Experimental Physics-I
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Lecture – 15
Basic Analysis (Contd.)

Today, I will discuss about the Error Analysis. So, when we do experiment so that whatever the decision of the measurement, so we cannot tell that our data is error free. There always there will be error. So, only what we can do? We can try to find out the best value of our parameter which we want to find out from the measurement.

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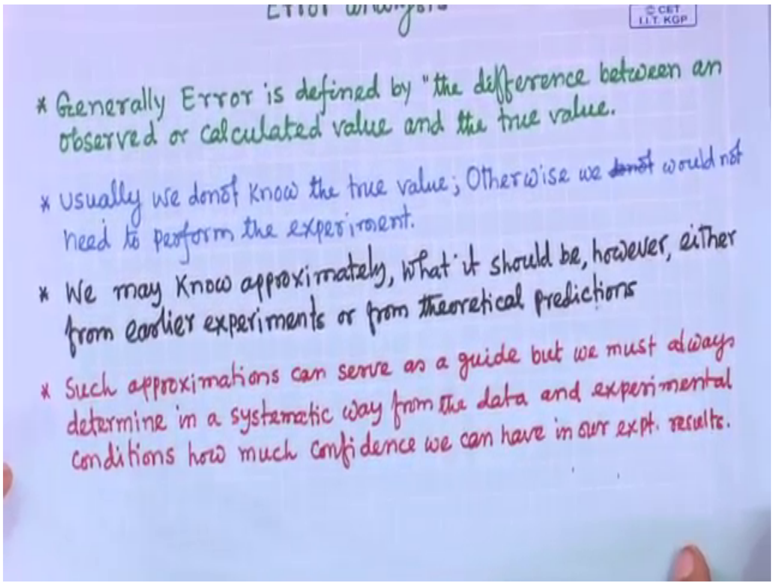

So, that what is Error? Basically if we ask this question; what is error? So, this error generally we define the errors as or by "the difference between an observed or calculated value and the true value". So, some standard values are available and for the same parameter, we have done experiment and find out this that parameter and then, whatever the parameter experimentally if we got the value of that parameter that we compare with the standard value; that is we are telling true value and see this how close our value to the true value.

So, the difference between these true value and our experimental value; so, that we take as a error in our measurement ok. But problem is usually in most of the cases, we do not know the true value or standard value. Otherwise we would not need to perform this experiment ok. So, most of the time what happens? Nearly, we may know the, we may know approximately what it should be or however, either from some earlier experiments or from some theoretical predictions. So, that value is it is not true value; it is the available experimental value or the theoretical value.

Now, we are performing experiment to find out that parameter and then, we check whether our, this measurement value; how close it is with the earlier experimental value or the theoretical value. So, that way we check our data, we check our result with standard or true value or some available values from theory or other experiment. So, such this approximations can serve as a guide, but we must always determine in a systematic way from the data and experimental conditions; how much confidence we can have in our experimental results ok.

So, we will do experiment and find out the result and that result, we will compare with the true value or the available experimental value or the value predicted by the theory and then, basically we will have confidence in our measurement in our results. So, this is the way we generally get confidence on our measurement and measurements and our result and then, that is basically we are estimating the error in our measurement. So, how to estimate the error in our measurement and what are the sources of error and how we can minimize error?

So, that is what that is what we will discuss. We will discuss also what precaution we should take to minimize the error. So, that is the aim for our, this lecture. .So, there are some common things you know this we should know this. So, when we measure some parameter say x parameter we are measuring.

