

Experiment Number

- ❖ To find the value of Planck's constant and photoelectric work function of the material of the cathode using a photoelectric cell.

Learning Objectives

1. To understand the working of a photo-electric cell.
2. To study the dependency of photoelectric current on incident light intensity and frequency.
3. To study variation of stopping potential with incident light frequency.
4. To find out the value of Plank's constant.
5. To find out the value of value of work function of a given material.

The student will also be able

- 1. To visualize (virtually) the photoelectric effect and resultant photocurrent when the incident radiation wavelength is less than the threshold wavelength by using the change wavelength slide bar.**
- 2. To understand the concept of stopping potential by changing the retarding potential using the slide bar in the virtual lab. The gradual decrease will be observable.**
- 3. To understand the impact of intensity variation on the photocurrent value.**
- 4. To perform the experiment by choosing different cathode material and understand the concept that different materials have different work functions.**

Basic Understandings

What is photoelectric effect?

When light of suitable frequency is incident onto a clean metal surface it will cause electrons to leave that surface (the light will eject the electrons from the surface). This is called photoelectric effect and the electrons are called photoelectrons.

Materials: Alkali metals like lithium, sodium, potassium etc. are found to be very photo-sensitive. They emit electrons even when ordinary visible light falls on them. Experiments show that with light of suitable frequencies (ultraviolet rays, X-rays and γ -rays) almost all metals exhibit photoelectric effect.

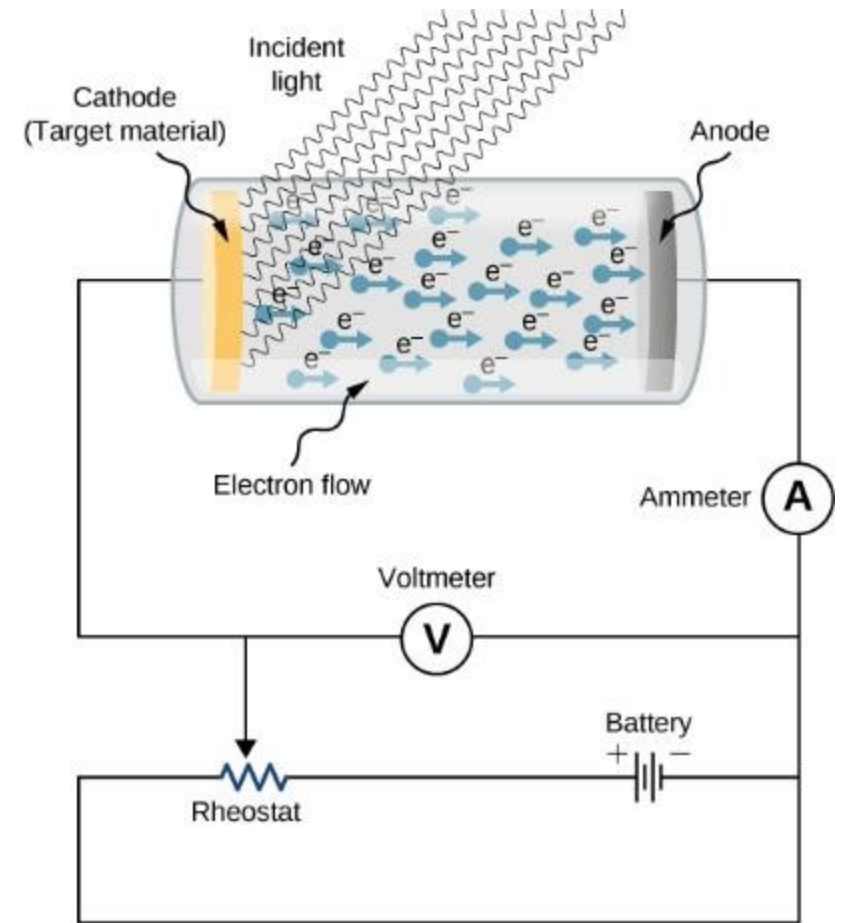


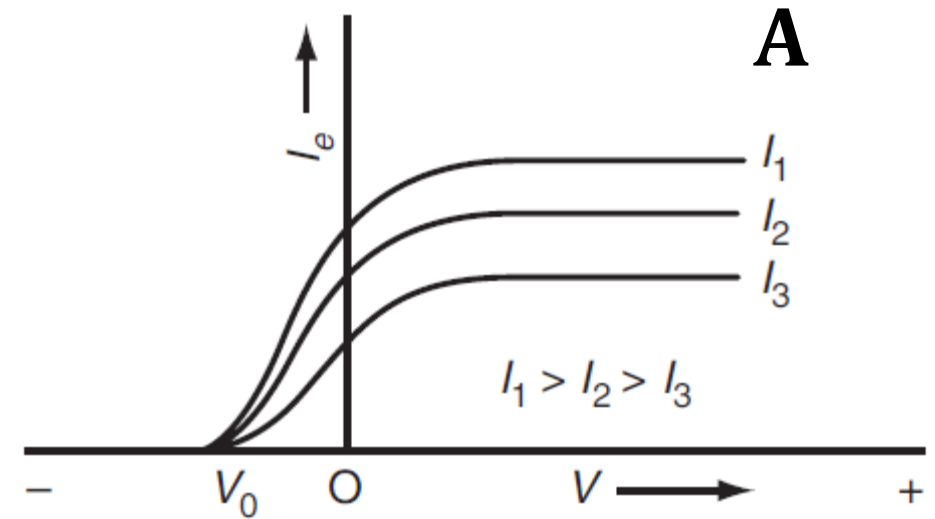
Fig. An experimental setup to study the photoelectric effect. The anode and cathode are enclosed in an evacuated glass tube. The voltmeter measures the electric potential difference between the electrodes, and the ammeter measures the photocurrent. The incident radiation is monochromatic.

Experimental observations

(1) If the frequency of the incident radiation is greater than the threshold frequency (ν_0) (certain minimum frequency), only then the emission of electrons takes place.

