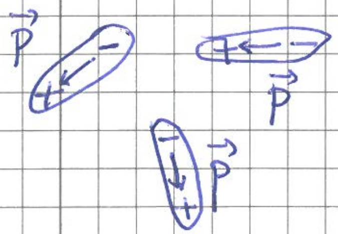
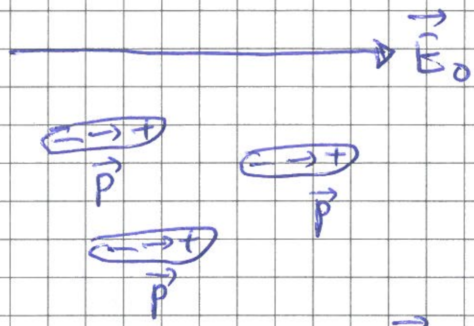
Isolatorer

- Ingen frie ladninger, men "bundet" ladning som polariseres i ytre felt $\vec{E}_0$:

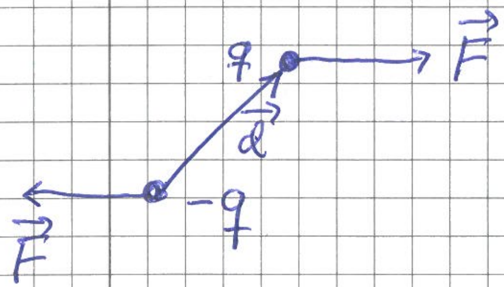




$\sum_i \vec{p}_i \approx 0$ når $\vec{E}_0 = 0$

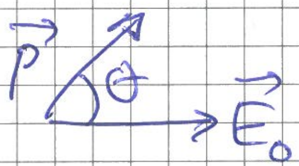
$\sum_i \vec{p}_i \neq 0$ når $\vec{E}_0 \neq 0$

- Ytre felt $\vec{E}_0$ $\Rightarrow$ Innretting av dipoler: [Øving Nr 3]

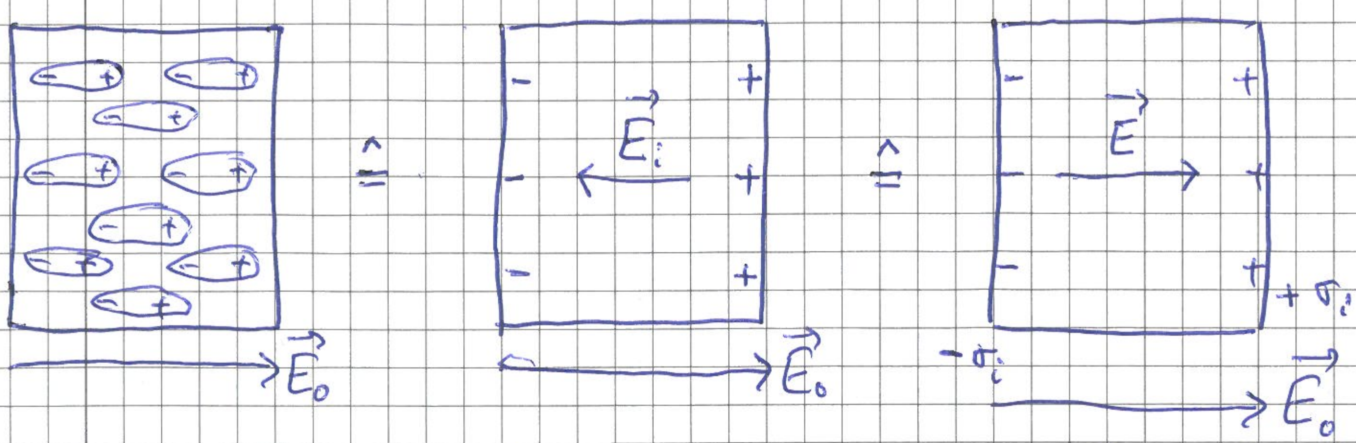


Dreiemoment: $|\vec{\tau}| = pE_0 \sin\theta$

$\vec{\tau} = \vec{p} \times \vec{E}_0$



- Netto makroskopisk effekt av ytre $\vec{E}_0$:



- $\rho = 0$ inni; indusert nettoladning $\pm\sigma_i$ på overflaten
- indusert felt $\vec{E}_i$ inni $\Rightarrow$ svekket felt inni: $\vec{E} = \vec{E}_0 + \vec{E}_i$

