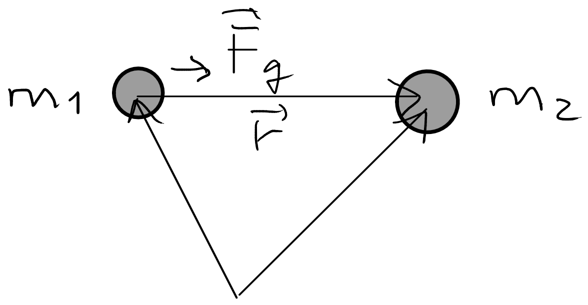
Modello di punto materiale

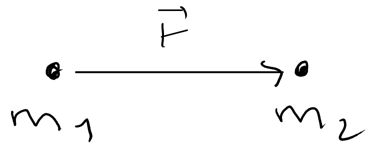
Attrazione gravitazionale : $\vec{F}_g = G \frac{m_1 m_2}{|\vec{r}|^2} \frac{\vec{r}}{|\vec{r}|}$

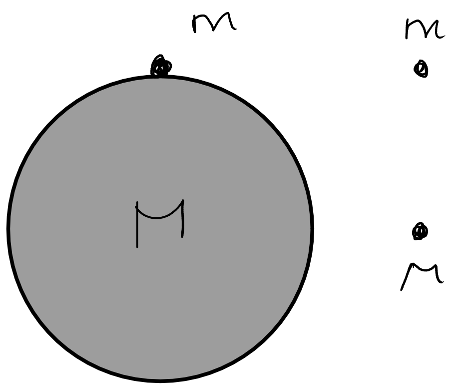


$\longrightarrow$

modello

corpi ≡ particelle





Teor. Gauss ⇓

Nel caso di un corpo sferico, l'attrazione tra i corpi è la stessa che si avrebbe se la massa della sfera fosse concentrata nel suo centro

Corpi ≡ particelle (massa puntiforme, punti materiali)

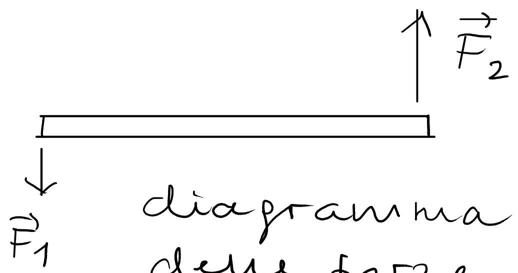


diagramma delle forze

$\longrightarrow$

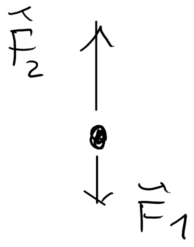
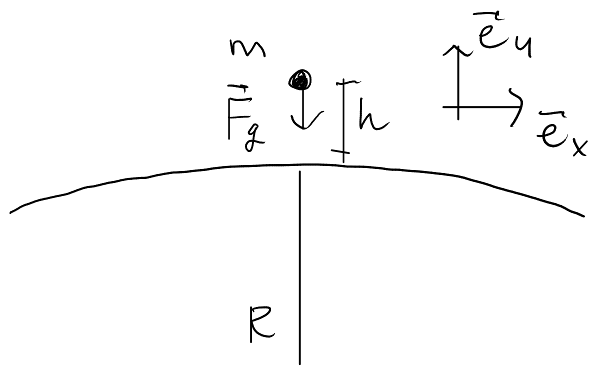


diagramma di corpo libero

Applicazione: accelerazione di gravità terrestre



II Newton: $\sum \vec{F} = m\vec{a}$

$$\vec{F}_g = m\vec{a}$$

$$-G\frac{M m}{(R+h)^2} = -m g \rightarrow \text{componente } y$$

definisco g come positiva

1) $h = 0$

$$\frac{GM}{R^2} = g \qquad g = \frac{GM}{R^2}$$

es. calcola M della terra

2) $0 < h \ll R$

$$g(h) = G\frac{M}{(R+h)^2} = \underbrace{G\frac{M}{R^2}}_{g(0)}\frac{1}{(1+\frac{h}{R})^2} = G\frac{M}{R^2}\left(1+\frac{h}{R}\right)^{-2} \approx G\frac{M}{R}\left(1-2\frac{h}{R}\right)$$

