Experimental Physics I
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Lecture – 03
Basic tools and apparatus (Contd.)

So in last class we have discussed about the significant digit and doubtful digit and how to decide the significant figure; when we add or multiply this individual number depending on the least count of the instrument one has to decide the significant figure. So, we took example of meter scale and we calculated the length, breadth and thickness and then find out this volume of this a regular shaped body.

So, in meter scale; so today actually I will continue the discussion on Basic tools and apparatus in our laboratory.

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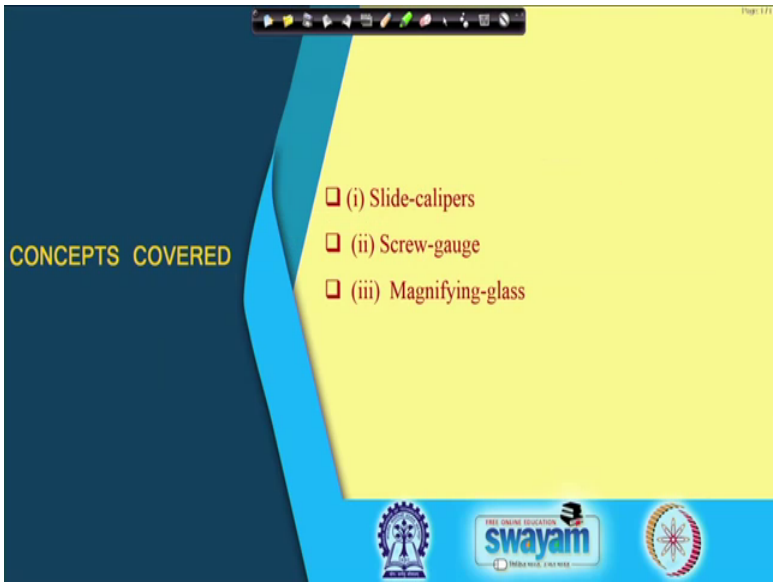

So, today mainly we will discuss about the slide calipers screw gauge and magnifying glass how you are using to find out the basically coinciding of the lines in slide calipers, and screw gauge to find out the digits after the decimal point.

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So, next first we will discuss about the slide calipers; that is actually in class 11 student do this experiment. But I will then just discuss once more because in whole life for any experiment most of the experiment we need this instrument, and we should have clear idea about this instrument how to use and what is the significance of this instrument.

So let us start with the meter scale.

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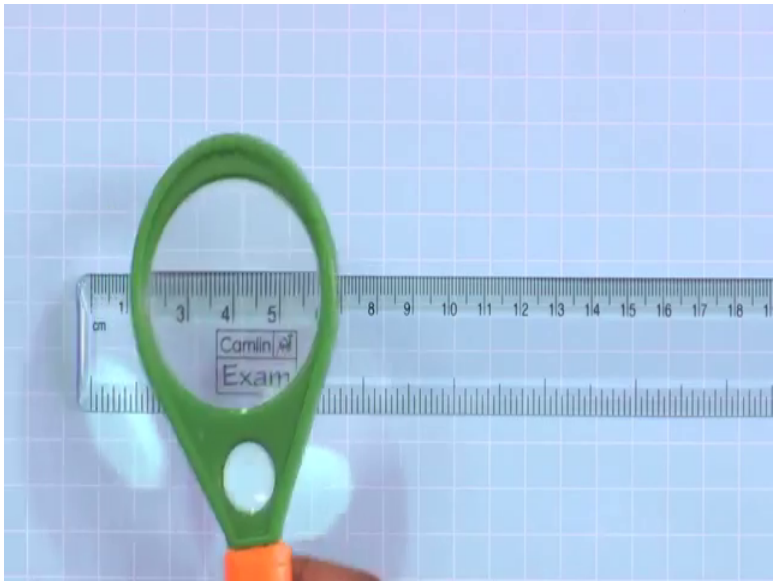

So, we have meter scale and theirs this least count is millimeters because between this 1 and 2 say between 1 and 2 how many lines are there? This you can count it is 10 lines are

there 10 divisions are there. So, each division is 1 millimeter right; so that means 0.1 centimeter is the least count.

