

# Electrostatics Grade 10 Questions And Answers

ISU Physics

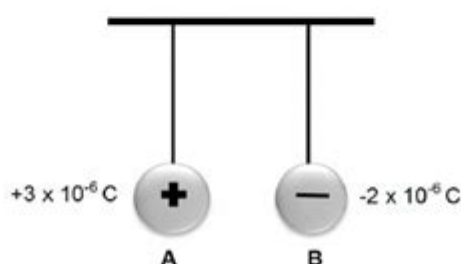
Grade 10

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## Electrostatics worksheet lesson 1

### Question 1

Two small identical spheres, A and B, are suspended on long silk threads, as shown in the sketch below. The spheres carry charges of  $+3 \times 10^{-6} \text{ C}$  and  $-2 \times 10^{-6} \text{ C}$  respectively.



1.1 Which sphere has an excess of electrons and why (Aiii 3-4)?

The two spheres are allowed to touch.

1.2 Will the electrons be transferred from A to B or B to A (Ai 1-2)?

The spheres are now separated.

1.3 Calculate the new charge on sphere B (Aii 3-4).

1.4 Calculate the number of electrons transferred during contact (Aii 5-6).

## electrostatics grade 10 questions and answers

electrostatics grade 10 questions and answers are crucial for students aiming to master the fundamental principles of electric charge, forces, and fields. This comprehensive guide delves into common electrostatics concepts typically covered in grade 10 physics, providing detailed explanations and solutions to typical questions. We will explore topics such as charging by friction, conduction, and induction, Coulomb's Law, electric fields, electric potential, and the behavior of conductors and insulators. Understanding these

electrostatics grade 10 questions and answers will equip students with the knowledge to tackle more complex physics problems and build a strong foundation for future studies in electromagnetism. This resource is designed to be a valuable study aid, breaking down challenging concepts into easily digestible explanations.

- Introduction to Electrostatics
- Understanding Electric Charge
- Methods of Charging Objects
- Coulomb's Law Explained
- Electric Fields and Field Lines
- Electric Potential and Potential Difference
- Conductors and Insulators in Electrostatics
- Common Electrostatics Grade 10 Questions and Solutions
- Tips for Studying Electrostatics

## Introduction to Electrostatics

Electrostatics is a branch of physics that deals with stationary electric charges and the forces they exert on each other. In grade 10, students begin their journey into the fascinating world of electricity, starting with the most basic principles. Understanding electrostatics is fundamental, as it lays the groundwork for more advanced topics like circuits, magnetism, and electromagnetic waves. This section will introduce the core concepts that form the basis of all electrostatic phenomena, preparing students for the detailed questions and answers that follow.

At its heart, electrostatics explores what happens when objects possess an imbalance of electric charge. This imbalance can lead to attractions or repulsions between objects, a phenomenon we witness in everyday life, from static cling to the operation of certain electronic devices. The study of these static charges is not just theoretical; it has practical applications in areas like electrostatic precipitators used to clean air and the development of capacitors for energy storage.

# Understanding Electric Charge

Electric charge is a fundamental property of matter that causes it to experience a force when placed in an electric field. There are two types of electric charge: positive and negative. Protons, found in the nucleus of an atom, carry a positive charge, while electrons, orbiting the nucleus, carry a negative charge. Typically, an atom is electrically neutral because it has an equal number of protons and electrons.

The fundamental unit of electric charge is the elementary charge, denoted by the symbol 'e'. The magnitude of the charge on an electron is approximately  $1.602 \times 10^{-19}$  Coulombs (C), and the charge on a proton is equal in magnitude but opposite in sign. When an object gains or loses electrons, it becomes charged. Gaining electrons results in a net negative charge, while losing electrons results in a net positive charge.

Key properties of electric charge include:

- **Quantization:** Electric charge exists in discrete units, multiples of the elementary charge.
- **Conservation:** In an isolated system, the total electric charge remains constant; charge cannot be created or destroyed, only transferred.
- **Superposition:** The total charge of a system is the algebraic sum of the individual charges within it.