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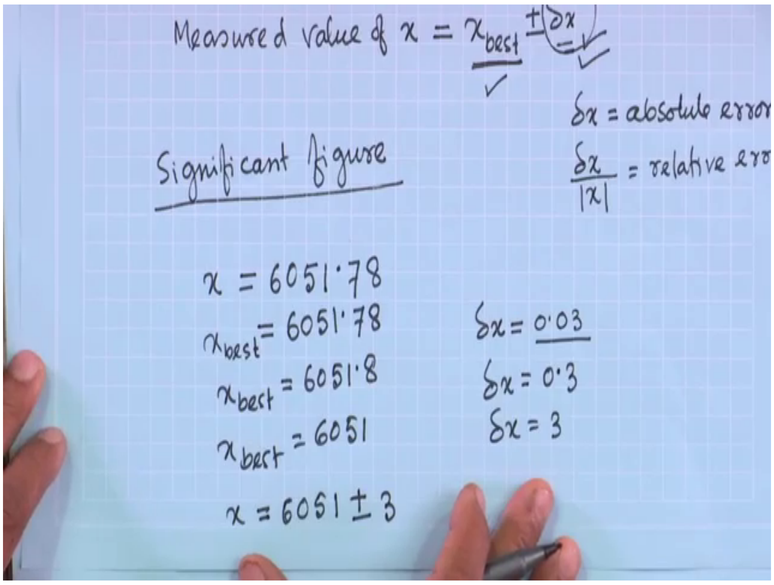

So, measured value of x; measured value of x ok. So, that how will express this measured value of x? Generally, we express in this way. So, you can generally we write x best plus minus delta x that means, this x best that is the value we are reporting for parameter x with some error. So, that we have written as a delta x.

So, this delta x is generally we tell this is a basically absolute error; absolute is the absolute error absolute error for uncertainties. So, there is another definition of error. This is called relative error. So, that we express by delta x by x. So, this mod x is all the time it should be positive value. So, this we tell is a relative error ok.

So, in this class basically we will discuss how to how to find out this x best and how to find out this delta x right and then, also how to write see when we calculate this parameter ok, this measured value of x it may not be the just we have measured this value directly. It may happen that this x is related with some other 3-4 parameters which we are measuring directly and then, this x is related with this those parameters and from there basically we are calculating this x.

Now, when you are calculating this you may get after decimal few digit ok, but how to write that x best means what should be the up to which decimal point we should keep or so, what is the significant of this of the number of decimal number of digits after the decimal points. So, these things we should understand and we will discuss about it. So, basically when we are writing this result x best.

So, we should have knowledge of significant figure significant figure ok. So, what is significant figure that I have already discussed, but again I will repeat it with some example. So, say it is that significant digit here it is basically in this case it is controlled by this by this also it is controlled or it is related with this delta x it is related with this error ok.

So, there should be matching between this between this x best and this delta x for; matching in the sense, this after decimal point, how many digit should be there that will be decided seeing the seeing this delta x. So, so let me give you example. So, say you have calculated some parameter that x parameter x that value you got from calculation. So, 60 say 6051.78 that is what you got ok.

Now x best x best basically x best; so, how to write this x best, that will depend on this delta x ok. So, if delta x is say 0.03 ok. So, we will discuss later on how we decided this delta x equal to 0.03 that we will discuss later on. So, that is the main part of this subject error analysis.

So, if this uncertainty error absolute error is 0.03 and you have calculated your measured value of x, you have calculated 6051.78. Now, how to write this x best plus minus delta x? So, both value x and delta x is available. Now you have to write our result, final result in terms of x best plus minus delta x.

So, x best in this case if it is you say here after decimal, this 2 digits are there ok. So, we can claim our accuracy up to 2 digits after decimal. So, in x best value we can keep up to 2 digit; we cannot keep more than 2 digit. If it is more than 2 digit; that means, we are claiming more accuracy. So, we cannot claim more accuracy because our error is telling us our accuracy is up to 2 decimal point.

So, this I will write result 6051.780. This if I put 0, this value is same; but I cannot put here third digit. Then, I am claiming the accuracy up to third digit. So, because this if I put this 0 here. So, this 0 is significant fig digit ok. So, that is I will have told already, but again I will tell about this significant digit our figure. So, this I have to keep up to second decimal. So, I cannot write one 0 more here. All though, this both values are magnitudes are same, but I cannot write because it will it will have different significant ok. So, that is what is a significant figure.

So, up to 2 decimal point, we can keep. Now, if you do measurement this error absolute error is say 0.3; 0.3, then you can. So, uncertainty or error already in first decimal point. So, here also x best in that case x best, we have to write we have to write 6051 point now 7. So, now, 7 is followed by 8 ok. So, we can write this 8. So, this as you know the rules as and I told you also; it greater than 5 or less than 5 or equal 5 whatever is. Again probably, I will I will just repeat it. So, this will be the, your x best.

