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.

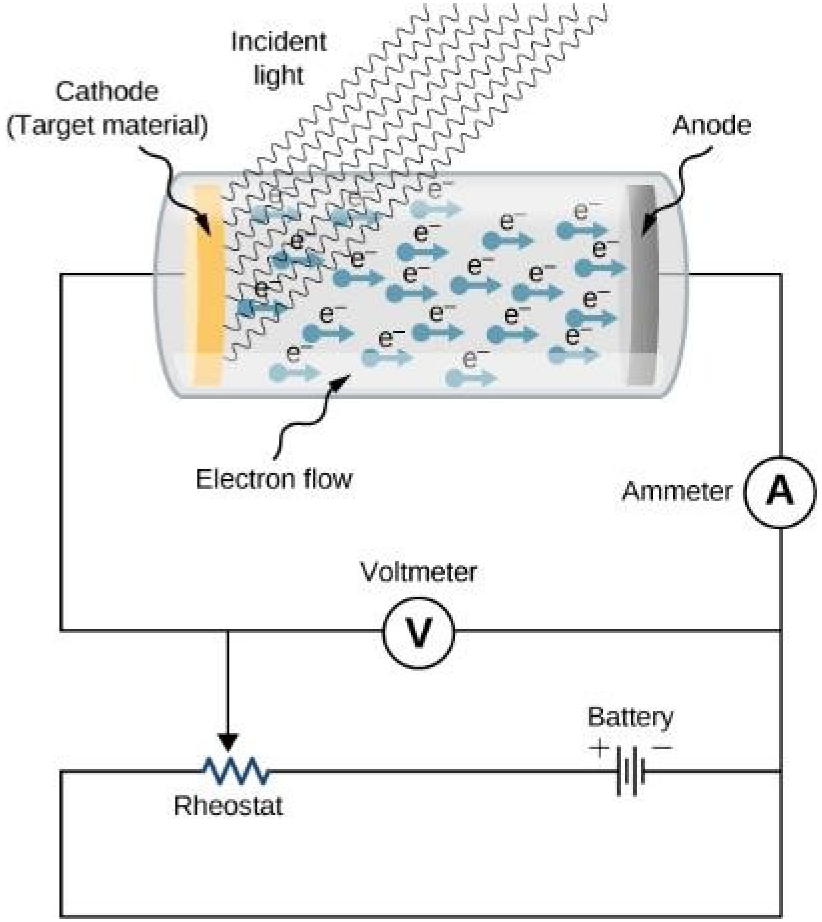


Fig. An experimental setup to study the photoelectric effect. The anode and cathode are enclosed in an evacuated glass tube. The voltmeter measures the electric potential difference between the electrodes, and the ammeter measures the photocurrent. The incident radiation is monochromatic.

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 ɣ-rays) almost all metals exhibit photoelectric effect.

@Dr. Subhojyoti Sinha

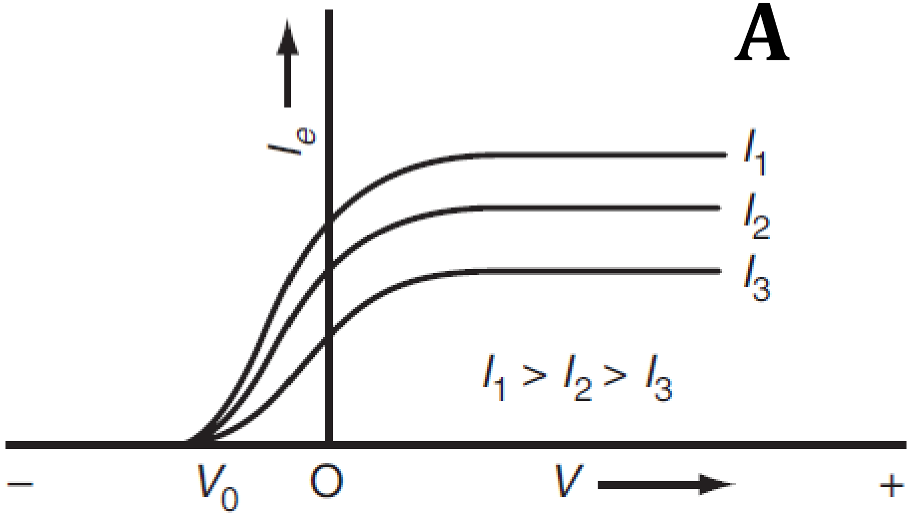
Ref: Concept of Modern Physics by Arthur Beiser

Experimental observations

(1) If the frequency of the incident radiation is greater than the threshold frequency (υ_0) (certain minimum frequency), only then the emission of electrons takes place.

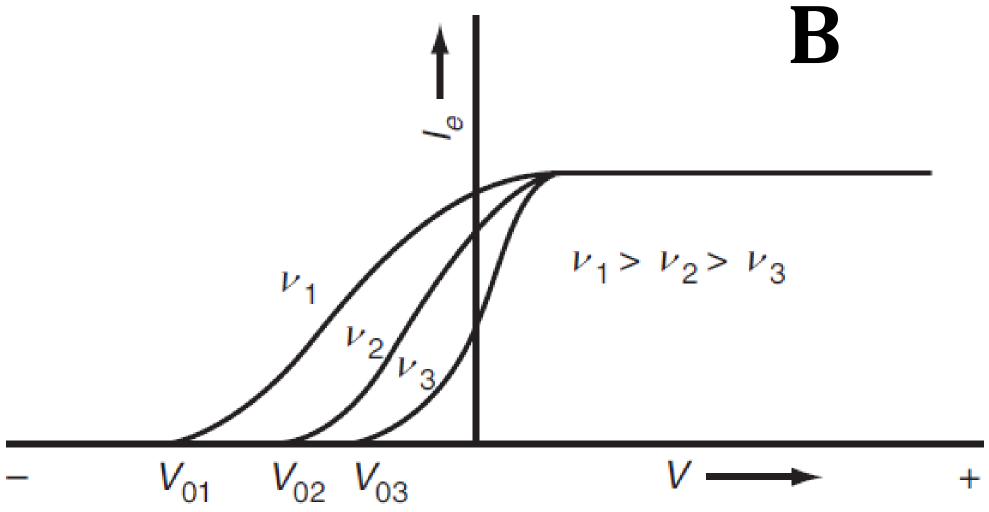
(2) There is no time lag between illumination of the metal surface and the emission of electrons.