## Properties of Electric Charge

The behavior of electric charges is governed by specific laws. Like charges repel each other (positive repels positive, negative repels negative), while unlike charges attract each other (positive attracts negative). This fundamental principle is the basis for many electrostatic interactions. The force between charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them, a concept formally described by Coulomb's Law.

## The Elementary Charge

The elementary charge, 'e', is the smallest unit of electric charge observed in nature. All observable electric charges are integer multiples of this fundamental value. This concept is crucial for understanding how objects acquire charge and the magnitude of those charges. For example, if an object has a charge of  $-3.2 \times 10^{-19}$  C, it means it has gained 2 extra electrons, as  $2 \times (-1.602 \times 10^{-19} \text{ C}) = -3.204 \times 10^{-19} \text{ C}$ .

# Methods of Charging Objects

Objects can become electrically charged through several mechanisms. Understanding these methods is essential for solving many electrostatics grade 10 questions. The primary ways to charge an object are by friction, conduction, and induction.

## Charging by Friction (Triboelectric Effect)

Charging by friction occurs when two different materials are rubbed together. During this process, electrons are transferred from the surface of one material to the surface of the other. The material that loses electrons becomes positively charged, while the material that gains electrons becomes negatively charged. The direction of electron transfer depends on the materials' positions on the triboelectric series, which ranks materials based on their tendency to gain or lose electrons.

For instance, if a glass rod is rubbed with a silk cloth, the glass rod typically loses electrons and becomes positively charged, while the silk cloth gains electrons and becomes negatively charged. This is a common method for demonstrating static electricity.

## Charging by Conduction

Charging by conduction, also known as charging by contact, involves the transfer of charge between two objects when they are brought into direct contact. If a charged object touches a neutral conductor, some of the charge from the charged object will flow onto the neutral conductor. If the charged object is positive, it will attract electrons from the neutral conductor, leaving it with a net positive charge. If the charged object is negative, it will repel electrons onto the neutral conductor, leaving it with a net negative charge.

If a charged object touches another conductor of the same material and size, and they are allowed to reach equilibrium, the charge will be shared equally between them. This results in both objects having the same sign of charge but a reduced magnitude.

## Charging by Induction

Charging by induction is a method of charging an object without direct contact. This process involves bringing a charged object near a conductor. The presence of the charged object causes a separation of charges within the conductor. If the conductor is then grounded (connected to the Earth, which acts as a vast reservoir of electrons), electrons can either flow from the Earth to the conductor or from the conductor to the Earth, depending on the sign of the inducing charge. Once the ground connection is removed, the conductor retains a net charge opposite in sign to that of the inducing object.

For example, to charge a neutral metal sphere negatively by induction, a positively charged rod is brought near it. Electrons in the sphere are attracted to the side nearest the rod, leaving the opposite side with a net positive charge. If the sphere is then grounded while the rod is still nearby, electrons from the Earth flow onto the sphere. When the ground is removed, the sphere is left with a net negative charge, and the positive charge is uniformly distributed.

## Coulomb's Law Explained

Coulomb's Law is a fundamental law in electrostatics that quantifies the electrostatic force between two stationary point charges. It states that the magnitude of the electrostatic force between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between their centers.

The formula for Coulomb's Law is:

$$F = k \frac{|q_1 q_2|}{r^2}$$

Where:

- $F$  is the magnitude of the electrostatic force.
- $k$  is Coulomb's constant, approximately  $8.9875 \times 10^9 \, \text{N} \cdot \text{m}^2 / \text{C}^2$ . Often approximated as  $9 \times 10^9 \, \text{N} \cdot \text{m}^2 / \text{C}^2$ .
- $q_1$  and  $q_2$  are the magnitudes of the two point charges.
- $r$  is the distance between the centers of the two charges.

