KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
Coimbatore - 641021.
(For the candidates admitted from 2016 onwards)

SUBJECT : Elements of Modern Physics Practicals – I
SEMESTER : **v** **SUBJECT CODE**: **16PHU512A**
CLASS : **I B.Sc.PHYSICS**

SEMESTER – V

16PHU512A Elements of Modern Physics (PRACTICAL) L T P C

- - 4 2

Any 8 Experiments

1. Measurement of Planck's constant using black body radiation and photo-detector

2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

3. To determine work function of material of filament of directly heated vacuum diode.

4. To determine the Planck's constant using LEDs of at least 4 different colours.

5. To determine the wavelength of H-alpha emission line of Hydrogen atom.

6. To determine the ionization potential of mercury.

7. To determine the absorption lines in the rotational spectrum of Iodine vapour.

8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

9. To setup the Millikan oil drop apparatus and determine the charge of an electron.

10. To show the tunneling effect in tunnel diode using I-V characteristics.

11. To determine the wavelength of laser source using diffraction of single slit.

12. To determine the wavelength of laser source using diffraction of double slits.

13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane

diffraction grating

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia

Publishing House

2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,

reprinted 1985, Heinemann Educational Publishers

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Experiment No: 1 **Date:**

Aim : To determine the ionization potential of mercury used inside a Thyratron tube.

1. Apparatus required: Thyratron tube, variable power supply, ammeter, voltmeter, connecting wires.

2. Theory: Ionization potential is defined as the minimum amount of energy required in (ev) electron – volts to just remove an electron from an atom. Here the ionization potential of mercury can be determined by filling the vapours of mercury in a diode or triode tube. The hot cathode has filled triode is known as Thyratron.

In our experiment when a positive potential is applied to the plate and it is increased slowly, plate current also increases slowly. But when plate potential increases beyond a particular value, plate current increases more rapidly. This is because the electrons arriving at the anode gain enough energy to knock out electrons from the atoms of the gas close to anode. These electrons are also attracted by plate and hence causing increase in plate and current. The positive ions so produced neutralize the space charge which further helps in increasing the kinetic energy of thermal electrons. This value of plate potential at which plate current shows large increase is known as ionization potential of the gas (vapours). The circuit connections are shown in Fig.1.

Circuit diagram:

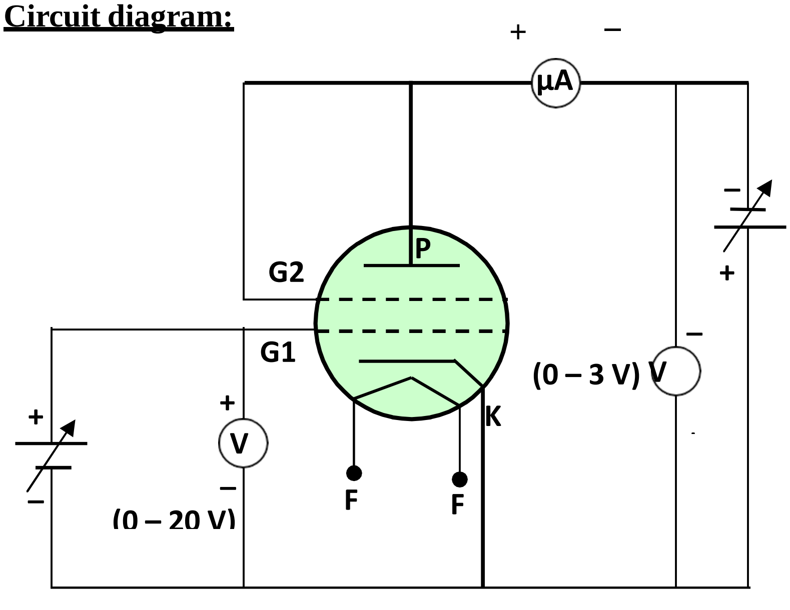
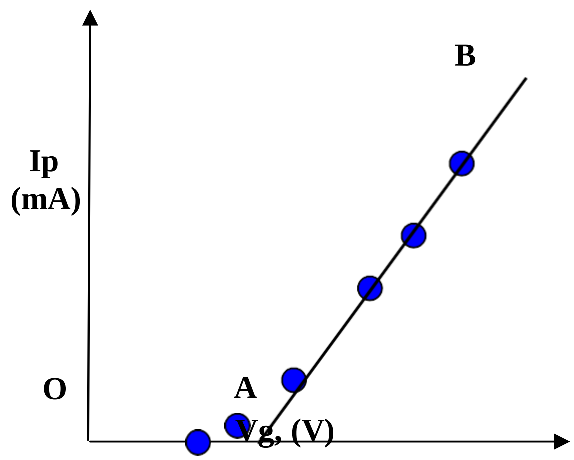


Fig.1

3. Procedure:

(i). Make connections as in Fig.1 and switch on power supply.
(ii). Vary plate voltage, V_g = 1 – 20 V and take reading of plate current, I_p , for each one.
(iii). Draw graph between V_g & I_p.
(vi) Draw a straight line AB between last few points. This line intersects with X-axis at A. OA gives the value of observed ionization potential of mercury.

I. To find observed ionization potential



4. Observations Table:

I. Table to find observed ionization potential

S.NO.	Grid voltage, V	Plate current, μA
1		
2		
3		
4		
5		

5. Result:

The ionization potential of mercury is_____Volts.