$\frac{h}{R} \ll 1$

$$(1+x)^\alpha \approx 1 + \alpha x$$

variazione relativa di g con h

$$\frac{\Delta g}{g} \approx -2\frac{h}{R}$$

$g = 9{,}81 \ \frac{m}{s^2}$ → incertezza relativa $\approx \frac{1}{1000}$

$$\frac{1}{1000} \approx -2\frac{h}{R}$$

$$|h| \approx \frac{1}{2}\,\frac{6000\ km}{1000} = 3\ km$$

⇒ fino a $|h| \approx 3\,km$, $g = 9{,}81\ m/s^2$ è ok

Es.: stimare la differenza percentuale $\frac{\Delta g}{g}$ tra l'accelerazione di gravità terrestre ai poli e quella all'equatore

$R_0 = 6{,}378 \times 10^6\ m$ equatore

$R_1 = 6{,}356 \times 10^6\ m$ poli

2. Interazioni elettrostatiche

Sia attrattiva che repulsiva, "forte"

~1600 fenomeno generale

~1700 misure quantitative

Franklin carica può essere ±

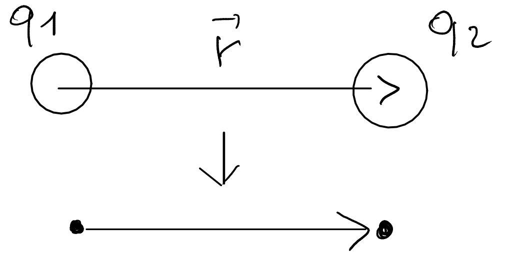
grandezza fisica → carica elettrica q SI: C

Coulomb

Coulomb ↓ C

Costante di Coulomb:

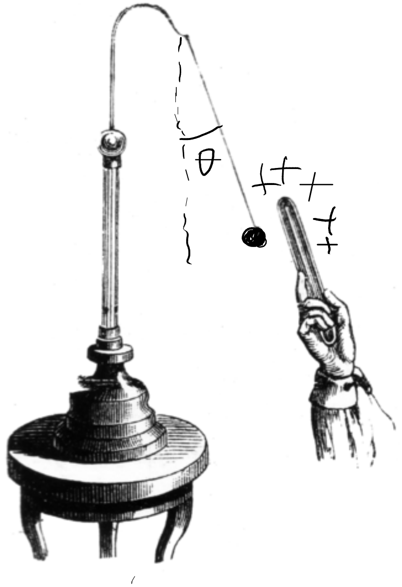
$$k_e = 8{,}99 \times 10^{9} \; \frac{N\,m^2}{C^2}$$



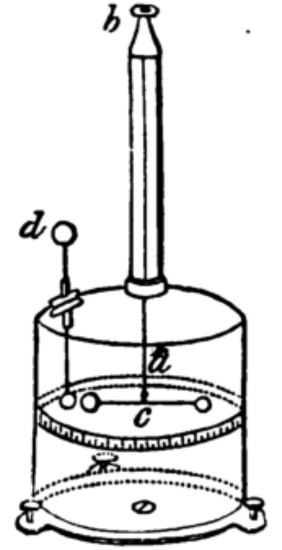
$$|\vec{F}_e| \sim |q_1 q_2| \qquad |\vec{r}| = \text{cost}$$

$$\sim \frac{1}{|\vec{r}|^2} \qquad q_1, q_2 = \text{cost}$$

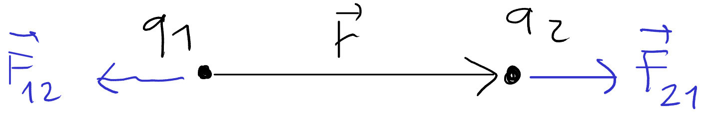
$$|\vec{F}_e| = k_e \frac{|q_1 q_2|}{|\vec{r}|^2}$$



