

EXCEL DASTURIDAN FOYDALANIB ELEKTR MAYDONNI ANIQLASH

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Annotatsiya: Excel dasturi asosid elektr maydon kuchlanganligi va potensialning o'zgarishini masofaga bog'liqligini xisoblash orqali talabalarga tushuntirib berish.

Kalit so'zi: Xalqa, kuchlanganlik vektori, potenciallar farqi, elektrostatik maydon, superpozitsiya prinsipi.

Аннотация: Объясните учащимся, что Excel основан на расчете напряженности электрического поля и изменения потенциала в зависимости от расстояния.

Ключевые слова: кольцо, вектор напряжения, разность потенциалов, электростатическое поле, принцип суперпозиции.

Annotation: Explain to students that Excel is based on calculating the electric field strength and potential change as a function of distance.

Keywords: Ring, voltage vector, potential difference, electrostatic field, superposition principle.

Radiusi R bo'lgan zaryadlangan xalqa o'qi bo'ylab, xalqa markazidan L masofada yotuvchi A nuqtadagi elektr maydon kuchlanganligi va potensialini aniqlash uchun superpozitsiya prinsipidan foydalaniladi.

Avvalo, xalqani n ta kichik dl elementlarga ajratamiz: $l = \sum_{i=1}^n dl_i$ (1). Har bir dl elementga to'g'ri keladigan zaryad dq bo'lsin. Bu zaryadning A nuqtadagi $d\vec{E}$ kuchlanganlik vektori dl element bilan A nuqtani tutashtiruvchi r chiziq bo'ylab yo'nalgan. Butun xalqaning A nuqtadagi elektr maydon kuchlanganligini topish uchun barcha dl elementlarning $d\vec{E}$ vektorlarini geometrik qo'shish lozim. $d\vec{E}$ vektorni ikkita tashkil etuvchiga ajratamiz: 1) gorizontal tashkil etuvchisi $dE_x = dE \cos \alpha$; 2) vertikal tashkil etuvchisi $dE_y = dE \sin \alpha$. Har bir diametral qarama-qarshi ikki elementning dE_y tashkil etuvchilari bir birini so'ndiradi, ya'ni vertikal yo'nalish bo'yicha natijaviy maydon kuchlanganligi nolga teng bo'ladi ($E_y = 0$). Shuning uchun umumiy maydon kuchlanganligi gorizontal tashkil etuvchilarning yig'indisidan iborat bo'ladi: $E = E_x$; $E = \sum_{i=1}^n dE_{x_i}$ (2). Zaryadning xalqa bo'ylab uzluksiz taqsimlanganligini e'tiborga olib, (2) ni integral ko'rinishda yozamiz: $E = \int dE_x = \int dE \cos \alpha$ (3). dl elementning A nuqtadagi elektr maydon kuchlanganligi $dE = k \frac{dq}{r^2}$ (4). Chizmaga ko'ra $\frac{L}{r} = \cos \alpha$ ni hisobga olib, (4) ni

$dE \cos \alpha = k \frac{L \cdot dq}{r^3}$ (5) ko‘rinishda yozamiz. (5) asosida (3) integralni hisoblash orqali

natijaviy elektr maydon kuchlanganligini topamiz: $E = k \frac{L}{r^3} \int dq = k \frac{L \cdot q}{r^3}$ (6). Agar r

masofani R va L masofalar orqali ifodalasak, $r = \sqrt{R^2 + L^2}$ (7). (6) formulani quyidagi

ko‘rinishda yozib olamiz: $E = k \frac{L \cdot q}{r^2 \cdot r}$ (8) yoki $E = k \frac{L \cdot q}{(R^2 + L^2) \cdot \sqrt{R^2 + L^2}} = k \frac{L \cdot q}{(R^2 + L^2)^{3/2}}$

(9). (9) formula xalqa o‘qida yotuvchi A nuqtadagi elektr maydon kuchlanganligini ifodalaydi.

