MODULE 4: LEDs

SUMMER CHALLENGE

Electrical Engineering: Smart Lighting

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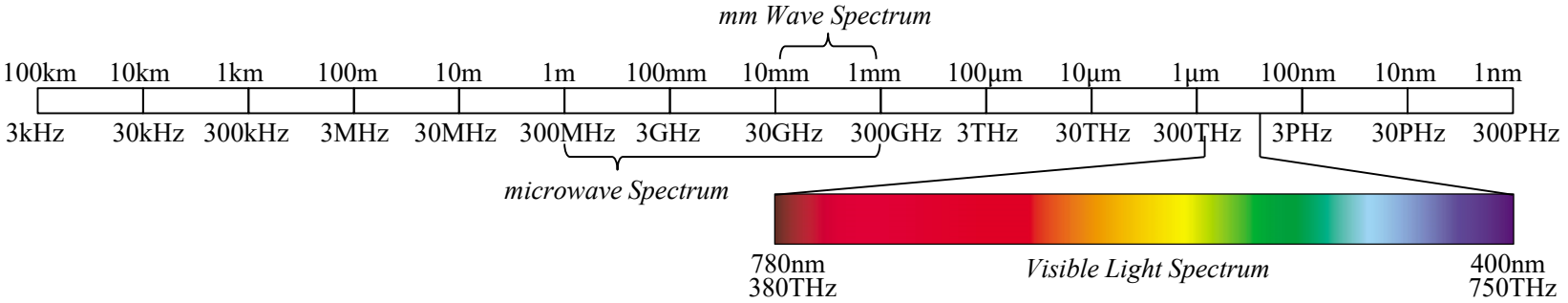
Overview

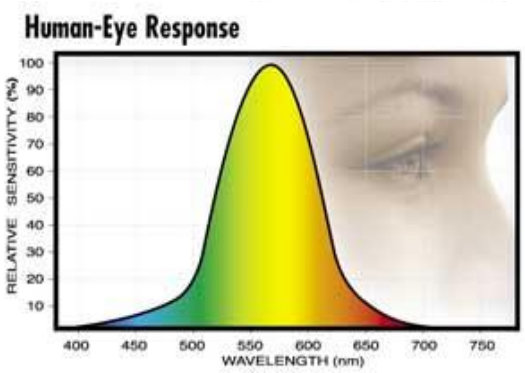
- From “Lighting” to Smart Lighting
- What is a Diode?
- LEDs!
- Electrical Power
- LED Drivers

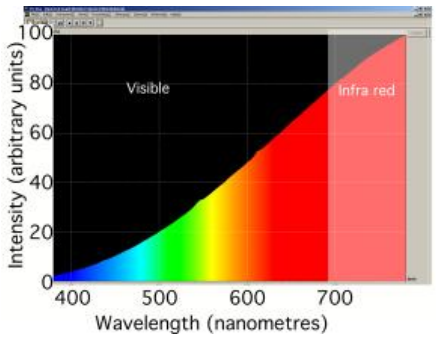
Lighting & Color Science

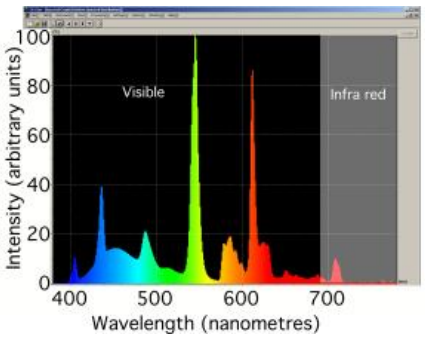
- Visible Light is a form of electromagnetic radiation

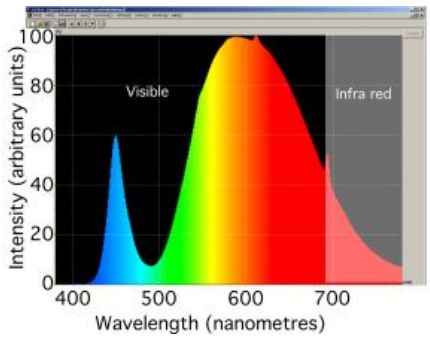


- The human eye responds to the visible light spectrum
- White light is the presence of all colors