(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 υ is made of photons. A photon’s energy depends only on its frequency . Explicitly, the **energy of a photon** is E=h

Having this quantum understanding, the energy balance is

=h +

= or = -

- . Compare it with y=mx + c

So, by plotting graph between and and finding the slope we can find out the value of Plank’s constant. Work function =

where KEmax is the maximum kinetic energy, that an electron has at the very instant it gets detached from the surface. In this energy balance equation, 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.** is the threshold frequency.

Questions on basic understandings

Check your understanding **Q**

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

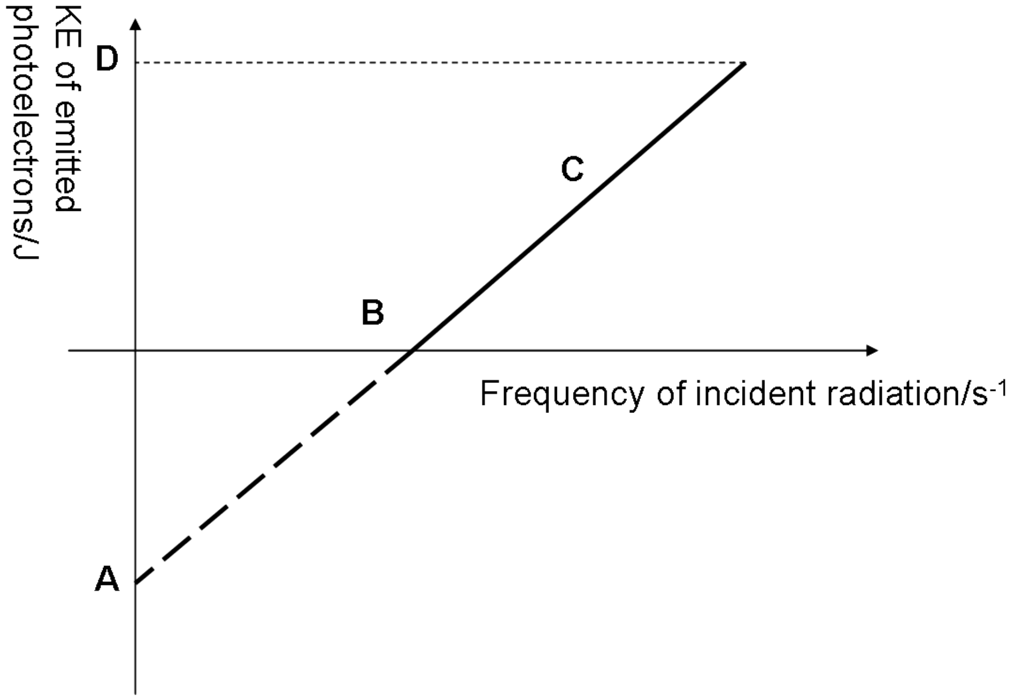
(A)Resonant frequency
(B)Plasma frequency
(C)Threshold frequency
(D) Ultrasonic frequency

Check your understanding

Q

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

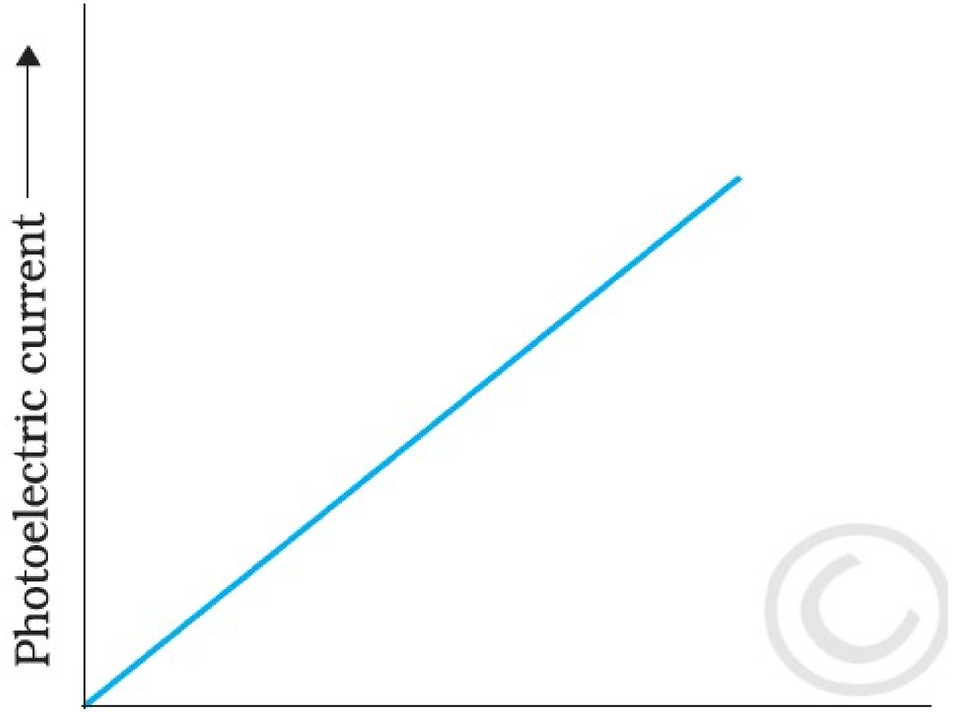
(A) work function and threshold frequency respectively
(B) stopping potential and threshold frequency respectively
(C) work function and kinetic energy respectively
(D) threshold frequency and work function respectively



