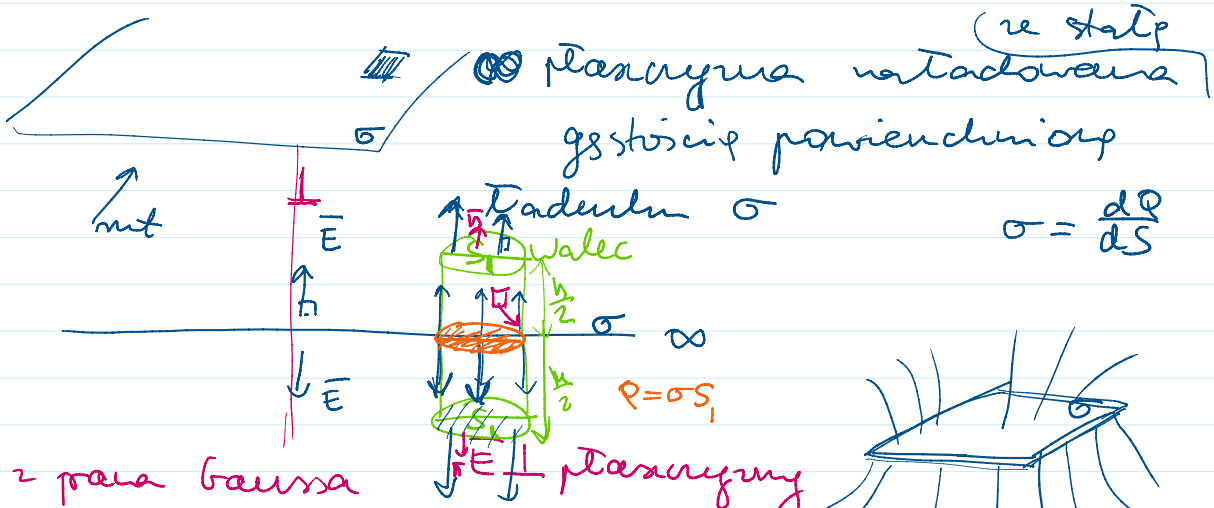
Wykład 25

środa, 2 czerwca 2021 07:52

Kondensatory — capacitor ← volume – objętość, capacity – pojemność, capacitance

↑ do gromadzenia ładunku swobodnego

Kondensator płaski



Pole $\bar{E}$ z prawa Gaussa

$$\oint \bar{E} d\bar{S} = \frac{Q}{\varepsilon_0}$$

$$\int_{\text{pow. bocznej}} \bar{E} d\bar{S} + 2\int_{\text{podst.}} \bar{E} d\bar{S} = \frac{Q}{\varepsilon_0}$$

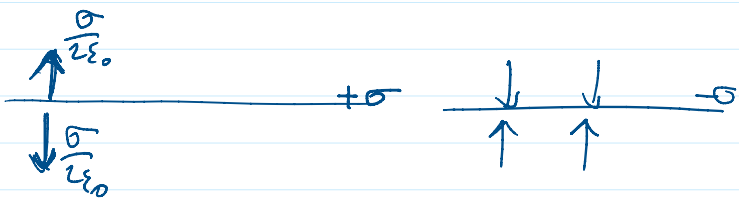
$d\bar{S} = dS\,\bar{n}$, $\bar{E} \perp d\bar{S}$, $\bar{E} d\bar{S} = 0$

$$2\int E\,dS = \frac{Q}{\varepsilon_0}$$

$\sigma = \frac{Q}{S_1}$

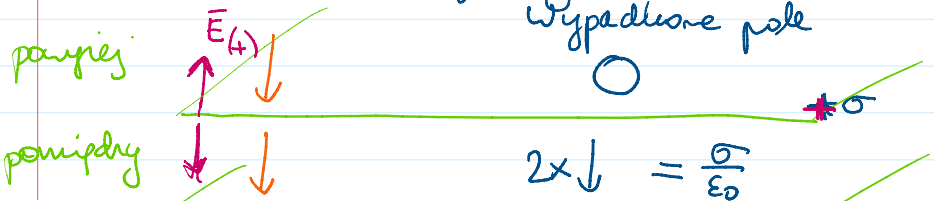
$$2E\left(\frac{h}{2}\right) \cdot S_1 = \frac{\sigma \cdot S_1}{\varepsilon_0}$$

