

**Formler i elektromagnetisme:**

$$\mathbf{F} = \frac{Qq}{4\pi\epsilon R^2} \hat{\mathbf{R}}, \quad \mathbf{E} = \mathbf{F}/q, \quad V_P = \int_P^{\text{ref}} \mathbf{E} \cdot d\mathbf{l}, \quad V = \frac{Q}{4\pi\epsilon R}, \quad \mathbf{E} = -\nabla V,$$

$$\oint_S \mathbf{D} \cdot d\mathbf{S} = Q_{\text{fri i } S}, \quad \nabla \cdot \mathbf{D} = \rho, \quad \mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}, \quad \mathbf{P} = \epsilon_0 \chi_e \mathbf{E}, \quad \mathbf{D} = \epsilon \mathbf{E},$$

$$\epsilon = \epsilon_0(1 + \chi_e), \quad C = Q/V, \quad C = \epsilon S/d, \quad W_e = \frac{1}{2} CV^2, \quad w_e = \frac{1}{2} \mathbf{D} \cdot \mathbf{E},$$

$$\mathbf{p} = Q\mathbf{d}, \quad \mathbf{J} = NQ\mathbf{v}, \quad \mathbf{J} = \sigma \mathbf{E}, \quad P_J = \int_v \mathbf{J} \cdot \mathbf{E} dv,$$

$$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{I d\mathbf{l} \times \hat{\mathbf{R}}}{R^2}, \quad d\mathbf{F} = I d\mathbf{l} \times \mathbf{B}, \quad \mathbf{F} = Q(\mathbf{E} + \mathbf{v} \times \mathbf{B}), \quad \mathbf{T} = \mathbf{m} \times \mathbf{B},$$

$$\mathbf{m} = I\mathbf{S}, \quad \mathbf{H} = \frac{\mathbf{B}}{\mu_0} - \mathbf{M}, \quad \mathbf{M} = \chi_m \mathbf{H}, \quad \mathbf{B} = \mu \mathbf{H}, \quad \mu = \mu_0(1 + \chi_m),$$

$$\nabla \cdot \mathbf{B} = 0, \quad \oint_C \mathbf{H} \cdot d\mathbf{l} = \int_S \mathbf{J} \cdot d\mathbf{S}, \quad w_m = \frac{1}{2} \mathbf{B} \cdot \mathbf{H},$$

$$L_{12} = \frac{\Phi_{12}}{I_1} = L_{21} = \frac{\Phi_{21}}{I_2}, \quad L = \frac{\Phi}{I}, \quad W_m = \frac{1}{2} \sum_{k=1}^n I_k \Phi_k = \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n L_{jk} I_j I_k,$$

$$\mathbf{F} = -(\nabla W_m)_{\text{uten kilder eller tap}}, \quad \mathbf{F} = +(\nabla W_m)_{I=\text{konst}}, \quad \nabla \cdot \mathbf{J} + \frac{\partial \rho}{\partial t} = 0.$$

**Maxwells likninger:**

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \quad \oint_C \mathbf{E} \cdot d\mathbf{l} = -\int_S \frac{\partial \mathbf{B}}{\partial t} \cdot d\mathbf{S}, \quad e = -\frac{d\Phi}{dt},$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}, \quad \oint_C \mathbf{H} \cdot d\mathbf{l} = \int_S \left( \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t} \right) \cdot d\mathbf{S},$$

$$\nabla \cdot \mathbf{D} = \rho, \quad \oint_S \mathbf{D} \cdot d\mathbf{S} = Q_{\text{fri i } S},$$

$$\nabla \cdot \mathbf{B} = 0, \quad \oint_S \mathbf{B} \cdot d\mathbf{S} = 0.$$

**Potensialer i elektrodynamikken:**

$$\mathbf{B} = \nabla \times \mathbf{A}, \quad \mathbf{E} = -\nabla V - \frac{\partial \mathbf{A}}{\partial t}, \quad \nabla^2 V - \epsilon\mu \frac{\partial^2 V}{\partial t^2} = -\frac{\rho}{\epsilon}, \quad \nabla^2 \mathbf{A} - \epsilon\mu \frac{\partial^2 \mathbf{A}}{\partial t^2} = -\mu \mathbf{J},$$

$$V(\mathbf{r}, t) = \frac{1}{4\pi\epsilon} \int_v \frac{\rho(\mathbf{r}', t - R/c) dv'}{R}, \quad \mathbf{A}(\mathbf{r}, t) = \frac{\mu}{4\pi} \int_v \frac{\mathbf{J}(\mathbf{r}', t - R/c) dv'}{R}.$$

