

Electromagnetic Field Theory

Week 3

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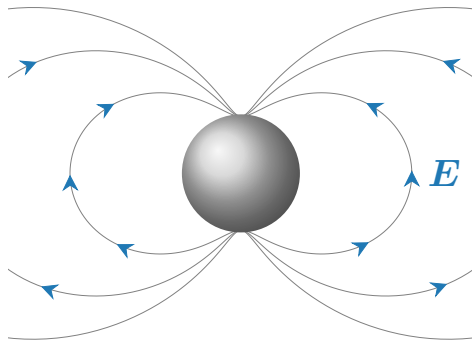
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1. Work in Electrostatics, Electric Potential
2. Elementary Electric Dipole





Work in Electrostatic Field

$$W = - \int_a^b \mathbf{F} \cdot d\mathbf{l}, \quad [\text{J}]$$

Electric potential

$$- \int_a^b \mathbf{E} \cdot d\mathbf{l} = \varphi(b) - \varphi(a)$$

$$\varphi = - \int \mathbf{E} \cdot d\mathbf{l} + K, \quad [\text{V}]$$



Electric Field Over Closed Path

- integral form

$$\oint_l \mathbf{E} \cdot d\mathbf{l} = 0$$

- differential form

$$\nabla \times \mathbf{E} = \mathbf{0}$$



Relation Between Electric Field and Potential

$$\mathbf{E} = -\nabla\varphi$$

voltage

$$U_{AB} = \varphi(B) - \varphi(A), \quad [\text{V}]$$



Summary

Coulomb's law

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \int_{V'} \rho(\mathbf{r}') \frac{(\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} dV$$

Integral form

$$\oiint_S \mathbf{E} \cdot d\mathbf{S} = \frac{Q}{\epsilon_0}$$

$$\oint_l \mathbf{E} \cdot d\mathbf{l} = 0$$

Differential form

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \times \mathbf{E} = \mathbf{0}$$



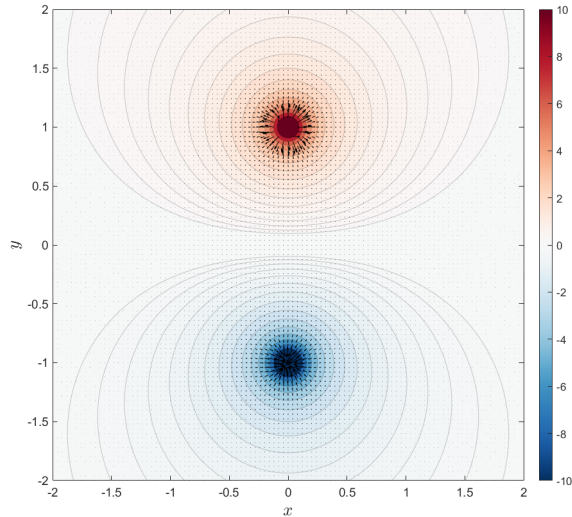
Elementary Electric Dipole

The potential generated by elementary dipole

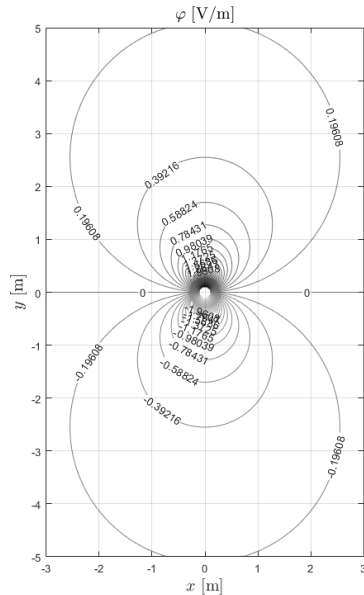
$$\varphi(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \frac{p \cos(\theta)}{R^2} = \frac{1}{4\pi\epsilon_0} \frac{\mathbf{p} \cdot \hat{\mathbf{r}}}{R^2}, \quad [\text{V}]$$

Electric field of elementary dipole? **Solved in the exercises!**

Electric Field of Two Opposite Charges



- Electric potential of the elementary dipole:



Questions?

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