BASIC PHYSICS FOR ARCHITECTS

PH-111

PRACTICAL WORKBOOK

FOR

First Year

Batch: _____

NAME OF STUDENT: _____

CLASS ROLL NO.: _____ **SECTION:** _____

DISCIPLINE: _____

SEMESTER: _____

DEPARTMENT OF PHYSICS

NED UNIVERSITY OF ENGINEERING & TECHNOLOGY,
KARACHI, PAKISTAN.

PRACTICAL WORK BOOK

For The Course

Basic Physics for Architects

(PH-111)

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CERTIFICATE

Certified that Mr./ Ms_____of class **First year Engineering** Bearing Seat No: _____ Department_____has completed the course in **Basic Physics for Architects Practical** as prescribed by the NED University of Engineering & Technology, Karachi for the Academic Session_____.

Date:_____ _____

Lab. Teacher

Basic Physics for Architects Practical

Name of Student: _____

Class Roll No.:_____ **DISCIPLINE:** _____

Physics an Experimental Science:

Science is based on observation and experiment. We have to measure quantities to compare our theories with reality. **Accuracy** indicates how close the measured value is to the true value. And no measurement is exact. There will always be some uncertainty in the result. If you say that a table is 2.50 m long, you are implying that its length is probably between 2.495 m and 2.505 m, i.e., you know the uncertainty in length is about ± 0.005 m. if in place of a meter stick with centimeter marking you use the one with millimeter markings and measure the length of the table carefully, you could measure the length to ± 0.5 mm rather than the previous case ± 0.5 cm. You would indicate this precision with four digits, such as 2.503 m. As another example consider that you measure the time of a runner in the 100-meter dash. It turns out to be 9.84 s. If your measurement is accurate to plus minus 0.05 s, the actual time can be anywhere between 9.84 - 0.05=9.79 s and 9.84+0.05 =9.89 s. You would write your answer as

$$9.84 \pm 0.05 \text{ s}$$

The percent uncertainty would be .05/9.84 x100 =0.5%.

Significant digits and experimental accuracy:

Suppose you quote your result that x = 3m. This implies that you know x to be between 2 m and 3 m. However, if you say that x = 3.1415 then you are implying that x is known to you with greater precision. It lies somewhere between 3.14158 m and 3.14160 m. In the first case x is known to only one significant figure whereas in the second case it is known to six significant figures.

Rules to be followed in deciding how many significant figures there are in any operation carried out with numbers.

1. Count from the left and ignore all leading zeros, keep all digits up top the first doubtful one. x = 3m has one significant figure, the value expressed as x=0.003km also implies one significant figure. Similarly, if you write x = 0.0030 km again you have two significant figure. Be a bit careful. If you say x = 300 m then it does not indicate how many significant figures there are as there is no decimal here. It is better to express in this situation in the scientific notation as $x = 3 \times 10^2$ would indicate one significant figure and $x = 3.00 \times 10^2$ would indicate three.
2. When multiplying or dividing, keep a number of significant figures in the product or quotient no greater than the number of significant figures in the least precision of the factors. Thus

$$2.8 \times 3.14159 = 8.8$$

Sometimes you make a judgment as for instance you express

$$9.8 \times 3.04 - 10.2$$

Although 9.8 has only two digits it is so close to 10.0 which is a number with three significant digits, that is we express the final answer as three significant digits in place of two.

(i) In adding or subtracting the least significant digit (the one on the right most Position), of the sum or the difference occupies the same relative position as the lest significant digit of the quantities being added or subtracted. In this the number if significant figures is not important; it is the position of the least significant digit that is important. The least significant figures are in boldface in the example below.

103 .9

2.10
0.319
106.319

You should write the final result as 106.3 since you should include only one least significant digit. The least significant digit is also called the doubtful digit.

Errors associated with observations:

One should be able to distinguish between *mistakes and errors.* The term mistake indicates a fault in the measurement, which can be avoided by care on part of the observer. An example is recording of a wrong number, which means not noting down the value on the scale but writing a different value. On the Other hand, an error can occur in even the most careful observation. As in the case of careful use of equipment, this has an error in graduation. We consider below the various types of error.

Constant errors are those, which affect the result of a series of experiment by the same amount. For instance, a scale in which the length of a centimeter is given not as 1 cm but as 0.99 cm. Such a scale will constantly give a larger value of length. Such deviation is difficult to detect. A measurement of the same quantity by a different method may make it possible to detect the constant error. and to rectify it. *Systematic errors are* those that occur according to same definite rule. If for example if the pointer is not pivoted at the center, then an error can occur. Systematic error can be avoided once the source is detected. *Personal errors* cam arises from the fact that the person is not making the recording correctly. For instance, in noting the time when the pendulum crosses the center, the observer may note it late. This can be avoided if the observer is vigilant or the has a bad eyesight get it corrected.

Even when all the above three mentioned errors do not exist, errors still occur. These are called *random errors.* These cannot be traced to any cause. One can illustrate the random by firing of shots at the target. Even if the rifleman is fully trained and excellent at this, all his shorts will not hit the target. The shots will be scattered around the target point. This would be due to the consequence of taking the aim.

In order to arrive at a result close to the true value, one has to take a large number of measurements. The larger the number of observations the better the result. Let there are "such measurements $x_1, x_2, \ldots x_n$. Then the mean value X is obtained from the following relation,

$$\bar{x} = \frac{x_1 + x_2 \ldots\ldots\ldots x_n}{n}$$

If the true value is x_1, then the percentage error can be obtained as,

$$\%Error = \frac{|\ x - x_1\ |}{x_1} * 100$$

To gain some insight on to the selection of tools for measurements consider measuring the volumetric density of mass *M* and sides length a,b and c. Let these have the values 50 gm, 10 cm, 5 cm, l mm respectively. If you can measure the mass up to a milligram and have a vernier calipers of least count 0.1 mm and the micrometer screw gauge with a least count of 0.01 mm, you can get the percentage accuracies with which the corresponding quantities can be measured. They are $\frac{1}{50}, \frac{1}{10}, \frac{1}{5}$ and 1. The influence of these on the final measurement of density can be obtained by noting that the density $\rho = \frac{1}{abc}$

The error of ρ in terms of the variation in other quantities is

$$\frac{\delta\rho}{\rho} = \frac{\delta M}{M} - \frac{\delta a}{a} - \frac{\delta b}{b} - \frac{\delta c}{c}$$

The maximum error will be if we take all positive, hence

$$\frac{\delta\rho}{\rho} = \frac{\delta M}{M} + \frac{\delta a}{a} + \frac{\delta b}{b} + \frac{\delta c}{c}$$

In this case the fraction $\frac{\delta c}{c}$ corresponds to 1 percent and the other contributions $\frac{\delta c}{\rho}$ are insignificant. This is particularly the case in the determination of the mass. It is not worthwhile to exercise great care in the determination of mass of 50 gm to an accuracy of 1 mg.

