1.6: The CGS System of Units

The CGS system of units is still used by many scientists and they are commonly used in many older articles and books dealing with topics in electricity and magnetism. For that reason it is useful for reference purposes to explicitly display Maxwell's equations written using the CGS system of units.

$$\text{curl}(\overrightarrow{\text{E}}) = -\frac{1}{c}\frac{\partial \overrightarrow{\text{B}}}{\partial t}. \tag{1.6.1}$$

$$\text{div}(\overrightarrow{\text{B}}) = 0. \tag{1.6.2}$$

$$\text{curl}(\overrightarrow{\text{B}}) = \frac{4\pi}{c}\left(\overrightarrow{\text{J}}_f + \text{ccurl}(\overrightarrow{\text{M}}) + \frac{\partial \overrightarrow{\text{P}}}{\partial t}\right) + \frac{1}{c}\frac{\partial \overrightarrow{\text{E}}}{\partial t}. \tag{1.6.3}$$

$$\text{div}(\overrightarrow{\text{E}}) = 4\pi\left(\rho_f - \text{div}(\overrightarrow{\text{P}})\right). \tag{1.6.4}$$

In this system of units c = 2.998 × 10^{10} cm/sec. and $\vec{E}$ and $\vec{B}$ have the same units (stat-Volts/cm). However, for historical reasons, the units of $\vec{B}$ are
known as Gauss. 10^4 Gauss are equal to 1 Weber/m^2: the unit 1 Weber/m^2 is also called a Tesla. The electric field is measured in stat-Volts/cm where 1 stat-Volt is equal to 299.8 Volts; (yes, these are the same significant figures as occur in the speed of light!). An electric field of 1 stat-Volt/cm (sometimes stated as 1 esu/cm) is approximately equal to 30,000 Volts/m.

If auxillary vector fields $\vec{D}$ and $\vec{H}$ are introduced through the relations

$$\overrightarrow{\text{D}} = \overrightarrow{\text{E}} + 4\pi\overrightarrow{\text{P}},$$

and

$$\overrightarrow{\text{B}} = \overrightarrow{\text{H}} + 4\pi\overrightarrow{\text{M}},$$

then equations (1.6.3 and 1.6.4) become

$$\text{curl}(\overrightarrow{\text{H}}) = \frac{4\pi}{c}\overrightarrow{\text{J}}_f + \frac{1}{c}\frac{\partial \overrightarrow{\text{D}}}{\partial t}, \tag{1.6.5}$$

$$\text{div}(\overrightarrow{\text{D}}) = 4\pi\rho_f \tag{1.6.6}$$

The first two equations, Equations (1.6.1, 1.6.2), remain the same. The vector $\vec{D}$ has the same units as $\vec{E}$, and the vector $\vec{H}$ has the same units as $\vec{B}$, although for historical reasons the units of $\vec{H}$ are called Oersteds.

The relation between charge density and current density in the MKS and the CGS systems can be deduced from the ratio of the proton charge as measured in both sets of units. This ratio is

$$\frac{e_p|_{esu}}{e_p|_{MKS}} = 2.9979 \times 10^9.$$

It follows from this ratio that 2998 esu/cm^3 is equal to 1 Coulomb/m^3 . Similarly, a current density of 1 Amp`ere/m^2 is equal to 2.998×10^5 esu/cm^2 . The conversion from MKS to CGS magnetic units is easy to remember since the earth's magnetic field is approximately 1 Oersted which is equal to 10^{-4} Tesla (Webers/m^2).