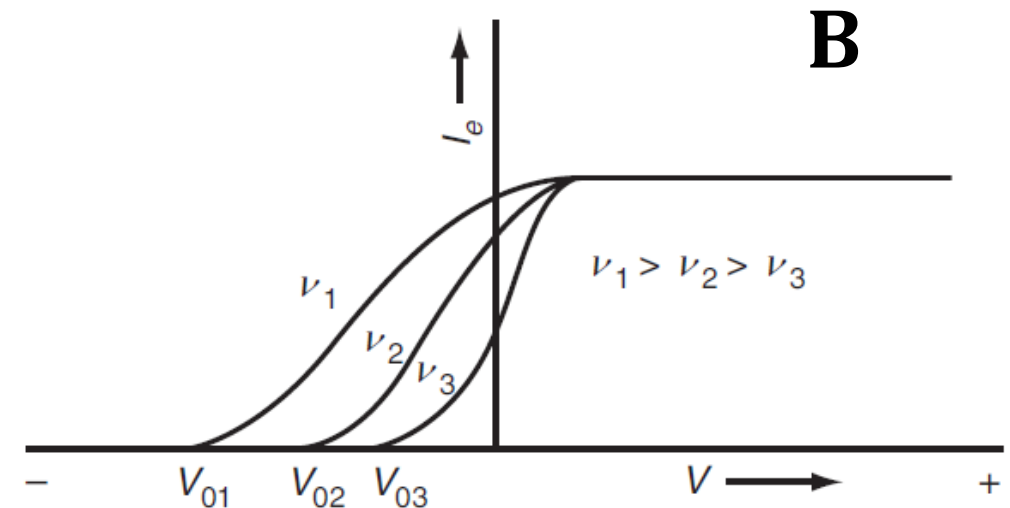
(2) There is no time lag between illumination of the metal surface and the emission of electrons.

(3) The photoelectric current increases with the increasing intensity I of the incident radiation, if the frequency is kept constant. As shown in Fig. A.



(4) The maximum kinetic energy E_K of the photoelectrons is independent of the intensity I of the incident light. That is stopping potential is same for the light of different intensities having same frequency.

(5) The maximum kinetic energy of the photoelectrons depends on the frequency of the incident radiation. From Fig. B, we observe that at different frequencies, stopping potential is also different but the saturation current remains the same



Einstein's approach to explain the features of this effect

In Einstein's approach, a beam of monochromatic light of frequency ν is made of photons. A photon's energy depends only on its frequency. Explicitly, the **energy of a photon** is $E = h\nu$

Having this quantum understanding, the energy balance is

$$h\nu = \phi + K_{\text{max}}$$

$$= \phi \quad \text{or} \quad = 0$$

- . Compare it with $y = mx + c$

So, by plotting graph between K_{max} and ν and finding the slope we can find out the value of Plank's constant. Work function $= \phi$

where K_{max} is the maximum kinetic energy, that an electron has at the very instant it gets detached from the surface. In this energy balance equation, ϕ is the energy needed to detach a photoelectron from the surface. This energy is called **the work function** of the metal. **Each metal has its characteristic work function.** ν_0 is the threshold frequency.

Questions on **basic understandings**

Q 2.1: The minimum frequency of the incident electromagnetic radiation that can cause the emission of photoelectrons with zero kinetic energy from the cathode surface and below which no emission occurs is called

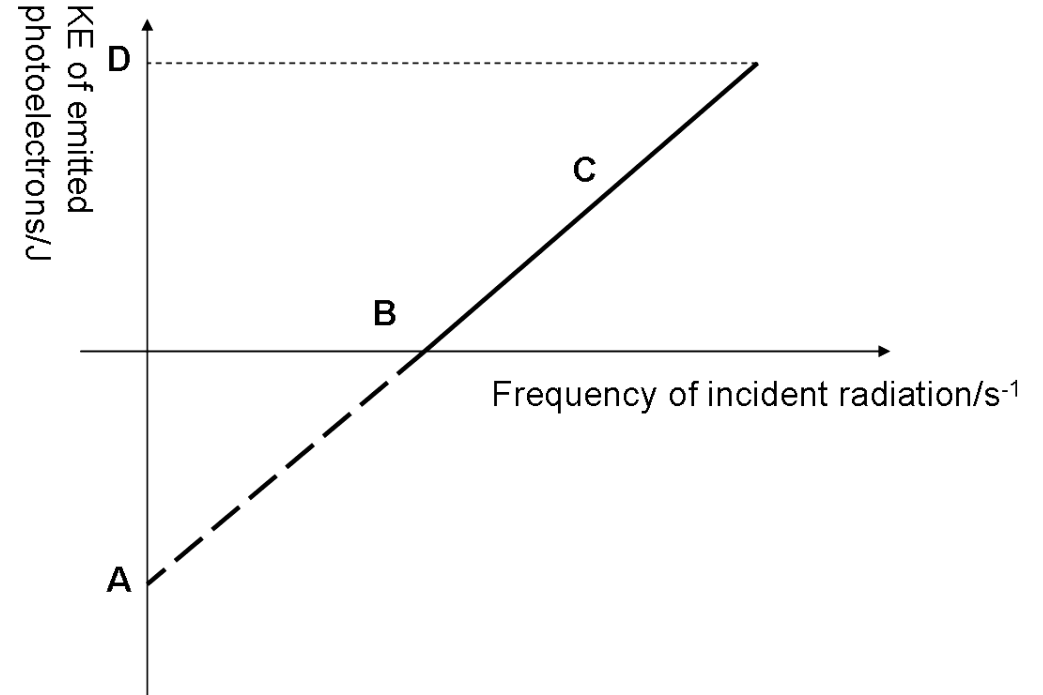
- (A) Resonant frequency**
- (B) Plasma frequency**
- (C) Threshold frequency**
- (D) Ultrasonic frequency**

