Electrostatic Equations for Dielectrics in MKSA and Gauss Units

The displacement field and the Gauss Law:

In MKSA units:

$$\mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P} \tag{1}$$

$$\nabla\cdot\mathbf{D} = \rho_{\text{free}} \tag{2}$$

In Gauss units:

$$\mathbf{D} = \mathbf{E} + 4\pi\mathbf{P} \tag{3}$$

$$\nabla\cdot\mathbf{D} = 4\pi\rho_{\text{free}} \tag{4}$$

Susceptibility, permittivity, and the dielectric constant:

In MKSA units:

$$\mathbf{P} = \chi\epsilon_0\mathbf{E} \tag{5}$$

$$\mathbf{D} = \epsilon_{\text{abs}}\mathbf{E} = \epsilon_{\text{rel}}\epsilon_0\mathbf{E} \tag{6}$$

$$\epsilon_{\text{rel}} = 1 + \chi \tag{7}$$

In Gauss units:

$$\mathbf{P} = \chi\mathbf{E} \tag{8}$$

$$\mathbf{D} = \epsilon\mathbf{E} \tag{9}$$

$$\epsilon = 1 + 4\pi\chi \tag{10}$$

Note: the dielectric constant $\epsilon = \epsilon_{\text{rel}}$ is dimensionless and has the same numeric value in both systems of units. But the susceptibility χ — which is also dimensionless — differs between the two systems by a factor of 4π, $\chi[\text{MKSA}] = 4\pi \times \chi[\text{Gauss}]$.

Coulomb force in a dielectric:

$$\text{In MKSA units} \quad F = \frac{1}{4\pi\epsilon_{\text{rel}}\epsilon_0} \times \frac{q_1 q_2}{r^2} \tag{11}$$

$$\text{In Gauss units} \quad F = \frac{1}{\epsilon} \times \frac{q_1 q_2}{r^2} \tag{12}$$