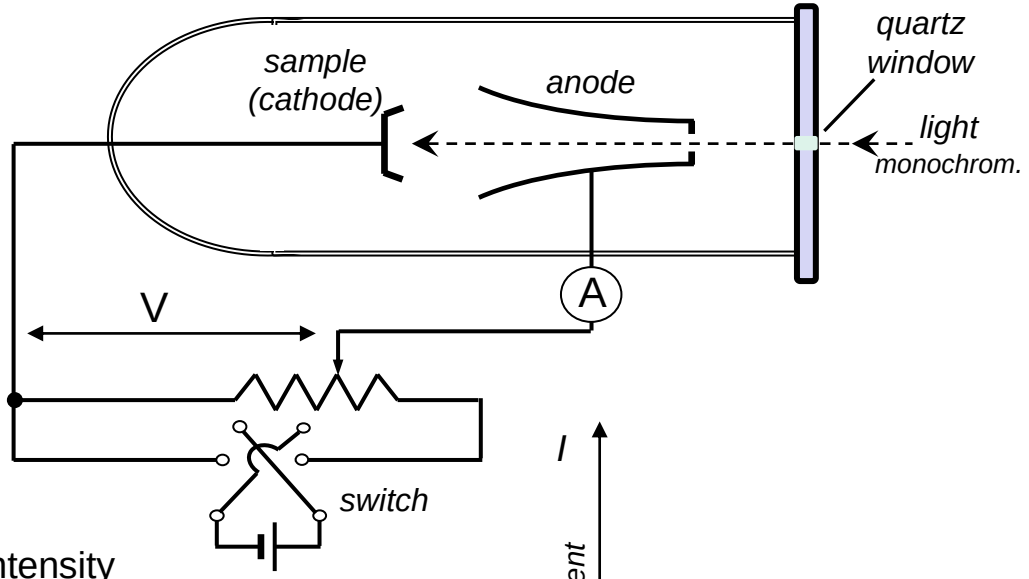
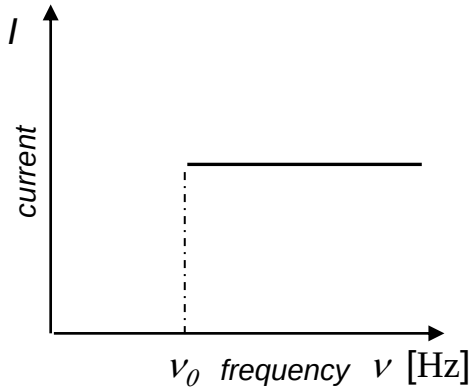
# **Problem 02:** Photoelectric effect

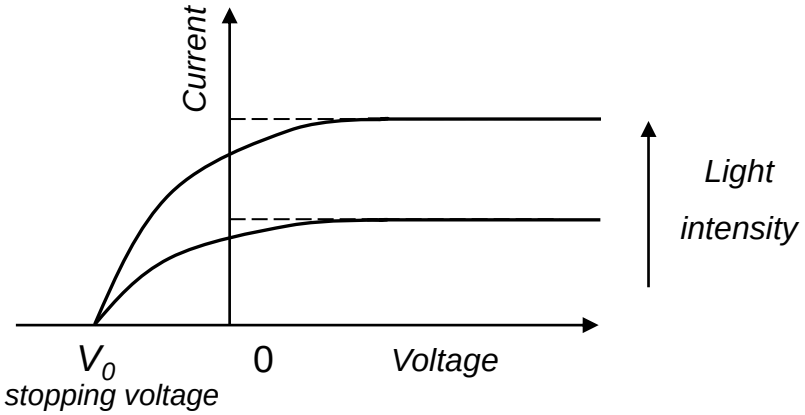
**Photoelectric effect:** *the effect of releasing electrons from substances due to incident light*

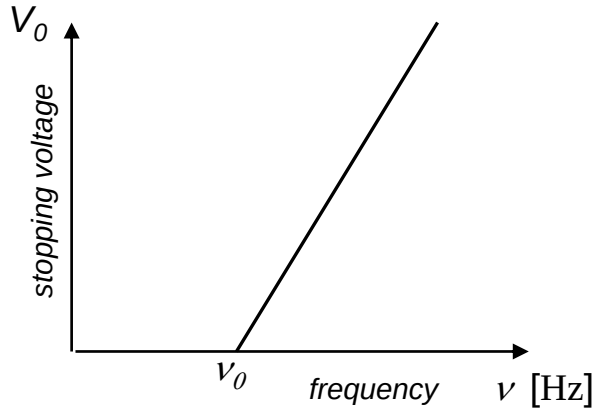
Investigations by Lenard 1902, Millikan 1914




