

5.2: Electric Field Due to Point Charges

The electric field intensity associated with a single particle bearing charge q_1 , located at the origin, is (Section 5.1)

$$\mathbf{E}(\mathbf{r}) = \hat{\mathbf{r}} \frac{q_1}{4\pi\epsilon r^2}$$

If this particle is instead located at some position \mathbf{r}_1 , then the above expression may be written as follows:

$$\mathbf{E}(\mathbf{r}; \mathbf{r}_1) = \frac{\mathbf{r} - \mathbf{r}_1}{|\mathbf{r} - \mathbf{r}_1|} \frac{q_1}{4\pi\epsilon |\mathbf{r} - \mathbf{r}_1|^2}$$

or, combining like terms in the denominator:

$$\mathbf{E}(\mathbf{r}; \mathbf{r}_1) = \frac{\mathbf{r} - \mathbf{r}_1}{|\mathbf{r} - \mathbf{r}_1|^3} \frac{q_1}{4\pi\epsilon}$$

Now let us consider the field due to multiple such particles. Under the usual assumptions about the permittivity of the medium (Section 2.8), the property of superposition applies. Using this principle, we conclude:

The electric field resulting from a set of charged particles is equal to the sum of the fields associated with the individual particles.

Stated mathematically:

$$\mathbf{E}(\mathbf{r}) = \sum_{n=1}^N \mathbf{E}(\mathbf{r}; \mathbf{r}_n)$$

where N is the number of particles. Thus, we have

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon} \sum_{n=1}^N \frac{\mathbf{r} - \mathbf{r}_n}{|\mathbf{r} - \mathbf{r}_n|^3} q_n$$

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