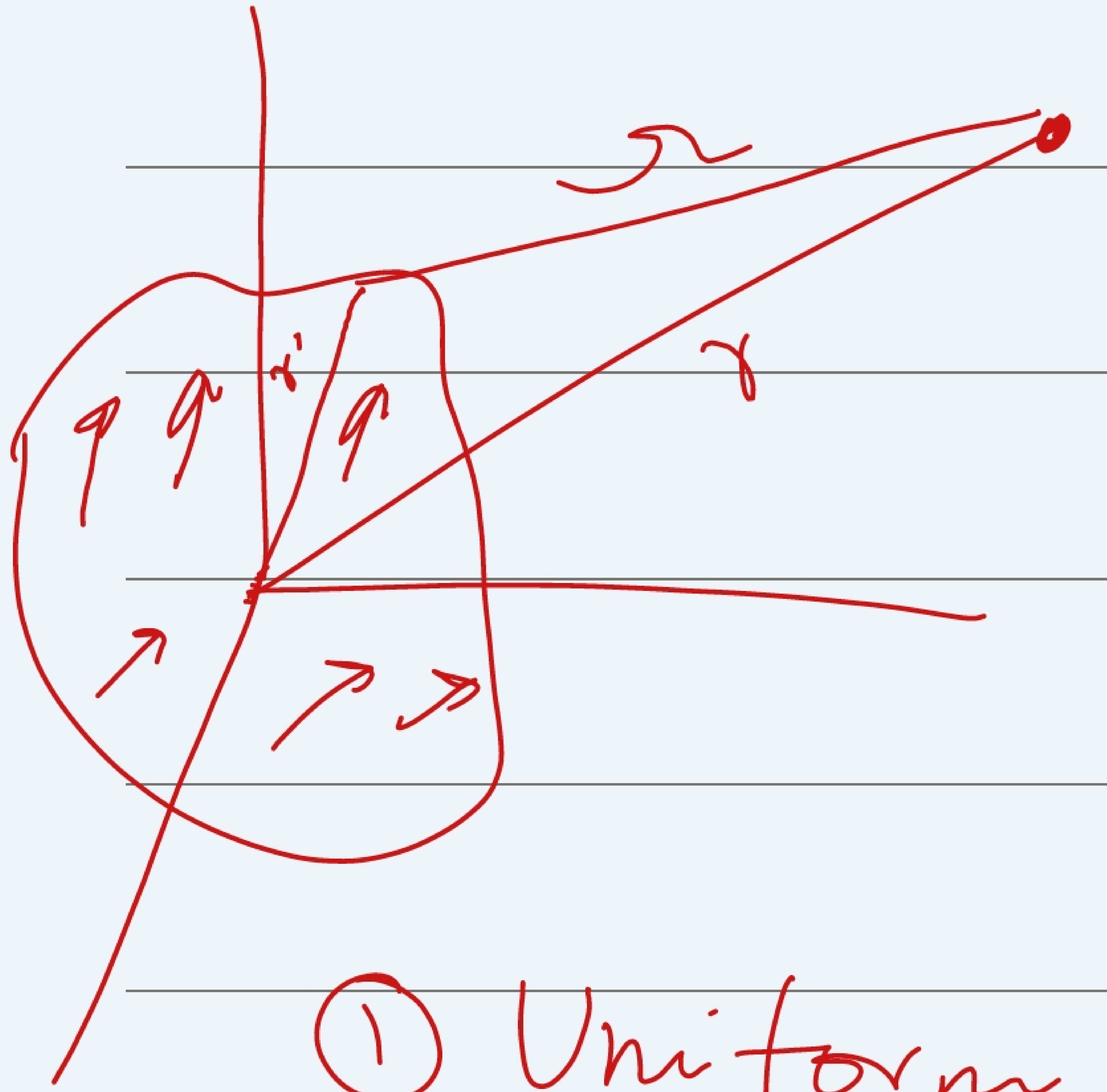


$$\boxed{V_{dip}(r) = \int \frac{\vec{P}\cdot\hat{\mathscr{r}}}{\mathscr{r}^2}\, d\tau}$$

$\vec\nabla\cdot\vec D = \rho_f$ $\qquad \oint \vec D\cdot d\vec a = Q_f$

$\nabla\cdot E = \frac{\rho}{\epsilon_0}$ $\qquad \oint \vec E\cdot d\vec a = \frac{\sum q_{en}}{\epsilon_0}$

