Physics 208, Lecture 6

Today’s Topics
- Capacitance (Ch. 26.1-3)
- Capacitors and Capacitance
- Calculating Capacitance for parallel-plate, cylindrical, spherical capacitors.
- Combinations of capacitors
- Hope you have previewed!

About Exam 1
- When and where
  - Monday Feb. 14th 5:30-7:00 pm
  - (room to be announced)
- Format
  - Closed book
  - One 8x11 formula sheet allowed, must be self prepared, no photo copying/download-printing of solutions, lecture slides, etc.
  - 20-25 multiple choice questions
  - Bring a calculator (but no computer). Only basic calculation functionality can be used.
  - Bring a B2 pencil for Scantron.
- Special requests:
  - Have to be approved. Deadline is 12pm tomorrow (Feb 4th.)
  - All specially arranged tests (e.g. those at alternative time) are held in our 202 labs. (for approved requests only)

Chapters Covered
- Chapter 23: Electric Fields
- Chapter 24: Gauss’s Law
- Chapter 25: Electric Potential
- Chapter 26: Capacitance

I will not post past/sample exams as none that I can find are representative. Often those can be misleading.

I will use next Thursday’s lecture to review for the test. (and will show a few sample test questions to help you get familiar with the test style)

Exercise: Parallel Plates
- Find the potential difference between the two large conductor plates of area A and separation d

\[ \Delta V = \frac{Qd}{\varepsilon_0 A} \]

Answer
- See board

Note: \( \Delta V \) is proportional to \( Q \)
Capacitors

- A generic capacitor:
  - Two conductors oppositely charged
  - \( \Delta V \propto Q \)

- Capacitor are very useful devices:
  - Timing control, noise filters, energy buffer, frequency generator/selector/filter, sensors, memories...

Capacitance

- \( \Delta V \propto Q \rightarrow Q = C \Delta V \rightarrow C \) is called capacitance
- \( C = Q / \Delta V \): amount of charge per unit of potential diff.
  - Unit: Farad (F) = 1 Coulomb/Volt
  - Parallel-plate: \( C = \varepsilon_0 A / d \)
  - Cylindrical and Spherical: see examples in text
    - Cylindrical: \( C = \frac{k}{2 \ln(b/a)} \)
    - Spherical: \( C = \frac{ab}{k(b - a)} \)

Demo: Charging A Pair of Parallel Conductors

- \( \Delta V = V_+ - V_- \)
- Uncharged
- Charging

Charging A Capacitor

- Electric potential energy gained:
  - After charging the capacitor stores potential energy:
    - \( U = \frac{1}{2} Q^2 / C \)
Discharging A Capacitor

\[ \Delta V = \frac{Q}{C} \]

- Charged
- Uncharged

\[ du = \Delta V dq \]

Potential energy released:

\[ U = \int dU = \int \Delta V (-dq) = \int \frac{q}{C} dq = \frac{Q^2}{2C} \]

The originally charged capacitor has potential energy:

\[ U = \frac{1}{2} \frac{Q^2}{C} \]

Combinations of Capacitors In Series

\[ C_{\text{series}} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots} \]

Effective Capacitance

\[ C = \frac{Q}{\Delta V} \Rightarrow C = \frac{1}{C_1 + C_2} \]

Charge conservation:

\[ Q = Q_1 = Q_2 \]

Effective Capacitance

\[ C_{\text{parallel}} = C_1 + C_2 + C_3 + \cdots \]

Note: \( C_{\text{parallel}} \) always > \( C_i \)

Quick Quiz/exercise: Combination of Capacitors

- What is the effective capacitance for this combination?
  - \( C_1 = 1 \mu F \), \( C_2 = 2 \mu F \), \( C_3 = 3 \mu F \)
  1. \( C = 6 \mu F \)
  2. \( C = 3 \mu F \)
  3. \( C = 1.5 \mu F \)
  4. None of above