$$\bar{E}(z) = \frac{\overset{\swarrow\, 2\pi b \rho_\ell}{Q}}{4\pi\varepsilon_0} \cdot \frac{z}{\sqrt{z^2+b^2}^{\,3}}\, \bar{a}_z$$

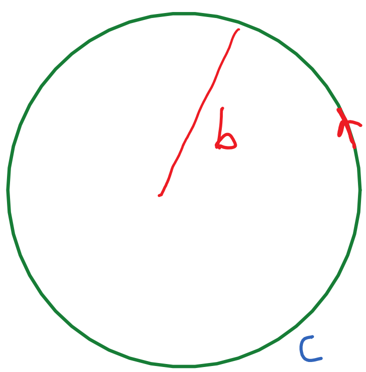
$$\bar{E}(0) = 0$$

$z \gg b$

$z > 0$

$$\bar{E}(z) = \frac{Q}{4\pi\varepsilon_0 z^2}\, \bar{a}_z$$

$$\nabla \times \bar{E} = \cancel{-\frac{\partial \bar{B}}{\partial t}} = 0$$



c

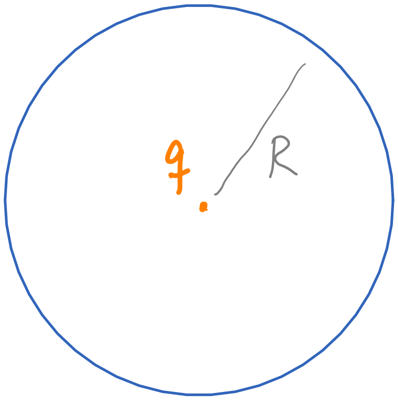
$$d\bar{l} = \bar{a}_\phi \overbrace{b\, d\phi}^{dl}$$

$$\oint d\bar{l} = b \int_0^{2\pi} \bar{a}_\phi\, d\phi = 0$$

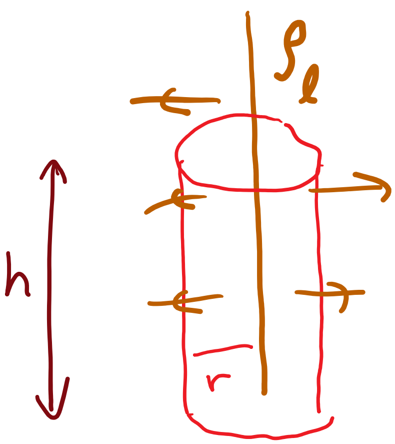
$$\oint dl = \int_0^{2\pi} b\, d\phi = b \int_0^{2\pi} d\phi = 2\pi b$$

$\varepsilon_0 \qquad \bar{D}(\bar{R}) = \varepsilon_0 \bar{E}(\bar{r})$

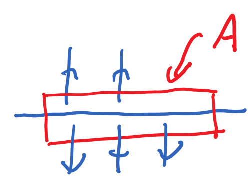
$\nabla \cdot \bar{D} = \rho_v$

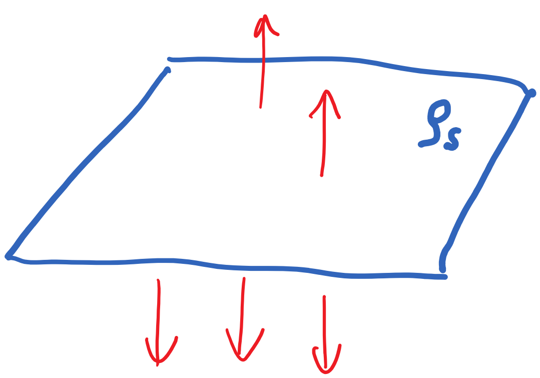


$$\bar{D}(\bar{R}) = \frac{q}{4\pi R^2}\,\bar{a}_R$$



$$\bar{D} = \frac{\rho_\ell h}{2\pi r h}\,\bar{a}_r = \frac{\rho_\ell}{2\pi r}\,\bar{a}_r$$





$$\bar{D} = \frac{\rho_s A}{2A}\,(\pm\bar{a}_z)$$

$$= \frac{\rho_s}{2}\,(\pm\bar{a}_z)$$

$$\int \nabla \cdot \bar{D}\, dV = \oint \bar{D} \cdot d\bar{S}$$

S_v

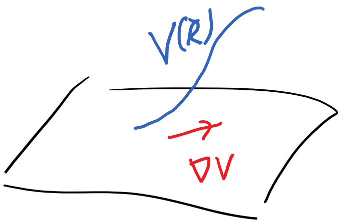
$\nabla \times \bar{E} = 0$ (STATICS)

$\uparrow$

$-\nabla V$

$$\underset{V/m}{\bar{E}(\bar{R})} = -\overset{1/m}{\nabla}\, \overset{V}{V(\bar{R})}$$

