COURSE GUIDE

This physics practical has been designed in such a way that you will develop some manipulative skills in handling some physics apparatus.

This physics practical course will show you how to

Determine the relationship between the two variables in form of a graph.
Thus the first thing you have to do is to study the concept of graph in Unit I.
In measurement, you are supposed to be accurate as possible but no measurement is absolutely correct because of the errors that are bound to occur due to personal errors.

Getting Set for the Practical

You are supposed to read the experiment, as many times as possible so that you know how you will carryout the experiment in question.
On the day of the experiment you are to make sure that you assemble all the apparatus required from the Laboratory Technologist Set up the apparatus carefully and neatly on the working bench.

Estimation of errors where possible

There is no need to repeat in your report, the section on apparatus, procedure or theoretical consideration.

[...]

Dr.

[...]

As a physics student, you will be involved in observing some physical phenomena and measuring physical quantities such as length, mass, time, temperature and current of electricity. These are called fundamental physical quantities.

Thus in your practical sessions in the laboratory, you will be developing practical skills in measuring physical quantities and the show the relationship between the two physical quantities to be measured through the use of

In this unit therefore, you will be introduced to the various types of graphs and how to use such graphs to obtain the physical constants required.

There are two types of variables independent variable dependent variable

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For example, if the value of quantity P depends on the value of quantity Q, then, Q is the independent variable while P is the dependent variable.
For example, the change in position of an object with respect to time. Time is regarded as the independent variable while the change in position is regarded as the dependent variable.

[...]

When x = 3 then y = 3m and so on.

Increase in y - Increase in y = m = Δy

Thus a straight line through the origin shows that the quantity y is directly proportional to x.

[...]

When x = 3 then y = 3m +band soon.
Again if we plot the graph of y on the vertical axis against x on the horizontal axis we also obtain a straight line.

Increase in y

If the line slopes downwards as shown in fig.

Increase in ℓ

The value of g, acceleration due to gravity may then be substitution of values of known variables in the relation.

[...]

= K a constant The oscillation of a weighted spiral spring is another example.

Increase in M
The intercept on the vertical axis is obtained when M = 0.

RELATIONSHIP

Suppose two physical quantities P and Q are related as P = kQn where the values of k and n are not known we can reduce the expression to a linear one by taking the logarithm of both sides of the equation.

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[...]

Thus the value of k is obtained.

3=-3+x x=

The antilog of 0.2700 = 1.86

POINT

From the equations y = mx +b the highest power to which x is raised is 1 hence when y is plotted against x, we obtain a straight line graph.
But for equations such as y = ax2 y = ax + bx y = ax2 + c they produce non-linear graphs because when you plot the values of y against x, we do not produce a straight line graph. You will observe that the graphs produced are usually parabolic because they are quadratic functions. The equations are described as being quadratic because the highest power to which x is raised is 2.

BK

AK which must be interpreted to scale.
Displacement-time, velocity-time and Newton's cooling curves are examples of nonlinear graphs, which enable us to measure the rate of change of displacement, velocity and other quantities such as temperature with time.

Time in minutes

Temperature in °C t/0C t/min The gradient or slope is obtained from the tangent drawn on the graph at time t = 2 min.

See Text

Graphs are pictorial ways of showing how two physical measurements are related.

Then the equation that relates the two variables such as y and x are expressed y = mx or y = mx + c y = dependent variable m = the slope or gradient of the slope c = intercept on the y-axis when x = 0

The first equation tells us that the line passes through the origin while the second equation does not.

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Suppose the formula relating T and M is M +m where m = effective mass of the spring and k = spring constant

Determine the values of m and k.

[...]

In carrying out scientific investigations as in physics practical, we know that scientists use devices to measure and thereby quantify physical quantities.
But even the best of devices yield inexact measurements. We express these measurements as approximate numbers. We distinguish between numbers such as 3.2 cm and 3.20 cm. These are the results of measurements using different devices. While doing computations with these numbers special care is required.

ERRORS: EXPRESSING THE RESULTS OF MEASUREMENTS

We are familiar with at least two reasons why all measurements are inexact.
Firstly, the measuring instrument itself, such as the zero error, causes error.
Secondly, error can be due to limitations of human judgement and perception, such as in aligning the end of a rod to be measured with the zero of the centimetre scale. To better appreciate the inexact nature of measurement let us reflect on the process of measurement of length. Let us obtain a `perfect' centimetre scale, which has clear and equal marking of millimetres. We desire to measure the length of three arrows A, B and C .

