Formelliste
TFY4155/FY1003 Elektrisitet og magnetisme

Formlenes gyldighetsområde og de ulike symbolenes betydning antas å være kjent. Symbolbruk som i forelesningene. Siste revisjon: 01.12.09 (kan bli endringer før eksamen.) (2 sider).

(Q, ρ og σ uten indeks viser til *frie* ladninger. Q_i, ρ_i og σ_i er indusert ladning)

Coulombs lov: $\vec{F}_{12} = \frac{1}{4\pi\epsilon}\frac{q_1 q_2}{r^2}\hat{\mathbf{r}}$ $\quad \vec{E} = \frac{1}{4\pi\epsilon}\frac{q}{r^2}\hat{\mathbf{r}}$

Gauss' lov integralform: $\oiint \vec{D}\cdot \mathrm{d}\vec{A} = Q$ $\quad \oiint \vec{E}\cdot \mathrm{d}\vec{A} = Q/\epsilon$ $\quad \oiint \vec{P}\cdot \mathrm{d}\vec{A} = -Q_\mathrm{i}$ $\quad \oiint \vec{B}\cdot \mathrm{d}\vec{A} = 0$

Gauss' lov differensialform: $\mathrm{div}\vec{D} = \rho$ $\quad \mathrm{div}\vec{E} = \rho/\epsilon$ $\quad \mathrm{div}\,\vec{P} = -\rho_\mathrm{i}$ $\quad \mathrm{div}\vec{B} = 0$

Fluks: $\Phi_E = \iint \vec{E}\cdot \mathrm{d}\vec{A}$ $\quad \Phi = \iint \vec{D}\cdot \mathrm{d}\vec{A} = \epsilon\,\Phi_E$ $\quad \Phi_B = \iint \vec{B}\cdot \mathrm{d}\vec{A}$

Amperes lov: $\oint \vec{B}\cdot \mathrm{d}\vec{s} = \mu\left(I_c + \epsilon\frac{\partial \Phi_E}{\partial t}\right)$ $\quad \oint \vec{H}\cdot \mathrm{d}\vec{s} = I_c + \frac{\partial \Phi}{\partial t}$ $\quad \mathrm{curl}\,\vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$

Faradays lov: $\mathcal{E} = -\frac{\partial \Phi_B}{\partial t} = -L\frac{\mathrm{d}I}{\mathrm{d}t}$ $\quad \oint \vec{E}\cdot \mathrm{d}\vec{s} = -\frac{\partial \Phi_B}{\partial t}$ $\quad \mathrm{curl}\,\vec{E} = -\frac{\partial \vec{B}}{\partial t}$

Maxwells likninger: $\mathrm{div}\vec{D} = \rho$ $\quad \mathrm{div}\vec{B} = 0$ $\quad \mathrm{curl}\,\vec{E} = -\frac{\partial \vec{B}}{\partial t}$ $\quad \mathrm{curl}\,\vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$

Elektrisk dipolmoment: $\vec{p} = q\vec{d}$ (fra − til +) Polarisering: $\vec{P} = \frac{\sum \vec{p}}{V}$

Magnetisk (dipol)moment: $\vec{\mu} = I\vec{A}$ Magnetisering: $\vec{M} = \frac{\sum \vec{\mu}}{V}$

$\vec{D} = \epsilon_0\vec{E} + \vec{P} = \epsilon\vec{E} = \epsilon_\mathrm{r}\epsilon_0\vec{E}$ $\quad \vec{P} = \chi_\mathrm{e}\epsilon_0\vec{E}$ $\quad \epsilon_\mathrm{r} = 1 + \chi_\mathrm{e}$

$\vec{B} = \mu_0\vec{H} + \mu_0\vec{M} = \mu\vec{H} = \mu_\mathrm{r}\mu_0\vec{H}$ $\quad \vec{M} = \chi_\mathrm{m}\vec{H}$ $\quad \mu_\mathrm{r} = 1 + \chi_\mathrm{m}$

Elektrisk potensial: $V_a - V_b = -\int_b^a \vec{E}\cdot \mathrm{d}\vec{s}$, $\quad \vec{E} = -\vec{\nabla}V$,

Energi og energitetthet: $U = \frac{1}{2}\iiint V\mathrm{d}q$ Elektrisk: $u = \frac{1}{2}\vec{D}\vec{E}$ Magnetisk: $u = \frac{1}{2}\vec{B}\vec{H}$

Kondensatorer: $C = \frac{Q}{V}$ Kulekondensator: $C = 4\pi\epsilon_0 R$ Energi: $U = \frac{1}{2}QV = \frac{1}{2}CV^2$

Platekondensator: $C = \epsilon\frac{A}{d}$ Parallellkopling: $C = \sum_i C_i$ Seriekopling: $\frac{1}{C} = \sum_i \frac{1}{C_i}$

Kraft på strømførende leder: $\mathrm{d}\vec{F} = I\mathrm{d}\vec{s}\times\vec{B}$ Lorentzkrafta: $\vec{F} = q\left(\vec{E} + \vec{v}\times\vec{B}\right)$

