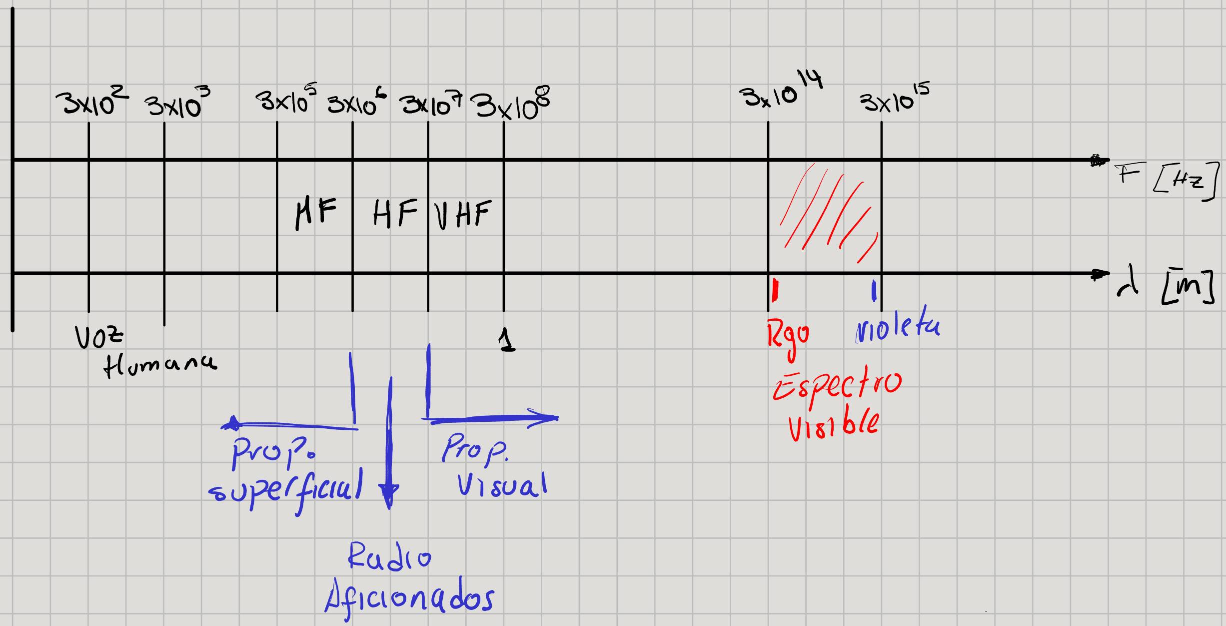
medios $\begin{cases} \mu \\ \varepsilon \\ \sigma \end{cases}$ Definen al Medio.

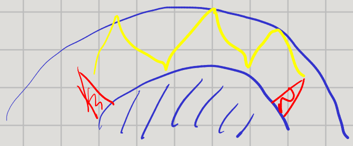
Espectro

Vacio $\begin{cases} \mu = \mu_0 & - \ 4\pi \times 10^{-7} \ H/m \\ \varepsilon = \varepsilon_0 & - \ \frac{1}{36\pi \cdot 10^{9}} \ F/m \\ \sigma = \sigma_0 & - \ 0 \end{cases}$

$$\lambda = \frac{c}{F}$$

$$V_p = \frac{1}{\sqrt{\mu \varepsilon}}$$

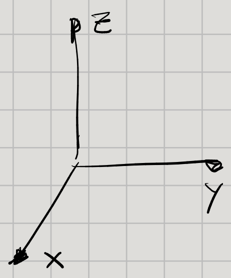




Depende de cond. del medio

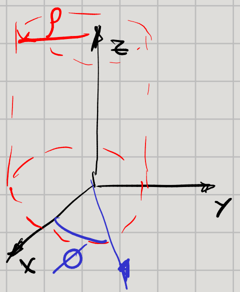
Sistemas de Coordenadas

a) Rectangulares



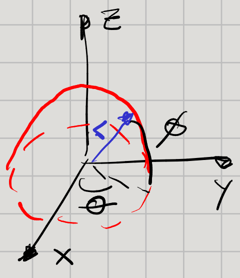
(x, y, z)