POSSIBLE ERROR AND PRECISION

We have seen that the maximum possible error, barring any mistake in measuring, in a measurement is 1/2 of the unit of measurement. The possible error is thus due to inherent imprecision in measuring devices.

[...]

So far we have considered measurement of nearly equal lengths with emphasis on precision. Let us now consider measurement of much different lengths. Suppose, two measurements yield 3.2 cm and 98.6 cm using the same metre stick.

*Relative error is the ratio of possible error to the total measurement

Let us compare measurements 3.2 cm and 98.6 cm. Both have equal unit of measure and are therefore equally precise. But the measurement 98.6 cm has less relative error and is therefore more accurate.
Comparison of measurements 7.4s and 98 s is more revealing.

SCIENTIFIC NOTATION

In the system of measurement that we use a measurement is expressed in decimal numerals. While measuring interatomic distances, we use very large,` numbers. On the other hand, while measuring interstellar distances we use very large numbers.

SIGNIFICANT DIGITS

We have seen in section 3.1.1 that a measurement reported as 5.32 cm is more precise than 5.3 cm. The number of digits in these measurements are three and two, respectively.

Possible Error

We can see from this table that the unit of measure and the possible error in all the cases are different.

[...]

S/No.

They are significant

They are also significant. The zeros are significant only if they come from a measurement.

Significant

From the above discussion justify that a measurement possessing greater number of significant digits has greater relative accuracy.

COMPUTATIONS WITH APPROXIMATE NUMBERS

In section 3.1, we have seen that the reported measurements have errors in the last digit.

MULTIPLICATION AND DIVISION

Let us consider multiplication first. We want to multiply 1. 23 by 2. 3.
We see that the product contains three digits, which contain errors.

RULE: The product of two measurements should be rounded off

Divide 2.1 by 1.54.

SOLUTON

Let us consider the multiplication of the following numbers, which have already been rounded off to significant digits.
which must be rounded of to 3.9 x 102.

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ADDITION AND SUBTRACTION

9 so that it contains only one digit containing error. Rounding off is necessary because the sum cannot be more precise than individual measurements. We note that the sum 5.

Se l f Assessment Question 9

Subtract 2.11 from 2.1546
Self Assessment Question. 10.
Compute the sum of 2.1546 m, 2.11 m and 2.125 m.
HINT: In such cases we can use the following saving rule.
Labour Saving Rule: Before adding round off the numbers so that they contain one more digit of precision than the number of precision digits in the least precise. Thus the addends become 2.155 m, 2.11 m and

[...]

In the last unit we studied about errors in measurements due to imprecision of measuring devices. The results of measurements were expressed as approximate numbers. We also learn about performing basic operations of addition, subtraction, multiplication and division of approximate numbers and expressing results using correct number of significant digits. We assumed that the measuring instruments as well as the observers were perfect.
However, as you are aware, there can be defects in measuring instruments and also humans are not perfect.

TYPES OF ERRORS

Every measuring instrument has a limitation in that it cannot measure physical quantities smaller than a certain value known as the least count of instrument. For example, a meter scale can measure only up to 1 mm .

SYSTEMATIC ERRORS

The systematic errors, also called determinant errors, are due to causes which can be identified.

Zero Error

In the case of vernier callipers, for example, when the jaws are in contact, the zero of the vernier may not coincide with the zero of the main scale.

Back lash Error

While measuring a physical quantity there may be an error due to wear and tear in the instruments like screw gauge or spherometer due to defective fittings.

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End Correction

Sometimes the zero marking of the metre scale may be worn out.

Errors due to changes in the Instrument parameters

Usually, in experiments involving electrical quantities, the value of the electrical quantities change during the course of the experiment due to heating or other causes.

Defective Calibration

Occasionally instruments may not be properly calibrated leading to errors in the results of measurement.

Environmental

These arise due to causes like unpredictable fluctuations inline voltage, variation in temperature etc. They could also be due to mechanical vibrations and wear and tear of the systems.