6. Precautions:

(i). A gas filled tetrode must be used.
(ii). The connections should be proper before switching on the power supply.

Experiment No: 2 **Date:**

Emission spectra of Hydrogen (Balmer series) and determination of Rydberg's constant

Objective

i) To measure the wavelengths of visible spectral lines in Balmer series of atomic hydrogen

ii) To determine the value of Rydberg's constant

Introduction

In the 19th Century, much before the advent of Quantum Mechanics, physicists devoted a considerable effort to spectroscopy trying to deduce some physical properties of atoms and molecules by investigating the electromagnetic radiation emitted or absorbed by them. Many spectra have been studied in detail and amongst them, the hydrogen emission spectrum which is relatively simple and shows regularity, was most intensely studied.

Theoretical Background

According to Bohr's model of hydrogen atom, the wavelengths of Balmer series spectral lines are given by

$$\frac{1}{\lambda} = R_y\left[\frac{1}{n^2} - \frac{1}{m^2}\right] \quad (1)$$

where, n = 2 and m = 3, 4, 5, 6 … and Rydberg's constant …

$$R_y - \frac{e^4 m_e}{8\varepsilon_0^2 h^3 c} = 1.097\times10^7 m^{-1} \quad (2)$$

where ‘e’ is the charge of 1 electron, ‘m_e’ is mass of one electron, ‘□$_0$’ is permittivity of air = 8.85 □ 10-12), ‘h’ is Planck’s constant and ‘c’ is velocity of light.

The wavelengths of the hydrogen spectral emission lines are spectrally resolved with the help of a diffraction grating. The principle is that if a monochromatic light of wavelength
□ falls normally on an amplitude diffraction grating with periodicity of lines given by ‘g’

(= 1/N, where N is the number of grating lines per unit length), the intensity peaks due to principal maxima occur under the condition:

$$g \sin \alpha = p\lambda \qquad \ldots(2)$$

where ‘□’ is the diffraction angle and p = 1, 2, 3, … is the order of diffraction.

In the first part of the experiment, the grating constant ‘g’ is determined by measuring the diffraction angles for the known spectral lines of a mercury (Hg) spectral tube (Mercury- vapour lamp). The Hg spectral tube is then replaced by a hydrogen (atomic) spectral tube,
in which, H_2 is converted into atomic hydrogen due to collision ionization. The electrons in H atoms are excited to higher energy levels through collisions with other electrons. When these electrons return to lower energy levels, the atom emits electromagnetic radiation of discrete frequencies in various spectral ranges. Balmer's series spectral lines fall in ultraviolet and visible ranges and the latter wavelengths are determined in this experiment by measuring the corresponding diffraction angles. Usually, only first order diffraction is studied, for which the value of ‘p’ in Eq. 2 is taken to be unity.

Experimental Set-up

The experimental set-up is shown in Fig. 1. Hydrogen or mercury spectral tubes are used as the source of light. The spectral tube is fixed between two high voltage electrodes. A grating and a spectrometer will be used to analyse different spectra. First, a mercury source is used to determine the grating element (g). Then using this value of g and a hydrogen spectral tube the unknown lines of Balmer series of hydrogen spectra are determined.

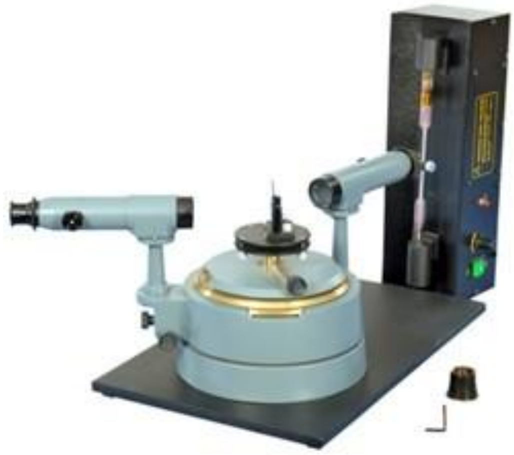


Figure 1: Experimental set-up

Procedure

A. **<u>Adjusting the spectrometer</u>**:

Follow the support manual for spectrometer provided in the appendix for basic adjustment of spectrometer. Determine the vernier constant of the spectrometer. Fix the grating on the prism table. Do not disturb the spectrometer henceforth throughout the experiment.

B. **Determination of g**:

1. Bring in the Hg source close to the collimator of the previously leveled spectrometer.
2. Then switch ON the power supply and let the Hg lamp warm up.
3. Look through the telescope to notice the three first order spectral lines of Hg (yellow, green and blue) on both sides of the direct image of the slit at the center. Make the spectral lines vertical by turning the grating slightly in its plane.
4. Note down the positions of the cross wire for each line on one side using the two verniers on the spectrometer. Use a torch, if needed, to read the verniers.
5. Repeat the above step by turning the telescope to the other side too. Determine the diffraction angle, □, for all the three spectral lines of Hg spectrum. Using the spectral data of Hg given below, calculate g.
6. Switch off the power supply and remove the Hg spectral tube.

