

Elektrostatika.Kulon qonuni



- Ikkita zaryadlangan jismlar orasidagi o'zaro ta'sir kuchi Kulon qonuniga ko'ra quyidagi tenglama orqali ifodalanadi:

$$F = \frac{q_1 q_2}{4\pi\epsilon\epsilon_0 r^2}$$

bunda q_1 va q_2 lar jismlarning elektr zaryadlari, r -ular orasidagi masofa, ϵ -muhitning dielektrik singdiruvchanligi, ϵ_0 elektr doimiysi bo'lib, u $\epsilon_0 = 8.85 \cdot 10^{-12} \text{ F/m}$ ga teng.

- Kulon qonunini ifodalovchi tenglamadagi barcha o'zgarmas kattaliklar uchun quyidagicha belgilash kiritamiz:

$$k = \frac{1}{4\pi\epsilon_0}$$

Unga ko'ra $k = 9 \cdot 10^9 \text{ Nm}^2 / \text{C}^2$. Bundan Kulon qonuni

$$F = k \frac{q_1 q_2}{\epsilon r^2}$$

ko'rinishga keladi.

- Ixtiyoriy ikkita zaryadning o'zaro ta'sir potensial energiyasini umumiy holda quyidagi ko'rinishda yozish mumkin:

$$W_p = \frac{1}{4\pi\epsilon\epsilon_0} \frac{q_1 q_2}{r} = k \frac{q_1 q_2}{r^2}$$

Masala yechish namunalari

1. Havoda bir-biridan qanday masofada 1 mkC va 10 nC zaryadlar 9 mN kuch bilan o'zaro tasirlashadi.

Berilgan: $q_1 = 1\text{ mkC}$, $q_2 = 10\text{ nC}$, $F = 9\text{ mN}$, $\varepsilon = 1$

Topish kerak: $r - ?$

Yechilishi: Kulon qonuniga ko'ra $F = k \frac{q_1 q_2}{\varepsilon r^2}$, bundan $r^2 = k \frac{q_1 q_2}{\varepsilon F}$ yoki

$r = \sqrt{k \frac{q_1 q_2}{\varepsilon F}}$ dan r ni hisoblasak, $r = 10\text{ sm}$ kelib chiqadi. Javobi: 10 sm .

2. Havoda bir-biridan $r_1 = 20\text{ sm}$ masofada joylashgan ikkita nuqtaviy zaryad o'zaro qandaydir kuch bilan ta'sirlashadi. Xuddi shunday kuch bilan moyda o'zaro ta'sirlashishi uchun ularni qanday r_2 masofaga joylashtirish kerak? Havo uchun muhitning dielektrik singdiruvchanligi $\varepsilon_1 = 1$ va moy uchun $\varepsilon_2 = 5$ deb oling.

Berilgan: $F_1 = F_2$, $\varepsilon_1 = 1$, $\varepsilon_2 = 5$, $r_1 = 20\text{ sm}$

Topish kerak: $r_2 - ?$

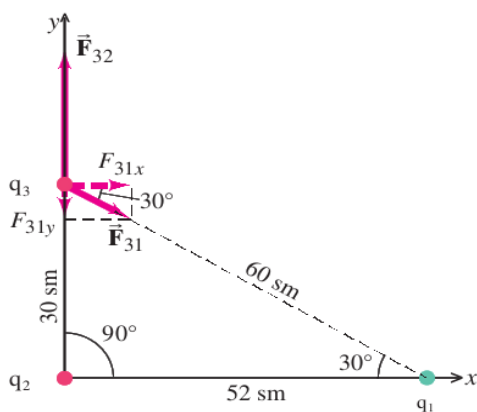
Yechilishi: Zaryadlarning havoda o'zaro ta'sir kuchi $F_1 = k \frac{q_1 q_2}{\varepsilon_1 r_1^2}$ kabi

aniqlanadi, zaryadlarning moydagi o'zaro ta'sir kuchi esa $F_2 = k \frac{q_1 q_2}{\varepsilon_2 r_2^2}$ ga teng.

