TURBO
Continuous change

دفتر :

فيــزيــاء 2

physics 2

الاسبوع (6)

إعــداد
بتول مصلح للدكتور: غسان

اللجنة الأكاديمية لقسم الهندسة الصناعية

2025

TurboIEG.Com

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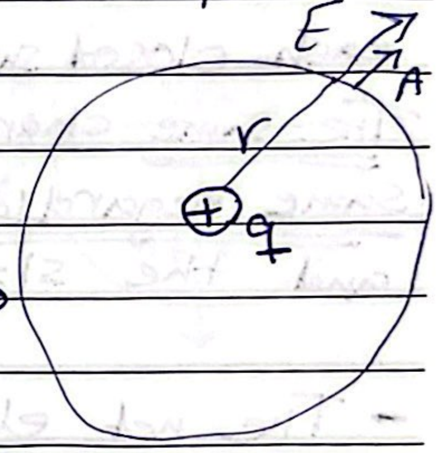
example: electric field due to a point charge q



$$\oint \bar{E} \cdot d\bar{A} = \frac{q_{in}}{\epsilon_0}$$

$$\oint E\, dA = \frac{q}{\epsilon_0}$$

Gauss's surface

$$E \oint dA = \frac{q}{\epsilon_0}$$

$$E\, 4\pi r^2 = \frac{q}{\epsilon_0} \rightarrow E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} = \frac{Kq}{r^2}$$

example: electric field due to a thin sphyrical shell of radious a and uniformally charge Q

ⓐ inside the shell $(r<a)$

$$\oint \bar{E}_{in} \cdot d\bar{A} = \frac{q_{in}}{\epsilon_0} = \text{Zero}$$

$$\bar{E}_{in} = 0$$

ⓑ outside the shill $(r>a)$

$$\oint \bar{E}_{out} \cdot dA = \frac{q_{in}}{\epsilon_0}$$

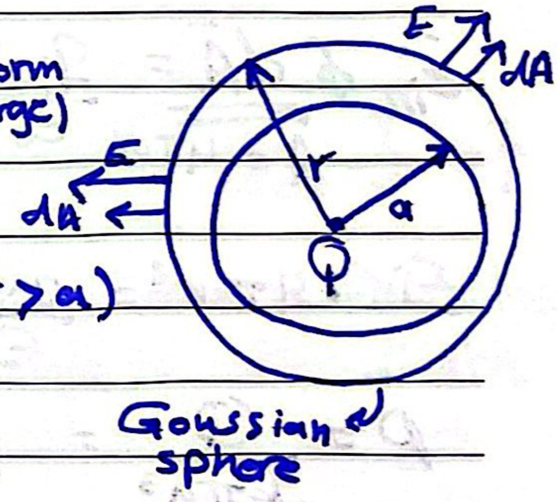
$$E_{out}(4\pi r^2) = \frac{Q}{\epsilon_0} \quad E_{out} = \frac{KQ}{r^2}$$

Gauss's law

$$\Phi_0 = \oint \bar{E}\cdot d\bar{A} = \frac{q_{in}}{\epsilon_0}$$

Ex. 24.3 $\rightarrow$ uniform charged solid insulating sphere of radius a and total charge Q

$$\rho = \frac{Q}{\frac{4}{3}\pi a^3} = \text{const (uniform charge)}$$



A) Outside the sphere $(r > a)$

$$\oint \bar{E}_{out}\cdot d\bar{A} = \frac{q_{in}}{\epsilon_0}$$

$$\oint E_{out}\, d\bar{A} = \frac{q_{in}}{\epsilon_0}$$

$$E_{out}\oint d\bar{A} = \frac{q_{in}}{\epsilon_0} \rightarrow E_{out}\cdot 4\pi r^2 = \frac{Q}{\epsilon_0}$$

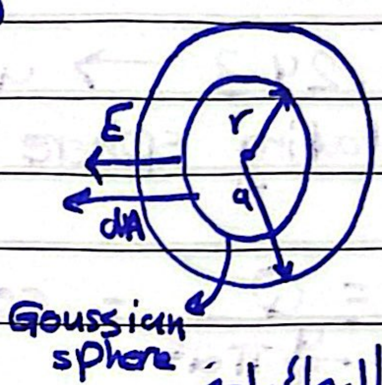
$$E_{out} = \frac{Q}{4\pi r^2\epsilon_0} = \frac{KQ}{r^2} \rightarrow$$ مجال خارج كرة مشحونة بشحنة منتظمة

كأنها point charge موجودة بالمركز بالتالي بتصير الكرة زي ال point charge

"يتبع"

B المشكلة بتصير جوا الكرة وهو المطلوب

inside the sphere $(r<a)$



و المجال والمساحة متوازيات

$$\oint \vec{E}_{in} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

$$E_{in} \underbrace{\oint d\vec{A}}_{A = 4\pi r^2} = \frac{q_{in}}{\epsilon_0}$$

$$E_{in} \cdot 4\pi r^2 = \frac{q_{in}}{\epsilon_0}$$

$$\rho = \frac{Q}{\frac{4}{3}\pi a^3} = \frac{q_{in}}{\frac{4}{3}\pi r^3}$$

$$q_{in} = \frac{Q r^3}{a^3}$$

$$\rightarrow E_{in} \cdot 4\pi r^2 = \frac{Q r^3}{\epsilon_0 a^3}$$

$$E_{in} = \frac{1}{4\pi\epsilon_0} \frac{Q r}{a^3}$$

$$E_{in} = \frac{k Q r}{a^3}$$

نتيج

ex: 24.4 موجود رسمة الـ في الدقيقة 18:00

$EA = \frac{q_{in}}{\epsilon_0}$ الشحنة الي موجودة بالداخل

$q_{in} = \lambda L$

$EA = \frac{\lambda L}{\epsilon_0}$

$E(2\pi r \cancel{L}) = \frac{\lambda \cancel{L}}{\epsilon_0} \longrightarrow E = \frac{\lambda}{2\pi\epsilon_0 r}$ $E = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r} \times \frac{2}{2}$

