Lab: AP Review Sheets Brandon Chui

Capacitance

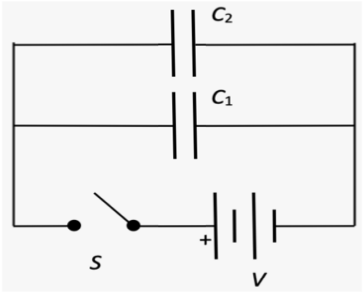
Background:
This chapter covers capacitance, and this chapter builds off of our understanding of electric charges and fields, Gauss's Law, and electric potential.

Major Topics:
The major topics covered in the capacitance unit are capacitance, capacitors in series, capacitors in parallel, energy in a capacitor, and dielectrics.

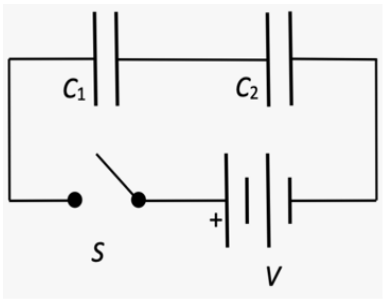
Important Vocabulary:
- Capacitance: a measure of a conductor's ability to store charge; units are Farads (F)
- Conventional Current: the movement of positive electron holes in a circuit
- Capacitors in Parallel: capacitors connected in a manner in which charges travel through either capacitor
- Capacitors in Series: capacitors connected in a manner in which charges travel through both capacitors
- Equivalent/Effective Capacitance: the overall capacitance of capacitors in parallel/series
- Dielectric: an insulator inserted between the plates of a capacitor; this insulator results in a decrease in the potential difference between the two plates by a factor K (dielectric constant)

Important formulae:
- $C = Q/V$
- Capacitors in Parallel: $C_{effective} = C_1 + C_2$
- Capacitors in Series: $\frac{1}{C_{effective}} = \frac{1}{C_1} + \frac{1}{C_2}$
- Energy in a Capacitor: $U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$
- Dielectrics: $V = \frac{V_0}{K}$; $C = KC_0$
- Parallel Plate Capacitors with a Dielectric: $C_{||} = K\frac{A\varepsilon_0}{d}$

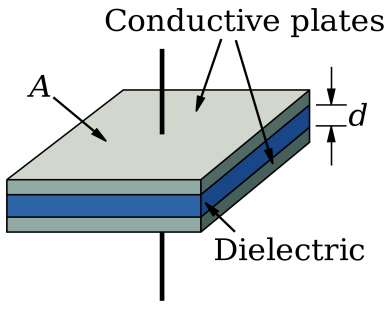
Diagrams:



Capacitors in Parallel



Capacitors in Series



Dielectric

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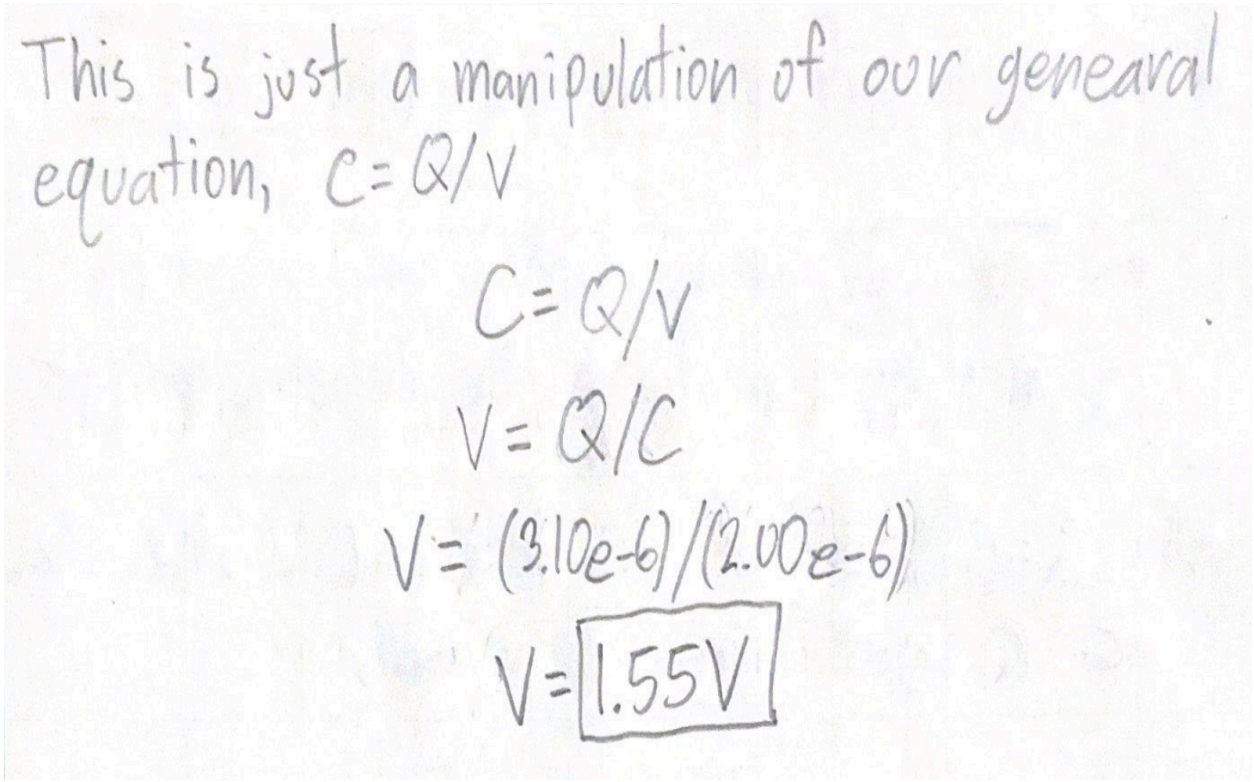
Capacitance