(9) formulaning bir necha xususiy hollarini qarab chiqamiz: 1) Agar $L \gg R$ bo‘lsa, katta masofalarda zaryadlangan xalqani nuqtaviy zaryad sifatida qarash mumkin, u holda (9) ni $E = k \frac{q}{L^2}$ (10) ko‘rinishda yozamiz; 2) Agar $L=0$ bo‘lsa, ya’ni

xalqaning markazida $E=0$ bo‘ladi; 3) Qanday L_m masofada elektr maydon kuchlanganligi eng katta (**maksimum**) bo‘ladigan nuqtani topishga urinib ko‘raylik. Buning uchun r va L kattaliklarni α burchak orqali ifodalaymiz: $R = r \sin \alpha$ $L = r \cos \alpha$

$$(11) E = k \frac{q}{R^2} \cos \alpha \sin^2 \alpha \quad (12).$$

Elektr maydon kuchlanganligining maksimal qiymatini topish uchun Ye dan α bo‘yicha hosila olinib, bu hosilani nolga tenglash lozim: $\frac{dE}{d\alpha} = 0$ (13) ya’ni

$$\frac{dE}{d\alpha} = k \frac{q}{R^2} (\cos^2 \alpha \cdot 2 \sin \alpha - \sin^3 \alpha) = 0 \quad (14) \text{ bundan } \cos^2 \alpha \cdot 2 \sin \alpha = \sin^3 \alpha \quad 2 \cos^2 \alpha = \sin^2 \alpha$$

$$2 = \operatorname{tg}^2 \alpha \quad (15). \text{ Chizmaga asosan } \frac{R}{L} = \operatorname{tg} \alpha; \quad \frac{R^2}{L^2} = \operatorname{tg}^2 \alpha; \quad L_m = \frac{R}{\sqrt{2}} \quad (16) \text{ demak, elektr}$$

maydon kuchlanganligining maksimal qiymati L_m masofadagi nuqtada bo‘lar ekan. U

$$\text{holda (9) formulani boshqacha ko‘rinishda yozamiz: } E_m = k \frac{L_m \cdot q}{(2L_m^2 + L_m^2)^{3/2}} = k \frac{L_m \cdot q}{(3L_m^2)^{3/2}}$$

$$(17); \quad E_m = k \frac{q}{5,196 L_m^2} \quad (18) \text{ } L_m \text{ masofaning yarmiga teng (} L=0,5L_m \text{)}$$

masofada yotuvchi nuqtaning elektr maydon kuchlanganligi:

$$E = k \frac{L_m \cdot q}{2(2L_m^2 + \frac{L_m^2}{4})^{3/2}} = k \frac{L_m \cdot q}{2(\frac{9}{4}L_m^2)^{3/2}} \quad (19) \quad E = k \frac{L_m \cdot q}{2 \cdot 2,25^{3/2} L_m^3} = k \frac{q}{6,75 L_m^2} \quad (20). \quad (18) \text{ va } (20)$$

$$\text{ifodalarning nisbatini olamiz: } \frac{E_m}{E} = \frac{6,75}{5,196} = 1,3 \quad (21). \text{ Bundan ko‘rinadiki, } L=0,5L_m$$

masofadagi elektr maydon kuchlanganligi (Ye) maksimal elektr maydon kuchlanganligi (Ye_m) dan 1,3 marta kichik ekan.

4) Agar xalqa zaryadining chiziqli zichligi berilgan bo‘lsa, A nuqtadagi natijaviy potensialni ham topish mumkin. dl kichik elementning A nuqtadagi

$$\text{potensialni} \quad d\varphi = k \frac{dq}{r} \quad (22). \quad 2 \quad \tau = \frac{dq}{dl} \Rightarrow dq = \tau \cdot dl \quad (23) \text{ ni hisobga}$$

$$\text{olib, } d\varphi = k \frac{\tau \cdot dl}{r} \quad (24).$$

Butun xalqaning A nuqtadagi potensialini topish uchun esa integrallashdan foydalanamiz:

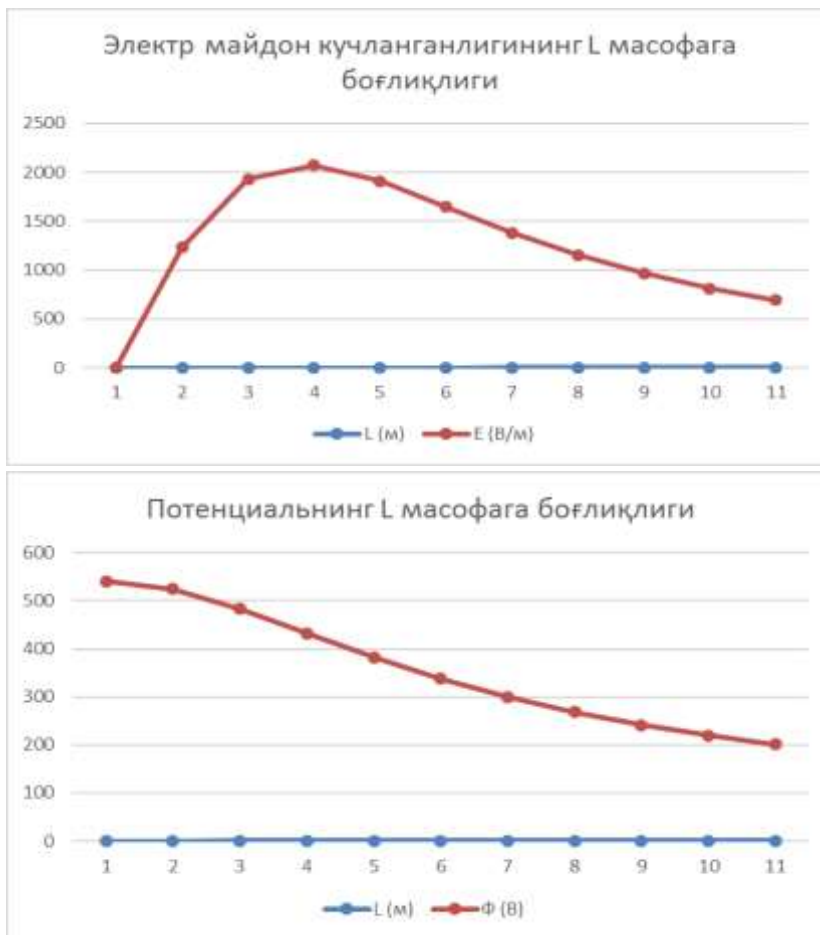
$$\varphi = \int d\varphi = k \frac{\tau}{\sqrt{R^2 + L^2}} \int_0^{2\pi R} dl \quad (25) \quad \varphi = k \frac{\tau \cdot 2\pi R}{\sqrt{R^2 + L^2}} \quad (26)$$

$\varphi = \frac{1}{4\pi\epsilon_0} \frac{\tau \cdot 2\pi R}{\sqrt{R^2 + L^2}} = \frac{\tau \cdot R}{2\epsilon_0 \sqrt{R^2 + L^2}} \quad (27)$. Bu formula xalqaning markazidan L masofadagi maydon potensialini hisoblashga imkon beradi.

L=0 bo'lgandagi, ya'ni xalqa markazidagi potensial quyidagi ko'rinishda bo'ladi: $\varphi = \frac{\tau}{2\epsilon_0} \quad (28)$. Shuni alohida ta'kidlash lozimki, potensialning ishorasi faqat elektrostatik maydon manbai bo'lgan zaryadning ishorasi bilan aniqlanar ekan.

Quyida (9) va (27) formulalar asosida elektr maydon kuchlanganligi va potensialni Excel dasturidan foydalanib hisoblaymiz va grafik ko'rinishida tasvirlaymiz:

| A | B | C | D | E | F | G | H | I | J |
|----|----------|----------|-------|--------------|-------|--------------|---------|---------|-------|
| № | k | q (KI) | R (m) | stepen (R;2) | L (m) | stepen (L;2) | (E9+G9) | E (B/m) | F (V) |
| 1 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0 | 0 | 0,01 | 0 | 540 |
| 2 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,025 | 0,000625 | 0,01063 | 1232,7 | 523,9 |
| 3 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,05 | 0,0025 | 0,0125 | 1932,0 | 483,0 |
| 4 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,075 | 0,005625 | 0,01563 | 2073,6 | 432,0 |
| 5 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,1 | 0,01 | 0,02 | 1909,2 | 381,8 |
| 6 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,125 | 0,015625 | 0,02563 | 1645,5 | 337,3 |
| 7 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,15 | 0,0225 | 0,0325 | 1382,5 | 299,5 |
| 8 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,175 | 0,030625 | 0,04063 | 1154,1 | 267,9 |
| 9 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,2 | 0,04 | 0,05 | 966,0 | 241,5 |
| 10 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,225 | 0,050625 | 0,06063 | 814,0 | 219,3 |
| 11 | 9,00E+09 | 6,00E-09 | 0,1 | 0,01 | 0,25 | 0,0625 | 0,0725 | 691,6 | 200,6 |



Foydalanilgan adabiyotlar

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