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THE CORRELATION BETWEEN ELECTRIC CURRENT PRODUCED AND THE LIGHT SOURCE DISTANCE IN PHOTOELECTRIC EFFECT EXPERIMENTS

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ABSTRACT

In experimental observations of the relationship between the electric current generated and the distance of the light source on the Planck constant device, it can show a comparison between the electric current generated and the variable distance of the light source. The experimental equipment specifications use the Planck constant experimental set with a 12v/35w tungsten halogen lamp, output 15v, accuracy +-0.2%, power requirement 220V, fuse rating 0.5A and red filter. Experiments using the concept of the photoelectric effect phenomenon begin by irradiating metal materials with constant photon light and then the light passes through a red light filter with a wavelength of 635 nm. The use of a filter is done by placing a 635 nm light filter on the light propagation path to the metal material, so that the light that passes through the filter is only light with a wavelength of 635 nm. The choice of the red filter is due to the fact that the frequency of light with a wavelength of 635 nm can cause electrons to come out of the metal as a result of photons hitting electrons in the metal. After the metal material is irradiated with photon light, the electron charges on the metal will be disturbed and come out of the metal. The movement of these electrons produces an electric current whose value can be seen. By testing distances of 18, 20, 22, 24, 26, 28, and 30 cm, the results of a current value of 0.528 are obtained; 0.382; 0.295; 0.232; 0.182 and 0.154. From these experiments it was shown that the further away the light source, the smaller the electric current generated due to the light. This is because the closer the distance to the light source, the more light intensity hitting the metal, this results in a greater number of photons hitting the metal.

Keywords: experiment, current, light, distance, photoelectric

INTRODUCTION

In the practicum, the steps of the activity must refer to the steps of scientific activity. Scientific activity steps in the laboratory can be carried out using science process skills. Science process skills are skills needed to obtain, develop and apply concepts [1]. Science process skills are intellectual skills possessed and used by scientists in researching natural phenomena, principles, and laws that exist in science [1]. process skills consist of basic skills and integrated skills. Basic skills consist of six skills: observing, classifying, predicting, measuring, inferring, and communicating. Integrated skills consist of identifying variables, tabulating data, presenting data in graphical form, describing relationships between variables, collecting and processing data, analyzing research, formulating hypotheses, defining variables operationally, and designing research or experiments[1,2]. These are scientific skills and techniques in the laboratory to discover new information about the world.

With light, humans on Earth can live and carry out daily activities. Each light source has a light value called light intensity [3]. In the field of physics, light is electromagnetic radiation with both visible and invisible wavelengths. In addition, light is a package of particles called photons. The inverse square or inverse square law, is a physical law that states a physical quantity or power is inversely proportional to the square of the distance from its emitting source [4]. The inverse square law is generally applied to a continuous force, energy, or quantity radiating radially from its source. Light in the form of visible electromagnetic waves has a wavelength of about 380-750 nm [5]. In physics, many scientific phenomena apply the principle of the use of light to find other physical values.

In 1899, Joseph John Thomson examined ultraviolet light in a cathode ray tube. Thomson concluded that cathode rays are composed of negatively charged particles, which he called electrons. In the study, Thomson placed a metal plate, the cathode, in a vacuum tube, and shone it with high-frequency radiation. The radiation emitted by a black body is not continuous but in packets of energy called quantum (photons). The number of energy packets of each photon will correspond to the wavelength of the light it emits, which can be formulated as follows [6]:

$$E = h.f = h\,\frac{c}{Y} \tag{1}$$

Molecules emit energy in discrete units of light energy[7,8]. Based on quantum theory, Planck was able to unify the Wien and Rayleigh-Jeans radiation laws that are appropriate for all wavelength spectra emitted by objects. Planck's quantum theory was the basis for the birth of modern physics, which opened up a new human understanding of the nature of light particles. Previously, classical physics viewed light only as a wave. Before discussing its applications, you first need to know what the photoelectric effect is. When a photon of light is fired at a metal surface [9], the photon will hit the electrons on the metal surface so that the electrons can be released. The phenomenon of electron loss from the metal surface in physics is called the photoelectric effect. The photoelectric effect requires photons with energies of a few electron volts more than 1 MeV from elements that have high atomic numbers. The release of electrons in the metal causes an electric current that can be read when connected to a simple circuit [10]. The variable distance between the light source and the metal is inversely related [11,12]. If the wavelength of light travels across the metal by changing the variable distance, the greater the distance, the smaller the electric current. This also applies to vice versa. So the distance of the light source in the photoelectric effect uses the principle of the inverse square law [13,14]. By referring to the inverse square law, the correlation between the current and the distance of the light source can be connected.

$$E = \frac{1}{r^2} \quad (2)$$

The study of the photoelectric effect led to important steps in understanding the quantum properties of light and electrons, influencing the establishment of the concept of wave-particle duality. These light phenomena that affect the motion of electric charges include the photoconductive effect (photoconductivity or photosensitivity), photovoltaic effect, and photoelectrochemical effect.

METHOD

In the photoelectric effect experiment, an experiment was conducted to see the comparison of the current generated by the photoelectric effect event with the variable distance of the light source. The experiment used a photoelectric effect experiment set with specifications 12v/35 w halogen tungsten lamp; 15v output; +-0.2% accuracy; -10o C to 60o C relative humidity storage; 0o C to 50o C operating temperature; 220 V power requirement; 0.5 A fuse rating; power cord with plug 3; red, blue, green, yellow 1, and yellow 2 light filters, FIGURE 1.