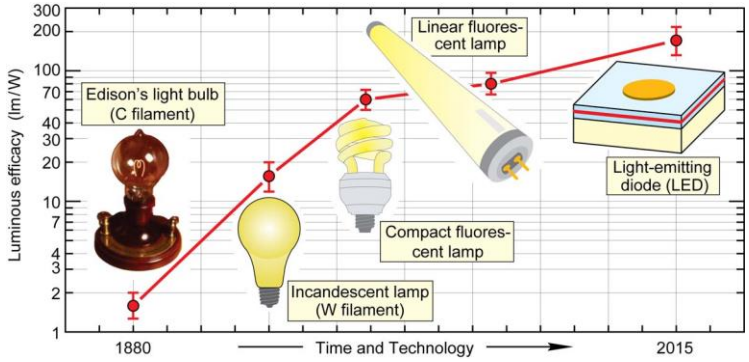




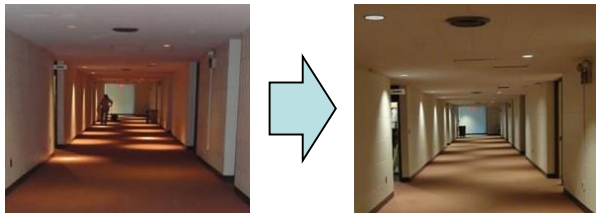


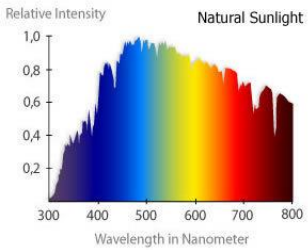
Smart Lighting

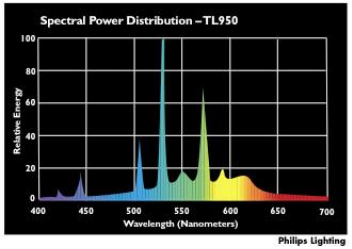
- In what ways can light be better?
  - Energy Efficiency



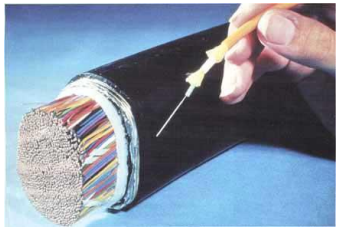
  - Healthy Lighting







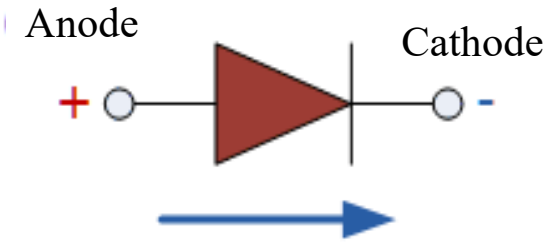
  - Productivity (Data access)

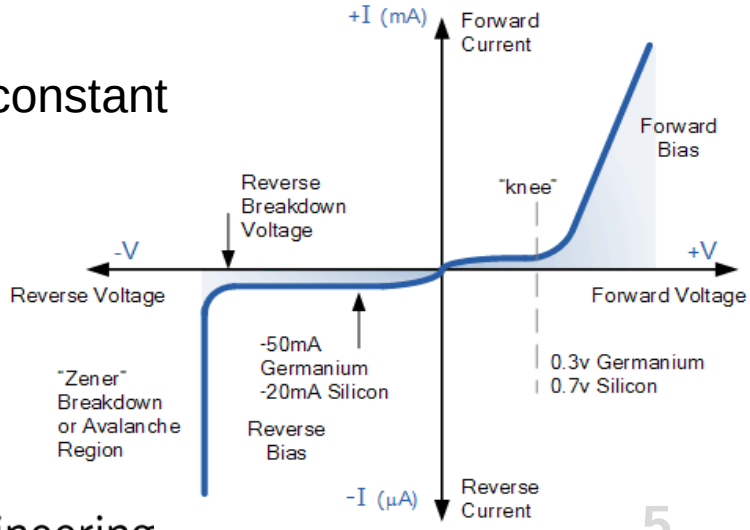


What is a diode?