- Emission of electrons observed when $\nu > \nu_0$
- Measured photocurrent depends on light intensity and does not depend on frequency
- Stopping voltage depends on frequency



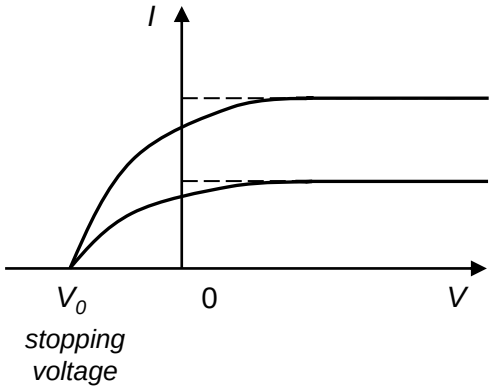



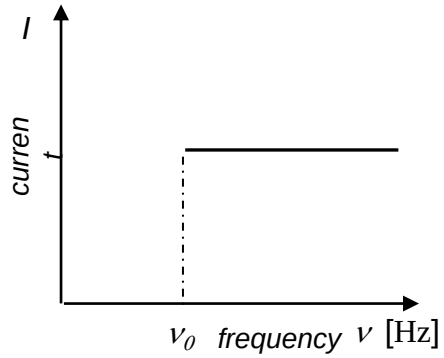



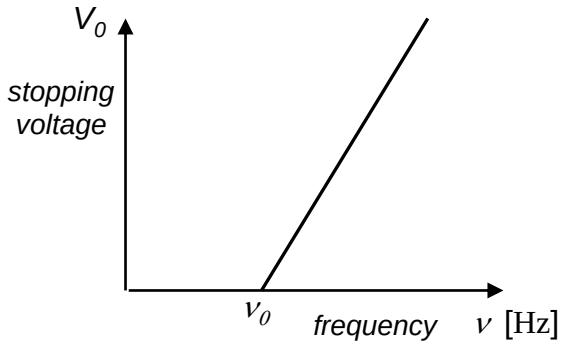

**Classical vs quantum interpretations**

**Classical (wave nature) expectations:**

- The amplitude of the ***E*** field of the light wave increases with the light intensity; the force acting on an electron is ***F***=e***E***; its kinetic energy should increase with the intensity. *Not observed*.
- Should occur for any freq provided that the intensity is sufficiently high. *It is not observed below* $\nu_0$.
- The energy of light is distributed uniformly on the wave surface, so if electrons gain energy from the wave, there should be some delay between the onset of the light and the moment of releasing the electrons. *Not observed.*




**Einstein's (corpuscular) interpretation:**

- The energy of light emitted as localized portions – quanta (*photons*).
- The energy of a photon, *E*, is defined by the frequency of the light, $\nu$: $E = h\nu$
- Photons act like particles when interacting with matter.
- Electrons gain energy from the light only in photon quanta – one electron absorbs one photon.

The kinetic energy gained by electrons: $E_{kin} = h\nu - W$ $W$ – some energy needed to be released

The most weakly bound electrons (surface of the material, no losses within, etc.) gain the maximum kinetic energy.

$E_{kin\,\max} = h\nu - W_0$ $W_0$ – work function

On the other hand: $E_{kin\,\max} = eV_0$ *Why?*

So,: $E_{kin\,\max} = h\nu - W_0 = eV_0$ ⇒ $\boxed{V_0 = \frac{h\nu}{e} - \frac{W_0}{e}}$

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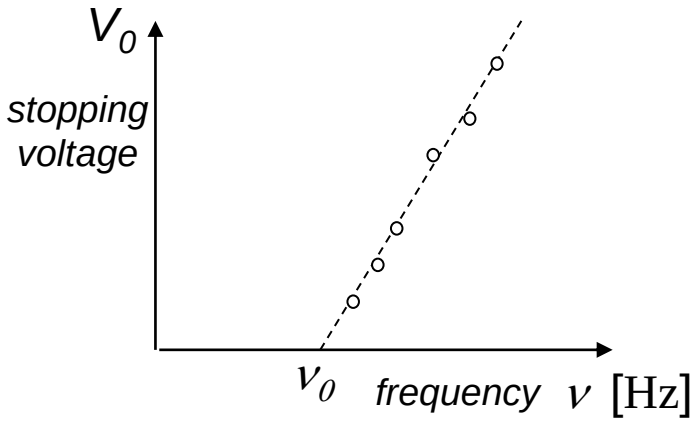
**Example:**

Measurements for sodium as the cathode material gave the result:

$\nu_0 = 4.39\text{x}10^{14}$ [Hz]

$\lambda_0 = 6.83\text{x}10^{-7}$ [m] = 683.4 [nm]




Find the workfunction of the material:

$W_0 =$ 2.91E-19 [J] = 1.82 [eV]