The direction of the force is along the line connecting the two charges. If the charges have the same sign (both positive or both negative), the force is repulsive. If the charges have opposite signs (one positive and one negative), the force is attractive.

## Calculating Electrostatic Force

When solving problems involving Coulomb's Law, it's important to pay attention to the units. Charges must be in Coulombs (C), and distances must be in meters (m) to obtain the force in Newtons (N). If multiple charges are present, the net force on a particular charge is the vector sum of the forces exerted by

all other charges on it, according to the principle of superposition.

For example, if two charges,  $q_1 = +2.0 \text{ } \mu\text{C}$  and  $q_2 = -3.0 \text{ } \mu\text{C}$ , are separated by a distance of  $0.1 \text{ m}$ , the magnitude of the force between them can be calculated as:

$$F = (9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{[(2.0 \times 10^{-6} \text{ C})(-3.0 \times 10^{-6} \text{ C})]}{(0.1 \text{ m})^2}$$

$$F = (9 \times 10^9) \frac{(6.0 \times 10^{-12})}{(0.01)} \text{ N}$$

$$F = (9 \times 10^9) \times (6.0 \times 10^{-10}) \text{ N}$$

$$F = 5.4 \text{ N}$$

Since the charges are opposite, the force is attractive.

## Electric Fields and Field Lines

An electric field is a region around a charged object where another charged object would experience an electrostatic force. Electric fields are a way to visualize and describe the influence of a charge on the space around it. The electric field at a point is defined as the force per unit positive test charge placed at that point.

The formula for the electric field ( $E$ ) created by a point charge ( $q$ ) at a distance ( $r$ ) is:

$$E = k \frac{|q|}{r^2}$$

The unit of electric field is Newtons per Coulomb (N/C) or Volts per meter (V/m). The direction of the electric field at any point is the direction of the force that would be exerted on a positive test charge at that point.

## Electric Field Lines

Electric field lines are imaginary lines used to represent the direction and strength of an electric field. They are drawn such that:

- Electric field lines originate from positive charges and terminate on negative charges.
- The direction of the electric field at any point is tangent to the field line at that point.
- The density of the field lines (the number of lines per unit area) represents the magnitude of the electric field; closer lines indicate a stronger field.

- Electric field lines never cross each other.

For a single positive point charge, the field lines radiate outwards radially. For a single negative point charge, the field lines point radially inwards. For a pair of equal and opposite charges (an electric dipole), the field lines form curved paths from the positive charge to the negative charge. For two positive charges, the field lines repel each other.

## Electric Field Due to Multiple Charges

When multiple charges are present, the electric field at any point is the vector sum of the electric fields produced by each individual charge at that point. This application of the superposition principle is crucial for solving more complex problems involving electric fields.

## Electric Potential and Potential Difference

Electric potential is a scalar quantity that describes the amount of electric potential energy per unit charge at a specific point in an electric field. It is defined as the work done per unit charge in bringing a positive test charge from infinity to that point against the electric field.

The electric potential ( $V$ ) at a distance ( $r$ ) from a point charge ( $q$ ) is given by:

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

The unit of electric potential is the Volt (V), where 1 Volt equals 1 Joule per Coulomb ( $1 \text{ V} = 1 \text{ J/C}$ ).

Electric potential is a scalar quantity, meaning it has magnitude but no direction.

## Electric Potential Difference

Electric potential difference (also known as voltage) is the difference in electric potential between two points. It represents the work done per unit charge to move a charge between these two points. If we move a charge  $q$  from point A to point B, where the potential at A is  $V_A$  and the potential at B is  $V_B$ , the work done ( $W$ ) by an external agent against the electric field is:

$$W = q (V_B - V_A)$$

This potential difference drives the flow of charge in conductors, creating electric current.

