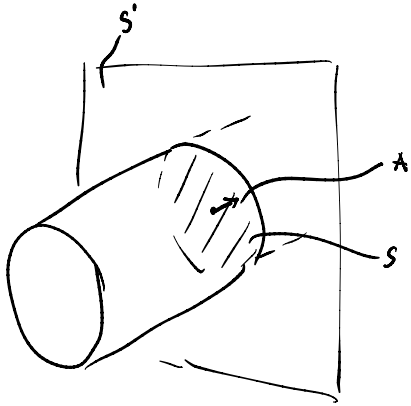
STRØM & MOTSTAND

$$I_s = \frac{\Delta q}{\Delta t}$$

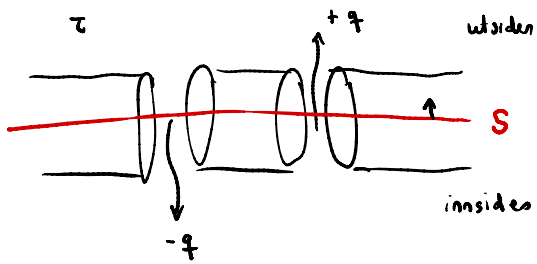
"Netto ladning gjennom overflate per tid"



TEST

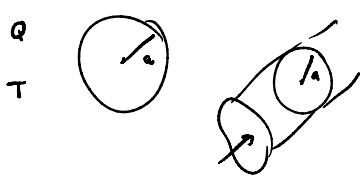
I_s for mye til ute = ?

$$I_s = \frac{+q+q}{\tau} = \frac{2q}{\tau}$$

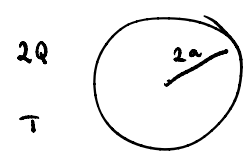


TEST

$$I_1 = \frac{Q}{T}$$



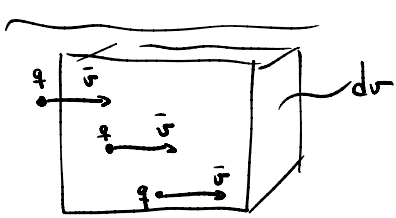
$$I_2 = ? = \frac{2Q}{T} = 2I_1$$



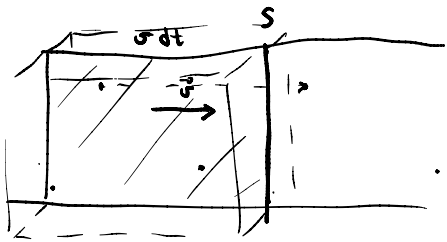
STRØMTETTHET

ladninger per volum: N

$$dq = qN\,d\sigma$$



Hvor mange ladninger går gjennom S: løpet av dt



$$dq = qN\,dv = qNv\,dt\cdot S$$

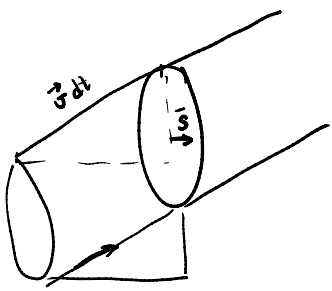
$$I = \frac{dq}{dt} = qNvS\frac{dt}{dt} = \boxed{qNv}S$$

J_s strømtetthet

$$dv = \vec{v}dt\cdot\vec{S}$$

$$\vec{v}dt\cdot S\hat{n}$$

projeksjon

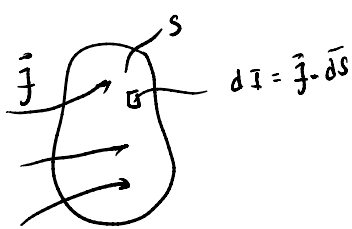


$$I = \frac{dq}{dt} = qN\vec{v}\,dt\cdot\vec{S}/dt$$

$$= \underbrace{qN\vec{v}}_{\vec{J}}\cdot\vec{S}$$

$\vec{J}$: strømtetthet

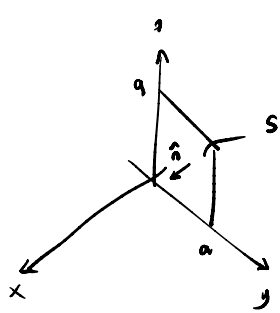
Finn I fra $\vec{J}$



$$I_S = \int_S \vec{J}\cdot d\vec{S}$$

TEST

$$\vec{J} = \frac{I_0}{A}\hat{x}$$

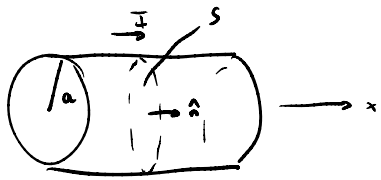


$I_S = ?$

$$I_S = \int_S \vec{J}\cdot d\vec{S} = \vec{J}\cdot\vec{S} = \frac{I_0}{A}\hat{x}\cdot a^2\hat{x} = \frac{I_0}{A}a^2 = I_0\frac{a^2}{A}$$

TEST

Anta $\vec{j}$ är uniform och $\parallel$ med x-axeln.



