Lezione # 14
26/4/22

Data II PARZIALE
25/5/22

11:00 – 12:30 } GRUPPI
1300 – 1430 }

ELETTROMAGNETISMO

ELETTROFISIOLOGIA {
- CUORE/MUSCOLI/POLMONI
- CERVELLO

DIAGNOSI {
- RMN
- TAC
- ECOGRAFIA
- SPETTROMETRIA MASSA

ELETTROSTATICA ($\vec{v} = \vec{0}$)

Carica elettrica ↳ proprietà intrinseca della materia ↳ p^+ ; e^-

1) quantizzata $|e^-| = 1,6 \; 10^{-19}$ C

$|q|$ = Coulomb = C

$Q_{TOT} = n \, |e^-|$
↑
numero intero

2) $q > 0$ e $q < 0$ (SEGNO)

• cariche di segno opposto si attirano

⊕ ←→ ⊖

•• " con lo stesso si respingono

← ⊕ ⊕ →

← ⊖ ⊖ →

MATERIALI: a) CONDUTTORI consentono passaggio carica elettrica (corrente elettrica)
metalli - Cu

b) ISOLANTI non consentono passaggio di carica elettrica
PLASTICA
LEGNO
GOMMA

di carica elettrica

PLASTICA
LEGNO
GOMMA

C) SEMI-CONDUTTORI — metà strada conduttore/isolante

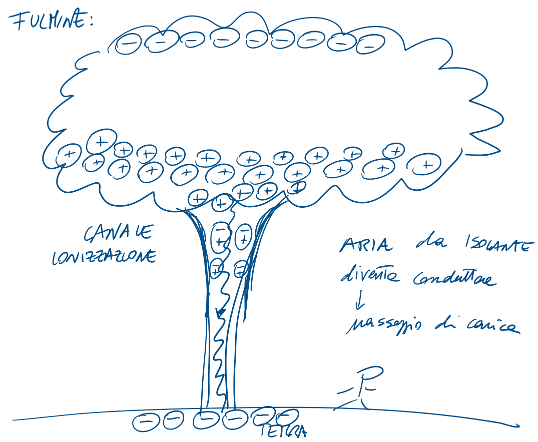
SILICIO

D) SUPER CONDUTTORI — Resistenza al passaggio di carica $\rightarrow 0$

quando la Temperatura $\rightarrow 0$

ARIA ↳ ISOLANTE

FULMINE:



CARICA PUNTIFORME

↳ Nessuna estensione spaziale $q \neq 0$

$\overset{1}{\oplus}$

$\ominus^{2}$

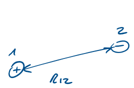
Due cariche p.tiformi q_1, q_2

$$F_{12} = \frac{1}{4\pi \varepsilon_0} \frac{|q_1||q_2|}{r_{12}^2}$$

→ modulo delle cariche

↳ quadrato della distanza

$F_{12} \propto |q_1||q_2|$

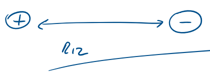


ε_0 = costante dielettrica del vuoto

Se le cariche fossero immerse in un mezzo diverso dal vuoto

$$\varepsilon_0 \rightarrow \varepsilon = \varepsilon_0 \varepsilon_r$$

↳ costante dielettrica relativa

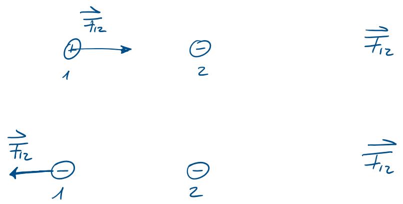


$$\boxed{F_{12} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_1||q_2|}{r_{12}^2}}$$ (Modulo)

Direzione: è lungo la retta congiungente le due cariche

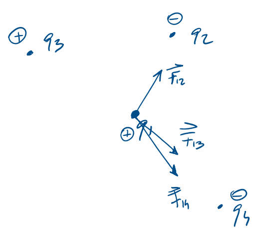
— — - ⊕ - — - ⊖ - —

Verso: $\begin{cases} \text{attrattivo: cariche segno opposto} \\ \text{repulsivo: " stesso segno} \end{cases}$



$$\left[\frac{1}{4\pi\varepsilon_0} = 8{,}99 \; 10^9 \; \frac{Nm^2}{C^2} \right]$$