$\nabla\times E = 0 \Leftarrow \oint \vec E\cdot d\vec l = 0$

$\vec\nabla\times\vec D = \vec\nabla\times\vec P$

$\vec P = \frac{p}{V}$

① Uniform polarization : $\sigma_b \neq 0$, $\rho_b = 0$

② Non-Uniform " : $\sigma_b \neq 0$, $\rho_b \neq 0$

$\sigma_b = \vec P\cdot\hat{n}$

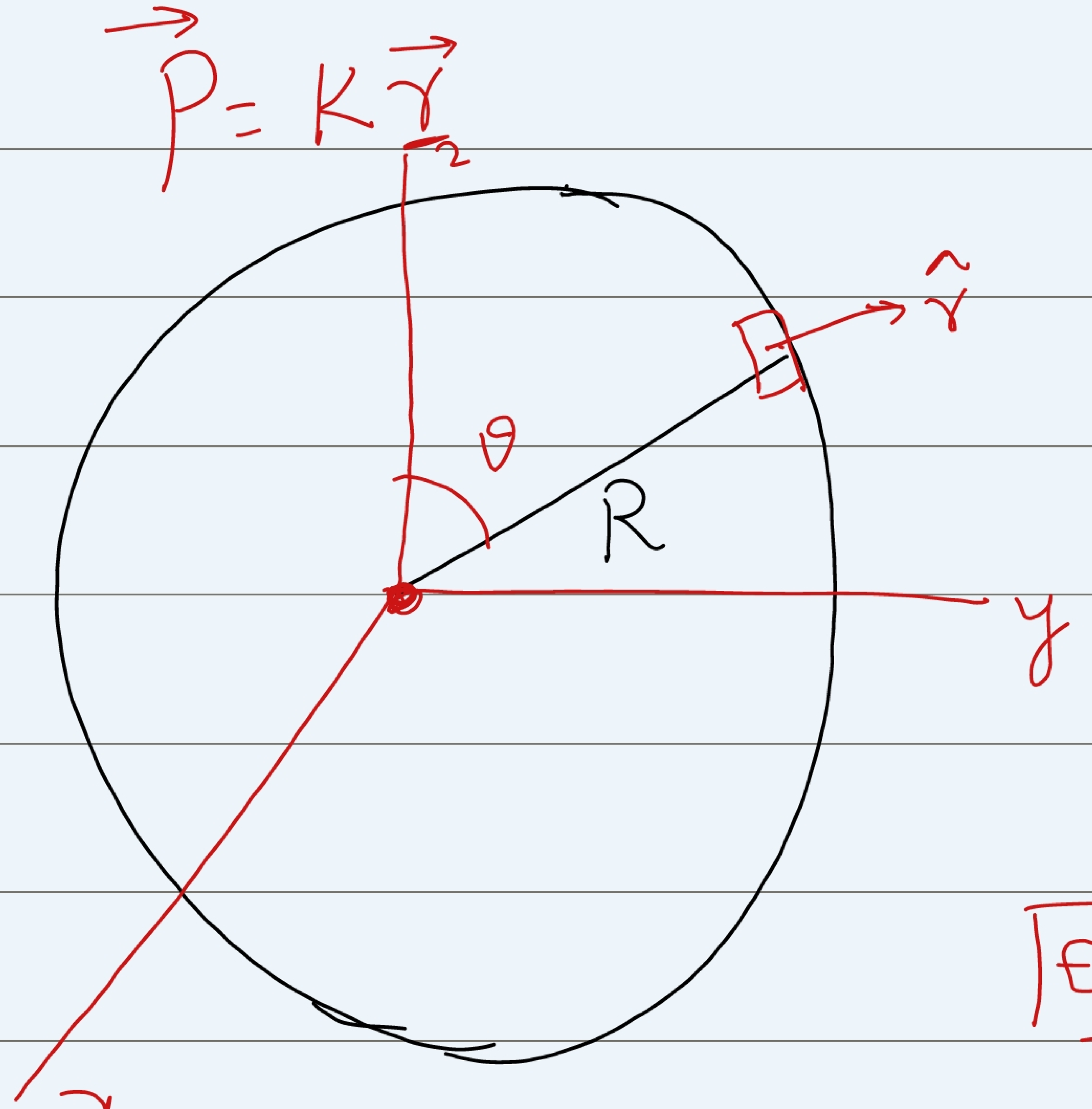
$\rho_b = -\vec\nabla\cdot\vec P$

Ex:

