**Experimental Physics I**
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**Lecture - 16**
**Basic analysis (Contd.)**

So, I was discussing in last class that, we will measure some parameter and then how to report the result. So, that basically if measured parameter is x then we report as a x is equal to x best plus minus delta x.

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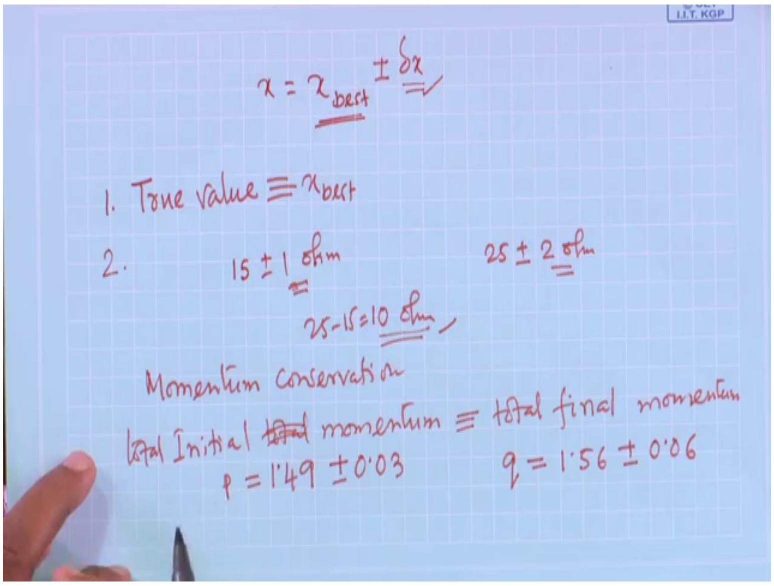


So, delta x is basically error in the measurement, as I told this what are the factor determine this delta x that we will discuss later on. But, this x best it is controlled, it is a the x best basically you will calculate, you will calculate the value of x, now that you are writing in this format. Now x best what will be the significant figure of this x best that will depend on this delta x ok.

Now, you have to know the significant figures what is significant figures so, that I have discussed and now you are able to write your result in a proof of format. So, then always we will try to understand, we try to get confidence on our result. For that we compare our result with, compare our result in different ways. One ways is as I told, if standard value or true value is available, true value of this parameter is available, then we compare with this x best we compare with this true value ok.

So, if it is close to these true values. So, they will this is fine, your result is quite good we are very happy ok. So, this way we compare, but if true value is not available for some parameter, then second way we try to get confidence that we compare with this result with other experiment result, somebody has done this measurement and reported the result. So, that is example I gave you that if you measure of this resistance of a resistor, and find out this value basically say 15 plus minus 1 ohm.

And your friend have measured the resistance of the same resistor and he found that 25 plus minus 2 ohm so; obviously, so, how to compare? So, we take the difference between this two value. So, this difference is basically 25 minus 15 equal to 10 ohm ok. So, this 10 ohm is not within the range of error 2 ohm or 1 ohm. So, definitely it is your result is whether correct or not. So, we cannot tell confidently.

So, something wrong in your measurement or your friends measurement ok. So, one may be correct another may be wrong or both may be wrong ok. So, to find out that one again you have to repeat the measurement and compare it ok. So, this way we compare our experimental result to get confidence, to conclude that no our result whatever I got this is very good result. Although, if as I told this all the time this error will be there, error will be there, but that should be that should be estimated and that is the delta x, that we will discuss later.

Second point is that, second point is that this you got some you can you got you are measuring some say or you are doing some experiment to verify the some law, to verify some law ok. So, suppose you are studying the momentum conservation of this in the isolated system. So, or in that case it's the you have. So, you have to measure the iso momentum conservation, momentum conservation; in this type of experiment you are basically verifying the momentum conservation.

So, what does it mean? The initial total momentum of the in total momentum initial momentum of the system should be equal to total initial momentum should be equal to total final momentum of the system, final momentum of the system final momentum of the system. So, from momentum conservation, this is the condition that is available with you ok. Now, for this experiment you are we have measured first we have measured the initial momentum. So, that you say P initial momentum P equal to some value you got one point say 49 plus minus 0.03.

And then final momentum you got final momentum you got say q that is that is 1.56 plus minus 0.06 say this the. So now, you see this definitely this two values are different now whether you will conclude that momentum is not conserve or your measurement is wrong. So, how to decide? So; that means, how to get confidence on your result?

So, how to do that? So, that is what I am discussing. So, in this case then generally we take the help of just we plot the difference or if I think we in this case we will not plot different because this is one measurement, later on I will show also we plot difference. So, in this case what we will do?

