EE16A Lecture 2: Introduction to Imaging & Basic Electrical Circuits

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Announcements

- **We now have a full set of GSIs!**
  - Nathan Mailoa
  - Vik Iyer
- **Course website:**
  - **http://inst.eecs.berkeley.edu/~ee16a/sp15/**
- **If you haven't already, attend a discussion session tomorrow for Python install**
  - Reminder: no labs/GSI office hours this week
- **HW0 out today**

Announcements

- **Room/schedule updates:**
  - Homework parties: Mon. 6-8pm 540AB Cory
  - Office hours:
    - Gireeja: Mon. 6:30-7:30pm, 540AB Cory and Tues. 3:30-4:30pm, 400 Cory
    - Vasuki: Wed. 11am-12pm, 258 Cory
    - Paroma: Wed. 2:30-3:30pm, 212 Cory
    - Nathan: Fri. 3-4pm, 293 Cory

Imaging

- **Everyone knows about cameras…**

- **What else might you be interested in "imaging"?**

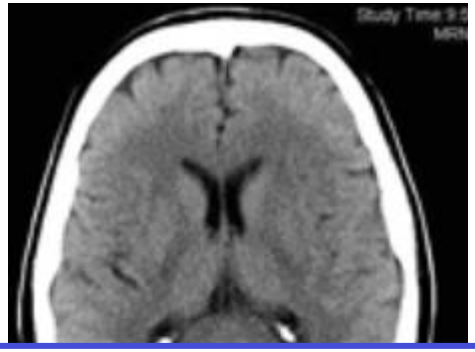
Medical Imaging ca. 1895

- **Need to find a way to see inside without "light"**

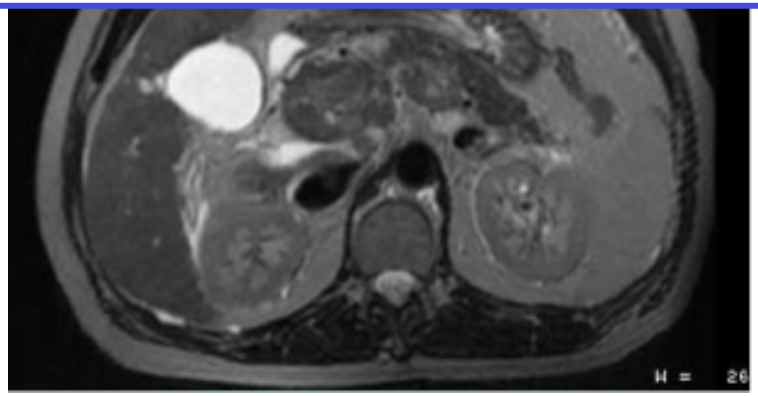
Medical Imaging Today

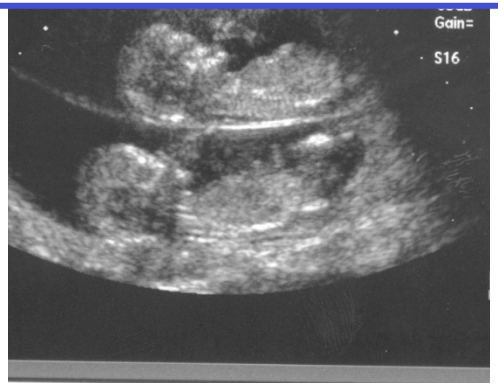
X-Ray

CT

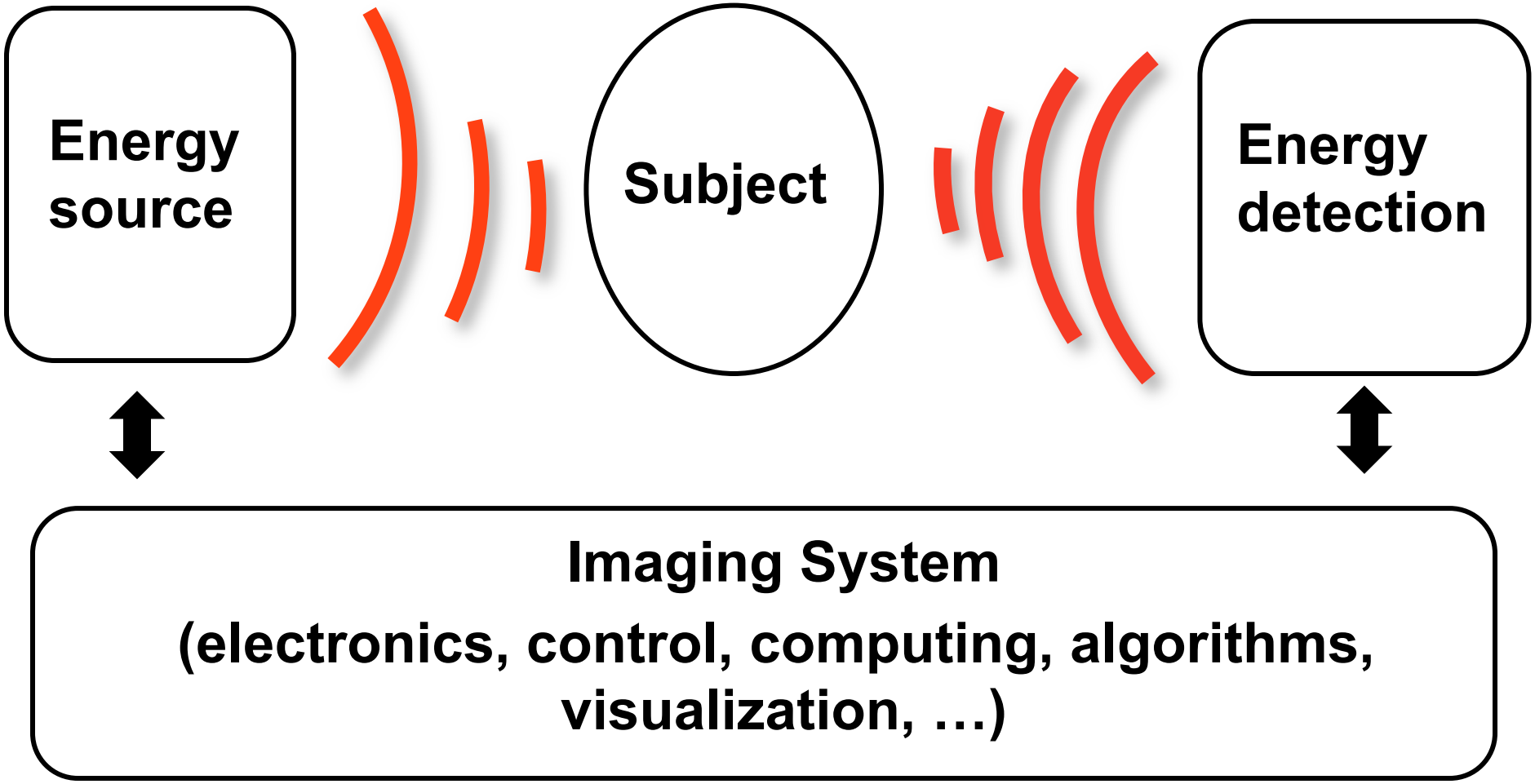


All of these were enabled/dramatically advanced by the mathematical and hardware design techniques you will learn in this class!





Imaging In General



Simplest Possible Imager

- **What is the absolute smallest number of components you need to make an imaging system?**

Simple Imager Example

Simple Imager Example

So Why Did We Talk About an Imager with Just One Sensor?

- **After all, today's cameras have millions of pixels…**

- **Great teaching vehicle: you can actually get a lot out of surprisingly simple designs**
  - Once you know the right techniques!

