Universidad de Chile
Facultad de Ciencias Físicas y Matemáticas
Departamento de Física
FI2002 – Electromagnetismo

Formulario Electromagnetismo.

Profesor: Domenico Sapone
Auxiliares: Camila Montecinos
Vicente Pedreros

1. Formulario Matemático

(1) **Sistemas de Coordenadas Cilíndricas.**

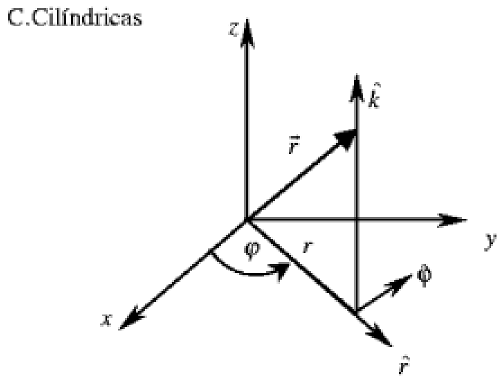

Figura 1: Coordenadas Cilíndricas

$$\vec{r} = r\hat{r} + z\hat{k}$$
$$x = rcos(\varphi)$$
$$y = rsen(\varphi)$$
$$z = z$$

(2) **Sistemas de Coordenadas Esféricas.**

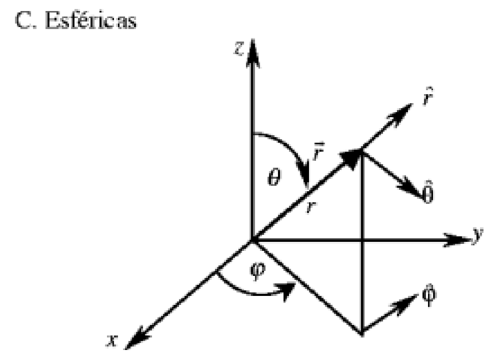

Figura 2: Coordenadas Esféricas.

$$\vec{r} = r\hat{r}$$
$$x = rsen(\theta)cos(\varphi)$$
$$y = rsen(\theta)sen(\varphi)$$
$$z = rcos(\theta)$$

1.1. Gradientes.

(1) **Cartesianas.**

$$\nabla\phi = \frac{\partial\phi}{\partial x}\hat{i} + \frac{\partial\phi}{\partial y}\hat{j} + \frac{\partial\phi}{\partial z}\hat{k}$$

(2) **Cilíndricas.**

$$\nabla\phi = \frac{\partial\phi}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial\phi}{\partial\varphi}\hat{\varphi} + \frac{\partial\phi}{\partial z}\hat{k}$$

(3) **Esféricas.**

$$\nabla\phi = \frac{\partial\phi}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial\phi}{\partial\theta}\hat{\theta} + \frac{1}{rsen(\theta)}\frac{\partial\phi}{\partial\varphi}\hat{\varphi}$$

1.2. Divergencias.

(1) **Cartesianas.**

$$\nabla \cdot \vec{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

(2) **Cilíndricas.**

$$\nabla \cdot \vec{A} = \frac{1}{r}\frac{\partial (rA_r)}{\partial r} + \frac{1}{r}\frac{\partial A_\varphi}{\partial \varphi} + \frac{\partial A_z}{\partial z}$$

(3) **Esféricas.**

$$\nabla \cdot \vec{A} = \frac{1}{r^2}\frac{\partial (r^2 A_r)}{\partial r} + \frac{1}{rsen(\theta)}\frac{\partial (sen(\theta)A_\theta)}{\partial \theta} + \frac{1}{rsen(\theta)}\frac{\partial A_\varphi}{\partial \varphi}$$

1.3. Elementos Diferenciales.

1.3.1. De linea.

(1) **Cartesianas.**

$$d\vec{l} = dx\hat{i} + dy\hat{j} + dz\hat{k}$$

(2) **Cilíndricas.**

$$d\vec{l} = dr\hat{r} + rd\theta\hat{\theta} + dz\hat{k}$$

(3) **Esféricas.**

$$d\vec{l} = dr\hat{r} + rd\theta\hat{\theta} + rsen(\theta)d\varphi\hat{\varphi}$$

