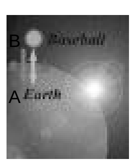
# Electric Potential

## Electric Potential and Capacitance

- Recall that in the presence of the gravitational field, we defined potential energy and work done. We will now define similar quantities for electrical forces. We will also examine the capacity of systems to hold charge.

## Gravitational Analogy

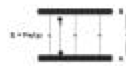
- When an object is raised a vertical distance, h, the change in the potential energy is positive and equal to the work done by the external force.




  - $U_g = U_B - U_A = Fh = mgh$
- Like Gravitational PE, Electric PE is based on an arbitrary reference point.

## Electric Potential Energy

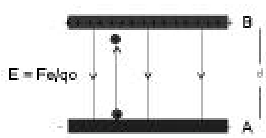
- Recall the electrostatic force on a test charge placed in a uniform electric field = $q_oE$
  - ➢ $F_e = q_o E$



- Therefore we must apply a force of at least this magnitude to move a charge that is in a uniform electric field.
- When this is done, we do work on the charge.
  - ➢ $W = Fd$

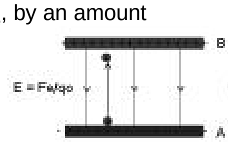
## Electric Potential Energy (cont.)

- If we substitute electrostatic force into our work equation we get:
  - ➢ $W = q_o Ed$
    - (note: d is the distance parallel to the electric field only!)




## Electric Potential Energy (cont.)

- Recall the relationship between potential energy and work
  - ➢ $U_e = U_B – U_A = W = q_oEd$
- Like gravitational potential energy, by moving the test charge from point A to point B, we increase the charge's ELECTRIC POTENTIAL ENERGY, $U_e$, by an amount equal to the work done on the charge.



## Electric Potential Difference

- Electric Potential Difference or Voltage($V$) = Change in Potential Energy per unit positive test charge.
  - $V = ?\ U_e / q_o = W / q_o$
- SI unit of Potential Difference is J/C
- This unit has been renamed the Volt.
  - 1 V = 1 J/C

## Electric Potential Difference (cont.)

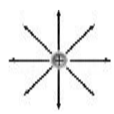
- The potential difference between two points in a uniform electric field depends on
  - the E-field strength
  - the distance between the points

$\Delta V = Ed$ (parallel plates)

## Electric Potential Difference (cont.)

- Does ?V = Ed in the field around a point charge?

NO!!



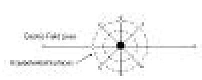
- Why? The strength of the electric field is not uniform, it depends on the distance from the charge

## Electric Potential Difference (cont.)

- For a point charge
  - $V = kq/r$
- For multiple point charges, it is the vector sum of the individual potential differences
  - $V_{total} = V_1 + V_2 + V_3 + \ldots$

## Equipotential Surfaces

- An equipotential surface is a locus of points in an electric field that are all at the same electrical potential. An example is the locus of points equidistant from an isolated point charge.
  - Note equipotential surfaces are perpendicular to the electric field lines.



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