**Grensebetingelser:**

$$\mathbf{E}_{1t} = \mathbf{E}_{2t}, \quad \mathbf{D}_{1n} - \mathbf{D}_{2n} = \rho_s \hat{\mathbf{n}}, \quad \mathbf{H}_{1t} - \mathbf{H}_{2t} = \mathbf{J}_s \times \hat{\mathbf{n}}, \quad \mathbf{B}_{1n} = \mathbf{B}_{2n}.$$

**Konstanter:**

$$\mu_0 = 4\pi \cdot 10^{-7} \text{ H/m}$$

$$\epsilon_0 = 1/(\mu_0 c_0^2) \approx 8.854 \cdot 10^{-12} \text{ F/m}$$

$$\text{Lyshastighet i vakuum: } c_0 = 1/\sqrt{\mu_0 \epsilon_0} = 299792458 \text{ m/s} \approx 3.0 \cdot 10^8 \text{ m/s}$$

$$\text{Lyshastighet i et medium: } c = 1/\sqrt{\mu \epsilon}$$

$$\text{Elementærladningen: } e = 1.6 \cdot 10^{-19} \text{ C}$$

$$\text{Elektronets hvilemasse: } m_e = 9.11 \cdot 10^{-31} \text{ kg}$$

$$\text{Standard tyngdeakselerasjon: } g = 9.80665 \text{ m/s}^2$$

$$\text{Gravitasjonskonstant: } \gamma = 6.673 \cdot 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2.$$

**Differensielle vektoridentiteter:**

$$\begin{aligned} \hat{\mathbf{x}} \cdot \nabla V &= \frac{\partial V}{\partial x} \quad (x \text{ vilkårlig akse}) \\ \nabla(V+W) &= \nabla V + \nabla W \\ \nabla(VW) &= V\nabla W + W\nabla V \\ \nabla f(V) &= f'(V)\nabla V \\ \nabla(\mathbf{A} \cdot \mathbf{B}) &= (\mathbf{A} \cdot \nabla)\mathbf{B} + (\mathbf{B} \cdot \nabla)\mathbf{A} \\ &\quad + \mathbf{A} \times (\nabla \times \mathbf{B}) + \mathbf{B} \times (\nabla \times \mathbf{A}) \\ \nabla \cdot (\mathbf{A} + \mathbf{B}) &= \nabla \cdot \mathbf{A} + \nabla \cdot \mathbf{B} \\ \nabla \cdot (V\mathbf{A}) &= V\nabla \cdot \mathbf{A} + \mathbf{A} \cdot \nabla V \\ \nabla \cdot (\mathbf{A} \times \mathbf{B}) &= \mathbf{B} \cdot \nabla \times \mathbf{A} - \mathbf{A} \cdot \nabla \times \mathbf{B} \\ \nabla \times (\mathbf{A} + \mathbf{B}) &= \nabla \times \mathbf{A} + \nabla \times \mathbf{B} \\ \nabla \times (V\mathbf{A}) &= (\nabla V) \times \mathbf{A} + V\nabla \times \mathbf{A} \\ \nabla \cdot (\nabla \times \mathbf{A}) &= 0 \\ \nabla \cdot (\nabla V) &= \nabla^2 V \\ \nabla \times (\nabla V) &= 0 \\ \nabla \times (\nabla \times \mathbf{A}) &= \nabla(\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A} \end{aligned}$$

