FIZIKA II
zapiski z avditornih vaj

Šolsko leto	2007 / 2008
Izvajalec	Miha Fošnarič
Avtor dokumenta	Aljoša Praznik
Sodelavci	Blaž Potočnik, Aljoša Praznik

UREJANJE DOKUMENTA

VERZIJA	01	**REVIZIJA**	01
DATUM	24. 2. 2009		
ZADNJI POPRAVLJAL	/		
PREGLEDAL	Blaž Potočnik, Aljoša Praznik		

OPOMBE

POPRAVKI

Miha Fošnarič

Fizika 2 - vaje

22.02.2008

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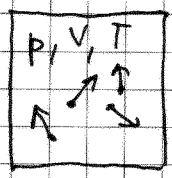
I

Kinetična teorija plinov



$$p \cdot V = \frac{m}{M} R T$$

M – masa kilomola; R – splošna plinska konstanta

N = št. gradnikov $\quad R = N_A \cdot k_B$; $\quad N_A = 6{,}02 \cdot 10^{26}\ \mathrm{kmol}^{-1}$

Boltzmanova konstanta $k_B = 1{,}38 \cdot 10^{-23}\ \frac{J}{K}$

$$p \cdot V = \frac{N \cdot m_1}{N_A \cdot m_1} N_A \cdot k_B \cdot T \Rightarrow \boxed{p \cdot V = N \cdot k_B \cdot T}$$

$\langle \vec{v} \rangle = \overline{\vec{v}} = 0 \Rightarrow$ povprečna hitrost je nič

$\langle v^2 \rangle \neq 0 \Rightarrow$ po smeri ni nič

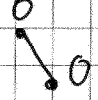
$$\langle W_{K,\,translacija} \rangle = \frac{1}{2} m_1 \langle v^2 \rangle = \frac{1}{2} m_1 \langle v_x^2 \rangle + \frac{1}{2} m_1 \langle v_y^2 \rangle + \frac{1}{2} m_1 \langle v_z^2 \rangle =$$

$$= \boxed{\frac{3}{2} k_B \cdot T}$$ – za enoatomne molekule (točkasta oblika)

$$\langle W_{K,\,rotacija} \rangle = \frac{2}{2} k_B \cdot T$$ – ni točkasta oblika (prištejemo za večatomne mol.)

Primer:

kisik (O_2)



$T = 20°C$

$M_{O_2} = 32\ \mathrm{kg/kmol}$

$\langle W_K \rangle = ?$

$$\langle W_K \rangle = \frac{5}{2} k_B \cdot T = \frac{5}{2} \cdot 1{,}38 \cdot 10^{-23} \frac{J}{K} \cdot 293\,K$$

$$= \underline{\underline{10^{-20}\ J}}$$

povprečna velikost hitrosti

$\sqrt{\langle v^2 \rangle} = ?$

$$\frac{1}{2} m_1 \langle v^2 \rangle = \frac{3}{2} k_B \cdot T$$

$$\langle v^2 \rangle = \frac{3 k_B \cdot T}{m_1} \quad / \ m_1 = \frac{M_{O_2}}{N_A}$$

$$\sqrt{\langle v^2 \rangle} \simeq 478\ \frac{m}{s}$$

Kisik (O_2)

$N = 2 \cdot 10^{20}$

$M_{O_2} = 32 \frac{kg}{kmol}$

$\langle v^2 \rangle = 36 \cdot 10^4 \frac{m^2}{s^2}$

$p = 1{,}28 \cdot 10^3 \, Pa$

$V_{posode} = ?$

$$p \cdot V = N \cdot k_B \cdot T$$

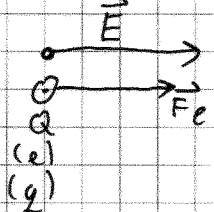
$$V = \frac{N \cdot k_B \cdot T}{p}$$

$$\frac{1}{2} m_1 \langle v^2 \rangle = \frac{3}{2} k_B \cdot T$$

$$T = \frac{M_{O_2} \langle v^2 \rangle}{3 N_A \cdot k_B}$$

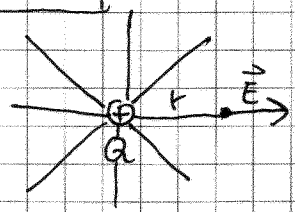
$$V = \frac{N \cdot k_B}{p} \cdot \frac{M_{O_2} \langle v^2 \rangle}{3 N_A \cdot k_B} \simeq 1 \, dm^3 = 1 \, l$$

Električno polje



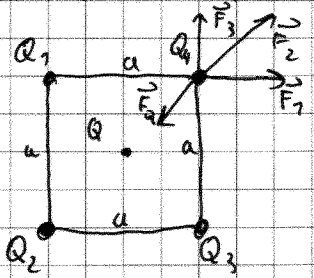
$$\vec{F} = Q \cdot \vec{E}$$

Polje točkastega naboja



$$\vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2} \cdot \frac{\vec{r}}{r}$$

Primer: 4 točkasti naboji v oglji$\check{s}$čih kvadrata



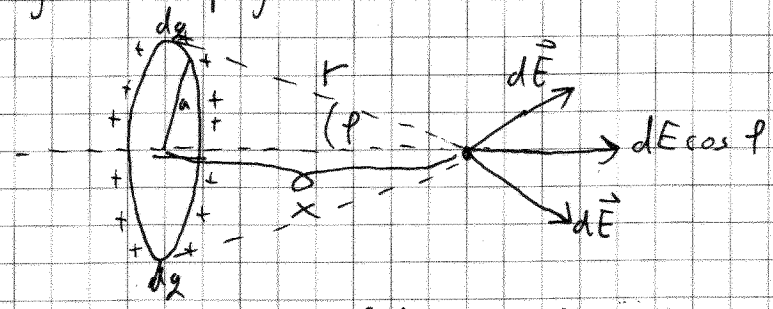
$$Q_1 = Q_2 = Q_3 = Q_4 = 1 \, As = 1 \, C = Q$$

$Q_0 = ?$ (v ravnovesju)

V x smeri: $F_1 + F_2 \cos 45° - F$

Izračunaj jakost polja v osi nael. krožne zanke

$a = 1\,m$
$q = 10^{-7}\,As$
$x = 3\,m$
$E = ?$



$\cos\varphi = \frac{x}{r}$ $\quad E = \int dE \cdot \cos\varphi$

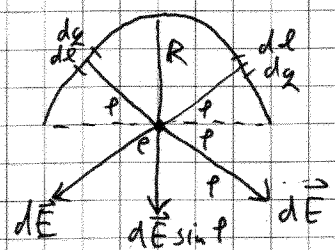
$dE = \frac{dq}{4\pi\varepsilon_0 r^2}$

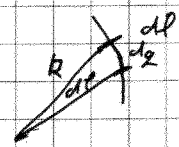
$$E = \int \frac{dq}{4\pi\varepsilon_0 r^2}\,\frac{x}{r} = \frac{x}{4\pi\varepsilon_0 r^3}\int dq = \boxed{\frac{x}{4\pi\varepsilon_0 r^3}\cdot q} = 85\,\frac{V}{m}$$

$E(x=0) = 0$

Tanka kovinska žica je zvita v polkrog ($r = 0{,}1\,m$), naelektrena je enakomerno z dolžinsko enoto naboja. ($\lambda = \frac{q}{l} = 10^{-4}\,C/m$)

$R = 0{,}1\,m$
$\lambda = 10^{-4}\,\frac{C}{m}$
$e = 10^{-9}\,C$
$F = ?$





$$E = \int dE\sin\varphi\;;\quad dE = \frac{dq}{4\pi\varepsilon_0 r^2}\;;\quad dq = \lambda\cdot dl = \lambda\cdot R\cdot d\varphi$$

$$E = \int_0^{\pi}\frac{\lambda R\,d\varphi}{4\pi\varepsilon_0 R^2}\sin\varphi = \frac{\lambda}{4\pi\varepsilon_0 R}\int_0^{\pi}\sin\varphi\,d\varphi = \frac{\lambda}{4\pi\varepsilon_0 R}\left(-\cos\varphi\right)\Big|_0^{\pi} = \frac{\lambda}{4\pi\varepsilon_0 R}(1+1) =$$

$$E = \frac{\lambda}{2\pi\varepsilon_0 R}$$

$$F = e\cdot E = \frac{e\lambda}{2\pi\varepsilon_0 R} = 1{,}8\cdot 10^{-2}\,N$$

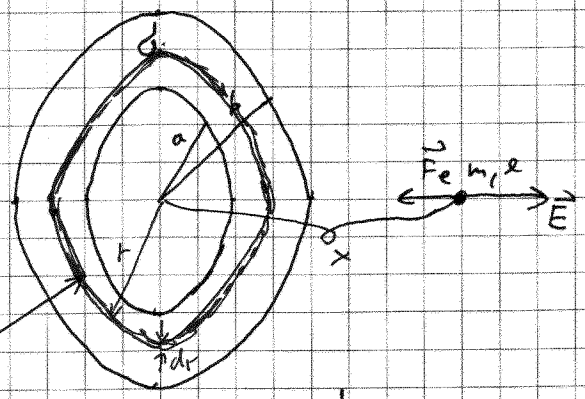
11. naal / str. 13

$m = 0{,}1\,g$ } krogljica, ki se lahko giblje vzdolž tankega plošča tega
$e = 10^{-5}\,As$ } krogobarja (a,b) zaradi, ko jo malenkost izmaknemo iz središčne lege.

$a = 5\,cm$
$b = 10\,cm$
$\sigma = 10^{-5}\,\frac{As}{m^2}$

$t_0 = ?$

$x << a$



e
$\sigma \cdot dS = \sigma \cdot 2\pi \cdot r \cdot dr$; $dE = \frac{dq\, x}{4\pi\varepsilon_0 (r^2+x^2)^{3/2}}$

$$E = \int dE = \int_a^b \frac{\sigma \cdot 2\pi \cdot r \cdot dr \cdot x}{4\pi\varepsilon_0 (r^2+x^2)^{3/2}} = \frac{\sigma x}{2\varepsilon_0} \int_a^b \frac{r \cdot dr}{(r^2+x^2)^{3/2}} = \frac{\sigma x}{2\cdot\varepsilon_0} \int_{u(a)}^{u(b)} \frac{du}{2u^{3/2}} =$$

$$E = -\frac{\sigma x}{2\varepsilon_0}\left[(b^2+x^2)^{-\frac{1}{2}} - (a^2+x^2)^{-\frac{1}{2}}\right]$$

$$E(x<<0) = \frac{\sigma x}{2\varepsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right) \quad \text{— majhni odmiki}$$

$$F = m\,a \Rightarrow e\cdot E = m\cdot \ddot{x} \qquad \boxed{\ddot{x} = -\omega^2 \cdot x}$$

$$e\cdot\frac{\sigma x}{2\varepsilon_0}\left(\frac{1}{a}-\frac{1}{b}\right) = m\cdot\ddot{x} \Rightarrow \omega^2$$

$$\ddot{x} = -\frac{|e|\sigma\left[\frac{1}{a}-\frac{1}{b}\right]}{2\varepsilon_0 m}\, x$$

$$t_0 = \frac{2\pi}{\omega}$$

$$t_0 = 2\pi\cdot\sqrt{\frac{2\varepsilon_0 m}{|e|\sigma\left(\frac{1}{a}-\frac{1}{b}\right)}} = 8{,}36\cdot 10^{-3}\,s$$

Prispevek gravitacije

$m_K = 0{,}5\,kg$

$t_0 = ?$

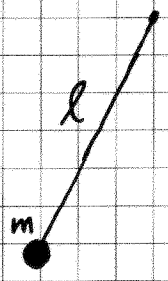
$dF_g = G\,\frac{dm_m \cdot m}{r^2}$

$\sigma_m = \frac{m_K}{\pi(b^2-a^2)}$

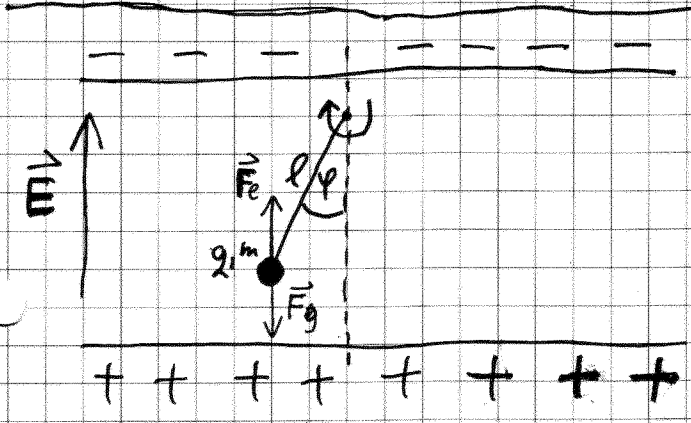
Rezultat $t_0 = 2\pi\sqrt{\frac{a\cdot b(b-a)}{G\cdot m_K}} = 17200\,s$

29.02.2008

Matematično nihalo



$$t_0 = \sqrt{\frac{l}{g}}$$



$$M = J \cdot \alpha$$

$$(F_e - F_g) \cdot l \cdot \sin\varphi = m l^2 \cdot \ddot{\varphi}$$

$\sin\varphi \approx \varphi$ (za majhne kote)

$$\boxed{\ddot{\varphi} = -\text{konstanta} \cdot \varphi}$$ sinusno nihanje

$$(q \cdot E - m \cdot g) \cdot \varphi = m \cdot l \cdot \ddot{\varphi}$$

$$\ddot{\varphi} = -\frac{m \cdot g - q \cdot E}{m \cdot l} \cdot \varphi$$

$\frac{m \cdot g - q \cdot E}{m \cdot l} = \omega^2$

$$t_0 = \frac{2\pi}{\omega} = 2\pi \cdot \sqrt{\frac{m \cdot l}{m g - q E}} \Rightarrow \boxed{t_0 = 2\pi \sqrt{\frac{l}{g - \frac{qE}{m}}}}$$

če je q ali E enak 0 je navadno mat. nihalo.

Gaussov zakon (zakon o el. pretoku)

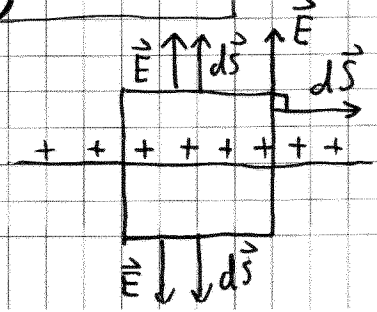
$$\boxed{\oint \vec{D} \cdot d\vec{S} = e}$$

$$\vec{D} = \varepsilon \varepsilon_0 \vec{E}$$

$$\varepsilon_0 \oint \vec{E} \cdot d\vec{S} = e$$

$$\varepsilon_0 E \cdot 2S = e$$

$$E = \frac{e}{\varepsilon_0 2S} \quad \sigma = \frac{e}{S}$$



$$\boxed{E = \frac{\sigma}{2\varepsilon_0}}$$

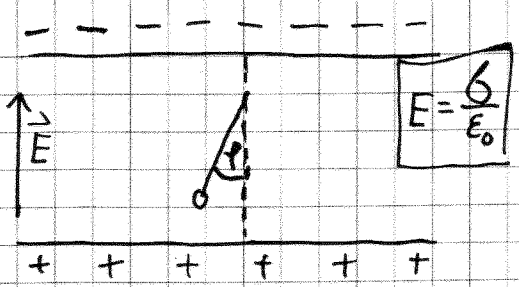
E v okolici naelektrene ploščice

$l = 1\ cm$
$q = 20 \cdot 10^{-9}\ As$
$m = 2g$
$\delta = \pm 5\ \frac{\mu As}{m^2}$

$t_0 = ?$

$$t_0 = 2\pi\sqrt{\frac{l}{g - \frac{q\delta}{\varepsilon_0 m}}}$$

$$t_0 = 0{,}3\ s$$



$l = 13\ cm$
$m = 0{,}1\ g$
$d = 12\ cm$

$q = ?$

RAVNOVESJE:

$$\sum_i \vec{F}_i = 0 \qquad \sin\varphi = \frac{d}{2l}$$

x: $F_e - F_{Vx} = 0$

$F_{Vx} = F_V \cdot \sin\varphi$

$F_e - F_V \cdot \sin\varphi = 0$

$\Rightarrow F_V = \frac{F_e}{\sin\varphi}$

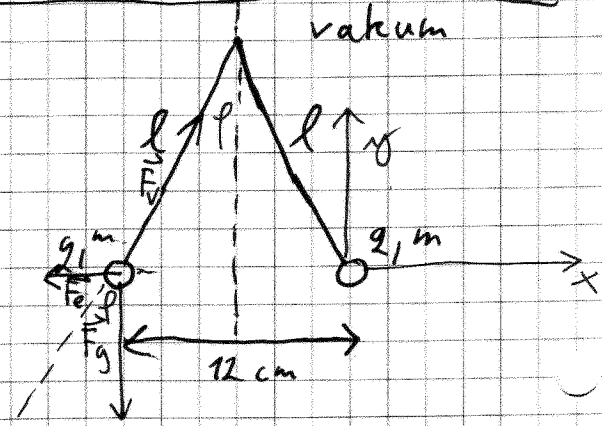
y: $F_g - F_{Vy} = 0$

$F_g - F_V \cos\varphi = 0$

$m \cdot g - \frac{F_e}{\sin\varphi}\cos\varphi = 0$

$$m \cdot g - \frac{q^2}{4\pi\varepsilon_0 d^2}\operatorname{ctg}\varphi = 0 \Rightarrow \boxed{q = \sqrt{\frac{mg\,4\pi\varepsilon_0 d^2}{\operatorname{ctg}\varphi}}}$$

$$q = 2{,}86 \cdot 10^{-8}\ As$$



v alkoholu

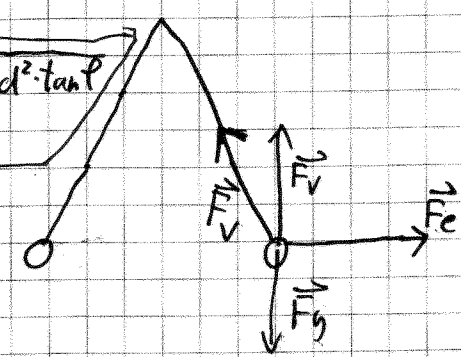
$\rho = 0{,}8 \cdot 10^3\ \frac{kg}{m^3}$

$\varepsilon = 26$

$V_k = 10^{-7}\ m^3$

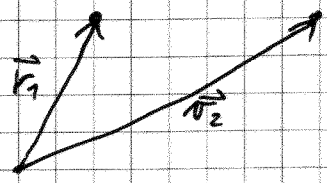
$$\boxed{q = \sqrt{(m \cdot g - V \cdot \rho g) \cdot 4\pi \cdot \varepsilon\varepsilon_0 d^2 \cdot \tan\varphi}}$$

$$q = 6{,}52 \cdot 10^{-8}\ As$$



El. napetost

$$u(\vec{r}_2,\vec{r}_1) = -\int_{\vec{r}_1}^{\vec{r}_2} \vec{E}\cdot d\vec{s}$$



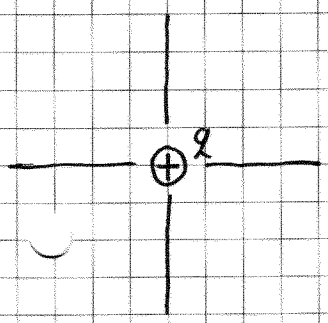
$$u(\vec{r}_2,\vec{r}_1) = -\underbrace{\int_{\infty}^{\vec{r}_2} \vec{E}\cdot d\vec{s}}_{V(\vec{r}_2)} - \left(-\underbrace{\int_{\infty}^{\vec{r}_1} \vec{E}\cdot d\vec{s}}_{V(\vec{r}_1)}\right)$$

$$= +V(\vec{r}_2) - V(\vec{r}_1)$$

$$\Delta W_p = e\cdot u$$

$$\Delta W_p = W_p(\vec{r}_2) - W_p(\vec{r}_1) =$$

$$= e\,V(\vec{r}_2) - e\,V(\vec{r}_1)$$



$$\vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}\,\frac{\vec{r}}{r}$$

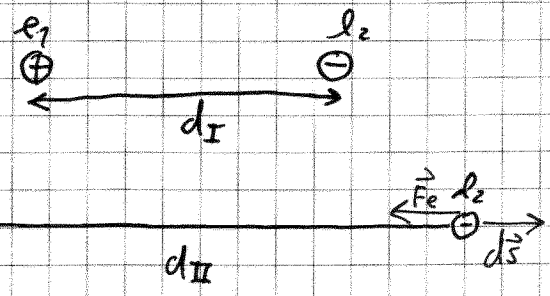
$$V(r) = -\int_{\infty}^{r} E\,dr = -\int_{\infty}^{r} \frac{Q}{4\pi\varepsilon_0 r^2}\,dr = -\frac{Q}{4\pi\varepsilon_0}\left(-\frac{1}{r}\right)\Big|_{\infty}^{r}$$

$$V(r) = \frac{Q}{4\pi\varepsilon_0 r}$$

12. naloga / stran 14 (drugi podatki)