FIGURE 1. Photoelectric Effect Experiment Set

In FIGURE 1, the first step is to prepare a set of photoelectric devices that are placed on a flat plane in a dark room. This is so that light is not contaminated or light other than the source does not affect the data generated. Then install a red light filter with a wavelength of 635 nm. The selection of the red filter is due to the threshold frequency. It is known that only certain frequencies of light can cause electron discharge. If the frequency of incident light is too low (for example, red light), then no electrons are ejected even if the light intensity is very high or it shines onto the surface for a long time. If the light frequency is higher (e.g., green light), then electrons are capable of being ejected from the metal surface even if the light intensity is very low or it shines only for a short time. This minimum frequency required to cause the ejection of electrons is referred to as the threshold frequency.

(a)

(b)

FIGURE 2. Light source and chamber, (a) Placement of the filter on the light source. (b) metal chamber

In FIGURE 2, (a) the light filter is mounted on the drawtube correctly so that there is no leakage of light on the metal. (b) The drawtube is an open funnel so that light from the light source can enter the metal in the chamber.

The second step is to set the initial distance to take the current data that will be generated. The distance between the light source and the metal has 7 variables, namely (18, 20, 22, 24, 26, 28, and 30) cm. This is to determine the effect of distance on the current generated due to the photoelectric effect process.

(a)

(b)

FIGURE 3. Setting the initial distance between the light source and the metal. (a) Initial distance setting of 35 cm. (b) The distance between the light source and the metal

In FIGURE 3, (a) The initial distance specified is 18 cm, calculated from the chamber to the arrow on the light source, (b) The position of the light source and metal is parallel to the light source which can be changed.

The third step is to turn on the light source so that the metal in the chamber receives light on the metal in the chamber. The amount of light intensity on the light source is set to medium intensity by slowly turning the button to the right.

FIGURE 4. Light Intensity Regulator

In FIGURE 4 the rays coming out of the light source have a frequency, when the frequency of the light given is still low, even though the intensity of the light given is maximum, the photons do not have enough energy to release electrons from their bonds. But when the frequency of light given is higher, even though there is only 1 photon (low intensity) with sufficient energy, the photon can release 1 electron from its bond. When the electrons in the metal are released, there are electron charges that flow from point to point in a circuit. In the first data collection, the current value read at a distance of 18 cm is 0.696 Ampere. Furthermore, the current value read at a distance of (20, 22, 24, 26, 28, and 30)cm is (0.528; 0382; 0.295; 0.232; 0.182; and 0.154) Ampere.

RESULT AND DISCUSSION

Based on experiments using a red light filter with a wavelength of 635 nm. Experiments using photoelectric effect devices with the same light intensity for all light source distance variables obtained the data shown in TABLE 1.

TABLE 1. Distance and Current

Distance r (cm)	$(1/r^2).10^3.cm^{-2}$	Current (I) Amperes
18	3.09	0.696
20	2.50	0.528
22	2.07	0.382
24	1.74	0.295
26	1.48	0.232
38	1.28	0.182
30	1.11	0.154

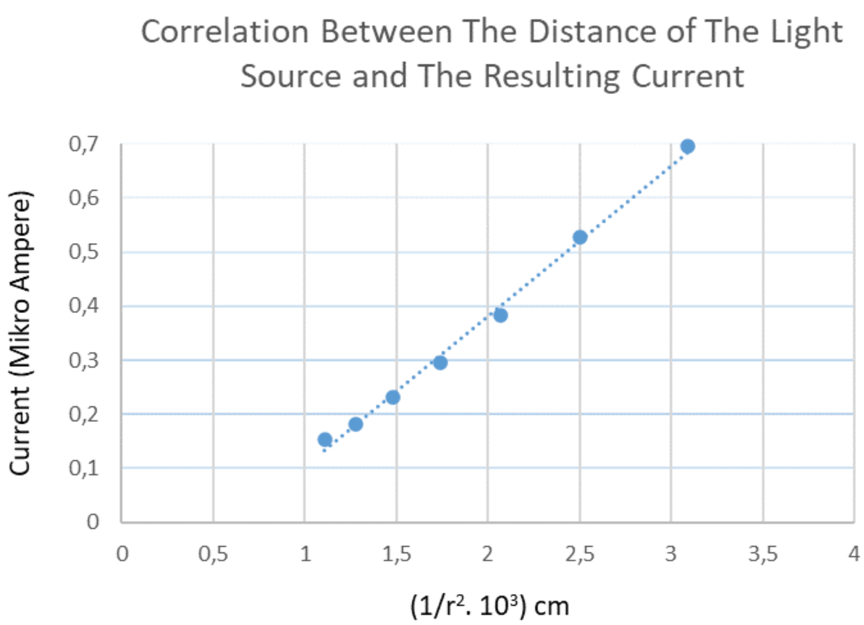

FIGURE 5. The correlation between the distance of the light source and the resulting current

In the data TABLE 1. When the source distance is close to the metal, the photon beam will hit the metal a lot, this results in photons pushing electrons out of the metal. The moving electrons will be read on the current meter in a simple circuit. From several variables of light source distance with the same light intensity, it will be found that the farther the light source distance, the lower the current obtained as a result of the photoelectric effect. This refers to the law of inverse square when calculating lux light.

The relationship between the distance of the light source and the current generated can be seen in TABLE 1. At an initial distance of 18 cm, the current generated was 0.696 amperes and at a final distance of 30 cm, the current obtained was 0.154 amperes. The distance of the light source resulted in many scattered photons so that only a few hit the metal.

CONCLUSION

By using the steps of science process skills in the experiment of the relationship between the distance of the light source and the current produced, it was concluded that the distance of the light source would be inversely proportional to the current produced. This applies the inverse square law in calculating lux light. In the experiment, the distance of the light source as far as 18 cm produces a current of 0.696 amperes while at a distance of 30 cm, the light source gets a current of 0.154 amperes. So the inverse square law applies to the experiment of the relationship between the distance of the light source and the current produced.

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