## Relationship between Electric Field and Potential

There is a direct relationship between the electric field and electric potential. The electric field is related to the rate of change of electric potential with distance. Specifically, in one dimension,  $E_x = -\frac{dV}{dx}$ . In three dimensions, the electric field is the negative gradient of the electric potential:  $\vec{E} = -\nabla V$ . This means that the electric field points in the direction of the steepest decrease in electric potential.

## Conductors and Insulators in Electrostatics

Materials can be classified based on their ability to allow electric charges to move through them. This classification is fundamental to understanding electrostatic phenomena.

### Conductors

Conductors are materials in which electric charges, typically electrons, are free to move. Metals are excellent conductors because they have loosely bound valence electrons that can move easily throughout the material. When a conductor is placed in an electric field, the free charges within it redistribute themselves until the electric field inside the conductor becomes zero.

Key properties of conductors in electrostatic equilibrium:

- The net electric field inside a conductor is zero.
- Any net charge on a conductor resides entirely on its outer surface.
- The electric field just outside the surface of a conductor is perpendicular to the surface.
- The potential is constant throughout the entire conductor.

### Insulators

Insulators, also known as dielectrics, are materials in which electric charges are not free to move. The electrons in insulators are tightly bound to the atoms and cannot easily move from one atom to another. When an insulator is placed in an electric field, the charges within the atoms can be slightly displaced, leading to a phenomenon called polarization, but there is no net flow of charge through the material.



Examples of insulators include rubber, glass, plastic, and wood. While they don't allow free charge movement, they can still be affected by electric fields and play important roles in electrostatic devices like capacitors.

## Semiconductors

Semiconductors are materials with electrical conductivity between that of conductors and insulators. Their conductivity can be controlled by adding impurities (doping) or by changing conditions like temperature or light exposure. While typically covered in later grades, it's useful to know they exist as a bridge between conductors and insulators.

## Common Electrostatics Grade 10 Questions and Solutions

This section provides examples of typical electrostatics questions encountered in grade 10 and their step-by-step solutions. Practicing these will solidify your understanding.

### Question 1: Charging by Friction

You rub a plastic comb with a wool cloth. The plastic comb becomes negatively charged. What happens to the wool cloth, and why?

**Answer:** The wool cloth becomes positively charged. When the plastic comb is rubbed with the wool cloth, electrons are transferred from the wool to the plastic. Since the wool loses electrons, it develops a net positive charge, while the plastic comb gains electrons and becomes negatively charged.

### Question 2: Coulomb's Law Calculation

Two point charges,  $q_1 = +4.0 \text{ } \mu\text{C}$  and  $q_2 = +6.0 \text{ } \mu\text{C}$ , are placed  $0.2 \text{ m}$  apart in a vacuum. Calculate the magnitude and direction of the electrostatic force between them.

**Solution:**

Given:  $q_1 = +4.0 \text{ } \mu\text{C} = 4.0 \times 10^{-6} \text{ C}$ ,  $q_2 = +6.0 \text{ } \mu\text{C} = 6.0 \times 10^{-6} \text{ C}$ ,  $r = 0.2 \text{ m}$ ,  $k = 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ .

Using Coulomb's Law:  $F = k \frac{q_1 q_2}{r^2}$

$$F = (9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{(4.0 \times 10^{-6} \text{ C})(6.0 \times 10^{-6} \text{ C})}{(0.2 \text{ m})^2}$$
$$F = (9 \times 10^9) \frac{24 \times 10^{-12}}{0.04} \text{ N}$$

$$F = (9 \times 10^9) \times (600 \times 10^{-12}) \text{ N}$$

$$F = 5.4 \text{ N}$$

Since both charges are positive, they repel each other. Therefore, the force is repulsive.

### Question 3: Electric Field Strength

What is the electric field strength at a distance of  $0.5 \text{ m}$  from a point charge of  $+5.0 \mu\text{C}$ ?

**Solution:**

Given:  $q = +5.0 \mu\text{C} = 5.0 \times 10^{-6} \text{ C}$ ,  $r = 0.5 \text{ m}$ ,  $k = 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ .

Using the electric field formula:  $E = k \frac{|q|}{r^2}$

$$E = (9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \frac{|5.0 \times 10^{-6} \text{ C}|}{(0.5 \text{ m})^2}$$

$$E = (9 \times 10^9) \frac{5.0 \times 10^{-6}}{0.25} \text{ N/C}$$

$$E = (9 \times 10^9) \times (20 \times 10^{-6}) \text{ N/C}$$

$$E = 180 \times 10^3 \text{ N/C} = 1.8 \times 10^5 \text{ N/C}$$

The electric field is directed radially outward from the positive charge.

### Question 4: Electric Potential Difference

A charge of  $2.0 \mu\text{C}$  is moved from a point where the electric potential is  $10 \text{ V}$  to a point where the electric potential is  $25 \text{ V}$ . How much work is done?

**Solution:**

Given:  $q = 2.0 \mu\text{C} = 2.0 \times 10^{-6} \text{ C}$ ,  $V_A = 10 \text{ V}$ ,  $V_B = 25 \text{ V}$ .

Work done ( $W$ ) is given by  $W = q \Delta V = q(V_B - V_A)$ .

$$W = (2.0 \times 10^{-6} \text{ C}) (25 \text{ V} - 10 \text{ V})$$

$$W = (2.0 \times 10^{-6} \text{ C}) (15 \text{ V})$$

$$W = 30 \times 10^{-6} \text{ J} = 3.0 \times 10^{-5} \text{ J}$$

The work done is positive, meaning work is done against the electric field.

### Question 5: Charging by Induction (Conceptual)

How can you charge a neutral metal rod negatively using a positively charged glass rod without touching

the metal rod directly?

**Answer:**

1. Bring the positively charged glass rod near one end of the neutral metal rod. This will cause the electrons in the metal rod to be attracted towards the glass rod, accumulating on the near side. The far side of the metal rod will become positively charged due to a deficiency of electrons.
2. While keeping the glass rod in place, connect the far end of the metal rod to the ground (e.g., with a wire to the Earth). Electrons from the Earth will flow onto the metal rod, attracted by the positive charge on the far end.
3. Remove the ground connection while the positively charged glass rod is still held near the metal rod. The excess electrons from the Earth are now trapped on the metal rod.
4. Finally, remove the positively charged glass rod. The excess electrons, now evenly distributed, will leave the metal rod with a net negative charge.

## Tips for Studying Electrostatics

Mastering electrostatics requires a combination of conceptual understanding and problem-solving skills. Here are some effective strategies for grade 10 students:

- **Visualize Concepts:** Use diagrams to represent charges, electric fields, and forces. Drawing electric field lines for different charge configurations can greatly aid understanding.
- **Practice Regularly:** Consistent practice of electrostatics grade 10 questions is key. Work through textbook problems, past papers, and online resources.
- **Understand Units:** Pay close attention to units (Coulombs, Newtons, Volts, meters) and ensure you convert them correctly, especially when dealing with prefixes like micro- ( $\mu$ ) or nano- (n).
- **Focus on Fundamentals:** Ensure you have a firm grasp of the basic principles: the nature of charge, methods of charging, Coulomb's Law, and the definition of electric fields and potentials.
- **Master Vector Addition:** For problems involving multiple charges, remember that electric forces and fields are vector quantities. You'll need to use vector addition (or components) to find the resultant force or field.

- **Relate Concepts:** Understand how electric fields, electric potential, and forces are interconnected. For example, know that electric fields do work when charges move through a potential difference.
- **Seek Help:** Don't hesitate to ask your teacher or classmates for clarification if you encounter difficulties.

## Frequently Asked Questions

### What is the fundamental unit of electric charge, and what are the two types of electric charge?

The fundamental unit of electric charge is the elementary charge, denoted by 'e'. There are two types of electric charge: positive charge (associated with protons) and negative charge (associated with electrons).