So, this way its controlled with delta x equal to 3. Then, you see this accuracy now after decimal point, there is no accuracy. You cannot claim the accuracy after 2 decimal point. So, in this case x best you have to keep you have to keep 6051. So, your result basically x, we have to write; x we have to write x 6051 plus minus 3.

So, this is the way one has to write the result x equal to x best minus del. So, del x. So, this way one has to write their result ok. So, next as I told this significant figure to find out the significant figure, there is some rules that I will just remind you. So, this what are the rules? Here just I have noted down.

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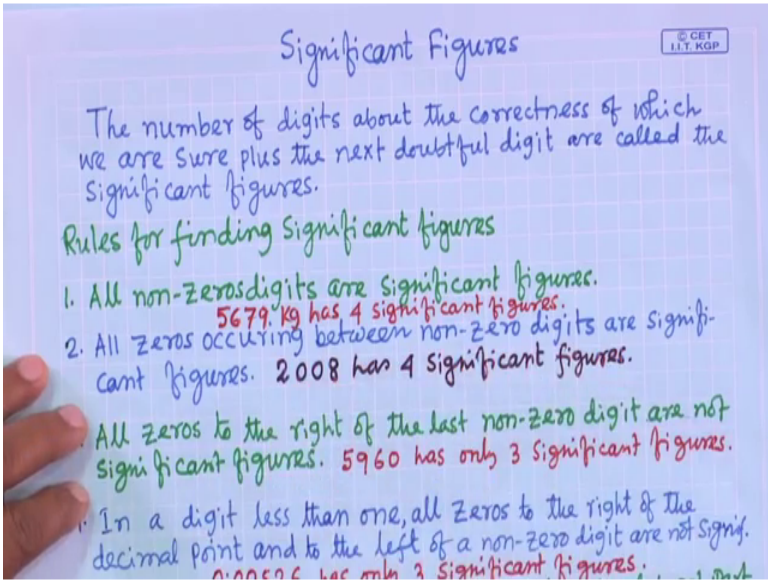

So, significant figure the number of digits about the correctness of which we are sure plus the next doubtful digit are called the significant digit. So, what is doubtful digit that I have discussed right. So, you can keep the number of digits up to which you are sure about the correctness as well as you keep one additional digit thereafter which is doubtful and they are generally doubtful that we have to put in a bracket ok.

Up to this you can you can you can claim as a significant figure. So, if you do not write the doubtful digit that is also fine, but if you write that maximum 1 doubtful digit you can write. So, either without doubtful digit or with doubtful 1 digit, so that we tell this significant figure.

Now, rules for finding significant figures is that this all non de non-zero digits are significant figures for example, this 5679 kg. This number has 4 significant figures right. Then, second one is all zeros occurring between non-zero digits are significant figures ok. What does it mean? So, take an example this 2008, it is a number. So, now, 2 is significant figure; 8 is significant figure ok; not figure this yeah. So, digits I can tell.

So, now yeah basically non zero digits and between this non-zero digits whatever the zeros are there. So, that is taken as a significant figures. So, here number of significant figure is 4 ok. Then third rule is all zeros to the right to the right of the last non-zero non zero digits are not significant figure ok. So, far we have not considered the decimal point. So, it is a whatever this 3 rules am discussing so that is basically we put decimal points or if there is no decimal points. So, all zeros to the right of the non-zero digit are not significant figure example 5960.

So, this is the 0 at the right of this non-zero digit. So, this is not taken as significant figure ok. So, in this case all the 4 digits are there, but significant figure, we are telling this is the 3 significant figure ok. So, this there is a ambiguity in this rule. If we fail according to rule it is there, but it is a difficult to digest it accept it ok. In practical case if you think that this 0 is significant, you cannot ignore it ok.

So then, to consider it as a significant figure. So, you have to write this one different way that I will tell you. So, we do not want to validate it because this rules may be may be useful in most of the cases, but in some cases it looks ambiguity ok. So, if we use this rules, then it does not represent our practical result.

So, because in our practical result if you fail this 4th digit here 0; this is significant figure, it should be significant figure, then its result you have to write in different way that I will tell you using the decimal point. So, first validating the rules, we can we can just apply tricks and make this digits significant.

