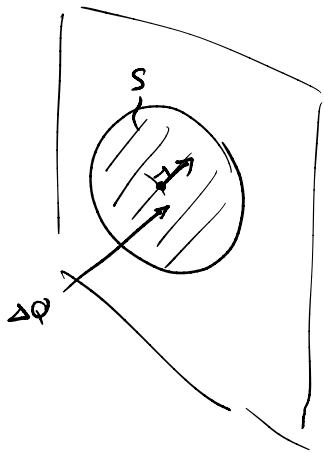
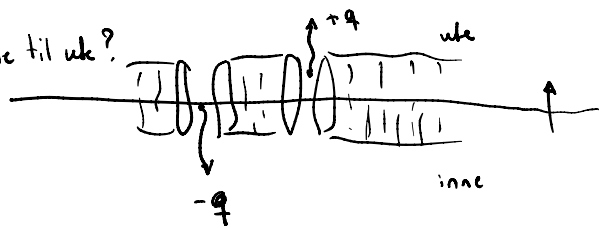
Strøm

$$I_S = \frac{\Delta Q}{\Delta t}$$



TEST

Er det netto strøm fra inne til ute?

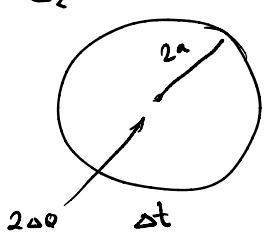


$I > 0$?
$I < 0$?
$I = 0$?

TEST

$$I = \frac{\Delta Q}{\Delta t}$$

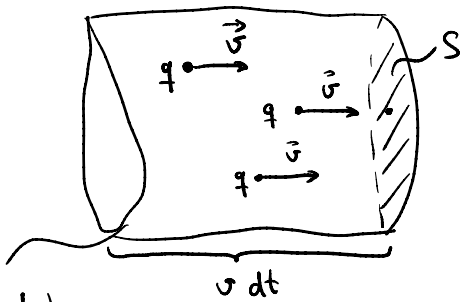
$I_2 = ?$



I_1



Strømtetthet



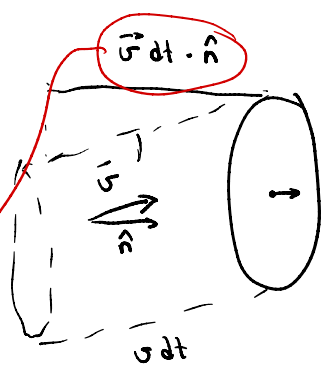
$dq = N\,dv\,q$

antall ladninger per volum

$dq = N\,S\,v\,dt\cdot q = Nvq\cdot S\,dt$

$\frac{dq}{dt} = \underbrace{Nvq}_{\vec{J}}\cdot S$

Hvor mye ladning går igjennom per tid:



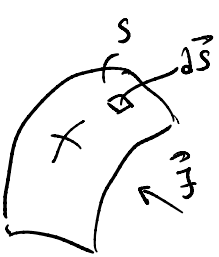
$dq = N\,dv\cdot q$

$dq = N\,\vec{v}\,dt\cdot\hat{n}\,q\,S$

$I = \frac{dq}{dt} = \underbrace{N\vec{v}q}_{\vec{J}}\cdot\underbrace{\hat{n}S}_{\vec{S}}$

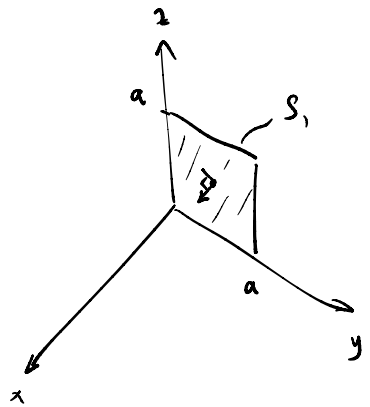
Hvis S ikke er plan

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



TEST

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



Ηρα είναι $I_{S_1} = ?$

$$I_{S_1} = \int_{S_1} \vec{j}\cdot d\vec{S}$$

$$= \vec{j}\cdot\int_{S_1} d\vec{S}$$

$$I_{S_1} = \frac{I_0}{A}\hat{x}\cdot a^2\hat{x} = I_0\frac{a^2}{A}$$

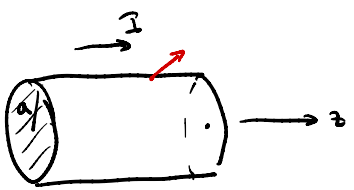
TEST

$\vec{j} = ?$

$\vec{j} = j_z\hat{z}$

{ uniform | sylinder

null ellers



$$\vec{S} = S\hat{z}$$

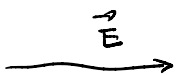
$$\vec{j}\cdot\vec{S} = I$$

$$j_z S = I \Rightarrow j_z = \frac{I}{S} = \frac{I}{\pi a^2}$$

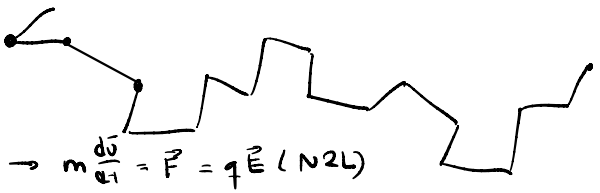
Ohms lov

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

Hvis vi ser på en ladning q i et felt $\vec{E}$:



