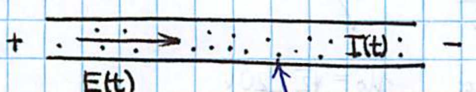
$U(t)$; $U = IR$

Ohmov zakon velja tudi, če se napetost spreminja, npr.: bakrena žica:



$m \sim 10^{-31}$ kg
$e \sim 10^{-19}$ As

$ma = Ee$

- m: velikostni razred 10^{-31}
- a: velikostni red 1
- $E e$: velikostni razred 10^{-19}

$a \sim 10^{+12}$ m/s

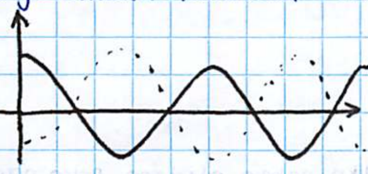
Mobitel: 1 GHz = 10^9/s (gibanje antene s frekvenco).

Tj. elektroni se z lahkoto gibljejo oz. sledijo zunanjim poljem. Če spreminjamo U s časom ($U(t)$), potem bodo pospeški dovolj veliki, da bo tok sledil z lahkoto: $U(t) = I(t)R$

Če se velikostni red polja poveča za 1000x, tedaj Ohmov zakon ne velja več (tok ne more slediti spremembam).

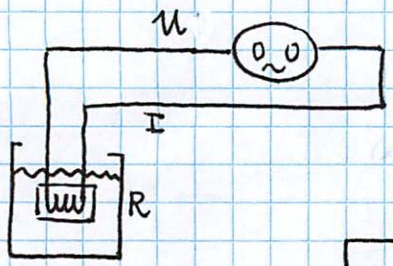
ČASOVNO ODVISNI IZVOR NAPETOSTI

Npr. vtičnice (napetost je sinusna izmenična – nihanje, projekcija vrtenja)

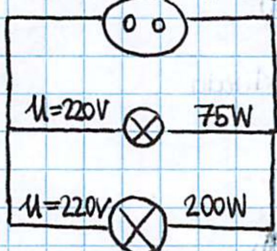


Vse elektrarne morajo delovati sinhronizirano (in ne zamujati, itd.), da imamo električni tok, kot je.
Vsota krivulj…. Kaj bi se dobili?

$U = U_0 \cos\omega t$, $\omega = 2\pi\nu$, $\nu = 50$/s (50 Hz)



$P = IU = I^2R = \frac{U^2}{R}$ → tok odvisen od upora (večji upor, manjši tok)



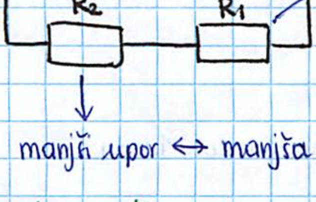
(a) $P_1 = \frac{U_1^2}{R_1} = I_1^2 R_1$

$P_2 = \frac{U_2^2}{R_2} = I_2^2 R_2$

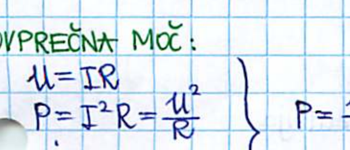
Če je žarnica priklopljena in je $U = 220$ V, le takrat ima moč 75 W. Iz U in P_1 pa lahko dobimo upor žarnice R_1.

$P_2 = 200$ W
Ta žarnica sveti bolj (debelejša žica), ker je tok, zaradi manjšega upora R_2, večji.

(b)



Za izračun velja enačba:
$P = IU = I^2R = \frac{U^2}{R}$

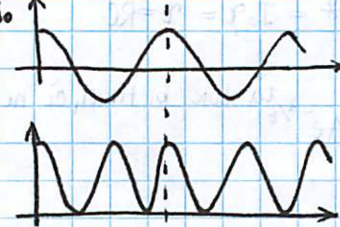


R_1 → večji upor (saj je moč manjša) ↔ večja napetost (manjši tok?)

R_2 → manjši upor ↔ manjša napetost (več toka gre skozi)

POVPREČNA MOČ:

$$\left.\begin{array}{l} U = IR \\ P = I^2R = \frac{U^2}{R} \\ \vdots \\ U = U_0\cos\omega t \end{array}\right\} \quad P = \frac{U_0^2}{R}\cos^2\omega t$$



← nihanje nitke v žarnici

$\overline{P} = \frac{1}{T}\int_0^T P(t)\,dt = \frac{1}{2}\frac{U_0^2}{R} = \frac{U_{ef}^2}{R}$

