ENHANCING STUDENTS' CREATIVE COMPETENCE IN THE TOPIC "SPECIFIC ENERGY OF CHARGED CONDUCTORS AND CAPACITORS"

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Annotation. This article examines methods for developing students' topic-specific creative competence in learning physics, focusing on the topic "Specific Energy of Charged Conductors and Capacitors." The study emphasizes the importance of practical exercises and problem-solving in helping students understand fundamental concepts, apply theoretical knowledge, and develop critical thinking skills. By introducing systematic approaches, step-by-step problem-solving methods, and illustrative examples, students are encouraged to actively engage with the material and creatively approach new challenges. The article also highlights the educational and developmental significance of these exercises, demonstrating how they foster analytical thinking, problem-solving skills, and the ability to apply knowledge in practical situations.

Keywords: creative competence, physics education, charged conductors, capacitors, specific energy, problem-solving, practical exercises, critical thinking, student engagement.

Introduction. The modern education system aims not only to equip students with knowledge but also to develop their competencies in creative thinking, problem-solving, analytical reasoning, and innovative approaches. Creative competence generally refers to a person's ability to think in new ways, solve problems using unconventional methods, generate original ideas, and apply them in practice. In the context of education, creative competence is the capacity of students and teachers to engage in innovative thinking, solve problems creatively, and develop and implement novel ideas. This competence goes beyond merely acquiring knowledge; it also involves the ability to adapt and apply knowledge to new situations. In the study of electricity and magnetism, both the teacher's expertise and the students' creative thinking abilities play a crucial role in understanding complex concepts. Specifically, in teaching the topic "Specific Energy of Charged Conductors and Capacitors," these approaches are of particular importance.

During the process of charging a capacitor, when an infinitesimal charge dq is transferred to it, the electric forces perform an infinitesimal work. This work is given by: $dA = Udq$ (1)

From the relation for voltage $U = \frac{q}{C}$ equation (1) can be rewritten as follows:

$$dA = \frac{q}{C}dq = \frac{1}{C}qdq \quad (2)$$

If expression (2) is integrated from 0 to q the total work done in charging the capacitor is obtained: $A = \int_0^q \frac{1}{C} \cdot qdq = \frac{1}{C}\int_0^q qdq = \frac{q^2}{2C}$

$$A = \frac{q^2}{2C} \quad (3)$$

Equation (3) represents the total work done during the charging of a capacitor, which is equal to the energy acquired by the capacitor from the electric field:

$$W = \frac{q^2}{2C} \quad (4)$$

This formula expresses the energy stored in a charged capacitor during the charging process.

Since the charge q is given by $q = C \cdot U$ equation (4) can be rewritten in the following form:

$$W = \frac{q^2}{2C} = \frac{(C \cdot U)^2}{2C} = \frac{C \cdot U^2}{2} \quad (5)$$

Since the capacitance is defined as $C = \frac{q}{U}$ equation (4) can be expressed in the following form:

$$W = \frac{q^2}{2C} = \frac{q^2}{2 \cdot \frac{q}{U}} = \frac{q \cdot U}{2} \quad (6)$$

If a graph showing the relationship between charge and voltage is given, the area under the curve represents the work done in charging the capacitor (Figure 1).

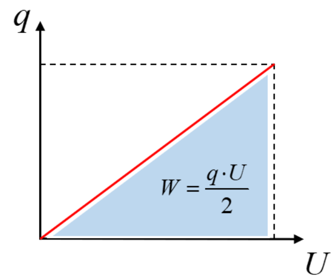

Figure 1.

Since we most often encounter a parallel-plate capacitor when solving problems, the above energy formulas can be applied specifically to the energy of a parallel-plate capacitor. We use the capacitance $C=\frac{\varepsilon\varepsilon_0 S}{d}$ and the voltage $U=E\cdot d$ of the parallel-plate capacitor in these expressions.

$$W=\frac{C\cdot U^2}{2}=\frac{\frac{\varepsilon\varepsilon_0 S}{d}\cdot U^2}{2}=\frac{\varepsilon\varepsilon_0 S\cdot U^2}{2d}=\frac{\varepsilon\varepsilon_0 S\cdot E^2\cdot d^2}{2d}=\frac{\varepsilon\varepsilon_0 S\cdot d\cdot E^2}{2}\quad(7)$$