1.3.2. De Superficie.

(1) **Cartesianas.**

$$d\vec{S} = dydz\hat{i} + dxdz\hat{j} + dxdy\hat{k}$$

(2) **Cilíndricas.**

$$d\vec{S} = rd\theta dz\hat{r} + drdz\hat{\theta} + rd\theta dr\hat{k}$$

(3) **Esféricas.**

$$d\vec{S} = r^2 sen(\theta)d\theta d\varphi\hat{r} + rsen(\theta)drd\varphi\hat{\theta} + rd\theta dr\hat{\varphi}$$

1.3.3. De Volumen.

(1) **Cartesianas.**

$$dV = dxdydz$$

(2) **Cilíndricas.**

$$dV = rdrd\varphi dz$$

(3) **Esféricas.**

$$dV = r^2 sen(\theta)drd\varphi d\theta$$

2. Formulario electromagnetismo

$$Carga(s)\ puntual(es): \quad \vec{E} = \frac{Q(\vec{r}-\vec{r'})}{4\pi\varepsilon_0\|\vec{r}-\vec{r'}\|^3} \qquad \vec{E} = \sum_{i=1}^{m} \frac{q_i(\vec{r}-\vec{r'})}{4\pi\varepsilon_0\|\vec{r}-\vec{r'}\|^3}$$

$$\textit{Campo por definición:}\ \vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{(\vec{r}-\vec{r'})\ dq}{\|\vec{r}-\vec{r'}\|^3}$$

$$\textit{Fuerza:}\ \vec{F} = \int \vec{E}\cdot dq \quad (\textit{Distribución continua}) \quad \vec{F} = q\cdot\vec{E} \quad (\textit{Cargas discretas})$$

$$\textit{Ley de Gauss:}\ \oint \vec{E}\cdot d\vec{S} = \frac{Q_{enc}}{\epsilon_0} \qquad \vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}$$

$$V(b)-V(a) = -\int_a^b \vec{E}\cdot dl \qquad -\nabla V = \vec{E} \qquad V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{\|\vec{r}-\vec{r'}\|}$$

$$\textit{Trabajo:}\ W = \int_a^b \vec{F}\cdot d\vec{r} \qquad W = -\Delta U \ \ (\textit{Electroestática}) \qquad \Delta U = q\cdot\Delta V$$

$$\oint \vec{D}\cdot d\vec{S} = Q_{libre} \qquad \vec{D} = \epsilon_0\vec{E}+\vec{P} \qquad \vec{D} = \epsilon\vec{E} \qquad \epsilon = \kappa\epsilon_0 \qquad \kappa = 1+\chi$$

$$\rho_p = -\vec{\nabla}\cdot\vec{P} \qquad \sigma_p = \vec{P}\cdot\hat{n}\ |_{borde}$$

Condiciones de borde:

$$E_{1t} = E_{2t} \qquad D_{2n}-D_{1n} = \sigma_L$$

$$C = \frac{Q}{V} \qquad C = \frac{\epsilon A}{d}\ (\textit{Capacitor placas paralelas}) \qquad U = \frac{1}{2}CV^2 \qquad U = \frac{1}{2}\iiint \vec{D}\cdot\vec{E}dV$$

$$I = \iint \vec{J}\cdot d\vec{S} \qquad \vec{J} = g\vec{E} \qquad V = I\cdot R \qquad I = \frac{dQ}{dt} \qquad R = \rho\frac{L}{A} \qquad \rho = \frac{1}{g}$$

Biot-Savart: $\vec{B} = \frac{\mu_0}{4\pi} \int \frac{I \cdot \vec{dl} \times (\vec{r} - \vec{r'})}{\| \vec{r} - \vec{r'} \|^3}$ *Ley de Ampere:* $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$

$$\oint \vec{H} \cdot d\vec{l} = I_{encL} \qquad \vec{B} = \mu_0(\vec{H} + \vec{M}) \qquad \vec{B} = \mu\vec{H}$$

$$\vec{J}_M = \vec{\nabla} \times \vec{M} \qquad \vec{K}_M = \vec{M} \times \hat{n} \,|_{borde}$$

$$\phi = \iint \vec{B} \cdot d\vec{S} \qquad \epsilon = -\frac{d\phi}{dt}$$