

~ T.2 - CAMPO ELÉCTRICO ~

COULOMB

CARGAS PUNTUALES

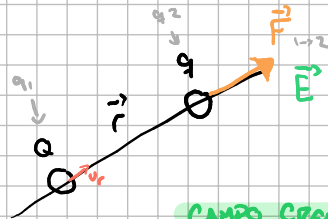
$$\vec{F}_{12} = k \frac{q_1 q_2}{r_{12}^2} \vec{U}_r$$

$$[Q] = C \quad [F] = N \quad [r] = m$$

$$[k] = Nm^2/C^2$$

También puede medirse en función de ϵ_0 .

$$\frac{Nm^2}{C^2} = \frac{1}{4\pi\epsilon_0}$$

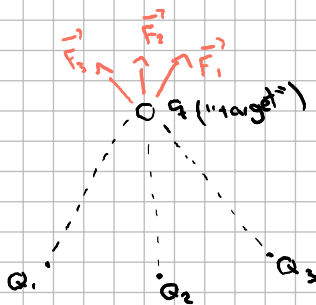


CAMPO CREADO POR Q1

$$\vec{F} = \frac{Qq}{r^2} \vec{U}_r = q \vec{E}$$

$$\vec{E} = k \frac{Q}{r^2} \vec{U}_r$$

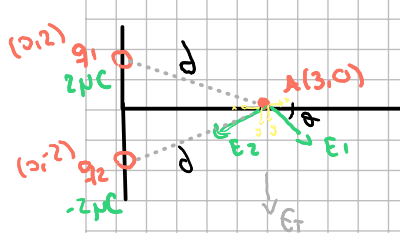
SUPERPOSICIÓN



$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$$

EJERCICIO

Calcular campo eléctrico en A(3,0).



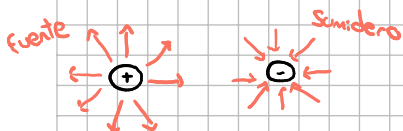
$$d = \sqrt{2^2 + 3^2} = \sqrt{13}$$

Las componentes x se cancelan, ya que una carga es 2µC y otra -2µC.

$$E_y(3,0) = E_{1y}(3,0) + E_{2y}(3,0) =$$

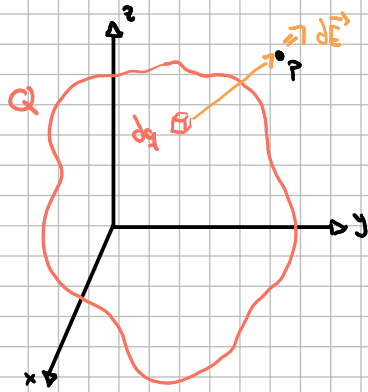
$$= -2Eq \sin \theta = -2 \cdot k \frac{q}{d^2} \vec{j} \cdot \sin \theta = -1'54 \cdot 10^3 \vec{j} \text{ N/C} \quad \text{o } V/m$$

LÍNEAS DE FUERZA/CAMPO



- \vec{E} es tangente a las líneas de campo.
- $|\vec{E}|$ es proporcional a la densidad de líneas.

DIST. CONTÍNUAS



$$d\vec{E} = k \frac{dq}{r^2} \vec{u}_r$$

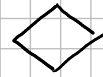
$$\vec{E} = \int d\vec{E}$$

$$\vec{E} = \sum_{i=1}^n \vec{E}_i$$

DENSIDADES DE CARGA



$$dq = \lambda dl \quad \text{C/m}$$

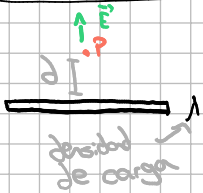


$$dq = \sigma ds \quad \text{C/m}^2$$



$$dq = \rho dV \quad \text{C/m}^3$$

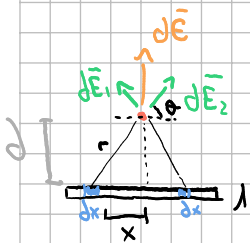
HILO RECTILÍNEO ∞



$$\vec{E} = \int k \frac{dq}{r^2} \vec{u}_r$$

→

→ HILO

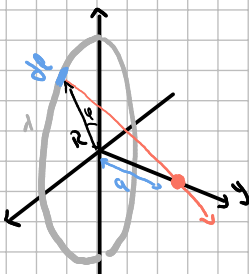


$$dE = k \frac{dq}{r^2} \sin \theta \cdot 2 = 2k \frac{\lambda dx}{x^2 + d^2} \cdot \frac{d}{\sqrt{x^2 + d^2}}$$