EXPERIMENT# 01

OBJECT:

To study the spectral characteristics of photocell and determine the Planck's Constant.

APPARATUS:

A photocell, A DC micrometer, A reversing key, a rheostat, DC power supply, filters of different colours and Halogen tungsten lamp.

THEORY:

When light falls on certain materials like selenium etc. (which has low work function.). Electrons are emitted from their surfaces. These electrons are called *"Photo-Electrons"* and the phenomenon governing such an emission is called the photo-electric effect the material is said to be *"Photo-sensitive material".*

In a photo-cell the photo-electric effect is utilized. It is used to convert light energy into electrical energy. The emission of photoelectrons depend upon the frequency which is proportional to the energy of the incident radiation , so by changing the frequency, the energy of the incident light can be changed which can be done by taking filters of different colors(wavelength) .

According to their construction the photoelectric cells are of three types.

(I) Photo emissive cell (ii) Photo Conductive cell (iii) Photo Voltaic cell

A phototube or photoelectric cell is a type of gas-filled or vacuum tube that is sensitive to light. Such a tube is more correctly called a 'photo emissive cell' to distinguish it from photovoltaic or photoconductive cells. Phototubes operate according to the photoelectric effect: Incoming photons strike a photocathode, generating electrons, which are attracted to an anode. Thus current flow is dependent on the frequency and intensity of incoming photons. The light wavelength range over which the device is sensitive depends on the material used for the photo emissive cathode. A cesium-antimony cathode gives a device that is very sensitive in the violet to ultra-violet region with sensitivity falling off to blindness to red light. Cesium on oxidized silver gives a cathode that is most sensitive to infra-red to red light, falling off towards blue, where the sensitivity is low but not zero

WORKING FORMULA:

According to Einstein Photoelectric Effect Equation We have

$$hf = \phi + eVo$$

$$Vo = \frac{h}{e} f - \frac{\phi}{e}$$

PROCEDURE:

1. Slide light source to 25cm position, turn on the power after 5 minutes of pre-heating time. Set current multiplier at "x1" position.
2. Insert the red colour filter (635nm) into drawtube, set light intensity adjustor at stronger light, voltage direction switch at "-", display mode switch at current display. Adjust the Accelerating voltage to about 0V and set the current multiplier at "x0.001". Increase the accelerating voltage to decrease the photocurrent to zero. Note this accelerating voltage which is the stopping potential Vo for 635nm wavelength.
3. Get the stopping potential Vo of other four wavelength (570nm,540nm,500nm and 460nm).
4. Plot a graph between stopping potential and wavelength by using recorded data and determine the Planck's constant.

CIRCUIT DIAGRAM:

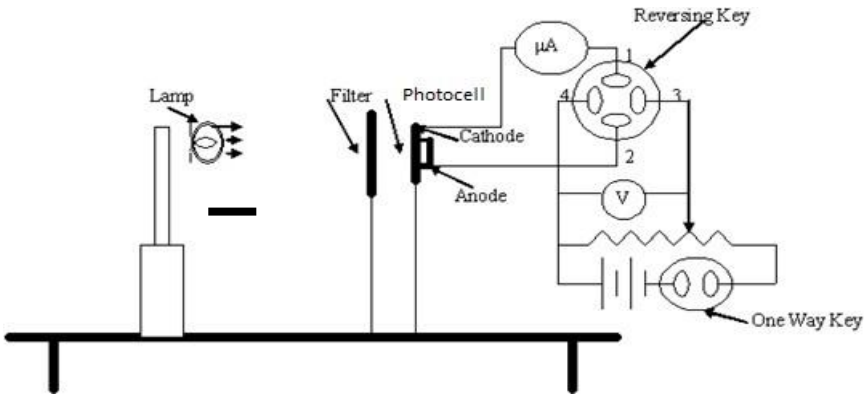


Figure-1

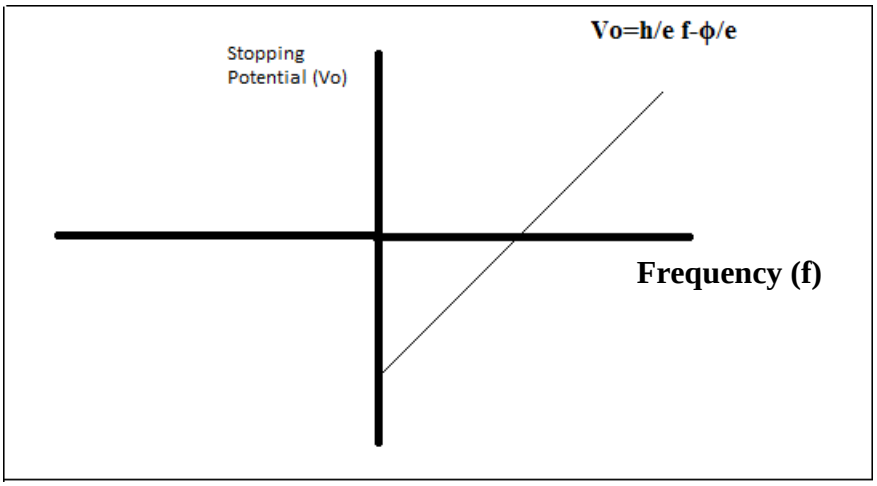


Figure-2

OBSERVATIONS:

Position of the lamp:_____cm
Position of the cell:_____cm

S.No	Colour of filter	Wavelength(λ) m	Frequency(f) Hz	Stopping Potential (Vo) Volt

CALCULATIONS:

RESULT:

The value of Planck's constant is_____.
The percentage error in observed value is_____.
The work function of cathode material is_____.

PRECAUTIONS:

1. The solar cell should be exposed to the sun light before using it in the experiment.
2. The light from the lamp should fall normally on the cell.
3. To avoid the over overheating the solar cell, the lamp should be switched off during the observations.
4. The connections should be tight.