Check your understanding

Q

Q 2.2: In this graph the point A and B represent

- (A) work function and threshold frequency respectively
- (B) stopping potential and threshold frequency respectively
- (C) work function and kinetic energy respectively
- (D) threshold frequency and work function respectively

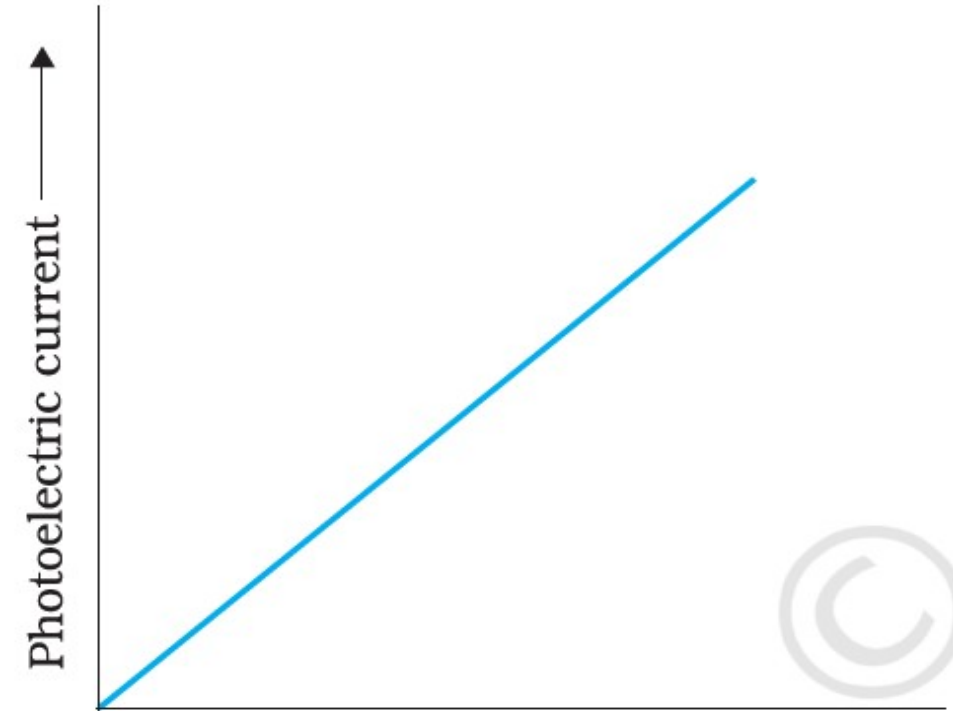


Check your understanding

Q

Q 2.3: In this graph it can be observed that photocurrent increases with increase in the value of the variable along x- axis. What is plotted along x axis?

- (A) Frequency of the incident light beam
- (B) Stopping potential
- (C) Intensity of the incident beam
- (D) Wavelength of the incident light beam



Check your understanding

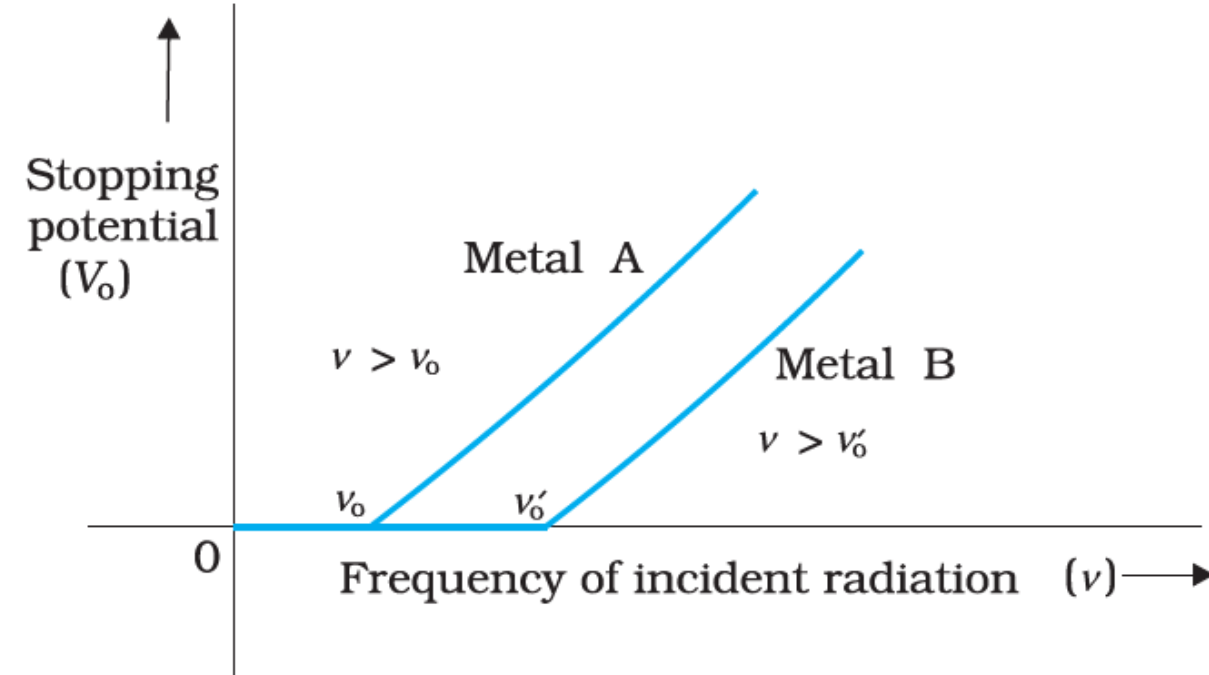
Q 2.4: Which of the following is true?

