Elektrické pole

dielektrikum

Potenciál elektrostatického pole

$$\vec{E} = -\mathrm{grad}\,\varphi$$

$$d\varphi = -\vec{E} \cdot d\vec{r}$$

$$d\varphi = \frac{dW_p}{Q}$$

$$dW_p = -dA = -\vec{F} \cdot d\vec{r} = -Q\vec{E} \cdot d\vec{r}$$

konzervativní pole

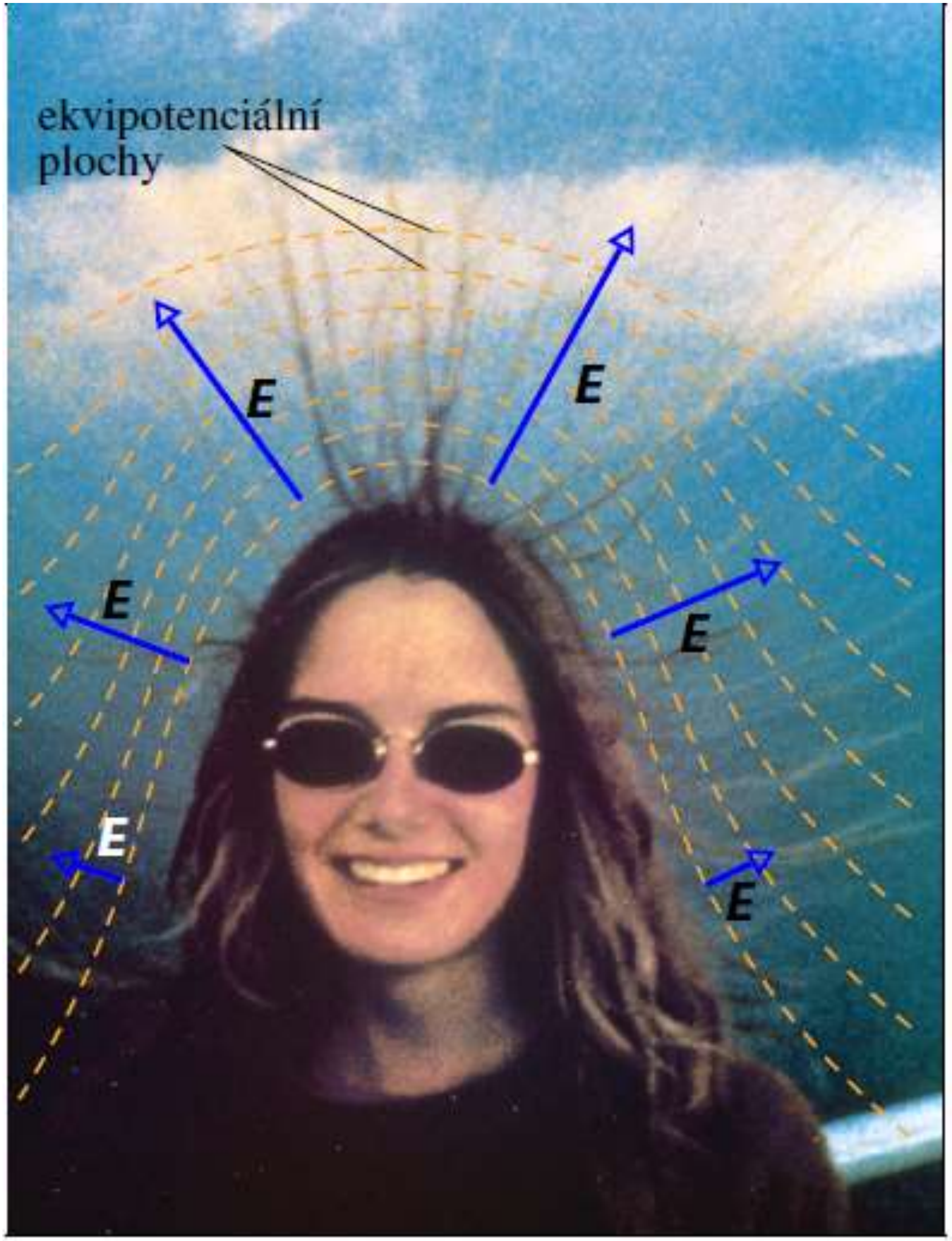
$$\oint_l \vec{F} \cdot d\vec{l} = 0$$

$$\oint_l \vec{E} \cdot d\vec{l} = \iint_S \mathrm{rot}\,\vec{E} \cdot d\vec{S} = 0$$

$$\oint_l Q\vec{E} \cdot d\vec{l} = 0$$

$$\mathrm{rot}\,\vec{E} = 0$$

$$\oint_l \vec{E} \cdot d\vec{l} = 0$$



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$$\mathrm{rot}\,\vec{E} = 0$$

$$\mathrm{div}\vec{E} = \frac{1}{\varepsilon_0}\rho$$

$$\vec{E} = -\mathrm{grad}\varphi$$

$$\mathrm{rot}\,\mathrm{grad}\,\varphi = 0$$

$$\mathrm{div}\,\mathrm{grad}\varphi = \nabla^2\varphi = \frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{\partial y^2} + \frac{\partial^2\varphi}{\partial z^2} = \Delta\varphi$$

$$\Delta\varphi = -\frac{\rho}{\varepsilon_0}$$ **Poissonova rovnice**

$$\Delta\varphi = 0$$ **Laplaceova rovnice**

Kapacita

Potenciál vodivé koule nabité nábojem Q

$$d\varphi = -\vec{E}\cdot d\vec{r}$$

$$\varphi = -\int \vec{E}\cdot d\vec{r} = -\int E\,dr = -\int \frac{Q}{4\pi\varepsilon_0 r^2}dr = -\frac{Q}{4\pi\varepsilon_0}\int\frac{1}{r^2}dr = \frac{Q}{4\pi\varepsilon_0 r} + K$$

$$K = 0 \;\Rightarrow\; \varphi(r) = \frac{Q}{4\pi\varepsilon_0 r}$$

$$\varphi = \frac{1}{C}Q \quad\Rightarrow\quad C = \frac{Q}{\varphi}$$ kapacita vodiče

