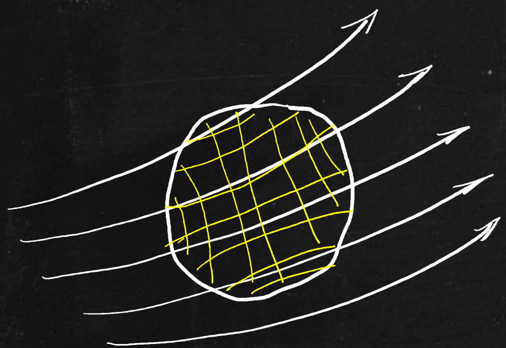
Flux 通量



Electric Flux

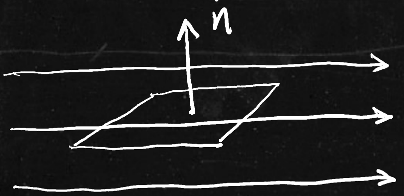
$$\Phi = \iint_{\text{entire surface}} \vec{E} \cdot d\vec{A}$$

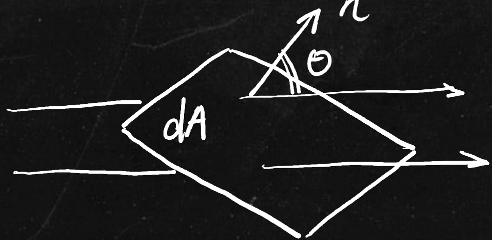
$E\,dA\cos\theta$

$d\vec{A} = dA \cdot \hat{n}$

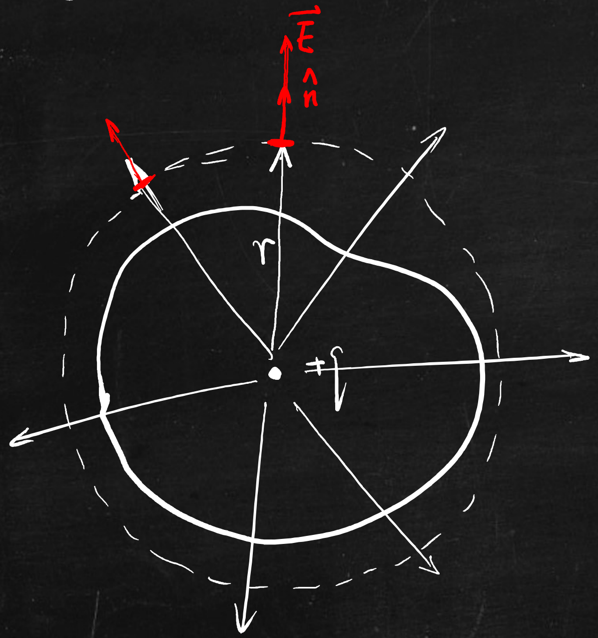
element surface 面积元

right hand rule.





Gauss's Law.



$$\Phi = \frac{q_{net}}{\varepsilon_0}$$

$$\underset{(S)}{\oiint} \vec{E} \cdot d\vec{A} = \frac{q_{net}}{\varepsilon_0}$$

$$q_{net} = \underset{(V)}{\iiint} \rho \, dV$$

ρ – charge density

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$

$$E \cdot 4\pi r^2 = \Phi$$

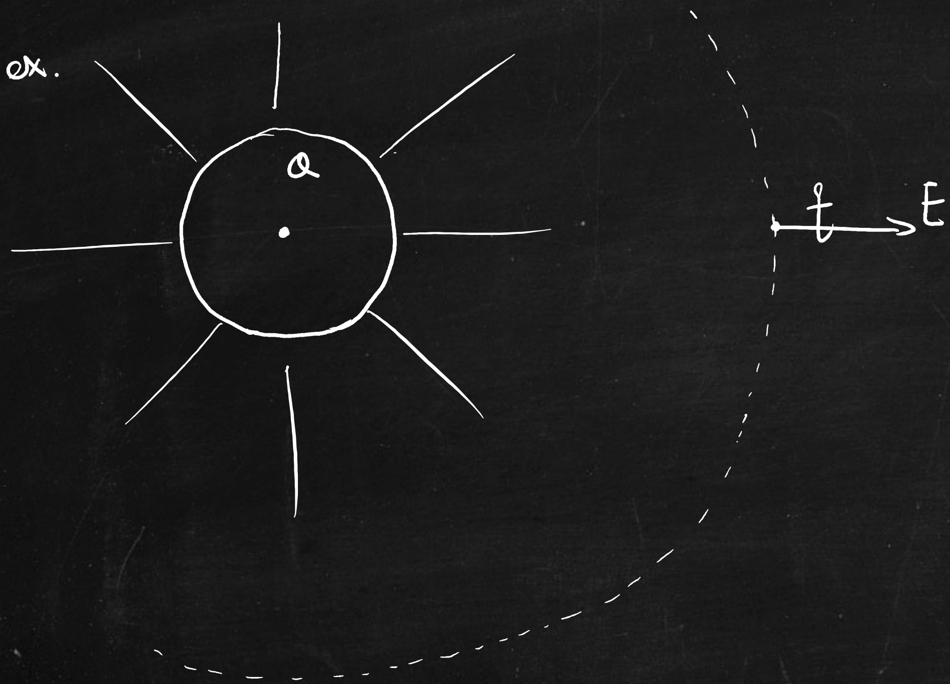
$$E \cdot 4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$\Phi = \frac{q}{\varepsilon_0}$$