Masala shartiga ko'ra $F_1 = F_2$ bo'lni uchun $k \frac{q_1 q_2}{\varepsilon_1 r_1^2} = k \frac{q_1 q_2}{\varepsilon_2 r_2^2}$, bundan

$r_2^2 = \frac{\varepsilon_1 r_1^2}{\varepsilon_2}$ yoki $r_2 = \sqrt{\frac{\varepsilon_1 r_1^2}{\varepsilon_2}}$. Javobi: 9 sm .

3. 1-rasmdan foydalangan holda $q_1 = 8.6 \cdot 10^{-5}\text{ C}$ va $q_2 = 5 \cdot 10^{-5}\text{ C}$ zaryadlarning $q_3 = 6.5 \cdot 10^{-5}\text{ C}$ zaryadga ta'sir etuvchi natijaviy kuchni aniqlang.



1-rasm

Yechilishi:

$$F_{31} = k \frac{q_1 q_3}{r_{31}^2} = \frac{9 \cdot 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2 \times 6.5 \cdot 10^{-5} \text{ C} \times 8.6 \cdot 10^{-5} \text{ C}}{(0.6 \text{ m})^2} = 140 \text{ N}$$

$$F_{32} = k \frac{q_2 q_3}{r_{32}^2} = \frac{9 \cdot 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2 \times 6.5 \cdot 10^{-5} \text{ C} \times 5.0 \cdot 10^{-5} \text{ C}}{(0.3 \text{ m})^2} = 325 \text{ N}$$

Endi kuchlarning x o'qiga proyeksiyasini topamiz:

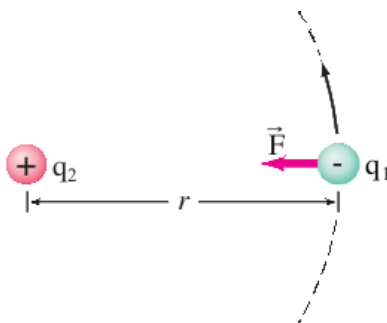
$$F_{31x} = F_{31} \cos 30^\circ = 140 \text{ N} \cdot \cos 30^\circ = 120 \text{ N} \quad F_{31y} = -F_{31} \sin 30^\circ = -140 \text{ N} \cdot \sin 30^\circ = -70 \text{ N}$$

demak, $F_x = F_{31x} = 120 \text{ N}$, $F_y = F_{32} + F_{31y} = 325 \text{ N} - 70 \text{ N} = 255 \text{ N}$.

$$\text{Natijaviy kuchni hisoblasak, } F = \sqrt{F_x^2 + F_y^2} = \sqrt{(120 \text{ N})^2 + (255 \text{ N})^2} = 280 \text{ N}$$

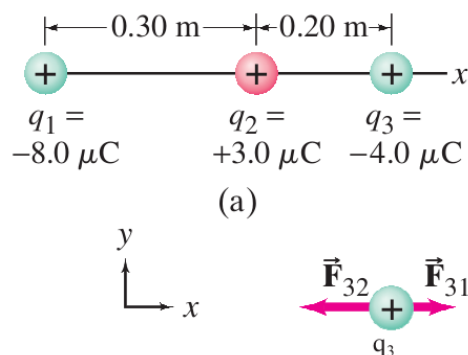
Mustaqil yechish uchun masalalar:

1. Vodorod atomining yadrosi bilan elektroni orasidagi tortishish kuchi topilsin (2-rasm). Vodorod atomining radiusi $0.5 \cdot 10^{-8} \text{ m}$, yadro zaryadi elektron zaryadiga miqdor jihatdan teng va qarama-qarshi ishorali ($F = 9.23 \cdot 10^{-8} \text{ N}$).



