Mass. EMP

$\vec{r}$ - radij vektor točke u kojoj računamo potencijal

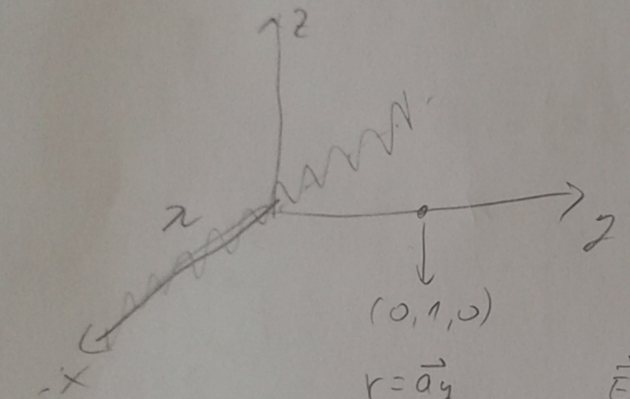
$T(2,3,1)$

$\vec{r} = 2\vec{a}_x + 3\vec{a}_y + \vec{a}_z$

$\vec{r}'$ - radij vektor naboja

λ , σ , ρ

lin plošn vol.



$(0,1,0)$

$r = \vec{a}_y$

$\vec{r}' = x\vec{a}_x + 0 \cdot \vec{a}_y + z \cdot \vec{a}_z = x\vec{a}_x$

$\vec{R} = \vec{r} - \vec{r}' = -x a_x + \vec{a}_y$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int_l \frac{\lambda \, \vec{R}}{|\vec{R}|^3} \, dl$$

$|\vec{R}| = \sqrt{x^2 + 1}$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int \frac{\lambda(-x\vec{a}_x + \vec{a}_y)}{(x^2+1)^{\frac{3}{2}}} \, dl$$

$dl = \sqrt{x'^2 + y'^2 + z'^2}$

$y = 0 \Rightarrow y' = 0$

$z = 0 \Rightarrow z' = 0$

$x = t \Rightarrow x' = 1$

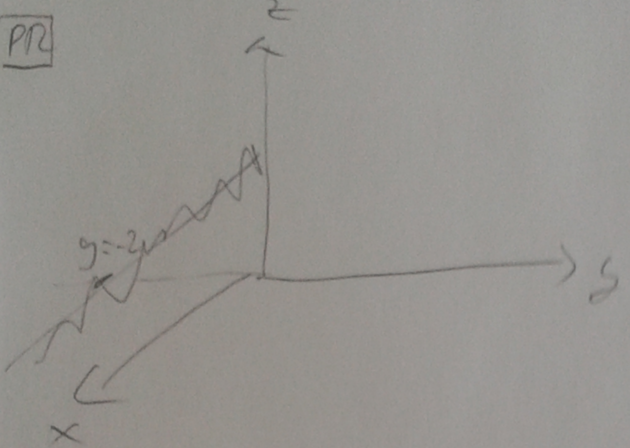
$dl = dt$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int_{-\infty}^{\infty} \frac{\lambda(-t\vec{a}_x + \vec{a}_y)}{(t^2+1)^{\frac{3}{2}}}$$

- u y osi $\quad \vec{r}' = y\vec{a}_y$

- u z osi $\quad \vec{r}' = z\vec{a}_z$

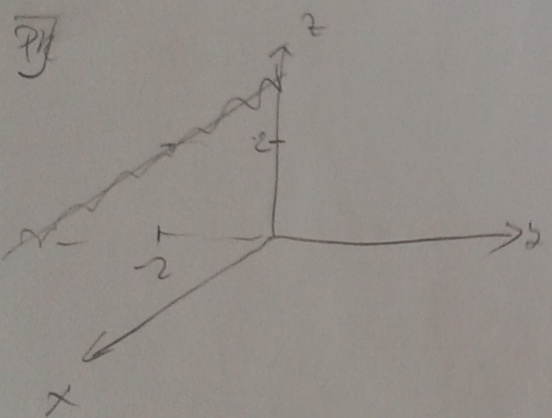
PR



$\vec{r}' = x\vec{a}_x - 2\vec{a}_y + 0\cdot\vec{a}_z$

$$\left.\begin{array}{ll} x = t & \Rightarrow x' = 1 \\ y = -2 & \Rightarrow y' = 0 \\ z = 0 & \Rightarrow z' = 0 \end{array}\right\} \begin{array}{l} dl = dt \\ t\Big|_{-\infty}^{\infty} \end{array}$$

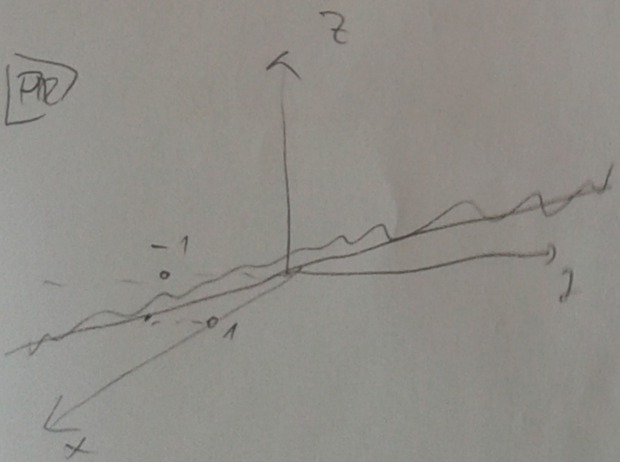
PR



$\vec{r}' = x\vec{a}_x - 2\vec{a}_y + 2\vec{a}_z$

$$\left.\begin{array}{ll} x = t & x' = 1 \\ y = -2 & y' = 0 \\ z = 2 & z' = 0 \end{array}\right\} \begin{array}{l} dl = dt \\ t\Big|_{-\infty}^{\infty} \end{array}$$

