King Saud University
College of Science
Physics & Astronomy Dept.

# 111 PHYS (GENERAL PHYSICS 2)
# CHAPTER 25: Electric Potential
# LECTURE NO. 6

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# 25.3 Electric Potential and Potential Energy Due to Point Charges

$$V_B - V_A = -\int_A^B \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}}$$

$$V_B - V_A = -k_e q \int_{r_A}^{r_B} \frac{dr}{r^2} = k_e \frac{q}{r}\bigg|_{r_A}^{r_B}$$

$$V_B - V_A = k_e q \left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

This tells us that the electric field of a fixed point charge q is conservative. Furthermore, Eqaution expresses the important result that the potential difference between any two points A and B in a field created by a point charge depends only on the radial coordinates r A and r B .

# 25.3 Electric Potential and Potential Energy Due to Point Charges

It is customary to choose the reference of electric potential for a point charge to be $V = 0 \ \ at \ r_A = \infty$. With this reference choice, the electric potential due to a point charge at any distance r from the charge is

$$V = k_e \frac{q}{r}$$

For a group of point charges, we can write the total electric potential at P as

$$V = k_e \sum_i \frac{q_i}{r_i}$$

# 25.3 Electric Potential and Potential Energy Due to Point Charges

Now imagine that an external agent brings a charge $q_2$ from infinity to point P. The work that must be done to do this is given

$$W = q_2 \Delta V$$

This work represents a transfer of energy across the boundary of the two-charge system.

$$\Delta U = W = q_2 \Delta V \quad \rightarrow \quad U - 0 = q_2 \left( k_e \frac{q_1}{r_{12}} - 0 \right)$$

$$U = k_e \frac{q_1 q_2}{r_{12}}$$

# 25.3 Electric Potential and Potential Energy Due to Point Charges

- If the charges are of the same sign, then U is positive. Positive work must be done by an external agent on the system to bring the two charges near each other (because charges of the same sign repel).

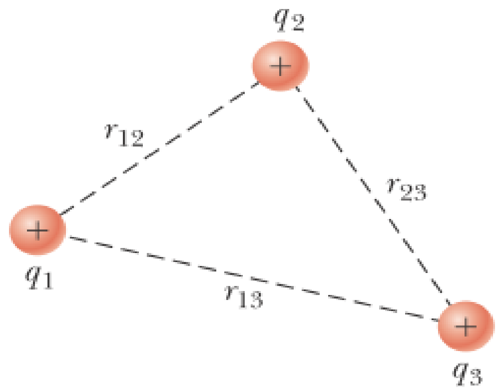
- If the charges are of opposite sign, then U is negative. Negative work is done by an external agent against the attractive force between the charges of opposite sign as they are brought near each other.

# 25.3 Electric Potential and Potential Energy Due to Point Charges

If the system consists of more than two charged particles, we can obtain the total potential energy of the system by calculating $U$ for every *pair* of charges and summing the terms algebraically. For example, the total potential energy of the system of three charges shown in Figure 25.9 is

$$U = k_e\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right) \quad \textbf{(25.14)}$$

The potential energy of this system of charges is given by Equation 25.14.



# 25.3 Electric Potential and Potential Energy Due to Point Charges

- What is the electric potential at a point located at the middle between two charges equal but opposite?

- Tow charges $12 \times 10^{-6} C,$
$-12 \times 10^{-6} C, where\ the\ distance\ between\ them\ is\ 20\ cm.$
  - Find the potential at point a and b?
  - The electric potential energy for a positive charge $4 \times 10^{-19}\ C\ \ locates\ at\ point\ a\ and\ b$?
  - The potential difference between a and b?