$$\rho_b = -\vec{\nabla} \cdot \vec{P}$$

$$= -\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 K r\right)$$

$$= -3K$$



$$\sigma_b = \vec{P}(r') \cdot \hat{n} = KR$$

$$\boxed{E = 0}$$

Total charge $= \int \sigma_b \, da + \int \rho_b \, d\tau$

$$= KR\, 4\pi R^2 + (-)\, 3K\, \frac{4}{3}\pi R^3 = 0$$

$$\rho = \rho_b + \rho_f \quad , \quad \rho_b = -\vec{\nabla}\cdot\vec{P}$$

$$\epsilon_0 \nabla\cdot E = \rho = \rho_f + \rho_b$$

$$= \rho_f - \vec{\nabla}\cdot\vec{P}$$

$$\Rightarrow \nabla\cdot\underbrace{[\epsilon_0\vec{E} + \vec{P}]}_{\vec{D}} = \rho_f$$

$$\boxed{\vec{\nabla}\cdot\vec{D} = \rho_f}$$

$$\int(\vec{\nabla}\cdot\vec{D})\,d\tau = \int \rho_f\, d\tau$$

$$\boxed{\oint \vec{D}\cdot d\vec{a} = Q_f}$$

$$\vec{P} \propto \vec{E}$$

Linear Dielectric $\vec{P} = \epsilon_0 \chi_e \vec{E}$

$$\vec{P} = \frac{\vec{p}}{V}$$

$$\vec{p} = \alpha\vec{E}$$

α → Atomic polarizability

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P}$$

$$\vec{\nabla}\times\vec{D} = \epsilon_0 \nabla\times\vec{E} + \vec{\nabla}\times\vec{P}$$

$$\boxed{\nabla\times\vec{D} = \vec{\nabla}\times\vec{P}}$$

$$\oint(\nabla\times\vec{D})\cdot d\vec{a} = \oint(\vec{\nabla}\times\vec{P})\cdot d\vec{a}$$

$$\boxed{\oint \vec{D}\cdot d\vec{l} = \oint(\vec{\nabla}\times\vec{P})\cdot d\vec{a}}$$

