

1. Use separation of variables  
 solution is  $X(x) = Ae^{\kappa x} + Be^{-\kappa x}$   
 even, so  $X(x) = A(e^{\kappa x} + e^{-\kappa x})$

$$\frac{d^2 X}{dx^2} = \kappa^2 X$$

$$\frac{d^2 Y}{dy^2} = -\left(\frac{\pi}{a}\right)^2 Y$$

$$\kappa^2 - \left(\frac{\pi}{a}\right)^2 = 0 \Rightarrow \kappa = \frac{\pi}{a}$$

$$\Rightarrow V(x, y) = A \sin\left(\frac{\pi y}{a}\right) (e^{\frac{\pi x}{a}} + e^{-\frac{\pi x}{a}})$$

Normalize to match boundary condition

$$\Rightarrow V(x, y) = \sin\left(\frac{\pi y}{a}\right) \frac{(e^{\frac{\pi x}{a}} + e^{-\frac{\pi x}{a}})}{e^{\frac{\pi b}{a}} + e^{-\frac{\pi b}{a}}}$$

$$= \sin\left(\frac{\pi y}{a}\right) \cosh\left(\frac{\pi x}{a}\right) / \cosh\left(\frac{\pi b}{a}\right)$$

$$2.a. \quad \nabla^2 V = \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 \frac{\partial V}{\partial r})$$

$$\frac{\partial}{\partial r}(1) = 0 \Rightarrow 1 \text{ is solution}$$

$$\frac{\partial}{\partial r}(r^2 \frac{\partial}{\partial r} \frac{1}{r}) = \frac{\partial}{\partial r}(-1) = 0 \Rightarrow \frac{1}{r} \text{ is solution}$$

$$b. \quad r < a: V = A \cdot 1 = C_0$$

$$r > 2a: V = \frac{B}{r} = C_1 \cdot \frac{2a}{r}$$

$$a < r < 2a: V = A' + \frac{B'}{r}$$

$$V(a) = C_0 = A' + \frac{B'}{a}$$

$$V(2a) = C_1 = A' + \frac{B'}{2a}$$

$$B' \left(\frac{1}{a} - \frac{1}{2a}\right) = C_0 - C_1$$

$$\Rightarrow B' = 2a(C_0 - C_1)$$

$$A' = C_0 - 2(C_0 - C_1) = 2C_1 - C_0$$

$$V(r) = 2C_1 - C_0 + 2a(C_0 - C_1)/r$$

$$1c. \vec{E} = -\nabla V$$

$$= 2a (C_0 - C_1) / r^2 \hat{r}$$

$$1d. \vec{E}_{vac} = \frac{Q}{4\pi\epsilon_0 r^2} \hat{r}$$

$$\frac{\epsilon}{\epsilon_0} = \vec{E}_{vac} / \vec{E} = \epsilon_r = \frac{Q}{4\pi\epsilon_0 \cdot 2a (C_0 - C_1)}$$