(A) The work function of the metal A is more than the work function of the metal B

(B) The work function of the metal B is more than the work function of the metal A

(C) The work function of the metal A is equal to the work function of the metal B

(D) None of the above



Check your understanding

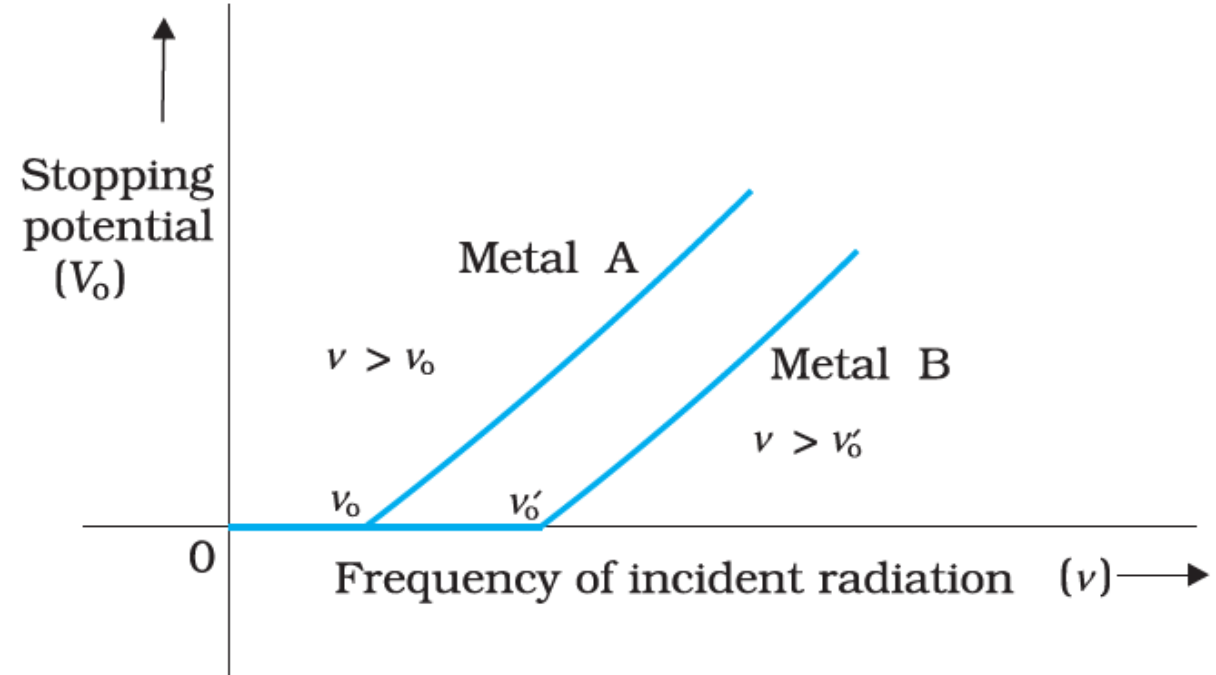
Q 2.5: Which of the following is the correct interpretation of the graph?

(A) For a frequency ν of incident radiation, lower than the cut-off frequency (ν_0, ν_0'), no photoelectric emission is possible even if the intensity is large.

(B) The maximum kinetic energy of the photoelectrons varies linearly with the frequency of incident radiation,

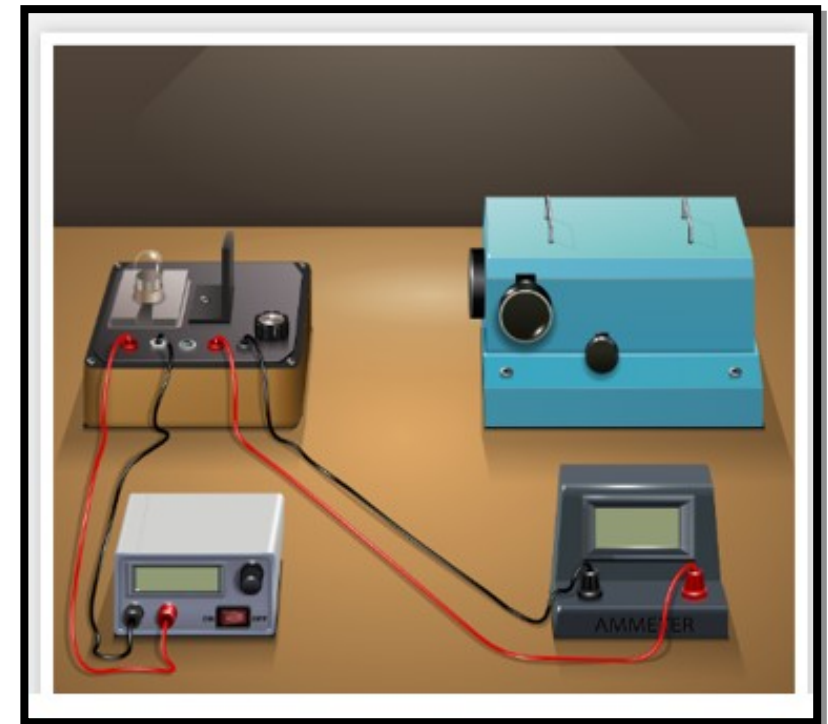
(C) The maximum kinetic energy of the photoelectrons is independent of the frequency of incident radiation,

(D) Both option (A) and (B)



