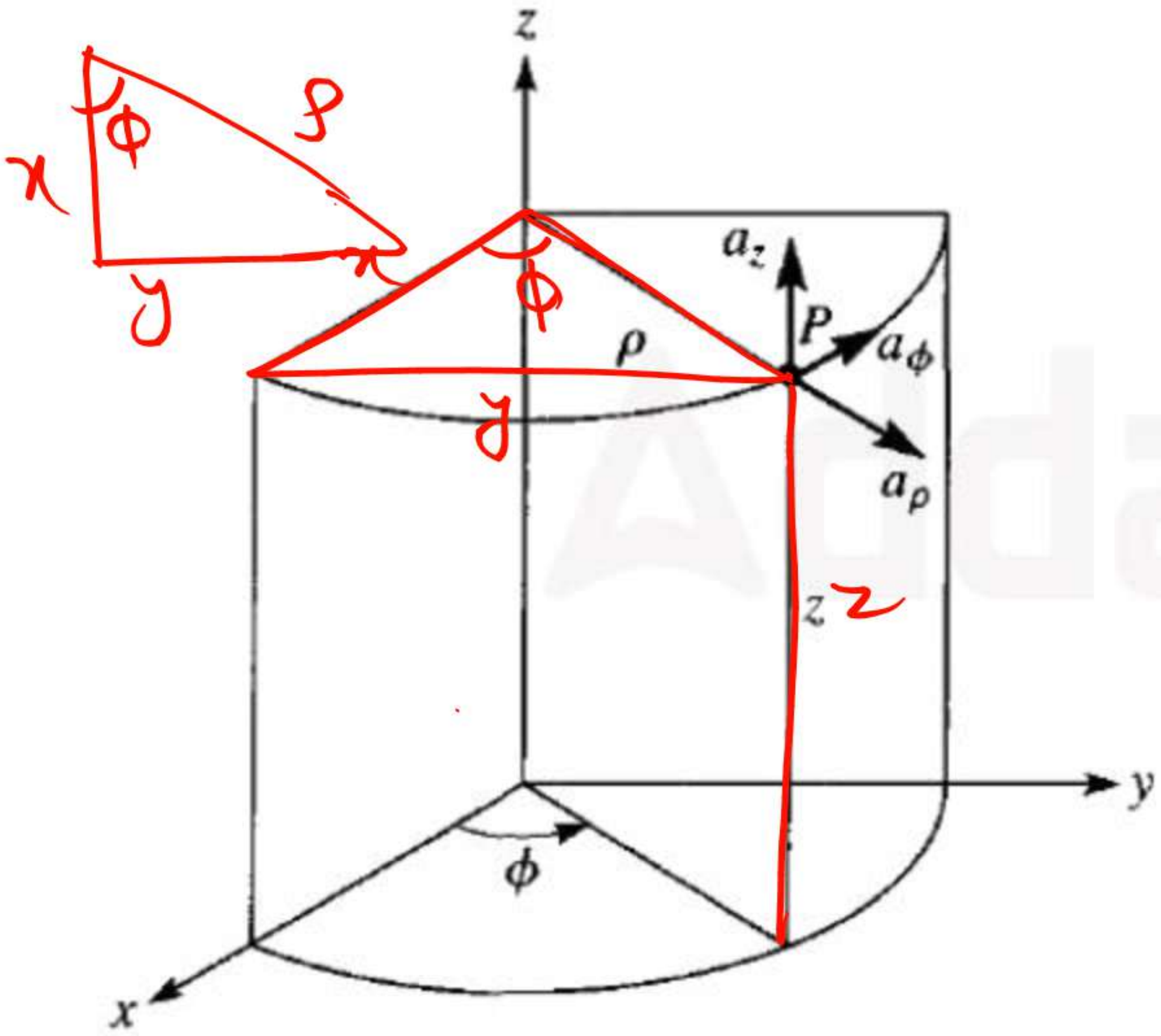
$$P(x, y, z) \longrightarrow P(\rho, \phi, z)$$

