PHYSICS 252   EXPERIMENT NO. 2
THE PHOTOELECTRIC EFFECT

Introduction

In this experiment you will use the photoelectric effect to measure the Planck constant h. This classical experiment led to the first precise determination of h, and in 1926 R.A. Millikan received the Nobel Prize for it.

A phototube is illuminated by light of a known wavelength. Electrons are ejected from the photocathode with some kinetic energy K. They are collected as anode current unless a variable retarding potential V is large enough to stop the electrons. For a given potential V all electrons with $K < eV$ will be stopped, and at some value V_0 even the fastest electrons with a kinetic energy K_{max} will be stopped when

$$K_{max} = h\nu - W = e\,V_0\ , \tag{1}$$

with ν the frequency of the incident light, and W the workfunction of the cathode material. Derive and explain the meaning of this equation. By measuring V_0 for different wavelengths (and ν) one can determine h/e and, since e is known, h.

Apparatus

The set-up is sketched in the Figure and consists of a phototube, a rheostat to adjust the retarding voltage, a mercury arc light source with different color filters, a battery to supply retarding voltage, measured by a voltmeter, and a 1 MΩ resistor plus a digital voltmeter (DVM) to read the anode current as a voltage across the resistor.

Measurement

1. Wire the circuit as shown in the Figure. Choose one of the filters, note the wavelength printed on the filter. Switch on the mercury lamp and position it to illuminate the tube. It should be about 25 cm distant from the phototube and aligned to give the maximum current reading (voltage on the digital voltmeter). Use a black cloth to protect the phototube from room light. Be careful NOT TO CHANGE the distance or alignment between phototube and light source afterwards!
2. Vary the retarding voltage from 0 to 3 V in steps of 0.1 V and measure the anode current (determined by the digital voltmeter reading the 1 MΩ resistor). Take this measurement twice for each of the three wavelengths.

3. For each wavelength, determine the stopping potential V_0 from a plot of the anode current I versus the retarding potential V.

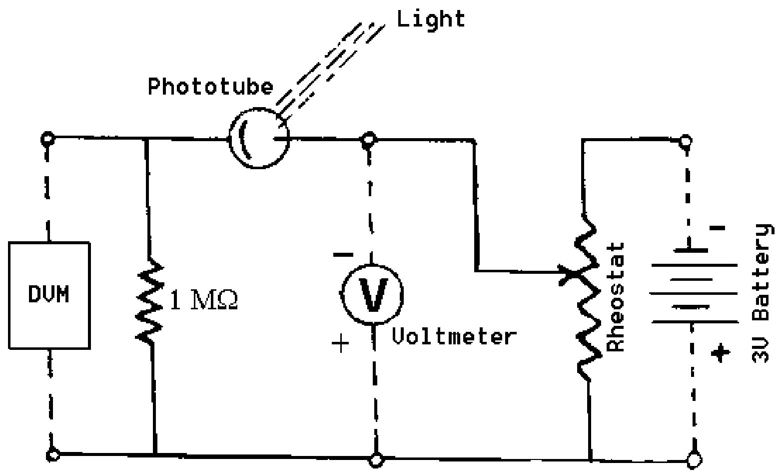

Figure 1: Photocell and connection diagram

4. Then plot V_0 versus the frequency (three data points). These points should lie on a straight line (see equation 1). Determine h/e from this line and calculate h. Estimate the error in your value of h/e and h by determining the range of possible slopes consistent with your data. Compare your result with the accepted value $h = 6.63\times10^{-34}$ Js.

5. Determine the value of W for the photocathode.

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