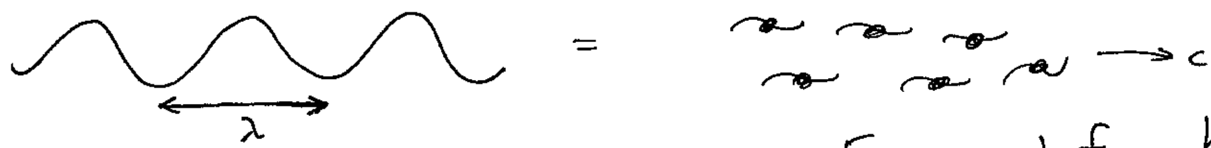
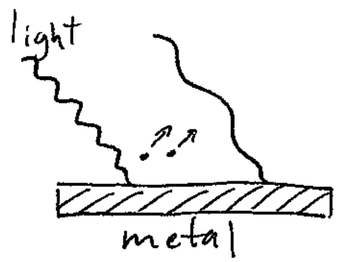
LAST TIME: The photon picture of light



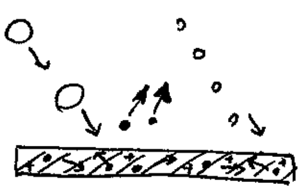
$$E_{photon} = hf = \frac{hc}{\lambda}$$

Einstein: explains photoelectric effect



- electrons emitted only for short enough wavelength.

Einstein's picture:



single photon energy must be large enough to overcome binding energy of electrons to metal

$$hf > W$$

↑ "work function"
= minimum energy required to remove an electron
→ basic property of metal.

How can we test Einstein's picture quantitatively?

we control: wavelength, intensity (power)

Can measure: current, energy of PHOTOELECTRONS.

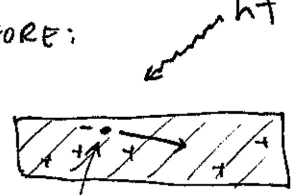
Use photon model to predict energy, current from wavelength, intensity.

① Current: double light power ⟹ double # photons per time ⟹ double rate of ejection events ⟹ double current.

∴ current $\propto$ light power ($\propto$ intensity for fixed light geometry)

② Energy

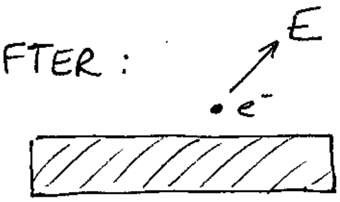
BEFORE:



hf = energy of photon
= max. energy that an electron can gain

electron: binding energy AT LEAST W

AFTER:

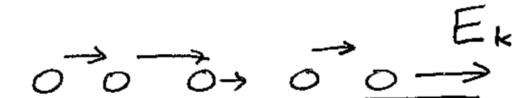


E_k^{max} = maximum final kinetic energy of electrons

⟹ $$\boxed{E_K^{max} = hf - W}$$

How can we measure maximum kinetic energy?

Analogy: bunch of rolling balls

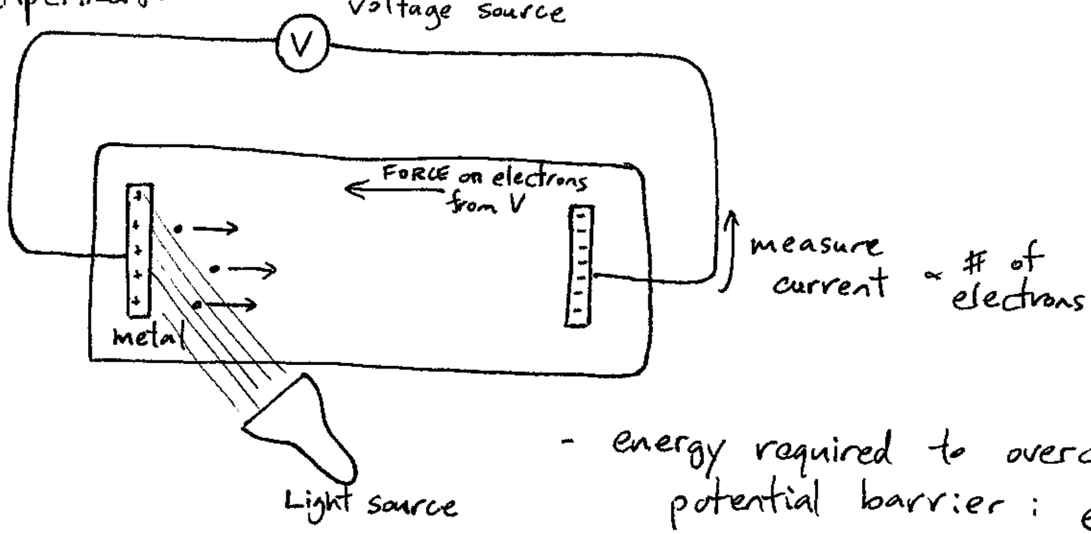


Make them go up ramp.
For $h > h_{stop}$, no more balls.

$$E_k^{max} = m \cdot g \cdot h_{stop}$$

"Hill" for electrons is voltage difference

Millikan's Experiment.

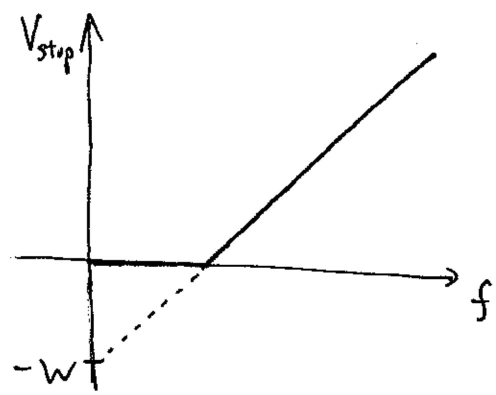


- energy required to overcome potential barrier : $e \cdot V$
- increase voltage until current stops

$$E_k^{max} = e V_{stop}.$$

Einstein's prediction:

$$e V_{stop} = E_k^{max} = hf - W$$



Experimental results matched Einstein's prediction (Nobel prize 1921)