b) Cilíndricas



(ρ, ϕ, z)

c) esféricas

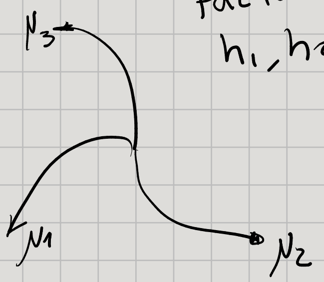


(r, θ, ϕ)

d) generalizadas

factor Escala

h_1, h_2, h_3



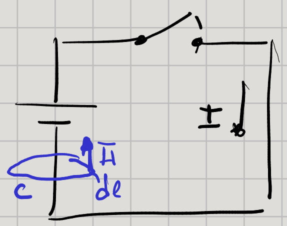
Equivalencias

Gen	$h_1 d\mu_1$	$h_2 d\mu_2$	$h_3 d\mu_3$
Rec	$1 \; dx$	$1 \; dy$	$1 \; dz$
Cil	$1 \; d\rho$	$\rho \; d\phi$	$1 \; dz$
Esf	$1 \; dr$	$r \; d\theta$	$r \sin\theta \; d\phi$

U.T. N° 2 Ec. de Maxwell

2.1. Ley de Ampere

Para CC



$$\oint_c \bar{H} \, d\bar{l} = I$$

$\bar{H}$ = Intensidad de campo Mg $[A/m]$

$\bar{E}$ = Intensidad de campo Elec. $[V/m]$

$\dfrac{\bar{E}}{\bar{H}} \left[\dfrac{V/m}{A/m}\right] = \eta \; [\Omega]$ Impedancia intrínseca del medio.

Definición del medio

$$\text{medio} \begin{cases} \mu \\ \varepsilon \\ \sigma \left[\frac{1}{\Omega m}\right] \end{cases} \longrightarrow \text{Conductividad}$$

solo para dielectricos

$$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \sqrt{\frac{4\pi \cdot 10^{-7}}{\frac{1}{36\pi \cdot 10^{9}}}} = \sqrt{4 \cdot 36 \cdot \pi^2 \cdot 10^2} = 2 \cdot 6 \cdot \pi \cdot 10 = 120\pi$$

2.2. Ley de trabajo Eléctrico

$$\int_a^b \bar{E} \cdot d\bar{l} = V_b - V_a$$

$$\oint_c \bar{E} \, d\bar{l} = 0$$

2.3. Ley de Gauss de $\bar{E}$

$$\oint \bar{E} d\bar{s} = \frac{Q}{\varepsilon_0}$$ Hla

$$\oint \bar{D} d\bar{s} = Q$$ Proge

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

2.4 Ley de Gauss para $\bar{B}$

$$\oint \bar{B} d\bar{s} = 0 \qquad \boxed{B = \mu \bar{H}}$$

↳ No hay monopolos.

Tabla de ecuaciones de campos estáticos

solo p/ medios discontinuos.

	Integral	Vectorial	
Ampere	$\oint \bar{H} d\bar{\ell} = I$	$\bar{\nabla} \times \bar{H} = J_c \left[\frac{A}{m^2}\right]$	Stokes
T. Elec	$\oint \bar{E} d\bar{\ell} = 0$	$\bar{\nabla} \times \bar{E} = 0$	
Gauss $\bar{E}$	$\oint \bar{D} d\bar{s} = Q$	$\bar{\nabla} . \bar{D} = \rho \left[\frac{C}{m^3}\right]$	Divergencia
Gauss $\bar{B}$	$\oint \bar{B} d\bar{s} = 0$	$\bar{\nabla} . \bar{B} = 0$	

