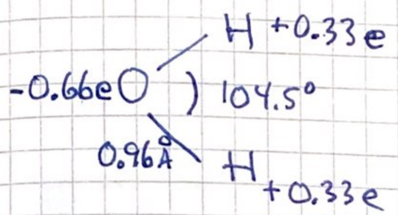
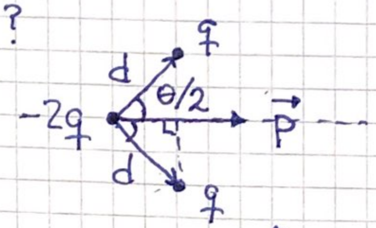
24.01.22 F9, F10

Sist: Dipolmoment: $\vec{p} = \sum_i q_i \vec{r}_i$ evt $\vec{p} = \int \vec{r}\, dq$

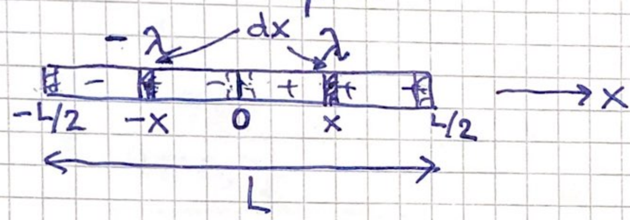
Eks 1: H_2O, $p = ?$





$$p = 2\cdot qd\cdot\cos\frac{\theta}{2} = 2\cdot 0.33e\cdot 0.96Å\cdot\cos 52.25^\circ$$
$$= 0.39\ eÅ = 0.39\cdot 1.6\cdot 10^{-19}\,C\cdot 10^{-10}\,m$$
$$= 6.2\cdot 10^{-30}\ Cm$$

Eks 2: Stav-dipol



$\pm\lambda$ = ladn. pr lengdeenhet

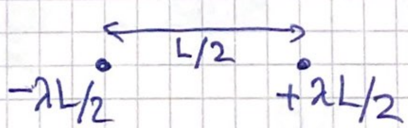
Ladn.paret $\pm dq = \pm\lambda\cdot dx$ i pos. $\pm x$ bidrar med $d\vec{p} = 2x\cdot\lambda dx\,\hat{x}$

⇒ Totalt:

$$\vec{p} = \int d\vec{p} = \int_0^{L/2} 2x\lambda\, dx\,\hat{x} = 2\lambda\hat{x}\Big|_0^{L/2}\frac{1}{2}x^2 = \frac{1}{4}\lambda L^2\hat{x}$$

Enhet: • $[\lambda L^2] = \frac{C}{m}\cdot m^2 = C\cdot m$ OK

• Med $p = \frac{1}{4}\lambda L^2$ har vi det samme som 2 punktladn. $\pm\lambda\cdot L/2$ i innbyrdes avstand $\frac{1}{2}L$:



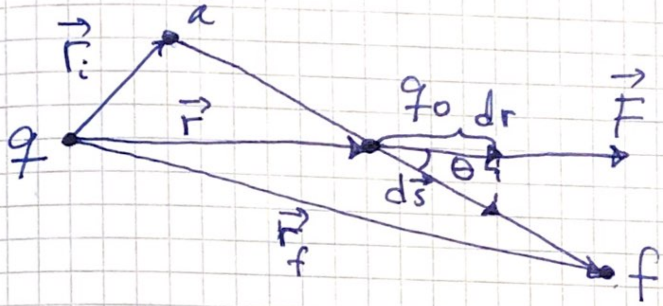
$p = \frac{1}{4}\lambda L^2$

OK

Pot. energi. Elektrisk potensial

[OS2 7.1–2 ; YF 23.1–2 ; LHL 19.9, 20.3]

Pot. energi U for ladn. par q og q_0:



$\vec{F}\cdot d\vec{s}$

$= \underline{F \cdot ds \cdot \cos\theta}$

$= F \cdot dr$

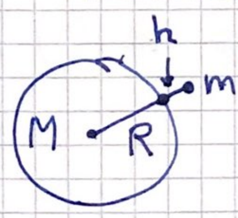
$$\Delta U = U_f - U_i \underset{(\text{FY6013})}{\overset{\text{def}}{=}} -\int_i^f \vec{F}\cdot d\vec{s} = -\int_{r_i}^{r_f} \frac{q q_0}{4\pi\varepsilon_0 r^2}\cdot dr$$

$$= \underline{\frac{q q_0}{4\pi\varepsilon_0 r_f} - \frac{q q_0}{4\pi\varepsilon_0 r_i}}$$