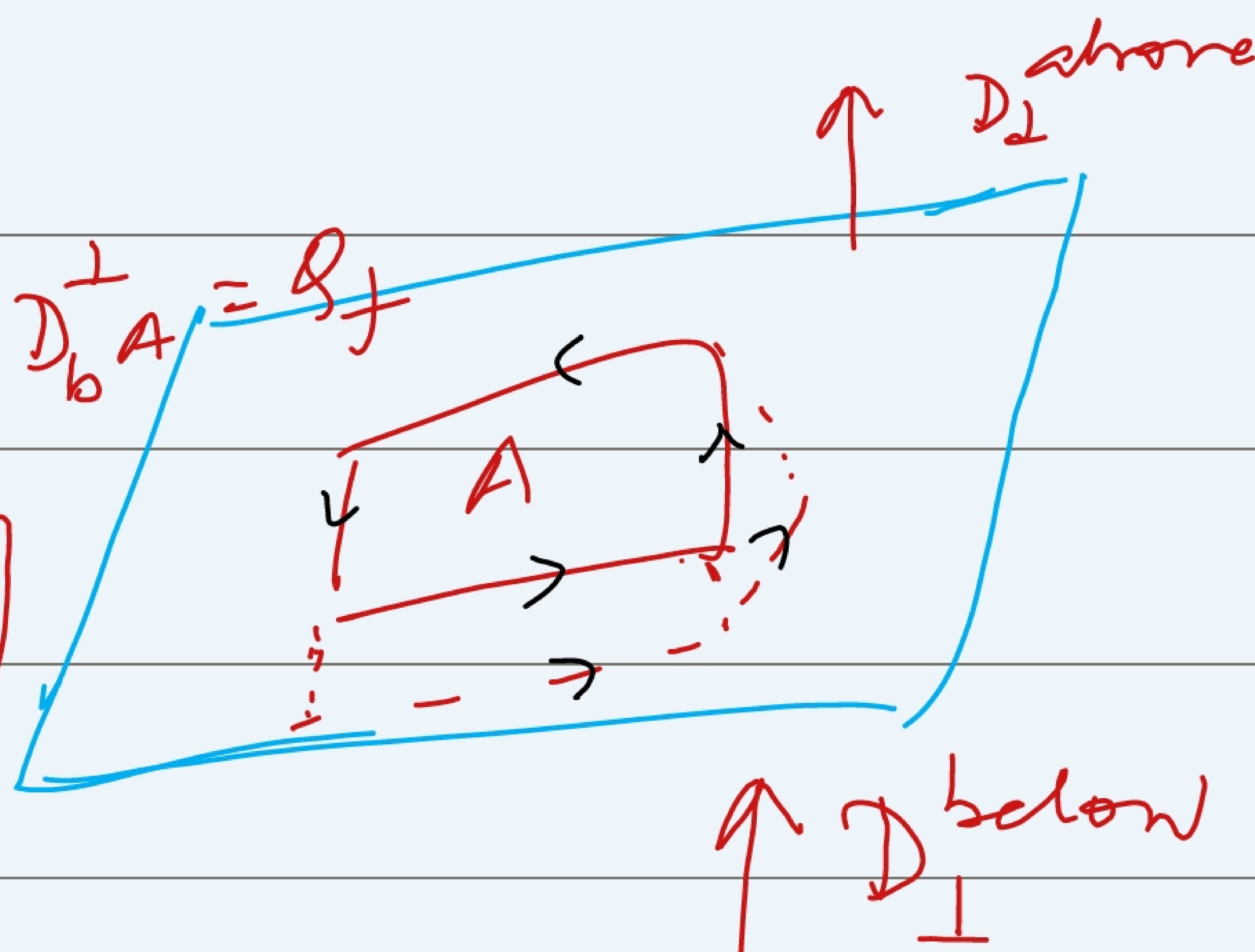
$B \to \mathcal{E}(t)$

$B(t)$

$$\nabla\cdot\vec{D} = \rho_f$$

$$\oint \vec{D}\cdot d\vec{a} = Q_f \Rightarrow D_a^\perp A - D_b^\perp A = Q_f$$

① $\boxed{D^\perp_{above} - D^\perp_{below} = \sigma_f}$



② $\nabla\times D = \nabla\times\vec{P}$

$$D_a^\parallel - D_b^\parallel = P_a^\parallel - P_{below}^\parallel$$

Linear Dielectrics

$$\vec{P} = \epsilon_0 \chi_e \vec{E}$$

ϵ_0 → free Medium; χ_e → Electrical Susceptibility (Material)

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P}$$

$$= \epsilon_0 \vec{E} + \epsilon_0 \chi_e \vec{E}$$

$$\vec{D} = \underbrace{\epsilon_0 [1 + \chi_e]}_{\epsilon} \vec{E}$$

$$\vec{D} = \epsilon \vec{E}$$

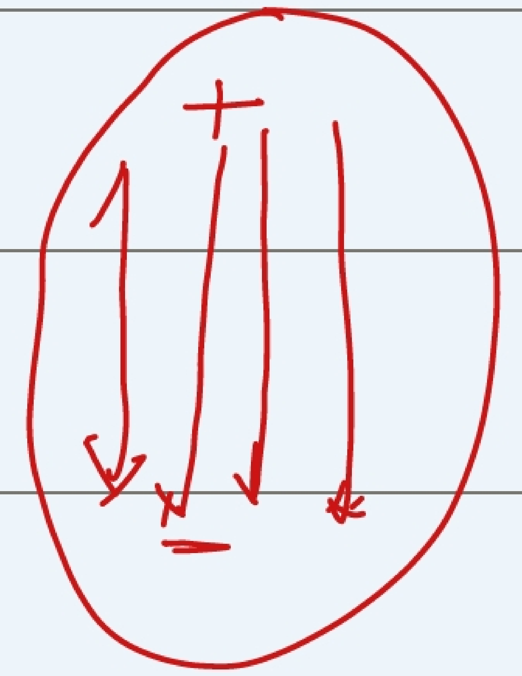
$$\epsilon_r = \frac{\epsilon}{\epsilon_0} = (1 + \chi_e)$$

α

How α & χ_e are connected?

Dipole moment $\vec{p} = \alpha \vec{E}_{else}$.

E_{else}.



Suppose density of atoms is $N = \dfrac{1}{\left(\frac{4\pi}{3}\right) R^3}$

Polarization $\vec{P}$ (dipole moment per unit volume) $= N \alpha E_{else}$.

$$\vec{P} = \epsilon_0 \chi_e \vec{E} = \epsilon_0 \chi_e [E_{self} + E_{else}]$$

$$E_{self} = -\frac{p}{4\pi\epsilon_0 R^3} = -\frac{\alpha E_{else}}{4\pi\epsilon_0 R^3}$$

$$\vec{E} = \vec{E}_{else} + \vec{E}_{self}$$

$$= \left[1 - \frac{\alpha}{4\pi\epsilon_0 R^3}\right] E_{else}$$

$$\boxed{\vec{E} = \left[1 - \frac{N\alpha}{3\epsilon_0}\right] \vec{E}_{else}}$$