$U_0 = \sqrt{2}\,U_{ef}$

$U_{ef} = 220V$

$U_0 = \sqrt{2}\ 220V$

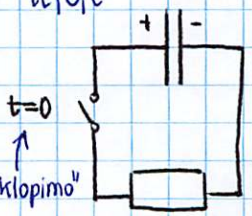
$P = 75W = \frac{U^2}{R}$

$U = 220V$

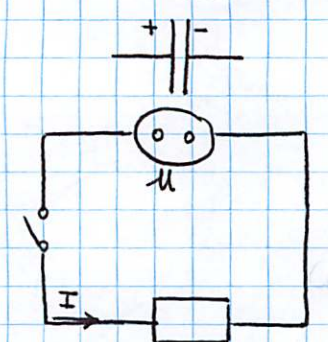
POLNENJE IN PRAZNENJE KONDEZATORJA

(a) Praznenje kondezatorja: (osciloskop)??

U, C, e

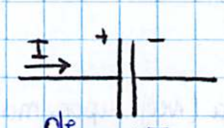


$U(0)$
$U(t)$

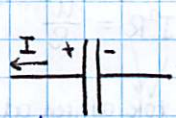


$U - IR = 0$; $C = \frac{e}{U}$ → Koliko naboja glede na neko napetost lahko spravimo na ploščo (npr. kondezator).

$\frac{e(t)}{C} - I(t)R = 0$



$\frac{de}{dt} = +I$
(večji naboj)



$\frac{de}{dt} = -I$
(manjši naboj)

vstavimo (*)

(*) $\frac{e(t)}{C} + \frac{de}{dt}R = 0$ homogena diferencialna enačba 1. reda

$\frac{de}{dt} + \frac{e}{\tau} = 0$, $\tau = R \cdot C$

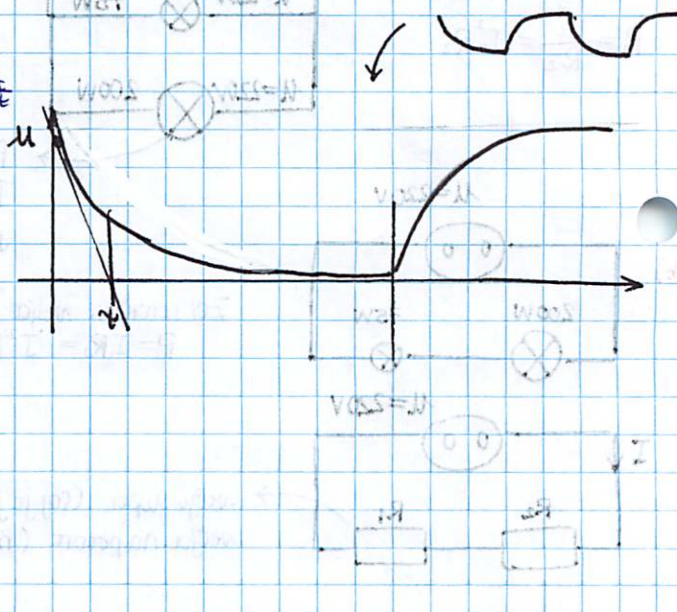
$\int_{e(0)}^{e} \frac{de}{e} = -\int_0^t \frac{dt}{\tau} \iff \ln\frac{e}{e(0)} = \frac{t}{\tau} \iff e = e(0)e^{-\frac{t}{\tau}}$

$U_0 = 1 - \frac{t}{\tau} + \frac{1}{2!}\left(\frac{t}{\tau}\right)^2 + \dots$

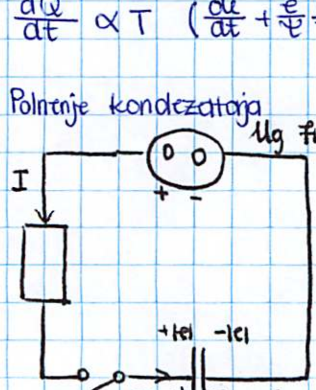
$U = \frac{e}{C}$

$U(t) = U_0 e^{-\frac{t}{\tau}}$

$\frac{dQ}{dt} \propto T \quad \left(\frac{de}{dt} + \frac{e}{\tau} = 0\right)$



(b) Polnenje kondezatorja



↳ spraznjen kondezator

$U_g - IR - U_C = 0 \quad U_C = \frac{e}{C}$

$U_g - IR - \frac{e}{C} = 0$

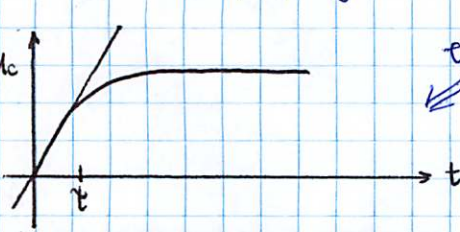
$\frac{de}{dt} = +I$

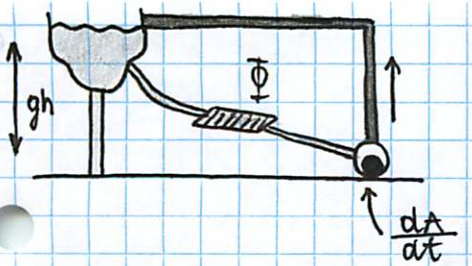
$U_g - \frac{de}{dt}R - \frac{e}{C} = 0$ nehomogena diferencialna enačba 1. reda

