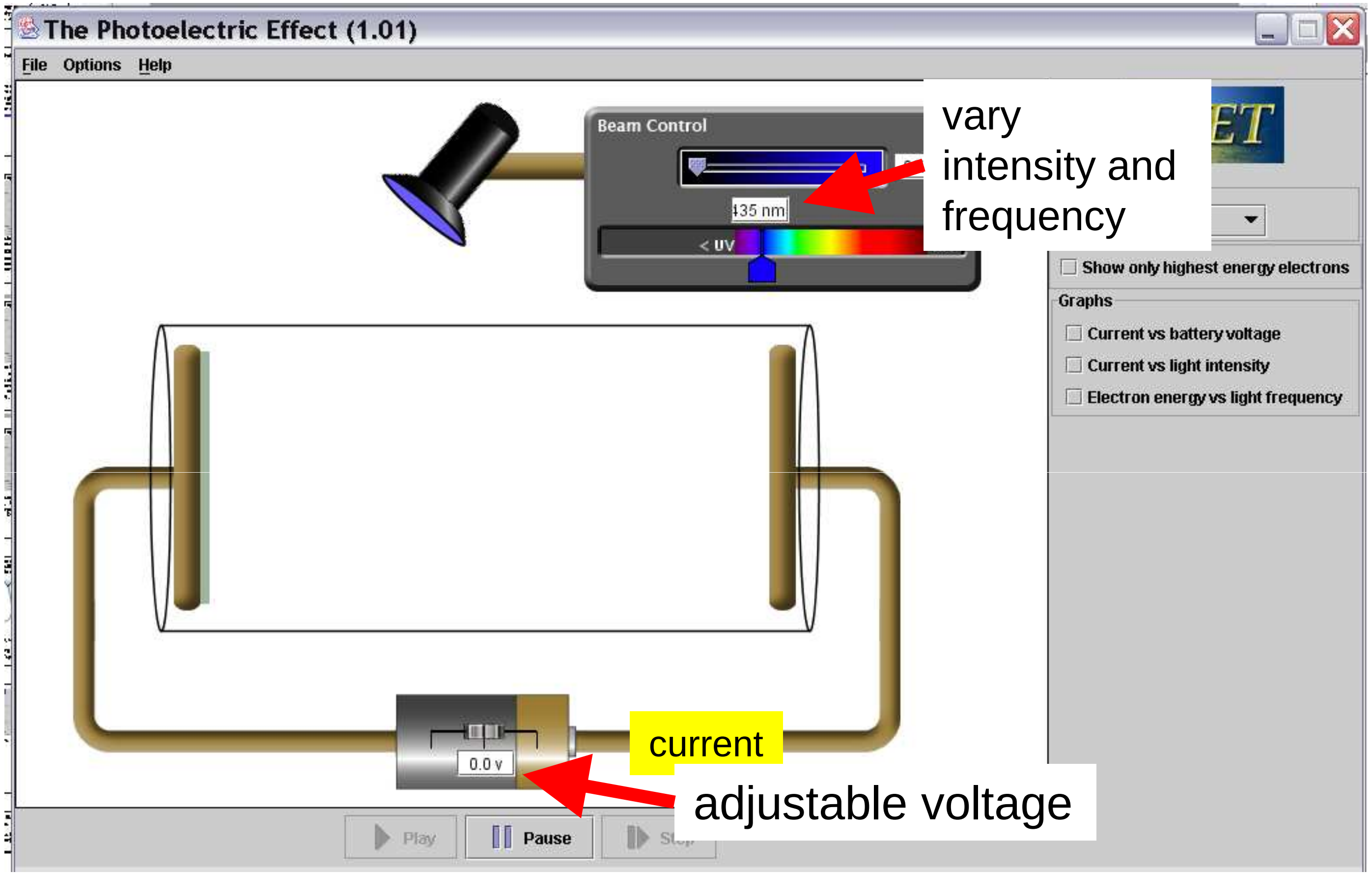
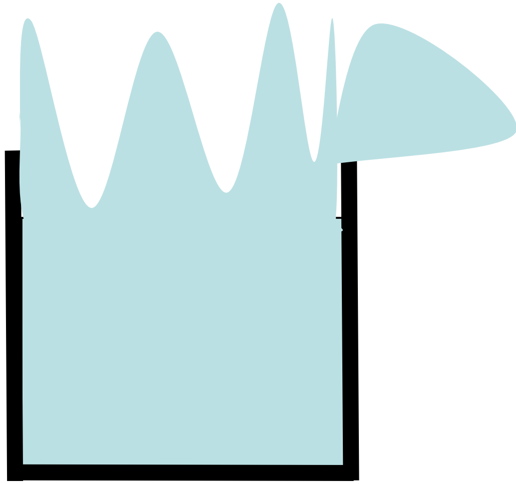
Photoelectric effect