$E = \frac{2\lambda}{4\pi\epsilon_0 r} \longrightarrow E = \frac{2k\lambda}{r}$ → Electric field due to aline charge of infinit lingth

ex: 24.5 الـ رسمة في الدقيقة 25:31

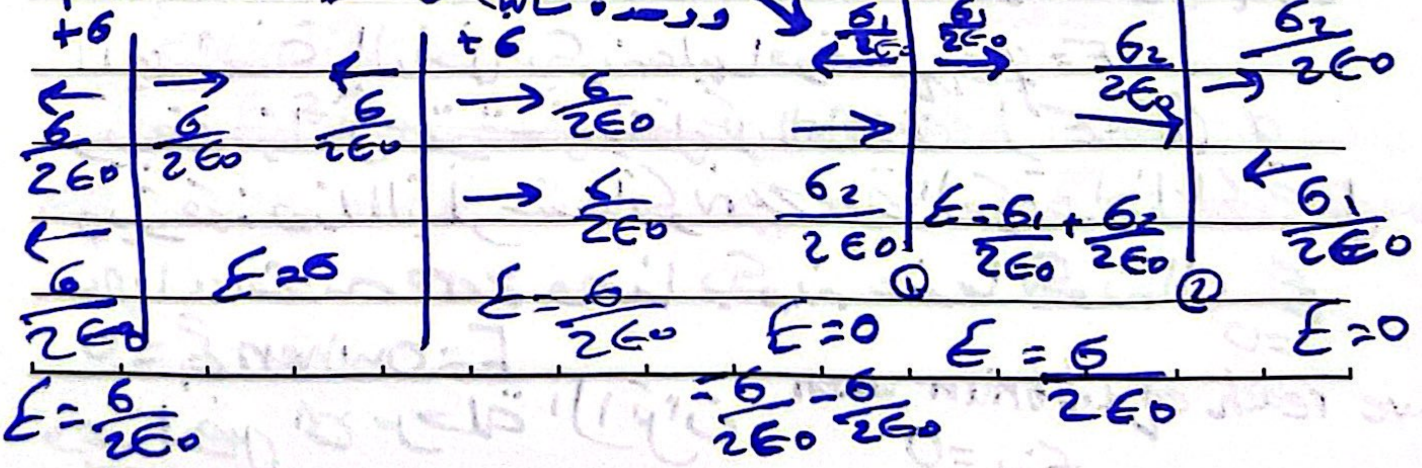
$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$

$EA + EA = \frac{\sigma A}{\epsilon_0} \longrightarrow 2E\cancel{A} = \frac{\sigma \cancel{A}}{\epsilon_0}$

لأنه جسم غير ناقل

$E = \frac{\sigma}{2\epsilon_0}$ → electric field due to anon conducting sheet of infinite extent

problem 56



conductors in electrostatic equilibrium:

electrostatic equilibrium :- تعني انه التيار zero

وهذا يعني اننا اذا أخذنا اي مقطع من الموصل

يكون كمية الشحنات اللي بتروح لليسار نفس

كمية الشحنه اللي بتروح لليمين

= No net motion of charge

properties of conductors in electrostatic equilibrium.

1) $E_{in} = 0$ (inside the conductor)

ليه؟ اذا كان عنا موصل موجود داخل مجال كهربائي

خارجي E هذا المجال حيأثر على اي شحنه جوا

اذا كانت موجبة رح يأثر عليها بقوة لليمين (مع اتجاه

المجال) واذا كانت سالبة عكس اتجاه المجال

فبتراكم الموجب على اليمين وتتراكم السالب على اليسار

فبتكون مجال كهربائي اخر داخل الموصل بسبب التراكمات

ومحصلة المجال الداخلي والخارجي هي بالتالي

$E_{in} = E - E'$ → الداخلي

اي شحنة بالداخل بيكون عليها قوة $F = qE_{in}$

$q(E - E')$ ~~ويبقى يتأثر بقوة بينقل كل الشحنات~~

ويتوقف هذا التيار عندما تكون محصلة القوة داخل الموصل

على اي شحنه zero وهذا يكون عندما يكون ال $E = 0$

$F = 0$ when $E_i = 0$

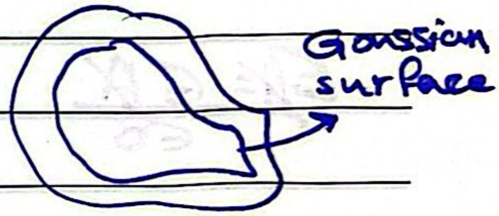
we reach equilibrium when $E_{in} = 0$

وهنا نصل الى مرحلة الاتزان

② if an isolated conductor is charge (مشحون) then the charge reside on its surface.

ويمكننا فحصها من الخاصية اللي قبلها انه المجال داخل الموصل zero

$$\oint E_{in} \cdot dA = \frac{q_{in}}{\epsilon_0}$$



$q_{in} = 0$

→ the charge reside on the surface

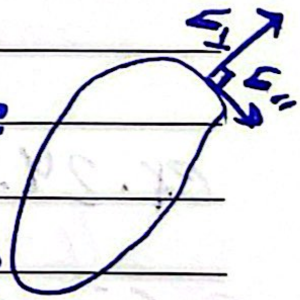
③ Just outside of the conductor

a) $\bar{E} \perp$ surface

b) $E = \frac{\sigma}{\epsilon_0}$

a) let $\bar{E}$ is not normal to the surface

→ $E_{\parallel}$ affect a force of $q\bar{E}_{\parallel}$ parallel to the surface



→ there is net motion of charge parallel to the surface

→ the conductor is not in electrostatic equilibrium

→ for the conductor to be in electrostatic eq we must have $E_{\parallel} = 0$ → $\bar{E} \perp$ surface

شرح

b) apply Gauss's low

$$\oint \bar{E} \cdot d\bar{A} = \frac{q_{in}}{\epsilon_0}$$

$$EA + E_n A = \frac{\sigma A}{\epsilon_0}$$

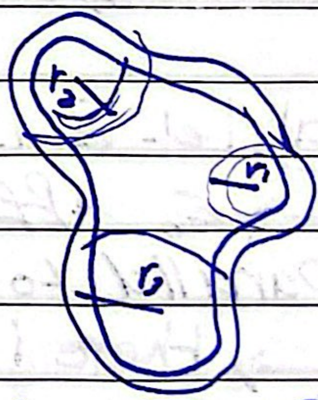
$$E\cancel{A} = \frac{\sigma \cancel{A}}{\epsilon_0} \qquad \boxed{E = \frac{\sigma}{\epsilon_0}}$$