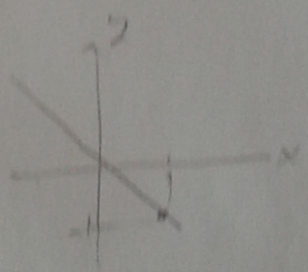
PR



$z = 0 \Rightarrow z' = 0$

$x = t \Rightarrow x' = 1$

$y = -t \Rightarrow y' = -1$

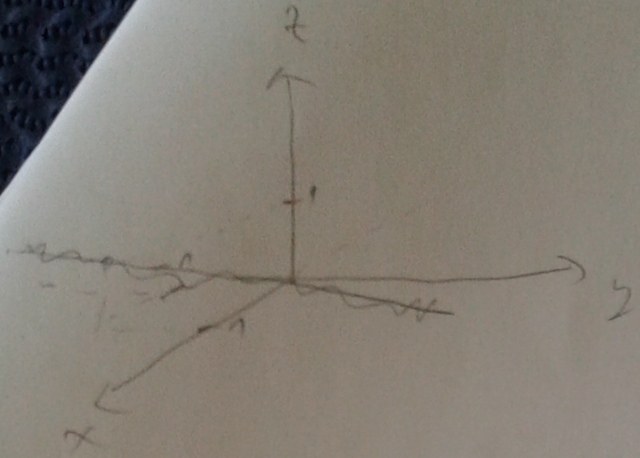


$dl = \sqrt{(1)^2 + (-1)^2 + 0^2}$

$= \sqrt{2}\,dt$

$\vec{r}' = x\vec{a}_x + y\vec{a}_y = t\vec{a}_x - t\vec{a}_y$

$t\Big|_{-\infty}^{\infty}$



$$\frac{x-x_1}{x_2-x_1}=\frac{y-y_1}{y_2-y_1}=\frac{z-z_1}{z_2-z_1}=t$$

$$\frac{x-1}{-1}=\frac{y+1}{+1}=\frac{z-1}{-1}=t$$

$x=-t+1 \qquad x'=-1$

$y=t-1 \qquad y'=1$

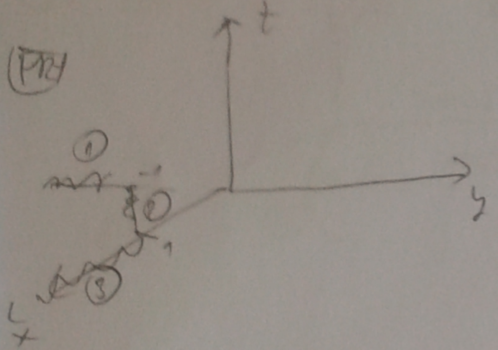
$z=-t+1 \qquad z'=-1$

$$\vec{r}\,'=x\vec{a}_x+y\vec{a}_y+z\vec{a}_z=$$
$$=(-t+1)\vec{a}_x+(t-1)\vec{a}_y+(-t+1)\vec{a}_z$$

$$dl=\sqrt{3}\,dt$$

$$t\Big|_{-\infty}^{\infty}$$

P12



① $\vec{r}_1\,'=y\vec{a}_y \qquad y\Big|_{-\infty}^{1}$

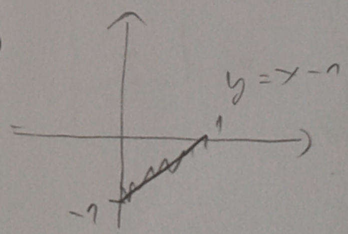
$x=0 \qquad x'=0$

$y=t \qquad y'=1 \qquad dl=dt$

$z=0 \qquad z'=0$

$$t\Big|_{-\infty}^{1}$$

②



$x=t$

$y=t-1 \qquad t\Big|_0^1$

$z=0$

$x'=1$

$y'=1$

$z'=0 \qquad dl=\sqrt{2}\,dt$

$$\vec{r}_2\,'=x\vec{a}_x+y\vec{a}_y=$$
$$=t\vec{a}_x+(t-1)\vec{a}_y$$

③ $z=0 \qquad z'=0$

$y=0 \qquad y'=0$

$\vec{r}_3\,'=x\vec{a}_x$

$x=t \qquad x'=1$

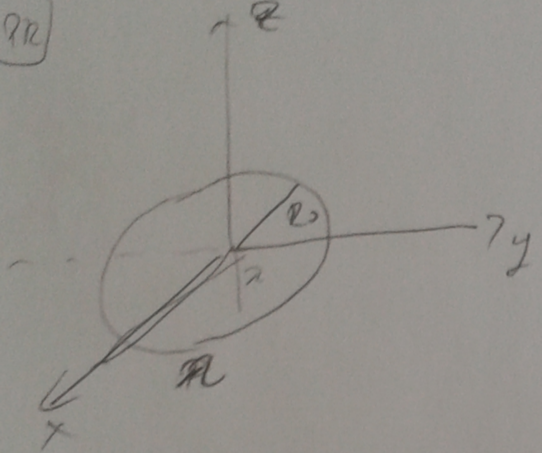
$dl=dt$

$$t\Big|_1^{\infty}$$

$$\vec{E}_{uk} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = E_x \vec{a}_x + E_y \vec{a}_y + E_z \vec{a}_z$$

$$|\vec{E}| = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

ΠΡ



$$\vec{r}' = x\vec{a}_x + y\vec{a}_y =$$
$$= R_0 \cos\alpha\, \vec{a}_x + R_0 \sin\alpha\, \vec{a}_y$$