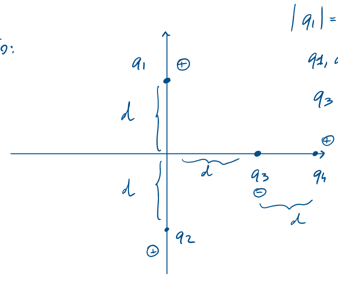
Se la carica è immersa in un sistema di cariche?



La Forza di Coulomb complessiva: $\vec{F}_1^{RIS} = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \ldots$

$$\begin{cases} F_{1,x}^{RIS} = F_{12,x} + F_{13,x} + \text{—} \\ F_{1,y}^{RIS} = F_{12y} + F_{13y} + \text{—} \end{cases}$$

Esercizio:



$|q_1| = |q_2| = |q_3| = |q_4| = q$

$q = 1{,}6\,10^{-19}\,C$

$q_1, q_2, q_4 > 0$

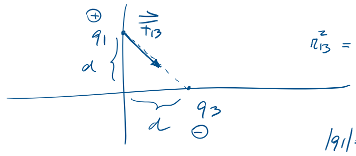
$q_3 < 0$

$d = 1m$

$\frac{1}{4\pi\varepsilon_0} = 8{,}9\,10^9 \frac{Nm^2}{C^2}$

1) $F_{13} = ?$

2) $\vec{F}_{1,TOT} = ?$



$r_{13}^2 = 2d^2 = d^2 + d^2$

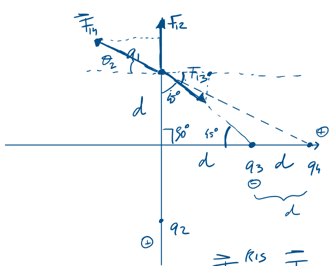
$|q_1| = |q_3| = q$

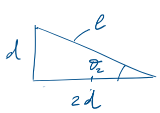
$$F_{13} = \frac{1}{4\pi\varepsilon_0} \frac{|q_1||q_3|}{r_{13}^2} = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{r_{13}^2} = 8{,}9\,10^9 \cdot \frac{(1{,}6)^2\,10^{-38}}{2}$$

$$= 8{,}9\ 10^{-29}\ 2{,}56\ \frac{1}{2}$$

$$= 11{,}39\ 10^{-29} = 1{,}139\ 10^{-28}\ N$$

2)



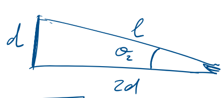


$$\vec{F}_1^{ris} = \vec{F}_{13} + \vec{F}_{12} + \vec{F}_{14}$$

$$\to F_{1,x}^{ris} = F_{13}\cos 45° - F_{14}\cos(26{,}5°)$$

$l \sin\theta_2 = d$

$l \cos\theta_2 = 2d$



$tg\,\theta_2 = \frac{1}{2}$ $\boxed{\theta_2 = arctg\left(\frac{1}{2}\right)}$

$\boxed{\theta_2 = 26{,}5°}$

$$\left[F_c = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r_{12}^2} \right]$$

$\theta_1 = 45°$

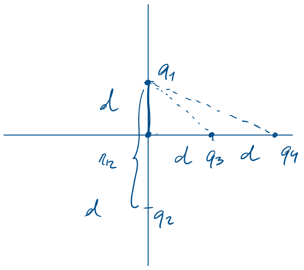
$\theta_2 = 26{,}5°$

$$\begin{cases} F_x^{ris} = F_{13}\cos\theta_1 - F_{14}\cos\theta_2 \\ F_y^{ris} = -F_{13}\sin\theta_1 + F_{12} + F_{14}\sin\theta_2 \end{cases}$$