- **In some systems the sources and/or detectors might actually be expensive**
  - Take this opportunity to learn a little more about how detectors usually work
  - And how we get them to "talk" to our electronic systems

Photodetector Basics

- **Let's focus on light as our example source**
  - Same basic principles apply to many other detectors

- **Turns out that light comes in discrete packets called photons**
  - The brighter a source of light is
  - The more photons it is emitting over a given period of time

- **An electronic photodetector captures these photons and converts them to electrons**
  - Electrons are the basic unit of **electrical charge (Q)**

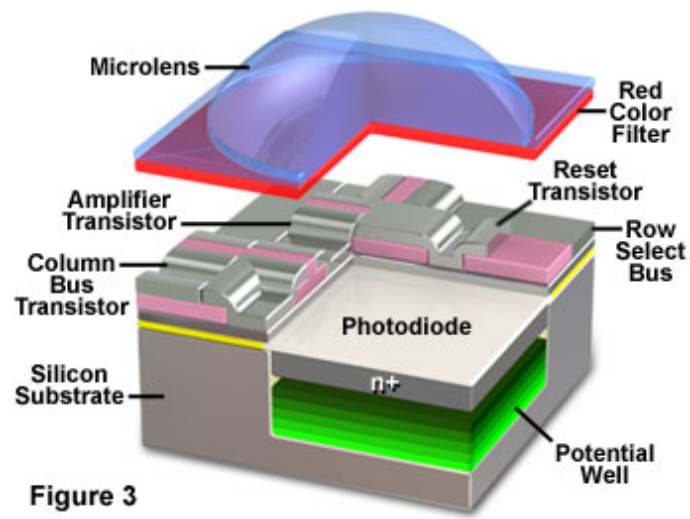


Figure 3

So What Do We Do With Those Electrons?

- **Simplest option might be to let those electrons build up somewhere over a period of time**
  - And then count how many we accumulated

- **All electrical elements (including the photodetectors themselves) can actually build up charge (electrons)**
  - The more charge they store, the higher the **voltage (V)** across them
  - The relationship between the amount of charge and the voltage is known as **capacitance (C)**
    - Defined by **Q = C*V**
  - The number of electrons flowing through the device per unit time is defined as the **current (I)**

A Useful Analogy

- **Photodetector is like a bucket in the rain**
  - Rain drops = photons
  - Drops in the bucket = electrons
  - Level of water in the bucket ≈ voltage

- **What happens to the water level (voltage) over time as you leave it out in the rain (exposed to light)?**

