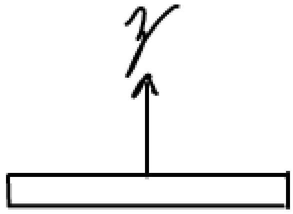
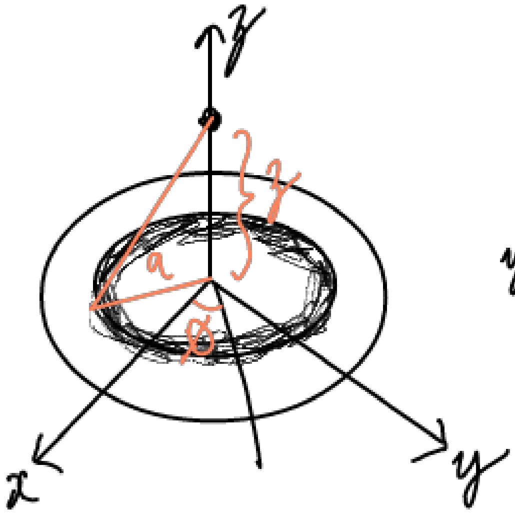
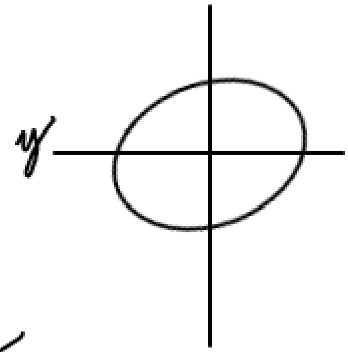
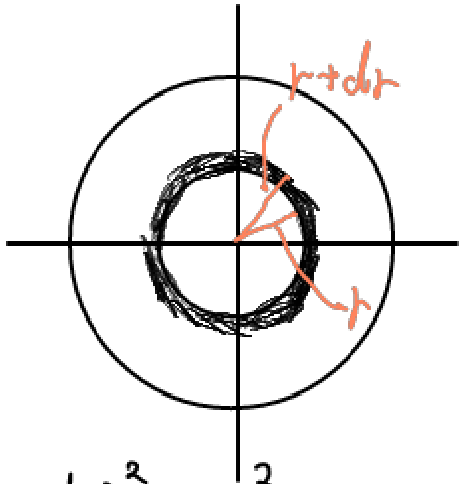
1. flux
2. Gauss Law





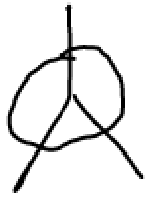




$$dQ = dA\,\rho_s$$
$$= \rho_s(2\pi r\,dr)$$

$$\pi(r+dr)^2 - \pi r^2$$
$$\pi(\cancel{r^2} + 2r\,dr + dr^2) - \cancel{\pi r^2}$$
$$\pi 2r\,dr + dr^2\pi$$

$$\vec{E}_{disk}(z) = \frac{\rho_s}{2\epsilon_0}\left[1 - \frac{z}{z^2+a^2}\right]\hat{z}$$ for disk



(1) as $z \gg a$

$$= \frac{\rho_s}{2\epsilon_0}\left[1 - \frac{1}{\sqrt{1+\left(\frac{a}{z}\right)^2}}\right]\hat{z}$$

$x \ll 1$

$$(1+x)^n \approx 1 + nx$$

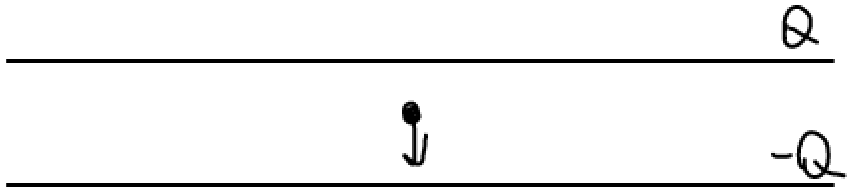
$$\vec{E} = \frac{\rho_s}{2\epsilon_0}\left[1 - \left(1+\left(\frac{a}{z}\right)^2\right)^{-\frac{1}{2}}\right] \qquad Q = \rho_s\pi a^2$$

$$\approx \frac{\rho_s}{2\epsilon_0}\,\frac{a^2}{2z^2} = \frac{Q}{2\pi\epsilon_0 \cdot 2z^2}$$