Graph Paper

VIVA VOCE

Q1: Explain the construction and working of photocell.

Q2: What sensitive material is used when the cell is to be used for a visible light?

Q3: What is threshold frequency?

Q4: What is photo-electric work function?

Q5: How will you determine the stopping potential?

Q6: Does the violet light have more energy than red light?

Q7: What is the effect of intensity on photoelectric current?

Q8: What is the order of current in photocell?

EXPERIMENT # 02

OBJECT:

To find the ionization potential of mercury using a gas filled diode.

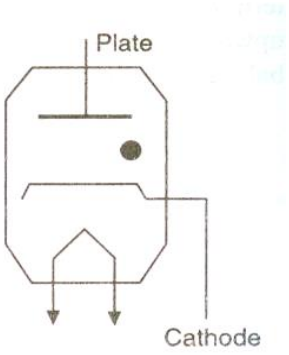
APPARATUS:

A gas filled (mercury vapors) diode, a D.C, power supply, a voltmeter, micro-ammeter, a potentiometer.

THEORY:

Ionization potential: *The least energy required to remove the most loosely bound electron from an isolated free neutral atom is known as the ionization potential of the atom.*

Ionization potential of mercury: The ionization potential of mercury can be determined by introducing mercury vapor at a low pressure of 10 mm to 50 mm of mercury column in an evacuated tube fitted with a cathode and an anode. A mercury vapor filled gas diode is the most suitable for the purpose. The cathode of the gas diode may be directly or indirectly heated type. A hot cathode gas filled diode is known as a *phanotron* [Incidentally a gas filled triode is known *as a Thyratron*] A gas filled diode is symbolically represented as shown in Fig. The **dot** in the tube shows the presence of the gas (or vapor).



When the anode or plate of the gas filled diode is at a positive potential with respect to the cathode, electrons moves across the tube from the cathode to the anode. This electronic current depends upon two factors:

(i) The number of electrons emitted per unit area from the cathode and its temperature.
(ii) *The effect of space-charge* – the negatively charged region containing the electron cloud due to the accumulation of electrons emitted by the cathode.

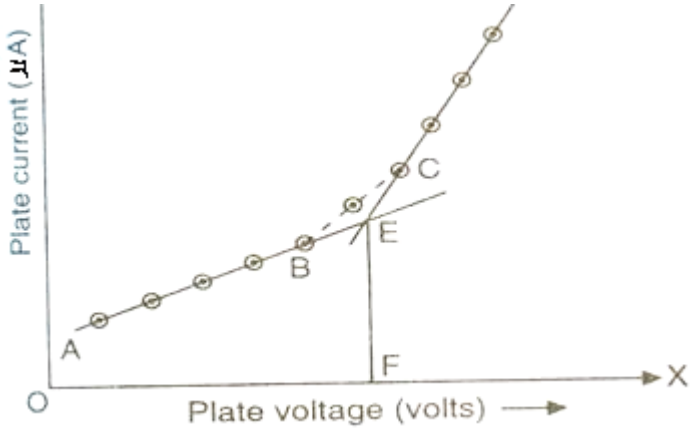
As the plate potential is increased the plate current slowly increases. But when the plate potential is increased beyond a particular value the plate current increases. But when the plate potential is increased beyond a particular value the plate current increases much more rapidly than it does below that critical value. This is because when the plate potential approaches this critical value the electrons arriving at the anode gain enough energy to knock out the electrons from the atoms of the gas close to the anode. These electrons are also attracted by the anode causing an increase in plate current and the positive ions neutralize some of the space charge, which further helps to increase the kinetic energy of the thermo-electrons. This potential is equal to the ionization potential of the gas (or vapor) and for this value of plate potential there is a marked increase in plate current.

If a graph is plotted between plate potential and plate current (for a constant value of filament current) the plate current at first increases slowly for a given increase in plate voltage and when the plate potential is equal to or greater than the ionization

potential there is a greater increase in plate current for the same increase in plate potential.

The change in slope is, however, not very abrupt but there is a short-curved portion within which the change in plate current goes on becoming more and more rapid.

To find the value of ionization potential the two straight portions *AB* and *CD* of the graph are produced to meet at a point *E*. If we draw a perpendicular *EF* on the *X*-axis, then *OF* represents the ionization potential.



PROCEDURE:

1. Make the circuit connection as shown in circuit diagram.
2. switch on the power supply. The filament is heated in a short time to becomered hot.
3. Adjust the voltmeter reading to 0.5 volt and note the corresponding value of the current in the micro-ammeter.
4. Increase the plate potential by 0.5 volt and note the voltmeter reading as well as the micro-ammeter reading. Proceed till the plate potential is about 15 volts.
5. Taking the plate voltage along the *X*-axis and plate current along the *Y*-axis plot a graph between plate current and plate voltage as shown in above Fig. Draw the straight-line *AB* between the first few points and the straight-line *CD* between the last few points and produce *AB* and *DC* to meet at *E*. Draw *EF* perpendicular to the *X*-axis, then *OF* gives the value of ionization potential of mercury.

OBSERVATIONS:

S.No.	*Plate voltage volts*	*Plate current μA*
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

CALCULATIONS:

$$Percentage\ error = \left| \frac{Obs.\ value - s\tan d.value}{stand.\ value} \right| \times 100$$

RESULTS:

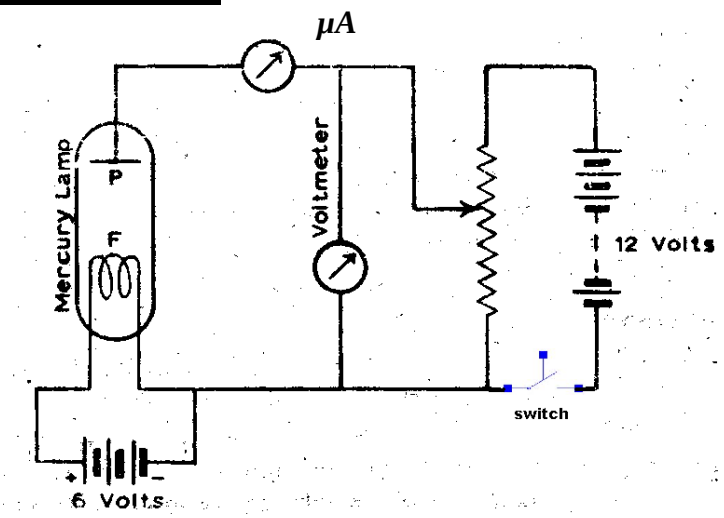
Ionization potential of mercury from the graph =.....Volts
Standard value of ionization potential = ...Volts
Percentage error = ...%