$q_1 = +10^{-8}\,As$
$q_2 = -2\cdot10^{-7}\,As$
$d_I = 10\,cm$
$d_{II} = 20\,cm$

$$A = \int \vec{F}\cdot d\vec{s}$$



$A = ?$

1. način

$$A = -\int_{d_I}^{d_{II}} \frac{q_1\cdot q_2}{4\pi\varepsilon_0 d^2}\cdot d\vec{d}$$

$$A = -\frac{q_1 q_2}{4\pi\varepsilon_0}\left(-\frac{1}{d}\right)\Big|_{d_I}^{d_{II}}$$

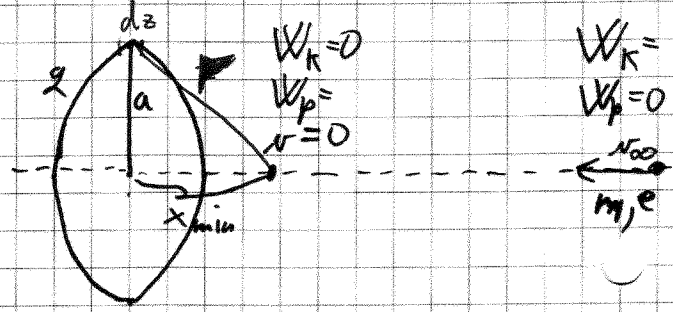
$$A = -\frac{q_1 q_2}{4\pi\varepsilon_0}\left(\frac{1}{d_I}-\frac{1}{d_{II}}\right) \quad \left[\frac{As\ As\ V}{As\ m}\right] = \left[As\cdot\frac{J}{As}\right] = [J]$$

2. način

$$A = \Delta W_p = V_{II}\cdot q_2 - V_I q_2 = \frac{q_1 q_2}{4\pi\varepsilon_0 d_{II}} - \frac{q_1 q_2}{4\pi\varepsilon_0 d_I} = 8{,}9\cdot10^{-5}\,J$$

16. naloga / stran 17

$m = 3\,g$
$q = 8\,\mu As$
$a = 3\,cm$
$Q = 0{,}1\,\mu As$
$v_\infty = 30\,km/s$



$x_{min} = ?$

$$\Delta W_K + \Delta W_p = 0$$

$$dV = \frac{dq}{4\pi\varepsilon_0 r}$$

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

$$\frac{m\cdot v^2}{2} - 0 + \left(0 - \frac{q\cdot e}{4\pi\varepsilon_0 r}\right) = 0$$

$$\frac{m v_\infty^2}{2} - \frac{q\cdot e}{4\pi\varepsilon_0 r} = 0$$

$$r = \frac{q\cdot e}{2\pi\varepsilon_0 m v_\infty^2}$$

$$r = 6{,}9\,cm$$

$$x = \sqrt{r^2 - a^2} = 6{,}22\,cm$$

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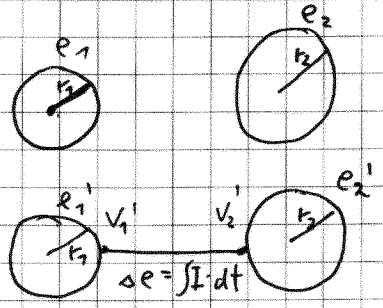
20. nal. / str. 78

$r_1 = 2\,cm$
$e_1 = 2 \cdot 10^{-6}\,As$
$r_2 = 5\,cm$
$e_2 = 10^{-6}\,As$

$e_1' = ?$
$e_2' = ?$
$\sigma_1' = ?$
$\sigma_2' = ?$



povežemo z žico

$$V_1' = V_2'$$

$$\frac{e_1'}{4\pi\varepsilon_0 r_1} = \frac{e_2'}{4\pi\varepsilon_0 r_2}$$

$$e_2' = e_1' \cdot \frac{r_2}{r_1}$$

OHRANITEV NABOJA

$$e_1 + e_2 = e_1' + e_2'$$

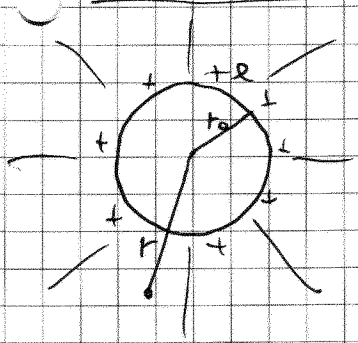
$$e_1 + e_2 = e_1' + e_1' \frac{r_2}{r_1} = e_1'\left(1 + \frac{r_2}{r_1}\right) \Rightarrow e_1' = \frac{e_1 + e_2}{\left(1 + \frac{r_2}{r_1}\right)} = 0{,}856 \cdot 10^{-6}\,As$$

$$e_2' = 2{,}14 \cdot 10^{-6}\,As$$

$$\sigma_1' = \frac{e_1'}{4\pi r_1^2} = 1{,}7 \cdot 10^{-4}\,As/m^2$$

$$\sigma_2' = \frac{e_2'}{4\pi r_2^2} = 0{,}68 \cdot 10^{-4}\,As/m^2$$

Izračun potenciala s pomočjo Gaussa:



$$\oint \vec{D} \cdot d\vec{S} = e$$

$$\vec{D} = \varepsilon \cdot \varepsilon_0 \vec{E}$$

$$\varepsilon_0 \oint E\,dS = e$$

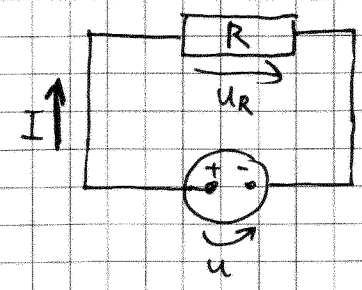
$$\varepsilon_0 \cdot E \cdot 4\pi r^2 = e$$

$$E = \frac{e}{4\pi\varepsilon_0 r^2} \Rightarrow V = \frac{e}{4\pi\varepsilon_0 r}$$

Polje $\vec{E}$ zunaj krogle je tak, kot bi bil ves naboj v središču.

Električni tok

$$I = \frac{de}{dt}$$
$$A = e \cdot U$$
$$P = \frac{dA}{dt} = \frac{de}{dt} U$$
$$P = U \cdot I$$



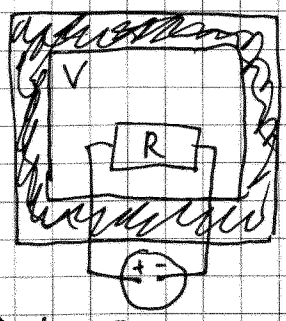
$$U = R \cdot I$$
$$U + U_R = 0$$
$$U_R = -U = -R \cdot I$$

Skozi upor $R = 70\ \Omega$, ki je potopljen v $1\ dm^3 = 1\ l$ vode, se v 7,5 ure pretečе $10^4\ As$ naboja. Koliko se segreje voda v 10 min?

$R = 10\ \Omega$
$V = 1\ dm^3$
$t = 90\ min$
$e = 10^4\ As$
$t_1 = 10\ min$

$I = \frac{e}{t}$

$\Delta T = ?$



$P \cdot t_1 = A = Q$

voda
$c_v = 4200\ J/kg\,K$
$\rho = 1000\ kg/m^3$

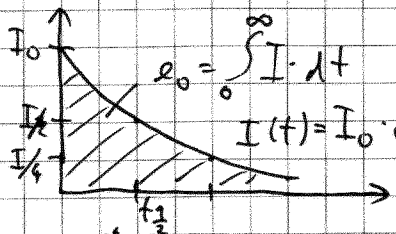
$$P \cdot t_1 = Q = m \cdot c_v \cdot \Delta T$$
$$R I^2 t_1 = m \cdot c_v \cdot \Delta T \Rightarrow \Delta T = \frac{R I^2 \cdot t_1}{m \cdot c_v} = 4,9\ K$$

Skozi upor $R = 8\ \Omega$ steče v dolgem času naboj $e = 30\ As$. Koliko toplote se sprosti v uporu, če pada tok eksponentno proti nič, tako da se vsakih 24 s zmanjša za $\frac{1}{2}$.

$R = 8\ \Omega$
$e_0 = 30\ As$
$t_{1/2} = 24\ s$

$A = Q = ?$

$I(t) = I_0 \cdot e^{-\frac{t}{\tau}}$



$$e_0 = \int_0^\infty I \cdot dt$$
$$I(t) = I_0 \cdot e^{-\frac{t}{\tau}}$$

$$Q = A = \int_0^\infty P \cdot dt = \int_0^\infty U \cdot I \cdot dt = \int_0^\infty I^2 \cdot R \, dt =$$
$$= \int_0^\infty I_0^2 e^{-\frac{2t}{\tau}} R \cdot dt = I_0^2 R \int_0^\infty e^{-\frac{2t}{\tau}} dt =$$

$$Q = I_0^2 R \left. \frac{e^{-\frac{2t}{\tau}}}{-\frac{2}{\tau}} \right|_0^\infty = -\frac{I_0^2 R \tau}{2} \cdot \left(e^{-\infty} - e^{-0}\right) = \boxed{Q = \frac{I_0^2 \cdot R \cdot \tau}{2}}$$

$$e_0 = \int_0^\infty I \, dt = \int_0^\infty I_0 e^{-\frac{t}{\tau}} \cdot dt = I_0 \left. \frac{e^{-\frac{t}{\tau}}}{-\frac{1}{\tau}} \right|_0^\infty = -I_0 \tau \left(e^{-\infty} - e^{0}\right)$$

$$e_0 = \tau \cdot I_0$$

$$\boxed{I_0 = \frac{e_0}{\tau}}$$

OB $t = t_{1/2}$:

$$\frac{I_0}{2} = I_0 e^{-\frac{t_{1/2}}{\tau}}$$

$$\boxed{\tau = \frac{t_{1/2}}{\ln 2}}$$

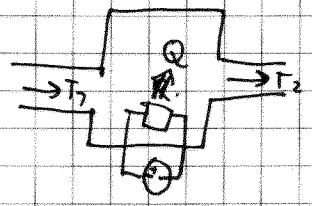
$$Q = \frac{I_0^2 \cdot R \cdot \tau}{2} = \frac{e_0^2 \cdot R \cdot t_{1/2}}{\tau^2 \cdot 2 \cdot \ln 2} = 104\ J$$

Imamo pretočni bojler skozi katerega teče volumski pretok vode 9 l/min. Voda se v bojlerju segreje iz 75°C na 70°C. Bojler je priključen na $U_{ef} = 220\,V$. Izkoristek grelca je 85% kolikšna je amplituda izmeničnega toka skozi žice?

$\Phi_V = 9\,l/min$
$T_1 = 75°C$
$T_2 = 70°C$ } $\Delta T = 5K$
$U_{ef} = 220\,V$
$\eta = 0,85$

$I_0 = 2$

$c_p = 4200\,J/kgK$
$\rho = 1000\,kg/m^3$



$U = U_0 \cdot \cos(\omega t)$
$I = I_0 \cdot \cos(\omega t + \delta)$
za upor je $\delta = 0$

$Q = m \cdot c_p \cdot \Delta T$
$\frac{Q}{t} = \frac{m \cdot c_p \cdot \Delta T}{t}$; $\Phi_m = \rho \cdot \Phi_V$

$\eta \cdot \bar{P} = \rho \cdot \Phi_V \cdot c_p \cdot \Delta T$

$P = U \cdot I$

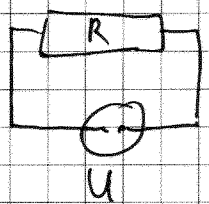
$P(t) = U_0 \cdot \cos(\omega t) \cdot I_0 \cos(\omega t + \delta)$

$\bar{P} = ?$

NEKA INTEGRACIJA

$\bar{P} = \frac{1}{2} U_0 \cdot I_0 \cdot \cos\delta = \frac{U_0}{\sqrt{2}} \cdot \frac{I_0}{\sqrt{2}} \cos\delta$

U_{ef} I_{ef}



$U = R \cdot I$
$\delta = 0 \Rightarrow \cos\delta = 1$
$\boxed{\bar{P} = U_{ef} \cdot I_{ef}}$
} Pri uporu je fazni zamik (δ) enak 0.

$\eta \cdot \bar{P} = \rho \cdot \Phi_V \cdot c_p \cdot \Delta T$

$\eta \cdot U_{ef} \cdot \frac{I_0}{\sqrt{2}} = \rho \cdot \Phi_V \cdot c_p \cdot \Delta T$

$\Rightarrow I_0 = \frac{\sqrt{2} \cdot \rho \cdot \Phi_V \cdot c_p \cdot \Delta T}{U_{ef} \cdot \eta} = 262\,A$

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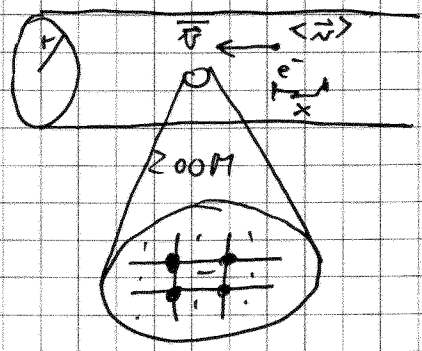
Alenka®

37. nal. / str. 32.

$N_{at} = N_e$
$2r = 1\,mm$
$I = 1\,A$
$\rho = 9\ g/cm^3$
$M = 64\ kg/kmol$

$\bar{v} = ?$



x = prepotovana razdalja
$e = -e_0 = -1{,}6 \cdot 10^{-19}\,As$
$N_A = 6{,}02 \cdot 10^{26}\,kmol^{-1}$

V kovinski mreži pride povprečno na en atom en prevodniški elektron. Kakšna povp. hitrost elektr., ko po žici spušča tok 1 A.

IZPELJAVA

$$I = \frac{de}{dt} = \frac{N_{el} \cdot e}{t}$$

$$j = \frac{N_{el} \cdot e \cdot x}{S \cdot t \cdot x} = \frac{N_{el} \cdot e \cdot \bar{v}}{V} = n \cdot e \cdot \bar{v}$$

gostota nosilcev naboja $n = \frac{N_{el}}{V}$

$$j = \frac{I}{S} = n \cdot e \cdot \bar{v}$$

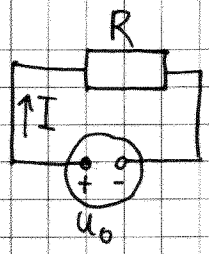
$$n = \frac{N_e}{V} = \frac{N_{at}}{V}$$
$$n = \frac{N_e}{V} = \frac{m \cdot N_A}{V \cdot M}$$

$N_{at} = \frac{m}{m_1} = m \cdot \frac{N_A}{M}$
$m_1 = \frac{M}{N_A}$

$$\frac{I}{S} = \rho \frac{N_A}{M} \cdot e \cdot \bar{v}$$

$$\bar{v} = \frac{I \cdot M}{S \cdot r^2 \pi \cdot \rho \cdot N_A \cdot (-e_0)} = -9{,}43 \cdot 10^{-5}\,\frac{m}{s} \approx -0{,}1\,\frac{mm}{s}$$

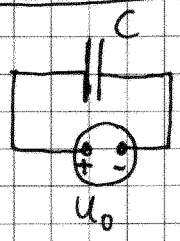
14.03.2008



$U_0 = R \cdot I$

$U_0 + U_R = 0$

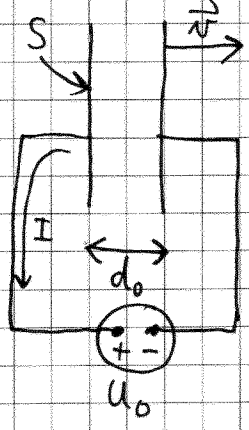
$U_R = -R \cdot I$



$e = U_0 \cdot C$

$U_0 + U_C = 0$

$U_C = -\frac{e}{C}$



$S = 150\,cm^2$ $\quad \vec{v} = 1\,\frac{m}{s}$

$d_0 = 1\,mm$ $\quad t_1 = 1\,ms$

$U_0 = 12\,V$

$I(t_1) = ?$

Razmaknemo plošči, kak tok steče?

$$C = \varepsilon_0 \frac{S}{d_0}$$

$$C = \varepsilon_0 \frac{S}{d_0 + v \cdot t}$$

$$e = C \cdot U_0$$

$$I = \frac{de}{dt} = \frac{d(C \cdot U_0)}{dt} = U_0 \cdot \frac{dC}{dt}$$

$$\frac{dC}{dt} = \varepsilon_0 S \frac{0 - v}{(d_0 + v \cdot t)^2} = -\varepsilon_0 S \frac{v}{(d_0 + v \cdot t)^2}$$

$$\boxed{I = -\frac{U_0 \cdot \varepsilon_0 \cdot S \cdot v}{(d_0 + v \cdot t)^2}} = -0{,}4\,\mu A$$

Energija kondenzatorja

$$W_e = \frac{1}{2} C U_c^2$$

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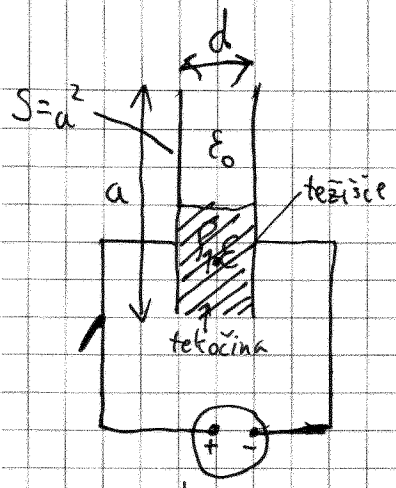


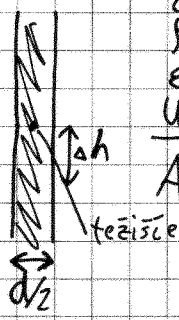
Priključimo na napetost, nato vir odklopimo. Plošči stisnemo tako, da pride gladina tekočin do vrha. Koliko dela opravimo da plošči zbližamo?

① Nabijemo z U_1

② Izolirano plošči → $Q_1 = Q_2$

$C_1 U_1 = C_2 \cdot U_2 \Rightarrow U_2 = \frac{C_1 \cdot U_1}{C_2}$

③ Stisnemo plošči



$a = 10\ cm$
$d = 3\ mm$
$\rho_1 = 1\ kg/dm^3$
$\varepsilon = 80$
$U = 800\ V$

$A = ?$

$A = \Delta W_p + \Delta W_e$

$A = m \cdot g \cdot \Delta h + \frac{1}{2} C_2 U_2^2 - \frac{1}{2} C_1 U_1^2 =$

$A = \rho_1 \cdot \frac{a^2 \cdot d}{2} \cdot g \cdot \frac{a}{4} + \frac{1}{2} C_2 \frac{C_1^2 \cdot U_1^2}{C_2^2} - \frac{1}{2} C_1 U_1^2 =$

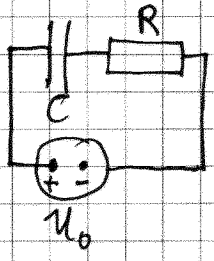
$A = \frac{1}{8} \rho_1 a^3 \cdot d \cdot g + \frac{1}{2} C_1 U_1^2 \left(\frac{C_1}{C_2} - 1 \right)$

$C_2 = \varepsilon \cdot \varepsilon_0 \frac{a^2}{d/2} = \underline{2 \varepsilon \varepsilon_0 \frac{a^2}{d}}$

$C_1 = C_I + C_{II} = \varepsilon_0 \frac{a^2}{2d} + \varepsilon \cdot \varepsilon_0 \frac{a^2}{2d} = \underline{(1+\varepsilon)\left(\varepsilon_0 \frac{a^2}{2d}\right)}$

$A = 3{,}67 \cdot 10^{-3}\ J - 2{,}86 \cdot 10^{-4}\ J = \underline{3{,}38 \cdot 10^{-3}\ J}$

Polnjenje kondenzatorja



$U_0 + U_C + U_R = 0$

$U_0 - \frac{e}{C} - RI = 0 \quad / \frac{d}{dt}$

$0 - \frac{1}{C} \frac{de}{dt} - R \frac{dI}{dt} = 0 \qquad I = \frac{de}{dt}$

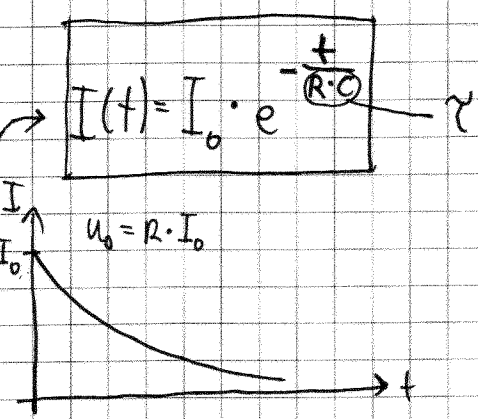
$-\frac{1}{C} \cdot I = R \cdot \frac{dI}{dt}$

$\frac{dI}{I dt} = -\frac{1}{R \cdot C}$

$\int_{I_0}^{I} \frac{dI}{I} = -\frac{1}{R \cdot C} \int_0^{t_1} dt$

$\ln \frac{I(t_1)}{I_0} = -\frac{1}{R \cdot C} \cdot t_1 \quad / \exp$

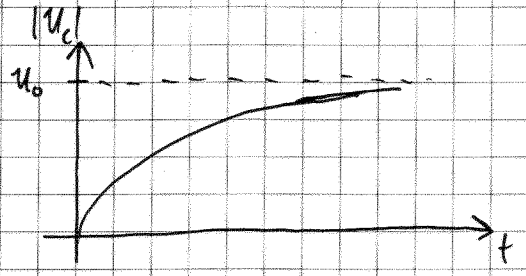
$I(t) = I_0 \cdot e^{-\frac{t}{R \cdot C}}$



$$U_c = -U_0 - U_R = -U_0 + \underbrace{R I_0}_{U_0} e^{-\frac{t}{RC}}$$

$$U_c = -U_0 (1 - e^{-\frac{t}{R \cdot C}})$$

$$|U_c| = U_0 (1 - e^{-\frac{t}{R \cdot C}})$$



$C = 100\ \mu F$
$R = 1000\ \Omega$

$$W_e = \frac{1}{2} C \cdot U_0^2$$
$$W_c = \frac{1}{2} C U_c^2$$

Čas, ko je energija na kond. 25% energije, ki jo lahko kondenzator prejme.

