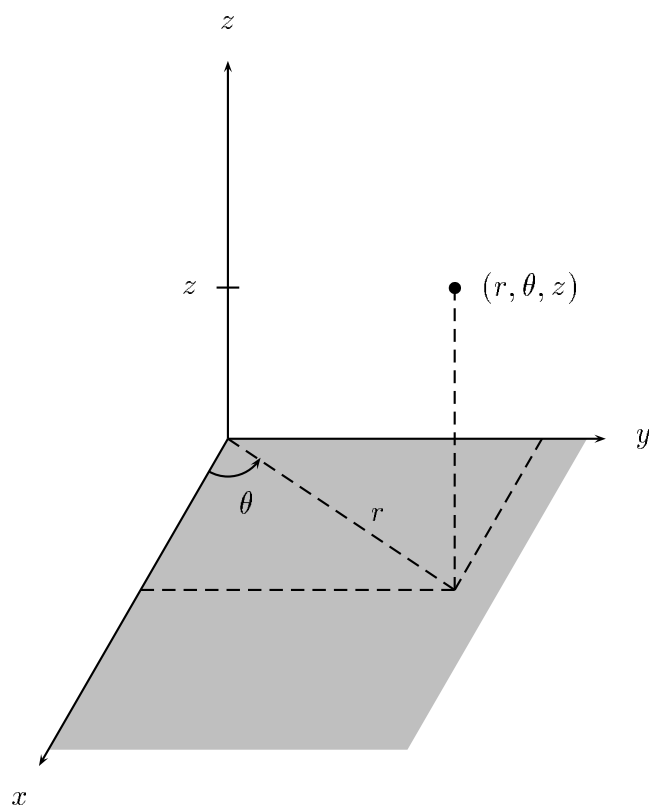


# Cylindrical Coordinates



$$\begin{aligned}x &= r \cos \theta \\y &= r \sin \theta \\z &= z\end{aligned}$$

$$\begin{aligned}r^2 &= x^2 + y^2 \\ \tan \theta &= y/x \\ z &= z\end{aligned}$$

$$\begin{aligned}\hat{i} &= \cos \theta \hat{r} - \sin \theta \hat{\theta} \\ \hat{j} &= \sin \theta \hat{r} + \cos \theta \hat{\theta} \\ \hat{k} &= \hat{k}\end{aligned}$$

$$\begin{aligned}\hat{r} &= \cos \theta \hat{i} + \sin \theta \hat{j} \\ \hat{\theta} &= -\sin \theta \hat{i} + \cos \theta \hat{j} \\ \hat{k} &= \hat{k}\end{aligned}$$

$$d\vec{s} = dr \hat{r} + r d\theta \hat{\theta} + dz \hat{k}; \quad dV = r dr d\theta dz$$

$$\nabla f = \frac{\partial f}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \hat{\theta} + \frac{\partial f}{\partial z} \hat{k}$$

$$\nabla \cdot \vec{v} = \frac{1}{r} \frac{\partial}{\partial r} (rv_r) + \frac{1}{r} \frac{\partial v_\theta}{\partial \theta} + \frac{\partial v_z}{\partial z}$$

$$\nabla \times \vec{v} = \left[ \frac{1}{r} \frac{\partial v_z}{\partial \theta} - \frac{\partial v_\theta}{\partial z} \right] \hat{r} + \left[ \frac{\partial v_r}{\partial z} - \frac{\partial v_z}{\partial r} \right] \hat{\theta} + \frac{1}{r} \left[ \frac{\partial}{\partial r} (rv_\theta) - \frac{\partial v_r}{\partial \theta} \right] \hat{k}$$

$$\nabla^2 f = \frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial f}{\partial r} \right) + \frac{1}{r^2} \frac{\partial^2 f}{\partial \theta^2} + \frac{\partial^2 f}{\partial z^2}$$