Electrical potential energy can be associated with a charge in a uniform field

Consider a positive charge in a uniform electric field. (A uniform field is a field that has the same value and direction at all points.) Assume the charge is displaced at a constant velocity *in the same direction as the electric field,* as shown in **Figure 2.**

There is a change in the electrical potential energy associated with the charge's new position in the electric field. The change in the electrical potential energy depends on the charge, q, as well as the strength of the electric field, E, and the displacement, d. It can be written as follows:

$$\Delta PE_{electric} = -qEd$$

The negative sign indicates that the electrical potential energy will increase if the charge is negative and decrease if the charge is positive.

As with other forms of potential energy, it is the *difference* in electrical potential energy that is physically important. If the displacement in the expression above is chosen so that it is the distance in the direction of the field from the reference point, or zero level, then the initial electrical potential energy is zero and the expression can be rewritten as shown below. As with other forms of energy, the SI unit for electrical potential energy is the joule (J).

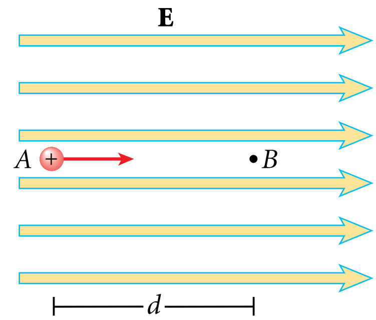

Figure 2
A positive charge moves from point *A* to point *B* in a uniform electric field, and the potential energy changes as a result.

ELECTRICAL POTENTIAL ENERGY IN A UNIFORM ELECTRIC FIELD

$$PE_{electric} = -qEd$$

electrical potential energy =
−(charge × electric field strength × displacement from the reference point in the direction of the field)

This equation is valid only for a uniform electric field, such as that between two oppositely charged parallel plates. In contrast, the electric field lines for a point charge are farther apart as the distance from the charge increases. Thus, the electric field of a point charge is an example of a nonuniform electric field.

Electrical potential energy is similar to gravitational potential energy

When electrical potential energy is calculated, d is the magnitude of the displacement's component *in the direction of the electric field.* The electric field does work on a positive charge by moving the charge in the direction of $\boldsymbol{E}$ (just as Earth's gravitational field does work on a mass by moving the mass toward Earth). After such a movement, the system's final potential energy is less than its initial potential energy. A negative charge behaves in the opposite manner, because a negative charge undergoes a force in the opposite direction. Moving a charge in a direction that is perpendicular to $\boldsymbol{E}$ is analogous to moving an object horizontally in a gravitational field: no work is done, and the potential energy of the system remains constant.