$$E = \int dE = \int_{-\infty}^{\infty} 2k \frac{\lambda dx}{x^2 + d^2} \cdot \frac{d}{\sqrt{x^2 + d^2}} = 2k\lambda d \int_{-\infty}^{\infty} \frac{dx}{(x^2 + d^2)^{3/2}} = 2k\lambda d \cdot \frac{1}{d^2}$$

$$\Rightarrow E = \frac{2k\lambda}{d}$$

→ ANILLO



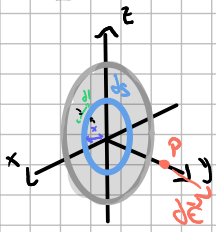
$$\begin{aligned} dq &= \lambda dl \\ \cos \theta &= \frac{a}{r} \\ dl &= R d\phi \end{aligned} \Rightarrow dE = k \frac{dq}{r^2} \cos \alpha = R^{-1}$$

$$\vec{E} = k \frac{Qa}{[a^2 + R^2]^{3/2}} \vec{u}_y$$

si asumimos la Q en el centro (d >>> R)

$$\vec{E} = k \frac{Q}{a^2} \vec{u}_y$$

→ Disco



$$E = \int dE = \int \frac{k dq}{(x^2 + r^2)^{3/2}} = k\sigma \int \frac{2\pi r \sigma}{\dots} dx = k\sigma 2\pi \sigma \int_0^R \frac{x}{\dots} dx$$

GAUSS

~ FLUJO DE CAMPO ELÉCTRICO

$$\Phi = \vec{E} \cdot \vec{S}$$

$$d\Phi = \vec{E} \cdot d\vec{S}$$

$$\Phi = ES \cos\theta$$

$$\Phi = ES$$

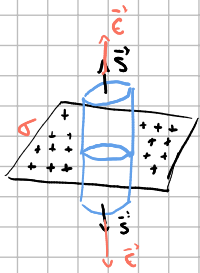
$$\Phi = \int d\Phi = \iint_S \vec{E} \cdot d\vec{S}$$

- Teorema Gauss:

$$\Phi = \frac{Q_{\text{generada}}}{\epsilon_0}$$

$$\iint \vec{E} \cdot d\vec{S} = \frac{Q_{\text{enc}}}{\epsilon_0}$$

► PLANO DIeléCTRICO (aislante)



cilindro "imaginario" para aplicar Gauss.

$$\iint \vec{E} \cdot d\vec{S} = \frac{Q_{\text{enc}}}{\epsilon_0}$$

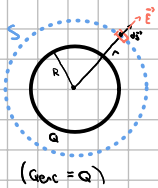
► por geometría: $Q = \sigma S$

$$2ES = \frac{\sigma S}{\epsilon_0} \Rightarrow E = \frac{\sigma}{2\epsilon_0}$$

► ESFERA DIeléCTRICA

► $r > R$

(r = radio donde se mide \vec{E} , R = radio esf.)

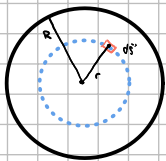


$$\iint \vec{E} \cdot d\vec{S} = \frac{Q_{\text{enc}}}{\epsilon_0}$$

$$\frac{Q}{\epsilon_0} = E \oint dS = E 4\pi r^2 \quad (\text{superf. esfera})$$

$$\vec{E} = \frac{Q}{\epsilon_0} \cdot \frac{1}{4\pi r^2} \vec{u}_r$$

► $r < R$



$$E 4\pi r^2 = \frac{Q_{\text{enc}}}{\epsilon_0} = \frac{P V_{\text{enc}}}{\epsilon_0} \quad (\text{dens. vol})$$

► por geometría: $V_{\text{enc}} = \frac{4}{3}\pi r^3$, $P = \frac{Q}{V} = \frac{Q}{\frac{4}{3}\pi R^3}$

$$\Rightarrow E = \frac{\frac{Q}{\frac{4}{3}\pi R^3} \cdot \frac{4}{3}\pi r^3}{\epsilon_0} \cdot \frac{1}{4\pi r^2} \Rightarrow \vec{E} = \frac{Q}{\epsilon_0} \cdot \frac{r}{4\pi R^3} \vec{u}_r$$

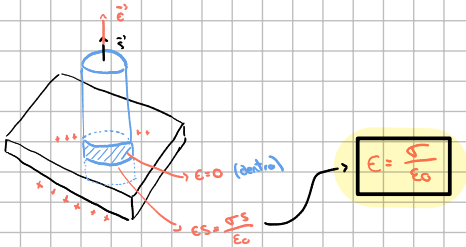
§ Cargas en conductores: \vec{E} dentro de conductor = 0

$$\vec{E} = 0 \Rightarrow \oint \vec{E} \cdot d\vec{S} = \frac{Q_{enc}}{\epsilon_0} = 0 \Rightarrow Q_{enc} = 0$$