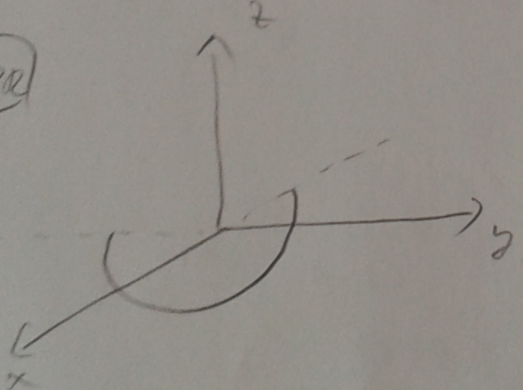
$$\alpha \Big|_0^{2\pi}$$

$$dl = \sqrt{x'^2 + y'^2 + z'^2}\, d\alpha$$

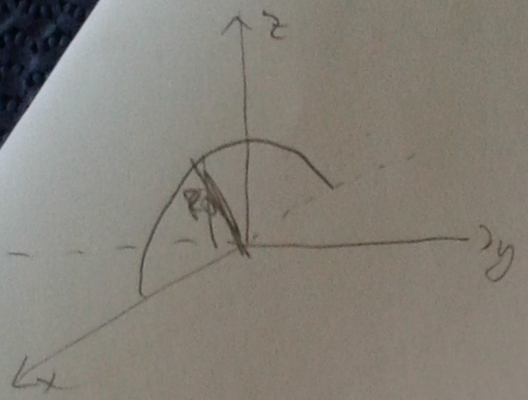
$$x' = -R_0 \sin\alpha$$
$$y' = R_0 \cos\alpha$$
$$z' = 0$$

$$dl = R_0\, d\alpha$$

ΠΡ



$$\alpha \Big|_{-\frac{\pi}{2}}^{\pi}$$



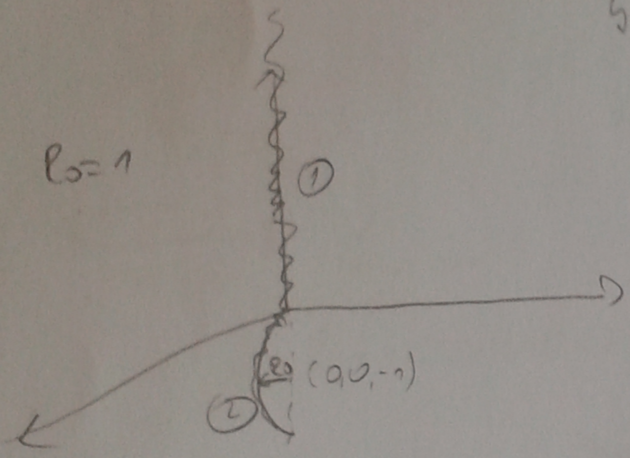
$$\vec{r}' = x\vec{a}_x + z\vec{a}_z$$

$$\alpha\Big|_0^{\pi}$$

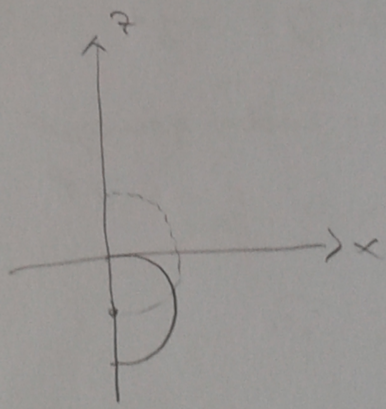
$$dl = R_0\, d\alpha$$

$$x = \rho_0 \cos\alpha$$
$$z = \rho_0 \sin\alpha$$
$$y = 0$$

$\boxed{PR}$ $\rho_0 = 1$



① $\vec{r}_1 = z\vec{a}_z$ $\quad z\Big|_0^{\infty}$



$$y = 0$$

$$x^2 + (z+1)^2 = 1$$

$$x = \overset{1}{r}\cos\varphi$$
$$z+1 = \underset{1}{r}\sin\varphi$$

$$\alpha\Big|_{-\frac{\pi}{2}}^{\frac{\pi}{2}}$$

$$r' = x\vec{a}_x + z\vec{a}_z = \cos\varphi\,\vec{a}_x + (\sin\varphi - 1)\vec{a}_z$$

- kad su veličini računaj preko formula sa $\vec{r}$ i $\vec{\sigma}$

- Gauss kod cilindra, kugli itd

$\boxed{\text{Gaussov zakon}}$

$$\oiint \vec{E}\,\vec{n}\,dS = \frac{1}{\varepsilon} \underbrace{\iiint_V \rho\, dV}_{\text{obuhvaćeni naboj}}$$

- integral predstavlja obuhvaćeni naboj

ili

$$= \frac{1}{\varepsilon} \iint_S \sigma\, dS$$

ili

$$= \frac{1}{\varepsilon} \int_l \lambda\, dl$$

- zadano polje treba raspodjelu naći

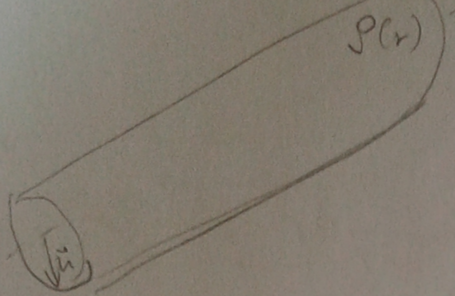
$$\nabla \vec{E} = \frac{\rho_d}{\varepsilon}$$

- kada treba polje a imamo zadan potencijal

$$\vec{E} = -\nabla \varphi$$

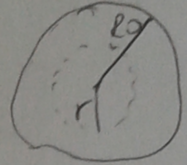
besk. cilindar

— pazi na naboj koji si obuhvatio!