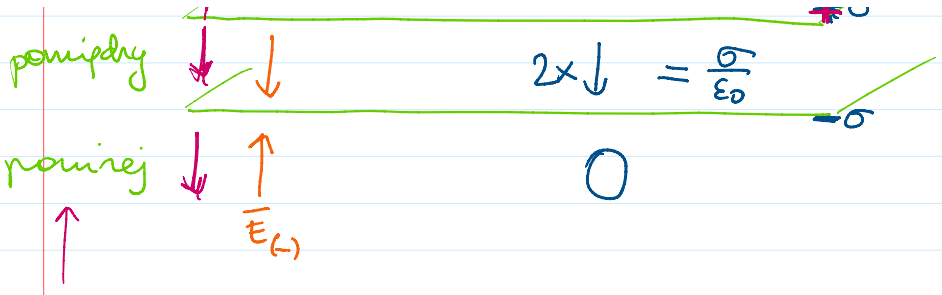
$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

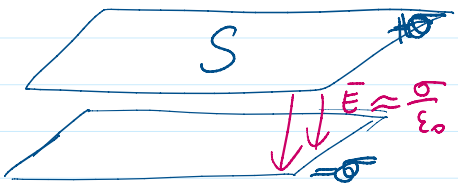


Dwie ∞ płaszczyzny: $\pm\sigma$, równoległe

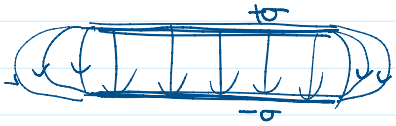
Wypadkowe pole

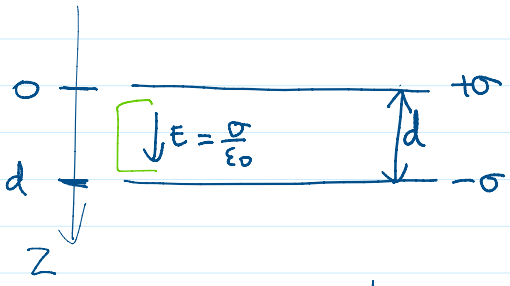






2 okładki skończone w pobliżu





napięcie U lub V

Różnica potencjałów między okładkami:

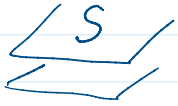
$$E = -\operatorname{grad}\phi = -\frac{d\phi}{dz}$$

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

$$E\,dz = -d\phi \qquad \phi(z) = -E\cdot z + \phi_0$$

Różnica potencjałów $\Delta\phi = U = \phi(0) - \phi(d) =$

$$U = Ed$$



$\frac{\sigma}{\varepsilon_0}$

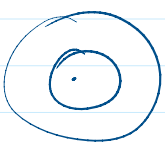
$$U = \frac{\sigma d}{\varepsilon_0}$$

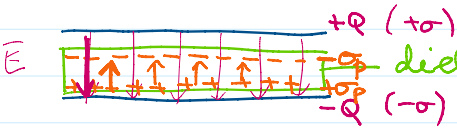
$$U = \frac{Q\,d}{S\,\varepsilon_0} \Rightarrow \left(\frac{Q}{U} = \frac{Q}{V} = \frac{\varepsilon_0 S}{d}\right)$$

Stosunek $\frac{Q}{V}$ nazywamy pojemnością kondensatora C

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 S}{d}$$ dla kondensatora płaskiego





dielektryk o stałej $\varepsilon > 1$

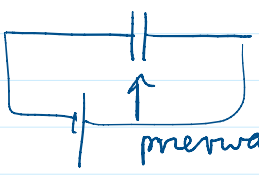
efektywnie $\varepsilon_0 \to \varepsilon\varepsilon_0$

$$C = \frac{\varepsilon_0 S}{\ldots} \to \ldots \quad \varepsilon\varepsilon_0 S$$

$$C_0 = \frac{\varepsilon_0 S}{d} \rightarrow C = \frac{\varepsilon \varepsilon_0 S}{d}$$

efektywnie $\varepsilon_0 \rightarrow \varepsilon\varepsilon_0$

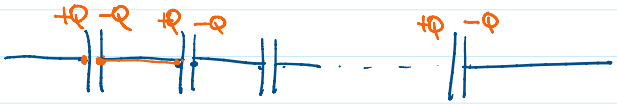
Pojemność kondensatora z dielektrykiem jest większa o czynnik ε.



oznaczenie kondensatora w obwodzie elektr. nie przenosi prądu stałego

przerwany obwód

łączenie kondensatorów $C = \frac{Q}{U}$



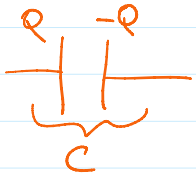
(a) szeregowe

$C_1 \quad C_2 \quad C_3 \quad \dots \quad C_n$

$U_1 \quad U_2 \quad U_3 \quad \dots \quad U_n$

Jaka jest pojemność takiego układu?