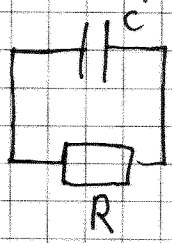
$$W_c(t_1) = \frac{1}{4} W_0$$

$t_1 = ?$

$$\frac{1}{2} C U_c^2 = \frac{1}{4} \cdot \frac{1}{2} C \cdot U_0^2 \ / \sqrt{\ }$$
$$|U_c| = \frac{1}{2} U_0$$
$$U_0 \cdot (1 - e^{-\frac{t}{\tau}}) = \frac{1}{2} U_0$$
$$1 - \frac{1}{2} = e^{-\frac{t_1}{\tau}} \ / \ln$$
$$\ln \frac{1}{2} = -\frac{t_1}{\tau}$$
$$t_1 = -\tau \cdot \ln \frac{1}{2} = \boxed{R \cdot C \cdot \ln 2 = t_1}$$

$$t_1 = 1000 \Omega \cdot 100 \cdot 10^{-6} \frac{As}{V} \cdot \ln 2 =$$
$$t_1 = 0{,}07\ s$$

Praznjenje kondenzatorja

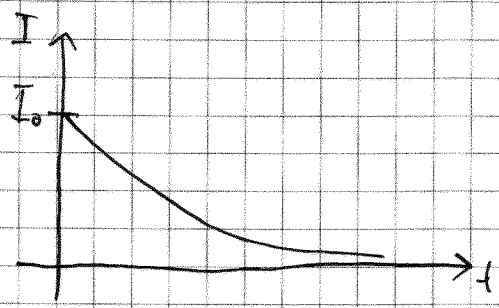


$$U_C + U_R = 0$$

$$-\frac{e}{C} - R \cdot I = 0 \quad / \frac{d}{dt}$$

$$-\frac{1}{C}\frac{de}{dt} - R\frac{dI}{dt} = 0$$

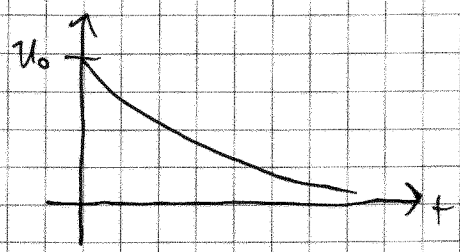
$$-\frac{1}{C} I = R\frac{dI}{dt} \Rightarrow \boxed{I(t) = I_0\, e^{-\frac{t}{R \cdot C}}}$$



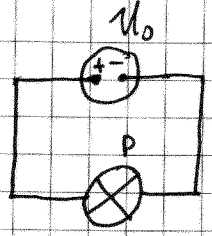
$$U_C = -U_R = +R \cdot I$$

$$U_C = \underbrace{R \cdot I_0}_{U_0} \cdot e^{-\frac{t}{R \cdot C}}$$

$$U_C = U_0 \cdot e^{-\frac{t}{RC}}$$



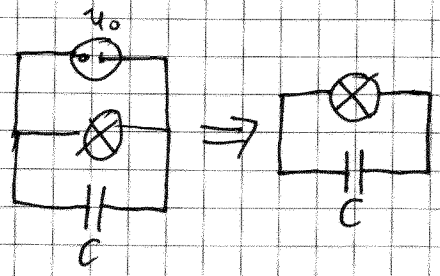
Žarnica
$P = 100\,W$
$U_0 = 110\,V$



$P = U_0 \cdot I_0 = \frac{U_0^2}{R}$

$R = \frac{U_0^2}{P}$

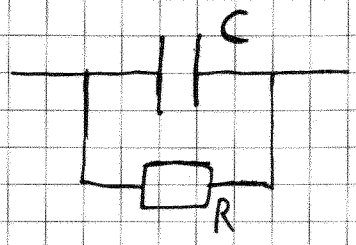
Kakšen kondenzator moramo priklopiti, da bo žarnica svetila še 10 s, najmanjša napetost, da še sveti je 20 V.



$U_{min} = 20\,V$
$t_1 = 10\,s$

$C = ?$

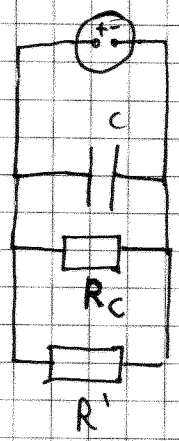
$$U_c(t_1) = U_{min}$$
$$U_{min} = U_0 e^{-\frac{t}{R \cdot C}}$$
$$\frac{U_{min}}{U_0} = e^{-\frac{t}{R \cdot C}} \quad / \ln$$
$$\ln \frac{U_{min}}{U_0} = -\frac{t_1 P}{U_0^2 C}$$
$$C = -\frac{t_1 P}{U_0^2 \cdot \ln \frac{U_{min}}{U_0}}$$
$$C = 0{,}05\,F$$



Realni kondenzator

$C = 25\,\mu F$
$U_0 = 60\,V$
$U = 50\,V$
$t_0 = 10\,ms$
$R' = 500\,\Omega$

$U_c'(t_1) = ?$



Zaradi slabe izolacije pade napetost na kondenzatorju na 50 V v 10 ms.

Do katere napetosti se bo spraznil kondenzator, če nanj priključimo R' v istem času.

$$U_c'(t_1) = U_0 \cdot e^{-\frac{t_1}{R \cdot C}}$$

$$\frac{U_c'(t_1)}{U_0} = e^{-\frac{t_1}{R_2 C}}$$

$$\ln \frac{U_c'(t_1)}{U_0} = -\frac{t_1}{R_2 C}$$

$$R_c = +\frac{t_1}{C}\left(\ln \frac{U_0}{U_c(t_1)}\right)^{-1} = 2200\,\Omega$$

$$\frac{1}{R} = \frac{1}{R_c} + \frac{1}{R'}$$

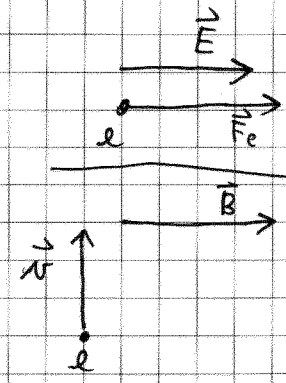
$$R = 407{,}2\,\Omega$$

$$U_c'(t_1) = U_0 \cdot e^{-\frac{t_1}{R \cdot C}} = 22{,}5\,V$$

$$\frac{U_c'(t_1)}{U_0} = e^{-\frac{t_1}{R \cdot C}} \quad / \ln$$

$$\ln \frac{U_c'(t_1)}{U_0} = -\frac{t_1}{R \cdot C}$$

$$t_1 = \ln \frac{U_0}{U_c'(t_1)} \cdot R \cdot C = 22{,}5\,s$$



$\vec{F}_e = e \cdot \vec{E}$

$m \cdot \vec{a} = e \cdot \vec{E}$

$\vec{F}_m = e\,\vec{v} \times \vec{B}$

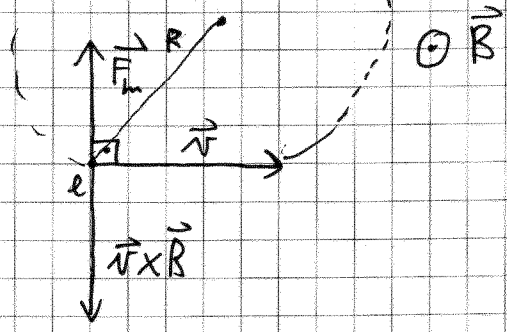
$\vec{F}_m \perp \vec{v}$

$W_k = 10\,eV$

$B = 10^{-4}\,T$

$e = -e_0 = -1{,}6 \cdot 10^{-19}\,As$

$m_e = 0{,}51\,\frac{MeV}{c_0^2}$



$R = ?$

$t_0 = ?$

$F_m = e_0 \cdot v \cdot B$

$|a_r| = \frac{v^2}{R} = \omega^2 R$

$m \cdot a_r = e_0 \cdot v \cdot B$

$m \cdot \frac{v^2}{R} = e_0 \cdot B$

$$\boxed{R = \frac{m \cdot v}{e_0 \cdot B}}$$

$W_K = \frac{1}{2} m_e v^2$

$v = \sqrt{\frac{2 W_K}{m_e}} = \sqrt{\frac{2 \cdot 10\,eV\,c_0^2}{0{,}511 \cdot 10^6\,eV}} = 0{,}0063 \cdot c_0$

$v = 1{,}89 \cdot 10^6\,\frac{m}{s}$

$R = \frac{m_e \cdot v}{e \cdot B} = \underline{\underline{11\,cm}}$

$t_0 = \frac{s}{v} = \frac{2\pi R}{v} = 3{,}6 \cdot 10^{-7}\,s$

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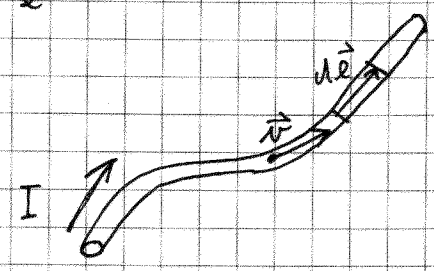
21.03.2008

• $\vec{F} = e\,\vec{v} \times \vec{B}$



$$I = \frac{de}{dt} \Rightarrow e = \int I \cdot dt$$

$$\vec{F} = \int I \underbrace{dt\,\vec{v}}_{d\vec{l}} \times B$$

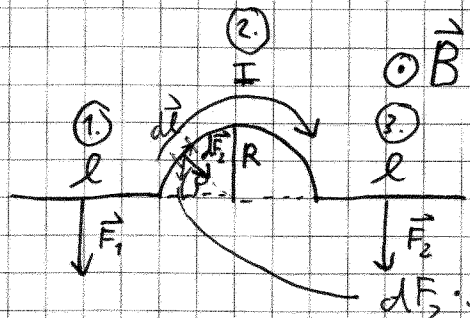
$$\boxed{\vec{F} = I \int d\vec{l} \times B}$$

Imamo vodnik.

l, R, I, B

$F = ?$ $\quad d\vec{l} \perp \vec{B}$

$F_1 = F_3$



$dF_2 \cdot \sin\varphi$ (za komponente v y smeri)

$|d\vec{l} \times \vec{B}| = dl \cdot B$

$F_1 = F_2 = I \int dl\, B = I\, l\, B$

$F_2 = \int dF_2 \cdot \sin\varphi \qquad d\varphi = \frac{dl}{R}$

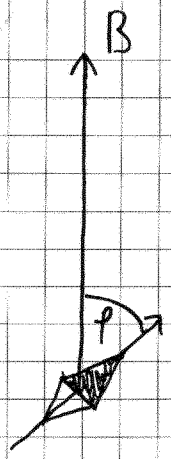
$dF_2 = I \cdot dl \cdot B = I\, R\, d\varphi \cdot B$

$F_2 = I \cdot R \cdot B \int_0^{\pi} \sin\varphi\, d\varphi = I \cdot R \cdot B\, (-\cos\varphi)\Big|_0^{\pi} = I \cdot R \cdot B\, (-\cos\pi + \cos 0)$

$\boxed{F_2 = 2 \cdot I \cdot R \cdot B}$ kot če bi imeli raven vodnik z dolžino $2R$.

$F = F_1 + F_2 + F_3 = 2 \cdot I \cdot l \cdot B + 2 \cdot I \cdot R \cdot B$

$F = 2 \cdot I \cdot B\, (l + R)$



Magnetni dipolni moment

$$\vec{M} = \vec{p}_m \times \vec{B}$$

$$M = p_m \cdot B \cdot \sin\varphi$$

Zemeljsko mag. polje. V njem niha magnetnica okoli navpične osi s frekvenco 0,02 Hz. Kakšna je gostota mag. polja, če niha s frekvenco 0,8 Hz.

$B_0 = 2 \cdot 10^{-4}$ T.

$\nu_0 = 0{,}02$ Hz

$\nu_1 = 0{,}8$ Hz

$B_1 = ?$

$$M = J \cdot \alpha$$

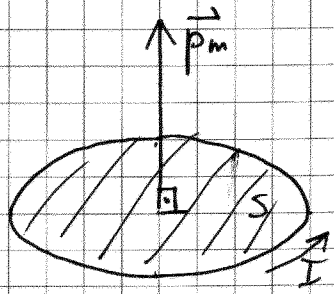
$$-p_m \cdot B \cdot \underbrace{\sin\varphi}_{\varphi} = J \cdot \ddot{\varphi}$$

$$\ddot{\varphi} = -\underbrace{\frac{p_m \cdot B}{J}}_{\omega^2} \cdot \varphi$$

$$\nu = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{p_m \cdot B}{J}}$$

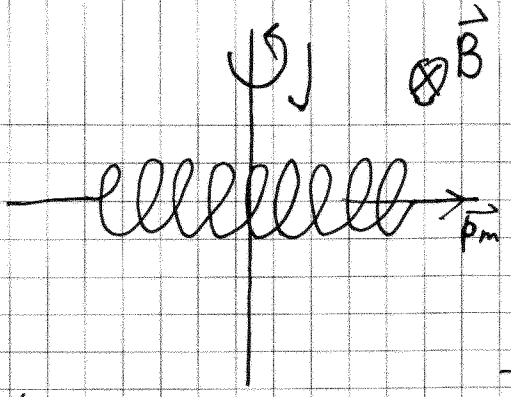
$$\frac{\nu_1^2}{\nu_0^2} = \frac{\frac{1}{4\pi^2}\frac{p_m B_1}{J}}{\frac{1}{4\pi^2}\frac{p_m B_0}{J}}$$

$$B_1 = B_0 \cdot \frac{\nu_1^2}{\nu_0^2} = 2 \cdot 10^{-4}\,\mathrm{T} \cdot \frac{64 \cdot 10^{-2}\,\mathrm{Hz}^2}{4 \cdot 10^{-4}\,\mathrm{Hz}^2} = 0{,}32\,\mathrm{T}$$



$$\vec{p}_m = I \cdot \vec{S}$$

tuljava $\vec{p}_m = N \cdot I \cdot \vec{S}$



Tuljava s 40 ovoji, $S = 70\,cm^2$ se nahaja v homogenem mag. polju. Kakšen je kotni pospešek, ko skozi spustino tok.

$t = 0 : \vec{p}_m \perp \vec{B}$

$\sin\varphi = 1 \Rightarrow \varphi = 90°$

$N = 40$

$S = 70\,cm^2$

$B = 0{,}8\,T \quad I = 0{,}2\,A$

$J = 0{,}0015\,kgm^2$

$\alpha = ?$

$M = J \cdot \alpha$

$p_m \cdot B = J \cdot \alpha$

$$\alpha = \frac{p_m \cdot B}{J} = \frac{N \cdot I \cdot S \cdot B}{J} = 4{,}27\,s^{-2}$$

$$A = \int_{\varphi_1}^{\varphi_2} M \cdot d\varphi = \int_{\varphi_1}^{\varphi_2} p_m \cdot B \cdot \sin\varphi \, d\varphi = -p_m B \cos\varphi \Big|_{\varphi_1}^{\varphi_1}$$

$$A = \underbrace{-p_m \cdot B \cdot \cos\varphi_2}_{W_m(\varphi_2)} - \underbrace{(-p_m \cdot B \cdot \cos\varphi_1)}_{W_m(\varphi_1)}$$

$$\boxed{W_m = -p_m \cdot B \cdot \cos\varphi = -\vec{p}_m \cdot \vec{B}}$$

$N = 100$
$r = 5\,cm$
$I = 0{,}1\,A$
$B = 1{,}5\,T$
$\varphi_1 = 0$
$\varphi_2 = 180°$

$A = ?$

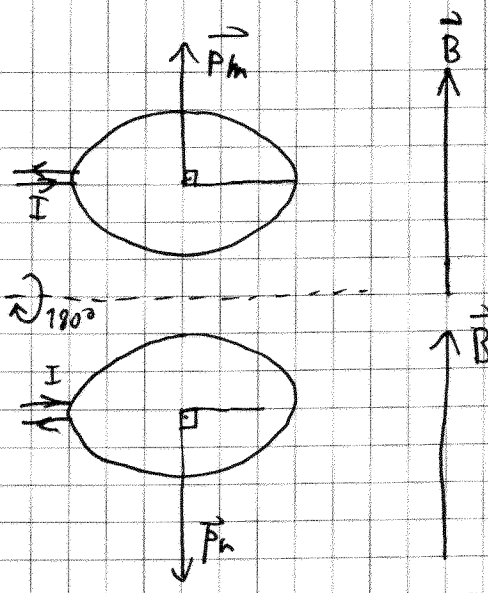
$A = \Delta W_k = W_m(\varphi_2) - W_m(\varphi_1)$

$A = -p_m B \cos 180° + p_m B \cos 0°$

-1 $\quad$ 1

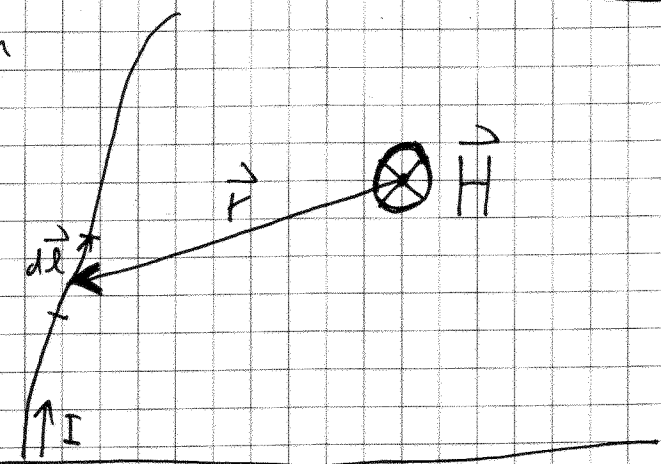
$$\boxed{A = 2 \cdot p_m \cdot B}$$

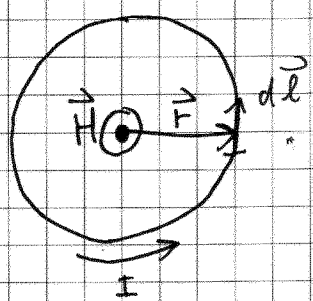
$$A = 2 \cdot N \cdot I \cdot \pi r^2 \cdot B = 0{,}24\,J$$



Biot-Savartov zakon

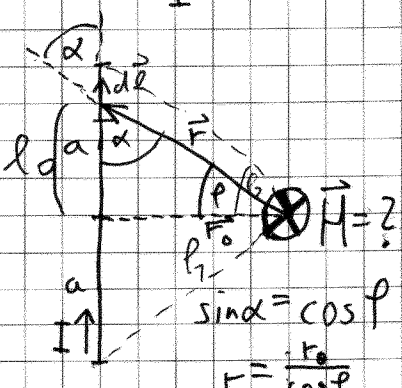
$$\boxed{\vec{H} = \frac{I}{4\pi} \int \frac{\vec{r} \times d\vec{l}}{r^3}}$$





$$H = \frac{I}{4\pi} \int \frac{r\,dl}{r^3} = \frac{I}{4\pi r^2} 2\pi r =$$

$$\boxed{H = \frac{I}{2r}}$$



$$H = \frac{I}{4\pi} \int \frac{r \cdot dl \cdot \sin\alpha}{r^3} = \frac{I}{4\pi} \int \frac{\frac{1}{r_0 \cos^2\varphi} \cdot \cos\varphi}{\frac{r_0^2}{\cos^2\varphi}} d\varphi$$

$$H = \frac{I}{4\pi r_0} \int_{\varphi_1}^{\varphi_2} \cos\varphi \cdot d\varphi$$

$$H = \frac{I}{4\pi r_0} (\sin\varphi_2 - \sin\varphi_1)$$

$\sin\alpha = \cos\varphi$

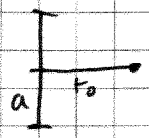
$r = \frac{r_0}{\cos\varphi}$

$l = r_0 \cdot \operatorname{tg}\varphi$

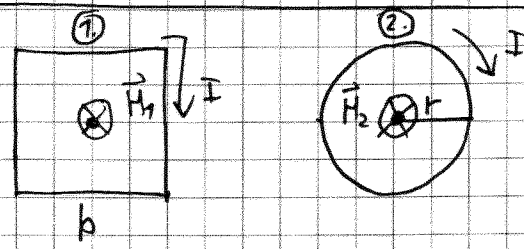
$dl = r_0 \frac{1}{\cos^2\varphi} \cdot d\varphi$

$\sin\varphi_2 = \frac{a}{\sqrt{a^2 + r_0^2}}$ $\quad$ $\sin\varphi_1 = \frac{-d}{\sqrt{a^2 + r_0^2}}$

$$H = \frac{I}{2\pi r_0} \frac{a}{\sqrt{a^2 + r_0^2}}$$



$l_1 = l_2$ } $4 \cdot b = 2\pi r$
$N_1 = N_2$
$I_1 = I_2$



Kakšno je razmerje mag. poljskih jakosti v središču zank?