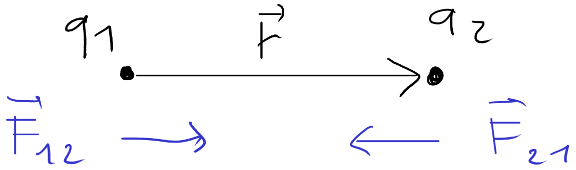
Elettroscopio



Elettrometro di Coulomb



$$\vec{F}_{12} = -k_e \frac{q_1 q_2}{|\vec{r}|^2} \frac{\vec{r}}{|\vec{r}|} = -\vec{F}_{21} \qquad q_1 \cdot q_2 > 0$$



$$\vec{F}_{12} = -k_e \frac{q_1 q_2}{|\vec{r}|^2} \frac{\vec{r}}{|\vec{r}|} = -\vec{F}_{21} \qquad q_1 \cdot q_2 < 0$$

$$\vec{F}_{12} = - K_e \frac{q_1 q_2}{|\vec{r}|^2} \frac{\vec{r}}{|\vec{r}|}$$

Protone : $m = 1.672 \times 10^{-27}$ kg $\quad q = +1.602 \times 10^{-19}$ C

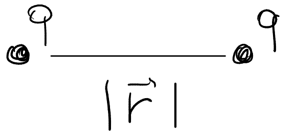
Elettrone : $m = 9.109 \times 10^{-31}$ kg $\quad q = -1.602 \times 10^{-19}$ C

Neutrone : $m = 1.674 \times 10^{-27}$ kg $\quad q = 0$ C

Carica elementare

$e \equiv +1.602 \times 10^{-19}$ C

Es.: calcola $\frac{|\vec{F}_e|}{|\vec{F}_g|}$ tra protoni



$$\frac{|\vec{F}_e|}{|\vec{F}_g|} = \frac{k_e \frac{q^2}{\cancel{|\vec{r}|^2}}}{G \frac{m^2}{\cancel{|\vec{r}|^2}}} = \frac{k_e}{G}\left(\frac{q}{m}\right)^2 = \frac{9 \times 10^9 \frac{N m^2}{C^2}}{6 \times 10^{-11} \frac{N m^2}{kg^2}} \left(\frac{\cancel{1.6} \times 10^{-19}\, C}{\cancel{1.6} \times 10^{-27}\, kg}\right)^2$$

$$= 1.5 \times 10^{20} \times (10^8)^2 = 1.5 \times 10^{20} \times 10^{16} \approx \underline{10^{36}}$$