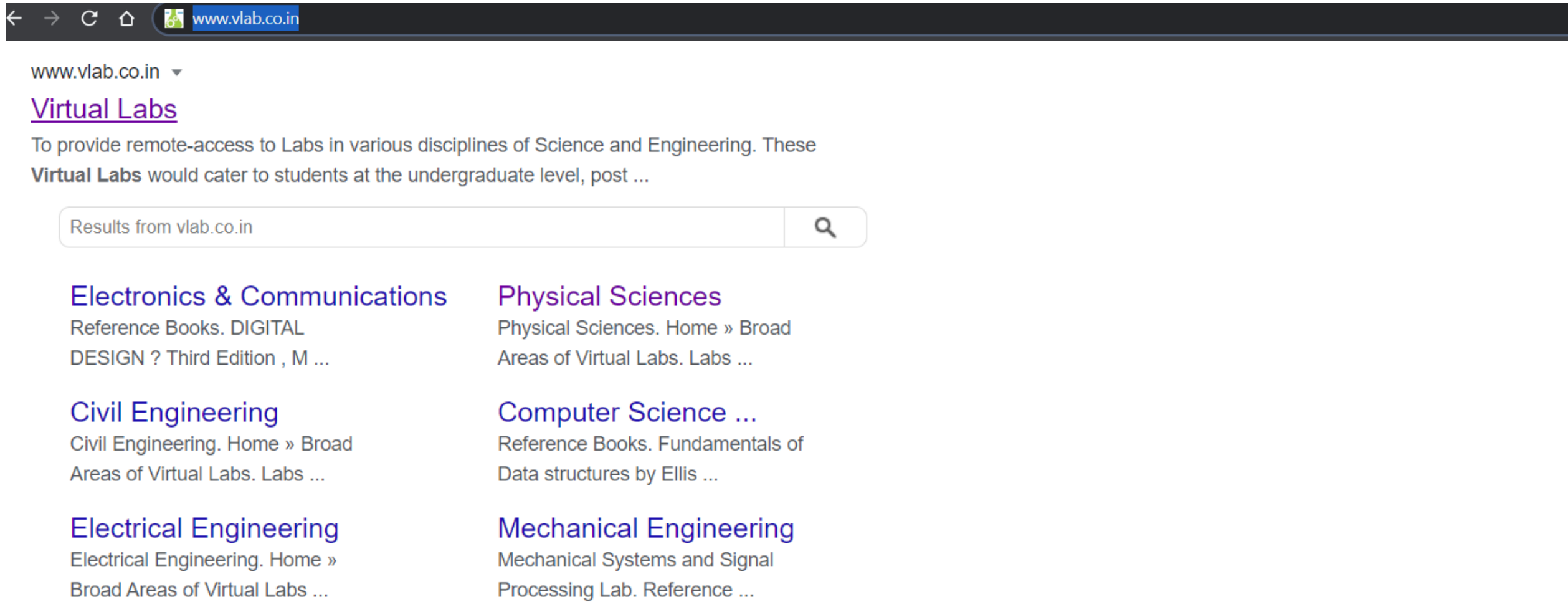
Apparatus required for the experiment

A photocell, Power supply, digital ammeter and voltmeter, Filters of different colors (wavelength)



Step by Step guide to perform the experiment in Virtual lab

Type this link on the address bar or Click on this link : <https://www.vlab.co.in/>



The screenshot shows a web browser window with the address bar displaying www.vlab.co.in. The page content includes a header with the text "Virtual Labs" and a description: "To provide remote-access to Labs in various disciplines of Science and Engineering. These Virtual Labs would cater to students at the undergraduate level, post ...". Below this is a search bar with the text "Results from vlab.co.in" and a magnifying glass icon. The main content area is organized into two columns, each with a category header and a list of links.

www.vlab.co.in ▾

Virtual Labs

To provide remote-access to Labs in various disciplines of Science and Engineering. These **Virtual Labs** would cater to students at the undergraduate level, post ...

Results from vlab.co.in 🔍

Electronics & Communications Reference Books. DIGITAL DESIGN ? Third Edition , M ...	Physical Sciences Physical Sciences. Home » Broad Areas of Virtual Labs. Labs ...
Civil Engineering Civil Engineering. Home » Broad Areas of Virtual Labs. Labs ...	Computer Science ... Reference Books. Fundamentals of Data structures by Ellis ...
Electrical Engineering Electrical Engineering. Home » Broad Areas of Virtual Labs ...	Mechanical Engineering Mechanical Systems and Signal Processing Lab. Reference ...

This page will open. Scroll down the page and click on Physical sciences



An Initiative of
Ministry of Human Resource Development
Under the National Mission on Education through **ICT**



HOMEABOUT USNEWSLETTERNEW LAB DEVELOPMENTBECOME NODAL CENTEROUTREACH PORTALPARTICIPATING INSTITUTESCONTACT US








OBJECTIVESTHE PHILOSOPHYSALIENT FEATURES

Broad Areas of Virtual Labs

 Electronics & Communications	 Biotechnology and Biomedical Engineering
 Computer Science & Engineering	 Civil Engineering
 Electrical Engineering	 Physical Sciences
 Mechanical Engineering	 Chemical Sciences
 Chemical Engineering	

Scroll down the page end click on Modern Physics Lab

HOME	ABOUT US	NEWSLETTER	NEW LAB DEVELOPMENT	BECOME NODAL CENTER	OUTREACH PORTAL	PARTICIPATING INSTITUTES	CONTACT US
Reference Books ▼ Syllabus Mapping ▼					VIDYAPEETHAM		
Laser Optics Virtual Lab					AMRITA VISHWA VIDYAPEETHAM		
Reference Books ▼ Syllabus Mapping ▼							
Heat & Thermodynamics Lab					AMRITA VISHWA VIDYAPEETHAM		
Reference Books ▼ Syllabus Mapping ▼							
Modern Physics Lab					AMRITA VISHWA VIDYAPEETHAM		
Reference Books ▼ Syllabus Mapping ▼							
Harmonic Motion and Waves Lab					AMRITA VISHWA VIDYAPEETHAM		
Reference Books ▼ Syllabus Mapping ▼							
 Click Here for Related NPTEL video lectures							
Labs Under Maintenance							
Basics of Physics Lab (New)					IIT KANPUR		

Click on Photoelectric Effect

you are here->home->physical sciences->modern physics virtual lab

You are logged in as Dr. Subhojyoti Sinha || Help || Log out

Modern Physics Virtual Lab

Modern physics refers to the post-Newtonian conception of physics developed in the first half of the 1900's. These concepts embody the study of tiny (subatomic) particles or lightening fast speeds. They find applications in technologies such as atomic energy or semiconductors.



Franck-Hertz Experiment

The Franck-Hertz Experiment makes it possible to observe the quantization of energy states in an atom.