**Integralidentiteter:**

$$\begin{aligned} \int_v \nabla V dv &= \oint_S V d\mathbf{S} \\ \int_v \nabla \cdot \mathbf{A} dv &= \oint_S \mathbf{A} \cdot d\mathbf{S} \quad (\text{Divergensteoremet}) \\ \int_v \nabla \times \mathbf{A} dv &= \oint_S d\mathbf{S} \times \mathbf{A} \\ \int_S \nabla \times \mathbf{A} \cdot d\mathbf{S} &= \oint_C \mathbf{A} \cdot d\mathbf{l} \quad (\text{Stokes' teorem}) \end{aligned}$$

**Kartesisk koordinatsystem:**

$$\begin{aligned} \nabla V &= \frac{\partial V}{\partial x} \hat{\mathbf{x}} + \frac{\partial V}{\partial y} \hat{\mathbf{y}} + \frac{\partial V}{\partial z} \hat{\mathbf{z}} \\ \nabla \cdot \mathbf{A} &= \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z} \\ \nabla \times \mathbf{A} &= \hat{\mathbf{x}} \left( \frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z} \right) \\ &\quad + \hat{\mathbf{y}} \left( \frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x} \right) + \hat{\mathbf{z}} \left( \frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y} \right) \\ \nabla^2 V &= \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} \\ \nabla^2 \mathbf{A} &= (\nabla^2 A_x) \hat{\mathbf{x}} + (\nabla^2 A_y) \hat{\mathbf{y}} + (\nabla^2 A_z) \hat{\mathbf{z}} \end{aligned}$$

**Sylindrisk koordinatsystem:**

$$\begin{aligned} \nabla V &= \frac{\partial V}{\partial r} \hat{\mathbf{r}} + \frac{1}{r} \frac{\partial V}{\partial \phi} \hat{\phi} + \frac{\partial V}{\partial z} \hat{\mathbf{z}} \\ \nabla \cdot \mathbf{A} &= \frac{1}{r} \frac{\partial(rA_r)}{\partial r} + \frac{1}{r} \frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z} \\ \nabla \times \mathbf{A} &= \hat{\mathbf{r}} \left( \frac{1}{r} \frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z} \right) \\ &\quad + \hat{\phi} \left( \frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r} \right) + \hat{\mathbf{z}} \left( \frac{\partial(rA_\phi)}{\partial r} - \frac{\partial A_r}{\partial \phi} \right) \\ \nabla^2 V &= \frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial V}{\partial r} \right) + \frac{1}{r^2} \frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2} \end{aligned}$$

**Sfærisk koordinatsystem:**

$$\begin{aligned} \nabla V &= \frac{\partial V}{\partial r} \hat{\mathbf{r}} + \frac{1}{r} \frac{\partial V}{\partial \theta} \hat{\theta} + \frac{1}{r \sin \theta} \frac{\partial V}{\partial \phi} \hat{\phi} \\ \nabla \cdot \mathbf{A} &= \frac{1}{r^2} \frac{\partial(r^2 A_r)}{\partial r} \\ &\quad + \frac{1}{r \sin \theta} \frac{\partial(\sin \theta A_\theta)}{\partial \theta} + \frac{1}{r \sin \theta} \frac{\partial A_\phi}{\partial \phi} \\ \nabla \times \mathbf{A} &= \frac{\hat{\mathbf{r}}}{r \sin \theta} \left( \frac{\partial(\sin \theta A_\phi)}{\partial \theta} - \frac{\partial A_\theta}{\partial \phi} \right) \\ &\quad + \frac{\hat{\theta}}{r} \left( \frac{1}{\sin \theta} \frac{\partial A_r}{\partial \phi} - \frac{\partial(rA_\phi)}{\partial r} \right) \\ &\quad + \frac{\hat{\phi}}{r} \left( \frac{\partial(rA_\theta)}{\partial r} - \frac{\partial A_r}{\partial \theta} \right) \\ \nabla^2 V &= \frac{1}{r^2} \frac{\partial}{\partial r} \left( r^2 \frac{\partial V}{\partial r} \right) \\ &\quad + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial V}{\partial \theta} \right) \\ &\quad + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2 V}{\partial \phi^2} \end{aligned}$$