$|\vec{E}| = |\vec{E}_0| - |\vec{E}_i|$

Isolatorens relative permittivitet (evt. dielektrisitets-konstant) ε_r def. ved

$$\boxed{E = \frac{1}{\varepsilon_r} E_0}$$

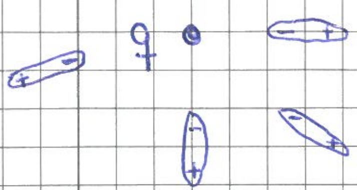
$$[\varepsilon_r] = 1$$

Stoff	ε_r	Stoffets permittivitet $\varepsilon = \varepsilon_r \cdot \varepsilon_0$
Vakuum	1	ε_0
Tørr luft	1,00054	$1.00054\,\varepsilon_0$
Plast	2 – 6	$(2-6)\cdot\varepsilon_0$
Rent vann	80	$80\,\varepsilon_0$
Perfekt metall	∞	∞

Felt fra ladning q i vakuum: $E_{vac}(r) = \dfrac{q}{4\pi\varepsilon_0 r^2}$

Felt ——— " ——— dielektrikum med relativ perm. ε_r:

$$E(r) = \frac{1}{\varepsilon_r} E_{vac}(r) = \frac{q}{4\pi\varepsilon_r\varepsilon_0 r^2} = \frac{q}{4\pi\,\varepsilon\, r^2}$$



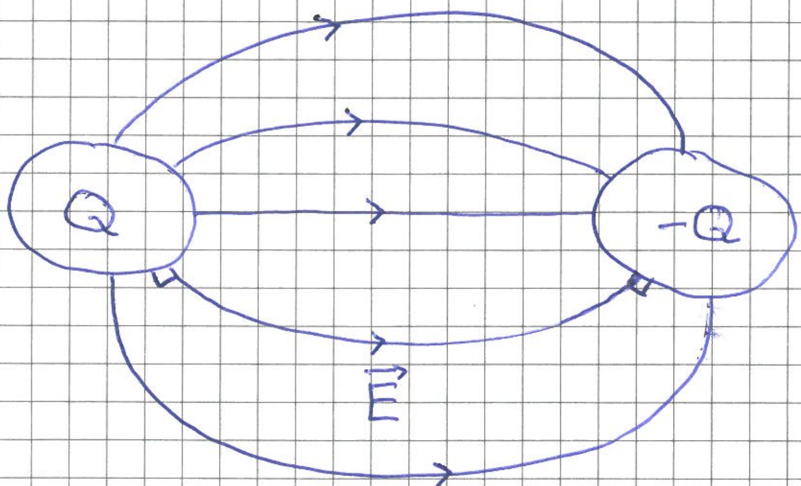
Svekket felt pga polarisering av mediet rundt q

Lysfarten i vakuum: $c \approx 3\cdot 10^8$ m/s ; i dielektrikum: $v = \dfrac{c}{\sqrt{\varepsilon_r}} < c$

Brytningsindeksen til et stoff: $n = \sqrt{\varepsilon_r}$

Kondensator og kapasitans [YF 24; LHL 20]

Kondensator = To ledere med ladning $\pm Q$:



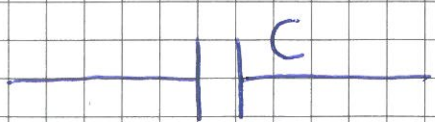
Coulombs lov $\Rightarrow$ E prop. med Q

$\Rightarrow V = V_+ - V_- = -\int_-^+ \vec{E} \cdot d\vec{s}$

også prop. med Q

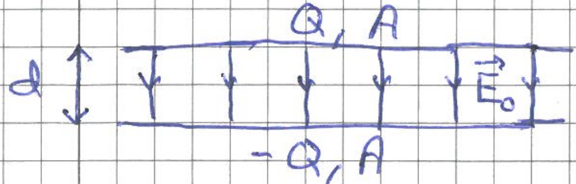
Kondensatorens kapasitans:

$$\boxed{C = Q/V}$$

- $[C] = C/V = F$ (farad)
- Kretssymbol: 

- Lagrer ladning og energi
- C avhenger av utforming og medium mellom lederne
- Beregning av C: Anta $\pm Q$ og regn ut V; da er $C = \frac{Q}{V}$

Platekondensator:

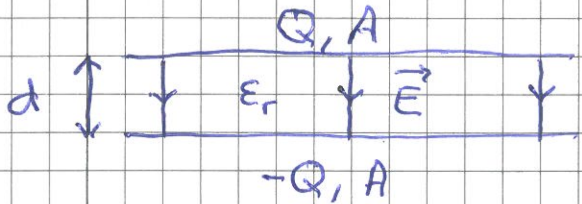


$d \ll \sqrt{A} \Rightarrow$ uniformt $E_0 = \dfrac{\sigma_0}{\varepsilon_0} = \dfrac{Q/A}{\varepsilon_0}$ mellom platene

$$\Rightarrow V_0 = E_0 d = \frac{Q d}{\varepsilon_0 A}$$

$$\Rightarrow C_0 = \frac{Q}{V_0} = \underbrace{\varepsilon_0}_{\text{medium}} \underbrace{\frac{A}{d}}_{\text{geometri}}$$