SCALAR POTENTIAL

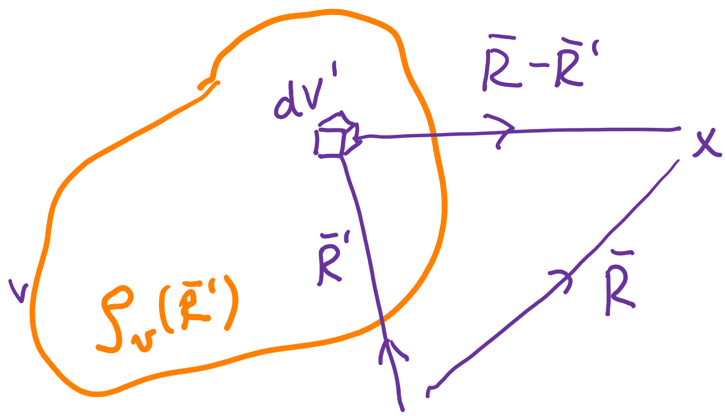


q MONOPOLE

$$\bar{E}_m = \frac{q}{4\pi\epsilon_0 R^2}\,\bar{a}_R = -\nabla V_m = -\bar{a}_R \frac{dV_m}{dR}$$

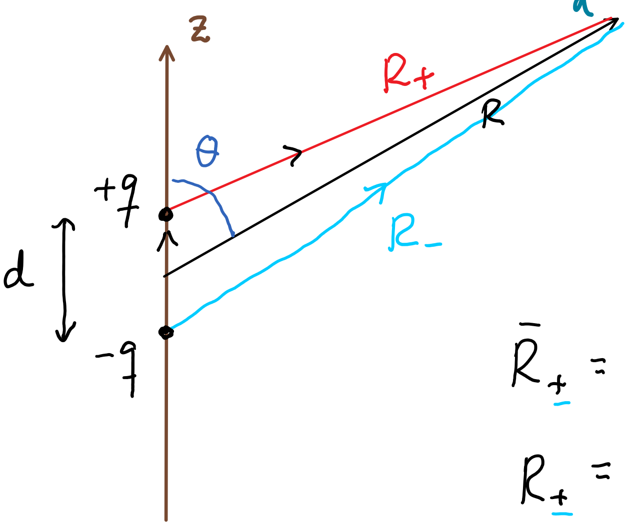
$$-\frac{d}{dR} R^{-1} = +R^{2}$$

$$V_m = \frac{q}{4\pi\epsilon_0 R}$$



$$V(\bar{R}) = \int_v \frac{\rho_v(\bar{R}')\,dv'}{4\pi\epsilon_0\,|\bar{R}-\bar{R}'|}$$

DIPOLE



$$V_d(\bar{R}) = ?$$

$$V_d(R) = V_+ + V_-$$

$$V_+ = \frac{q}{4\pi\varepsilon_0 R_+}$$

$$\bar{R}_{\pm} = \bar{R} \mp \bar{a}_z \frac{d}{2}$$

$$R_{\pm} = \sqrt{\bar{R}_{\pm}\cdot\bar{R}_{\pm}} = \sqrt{\left(\bar{R} \mp \bar{a}_z \frac{d}{2}\right)\cdot\left(\bar{R} \mp \bar{a}_z \frac{d}{2}\right)}$$

$$= \sqrt{R^2 \mp \underbrace{\bar{R}\cdot\bar{a}_z}_{R\cos\theta} \frac{d}{\cancel{2}}\cancel{2} + (d/2)^2}$$

$d << R$

$$= R\sqrt{1 \mp \frac{d\cos\theta}{R} + \cancel{\left(\frac{d}{2R}\right)^2}}$$

$$\simeq R\left(1 \mp \frac{d\cos\theta}{2R}\right)$$

$$V_d(\bar{R}) = \frac{+q}{4\pi\varepsilon_0 R_+} + \frac{-q}{4\pi\varepsilon_0 R_-}$$

$$= \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{R\left(1-\frac{d\cos\theta}{2R}\right)} - \frac{1}{R\left(1+\frac{d\cos\theta}{2R}\right)}\right)$$

$$= \frac{q}{4\pi\varepsilon_0 R}\left(\cancel{1} + \frac{d\cos\theta}{2R} - \left(\cancel{1} - \frac{d\cos\theta}{2R}\right)\right)$$

$$= \frac{qd\cos\theta}{4\pi\varepsilon_0 R^2} = V_d$$

$$\bar{E}_d = -\nabla V_d = -\left(\bar{a}_R \frac{\partial V_d}{\partial R} + \frac{1}{R} \bar{a}_\theta \frac{\partial V_d}{\partial \theta} \right)$$

$$= \frac{qd}{4\pi\varepsilon_0} \left(2\bar{a}_R \frac{\cos\theta}{R^3} + \bar{a}_\theta \frac{\sin\theta}{R^3} \right)$$

$$= \frac{qd}{4\pi\varepsilon_0 R^3} \left(2\cos\theta\, \bar{a}_R + \sin\theta\, \bar{a}_\theta \right)$$

$$\frac{1}{1+x} \simeq 1 - x + x^2 \qquad \sqrt{1+x} \simeq 1 + \frac{x}{2}$$

$|x| << 1$ $\qquad$ $|x| << 1$

$$(1+x)^a \simeq 1 + ax$$