Announcements

- Bring circuit supplies to lab this week.
  - Scientific Supply Store only takes cash or check
- Be on time to lab
  - Labs start at 1pm or 3pm depending on section
  - 5 min late – miss the lab quiz
  - 10 min late – counted absent
- Labs are building blocks to design process and documentation.
- Work problems at the end of Chapter 6 for practice. Solutions on web site.
- Read Chapter 6 before next lecture.
Extracurricular Professional Mtgs

- Memos
  - Refer to web site before attending.
  - Turn in **hard copy** to me in **lecture only**!
    - Memos cannot be turned in any other time.

- Meetings
  - Look out for meetings on your own.
  - I will announce IEEE meetings when I hear about them.

Circuit Basics

- Electricity flows through a circuit just like water through a pipe.
  - charge -- water in a pipe
  - current -- water flow
  - voltage -- pressure
  - resistance -- resistance to flow (inverse of pipe cross-sectional area)
  - capacitance -- water stored under pressure (e.g. a balloon)
A Key Difference

This can’t happen with a wire!

Units

- charge -- coulombs (C)
- current -- amperes (A), A=C/s
- voltage -- volts (V)
- resistance -- ohms (Ω), Ω=V/A
- capacitance -- farads (F), F = C/V

Note: farads are huge units -- usually use µF (microfarads)
Circuit Elements

- voltage source (e.g. battery) -- water pump with specified pressure. Units: volts (V)

AC to DC

- AC = alternating current (wall plug-in)
- DC = direct current (battery)
Circuit Elements

- resistor -- pipe with small cross-sectional area that impedes water flow. Units: ohms (Ω)

R1

1k

→ Wire can be viewed as a resistor with very low or zero resistance.

Circuit Elements

- capacitor -- balloon or membrane across a pipe that can stretch with water pressure. Units: farads (F)

C1

1n
Circuit Elements

- diode -- valve that only allows water to flow one direction. (No units)

D1

An LED is a Light-Emitting Diode.

Ohm’s Law

- The current $I$ flowing through a resistor is proportional to the voltage $V$ across it and inversely proportional to the resistance $R$:

$$\frac{V}{R} = I$$

or

$$V = IR$$
Ohm’s Law - Example

Always:
- Label current directions
- Put +/- signs on voltages

\[ I = \frac{5}{100} = 0.05\text{A} \]

*Passive sign convention:* place the positive voltage reference at the same terminal that the current enters

Connection Types

- Series
- Parallel
Series Connection

- Current is the same through all elements.

![Diagram of series connection with two resistors and a voltage source.]

Series Connection

- Resistors add in series. These are equivalent.

![Diagram of series connection with two resistors and a voltage source.]

Ex: $R_1=50\,\Omega$, $R_2=100\,\Omega \implies R=150\,\Omega$
Multiple Voltage Sources

- Multiple voltage sources in series add.
- These circuits are equivalent.

Wait – I thought they ADDED!

- $10 + 4 = 6$?
- Have to look at the polarity
Parallel Connection

- The voltage is the same in all elements.

\[ V_1 \]
\[ \begin{array}{c}
R_1 \\
R_2
\end{array} \]

Parallel Connection

- The reciprocal of resistance adds.

\[
\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad \Rightarrow \quad R = \frac{R_1 R_2}{R_1 + R_2}
\]

Ex: \( R_1 = 50 \, \Omega, \, R_2 = 100 \, \Omega \Rightarrow R = \frac{(50)(100)}{150} = 33.33 \, \Omega \)
Series vs. Parallel

- Are the lights in your house/apartment wired in series or parallel?

\[ V_1 \quad \begin{array}{c|c} + \\hline R_1 \quad \hline \quad + \end{array} \quad R_2 \quad \begin{array}{c|c} + \\hline \quad \hline \quad - \end{array} \quad V_2 \]

*Answer: Parallel!*

Voltage Division

\[ V_2 = \frac{R_2}{R_1 + R_2} V_1 \]

- If \( R_1 \) represents the wire resistance and \( R_2 \) represents the motor and motor circuit resistance, we want \( R_1 \) to be as small as possible. This will deliver the maximum voltage to the motor.

*A voltage-division problem will be on next Tuesday’s quiz!!!*
Voltage Division - Example

\[ V_2 = \frac{20}{10 + 20} \times 15 = 10V \]

Breadboards

- Used for rapid prototyping
  - Easier & faster than soldering
  - Allow for easy alterations
- Generally for temporary use
- Components just plug in
How a Breadboard Works

- Connect components by plugging them in
- Components are connected by copper wires underneath holes

Connecting Resistors in Series
Connecting Resistors in Parallel