① polje gdje imamo naboj

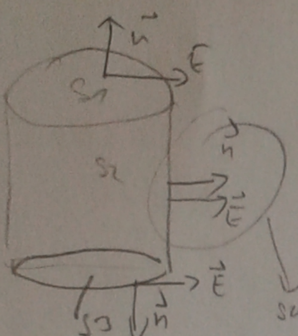
$r < R_0$



nismo obuhvatili sav naboj

obuhvaćena ploha

$$\oint \vec{E}\,\vec{n}\,dS = \frac{1}{\varepsilon}\iiint \rho\, dV$$



samo ovo ostane

$\vec{E}\cdot\vec{n} = |E||n|\cos 0 = E$

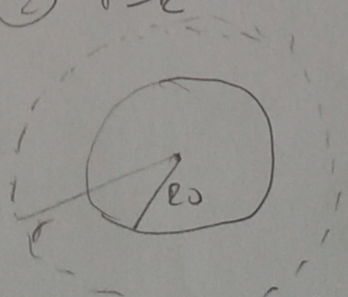
$$E\cdot \underbrace{2r\pi\cdot l}_{\text{površina plašta valjka}} = \frac{1}{\varepsilon}\int_0^{2\pi} d\varphi \int_0^r r\cdot\rho(r) \int_0^l dz$$

$$E\cdot 2r\pi = \frac{1}{\varepsilon}\cdot 2\pi \int_0^r r\rho(r)\,dr$$

npr $\rho = r$

$$E_1 = \frac{1}{\varepsilon r}\int_0^r r^2\,dr = \frac{1}{\varepsilon r}\,\frac{r^3}{3}\Big|_0^r = \frac{r^2}{3\varepsilon}$$

② $r > R$

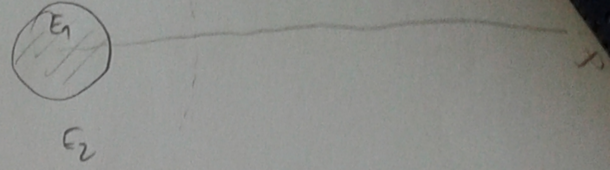


— naboj je samo od 0 do R_0

$$E\cdot 2r\pi\cdot l = \frac{1}{\varepsilon}\int_0^{2\pi} d\varphi \int_0^{R_0} r\,dr \cdot l$$

$$E_2 = \frac{1}{\varepsilon r}\,\frac{R_0^3}{3}$$

$$\varphi = -\int \vec{E}\, d\vec{l}$$



- jer se polje širi radijalno $\Rightarrow$ $\vec{E}\, d\vec{l} = E\, dr$

$$\varphi = -\int_{\infty}^{r} E\, dr$$

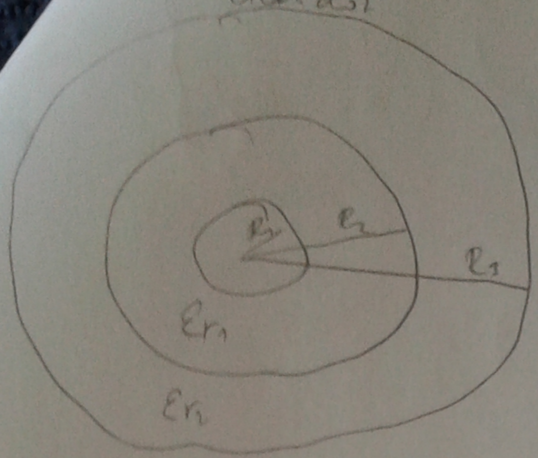
① $r > R_0$

$$\varphi(r) = -\int_{2R_0}^{r} \frac{R_0^3}{3\varepsilon r}\, dr = -\frac{R_0^3}{3\varepsilon} \ln r \Big|_{2R_0}^{r}$$

② $r \leq R_0$

$$\varphi(r) = -\int_{2R_0}^{r} E\, dr = -\int_{2R_0}^{R_0} E_2\, dr - \int_{R_0}^{r} E_1\, dr$$

Cilindar



$$\rho = \begin{cases} 0 & r < R_1 \\ \dfrac{10^{-9}}{r^4} & R_1 \le r \le R_2 \\ \dfrac{10^{-9}}{r^3} & R_2 \le r \le R_3 \end{cases}$$