$$\Phi = \frac{q_1 + q_2 + \cdots + q_n}{\varepsilon_0} = \frac{q_{net}}{\varepsilon_0}$$

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2} = k_e \frac{q_1 q_2}{r^2}$$

ex.

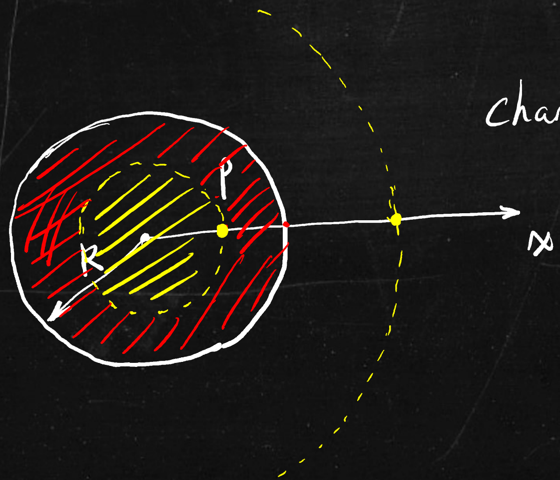


$$\boxed{4\pi r^2 \cdot E = \frac{Q}{\varepsilon_0}} \qquad E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

$$F = E \cdot q = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Qq}{r^2}$$

$$V = \frac{4}{3}\pi R^3$$

ex.



charge density ρ

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{r^2} \qquad Q = \rho \cdot V = \rho \cdot \frac{4}{3}\pi R^3$$

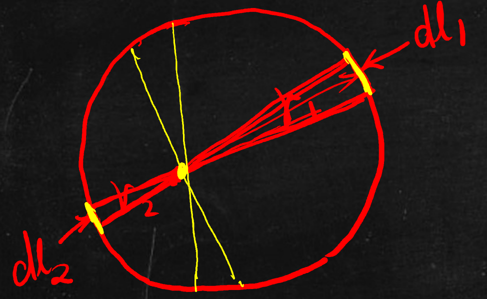
$$= \frac{1}{\cancel{4}\cancel{\pi}\varepsilon_0} \cdot \frac{\rho \cdot \frac{\cancel{4}}{3}\cancel{\pi}R^3}{r^2}$$

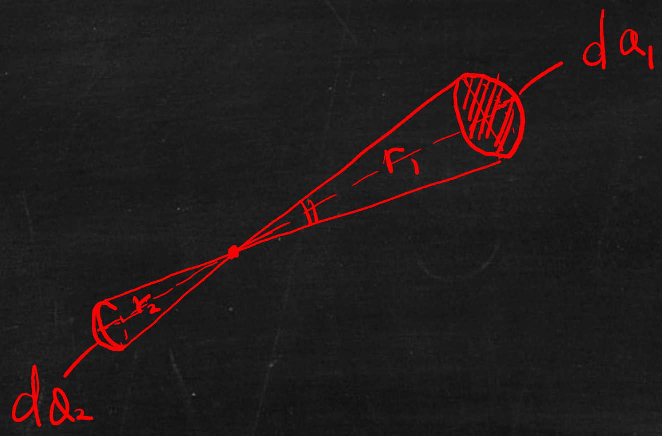
$$= \frac{\rho \cdot R^3}{3\varepsilon_0} \cdot \frac{1}{r^2}$$

① $$4\pi r^2 \cdot E = \frac{\rho \cdot V}{\varepsilon_0} \qquad V = \frac{4}{3}\pi r^3$$

$$\cancel{4\pi r^2} \cdot E = \frac{\rho}{\varepsilon_0} \cdot \frac{\cancel{4}}{3}\cancel{\pi} r^{\cancel{3}} = \frac{\rho}{3\varepsilon_0} \cdot r$$