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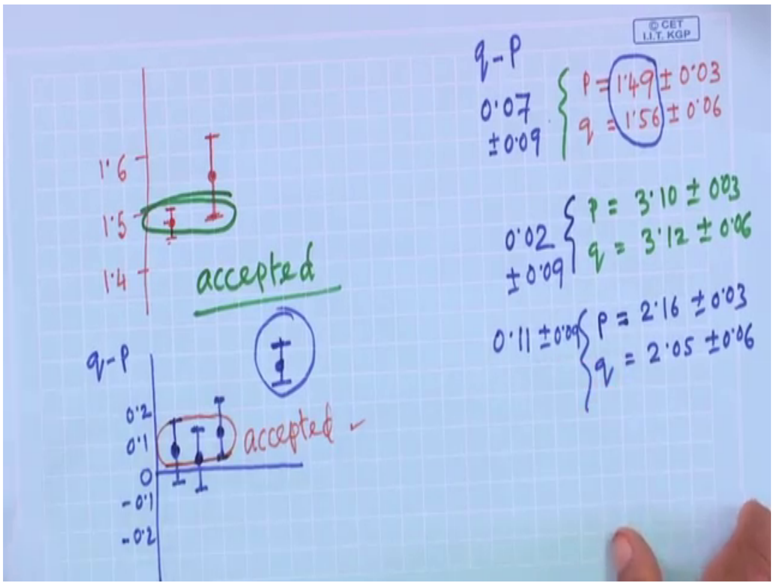


In this case I will do this, I will just take a graph paper I will take a graph paper and then I will scaled it say this is 1.4, this is 1.5 because my value initial value; what value I we got? P equal to initial momentum 1.49 plus minus 0.03 and final momentum q equal to 1.56 plus minus 0.06.

So, now I will basically plot it. So, its range is 1.4 to 1.6. So, I will I will take a scale and then if we plot. So, here what is this 1.49. So, it is close to 1.49, it is close to 1.5. So, this value basically I can plot this value say it is and plus minus 03, plus minus 03. So, I can I can this is the point 1.49 and then some error bar on this uncertainty error bar 0.3 say this is the plus minus ok.

And then another one is 1.56 1.5. So, this is 1.55. So, it will be slightly higher than this 1.55 and plus minus 06 so, double of it. So, this each one is 0.05 so; that means, this error bar will be this 0.6 plus 0.6 minus 0.6 this is the error ok. Now here you have to see that if these two results are overlapping, then it's a excepted result it's a good result. So, excepted result we can say. So, there is a overlapping in this result there is a overlapping in this result of this two. So, if you plot and this find out that is there is a overlapping of this two results, then we tell this is the excepted result, this is the is the good result ok. So, this way we compare the result.

Now, you see momentum your measuring of a system momentum, you are measuring of a of a isolated system to check the verify the conversation of momentum. So, this whatever this over data you got this one set of data, you can repeat the measurement you can get another sets of data ok. So, another sets of data you are getting say P equal to P equal to 3.10 plus minus 0.03 0.03 0.03 and q you are getting 3.12 plus minus 0.06 ok.

This is another set of data how from the form from the same system. So, because here this you can you because this initial momentum. So, it depends on the initial velocity you know. So, that may be during different measurement means if you are repeating the measurement you can now keep may not be able to keep the velocity same. All the mass same if you take two ball one ball is one ball and there is another ball. So, they have initial velocity. So, they have initial momentum total momentum you will get that is the p and now there is a collision between this two and then after collision there is a elastic collision of course, there is a velocity of this two ball will be different ok.

So, this velocity all the mass of this two ball are remain same in each experiment, but their velocity cannot control it can be arbitrary ok. So, that is why this values p value for this is 1.49, this can be 3.10 and this again if you repeat this experiment, then third set of data I will get say 2.16 plus minus 0.03 and q equal to 2.05 plus minus 0.06. So, these three sets of data we have taken ok.

Now, as I told that you cannot control the velocity all the mass are same. So, momentum will be different and this magnitude wise it a huge difference. So, our aim is to just compare just between this two because we know this should this two should be the same. Now here three sets of data. Now conservation of momentum whether this one is followed, this one is verifying in better way or this one or this one ok. So, if in this situation, how to compare this result ok? How to compare this result to get confidence that our measurements; all are very good or one of them is not correct.

