MEDIOS DE ENLACE

3R1

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2025

Gauss

Ecuación de campos estáticos

Ecuación de Maxwell

Ecuación de campos estáticos

Ley de Coulomb

$$\underset{q_1}{\oplus} \longrightarrow \overset{r}{\cdots\cdots} \longleftarrow \underset{q_2}{\ominus}$$

$$F = \frac{1}{4\pi\varepsilon} \cdot \frac{q_1 \cdot q_2}{r^2} \quad [\text{Newton}] \quad \text{Fuerza}$$

Campo Eléctrico

$$\frac{F}{q_2} = \frac{\text{Newton}}{\text{Coulomb}} = \bar{E} = \frac{1}{4\pi\varepsilon} \cdot \frac{q_1}{r^2} \left[\frac{V}{m}\right]$$

$$\bar{E} = \frac{1}{4\pi\varepsilon} \cdot \frac{q_1}{r^2} \left[\frac{V}{m}\right]$$

POTENCIAL

$$V = E \cdot r = \frac{1}{4\pi\varepsilon} \cdot \frac{q}{r} \, [V]$$

$$V_a - V_b = \int_{aC}^{b} E\,dr = [V]$$

$$\oint_C E\,dr = 0$$

Ley de trabajo Eléctrico

LEY DE GAUSS ($\bar{E}$)

$$\oint \overbrace{\bar{E}}^{D}\, ds = \frac{Q}{\varepsilon}$$

$$\bar{D} = \varepsilon \bar{E}$$

Desplazamiento eléctrico

$$\oint_S \bar{D}\, ds = Q$$

TEOREMA STOKES

Integral línea　　　　Integral superficie

Relaciona $\oint_C dr$ con $\int_S \ldots\ldots ds$

$$\boxed{\oint_C \bar{E}\, dr = \int \nabla \times \bar{E}\, ds}$$

Forma integral　　　　Forma vectorial

TEOREMA DE LA DIVERGENCIA

$$\boxed{\oint \bar{D}\, ds = \int \nabla \cdot \bar{D}\, dv}$$

$$\oint \overset{D}{\bar{E}}\, ds = \frac{Q}{\varepsilon}$$

Densidad Volumétrica carga

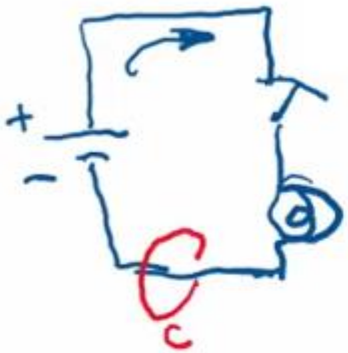
$$\rho = \frac{Q}{m^3} \quad \therefore \quad Q = \int \rho\, dv$$

$$\oint \bar{D}\, ds = \int \nabla \cdot \bar{D}\, dv = Q = \int \rho\, dv$$

$$\boxed{\nabla \cdot \bar{D} = \rho}$$

si $Q = 0 = \rho$

Ley de Ampere



$$\boxed{\oint_C \bar{H} dr = I}$$

$$\bar{B} = \mu \bar{H}$$

$$I = \oint_C \bar{H} dr = \int \nabla \times H \, ds$$

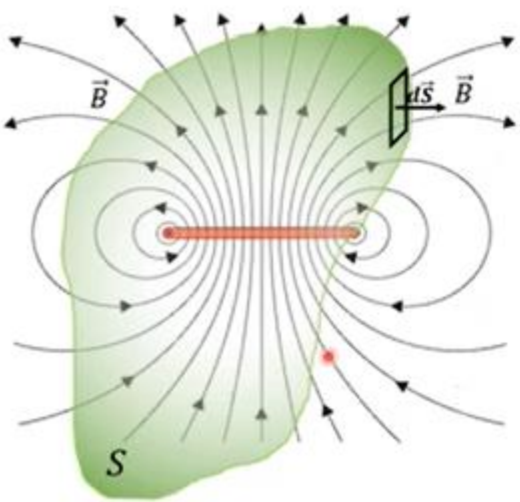
$$J = \frac{A}{m^2} \therefore I = \int J \, ds$$

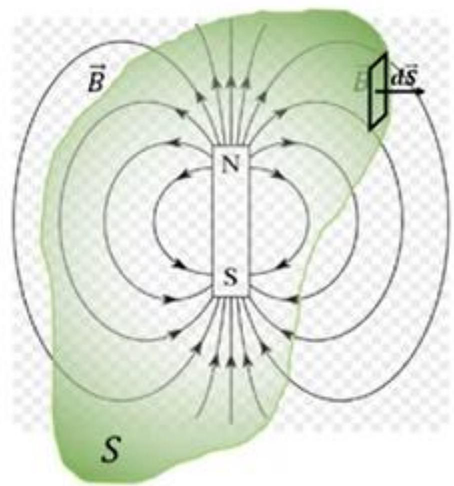
$$\boxed{\nabla \times H = J}$$

Densidad
Superficial
de corriente

Ley de Gauss ($\bar{H}$)

$$\boxed{\oint \bar{B}\, ds = \int \underbrace{\nabla \cdot \bar{B}}_{=0}\, dv = 0}$$