We use the capacitance $C=\frac{\varepsilon\varepsilon_0 S}{d}$ and charge $q=\sigma\cdot S$ of a parallel-plate capacitor:

$$W=\frac{q^2}{2C}=\frac{(\sigma\cdot S)^2}{2\frac{\varepsilon\varepsilon_0 S}{d}}=\frac{\sigma^2 S\cdot d}{2\varepsilon\varepsilon_0}(8)$$

The energy per unit volume of an electric field is called the energy density. Energy density is denoted by the symbol ω It is defined as follows: $\omega=\frac{W}{V}$ (9)

The unit of energy density is the: $[\omega]=\frac{[W]}{[V]}=\frac{J}{m^3}$

Let us determine the energy density of a parallel-plate capacitor in a specific case. Considering that the volume is $V=S\cdot d$ the following formulas can be derived:

$$\omega=\frac{W}{V}=\frac{\frac{\varepsilon\varepsilon_0 S\cdot U^2}{2d}}{S\cdot d}=\frac{\varepsilon\varepsilon_0\cdot U^2}{2d^2}(10)$$

$$\omega=\frac{W}{V}=\frac{\frac{\varepsilon\varepsilon_0 S\cdot d\cdot E^2}{2}}{S\cdot d}=\frac{\varepsilon\varepsilon_0\cdot E^2}{2}\quad(11)$$

$$\omega = \frac{W}{V} = \frac{\frac{\sigma^2 S \cdot d}{2\varepsilon\varepsilon_0}}{S \cdot d} = \frac{\sigma^2}{2\varepsilon\varepsilon_0} \quad (12)$$

Equations (10), (11), and (12) are formulas for determining the energy density of a parallel-plate capacitor.

Based on the theoretical knowledge they have acquired on the topic, students can apply their creative abilities to solve related problems using various methods. This approach reflects the integration of theory and practice. Below are several examples of problem-solving related to the topic:

1. A capacitor with a capacitance of $30\mu F$ is charged to a potential of $100V$. Determine the energy stored in the capacitor.

Solution:

The energy stored in a capacitor is given by: $W = \frac{CU^2}{2}$

Substitute the given values: $W = \frac{CU^2}{2} = \frac{30 \cdot 10^{-6} F \cdot (100V)^2}{2} = 15 \cdot 10^{-2} J$

Answer:

The energy stored in the capacitor is $W = 15 \cdot 10^{-2} J$

2. A parallel-plate capacitor has a potential difference of $210V$. Across its plates. Each plate has an area of $180sm^2$ and the charge on each plate is $1 \cdot 10^{-9} Cl$ Determine: The energy stored in the capacitor and the distance between the plates.

Solution:

The energy stored is: $W = \frac{q \cdot \Delta\varphi}{2}$

$$W = \frac{q \cdot \Delta\varphi}{2} = \frac{1 \cdot 10^{-9} Cl \cdot 210V}{2} = 105 \cdot 10^{-9} J$$

For a parallel-plate capacitor: $C = \frac{\varepsilon \cdot \varepsilon_0 \cdot S}{d}$; $d = \frac{\varepsilon \cdot \varepsilon_0 \cdot S}{C}$; $d = \frac{\varepsilon \cdot \varepsilon_0 \cdot S \cdot \Delta\varphi}{q}$

$$d = \frac{\varepsilon \cdot \varepsilon_0 \cdot S \cdot \Delta\varphi}{q} = \frac{1 \cdot 8{,}85 \cdot 10^{-12} \frac{F}{m} \cdot 180 \cdot 10^{-4} m^2 \cdot 210V}{1 \cdot 10^{-9} Cl} = 3{,}34 \cdot 10^{-2} m = 3{,}34 sm$$

Answer:

Energy stored in the capacitor: $W = 105 \cdot 10^{-9} J$

Distance between the plates: $d = 3{,}34 sm$

In teaching the topic “Specific Energy of Charged Conductors and Capacitors,” developing students’ creative competence ensures a deep understanding of physical laws, independent thinking, and the ability to approach problems creatively. Using problems based on real-life situations within this topic plays a key role in fostering students’ creative thinking. Incorporating a creative approach into the educational process not only facilitates meaningful mastery of the subject but also prepares students for modern science and technology.

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