Spectral data of Hg

Colour	λ /nm	Transition
yellow	581 ± 1	6 1D1 → 6 1P1 6 3D1 → 6 1P1
green	550 ± 1	7 3S1 → 6 3P1
green	494 ± 2	8 1S1 → 6 1P1
blue	437 ± 2	7 1S → 6 1P1

C. Studying hydrogen spectrum

1. In presence of the instructor/lab operator bring in the hydrogen source to the front of collimator. Then switch ON the power supply.
2. Repeat steps B.3 to B.4 (mentioned above) and note down the positions of the cursors for 3 spectral lines (red, green and violet) of the hydrogen spectrum.
3. Using the value of g determined earlier, calculate the wavelength of each of the spectral lines.
4. Switch off hydrogen spectral tube.

Observation

Table 1: **Determination of g**

Colour/ λ(nm)	Left side						Right side						Vernier 1 2θ(deg)	Vernier 2 2θ(deg)	Avg. θ(deg)	g
	Vernier 1(deg)			Vernier 2(deg)			Vernier 1(deg)			Vernier2(deg)						
	MSR	VSR	TOTAL	MSR	VSR	TOTAL	MSR	VSR	TOTAL	MSR	VSR	TOTAL				

Mean value of g =-------

Table 2: **Determination of spectral lines of hydrogen**

Colour/ Line/ Literature Value (nm)	Left side						Right side						Vernier 1 2θ(deg)	Vernier 2 2θ(deg)	Avg. θ(deg)	λ (nm)
	Vernier 1(deg)			Vernier 2(deg)			Vernier 1(deg)			Vernier2(deg)						
	MSR	VSR	TOTAL	MSR	VSR	TOTAL	MSR	VSR	TOTAL	MSR	VSR	TOTAL				
Red/H_α/656.28																
Green/H_β/486.13																
Violet/H_γ/434.05																

Results and analysis

1. Assign appropriate values of n and m (n = 2 and m = 3, 4 ...) to each λ (average value). Tabulate the values of n and m, the corresponding values of $\left(1/n^2 - 1/m^2\right)$ and $1/\lambda$.
2. Plot $1/\lambda$ vs. $\left(1/n^2 - 1/m^2\right)$ on a graph sheet. Indicate the error bars of $\Delta(1/\lambda)$ by calculating $1/\lambda^2 \, \Delta\lambda$ in each case. Indicate n and m for the three data points on the graph.
3. Draw the linear graph. From the slope of the graph and the error in the slope, determine the value of Rydberg's constant and the corresponding random error. Write the final result with its uncertainty.

Precautions

1. Handle the spectral tube with utmost care.
2. Never touch the surface of the grating by hand. Always hold it from the sides.
3. Do not change the positions of the spectrometer and the spectral tube throughout the experiment.
4. Switch OFF power supply before making any changes in the spectral tube arrangement.

Experiment No: 3 **Date:**

Determination of Planck's constant and work function of metals using photoelectric effect

Objective

I. To determine Planck's constant '*h*' from the stopping voltages measured at different frequencies (wavelengths) of light.
II. To determine the work function "□" of a metal.

Introduction

One of the most important experiments from the early 20th century was the photoelectric effect experiment. In this experiment, shining light upon a metal surface may cause electrons to be emitted from the metal. In 1905, Albert Einstein working in a Swiss patent office published a paper in which he explained the photoelectric effect. He argued that light was not a wave – it is *particulate* – and it travels in little energy bundles (or packets) called *photons*. The energy of one of these photons is hv, where h is the fundamental constant of nature as proposed by Max Planck to explain blackbody radiation, and v is the frequency of the photon. This novel interpretation of light turned out to be very significant and secured a Nobel Prize for Albert Einstein. Robert Millikan, co-founder of the California Institute of Technology and fellow Nobel Prize Winner, performed the careful experimental verification of Einstein's predictions.

Theory:

An electron in a metal can be modelled as a particle in an average potential well due to the net attraction and repulsion of protons and electrons. The minimum depth that an electron is located in the potential well is called the work function of the metal, "□" (see Fig. 1). In other words, it is a measure of the amount of work that must be done on the electrons (located in the well) to make it free from the metal. Since different metal atoms have different number of protons, it is reasonable to assume that the work function ("□") depends on the metal. This is also supported by the fact that different metals have different values for electrical properties that should depend on the electron binding including conductivity. The electron in the potential well of a metal is shown below in Fig. 1. It is analogous to a marble trapped in a water-well. The shallower the well (i.e. the lower the work function "□"), less is the energy required to cause the emission of the electron. If we shine a light with sufficient energy then an electron is emitted.

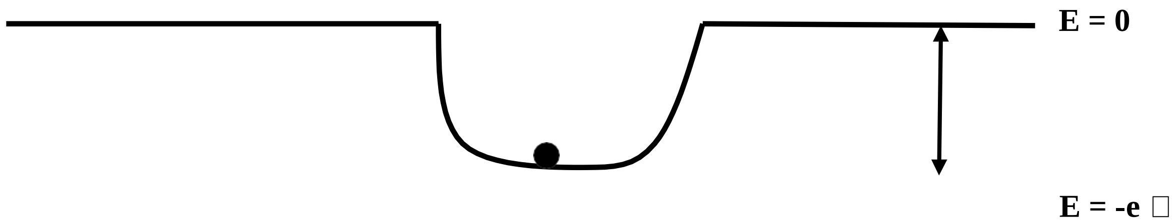


Figure 1: Electron in a potential well at a depth "ϕ"