A Useful Analogy

- **What happens to the water level (voltage) if the rain (light) is sporadic?**

- **What happens if we leave the bucket out in the rain too long?**

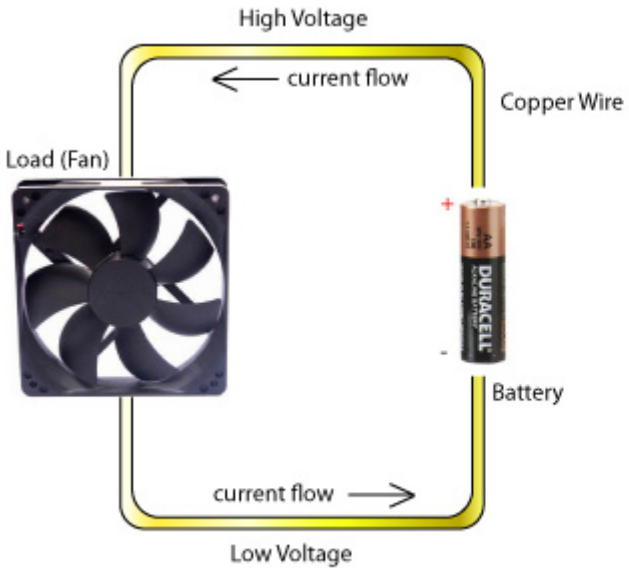
Getting Water Out of the Bucket

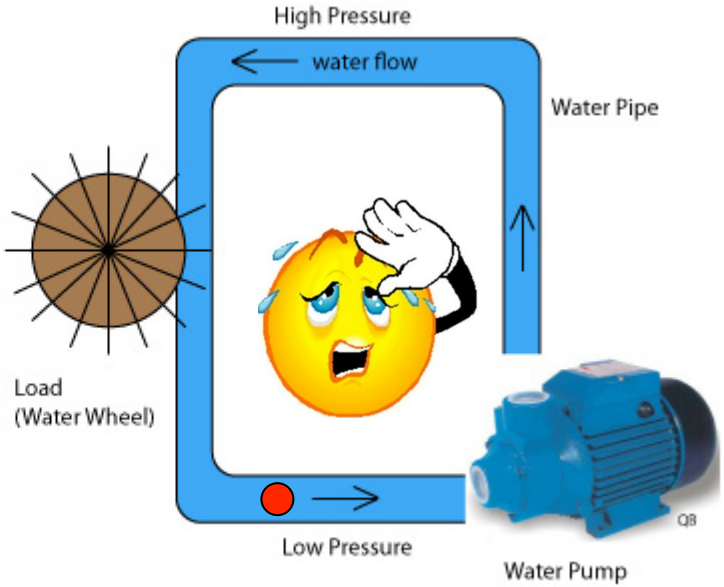
A More Accurate Analogy (1)

- **Electrons don't like to be next to each other**
  - So the more of them we get bunched up (stored) together, the more work we have to do to get them to accumulate

- **Because of this, voltage is actually more analogous to pressure**
  - And not water level

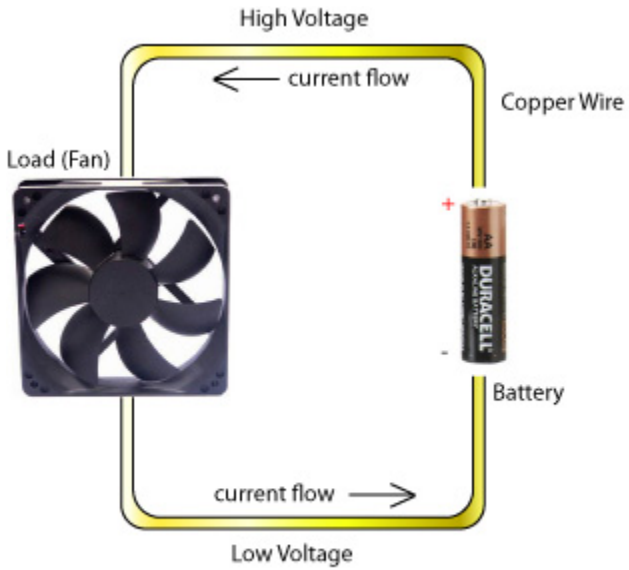
A More Accurate Analogy (2)

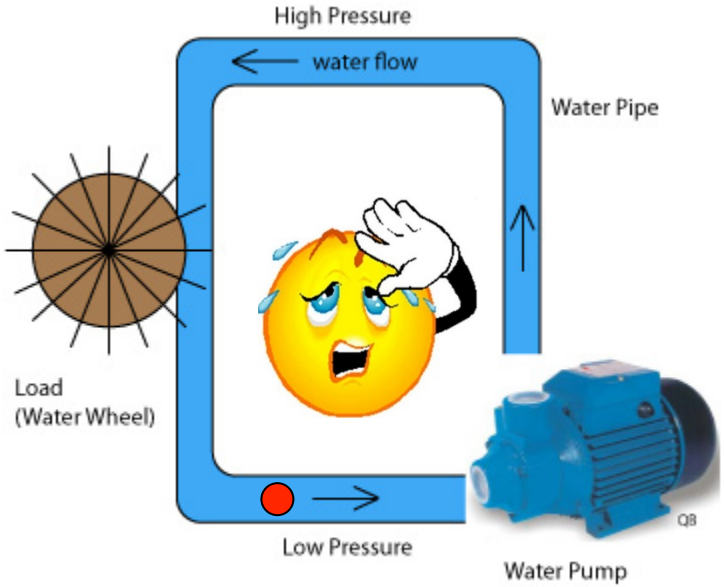




- **If the pump pushes a water droplet up and then let sit go, it quickly goes back down, turning the water wheel**
- **Similarly, an electron at the negative end of the battery flows through the wire to the positive end, spinning the fan (in this case)**