Now, in this when we use this instrument; so our error will be basically in the measurement length measurement. So, that will be plus minus; so whatever the result we will get, so there we write plus minus 0.1 centimeter; why we write this error? Because as I told that we here is this 1 millimeter division is visible. And if the reading is between 2 lines then it one can guess to the next decimal whether this 0.0 5 or 0.03, 0.07 actually that is the guess. So, since you can see it is visible; so you can guess and that digit second digit after decimal that we take as a doubtful digit ok.

So, your reading can be say 2.4 or it can be 2.5; if it is in between 2.4 and 2.5. So, you can write that 2.45 or 4 3 or 4 7; so, the second digit after decimal that is the doubtful one. So that means, we need more precise instrument to measure length more accurately; so, that is why the concept of Vernier slide calipers is into introduced and then even better instrument we have.

So, that is the next one is screw gauge; so it has better resolution better least count. So, these 2 instrument we will discuss today

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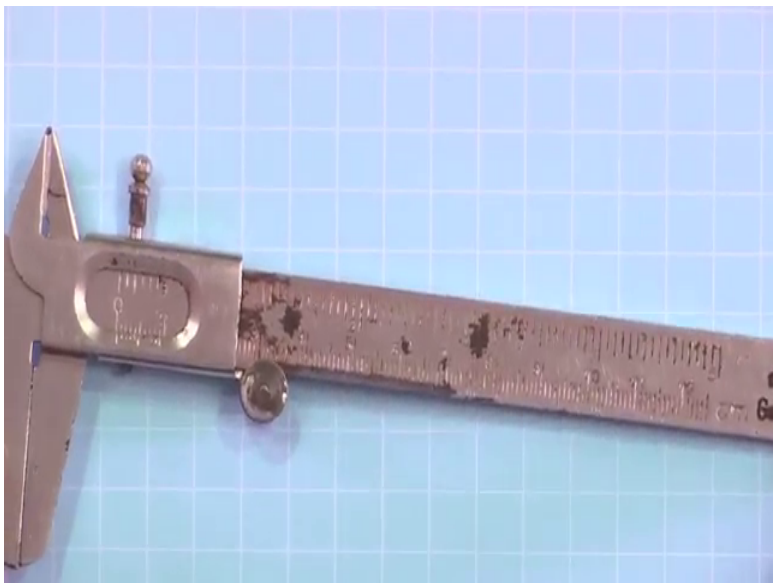

So, I will show you this very common slide calipers we use in our instrument in our laboratory say this is the slide calipers ok; this is the slide calipers. So, I will show you

second slide calipers which one is better than this one. So, this means resolution wise least count wise.

So, here; so you have to familiar with this slide calipers right. So, here you can see this in top this is called jaw upper jaw and lower jaw; see if I just move it I think I have to loosen it. So, you can see this upper this 2 jaw and lower this 2 jaw and another when I am moving; so another prong tail is coming out. So, if I closed it; so now it coincide this prong that in this coincide with this edge; and here this also this two sharp edge parallel edge that also the coincide and this lower one also this two jaws this is parallel edge they coincide.

Now, in this condition we have to see here the 2 scales are there one is main scale right and another is vernier scale. So, I think now we will use the magnifying glass to see it if you see you see this 2 scale. One is main scale and another is called vernier scale; now on vernier scale you can see 0 and I think it is written 9 and then bigger one no 0 and there is 1 means in between there are 10 divisions ok. So, in vernier scale there are 10 divisions and 0 of vernier scale it coincides with the 0 of the main scale; you can see 0 of the main scale it coincide 0 of the main scale right.

So, that we have to check whether 0 of the vernier scale coincide with the 0 of the main scale or not. So, at this condition that is initial condition when these lower jaws and upper jaws their parallel it is coincide with each other and this at the end this prong tail coincide with the edge of this main scale ok.

So, this is the initial condition; here we find out the whether is there initial whether 0 error is there or not what is 0 order error. So at this condition initial condition initial condition; so, this 0 of the vernier scale whether coincide with the 0 of the main scale. So, if they coincide then we tell 0 error is nil; there is no 0 error and if they do not coincide. So, 2 case there are there may be 2 cases; one is 0 of the vernier scale that cross this 0 of the main scale.

Means if 0 of the vernier scale is at the left of the 0 of the main scale this is one case and another case 0 of the vernier scale is at the right of the 0 of the main scale. So, these 3 cases one is 0 of the vernier scale will coincide with the 0 of the main scale, another is it will not coincide 0 of the vernier scale is at the left of the 0 of the main scale and third case may be that 0 of the vernier scale is at the right side of the 0 of the main scale.