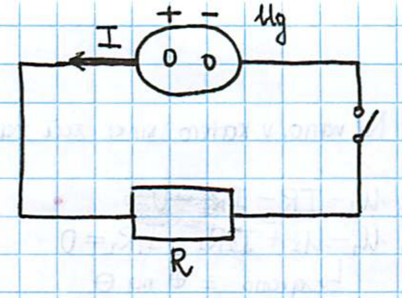
$\dot{e} + \frac{e}{\tau} = \frac{U_g}{R} = I_0$; $\tau = RC$

I_0 ↓ ta tok bi tekel, či ne bi bilo kondezatorja

$e(t) = e_p + Ae^{-t/\tau}$

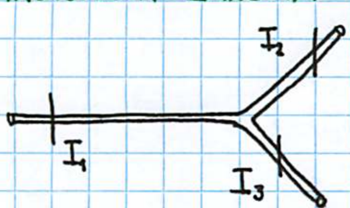




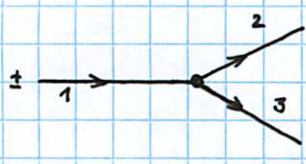


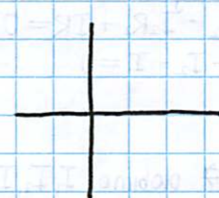
$\mathcal{U}_g = IR$

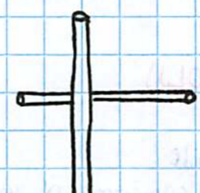
KIRCHOFFOVA ZAKONA



$I = I_1 + I_2$





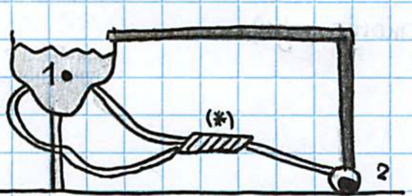


$I_1 - I_2 - I_3 = 0$

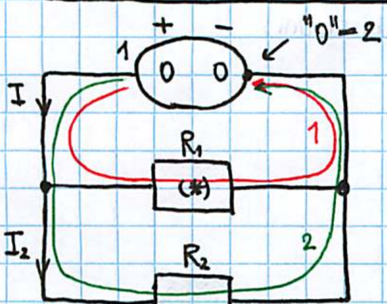
1. zakon:

$$\sum_{i=1}^{N} I_i = 0$$

Vsota tokov v vsakem vozlišču je enaka 0, če je tok, ki teče v vozlišče, pozitiven.



(*) Najnižja energija ~ napetost se mu zmanjša.



$+\mathcal{U}_g - IR = 0$ (če imamo le eno cev – primer z vodo zgoraj)

$\mathcal{U}_g - I_1R_1 = 0$

$\mathcal{U}_g - I_2R_2 = 0$

$\mathcal{U}_g + \mathcal{U}_r = 0$

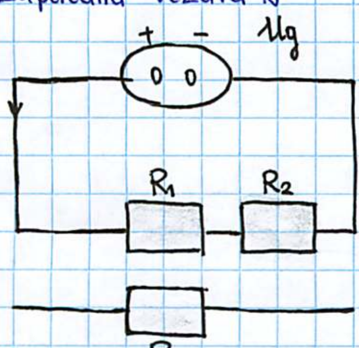
$\mathcal{U}_r = -IR$

2. zakon:

$$\sum_i \mathcal{U}_i = 0$$

Primeri:

