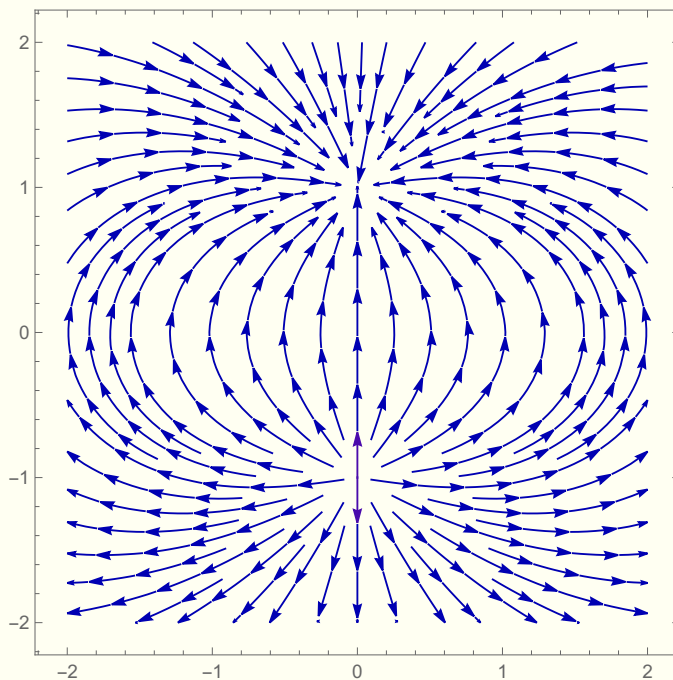


## 1. Der Dipol

$$k = \frac{1}{4\pi\epsilon_0}; \quad x_1 = -\frac{d}{2}; \quad x_2 = \frac{d}{2}$$

$$(a) \quad V_{ges} = V_+ + V_- = kq \left( \frac{1}{r_+} - \frac{1}{r_-} \right)$$



$$(b) \quad d \ll r; \quad \vec{p} := q\vec{d}; \quad d \cos(\theta) = \vec{d}$$

$$\begin{aligned} V &= kq \left( \frac{1}{r_+} - \frac{1}{r_-} \right) = kq \left( \frac{r_- - r_+}{r_+ r_-} \right) \approx kq \frac{d \cos(\theta)}{r^2} \\ &= k \frac{p \cos(\theta)}{r^2} = \underline{\underline{k \frac{\vec{p} \cdot \vec{r}}{r^3}}} \end{aligned}$$

$$\begin{aligned} r_- - r_+ &\approx d \cos(\theta) \\ r_+ r_- \pm l &\approx r^2 \end{aligned}$$

$$(c) \quad |\vec{M}| = |\vec{p} \times \vec{E}| = pE \sin(\theta); \quad E_{pot} = - \int_{\theta}^{\pi/2} |\vec{M}| \, d\tilde{\theta}$$

$$\begin{aligned} E_{pot} &= - \int_{\theta}^{\pi/2} |\vec{M}| \, d\tilde{\theta} = -pE \int_{\theta}^{\pi/2} \sin(\tilde{\theta}) \, d\tilde{\theta} = -pE \cos(\theta) \\ &= \underline{\underline{-\vec{p} \cdot \vec{E}}} \end{aligned}$$

## 2. Kondensator mit Dielektrikum

$$k = \frac{1}{4\pi\epsilon_0}; \quad C = \frac{\epsilon A}{d}; \quad \epsilon_{rel} = \frac{\epsilon}{\epsilon_0}$$

(a)

$$\begin{aligned} C_1 &= \frac{\epsilon_0 a(a-h)}{d} \\ C_2 &= \frac{\epsilon_r a h}{d} \\ C_{ges} &= C_1 + C_2 = \underline{\underline{\frac{\epsilon_0 a}{d} (\epsilon_{rel} h + a - h)}} \end{aligned}$$