- A device that allows current to flow in *one* direction; always has polarity (e.g., LED)

- Forward Bias Voltage
  - For current to flow, diodes require a turn-on voltage (i.e., forward bias voltage)
  - In an *ideal* diode, voltage drop remains constant

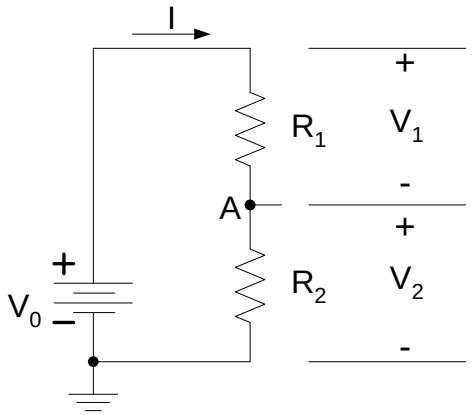




Kirchhoff's Voltage Law

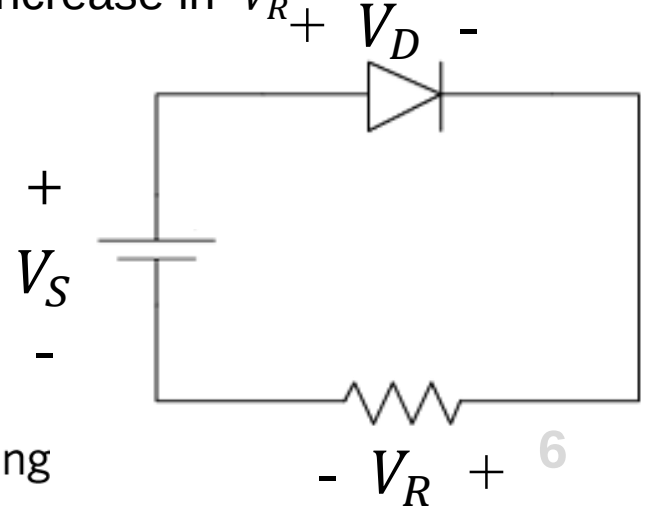
- *The algebraic sum of all voltages in a loop must equal 0*