① $r < R_1$

$$\oint\!\!\oint \vec{E}\,\vec{n}\,dS = \frac{1}{\varepsilon} \underbrace{\iiint \rho\, dV}_{0}$$

$$E = 0$$

② $R_1 \le r \le R_2$

$$\oint\!\!\oint \vec{E}\,\vec{n}\,dS = \frac{1}{\varepsilon} \iiint \rho\, dV$$

$$E\, 2 r \pi \cancel{l} = \frac{1}{\varepsilon} \int_0^{2\pi} d\varphi \int_{R_1}^{r} r \frac{10^{-9}}{r^4}\, dr \cdot \underbrace{\int_{-\infty}^{\infty} dz}_{l}$$

$$E\, \cancel{2} r \cancel{\pi} = \frac{\cancel{2\pi}}{\varepsilon} 10^{-9} \left. \frac{r^{-2}}{-2} \right|_{R_1}^{r}$$

$$E_1 = \frac{10^{-9}}{\varepsilon \cdot r} \left(-\frac{1}{2}\right) \left(\frac{1}{r^2} - \frac{1}{R_1^2}\right)$$

$$\varepsilon = \varepsilon_0 \varepsilon_{r1}$$

③ $R_2 \le r \le R_3$

$$\oint\!\!\oint \vec{E}\,\vec{n}\,dS = \frac{1}{\varepsilon} \iiint \rho\, dV$$

$$E \cdot 2 r \pi \cdot l = \frac{1}{\varepsilon_1} \int_0^{2\pi} d\varphi \int_{R_1}^{R_2} r \frac{10^{-9}}{r^4}\, dr \cdot l + \frac{1}{\varepsilon_2} \int_0^{2\pi} d\varphi \int_{R_2}^{r} r \frac{10^{-9}}{r^3}\, dr \cdot l$$

$$\varepsilon_1 = \varepsilon_0 \varepsilon_{r1}, \quad \varepsilon_2 = \varepsilon_0 \varepsilon_{r2}$$

$$E_2 r = \frac{1}{\varepsilon_1} 10^{-9} \left. \frac{r^{-2}}{-2} \right|_{R_1}^{R_2} + \frac{10^{-9}}{\varepsilon_2} \left(\frac{r^{-1}}{-1}\right)$$

$$E_2 = \frac{10^{-9}}{r} \left(\frac{1}{2\varepsilon_1} \left(\frac{1}{R_1^2} - \frac{1}{R_2^2} \right) + \frac{1}{2\varepsilon_2} \left(\frac{1}{R_2} - \frac{1}{r} \right) \right)$$

④

$$E_3 = \frac{10^{-9}}{r}\left\{\frac{1}{2\varepsilon_1}\left(\frac{1}{R_1^2}-\frac{1}{R_2^2}\right)+\frac{1}{2\varepsilon_2}\left(\frac{1}{R_2}-\frac{1}{R_3}\right)\right\}$$

$r > R_3$ $$\varphi(r) = -\int E_3\,dr$$

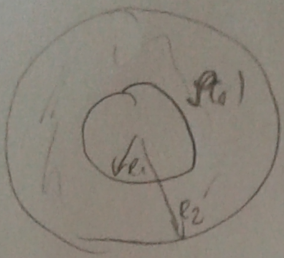
$R_2 \le r \le R_3$ $$\varphi(r) = -\int_A^{R_3} E_3\,dr - \int_{R_3}^{r} E_2\,dr$$

$R_1 < r < R_2$ $$\varphi(r) = -\int_A^{R_3} E_3\,dr - \int_{R_3}^{R_2} E_2\,dz - \int_{R_2}^{r} E_1\,dr$$

$r < R_1$ $$\varphi(r) = -\int_A^{R_3} E_3\,dr - \int_{R_3}^{R_2} E_2\,dr - \int_{R_2}^{R_1} E_1\,dr$$

Sfera

- od 0-R_1 nema naboja



$r < R_1$

$$\oint \vec{E}\vec{n}\,dS = \frac{1}{\varepsilon}\underbrace{\iiint \rho\, dV}_{0}$$

$$E = 0$$

$R_1 < r < R_2$

$$E \cdot 4r^2\pi = \frac{1}{\varepsilon}\int_0^{2\pi} d\varphi \int_0^{\pi} \sin\theta\, d\theta \int_{R_1}^{r} r^2 \cdot \overbrace{\frac{10^{-9}}{r^5}}^{\text{pretpostavljeni } \rho}$$

$$E\, 4r^2\pi = \frac{1}{\varepsilon}\, 2\pi \cdot 2 \cdot 10^{-9} \left(\frac{r^{-2}}{-2}\right)\Bigg|_{R_1}^{r}$$

$$E_1 = \frac{1}{2\varepsilon r^2} \cdot 10^{-9}\left(\frac{1}{R_1^2} - \frac{1}{r^2}\right)$$

$r > R_2$

$$E\, 4r^2\pi = \frac{1}{\varepsilon}\int_0^{2\pi} d\varphi \int_0^{\pi} \sin\theta\, d\theta \int_{R_1}^{R_2} r^2 \cdot \frac{10^{-9}}{r^5}\, dr$$

$$E\, 4r^2\pi = \frac{1}{\varepsilon}\, 2\pi \cdot 2 \cdot \left(\frac{1}{R_1^2} - \frac{1}{R_2^2}\right) \cdot 10^{-9}$$

$$E = \frac{10^{-9}}{2\varepsilon r^2}\left(\frac{1}{R_1^2} - \frac{1}{R_2^2}\right)$$

