



SKJ Education

LC HL PHYSICS

CORE PHYSICS

PROGRAM: WEEK 2

ELECTRIC

FIELDS

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LC HL PHYSICS – CORE PROGRAM

Week 2: Electric Fields

Learning Objectives

- To explain and apply concepts related to electric forces and fields.
- To understand the properties of conductors and insulators, and the methods of charging by contact and induction.
- To calculate forces using Coulomb's Law for single and multiple point charges.
- To analyse the concept of the electric field and describe electric field lines and their symmetry.

Key Terms - Week 2

- **Electric Charge:** A fundamental property of matter that can be positive or negative.
- **Conductors and Insulators:**
 - **Conductors:** Materials that allow the free flow of electric charge (e.g., metals).
 - **Insulators:** Materials that resist the flow of electric charge (e.g., glass, rubber).
- **Charging Methods:**
 - **Charging by Contact:** Transferring charge between objects in physical contact.
 - **Charging by Induction:** Transferring charge without physical contact, by re-distributing charge within an object.
- **Coulomb's Law:** $F = \frac{kq_1q_2}{r^2}$, describing the force between two point charges.
- **Electric Field (E):** A vector field that represents the force per unit charge at a given point, given by $E = \frac{F}{q}$.
- **Electric Field Lines:** Visual representations of the electric field, showing the direction and magnitude of the field at different points.
- **Symmetry of Electric Fields:** The electric field around a charge or group of charges exhibits symmetry, which can be used to simplify calculations and understand the behaviour of the field.

Weekly Challenge: Investigate a real-world application of electric fields, such as an electrostatic precipitator or a Van de Graaff generator. Analyse the electric field and forces involved, and describe how they are used to achieve a specific purpose. Share your findings on Google Classroom.



WEEK 2 STUDY PLAN

Day	Activities & Time Commitment	✓	Rating (1-10)
Monday	- Review Learning Objectives (5 min) - Rank your current ability (5 min) - Review Key Terms (10 min) - Complete Exercise A1 (15 min) - Watch Video (Exercise A2) (20 min) <i>Focus: PREPARATION</i>		
Tuesday	- Complete Exercise B (60 min) <i>Focus: QUESTIONING</i>		
Wednesday	- Reflect on content so far (what has been challenging?) (10 min) - Plan remaining study sessions (10 min) <i>Focus: PROCESSING</i>		
Thursday	- Complete Exercise C (30 min) - 1-hour online lesson (60 min) <i>Focus: ERROR ANALYSIS</i>		
Friday	- Complete Exercise D (45 min) <i>Focus: REVISION</i>		
Saturday	- Complete Exam Question Assessment (D) (60 min) <i>Focus: EXECUTION</i>		
Sunday	- Correct assessment (30 min) - Complete self-reflection (15 min) - Plan next week (15 min) <i>Focus: REFLECTION & RECHARGING</i>		

Study Tips for Success

- **Active Recall:** After studying, close your notes and write down **everything you remember**. Force your brain to grow.
- **Spaced Repetition:** Review concepts **multiple times** over several days.
- **Physics in Action:** Look for **real-world examples** of the concepts you're learning.
- **Ask Questions:** Don't hesitate to ask for help when concepts are unclear. Reach out via *Google Classroom* or email; steven@skjeducation.com.

A1. Proficiency Drills

Learning Focus: Mastering the fundamentals of **electric fields**, including **Coulomb's Law**, **electric field strength**, and **field line representations**.

Part 1: Electric Charge and Materials

Key Concepts

Electric Charge: A fundamental property of matter. Exists in two types: positive (+) and negative (-). The elementary charge is $e = 1.60 \times 10^{-19}$ C.

Conductors: Materials in which charges can move freely (e.g., metals). Electrons are loosely bound.

Insulators: Materials in which charges cannot move freely (e.g., rubber, glass). Electrons are tightly bound.

Charging by Contact: Transfer of charge through direct touching. Objects end up with the **same** sign of charge.

Charging by Induction: Redistribution of charge without contact, using a nearby charged object. Objects end up with **opposite** signs of charge.

Task #1: Identify and classify the following.

1. Classify each material as a conductor or insulator: copper, plastic, aluminium, wood.
2. A negatively charged rod touches a neutral metal sphere. The sphere becomes charged.
3. A positively charged rod is brought near (but not touching) a neutral metal sphere. The side nearest the rod becomes _____ charged.
4. How many electrons are in a charge of -3.2×10^{-19} C? _____ electrons.

Part 2: Coulomb's Law - The Maths

Essential Formulae

Coulomb's Law: The magnitude of the electrostatic force between two point charges.