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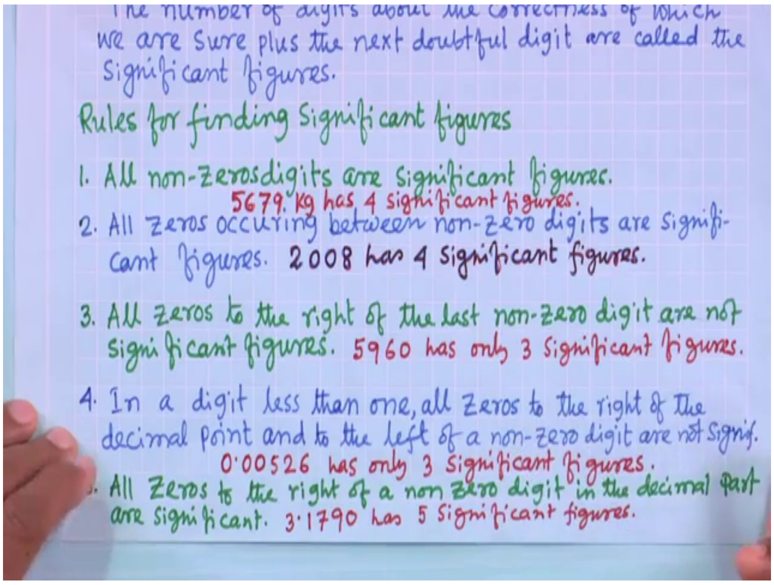

So, fourth rule is in a digit less than 1, in a digit less than 1 means decimal point there is a decimal there will be decimal point. All zeroes to the right of the decimal point and to the left of a non-zero digit left of a non-zero digit are not significant. So, what it is telling if we take example the 0.00526. So, here it is telling these to the left of a non-zero digit are not significant to the left of a if it is less than less than 1.

So, it is the decimal point is there. So, this number less than 1. In this case all zeroes to the left of a non-zero digit is not significant. So, here then significant only 526. So, it has only 3 significant figures according to rule and all zeroes to the right of the decimal point. All zeroes to the right of the decimal point to the right of the decimal point and to the left of the non-zero digit ok.

So, this decimal point and this 526 say non-zero digits. So, between this 00 is there. So, that will not be counted as a significant figure. So, here effectively the significant figure is basically 3 ok. So, fifth rule is all zeroes to the right of a non-zero digit in the decimal part ok, in the decimal part is or are significant means 3.1790. So, this 0, it is the right to the right of a non-zero digit in the decimal part ok.

So, these 0 will be taken as a significant digit and then, in this case this total this significant figure has 5 significant figures, significant digits significant that is significant figures we are telling. So, this is the rule for writing the significant figure ok.

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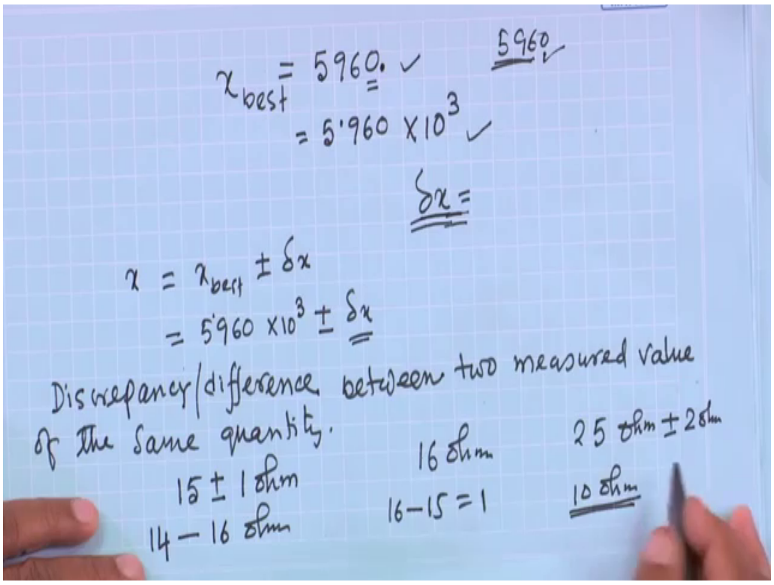

So, this is very useful for writing for writing the x best for writing the x best. So, as I told this if x best if 5960 as for this rule, this significant figure is 3; 1 2 3. So, this 0 to the right of these non-zero digits are not significant. But if you feel that this is significant, this is significant we cannot neglect this one. Then, basically we generally write just this way we use 1 decimal point, but after that we do not put 0. Then, it will have. So, then significant will be significant digit will be 5.