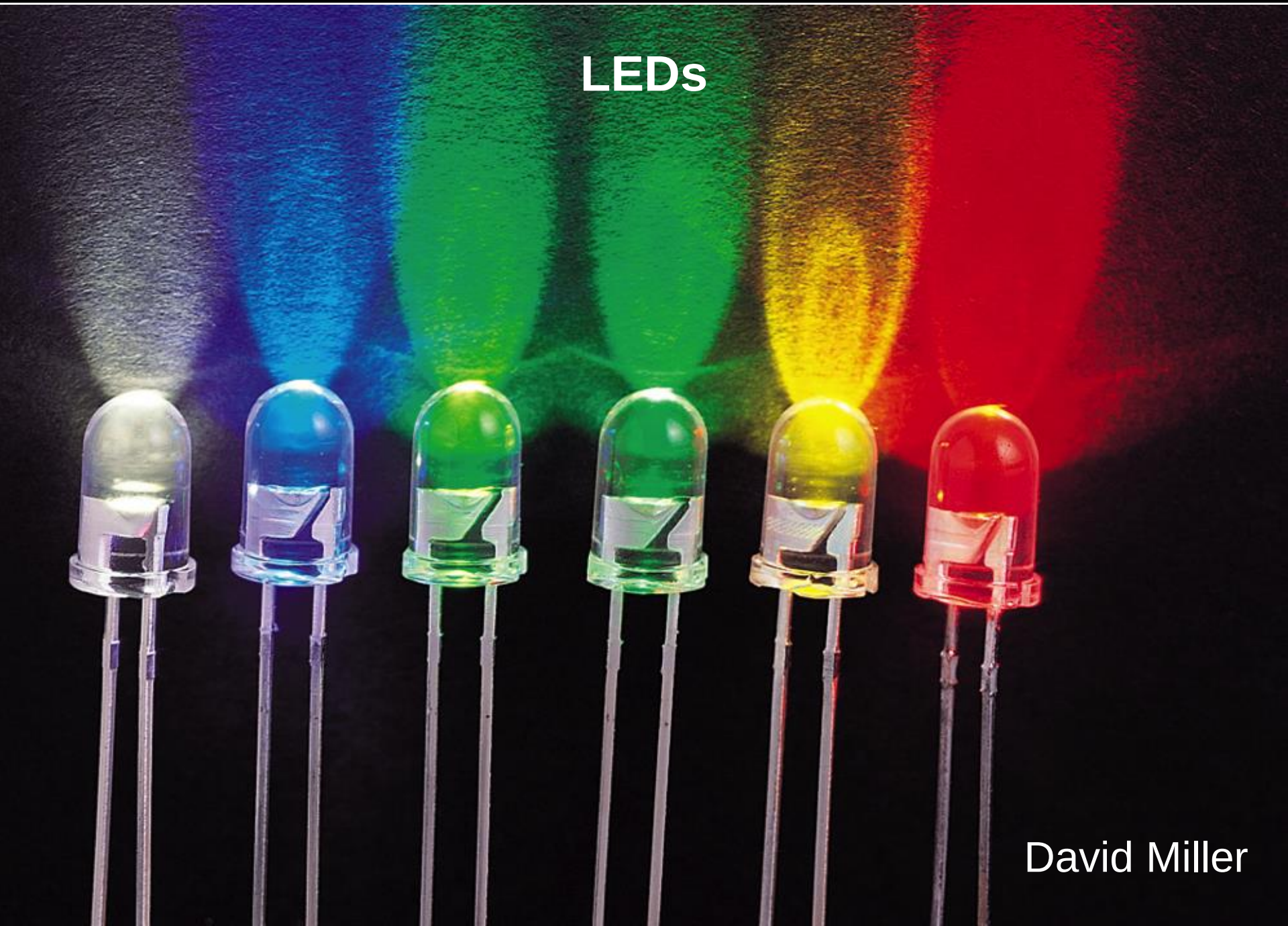
$$V_0 + (-V_1) + (-V_2) = 0$$



- Relationship to Diode circuits
  - Once the diode reaches the turn on voltage, V_R increases with V_S
  - Current through the circuit increases with increase in V_R

$$V_S + (-V_D) + (-V_R) = 0$$




LEDs
David Miller

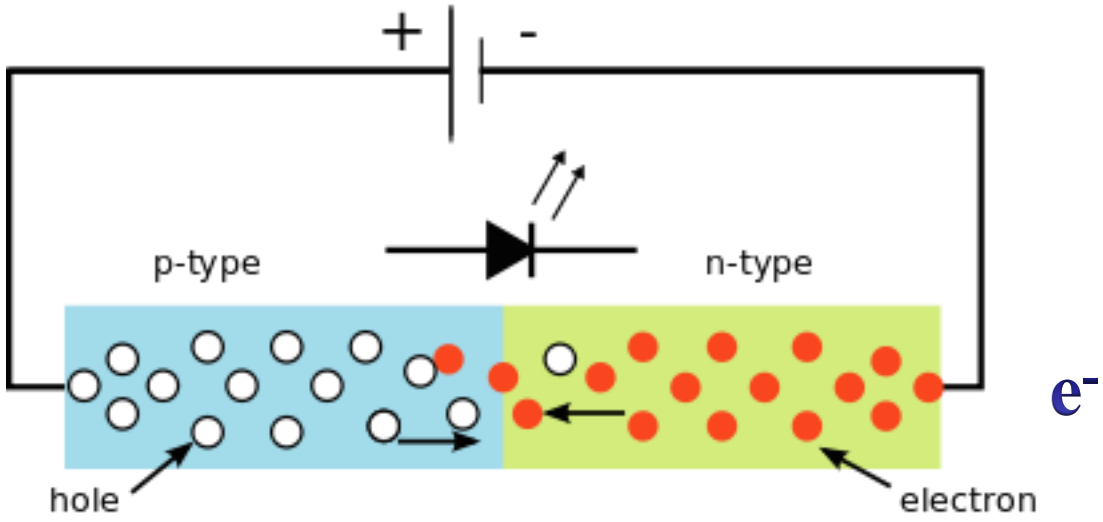
How Do LEDs Work?