$\frac{H_1}{H_2} = ?$

$$H_2 = \frac{N \cdot I}{2r}$$

$r_0 = \frac{b}{2}$
$a = \frac{b}{2}$

$$H_1 = 4 \cdot H_b = 4 \cdot \frac{NI}{2 \cdot \pi \cdot \frac{b}{2}} \cdot \frac{\frac{b}{2}}{\sqrt{\left(\frac{b}{2}\right)^2 + \left(\frac{b}{2}\right)^2}} = 2 \cdot \frac{N \cdot I}{\pi \sqrt{\frac{b^2}{4} + \frac{b^2}{4}}}$$

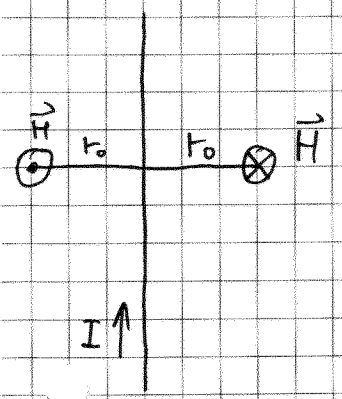
$$H_1 = \frac{2 \cdot N \cdot I \sqrt{2}}{\pi b}$$

$$\frac{H_1}{H_2} = \frac{2 \cdot N \cdot I \cdot \sqrt{2}}{\pi \cdot b} \cdot \frac{2 \cdot \frac{2b}{\pi}}{N \cdot I} \qquad r = \frac{2b}{\pi}$$

$$\frac{H_1}{H_2} = \frac{8\sqrt{2}}{\pi^2} = 1{,}15$$

Amperov zakon (zakon o mag. napetosti)

$$\oint \vec{H} \cdot d\vec{s} = I$$



$\vec{H} \parallel d\vec{s}$

$$\oint H\, ds = I$$

$$H \cdot 2\pi r_0 = I \Rightarrow \boxed{H = \frac{I}{2\pi r_0}}$$

$R = 1\,cm$
$I = 7000\,A$, $\boxed{j = \frac{I}{\pi R^2}}$
$r = 0{,}5\,cm$

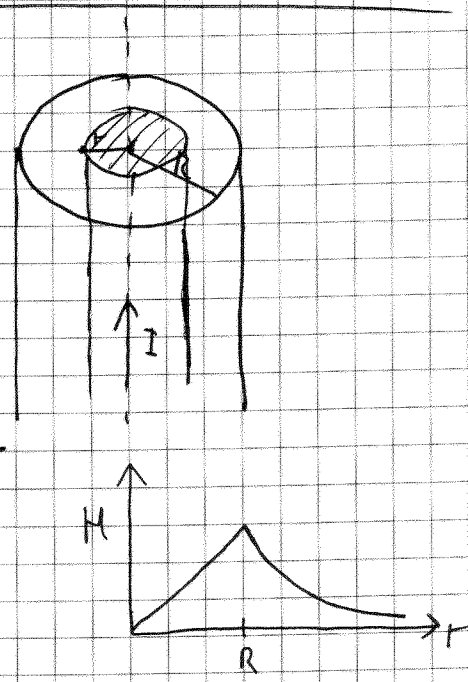
$H(r) = ?$

$$\oint \vec{H} \cdot d\vec{s} = j \cdot r^2 \pi \qquad \vec{H} \parallel d\vec{s}$$

$$\oint H\, ds = \frac{I}{\pi R^2} \pi r^2$$

$$H \cdot 2\pi r = \frac{I}{\pi R^2} \pi r^2$$

$$\boxed{H = \frac{I \cdot r}{2\pi R^2}} = 7958\,\frac{A}{m}$$



Gaussov zakon (zakon o el. pretoku)

$$\oint \vec{D} \cdot d\vec{S} = Q$$

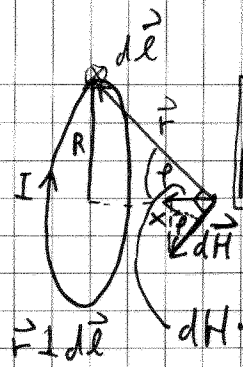
Zakon o mag. pretoku.

$$\oint \vec{B} \cdot d\vec{S} = 0$$

$$c_0 = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

27.03.2008

II



V SREDIŠČU:

$$H = \frac{I}{2R}$$

$$\vec{H} = \frac{I}{4\pi}\int \frac{\vec{r}\times d\vec{l}}{r^3} \Rightarrow dH = \frac{I}{4\pi}\frac{r \cdot dl}{r^3}$$

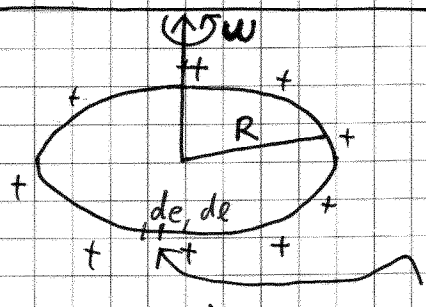
$$H = \int dH \cdot \sin\varphi$$

$$H = \int \frac{I}{4\pi}\frac{r \cdot dl}{r^3}\frac{R}{r} = \frac{I \cdot R}{4\pi r^3}\overbrace{\int dl}^{2\pi R}$$

NA OSI

$$r = \sqrt{R^2+x^2}$$

$$H = \frac{I R^2}{2 r^3} = \frac{I R^2}{2\sqrt{R^2+x^2}^3}$$



Obroč vrtimo okoli osi.

$$\underline{e, R, \omega}$$

$$p_m = ?$$

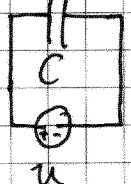
$$de = \frac{e}{2\pi R}\cdot dl$$

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

$$p_m = \frac{de}{dt}\cdot S \Rightarrow p_m = \frac{e}{2\pi R}\frac{dl}{dt}\cdot S = \frac{e}{2\pi R}\cdot \omega \cdot R \cdot \pi R^2$$

$\frac{dl}{dt} \uparrow v = \omega \cdot R$

$$\Rightarrow \boxed{p_m = \frac{e \cdot \omega \cdot R^2}{2}}$$



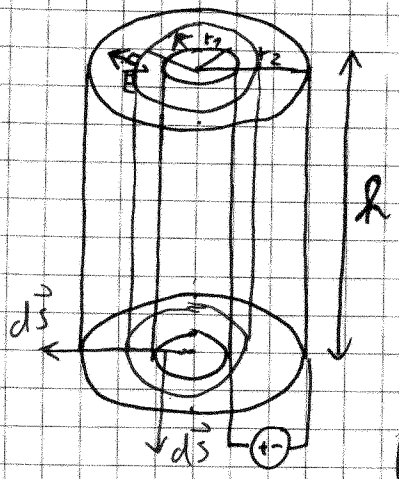
$$e = C \cdot u$$

$$u + u_c = 0$$

$$u_c = -\frac{e}{C}$$

$$C = -\frac{e}{u_c}$$

VALJAST KOND.



$$U_c = -\int_{r_1}^{r_2} \vec{E}\cdot d\vec{r}$$

$$\oint \vec{D}\cdot d\vec{S} = q$$

$$\varepsilon\varepsilon_0 \oint \vec{E}\cdot d\vec{S} = q$$

$$\varepsilon\varepsilon_0 E \cdot 2\pi r h = q$$

$$E = \frac{q/h}{2\pi\varepsilon\varepsilon_0 r}$$

$$U_c = -\int_{r_1}^{r_2} E\cdot dr$$

$$U_c = -\int_{r_1}^{r_2} \frac{q/h}{2\pi\varepsilon\varepsilon_0 r}\,dr = \boxed{-\frac{q/h}{2\pi\varepsilon\varepsilon_0}\ln\frac{r_2}{r_1} = U_c}$$

$$\boxed{C = \frac{2\pi\varepsilon\varepsilon_0 h}{\ln\frac{r_2}{r_1}}}$$

KROGELNI KONDENZATOR

$$C = -\frac{q}{U_c} \qquad E = \frac{q}{4\pi\varepsilon\varepsilon_0 r^2}$$

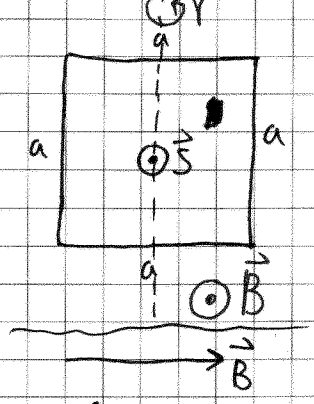
$$U_c = -\int_{r_1}^{r_2} E\cdot dr = -\frac{q}{4\pi\varepsilon\varepsilon_0}\int_{r_1}^{r_2}\frac{dr}{r^2} = \boxed{-\frac{q}{4\pi\varepsilon\varepsilon_0}\left(\frac{1}{r_1}-\frac{1}{r_2}\right) = U_c}$$

$$\boxed{C = \frac{4\pi\varepsilon\varepsilon_0}{\frac{1}{r_1}-\frac{1}{r_2}}}$$

Indukcija

$$u_i = \frac{d\Phi_m}{dt} \qquad \Phi_m = \int \vec{B} \cdot d\vec{S}$$

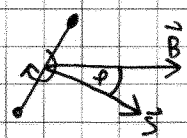
str. 52 / 86. naloga



$\rho = 0{,}03 \ \frac{\Omega\,mm^2}{m}$ ... žica
$S_0 = 1\ mm^2$
$S = 121\ cm^2$
$a = 11\ cm$
$\nu = 20\ Hz$
$B = 1\ T$

$I_0 = ?$

Okvir vrtimo okrog njegove simetrale.
Kolikšna je amplituda toka, ki teče po okvirju?



$$\varphi = \omega \cdot t \qquad \Phi_m = \vec{B} \cdot \vec{S} = B \cdot S \cdot \cos\varphi = B \cdot S \cdot \cos(\omega \cdot t)$$

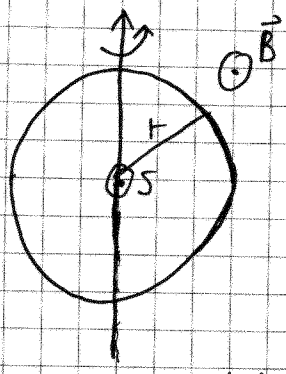
$$u_i = \frac{d\Phi_m}{dt} = \boxed{-B \cdot S \cdot \omega \cdot \sin(\omega \cdot t) = u_i}$$

$$I = \frac{u_i}{R} = \boxed{-\frac{B \cdot S \cdot \omega}{R} \sin(\omega \cdot t) = I}$$

$\frac{B \cdot S \cdot \omega}{R} = I_0$

$$I_0 = \frac{B \cdot a^2 \cdot 2\pi\nu}{\rho \cdot \frac{4a}{S_0}} = \frac{B \cdot a \cdot \pi \cdot \nu \cdot S_0}{2\rho} = 115\ A$$

str. 52 / 87. nal.



$\rho = 0{,}1 \frac{\Omega mm^2}{m}$
$r = 10\ cm$
$S_0 = 1\ mm^2$
$B = 0{,}1\ T$
$\nu = 10^4\ Hz$
$\langle M \rangle = ?$

Kakšen navor je potreben, da se obroč zavrti z $\nu = 10\ Hz$.

$\vec{p}_m = I \cdot \vec{S}$

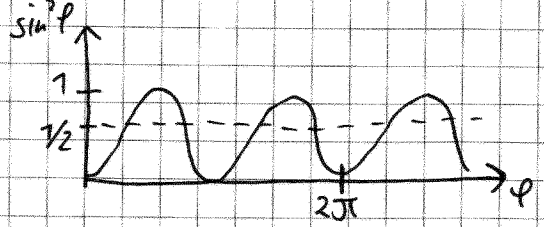
$\vec{M} = \vec{p}_m \times \vec{B}$

$M = p_m B \cdot \sin\varphi$

$M = I \cdot S \cdot B \cdot \sin\varphi$

INDUKCIJA

$I = -\frac{B \cdot S \cdot w}{R} \cdot \sin(w \cdot t) \Rightarrow \boxed{M = -\frac{B^2 \cdot S^2 \cdot w}{R} \cdot \sin^2\varphi}$



$\langle \sin^2\varphi \rangle = \frac{1}{2\pi} \int_0^{2\pi} \sin^2\varphi \cdot d\varphi = \frac{1}{2}$ (integral $0 \to \pi$)

$\langle M \rangle = -\frac{B^2 \cdot S^2 \cdot w}{R} \underbrace{\langle \sin^2\varphi \rangle}_{1/2} = -\frac{B^2 \cancel{S^2} r^4 \cancel{2\pi} \cdot \nu}{2 \rho \cdot \frac{\cancel{2\pi} r}{S_0}} = -\frac{B^2 \cdot \pi^2 \cdot r^3 \cdot \nu \cdot S_0}{2 \cdot \rho}$

$\langle M \rangle =$

---

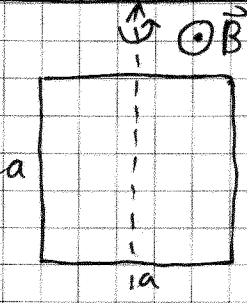
88. nal. / str. 53

$\rho = 0{,}1 \frac{\Omega mm^2}{m}$
$S_0 = 1\ mm^2$
$a = 10\ cm$
$B = 0{,}1\ T$
$\nu = 60\ Hz$
$A = ?\ (\text{za 1 obrat})$

Koliko dela opravimo za en obrat okvirja?

$A = \int_0^{2\pi} M \cdot d\varphi = \int_0^{2\pi} \frac{B^2 \cdot S^2 \cdot w}{R} \cdot \sin^2\varphi \, d\varphi =$

$A = \frac{B^2 \cdot S^2 \cdot w}{R} \cdot \underbrace{\int_0^{2\pi} \sin^2\varphi \cdot d\varphi}_{\pi} =$



$\boxed{A = \frac{\pi \cdot B^2 \cdot S^2 \cdot w}{R}}$ ← delo za en obrat, ⇒ a več krat N.

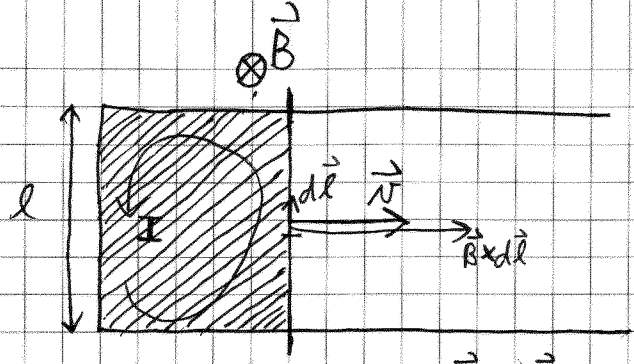
2. način $A = \int_0^{t_0} P \cdot dt = \int_0^{t_0} U \cdot I \cdot dt = \underline{D.N.} =$

$A = \frac{\pi \cdot B^2 \cdot a^4 \cdot 2\pi \cdot \nu}{\rho \frac{4a}{S_0}} =$

3. način $A = \langle M \rangle \cdot 2\pi$

$A = \frac{\pi^2 \cdot B^2 \cdot a^3 \cdot \nu \cdot S_0}{2\rho} = 3 \cdot \pi^2 \cdot 10^{-3}\ J$

$= 0{,}03\ J$

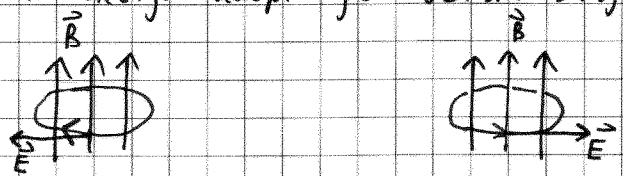


$$\boxed{u_i = \int \vec{v} \cdot (\vec{B} \cdot d\vec{l})}$$

$$\boxed{u_i = v \cdot B \cdot l} \qquad \vec{B} \perp d\vec{l}, \quad (\vec{B} \times d\vec{l}) \parallel \vec{v}$$

LENZOVO PRAVILO

Indukcija nasprotuje vzroku svojega nastanka.

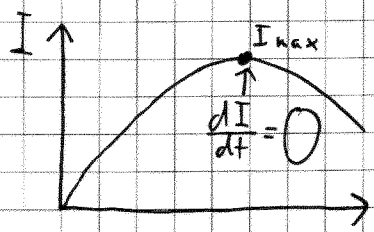


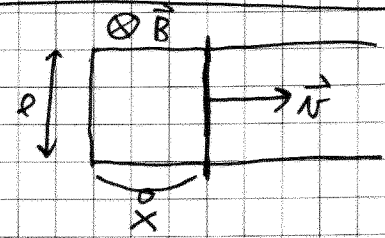
$\frac{d\vec{B}}{dt} > 0$ $\qquad$ $\frac{d\vec{B}}{dt} < 0$

$l = 5\ cm$
$B = 1\ T$
$x(t=0) = 0$
v = enakomerno pospešeno $= a \cdot t$
$a = konst.$

$x = ?\ (I = max)$

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





$u_i = a \cdot t \cdot B \cdot l$

$R = \rho \cdot \frac{2l + 2x}{S_0}$; $x = \frac{a \cdot t^2}{2}$

$R = \rho \frac{2l + at^2}{S_0}$

$$I = \frac{u_i}{R} = \frac{a \cdot B \cdot l \cdot S_0}{\rho} \cdot \frac{t}{2l + at^2}$$

$$\frac{dI}{dt} = \frac{a \cdot B \cdot l \cdot S_0}{\rho} \cdot \frac{1 \cdot (2l + at^2) - t \cdot (0 + 2at)}{(2l + at^2)^2} = 0$$

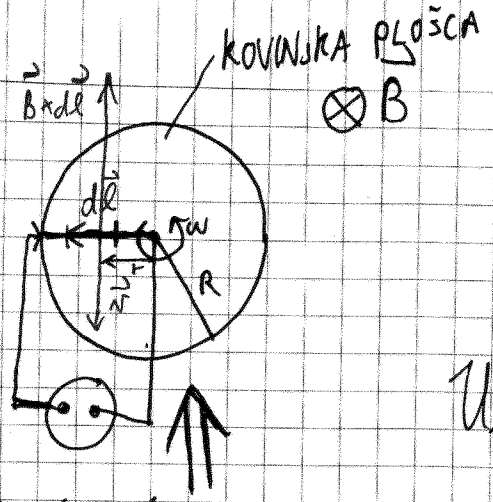
$$2l + at^2 - 2at^2 = 0$$

$$2l = at^2$$

$$l = \frac{at^2}{2} = x$$

$$x = l = 5\ cm$$

3 A



93. naloga / str. 54

$R = 20\,cm$

$\omega = 200\,s^{-1}$

$B = 0,1\,T$

$U_i = ?$

$$U_i = -\int v \cdot B \cdot dl$$

$$v = \omega \cdot r$$

$$U_i = -\int_0^R \omega \cdot r \cdot B \cdot dr$$

$$\boxed{U_i = -\omega \cdot B \frac{R^2}{2}} = -200\,s^{-1} \cdot 0,1\,T \cdot \frac{0,04\,m^2}{2} = \underline{\underline{-0,4\,V}}$$

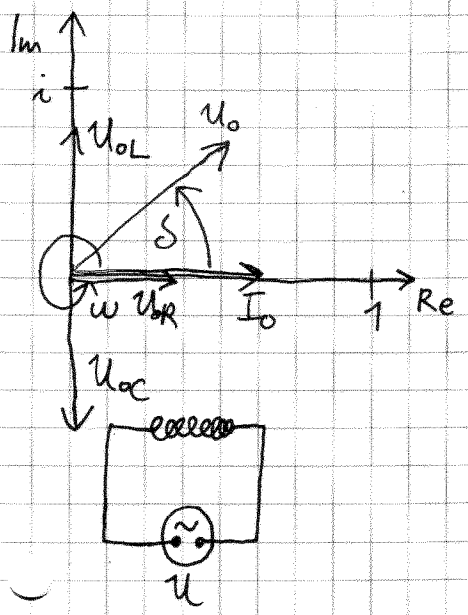
$U_i = \frac{d\Phi_m}{dt} = 0$ V TEM PRIMERU NE VELJA

INDUKCIJSKI ZAKON

$$\oint \vec{E} \cdot d\vec{s} = -\int \frac{\partial \vec{B}}{\partial t} \cdot d\vec{S}$$

17.04.2008

KAZALČNI DIAGRAM



$$I = I_0 \cdot e^{i\omega t}$$
$$U = U_0 \cdot e^{i\omega t}$$
; $e^{i\omega t} = \cos\omega t + i \sin\omega t$

$$U_0 = Z \cdot I_0$$
Z ↑ impendanca

$$\tan\delta = \frac{\mathrm{Im}\, Z}{\mathrm{Re}\, Z}$$

$$P = U \cdot I$$
$$\overline{P} = \frac{1}{2} |I_0||U_0| \cos\delta = |U_{ef}| \cdot |I_{ef}| \cos\delta$$

če imamo samo upor je napetost v fazi s tokom.
če imamo kondenzator napetost zaostaja za $\frac{1}{4}$ nihaja
če imamo tuljavo napetost prehiteva za $\frac{1}{4}$ nihaja.