$$3. \vec{p}(\vec{r}) = \int \vec{r}' \rho(\vec{r}') d\tau'$$

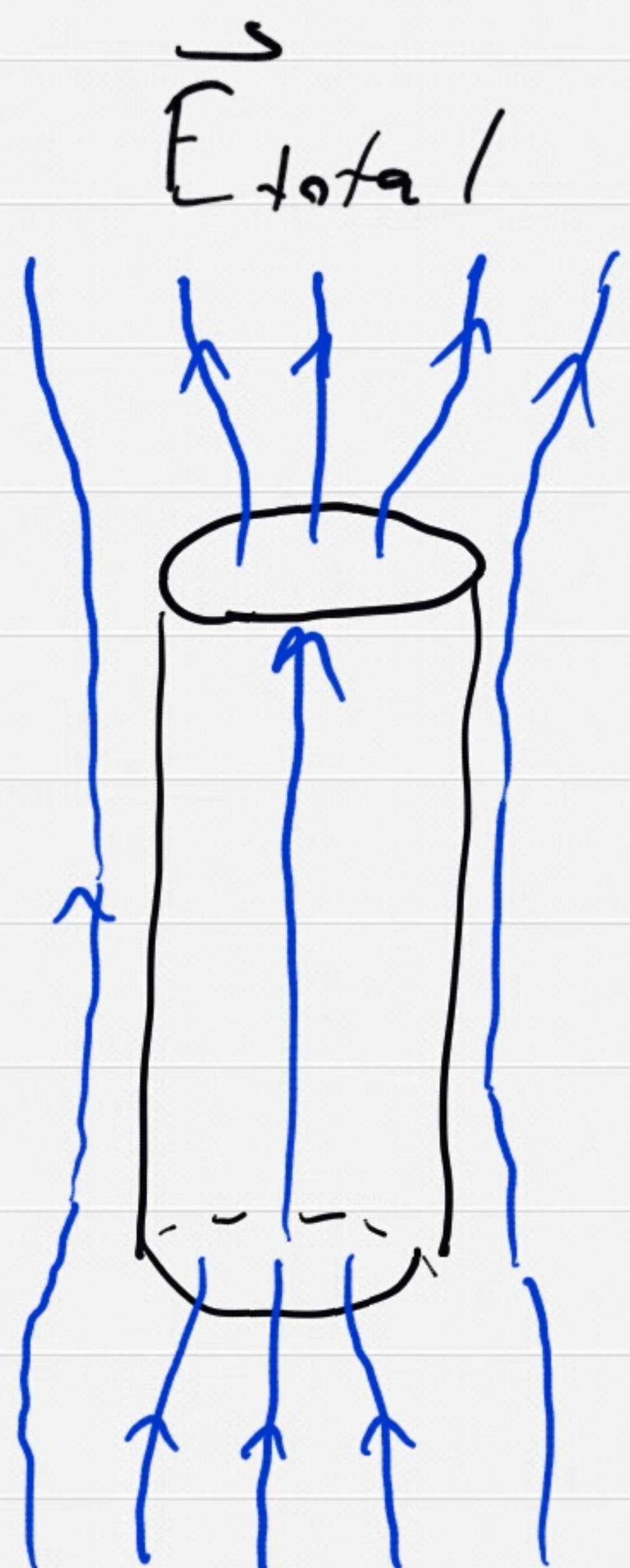
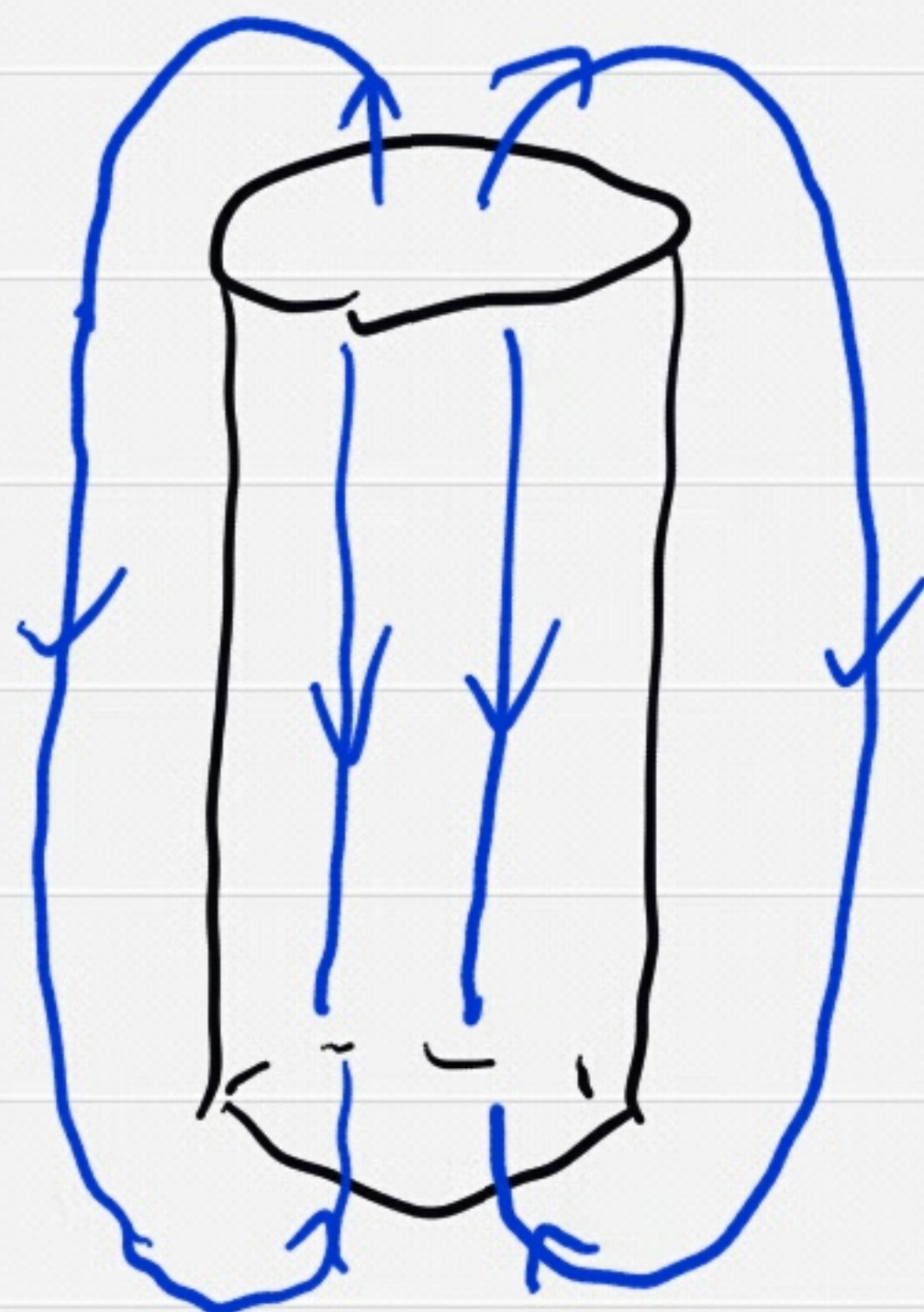
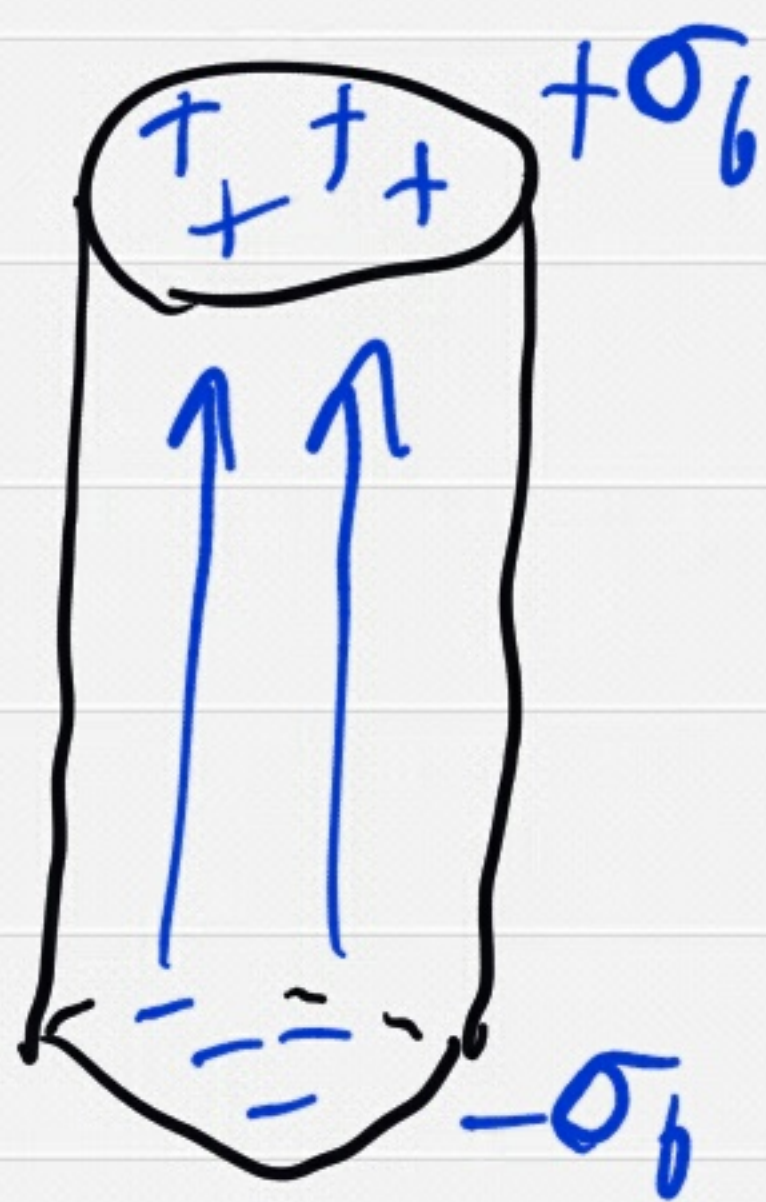
$$= \sum q \vec{r}' \text{ for point charges}$$

$$= \frac{q}{2} [-d/2, d/2] + \frac{q}{2} [d/2, d/2]$$

$$- q [0, -d/2]$$

$$= qd \hat{y}$$

$$4. \quad \vec{p} \quad \vec{E}_{int} \quad \vec{E}_{total}$$



S. Need  $\vec{v} \parallel \vec{B}$ .

- Since  $\vec{B}$  circulates  
around wire, need  
circular trajectory  
around wire.