So, how to compare? So, in this case we take we plot the difference ok. We plot the difference. So, here difference is how much this is 0.07 difference between this two, and what will be the plus minus? So, generally later on you will I will show you that this error of individual one for final this for final for final error. So, these are additive we have to add them. So, this error we take zero point error range we take 0.09 and in this case it's the 0.02 this difference, in this case plus minus again this for all cases 0.09 in this case it is 0.11 and this plus minus 0.09 ok.

So, we find out this difference and we plot it we plot it we plot it difference we plot it. So, if difference is 0 if this difference is 0. So, this is the best result there is no question. So, so if difference is 0. So, is the best result, but in our cases difference are not zero, but, but what is the difference what is a how big this difference so, that to and in each cases to compare that one if you plot this discrepancy or difference. So, in first cases; so, this is 0.1, then I can write this one I think yeah I should take this one is a 0.1, 0.2 minus 0.1, minus 0.2, 0.2 and we have taken basically q minus p. So, these are basically q minus p we have taken. So, here we are plotting basically q minus p difference with error bar we will plot.

So, here 0.7, 0.7 means some where here point and then plus minus 0.9 means 0.1 plus minus so, 0.9. So, almost I think this is 0.7. So, 0.2 this is my point for second one, this is 0.2 this one 0.2 here 0.2 and then plus minus 0.9. So, its length will be same for all and then this is 0.11. So, this 0.11 it is close to here and then have to 11 from 9 I think (Refer Time: 18:40). So, how good your this three measurement to compare it if I if you plot this difference? Its if it is 0 its absolute result (Refer Time: 18:55) excellent result, but that never happens, but now if you compare this and then you can tell this there is a overlapping among this difference, it is not that is here one result is here another we are getting like this then we have to this result will not be accepted, this something wrong in this measurement. So, we have to discard this data.

So, but in this case is nicely overlapping among this. So, overlapping region you can say this to overlapping region is this. So, there is a overlapping among this three results then this result we tell this is accepted all measurements, are accepted and results are good.

So, this is the way we compare our results, just we will measure and just report the results following the significant figure and the this error plus minus delta x that is not enough. So, you have to you have to try to get confidence on an measure, how confidently you will tell that our result is very good our measurement is perfect. So, for this these are the ways to conclude it to tell your result very confidently.

So, next example I can tell that this also we check our result we check our result using the using the graph. So, how to how to how to check your result or how to how to get confidence on a result? So, there are different ways to check it and for all experiment, for one experiment all checking is not possible. So, for different experiment different situations and for different situations different ways are there and that is what I am discussing. So, sometimes we check the result using the graph in which cases say Ohms law you are verifying Ohms law. Ohms law right so, V equal to IR ok.

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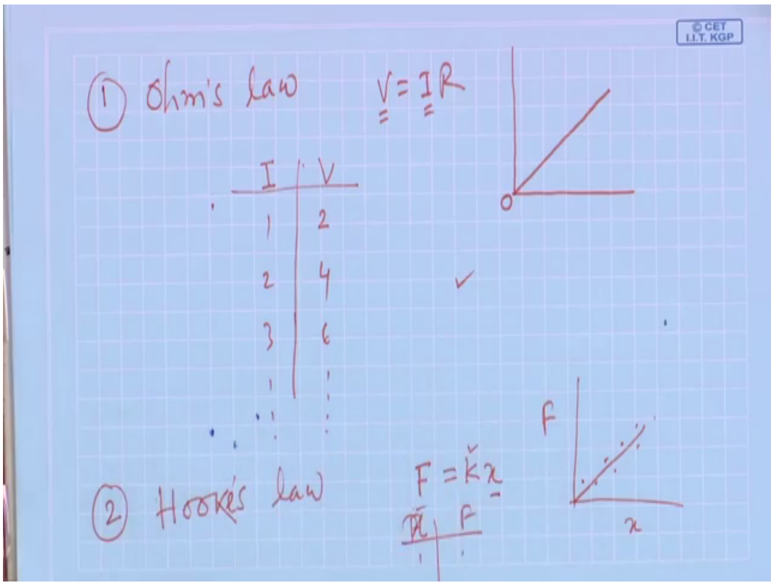


So, basically you are varying I and measuring V right you know how to measure the Ohms law right and you know this is a linear relation between V and I and if you get your result theoretically you can tell that there should be this relation can be represented like this, see it will be straight line passing through the 0 right. So, this is in your hand this is the standard one.

Now, you got the data, you got the data means current verses voltage. So, 1 2 3 whatever this say 2 yes so, I think 2 4 6 etcetera etcetera ok; so, this data to check that your data your experiment is correct or not ok. So, what we will do? We will so, we will plot this data and we will see whether this data is present in can be represented by a straight line we should pass through the 0. If so, then I will tell my experiment is very correct. So, this is another way to check your result using the graph.