Graph paper

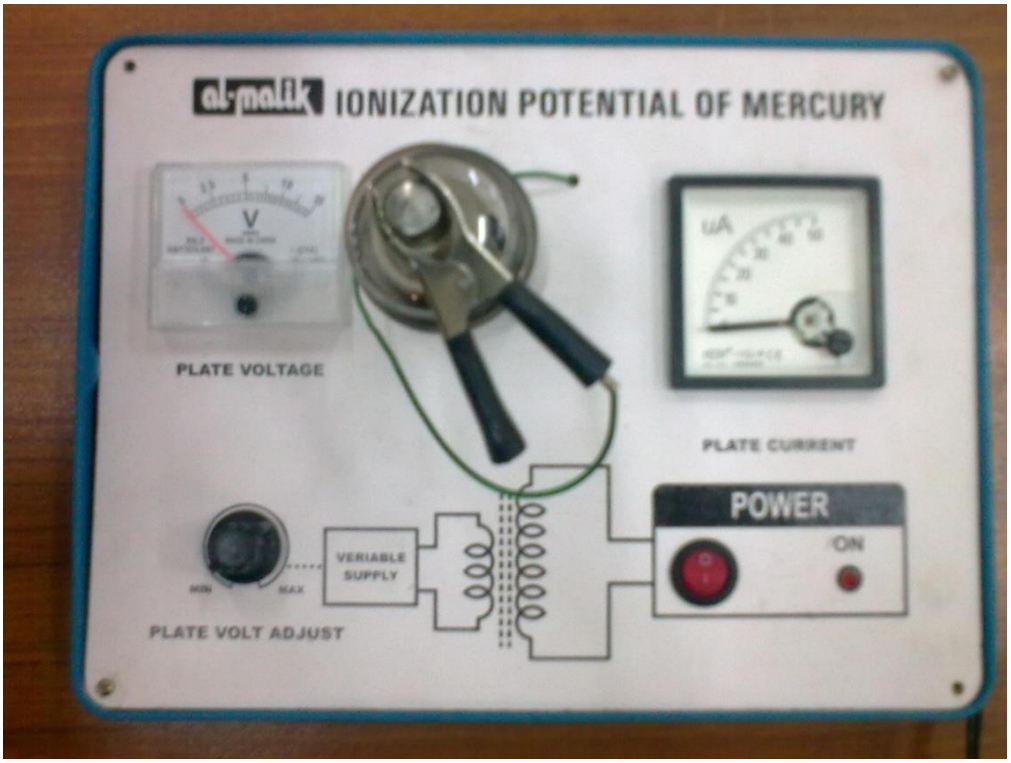
PRECAUTIONS AND SOURCES OF ERRORS:

1. A gas filled mercury vapor diode must be used.
2. The positive of the voltmeter as also that of the micro-ammeter must be connected to the positive of the *D.C.* supply.
3. The plate potential should not exceed 15 volts.
4. To find the exact position of ionization potential two straight lines joining the first few points and the last few points should be produced to meet. A smooth curve joining all the points should not be drawn.
5. For accurate measurement of voltage, a *V.T.V.M* may be used in place of an ordinary voltmeter.

CIRCUIT DIAGRAM:



PHOTOGRAPH OF THE APPARATUS



VIVA VOCE

Q.1 What is the object of your experiment?

Q.2 What are ions?

Q.3 What do you mean by ionization?

Q.4 What is excitation?

Q.5 What is ionization potential?

Q.6 Differentiate between excitation and ionization potential?

EXPERIMENT # 03

OBJECT:

To determine the velocity of wave propagation in stretched string by using sonometer.

APPARATUS:

WA-9611 Sonometer, WA-9613 Driver/Detector Coils, Function Generator, Dual trace oscilloscope, Mass and mass hanger.

THEORY:

When two exactly same waves (i-e.same amplitude, frequency and time period) travel in opposite direction with same velocity superimpose on one another the resultant wave obtained is called *standing* or *stationary wave.*

Hence, we can say that the wave length of standing wave in a vibrating string may be a function of the tension, liner mass density of string, frequency and the velocity of the wave.

If λ is the wavelength of standing wave and υ is their velocity, the frequency of the vibration f can be determined by the relation.

$$\upsilon = f\lambda \quad \text{_____(}i\text{)}$$

The velocity of transverse wave in a string is

$$v = \sqrt{\frac{T}{\mu}} \quad \text{_____(}ii\text{)}$$

T is the tension applied to the string and **μ** is the liner mass density

Substituting the above value of υ from (*i*) to (*ii*)

$$f\lambda = \sqrt{\frac{T}{\mu}}$$

$$f = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

whereas the distance l between successive nodes on string give the wavelength of string waves. When string is vibrating in one loop we have

$$l = \lambda/2$$
$$\lambda = 2l$$

and

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

The above equation gives the frequency of transverse wave in a staring.

$$\mu = \frac{1}{4L^2}\frac{T}{f^2}$$

PROCEDURE:

1. Set up the Sonometer as shown in Figure.
2. Set the bridges 60cm apart. Use any of the included strings and hang a mass of approximately 1 kg from the tensioning lever. Adjust the string knob so that the tensioning lever is horizontal. Position the driver coil approximately 5 cm from one of the bridges and position the detector coil near the center of the wire.
3. Set the signal generator to produce a sine wave.
4. Slowly increase the frequency of the signal driving the driving coil, starting with a frequency of 1 Hz. Determine the lowest frequency for a given tension at which resonance occurs. Record this value in table.
5. Record the string tension (T) in the table. Note the distance between the two wedges.