Hur är då $\vec{j}$?

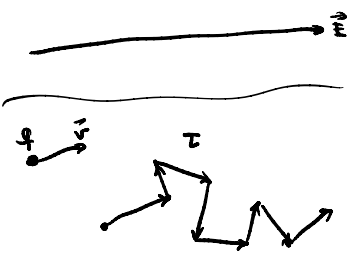
$$\int_S \vec{j} \cdot d\vec{S} = I_S = I$$

$$\int_S j\hat{x} \cdot d\vec{S} = j \int_S \overbrace{\hat{x} \cdot dS\hat{x}}^{=1} = j \int_S dS = j\pi a^2 = I$$

$$\boxed{\vec{j} = \frac{I}{\pi a^2}\hat{x}}$$

OHMS LOV $(V = RI)$





$$\vec{v} = \vec{v}_0 + \frac{q\vec{E}}{m}t \quad , t \in [0, \tau)$$

$$\sum \vec{F} = q\vec{E} = m\vec{a} \Rightarrow \vec{a} = \frac{q\vec{E}}{m}$$

$$\vec{v} = \vec{v}_0 + \vec{a}t$$

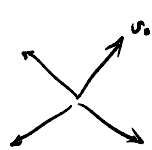
$$\Delta\vec{r} = \int_0^\tau \vec{v}\,dt$$

$$= \int_0^\tau \left(\vec{v}_0 + \frac{q}{m}\vec{E}t\right)dt = \vec{v}_0\tau + \frac{1}{2}\frac{q}{m}\vec{E}\tau^2$$

$$\langle \Delta\vec{r} \rangle = \langle \vec{v}_0\tau \rangle + \left\langle \frac{1}{2}\frac{q}{m}\vec{E}\tau^2 \right\rangle$$

$$\langle \Delta\vec{r} \rangle = \frac{1}{2}\frac{q}{m}\vec{E}\tau^2$$

$$\vec{v}_d = \frac{\langle \Delta\vec{r} \rangle}{\tau} = \frac{1}{2}\frac{q}{m}\vec{E}\tau$$



$$\vec{j} = qN\vec{v} = qN\frac{1}{2}\frac{q}{m}\vec{E}\tau = \frac{Nq^2\tau}{2m}\vec{E}$$

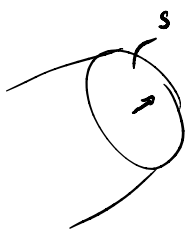
$$\boxed{\vec{j} = \sigma\vec{E}}$$

Ohms lov på mikroskopisk form

$$\vec{j} = \sigma\vec{E}$$

Strøm $I = \frac{\Delta q}{\Delta t}$

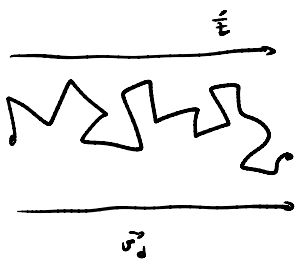
Strømtetthet $\vec{j}$: $I = \int_S \vec{j}\cdot d\vec{S}$



$$\vec{j} = qN\vec{v}$$

Ohms lov $\vec{j} = \sigma\vec{E}$

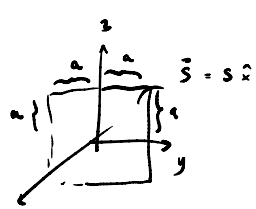
$$dI = \vec{j}\cdot d\vec{S}$$



TEST

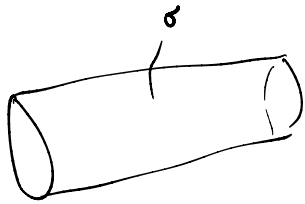
$\vec{E} = E_0\hat{x}$, i el materiale med σ

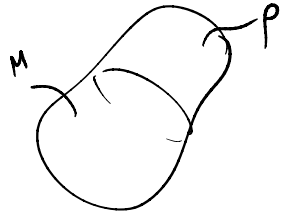
Hva er $\vec{j}$?