Biot-Savarts lov: $\vec{B} = \frac{\mu_0}{4\pi}\frac{q\,\vec{v}\times\hat{\mathbf{r}}}{r^2}$ $\quad \mathrm{d}\vec{B} = \frac{\mu_0}{4\pi}\frac{I\mathrm{d}\vec{s}\times\hat{\mathbf{r}}}{r^2}$

H-felt rundt ∞ lang leder: $H_\theta = \frac{I}{2\pi r}$ H-felt i lang, tynn solenoide: $H = I\cdot n = I\cdot\frac{N}{\ell}$

Ohms lov: $V = RI$, $\sigma\vec{E} = \vec{J}$ Strømtetthet: $\vec{J} = nq\vec{v}_\mathrm{d}$ der $\vec{v}_\mathrm{d} = \mu\vec{E}$ = driftsfart.

Spoler: $L = N\frac{\Phi_B}{I}$ $\quad U = \frac{1}{2}LI^2$

Lenz lov: En indusert strøm er alltid slik at den forsøker å motvirke forandringen i den magnetiske fluks som er årsak til strømmen.

Nablaoperatoren:

Kartesiske koordinater (x, y, z)*, med enhetsvektorer henholdsvis* $\hat{\mathbf{i}}$, $\hat{\mathbf{j}}$ *og* $\hat{\mathbf{k}}$*:*

$$\begin{aligned}
\text{grad}V = \vec{\nabla} V &= \hat{\mathbf{i}}\,\frac{\partial V}{\partial x} + \hat{\mathbf{j}}\,\frac{\partial V}{\partial y} + \hat{\mathbf{k}}\,\frac{\partial V}{\partial z} \\
\text{div}\vec{D} = \vec{\nabla}\cdot\vec{D} &= \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z} \\
\vec{\nabla}^2 V &= \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} \\
\text{curl}\,\vec{D} = \vec{\nabla}\times\vec{D} &= \begin{vmatrix} \hat{\mathbf{i}} & \hat{\mathbf{j}} & \hat{\mathbf{k}} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ D_x & D_y & D_z \end{vmatrix}
\end{aligned}$$

Sylinderkoordinater (r, ϕ, z)*, med enhetsvektorer henholdsvis* $\hat{\mathbf{r}}$, $\hat{\phi}$ *og* $\hat{\mathbf{k}}$:

$$\begin{aligned}
\vec{\nabla} V &= \hat{\mathbf{r}}\,\frac{\partial V}{\partial r} + \hat{\phi}\,\frac{1}{r}\frac{\partial V}{\partial \phi} + \hat{\mathbf{k}}\,\frac{\partial V}{\partial z} \\
\vec{\nabla}\cdot\vec{D} &= \frac{1}{r}\frac{\partial}{\partial r}(rD_r) + \frac{1}{r}\frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z} \\
\vec{\nabla}^2 V &= \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2}
\end{aligned}$$

Kulekoordinater (r, θ, ϕ)*, med enhetsvektorer henholdsvis* $\hat{\mathbf{r}}$, $\hat{\theta}$, $\hat{\phi}$:

$$\begin{aligned}
\vec{\nabla} V &= \hat{\mathbf{r}}\,\frac{\partial V}{\partial r} + \hat{\theta}\,\frac{1}{r}\frac{\partial V}{\partial \theta} + \hat{\phi}\,\frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi} \\
\vec{\nabla}\cdot\vec{D} &= \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 D_r\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(D_\theta \sin\theta) + \frac{1}{r\sin\theta}\frac{\partial D_\phi}{\partial \phi} \\
\vec{\nabla}^2 V &= \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial V}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial \phi^2}
\end{aligned}$$

Divergensteoremet og Stokes' teorem for et tilfeldig vektorfelt $\vec{F}$*:*

$$\oiint \vec{F}\cdot \mathrm{d}\vec{A} = \iiint \vec{\nabla}\cdot\vec{F}\;\mathrm{d}\tau$$

$$\oint \vec{F}\cdot \mathrm{d}\vec{s} = \iint \left(\vec{\nabla}\times\vec{F}\right)\cdot \mathrm{d}\vec{A}$$

Infinitesimale volumelement:

$$\begin{aligned}
\mathrm{d}\tau &= \mathrm{d}x\,\mathrm{d}y\,\mathrm{d}z \\
\mathrm{d}\tau &= r^2\,\mathrm{d}r\,\sin\theta\,\mathrm{d}\theta\,\mathrm{d}\phi \xrightarrow{\text{kulesymmetri}} 4\pi r^2\,\mathrm{d}r \\
\mathrm{d}\tau &= r\,\mathrm{d}r\,\mathrm{d}\phi\,\mathrm{d}z \xrightarrow{\text{syl.symmetri}} 2\pi r\,\mathrm{d}r\,\ell
\end{aligned}$$