So in one this in first case when they coincide then we tell the 0 error is nil, if it is left 0 of the vernier scale is at the left then we tell that it is a negative error. And if it is at the right of the right side of the 0 of the main scale; then we tell is the positive error. And so how to how to take care of this error; when we will note down the final reading of the length; so, let me tell you that one. So, this you see if you take so, I will take this meter scale.

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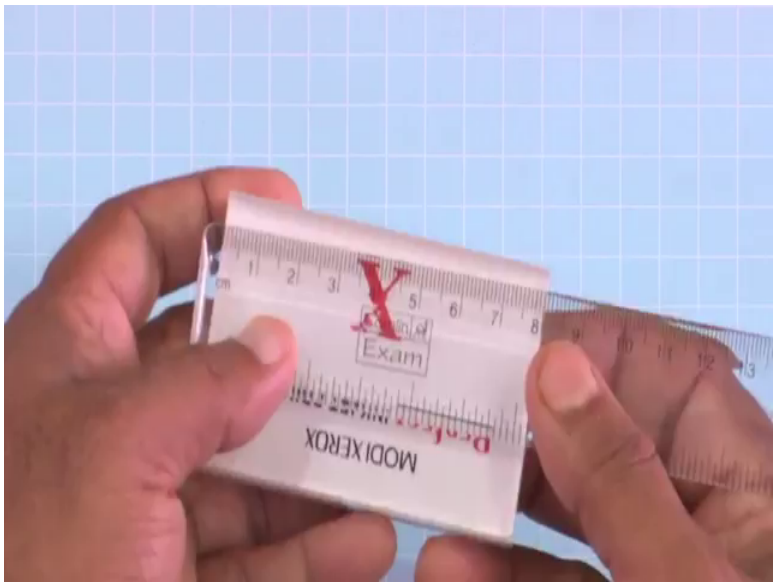

Now, if you measure if you measure the length of this block ok. If you want to measure the length of this block or width of this block or thickness of this block using the meter scale. So, generally what we do? We think, I to take this say; so the 0 of the main scale 0 of this meter scale so that generally at the left of this body.

So, we try to make it coincide with this edge fine it is coincide then we take the reading of this right hand side. So, it is 7.8; I can see it is 7.8; this reading is 7.8 right and probably its slightly more than 7.8 ok; so let me it is 7.8 ok.

So, this length this one we can measure. So, because why we are taking directly the sitting 7.8? Whatever you showing at the right side of this body, because this left side of the body is coincide with the 0 of the scale. Now it is on the always one may not measure this way. So, this left edge of this body you may it may be say it is coincide at say I can take it as 2 then right hand side you can see the reading is 9.8; it is 9.8; it is 9.8 right.

So, in this case what we will tell? This because length is same 7.8, but reading now initial reading is 2 initial reading is say; it is 2 and initial reading is 2 and this final reading is 9.8. So, what will be the length then? Then what we do? We write that you are reading.

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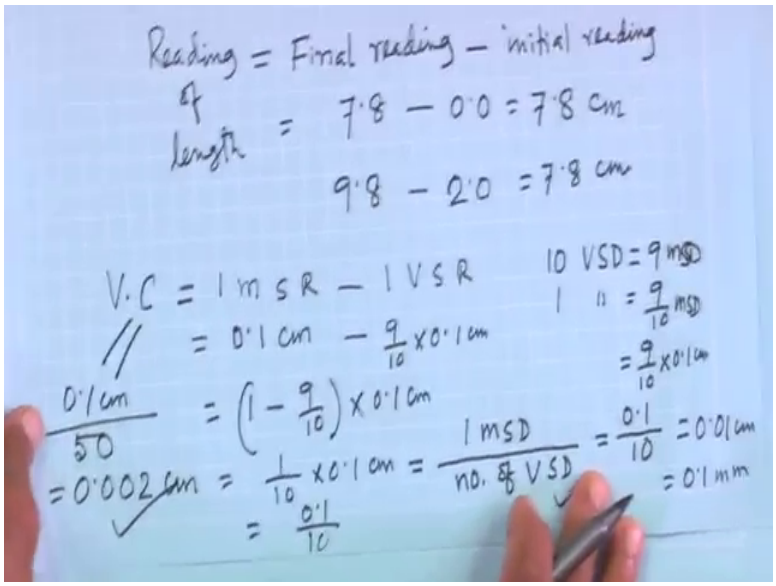

Reading is basically or length; we can write reading is equal to final, final reading minus initial reading right initial reading; initial reading ok. So final reading in one case we took the 7.8 minus initial reading was 0 0.0. So, final reading was final reading was 7.8; 7.8 centimeter and another case this final reading was 9.8 minus this was 2.0 ok; it is then also it is 7.8. So, in whatever the way we are measuring; so, our length is 7.8 centimeter right.