When a photon with frequency "v" strikes the surface of a metal, it imparts all of its energy to a conduction electron near the surface of the metal. If the energy of the photon (*hv*) is greater than the work function (ϕ), the electron may be ejected from the metal. If the energy is less than the work function, the electron will simply acquire some kinetic energy that will dissipate almost immediately in subsequent collisions with other particles in the metal. By conservation of energy, the maximum kinetic energy with which the electron could be emitted from the metal surface T_{max}, is related to the energy of the absorbed photon *hv*, and the work function ϕ, by the relation,

$$T_{max} = \frac{1}{2} m v_{max}^2 = h\nu - e\phi \qquad \ldots (1)$$

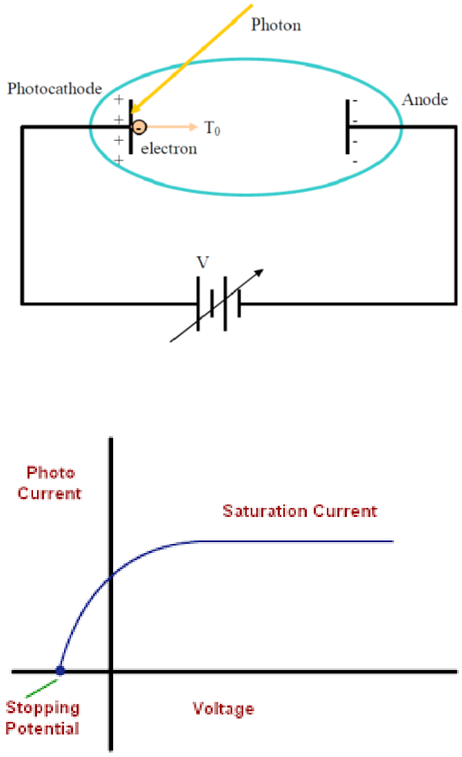
Now consider the case of electrons being emitted by a photocathode in a vacuum tube, as illustrated Fig.2. In this case, all emitted electrons are slowed down as they approach the anode, and some of their kinetic energy is converted into potential energy. There are three possibilities that could happen.

i) First, if the potential is small then the potential energy at the anode is less than the kinetic energy of the electrons and there is a current through the tube.

ii) The second is if the potential is large enough the potential energy at the anode is larger than the kinetic energy and the electrons are driven back to the cathode. In this case, there is no current.

iii) The third case is if the voltage just stops the electrons (with maximum kinetic energy T_{max}) from

Figure 2: A schematic of a vacuum Phototube and a typical I-V characteristics



reaching the anode. The voltage required to do this is called the “stopping potential" (V_0). A typical I- V characteristics for a given frequency of light is also depicted in Fig. 2.

Thus Eq. 1 can be rewritten as,

$$eV_0 = h\nu - e\phi \qquad \dots (2)$$

$$V_0 = \frac{h}{e}\nu - \phi \qquad \dots (3)$$

It is worth noting here that, since the anode and cathode surfaces are different, an additional contact potential “A” comes into the picture which simply gets added to the work function “ϕ”. Eq. (3) can be written in terms of wavelength as

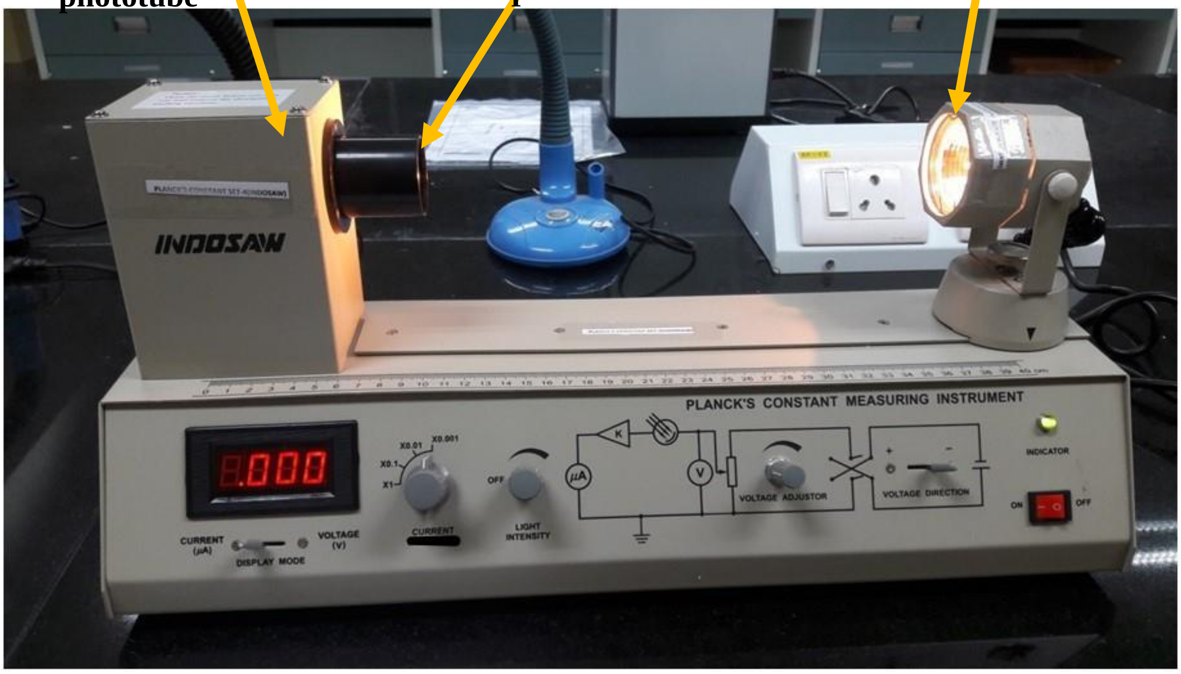
$$V_0 = \left(\frac{hc}{e}\right)\left(\frac{1}{\lambda}\right) - (\phi + A) \qquad \dots (4)$$

Standard value of **h** is known[1] to be 6.626×10^{-34} J-s.

