Edgenuity

Warm-Up | Electric Potential Difference

Lesson Question

What is the relationship between electric potential energy and electric potential difference?

Lesson Goals

Differentiate electric potential energy and electric potential difference.

Solve problems involving electric potential energy and electric potential difference.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

electric potential	the electric potential energy of a charged particle divided by its charge
electric potential difference	the difference in electric potential between two positions
electric potential energy	the potential energy an electric charge has due to its location in an electric field
volt	the SI unit of electric potential difference

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Gravitational Potential Energy

- Gravitational potential energy is the stored energy of a mass due to its height above a reference position.

$\Delta PE = W$

- An object's gravitational potential energy is equal to the work required to lift the object.
  - Measured in joules (J)
    - $1\text{J} = 1\text{N} \cdot \text{m}$

$W = Fd$

$\Delta PE = mgh$

- Recall that $g = 9.8 \frac{\text{m}}{\text{s}^2}$.

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Symbols to Remember

Symbol	Description	Symbol	Description	Symbol	Description
d	distance	g	acceleration due to gravity	PE_g	gravitational potential energy
E	electric field strength	h	height	q	charge
F_e	electromagnetic force	k	Coulomb's constant	U	electric potential energy
F_g	gravitational force	m	mass	μ	micro or 10^{-6}

Electric Potential Energy Formula

- The **electric potential energy** (U) is the potential energy an electric charge has due to its location in an electric field.
- Whether the potential energy is gravitational or electric, potential energy is equal to the work required to move the mass or the charge.
  - Changing the distance of a charge changes its potential energy.
- The unit for electric potential energy is the joule (J).

$$\Delta U = W$$

$$W = F \times d$$

$$U = qEd$$

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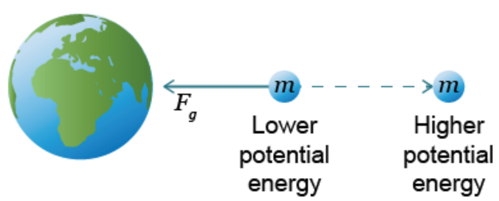
Gravitational and Electric Potential Energy

Since there is a direction relationship between gravitational potential energy and distance, the gravitational potential energy increases as the height increases.

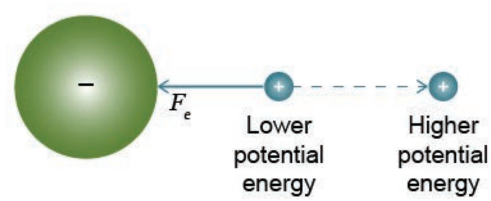
$PE_g = mgh$

Gravitational Potential Energy



$U = qEd$

Electric Potential Energy



As the point charge moves from its original location farther away from the source of electric field, the electric potential energy increases as well.

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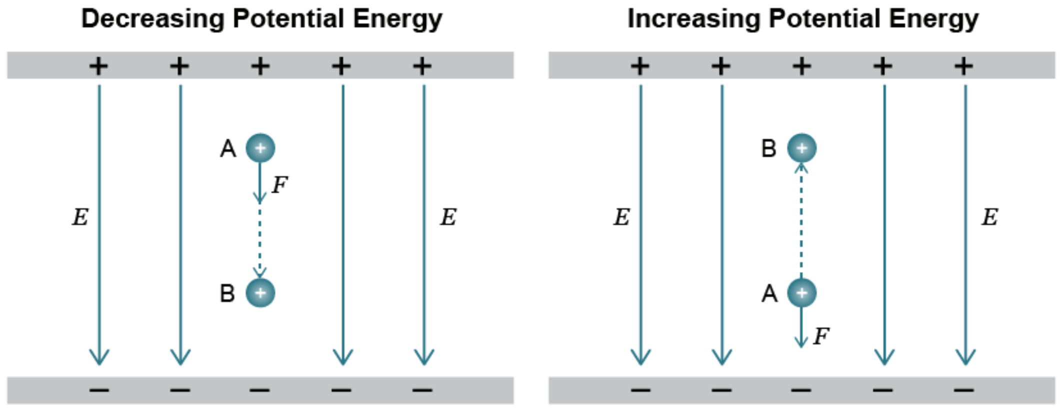
Potential Energy of Positively Charged Particles in a Uniform Electric Field

$$U = qEd$$



The amount of electric potential energy will **decrease** as that positive charge gets **closer** to the negative plate.

An additional force must be applied to overcome the **repulsive** force from the positive plate. This additional force does **work** on the positive particle, and that work is converted into electric potential energy.

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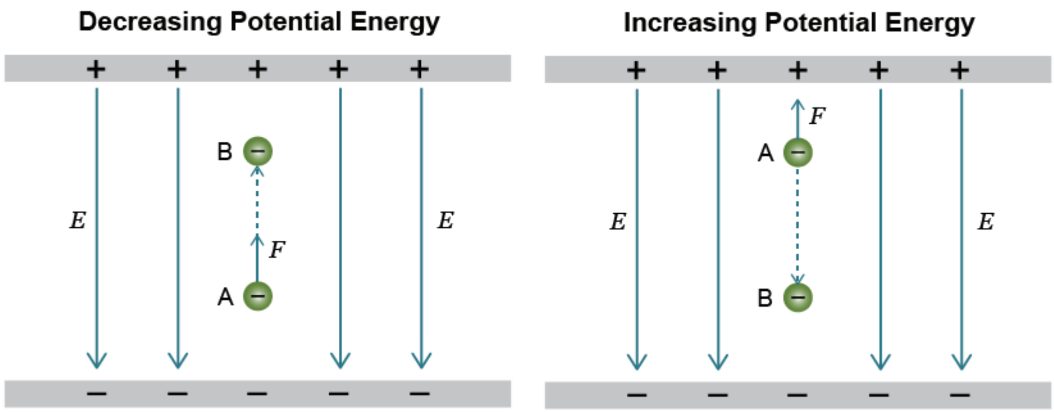
Potential Energy of Negatively Charged Particles in a Uniform Electric Field



The amount of electric potential energy will [decrease] as that negative charge gets closer to the positive plate.