Ec. de Maxwell

1. $\oint \bar{H} . d\bar{\ell} = \int \left(J_c + \varepsilon \frac{\partial \bar{E}}{\partial t}\right) ds \qquad \bar{\nabla} \times \bar{H} = \bar{J}_c + \varepsilon \frac{\partial \bar{E}}{\partial t}$

2. $\oint \bar{E} d\bar{\ell} = -\int \mu \frac{d\bar{H}}{\partial t} ds \qquad \bar{\nabla} \times \bar{E} = -\mu \frac{\partial \bar{H}}{\partial t}$

21 abril 2025

UT N° 3 sc Condiciones de contorno

1ª ec Mxuel

$$\oint H\,dl = \int \left(J + \varepsilon \frac{\partial E}{\partial t}\right) ds$$

2ª Ec Mxuel

$$\oint \bar{E}\,dl = -\mu \int \frac{\partial H}{\partial t}\, ds$$

3ª ec Mxuel

$$\oint D\,ds = Q$$

4ta Ec Mxuel

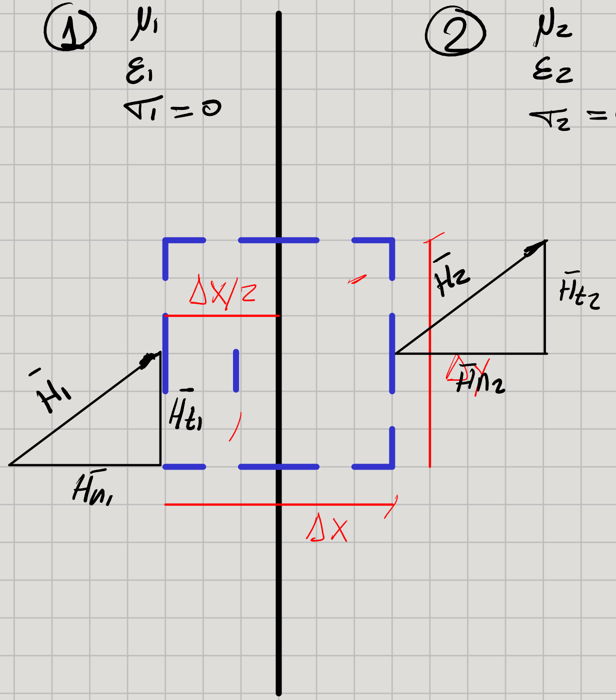
$$\oint B\,ds = 0$$

Dielectrico

Dielectrico

① μ_1 ε_1 $\sigma_1 = 0$

② μ_2 ε_2 $\sigma_2 = 0$ → Dielectrico.



Para la ec 1

$J = 0$

$$H_{t1}\Delta y + H_{n1}\Delta x/2 + H_{n2}\Delta x/2 - H_{t2}\Delta y - H_{n2}\Delta x/2 - H_{n1}\Delta x/2 = \varepsilon \frac{\partial E}{\partial t}\Delta x \Delta y$$

si $\Delta x \to 0$

$$H_{t1}\Delta y - H_{t2}\Delta y = 0$$

$$H_{t1} = H_{t2}$$

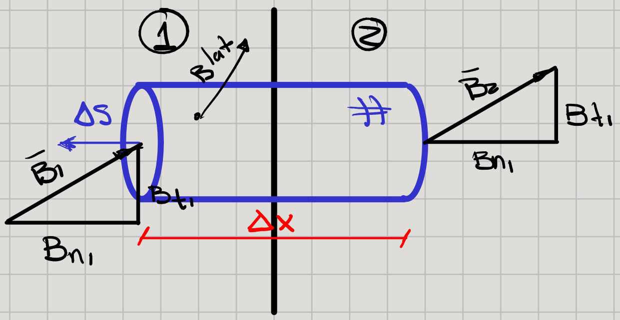
No alcanza para calcular el ángulo de refracción

Para la ec 2.

