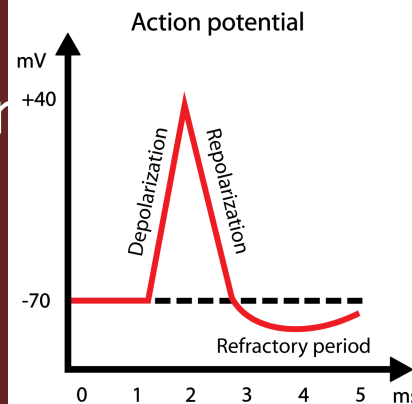
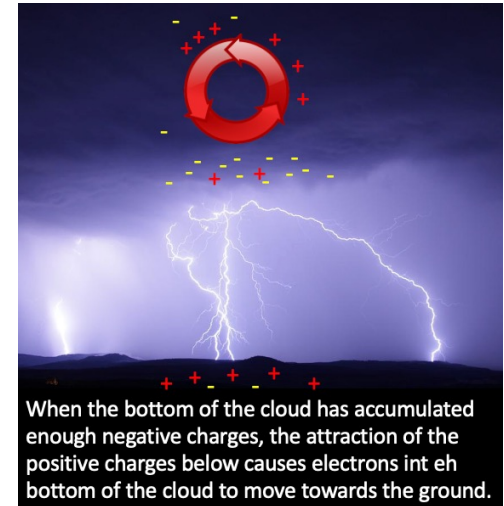


Electric Potential

- Force of Gravity and Gravitational Potential Energy
- Electric Force and Electric Potential Energy
- Electric Potential Difference (Voltage)
- Electric Field
- Application – Lightning
- Application – Nerve Conduction
- Application – Heartbeat
- Application - Batteries

$$\varepsilon = \frac{F_E}{q}$$



Preview File

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- Student versions have portions of the text removed which is given in the teacher version and appear as _____ which the students are to fill in
- Other slides may have on them, this represents writing that has been removed on this sample

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Force of Gravity and Gravitational Potential Energy

- We know that the magnitude of the force of gravity between any two masses is given by:
- The corresponding gravitational potential energy between two masses is given by:

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$E_g = -\frac{Gm_1m_2}{r}$$

Electric Force and Electric Potential Energy

- The magnitude of the force of attraction or repulsion between any two charges is given by:
- Therefore, the corresponding **electrical potential energy** between two charges is given by:

$$F_E = \frac{kq_1q_2}{r^2}$$

$$E_E = \frac{kq_1q_2}{r}$$

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Electric Potential Difference (Voltage)

- The Electrical Potential Energy (E_E) is the energy stored (potential) in a system of two charges a distance apart
- Work must be done on a system to increase the potential energy just like work is needed to increase gravitational potential energy by lifting an object above the ground

- _____

$$W = \Delta E_E$$

Electric Potential Difference (Voltage)

$$V = \frac{E_E}{q_2} \quad \leftarrow \quad E_E = \frac{kq_1q_2}{r}$$

- The Electric Potential Difference (V) defines the energy per charge

$$V = \frac{\cancel{kq_1q_2}}{\cancel{q_2}r}$$

- This is a more valuable expression of energy because it does not depend on both charges

$$V = \frac{kq_1}{r}$$

Electric Potential Energy (E_E) vs. Electric Potential Difference (V)

- Electric Potential Energy (E_E) isn't the same as Electric Potential Difference (V)
- The units of electric potential energy are joules (J), electric potential difference is the amount of potential energy per coulomb with units (J/C) or volts (V)
- The two values are equated via:

$$E_E = qV$$

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Check Your Understanding

Calculate the electric potential at a distance of 0.40 m from a spherical point charge of $+6.4 \times 10^{-6} \text{ C}$.

$$V = \frac{kq}{r}$$

Check Your Understanding

How much work must be done to increase the potential of a charge of $3.0 \times 10^{-7} \text{ C}$ by 120 V?

$$V = \frac{kq}{r}$$

$$E_E = qV$$

$$W = \Delta E_E$$

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Electric Field

- An area around a charged particle or object where a force would be exerted on other charged particles or objects
- _____

$$\vec{\mathcal{E}} = \frac{\Delta V}{r}$$

Check Your Understanding

The electric potential difference between the inside and outside of a neuron cell membrane of thickness 5.0 nm is typically 0.070 V.

