Form with equations for Electricity and Magnetism

Speed of light: $c = 3.00 \cdot 10^8 \,\mathrm{m/s}$

Magnetic permeability of vacuum: $\mu_0 = 4\pi \cdot 10^{-7}\ \mathrm{N/A^2}$

Electrical permittivity of vacuum: $\varepsilon_0 = \dfrac{1}{\mu_0 c^2} = 8.854 \cdot 10^{-12}\ \dfrac{\mathrm{C^2}}{\mathrm{Nm^2}}$

Charge of an electron: $e = 1.6 \cdot 10^{-19}\ \mathrm{C}$

Coulomb’s law: $\vec{F} = k\dfrac{q_1 q_2}{r_{1,2}^2}\hat{r}_{1,2}$ with $k = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \cdot 10^9\ \mathrm{Nm^2/C^2}$

Force on a charge in an electric field $\vec{F} = q\vec{E}$

Torque on an electric dipole: $\vec{\tau} = \vec{p} \times \vec{d}$ with the electric dipole moment: $\vec{p} = q\vec{d}$

Potential energy of an electric dipole: $U = -\vec{p} \cdot \vec{E}$

Potential difference: $\Delta V_{AB} = V_B - V_A = -\int_{r_a}^{r_b} \vec{E} \cdot \mathrm{d}\vec{r}$

Potential of a charge distribution: $V = \iiint_V \dfrac{k}{r}\mathrm{d}q$

Electric field of a change in potential: $\vec{E} = -\vec{\nabla} V$

Force on a charge in a magnetic field: $\vec{F} = q\vec{v} \times \vec{B}$

Lorenz’s law: $\vec{F} = I\vec{L} \times \vec{B}$

Torque on a magnetic dipole: $\vec{\tau} = \vec{\mu} \times \vec{B}$ with the magnetic dipole moment: $\vec{\mu} = NI\vec{A}$

Potential energy of a magnetic dipole: $U = -\vec{\mu} \cdot \vec{B}$

Biot-Savart’s law: $\vec{B} = \int \mathrm{d}\vec{B} = \int \dfrac{\mu_0}{4\pi}\dfrac{I\,\mathrm{d}\vec{L} \times \hat{r}}{r^2}$

Electrical current $I = \dfrac{\Delta Q}{\Delta t} = nqA\left|\vec{v}_d\right|$ with $\vec{v}_d$ the drift velocity.

Current density $\vec{J} = nq\vec{v}_d = \sigma\vec{E}$ with σ the conductivity.

Resistance: $R = \dfrac{\rho l}{A} = \dfrac{l}{\sigma A}$ with ρ the resistivity.

Ohm’s law: $V = IR$.

Energy density of the electric field: $u_E = \dfrac{1}{2}\varepsilon_0 \varepsilon_r E^2$

Capacity: $C = \dfrac{Q}{V}$

Energy stored in a capacitor: $U = \dfrac{1}{2}CV^2$

Energy density of the magnetic field: $u_B = \dfrac{B^2}{2\mu_0\mu_r}$

Inductance: $L = \dfrac{\Phi_B}{I}$

Energy stored in an inductance: $U = \dfrac{1}{2}LI^2$

The electric flux $\Phi_E = \int \vec{E} \cdot \mathrm{d}\vec{A}$

Gauss's law for the electric field:

- In vacuum (book): $\oint \vec{E} \cdot \mathrm{d}\vec{A} = \int \vec{\nabla} \cdot \vec{E} \mathrm{d}V = \frac{1}{\varepsilon_0} \int \rho \mathrm{d}V$
- Including material properties: $\oint \vec{D} \cdot \mathrm{d}\vec{A} = \int \vec{\nabla} \cdot \vec{D} \mathrm{d}V = \int \rho_f \mathrm{d}V$

The magnetic flux $\Phi_B = \int \vec{B} \cdot \mathrm{d}\vec{A}$

Gauss's law for the magnetic field: $\oint \vec{B} \cdot \mathrm{d}\vec{A} = \int \vec{\nabla} \cdot \vec{B} \mathrm{d}V = 0$

Faraday's law: $\oint \vec{E} \cdot \mathrm{d}\vec{r} = \int (\vec{\nabla} \times \vec{E}) \cdot \mathrm{d}\vec{A} = -\frac{\mathrm{d}}{\mathrm{d}t} \int \vec{B} \cdot \mathrm{d}\vec{A}$

Ampère's law:

- In vacuum (book): $\oint \vec{B} \cdot \mathrm{d}\vec{r} = \int (\vec{\nabla} \times \vec{B}) \cdot \mathrm{d}\vec{A} = \mu_0 \int \vec{J} \cdot \mathrm{d}\vec{A} + \mu_0 \varepsilon_0 \frac{\mathrm{d}}{\mathrm{d}t} \int \vec{E} \cdot \mathrm{d}\vec{A}$
- Including material properties: $\oint \vec{H} \cdot \mathrm{d}\vec{r} = \int (\vec{\nabla} \times \vec{H}) \cdot \mathrm{d}\vec{A} = \int \vec{J}_f \cdot \mathrm{d}\vec{A} + \frac{\mathrm{d}}{\mathrm{d}t} \int \vec{D} \cdot \mathrm{d}\vec{A}$

The constitutive equations:

- For dielectric materials in general: $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$
- For linear dielectric materials: $\vec{D} = \varepsilon_0 \vec{E} + \vec{P} = \varepsilon_0 \varepsilon_r \vec{E} = \varepsilon_0 \kappa \vec{E} = \varepsilon_0 (1 + \chi_e) \vec{E}$
- For magnetic materials in general: $\vec{B} = \mu_0 \vec{H} + \mu_0 \vec{M}$
- For linear magnetic materials: $\vec{B} = \mu_0 (\vec{H} + \vec{M}) = \mu_0 (1 + \chi_m) \vec{H} = \mu_0 \mu_r \vec{H}$

The Poynting vector: $\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$

Momentum of an electromagnetic wave: $p = \frac{U}{c}$

For an electromagnetic wave in vacuum: $E = cB$ and $f \lambda = c$.