Ec. de Campos Electrost. y Magn.

forma Integral	forma Vectorial
$\oint \bar{E}\, dr = 0$	$\nabla \times \bar{E} = 0$
$\oint \bar{D}\, ds = Q$	$\nabla \cdot \bar{D} = \rho$
$\oint \bar{H}\, dr = I$	$\nabla \times \bar{H} = J$
$\oint \bar{B}\, ds = 0$	$\nabla \cdot \bar{B} = 0$

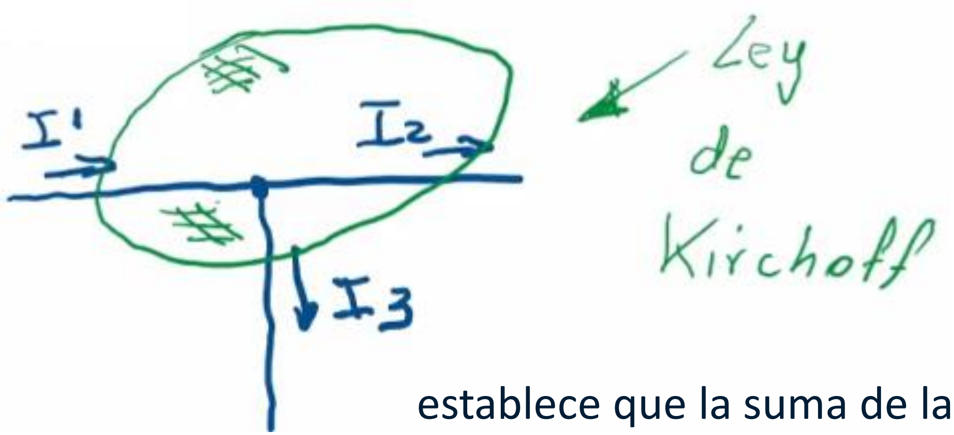
LEY DE CONTINUIDAD ELECTRICA

$$\nabla \times H = J$$

Densidad Superficial de corriente

$$\underbrace{\nabla \cdot \nabla \times \bar{H}}_{\text{Ident. Vectorial}} = \nabla \cdot J = 0$$

Expresión vectorial de Kirchhoff



establece que la suma de las corrientes que entran y salen de un nodo es igual a cero

