

KSU

Phys 109

Chapter 21

Electric Potential

Mr. Abdullah Mohamed

@Chem31Phys

خاص بالمشاركين فقط

1. Electric Potential Energy and Electric Potential

Electric potential tells us how much **electric potential energy** a charge would have **per unit charge** at a certain point.

$$V = \frac{U_{elec}}{q}$$

Where:

Symbol	Meaning	Unit
V	Electric potential	Volt, V
U_{elec}	Electric potential energy	Joule, J
q	Charge	Coulomb, C

The unit of electric potential is:

$$1 V = 1 \frac{J}{C}$$

So, a potential of **1 volt** means **1 joule of electric potential energy per coulomb of charge**.

2. Relationship Between Electric Potential and Potential Energy

From:

$$V = \frac{U_{elec}}{q}$$

We can rearrange:

$$U_{elec} = qV$$

For a change in potential energy:

$$\Delta U_{elec} = q\Delta V$$

And:

$$\Delta V = V_B - V_A$$

So:

$$\Delta U_{elec} = q(V_B - V_A)$$

Very important exam point

Electric potential (V) is created by the source charges, not by the moving charge itself.

So, when calculating:

$$\Delta V$$

the result is independent of the charge q .

But when calculating:

$$\Delta U_{elec}$$

the result depends on the moving charge (q).

3. Sign Rules for Electric Potential Energy

This is a common exam trap.

For a positive charge

If a positive charge moves to a lower potential:

$$\Delta V < 0$$

then:

$$\Delta U = q\Delta V < 0$$

So the electric potential energy decreases.

For a negative charge

If a negative charge moves to a lower potential:

$$q < 0, \Delta V < 0$$

then:

$$\Delta U = q\Delta V > 0$$

So the electric potential energy increases.

Quick rule

Charge	Moves to higher (V)	Moves to lower (V)
Positive charge	(U) increases	(U) decreases
Negative charge	(U) decreases	(U) increases

4. Capacitance and Capacitors

What is a capacitor?

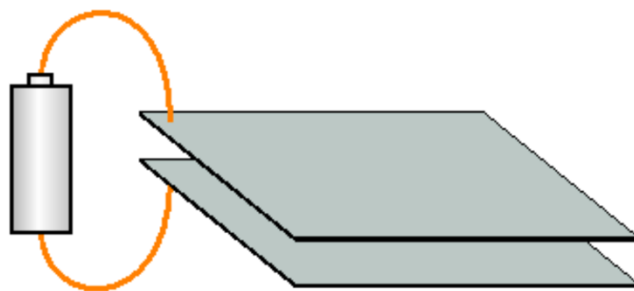
A capacitor is a device made of **two conductors** carrying **equal but opposite charges**.

Usually, these conductors are called **plates**.

One plate has: $+Q$

and the other has: $-Q$

Capacitors are used to **store electric charge** and electric energy.



5. Capacitance

measures how much charge a capacitor can store for a given potential difference.

$$Q = C\Delta V_C$$

Where:

Symbol	Meaning	Unit
Q	Charge stored on capacitor	Coulomb, C
C	Capacitance	Farad, F
ΔV_C	Potential difference across capacitor	Volt, V

Rearranged:

$$C = \frac{Q}{\Delta V_C}$$

The SI unit of capacitance is the farad:

$$1 F = 1 \frac{C}{V}$$

Meaning: a capacitor has capacitance of 1 farad if it stores 1 coulomb of charge when connected across 1 volt.

6. Parallel-Plate Capacitor

A parallel-plate capacitor consists of two flat conducting plates separated by a small gap.

Its capacitance depends only on geometry:

$$C = \frac{\epsilon_0 A}{d}$$

Where:

Symbol	Meaning
C	Capacitance
ϵ_0	Permittivity of free space
A	Area of plates
d	Distance between plates

The constant: $\epsilon_0 = 8.85 \times 10^{-12} \frac{F}{m}$

Important relationships $C \propto A$

If plate area increases, capacitance increases.

$$C \propto \frac{1}{d}$$

If plate separation increases, capacitance decreases.

Exam interpretation

<i>Change</i>	<i>Effect on capacitance</i>
Increase plate area (A)	Capacitance increases
Decrease plate area (A)	Capacitance decreases
Increase distance (d)	Capacitance decreases
Decrease distance (d)	Capacitance increases

7. Dielectrics and Capacitors

A dielectric is an **insulating material** placed between the plates of a capacitor.

Examples include:

- Air
- Paper
- Glass
- Water
- Teflon

When a dielectric is inserted, the capacitance increases.

The new capacitance is:

$$C = \kappa C_0$$

Where:

Symbol	Meaning
C	Capacitance with dielectric
C_0	Capacitance without dielectric
κ	Dielectric constant

For a parallel-plate capacitor with a dielectric:

$$C = \frac{\kappa \epsilon_0 A}{d}$$

8. Dielectric Constants from the Chapter

Important exam idea

Higher κ means higher capacitance.

For example, if: $\kappa = 100$

then: $C = 100C_0$

So the capacitor stores 100 times more charge for the same voltage.

Material	Dielectric constant (κ)
Vacuum	1
Air	1.0004, usually use 1.00
Teflon	2.0
Paper	3.0
Pyrex glass	4.8
Cell membrane	9.0
Ethanol	24
Water	80
Strontium titanate	300

9. Must-Know Formula Sheet

Concept	Formula
Electric potential	$V = \frac{U_{elec}}{q}$
Electric potential energy	$U_{elec} = qV$
Change in electric potential	$\Delta V = V_B - V_A$
Change in electric potential energy	$\Delta U = q\Delta V$
Capacitor charge	$Q = C\Delta V_C$
Capacitance	$C = \frac{Q}{\Delta V_C}$
Parallel-plate capacitor	$C = \frac{\epsilon_0 A}{d}$
Capacitor with dielectric	$C = \kappa C_0$
Parallel-plate capacitor with dielectric	$C = \frac{\kappa \epsilon_0 A}{d}$