(b)

$$E = \frac{CU^2}{2} = \underline{\underline{\frac{U^2 \epsilon_0 a (\epsilon_{rel} h + a - h)}{2d}}}$$

(c)

$$\begin{aligned} E' &= \frac{C'U^2}{2} = \frac{U^2 \epsilon_0 a (\epsilon_{rel} (h + \Delta h) + a - (h + \Delta h))}{2d} \\ \Delta E &= \underline{\underline{\frac{U^2 \epsilon_0 a}{2d} (\epsilon_{rel} \Delta h - \Delta h)}} \end{aligned}$$

$$\begin{aligned} E_{pot} &= \frac{mgh}{2} = \frac{\rho a d g h^2}{2} \\ E'_{pot} &= \frac{\rho a d g (h + \Delta h)^2}{2} \\ \Delta E_{pot} &= \underline{\underline{\frac{\rho g a d}{2} (\Delta h^2 + 2h\Delta h)}} \end{aligned}$$

(d)

$$\Delta q = 2 \frac{\Delta E}{U} = \underline{\underline{\frac{U \epsilon_0 a}{d} (\epsilon_{rel} \Delta h - \Delta h)}}$$

(e)

(f)  $a = 0.1 \text{ m}; \quad d = 5.0 * 10^{-3} \text{ m}; \quad h = 0.05 \text{ m}; \quad U = 7 \text{ kV}$   
 $\epsilon_r = 80; \quad \rho = 1.0 * 10^3 \text{ kg/m}^3$

$$C_{ges} = C_1 + C_2 = \frac{\epsilon_0 a}{d} (\epsilon_{rel} h + a - h) = \underline{\underline{7.17 * 10^{-10} \text{ F}}}$$

$$E_{pot} = \frac{mgh}{2} = \underline{\underline{6.1 * 10^{-3} \text{ J}}}$$

### 3. Kapazität eines Koaxialkabels

$$k = \frac{1}{4\pi\epsilon_0}; \quad C = \frac{\epsilon A}{d}; \quad \epsilon_{rel} = \frac{\epsilon}{\epsilon_0}$$

(a) For  $r \leq d \leq R$ :

$$\frac{q_{in}}{\epsilon_0} = \oint \vec{E}(\vec{d}) \cdot d\vec{A} = E(d) \oint dA = E(d) 2\pi dl$$

$$E(d) = kq \frac{2}{dl}$$

For  $R < d$ :

$$q_{in} = 0$$

$$E(d) = 0$$

$$E(d) = \begin{cases} kQ \frac{2}{lr} & \text{for } r \leq d \leq R, \\ 0 & \text{for } R < d. \end{cases}$$

(b) For  $r \leq d \leq R$ :

$$E(d) = kq \frac{2}{dl}$$

$$V(d) = \int_d^\infty \vec{E}(r) \cdot dr = \int_d^R kq \frac{2}{rl} \cdot dr + \underbrace{\int_R^\infty 0 \cdot dr}_{=0}$$

$$V(d) = \frac{2kq}{l} \ln\left(\frac{R}{d}\right)$$

$$V(d) = \begin{cases} \frac{2kq}{l} \ln\left(\frac{R}{d}\right) & \text{for } r \leq d \leq R, \\ 0 & \text{for } R < d. \end{cases}$$

(c)  $r = 7.0 * 10^{-4} \text{ m}; \quad R = 2.5 * 10^{-3} \text{ m}; \quad C = 500 \text{ pF}$

$$C = \frac{q}{V(r)} = \frac{l}{2k \ln\left(\frac{R}{r}\right)}$$

$$l = \frac{C}{2k \ln\left(\frac{R}{r}\right)}$$
$$= \underline{\underline{11.44 \text{ m}}}$$

(d)  $I = 0.1 \text{ A}; \quad U = 10 \text{ V}$

$$t = \frac{CU}{I} = \underline{\underline{50 \text{ ns}}}$$