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

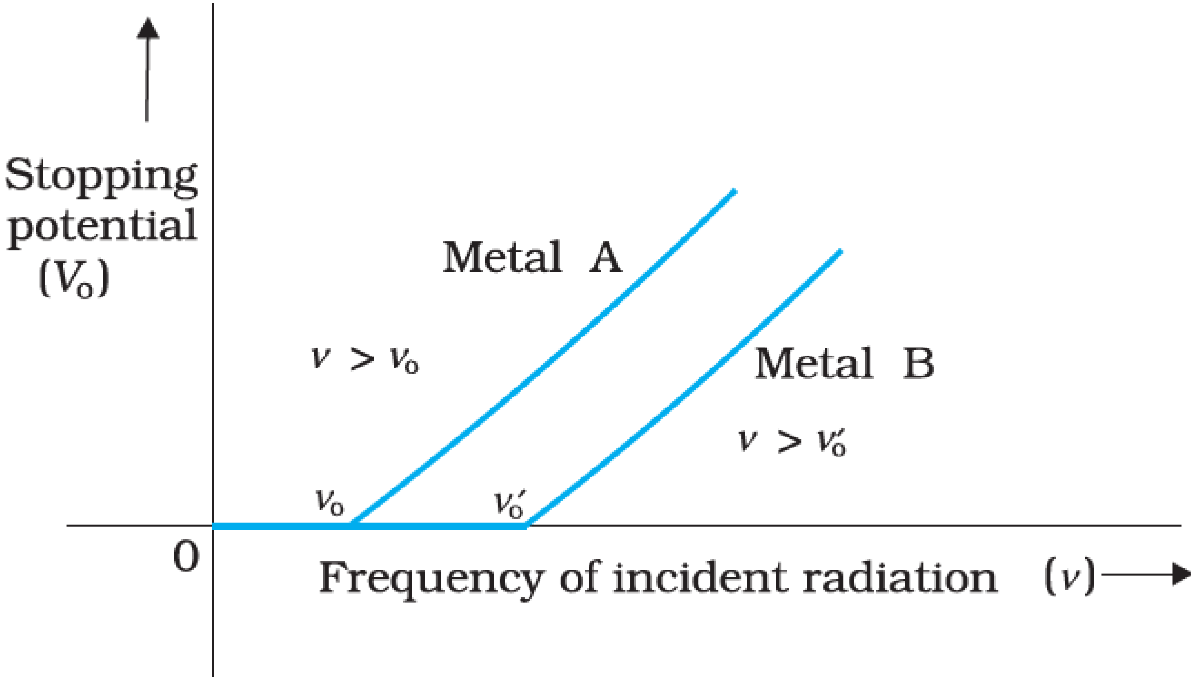
Q 2.4: Which of the following is true?

(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

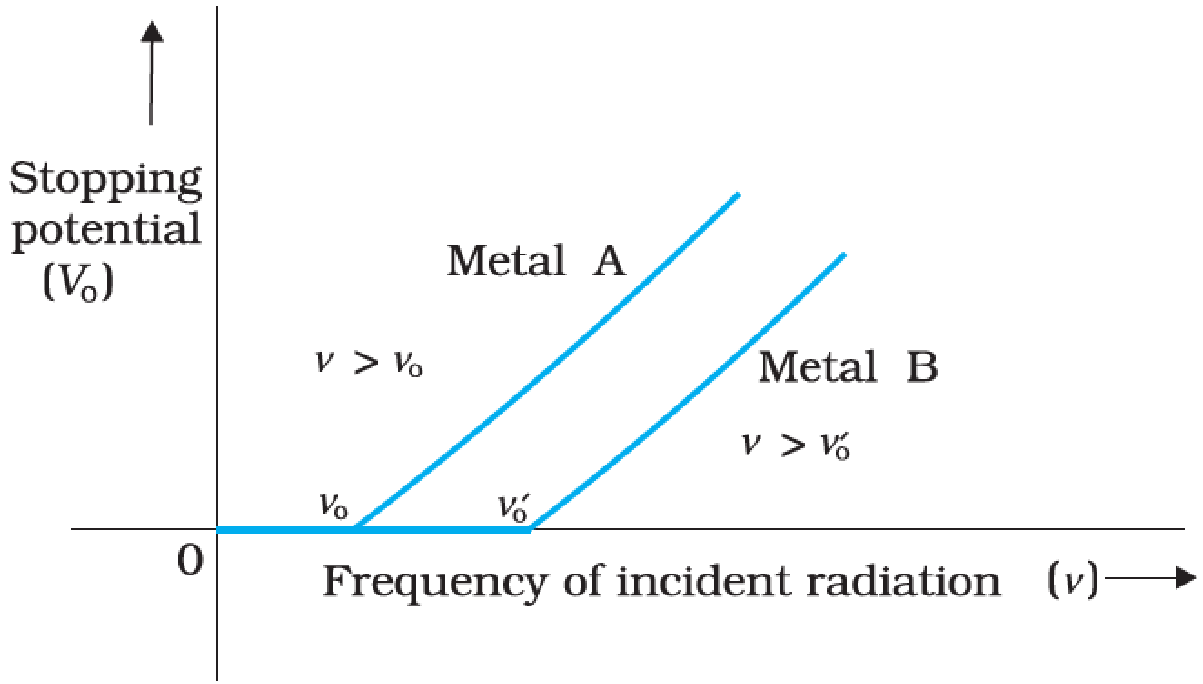
(D) None of the above



Check your understanding

Q

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



(A)For a frequency υ of incident radiation, lower than the cut-off frequency (υ_0, υ_0') , no photoelectric emission is possible even if the intensity is large.