4] on an irregularlly shaped conductor σ and $\bar{E}$ are large where the redius of curvature is small

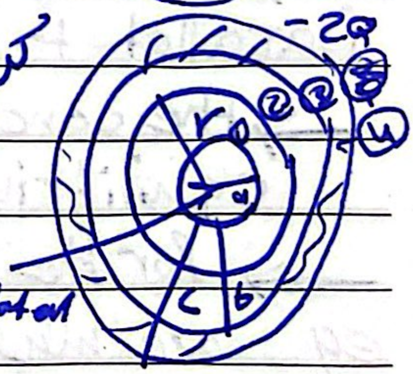
$r_1 < r_2 < r_3$

$\sigma_1 > \sigma_2 > \sigma_3$

$E_1 > E_2 > E_3$



ex. 24.7 كرة عازلة محاطة بقشرة معدنية



ⓐ $\oint \bar{E} \cdot dA = \frac{q_{in}}{\epsilon_0}$

$r < a$

$$\oint \bar{E} \cdot dA = \frac{q_{in}}{\epsilon_0}$$

$$E_1(4\pi r^2) = \frac{q_{in}}{\epsilon_0}$$

$$\rho = \frac{Q}{\frac{4}{3}\pi a^3} = \frac{q_{in}}{\frac{4}{3}\pi r^3} \qquad q_{in} = \frac{Q r^3}{a^3}$$

$$E_1(4\pi r^2) = \frac{Q r^3}{\epsilon_0 a^3} \qquad E_1 = \frac{K Q r}{a^3}$$

ربيع

(2) $a < r < b$

$$\oint \bar{E}_2 \cdot dA = \frac{q_{in}}{\epsilon_0}$$

$$E_2 (4\pi r^2) = \frac{Q}{\epsilon_0}$$

$$E_2 = \frac{KQ}{r^2}$$

(3) $b < r < c$

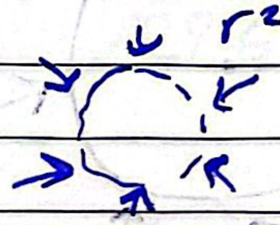
$E = 0$ inside the conductor

(4) $c < r$

$\oint \bar{E}_4 \cdot dA = \frac{q_{in}}{\epsilon_0}$ Gauss مناخذ سطح *

$$E_4 (4\pi r^2) = -\frac{Q}{\epsilon_0}$$

$E_4 = -\frac{KQ}{r^2}$ ومعنا الناقص انه المجال على سطح Gauss صيك اتجاهه ←



لو سألنا هاي الشحنه $-2Q$ كم منها على السطح الخارجي وكم على السطح الداخلي سميه q' الخارجي و الداخلي q''

$$q' + q'' = -2Q$$

$E_3 = 0 \rightarrow \oint \bar{E}_3 \cdot dA = \frac{q_{in}}{\epsilon_0}$ $\boxed{q' = -Q}$

$$0 = \frac{q_{in}}{\epsilon_0}$$

$q_{in} = 0 \rightarrow q'' + Q = 0$

$q'' = -Q$ $q' + q'' = -2Q$

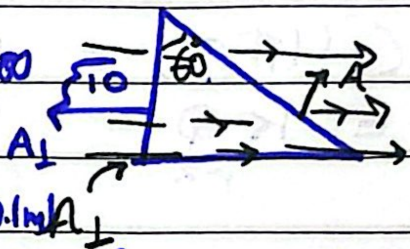
$q' - Q = -2Q$

"محاضرة "٩

problems 24.4 الرسمة في بداية المحاضرة
ولو بدنا نرسمة 2D

$E = 7.8 * 10^4 \ N/C$

a Flux $\Phi_{A_\perp} = E A_\perp \cos 180$



$-1 * (7.8 * 10^4) * (0.3m * 0.1m) A_\perp$

$= -3.34 * 10^3 \ N.m^2/C \quad -3.34 \ kNm^2/C$

b $\Phi_A = -\Phi_{A_\perp} = 3.34 * 10^3 \ N.m^2/C = 3.34 \ kN m^2/C$

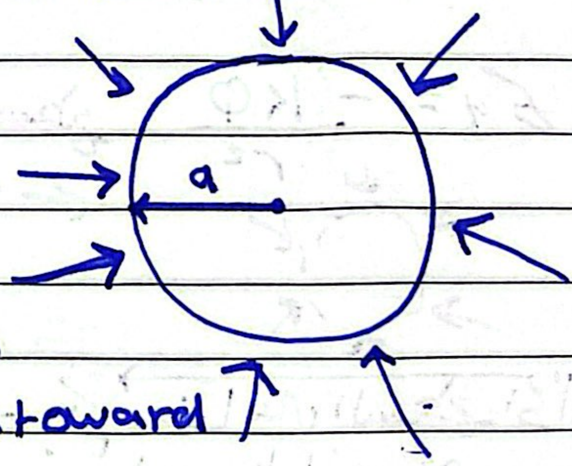
$\Phi_A = EA \cos 60$

$7 * 8 * 10^4 * (0.3m * 0.2m)(\frac{1}{2})$

$3.34 * 10^3 \ N.m^2/C$

$\Phi_{tot} = \Phi_A + \Phi_{A_\perp} = (0)$ zero

problem 24.10



$a = 0.75 \ m$

$E = 890 \ N/C$ at $r = a$
$= 0.75 m$

b Negative, Because E is toward the center

Because E = constant at the surface of the shell then the charge has spherical symmetric distributed concentric with the shell

"تبع"