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

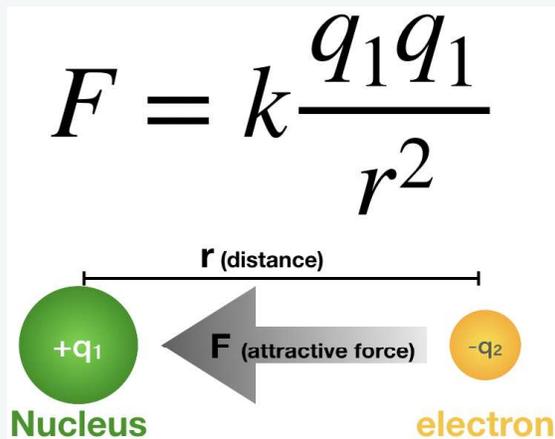
where $k = 8.99 \times 10^9$ N · m²/C².

Electric Field Strength (E): The force per unit positive charge at a point in space.

$$E = \frac{F}{q} \text{ and } E = k \frac{Q}{r^2}$$

Units: N/C or V/m.

Superposition Principle: The net force (or field) is the **vector sum** of individual forces (or fields).


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



Task #2: Perform these basic calculations.

1. Two point charges of $+3.0 \mu\text{C}$ and $-2.0 \mu\text{C}$ are separated by 0.50 m. What is the magnitude of the electrostatic force between them?
2. A point charge of $+5.0 \mu\text{C}$ creates an electric field. What is the electric field strength at a distance of 0.20 m from the charge?
3. An electron experiences a force of $3.2 \times 10^{-15} \text{ N}$ in an electric field. What is the electric field strength?
4. Two identical charges of $+4.0 \mu\text{C}$ are placed 0.30 m apart. What is the magnitude of the force each charge exerts on the other?

Part 3: Electric Field Lines and Patterns

Physics Vocabulary

- **Electric Field Lines:** Visual representations of the electric field. They point in the direction a **positive test charge** would move. Lines originate from positive charges and terminate on negative charges.
- **Field Line Density:** The spacing of field lines indicates field strength—**closer lines** mean a **stronger field**.
- **Symmetry:** Field patterns reflect the charge distribution. A single point charge has **radial symmetry**; a dipole has characteristic curved field lines.

Task #3: Two point charges are arranged as shown: $q_1 = +6.0 \mu\text{C}$ is at the origin, and $q_2 = -6.0 \mu\text{C}$ is at $x = 0.40 \text{ m}$.

Electric Dipole Analysis

Question

- a) What is the electric field strength at the midpoint between the two charges?
- b) In what direction does the net electric field point at this midpoint?

Your Answer

N/C

Answers:

- **Task #1:** 1. Conductors: copper, aluminium; Insulators: plastic, wood. 2. negatively. 3. negatively (induced). 4. 2 electrons.
- **Task #2:**
 1. 0.216 N
 2. $1.12 \times 10^6 \text{ N/C}$
 3. $2.0 \times 10^4 \text{ N/C}$
 4. 1.60 N
- **Task #3:** a) $2.70 \times 10^6 \text{ N/C}$, b) In the positive x -direction (toward q_2).



Task #4: Challenge Questions

Attempt as many questions as quickly as possible. Pay close attention to vector directions and the superposition of fields from multiple charges.

1. Three point charges are arranged in a line: $q_1 = +2.0 \mu\text{C}$ at $x = 0$, $q_2 = -4.0 \mu\text{C}$ at $x = 0.10 \text{ m}$, and $q_3 = +2.0 \mu\text{C}$ at $x = 0.20 \text{ m}$. Calculate the net force on q_2 .
2. A small sphere carrying a charge of $+8.0 \mu\text{C}$ is placed in a uniform electric field of strength $5.0 \times 10^4 \text{ N/C}$. Calculate the magnitude of the electric force on the sphere and state the direction relative to the field.
3. Explain why the electric field inside a conductor in electrostatic equilibrium is zero. What happens to excess charge placed on a conductor?
4. Two point charges, $+Q$ and $-Q$, are separated by a distance d . Sketch the electric field lines for this dipole arrangement and explain why the field is strongest near the charges and weakest at points far from both charges.

A2. Video Suggestion

Watch: Electric Field Strength — A-level Physics — Science Shorts

Link: <https://www.youtube.com/watch?v=mdulzEfQXDE>

Why: This video provides a focused and clear explanation of electric field strength—the force per unit charge experienced in an electric field. It is tailored for high-school or A-level physics, breaking down the core concept, formula ($E = F/Q$), and unit (N/C) with concise diagrams and examples. The presenter's step-by-step approach makes it easier to understand how electric fields exert forces on charges and how to perform basic calculations. It's a great resource to solidify your foundational understanding before tackling more complex problems involving radial and uniform fields.



Self-Assessment

After completing the assessment:

- Grade your work honestly
- Identify areas needing improvement
- Scan and submit via Google Classroom
- Reflect on your performance in your weekly reflection

Another excellent week of work completed - ***well done!*** You are another step closer to *smashing your exams*, and another week closer to your summer holidays!

Weekly Reflection Zone

What worked well this week?

What challenges did I face?

What surprised me the most this week?

Key physics concepts I want to review:

Goals for next week: