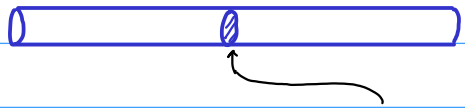
Elektriske kretser

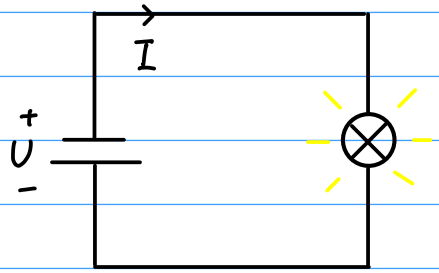
Strøm: $I = \frac{q}{t} = \frac{\text{ladning}}{\text{tid}}$

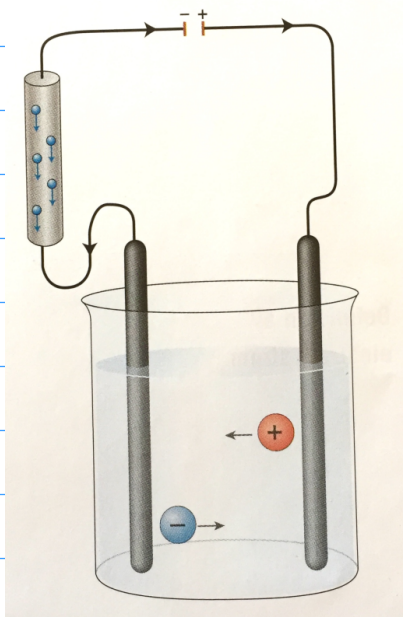
Enhet strøm: $[I] = \frac{C}{s} = A$ = ampere



$I = \frac{\text{ladn. gjennom tverrsnittet ila tidsint}}{t}$

Krets:





Grimenes, Jestad, Sletbak: Grunnleggende fysikk for universitet og hogskole

Strømretning:

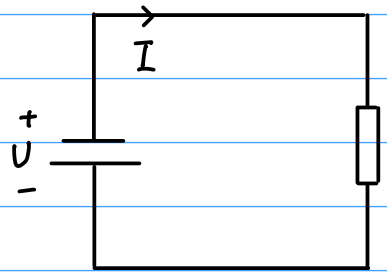
Strøm ⟶ kan bestå av

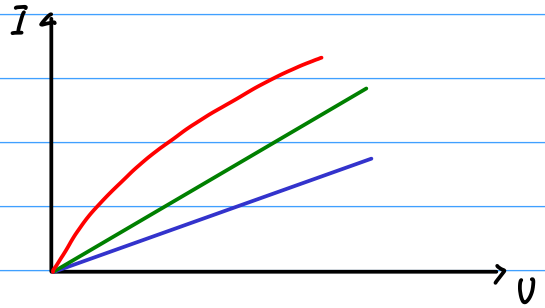
+ ladn: ⟶ eller

− ladn: ⟵ eller begge.

I tilfellene der strømmen består av elektroner er strømretningen motsatt av bevegelsen til elektronene

Sammenheng mellom strøm og spenning:





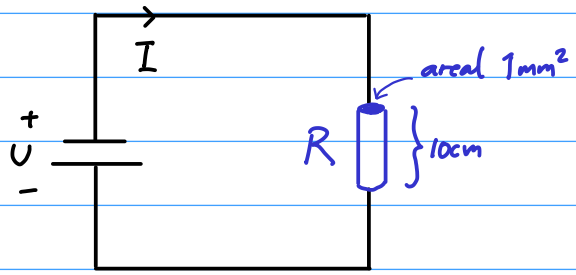
Ofte er sammenhengen lineær (Ohms lov):

$$I = \frac{U}{R}, \quad R = \frac{U}{I}, \quad [R] = \frac{V}{A} = \Omega \text{ (ohm)}$$

R kalles resistans (motstand).

