List of Experiments for B. Tech. 1st Year Physics Laboratory 2023-24

1. To study the variation of magnetic field with position of paired coils in Helmholtz arrangement along the axis of the coils carrying current.
2. Determination of reverse saturation current I_0 and material constant in PN junction.
3. Study the temperature dependence of resistivity of a semiconductor (Four probe method) and to determine band gap of experimental material (Ge).
4. Measuring the surface tension using the 'break-away' method.
5. To determine the first excitation potential of a gas by Frank- Hertz Experiment.
6. To determine Planck's Constant and work function using photo electric effect.
7. To study the intensity distribution due to diffraction from single slit and to determine the slit width.

INSTRUCTIONS TO STUDENTS

1. Essential Component:

Laboratory work is an integral part of the course and satisfactory completion of it is required. Your performance in the laboratory is taken into account in evaluating the performance in the course. The laboratory grade is based on the reports you write, and on your performance in examinations on laboratory work.

The objective of the laboratory is learning. The experiments are designed to illustrate phenomenon of different areas of Physics and to expose you to measuring instruments. Conduct the experiments with interest and with an attitude of learning. The duration of the laboratory is for 2 hours. You are supposed to be fully engaged for the complete duration of the laboratory. You cannot leave the laboratory until the completion of the laboratory class hours. Work quietly and carefully.

2. Pre-lab Preparedness:

Be prompt in arriving to the laboratory and come well prepared for the experiment. Before coming to the laboratory class you must carefully read the instructions given for performing the experiment of the day. Unless you come fully prepared with this background material you will not be able to complete the required work and you will miss the opportunity of learning all aspects of the experiment. Thus, for your own benefit, prior study of the instruction manual is very important.

3. Equipment needs your care:

On reaching the laboratory you should check the apparatus provided and ascertain if there are any shortage or malfunctions. Set up the equipment in accordance with the instructions. Proceed carefully and methodically. Remember that scientific equipment is expensive and quite susceptible to damage. So handle it carefully. If the apparatus is complicated ask the instructor to inspect before you proceed with the actual performance of the equipment. Every time switch off the setup before leave. Please do not fiddle idly with apparatus. Handle instruments with care. Report any breakage to the instructor. Return all the equipment you have signed out for the purpose of your experiment.

4. You must bring practical notebook and an observation record book in every practical class for recording the observations. All work must be done in ink.

You must get at least one observation checked and signed by your instructor, failing which, your report will not be graded. Make the measurements required and record them neatly in tabular form. Double-check to make sure that you have recorded all necessary data. You must complete all experimental work in one class of two hours. After completing the experiments get the reading signed by the instructor and get new experiment allotted for the next turn.

The completed report must be submitted in next practical class and get it checked by the concerned faculty. You must be ready for viva about the experiment being checked because you will be evaluated in each class for sessional marks.

5. Acceptable results with given apparatus:

It is more important to see what results you get with given apparatus rather than what is the 'correct' result. The apparatus given to you is capable of certain accuracy and your result may be completely acceptable even if it differs from 'correct' results. You must learn to do things on your own even if you might make mistakes some time.

Be totally honest in recording and representing your data. Never make up readings or doctor them to get a better fit for a graph. If a particular reading appears wrong repeat the measurement carefully. In any event all the data recorded in the table have to be faithfully displayed on the graph.

6. Graphics:

Each graph should occupy one complete sheet; the information as to quantities plotted, scale chosen and units should be mentioned clearly in ink along complete figure caption. All presentations of data, table, graphs and calculations should be neatly and carefully done.

7. Figures/Circuit diagrams:

Neat and clean figures/ circuit diagrams should be drawn for each practical with complete figure captions.

8. Following is the Format of the Reports:

a. Date
b. Objective
c. Apparatus used
d. Formulae used
e. Observation (least count, tables should be neat and self explanatory)
f. Calculations (on the left side of the page) including maximum permissible error (MPE).
g. Results: Experimental value ± MPE; Standard value (Calculation of maximum possible error is essential. Compare it with the result)
h. Precautions and sources of error.