So, what formula you we are using? That is the final reading whatever we are taking minus the initial reading. So, then it will give you the reading ok; reading of the length reading of the length in this case reading of the length fine.

So, this is the basic formula to get the reading of length or breadth or width whatever ok. So, if we take this is the basic formula final reading minus initial reading. So now, using this formula we will find out we will see the how one can take care of the 0 reading in case of slide calipers and screw gauge ok.

So, let me let me come to this come to back to this slide calipers. Now in slide calipers in slide calipers we have; so first what we should do? We should we should find out the 0 error ok; so in this case for this instrument, the 0 error is nil I mean 0. So, initial reading is; so 0 error is I would say 0.0 or 0.00 centimeter; so which one we will write; so that will come later on.

So, before starting measurement of the length what we have to do? We have to find out the 0 error. So, in this instrument the 0 error is 0 ok; next we have to find out the vernier constant; so, vernier constant how one can find out? We have to see here in vernier constant vernier scale there are 10 divisions. Now tenth division it at this condition the tenth division it coincides with the how many division of the at which division of the main scale? So, in this case you can see the tenth division of vernier scale that coincide with the ninth division of this main scale right; so, that we have to find out.

So, it is fine here this tenth division of vernier scale coincide with the 9 division of the main scale. What does it mean? It means that the length of the 10 division of vernier scale is equal to the length of the 9 division of the main scale. Now what is the value of the 9 division of the main scale? Each division in main scale is 1 millimeter right. So, 9 division of main scale this length; that reading will be or length will be the 9 into 0.1 centimeters. So, that is the length of the 9 division in main scale; so that means, 10 division length of 10 division of vernier scale is equal to 9 millimeter or 9 into 0.1 centimeter right.

So, now definition of vernier constant is difference; definition of the vernier constant is basically is basically difference of; so vernier constant vernier constant is the definition is difference between the 1 main scale reading and the 1 vernier scale reading. So, 1 main scale reading minus 1 vernier scale reading.

So, one main scale reading is 1 millimeter means 0.1 centimeter right minus 1 vernier scale reading is how much? So, we have seen that 10 division vernier scale division equal to 9 main scale division right main scale division main scale division so that means, 1 vernier scale division equal to 9 by 10 main scale division right.

So, this means this 9 by 10 into 0.1 centimeter right. So, one vernier scale division equal to 9 by 10 into 0.1 centimeter. So, 9 by 10 into 0.1 centimeter; so if you take difference 1

minus 9 by 10 into 1 main scale division that is 0.1 centimeter. So, from here you are getting 1 by 10 into 0.1 centimeter.

So, what it is? It is basically 1 this basically 1 main scale division divided by number total number of number of vernier scale division ok. So, in this case 1 main scale division in our case; so that is 0.1 divided by number of vernier scale division is 10.

So, here whatever you are getting from definition 0.1 by 10. So, it is nothing, but the 1th main scale division divided by number of vernier scale division. So, that is why generally students just take this one just see what is the value of the one main scale division and then just what is the total number of vernier scale division. So, just divided to this and then get the result; so that is the vernier constant ok.

So, this has come from the from the basic definition of the vernier constant and in this instrument this vernier constant is 0.01 centimeter; so that means, it is 0.1 millimeter right. So, now you see the in meter scale the least count was 1 millimeter; now in this case this vernier scale it is 0.1 millimeter. So, one order of magnitude means 10 times better this resolution least count is 10 times better of this vernier slide calipers then the meter scale.

So, that is why for accurate measurement better measurement. So, people use wherever possible people use the; slide calipers. So this is the way one has to find out the vernier constant and for this instrument whatever I have shown; here this vernier constant is vernier constant is 0.01 centimeter ok.

Now, I will show you another slide calipers that has even better least count better vernier constant. So, let me show you this one.

