

Formulari EM

Canvis de Coordenades

Coordenades cilíndriques (s, θ, z)

$$s = \sqrt{x^2 + y^2} \quad \theta = \arctan \frac{y}{x} \quad z = z$$

$$x = s \cos \theta \quad y = s \sin \theta \quad z = z$$

$$\begin{pmatrix} A_x \\ A_y \\ A_z \end{pmatrix} = \begin{pmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} A_s \\ A_\theta \\ A_z \end{pmatrix}$$

Coordenades esfèriques (r, θ, φ)

$$r = \sqrt{x^2 + y^2 + z^2} \quad \theta = \arccos \frac{z}{r} \quad \varphi = \frac{y}{x}$$

$$x = r \sin \theta \cos \varphi \quad y = r \sin \theta \sin \varphi \quad z = r \cos \theta$$

$$\begin{pmatrix} A_x \\ A_y \\ A_z \end{pmatrix} = \begin{pmatrix} \sin \theta \cos \varphi & \sin \theta \sin \varphi & \cos \theta \\ \sin \theta \sin \varphi & \cos \theta \sin \varphi & -\sin \theta \\ \cos \theta & -\sin \theta & 0 \end{pmatrix} \begin{pmatrix} A_s \\ A_\theta \\ A_\varphi \end{pmatrix}$$

$$d\vec{S}_{r=cte} = r^2 \sin \theta d\theta d\varphi \quad d\vec{S}_{\theta=cte} = r \sin \theta dr d\varphi$$

$$d\vec{S}_{\varphi=cte} = r dr d\theta$$

Electrostatica

$$\vec{F}_{q_1 q_2} = k \frac{q_1 q_2}{d^2} \frac{\vec{r}_2 - \vec{r}_1}{\|\vec{r}_2 - \vec{r}_1\|} \quad \vec{E}_q(\vec{r}) = \frac{kq}{\|\vec{r} - \vec{r}_q\|^2} \frac{(\vec{r} - \vec{r}_q)}{\|\vec{r} - \vec{r}_q\|}$$

$$\vec{F} = q\vec{E} \quad \vec{p} = q\vec{l} \quad \vec{M} = \vec{p} \times \vec{E}$$

$$\int_Q d\vec{E} = k \int_Q \frac{dq}{\|\vec{r} - \vec{r}'\|^2} \frac{(\vec{r} - \vec{r}')}{\|\vec{r} - \vec{r}'\|}$$

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

$$\text{Llei de Gauss} \quad \oint_S \vec{E} d\vec{S} = \frac{q_{int}}{\epsilon_0}$$

$$\text{Forma diferencial} \quad \nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

$$W = \int_C \vec{F} d\vec{r} = -\Delta U$$

$$\Delta V = -\int \vec{E} d\vec{r} \quad dV = -\vec{E} d\vec{r} = \Delta V$$

$$\vec{E} = -\vec{\nabla} V \quad \Gamma = \oint_C \vec{E} d\vec{l} = \int_S (\vec{\nabla} \times \vec{E}) = 0$$

$$\text{rot } \vec{E} = \frac{\Gamma}{dS} = \vec{\nabla} \times \vec{E}$$

$$U = \frac{\epsilon_0}{2} \int |\vec{E}|^2 dV \quad \eta_E = \frac{1}{2} \epsilon_0 |\vec{E}|^2$$

Conductors

$$V = \frac{kQ}{r}$$

$$C = \frac{Q}{V}$$

Corrent

$$I = \frac{dq}{dt} = nqvS = \int_S \vec{j} \cdot d\vec{S} = \sigma ES$$

$$\vec{j} = nq\vec{v} = \sigma E$$

$$\rho_i = q_i n_i$$

$$\text{Equacio de continuïtat} \quad j_2 s_2 - j_1 s_1 = -\frac{dQ}{dt}$$

$$\Delta V = El$$

$$\frac{\Delta V}{l} = R$$

$$\rho = \frac{1}{\sigma} \quad R = \rho \frac{l}{S}$$

Magnetisme

$$\oint_C \vec{B} d\vec{l} = \mu_0 I$$

$$\vec{B} = \int_l d\vec{B} = \frac{\mu_0}{4\pi} \int_l \frac{I d\vec{l} \times \vec{r}}{r^3}$$

$$\vec{B}(\vec{r}_p) = \frac{\mu_0}{4\pi} q \frac{\vec{v} \times \vec{r}}{r^3}$$

$$\oint \vec{B} dS = 0$$

$$\epsilon = -\frac{\partial \Phi_B}{\partial t}$$

$$\vec{F} = I \vec{d}' \times \vec{B}$$

$$I = \frac{\epsilon}{R}$$

$$P = I^2 R$$

$$\oint_C \vec{B} \cdot d\vec{l} = \mu_0 I_0$$

$$\eta_B = \frac{1}{2\mu_0} |\vec{B}|^2$$

$$m = I \vec{S} \times \vec{B}$$

Electromagnetisme

$$\oint_C \vec{B} d\vec{l} = \mu_0 I + \mu_0 \epsilon_0 \frac{\partial \Phi_E}{\partial t}$$

$$\oint_C \vec{E} d\vec{l} = -\frac{\partial \Phi_B}{\partial t}$$

$$\text{Equacions de Maxwell}$$

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon}$$

$$\vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{j} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

Dielectrics

$$\sigma_b = \vec{P} \cdot \hat{n} \quad \rho_b = -\vec{\nabla} \cdot \vec{P}$$

$$\vec{P} = \epsilon_0 \chi \vec{E}$$

$$\vec{D} = \epsilon_0 \epsilon_r \vec{E} \quad \epsilon_r = 1 + \chi$$

$$\vec{S} = \vec{E} \times \vec{H} = \frac{1}{\mu} \vec{E} \times \vec{B}$$

Constants i Unitats

$$k = 9 \times 10^9$$

$$e = -1.602 \times 10^{-19}$$

$$\vec{p}$$

$$\vec{M}$$

$$\vec{E}$$

$$\Phi$$

$$\epsilon_0 = 8.8541 \times 10^{-12}$$

$$W$$

$$V$$

$$n$$

$$v$$

$$\vec{j}$$

$$\rho$$

$$\sigma$$

$$\sigma_b$$

$$\text{Const de Coulomb } \left[\frac{Nm^2}{C^2} \right]$$

$$\text{Càrrega Electrò } [C]$$

$$\text{Moment dipolar } [Cm]$$

$$\text{Moment de forces } [Nm]$$

$$\text{Camp Elèctric } \left[\frac{N}{C} \right]$$

$$\text{Flux Elèctric } \left[\frac{Nm^2}{C} \right]$$

$$\text{Permitivitat buit} \left[\frac{C^2}{Nm^2} \right]$$

$$\text{Treball } [Nm]$$

$$\text{Potencial } [V]$$

$$\text{portadors per } m^3$$

$$\text{velocitat } \left[\frac{m}{s^2} \right]$$

$$\text{vector densitat de corrent} [?]$$

$$\text{resistivitat} [\Omega m]$$

$$\text{conductivitat } \left[\frac{S}{m} \right]$$

$$\text{dens superficial de } C \left[\frac{C}{m^2} \right]$$