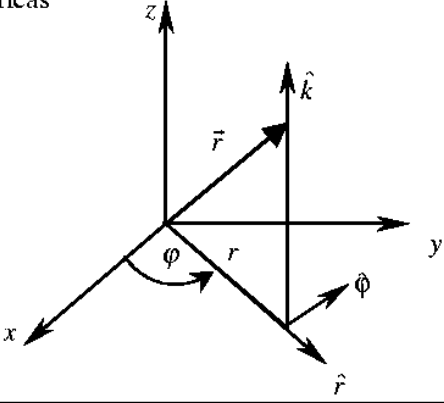
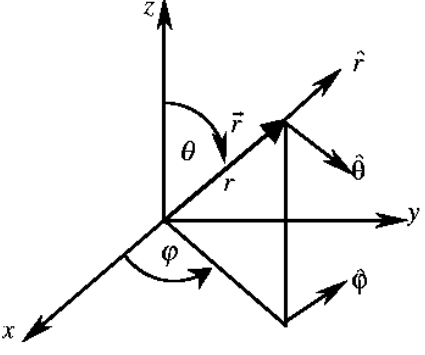


Formulario Matemático de Electromagnetismo

C. Cilíndricas  $\vec{r} = r\hat{r} + z\hat{k}$$x = r \cos \varphi$$y = r \sin \varphi$$z = z$	C. Esféricas  $\vec{r} = r\hat{r}$$x = r \sin \theta \cos \varphi$$y = r \sin \theta \sin \varphi$$z = r \cos \theta$
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1. Gradientes

Cartesianas $\nabla \phi = \frac{\partial \phi}{\partial x} \hat{i} + \frac{\partial \phi}{\partial y} \hat{j} + \frac{\partial \phi}{\partial z} \hat{k}$	Cilíndricas $\nabla \phi = \frac{\partial \phi}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial \phi}{\partial \varphi} \hat{\varphi} + \frac{\partial \phi}{\partial z} \hat{k}$	Esféricas $\nabla \phi = \frac{\partial \phi}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial \phi}{\partial \theta} \hat{\theta} + \frac{1}{r \sin \theta} \frac{\partial \phi}{\partial \varphi} \hat{\varphi}$
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2. Divergencias

Cartesianas $\nabla \cdot \vec{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$	Cilíndricas $\nabla \cdot \vec{A} = \frac{1}{r} \frac{\partial (r A_r)}{\partial r} + \frac{1}{r} \frac{\partial A_\varphi}{\partial \varphi} + \frac{\partial A_z}{\partial z}$
Esféricas $\nabla \cdot \vec{A} = \frac{1}{r^2} \frac{\partial (r^2 A_r)}{\partial r} + \frac{1}{r \sin \theta} \frac{\partial (\sin \theta A_\theta)}{\partial \theta} + \frac{1}{r \sin \theta} \frac{\partial A_\varphi}{\partial \varphi}$	

3. Rotores

Cartesianas $\nabla \times \vec{A} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ A_x & A_y & A_z \end{vmatrix} = \left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z} \right) \hat{i} + \left(\frac{\partial A_z}{\partial x} - \frac{\partial A_x}{\partial z} \right) \hat{j} + \left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y} \right) \hat{k}$
Cilíndricas $\nabla \times \vec{A} = \frac{1}{r} \begin{vmatrix} \hat{r} & r\hat{\varphi} & \hat{k} \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \varphi} & \frac{\partial}{\partial z} \\ A_r & rA_\varphi & A_z \end{vmatrix} = \frac{1}{r} \left\{ \left(\frac{\partial A_z}{\partial \varphi} - \frac{\partial (rA_\varphi)}{\partial z} \right) \hat{r} + r \left(\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r} \right) \hat{\varphi} + \left(\frac{\partial (rA_\varphi)}{\partial r} - \frac{\partial A_r}{\partial \varphi} \right) \hat{k} \right\}$
Esféricas $\nabla \times \vec{A} = \frac{1}{r^2 \sin \theta} \begin{vmatrix} \hat{r} & r\hat{\theta} & r \sin \theta \hat{\varphi} \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \varphi} \\ A_r & rA_\theta & r \sin \theta A_\varphi \end{vmatrix}$ $= \frac{1}{r^2 \sin \theta} \left\{ \left(\frac{\partial (r \sin \theta A_\varphi)}{\partial \theta} - \frac{\partial (rA_\theta)}{\partial \varphi} \right) \hat{r} + \left(\frac{\partial A_r}{\partial \varphi} - \frac{\partial (r \sin \theta A_\varphi)}{\partial r} \right) \hat{\theta} + \left(\frac{\partial (rA_\theta)}{\partial r} - \frac{\partial A_r}{\partial \theta} \right) r \sin \theta \hat{\varphi} \right\}$