$$\vec{P} = \epsilon_0 \chi_e \vec{E}$$

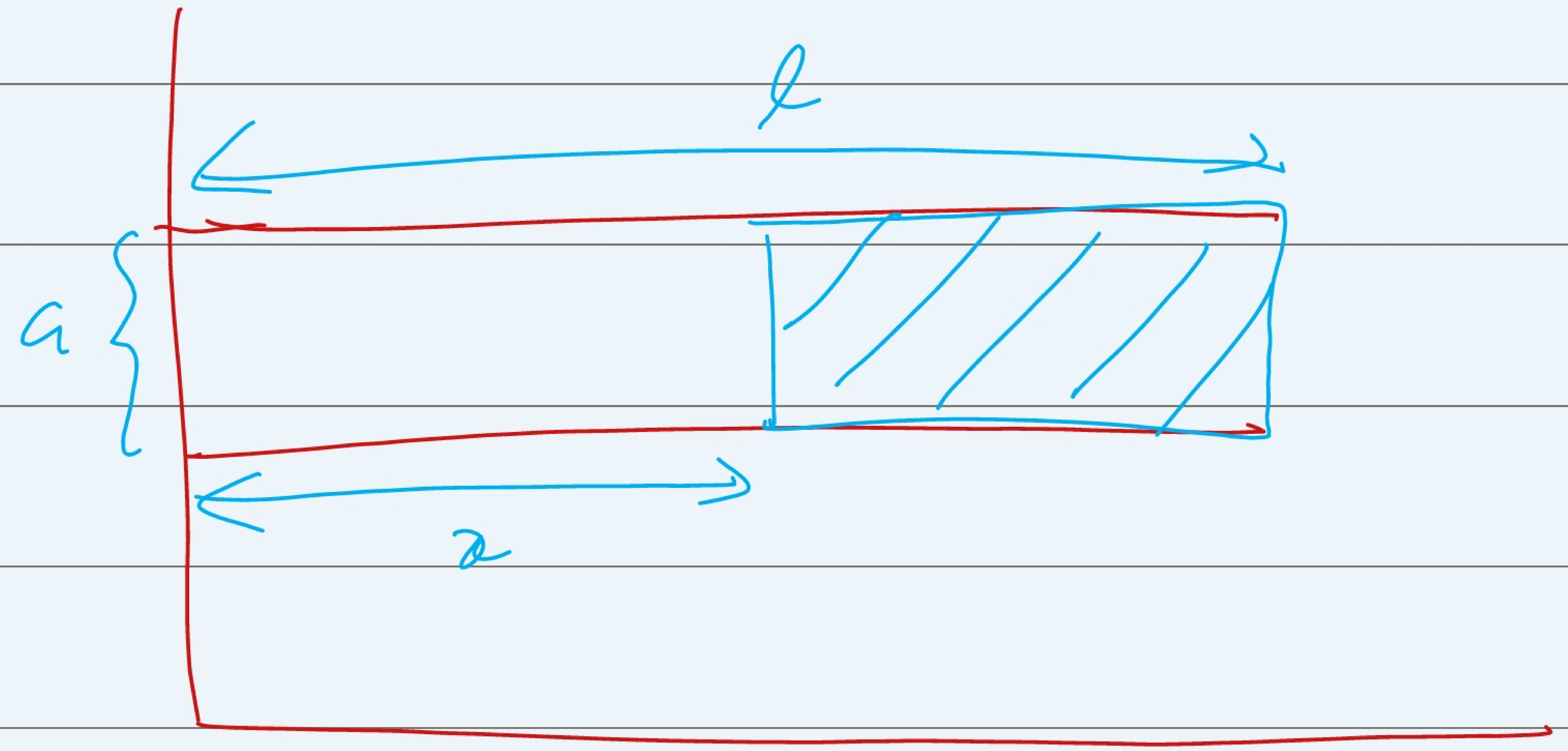
$$\underline{N\alpha E_{else}} = \epsilon_0 \chi_e E_{else}\left[1 - \frac{N\alpha}{3\epsilon_0}\right].$$

$$N\alpha \cancel{E_{else}}\left[1 + \frac{\cancel{\epsilon_0}\chi_e}{3\cancel{\epsilon_0}}\right] = \epsilon_0 \chi_e \cancel{E_{else}}$$

$$\epsilon_r = 1 + \chi_e.$$

$$\Rightarrow \boxed{N\alpha\left[\frac{3+\chi_e}{3}\right] = \epsilon_0 \chi_e} \longrightarrow \boxed{\alpha = \frac{3\epsilon_0(\epsilon_r - 1)}{N(\epsilon_r + 2)}}.$$

$\vec{F} = ?$



C.