6. Repeat steps (4) and (5) for different values of tension in the string.
7. Plot a graph between f^2 and tension T.
8. Calculate slope of the graph and find out linear density of string by using

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}\,.$$

9. Take one value of tension of string from graph paper and determine velocity of waves in string by

$$v = \sqrt{\frac{T}{\mu}}\,.$$

OBSERVATIONS:

Length of string between two bridges: _____

S.No.	Tension Dyne	Fundamental Frequency(f) Hz	f^2 Hz^2
1			
2			
3			
4			
5			

Graph Paper

CALCULATIONS:

$$\mu = \frac{\mathbf{1}}{\mathbf{4L^2}} \frac{\boldsymbol{T}}{\boldsymbol{f^2}}$$

$$v = \sqrt{\frac{T}{\mu}}$$

RESULT:

The velocity of vibrating string at tension _____ is found to be_____

PRECAUTIONS AND SOURCES OF ERRORS:

1. The wire should be of uniform cross-section, free from kinks and should be tight.
2. If detector is placed too close to the driver, it will pick up some interference. You can check for this interference by observing the waveform from the detector on an oscilloscope; when they are too close, the trace will change shape. For beat results keep the detector at least 10 cm apart from the driver.
3. The weight of the hanger should be included in the load.
4. The wire may not be uniform and form kinks.
5. The friction of the pulley may decrease the value of the applied tension.

PHOTOGRAPH OF THE APPARATUS

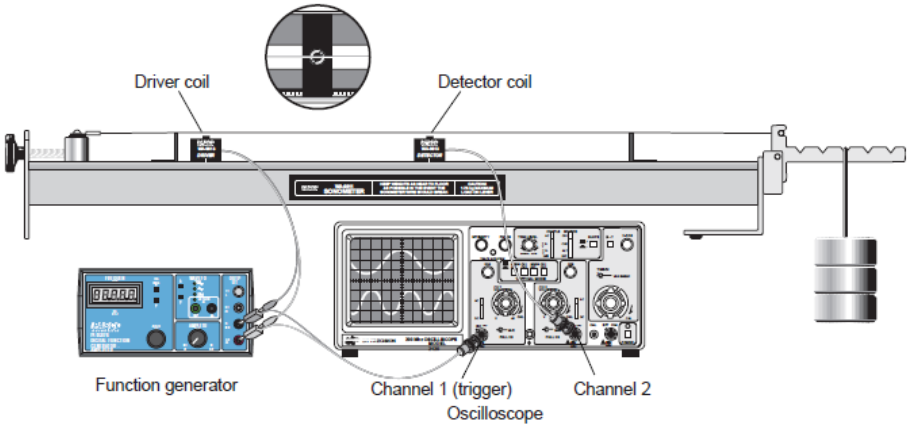


Figure 5 Using the Driver and Detector Coils

VIVA VOCE

Q.1 What is the object of your experiment?

Q.2 What is sonometer?

Q.3 What type of waves is produced on the string?

Q.4 What are nodes and antinodes?

Q.5 Why the sonometer does consists of a hollow wooden box?

Q.6 What do you mean by stationary or standing waves?

Q.7 What is the function of bridges in sonometer?

Q.8 What is resonance?

EXPERIMENT # 04

OBJECT:

To determine the refractive index of the material of a prism using spectrometer.

APPARATUS:

Prism, spectrometer, sodium lamp.

THEORY:

When a ray of light passing through a prism it suffers refraction as shown in fig.If EF is the incident ray, FG the refracted ray and GH the emergent ray, then the angle IDH is the angle of deviation. It is the angle between the direction of incident ray and emergent ray. The angle of deviation depends upon angle of incidence. For a certain value of angle of incident, the angle of deviation is minimum. If D_m denotes the angle of minimum deviation for a given prism of reflecting angle A, Then

The refractive index of the material of prism is given by:

$$\mu = Sin\frac{A+D_m}{2} \Big/ Sin\frac{A}{2}$$

SPECTROSCOPE:

A spectroscope basically consists of three parts: -

(i) Collimator
(ii) Prism table
(iii) Telescope

1. Collimator consists of a tube with s slit at one end and a converging lens at the other. The slit is directed towards the source of light. Width of the slit can be adjusted with the help of a screw. The width of the slit or in other words the width of the light beam is so adjusted that the final images in different wave lengths will be sharp and will not overlap. The slit lies in the focal plane of the lens of the collimator or in other words the distance between the lens and the slit is approximately equal to the focal length of the lens. Hence all the rays of light after passing through the lens will be parallel to each other.

2. Prism table is in the centre of the spectroscope, it can be turned about a vertical axis and it can be made horizontal accurately. After the light has passed through the collimator it passes through the prism, placed on the prism table, which disperses it. Since different wave lengths have different refractive indices, therefore different wave lengths are sent off indifferent directions. Instead of a prism, diffraction grating can also be used, with the help of which wave length of light can be measured accurately.

3. Telescope consists of a tube with a converging lens at each end. Light after passing through the prism or diffraction grating enters the first lens, which brings each beam of parallel rays to focus again, forming sharp image of the slit in each wavelength. These slit images are viewed through the second lens, which acts as a magnifying glass and is called eye piece. The telescope can be swung around a vertical axis and can be focused on different wave lengths of light that appear.

PROCEDURE:

Setting of spectrometer for parallel rays: -

1. Level the prism table horizontally by placing sprit level on it and using the leveling screw.
2. Focus the eye-piece by moving it in or out so that cross-wires are clearly visible without any strain on eye.
3. Rotate eye-piece to make one of the cross-wires vertical.
4. Switch on sodium lamp, open slit and adjust the position of the collimator so that slit is uniformly and brightly illuminated.

For Angle of prism:

5. Clean the prism and place it on prism table with its refracting edge A at the center of the table. Rotate prism table so that refracting edge points towards the collimator and light fall on both the polished faces of the prism.
6. Keeping the prism fixed rotate the telescope towards right hand till the image of the slit is obtained and coincides with vertical wire, note down the telescope reading for R.H.S. Don't disturb prism position and similarly rotate the telescope towards left hand till the image of the slit is obtained and coincides with vertical wire note down the telescope reading for L.H.S.
7. Repeat 5 and 6 two times.