Hvis fylt med dielektrikum med relativ perm. ε_r :



$$E = \frac{1}{\varepsilon_r} E_0 = \frac{Q/A}{\varepsilon_r \varepsilon_0} \Rightarrow V = E d = \frac{Q d}{\varepsilon_r \varepsilon_0 A}$$

$$\Rightarrow C = \frac{Q}{V} = \underbrace{\varepsilon_r \varepsilon_0}_{\text{medium}} \underbrace{\frac{A}{d}}_{\text{geometri}}$$

Dvs: Kapasitansen er <u>økt</u> med faktor $\varepsilon_r > 1$

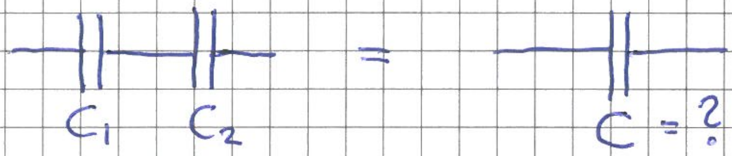
Eks: $A = 1\,\text{cm}^2$, $d = 1\,\text{mm}$, $\varepsilon_r = 4 \Rightarrow C \approx 3.5\,\text{pF}$

[$C = 1\,\text{F}$, $d = 1\,\text{mm}$ og $\varepsilon_r = 4$ krever areal $A \approx 3 \cdot 10^7\,\text{m}^2$!]

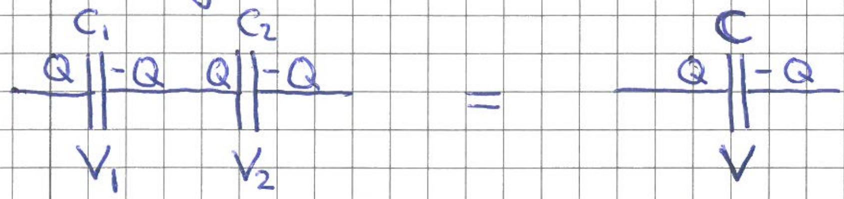
Når $[C] = \text{F}$, har vi $[\varepsilon] = [C \cdot d/A] = \underline{\text{F/m}}$

Kobling av flere kapasitanser [YF 24.2 ; LHL 20.2]

Seriekobling:



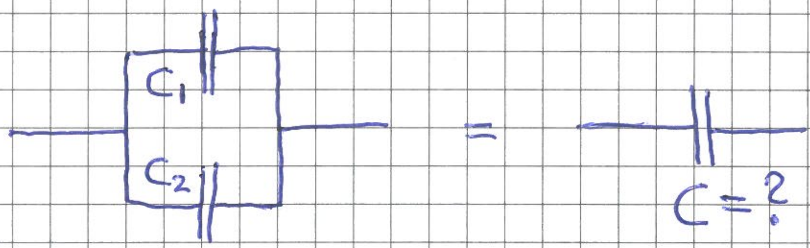
Lik ladning $\pm Q$:



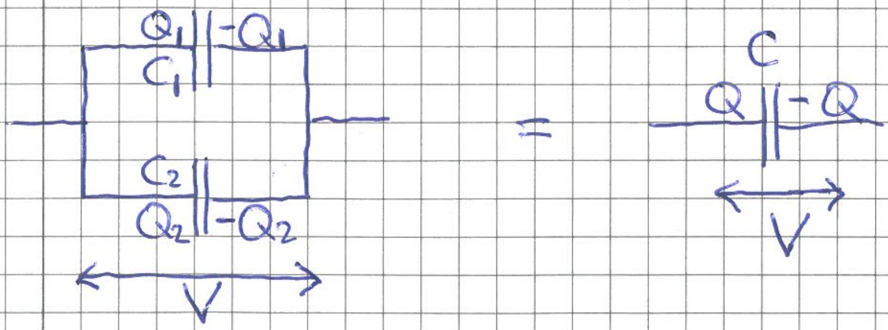
$$\Rightarrow \quad V_1 + V_2 = V \quad \Rightarrow \quad \frac{Q}{C_1} + \frac{Q}{C_2} = \frac{Q}{C} \quad \Rightarrow \quad \boxed{\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}}$$

Med N stk i serie: $\boxed{C^{-1} = \sum_{j=1}^{N} C_j^{-1}}$

Parallellkobling:



Likt potensialfall (lik spenning) V:



$$\Rightarrow \quad Q_1 + Q_2 = Q \quad \Rightarrow \quad C_1 V + C_2 V = C V$$

$$\Rightarrow \quad \boxed{C = C_1 + C_2}$$

Med N stk i parallell: $\boxed{C = \sum_{j=1}^{N} C_j}$