Alan Teorisi

Elektrostatik: Coulomb yasası ve elektrik alan

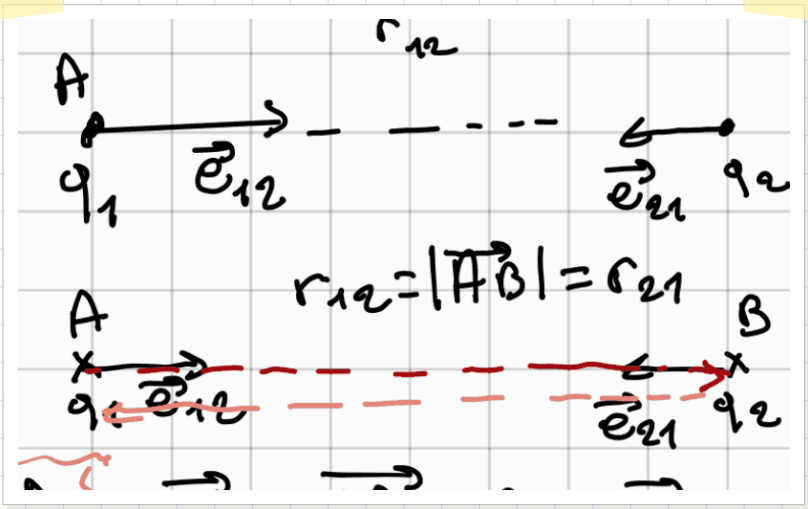
Orijinal not: Ders3.pdf

UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orj. s. 1

Elektrostatik



orijinal çizim, s. 1

$$\vec{e}_{12} = \frac{\vec{r}_{12}}{|\vec{r}_{12}|}, \qquad |\vec{e}_{12}| = |\vec{e}_{21}| = 1, \qquad \vec{e}_{21} = -\vec{e}_{12}$$

$$\vec{r}_{12} = r_{12} \cdot \vec{e}_{12}, \qquad \vec{r}_{21} = r_{21}\vec{e}_{21} = -r_{12}\vec{e}_{12}$$

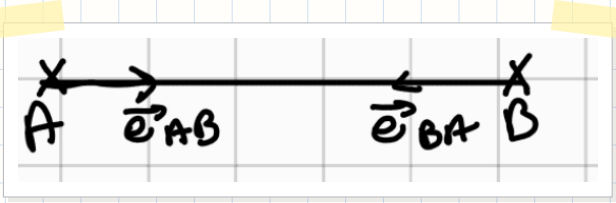
$$r_{12} = |\overrightarrow{AB}| = r_{21}$$

$$\varepsilon_0 = \frac{1}{36\pi} 10^{-9} \text{ F/m} \quad \text{(Boşluğun elektrik sabiti)}$$

$$\vec{r}_{12} = \overrightarrow{AB} = r_{12} \cdot \vec{e}_{12} = -\vec{r}_{21} = -r_{21}\vec{e}_{21}$$

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{(r_{12})^2} \vec{e}_{12} = -\vec{F}_{21}$$

($\vec{F}_{12}$: q_1'in q_2'ye uyguladığı kuvvet; $\vec{F}_{21}$: q_2'nin q_1'e uyguladığı kuvvet)



orijinal çizim, s. 1

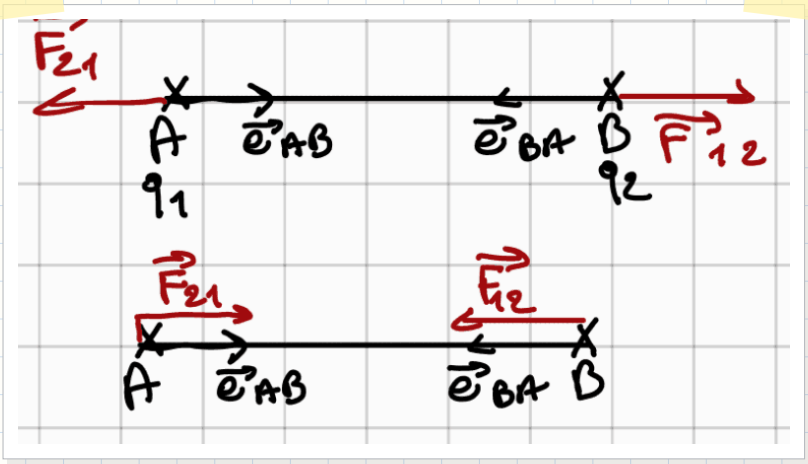
$$\overrightarrow{AB}, \qquad \vec{e}_{AB} = \frac{\overrightarrow{AB}}{|\overrightarrow{AB}|}$$

$$\vec{e}_{BA} = -\vec{e}_{AB} = -\frac{\overrightarrow{AB}}{|\overrightarrow{AB}|} = \frac{\overrightarrow{BA}}{|\overrightarrow{AB}|}$$