Similarly, say Ohms law and then this another is Hooks law, what is this? This stress and strains are linearly related right like if you take spring extension of spring. So, that that force is proportional to the extension. So, this proportionality constant we write k x ok. So, k is basically we tell spring constant. So, F equal to. So, you are applying force to extend it and measuring the extension for different force different extension. Now, this is again between force and this x is a linear relation this is a standard relation it is telling theoretically this expression is telling should be linear.

So, now if you do the measurement applying different force or for different extension: what is the force? So, you have data now you check how good your data how good your experiment just plot it and see whether you are getting these you are getting this linear fitting or not. So, just plot and check it ok. So, on the average it is linear. So, your are confident now that your experiment is correct. So, this is the way we check our result using the graph, depending which way you will check. So, that will depend on the situation means what are the things in your hand. So, with which you can compare your result your experiment. So, this way one can check the result to get the confidence. So, next I will discuss about the slightly further more.

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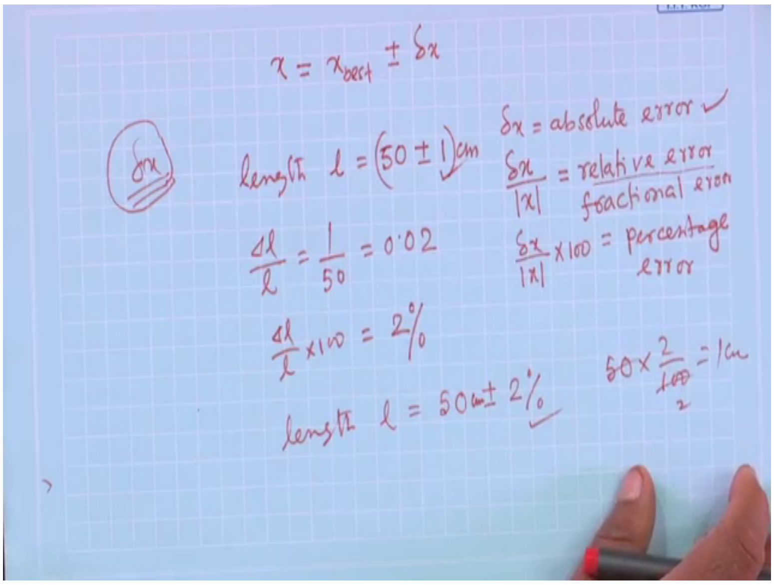


So, whatever error I have written this x equal to x best plus minus delta x ok. So, as I told this delta x is called the absolute error absolute error and then another error that is delta x by x if you represent this way, then you tell this the relative error relative error ok. Also if you delta x by x into 100 then we tell it's a percentage error is the percentage error is percentage error ok.

So, and this relative error whatever we are telling, this also we tell the fractional error fractional error fractional error ok. So, your error you can express by absolute error, you can express by fractional error you can express by percentage error ok. But, generally we will find out the convenient way to express the error for all result, if for all result for all experiment generally we do not write in absolute error, we write in fractional error or percentage error. So, that depends on the situation and how comfortably we can represent our result. So, depending on that one of them we use.

So, if you measure their length L right, length L that you say 50 plus minus 1 centimeter. So, this way we write, but other way also we write we can write this. So, what is the in percentage error also we can write. So, what is the relative error then here? In this case your delta l by l. So, that is delta l is 1 and l is 50. So, this is basically 0.02 ok. So, these will be the relative error ok.

So, but you result you cannot you can tell this is a relative error, but to express your result you cannot use this directly. So, to use to express this your length with error. So, generally if you take this percentage error from here. So, this percentage error is a so, you have to multiplied with 100. So, delta l by l into 100 so, that is basically here you will get 2 percent ok. So, then you can result your result this length l; length l equal to 50 plus minus 2 percent ok. You can write 50 centimeter here generally we write this way 50 plus minus 1 centimeter. So, also you can express your result 50 centimeter plus minus 2 percent. 2 percent means 2 percent of 50 centimeter ok. So, 2 percent of 50 centimeter, how much? Into 2 by 100 2 equal to 1; 1 centimeter, that is what here.

So, we express in terms of percentage error also we can express in absolute error. So, this way we present our final result and now next question is coming that as I told this how to find out the delta x. How to find out the delta x, that is what we need to discuss and yes and what are the origin of this delta x ok. So, for this basically you have to; we have to know the different source of error different what are the types of error ok. So, types of error in general we can classify types of error. I think I will discuss in next class this what are the types of errors. So, here I will stop it.

Thank you, for your attention yes.