A More Accurate Analogy (3)

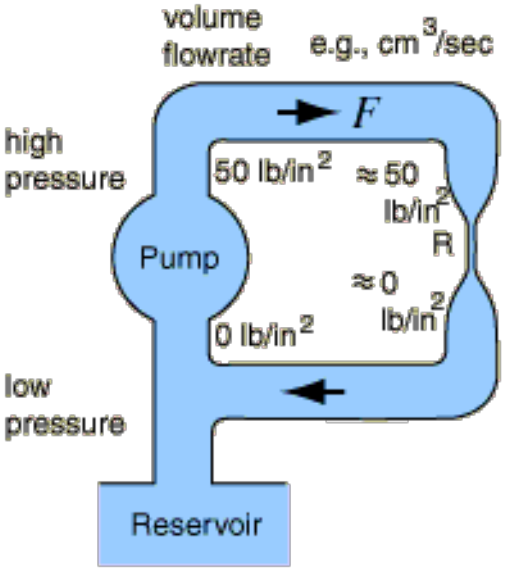


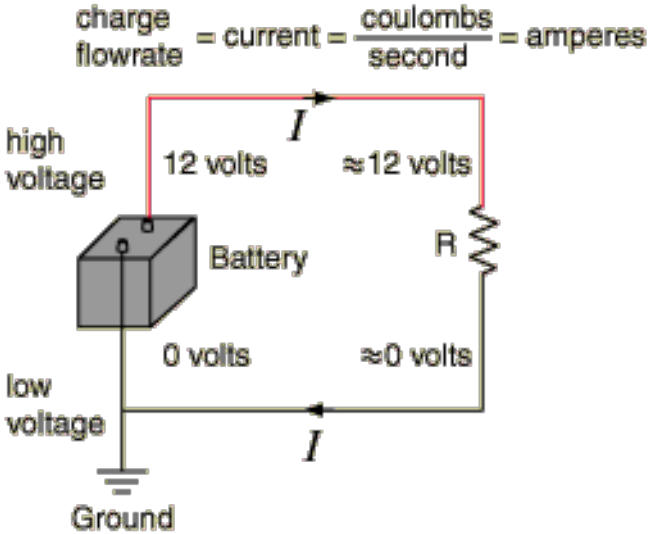


- **Voltage is defined as the work done per unit charge against the electric field**
  - Electric field is the result of the charged particles repelling (or attracting) each other
  - I.e., a source of voltage (battery) pushes the electrons
  - And as they move, they can do work on other elements in the circuit

Voltage, Current, and Resistance

- **Like before, current is the flow of charge (units: A)**
- **The driving force for the flow is the voltage (units: V)**
- **Resistance represents the "fight" the flow path imposes against the flow**
  - Denoted by 
  - Units of **Ohms** (Ω)