<u>Experimental Set up:</u>

The present experimental set-up (see Fig. 3) comprises of a tungsten-halogen light source with five different colour filters, a Cesium-type vacuum phototube, a built-in power supply and a current multiplier. The base of the phototube is built into a dark room and in front of it a receptor (pipe) is installed to mount filters.

Cs-type vacuum phototube **Recepto r** **Tungsten-Halogen lamp**



<u>Figure 3: Experimental set up</u>

Procedure:

1. Plug in and switch on the apparatus using the red button at the bottom right corner of the set up.
2. Before the lamp is switched on, put the toggle switch in current mode and check that the dark current is zero.
3. Turn on the lamp source (it may take 5-10 mins. to warm up). Set the light intensity near to maximum. Note that the intensity should be such that the value of current should not exceed the display range. In case it happens, you need to reduce the intensity. You should not change intensity while taking data.
4. Insert one of the five specified filters into the drawtube of the receptor.
5. Set the voltage direction switch to "+ve" polarity. Adjust the voltage knob at minimum and current knob at "X 0.1" position which means the resolution is up to one decimal point. Vary the voltage and record the current till the value of current becomes relatively constant. Use the display mode switch to record the values of voltage and the corresponding current each time
6. Now, set the voltage direction switch to "-ve" polarity. Adjust the voltage knob at minimum and current knob at "X 0.001" (we need higher resolution since current will be less here). Vary the voltage and record the current till the value of current becomes 0. Use the display mode switch to record the values of voltage and the corresponding current each time.
7. The above steps 5 and 6 provides data to plot the I-V characteristics of the phototube for the wavelength (or frequency) selected by the filter.
8. Repeat the steps 5-7 for all the filters provided.
9. Fill up the observation tables and draw necessary plots. Determine the values of planck's constant and work function of the metal used in the phototube.

Observations:

Specification of Filters:

Colour	Blue	Green	Yellow	Orange	Red
Wavelength (nm)	460	500	540	570	635

Table 1: For I-V characteristics

Voltage (+ ve polarity)					
Current (µA)					

Voltage (- ve polarity)					
Current (µA)					

Table 2: Data for stopping potential ~ wavelength

Stopping potential (V)					
Wavelength (nm)					

Graph:

1. Plot I~ V characteristics for different wavelengths.
2. Plot Stopping potential ~ (1/wavelength) and calculate slope and intercept using Eq.

Precautions:

1. Rotate all the knobs very slowly.
2. Handle the filters with utmost care and avoid touching their surfaces.

Experiment No: 4 **Date:**

Aim

To study the emission spectra of Hydrogen, Neon and mercury vapours.

Apparatus

Spectrometer, diffraction grating, mercury bulb, Hydrogen Bulb, neon bulb, etc.

Theory

When an atom or ion in substance got excited, they emit radiations of particular frequencies. These radiations are seen in the form of spectra. There are several types of spectra mainly,

- Continuous spectra-continuous band of colors is obtained.
- Absorption spectra-dark lines on a bright background.
- Emission spectra-bright lines on dark background.

In this experiment a diffraction grating optical spectrometer is used to study the spectra.

The diffraction grating provides the simplest and most accurate method for measuring wavelengths of light. It consists of a very large number of equidistant narrow parallel rectangular slit of equal width separated by equal opaque portion. The ruled widths are opaque to light and space between any two successive lines is transparent and act as parallel slits.Number of rulings per cm of grating used in visible region varies from 5,000 to 12,000 lines per mm.

The slits of a grating give rise to diffraction and the diffracted light interferes so as to set up interference patterns. Complete constructive interference occurs when the phase or path difference is equal to some whole number of the wavelength. In general the grating equation for constructive maxima is,

$$\mathbf{Sin\ \theta = Nm\ \lambda}$$

Where, m is called the order of the spectrum, λ the wavelength, N the number of lines per cm and θ the diffraction angle measured with respect to the direction of the light incident on the grating.

The apparatus

Spectrometer is an instrument which is used to measure the intensity and other properties of light. Direction of all rays should be same and for this light which is to be analyzed must pass through the grating as parallel beam.

The main parts of the spectrometer are:

Collimator: The collimator is used to produce parallel rays. It consists of an adjustable slit and convex lens.

Prism table: The prism table is circular in shape and is provided with three leveling screws. A central horizontal shelf for mounting either a prism or a grating.

Vernier table: The Vernier table is also circular in shape and can be rotated about a vertical axis. Two verniers are attached to the Vernier table and they move along the circular scale, when the Vernier table is rotated. The Vernier table and hence verniers can be fixed in any position by means of radial screw.

Telescope: An objective lens that focuses on the entering parallel rays in a plane so that the real image can be observed with the aid of the eyepiece. Cross hairs located in the focal plane of the objective lens. The telescope is attached to a circular scale and can be rotated about a vertical axis through the centre of the scale.