For Angle of Minimum deviation:

8. Note down reading of telescope when image is obtained directly without prism as *Direct Reading* this reading is constant.
9. Adjust the position of prism by rotating table (clock or anti-clock wise) such that at particular angle of incidence angle of deviation is minimum (i-e image is nearest to the direct image without prism) as shown in fig.
10. Note down the reading of the telescope this is the angle of min deviation position
11. Repeat 9and 10 two times, so calculate refractive index of the material of the

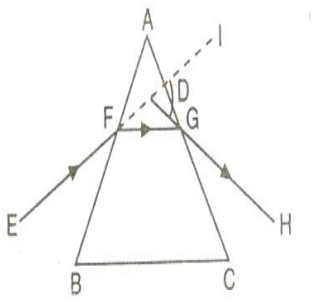


Fig.1

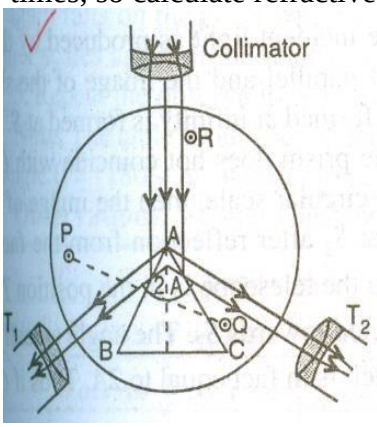


Fig.2

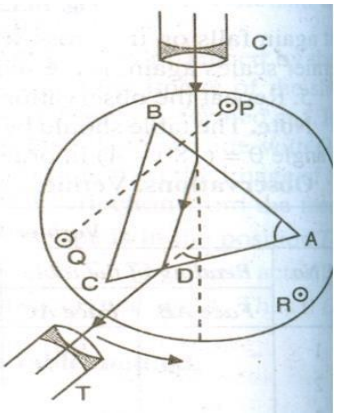


Fig.3

OBSERVATIONS:

Vernier constant =..... Degree.

(a) For Angle of prism:

S.No.	***R.H.S Reading a deg***	***L.H.S Reading b deg***	***Twice of angle of prism*** $\theta = \lvert b - a \rvert$ ***deg***	***Angle of prism*** $\therefore A = \theta / 2$ ***deg***	***Mean A deg***
1					
2					
3					

(b) For Angle of minimum deviation position:

S.No.	***Direct Reading a deg***	***Position of minimum deviation b deg***	***Angle of minimum deviation*** $D_m = \lvert b - a \rvert$ ***deg***	***Mean angle of minimum deviation D_m deg***
1				
2				
3				

CALCULATION:

$$\mu = Sin\frac{A+D_m}{2} \Big/ Sin\frac{A}{2}$$

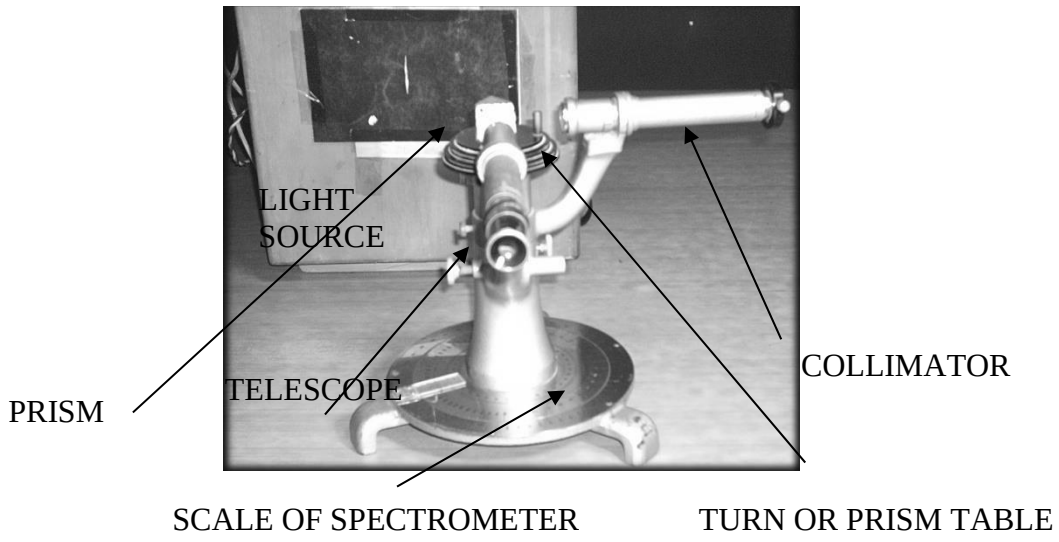
RESULT:

Refractive index of the material of prism if found to be =……

PRECUATIONS AND SOURCES OF ERROR:

1. The apparatus must be carefully leveled by sprit level before starting the experiment.
2. Telescope and the collimator must be focused for parallel rays by Schuster's methods.
3. Parallax must be removed.
4. The slit must be narrow and its, image be sharp and distance.
5. Before focusing telescope, collimator must be focused and once it is focused don't disturb its focusing.

PHOTOGRAPH OF THE APPARATUS



VIVA VOCE

Q.1 What is object of your experiment?

Q.2 What is refractive index of a material?

Q.3 Is there any effect of wavelength on refractive index?

Q.4 What is the relation between refractive index and velocity of light?

Q.5 What is the spectrometer?

Q.6 What are the different parts of a spectrometer?

Q.7 What is the angle of minimum deviation?

Q.8 Why the white light dispersed when passed through a prism?

Q.9 In visible spectrum which wave deviated more(red or blue)?

Q.10 What is an spectrum and how it is formed?

Q.11 What is a monochromatic light?

Q.12 What do you mean by ionization?

Q.13 How is the sodium light produced in a sodium lamp?

Q.14 What do you mean by diffraction of light?

Q.15 Differentiate between interference and diffraction.

EXPERIMENT # 05

OBJECT:

To compare the mass per unit length of two strings

APPARATUS:

WA-9611 Sonometer, WA-9613 Driver/Detector Coils, Function Generator, Dual trace oscilloscope, Mass and mass hanger.

THEORY:

When two exactly same waves (i-e.same amplitude, frequency and time period) travel in opposite direction with same velocity superimpose on one another the resultant wave obtained is called *standing* or *stationary wave*.

Hence, we can say that the wave length of standing wave in a vibrating string may be a function of the tension, liner mass density of string, frequency and the velocity of the wave.