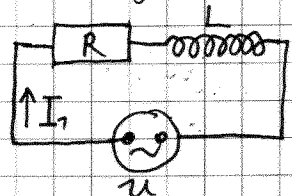
$$Z_R = R$$
$$Z_C = \frac{1}{i\omega C} = -\frac{i}{\omega C}$$
$$Z_L = i\omega L$$

i je kompleksen, predstavlja fazni zamik

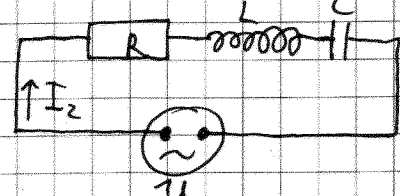
$$|Z| = \sqrt{(\mathrm{Re}\, z)^2 + (\mathrm{Im}\, z)^2}$$

FIZ II (UNI) 6.6.2006 3. naloga

$R = 50\,\Omega$
$L = 1\,mH$
$\omega = 50\,000\ s^{-1}$
$I_{ef1} = 0{,}7071\,A$
$I_{ef2} = 0{,}8575\,A$
$C = ?$



$$U_0 = Z_1 \cdot I_{01} = (Z_R + Z_L) \cdot I_0$$
$$U_0 = (R + i\omega L) \cdot I_{01} \,/\cdot |\,|$$
$$|U_0| = \sqrt{R^2 + \omega^2 L^2} \cdot I_{01} \,/ : \sqrt{2}$$
$$|U_{ef}| = \sqrt{R^2 + \omega^2 L^2} \cdot I_{ef1}$$



$$U_0 = Z_2 \cdot I_{02} = (Z_R + Z_L + Z_C) \cdot I_{02}$$
$$U_0 = \left(R + i\omega L - i\frac{1}{\omega C}\right) I_{02} \,/\, |\,|$$
$$|U_0| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \cdot I_{02} \,/ : \sqrt{2}$$
$$|U_{ef}| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \cdot I_{ef2}$$

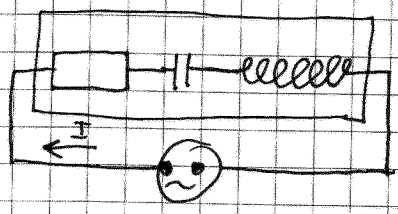
$$|U_{ef}| = |U_{ef}|$$
$$\sqrt{R^2 + \omega^2 L^2}\, I_{ef1} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}\, I_{ef2}$$

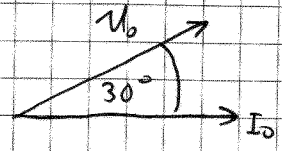
$$C_{1,2} = \begin{cases} 1\,\mu F \\ \frac{1}{4}\,\mu F \end{cases}$$

56. naloga / stran 42

$I_{ef} = 300\ mA$
$\bar{P} = 3\ mW$
$\delta = 30°$

$|Z| = ?$





$$\bar{P} = |U_{ef}| \cdot |I_{ef}| \cdot \cos\delta = |Z| \cdot I_{ef}^2 \cdot \cos\delta$$

$$|U_{ef}| = |Z| \cdot I_{ef}$$

$$|Z| = \frac{\bar{P}}{I_{ef}^2 \cos\delta} = \frac{3 \cdot 10^{-3} W \cdot 2}{0{,}09\ A^2 \cdot \sqrt{3}} = 0{,}0385\ \Omega$$

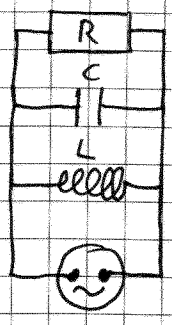
2. način
moč se uporablja samo na uporu $\delta = 0$.

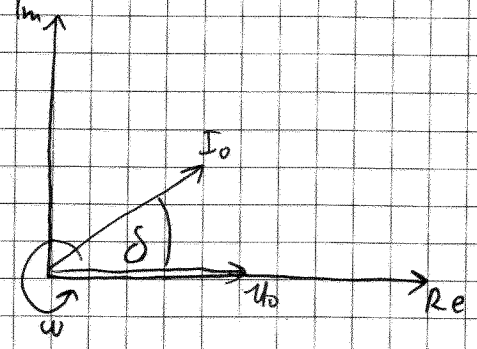
$$\bar{P} = U_{R_{ef}} \cdot I_{ef} = R \cdot I_{ef}^2 \Rightarrow R = \frac{\bar{P}}{I_{ef}^2} = \frac{1}{30}\ \Omega$$

$$|z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$\tan\delta = \frac{Im\,z}{Re\,z} = \frac{\omega L - \frac{1}{\omega C}}{R} \Rightarrow \omega L - \frac{1}{\omega C} = 0{,}07924\ \Omega$$

$$U = U_0 \cdot e^{i\omega t}$$
$$I = I_0 \cdot e^{i\omega t}$$
$$U_0 = Z \cdot I_0$$
$$\frac{U_0}{Z} = I_0$$
$$\left|\frac{1}{Z}\right| \cdot U_0 = |I_0|$$





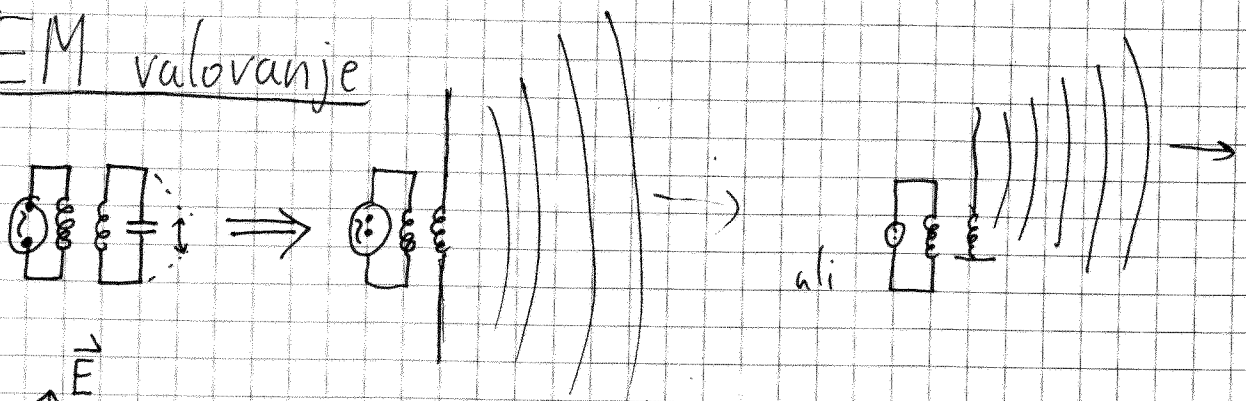
$$\frac{1}{Z} = \frac{1}{Z_R} + \frac{1}{Z_C} + \frac{1}{Z_L} = \frac{1}{R} + i\omega C + \frac{1}{i\omega L}$$

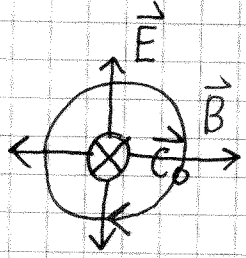
$$\frac{1}{Z} = \frac{1}{R} + i\left(\omega C - \frac{1}{\omega L}\right)$$

$$\left|\frac{1}{Z}\right| = \sqrt{\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2}$$

$$\tan\delta = \frac{Im\frac{1}{Z}}{Re\frac{1}{Z}} = \frac{\omega C - \frac{1}{\omega L}}{\frac{1}{R}} = R\left(\omega C - \frac{1}{\omega L}\right)$$

EM valovanje





$$c_0 = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = 3{,}00 \cdot 10^8 \frac{m}{s}$$

$$c = \frac{1}{\sqrt{\varepsilon \varepsilon_0 \mu \mu_0}} \leq c_0$$

$\vec{E} \perp \vec{B} \perp \vec{c}_0$

$\vec{E} = \vec{B} \times \vec{c}_0$

$E = B \cdot c_0$

$w_e = \frac{1}{2} \varepsilon_0 E^2 \quad \left(\frac{Ws}{V}\right)$ — gostota el. ener.

$w_m = \frac{1}{2} \frac{B^2}{\mu_0} = \frac{1}{2} \varepsilon_0 E^2$ — gostota mag.

$w = w_e + w_m = \varepsilon_0 E^2 = \varepsilon_0 E_0^2 \cos^2(\omega t - kx)$

$\overline{w} = \frac{1}{2} \varepsilon_0 E_0^2$

ENERGIJSKI TOK: $P = \frac{W}{t}$

POV. GOSTOTA EN. TOKA: $j = \frac{P}{S}$ $\quad j = \overline{w} \cdot c = \frac{1}{2} \varepsilon_0 c_0 E_0^2 = \frac{1}{2} E_0 \cdot H_0$

POYNTINGOV VEKTOR — gostota en. toka

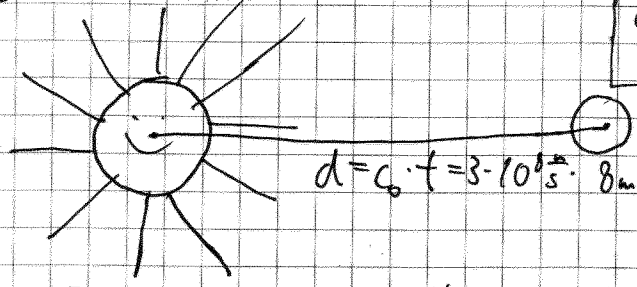
$\vec{\mathcal{P}} = \vec{E} \times \vec{H}$

SONCE

$j = 1360 \frac{W}{m^2}$

$P = ?$

SEVA IZOTROPNO



$d = c_0 \cdot t = 3 \cdot 10^8 \frac{m}{s} \cdot 8\,min = 1{,}5 \cdot 10^{11}\,m$ (480 s)

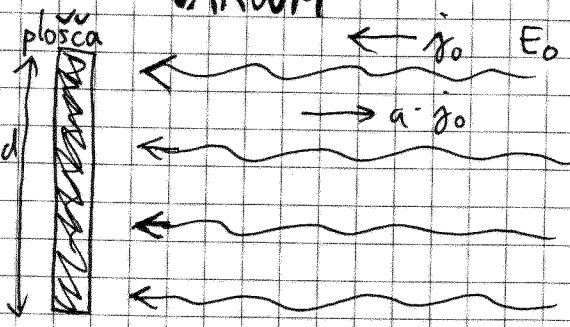
$j = \frac{P}{S} \Rightarrow P = j \cdot S = j \cdot 4\pi d^2 = 1360 \frac{W}{m^2} \cdot 4 \cdot \pi \cdot (1{,}5 \cdot 10^{11}\,m)^2$

$P \simeq 4 \cdot 10^{22}\,W$

$W = m \cdot c_0^2$

$P = \frac{dW}{dt} = \frac{dm \cdot c_0^2}{dt} \Rightarrow \frac{dm}{dt} = \frac{P}{c_0^2} \simeq 0{,}4 \cdot 10^{10} \frac{kg}{s} = 4\,000\,000 \frac{ton}{s}$

52 naloga / stran 77



$d = 1\,m$
$E_0 = 700\ \frac{V}{m}$
$a = 0{,}6$ (ODBOJNOST, ALBEDO)

$P_{izsevan} = ?$ v stacionarnem stanju

izsevan tok = absorbiranemu toku

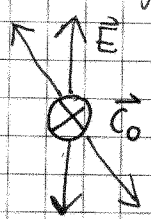
$P_{izs} = P_{ABS} = j_{ABS} \cdot S = j_{ABS} \cdot d^2$

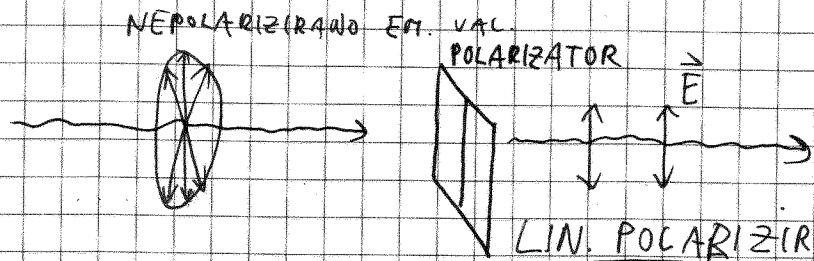
$j_0 = \frac{1}{2} \varepsilon_0 c_0 E_0^2$

$j_{ABS} = j_0 - a j_0 = (1-a) j_0$

$$P_{ABS} = (1-a)\frac{1}{2}\varepsilon_0 c_0 E_0^2 \cdot d^2 = 5{,}3\,W$$

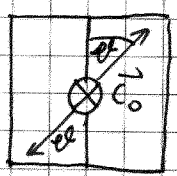
Polarizacija





LIN. POLARIZIRANO EM VAL

$$j' = j \cdot \cos^2\varphi = \frac{1}{2} j$$

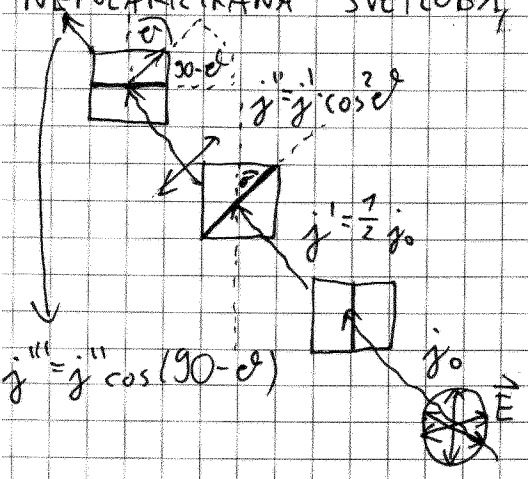


$$E_0' = E \cdot \cos\varphi$$

$$j' = \frac{1}{2}\varepsilon_0 c_0 E_0'^2 = \frac{1}{2}\varepsilon_0 c_0 E_0^2 \cos^2\varphi$$

$$j' = j \cdot \cos^2\varphi$$

NEPOLARIZIRANA SVETLOBA, TRIJE POLARIZATORJI



$\varphi = ?$, da bo največ svet. prišlo skozi j_0

$\varphi \,\#\, j''' = max.) = ?$

$$j''' = \frac{1}{2} j_0 \cos^2\varphi \cdot \cos^2(90-\varphi)$$

$$j''' = \frac{1}{2} j_0 \cos^2\varphi \cdot \sin^2\varphi \qquad \sin(2\varphi) = 2\sin\varphi\cos\varphi$$

$$j''' = \frac{1}{2} j_0 \frac{1}{4} \sin^2(2\varphi) = max$$

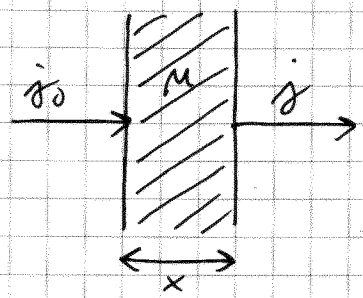
$$\sin(2\varphi) = \pm 1$$

$$2\varphi = \pm 90° \pm k\pi$$

$$\varphi = \pm\frac{\pi}{4} \pm k\pi$$

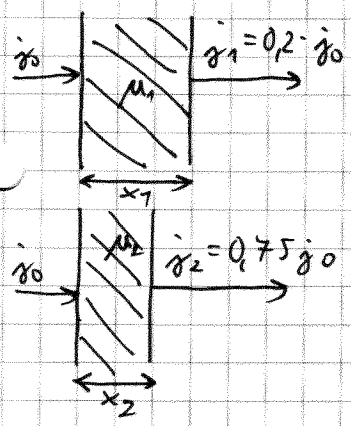
24.04.2008

Absorbcija



$$j = j_0 \cdot e^{-\mu \cdot x}$$

μ - absorpcijski koeficient



$j_1 = 0{,}2 \cdot j_0$

$j_2 = 0{,}75 \cdot j_0$

$\mu_1 = \mu_2 = \mu$

$x_1 : x_2 = ?$

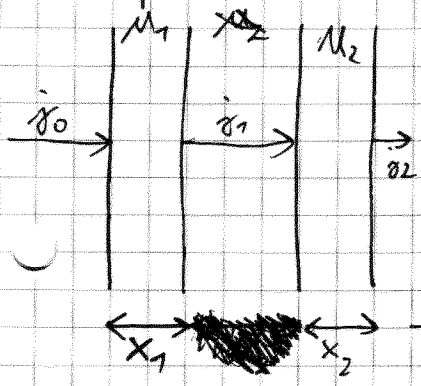
$$j_1 = j_0 \cdot e^{-\mu_1 \cdot x_1}$$

$$\frac{j_1}{j_0} = e^{-\mu_1 x_1}$$

$$\frac{-\ln \frac{j_1}{j_0}}{\mu_1} = x_1$$

$$\frac{x_1}{x_2} = \frac{\ln 0{,}2}{\ln 0{,}75} = 5{,}6$$

Šipa



$x_1 = 2\,mm$

$x_{\frac{1}{2}}^{(1)} = 5\,cm$

$x_2 = 1{,}5\,mm$

$x_{\frac{1}{2}}^{(2)} = 3\,cm$

$\frac{j_{ABS}}{j_0} = ?$

$$j = j_0 \cdot e^{-\mu x}$$

$$\frac{1}{2} j_0 = j_0 \cdot e^{-\mu x_{1/2}}$$

$$e^{\mu x_{\frac{1}{2}}} = 2$$

$$\mu \cdot x_{\frac{1}{2}} = \ln 2$$

$$\boxed{\mu = \frac{\ln 2}{x_{\frac{1}{2}}}}$$

$$j = j_0 \cdot e^{-\frac{\ln 2 \, x}{x_{1/2}}} \quad ; \; e^{\ln 2} = 2$$

$$\boxed{j = j_0 \cdot 2^{-\frac{x}{x_{1/2}}}}$$

$$j_2 = j_0 \cdot 2^{-\frac{x_1}{x_{1/2}^{(1)}}} \cdot 2^{-\frac{x_2}{x_{1/2}^{(2)}}}$$

$$j_{ABS} = j_0 - j_2 \Rightarrow \frac{j_{ABS}}{j_0} = \frac{j_0 - j_2}{j_0} = 1 - 2^{-\frac{x_1}{x_{1/2}^{(1)}}} \cdot 2^{-\frac{x_2}{x_{1/2}^{(2)}}} = 0{,}06 = 6\%$$

Optika

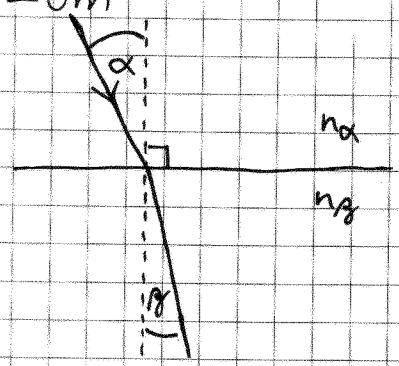
1.) $d \gg \lambda$: geometrijska optika