Preliminary adjustments

Check spectrometer, prism experiments of optical lab http://vlab.amrita.edu/?sub=1&brch=189&sim=851&cnt=2299

Adjustment of telescope- The telescope is adjusted by looking to a distant object, until the object cross wires are in sharp focus.

Adjustment of the collimator- The slit is opened slightly and is illuminated using the sodium lamp. The telescope is brought in line with a collimator. The image of the slit is observed through the telescope and is made to coincide with the vertical cross wire. The slit is made very narrow.

Adjustment of prism table- The prism table is leveled using the spirit level or by optical method. In the optical method, the leveling screws of the prism table are adjusted until the image of slit is bisected by horizontal cross wire.

In this experiment we are simulating the normal incidence position of grating and further calculations. For details please check the diffraction grating experiment in optics lab.

Procedure

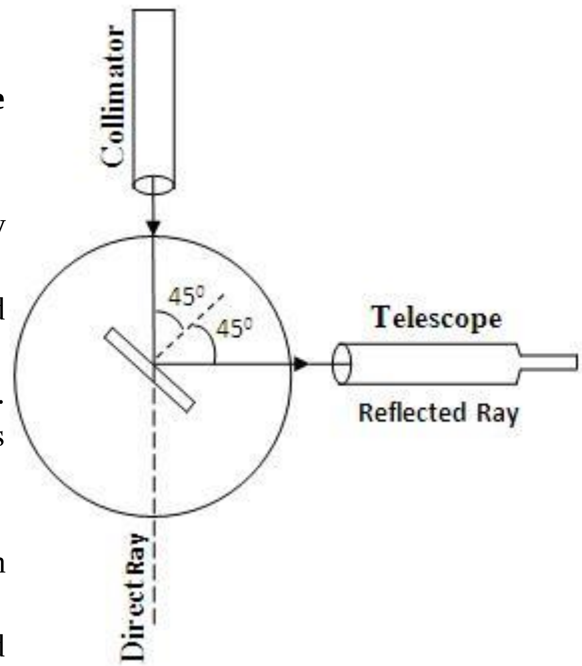
For doing simulation

1. Move the slider in 'Calibrate Telescope' and click 'START' button.
2. Click on Combo box to select lamp.
3. Click 'Switch On Light'.
4. Vernier reading is set to 0^0 and telescope at 90^0 by clicking on sliders of both.
5. Click the 'Place grating button'.
6. Turn the telescope to left. Coincide vertical cross wire with the green line on the pattern.
7. Note the readings of vernier 1 and vernier 2.
8. Telescope is moved to right side of direct image and vertical wire is made to coincide with green line of pattern.
9. Note the readings of vernier 1 and vernier 2.
10. Click on slider under Fine angle to get readings more precisely.

11. Difference between the two readings on the same vernier is taken.
12. Mean value of this difference gives 2Θ, twice the angle of diffraction. From this, the value of Θ is obtained for green line.
13. Assuming the wavelength of green line, 546nm, the no. of lines per mm is calculated using equation, N=SinΘ/mλ where m is the order.

For doing the real lab

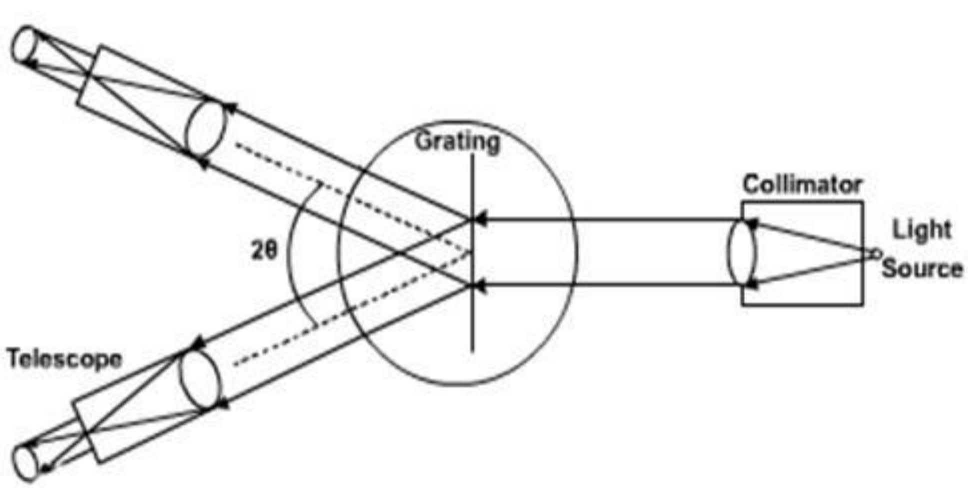
- **Setting the grating for normal incidence position.**



1. Vernier table is fixed after making the preliminary adjustments.
2. Illuminate the slit with mercury vapour lamp and make the slit narrow.
3. Bring the telescope in line with collimator. Coincide the direct image's slit with vertical cross wire.
4. Note down any one of the vernier reading.
5. Turn the telescope exactly through 90^0 and then clamp it.
6. Place the grating over the prism table with its ruled surface facing collimator and perpendicular to line joining two leveling screws of prism table.
7. Unclamp the Vernier and rotate until the reflected image coincides with the vertical cross wire.
8. The prism table is now fixed and the readings of Vernier are noted.
9. Vernier table is unclamped and rotated exactly 45^0 in the proper direction so that surface of grating becomes normal to the collimator.
10. Vernier table is now clamped.

