# Ex 2 - Blatt 1

$\boxed{1}$ Coulomb $\leftrightarrow$ Gravitation

a) $F_{e} = \frac{1}{4\pi\varepsilon_0} \frac{e^2}{r^2}$ $\qquad F_G = G \cdot \frac{m^2}{r^2}$

Verhältnis $\frac{F_e}{F_G} = \frac{e^2 \cancel{r^2}}{4\pi\varepsilon_0 G m^2 \cancel{r^2}} = \underline{\underline{4 \cdot 10^{42}}}$

b) Beide gleich stark, was für eine Masse?

$1 \overset{!}{=} \frac{e^2}{4\pi\varepsilon_0 G m^2} \Rightarrow m = \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}} = \underline{\underline{1{,}86 \cdot 10^{-9}\ \mathrm{kg}}}$

$(\approx 2 \cdot 10^{21} \cdot m)$

c) $F_e = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$ $\qquad F_G = G \cdot \frac{m_1 m_2}{r^2}$

$\frac{F_e}{F_G} \overset{!}{=} 1 \Rightarrow \frac{1}{4\pi\varepsilon_0 G} \frac{q_1}{m_1} \cdot \frac{q_2}{m_2} = 1$

$\frac{q}{m}$ soll für beide Massen gleich sein

$\Rightarrow 1 = \frac{1}{4\pi\varepsilon_0 G} \left(\frac{q}{m}\right)^2 \Rightarrow \frac{q}{m} = \sqrt{4\pi\varepsilon_0 G}$

$= \underline{\underline{8{,}62 \cdot 10^{-11}}}\ \frac{\mathrm{C}}{\mathrm{kg}}$

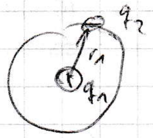
d) $\frac{q}{m}$ von Erde & Mond seien gleich

Ergebnis aus der c) $\frac{q}{m} = \frac{q_E}{m_E}$

$\Rightarrow q_E = \frac{q}{m} \cdot m_E = \underline{\underline{5{,}15 \cdot 10^{14}\ \mathrm{C}}}$

analog $q_M = m_M \cdot \frac{q}{m} = \underline{\underline{6{,}33 \cdot 10^{12}\ \mathrm{C}}}$

## 2 Atom

Wasserstoffatom 

$q_1 = -q_2 = e$

a) $\vec{F} = \vec{E} \cdot q$

$$\Rightarrow \quad E = \frac{F}{q} = \frac{1}{4\pi\varepsilon_0}\,\frac{e}{r_1^2} = \underline{\underline{5{,}15 \cdot 10^{11}}}\ \frac{V}{m}$$

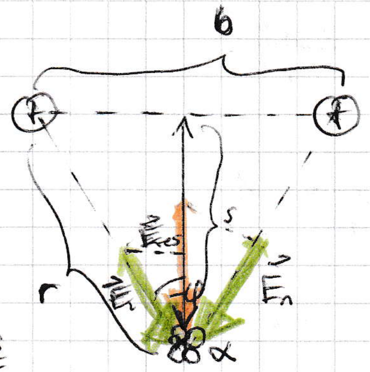
b) $$F = q \cdot E = -e \cdot E = -\underline{\underline{8{,}24 \cdot 10^{-8}}}\ N$$

c) Differenz in der Feldstärke $\quad r_2 = 4 \cdot r_1$

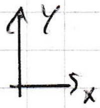
$$\Delta E = E_1 - E_2 = \frac{1}{4\pi\varepsilon_0}\,\frac{e}{r_1^2} - \frac{1}{4\pi\varepsilon_0}\,\frac{e}{r_2^2} = \frac{e}{4\pi\varepsilon_0 r_1^2}\left(\frac{16}{16} - \frac{1}{16}\right)$$

$$= E_1 \cdot \frac{15}{16} = \underline{\underline{4{,}828 \cdot 10^{11}}}\ \frac{V}{m}$$

## 3

a) 


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




$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$

$E_x$ - Komponenten heben sich auf

b) $$r = \sqrt{\left(\frac{b}{2}\right)^2 + s^2} \qquad E_{res} = 2 \cdot E \cdot \cancel{\cos\varphi}\ \cos\varphi$$

$$\Rightarrow \quad E_{res}(s) = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2 \cdot q \cdot s}{\left(\left(\frac{b}{2}\right)^2 + s^2\right)^{3/2}} \qquad q = e$$

$q_\alpha = 2e$

c) $$F(s) = q_\alpha \cdot E_{res}(s) \quad \Rightarrow \quad F(s) = \frac{e^2}{\pi\varepsilon_0} \cdot \frac{s}{\left(\left(\frac{b}{2}\right)^2 + s^2\right)^{3/2}}$$

d) $$F'(s) = \frac{dF}{ds} = \frac{e^2}{\pi\varepsilon_0}\left[\frac{1}{\left(\left(\frac{b}{2}\right)^2 + s^2\right)^{3/2}} - \frac{3}{2}\,\frac{2s^2}{\left(\left(\frac{b}{2}\right)^2 + s^2\right)^{5/2}}\right]$$

$$\frac{dF}{ds} = \frac{\left(\frac{b}{2}\right)^2 + s^2 - 3s^2}{\left(\left(\frac{b}{2}\right)^2 + s^2\right)^{5/2}} \cdot \frac{e^2}{\pi\varepsilon_0} \stackrel{!}{=} 0$$

$$\left(\frac{b}{2}\right)^2 = 2s^2 \quad \Rightarrow \quad s = \frac{b}{2\sqrt{2}} \approx \underline{\underline{2{,}616 \cdot 10^{-11}\,\text{m}}}$$

e) $$F\left(\frac{b}{2\sqrt{2}}\right) = \frac{e^2}{\pi\varepsilon_0} \cdot \frac{\frac{b}{2\sqrt{2}}}{\left(\left(\frac{b}{2}\right)^2 + \frac{1}{2}\left(\frac{b}{2}\right)^2\right)^{3/2}} = \frac{e^2}{\pi\varepsilon_0} \frac{b}{\cancel{2\sqrt{2}} \cdot \frac{3}{\cancel{2}} \frac{b^{\cancel{2}}}{4}}$$

$$= \frac{\cancel{e^2}}{\cancel{\pi\varepsilon_0}} \cdot \frac{\cancel{4}}{\cancel{3\sqrt{2}\,2b}} \quad \frac{e^2}{4\pi\varepsilon_0} \cdot \frac{\frac{b}{2\sqrt{2}}}{\left(\frac{3}{2}\right)^{3/2} \cdot \frac{b^{\cancel{3}}}{8}}$$

$$= \frac{e^2}{\pi\varepsilon_0} \cdot \frac{8\,4}{\left(\frac{3}{2}\right)^{3/2} \sqrt{2} \cdot b^2} = 2{,}588 \cdot 10^{-7}\,N$$