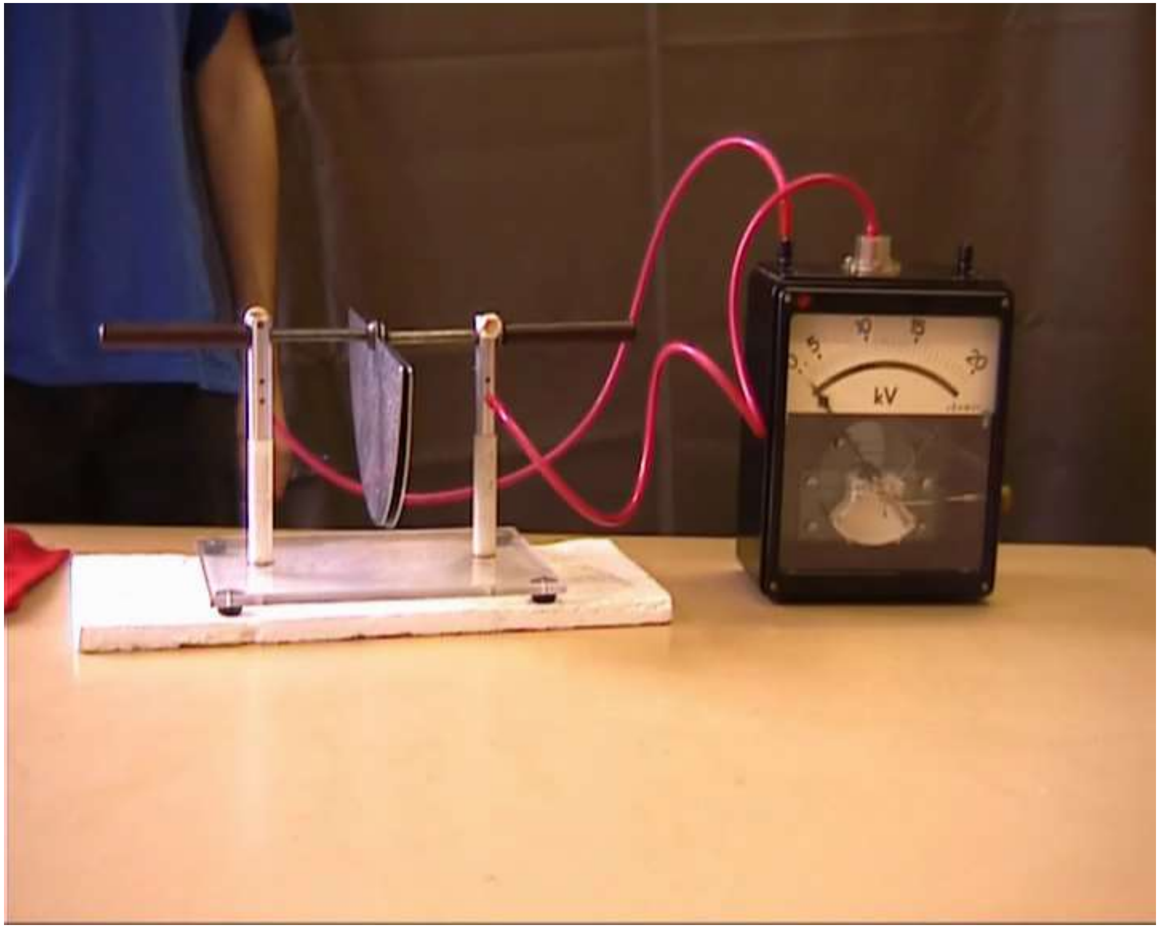
kondenzátory $C = \dfrac{Q}{U}$

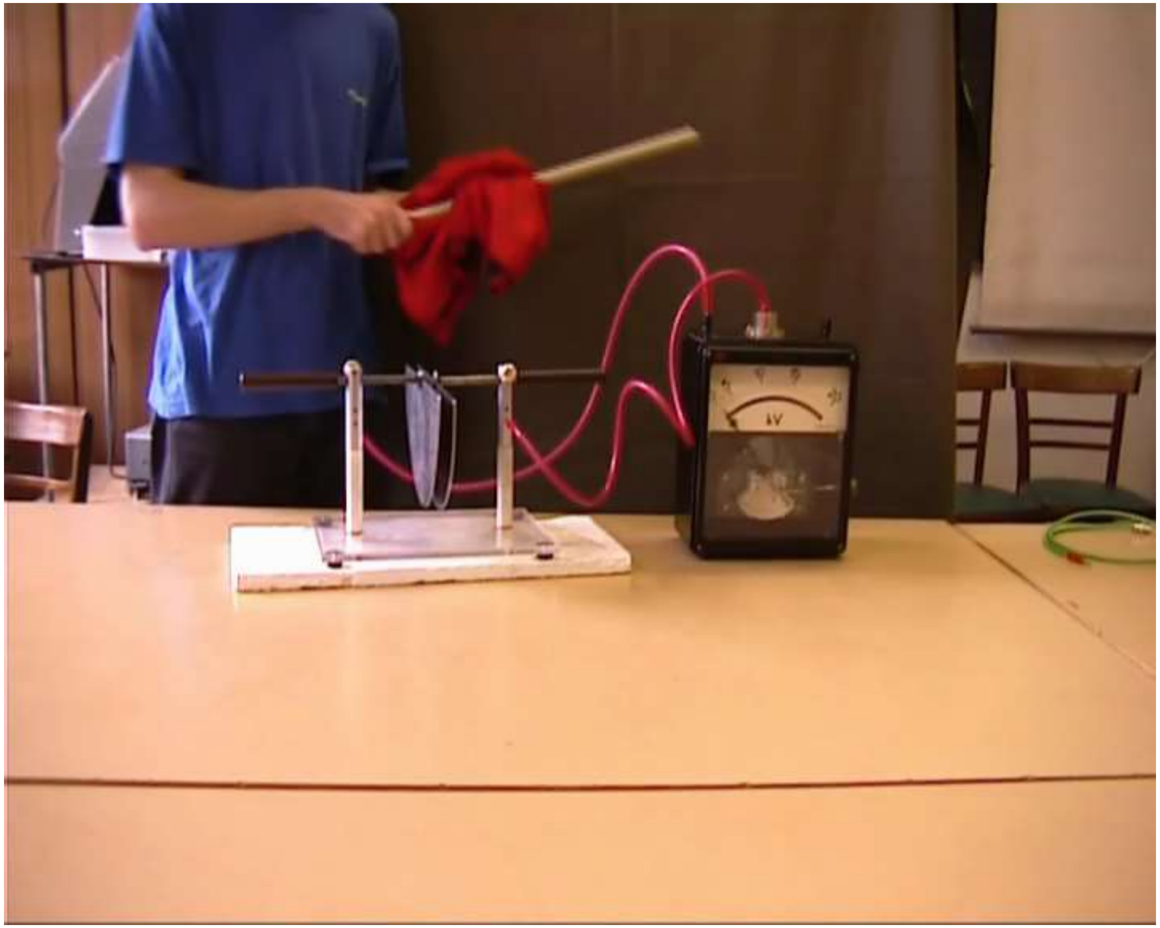
Deskový kondenzátor

$$d\varphi = -\vec{E}\cdot d\vec{l}$$

$$U = Ed = \frac{\sigma}{\varepsilon_0}d = \frac{Q}{\varepsilon_0 S}d \Rightarrow C = \frac{\varepsilon_0 S}{d}$$