So, just you put this or you can write or you can write this x best equal to using 5.960 into 10 to the power 3 ok. We write this way; then, what is the significant number here this as per rule. As per rule you see this non-zero 596 this 3 as here and this after in decimal part this 0 is significant now. So, then, this you have 2 number significant numbers 4 ok. So, that is why just instead of writing 5960. Then, significant is basically this up to 3 digit ok. This number is three and then, a single figure is 3.

So, but you take this four fourth digit as a significant. So, then you have to write either this way or this way. So, this rules for significant figures whatever this 5 rules I listed so that will not be validated. So, this what I will tell here basically how to write your result and that also is related with the it related with your this delta x whatever the error. So, that will control your x best ok.

The significant number what will be the significant number in x best that will be controlled by the delta x or it is related with also the delta x and then, this when you are fine you have written significant you have written your results considering the significant figure as well as taking care of the of the of the error delta x. Now your result is you have x best x equal to x best plus minus delta x and you have detail say 596 5960 say into 10 to the power 3.

So, then plus minus you have to delta x you have to you have to write you have to write. So, now, there are different situation occurs when we do experiments and find out the result and as I told you have to get confidence on your result and for that we always compare with the we analyze our result ok. We check our result ok.

So, very frequently as I told is there may not be standard result of 2 two result 2 value with which you will compare. So, in that case you have to compare some other experimental result or theoretical result or we have to repeat the measurement or we have to compare your result with the your colleagues or your friends result whatever he measured and got the same experiment for same parameters what result he got.

Now, so, then, you have to see that discrepancy or difference. So, to get confidence on our result; so, we analyze our result comparing with others. So, how to do that? So, that is what I am discussing. So, this we check the discrepancy or difference between 2 measured value between 2 measured value of the same of the same quantity of the same quantity of the same quantity.

Just for example, say you have measured the resistance and reported the result or got the results ok. Got the result say 15 plus minus 1 ohm ok. So, you know how to how to how to write the final result because this 15 your error is. So, there is no up to decimal points. So, the 1 ohm.

So, that you can keep only this, you cannot keep your, this 15.0 or something right. So, you have to write 15 without using any decimal point. So, this is the result for it. So, after writing getting this result, now you want to get confidence whether your result is correct or not. So, how we can check it? You can check that if from lab someone say this if standard value is given to you ok. So, this is the standard value of this of this resistor. So, then you can compare with that.

So, for that standard value let us say we are telling this 16 ohm ok; true value is 16 ohm. Somebody is the company has given this value for this resistor, then you can tell your result is discrepancy or difference between this two is 16 minus 15 is the 1 ok. So, and then it is within the range of your error ok. So, you are reporting your result basically it is you are telling this resistance of this resistor will be between 14 to 16 ohm.

So, it is true value is 16 ohm. So, it is your result is very good. Your measurement is quite accurate. It is a so, this accepted value or true value it is within your reported measurement range or it may happen that you standard true value is not there, then your friends have measured this resistance of this same resistor and he got this value say 25 ohm, 25 ohm; I think error reported say 2 ohm 2 ohm.

So that means, that means difference means. So, then you have to see the difference. Difference is 10 ohm; 25 minus 15 is 10 ohm ok. So, and error range in your case is 1 ohm plus minus that this case is with 2 ohm. So, this 10 ohm is if discrepancy is too high, it is not within the error range ok. It is not covered by this by error range ok. So, definitely there is a mistake in the measurement. Now mistake in the measurement of yours one or your friends one that one has to find out.

So, so that means, you cannot be sure about your results. In this case it is controversy. Now, one of the both can be wrong; measurement of both one can be wrong or your one can be writing or this other one can be correct or vice versa ok. So in this case, so when these type of controversy result you will get. So, then you have to repeat the experiment and check it ok. So, this situation may occur. So, I think I will continue discussion in next class.

So, thank you for your attention.