True value

Fig. 1 Set of measurements. Each point indicates the result of a measurement

DETERMINING SIZE OF ERROR

When we measure a quantity it is important to take several readings. It may be preferable that readings are taken by independent observer. This has the advantage that bias of a single observer is eliminated. The value obtained will indicate whether the data is scale limited or random. An error analysis can be made to determine the size of error from these readings. A typical set of values of a measurement is given below in table l.

S=d

√n where d is the average derivation and n is the number of observations. The precision index S is a measure of uncertainty of average. Using the data of table l, the precision index is S = d = 0.009 = 0.003

PROPAGATION OF ERROR

We have so far learnt how to determine the error in the measurement of a quantity, which can be measured directly.

ERROR PROPAGATION IN ADDITION AND SUBTRACTION

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Let us take the differential of this quantity, we get E = x + y + z if the error is small compared to the measurement we can replace the differential by `delta' to get E = x + y + z which is simply the sum of errors in x, y and z.

+ B

RULE 1: When independent measurements are multiplied or divided the fractional error in error in the result is the square root of the sum of squares of fractional errors in individual quantities.

+ T

V = 0.368 ms-1 x 0.07 = 0.02 ms-1

OPERATIONS

Errors in exponential quantity: Let us first consider a special case where a quantity appears with an exponent. For example, S = A2 = A x A. Here the two numbers multiplied together are identical and hence not independent. The rule mentioned above does not apply. Detailed analysis shows that logarithmic error gives a good estimate.

Error in -3 = 3 2 + 2

Similarly in other mathematical operations and deducing results from graphs the flowing rule is used.
RULE: The error in the result is found by determining how much change occurs in the result when the maximum error occurs in the data.

A brief title may be given at the top

Label the axes with the names of the physical quantities being presented along with units. It is customary to plot the independent variable on the x-axis and the dependent variable on the y-axis . We would write to the name of the variable represented on each axis along with units in which they are measured.
We should choose the range of the scales on the axis so that the points are suitably spread out on the graph paper and not cramped into one corner. Check for the minimum and maximum values of the data that has to be plotted.

[...]

In the above example, we have plotted the variable V, which is a linear function of T in a linear graph paper.

Money left with the man N K x 102

Let us plot these data on a linear graph paper. The paper will be of the type shown in fig. 3. Look at the graph carefully. You will find that seven of the ten experimental points are clustered together near the bottom right-hand corner of the graph.

[...]

Now plot log M against days as shown in fig. 4. You obtain a graph in which points are more clearly spaced evenly and hence you can more easily draw a straight line through the points. You might have realised that working out the log values for each data is tedious and it also introduces another step, which may introduce error between the data and the graph. Therefore, to plot such a data we use a graph paper called semi-logarithmic or log-linear graph paper where the lines on one axis have been drawn in a logarithmic fashion.

200 then log M

0=b+0 or b=2.30...y=2.30+kt

Putting these values in equation we get

93=2.30+7k.'. The slope k = - 2.1 = -0.3 and the equation of the straight line is y = 2.3-0.3t
From the graph of fig. 5 or in other words from equation can you find the equation of the curve plotted in fig. 3?

R 3 = kT 2

Where k is another constant.
If you consider the experimental data that shows how the quantity T depends on quantity R you will observe that R varies by two orders of magnitude and T varies by three orders of magnitude. In other words the experiment data follows equation . For a moment, suppose you do not know the exact relationship between the variables T and R. The you can suppose that R = kT n where n is another constant.
Now you will plot log R vs. log T on a linear graph paper.

[...]

It appears that most of our students are under the impression that the value of is equal to exactly. Unfortunately many books writers also have contributed to perpetuate and establish this false idea by setting numerical problems with data cooked up that using = 7, the factor always happily cancels out and the simplification becomes very easy.

For practical purposes at undergraduate level, the most convenient and comparatively more accurate thing to do will be to remember

Wherever the value of 7r is to be used in our calculations, the above values prove fruitful.

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In this unit you have been able to distinguish between random errors and systematic errors when measuring physical quantities and know Systematic errors to some extent, can be eliminated. Errors in the measurement of various physical quantities can also be computed. When graphs are used to show relationship between certain physical quantities, they can also be used to determine the errors in the calculation of slopes.

The restoring force F = mg sin Θ

Where, m = mass of bob and g = acceleration due to gravity.

From a = -g sin Θ

When Θ is very small then sin Θ = Θ rad.'. a = -g Θ

Compare

Where, 2 = angular velocity.'.