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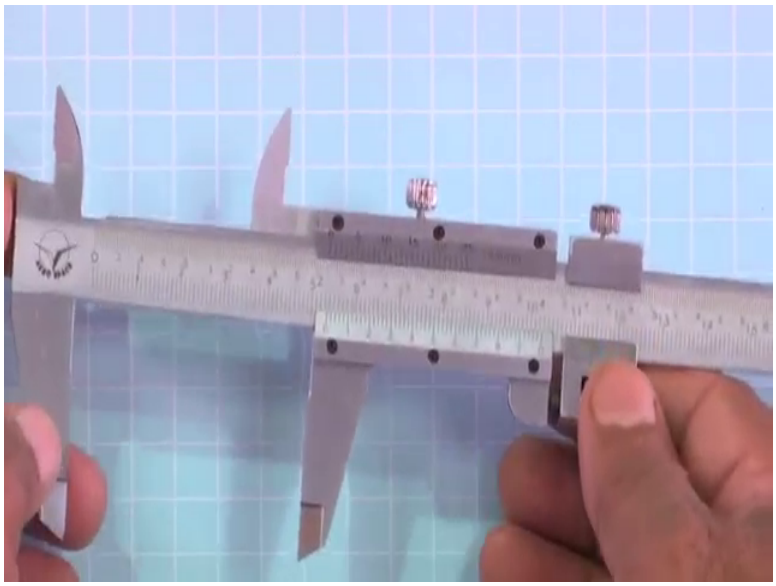

So, this is also used in nowadays this is more popular because it is vernier constant is better its I will show you what is the vernier constant for this. So, again you see it has from tail and this upper jaws and lower jaws. So, what is the use of this these 3 things that I will tell you. So, again you have to first you have to see; whether is there any 0 error ok

So, in this case also there is no 0 error you seems. So, you can just shake it yes 0 of the vernier scale coincide with the 0 of the main scale fine. So, 0 error for this slide calipers also it is nil it is 0. So, now, you see in vernier scale how many divisions are there? This you can see this is the 10 into 5; so this 50 division ok.

So, in vernier scale there are 50 division and in main scale what is the division? 1 main scale division equal to you can see that is 1 millimeter right. Now what with the vernier constant for this case? So, just you use your from the definition whatever we got this vernier constant equal to 1 main scale division divided by the total number of vernier scale division. So that means, 1 millimeter divided by 50 division so that means, 0.1 centimeter by 50 equal to 0.002. Earlier, so vernier constant for this slide calipers is 0.002; so it is a earlier one was having vernier constant that was 0.01; now 0.002.

So, it is this scale vernier slide calipers; its least count is better than the earlier one see it is; so basically 5 times better. So, for this one your vernier constant is vernier constant is your vernier constant is basically; for this case vernier constant is 0.1 centimeter; ones

main scale division divided by total number of vernier scale division this 50. So, it is a 0.002 centimeter ok. So it is the 5 times better than the earlier one; 5 times better than the earlier one ok.

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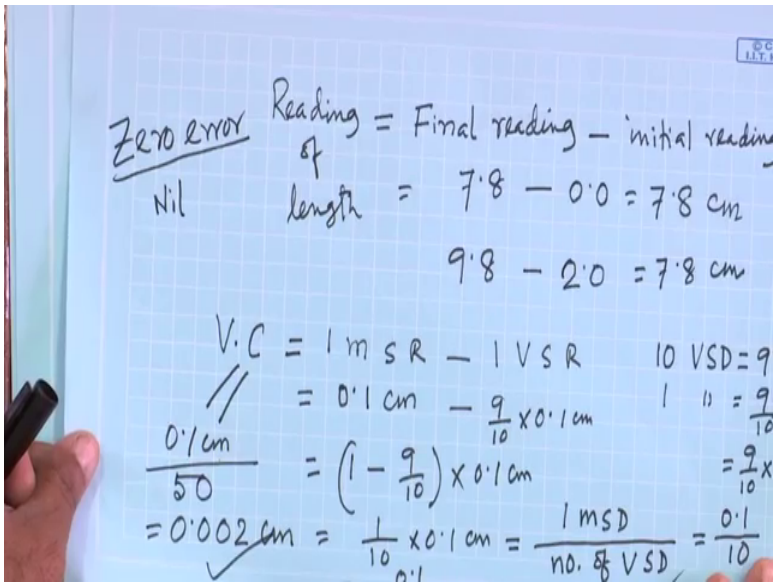

So, and also you have to note down zero error; zero error that is basically in this case nil. So, before starting measurement; so you have to find out these 2; one is zero error and another is vernier constant right.