(a) zaporedna vezava R

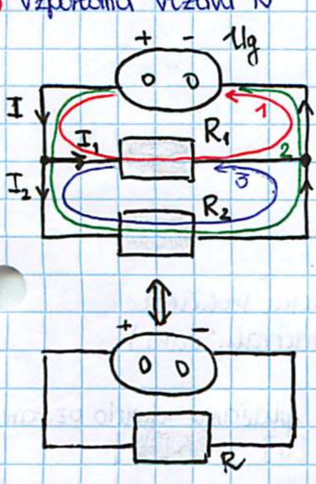


$+\mathcal{U}_g - IR_1 - IR_2 = 0$

$\mathcal{U}_g = I(R_1 + R_2)$

$\mathcal{U}_g = IR$, kjer $R = R_1 + R_2$

(b) vzporedna vezava R



$I - I_1 - I_2 = 0$

1. $\mathcal{U}_g - I_1R_1 = 0$
2. $\mathcal{U}_g - I_2R_2 = 0$
3. $-I_2R_2 + I_1R_1 = 0$

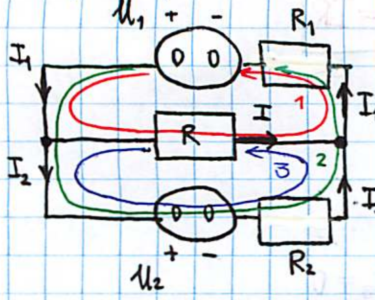
↑ nasprotni smeri kot teče tok

$I_1 = \frac{\mathcal{U}_g}{R_1}$

$I_2 = \frac{\mathcal{U}_g}{R_2}$ } ⊕

$\frac{\mathcal{U}_g}{R_1} + \frac{\mathcal{U}_g}{R_2} = I_1 + I_2 = I = \frac{\mathcal{U}_g}{R}$, kjer $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

(c) splošni primer

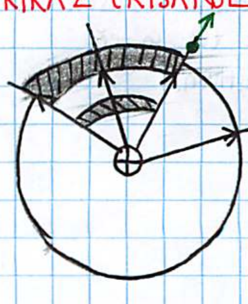


Ne vemo, v katero smer teče tok.

1. $U_1 - IR - IR_1 = 0$
2. $U_1 - U_2 + I_2R_2 - I_1R_1 = 0$
   ↳ gremo z ⊕ na ⊖
3. $-U_2 - I_2R_2 + IR = 0$
4. $I_1 - I_2 - I = 0$

$$\begin{pmatrix} -R & -R_1 & 0 \\ -1 & 1 & -1 \\ R & 0 & -R_2 \end{pmatrix} \cdot \begin{pmatrix} I \\ I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} -U_1 \\ 0 \\ +U_2 \end{pmatrix} \Longrightarrow \text{dobimo } I, I_1, I_2$$

PRIKAZ (RISANJE ELEKTRIČNIH POLJ)



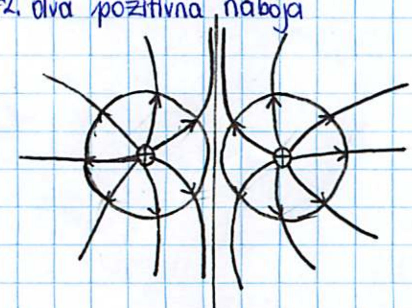
1. ↗ v smeri sile
2. razdalja med silnicama ∝ velikost polja $|E|$ (obratno sorazmerna z močjo/jakostjo polja)
3. ponor v ⊖ ; izvor v ⊕
4. silnice se ne razcepijo in ne sekajo

↖ po Gaussu se pretok ne bi ohranil!

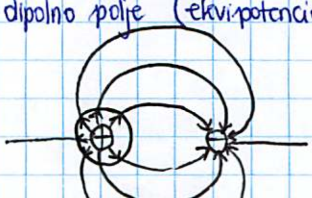
Primeri:

#1. točkast naboj

#2. dva pozitivna naboja



#3. dipolno polje (ekvipotencialne ploskve – prerezi)



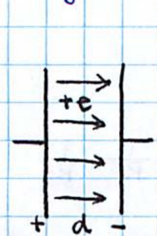
ELEKTRIČNO DELO IN ELEKTRIČNA MOČ

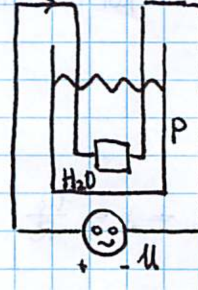
$A_g = F_g \cdot s = mgh = mU_g$

$P = \frac{A}{t} = \frac{m}{t} gh = \Phi_m gh = \Phi_m U_g$

$A_e = F_e s = eEd = eU$

$P_e = \frac{A_e}{t} = \frac{e}{t} Ed = IU$





$P = \frac{Q}{t} = \frac{mc_p \Delta T}{t}$

Za koliko se segreje neka količina snovi (v določenem intervalu časa)

Ko plačamo el. račun plačamo el. delo oz. energijo:

$A = \int_{t_1}^{t_2} P(t)dt \leftarrow [J] \quad P \sim [\frac{W}{s}]$