- a) Calculate the magnitude of the electric field in the membrane.
- b) Calculate the work you would have to do on a single sodium ion, of charge $+1.6 \times 10^{-19}$ C, to move it through the membrane from the region of lower potential into the region of higher potential.

$$E_E = qV$$

$$W = \Delta E_E$$

$$\vec{\mathcal{E}} = \frac{\Delta V}{r}$$

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Check Your Understanding

The magnitude of the electric field strength between two parallel plates is 450 N/C. The plates are connected to a battery with an electric potential difference of 95 V. What is the plate separation?

$$\vec{\mathcal{E}} = \frac{\Delta V}{r}$$

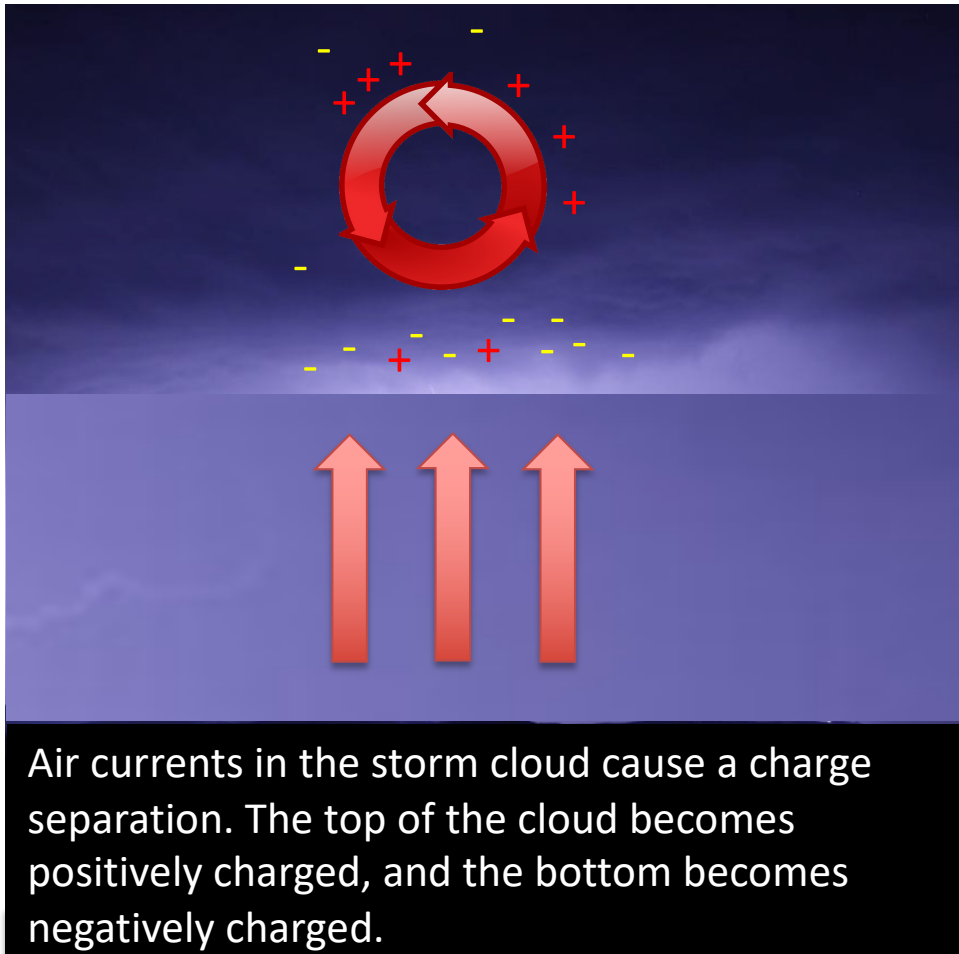
Two Connected Conducting Objects

If two objects have a different electric potential difference, electrons will move to reduce the difference to zero. This happens during a lightning discharge.