4. Laplacianos

Cartesianas	Cilíndricas
$\nabla^2 \phi = \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2}$	$\nabla^2 \phi = \frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial \phi}{\partial r} \right) + \frac{1}{r^2} \frac{\partial^2 \phi}{\partial \varphi^2} + \frac{\partial^2 \phi}{\partial z^2}$
Esféricas	
$\nabla^2 \phi = \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial \phi}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial \phi}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 \phi}{\partial \varphi^2}$	

5. Elementos diferenciales

De línea		
Cartesianas $d\vec{l} = dx\hat{i} + dy\hat{j} + dz\hat{k}$	Cilíndricas $d\vec{l} = dr\hat{r} + r d\varphi\hat{\varphi} + dz\hat{k}$	Esféricas $d\vec{l} = dr\hat{r} + r d\theta\hat{\theta} + r \sin \theta d\varphi\hat{\varphi}$
De superficie		
Cartesianas $d\vec{s} = dydz\hat{i} + dx dz\hat{j} + dx dy\hat{k}$	Cilíndricas $d\vec{s} = r d\varphi dz\hat{r} + dr dz\hat{\varphi} + r dr d\varphi\hat{k}$	Esféricas $d\vec{s} = r^2 \sin \theta d\theta d\varphi\hat{r} + r \sin \theta dr d\varphi\hat{\theta} + r d\theta dr \hat{\varphi}$
De volumen		
Cartesianas $dv = dx dy dz$	Cilíndricas $dv = r dr d\varphi dz$	Esféricas $dv = r^2 \sin \theta dr d\varphi d\theta$

donde:

en cartesianas	$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$
en cilíndricas	$\vec{A} = A_r\hat{r} + A_\varphi\hat{\varphi} + A_z\hat{k}$
en esféricas	$\vec{A} = A_r\hat{r} + A_\varphi\hat{\varphi} + A_\theta\hat{\theta}$

6. Identidades Vectoriales

$\nabla \times (\nabla \phi) = 0$

$\nabla \cdot (\nabla \times \vec{A}) = 0$

$\nabla \times (\nabla \times \vec{A}) = \nabla (\nabla \cdot \vec{A}) - \nabla^2 \vec{A}$

$\nabla (\phi \psi) = \phi \nabla \psi + \psi \nabla \phi$

$\nabla \cdot (\phi \vec{A}) = \phi \nabla \cdot \vec{A} + \vec{A} \cdot \nabla \phi$

$\nabla \times (f(r)\vec{r}) = 0$

$\nabla \left(\frac{1}{r} \right) = -\frac{\vec{r}}{r^3} \quad (\text{con } |\vec{r}| = r)$

$\nabla \cdot (\vec{A} \times \vec{B}) = \vec{B} \cdot (\nabla \times \vec{A}) - \vec{A} \cdot (\nabla \times \vec{B})$

$\nabla \cdot \vec{r} = 3 \quad \nabla \times \vec{r} = 0$

$\nabla (\vec{A} \cdot \vec{r}) = \vec{A}$

$\nabla \times (\phi \vec{A}) = \nabla \phi \times \vec{A} + \phi (\nabla \times \vec{A})$

$\nabla (r^n) = nr^{n-2} \vec{r}$

$\nabla^2 \left(\frac{1}{r} \right) = \delta(\vec{r})$

$\nabla^2 \left(\frac{1}{r} \right) = 0 \quad (\text{para } r \neq 0)$

$\nabla \times (\vec{A} \times \vec{B}) = (\vec{B} \cdot \nabla) \vec{A} - (\vec{A} \cdot \nabla) \vec{B} + \vec{A} \nabla \cdot \vec{B} - \vec{B} \nabla \cdot \vec{A}$

$\nabla \times (\phi \vec{A}) = \phi \nabla \times \vec{A} - \vec{A} \times \nabla \phi$