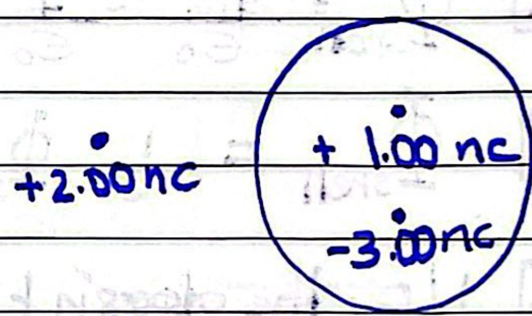
$\boxed{a}$ $E = \frac{K|Q|}{a^2}$

$Q = \frac{Ea^2}{K} = \frac{(890)(0.75)^2}{9*10^9}$

$|Q| = 5.57*10^{-8}\,c \qquad c = 55.7\,nc$

$Q = -55.7\,nc$

problem 24.8



$\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$

يعني الشحنة الي برا مابتهمني
لانه جسم مغلق *

$\Phi = \frac{q_{in}}{\epsilon_0}$

$= \frac{(1*10^{-9}c)+(-3*10^{-9}c)}{8.85*10^{-12}}$

$\Phi = -226\ N.m^2/c$

problem 24.11 → الرسمة في الدفينة 22:00

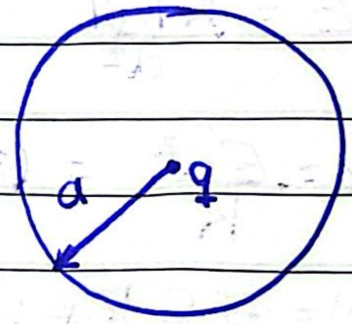
$\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$

$S_1: \Phi_1 = \frac{-2Q+Q}{\epsilon_0} = -\frac{Q}{\epsilon_0}$

$S_2: \Phi_2 = \text{zero}$

$S_3: -\frac{2Q}{\epsilon_0} \qquad S_4: \text{zero}$

$\boxed{\text{Problem}}$ 24.14



$q = 12\ \mu C$

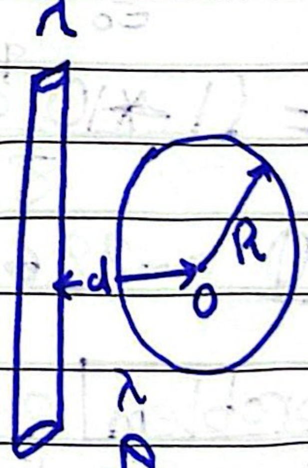
$a = 22\ cm = 0.22\ m$

$\boxed{a}$ $\Phi_{shell} = \frac{q_{in}}{\epsilon_0} = \frac{q}{\epsilon_0} = \frac{12 * 10^{-6}}{8.85 * 10^{-12}} = 1.36 * 10^{6}$ $N/m^2/c$

$\boxed{b}$ $\Phi_{shell} = \frac{1}{2} \Phi_{shell} = 6.78 * 10^{5}\ N.m^2/c$

$\boxed{c}$ No, the flux remains the same because it doesnt depart on the radius

$\boxed{\text{Problem}}$ 24.17



a) $R < d \rightarrow q_{in} = 0$

$\Phi = \frac{q_{in}}{\epsilon_0} = 0$

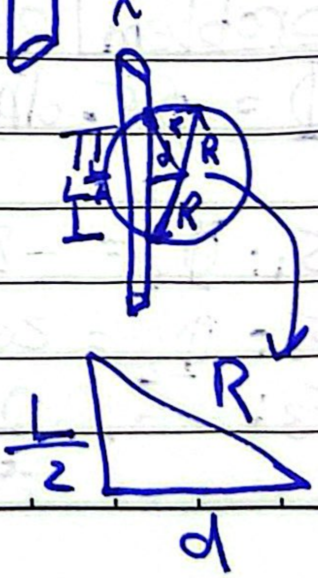
b) $R > d$

$\frac{L}{2} = \sqrt{R^2 - d^2}$

$L = 2\sqrt{R^2 - d^2}$

$q_{in} = \lambda L = 2\lambda\sqrt{R^2 - d^2}$

$\Phi = \frac{q_{in}}{\epsilon_0} = \frac{2\lambda\sqrt{R^2 - d^2}}{\epsilon_0}$



يتيح

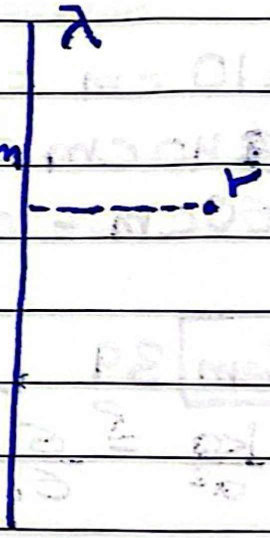
Problem 24.21 $\qquad$ 35:10 رسمتهالي لرقيقه

$\delta \longrightarrow 0$

a $\;\Phi_{\text{hemi-sphere}} = \frac{1}{2}\Phi_{\text{sphere}} = \frac{1}{2}\frac{Q}{\epsilon_0}$

b $\;\Phi_{\text{Flat}} = -\Phi_{\text{hemi-sphere}} = -\frac{Q}{2\epsilon_0}$

problem 24.24



$\lambda = -90\,\mu C/m = -90 * 10^{-6}\,C/m$

$E = \frac{2K\lambda}{r}$

a $\;r = 10\,cm = 0.1\,m$

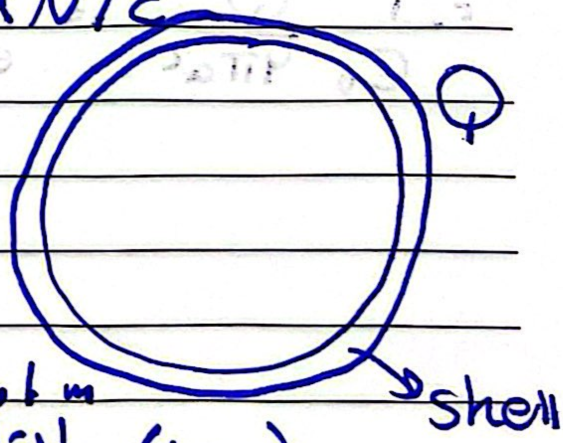
$E = \frac{2K\lambda}{r} = 16.2 * 10^{6}\,N/C$

$16.2\ \mu N/C$

b $\;r = 20\,cm = 0.2$

$E = \frac{2K\lambda}{r} = 8.09\ \mu N/C$

Problem 24.29



$a = 0.14\,m,\; Q = 32\,\mu C = 32 * 10^{-6}\,C$

$E_{in} = 0$

$E_{out} = \frac{KQ}{R^2}$

a $\;r = 10\,cm = .1\,m$

$E = E_{in} = 0$ بالتالي (جوا)

b $\;r = 20\,cm = 0.2\,m$ (برا)