Resistans R

Eks:



Anta $U = 10V$. Finn I.

$$I = \frac{U}{R}$$

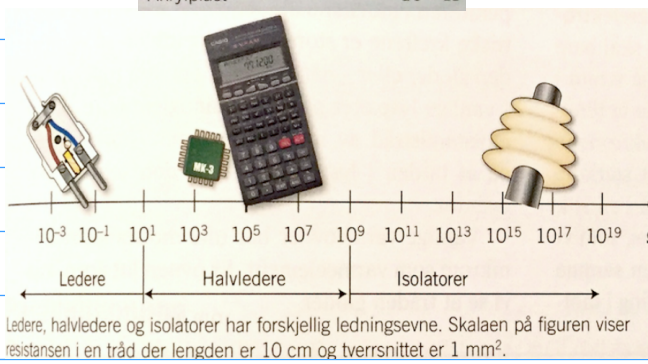
Sølv: $I = \frac{10V}{1{,}6 \cdot 10^{-3}\Omega} = 6250A$

Glass: $I = \frac{10V}{10^{17}\Omega} = 10^{-16}A$

R:

Resistansen i en del tråder og væskesøyler der lengden er 10 cm og tverrsnittet er 1 mm²

Sølv	$1{,}6 \cdot 10^{-3}\ \Omega$
Kopper	$1{,}7 \cdot 10^{-3}\ \Omega$
Aluminium	$2{,}7 \cdot 10^{-3}\ \Omega$
Konstantan	$50 \cdot 10^{-3}\ \Omega$
Kromnikkel	$110 \cdot 10^{-3}\ \Omega$
Karbon (grafitt)	$1{,}4\ \Omega$
Silisium	$10^{8}\ \Omega$
Vann, destillert	$5 \cdot 10^{8}\ \Omega$
Glass	10^{16}–$10^{17}\ \Omega$
Tre	$10^{17}\ \Omega$
Gummi	$5 \cdot 10^{18}\ \Omega$
Akrylplast	$10^{24}\ \Omega$

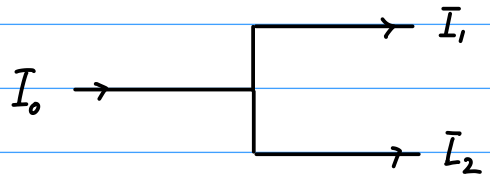


Ledere, halvledere og isolatorer har forskjellig ledningsevne. Skalaen på figuren viser resistansen i en tråd der lengden er 10 cm og tverrsnittet er 1 mm².

Grimenes, Jestad, Sletbak: Grunnleggende fysikk for universitet og hogskole

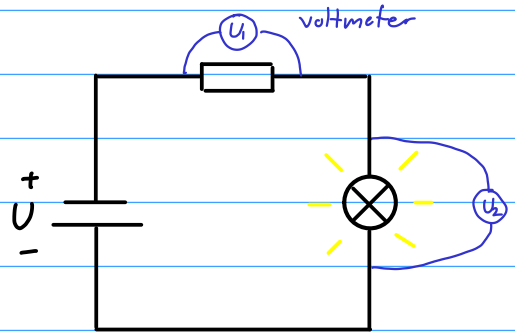
Regne på kretser

Kirchhoffs strømlov:



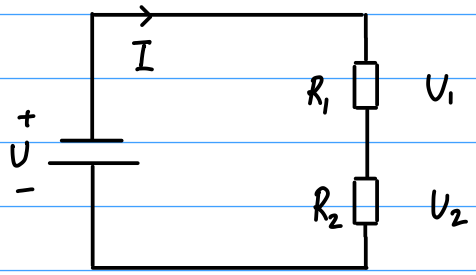
$$I_0 = I_1 + I_2$$

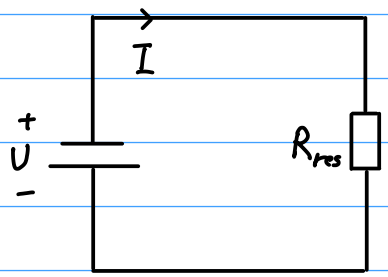
Kirchhoffs spenningslov:



$$U = U_1 + U_2$$

Seriekobling:





Samme strømmen I går gjennom begge motstandene.