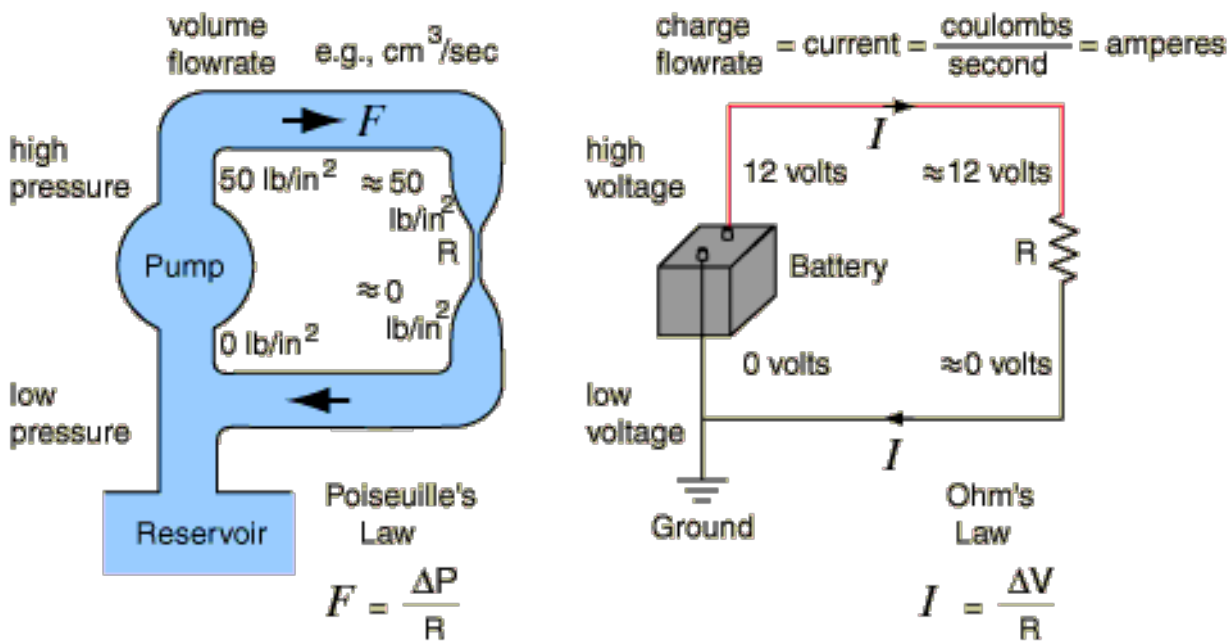




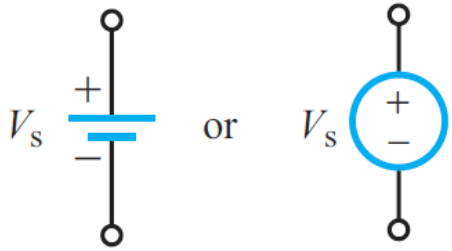
Ohm's Law

- **Defines the relationship between voltage, current, and resistance:**

