Core Concepts

Light and Matter

While it was thought classically to only be a wave, light behaves both as a particle and a wave. When light strikes matter, it transfers energy to the matter not as a wave, but as a particle, where the energy it transfers is equal to

$$E = hf$$

Where h is Planck's constant and f is the light's frequency. Classically we would expect the energy transferred to be proportional to the intensity of light, since this refers to the wave's amplitude. Conversely, while we would classically expect for the current of ejected electrons to be proportional to the frequency of light, since we would classically expect each wave crest of light to eject a set number of electrons, but we that current is dependent on intensity rather than frequency. In this sense, the classical model is backwards from what we understand today. Incident light doesn't always eject electrons because the material has a work function; that is, it takes a certain amount of energy to eject an electron, while smaller amounts will only excite electrons to a new state within the material.

Equipment

Light Sources

There are several options we could have used for light sources in this experiment. In general, we want to have some kind of source or sources such that we're able to have a variety of wavelengths. Rotating prisms or slits would allow us to select specific wavelengths by making the others diffract or refract away from the photocell. These can select any wavelength as long as

it's part of the light source, which is very convenient if you want many different wavelengths. It also requires smaller angles than something such as a diffraction grating would. However, this also means it requires a lot of calculation and precision to set up correctly. A grating monochromator functions similar to a prism or slit, but on reflection rather than refraction. This allows it to reflect wavelengths that prisms may not reliably refract. It requires larger angles than a prism or slit, however, meaning it takes more room to set up. A set of monochromatic light sources each of a different wavelength — such as a variety of lasers — could also work and would not require any special setup. However, this takes up a significant amount of time since the light source will need to be switched out and realigned each time. Therefore, what we used was a single light source with several monochromatic filters. These allow us to select a singular wavelengths without having to switch out our light source, which was a mercury lamp. The filters were mounted to the casing around the photocell so that all incident light was filtered and only one wavelength was allowed through.

Data Analysis

Data Correction

Because the anode is a ring, it receives much less incident light than the cathode. However, that is not to say it does not receive any incident light at all; electrons can still be ejected from the anode, even if they are much fewer. This results in a back-current which contributes to the total current reading, which is why the current is initially negative. Therefore, we used a fractional correction constant designed to remove the back-current from both the positive and negative currents. This fractional correction constant required us to have a positive voltage for each negative voltage we wanted to correct. However, we only took our data from -

4[V] to 1[V], so we were only able to correct our data from -1[V] to 1[V]. Since several stopping voltages were before -1[V], they were not corrected. In the future, it would be helpful to take data at least up to 1.5[V]. While our value for Planck's constant was very close to the expected value, it is still not as accurate as it could be.