$q_1, q_2 \gtrless 0$
$q_1 > 0$ veya < 0
$q_2 > 0$ veya < 0

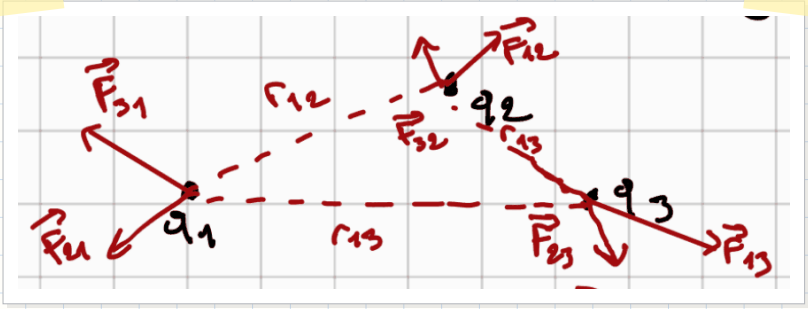
$q_1 \cdot q_2 > 0$ ise güçler birbirini iter

$q_1 \cdot q_2 < 0$ ise güçler birbirini çeker $\begin{pmatrix} q_1^+ \; q_2^- \\ q_2^+ \; q_1^- \end{pmatrix}$



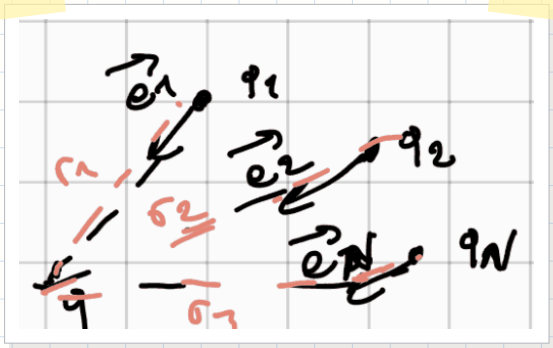
orijinal çizim, s. 1

orj. s. 2 İkiden fazla yük halinde superposition ilkesi geçerlidir



orijinal çizim, s. 2

$$\vec{F}_1 = \vec{F}_{31} + \vec{F}_{21}, \qquad \vec{F}_2 = \vec{F}_{12} + \vec{F}_{32}, \qquad \vec{F}_3 = \vec{F}_{23} + \vec{F}_{13}$$

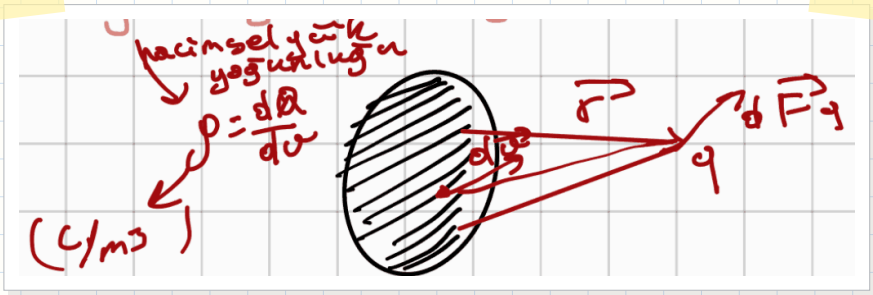


orijinal çizim, s. 2

$$\vec{F}_q = \frac{q}{4\pi\varepsilon_0} \sum_{n=1}^{N} \frac{q_n}{(r_n)^2} \vec{e}_n$$

Eğer yükler ayrık değil, sürekli bir yoğunlukta dağılmışsa

hacimsel yük yoğunluğu: $\rho = \frac{dQ}{dv}$ (C/m^3)



orijinal çizim, s. 2

$$d\vec{F}_q = \underbrace{\frac{1}{4\pi\varepsilon_0}}_{9\cdot10^9\ \mathrm{N}} \cdot \frac{q\,dQ}{r^2}\vec{e} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q\rho\,dv}{r^2}\vec{e}$$

$$\Rightarrow \vec{F}_q = \int_v d\vec{F}_q = \int_v \frac{1}{4\pi\varepsilon_0} \frac{q\rho\,dv}{r^2} \cdot \vec{e}$$

$$\vec{F}_q = \frac{q}{4\pi\varepsilon_0} \int_v \rho \frac{\vec{r}}{r^3} dv$$

$$\vec{F}_q = \frac{1}{4\pi\varepsilon_0} q \int_v \frac{\rho}{r^3} \cdot \vec{r}\,dv$$

