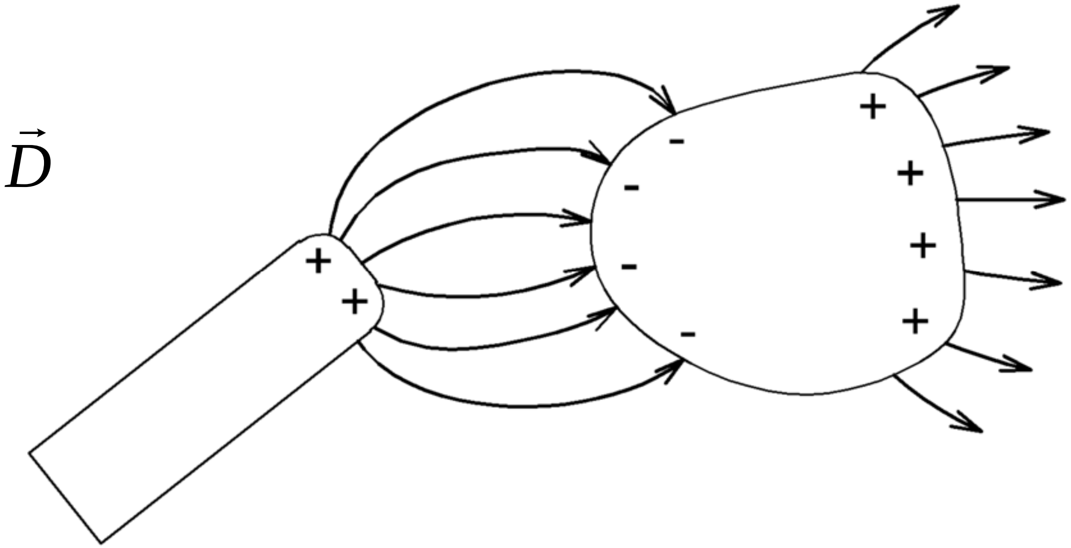
Conductors

electrostatic induction $\vec{D}$
(electrostatic influence)

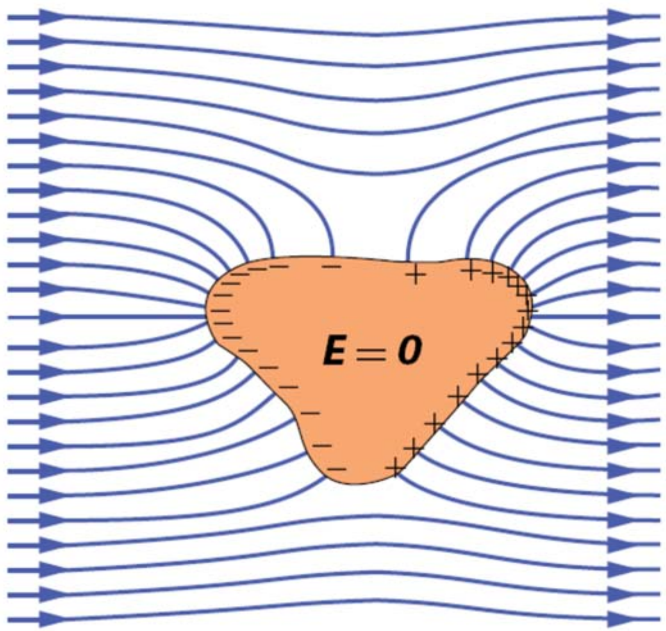


inside conductor $\vec{E} = 0$

$$\oiint_S \vec{E} \cdot d\vec{S} = 0\,?$$

$$E_{t1} - E_{t2} = 0$$

$$E_{n1} - E_{n2} = \frac{\sigma}{\varepsilon_0}$$



field lines perpendicular
to the body surface

Capacitance

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Potential of a sphere charged by charge Q $$\varphi(r) = \frac{Q}{4\pi\varepsilon_0 r}$$