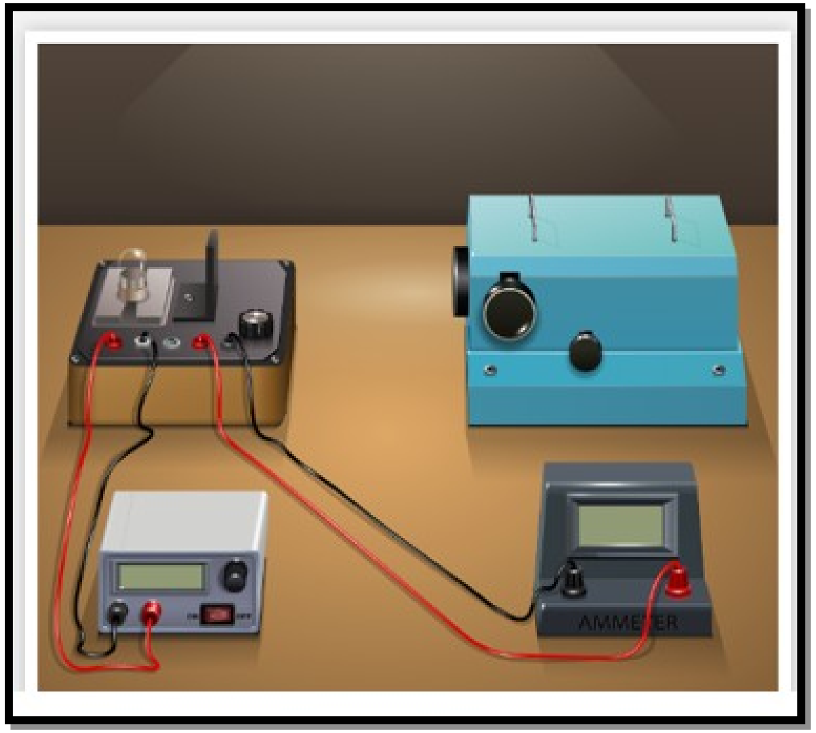
(B)The maximum kinetic energy of the photoelectrons varies linearly with the frequency of incident radiation,