- potencijal

$r > R_2$

$$\varphi(r) = -\int_A^{r} E_2\, dr$$

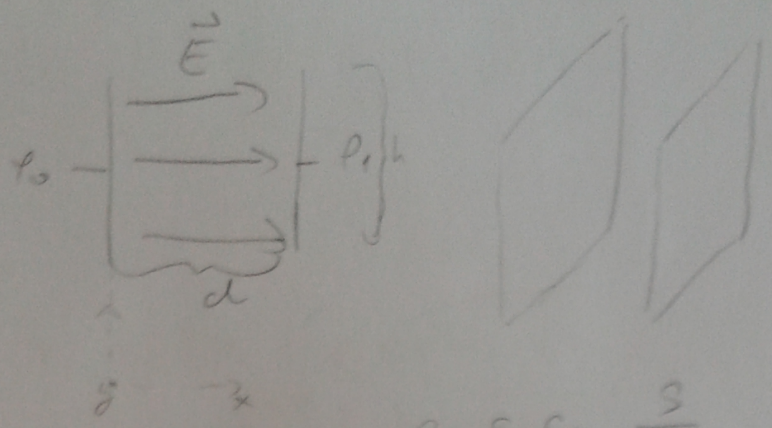
$R_2 < r < R_1$

$$\varphi(r) = -\int_A^{R_2} E_2\, dr - \int_{R_2}^{r} E_1\, dr$$

$r < R_1$

$$\varphi(r) = -\int_A^{R_2} E_2\, dr - \int_{R_2}^{R_1} E_1\, dr - \int 0$$

- KONDENZATOR



$$C = \varepsilon_0 \varepsilon_r \frac{S}{d}$$

$\Delta \varphi = 0$ - plän jesintom a

- u kartezijevom

$$\frac{\partial^2 \varphi}{\partial x^2} + \cancelto{0}{\frac{\partial^2 \varphi}{\partial y^2}} + \cancelto{0}{\frac{\partial^2 \varphi}{\partial z^2}} = 0 \quad \int$$

$$\frac{\partial \varphi}{\partial x} = C_1 \quad \int$$

$$\varphi = C_1 x + C_2$$

$$\varphi(0) = C_1 \cdot 0 + C_2 = \varphi_0 \Rightarrow C_2 = \varphi_0$$

$$\varphi(d) = C_1 \cdot d + C_2 = \varphi_1 \Rightarrow C_1 = \frac{\varphi_1 - \varphi_0}{d}$$

$$\boxed{\varphi(x) = \frac{\varphi_1 - \varphi_0}{d} x + \varphi_0}$$

↳ općeniti izraz za potencijal

$$W = \frac{1}{2} \varepsilon \iiint_V (\vec{E})^2 dV$$

$$\boxed{\vec{E} = -\nabla \varphi = \frac{\varphi_1 - \varphi_0}{d} \vec{a}_x}$$

$$W = \frac{1}{2}\varepsilon \int_0^d dx \int_0^h dy \int_0^a \left(\frac{\varphi_1-\varphi_0}{d}\right)^2 dz$$

$$W = \frac{1}{2}\varepsilon \frac{(\varphi_1-\varphi_0)^2}{d^{\cancel{2}}} \cdot \cancel{d} \cdot \underbrace{h \cdot a}_{S}$$

$$W = \frac{1}{2} C U^2 \Rightarrow C = \frac{2W}{U^2} = \frac{\cancel{2} \cdot \frac{1}{2}\varepsilon \frac{(\varphi_1-\varphi_0)^2}{d^2} \cdot S}{(\varphi_1-\varphi_0)^2}$$

$$= \varepsilon \frac{S}{d}$$

II način

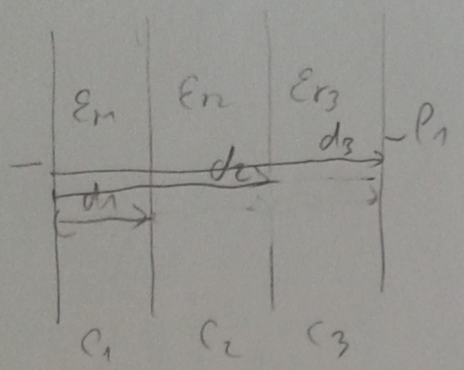
$$dR = \frac{1}{\varepsilon}\frac{dl}{S} = \frac{1}{\varepsilon}\frac{dx}{S} \quad / \int$$

$$R = \frac{1}{\varepsilon S}\int_0^d dx = \frac{d}{\varepsilon S}$$

$$C = \frac{1}{R} = \frac{\varepsilon S}{d}$$

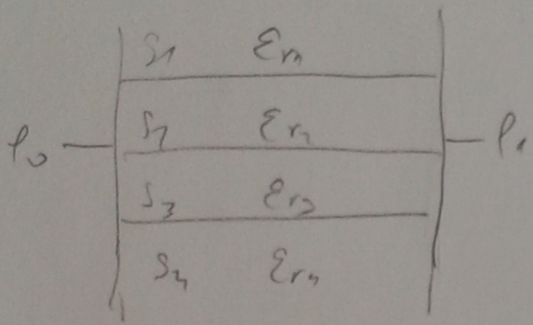
PZ

I



$$\frac{1}{C_{uk}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

II



$$C_{uk} = C_1 + C_2 + C_3 + C_4$$

I

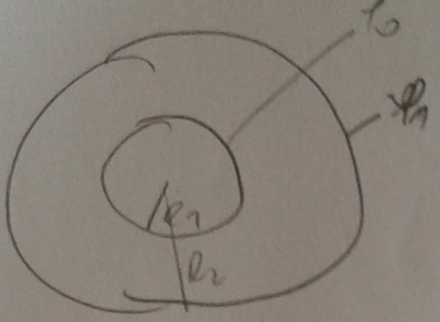
$$C_1 = \varepsilon_0 \varepsilon_{r1} \frac{S}{d_1}$$

$$C_2 = \varepsilon_0 \varepsilon_{r2} \frac{S}{d_2 - d_1}$$

$$C_3 = \varepsilon_0 \varepsilon_{r2} \frac{S}{d_3 - d_2}$$

II

CILINDRIČNI KONDENZATOR



$\Delta\varphi = 0$

u cilindričnom

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial \varphi}{\partial r}\right)=0 \quad / \cdot r / \int$$