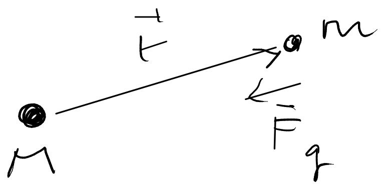
Campi di forze

~ 1800 Faraday → linee di forza

Maxwell → campo elettromagnetico

Campo: grandezza fisica che dipende dallo spazio e/o dal tempo

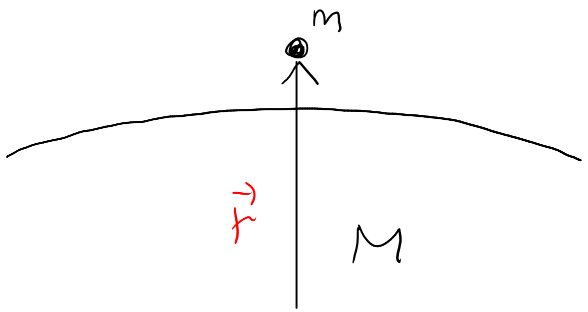
Campo gravitazionale



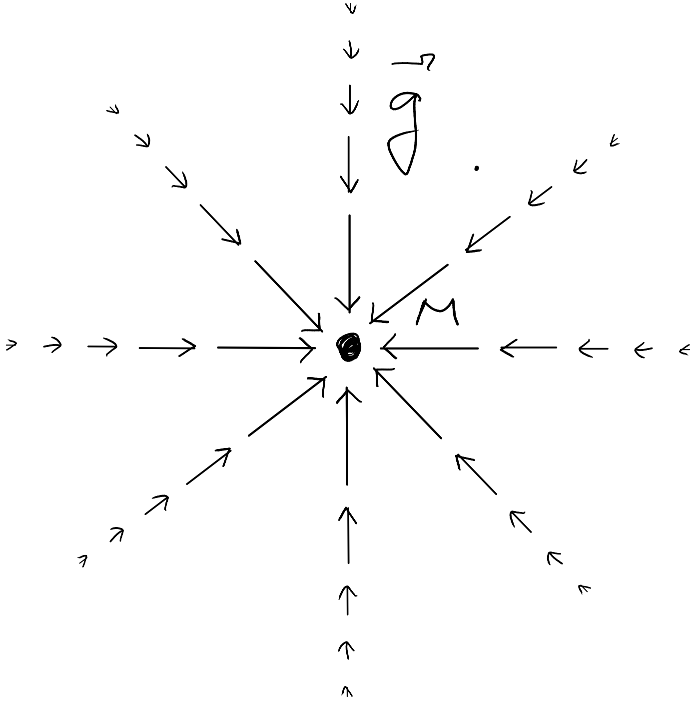
$$\vec F_g = -G \frac{mM}{|\vec r|^2}\frac{\vec r}{|\vec r|}$$

$$\vec g = \frac{\vec F_g}{m} \qquad SI: \frac{N}{Kg}$$

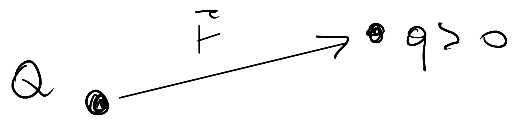
campo gravitazionale



$$\vec g = \underbrace{-G\frac{M}{|\vec r|^2}}_{g}\frac{\vec r}{|\vec r|} = \vec a$$