(2) $a \gg z$

$$E = \frac{\rho_s}{2\epsilon_0}\left[1 - \frac{z}{a}\right]\hat{z}$$

$$E = \frac{\rho_s}{2\epsilon_0}\hat{z}$$

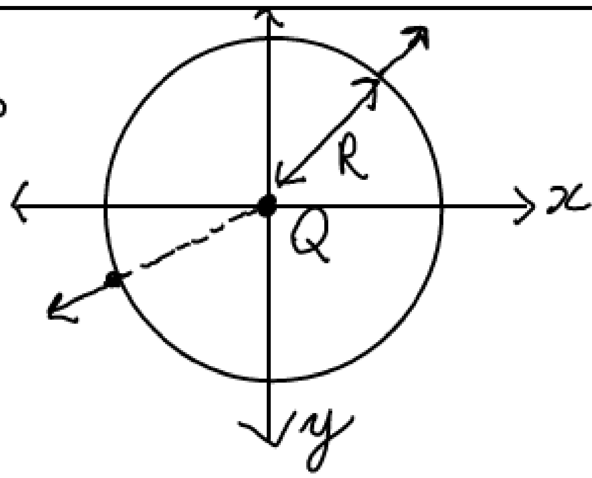


$$\left.\begin{aligned} E_Q &= \frac{\rho_s}{2\epsilon_0}(-\hat{z}) \\ E_{-Q} &= \frac{\rho_s}{2\epsilon_0}(-\hat{z}) \end{aligned}\right\} \frac{2\rho_s}{2\epsilon_0}(-\hat{z})$$

Flux

Gauss's Law

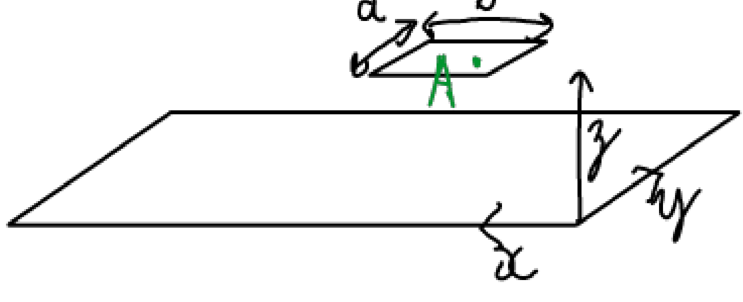
$K = \frac{1}{4\pi\epsilon_0}$



$E = \frac{kQ}{R^2}\hat{r}$

$$\Phi_A = E_\perp A = 4\pi R^2 |\vec{E}|$$
$$= 4\pi k Q$$

$$E = \frac{\rho_s}{2\epsilon_0}\hat{z}$$



$$\Phi_A = \frac{\rho_s}{2\epsilon_0}(ab)$$

$\Phi \Big|$ over or crossing dA

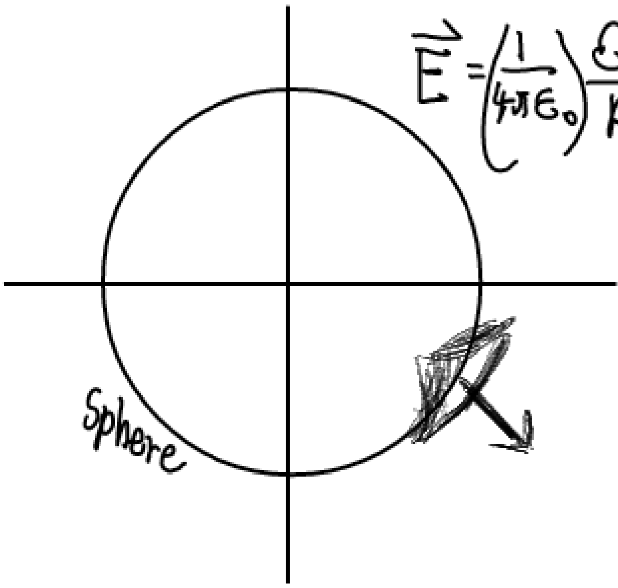
$$\vec{dA} = dA\,\hat{a}$$

$$= d\Phi_e$$

$$= E_\perp dA$$

$$= \vec{E} \cdot \vec{dA}$$

$$\Phi_e = \int_{\text{surface}} d\Phi_e = \int \vec{E} \cdot \vec{dA}$$



$$\vec{E} = \left(\frac{1}{4\pi\epsilon_0}\right)\frac{Q}{R^2}\,\hat{r}$$

$$= \int \frac{Q}{4\pi\epsilon_0 R^2}\,\cancel{\hat{r}} \cdot (\vec{dA})\,\cancel{\hat{r}}$$

$$= \frac{Q}{4\pi\epsilon_0 R^2}\int_{\text{sphere}} dA$$

surface of the sphere

$$= \cancel{4\pi R^2}\,\frac{Q}{\cancel{4\pi}\epsilon_0 \cancel{R^2}}$$

$$= \frac{Q}{\epsilon_0}$$

$$\boxed{\Phi_e \Big|_{\substack{\text{closed}\\ \text{surface}}} = \frac{Q}{\epsilon_0}}$$