$$r\frac{\partial \varphi}{\partial r}=C_1 \quad / : r / \int$$

$$\varphi = C_1 \ln r + C_2$$

$$\left.\begin{aligned}\varphi(r=R_1) &= C_1 \ln R_1 + C_2 = \varphi_0 \\ \varphi(r=R_2) &= C_1 \ln R_2 + C_2 = \varphi_1\end{aligned}\right\} -$$

$$C_1 \ln\left(\frac{R_1}{R_2}\right) = \varphi_0 - \varphi_1$$

$$C_1 = \frac{\varphi_0 - \varphi_1}{\ln\left(\frac{R_1}{R_2}\right)}$$

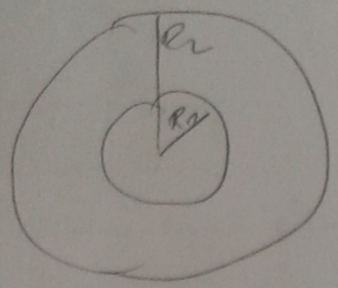
$$C_2 = \varphi_0 - C_1 \ln(R_1) = \varphi_0 - \frac{(\varphi_0 - \varphi_1)\ln(R_1)}{\ln\left(\frac{R_1}{R_2}\right)}$$

$$\vec{E} = -\nabla\varphi = -\frac{\partial \varphi}{\partial r}\vec{a}_r = -\frac{C_1}{r}\vec{a}_r$$

$$W = \frac{1}{2}\varepsilon \int_0^{2\pi} d\varphi \int_{R_1}^{R_2} r \frac{C_1^2}{r^2}\,dr \underbrace{\int dz}_{\ell} = \frac{1}{2}\varepsilon \cdot \ell \cdot 2\pi \, C_1^2 \ln r \Big|_{R_1}^{R_2} = \pi\varepsilon\ell \, C_1^2 \ln\frac{R_2}{R_1}$$

$$C = \frac{2W}{U^2} = \frac{2\pi\varepsilon \cdot l}{\ln\frac{R_2}{R_1}}$$

II način

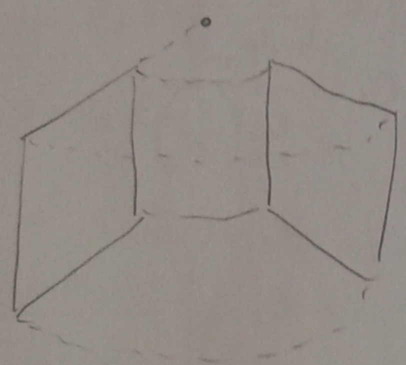


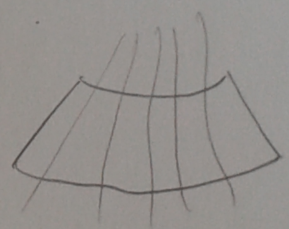
$$dR = \frac{1}{\varepsilon}\frac{dl}{S} = \frac{1}{\varepsilon}\frac{dr}{2r\pi l} \quad \Big/ \int$$

$$R = \frac{1}{2\pi\varepsilon l} \ln r \Big|_{R_1}^{R_2} = \frac{1}{2\pi\varepsilon l}\ln\frac{R_2}{R_1}$$

$$C = \frac{1}{R} = \frac{2\pi\varepsilon l}{\ln\frac{R_2}{R_1}}$$

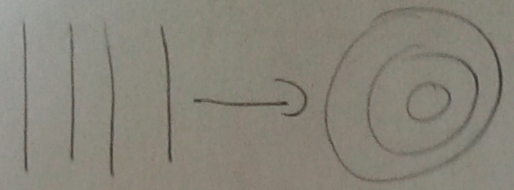
$\boxed{PR}$



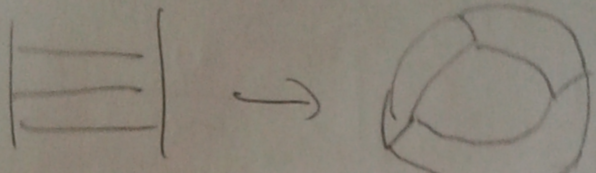


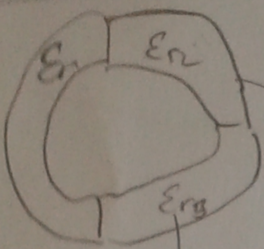
$$\frac{1}{r^2}\frac{\partial^2\varphi}{\partial\alpha^2} = 0$$ (ekvipotencijalne plohe ne ovise o r-u nego o α)

$$\vec{E} = -\nabla\varphi = -\frac{1}{r}\frac{\partial\varphi}{\partial\alpha}$$



runj'





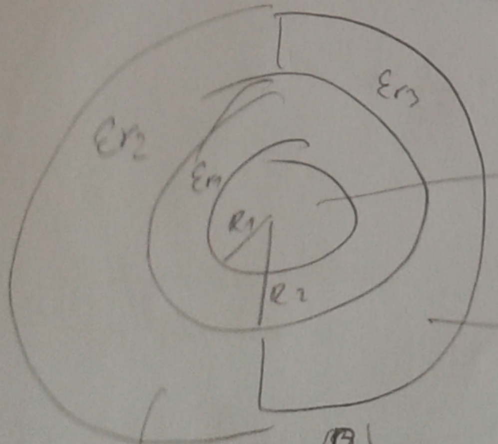
$$dR = \frac{1}{\varepsilon_1}\,\frac{dr}{\pi r l} \qquad \int$$