So, now let me tell you; so what we can measure with this? With this slide calipers; so whether we have more advantage of this slide calipers than the meter scale? So, one advantage is that least count is better you can measure the length more accurately. And second advantage is that if I tell you to find out the inner diameter inner diameter of a of a cylinders say this is my cylinder right.

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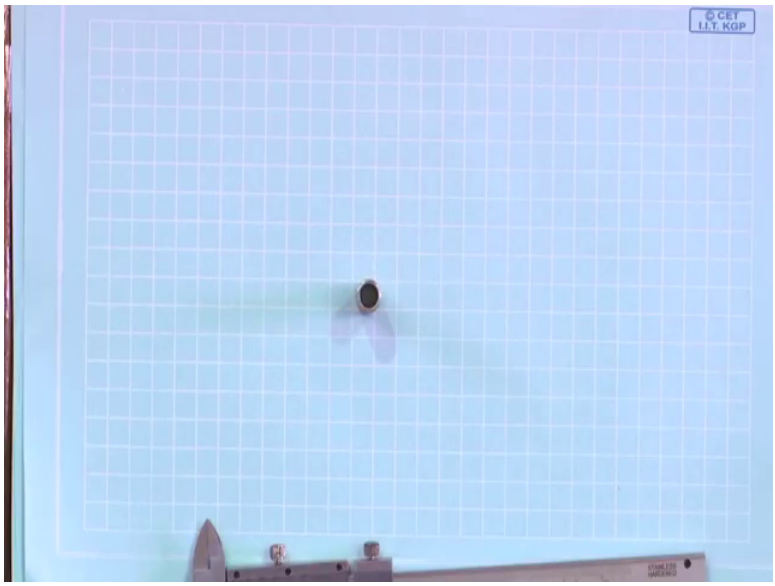

Here; I am showing cylinder. So, if I tell you this is what is the; what is the inner diameter of this of this of this cylinder inner diameter of the cylinder right.

So, with meter scale one can find out, but it will not be that it is a; I think here you can measure with meter scale also, but it will not be that convenient. And outer diameters also meter scale you can use, but it will not be that convenient. So, in this case slide calipers will be very helpful; so if you external diameter fine.

So, you can measure this; this way and find out what is the reading. So, now here let me tell you here let me tell you the how to take reading. So, this is the external diameter external diameter of this external diameter of this one right; then probably I will lock it for this; I will lock it ok.

Now I will take the reading of this one take the reading of this one. So, first I have to see that just I have to look at the 0 of the vernier scale. Now that 0 that line; now I have to take reading of the main scale this; what is the reading of the line just left just left of this 0 vernier reading ok.

So, here I can see the reading is just I think is 4 I think it is 4 and then 0 at the left of this 0 that is 4 and it is almost coincide with the no I think centimeter; so it is 1 sorry. So, 4 is just it is a on top of the scale. So, it is g it is 1; so left reading of the main scale left just left to the 0 in main scale.

So, that is 1 centimeters and it almost coincide with this next 1 millimeter. So, it is the 1.1, but I will not take 1.1 because I have to take the reading at the just left line of the main scale; so this I will take 1. Now then it is greater than 1; so to find out that how much it is greater I have to see the which line of the main scale; vernier scale coincide with the with the with which line of the with any line of the main scale ok.

So, here I can tell you that it is 48; it is 48 coincide with the; you can tell 60; sorry 50, 49 and I, but in my opinion it is 48. So, that means, 48 division of the; 48 division of the vernier scale; it coincide with the one line of the main scale. So, my vernier reading; it is called vernier reading is 48.