Soldering (Remote Trigger)

Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, the filler metal having a relatively low melting point.



Solar Panel Experiment (Remote Trigger)

Sunlight hits the solar cell - if the energy of the photon is high enough (\geq bandgap energy), it is absorbed on the P-side. This sends the "holes" towards the N-side. A potential difference (voltage) is thereby created across the p-n junction.



Photoelectric effect

The emission of photo electrons from metal surface when certain electromagnetic radiation incident on it is called Photoelectric effect.



Determination of Planck's Constant

This arrangement helps to determine the Planck's Constant.

**This page will open.
You have to login and
Click on simulator.**

**But it covers some
portion of the oven and
you have to toggle the
show variables option
while performing the
experiment.**

Alternatively you can click on the
following link (next page) for
the same simulator

The screenshot displays the VALUE @ Amrita website interface. The header features the logo on the left, the text "VALUE @ Amrita" in the center, and "Virtual Amrita Laboratories Universalizing Education" below it. On the right is the AMRITA VISHWA VIDYAPEETHAM logo. A navigation bar contains links: Home, Project, Workshop, Nodal Centres (with a dropdown arrow), News & Events, Publications, Survey (with a dropdown arrow), Contact us, and Log out. To the right of these links is a search bar labeled "ENHANCED BY Google" and a "Search" button. Below the navigation bar, a breadcrumb trail reads "you are here->home->physical sciences->modern physics virtual lab->photoelectric effect". On the right side of this section, it says "You are logged in as Dr. Subhojyoti Sinha || Help || Log out". The main heading "Photoelectric effect" is centered. Below it is a row of seven icons with labels: Theory (notepad and pencil), Procedure (gears), Self Evaluation (monitor with bar chart), Simulator (monitor with green line graph), Assignment (folder), Reference (stack of books), and Feedback (speech bubble with person icon). The "Simulator" icon is highlighted. Below this row is a blue header for the simulator titled "Photo Electric Effect" with a menu icon on the left and a help/question mark icon on the right. The main content area shows a 3D simulation of the photoelectric effect experiment setup. It includes a vacuum tube with a bulb, a blue power supply unit, a digital multimeter, and an ammeter, all connected by red and black wires on a wooden table surface.



you are here->home->physical sciences->modern physics virtual lab->photoelectric effect