$$\frac{Q}{\varphi} = C$$ Conductor capacity

for capacitors $$C = \frac{Q}{U}$$

parallel-plate capacitor

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

$$C = \frac{\varepsilon_0 S}{d}$$

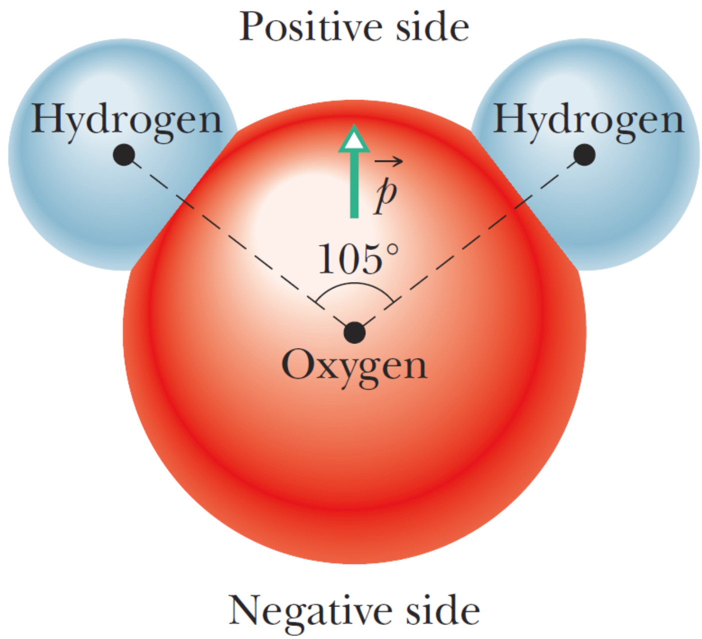
Dielectrics

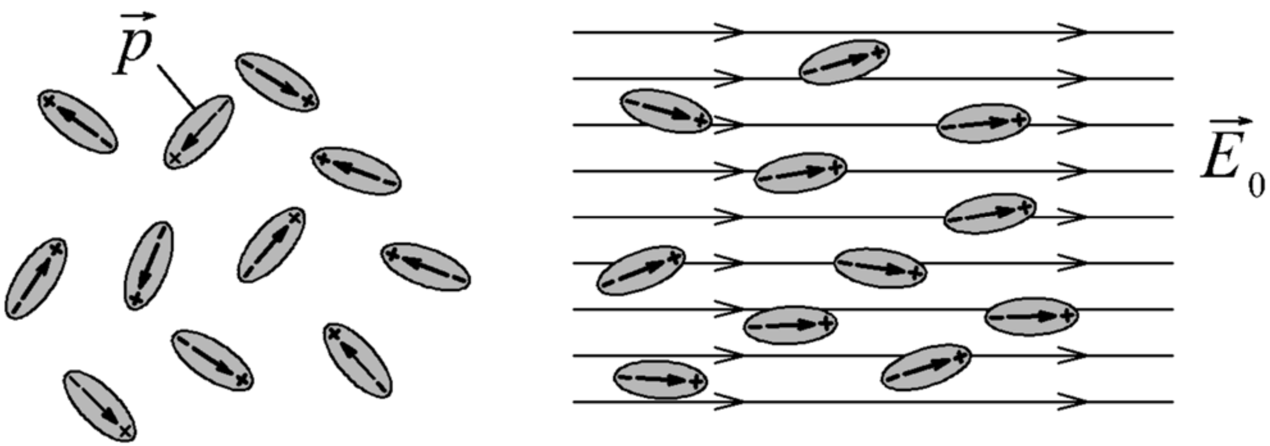
Non-polar

induced moment

Polar

permanent dipole moment





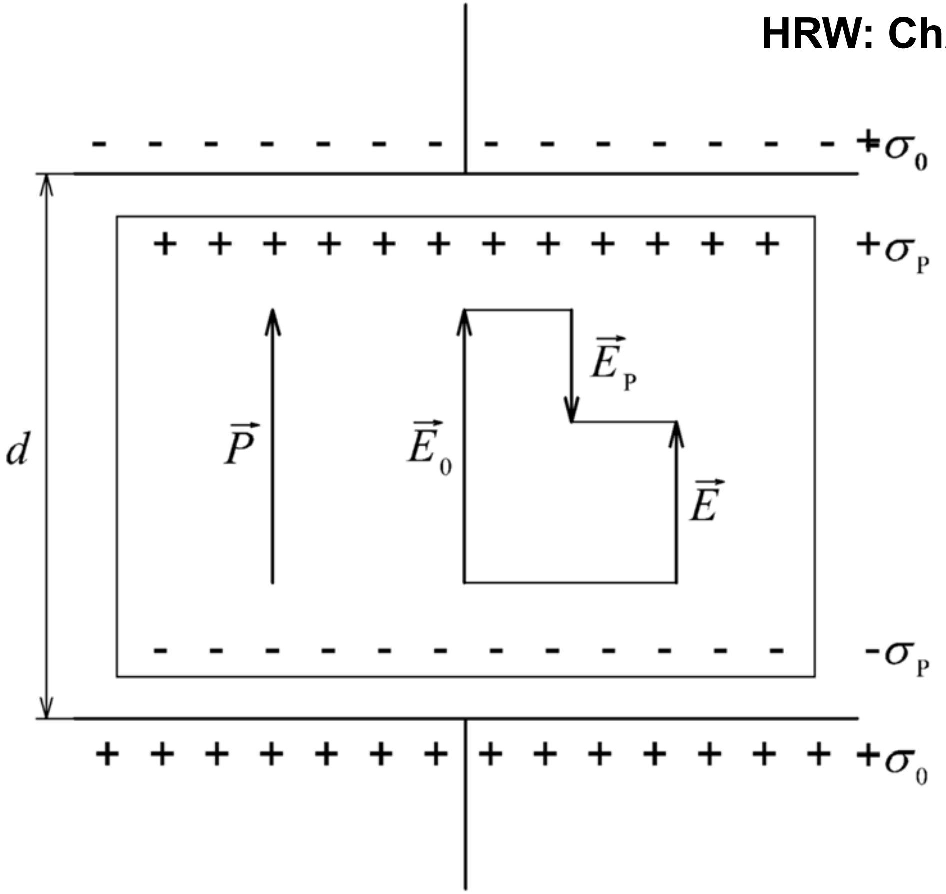
$$\vec{p}_V = \int_V \vec{P}(\vec{r})\,dV$$

$\vec{P}(\vec{r})$ polarization density

Induced surface charges

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

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



Electrostatic influence $\vec{D}(\vec{r}) = \varepsilon_0 \vec{E}(\vec{r}) + \vec{P}(\vec{r})$

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

χ_e electric susceptibility

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

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

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

$$\varepsilon_r = 1 + \chi_e$$

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

$\vec{E}_0 = \varepsilon_r \vec{E}$ relative permittivity

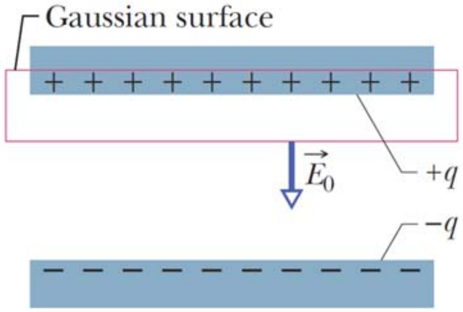
$\varepsilon = \varepsilon_0 \varepsilon_r$ electric permittivity

permanent density $\vec{P}_0(\vec{r})$