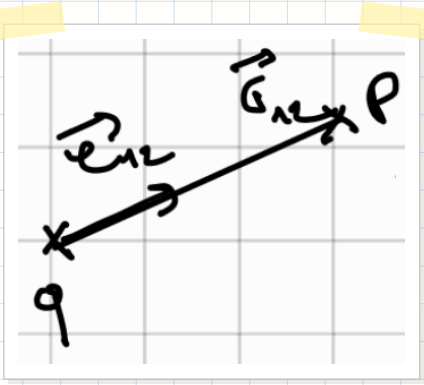
$$\rho = \rho_{iç} + \rho_{dış}$$

$$\vec{E}_q \mathrel{\hat{=}} \vec{F}_q$$

orj. s. 3

Elektrostatik alan

$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \int \frac{\rho\vec{r}}{r^3} dv \qquad 10^{-15}\ \mathrm{m} < r < \infty$$



orijinal çizim, s. 3

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r_{12})^3}\vec{r}_{12}$$

$$[\vec{E}] = \boxed{V/m} = \frac{N}{C}, \qquad [q] = C, \qquad [F] = N, \qquad [\varepsilon_0] = F/m$$

$$[\vec{r}] = m$$

Uygulama

> *Şekil:* Basılı soru (Pr.-2): bir proton ile elektron arasındaki mekanik ve elektrik çekim kuvvetlerinin oranı; aynısı iki elektron için. Basılı metin dijitalleştirilmedi.
> *(orijinal notta, s. 3)*

$$\frac{2e}{3} = k_1, \qquad \frac{-e}{3} = k_2$$

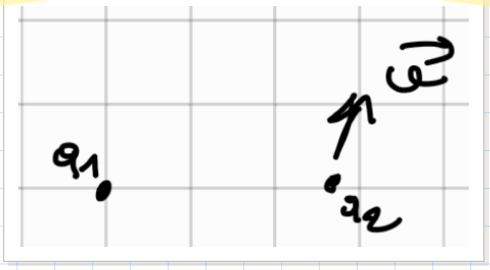
Maddesel ise: $N \cdot e$, $N \in \mathbb{Z}$

$$p = 2k_1 + k_2$$

$$n = 3k_1 + 2k_2$$

⋆ ek not

q_1 durgun ve q_2 hareketliyse Coulomb yasası bir yönde geçerlidir. Durgunun hareketliye olanı geçerlidir.



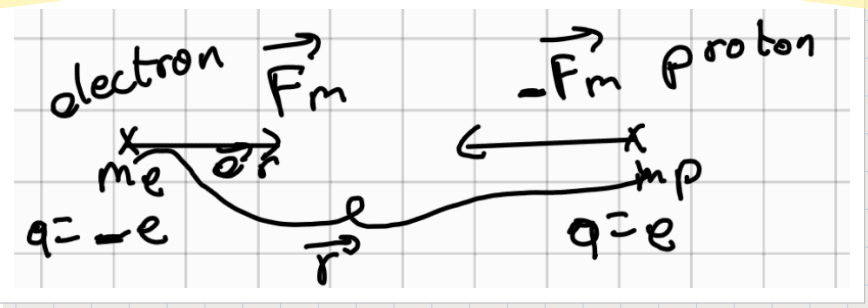
orijinal çizim, s. 3

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}^3}\vec{r}_{12}$$

$$\vec{F}_{12} \neq -\vec{F}_{21}$$

orj. s. 4

$$\vec{r} = r\,\vec{e}_r$$



orijinal çizim, s. 4

$$\varepsilon_0 = \left(\frac{1}{36\pi}\right)\cdot 10^{-9}\ \text{F/m}$$
$$m_e = 9{,}1\cdot 10^{-31}\ \text{kg}$$
$$m_p = m_n = 1{,}67\cdot 10^{-27}\ \text{kg}$$
$$e = 1{,}6\cdot 10^{-19}\ \text{C}$$
$$k = 6{,}67\cdot 10^{-11}\ \frac{\text{N m}^2}{\text{kg}^2}$$

$$\vec{F}_{mec} = k\frac{m_e m_p}{r^2}\vec{e}_r$$

$$\vec{F}_{elec} = \frac{1}{4\pi\varepsilon_0}\frac{|q_e||q_p|}{r^2}\vec{e}_r = \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r^3}\vec{r}$$

$$|\vec{F}_{mec}| = F_m \qquad |\vec{F}_{elec}| = F_{elec}$$

$$\frac{F_{mec}}{F_{elec}} = \frac{\dfrac{k\,m_e\,m_p\,|\vec{r}|}{r^3}}{\dfrac{1}{4\pi\varepsilon_0}\dfrac{e^2}{r^3}|\vec{r}|} = 4\pi\varepsilon_0\,k\,\frac{m_e m_p}{e^2}$$

(Kesirde pay ve paydadaki $|\vec{r}|$ ve r^3 çarpanları çizilerek sadeleştirilmiş.)

$$\Rightarrow F_{elec} = \frac{e^2}{m_e\cdot m_p}\cdot\frac{1}{4\pi\varepsilon_0 k}F_{mec}$$

$$F_{elec} = \frac{(1{,}6)^2\cdot 10^{-38}}{(9{,}1)(1{,}67)\,10^{-31}\cdot 10^{-27}}\cdot\frac{10^{11}}{4\pi\varepsilon_0\,6{,}67}F_{mec}$$

$$\approx \frac{10^{40}}{4}F_{mec}$$