$E = E_{out} = \frac{KQ}{r^2} = 7.19 * 10^{6}\,N/C$

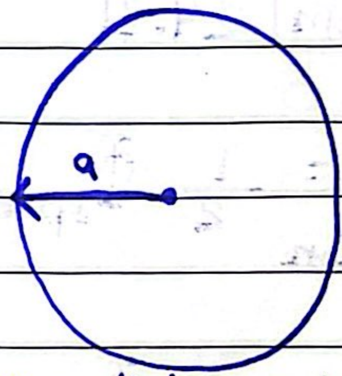
"شج"

$\boxed{\text{Problem}}$ 24.35

$a = 40\,cm \longrightarrow 0.4\ m$

$Q = 26\,\mu C = 26 \times 10^{-6}\,C$

$E_{in} = \frac{KQr}{a^3}$, $E_{out} = \frac{KQ}{r^2}$



$r = 0 \longrightarrow E = E_{in} = \frac{KQr}{a^3} = 0$ solid insulating sphere

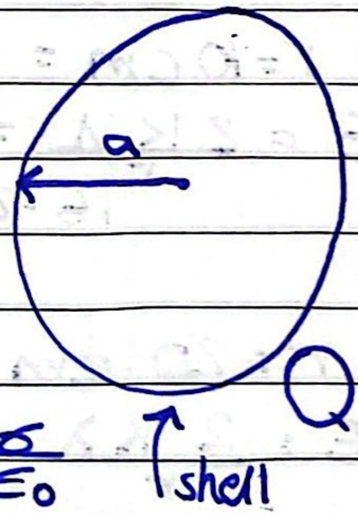
(b) $r = 10\ cm = 0.1\ m \rightarrow E = E_{in} = \frac{KQr}{a^3} = 365\,KN/C$

(c) $r = 40\ cm = 0.4\ m \rightarrow E = E_{out} = \frac{KQ}{r^2} = 1.46\,MN/C$

(d) $r = 60\,cm = 0.6\ m \Rightarrow E = E_{out} = \frac{KQ}{r^2} = 649\,KN/C$

$\boxed{\text{Problem}}$ 39

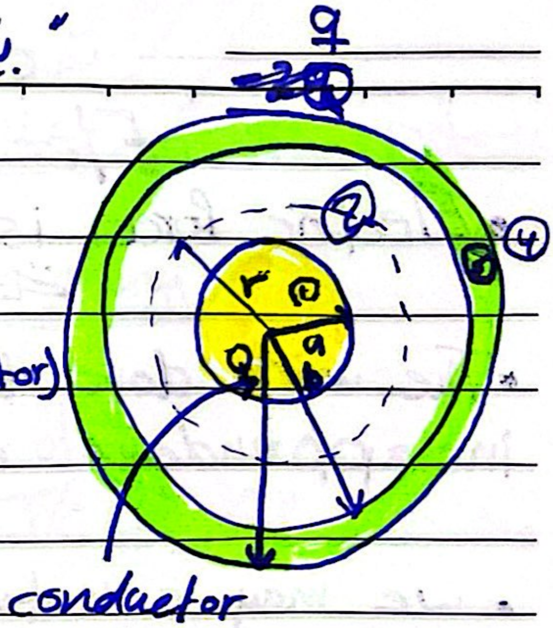
$E_{surface} = \frac{KQ}{a^2} \overset{?}{=} \frac{\sigma}{\epsilon_0}$ ✓ or $\frac{\sigma}{2\epsilon_0}$ ✗



$E_{surface} = \frac{KQ}{a^2} = \frac{1}{4\pi\epsilon_0}\frac{Q}{a^2}$

$= \frac{1}{\epsilon_0}\frac{Q}{4\pi a^2} = \frac{1}{\epsilon_0}\frac{Q}{A} = \frac{\sigma}{\epsilon_0}$

"نتيجة"



Problem 24.47

① $r<a$

$E_1 = 0$ (inside the conductor)

② $a<r<b$

$E_2 = \frac{KQ}{r^2}$

③ $b<r<c$

$E_3 = 0$ (inside the conductor)

④ $r>c$

$E_4 = K\frac{(q+Q)}{r^2}$

$q' + q'' = q$

$q'' = -Q$

$q' - Q = q$

$q' = Q + q$

ch.25

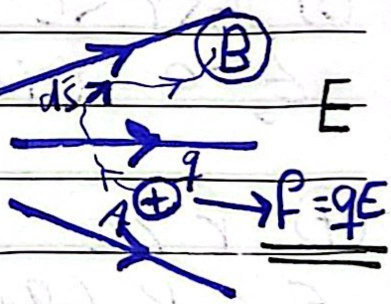
Electric potential

- Electric force is a conservative force
  الشغل لا يعتمد على المسافات

- The work done by the electric force is independent of the path

- we may construct a potential energy assosiated with the electric force

- the electric force on a charge q placed on the electric field $\vec{E}$ is $\vec{F} = q\vec{E}$



- The work done by the field on moving the charge q from point (a) to (B) is W

$$W = -\Delta U = \int_A^B \underbrace{\vec{F}}_{q\vec{E}} \cdot d\vec{s} = q\int_A^B \vec{E} \cdot d\vec{s}$$

لم محافظة

$$W = -\Delta U = -(U_B - U_A) = q\int_A^B \vec{E} \cdot d\vec{s}$$

$$\Delta U = U_B - U_A = -q\int_A^B \vec{E} \cdot d\vec{s}$$

$$\frac{\Delta U}{q} = \frac{U_B}{q} - \frac{U_A}{q} = -\int_A^B \vec{E}\, d\vec{s}$$

يتبع

Define the electric potential as the potential energy per unit charge

$V = \frac{U}{q} \rightarrow$ potinter energy

$\Delta V = V_B - V_A = -\int_A^B \bar{E} \cdot d\bar{s}$

SI unit of $V \rightarrow (V) \leftarrow J/C$ وحدة الجهد الكهربائي

$1\ V = 1(J/C)$

scaler ← محاضرة رقم "10"

$V = \frac{U}{q}$ definition of electric potention

جهد

$\Delta V = V_B - V_A = -\int_A^B E \cdot d\bar{s} \equiv$ potential difference

فرق الجهد

$\Delta U = q\ \Delta V$ U: potential energy

الفرق بين ال potential وال potential energy ؟

potential energy :- طاقة الوضع (U)

potential :- الجهد

comments

- $\Delta V = V_B - V_A = -\int_A^B \bar{E} \cdot d\bar{s}$ is independent of the pass B لـ A ما بتفرق الطريقة اللي حمشيها منه