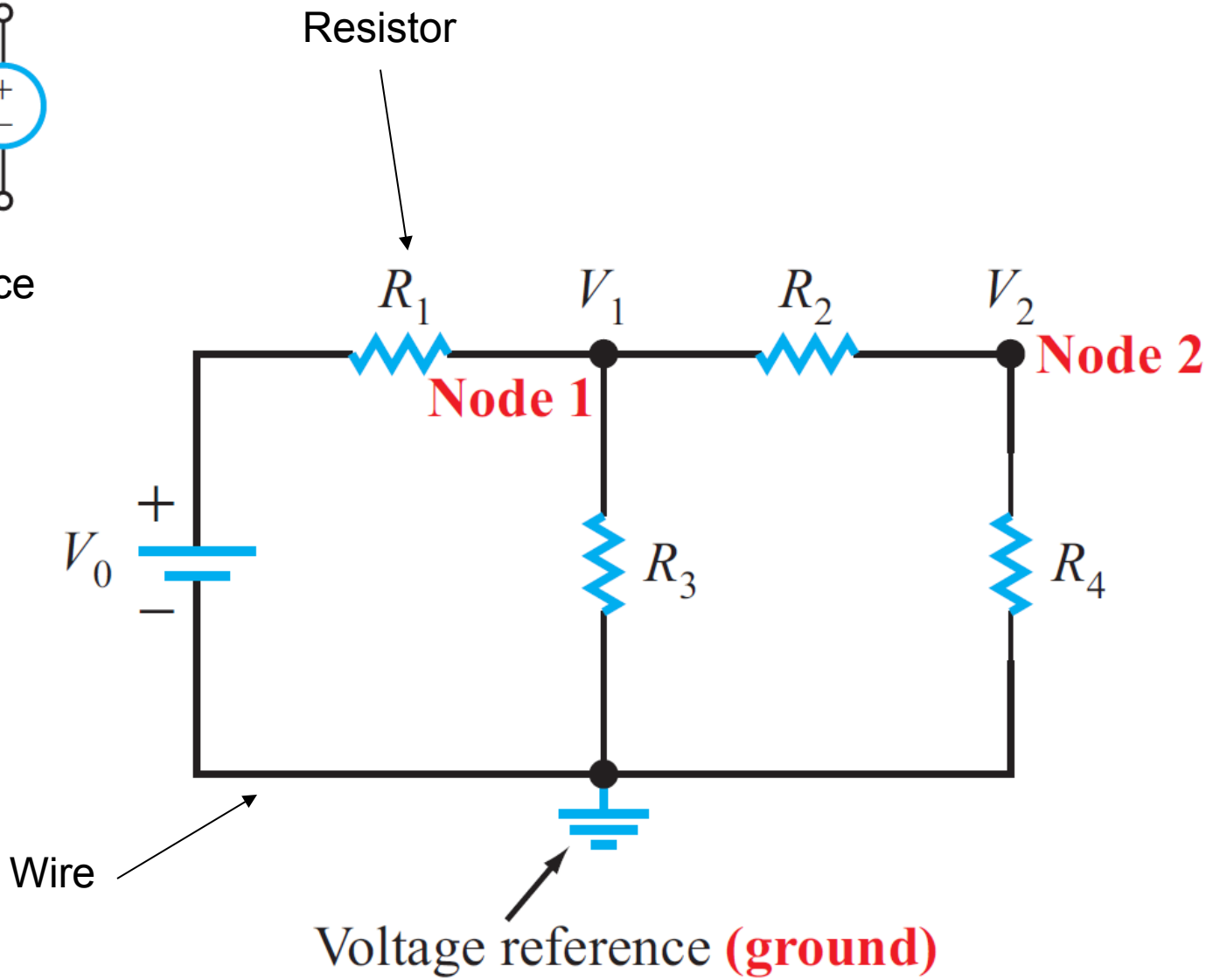
$$\Delta V = I * R$$



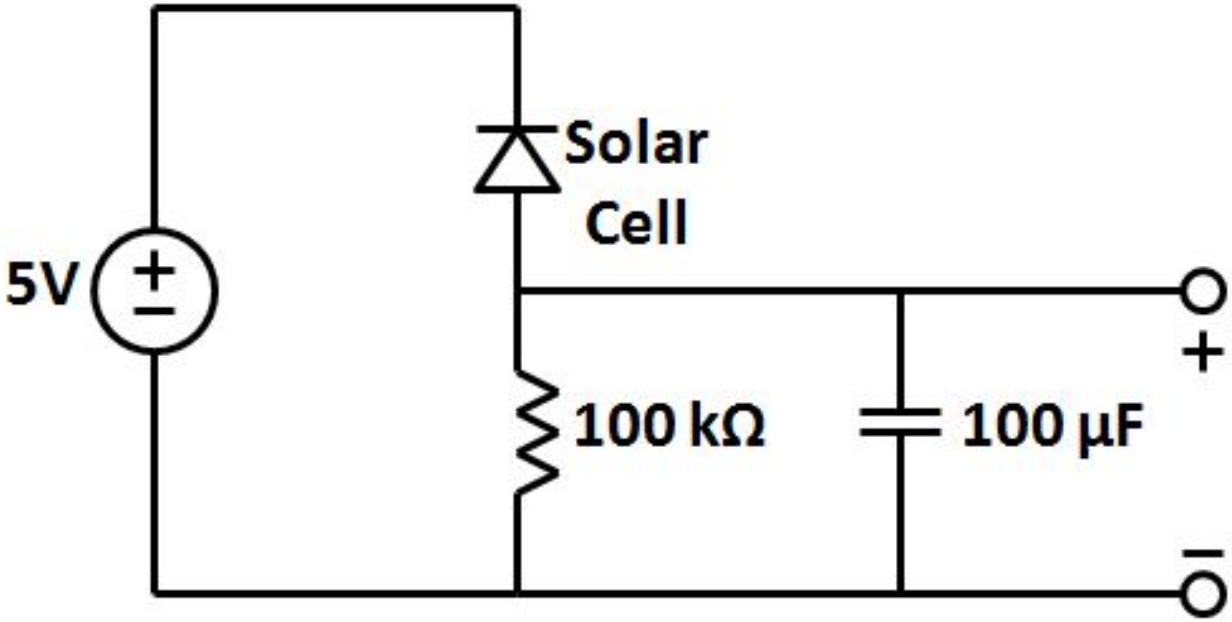
Representing Circuit Components



Voltage Source



Back to the Photodetector: The Actual Circuit You'll Use