2-rasm

- Bir-biridan $r_1 = 5\text{ sm}$ masofada turgan ikkita zaryad havo ($\varepsilon_1 = 1$) da o'zaro $F_1 = 120\text{ mkN}$ kuch bilan, ma'lum bir elektr o'tkazmaydigan suyuqlikda esa $r_2 = 10\text{ sm}$ masofada o'zaro $F_2 = 15\text{ mkN}$ kuch bilan ta'sirlashadi. Suyuqlikning dielektrik singdiruvchanligi nimaga teng? ($\varepsilon_2 = 2$).
- Ikkita nuqtaviy zaryad o'zaro ta'sir kuchining ular orasidagi masofaga bog'lanish grafigi chizilsin. Grafik $2 \leq r \leq 10\text{ sm}$ intervalda 2 sm oraliq bilan chizilsin. Zaryadlar miqdori mos ravishda $2 \cdot 10^{-8}\text{ C}$ va $3 \cdot 10^{-8}\text{ C}$.
- Ikkita protonning Nyuton tortishish kuchi ularning Kulon itarishish kuchidan necha marta kichik? Protonning zaryadi miqdor jihatdan elektron zaryadiga teng ($1.25 \cdot 10^{36}$ marta).
- Natriy atomini bombardimon qilayotgan proton va uning yadrosiga $6 \cdot 10^{-12}\text{ sm}$ gacha yaqin keldi deb hisoblab, proton bilan natriy yadrosining elektrostatik itarishish kuchi topilsin. Natriy yadrosining zaryadi proton zaryadidan 11 marta ko'p. Natriy atomi elektron qobig'ining ta'siri hisobga olinmasin ($F = 0.7\text{ N}$).
- Rasmda tasvirlangan uchta zaryaddan uchinchi zaryadga ta'sir qiluvchi natijaviy kuchni aniqlang (3-rasm), ($F = 0.5\text{ N}$).



3-rasm

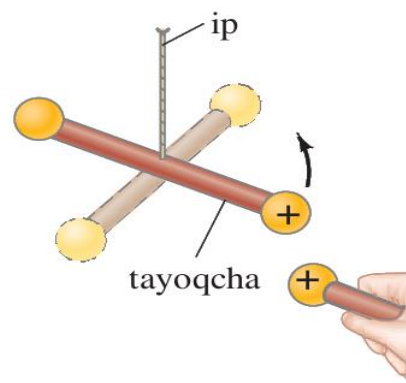
- Har birining og'irligi 0.2 kG bo'lgan ikkita zaryadlangan metal sharcha bir-biridan biror oraliqda turibdi. Agar shu oraliqda ularning elektrostatik energiyasi o'zaro gravitatsion ta'sir energiyasidan million marta kattaligi ma'lum bo'lsa, sharchaning zaryadi topilsin ($q = 1.7 \cdot 10^{-8}\text{ C}$).
- Zaryadi q va massasi m bo'lgan ikkita zarrachaning elektrostatik o'zaro ta'sir energiyasi ularning gravitatsion o'zaro ta'sir energiyasidan necha marta katta?

Masalani: 1) elektronlar uchun, 2) protonlar uchun yeching

$$\left(\frac{W_{el}}{W_{gr}} = 4.17 \cdot 10^{42}, \frac{W_{pr}}{W_{gr}} = 1.24 \cdot 10^{36} \right).$$