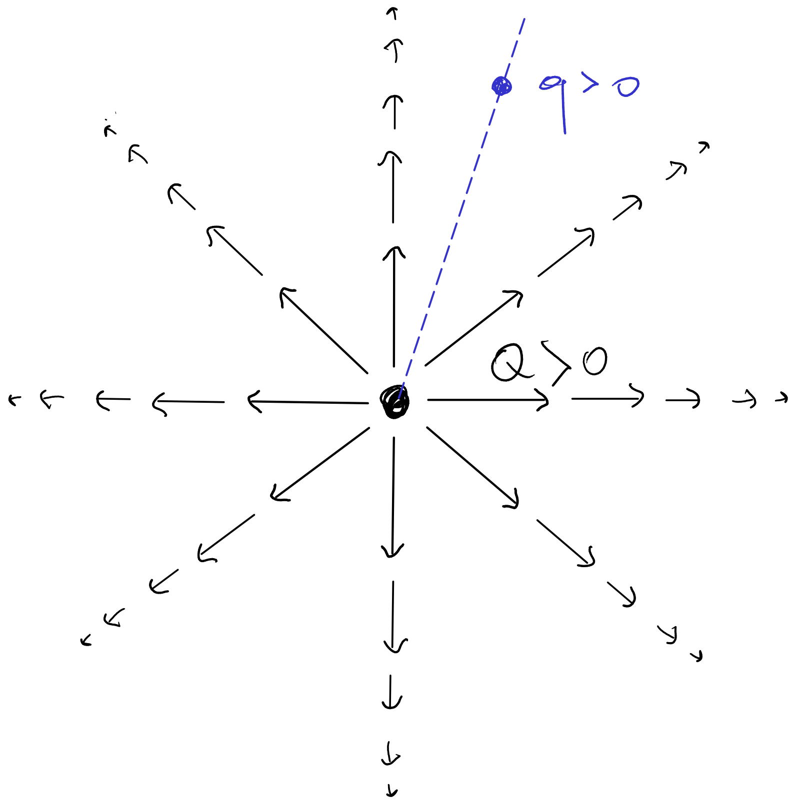
Campo elettrostatico

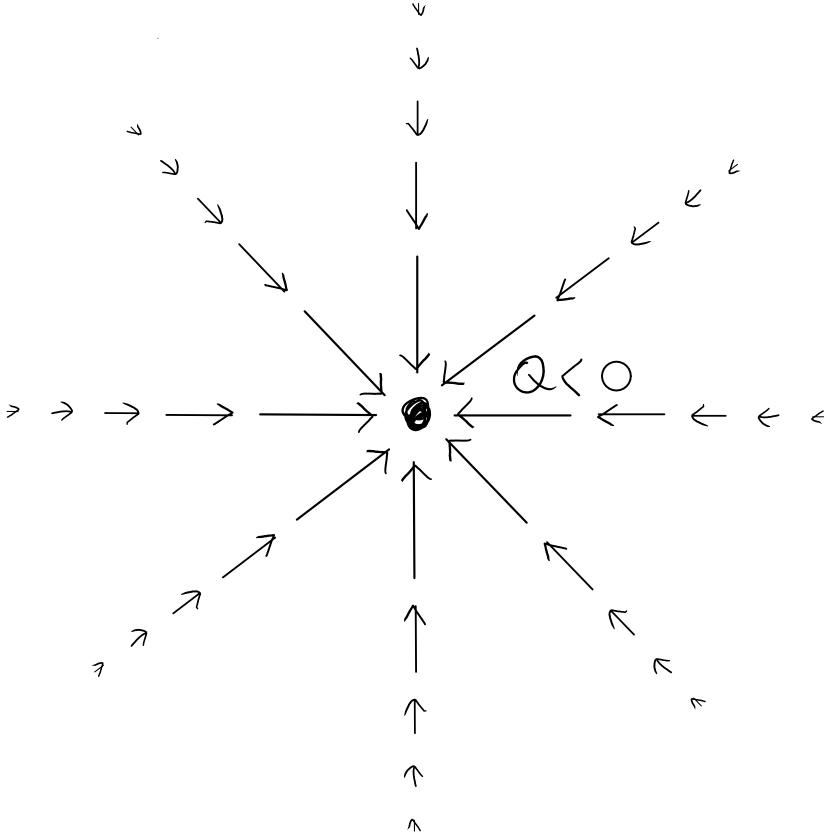


$$\vec{E} = k_e \frac{Q}{|\vec{r}|^2} \frac{\vec{r}}{|\vec{r}|}$$

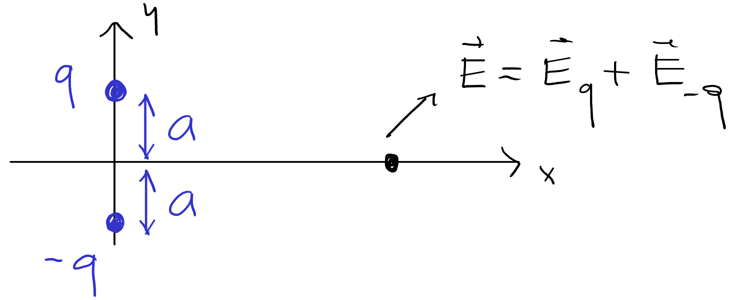
$$\vec{E} \equiv \frac{\vec{F}_e}{q} \qquad \text{SI: } \frac{N}{C}$$

campo elettrostatico





Es.: dipolo elettrico



1) Determina $|\vec{E}|$ per $x \gg a$ e mostra che

$$|\vec{E}| \sim \frac{1}{x^\alpha} \qquad \alpha = ?$$

2) Misura $|\vec{E}|$ in funzione di x su PHET e confronta con 1)