If λ is the wavelength of standing wave and υ is their velocity, the frequency of the vibration f can be determined by the relation.

$$\upsilon = f\lambda \quad \text{_____} (i)$$

The velocity of transverse wave in a string is

$$v = \sqrt{\frac{T}{\mu}} \quad \text{_____} (ii)$$

T is the tension applied to the string and **μ** is the liner mass density

Substituing the above value of υ from (*i*) to (*ii*)

$$f\lambda = \sqrt{\frac{T}{\mu}}$$

$$f = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

whereas the distance l between successive nodes on string give the wavelength of string waves. When string is vibrating in one loop we have

$$l = \lambda/2$$

$$\lambda = 2l$$

and

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

The above equation gives the frequency of transverse wave in a staring.

$$\mu = \frac{1}{4L^2}\frac{T}{f^2}$$

PROCEDURE:

10. Set up the Sonometer as shown in Figure.
11. Set the bridges 60cm apart. Use any of the included strings and hang a mass of approximately 1 kg from the tensioning lever. Adjust the string knob so that the tensioning lever is horizontal. Position the driver coil approximately 5 cm from one of the bridges and position the detector coil near the center of the wire.
12. Set the signal generator to produce a sine wave.
13. Slowly increase the frequency of the signal driving the driving coil, starting with a frequency of 1 Hz. Determine the lowest frequency for a given tension at which resonance occurs. Record this value in table.

14. Record the string tension (T) in the table. Note the distance between the two wedges.
15. Repeat steps (4) and (5) for different values of tension in the string.
16. Plot a graph between f^2 and tension T.
17. Calculate slope of the graph and find out linear density μ_1 of string by using

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}\ .$$

18. Replace the string in the sonometer and repeat step 11 to 17.
19. Note down the linear density of string as μ_2

OBSERVATIONS:

For linear density μ_1:
Length of string between two bridges: _____

S.No.	Tension Dyne	Fundamental Frequency(f) Hz	f^2 Hz^2
1			
2			
3			
4			
5			

For linear density μ_2:
Length of string between two bridges: _____

S.No.	Tension Dyne	Fundamental Frequency(f) Hz	f^2 Hz^2
1			
2			
3			
4			
5			

Graph Paper

CALCULATIONS:

$$\mu_1 = \frac{1}{4L^2}\frac{T}{f^2}$$

$$\mu_2 = \frac{1}{4L^2}\frac{T}{f^2}$$

$$\frac{\mu_2}{\mu_1} = \_\_\_\_\_$$

RESULTS AND DISCUSSION:

The ratio of linear mass density of both strings, μ_2/μ_1 is found to be :_____

PRECAUTIONS AND SOURCES OF ERRORS:

6. The wire should be of uniform cross-section, free from kinks and should be tight.
7. If detector is placed too close to the driver, it will pick up some interference. You can check for this interference by observing the waveform from the detector on an oscilloscope; when they are too close, the trace will change shape. For beat results keep the detector at least 10 cm apart from the driver.
8. The weight of the hanger should be included in the load.
9. The wire may not be uniform and form kinks.
10. The friction of the pulley may decrease the value of the applied tension.

PHOTOGRAPH OF THE APPARATUS

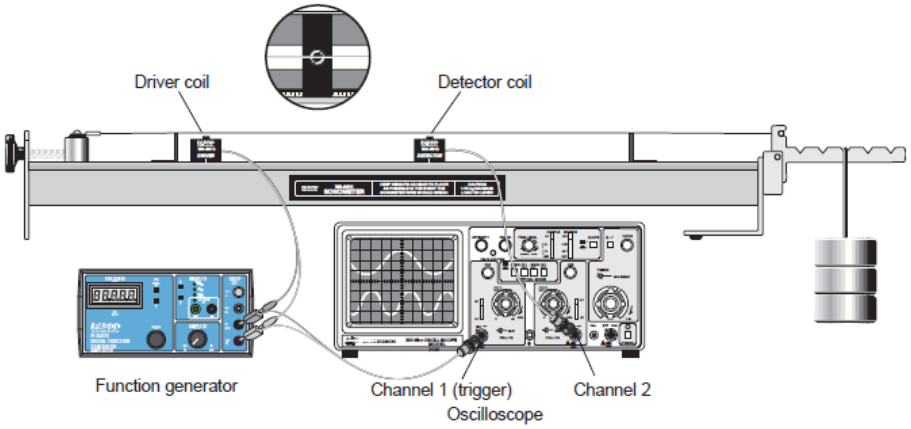


Figure 5 Using the Driver and Detector Coils

VIVA VOCE

Q.1 What is the object of your experiment?

Q.2 What is sonometer?

Q.3 What type of waves is produced on the string?

Q.4 What are nodes and antinodes?

Q.5 Why the sonometer does consists of a hollow wooden box?

Q.6 What do you mean by stationary or standing waves?

Q.7 What is the function of bridges in sonometer?

Q.8 What is resonance?

EXPERIMENT # 06

OBJECT:

To determine the wavelength of sodium light using diffraction grating

APPARATUS:

Spectrometer, sodium discharge tube with its power supply, diffraction grating, magnifying glass

WORKING FORMULA:

The wavelength of any spectral line can be calculated by the formula

$$m\lambda = a \sin\theta$$

Where

a = width of grating element (The spacing d between the slits on the diffraction grating can be calculated from the manufacturer's specification that the gratings have been ruled with N lines per cm $\therefore a = \frac{1}{N}$)

m= order of spectrum.

THEORY:

Diffraction gratings with a high line density resolve interference maxima into very sharp and widely spaced fringes. Moreover, the fringes are so narrow and so widely spaced that the different wavelengths of light passing through the grating produce fringes at angles sufficiently different that they can be distinguished from one another. That is, the deviation angle at which bright fringe is produced depends upon the wavelength of the light.

The angles at which these bright fringes occur can be measured with a device called a spectrometer. These angles, along with the diffraction grating line spacing can then be used to calculate the wavelength of the light passing through the grating via the grating equation

$m\lambda = a \sin\theta$ $\quad m = 1,2,3 \ldots\ldots\ldots$ (2.1)

where the order of the spectrum is given by the integer values of m. Light emitted from an elemental gas typically consists of a number of discrete wavelengths (colors). A grating spectrometer can be used to determine the wavelengths of these colors.

Spectrometer

A diagram showing the basic parts of a spectrometer is shown in Figure 2.1. Light enters the collimator through a slit at the front of the spectrometer. The collimating lens focuses the light into a parallel beam, which then passes through either a diffraction grating or a prism placed on the prism table. After being bent through some angle, the beam of light is then viewed through the telescope, which can be rotated until the image of the slit is centered on the cross hairs. The angle that the light has been bent through can then be read on the protractor using the vernier scale attached to the telescope.