Con el mismo procedimiento

$$E_{t1} = E_{t2}$$

Para la ec 3



si $\Delta x \to 0$

$$-B_{n1}\Delta S_1 + B_{lat}\Delta S_{lat} + B_{ns}\Delta S_2 = 0$$

$$B_{n1} = B_{n2}$$

$$\boxed{\begin{array}{l} B = \mu H \\ D = \varepsilon E \\ J = \sigma E \end{array}}$$

Para la ec 4

Con el mismo procedimiento

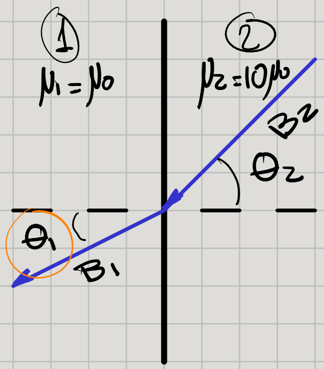
$$D_{n1} = D_{n2}$$

PROBLEMA N° 03.03.25

Dieléctrico - Dieléctrico.

Calcular el ángulo θ_1 con el que emerge el vector inducción **(B)** de un campo magnético de un material donde $\mu_1 = \mu_0$, si en el medio 2 de $\mu_2 = 10\,\mu_0$ su ángulo $\theta_2 = 74{,}60$ °.

Los ángulos están medidos desde la normal a la superficie de contorno.



Fórmulas

$$H_{t1} = H_{t2}$$

$$B_{n1} = B_{n2}$$

$$B = \mu H \to B_n = \mu H_n, \quad B_t = \mu H_t$$

$$tg\,\theta_1 = \frac{B_{t1}}{B_{n1}} \qquad tg\,\theta_2 = \frac{B_{t2}}{B_{n1}}$$

$$B_{n1} = \frac{B_{t1}}{tg\theta_1} \qquad B_{n2} = \frac{B_{t2}}{tg\theta_2}$$

$$B_{n1} = \frac{\mu_1 \cancel{H_{t1}}}{tg\theta_1} = B_{n2} = \frac{\mu_2 \cancel{H_{t2}}}{tg\theta_2}$$

$$\theta_1 = tg^{-1}\left(\frac{\mu_1}{\mu_2}\,tg\,\theta_2\right)$$

$$\theta_1 = tg^{-1}\left(\frac{1}{10}\,tg\,74{,}60\right)$$

$$\theta_1 = 14{,}953^{\circ}$$

El ángulo que emerge es $\boxed{\theta_1 = 14{,}953^{\circ}}$

Dieléctrico / Conductor perfecto

1^{ra} ec.

$\sigma = 0$ ① $\qquad\qquad \sigma \Rightarrow \infty$ ②

Densidad de corriente Lineal en la superficie

$$J_{LS} = \frac{I}{\Delta y} \qquad J = \frac{I}{\Delta x \, \Delta y} = \frac{J_{LS}}{\Delta x}$$

$$H_{t1}\Delta y + H_{n1}\Delta x/2 + H_{n2}\Delta x/2 - H_{t2}\Delta y - H_{n2}\Delta x/2 - H_{n1}\Delta x/2 = \frac{J_{LS}}{\Delta x}\Delta x \Delta y + \varepsilon\frac{\partial E}{\partial t}\Delta x \Delta y$$

$$\Delta x \to 0$$

$$H_{t1}\cancel{\Delta y} - H_{t2}\cancel{\Delta y} = J_{LS}\,\Delta y$$

$$H_{t1} = J_{LS}$$

$$H_{t2} = 0 \longrightarrow$$ No puede haber campo en el conductor.

3^{ra} ec.

$$\oint D\,ds = \int \rho\, dv$$

$$D_{n1} = \rho_s \qquad\qquad \rho = \frac{C}{m^3}$$

$$D_{n2} = 0 \qquad\qquad \rho_s = \frac{C}{m^2}$$