- **Standardizing the grating**

1. Move the telescope to observe the direct image. Diffraction patterns are seen on the either side of the direct image.



2. Turn the telescope to left. Coincide vertical cross wire with the green line on the pattern.
3. Note the readings of vernier 1 and vernier 2.
4. Telescope is moved to right side of direct image and vertical wire is made to coincide with green line of pattern.
5. Note the readings of vernier 1 and vernier 2.
6. Difference between the two readings on the same vernier is taken.
7. Mean value of this difference gives 2Θ, twice the angle of diffraction. From this, the value of Θ is obtained for green line.
8. Assuming the wavelength of green line, 546nm, the no. of lines per mm is calculated using equation, $N=\sin\Theta/m\lambda$ where m is the order.

- **To determine the wavelength of other lines**

  Repeat the same procedure as above for other lines, and calculate its wavelength using the equation, $\lambda=\sin\Theta/Nm$.

Observations

Colour of spectral line	Reading of diff:images				Difference (2Θ)		Mean (Θ)	Wavelength λ
	Left		Right					
	Ver1	Ver2	Ver1	Ver2	Ver1	Ver2		
Green								
Violet								
Blue								
Yellow								
Red								

Results

The wavelength of the prominent lines of the mercury spectrum are given in nanometre in the tabular column.

Number of grating per metre=................/m

Experiment No: 5 **Date:**

Aim

Determination of Planck's constant.

Apparatus

0-10 V power supply, a one way key, a rheostat, a digital milliammeter, a digital voltmeter, a 1 K resistor and different known wavelength LED's (Light-Emitting Diodes).

Theory

Planck's constant (h), a physical constant was introduced by German physicist named Max Planck in 1900. The significance of Planck's constant is that 'quanta' (small packets of energy) can be determined by frequency of radiation and Planck's constant. It describes the behavior of particle and waves at atomic level as well as the particle nature of light.

An LED is a two terminal semiconductor light source. In the unbiased condition a potential barrier is developed across the p-n junction of the LED. When we connect the LED to an external voltage in the forward biased direction, the height of potential barrier across the p-n junction is reduced. At a particular voltage the height of potential barrier becomes very low and the LED starts glowing, i.e., in the forward biased condition electrons crossing the junction are excited, and when they return to their normal state, energy is emitted. This particular voltage is called the **knee voltage** or the **threshold voltage**. Once the knee voltage is reached, the current may increase but the voltage does not change.

The light energy emitted during forward biasing is given as ,

$$E = \frac{hc}{\lambda} \qquad (1)$$

Where
c -velocity of light.
h -Planck's constant.
λ -wavelength of light.

If V is the forward voltage applied across the LED when it begins to emit light (the knee voltage), the energy given to electrons crossing the junction is,

$$E = eV \qquad (2)$$

Equating (1) and (2), we get

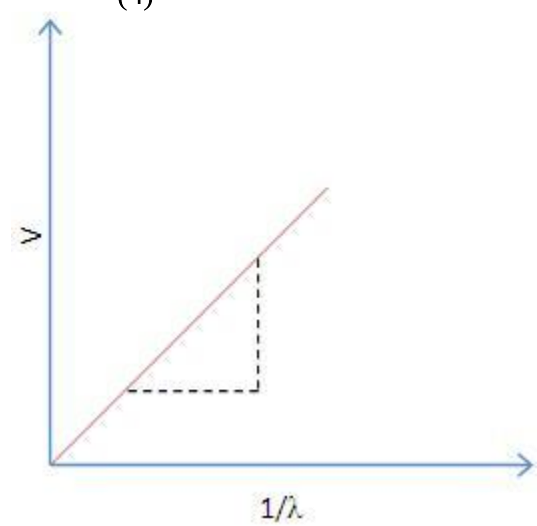
$$eV = \frac{hc}{\lambda} \qquad (3)$$

The knee voltage V can be measured for LED's with different values of λ (wavelength of light).

$$V = \frac{hc}{e}\left(\frac{1}{\lambda}\right) \qquad (4)$$

Now from equation (4), we see that the slope s of a graph of V on the vertical axis vs. 1/λ on the horizontal axis is

$$s = \frac{hc}{e} \qquad (5)$$



To determine Planck's constant h, we take the slope s from our graph and calculate