$U_1 = R_1 I$

$U_2 = R_2 I$

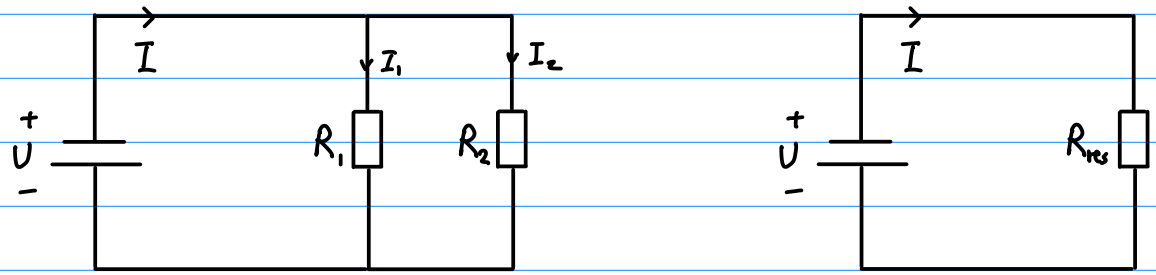
$U = U_1 + U_2 = R_1 I + R_2 I = (R_1 + R_2) I$

Ønsker å skrive $U = R_{res} I$

$$R_{res} = R_1 + R_2$$

Seriekobling

Parallellkobling:



Samme spenning U over R_1 og R_2.

$$I_1 = \frac{U}{R_1}, \quad I_2 = \frac{U}{R_2}$$

$$I = I_1 + I_2 = \frac{U}{R_1} + \frac{U}{R_2} = U\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Ønsker $I = \frac{U}{R_{res}} \Rightarrow U = R_{res} I$

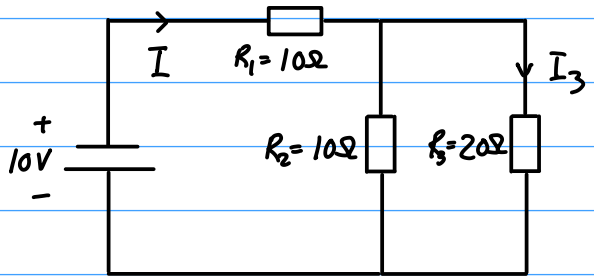
$$\cancel{I} = R_{res}\cancel{I}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$1 = R_{res}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\boxed{\frac{1}{R_{res}} = \frac{1}{R_1} + \frac{1}{R_2}}$$

Parallellkobling

Eks: Finn I og I_3.



Parallellkobl. av R_2 og R_3:

$$\frac{1}{R_{res}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{10\Omega} + \frac{1}{20\Omega}$$

$R_{res} = 6{,}67\,\Omega$

Totalt: $R_1 + R_{res} = 16{,}67\,\Omega$

$$I = \frac{10V}{16{,}67\Omega} = \underline{0{,}60A}$$

Spenning over R_1:

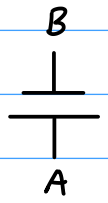
$U_1 = R_1 I = 10\Omega \cdot 0{,}60A = 6V$