T=2 ℓ

To obtain T, we shall then find the time for 20 oscillations.

[...]

= 85 cm, 75 cm, 65 cm, 55 cm 45 cm.

[...]

Estimate the error in g.

[...]

The intercept of the graph on the x-axis i.e. when T2 = 0 gives us the height H of the room.

[...]

Plot the graph of T2 on the vertical axis and h on the horizontal axis.

[...]

Now with the assistance of your friend, determine the height H of the room by using a tape.

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[...]

Metre Rule The spiral spring will behave as an elastic material if subjected to a force.
Provided its elastic limit is not exceeded you will expect that Hooke's law will be obeyed.

If the graph of the force F is plotted against the extension we shall obtain a linear graph like this

F/N.
∆F e/cm.

[...]

Plot the graph of weight in newtons on the y-axis against the extension on the x-axis.

[...]

Let M be the mass of the slotted weight.

F=Mg = ke

If the mass is pushed down through a displacement x due to a small increased force F.

F = ke + kx - ke F = kx = Ma where, a = acceleration imparted to mass M

Ma = kx.'. a = - k x i.e. a x

Compare a = - k x with

2 x = k x The period of oscillation T = 2.'. T = 2 M
This equation does not include the effective mass of the spiral spring in.

0 = 42 M + 42 m
Hence the effective mass of the spiral spring is the intercept of the graph on the xaxis.

With very fine capillary tubes the meniscus surface may be considered to be hemispherical and the weight of the liquid above the lowest point of the meniscus is given as r3 - 2 r3 pg = 1 r3 pg

This weight has to be added to the main weight of the water column.
:.

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[...]

Remove the tube from the water and clamp it horizontally to show the circular section of the tube d.

[...]

When ice block melts, it changes its state from solid to liquid at its melting point which is 0 °C. The amount of heat in joules required to change 1 kg mass of ice to liquid at its melting point defines the specific latent heat of fusion of ice .

[...]

m1C∆Θ1.

0 = final temperature of the mixture

But calorimeter and stirrer also lost some heat to the ice.

Q4 = M2C2∆Θ2

But ∆Θ2 = ∆Θ1.'.

Where, m2 = mass of calorimeter and stirrer C2 = specific heat capacity of calorimeter and stirrer which can be made of copper or aluminium

We then apply the principle of conservation of heat energy, Heat gained by ice heat lost by water.

[...]

When the temperature is about 10 °C above the room temperature Θ1.
Temperature of calorimeter + warm water = t1…….

[...]

Pieces of chalk A.
WB.
S.
When an object Q is on a surface S, the vertical forces acting on it are the weight W and the normal reaction R acting in opposite directions to each other.

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Frictional Force

But the normal reaction R is equal to the weight of the object , which is equal to i.e. the product of the mass of Q and the acceleration due to gravity
μ = Fr = Fr W mg.'.

T/N

ΔT.

Determination of the coefficient of static friction on two surfaces using an

AIM: To determine the coefficient of static friction between two surfaces by using the inclined plane.

W Sin Θ

Another way to determine the coefficient of static friction is the use of an The inclined plane is made up of two wooden boards hinged at one end.
On top of the upper board is placed a wooden block.

Sin Θ = μCos Θ

Attaching different weights on the wooden block can vary the normal reaction of the wooden block.

Place the wooden block Q on the upper wooden board of the inclined plane

Raise the upper board gradually to determine the angle Θ when the wooden block just starts to move.

[...]

Complete the table of observations by using the four-figure table to determine SinΘ and Cos Θ.

Calculate also the ratio of Sin Θ for each set of reading

Compare your results with that obtained from the graph.

[...]

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That is the relative density of the liquid is defined as the ratio of the mass of the liquid over the mass of an equal volume of water.

And the mass of bottle + water

:.mass of kerosene and mass of equal volume of water. .

Clean the bottle and stopper with Methylated spirit and dry it by using a hot air drier

Weigh the bottle and stopper empty by using the balance and record this mass as m1.

[...]

Be careful not to warm the bottle by the heat of the hand.

The relative density of kerosene The density of kerosene

……..
Determination of the relative density of a granular substance not soluble in water using the specific gravity bottle.

Balance Set of weights The relative density of a substance is defined as

R.D. =

[...]

VW = volume of water.'.

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