

Electromagnetic Field Theory

Week 7

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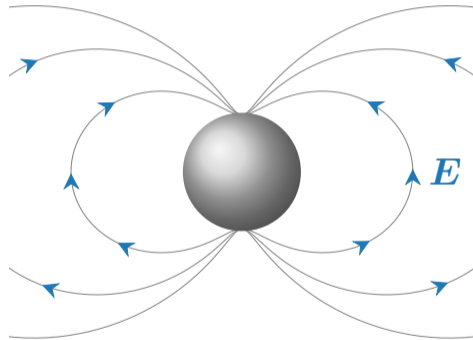
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1. Energy in Electrostatics
2. Virtual Work Method
3. Forces Acting on Polarized Particle
4. Ferroelectricity





Energy of a Set of Charges

Electrostatic energy of a group of charges

$$W = \frac{1}{8\pi\epsilon_0} \sum_{\substack{i,j \\ i \neq j}} \frac{q_i q_j}{|\mathbf{r}_i - \mathbf{r}_j|}.$$



Energy

Electrostatic energy evaluated for a charge density distribution.

- From charge density

$$W = \frac{1}{8\pi\epsilon_0} \int_V \int_{V'} \frac{\rho(\mathbf{r})\rho(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV dV'$$

- from potential

$$W = \frac{1}{2} \int_V \rho(\mathbf{r})\varphi(\mathbf{r}) dV,$$

item from electric field

$$W = \frac{1}{2} \int_V \epsilon(\mathbf{r})|\mathbf{E}(\mathbf{r})|^2 dV.$$

Energy in Capacitor



$$W = \frac{1}{2}CU^2$$

Virtual Work Method



Force acting in electrostatics

$$F = -\frac{dW}{dx}.$$



Forces Acting On a Dipole

Uniform field: Torque

$$\mathbf{N} = \mathbf{p} \times \mathbf{E}.$$

Non-uniform field: Torque & drift

$$\mathbf{N} = (\mathbf{p} \times \mathbf{E}) + (\mathbf{r} \times \mathbf{F}).$$



Electrets and Ferroelectricity

- ▶ Electrets (Permanent polarization)
- ▶ Ferroelectricity (Spontaneous polarization)
 - ▶ Ferroelectrics
 - ▶ Pyroelectrics
 - ▶ Piezoelectrics
 - ▶ ...

Questions?

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