You must keep your work place neat and clean and leave the lab neat and tidy.

Link for the Lab Manuals/Videos – https://www.iitr.ac.in/
Click on Departments → Physics → Academics → Teaching Laboratories → B.Tech Lab for 1st year.

O.C. B.Tech. Lab

Errors in Measurement

Measurement is the basis of scientific study. All measurements are, however, approximate values (not true values) within the limitation of measuring device, measuring environment, process of measurement and human error . If you measure the same object two different times, the two measurements may not be exactly the same. The difference between two measurements is called a **variation** in the measurements.

Another word for this variation - or uncertainty in measurement - is "**error**." This "error" is not the same as a "mistake." It does not mean that you got the wrong answer. The error in measurement is a mathematical way to show the uncertainty in the measurement. It is the difference between the result of the measurement and the true value of what you were measuring. We seek to minimize uncertainty and hence error to the extent possible.

Further, there is important aspect of reporting measurement. It should be consistent, systematic and revealing in the context of accuracy and precision.

Accuracy is a measure of how close the result of the measurement comes to the "true", "actual", or "accepted" value. It is associated with systematic error.

Precision of measurement is related to the ability of an instrument to measure values in greater details. The **precision of a measuring instrument** is determined by the smallest unit to which it can measure. The precision is said to be the same as the smallest fractional or decimal division on the scale of the measuring instrument. It is associated with random error.

Ways of Expressing Error in Measurement:

1. Greatest Possible Error:

Because no measurement is exact, measurements are always made to the "nearest something", whether it is stated or not. The **greatest possible error** when measuring is considered to be one half of that measuring unit. For example, you measure a length to be 3.4 cm. Since the measurement was made to the *nearest tenth*, the greatest possible error will be half of one tenth, or 0.05. For example, if a measurement made with a metric ruler is 5.6 cm and the ruler has a precision of 0.1 cm, then the tolerance interval in this measurement is 5.6 $\pm$ 0.05 cm, or from 5.55 cm to 5.65 cm. Any measurements within this range are "tolerated" or perceived as correct.

2. Absolute Error and Relative Error:

Error in measurement may be represented by the actual amount of error, or by a ratio comparing the error to the size of the measurement.

The **absolute error** of the measurement shows how large the error actually is, while the **relative error** of the measurement shows how large the error is in relation to the correct value.

Absolute errors do not always give an indication of how important the error may be. If you are measuring a football field and the absolute error is 1 cm, the error is virtually irrelevant. But, if you are measuring a small machine part (< 3cm), an absolute error of 1 cm is very significant. While both situations show an absolute error of 1 cm., the relevance of the error is very different. For this reason, it is more useful to express error as a relative error. We will be working with relative error.

Absolute Error:

Absolute error is simply the amount of physical error in a measurement.

$$E_{absolute} = | x_{measured} - x_{accepted} |$$

For example, if you know a length is 3.535 m $\pm$ 0.004 m, then 0.004 m is an absolute error. Absolute error is positive.The absolute error is the difference between the measured value and the actual value. (The absolute error will have the same unit label as the measured quantity.)

Relative Error:

Relative error is the ratio of the absolute error of the measurement to the accepted measurement. The relative error expresses the "relative size of the error" of the measurement in relation to the measurement itself.

$$\text{Relative Error} = \frac{|\text{measured value - actual value}|}{\text{actual value}}$$

Percent of Error or Percentage Error:

Error in measurement may also be expressed as a **percent of error.** The percent of error is found by multiplying the relative error by 100%.

$$\text{Percent of Error} = \frac{|\text{measured value - actual value}|}{\text{actual value}} \cdot 100\%$$

We must understand that an error in basic quantities propagate through mathematical formula leading to compounding of errors and misrepresentation of quantities