- the electric potential V is scaler

ثمة

- the potential V is a characteristic of $\bar{E}$

- The potential V at a point is independent of the charge at that point

- any charge moves in an electric field it experianses a change in the potential
$$\Delta V = V_B - V_A = -\int_A^B \bar{E} \cdot d\bar{s}$$

- The work done by the field
$$w_{field} = -\Delta U = -q\,\Delta V$$

- The work done by an agent against the field is $w_{agent} = +\Delta U = q\Delta V$

- SI unit of potential is volte (V)
$$1\,(V) = 1\,(J/C)$$

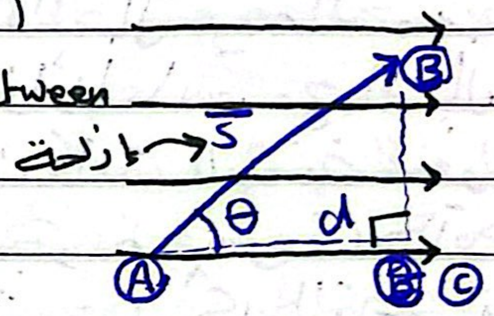
- SI unit of electric field V/m
$$V/m = N/C$$
$$\Delta V = -\int_A^B \bar{E} \cdot d\bar{s}$$

$$\boxed{\begin{array}{l} \Delta V = -\int_A^B \bar{E} \cdot ds \\ V = \frac{N}{C} \cdot m \\ V/m = N/C \end{array}}$$

potential in a uniform electric field

$\bar{E}$ = constant (uniform)

- The potential difference between (A) and (B)



$$V_B - V_A = -\int_A^B \bar{E} \cdot d\bar{s}$$

$$V_B - V_A = -\bar{E}\int_A^B ds = -\bar{E} \cdot S = -ES\cos\theta$$

يعني لما اكون داخل مجال كهربائي $\boxed{\text{منتظم}}$ ما في داعي اكامل بساطة $-\bar{E} \cdot \bar{S}$

we have $S\cos\theta = d$

$$V_B - V_A = -\bar{E} \cdot \bar{S} = -E\underbrace{S\cos\theta}_{d} = -Ed$$

in general if $\bar{E}$ is uniform

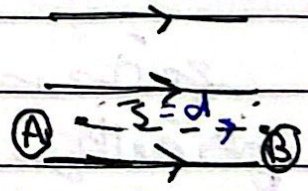
$$\Delta V = V_B - V_A = -\bar{E} \cdot \bar{S} = -ES\cos\theta$$

Tow cases

1. if $\bar{S} = \bar{d}$ is parallel to $\bar{E}$

$$\Delta V = -\bar{E} \cdot \bar{S} = -Ed$$

$$\Delta U = q\,\Delta V = -qEd$$



* اذا مشيت موازي للمجال $\Delta V \ominus$ يعني انه فرق الجهد يقل

$\Rightarrow$ if we move in direction of $\bar{E}$ فرق الجهد $\ominus$

the electric potential dicrease

$\rightarrow$ when a (positive / negative) charge moves in direction of $\bar{E}$ then the charge (lose / gains) potential energy (gains / lose) the same amount ... kinetic e...

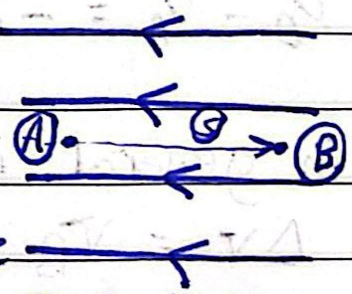
يتبع

* أنا عندي شحنة موجبة بدي انقلها من (A) to (B)
واحنا اتفقنا انه اذا بمشي باتجاه المجال فرق الجهد بقل
(بتمشي لحالها) فبتخسر جهد فأنا ماسك مع المجال
ΔV سالبة بحيث ال q اذا كانت الشحنة المنقولة
موجبة فأنا بكون خسرت طاقة ΔU = سالب
وضع فهاي طاقة الوضع بتروح لشكل طاقة حركة
$+\Delta K$ اما اذا كانت شحنة سالبة وبدي انقلها من
(B) الى (A) وفرق الجهد اوريدي سالب
فطاقة الوضع بتزيد وطاقة الحركة بتقل

(2) if s is oposite to E

$\Delta V = -E \cdot s \rightarrow -Ed\cos 180 = Ed > 0$

* اذا انا امشي عكس المجال الجهد بزيد
مع المجال الجهد بقل



if we move opposite to E the electric potential increase

$\Delta U = q\,\Delta V = qEd$ اذا ال q ⊕ طاقة الوضع
بتزيد واذا ⊖ بتخسر طاقة وضع

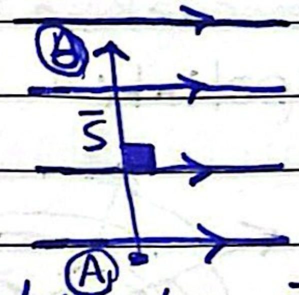
* اذا كانت وضع طبيعي يعني شحنة موجبة مع
المجال وشحنة سالبة عكس المجال بتخسر طاقة وضع

→ when (positive / negative) charge moves opposite to E then the charge (gains / lose) potential energy and (lose / gains) the same amount as kinetic energy

"نبيّه"

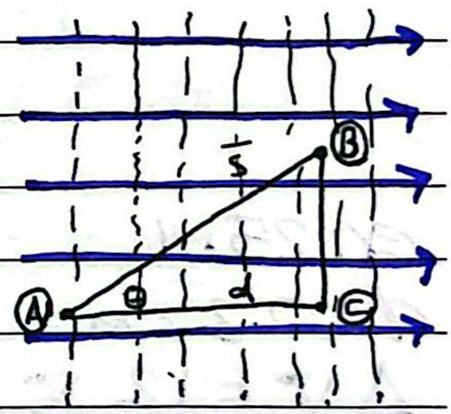
3) if $\vec{S} \perp \vec{E}$

$\Delta V = -\vec{E} \cdot \vec{S} = -ES\cos 90 = 0$



when we move perpendecular to $\vec{E}$ then there is no change in the potential ($\Delta V = 0$) and there is no chang in the potential energy ($\Delta U = q\Delta V = 0$)