Naturlig valg: $U = 0$ for $r \to \infty$

$$\Rightarrow \boxed{U(r) = \frac{q q_0}{4\pi\varepsilon_0 r}} = \text{pot. energi med } q, q_0$$

i innbyrdes avstand r



Velger her $U = 0$ når $r = R$

$$\Rightarrow U(r = R + h) = \underline{\frac{GMm}{R} - \frac{GMm}{R+h}}$$

$$\frac{1}{R+h} \overset{h \ll R}{\approx} \frac{1}{R(1 + h/R)} \approx \frac{1}{R}\cdot\left(1 - \frac{h}{R}\right) = \frac{1}{R} - \frac{h}{R^2}$$

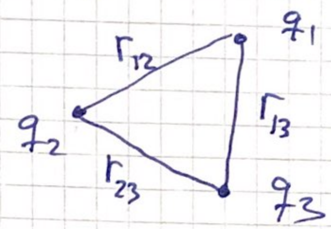
$$\Rightarrow U(h) \approx \cancel{\frac{GMm}{R}} - \cancel{\frac{GMm}{R}} + \frac{GMm\,h}{R^2} = \underline{m \cdot g \cdot h}$$

$$g = \frac{GM}{R^2} = \underline{9.81\ \text{m/s}^2}$$

Med flere ladninger $q_1 \ldots q_n$: (16)

Alle par vekselvirker parvis og bidrar med

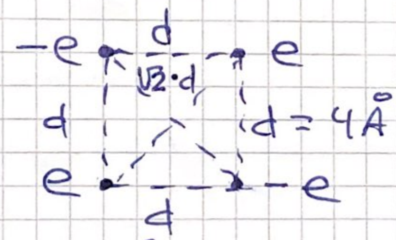
$$U_{ij} = \frac{q_i q_j}{4\pi \varepsilon_0 r_{ij}}$$



til total U :

$$U = U_{12} + U_{13} + \ldots + U_{1n}$$
$$+ U_{23} + \ldots + U_{2n} + \ldots + U_{n-1,n}$$
$$= \sum_{i=1}^{n-1} \sum_{\substack{j=2 \\ (j \neq i)}}^{n} U_{ij} = \sum_{i<j} U_{ij}$$
$$= \underline{\sum_{i<j} \frac{q_i q_j}{4\pi \varepsilon_0 r_{ij}}}$$

Eks: Finn U og p for systemet



$$U = \frac{e^2}{4\pi \varepsilon_0 d} \left\{ 4\cdot(-1) + 2 \cdot \frac{1}{\sqrt{2}} \right\}$$
$$= \frac{9\cdot 10^9 \cdot (1.6\cdot 10^{-19})^2}{4\cdot 10^{-10}} \text{ J} \cdot (-2.59) = \underline{\underline{-1.5\cdot 10^{-18} \text{ J}}}$$

$\underline{\underline{p = 0}}$ $\downarrow + \uparrow = 0$

evt. $\longleftarrow + \longrightarrow = 0$

Elektrisk potensial $\overset{\text{def.}}{=}$ pot. energi pr ladningsenhet

$$\boxed{V = \frac{U}{q_0} \; ; \quad [V] = \frac{J}{C} = V \text{ (volt)}}$$

For ladn. par q, q_0 i innb. avst. r:

$U = qq_0 / 4\pi\varepsilon_0 r$

$\Rightarrow$ q omgir seg med et potensial

$$\boxed{V(r) = \frac{q}{4\pi\varepsilon_0 r}} \quad \text{Coulombpotensialet}$$

Potensial forskjellen mellom to posisjoner f og i:

$$\Delta V = \frac{\Delta U}{q_0} = \frac{-\int_i^f \vec{F} \cdot d\vec{s}}{q_0} \overset{\vec{E} = \frac{\vec{F}}{q_0}}{=} -\int_i^f \vec{E} \cdot d\vec{s}$$

$$\Rightarrow \boxed{V_f - V_i = -\int \vec{E} \cdot d\vec{s}}$$

- Fra før: $[E] = \frac{N}{C}$. Nå: $\boxed{[E] = \frac{V}{m}}$
- Energienheten eV (elektronvolt) $\overset{\text{def}}{=}$ elementærladn. e mult. med pot. forskjell 1 V

$\Rightarrow$ $\underline{1\,eV} = 1.6 \cdot 10^{-19} \cancel{C} \cdot 1\, J/\cancel{C} = \underline{1.6 \cdot 10^{-19}\, J}$

(keV, MeV, GeV, meV, μeV ...)