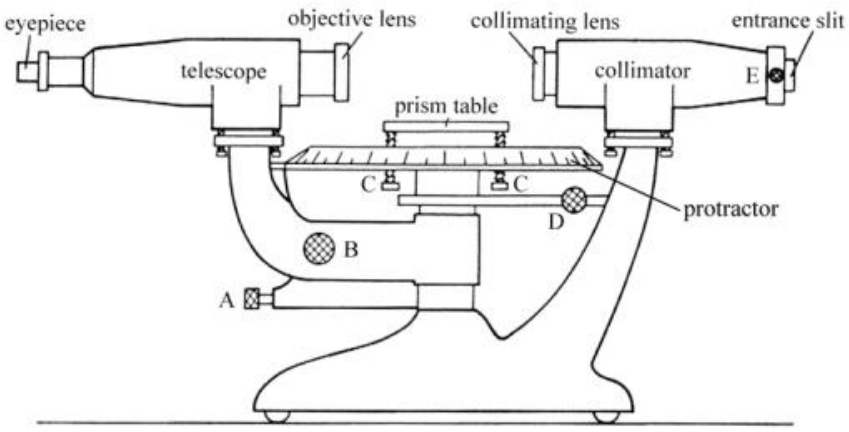


Figure 2.1

A. The knob at A is used to clamp the telescope in place so that it cannot be moved. It should always be loosened when large adjustments to the telescope's position are made.

B. The knob at B is used to finely adjust the position of the telescope. Knob A must be clamped before the fine adjustments can be made.

C. The knobs at C can be used to level the prism table with respect to the optical axis. Consult with your lab instructor before attempting this.

D. The knob at D is used to clamp the protractor as well as the prism (and grating) table. It must be clamped when angular readings are taken with the combination of the protractor and vernier scales.

E. The knob at E is used to adjust the width of the slit at the front of the collimator. One edge of the slit remains fixed on the optical axis, the other edge is adjustable.

The initial adjustment of the spectrometer consists of adjustments to the telescope and the collimator. First, adjust the eyepiece of the telescope so that the cross hairs are sharply focused. Next, swing the telescope to one side and point it at some distant object. (Take it out into the hall.) Adjust the telescope lens until the object is as sharply focused as possible and eliminate parallax between the image and the cross hairs. Once these adjustments have been made, they should not be touched for the rest of the experiment. Next, place a light in front of the entrance slit of the collimator. View the slit through the telescope. Adjust the collimator lens until the image of the slit is in the plane of the cross hairs. You should use parallax focusing to accomplish this. After these adjustments have been made, the light entering the slit on the front of the collimator will be focused into a parallel beam by the collimator lens. It will then be focused on the cross hairs of the telescope by the objective lens of the telescope. This image of the slit can then be viewed through the eyepiece.

PROCEDURE:

1. The setting of the telescope and the focusing of the collimator should be carried out as described in theory.
2. Then the grating should be accurately aligned perpendicular to the incoming light beam using the following procedure. Note the vernier reading with the undispersed image centered on the crosshair with the telescope in the straight-through position, and the grating removed. Rotate the telescope through 90° and clamp it in position. Mount the diffraction grating at the center of the spectrometer table. Rotate the grating so that it reflects the undispersed light toward the telescope.in this position the plane of the grating is inclined at an angle of 45° the incident light. Note the reading. Rotate the table by precisely 45° from this position so that the grating is normal to the collimator axis. Clamp the table in this position.
3. Unclamp the telescope and rotate it by precisely 90° back to the straight through position (T_0 in Fig.2.2) Check that the image is again centered on the crosshairs and record the vernier reading.

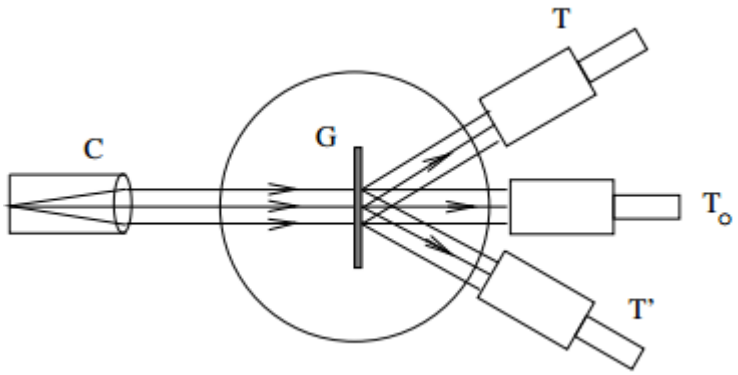


Figure 2.2

4. If the resolving power of the grating is suffiently high two distinct narrow lines corresponding to the wavelength 5890Å and 5896Å will appear as one in the first order spectrum. Turn the the telescope till the vertical cross wire coincides with the center of the image of the slit. Note the reading of the scale on the veriner. Similarly observe the first order spectrum on the other side of the direct image and note down the reading.
5. If the two angles differ by more than a few minutes of arc, the procedure should be repeated.

6. Similarly note the reading of the vernier reading by setting the telescope on the second order diffracted image.
7. Note the number of lines per inch as marked on a grating and replace it carefully in the box with ruled surface upward.

OBSERVATION:

Vernier constant=

Number of lines per inch on the grating N=……

a= 2.54/N =…… cm

Direct reading of the telescope:…..…..…..…..….

S.no	Order of spectrum	Color yellow	Spectrum on left side reading of telescope			Spectrum on right side reading of telescope			2θ=(a-b)	θ mean
1	**m=1**	i	MS	VS	TR	MS	VS	TR		
2										
1		ii								
2										
1	**m=2**	i								
2										
1		ii								
2										

CALCULATION:

RESULTS:
Wavelength of sodium light as calculated from

1st order spectrum

$\lambda_i =$ m $\lambda_{ii} =$ m

2nd order spectrum

$\lambda_i =$ m $\lambda_{ii} =$ m

Mean Wavelength
$\lambda_i =$ m

$\lambda_{ii} =$ m

RESULT AND DISCUSSION:

……
……
……
……

SOURCES OF ERROR AND PRECAUTIONS:

1. Before performing the experiment, the spectrometer should be adjusted.
2. Grating should be set normal to the incident light.
3. While taking observation, telescope and prism table should be kept fixed.

VIVA VOCE

Q.1 What is the object of your experiment?

Q.2 What is diffraction?

Q.3 What is diffraction grating?

Q.4 What is the condition for maxima in diffraction pattern?

Q.5 What is the condition for minima in diffraction pattern?

Q.6 How intensity of light varies in diffraction pattern?