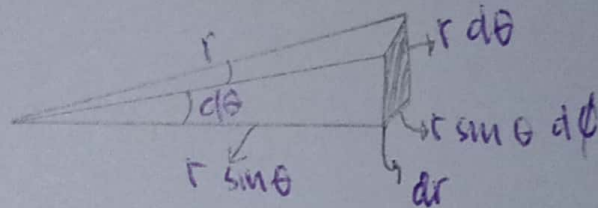
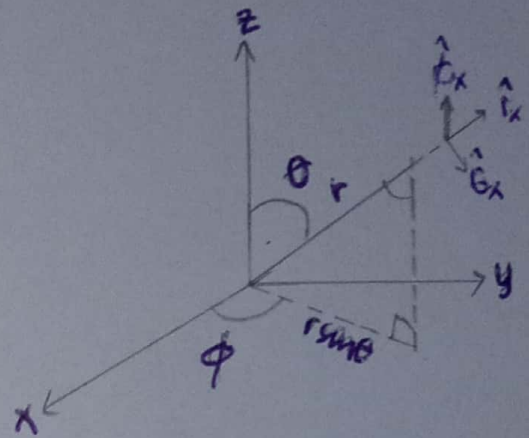
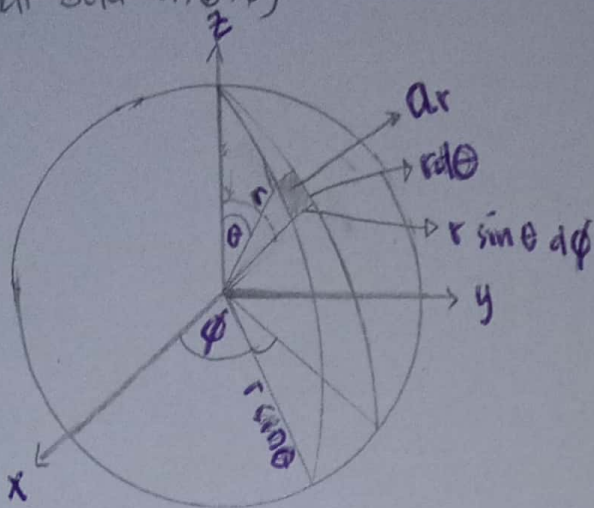


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1) Koordinat Bola (r, θ, ϕ)



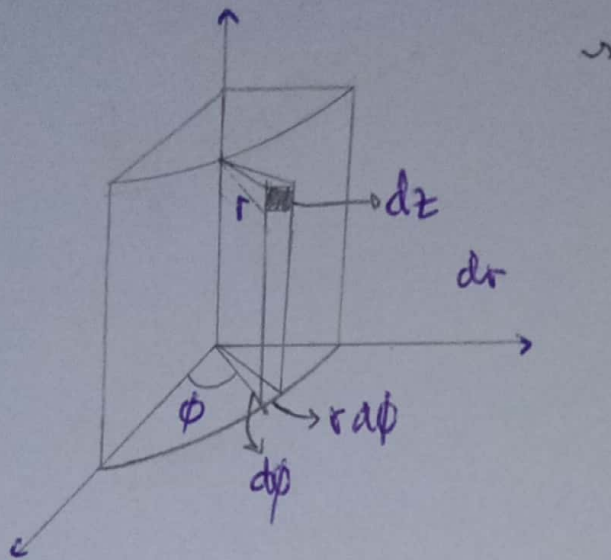
$$\begin{aligned} \sim d\vec{s} &= \vec{r} \times \vec{r} \\ &= r \sin \theta d\phi \cdot r d\theta \\ &= r^2 \sin \theta d\phi d\theta \text{ (luas)} \end{aligned}$$

$$\begin{aligned} \sim dV &= \vec{r} \times \vec{r} \times \vec{r} \\ &= r \sin \theta d\phi \cdot r d\theta \cdot dr \\ &= r^2 \sin \theta d\phi d\theta dr \text{ (volume)} \end{aligned}$$

$$\rightarrow \text{Gradien : } \nabla \phi = \hat{r} \frac{\partial \phi}{\partial r} + \hat{\theta} \left(\frac{1}{r} \frac{\partial \phi}{\partial \theta} \right) + \hat{\phi} \left(\frac{1}{r \sin \theta} \frac{\partial \phi}{\partial \phi} \right)$$

$$\begin{aligned} \rightarrow \text{Divergensi : } \nabla \cdot \vec{v} &= \frac{1}{r^2} \left(\frac{\partial}{\partial r} r^2 v_r \right) + \frac{1}{r \sin \theta} \frac{\partial}{\partial \theta} (v_\theta \sin \theta) \\ &\quad + \frac{1}{r \sin \theta} \frac{\partial v_\phi}{\partial \phi} \end{aligned}$$

2. Koordinat Silinder (r, ϕ, z)



$$\sim d\hat{r} = \hat{r}dr + \hat{\phi}r d\phi + \hat{z}dz$$

$$\sim dG = r dr d\phi dz$$

$$\sim \text{Gradien} \Rightarrow \nabla \phi = \hat{r} \left(\frac{\partial \phi}{\partial r} \right) + \hat{\phi} \left(\frac{1}{r} \frac{\partial \phi}{\partial \phi} \right) + \hat{z} \left(\frac{\partial \phi}{\partial z} \right)$$

$$\sim \text{Divergen} \Rightarrow \nabla \cdot \vec{v} = \frac{1}{r} \frac{\partial}{\partial r} (r v_r) + \frac{1}{r} \frac{\partial v_\phi}{\partial \phi} + \frac{\partial v_z}{\partial z}$$