Equipotential surfaces
is a surface one which all points have the same potential



$\Delta V_{BC} = V_B - V_C = 0$

$V_B = V_C$

→ B and C are on the same equipotential

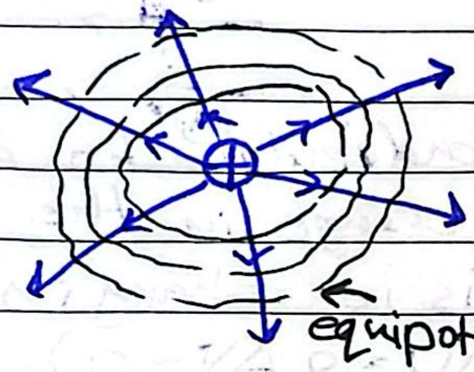
comments:

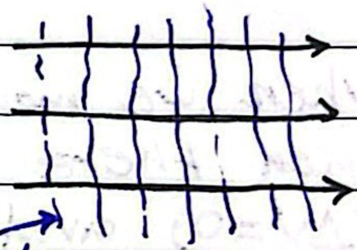
1) moving a charge along the same equipotential requires no work

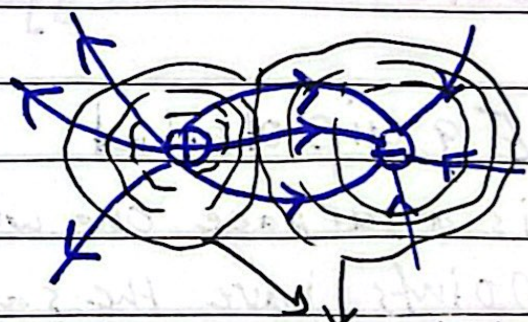
$\Delta V = 0 \longrightarrow W = \Delta U = q\Delta V = 0$

② the electric field is perpendecular to the equipotintial surfaces ($\vec{E} \perp$ equipotiental)

③ The surface of ~~the~~ a conductor is an equipotintial $\bar{E} \perp$ surface of conductor







ex: 25.1

$d = 0.3\ cm = 3*10^{-3}\ m$

$\Delta V = 12\ V$

$|\Delta V| = E d$

$E = \frac{\Delta V}{d} = \frac{12}{3*10^{-3}} \longrightarrow E = 4*10^{3}\ V/m$

ex: 25.2 1:10:22 الرسمة في المحاضرة 100 الدقيقة

$q = 1.6*10^{-19} C \quad m = 1.67*10^{-27} kg$

$v_A = 0 \quad v_B = ?? \quad E = 8*10^{4}\ V/m \quad d = 0.5 m$

$\Delta K + \Delta U = 0$ —— قانون حفظ الطاقة

$(\frac{1}{2} m v_B^2 - \cancel{\frac{1}{2} m v_A^2}) + q \underbrace{\Delta V}_{= -Ed} = 0 \rightarrow \frac{1}{2} m v_B^2 - qEd = 0$

$v_B = \sqrt{\frac{2qEd}{m}}$

$v_B = 2.8*10^{6}\ m/s$

محاضرة "11"

electric potential and potential energy due to ~~of~~ point charge

في رسمة في بداية المحاضرة

$$V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{s}$$

$$\bar{E} = \frac{KQ}{r^2}\hat{r}$$

$$\bar{E} \cdot ds = \frac{KQ}{r^2}\hat{r} \cdot d\bar{s}$$
$$= \frac{Kq}{r^2}(1)(ds)\cos\theta$$
$$= \frac{Kq}{r^2} ds \cos\theta$$

$\cos\theta = \frac{dr}{ds}$

$dr = ds \cos\theta$

$$= \frac{Kq}{r^2} dr \rightarrow V_B - V_A = -\int_A^B \bar{E} \cdot ds$$

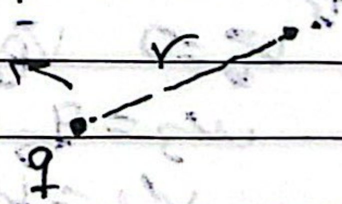
$$V_B - V_A = -\int_{r_A}^{r_B} \frac{Kq}{r^2} dr \rightarrow -Kq \int_{r_A}^{r_B} \frac{dr}{r^2}$$

$$= Kq\left(\frac{1}{r}\right)\Big|_{r_a}^{r_B} = \frac{Kq}{r_B} - \frac{Kq}{r_A}$$

$V_B - V_A = Kq\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$ = change in the potential difference due to a point charge as we move from r_A to r_B.

- The electric potential between tow point is independent on The path.

scaler $\leftarrow V = \frac{Kq}{r}$



- chose a reference point:

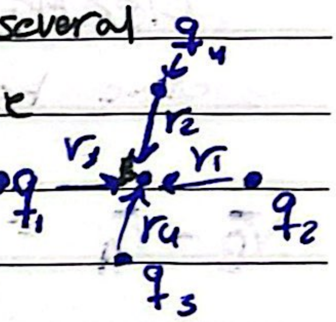
$V_A = 0$ at $r_A = \infty$

$V_B = V$ at $r_B = r \rightarrow V - 0 = Kq\left(\frac{1}{r} - 0\right)$

Thus, the potential at a distance r from a point charge q is defined as $V = \frac{Kq}{r}$

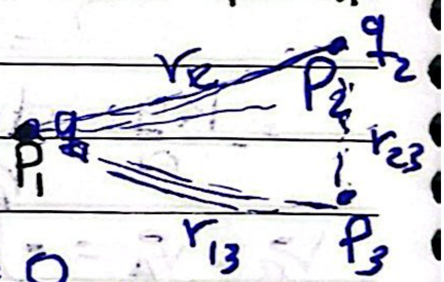
يتبع

- The electric potential due to several point charge is the sum of the potential due to each indivisual charge



$$V_B = V_1 + V_2 + V_3 + V_4 + \cdots$$
$$= \frac{KQ_1}{r_1} + \frac{KQ_2}{r_2} + \frac{KQ_3}{r_3} + \frac{KQ_4}{r_4} + \cdots$$

- consider the work done (change in potential energy) to assemble several point charge at some points:-