$$h = \frac{e}{c}s$$

using the known value

$$\frac{e}{c} = 5.33 \ x \ 10^{-28}\frac{Cs}{m}$$

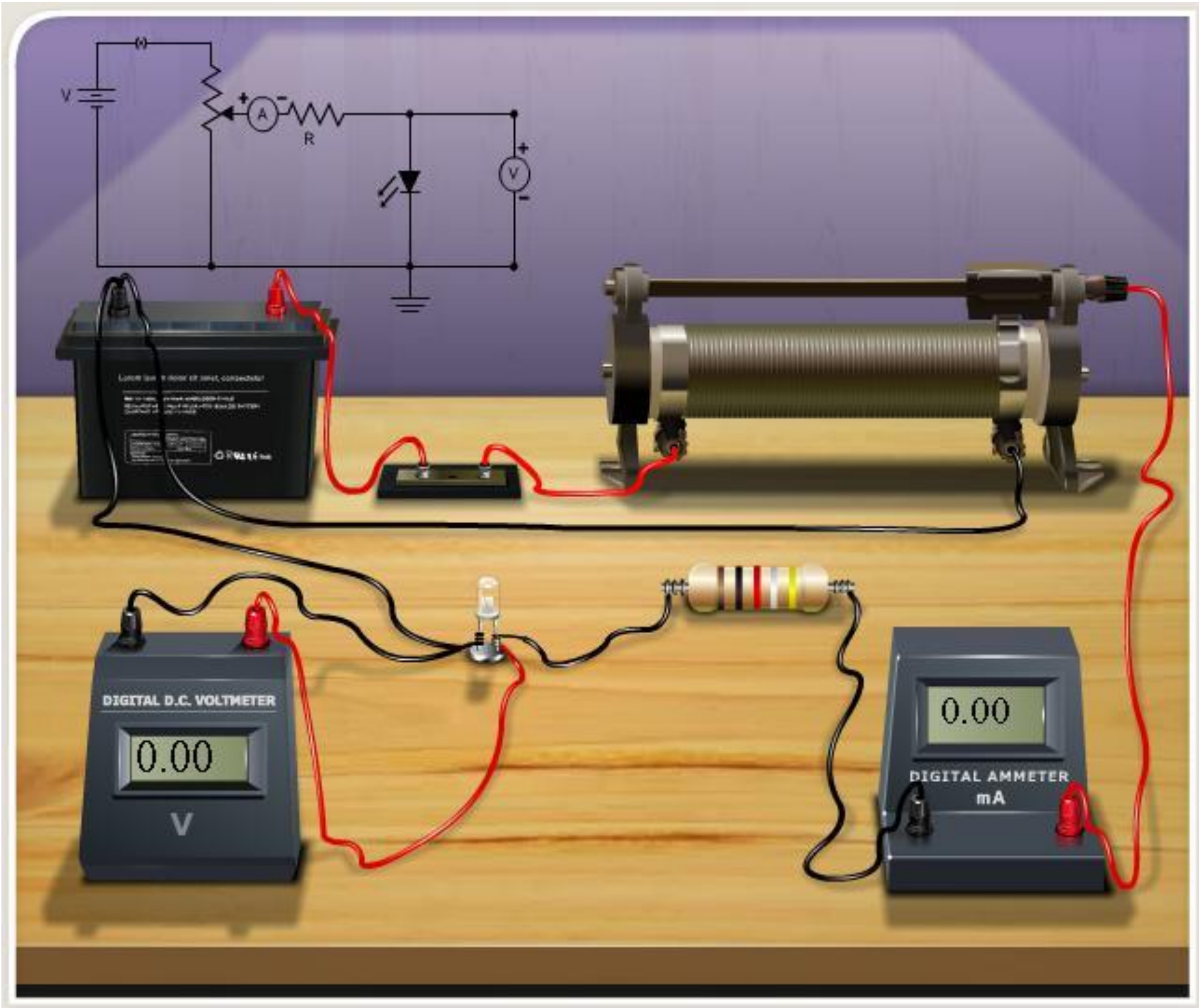
Alternatively, we can write equation (3) as

$$h = \frac{e}{c}\lambda V$$

calculate h for each LED, and take the average of our results.

Procedure for Simulation

Place the mouse pointer over the components and click to drag wire.

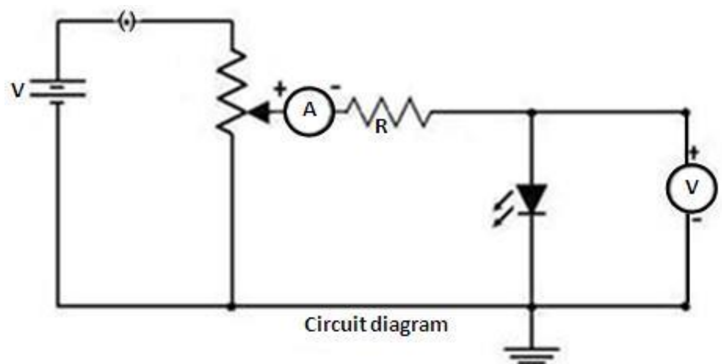


1. After the connections are completed, click on ‘Insert Key’ button.
2. Click on the combo box under ‘Select LED’ button.
3. Click on the ‘Rheostat Value’ to adjust the value of rheostat.
4. Corresponding voltage across the LED is measured using a voltmeter,which is the knee voltage.
5. Repeat, by changing the LED and note down the corresponding knee voltage.
6. Calculate ‘h’ using equation $h = \frac{e\lambda V}{c}$
7. The wave length of infrared LED is calculated by using equation, $\lambda = \frac{hc}{eV}$

Observations

Colour of LED	Wavelength (λ) nm	Knee voltage (V) volt	λxV	h = eλV/c

Procedure for Real lab



1. Connections are made as shown in circuit diagram.
2. Insert key to start the experiment.
3. Adjust the rheostat value till the LED starts glowing, or in the case of the IR diode, whose light is not visible, until the ammeter indicates that current has begun to increase.
4. Corresponding voltage across the LED is measured using a voltmeter,which is the knee voltage.
5. Repeat, by changing the LED and note down the corresponding knee voltage.
6. Using the formula given,find the value of the Planck's constant.

Results

Planck’s constant = Js.
Wavelength of IR LED = nm.