Electron emission from metal
Swimming pool analogy



Water is stucked in pool

Pool party with profs:
Little energy, little bit of splashing

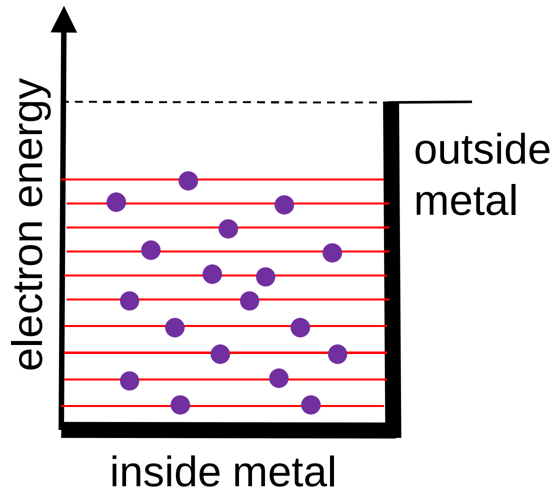
Pool party with students:
More energy, lots of splashing

Electron emission from metal

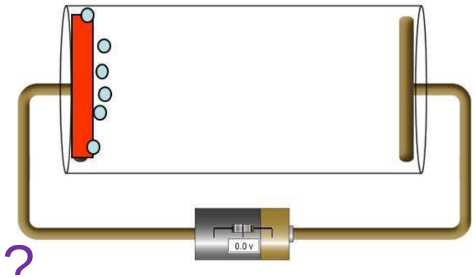
Put in energy by heating

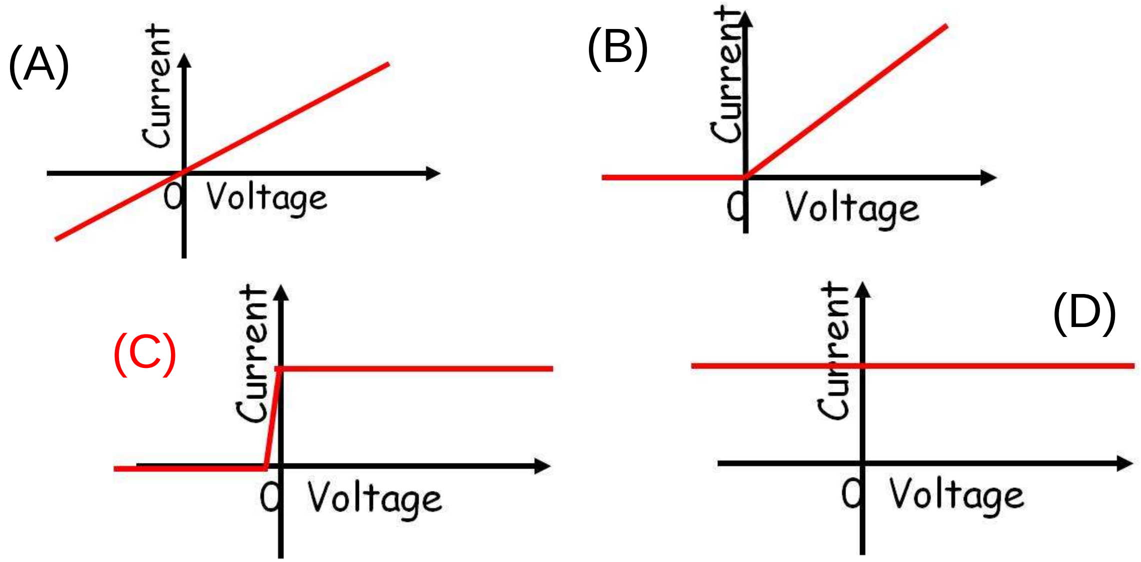
Little energy,
some electrons emitted
with small max energy

Much energy,
lots of energy emitted
with high max energy



Suppose one of the plates is heated up and a few electrons get enough energy to barely "splash" off. What is the current vs. voltage?

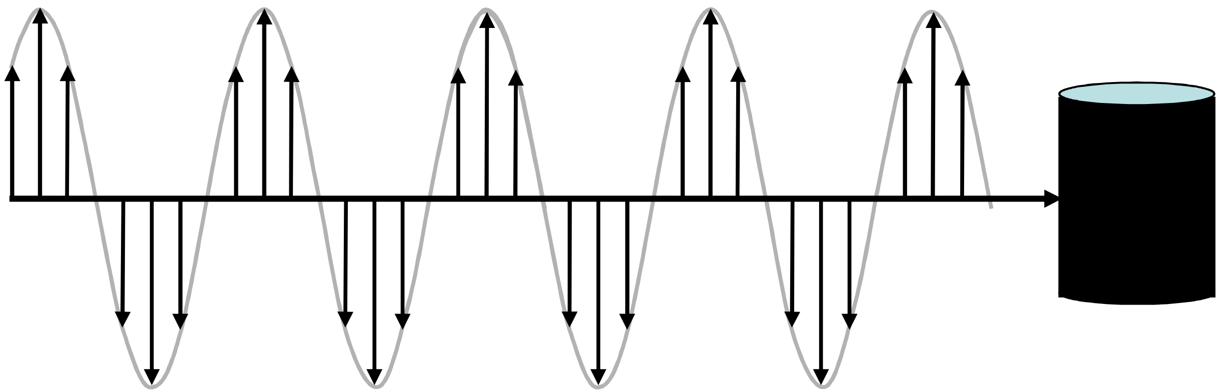




Note:

- *Voltage / potential difference between plates can**not** free electrons from metal plates. Thus, increasing the voltage does **not** increase the number of free electrons.*
- *It is the heating that controls the rate of electron set free per time and therefore the current.*

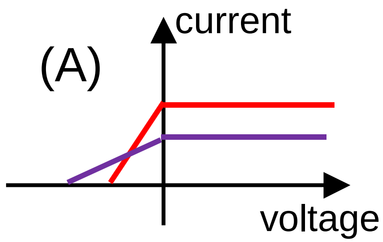
Light as electromagnetic wave

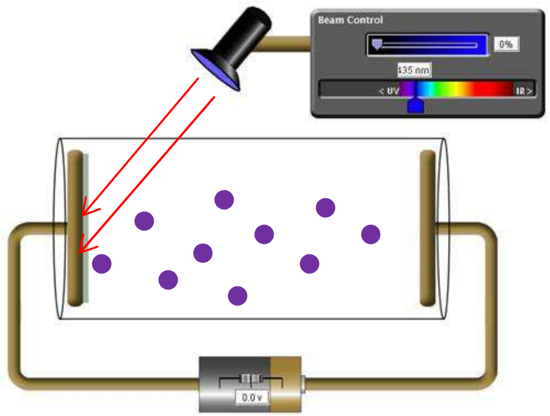


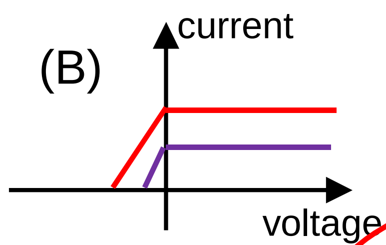
Remember: EM wave carries energy

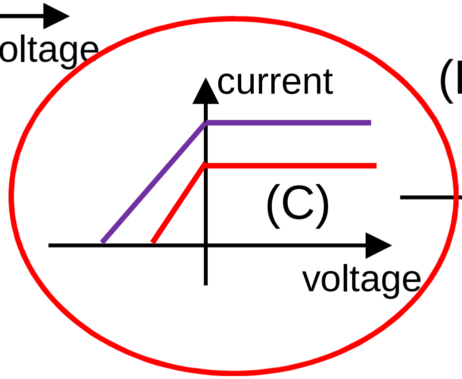
Energy ~ Intensity

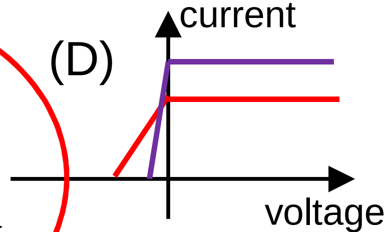
Energy is independent of frequency











Classical EM wave:
Graph for low and
high intensity?

See last slide and pool analogy:
higher intensity → more energy put in metal → more electrons set free with higher max energy → larger current and larger (negative) stopping voltage

Photoelectric effect: Classical expectations

- Increase of light intensity leads to
  increase of current and
  increase of maximum KE of e^-

- Increase of light frequency leads to
  no change in current and
  no change in maximum KE of e^-

- Measurable time delay between appearance
  of current and application of light

Photoelectric effect: Observations

- Increase of light intensity leads to
  increase of current and
  ~~increase of~~ no change in maximum KE of e^-

- Increase of light frequency leads to
  ~~no change in~~ current above threshold frequency and
  ~~no change in~~ increase of maximum KE of e^-

- No measurable time delay between appearance
  of current and application of light

Note: Almost all observations in the photoelectric effect
do not agree with our classical wave expectations.

Einstein's postulates

1. Light consists of discrete energy quanta ("photons") with $E = h*f$

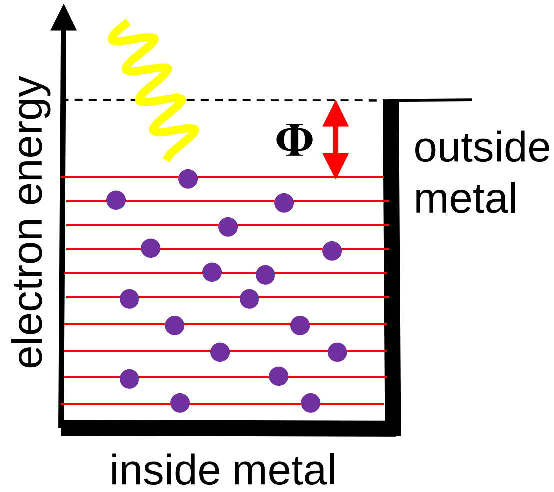
2. One photon is absorbed (interacts)

    - by *one* electron in metal

    - *entirely* (**not** in halves, or other fraction)

    - *instantaneously*

Photoelectric effect



Φ: Work function
Energy needed to free most loosely bound electron

Photon energy: E = hf

Energy conservation:

$$KE = hf - \Phi$$

→ Threshold frequency
linear dependence