You are logged in as Dr. Subhojyoti Sinha || Help || Log out

Photoelectric effect



Theory



Procedure



Self Evaluation



Simulator



Assignment

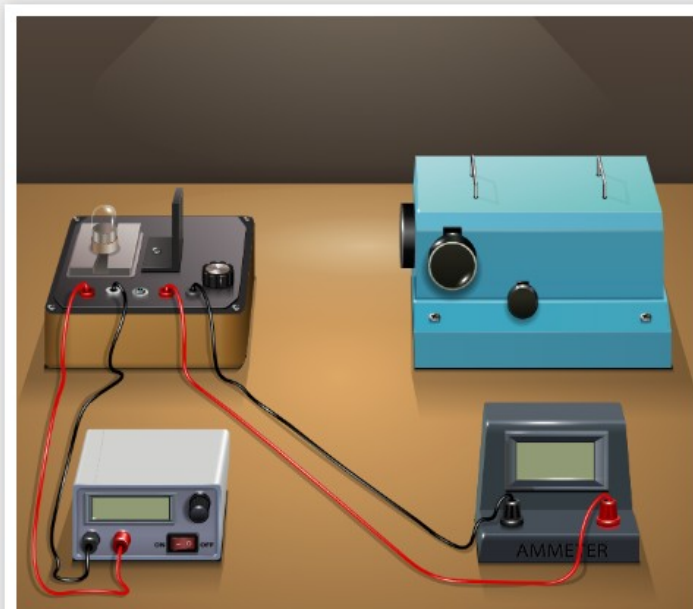


Reference



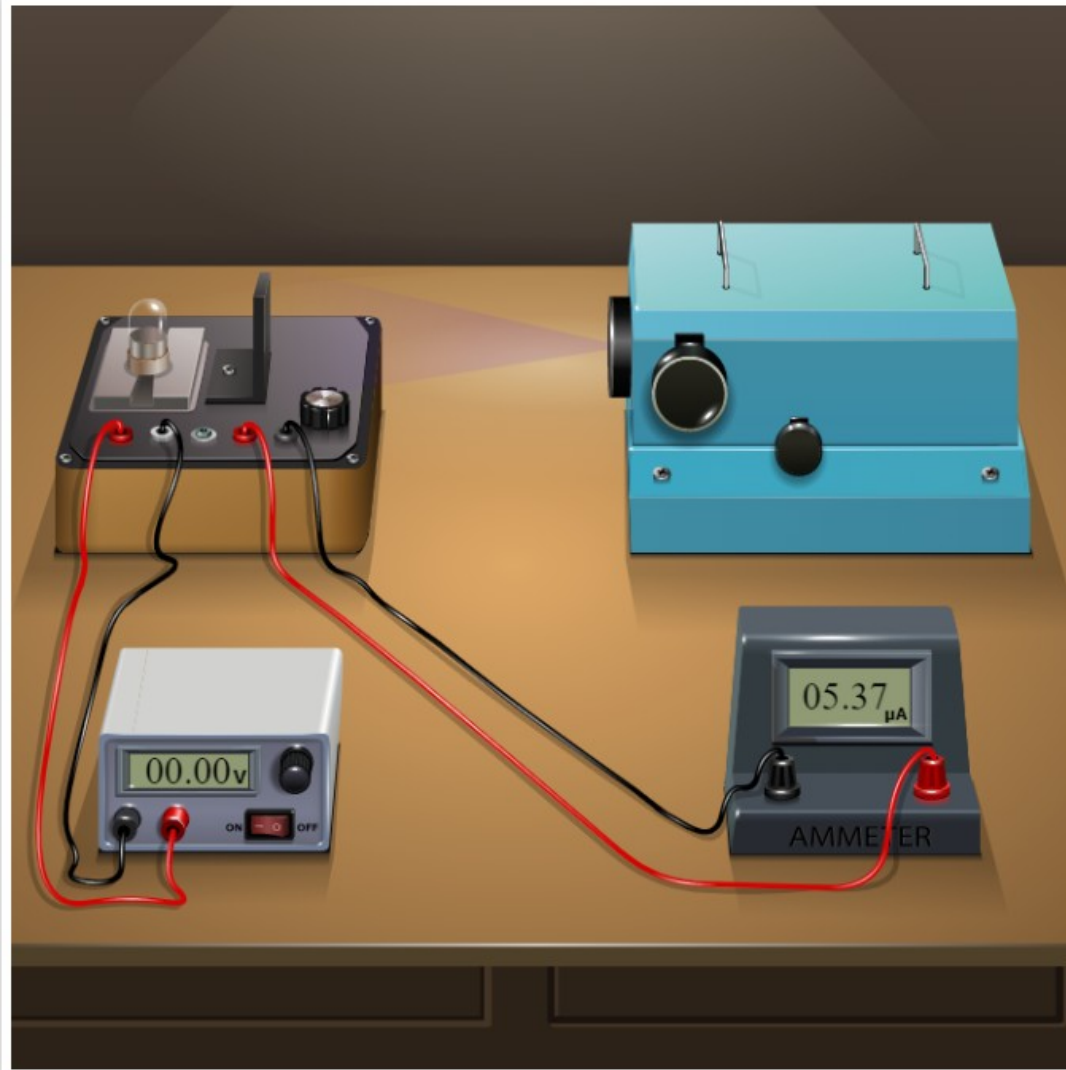
Feedback

Photo Electric Effect



Click here to zoom

Choose the Material, Switch the light on, Select plate area, Intensity of light, Then select the Wavelength of the light and switch it ON. Check the value of the phot



Copyright © Amrita University 2009 - 2015

VARIABLES

Choose Material:

Sodium ▼

Area of Plate : 0.2 cm^2



Intensity of Light : 10 w/m^2



Voltage Applied : 0 V



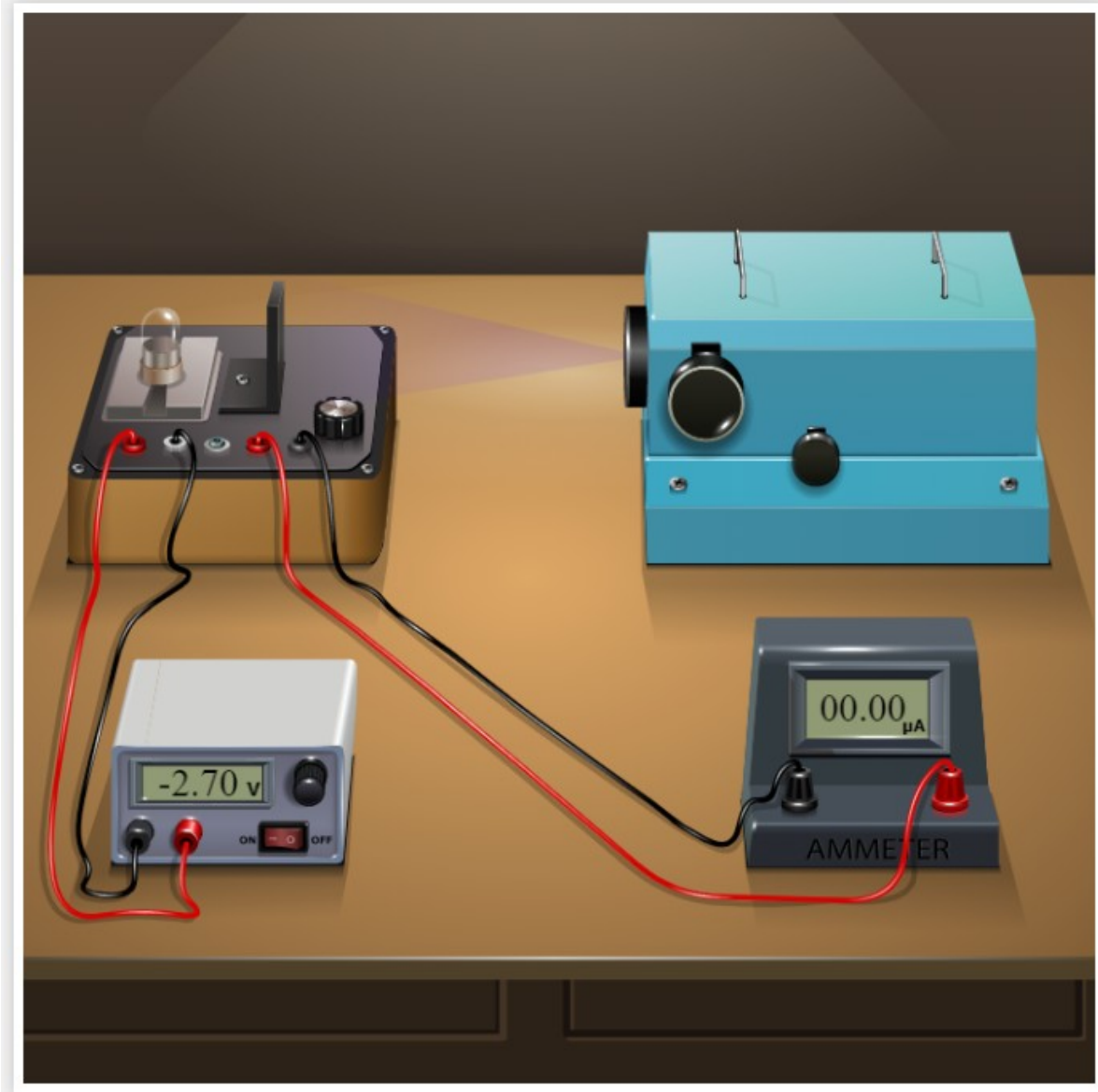
Wavelength of Light : 250 nm



SWITCH OFF LIGHT

RESET

Then gradually decrease the voltage (to negative value) so that the photo current becomes zero. This is the stopping potential. Find it for at least five different wavelengths (below threshold wavelength) of the incident light.