$$\begin{cases} F_x^{ris} = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1 q_3}{r_{13}^2}\cos\theta_1 - \frac{q_1 q_4}{r_{14}^2}\cos\theta_2 \right] \\ F_y^{ris} = \frac{1}{4\pi\varepsilon_0}\left[-\frac{q_1 q_3}{r_{13}^2}\sin\theta_1 + \frac{q_1 q_2}{r_{12}^2} + \frac{q_1 q_4}{r_{14}^2}\sin\theta_2 \right] \end{cases}$$

dato che $q_1 = q_2 = q_3 = q_4 = q$

$$\begin{cases} F_x^{ris} = \frac{q^2}{4\pi\varepsilon_0}\left[\frac{1}{r_{13}^2}\cos\theta_1 - \frac{1}{r_{14}^2}\cos\theta_2 \right] \\ F_y^{ris} = \frac{q^2}{4\pi\varepsilon_0}\left[-\frac{1}{r_{13}^2}\sin\theta_1 + \frac{1}{r_{12}^2} + \frac{1}{r_{14}^2}\sin\theta_2 \right] \end{cases}$$



$$r_{12} = 2d$$

$$r_{13} = \sqrt{d^2 + d^2} = d\sqrt{2}$$

$$r_{14} = \sqrt{d^2 + (2d)^2} = \sqrt{d^2 + 4d^2}$$

$$r_{14} = d\sqrt{5}$$

$$\begin{cases} F_x^{RIS} = \dfrac{q^2}{4\pi\varepsilon_0 d^2}\left[\dfrac{1}{2\cancel{d^2}}\cos\vartheta_1 - \dfrac{1}{5\cancel{d^2}}\cos\vartheta_2\right] \\[2ex] F_y^{RIS} = \dfrac{q^2}{4\pi\varepsilon_0 d^2}\left[-\dfrac{1}{2\cancel{d^2}}\sin\vartheta_1 + \dfrac{1}{4\cancel{d^2}} + \dfrac{1}{5\cancel{d^2}}\sin\vartheta_2\right] \end{cases}$$

$$\begin{cases} F_x^{RIS} = \dfrac{q^2}{4\pi\varepsilon_0 d^2}\left(\dfrac{1}{2}\cos\vartheta_1 - \dfrac{1}{5}\cos\vartheta_2\right) \\[2ex] F_y^{RIS} = \dfrac{q^2}{4\pi\varepsilon_0 d^2}\left(-\dfrac{1}{2}\sin\vartheta_1 + \dfrac{1}{4} + \dfrac{1}{5}\sin\vartheta_2\right) \end{cases}$$

$$\left[\frac{1}{4\pi\varepsilon_0} = 8{,}99\ 10^9\ \frac{Nm^2}{C^2}\right]$$

$$\begin{cases} F_x^{RIS} = 3{,}97\ 10^{-28}\ N \\ F_y^{RIS} = -3{,}54\ 10^{-30}\ N \end{cases}$$

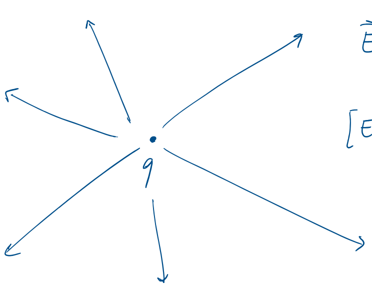
$$|F^{RIS}| = \sqrt{(3{,}97\ 10^{-28})^2 + (-3{,}54\ 10^{-30})^2} =$$

$$\boxed{F^{RIS} = 3{,}98\ 10^{-28}\ N}$$

Forza di Coulomb

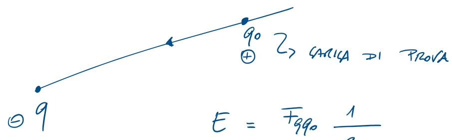
$$F_c = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}^2}$$

Campo Elettrico



$$\vec{E} = \frac{\vec{F}}{q}$$

$$[E] = \frac{N}{C}$$

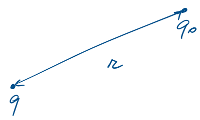


$$E = F_{qq_0} \frac{1}{q_0}$$

q_0 = carica di prova, per non perturbare il campo di q

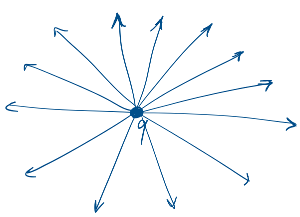
prendo $q_0 \ll q \Rightarrow E_0 \ll E$ $\quad E_0$ trascurabile