http://fyzweb.cz/materialy/videopokusy/POKUSY/KONDENZATOR/INDEX.HTM




kV

Dielektrika

- polární vlastní elektrický dipólový moment
- nepolární

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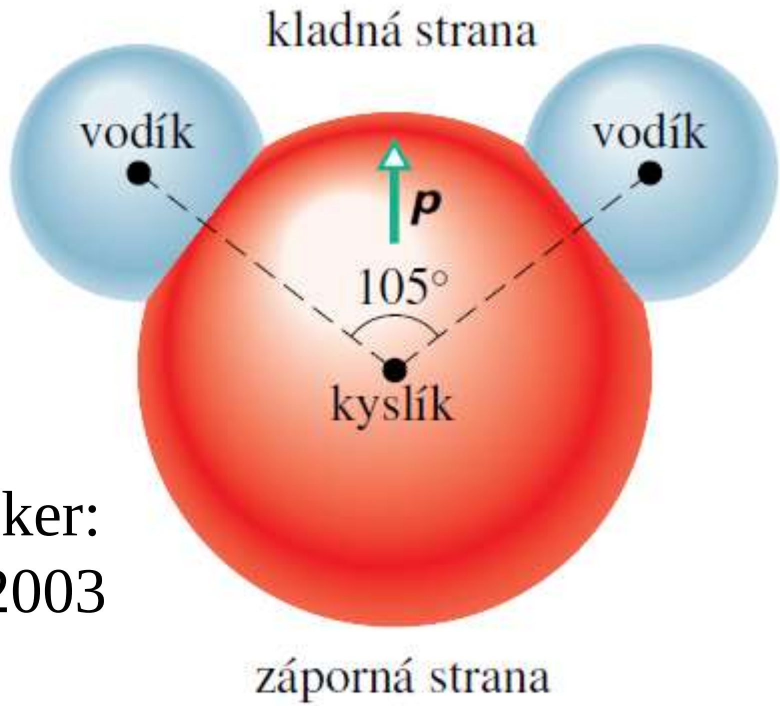
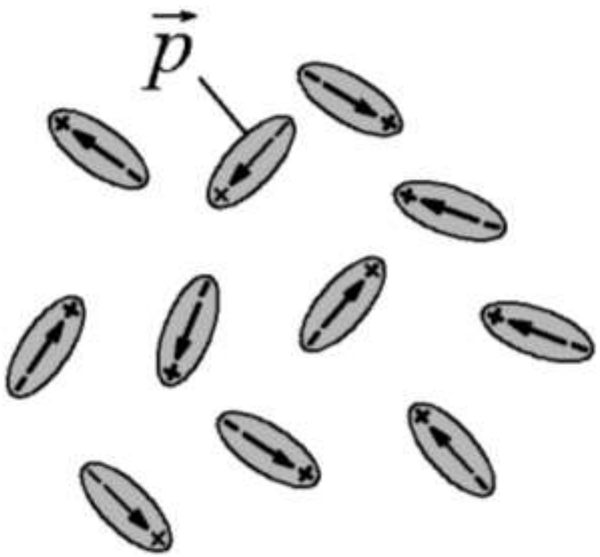
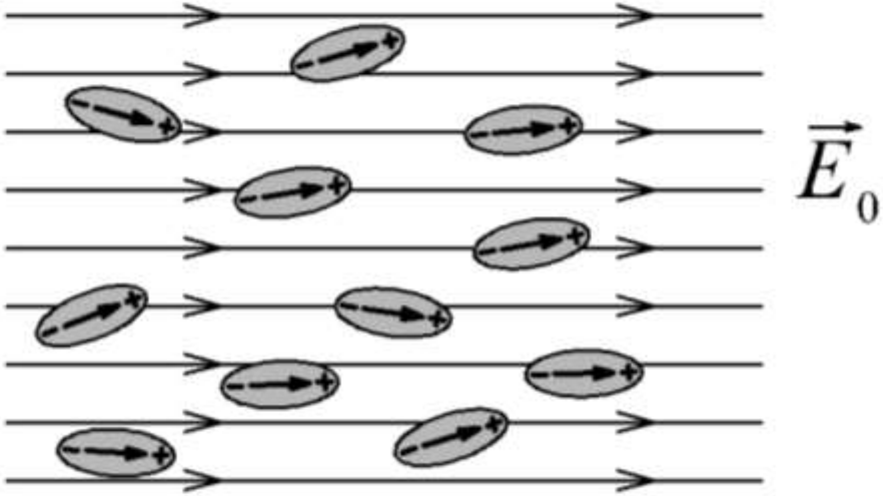
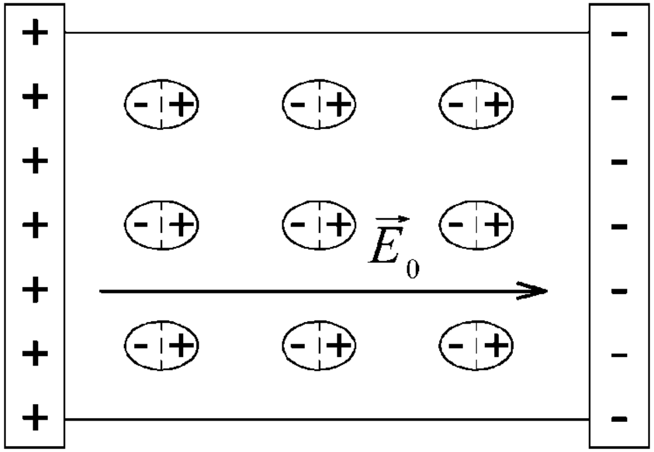
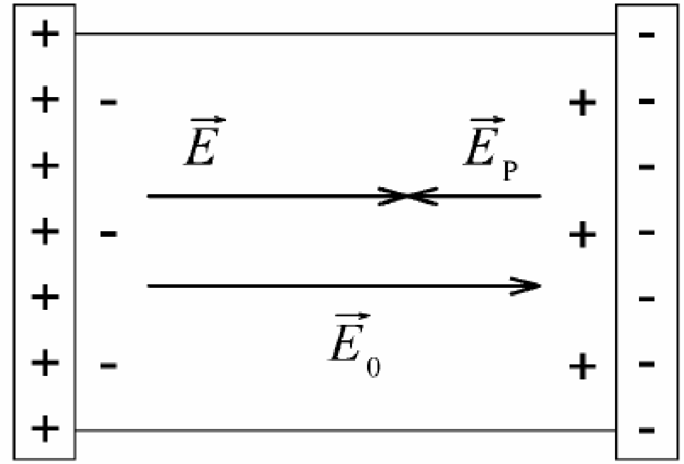