$U_i = \frac{Q}{C_i}$ dla całości



C

$U = U_1 + U_2 + \dots + U_n$

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

$$U = \frac{Q}{C_1} + \frac{Q}{C_2} + \dots$$

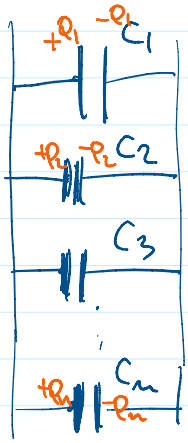
$$\frac{U}{Q} = \boxed{\frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n} = \frac{1}{C}}$$

Przypadek zwykły: $C_1 = C_2 = \dots C_n = C_0$

$$\frac{1}{C_0} + \frac{1}{C_0} + \dots \frac{1}{C_0} = \frac{n}{C_0} = \frac{1}{C} \qquad \boxed{C = \frac{C_0}{n}}$$

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

(b) równoległe



C_1

C_2

C_3

C_n

$Q_i = U \cdot C_i$

całkowity ładunek $Q = Q_1 + Q_2 + \dots Q_n$

$Q = U(C_1 + C_2 + \dots C_n)$

$C_1 \parallel C_2 \parallel \dots \parallel C_n$ (pod napięciem U)

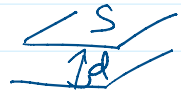
$Q = U(C_1 + C_2 + \dots + C_n)$

$$\frac{Q}{U} = C = C_1 + C_2 + \dots + C_n$$

gdy $C_1 = C_2 = \dots = C_0$ $\quad C = n \cdot C_0$

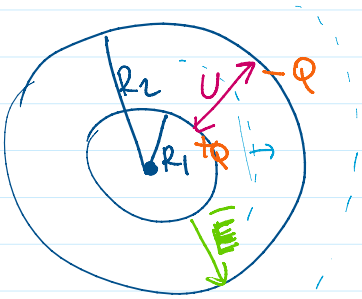
Przykłady innych kondensatorów (o innej geometrii)

(płaski $C = \frac{\varepsilon_0 S}{d}$)



(1) kondensator kulisty

Pojemność: $C = \frac{Q}{U}$



2 sfery współśrodkowe o promieniach R_1 i R_2

pole $\vec{E}$ między okładkami $E(r)$

r - promień od środka sfer

$\oint \vec{E} d\vec{S} = \frac{Q}{\varepsilon_0} = E(r) \cdot 4\pi r^2$

(a) $r < R_1 \quad E(r) = 0$

(b) $R_1 < r < R_2 \quad E(r) = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}$

(c) $r > R_2 \quad E(r) = 0$

(b) $E(r) = -\text{grad}\,\phi \quad -\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} = \left(\frac{d\phi}{dr}\right) \Rightarrow \phi(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r} + \phi_0$

Różnica potencjałów w obszarze (b): $U = \phi(R_1) - \phi(R_2)$

$$U = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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

$$C = \frac{4\pi\varepsilon_0}{\frac{1}{R_1} - \frac{1}{R_2}} = \frac{4\pi\varepsilon_0 R_1 \cdot R_2}{R_2 - R_1}$$

$$C = \frac{Q}{U} \qquad C = \frac{4\pi\varepsilon_0}{\frac{1}{R_1} - \frac{1}{R_2}} = \frac{4\pi\varepsilon_0 R_1 \cdot R_2}{R_2 - R_1}$$

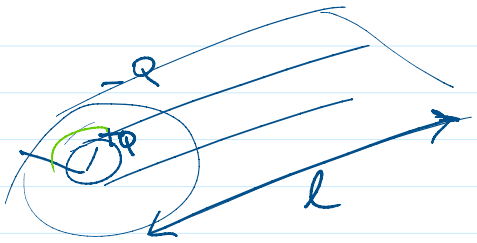
Gdy odsuwamy ekrany okładki do ∞ : $R_2 \to \infty$

$$C \to 4\pi\varepsilon_0 R_1$$

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

Jednostka pojemności: Farad : $1F = \frac{1C}{1V}$

(2) kondensator cylindryczny



$\frac{1}{r}$