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

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

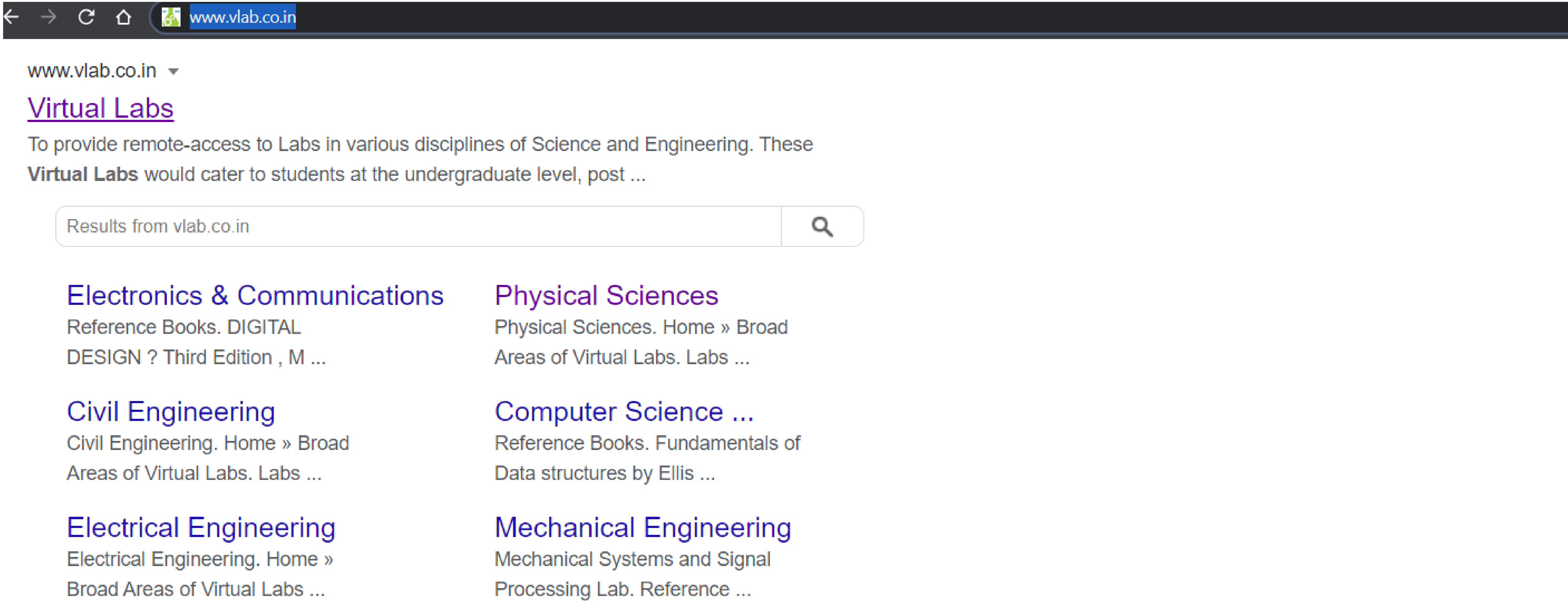
Apparatus required for the experiment

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/



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

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

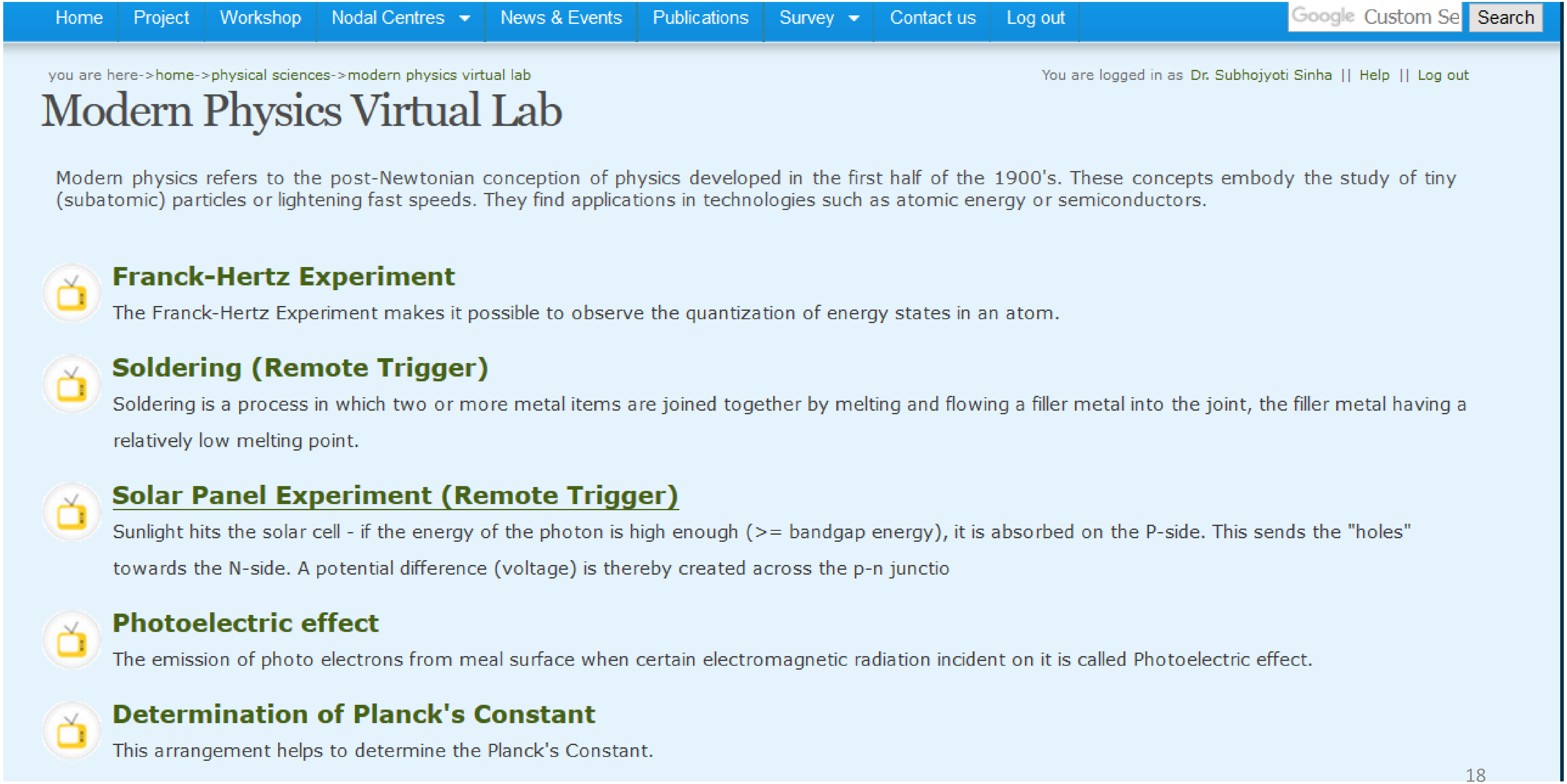
Laser Optics Virtual Lab Reference Books Syllabus Mapping	AMRITA VISHWA VIDYAPEETHAM
Heat & Thermodynamics Lab Reference Books Syllabus Mapping	AMRITA VISHWA VIDYAPEETHAM
Modern Physics Lab Reference Books Syllabus Mapping	AMRITA VISHWA VIDYAPEETHAM
Harmonic Motion and Waves Lab Reference Books Syllabus Mapping	AMRITA VISHWA VIDYAPEETHAM