$U_1 + U_3 = U = 10V, \quad U_3 = 4V$

$$I_3 = \frac{U_3}{R_3} = \frac{4V}{20\Omega} = \underline{0{,}20A}$$

Elektrisk energi og effekt

Spenning: $U_{AB} = \frac{W_{AB}}{q} = \frac{\text{arbeid}}{\text{ladning}}$



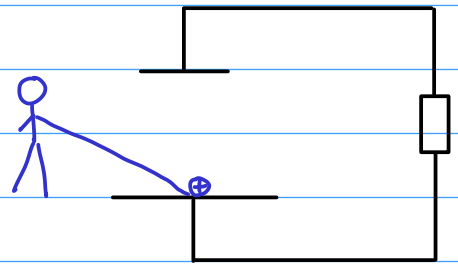
Arbeid: $W_{AB} = U_{AB} \cdot q = U_{AB} \cdot It$

$\uparrow I = \frac{q}{t}$

Effekt: $P = \frac{W_{AB}}{t} = U_{AB} I$.

Elektrisk effekt: $\boxed{P = UI}$. Med $U = RI$: $P = RI^2$

$P = \frac{U^2}{R}$



I : hvor mye ladn. per sek

U : hvor høyt løftes ladningene

Eks: Et mobilbatteri har kapasiteten 3000 mAh og spenningen 3,8 V. Hvor mye energi er lagret?

Energi $= Pt = UIt = 3{,}8\,V \cdot 3\,A \cdot 1\,h$

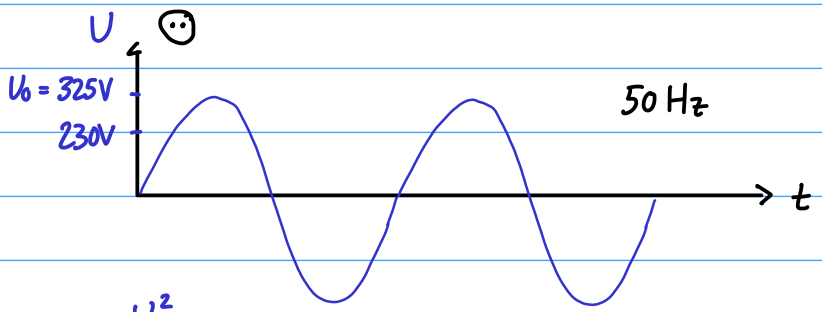
$= 11{,}4\,Wh = 11{,}4\,W \cdot 3600\,s = \underline{41\,kJ}$

Eks: En elektrisk panelovn leverer 1000 W. Spenningen $U = 230\,V$. Hva er strømmen gjennom ovnen? Resistansen?

$P = UI \Rightarrow I = \frac{P}{U} = \frac{1000\,W}{230\,V} = \underline{4{,}35\,A}$

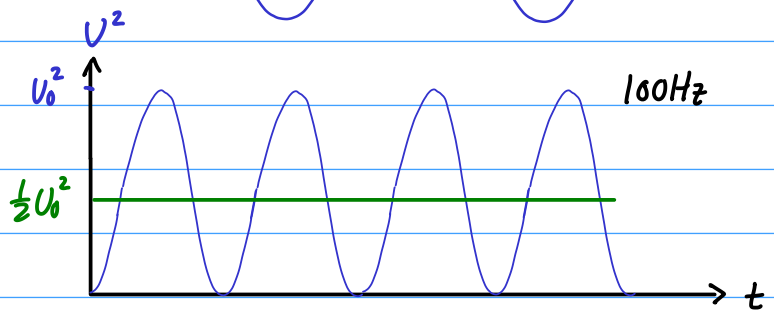
$R = \frac{U}{I} = \frac{230\,V}{4{,}35\,A} = \underline{52{,}9\,\Omega}$.

Vekselstrøm



$$U = U_0 \sin(\omega t)$$

$$P = \frac{U^2}{R}$$



Gjennomsittseffekt:

$$P = \frac{\frac{1}{2}U_0^2}{R} = \frac{U_{ekv}^2}{R}$$

$$U_{ekv}^2 = \frac{1}{2}U_0^2$$

$$U_{ekv} = \frac{U_0}{\sqrt{2}} = \frac{325V}{\sqrt{2}} = 230V$$