permanent dielectrics

HRW: Ch25

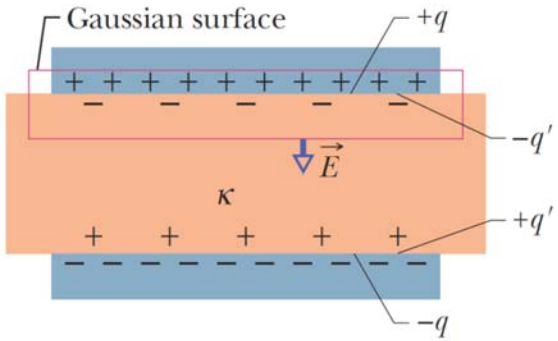
without dielectrics



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

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

with dielectrics



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

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

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

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

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

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

Energy of electric field

$$dW_p = -Q\vec{E} \cdot d\vec{l}$$

Capacitor charging

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

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

$$W_p = \frac{1}{2}\frac{Q_0^2}{C} = \frac{1}{2}Q_0U_0 = \frac{1}{2}CU_0^2$$

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

$$dW = U\ dQ = Ed\ dQ \qquad dQ = \varepsilon_0 S\ dE$$

$$dW = \varepsilon_0 SEd\ dE$$

$$W = \varepsilon_0 Sd \int_0^{E_0} E\ dE = \frac{1}{2}\varepsilon_0 SdE_0^2$$

density of electrostatic field energy

$$w = \frac{dW}{dV}$$

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

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