An additional [force] must be applied to overcome the repulsive force from the negative plate. This additional force does work on the negative particle. And now work is converted into [electric potential energy].

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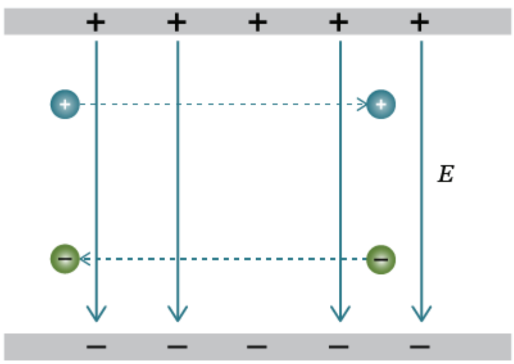
Potential Energy of Charged Particles Moving Perpendicular to a Uniform Electric Field



On the left, we see that the positive charge is moving perpendicular to the electric field. On the right, we see that the negative charge is also moving perpendicular to the electric field. This is similar to driving a car on a flat road. Because the distance from the ground doesn't change, the potential energy doesn't change either. So there's a constant electric potential energy for both the positive and negative charges.

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Electric Potential in a Uniform Electric Field

- **Electric potential** (V) is the electric potential energy of a charged particle divided by its charge.
  - A direct relationship exists between electric potential energy and electric potential.
- Electric potential indicates the strength of an electric field at a specific location.

$$V = \frac{U}{q}$$

- The volt (V) is the SI unit for electric potential.
- Volts are equivalent to $\frac{J}{C}$ and $N \cdot \frac{m}{C}$.

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Electric Potential in an Electric Field from a Point Charge

$V = \frac{U}{q}$ and $U = qEd$

$$V = \frac{\cancel{q}Ed}{\cancel{q}}$$

$V = Ed$ $\quad E = k\frac{q}{d^2}$

$$V = k\frac{q}{d^{\cancel{2}}} \times \cancel{d}$$

$$V = k\frac{q}{d}$$

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Electric Potential Difference

- For electrical **charges** to flow, an **electric potential difference** has to exist.
- Electric potential difference (ΔV) is the difference in electric potential (V) between two **positions**.
  - Also known as **voltage**
- It is also the **difference** in electric potential energy (U) between two positions divided by the charge.
- The unit of electric potential difference is the volt (V).

$$\Delta V = V_2 - V_1$$

$$V = \frac{U}{q}$$

$$\Delta V = \frac{\Delta U}{q}$$

Electric Potential Difference in a Uniform Electric Field

$\Delta V = \frac{\Delta U}{q}$ and **U** $= qEd$

$\Delta V = \frac{\Delta(qEd)}{q}$;

$\Delta V =$ **Ed**

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Work and Electric Potential Difference

$\Delta V = \dfrac{\Delta U}{q}$ and $\Delta U = W$

$\Delta V = \dfrac{\boxed{W}}{q}$

$W = \boxed{q\Delta V}$

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The magnitude of the electric field between the plates is $650\,\dfrac{\text{N}}{\text{C}}$. A proton is moved from the negative plate to the positive plate 6.0 cm away. Considering the electric potential difference, how much work is done? Recall that a proton's charge is 1.602×10^{-19} C.

$W = \boxed{q\Delta V}$ and $\Delta V = Ed$

$\Delta V = \left(650\,\dfrac{\text{N}}{\text{C}}\right)\boxed{(0.06\text{ m})}$

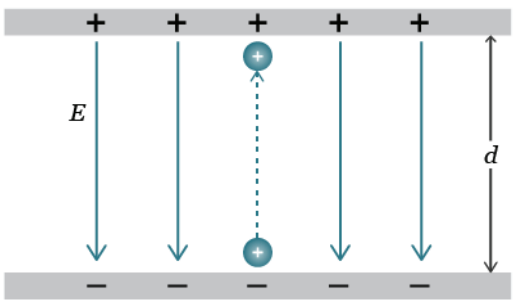
$\Delta V = 39\text{ V}$

$\Delta V = 39\text{V}$

$W = q\Delta V$

$W = (1.602 \times 10^{-19}\text{ C})(39\text{ V})$

$W = \boxed{6.3 \times 10^{-18}\text{ J}}$



Summary | Electric Potential Difference

Lesson Question

What is the relationship between electric potential energy and electric potential difference?

Answer

(Sample answer) Electric potential energy (U) is the amount of energy a charge has at a given location in an electric field, or $U = qEd$. The electric potential difference is the difference in electric potential energy between two positions divided by the charge, or $\Delta V = (U_a - U_b)/q$.

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Review: Formulas

Name	Symbol	Formula	Unit
electric potential energy	U	$U = qEd$	J
electric potential (uniform electric field)	V	$V = \frac{U}{q}$ $\Delta V =$ Ed	V
electric potential (point charge)	V	$V = k\frac{q}{d}$	V
electric potential difference (voltage)	ΔV	$\Delta V = \frac{\Delta U}{q}$ $\Delta V = Ed$	V
work	W	$W =$ $q\Delta V$	J

Summary | Electric Potential Difference

Use this space to write any questions or thoughts about this lesson.