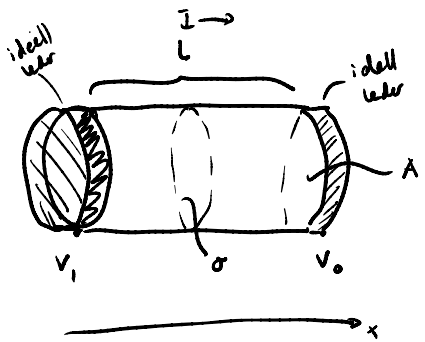
$$\vec{j} = \sigma\vec{E} = \sigma E_0\hat{x}$$

$$I_S = ? = \int_S \vec{j}\cdot d\vec{S} = \int_S \sigma E_0\hat{x}\cdot\hat{x}\,dS = \sigma E_0\int_S dS = \sigma E_0(2a)^2$$





Finn motstanden til en komponent



Anta I → Finn $\Delta V = V_1 - V_0$

Hva er $\vec{j}$?

Anta $\vec{j}$ er uniform

$$\vec{j} = j\hat{x}$$

Ohms lov $\vec{j} = \sigma\vec{E} \Rightarrow \vec{E} = \frac{1}{\sigma}\vec{j}$, $\vec{j} = \frac{I}{A}\hat{x}$ $\left(I = \int \vec{j}\cdot d\vec{S} = I\right)$

$$\vec{E} = \frac{1}{\sigma}\vec{j} = \frac{I}{\sigma A}\hat{x}$$

$$\Delta V = \int_1^0 \vec{E}\cdot d\vec{l} = \vec{E}\cdot\vec{L}^{L\hat{x}} = \frac{1}{\sigma}\frac{I}{A}L = \frac{L}{\sigma A}I$$

$$V_1 - V_0 = \Delta V = \underbrace{\left(\frac{L}{\sigma A}\right)}_{R} I$$

$$\boxed{\Delta V = RI}$$

Ohms lov på makroskopisk form

Metode: Finn R

(i) Anta I

(ii) Anta/finn $\vec{j}$

(iii) Finn $\vec{E}$

(iv) Finn V

(v) Finn $R = V/I$

Kondensator

(i) Anta Q

(iii) Finn E

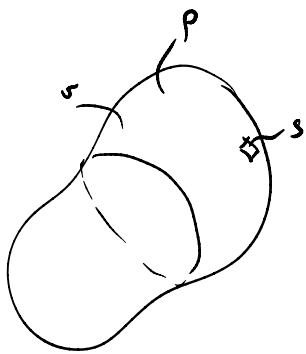
Finn V

Finn $C = Q/V$

LADNINGSBEVARING

Ladning er bevart (netto)

$$Q = \int_V \rho \, dv$$



I løpet av Δt:

$$I_S = \oint_S \vec{j} \cdot d\vec{S}$$

$$I_S = -\frac{dQ}{dt} = -\frac{d}{dt}\int_V \rho \, dv$$

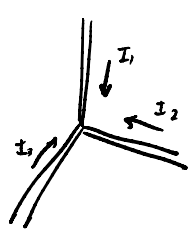
$$\oint_S \vec{j} \cdot d\vec{S} = -\frac{d}{dt}\int_V \rho \, dv$$

$$\int_V \nabla \cdot \vec{j} \, dv = -\frac{d}{dt}\int \rho \, dv \quad \Leftrightarrow \quad \boxed{\nabla \cdot \vec{j} = -\frac{\partial \rho}{\partial t}}$$ Ladningsbevaring

Hvis $\frac{\partial \rho}{\partial t} = 0 \Rightarrow \nabla \cdot \vec{j} = 0$

Netto strøm inn i et punkt er null

$$\sum_i I_i = 0$$



Kirchoffs strømlov: $\sum_i I_i = 0$

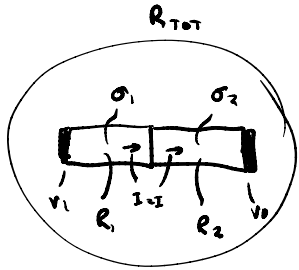
Kirchoffs spenningslov: $\oint E \cdot d\vec{l} = 0 \Rightarrow \sum_i \Delta V_i = 0$

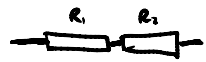


Kombinasjon av motstander

Serakobling $R_{TOT} = R_1 + R_2$

$= \sum R_i$





Parallell kobling $\frac{1}{R_{TOT}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_{TOT}} = \sum_i \frac{1}{R_i}$