$$\rho = \sqrt{x^2 + y^2}$$

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

$$z = z$$

Interconversion of Coordinates in Cylindrical and cartesian



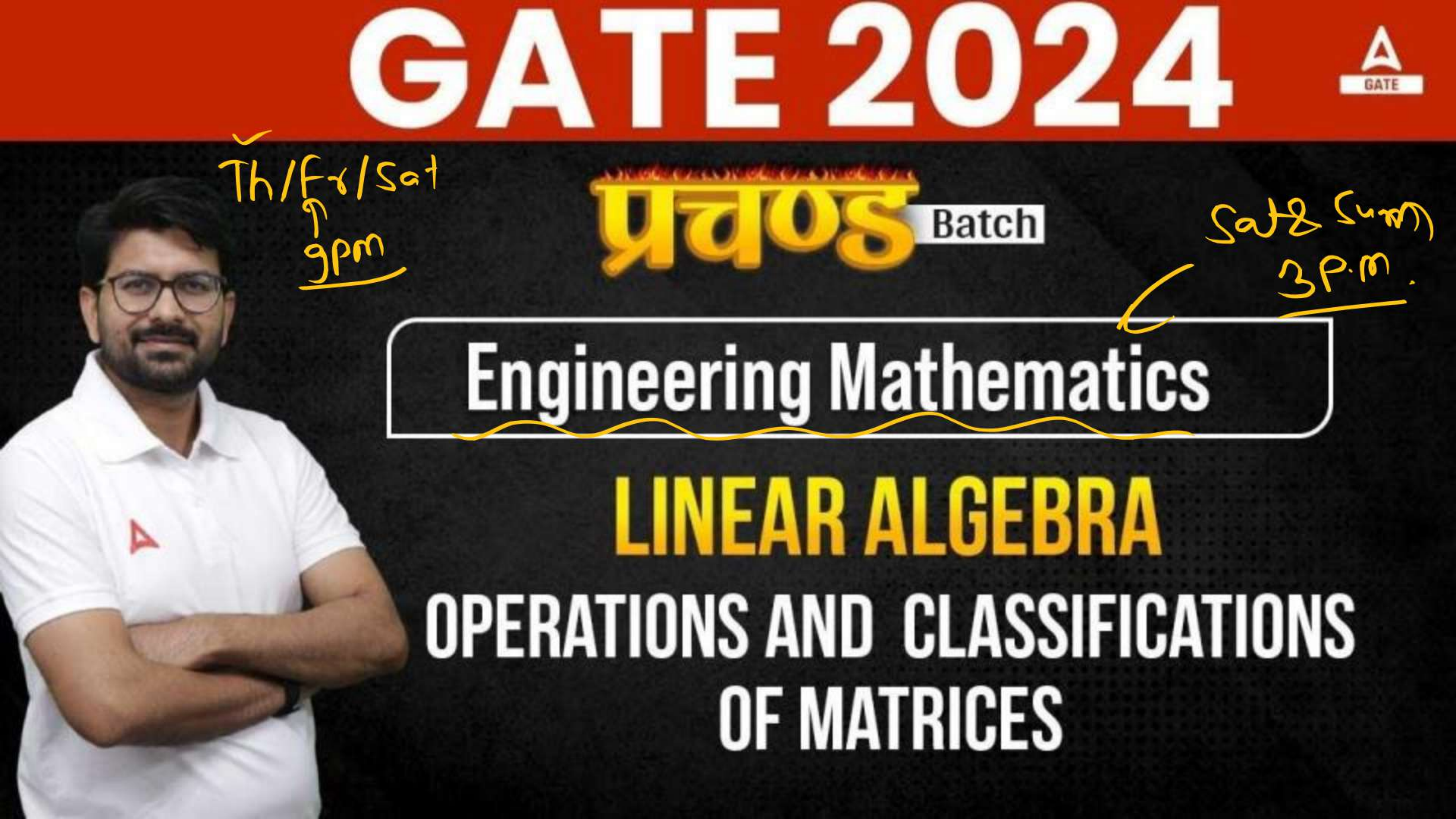
Cylindrical to Cartesian

$P(\rho, \phi, z) \longrightarrow P(x, y, z)$

$x = \rho \cos\phi$

$y = \rho \sin\phi$

$z = z$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