March 17, 2017 Physics 132 Prof. E. F. Redish

- **Theme Music:** **Kraftwerk**
  Ohm Sweet Ohm
- **Cartoon:** **Bill Watterson**
  Calvin & Hobbes

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Outline

- Recap: Principles of electric networks
  - Kirchhoff's laws
- Examples

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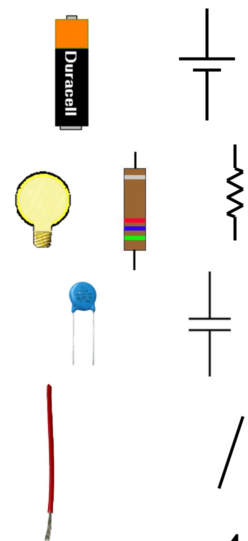
Electric circuit elements

- *Batteries* —devices that maintain a constant electrical pressure difference across their terminals (like a water pump that raises water to a certain height).
- *Resistances* —devices that have significant drag and oppose current. Pressure will drop across them.
- *Capacitors* – devices that can maintain a separation of charge if there is a potential difference maintained across the,
- *Wires* — have very little resistance. We can ignore the drag in them (mostly – as long as there are other resistances present).



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Foothold ideas: Kirchhoff's principles

1. ***Flow rule***: The total amount of current flowing into any volume in an electrical network equals the amount flowing out.
2. ***Ohm's law***: in a resistor, $\Delta V = IR$
3. ***Loop rule***: Following around any loop in an electrical network the potential has to come back to the same value (sum of drops = sum of rises).

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Very useful heuristic

- The Constant Potential Corollary (CPC) (Kirchhoff 0)
  - Along any part of a circuit with 0 resistance, then $\Delta V = 0$, i.e., the voltage is constant since in any circuit element

$$\Delta V = IR$$
$$R = 0 \Rightarrow \Delta V = 0$$
$$\text{(even if } I \neq 0\text{)}$$

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Electric Power

- The rate at which electric energy is depleted from a battery or dissipated (into heat or light) in a resistor is

$$Power = \frac{dW}{dt} = \frac{d}{dt}\left(q\Delta V\right) = \frac{dq}{dt}\Delta V = I\Delta V$$

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Units

- Current (I) — **Ampere** = Coulomb/sec
- Voltage (V) — **Volt** = Joule/Coulomb
- E-Field (E) — Newton/Coulomb = Volt/meter
- Resistance (R) — **Ohm** = Volt/Ampere
- Capacitance (C) — **Farad** = Coulomb/Volt
- Power (P) — **Watt** = Joule/sec

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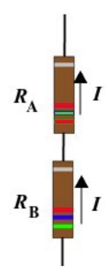
Series and parallel

- Series
  - Same current flows through both devices

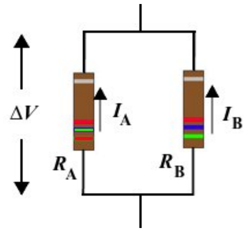


$$I = \frac{\Delta V_A}{R_A} = \frac{\Delta V_B}{R_B}$$

$$\frac{\Delta V_A}{\Delta V_B} = \frac{R_A}{R_B}$$

$$\Delta V = \Delta V_A + \Delta V_B = I(R_A + R_B)$$

- Parallel
  - Same voltage drop across both devices



$$\Delta V = I_A R_A = I_B R_B$$

$$\frac{I_A}{I_B} = \frac{R_B}{R_A}$$

$$I = I_A + I_B = \Delta V\left(\frac{1}{R_A} + \frac{1}{R_B}\right)$$

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