2.) $d \approx \lambda$: valovna optika

VIDNA SVETLOBA

$\lambda = 400\,nm$ — $\lambda = 800\,nm$

Lom

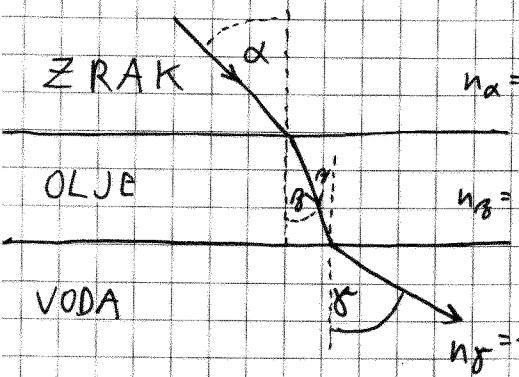


LOMNI KOLIČNIK

$$n = \frac{c_0}{c} = \frac{\frac{1}{\sqrt{\mu_0 \varepsilon_0}}}{\frac{1}{\sqrt{\varepsilon \varepsilon_0 \mu \mu_0}}} = \sqrt{\varepsilon \mu}$$

LOMNI ZAKON

$$\frac{\sin\alpha}{\sin\beta} = \frac{n_\beta}{n_\alpha}$$



$\alpha = 45°$

$\gamma = ?$

$$\frac{\sin\alpha}{\sin\beta} = \frac{n_\beta}{n_\alpha}$$

$$\frac{\sin\beta}{\sin\gamma} = \frac{n_\gamma}{n_\beta}$$

$$\sin\beta = \frac{\sin\alpha \, n_\alpha}{n_\beta}$$

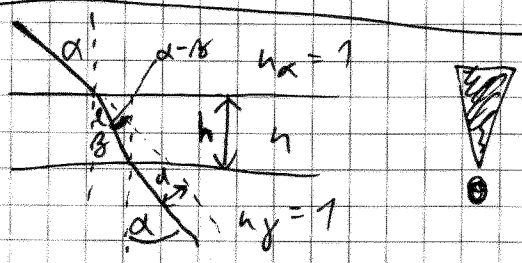
$$\sin\gamma = \frac{\sin\beta \, n_\beta}{n_\gamma}$$

$$\sin\gamma = \frac{\sin\alpha \, n_\alpha \, n_\beta}{n_\beta \, n_\gamma}$$

$$\sin\gamma = \frac{\sin\alpha \, n_\alpha}{n_\gamma}$$

$$\gamma = 32°$$

KOT DA OLJA NEBI BILO



$$d = l \cdot \sin(\alpha - \beta)$$

$$\cos\beta = \frac{h}{l}$$

$$l = \frac{h}{\cos\beta}$$

$$d = \frac{h}{\cos\beta} \cdot \sin(\alpha - \beta)$$

$$\boxed{d = h \sin\alpha \left[1 - \frac{\cos\alpha}{\sqrt{n^2 \cdot \sin^2\alpha}}\right]}$$

38

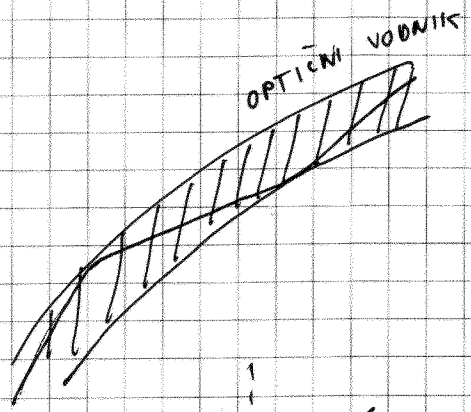
Totalni odboj (ko lomni zakon ni izpolnjen)

$\sin\beta = \sin\alpha \left(\frac{n_\alpha}{n_\beta}\right) > 1$

ko je $n_\alpha > n_\beta$

Mejni kot: $\sin\alpha_M \frac{n_\alpha}{n_\beta} = 1$

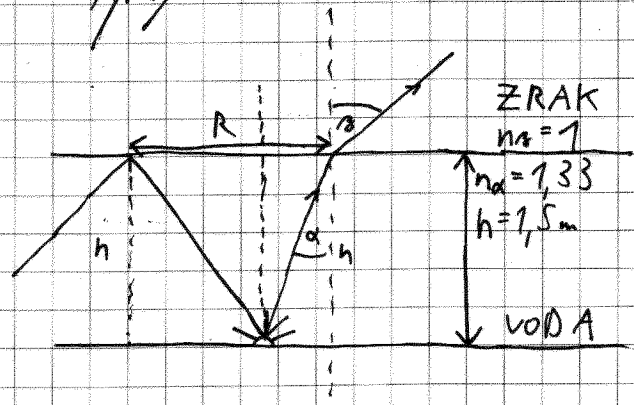
$$\sin\alpha_M = \frac{n_\beta}{n_\alpha}$$



4 nal. / str. 56

$h = 1,5\,m$

$R = ?$



$$\sin\alpha_M = \frac{n_\beta}{n_\alpha}$$

$$\alpha_M = 48,75°$$

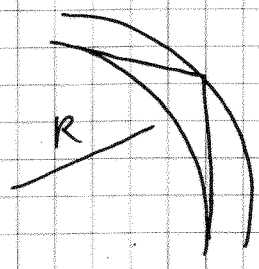
$$\tan\alpha_M = \frac{R}{h}$$

$$R = h \cdot \tan\alpha_M$$

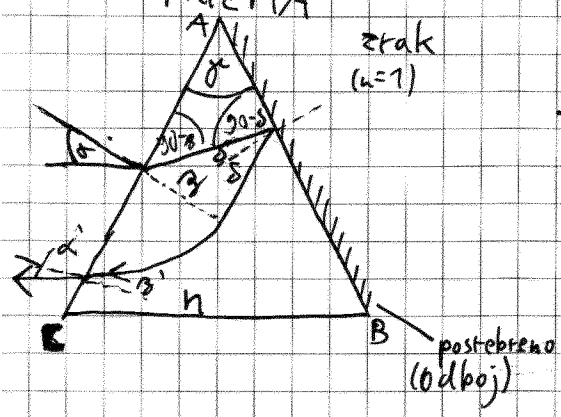
$$R = 1,71\,m$$

UKRIVLJENOST:

$C = \frac{1}{R}$



PRIZMA



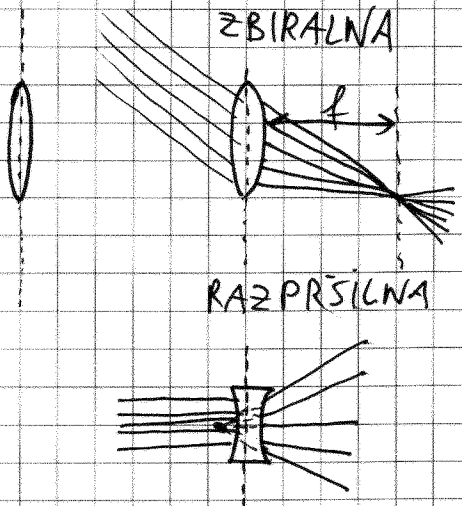
$\gamma = 30°$
$\alpha = 40°$

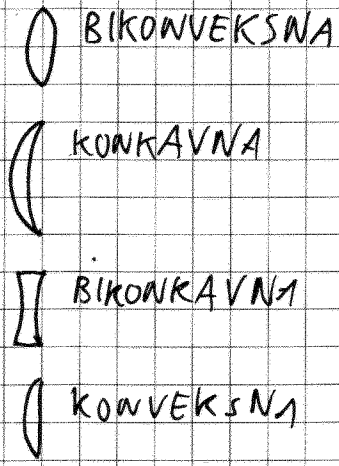
$\alpha' = ?$

$\gamma + (90° - \beta) + (90° - \delta) = 180°$

$\alpha' = 66,78°$

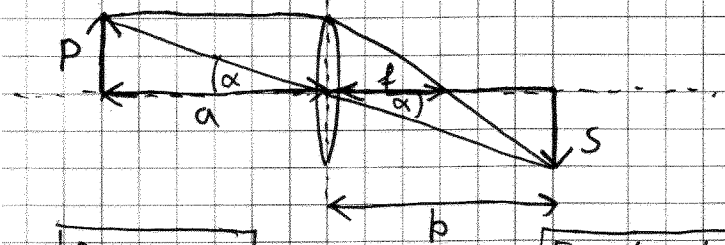
Tanke leče





VIDIMO TOČKO

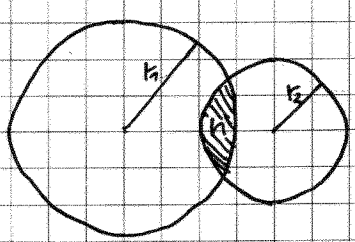
ZBIRALNA LEČA



Povečava:
$$\frac{P}{a} = \frac{S}{b}$$

Enačba leče:
$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

f - gorišča razdalja



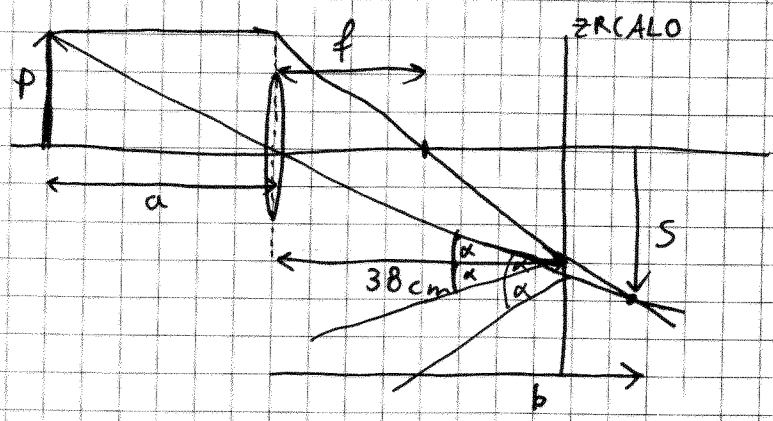
$$\frac{1}{f} = (n-1) \cdot \left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

16. nal. / str. 59

$P = 1{,}5\ cm$
$a = 30\ cm$
$f = 20\ cm$
$d = 38\ cm$

Kako velika je slika predmeta?

$S = ?$



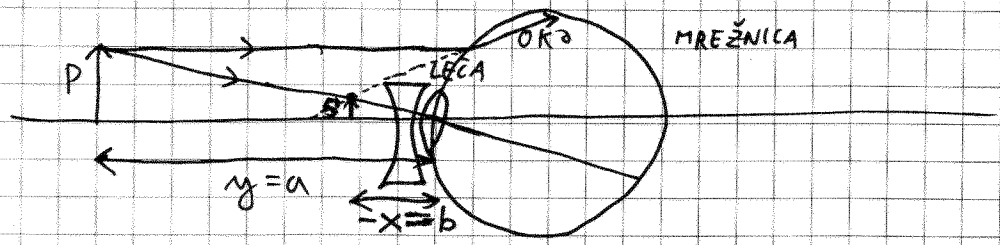
$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

$$\frac{1}{b} = \frac{1}{f} - \frac{1}{a}$$

$$b = \left(\frac{1}{f} - \frac{1}{a}\right)^{-1}$$

$$b = 60\ cm$$

$$S = P \cdot \frac{b}{a} = \underline{\underline{3\ cm}}$$



19. nal. / str. 60

KRATKOVIDNO OKO

$x = 1\ m$ (DO TE MERE VIDIMO JASNO)
$y = 5\ m$ (DO TE MERE VIDIMO JASNO Z OČALI)

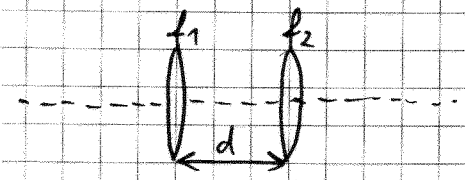
$D = ?$ (DIOPTRIJA) $D = \frac{1}{f}$

$$\frac{1}{f} = \frac{1}{a} + \frac{1}{b}$$

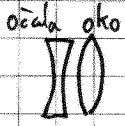
$$D = \frac{1}{f} = \frac{1}{y} + \frac{1}{-x} = \frac{1}{5\,m} - \frac{1}{1\,m} = 0{,}2\,m^{-1} - 1\,m^{-1} = -0{,}8\,m^{-1}$$

$$\underline{\underline{D = -0{,}8}}$$

Več leč



$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \qquad \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 \cdot f_2}$$



OKO: $\frac{1}{f_{OKO}} = \frac{1}{x} + \frac{1}{b}$

OČALA: $\frac{1}{f_{OČALA}} + \frac{1}{f_{LEČA}} = \frac{1}{y} + \frac{1}{b}$

$$\frac{1}{f_{LEČA}} = \frac{1}{y} + \frac{1}{b} - \frac{1}{f_{OKO}}$$

$$\frac{1}{f_{LEČA}} = \frac{1}{y} + \frac{1}{b} - \frac{1}{x} - \frac{1}{b}$$

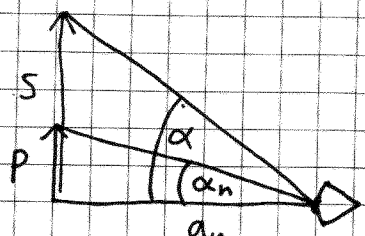
$$\frac{1}{f_{LEČA}} = \frac{1}{y} - \frac{1}{x} = -0{,}8\,/m$$

08.05.2008

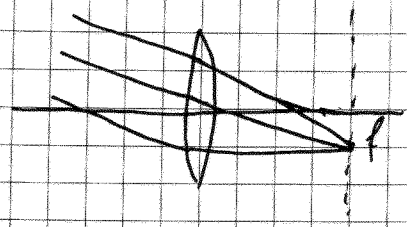
Mikroskop

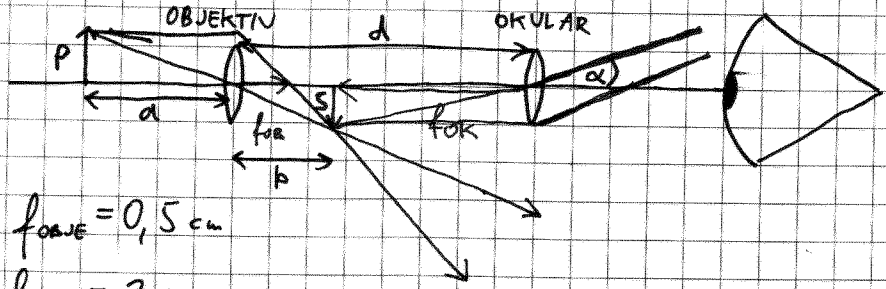
Povečava:

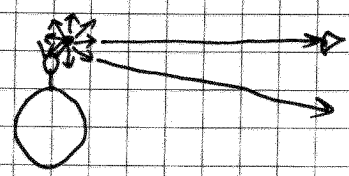
$$M = \frac{\operatorname{tg}\alpha}{\operatorname{tg}\alpha_n}$$



a_n normalna zorna razdalja







1 del) $f_{OBJE} = 0{,}5\,cm$

$f_{OKU} = 2\,cm$

$d = 22\,cm$

$a = ?$ (DA BO SLIKA NAVIDEZNO V NESKONČNOSTI)

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f_{OB}}$$

$$d = b + f_{OK} \Rightarrow b = d - f_{OK}$$

$$b = 20\,cm$$

$$\frac{1}{a} = \frac{1}{f_{OB}} - \frac{1}{b} = \frac{b - f_{OB}}{f_{OB} \cdot b}$$

$$a = \frac{f_{OB} \cdot b}{b - f_{OB}} = \frac{0{,}5\,cm \cdot 20\,cm}{19{,}5\,cm} = 0{,}51\,cm$$

2 del) $a_n = 25\,cm$

$M = ?$

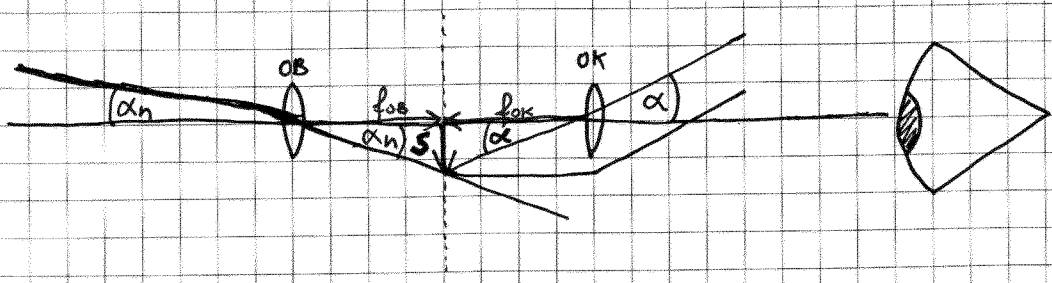
$$M = \frac{\frac{S}{f_{OK}}}{\frac{P}{a_n}} = \frac{S \cdot a_n}{P \cdot f_{OK}}$$

$$\boxed{\frac{P}{a} = \frac{S}{b}} \Rightarrow \frac{S}{P} = \frac{b}{a}$$

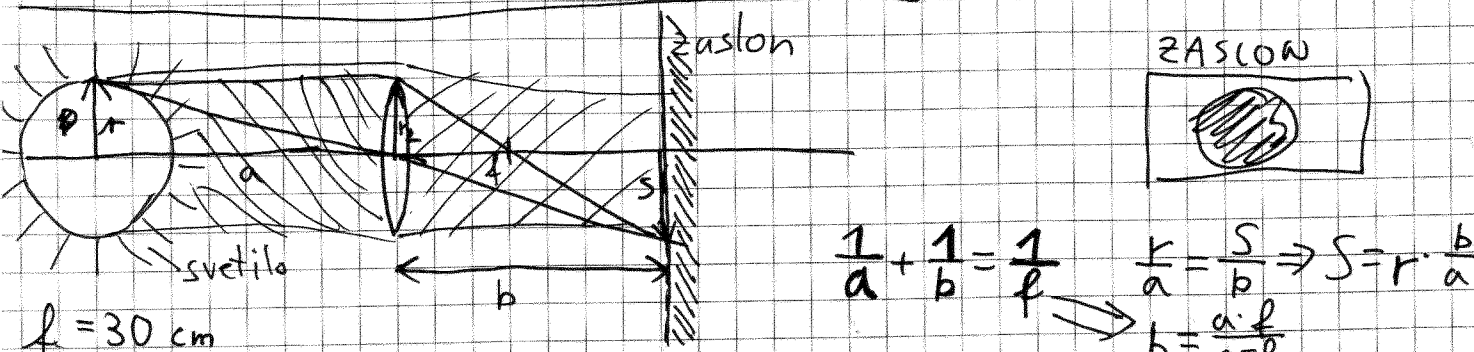
$$\frac{S}{P} = \frac{b}{a} = \frac{b}{\frac{f_{OB} \cdot b}{b - f_{OB}}} = \frac{b - f_{OB}}{f_{OB}} = \boxed{\frac{d - f_{OK} - f_{OB}}{f_{OB}} = \frac{S}{P}}$$

$$\boxed{M = \frac{(d - f_{OK} - f_{OB}) \cdot a_n}{f_{OB} \cdot f_{OK}}} = \frac{19{,}5\,cm \cdot 25\,cm}{0{,}5\,cm \cdot 2\,cm} \approx \underline{\underline{488}}$$

Daljnogled (astronomski)



$$M = \frac{\tan\alpha}{\tan\alpha_n} = \frac{\frac{S}{f_{OK}}}{\frac{S}{f_{OB}}} = \boxed{\frac{f_{OB}}{f_{OK}} = M}$$



$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f} \qquad \frac{r}{a} = \frac{S}{b} \Rightarrow S = r \cdot \frac{b}{a}$$

$$b = \frac{a \cdot f}{a - f}$$

$f = 30\ cm$
$a = 1{,}5\ m$
$r = 3\ cm$
$P = 10\ W$
$r_2 = 1\ cm$

$j_{NA\ SLIKIK} = ?$

$$j_{NA\ SLIKI} = \frac{P_L}{\pi S^2} = \frac{j_L \cdot \pi \cdot r_L^2}{\pi S^2}$$

$$j_L = \frac{P}{4\pi a^2}$$

$$j_{NA\ SLIKI} = \frac{P}{4\pi a^2} \cdot \frac{r_L^2}{S^2}$$

$$S = r \cdot \frac{a \cdot f}{(a-f)\,a}$$

$$\boxed{S = \frac{r \cdot f}{(a-f)}}$$ r je tudi: P

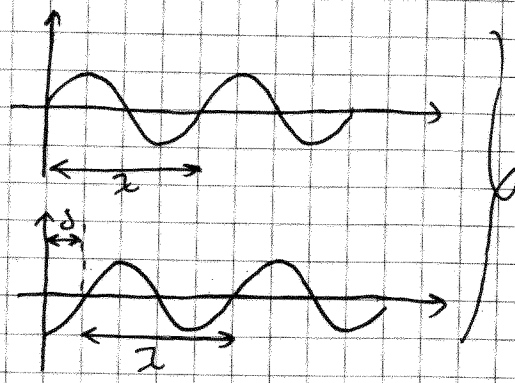
$$S = \frac{P \cdot f}{(a-f)}$$

$$j_{NA\ SLIKI} = \frac{P\, r_2^2\, (a-f)^2}{4\pi a^2\, r^2 \cdot f^2} = 0{,}63\ \frac{W}{m^2}$$

15.05.2008

Valovna optika

INTERFERENCA



+

OJAČITEV:

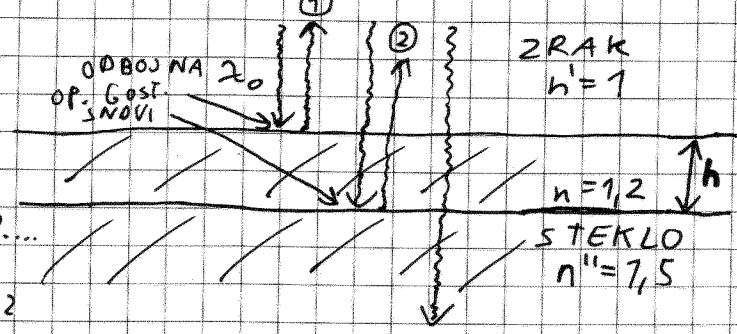
$\delta = N \cdot \lambda \quad N = 0, 1, 2, \ldots$

OSLABITEV:

$\delta = N \frac{\lambda}{2} \quad N = 1, 3, 5, \ldots$ liha št.