Mellom hver kollisjon



påvirkes av kraft $\vec{F} = q\vec{E} \rightarrow m\frac{d\vec{v}}{dt} = \vec{F} = q\vec{E}$ (N2L)

$$\vec{v} = \vec{v}_0 + \frac{q}{m}\vec{E}\cdot t$$

$$\Delta\vec{r} = \int_0^t (\vec{v}_0 + \frac{q}{m}\vec{E}t)\,dt = (\vec{v}_0 t + \frac{1}{2}\frac{q}{m}\vec{E}t^2)$$

Anta tid τ mellom hver kollisjon. (midlere fri tid)

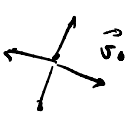


Anta at $\vec{v}_0$ er tilfeldig

$\langle \vec{v}_0 \rangle = 0$, fordi isotrop!

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

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



Denne hastigheten inngår i strømtetthet

$$\vec{j} = Nq\vec{v}_d = \underbrace{\frac{Nq^2\tau}{2m}}_{\sigma}\vec{E}$$

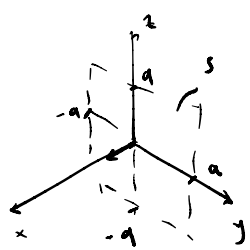
ledningsevne

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

Ohms lov på mikroskopisk form

TEST

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



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

Hva er $\vec{J}$? $\quad \vec{J} = \sigma\vec{E} = \sigma E_0\hat{x}$

Hva er I_S? $\quad I_S = \vec{J}\cdot\vec{S}$

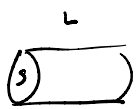
$= \sigma E_0\hat{x}\cdot S\hat{x} = \sigma E_0 S = \sigma E_0(2a)^2$

$I = 4\sigma E_0 a^2$

σ : material egenskap $\quad \rho = 1/\sigma$

ρ_m : massetetthet

ρ_v



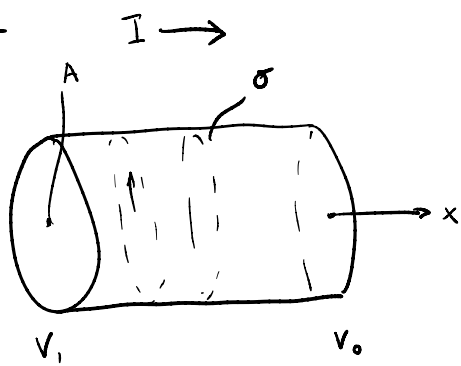
Finn egenskaper til en motstand

Anta I

Hva er $\vec{J}$?

(1) Anta ikke avh. av x

(2) Anta $\vec{J}$ er uniform i yz-planet

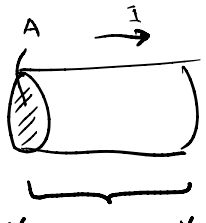


$\vec{J} = J_x\hat{x} \Rightarrow \vec{E} = \frac{1}{\sigma}\vec{J} = \frac{1}{\sigma}J_x\hat{x}$

Ohms lov

$\vec{J} = \sigma\vec{E} \Leftrightarrow \vec{E} = \frac{1}{\sigma}\vec{J}$

$$J_x = \frac{I}{A}$$



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

$$\Delta V = V_1 - V_0 = \int_1^0 \vec{E} \cdot d\vec{l}$$

$$= \int_{x=0}^{x=L} \frac{I}{A\sigma} dx = \frac{IL}{A\sigma} = \underbrace{\frac{L}{A\sigma}}_{R} I$$

$$G = \frac{1}{R} = \frac{\sigma A}{L}$$

$$V = \underbrace{R}_{\text{motstanden}} I$$

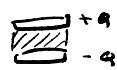
Metode for å finne R

(1) Anta I
(2) Finner $\vec{J}$
(3) Finn $\vec{E}$
(4) Finn V
(5) Finn $R = V/I$



Metode for å finne C

(1) Anta Q



(2) Finn E
(3) Finn V
(4) Finn $C = Q/V$

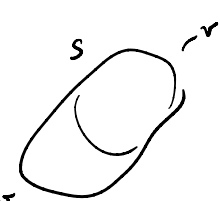
Effekt-tap

$$P_J = \vec{J} \cdot \vec{E}$$

$$V = RI$$

$$P = \int_V \vec{J} \cdot \vec{E} \, dv = IV = RI^2$$

Ladningsbevaring



$$Q = \int \rho \, dv$$

$$I_S = \oint \vec{J} \cdot d\vec{S} = -\frac{dQ}{dt} = -\frac{d}{dt} \int_V \rho \, dv$$

$$I_s = \int_V \nabla \cdot \vec{j} \, dv = -\frac{d}{dt} \int \rho \, dv$$

$$\boxed{\nabla \cdot \vec{j} = -\frac{\partial \rho}{\partial t}}$$ Ladingsbewaring