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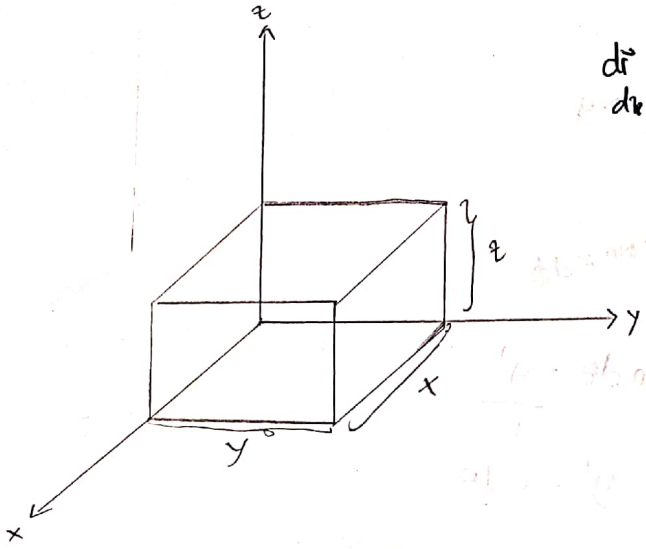
1) Koordinat Carterius (x, y, z)



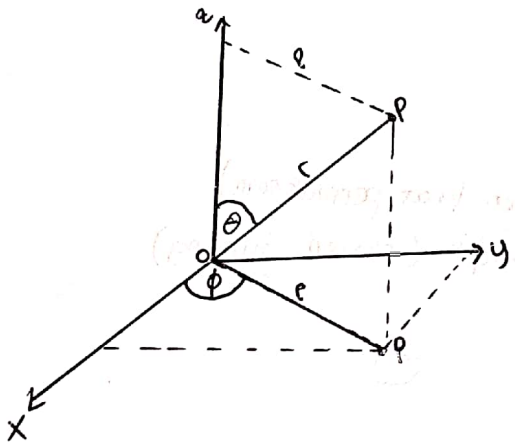
$d\vec{r} = \hat{i}\,dx + \hat{j}\,dy + \hat{k}\,dz$

$dv = dx\,dy\,dz$

- gradien : $\nabla t = \hat{i}\frac{\partial t}{\partial x} + \hat{j}\frac{\partial t}{\partial y} + \hat{k}\frac{\partial t}{\partial z}$
- Divergen : $\nabla \cdot \vec{V} = \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}$
- Rotasi : $\nabla \times \vec{V} = \hat{i}\left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z}\right) + \hat{j}\left(\frac{\partial V_x}{\partial z} - \frac{\partial V_z}{\partial x}\right) + \hat{k}\left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y}\right)$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ V_x & V_y & V_z \end{vmatrix}$$

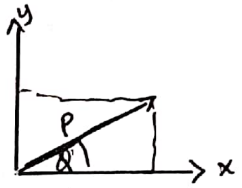
2) Sistem koordinat bola (r, ϕ, θ)



Persamaan koordinat bola

$x = \rho \cos\phi$
$\rightarrow x = r \sin\phi \cos\phi$
$y = \rho \sin\phi$
$\rightarrow y = r \sin\theta \sin\phi$
$z = r \cos\theta$

Analisis x y → bidang xy

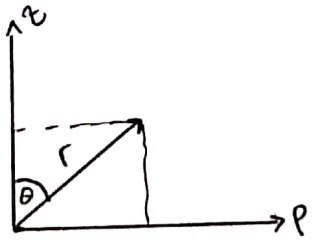


$\sin\phi = \frac{y}{\rho}$, $y = \rho \sin\phi$

$x = \rho \cos\phi$

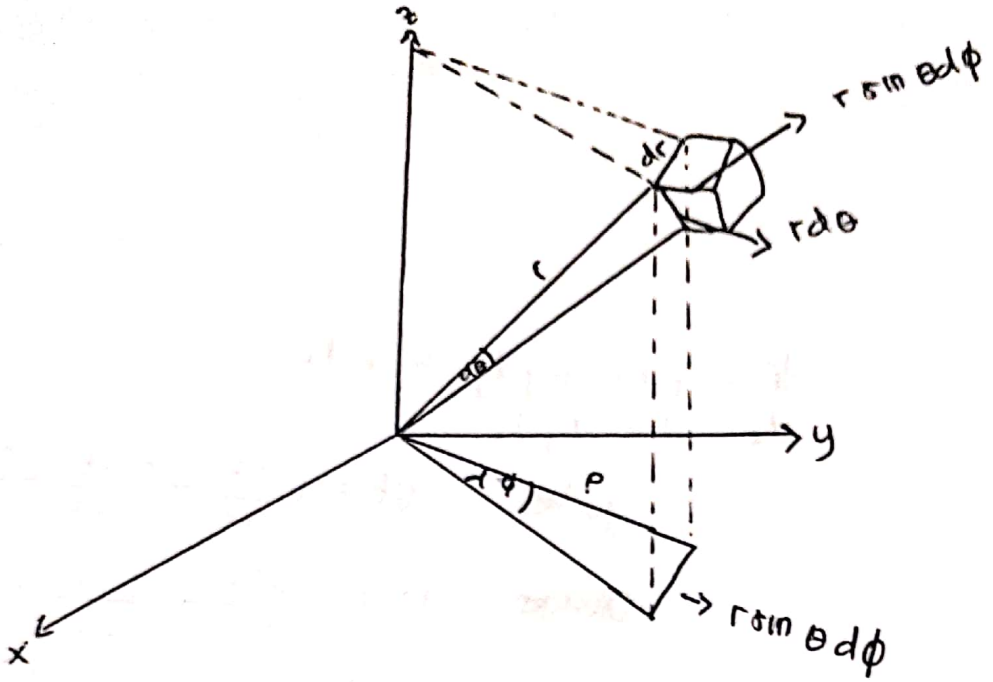
$z = z$

analisis zp bidang zp



$z = r \cos\theta$

$\rho = r \sin\theta$



$$\sin d\phi = \frac{x'}{\rho}$$

$$d\phi = \frac{x'}{r \sin\theta}$$

$$x' = r \sin\theta d\phi$$

$$\sin d\theta = \frac{y'}{r}$$

$$y' = r\, d\theta$$

maka, $dv = dr \cdot r d\theta \cdot r \sin\theta d\phi$

$dv = r^2 dr \sin\theta \, d\theta d\phi$ (elemen volume)

$\Rightarrow dv = r^2 \sin\theta \, dr d\theta d\phi$

$d\Delta = r d\theta \, r \sin\theta d\phi$

$\Rightarrow d\Delta = r^2 \sin\theta \, d\theta \, d\phi$ (elemen luar permukaan)

$\Rightarrow de^2 = dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta \, d\phi^2$ (elemen panjang)