Lecture 12

Chapter 26

Capacitance - Examples
Capacitance – Question #4

• A) In (a) are $C_1$ and $C_3$ in series?  
  YES
• B) In (a) are $C_1$ and $C_2$ in parallel?  
  YES
• Rank the $C_{eq}$ of the 4 circuits.
  All the same
Capacitance – Question #9

- After switches close for which circuit will the charge on the left-hand capacitor:
  - A) increase? 2
  - B) decrease? 3
  - C) same? 1

- Charge flows until the capacitors have the same potential, $V$

$$q = CV$$
Lecture 12

Chapter 27
Current and Resistance
Current (1)

• What happens when charges move?
  • **Isolated conductor** –
    – Random motion of conduction electrons in both directions so no net transport of charges
    – Same potential everywhere, no $E$ field inside or on surface so no electric $F$ on electrons

• **No current** in isolated conductor
Current (2)

• What happens when charges move?

• Adding a battery –
  – Bias flow of conduction electrons in one direction have net transport of charge
  – Not a single potential, have \( E \) field inside which exerts \( F \) on electrons

• Current in a conductor when attached to a battery
Current (3)

- Amount of current, \( i \) equals amount of \( q \) that passes in \( t \) through an area \( \perp \) to the flow
- If \( i \) doesn’t vary with time (called steady state) \( q \) is conserved, \( i \) is the same for all planes which pass through conductor
  - Orientation doesn’t matter

\[
i = \frac{dq}{dt}
\]
Current (4)

- SI unit for current is ampere

- Current is a scalar

- Use arrows to indicate charge flow along conductor

- $q$ is conserved so

\[ i_0 = i_1 + i_2 \]
Current (5)

• **Convention:** a current arrow is drawn in direction of + charge flow
  - Defined direction of current is opposite to direction of physical current (electrons are the moving charges)

• Current arrows are not vectors

• Bending or reorienting wires does not change

\[ i_0 = i_1 + i_2 \]
Current (6)

- Checkpoint #1 – What is the magnitude and direction of the current, \( i \), in the lower right-hand wire?
- \( q \) is conserved

\[
\begin{align*}
i_{in} &= i_{out} \\
i_{in} &= 11A \\
i_{out} &= 3A + i \\
i &= 8A
\end{align*}
\]

To the right
Current (7)

- Total current through a surface can be defined as
- **Current density**, $J$ – flow of charge through a cross section
- If $i$ uniform and parallel to $dA$
- SI unit for $J$ is $A/m^2$

\[
i = \int \vec{J} \cdot d\vec{A}
\]

\[
i = \int J dA = JA
\]

\[
J = \frac{i}{A}
\]
Current (8)

- Represent $J$ by streamlines

- $q$ is conserved so amount of $i$ cannot change

- $J$ becomes greater in narrower conductor

- Streamlines closer together mean greater $J$

\[ J = \frac{i}{A} \]
Current (9)

- No current in conductor; electrons move randomly with speeds $\approx 10^6$ m/s

- If current present, electrons also move with a drift speed $v_d$

- Drift speeds are tiny; $v_d \approx 10^{-5}$ or $10^{-4}$ m/s

- Why do the lights come on quickly?
  - $E$ field moves at speed of light