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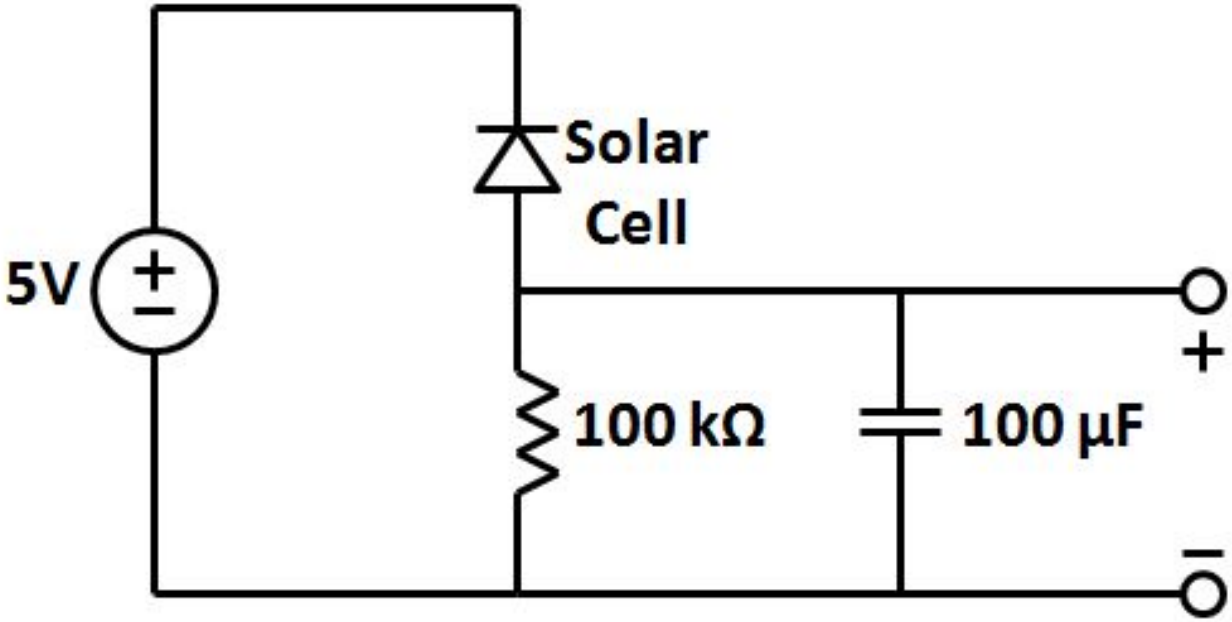

Backup: Capacitor Analogy Revisited

Backup: Parallel Connections