VARIABLES

Choose Material:

Sodium

Area of Plate : 0.2 cm^2

Intensity of Light : 10 w/m^2

Voltage Applied : -2.7 V

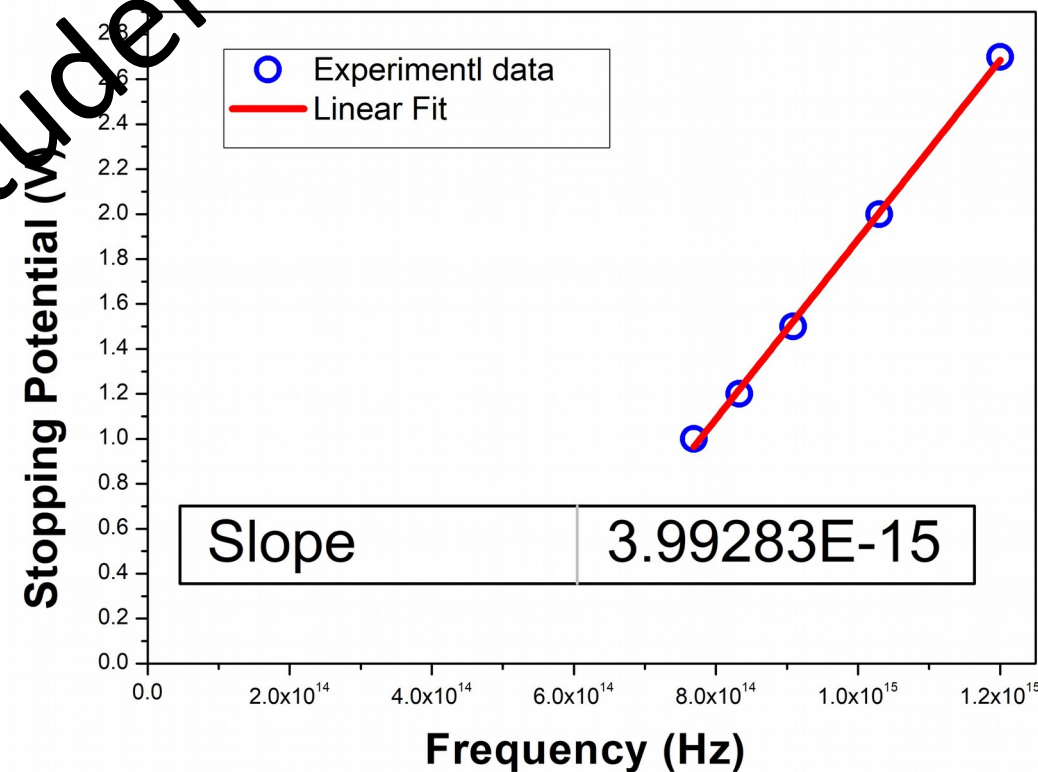
Wavelength of Light : 250 nm

SWITCH OFF LIGHT

RESET

Worksheet and Calculation

Serial number	Wavelength of light (nm)	Frequency (Hz) $\nu = c/\lambda$	Stopping potential (V)
1	250	1.20×10^{15}	-2.7
2	290	1.03×10^{15}	-2.0
3	330	9.09×10^{14}	-1.5
4	360	8.33×10^{14}	-1.2
5	390	7.69×10^{14}	-1.0



Calculated value of Planck's Constant = $e \times \text{slope} = 6.4 \times 10^{-34} \text{ J-s}$

Work function = $h\nu_0$ (in eV) where ν_0 is the threshold frequency (intercept on X-axis)

Activity Based Questions

while the students perform the experiment in virtual lab

A2.1 Consider the case when you perform the experiment with Sodium as cathode material and have fixed intensity, wavelength of the incident light. In the simulator how does the photocurrent varies with the change in cathode (illuminated) plate area (no retarding voltage applied)?

- (A) Photocurrent increases with increase in plate area**
- (B) Photocurrent decreases with increase in plate area**
- (C) Photocurrent remains same independent of plate area**
- (D) No such option to change plate area is available with the simulator**

A2.2 In this simulator, consider light of wavelength 300 nm is incident on the cathode material. There is no retarded potential applied to the cathode. Then which of the following is true

- (A) Photocurrent flows in the circuit if we choose Copper as the cathode material because the incident wavelength is below the required threshold wavelength.**
- (B) Photocurrent flows in the circuit if we choose Sodium as the cathode material because the incident wavelength is below the required threshold wavelength.**
- (C) Photocurrent flows in the circuit if we choose zinc as cathode material because the incident wavelength is below the required threshold wavelength.**
- (D) There will be no current in the irrespective of the cathode material because the incident wavelength is always below the required threshold wavelength.**

A 2.3 With this simulator, the maximum negative voltage that we can apply to the cathode

- (A) -5V
- (B) -10 V
- (C) -100 V
- (D) depends on which material we choose as cathode

A 2.4 Select plate area as 0.2 cm^2 , intensity of light 30 W/m^2 , wavelength of incident light equal to 250 nm in the simulator. The stopping potential

- (A) is independent of intensity of incident light**
- (B) decreases with decrease in intensity of the incident light**
- (C) decreases with increase in intensity of the incident light**
- (D) The given variables can not be selected in the simulator**

A 2.5 Consider light of wavelength 360 nm is incident on the cathode material. The frequency of the incident light is

- (A) 1.20×10^{15} MHz
- (B) 83.3 THz
- (C) 1.20×10^{15} kHz
- (D) 8.33×10^{14} Hz