Click Here for Related NPTEL video lectures

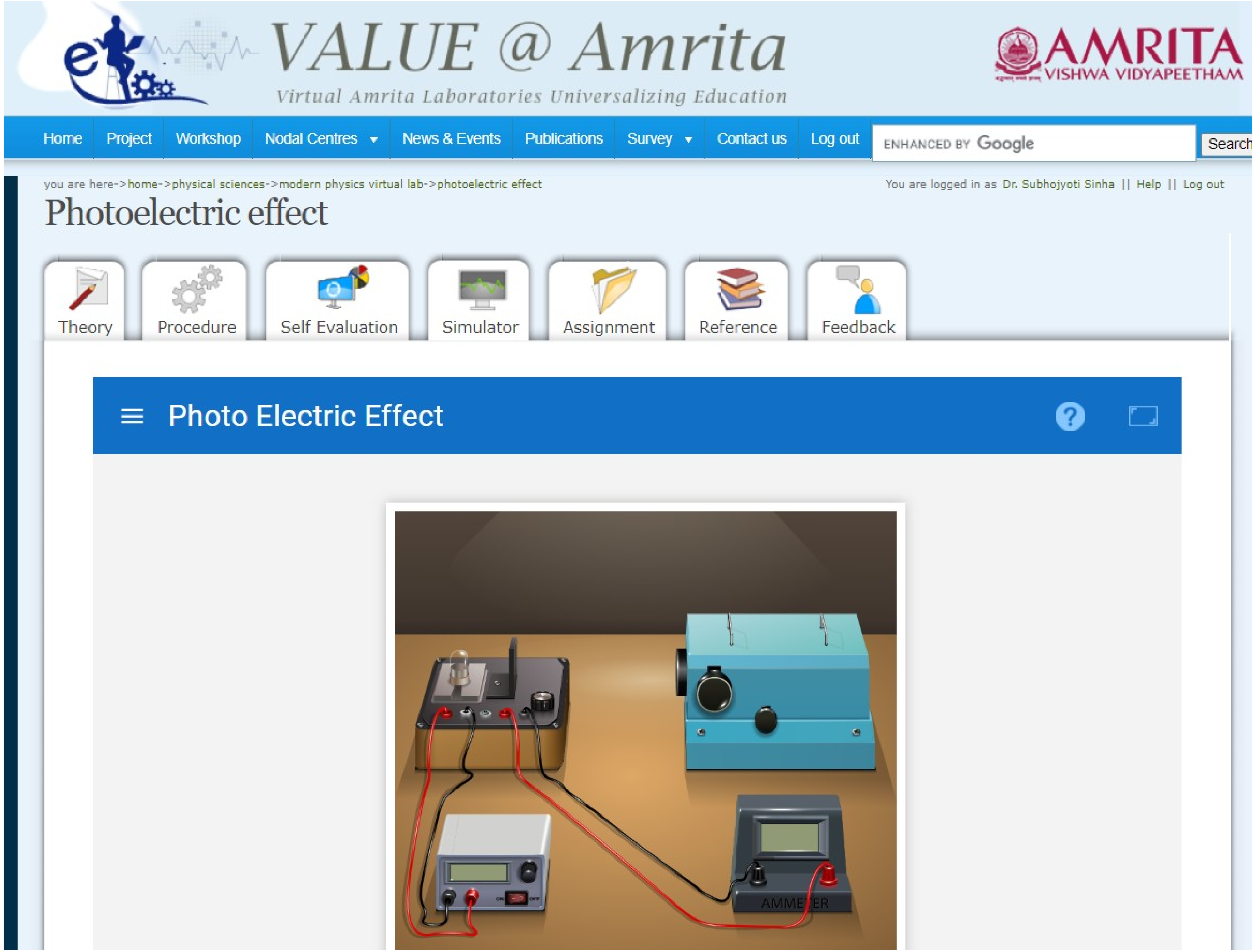
Labs Under Maintenance

Basics of Physics Lab (New)	IIT KANPUR

Click on Photoelectric Effect

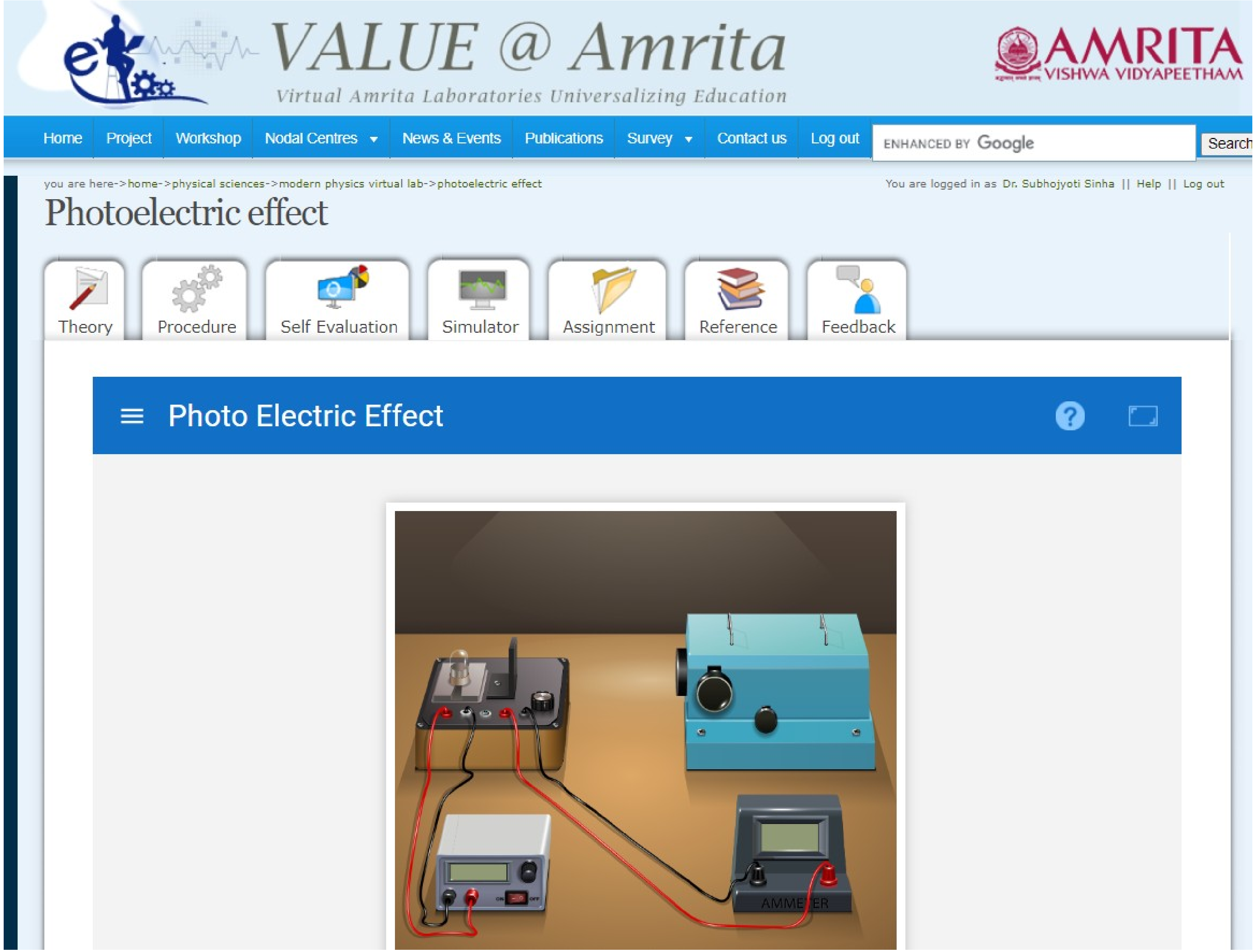


This page will open. You have to login and Click on simulator.