② $E = 0$





$$dE_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq_1}{r_1^2}$$

$$dE_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq_2}{r_2^2}$$

$$\frac{dl_1}{dl_2} = \frac{r_1}{r_2}$$

$$dq_1 = dA_1 \cdot \sigma$$

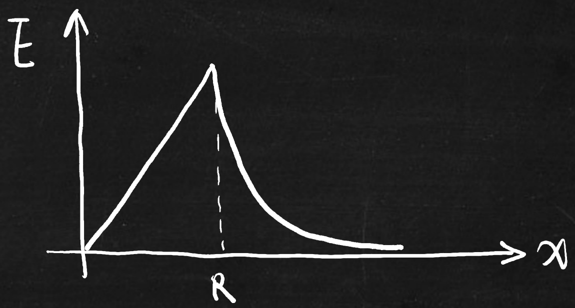
$$dq_2 = dA_2 \cdot \sigma$$

$$\frac{dq_1}{dq_2} = \frac{dA_1}{dA_2} = \frac{dl_1^2}{dl_2^2} = \frac{r_1^2}{r_2^2}$$

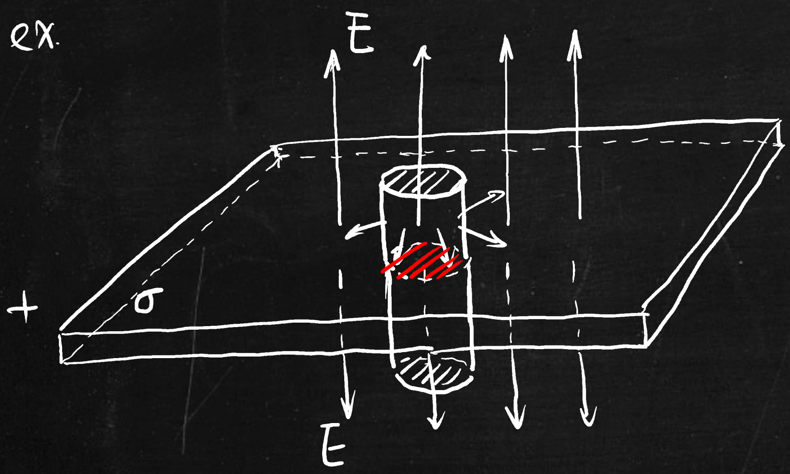
$$\frac{dq_1}{r_1^2} = \frac{dq_2}{r_2^2} \qquad \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq_1}{r_1^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq_2}{r_2^2}$$

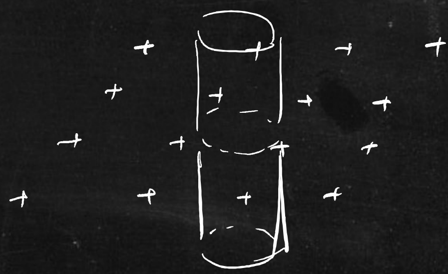
$$E = \frac{\rho}{3\varepsilon_0} \cdot r \qquad (r \le R)$$

$$E = \begin{cases} \dfrac{\rho}{3\varepsilon_0} r & r \le R \\ \dfrac{\rho R^3}{3\varepsilon_0} \cdot \dfrac{1}{r^2} & r > R \end{cases}$$



ex.

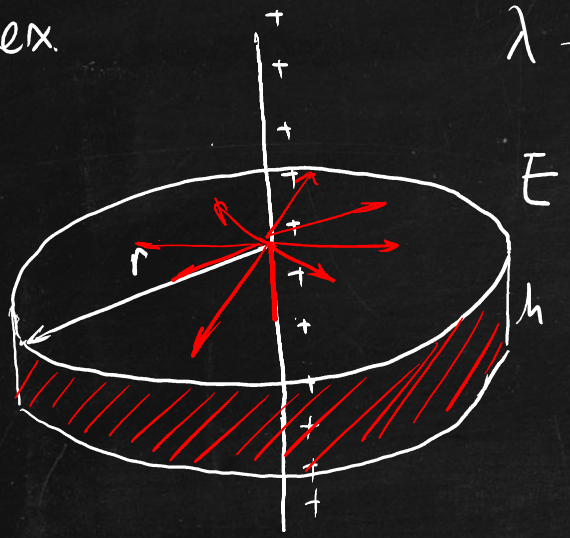




$$E \cdot 2\cancel{A} = \frac{q_{net}}{\varepsilon_0} = \frac{\sigma \cdot \cancel{A}}{\varepsilon_0}$$

$$E = \frac{\sigma}{2\varepsilon_0}$$

ex.



λ — linear charge density $\sigma \cdot \rho$

$$\Phi = 2\pi r \cdot \cancel{h} \cdot E = \frac{\lambda \cdot \cancel{h}}{\varepsilon_0}$$

$$E = \frac{\lambda}{2\pi r \varepsilon_0}$$