### What is Coulomb's Law, and what does it describe?

Coulomb's Law describes the electrostatic force between two stationary, electrically charged particles. It states that the force is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

### How does the electric field strength relate to the charge causing it and the distance from the charge?

The electric field strength (E) is directly proportional to the magnitude of the charge (Q) creating the field and inversely proportional to the square of the distance (r) from the charge. Mathematically,  $E = kQ/r^2$ , where k is Coulomb's constant.

### What is electric potential, and what is its unit?

Electric potential is the amount of work needed to move a unit positive charge from infinity to a specific point in an electric field. Its unit is the Volt (V).

### Explain the concept of electric potential difference (voltage) and its significance.

Electric potential difference, or voltage, is the difference in electric potential between two points. It represents the energy per unit charge transferred between those two points. Voltage drives the flow of electric charge (current) in a circuit.

## What is an electric dipole, and what is its dipole moment?

An electric dipole consists of two equal and opposite charges separated by a small distance. The electric dipole moment is a vector quantity that measures the strength and orientation of the dipole, pointing from the negative to the positive charge.

## How can conductors and insulators be distinguished based on their electrical properties?

Conductors allow electric charges to move freely through them (e.g., metals) due to loosely bound electrons. Insulators resist the flow of electric charge because their electrons are tightly bound to the atoms, making charge movement difficult (e.g., rubber, glass).

## Additional Resources

Here are 9 book titles related to electrostatics for Grade 10, with descriptions:

1. *Illustrating Electrostatics Principles*: This introductory textbook dives into the fundamental concepts of electrostatics. It covers topics such as electric charge, Coulomb's Law, and electric fields with clear explanations and numerous solved examples. The book is designed to build a strong conceptual understanding for Grade 10 students.

2. *Introducing Electrostatic Forces and Fields*: Focused on building a solid foundation, this book meticulously explains the nature of electric forces between charges. It delves into the concept of electric fields and how they are visualized. Expect detailed problem-solving strategies for calculating forces and field strengths.

3. *Illuminating Electric Potential and Potential Energy*: This resource explores the concepts of electric potential and potential energy in an accessible manner. It breaks down how work is done in electric fields and introduces the relationship between electric potential difference and electric field. Practice problems are geared towards application and understanding of these key energy-related concepts.

4. *Insights into Electrostatic Induction and Conductors*: This book provides a comprehensive look at electrostatic induction, explaining how charges redistribute themselves in conductors. It clarifies the behavior of charges in conductors and insulators under the influence of external electric fields. The text includes questions and answers that specifically address these phenomena.

5. *Interactive Electrostatic Applications*: Moving beyond theory, this book explores practical applications of electrostatics. It examines how electrostatic principles are used in everyday devices and technologies. The included Q&A section helps students connect theoretical knowledge to real-world scenarios.

6. *Illustrated Guide to Electrostatic Shielding and Capacitance*: This visual guide simplifies complex topics

like electrostatic shielding and capacitance. It uses diagrams and clear language to explain how electric fields are affected by conductors and introduces the basic principles of capacitors. The answer keys offer detailed explanations for the practice questions.

7. *Integrating Electrostatic Concepts for Grade 10*: Designed as a supplementary resource, this book aims to consolidate learning in electrostatics. It presents a variety of question types, from multiple-choice to numerical problems, with thorough explanations for each answer. The book reinforces key concepts learned throughout the electrostatics curriculum.

8. *Investigating Electric Charge Distribution*: This book focuses specifically on understanding how electric charges are distributed, particularly in different scenarios. It explores uniform and non-uniform charge distributions and their effects on electric fields. The included questions are crafted to test a deeper understanding of charge behavior.

9. *Introducing Gauss's Law in Electrostatics*: While perhaps a more advanced topic, this book introduces Gauss's Law in a simplified way suitable for Grade 10. It explains the law's significance in calculating electric fields for symmetrical charge distributions. The book provides guided practice problems and answers to build confidence with this powerful tool.

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