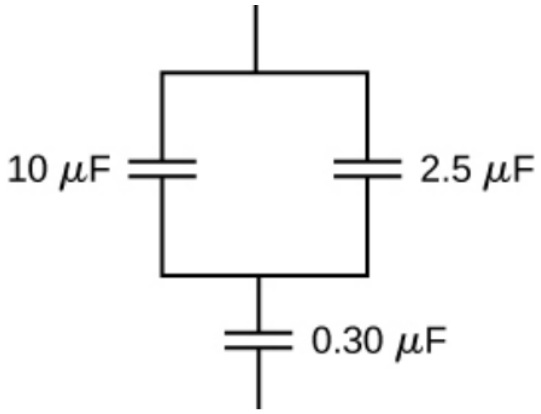
1) Calculate the voltage applied to a 2.00μF capacitor when it holds 3.10μC of charge.

Solution



Capacitance

2) Find the total capacitance of this combination of series and parallel capacitors shown to the right.



Solution

The first step is to find C_{eq} of the capacitors in parallel.

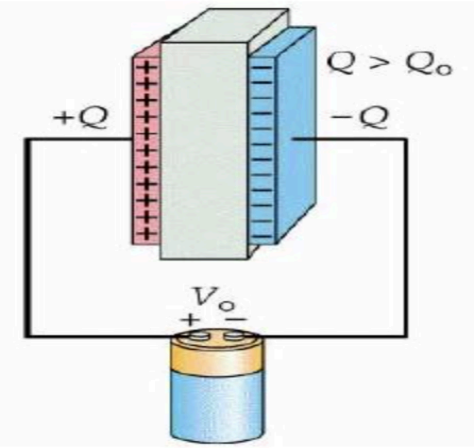
$$C_{eq_1} = C_1 + C_2$$
$$C_{eq_1} = (2.5e\text{-}6) + (10e\text{-}6)$$
$$C_{eq_1} = 1.25e\text{-}5\,F$$

Using C_{eq_1}, find C_{eq} of the whole system by treating it as capacitors in series.

$$\frac{1}{C_{eq_2}} = \frac{1}{C_{eq_1}} + \frac{1}{C_3}$$
$$\frac{1}{C_{eq_2}} = \frac{1}{1.25e\text{-}5} + \frac{1}{0.30e\text{-}6}$$
$$\frac{1}{C_{eq_2}} = 3413333.333$$
$$C_{eq_2} = \frac{1}{3413333.33}$$
$$C_{eq_2} = \boxed{2.93e\text{-}7\,F}$$

Capacitance

3) Let's say there is a parallel plate capacitor with the battery connected. Given that the battery stays connected while a dielectric is inserted, determine if the following quantities will increase, decrease, or stay the same.
    a) Potential difference (V)
    b) Capacitance (C)
    c) Charge (Q)
    d) Electric Field (E)
    e) Energy (U)



Solution

a) Since the battery is connected, V [stays the same]

b) C will [increase], given by $C=KC_0$, which means that C increases by a factor K, the dielectric constant.

c) Using $Q=CV$, since C increases and V stays the same, Q must [increase] as well.

d) Using $V=Ed$, since V and d remain constant, E also [stays the same].

e) Using $U=\frac{1}{2}QV$, since Q increases and V stays the same, U must [increase] as well.