(toda Q en superficie)

► LÁMINA CONDUCTORA



POTENCIAL ELECTROSTÁTICO

(ENERG. POTENCIAL)

$$dU = -\vec{F}(\vec{r}) \cdot d\vec{r}$$

$$\Delta U = U_B - U_A = - \int_A^B \vec{F}(\vec{r}) \cdot d\vec{r} \rightarrow \Delta U = -W_{campo}$$

$$(W = \int_A^B \vec{F}(\vec{r}) \cdot d\vec{r})$$



(POT. ELECTROS.)

$$V = \frac{U}{q}$$

$$dV = -\vec{E}(\vec{r}) \cdot d\vec{r}$$

$$\Delta V = V_B - V_A = - \int_A^B \vec{E}(\vec{r}) \cdot d\vec{r}$$

! [voltio: 1V = 1J / 1C]

$$dU = -\vec{F}(\vec{r}) \cdot d\vec{r}$$

► RELACIÓN CAMPO - POT.

$$dV = -\vec{E}(\vec{r}) \cdot d\vec{r} \leftrightarrow \vec{E}(\vec{r}) = -\nabla V(\vec{r})$$

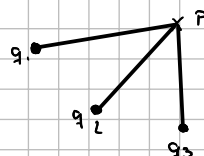
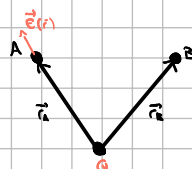
► POT. DEBIDO A Q PUNTUAL

$$V_B - V_A = - \int_A^B \vec{E}(\vec{r}) \cdot d\vec{r} = - \int_A^B k \frac{Q}{r^2} dr = -kQ \left[\int_A^B \frac{dr}{r^2} \right]$$

$$V_B - V_A = -kQ \left[-\frac{1}{r} \right]_A^B = kQ \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

Si tomamos pt. B en ∞ y $V_B = 0$:

$$V(\vec{r}) = k \frac{Q}{r} \Rightarrow V(\vec{r}) = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{r}$$

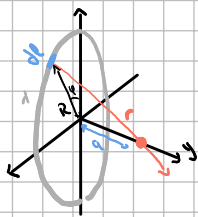


$$V_P = \sum V_i$$

(superposición)

T2 NUEVO - DESPUÉS POT.

▶ ANILLO



$$\begin{cases} dq = \lambda dl \\ \cos \theta = \frac{x}{r} \\ dl = R d\theta \end{cases} \rightarrow dE = k \frac{dq}{r^2} \cos \alpha = R^{-1}$$

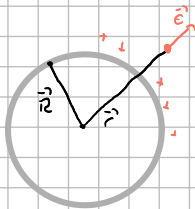
$$\vec{E} = k \frac{Qa}{(a^2 + x^2)^{3/2}} \vec{u}_y \quad \text{si asumimos la } Q \text{ en el centro } (d \gg R) \approx \vec{E} = k \frac{Q}{x^2} \vec{u}_y$$

$(r = \sqrt{a^2 + x^2})$

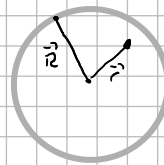
$$E = -\nabla V(x, y, z) = k \frac{Qy}{\sqrt{y^2 + a^2}} \vec{u}_y$$

▶ ES. COCERZA ESFERICA CARGADA

FUERA:



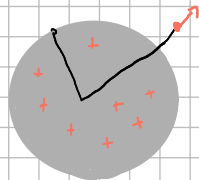
DENTRO:



$$(\vec{E} = 0)$$

$$V = -\int \vec{E}(r') \cdot d\vec{r}' = C$$

Q. HOMOGÉNEA:

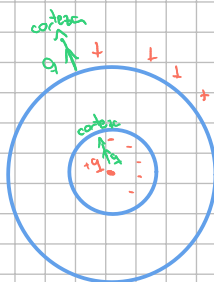


$$P = \epsilon E = \frac{Q}{4\pi R^2}$$

Gauss para $r > R$:

$$\begin{cases} V_{r > R} = \dots \\ V_{r < R} = \dots \end{cases} \rightarrow$$

↳ Continuidad: se igualan ambas eq. ($r > R$ y $r < R$) porque hay continuidad (en Ferm. Fis.).



RESUMEN

Coulomb

Gauss (Fisic.)

Cómo cambia campo elec y pot. con geom.