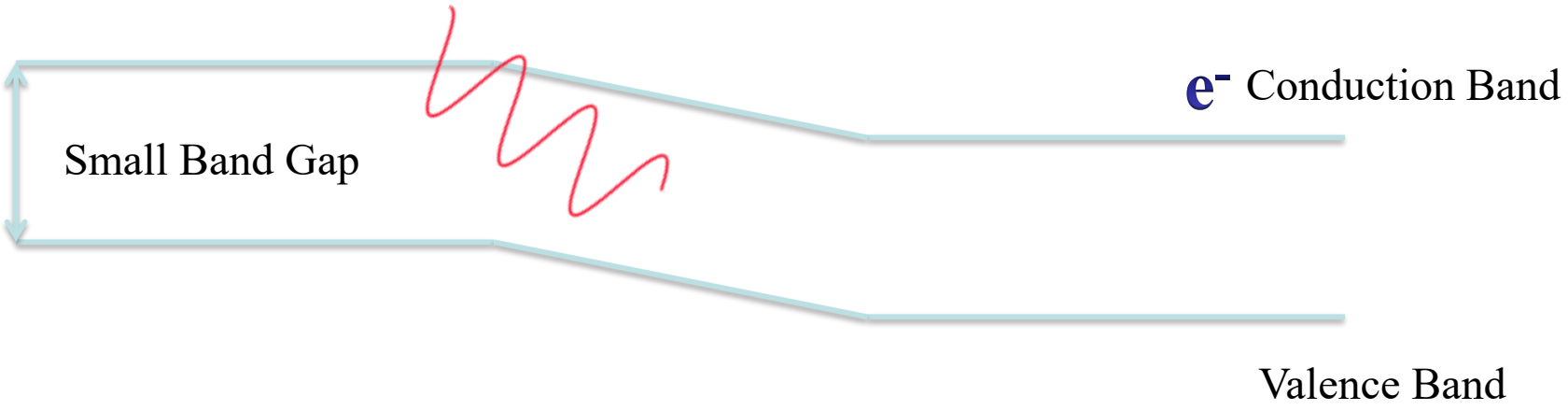
- LED Materials
  - Semiconducting materials: Resistance levels between those of a conductor and an insulator
  - Current can only flow in one direction
- Passing through the LED, electrons lose energy
  - Lost energy creates photons
  - Photons have discrete wavelength related to band-gap
- Band-gap width and energy
  - The wider the band-gap, the greater the energy of the photon released
  - Specialized materials & processes required to achieve wide band-gap
  - Planck's Relation:

$$E = \frac{hc}{l}$$

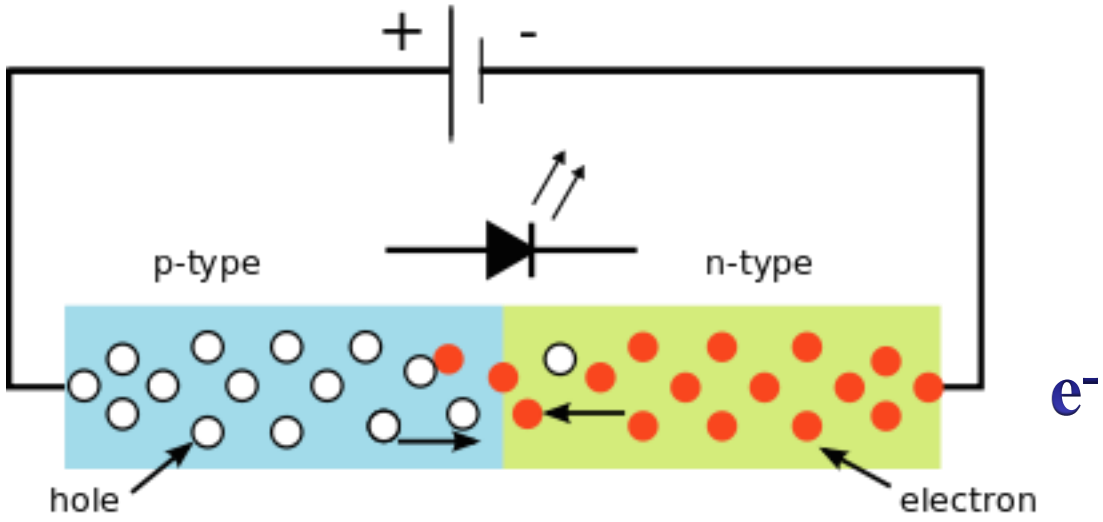
E: Energy
h: planck constant
c: speed of light
λ: wavelength

Small Band Gap: Low Energy Red Light





Large Band Gap: High Energy Blue Light



Experiment I

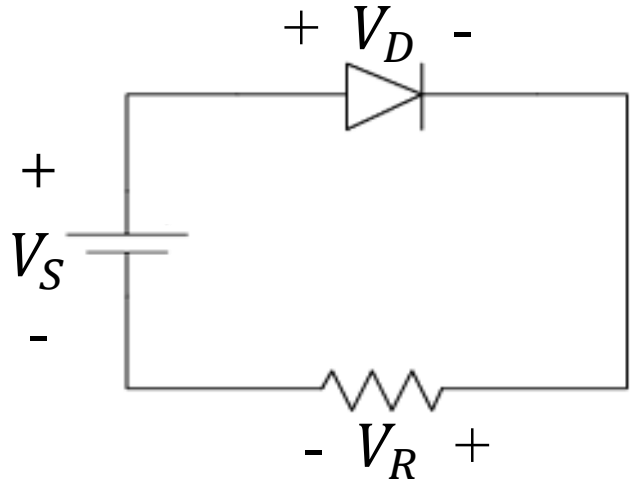
- LED circuit
- Determining the turn-on voltage

Electrical Power

- Power is the rate at which energy is consumed.

$$P = VI \Leftarrow$$ This is another one of those important equations…

- Power is measured in Watts [W] or [J/s]
- Energy *sources* (such as batteries) produce power while the *load* of the circuit absorbs power.



$$I = \frac{V_R}{R} = \frac{V_S - V_D}{R}$$

$$P_D = V_D I = \frac{V_D(V_S - V_D)}{R}$$

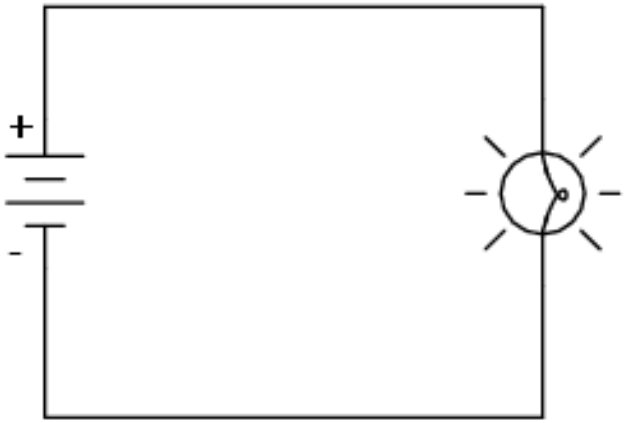
Electrical Power

$$V = IR$$

- Combining the previous equation with Ohm's
- Law:

$$P = VI = I^2R = {V^2}/{R}$$

- Consider a $60W$ incandescent attached to a $120V$ source
  - How does current change if you replace the 60W bulb with 120W bulb?



$$60 = 120I_1 \qquad 120 = 120I_2$$

Experiment II

- LED Drivers
- Power Consumption

Recap

- What did you 

today?