Outline

- Electric Fields
- Electric Potential

Office hours this week:
THURSDAY 4.30-5.30pm Rm 0208 (Course Center)
Ave: 5.1

<table>
<thead>
<tr>
<th>Correct</th>
<th>CD</th>
<th>(6*10^-4)(J/K)</th>
<th>B Boltzmann Distribution/Equation/Factor</th>
</tr>
</thead>
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Quiz 3

\[ \Delta S = \frac{Q_A}{T_A} + \frac{Q_B}{T_B} = \frac{-0.5J}{350K} + \frac{0.5J}{250K} = 0.0006J / K \]

\[ P = e^{\frac{E_1}{kT}} - \frac{(E_1 - E_0)}{kT} = e^{\frac{0.015eV}{0.025eV}} = e^{-0.6} = 0.55 \]
Our model system:
4 charges and a test charge $q_0$
Foothold idea: Electric Forces and Fields

When we focus our attention on the electric force on a particular object with charge $q_0$ (a “test charge”) we see the force it feels depends on $q_0$.

Define quantity that does not depend on charge of test object “test” charge -> **Electric Field $E$**

$$\vec{F}_{q_0}^{E_{net}} = \frac{k_C q_0 q_1}{r_{01}^2} \hat{r}_{1\rightarrow 0} + \frac{k_C q_0 q_2}{r_{02}^2} \hat{r}_{2\rightarrow 0} + \frac{k_C q_0 q_3}{r_{03}^2} \hat{r}_{3\rightarrow 0} + \ldots \frac{k_C q_0 q_N}{r_{0N}^2} \hat{r}_{N\rightarrow 0}$$

$$\vec{F}_{q_0}^{E_{net}} = q_0 \vec{E}(\hat{r}_0)$$

$$\vec{E}(\hat{r}_0) = \frac{k_C q_1}{r_{01}^2} \hat{r}_{1\rightarrow 0} + \frac{k_C q_2}{r_{02}^2} \hat{r}_{2\rightarrow 0} + \frac{k_C q_3}{r_{03}^2} \hat{r}_{3\rightarrow 0} + \ldots \frac{k_C q_N}{r_{0N}^2} \hat{r}_{N\rightarrow 0}$$

$E$ is defined everywhere in space not just in places where charges are present.
Does the potential energy of the system change when I add a test charge?
Foothold ideas:
Electrostatic Potential energy and Electrostatic Potential

- Again we focus our attention on a test charge!
- Usual definition of “electrostatic potential energy”: How much does the energy of our system change if we add the test charge

It’s really a change in potential energy!

\[ U_{q_0}^{\text{elec}}(\vec{r}_0) = \frac{k_e q_0 q_1}{r_{01}} + \frac{k_e q_0 q_2}{r_{02}} + \ldots + \frac{k_e q_0 q_N}{r_{0N}} = \sum_{i=1}^{N} \frac{k_e q_0 q_i}{r_{0i}} \]

- We ignore the electrostatic potential energies of all other pairs (since we assume the other charges do not move)
- We can pull the test charge magnitude out of the equation and obtain en **electrostatic potential**

\[ V(\vec{r}_0) = \frac{U_{q_0}^{\text{elec}}(\vec{r}_0)}{q_0} = \frac{k_e q_1}{r_{01}} + \frac{k_e q_2}{r_{02}} + \ldots + \frac{k_e q_N}{r_{0N}} = \sum_{i=1}^{N} \frac{k_e q_i}{r_{0i}} \]
Potential energy of a positive test charge near a positive source.

\[ U = \frac{kqQ}{r} \]

Electric Potential of a positive test charge near a positive source.

\[ V = \frac{kQ}{r} \]
What happens when I change the sign of the test charge

1. Potential energy graph changes
2. Electrostatic potential graph changes
3. Both change
4. Neither of the graphs changes