$$R_1 = \frac{1}{\pi \varepsilon_1 l} \ln \frac{R_2}{R_1}$$

$$C_1 = \frac{1}{R_1}$$

$$R_2 = \frac{1}{\frac{\pi \varepsilon_2 l}{2}} \ln \frac{R_2}{R_1}$$

$$R_3 = \frac{1}{\frac{\pi \varepsilon_3 l}{2}} \ln\left(\frac{R_2}{R_1}\right)$$



$$R_1 = \frac{1}{2\pi \varepsilon_1 l} \ln \frac{R_2}{R_1}$$

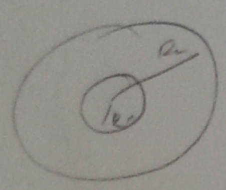
$$R_3 = \frac{1}{\pi \varepsilon_3 l} \ln\left(\frac{R_3}{R_2}\right)$$

$$R_2 = \frac{1}{\pi \varepsilon_2 l} \ln\left(\frac{R_3}{R_1}\right)$$

$$C_{23} = C_2 + C_3$$

$$\frac{1}{C_{123}} = \frac{1}{C_1} + \frac{1}{C_{23}}$$

PR4 kuglasti kondenzator



$$dR = \frac{1}{\varepsilon}\frac{dr}{4r^2\pi} \quad / \int$$

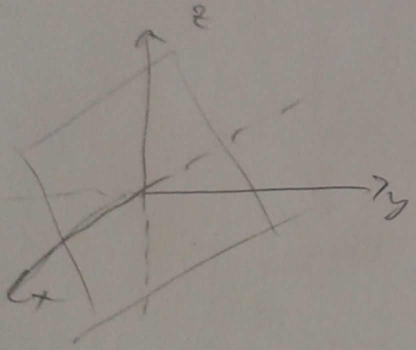
$$R = \frac{1}{4\pi\varepsilon}\,\frac{r^{-1}}{-1}\Big|_{R_1}^{R_2} = \frac{1}{4\pi\varepsilon}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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

- uvjeti na granici

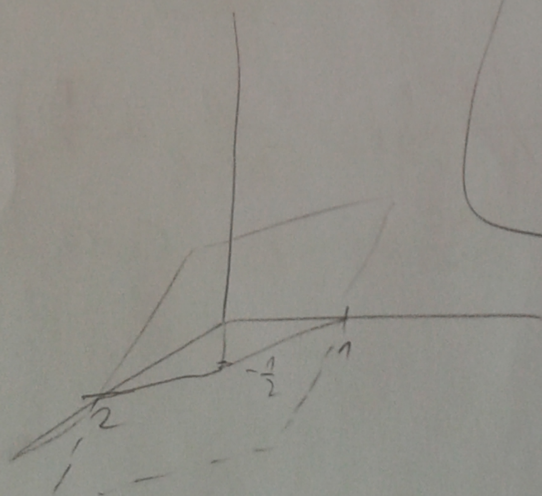
$\vec{n}_{12}$ → UVIJEK OD SREDSTVA 1 prema 2

→ JEDINIČNA JE



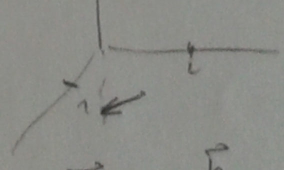
$$x + 2y - 4z = 2$$

$$\frac{x}{2} + \frac{y}{1} + \frac{z}{-\frac{1}{2}} = 1$$



sredstvo jedan je u ishodištu

$$\vec{n} = \vec{a_x} + 2\vec{a_y} - 2\vec{a_z}$$



$$\vec{n}_{12} = \frac{\vec{n}}{|\vec{n}|}$$

$$\vec{n}_{n} = \frac{\vec{a}_x + 2\vec{a}_y - 2\vec{a}_z}{3}$$

$$\vec{E}_{1t} = \vec{E}_{2t} \qquad \vec{E}_1 = \vec{E}_{1t} + \vec{E}_{1n}$$

$$\vec{D}_{1n} = \vec{D}_{2n} \qquad \vec{E}_2 = \vec{E}_{2t} + \vec{E}_{2n}$$

— pretp. da je zadan $\vec{E}_1 = 6\vec{a}_x - 3\vec{a}_y - 3a_z$

① $$\vec{E}_{1n} = \underbrace{\left|\vec{E}_1 \cdot n_{12}\right|}_{2} \cdot \vec{n}_{12} = 2\,\vec{n}_{12}$$

$$= 2 \cdot \frac{(\vec{a}_x + 2\vec{a}_y - 2\vec{a}_z)}{3}$$

② $$\vec{E}_{1t} = \vec{E}_1 - \vec{E}_{1n} = \frac{16}{3}\vec{a}_x - \frac{7}{3}\vec{a}_y - \frac{11}{3}\vec{a}_z$$

$$\hookrightarrow \vec{E}_{2t} = \frac{16}{3}\vec{a}_x - \frac{7}{3}\vec{a}_y - \frac{11}{3}\vec{a}_z$$

③ $$\vec{D}_{1n} = \vec{D}_{2n}$$

$$E_{1n} \cdot \varepsilon_1 = E_{2n}\,\varepsilon_2$$

$$E_{2n} = \frac{\varepsilon_1}{\varepsilon_2} E_{1n} = \frac{\cancel{\varepsilon_0}\,\varepsilon_{r1}}{\cancel{\varepsilon_0}\,\varepsilon_{r2}} E_{1n} =$$

$$= \frac{\varepsilon_{r1}}{\varepsilon_{r2}} E_{1n}$$