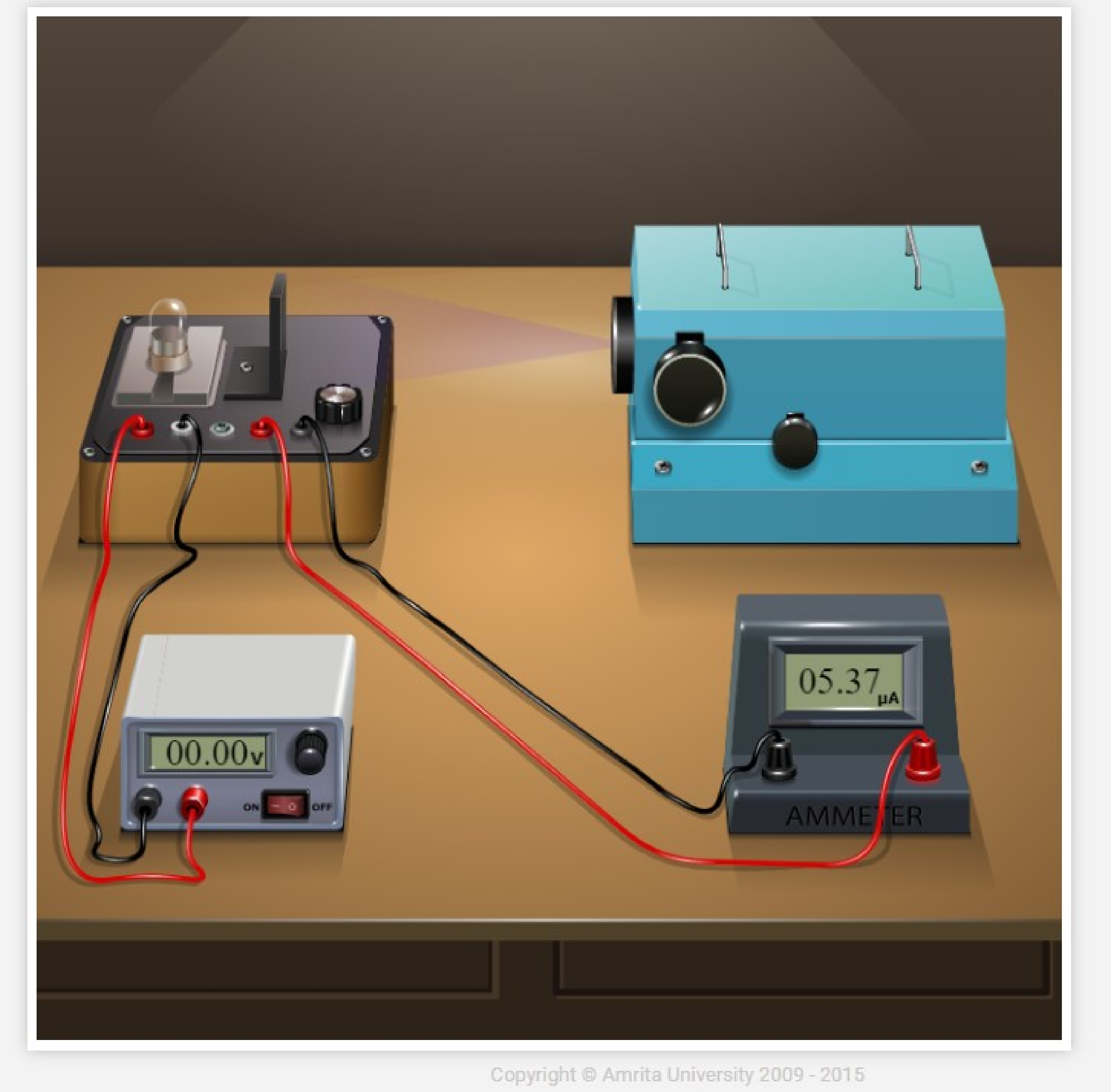
But it covers some portion of the oven and you have to toggle the show variables option while performing the experiment.

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



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



VARIABLES

Choose Material:

Sodium

Area of Plate : 0.2 cm^2

Intensity of Light : 10 w/m^2

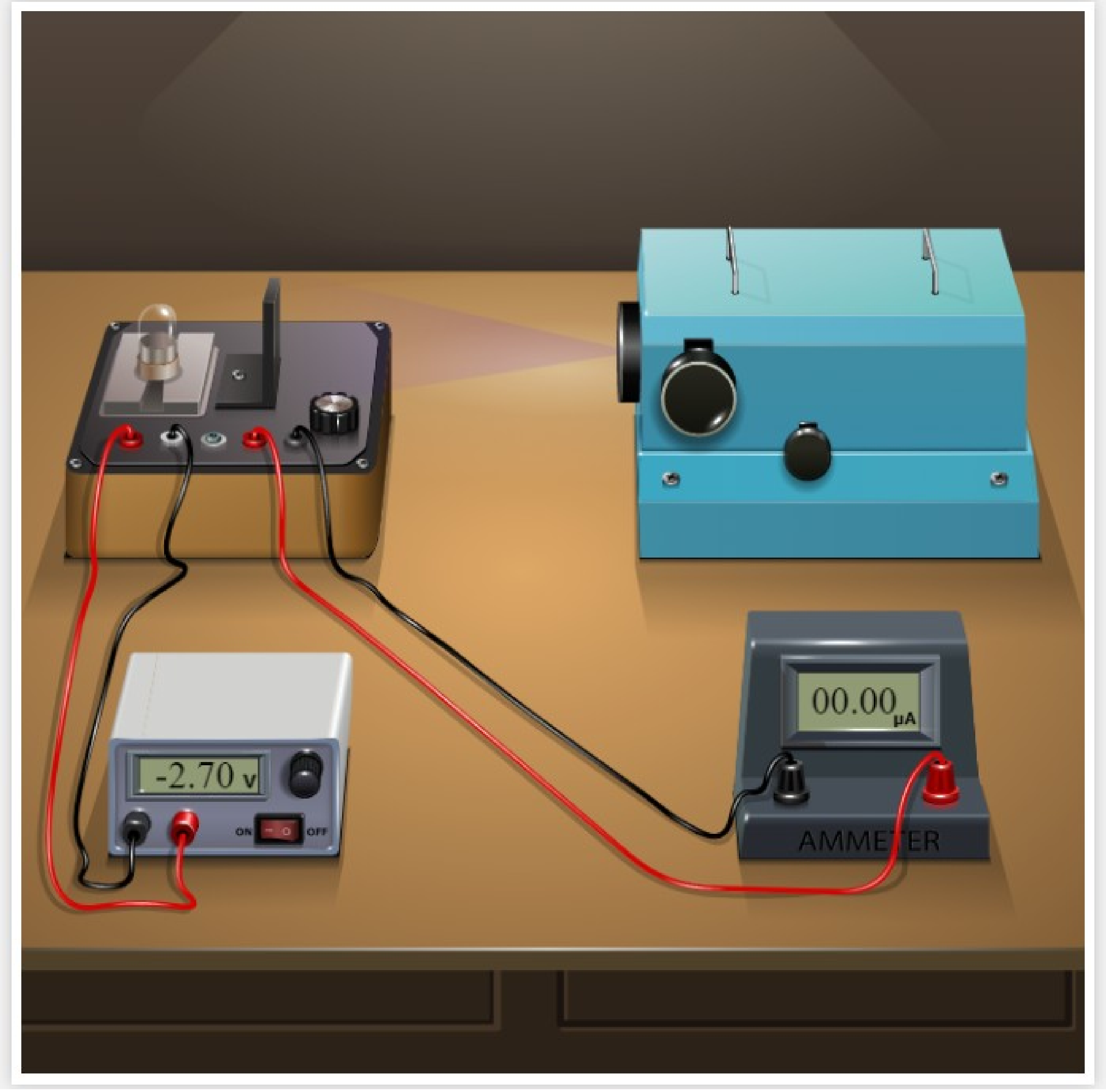
Voltage Applied : 0 V

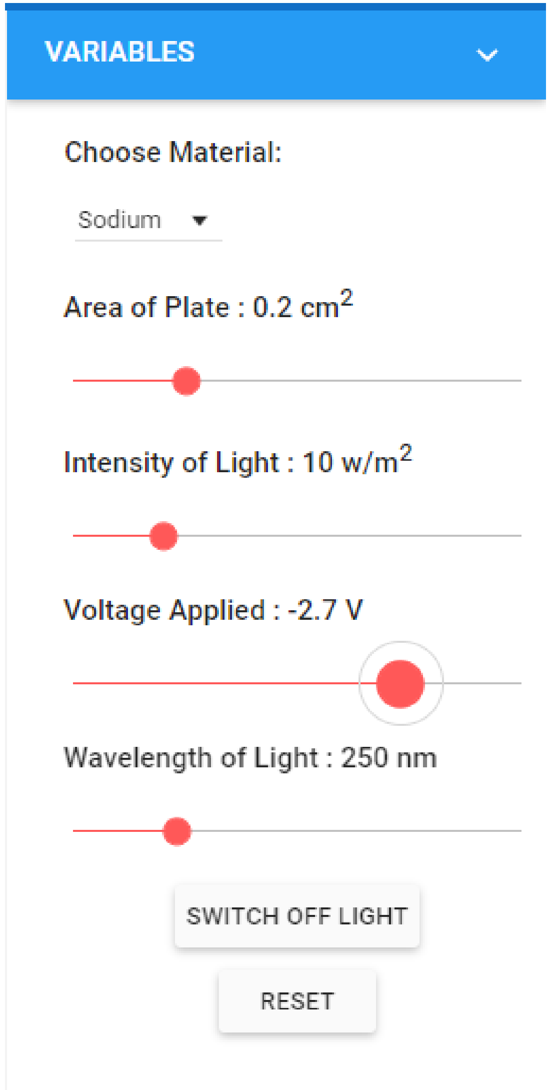
Wavelength of Light : 250 nm

SWITCH OFF LIGHT

RESET

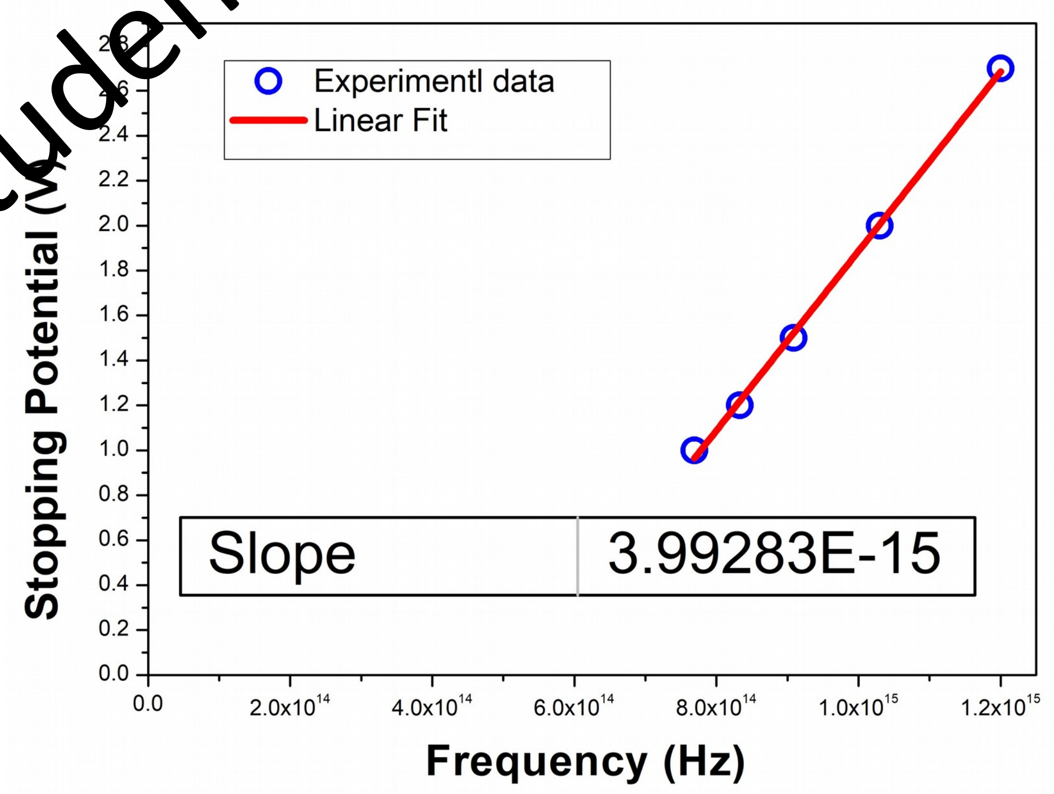
Then gradually decrease the voltage (to negative value) so that the photo current becomes zero. This is the stopping potential. Find it for at least five different wavelengths (below threshold wavelength) of the incident light.





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 × slope= 6.4×10^{-34} J-s

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

Dr. Subhojyoti Sinha

Activity Based Questions

while the students perform the experiment in virtual lab

Activity based question

A

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

Activity based question

A

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.

Activity based question

A

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

Activity based question

A

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

Activity based question

A

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