$q_1 : \infty \longrightarrow P_1$

$V_\infty = 0 \;,\; V_{P_1} = 0$

$w_1 = q\,\Delta V_1 = q\,(V_{P_1} - V_\infty) = 0$

لأنها بسبب q_1

$q_2 : \infty \longrightarrow P_2$

$V_\infty = 0 \;,\; V_{P_2} = \frac{Kq_1}{r_{12}}$

$w_2 = q_2\,\Delta V_2 \longrightarrow q_2(V_{P_2} - \cancel{V_\infty}) = \frac{Kq_1 q_2}{r_{12}}$

$w_2 = \frac{Kq_1q_2}{r_{12}} \quad w_1 = 0$

$q_3 : \infty \longrightarrow P_3$

$V_\infty = 0 \quad V_{P_3} = K\left(\frac{q_1}{r_{13}} + \frac{q_2}{r_{23}}\right)$

$w_3 = q_3\,\Delta V = q_3(V_{P_3} - \cancel{V_\infty})$

$w_3 = K\left(\frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right)$

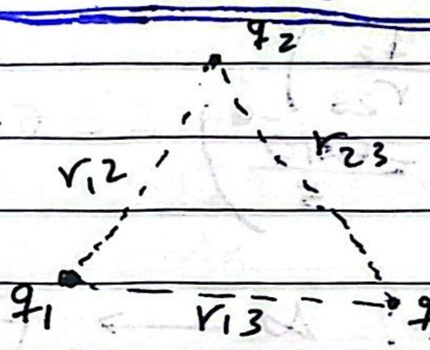
"تبع"

The total work is

$$W = W_1 + W_2 + W_3$$

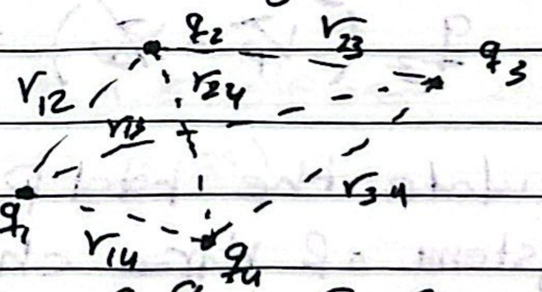
$$= K\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right) = \Delta U = U - \cancel{U_\infty}^{\,0}$$

$$\underline{W = U = K\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right)}$$



نعني اخذت كل زوجين سوا

in general we take the charges as pairs

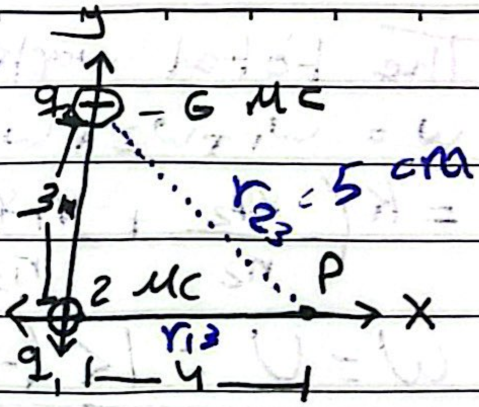


$$V = K\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_1 q_4}{r_{14}} + \frac{q_2 q_3}{r_{23}} + \frac{q_2 q_4}{r_{24}} + \frac{q_3 q_4}{r_{34}}\right)$$

Ex. 25.3

$q_1 = 2\,\mu C = 2*10^{-6}\,C$

$q_2 = -6\,\mu C = -6*10^{-6}\,C$



(A) $V_p = V_1 + V_2$

$K\left(\frac{q_1}{r_{13}} + \frac{q_2}{r_{23}}\right)$

$9*10^{9}\left(\frac{2*10^{-6}}{4} + \frac{-6*10^{-6}}{5}\right) = -6.29*10^{3}\,V$

(B) ΔU ? : q_3 : $\infty \longrightarrow P$; $q_3 = 3\,\mu C$

$w_3 = \Delta U = q_3 \Delta V$

$q_3(V_p - V_\infty) = 3*10^{-6} * -6.29*10^{3}$

$= -1.89*10^{-2}\,J$

(C) calculate the total potential energy stored in system of three charges

$U = K\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right)$

or

$W = U = W_1 + W_2 + W_3$

$0 + K\frac{q_1 q_2}{r_{12}} + K\left(\frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right)$

$9*10^{9}\left(\frac{2*10^{-6} * -6*10^{-6}}{4}\right) - (1.89*10^{-2})$

- if U is positive then work must be done to bring the charges together.
- if U is negative then work ~~must~~ is done to keep them apart

Obtaning the electric field from the electric potential

* بيصير بدي احسب ال E اذا انا عارفة ال V

$$V_B - V_A = -\int_A^B \bar{E}\cdot d\bar{s}$$

$$dV = -\bar{E}\cdot d\bar{s}$$

if the electric field has only one component E_x, then $\bar{E} = E_x\hat{i}$

$$d\bar{s} = dx\,\hat{i} + dy\,\hat{j} + dz\,\hat{k}$$

$$\bar{E}\cdot d\bar{s} = E_x\,dx$$

$$\longrightarrow dV = -E_x\,dx$$

$$\boxed{E_x = -\frac{dV}{dx}}$$

اذا الجهد بيعتمد على x, y, z ، لازم نحكي عن ال ∂

in general : $V = V(x, y, z)$

$$E_x = -\frac{\partial V}{\partial x}$$

$$E_y = -\frac{\partial V}{\partial y}$$

$$E_z = -\frac{\partial V}{\partial z}$$

ex. 25.4 — مسجلة في الدقيقة 1:07:06

(A) $V_p = k\left(\frac{q}{r_1} + \frac{-q}{r_2}\right)$ — symetric

$$kq\left(\frac{1}{\sqrt{a^2+y^2}} - \frac{1}{\sqrt{a^2+y^2}}\right) = 0$$

(B) $V_R = kq\left(\frac{1}{x+a} + \frac{-1}{x-a}\right)$

$$= -\frac{2kqa}{x^2-a^2}$$

(C) if $x >>> a$ $\quad V_R = -\frac{2kqa}{x^2-a^2} \longrightarrow x^2 - a^2 \approx x^2$

$$-\frac{2kqa}{x^2}$$

$$E_x = -\frac{dV}{dx} = -\frac{4kqa}{x^3}$$