$\delta = (2N+1) \frac{\lambda}{2} \quad N = 0, 1, 2, \ldots$

NAL. 33/STR 67



$\lambda_0 = 500\,nm$
$n' = 1$
$n = 1,2$
$n'' = 1,5$

$h = ?$

OSLABITEV

$\delta = (2N+1) \cdot \frac{\lambda}{2} \quad N = 0, 1, 2 \ldots$

$2h = (2N+1) \cdot \frac{\lambda}{2} \quad N = 0, 1, 2$

razlika poti

$n = \frac{c_0}{c}$

$v = v_0$

$c = \lambda \cdot \nu$

$\lambda = \frac{c}{\nu} = \frac{c_0}{n \nu_0} = \boxed{\frac{\lambda_0}{n} = \lambda}$

$2h = (2N+1) \cdot \frac{\lambda_0}{n} \cdot \frac{1}{2} \quad N = 0, 1, 2$

$N = 0:$

$h = \frac{\lambda_0}{4n} = \frac{500\,nm}{4 \cdot 1,2} = 0,1\,\mu m$

ODBOJ NA:

Ⓐ optično gostejši snovi

$\vec{E} \uparrow \rightarrow -\vec{E} \downarrow$ dodatni fazni zamik

$\delta_{OO} = \frac{\lambda}{2}$

Ⓑ optično redkejši snovi

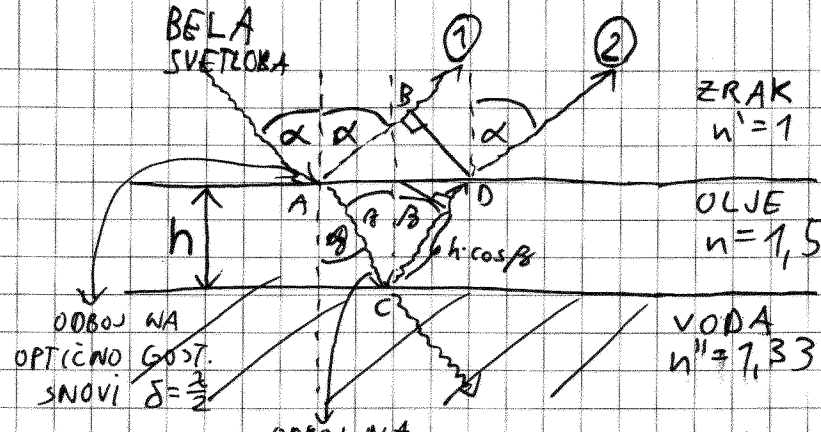
$\vec{E} \uparrow \rightarrow \vec{E} \uparrow \quad \delta_{OO} = 0$

LOMNI KOLIČNIK:

$n = \frac{c_0}{c}$ $n = 1$ - vakuum

Abeta

$\overline{ACD} - \overline{AB} \approx 2h \cdot \cos\beta$



$h = 0{,}1\ \mu m$
$\alpha = 30^\circ$
$n'' = 1{,}33$
$n = 1{,}5$
$n' = 1$

$\lambda_0 = ?$ (OJAČITEV)

OJAČITEV:

$\partial = N \cdot \lambda \quad N = 0, 1, 2, \ldots$

$2h\cos\beta + \frac{\lambda}{2} = N \cdot \lambda$

razlika poti

$2h\cos\beta = (N - \frac{1}{2})\lambda_0$

$\lambda = \frac{\lambda_0}{N}$

$\frac{\sin\alpha}{\sin\beta} = \frac{n}{n'_{=1}} = n$

$n \cdot \cos\beta = \sqrt{n^2 - \sin^2\alpha}$

$\frac{2h \cdot \sqrt{n^2 - \sin^2\alpha}}{N - \frac{1}{2}} = \lambda_0 \ ; \ N = 0, 1, 2 \ldots$

$N = 0$: NI REŠITVE

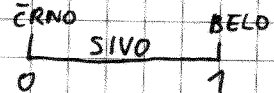
$N = 1$: $\lambda_0 = \frac{4h \cdot \sqrt{n^2 - \sin^2\alpha}}{1} = 565\ nm$ (rumena)

$N = 2$: $\lambda_0 = \frac{565\ nm}{3}$ = ni v vidnem delu spektra

400 nm — 800 nm

Sevanje črnega telesa
(sivega)

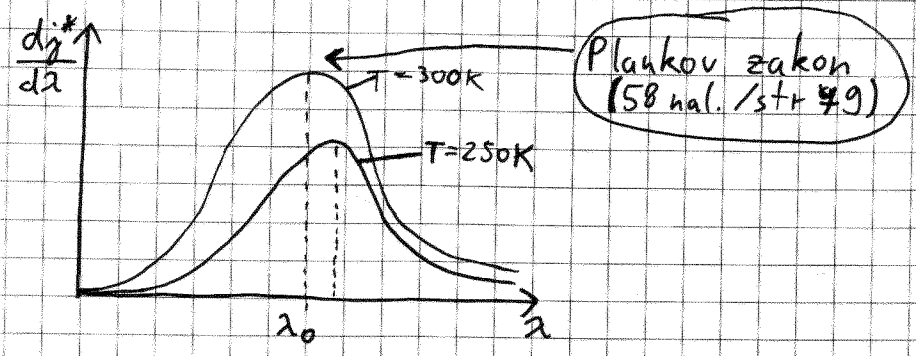
ODBOJNOST (a)



$a \neq a(\lambda)$

STEFANOV ZAKON:

$$j^* = (1-a)\,\sigma \cdot T^4 \qquad \sigma = 5{,}67 \cdot 10^{-8}\ \frac{W}{m^2 K^4}$$ - STEFANOVA KONSTANTA



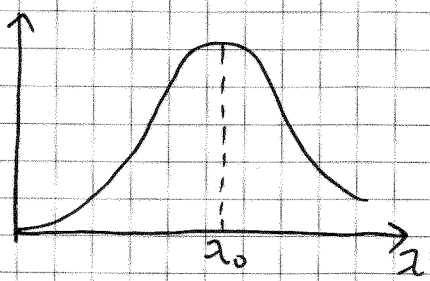
Planckov zakon (58 nal. / str. 49)

WIENOV ZAKON:

$$\lambda_0 \cdot T = k_W \qquad k_W = 2{,}9 \cdot 10^{-3}\ mK$$

$j_{\substack{SONCA\\NA\\ZEMLJI}} = 1360\ \frac{W}{m^2}$ - gostota sv. toka sonca na zemlji

TEMNI DELI VESOLJA



$\lambda_0 = 1\ mm$

$T = ?$

$j = ?$

$$\lambda_0 \cdot T = k_W$$

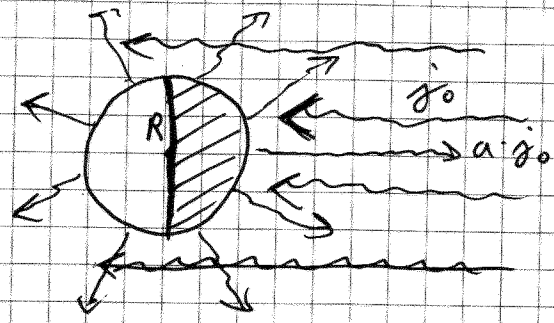
$$T = \frac{k_W}{\lambda_0} = \frac{2{,}9 \cdot 10^{-3}\ mK}{1 \cdot 10^{-3}\ m} = 2{,}9\ K$$

$$j^* = \sigma \cdot T^4 = 5{,}67 \cdot 10^{-8}\ \frac{W}{m^2 K^4} \cdot (2{,}9\ K)^4 = 4{,}01 \cdot 10^{-6}\ \frac{W}{m^2}$$

Abeta

$a = 0{,}52$
$j_0 = 1360 \frac{W}{m^2}$

$T = ?$ (RAVNOVESNO STANJE)



$P_{ABS} = P_{IZS}^*$

$(1-a) \cdot j_0 \cancel{\pi R^2} = (1-a) \cdot \sigma \cdot T^4 \cdot 4 \cancel{\pi R^2}$

$T = \sqrt[4]{\frac{j_0}{4\sigma}}$

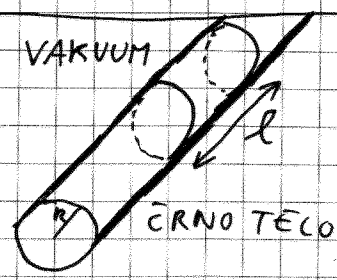
$T = 278\ K$

---

54 nal./str 79

$r = 4\ mm$
$\rho = 0{,}076 \frac{\Omega mm^2}{m}$
$I = 160\ A$

$T = ?$ (RAVNOVESNO STANJE)



$P_R = P^*$

$I^2 R = (1-0) j^* \cdot 2\pi r \cdot \ell$

$I^2 \cdot \rho \cdot \frac{\ell}{\pi r^2} = (1-0) \sigma \cdot T^4 \cdot 2\pi r \cdot \ell$

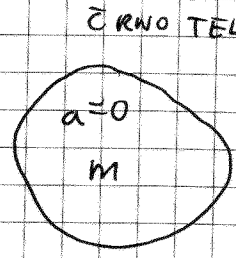
$T = \sqrt[4]{\frac{I^2 \cdot \rho}{2\pi^2 r^3 \sigma}}$

$T = 275\ K$

59. nal / str. 81

$m = 60\,g$
$a = 0$
$c_v = 200\ \frac{J}{kgK}$
$T_1 = 2500\ K$
$S = 10\ cm^2$
$T_2 = 1422\ K$

$t = ?$



$$p^* = -\frac{dW_n}{dt}$$

$$j^* \cdot S = -\frac{m \cdot c_v \cdot dT}{dt}$$

$$\sigma \cdot \int_{T_2}^{T_2} \frac{dT}{T^4} = \int_0^t \frac{\sigma \cdot S}{m \cdot c_v}\, dt$$

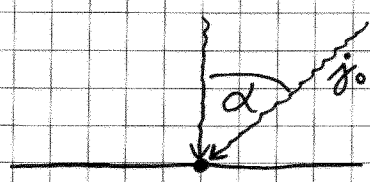
$$\frac{T^{-3}}{-3}\Big|_{T_1}^{T_2} = -\frac{\sigma S}{m \cdot c_v} t$$

$$t = \frac{m \cdot c_v}{3\sigma S}\left(\frac{1}{T_2^3} - \frac{1}{T_1^3}\right)$$

$$t = 20\ s$$

Fotometrija

OSVETLJENOST (j'):

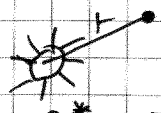


$$j' = j_0 \cdot \cos\alpha$$

SVETILNOST (I):

$$I = \frac{dp^*}{d\Omega}$$

izotropno svetilo:



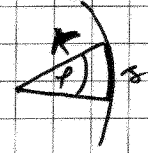
$$I = \frac{p^*}{4\pi} = \left[\frac{W}{sterad}\right]$$

$$j = \frac{p^*}{4\pi r^2} = \frac{I}{r^2}$$

KOT

$$\varphi = \frac{l}{r}\ [rad]$$

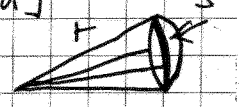
$$\varphi_0 = \frac{2\pi r}{r} = 2\pi$$



PROSTORSKI KOT

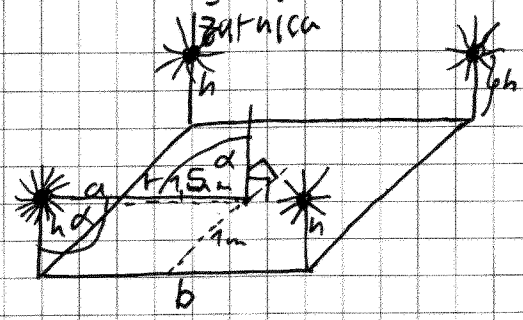
$$\Omega = \frac{S}{r^2}\ [Esterad]$$

$$\Omega = \frac{4\pi r^2}{r^2} = 4\pi$$



$a = 2\,m$
$b = 3\,m$
$h = 1\,m$
$P = 60\,W$

$j' = ?$ (na sredini)



~~$j = j_1 + j_2$~~

$j' = 4 \cdot j_0 \cdot \cos\alpha \quad i \quad \cos\alpha = \frac{h}{r}$

$j' = 4 \cdot \frac{P}{4\pi r^2} \cdot \frac{h}{r} \quad i \quad r^2 = h^2 + \left(\frac{a}{2}\right)^2 + \left(\frac{b}{2}\right)^2$

$j' = \frac{P \cdot h}{\pi r^3}$

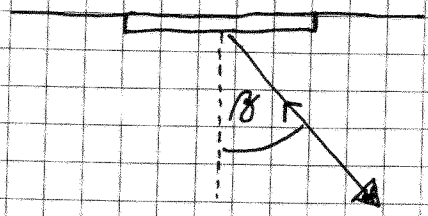
$j' = \frac{P \cdot h}{\pi \left(h^2 + \frac{a^2}{4} + \frac{b^2}{4}\right)^{3/2}}$

$j' = 2{,}18\ \frac{W}{m^2}$

22.05.2008

SVETLOST:

$$B_\perp = \frac{I}{S}$$



$I(\beta) = B \cdot S \cdot \cos\beta$

LAMBERTOV ZAKON:

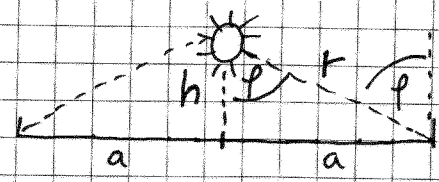
$B \neq B(\beta)$

48. nal. / str. 75

$2a = 15\,m$

$h = ?$ (OSVETLJENOST NA ROBU MAKSIMALNA)

$h \left(j'_{na\ robu} = max \right)$



$$j'_{NA\ ROBU} = j \cdot \cos\varphi = \frac{I}{r^2} \cdot \frac{h}{r}, \quad \cos\varphi = \frac{h}{r}, \quad r = \sqrt{a^2+h^2}$$

$$= \frac{I \cdot h}{(a^2+h^2)^{\frac{3}{2}}}$$

$$\frac{dj'_{NA\ ROBU}}{dh} = I \frac{1 \cdot (a^2+h^2)^{\frac{3}{2}} - h \cdot \frac{3}{2}(a^2+h^2)^{\frac{1}{2}} \cdot 2h}{(a^2+h^2)^3} = 0$$

$$(a^2+h^2)^{\frac{1}{2}} \cdot \left((a^2+h^2) - 3h^2 \right) = 0$$

$$a^2 + h^2 - 3h^2 = 0$$

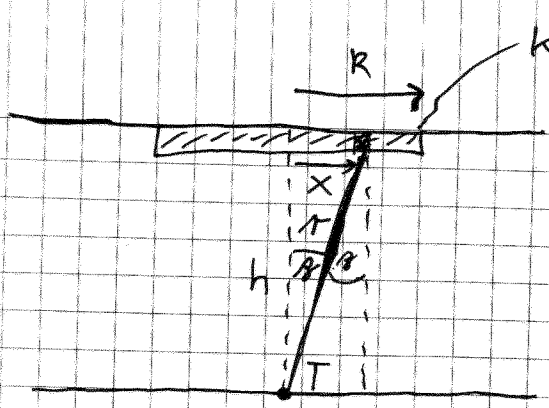
$$a^2 - 2h^2 = 0$$

$$h = \frac{a}{\sqrt{2}} = 5{,}3\,m$$

$$\tan\varphi = \frac{a}{h} = \sqrt{2}$$

$$\varphi = \arctan(\sqrt{2}) = 55°$$

5 A



$R = 40\,cm$

$B \neq B(\beta)$

$B = 200\ \frac{W}{m^2 \cdot sterad}$

$h = 2\,m$

$j'(T) = ?$

$dj' = \frac{dI}{r^2} \cdot \cos\beta$; $dI = B \cdot dS \cdot \cos\beta$; $\cos\beta = \frac{h}{r}$; $r^2 = h^2 + x^2$

$dS = 2\pi x\,dx$

$dj' = \frac{B \cdot 2\pi x\,dx \cdot \cos^2\beta}{r^2} = \frac{B \cdot 2\pi x\,dx\ h^2}{r^4}$

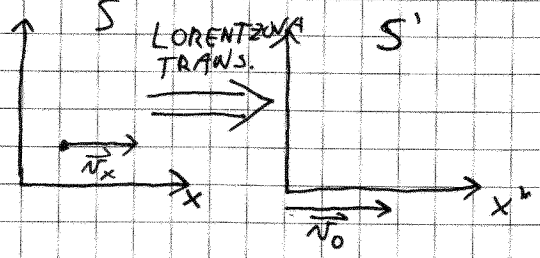
$j' = \int dj' = 2\pi B h^2 \int_0^R \frac{x\,dx}{(h^2+x^2)^2} \overset{\text{p.p.}}{=} \boxed{\pi B h^2 \left(\frac{1}{h^2} - \frac{1}{h^2+R^2}\right)}$

$j' = 12{,}08\ \frac{W}{m^2}$

Posebna teorija relativnosti

- NI GRAVITACIJE
- NEPOSPEŠENI (INERCIALNI) OP. SIST.

MAXWELL $\Rightarrow$ $\boxed{c_0 = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}}$



DOGODEK:

$= \begin{bmatrix} c_0 t \\ x \\ y \\ z \end{bmatrix}$ SVETOVNI ČETVEREC

$y' = y$ $\quad x' = \gamma(x - v_0 \cdot t)$; $\gamma = \frac{1}{\sqrt{1 - \frac{v_0^2}{c_0^2}}}$

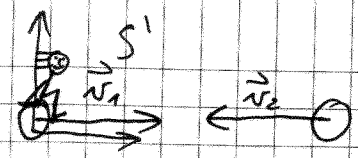
$z' = z$ $\quad t' = \gamma\left(t - \frac{v_0}{c_0^2} x\right)$

$\vec{v}_x = \frac{dx}{dt}$ $\quad dx' = \gamma(dx - v_0 \cdot dt)$; $dt' = \gamma\left(dt - \frac{v_0}{c_0^2} dx\right)$

$v_x' = \frac{dx'}{dt'}$ $\leftarrow$

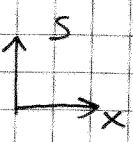
$$\boxed{v_x' = \frac{v_x - v_0}{1 - \frac{v_0 \cdot v_x}{c_0^2}}}$$ transformacija hitrosti

$v_1 = \frac{3}{5}c_0$, $v_2 = -\frac{4}{5}c_0$ } v sistemu S



$v_0 = v_1$
$v_x = v_2$

$v_2' = ?$ (v sistemu 1. delca s')



KLASIČNO:

$$v_2' = v_2 - v_1 = -\frac{4}{5}c_0 - \frac{3}{5}c_0 = -\frac{7}{5}c_0 \;//$$

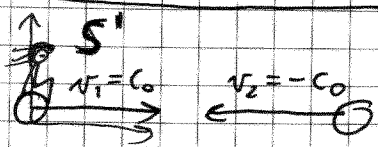
RELATIVISTIČNO:

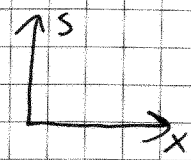
$$v_2' = \frac{v_2 - v_1}{1 - \frac{v_1 v_2}{c_0^2}} = \frac{-\frac{4}{5}c_0 - \frac{3}{5}c_0}{1 - \frac{\frac{3}{5}c_0 \cdot -(\frac{4}{5})c_0}{c_0^2}} = \frac{-\frac{7}{5}c_0}{1 + \frac{12}{25}}$$

$$v_2 = -\frac{7}{5}\cdot\frac{25}{37}c_0 = \underline{\underline{-\frac{35}{37}c_0}}$$

$v_1 = c_0$
$v_2 = -c_0$

$v_2' = ?$





KLASIČNO:

$$v_2' = v_2 - v_1 = -c_0 - c_0 = -2c_0 \;//$$

RELATIVISTIČNO:

$$v_2' = \frac{-c_0 - c_0}{1 - \frac{c_0(-c_0)}{c_0^2}} = \frac{-2c_0}{1+1} = \underline{\underline{-c_0}} \;\checkmark$$

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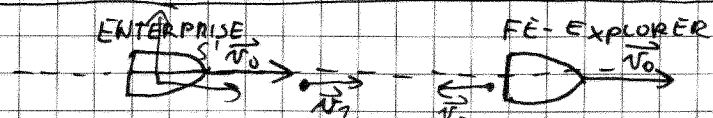
4. nal. 22.06.2004.



