19. ELECTROMAGNETIC RELATIONS

Quantity	Gaussian CGS	SI
Charge: Electron charge e: Potential: Magnetic field:	$2.997\,924\,58 \times 10^9$ esu $4.803\,206\,8 \times 10^{-10}$ esu $(1/299.792\,458)$ statvolt (ergs/esu) 10^4 gauss $= 10^4$ dyne/esu	$= 1$ C $= 1$ A s $= 1.602\,177\,33 \times 10^{-19}$ C $= 1$ V $= 1$ J C^{-1} $= 1$ T $= 1$ N A^{-1}m^{-1}
Lorentz force:	$\mathbf{F} = q\left(\mathbf{E} + \frac{\mathbf{v}}{c} \times \mathbf{B}\right)$	$\mathbf{F} = q\left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right)$
Maxwell equations:	$\nabla \cdot \mathbf{D} = 4\pi\rho$ $\nabla \times \mathbf{H} - \frac{1}{c}\frac{\partial \mathbf{D}}{\partial t} = \frac{4\pi}{c}\mathbf{J}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{E} + \frac{1}{c}\frac{\partial \mathbf{B}}{\partial t} = 0$	$\nabla \cdot \mathbf{D} = \rho$ $\nabla \times \mathbf{H} - \frac{\partial \mathbf{D}}{\partial t} = \mathbf{J}$ $\nabla \cdot \mathbf{B} = 0$ $\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0$
Materials: Permitivity of free space: Permeability of free space:	$\mathbf{D} = \epsilon\mathbf{E}, \quad \mathbf{H} = \mathbf{B}/\mu$ 1 1	$\mathbf{D} = \epsilon\mathbf{E}, \quad \mathbf{H} = \mathbf{B}/\mu$ $\epsilon_0 = 8.854\,187\ldots \times 10^{-12}$ F m^{-1} $\mu_0 = 4\pi \times 10^{-7}$ N A^{-2}
Fields from potentials:	$\mathbf{E} = -\nabla V - \frac{1}{c}\frac{\partial \mathbf{A}}{\partial t}$ $\mathbf{B} = \nabla \times \mathbf{A}$	$\mathbf{E} = -\nabla V - \frac{\partial \mathbf{A}}{\partial t}$ $\mathbf{B} = \nabla \times \mathbf{A}$
Static potentials: (coulomb gauge)	$V = \sum_{\text{charges}} \frac{q_i}{r_i} = \int \frac{\rho(\mathbf{r}')}{\lvert\mathbf{r}-\mathbf{r}'\rvert}\, d^3x'$ $\mathbf{A} = \frac{1}{c}\sum_{\text{currents}} \frac{\mathbf{I}_i}{r_i} = \frac{1}{c}\int \frac{\mathbf{J}(\mathbf{r}')}{\lvert\mathbf{r}-\mathbf{r}'\rvert}\, d^3x'$	$V = \frac{1}{4\pi\epsilon_0}\sum_{\text{charges}} \frac{q_i}{r_i} = \frac{1}{4\pi\epsilon_0}\int \frac{\rho(\mathbf{r}')}{\lvert\mathbf{r}-\mathbf{r}'\rvert}\, d^3x'$ $\mathbf{A} = \frac{\mu_0}{4\pi}\sum_{\text{currents}} \frac{\mathbf{I}_i}{r_i} = \frac{\mu_0}{4\pi}\int \frac{\mathbf{J}(\mathbf{r}')}{\lvert\mathbf{r}-\mathbf{r}'\rvert}\, d^3x'$
Relativistic transformations: ($\mathbf{v}$ is the velocity of the primed frame as seen in the unprimed frame)	$\mathbf{E}'_\parallel = \mathbf{E}_\parallel$ $\mathbf{E}'_\perp = \gamma(\mathbf{E}_\perp + \frac{1}{c}\mathbf{v} \times \mathbf{B})$ $\mathbf{B}'_\parallel = \mathbf{B}_\parallel$ $\mathbf{B}'_\perp = \gamma(\mathbf{B}_\perp - \frac{1}{c}\mathbf{v} \times \mathbf{E})$	$\mathbf{E}'_\parallel = \mathbf{E}_\parallel$ $\mathbf{E}'_\perp = \gamma(\mathbf{E}_\perp + \mathbf{v} \times \mathbf{B})$ $\mathbf{B}'_\parallel = \mathbf{B}_\parallel$ $\mathbf{B}'_\perp = \gamma(\mathbf{B}_\perp - \frac{1}{c^2}\mathbf{v} \times \mathbf{E})$
$\frac{1}{4\pi\epsilon_0} = c^2 \times 10^{-7}$ N A^{-2} $= 8.987\,55\ldots \times 10^9$ m F^{-1} ;	$\frac{\mu_0}{4\pi} = 10^{-7}$ N A^{-2} ;	$c = \frac{1}{\sqrt{\mu_0\epsilon_0}} = 2.997\,924\,58 \times 10^8$ m s^{-1}