POTENCIAL ELECTRICO / MAGNETICO

$$V = E \cdot r = \frac{1}{4\pi\varepsilon} \cdot \frac{q}{r} \, [V]$$

$$\rho = \frac{Q}{m^3}$$

Densidad Volumétrica carga

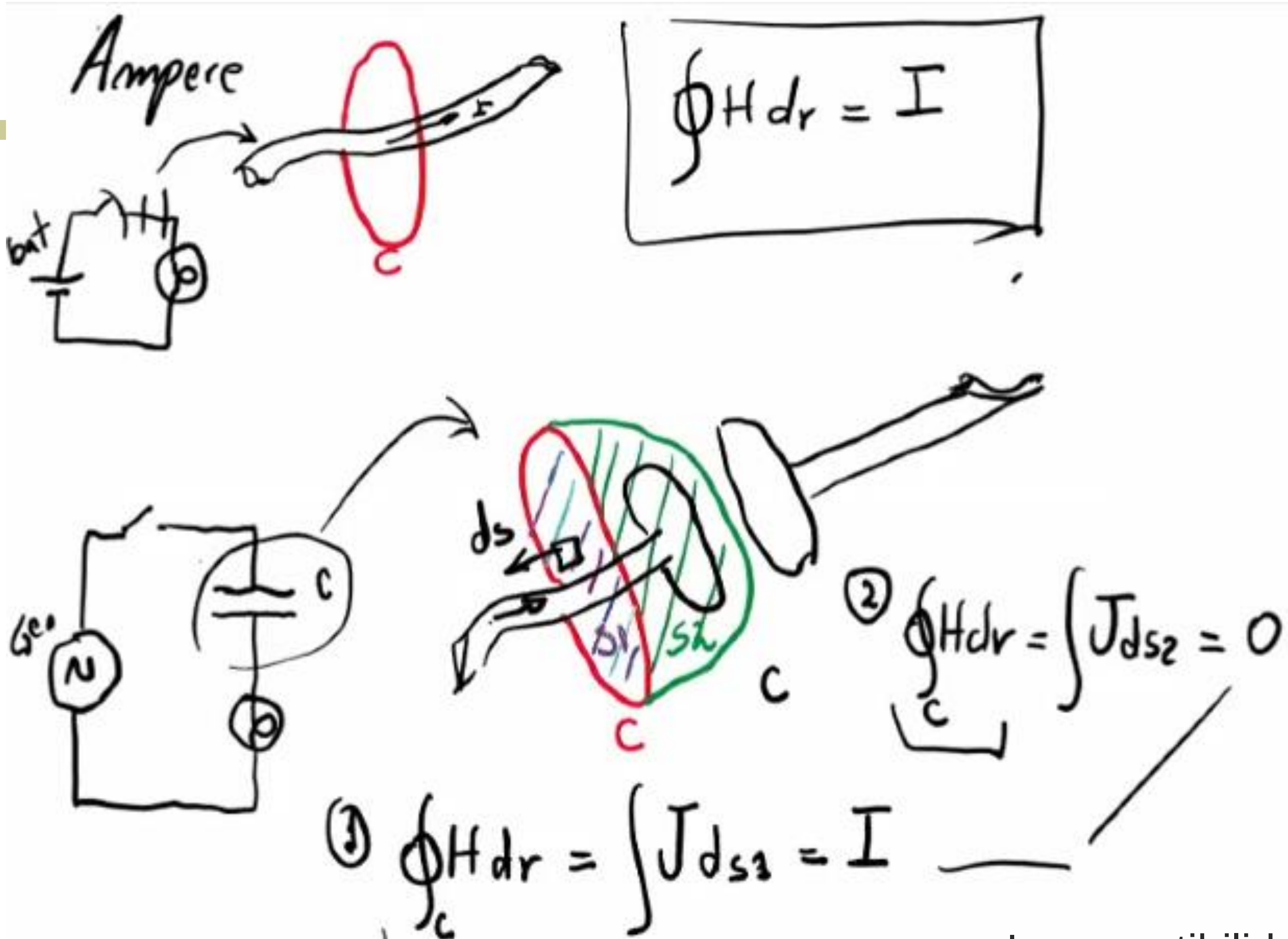
$$q = \int \rho \, dv$$

$$\bar{V} = \frac{1}{4\pi\varepsilon} \int \frac{\rho}{r} \, dv$$

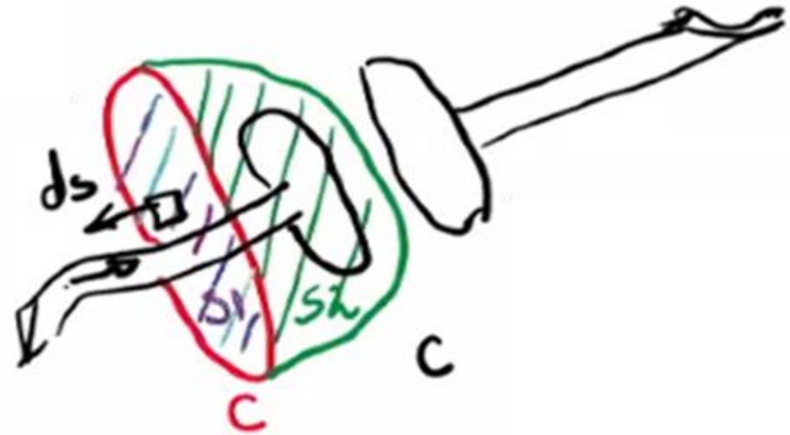
Vector de Potencial eléctrico

$$\bar{A} = \frac{\mu}{4\pi} \int \frac{I}{r} \, dl$$

Vector de Potencial magnético



Incompatibilidad
de la Ley de Amper



$$\int_{s_1} J\, ds_1 + \int_{s_2} J\, ds_2 \neq 0 \qquad \oint_{s_1+s_2} J\, ds \neq 0$$

$$I = \frac{\partial q}{\partial t} \qquad q = \int \rho\, dv$$

$$I = \int \frac{\partial \rho}{\partial t}\, dv \qquad \nabla \cdot D = \rho \qquad I = \int \nabla \cdot \frac{\partial D}{\partial t}\, dv$$

Teor. Div

$$I = -\oint J\, ds \qquad I = -\oint J\, ds = -\int \nabla J\, dv$$

$$\nabla \cdot \frac{\partial D}{\partial t} = -\nabla J \quad \therefore \quad \nabla\left(J + \frac{\partial D}{\partial t}\right) = 0$$

$$\nabla\cdot\left(\underbrace{J+\frac{\partial D}{\partial t}}_{\nabla\times H}\right)=0$$

$$\boxed{\nabla\times H = J+\frac{\partial D}{\partial t}}$$

si $\frac{\partial}{\partial t}=0$ $\quad\boxed{\nabla\times H = J}$

1ª Ec de Maxwell

o Ley de Ampere Generalizada (forma Vectorial)

$$\boxed{\nabla\times H = J+\frac{\partial D}{\partial t}}\qquad\boxed{\oint H\,dr = \int\left(J+\frac{\partial D}{\partial t}\right)ds}$$

forma Integral

Leyes de Maxwell

forma Vectorial — forma Integral

1) $$\boxed{\nabla \times H = J + \frac{\partial D}{\partial t}} \qquad \boxed{\oint H\,dr = \int \left(J + \frac{\partial D}{\partial t} \right) ds}$$

2) $$\boxed{\nabla \times E = -\mu \frac{\partial H}{\partial t}} \qquad \boxed{\oint E\,dr = -\mu \int \frac{\partial H}{\partial t}\, ds}$$

3) $$\boxed{\nabla \cdot \bar{D} = \rho} \qquad \boxed{\oint D\,ds = Q}$$

4) $$\boxed{\nabla \cdot \bar{B} = 0} \qquad \boxed{\oint B\,ds = 0}$$