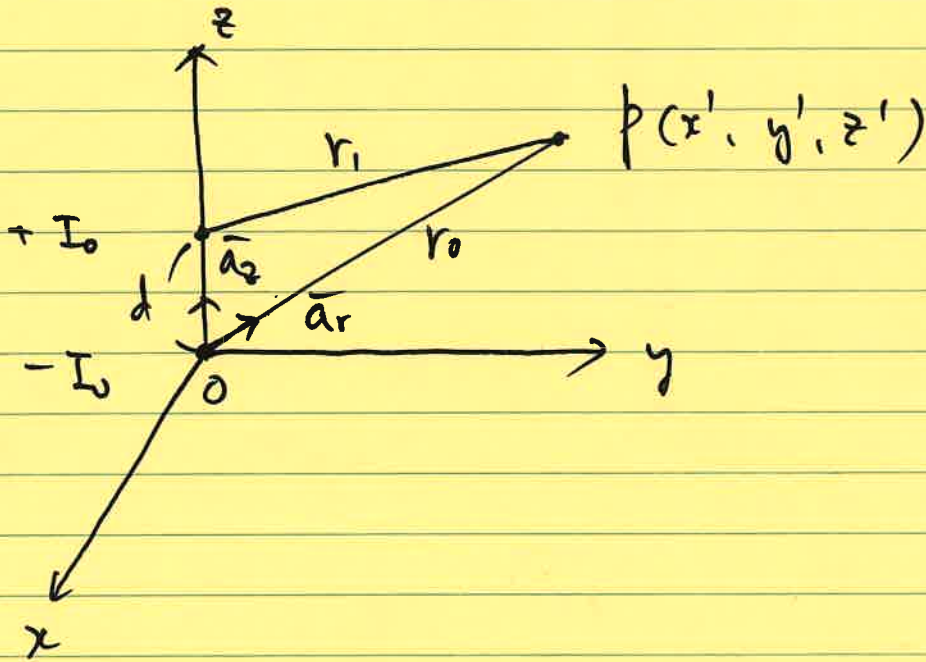


①

Dipole field



$$\phi(x', y', z') = -\frac{Q_0}{4\pi\epsilon_0} \frac{1}{r_0} + \frac{Q_0}{4\pi\epsilon_0} \frac{1}{r_1}$$

$$\frac{1}{r_1} = \frac{1}{r_0} + \frac{\partial}{\partial z} \left(\frac{1}{r} \right) \cdot d \quad : \text{ Taylor series expansion of } \frac{1}{r_1}$$

$$\phi = \frac{Q_0}{4\pi\epsilon_0} \frac{\partial}{\partial z} \left(\frac{1}{r} \right) d$$

$$= \frac{Q_0}{4\pi\epsilon_0} \left[\nabla \left(\frac{1}{r} \right) \cdot \vec{a}_z \right] d$$

$$= \frac{Q_0}{4\pi\epsilon_0} \nabla \left(\frac{1}{r} \right) \cdot \vec{d}$$

(2)

$$I_0 d = p \quad , \quad I_0 \vec{d} = \vec{p}$$

\Rightarrow dipole moment

$$\phi = \frac{1}{4\pi\epsilon_0} \nabla \left(\frac{1}{r} \right) \cdot \vec{p}$$

$$= \frac{1}{4\pi\epsilon_0} \frac{\vec{a}_r}{r^2} \cdot \vec{p}$$

$$= \frac{p}{4\pi\epsilon_0} \cdot \frac{\cos\theta}{r^2}$$