Application - Lightning

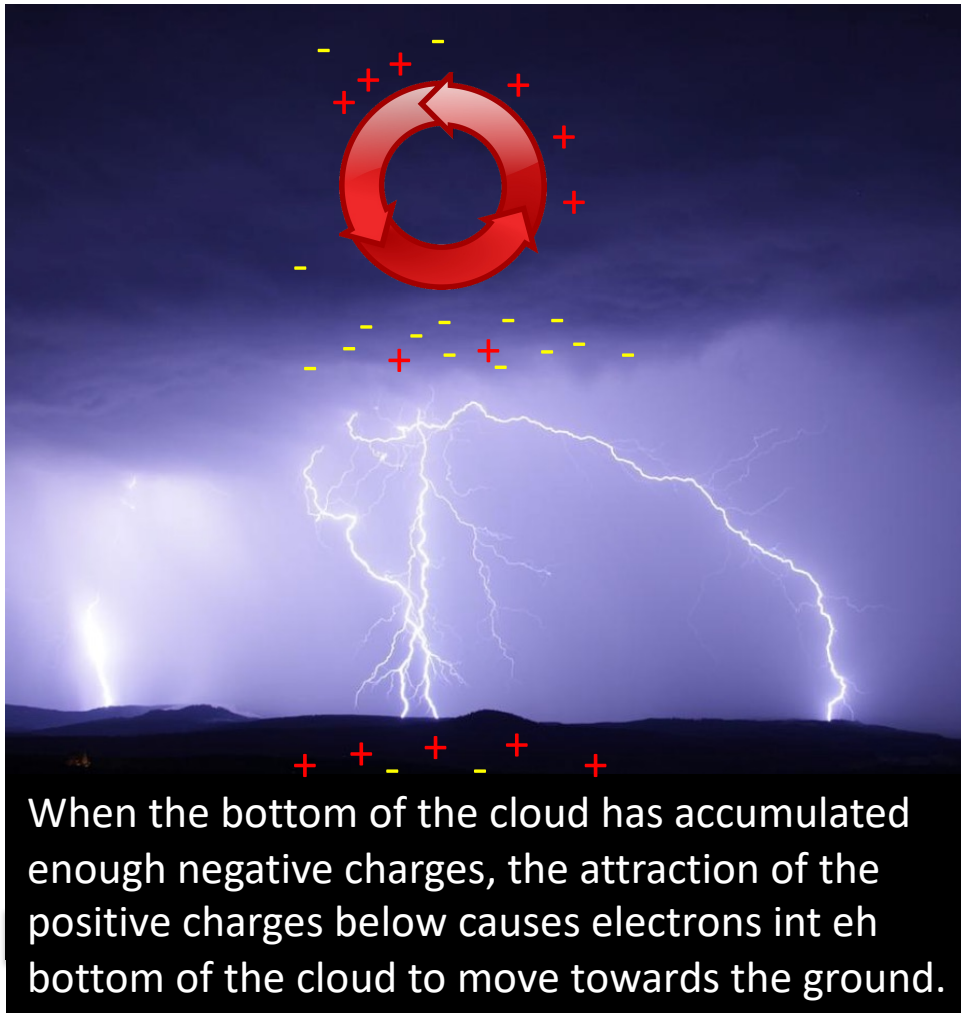
Lightning strikes are due to a HUGE potential difference between the cloud and the ground ($10^8 \text{ V} = 100,000,000 \text{ V}$).



The top of the cloud develops a charge of +40 C and the bottom, -40 C.

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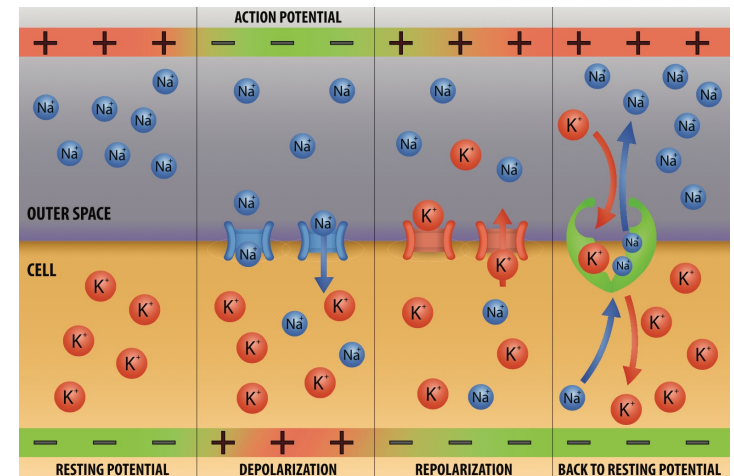
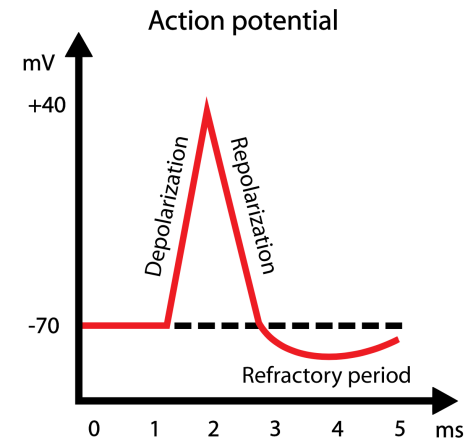
Application - Lightning



- Before the electrons can jump to the ground, the air needs to stop acting like an insulator
 - When the negative charge at the bottom of the cloud become large enough, it
-

Application – Nerve Conduction

- Nerves transmit electrical signals all around your body, keeping you alive and moving
- Signals are transmitted along nerve cells via action potentials where voltages switch from -70 mV to +30 mV



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Application - Batteries

- The potential of 1 volt equals 1 joule (J) of energy per 1 coulomb (C) of charge
- Therefore, a 1.5-volt battery gives 1.5 joules of energy to every 1 coulomb of charge passing through the battery
- One coulomb equals the charge of 6.24×10^{18} electrons
- _____