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q \cancel{q_0}}{r^2} \frac{1}{\cancel{q_0}}$$



$$\boxed{E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2}}$$

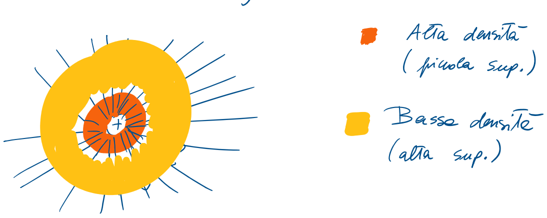
Campo elettrico generato da una carica puntiforme



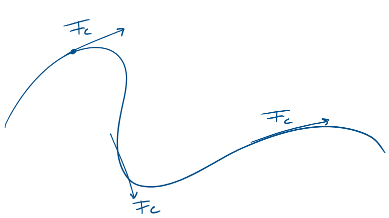
LINEE DI FORZA DEL CAMPO ELETTRICO

1) linee di forza escono sempre da ⊕
" " " entrano " in ⊖

2) Densità delle linee di forza $\propto$ all'intensità E



3) La F_c è sempre tangenziale alle linee di forza



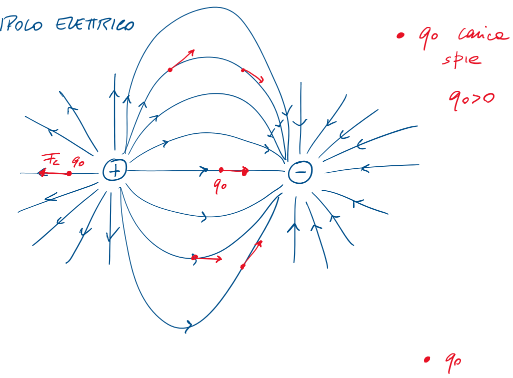
In generale se sono presenti più cariche elettriche $q_1, q_2, \ldots, q_n$ il campo elettrico risultante sarà la somma vettoriale di tutti i campi $E_1, E_2, \ldots, E_n$

$$\vec{E}_{TOT} = \vec{E}_1 + \vec{E}_2 + \ldots + \vec{E}_n$$

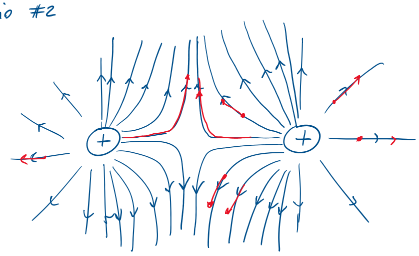
Ma da un p.to di vista delle linee di forza?

Qualche esempio:

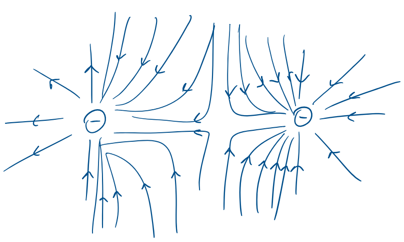
DIPOLO ELETTRICO

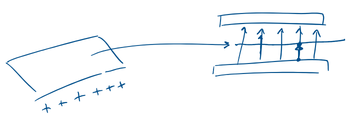


Esempio #2

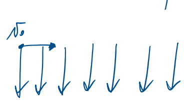


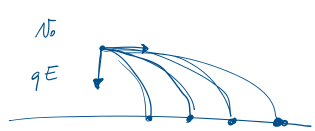
Esempio # 3





$$E = \frac{F}{q} \qquad \boxed{F = qE}$$





$$\cancel{m} a = \frac{qE}{m}$$

$\boxed{\text{DPI}}$ $\left\{ \begin{array}{l} \text{DOT} \\ \text{PER} \\ \text{INCH} \end{array} \right.$

$\boxed{\text{DPI}}$ DOT PER INCH