$v_0 = 0{,}85c_0$ (v sist. zemlje s)

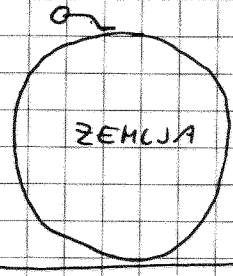
$v_1' = 0{,}85c_0$ } v sist. ladij s'
$v_2 = 0{,}85c_0$ }

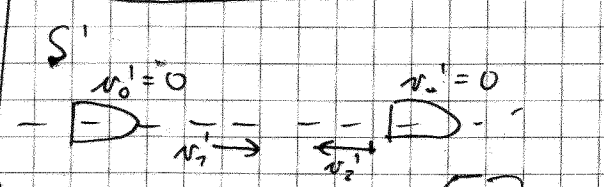
$v_1 = ?$ } v sist. zemlje.
$v_2 = ?$ }

$$v_x = \frac{v_x' + v_0}{1 + \frac{v_0 v_x'}{c_0^2}}$$

$$v_1 = \frac{v_1' + v_0}{1 + \frac{v_0 v_1'}{c_0^2}} = 0{,}987c_0$$

$$v_2 = \frac{v_2' + v_0}{1 + \frac{v_0 v_2'}{c_0^2}} = \underline{\underline{0}}$$





	S	S'
1. DOGODEK	$t_1=0 \quad x_1=0$	$t_1'=\gamma(t_1-\frac{v_0}{c_0^2}x_1)=0 \quad x_1'=\gamma(x_1-v_0t_1)=0$
2. DOGODEK	$t_2=\tau \quad x_2=0$	$t_2'=\gamma(t_2-\frac{v_0}{c_0^2}x_2)=\gamma t_2 \quad x_2'=-\gamma v_0 t$
	$\Delta t=t_2-t_1=\tau$	$\Delta t'=t_2'-t_1'=\gamma t_2=\gamma\cdot\tau$

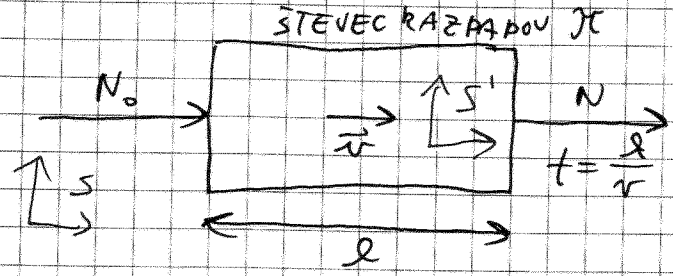
$$\boxed{\Delta t'=\gamma\cdot\Delta t} \qquad \gamma\geq 1$$

DOGODKA SE VS ZGODITA NA ISTEM KRAJU
τ - lastni čas

PODALJŠANJE (DILATACIJA) ČASA

PIONI (π)
$\tau=2{,}6\cdot10^{-8}\,s$ (LASTNI RAZPADNI ČAS)
$v=2{,}74\cdot10^8\,m/s$ V LAB. SIST. S
$l=710\,cm$

$$\boxed{N=N_0\cdot e^{-\frac{t}{\tau}}}$$



$\frac{N_0-N}{N_0}=1-\frac{N}{N_0}=?$ DELEŽ RAZPADLIH DELCEV

KLASIČNO:

$$1-\frac{N}{N_0}=1-e^{-\frac{t}{\tau}}=1-e^{-\frac{l}{v\cdot\tau}}=0{,}143\doteq 14\%$$

RELATIVISTIČNO: RAČ. V LAB. SISTEMU

$$1-\frac{N}{N_0}=1-e^{-\frac{l}{v\cdot\gamma\cdot\tau}}=$$

$$\doteq 6{,}1\,\%$$

RAZPADNI ČAS PIONA V SISTEMU S je $\gamma\tau$.

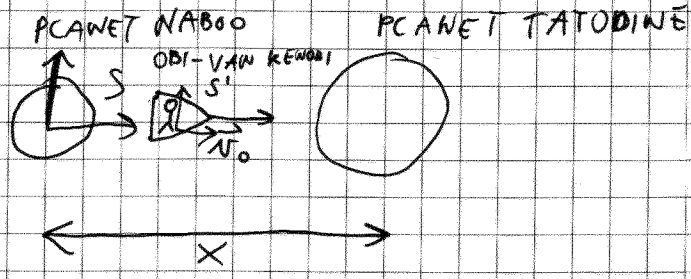
$$\gamma=\frac{1}{\sqrt{1-\frac{v^2}{c_0^2}}}=\frac{1}{\sqrt{1-\frac{(2{,}74\cdot10^8)^2}{(3\cdot10^8)^2}}}=2{,}456$$

V SIST. PIONA: - RAZPADNI ČAS JE τ
- MITROST ŠTEVCA JE $-v$
- DOLŽINA ŠTEVCA JE $\frac{l}{\gamma}$

SKRČENJE DOLŽIN (D.N.)

$$l'=\frac{l}{\gamma}$$

2005. 13. 6.
4. nal.



$v_0 = 0{,}95\, c_0$ (glede na planeta)
$t' = 4\,h$ (v SISTEMU LADJE)

$x = ?$ (v SISTEMU PLANETOV)

RAČUNAMO V SISTEMU S:

$$x = v_0 \cdot t$$

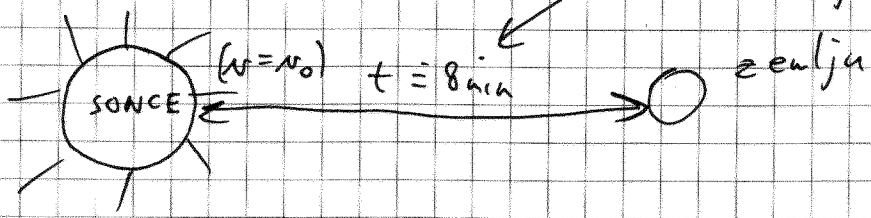
$$t = \gamma \cdot t' = 3{,}2 \cdot 4\,h = 12{,}8\,h$$

(t' ↑ LASTNI ČAS OBJEKTA)

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{0{,}95 c_0}{c_0}\right)^2}} = 3{,}2$$

$$x = 0{,}95 \cdot c_0 \cdot 12{,}8\,h = 12{,}16\, c_0 h \rightarrow \text{svetlobna ura}$$

FOTONI



Koliko časa mine za foton (τ)

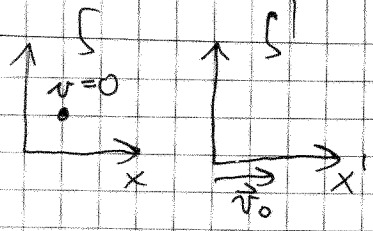
$$t = \gamma \cdot \tau$$

$$\gamma = \frac{t}{\tau} \Rightarrow \gamma = \frac{1}{\sqrt{1-\frac{c_0^2}{c_0^2}}} \Rightarrow \infty$$

$$\tau = \frac{8\,min}{\infty} = 0$$

ZA FOTONE ČAS STOJI

29.05.2008



Mirovna / lastna energija

$$E_0 = m \cdot c_0^2$$

Polna energija

$$E = \gamma \cdot m \cdot c_0^2 \qquad \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c_0^2}}}$$

Kinetična energija

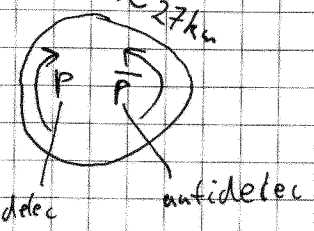
$$T = E - E_0 = (\gamma - 1) m c_0^2$$

$$E^2 = c_0^2 p^2 + E_0^2$$

Gibalna količina

$$\vec{p} = \gamma m \vec{v}$$

LARGE HADRON COLLIDER (LHC) - cern - Ženeva



Proton ($E_0 = m_p \cdot c_0^2 = 938\ MeV$)

$E = 7\ TeV = 7 \cdot 10^{12}\ eV$

$\frac{v}{c_0} = ?$

$$E = \gamma \cdot E_0$$

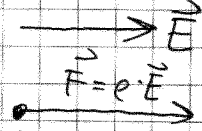
$$\frac{1}{\gamma} = \frac{E_0}{E}$$

$$\sqrt{1 - \frac{v^2}{c_0^2}} = \frac{E_0}{E} \quad /^2$$

$$1 - \frac{v^2}{c_0^2} = \frac{E_0^2}{E^2} \quad /\cdot(-1)$$

$$\frac{v^2}{c_0^2} = 1 - \frac{E_0^2}{E^2} \quad /\sqrt{\ }$$

$$\frac{v}{c_0} = \sqrt{1 - \frac{E_0^2}{E^2}} = 0,\!999999991$$



Pozitron (antielektron)

$e^+ = +e_0$

$E_0 = m_{e^+} \cdot c_0^2 = m_e \cdot c_0^2 = 0,511\ MeV$

$E = 3\ \frac{kV}{m}$

$t_1 = 3\ ns$

$s(t_1) = ?$

$$\vec{F} = e \cdot \vec{E}$$

$$\frac{d\vec{p}}{dt} = e \cdot \vec{E}$$

$$\frac{d(\gamma m \vec{v})}{dt} = e \vec{E}$$

$$\gamma \cdot m \cdot \vec{v} = e \vec{E} \cdot t$$

$$\frac{m \vec{v}}{\sqrt{1 - \frac{v^2}{c_0^2}}} = e \cdot E \cdot t \Rightarrow$$

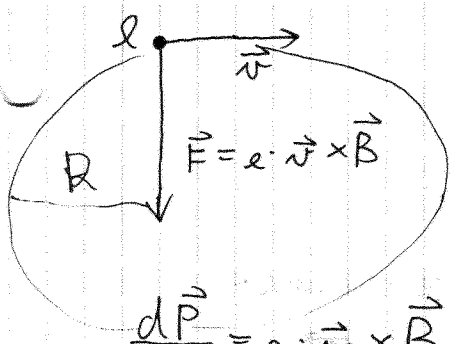
D.a.

$$\Rightarrow \boxed{\frac{v}{c_0} = \frac{\alpha \cdot t}{\sqrt{1 + \alpha^2 t^2}} \qquad \alpha = \frac{eE}{m c_0}}$$ 56

$$\boxed{s = \int_0^{t_1} v \cdot dt = \ldots = \frac{c_0}{\alpha} \cdot \left[\sqrt{\alpha^2 t^2 + 1} - 1\right]}$$

$s = 745\ m$

$\odot \vec{B}$ Magnetno polje



$$\frac{d\vec{p}}{dt} = e \cdot \vec{v} \times \vec{B}$$

$$\frac{d(\gamma \cdot m \cdot \vec{v})}{dt} = e \cdot \vec{v} \times \vec{B} \quad ; \; |\vec{v}| = v = \text{konst.} \Rightarrow \gamma = \text{konst.}$$

$$\gamma \cdot m \cdot \frac{d\vec{v}}{dt} = e \cdot \vec{v} \times \vec{B}$$

$$\gamma \cdot m \cdot \frac{v^2}{R} = e \cdot v \cdot B \Rightarrow \gamma \cdot m \cdot \frac{v}{R} = e \cdot B$$

$$\gamma \cdot m \cdot v = e \cdot R \cdot B$$

$$\Rightarrow \boxed{p = e \cdot R \cdot B}$$

Proton
$E_0 = 938$ MeV
$T = 4$ GeV
$R = 16$ m
$B = ?$

$$B = \frac{p}{e_0 \cdot R}$$

1. možnost $T = (\gamma - 1) \cdot E_0 \Rightarrow \gamma = \ldots \Rightarrow v = \ldots \Rightarrow p = \gamma \cdot m \cdot v$

2. možnost $(E_0 + T)^2 = c_0^2 p^2 + E_0^2$

$$E_0^2 + 2E_0T + T^2 = c_0^2 p^2 + E_0^2$$

$$\boxed{c_0 \cdot p = \sqrt{2E_0T + T^2}}$$

$$B = \frac{\sqrt{2E_0T + T^2}}{c_0 \cdot e_0 \cdot R} = 1{,}07\ \text{T}$$

FOTON (γ):

$m_\gamma = 0 \Rightarrow E_{0\gamma} = 0$

$$E = c_0 \cdot p$$

$$E = h \cdot \nu$$

h - Planckova konstanta

$h = 6{,}62 \cdot 10^{-34}\ Js$

$c = \lambda \cdot \nu \Rightarrow E = h \cdot \frac{c_0}{\lambda}$

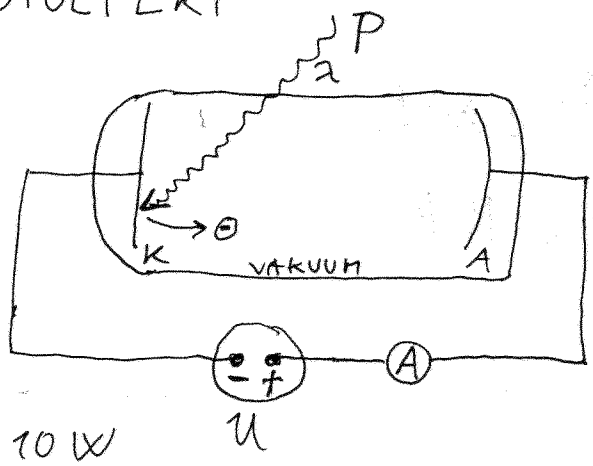
$$p = \frac{h}{\lambda}$$

DELEC $\Leftrightarrow$ VALOVANJE

$\lambda = \frac{h}{p}$!

↑ DE BROGLIE-VA VAL. DOLŽINA

FOTOEFEKT



FOTOCELICA

$P = 10\ W$

$\lambda = 705\ nm$

(vsak šesti foton izbije e^-)

$N_{e^-} = \frac{1}{6} N_\gamma$

$I = ?$ (NASIČEN EL. TOK)

⇓ vsak izbiti el. pride do anode

$$I = \frac{dq}{dt} = \frac{d(N_{e^-} \cdot e_0)}{dt} = \frac{1}{6} \frac{dN_\gamma}{dt} \cdot e_0$$

$$E_\gamma = \frac{h \cdot c_0}{\lambda}$$

$$E = \frac{h \cdot c_0}{\lambda} \cdot N_\gamma$$

$$P = \frac{dE}{dt} = \frac{dN_\gamma}{dt} \frac{h \cdot c_0}{\lambda}$$

$$\frac{dN_\gamma}{dt} = \frac{P \cdot \lambda}{h \cdot c_0}$$

$$I = \frac{1}{6} \frac{P \cdot \lambda}{h \cdot c_0} \cdot e_0 = 0{,}14\ A$$

MOPEDIST

$m = 100\ kg$
$v = 10\ \frac{m}{s}$

$\lambda = ?$

$$\lambda = \frac{h}{m \cdot v} = \frac{6{,}6 \cdot 10^{-34}\ J\,s}{100\ kg \cdot 10\ m/s} \doteq 6{,}6 \times 10^{-37}\ m$$

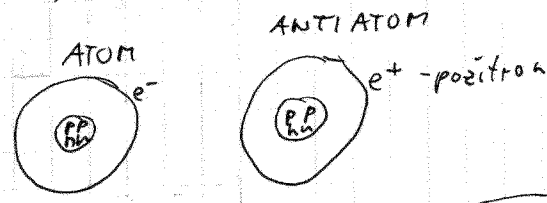
$$E_0 = m \cdot c_0^2$$

ENERGIJA $\Leftrightarrow$ masa

DELEC + ANTIDELEC $\Rightarrow$ γ (svetlobá)

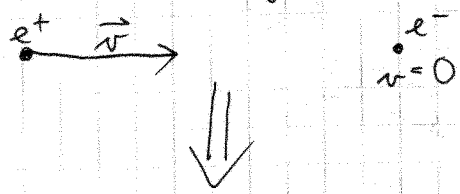
ANIHILACIJA

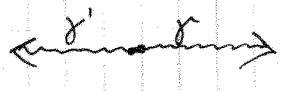
TVORBA PARA



ANTISNOV + SNOV $\Rightarrow$ γ nastaneta 2. žarka

$e^+ + e^- \Rightarrow \gamma' + \gamma$

① 

② 

$T = 20\ MeV$

$E_0 = m_{e^+} c_0^2 = m_{e^-} c_0^2 = 0{,}51\ MeV$

$\lambda' = ?$
$\lambda = ?$ (VAL. DOLŽINA SVETLOBE)

OHRANITEV ENERGIJE:

$$\underbrace{T + E_0}_{\text{POZITRON}} + \underbrace{E_0}_{\text{ELEKTRON}} = \frac{h c_0}{\lambda'} + \frac{h c_0}{\lambda}$$

$$T + 2E_0 = h \cdot c_0 \left(\frac{1}{\lambda'} + \frac{1}{\lambda}\right)$$

OHRANITEV GIB. KOLIČINE:

$$p_{e^+} = -\frac{h}{\lambda'} + \frac{h}{\lambda}$$

$$\frac{\sqrt{2E_0T + T^2}}{c_0} = -\frac{h}{\lambda'} + \frac{h}{\lambda}$$

$$\sqrt{2E_0T + T^2} = h c_0 \left(-\frac{1}{\lambda'} + \frac{1}{\lambda}\right)$$

λ, λ' D.N.

FIZ. 27.06.2006

4. naloga

$R_{zvezde} = 1{,}5 \cdot 10^9\ m$ (SEVA KOT ČRNO TELO)

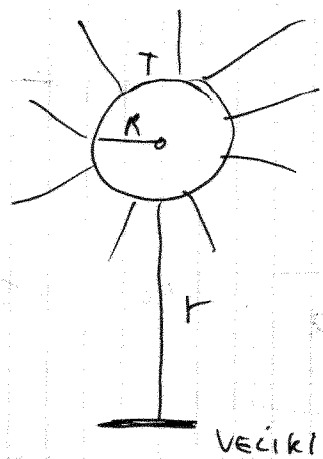
$T = 6000\ K$

$r = 10^{11}\ m$ (vesoljska jadrnica) črno telo

$S = 100\ m^2$

$m = 1\ kg$

$a = ?$



VEČJI VESOLJNIK

$$F = m \cdot a$$

$$a = \frac{F}{m} = \frac{1}{m}\frac{dP}{dt}$$

$$P_f = \frac{h}{\lambda}$$

ZVEZDA SEVA:

$$P^* = j^* \cdot S_z = \sigma \cdot T^4 \cdot S_z$$

$$= \sigma T^4 \cdot 4\pi R^2$$

SVETLOBNI TOK, KI PADE NA JADRO:

$$P_{ABS} = j_{ABS} \cdot S = \frac{P^*}{4\pi r^2} \cdot S$$

$$P_{ABS} = \sigma T^4 \frac{4\pi R^2}{4\pi r^2} \cdot S$$

$$P_{ABS} = \sigma T^4 \cdot \frac{R^2}{r^2} \cdot S$$

$$P_{ABS} = \frac{dE}{dt} = c_0 \cdot \frac{dP}{dt} \quad (= c_0 \cdot P)$$

$$a = \frac{1}{m}\frac{dP}{dt} = \frac{1}{m} \cdot \frac{P_{ABS}}{c_0} = \boxed{\frac{1}{m c_0} \cdot \sigma T^4 \frac{R^2}{r^2} \cdot S}$$

$$a = 5{,}5 \cdot 10^{-3}\ \frac{m}{s^2}$$