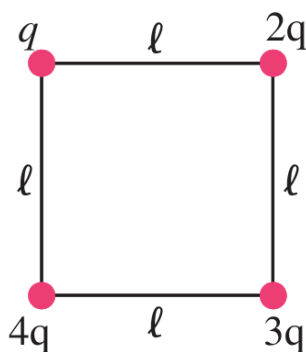
9. Biri ikkinchisidan 4 marta katta bo'lgan zaryad havoda bir-biridan 5sm masofada turibdi va 18 dina kuch bilan o'zaro itarishmoqda. Bu zaryadlar qanday masofada 8 dina kuch bilan ta'sirlashadi? Zaryadlar miqdori aniqlang ($q_1 = 14nC, q_2 = 3.5nC, r_2 = 7.5sm$).
10. Massasi $m = 3 \cdot 10^{-3} kg$, zaryadi $q_1 = 2 \cdot 10^{-8} C$ bo'lgan sharcha havo ($\varepsilon = 1$) da tok o'tkazmaydigan ingichka ipga osilgan. Agar sharchadan pastga $r = 0.1m$ masofada ikkinchi $q_2 = -1.5 \cdot 10^{-7} C$ zaryad joylashtirilgan bo'lsa, ipning taranglik kuchini toping. Og'irlik kuchining tezlanishini $g = 9.81 m/s^2$ deb oling ($32.1N$).
11. Og'irligi $980 mkN$, zaryadi $q = 20 nC$ bo'lgan sharcha havo ($\varepsilon = 1$) da ingichka ipak ipga osilgan. Ipning taranglik kuchi ikki marta kamayishi uchun pastga bu zaryadga ishorasi va miqdori bir xil bo'lgan boshqa bir zaryadni qanday masofaga joylashtirish lozim? ($8.57 sm$).
12. Uzunligi $l = 20 sm$ bo'lgan iplarga osilgan ikkita bir-xil sharcha bir-biriga tegib turibdi. Sharchalarga umumiy $q_0 = 0.4 mkC$ zaryad berilgandan keyin, ular bir-biridan shunday uzoqlashganki, bunda iplar orasidagi burchak $\alpha = 60^\circ$ ni tashkil etgan. Har bir sharchaning massasini toping ($1.59g$).
13. Uzunligi $l = 1m$ li ipak iplarga osilgan, har birining massasi $m = 0.25g$ dan bo'lgan, bir xil zaryadlangan ikkita sharcha havo ($\varepsilon = 1$) da bir-biridan $r = 6sm$ ga uzoqlashgan. Har bir sharchaning zaryadi nimaga teng? ($q = 5.4nC$).
14. Har birining uzunligi $60 sm$ dan bo'lgan ikkita ipak ipga massalari $0.42g$ bo'lgan ikkita sharcha osilgan. Bu iplarning bir uchi bitta nuqtaga mahkamlangan bo'lib ikkinchi uchiga mahkamlangan sharlar bir xilda zaryadlanib suvga tushirilgan. Agar sharlar itarishish kuchi tufayli bir-biridan $6sm$ uzoqlashgan bo'lsa ularda qancha zaryad bor? Suv uchun $\varepsilon = 81$ ga teng ($q = 79.6 nC$).

15. Bir-biridan 5 sm masofada turgan ikkita zaryad $\varepsilon_1 = 1$ bo'lgan muhitda 120 mN kuch bilan ta'sirlashmoqda, boshqa muhitda 10 sm masofada 15 mN kuch bilan ta'sirlashmoqda. ε_2 ni toping ($\varepsilon_2 = 2$).



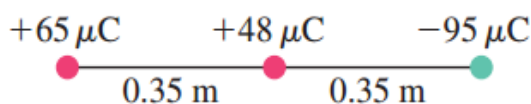
4-rasm

16. Kulon qonunidagi (4-rasm) proporsionallik koeffitsiyentini aniqlashda ishlatilgan Kulon tarozisi ishlash prinsipini tushintiring.
17. Tomonining uzunligi l bo'lgan kvadrat uchlariga q , $2q$, $3q$ va $4q$ zaryadlar joylashtirilgan. $2q$ zaryadga ta'sir qiluvchi kuch kattaligini va yo'nalishini toping (5-rasm), $(10.1 \cdot k \frac{q}{l^2}, 61^\circ)$.



5- rasm

18. Qiymatlari $+65 \mu\text{C}$, $+48 \mu\text{C}$ va $-95 \mu\text{C}$ bo'lgan zaryadlangan zarrachalar bir to'g'ri chiziqli joylashgan. O'rtadagi zarracha qolgan ikki zarrachadan bir xil 0.35 m masofada joylashgan. Har bir zarraga boshqa ikki zarraning ta'sir kuchini toping (6- rasm), $(120 \text{ N}, 560 \text{ N}, 450 \text{ N})$.



6- rasm