$$\vec{P}(\vec{r}) = \frac{d\,\vec{p}_V}{dV}$$

vázaný náboj

$$E_p = \frac{\sigma_p}{\varepsilon_0}$$

$\vec{P}(\vec{r})$ elektrická polarizace

$$\vec{E} = \vec{E}_0 + \vec{E}_p$$

$$\vec{P}(\vec{r}) = \varepsilon_0 \chi_e \vec{E}(\vec{r})$$

χ_e elektrická susceptibilita prostředí

$\vec{E}_0 = \varepsilon_r \vec{E}$ relativní permitivita prostředí $\left(\varepsilon_r = \dfrac{E_0}{E}\right)$

$\varepsilon = \varepsilon_0 \varepsilon_r$ permitivita prostředí elektrická indukce

$$\vec{D}(\vec{r}) = \varepsilon_0 \vec{E}(\vec{r}) + \vec{P}(\vec{r}) \;= \varepsilon_0 \vec{E}(\vec{r}) + \varepsilon_0 \chi_e \vec{E}(\vec{r}) = \varepsilon_0 (1 + \chi_e) \vec{E}(\vec{r})$$

$$\varepsilon_r = 1 + \chi_e$$

$$\vec{D}(\vec{r}) = \varepsilon_0 \varepsilon_r \vec{E}(\vec{r}) \;= \varepsilon \vec{E}(\vec{r})$$

ideálně měkké dieletrikum

ideálně tvrdé dieletrikum

permanentní polarizace $\vec{P}_0(\vec{r})$

$$\oiint_S \vec{E}_0 \cdot d\vec{S} = \frac{Q}{\varepsilon_0}$$ deskový kondenzátor bez dielektrika

$$E_0 S = \frac{Q}{\varepsilon_0}$$

$$\oiint_S \vec{E} \cdot d\vec{S} = \frac{Q - Q'}{\varepsilon_0}$$ deskový kondenzátor s dielektrikem