The error is communicated in different mathematical operations as detailed below:
(i) For x = (a ± b), $\Delta x = \pm(\Delta a + \Delta b)$
(ii) For x = a * b , $\Delta x/x = \pm(\Delta a/a + \Delta b/b)$
(iii) For x = a/b , $\Delta x/x = \pm(\Delta a/a + \Delta b/b)$
(iv) For $x = a^n b^m / c^p$, $\Delta x/x = \pm(n\Delta a/a + m\Delta b/b + p\Delta c/c)$

<u>General Rule:</u>

Let $$Z = \frac{A^p * B^q}{C^r},$$

Taking log on both sides

$$\log Z = p*\log A + q*\log B - r*\log C$$

Differentiating we get $$\frac{dZ}{Z} = p\frac{dA}{A} + q\frac{dB}{B} - r\frac{dC}{C}$$

then maximum fractional error in Z is given by

$$\frac{\Delta Z}{Z} = p\frac{\Delta A}{A} \pm q\frac{\Delta B}{B} \pm r\frac{\Delta C}{C}$$

Some Examples :

Example(1)

Let y=ab.
Then max. permissible error (m.p.e.) in y is obtained as
ln y=ln a + ln b, or $\Delta y / y = \Delta a / a + \Delta b / b$
here Δa is the least count of the instrument with which a is measured, similarly Δb is the least count of the instrument with which b is measured and y is the mean value of the function obtained in the lab. Hence the experimental value of y = mean $y \pm \Delta y$.

Example(2)

The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{L/g}$. Measured value of L is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1 s resolution. What is the accuracy in the g?

Solution :

As $T - 2\pi\sqrt{\frac{L}{g}}$ or $g = 4\pi^2(L/T^2)$

$$\therefore \frac{\Delta g}{g}\times 100 = \frac{\Delta L}{L}\times 100 + 2\times\frac{\Delta T}{T}\times 100$$, Now L=20.0cm, ΔL =0.1cm, T for 100 oscillation = 90sec , ΔT =1 sec

$$\therefore \frac{\Delta g}{g}\times 100 = \frac{0.1}{20.0}\times 100 + 2\times\frac{1}{90}\times 100$$ = 0.5+2.22=2.72%=3%

Example(3)

Find the relative error in Z, if $Z = A^4 B^{1/3} / CD^{3/2}$

Solution . In relative error in Z is $\frac{\Delta Z}{Z} = 4\times\frac{\Delta A}{A} + \frac{1}{3}\times\frac{\Delta B}{B} + \frac{\Delta C}{C} + \frac{3}{2}\frac{\Delta D}{D}$

Example(4)

A physical quantity X is given by $X = \frac{a^2 b^3}{c\sqrt{d}}$. If the percentage errors of measurement in a,b,c and d are 4%, 2%, 3% and 1% respectively, then calculate the percentage error in X.

Solution Given $X = \frac{a^2 b^3}{c\sqrt{d}}$, The percentage error in X is given by

$$100\times\frac{\Delta X}{X} = 2\frac{\Delta a}{a}\times 100 + 3\frac{\Delta b}{b}\times 100 + \frac{\Delta c}{c} + \frac{1}{2}\frac{\Delta d}{d}\times 100$$ =2x4% + 3x2% + 3% + 1/2x1%

Diameter of the wire causes maximum error in the value of γ

Example(5)

The specific resistance σ of a thin wire of radius r cm, resistance R Ω and length L cm given by $\sigma = \frac{\pi r^2 R}{L}$

If r=0.26 $\pm$ 0.02 cm, R=32 $\pm 1\Omega$ and L= 78 $\pm$ 0.01 cm, find the percentage error in σ.

Solution The percentage error in specific resistance σ is given by

$$\frac{\Delta\sigma}{\sigma}\times 100 = \left(2\frac{\Delta r}{r} + \frac{\Delta R}{R} + \frac{\Delta L}{L}\right)\times 100 = \left[\frac{2\times 0.02}{0.26} + \frac{1}{32} + \frac{0.01}{78}\right]\times 100$$ = [0.15 + 0.03 + 0.0001]x100 = 0.1801x100 = 0.18x100 = 18%