$$ES = \frac{Q - Q'}{\varepsilon_0}$$

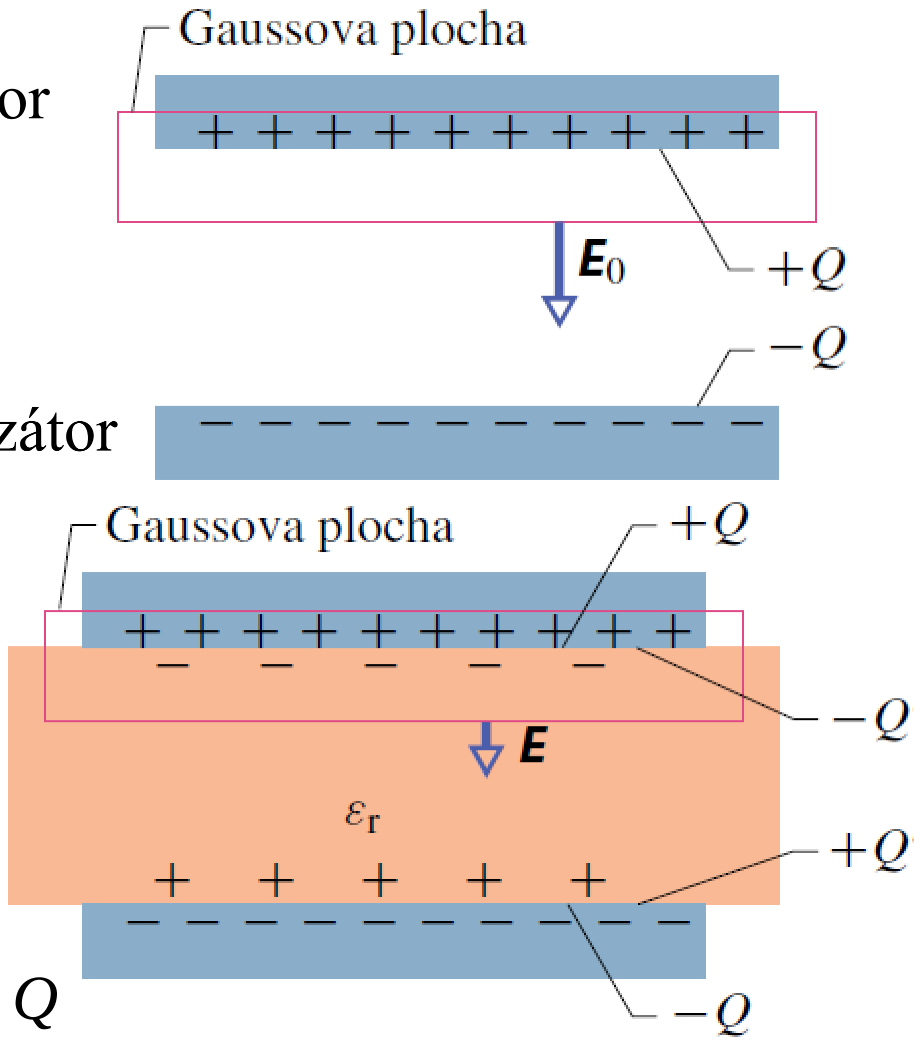
$$E = \frac{E_0}{\varepsilon_r} = \frac{Q}{\varepsilon_r \varepsilon_0 S} = \frac{Q - Q'}{\varepsilon_0 S}$$

$$\Rightarrow \quad Q - Q' = \frac{Q}{\varepsilon_r}$$

$$\oiint_S \varepsilon_0 \varepsilon_r \vec{E} \cdot d\vec{S} = Q$$

$$\oiint_S \varepsilon_r \vec{E} \cdot d\vec{S} = \frac{Q}{\varepsilon_0}$$

$$\oiint_S \vec{D} \cdot d\vec{S} = Q$$



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Energie elektrostatického pole

nabíjení kondenzátoru

$$dW_p = U\,dQ = \frac{Q}{C}dQ$$

$$W_p = \int_0^{Q_0} dW_p = \int_0^{Q_0} \frac{Q}{C}dQ = \frac{1}{C}\int_0^{Q_0} Q\,dQ = \frac{1}{2}\frac{Q_0^2}{C}$$

$$E_0 S = \frac{Q_0}{\varepsilon_0}$$

$$U_0 = E_0 d$$

$$W_p = \frac{1}{2}\frac{Q_0^2}{C} = \frac{1}{2}Q_0 U_0 = \frac{1}{2}CU_0^2$$

$$W_p = \frac{1}{2}Q_0 U_0 = \frac{1}{2}\varepsilon_0 E_0 S\, E_0 d = \frac{1}{2}\varepsilon_0 E_0^2 S d = W_e$$

hustota energie elektrostatického pole $w = \frac{dW}{dV}$

$$w = \frac{1}{2}\varepsilon_0 E_0^2$$

$$w = \frac{1}{2}\vec{E}\cdot\vec{D}$$