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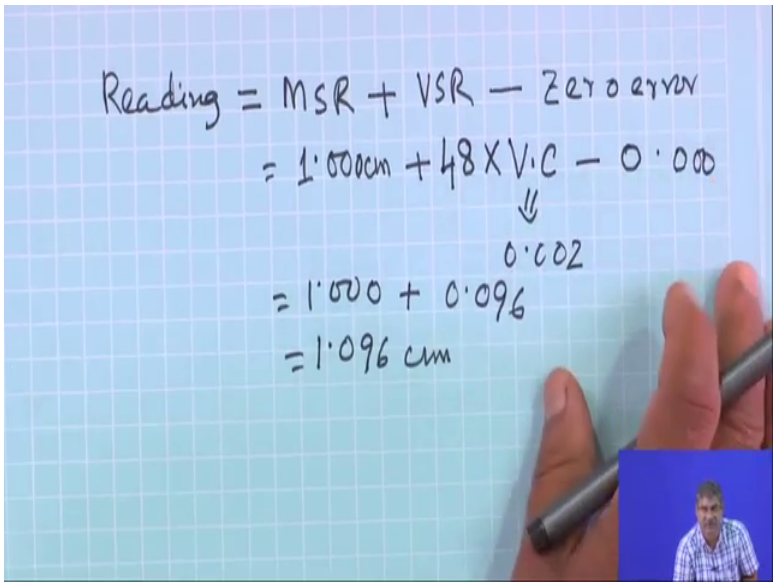

Now, basically your reading is equal to main scale reading plus vernier scale reading right. Now main scale reading how much I got? 1.00 centimeters plus vernier scale reading. So, this it is the 48 vernier scale division coincide with the main scale into vernier constant into vernier constant. In this case vernier constant is; it is basically vernier constant is 0.002 ok, so that means, it is coming 1.00. So actually I will write this way up to 3 decimal because here our accuracy in the third decimal ok. So 000 plus here I can see 96; 0.096.

So, my reading is 1.096 centimeter right; so this is you got the reading. You got the radius external diameter of the cylinder right; external diameter of the cylinder. Now, we have to take care of 0 error; so; so this is the reading I can say that is at the; this is the

reading at what I should say compared to meter scale; as I told that this is the final reading I have got, but what was the initial reading? That is the basically 0 reading right.

So, 0 reading in this case we are telling that it is; error is 0. So, that was initial reading error can be positive, error can be negative; so that we have to take care. So, actually your final reading; your final reading of length basically it is a reading when I am telling it is a reading of the length and another reading of this initial reading and final reading kind of things.

So, if we apply the definition of the reading of the length. So, finally, reading minus initial reading. So, this is the final reading if we take as a final reading then minus initial reading. So, that is 0 error 0 error 0 error; so 0 error. So, in this case 0 error was 0; 0.000; I can up to 3 digit I can write, so fine.

Now, here what I want to say; in meter scale in meter scale we have taken reading this final reading and initial reading. So, initial reading it is just I think I will tell you to understand the positive and negative error. So, here you see here when we are taking reading. So, what we are doing?

So, this object we are taking object you see earlier this I put a 2 and this it is a 9.8 ok. Now if I just if I just take this is a 1; it is the 1 and this 8 point I think 8.8 ok; it is a 8.8. So, I am decreasing the initial reading and right does if I go just if I go this initial reading becoming 0. When initial reading is becoming 0; then it is 7.8; when initial reading is 2 it is 9.8; it is 9.8.

So, that means, if this one this left edge of this body it coincide with a reading which is greater than 0 ok. So, that is getting minus from the final reading; so that is getting minus from the final reading right. So, that is getting minus from the final reading fine right

Now, that means, this right hand side that writes the right hand side is that reading is higher than the actual reading for the length. Now if you imagine that when 0 that is fine if you cross 0; if it cross 0 then what will be reading? It cross 0 then I can see this reading is 7 point say 7 it is around 7.7, it is around 7.7 right; if it cross 0 if it cross 0; 7.7 right.

So that means, that initia final reading is now less than the actual reading of the length ok; then what does it mean? Then this minus initial reading that is there. So, then this error we tell this is negative error. That means, I have to this error I have to add with the final reading right. So how you left? So, because my definition is final reading minus initial reading; so final reading minus if this is negative error 0 error; so minus of minus this initial reading right minus of minus this initial reading.

So, that will be minus into minus that will be plus. So, that is why when this edge of this body it cross it is at the left side of the 0 of the scale. So, then this reading initial reading you have to take minus of this reading and if it is right side of this 0, then we tell it is a positive error. So, whatever the reading earlier it was 2; now whatever the reading. So, that will be positive error and that will be minus initial reading this is a positive. So, it will get minus from the final reading ok.

So, this way one can understand what; which one is minus errors negative error which one is positive error. So, negative error get added with the final reading and positive error get minus from the; subtracted from this final reading ok. So, negative error added and positive error subtracted. So this way if we take the definition of this reading final reading minus initial reading; so then easily you can tell that negative error means it will be minus positive error means plus, but negative error added with the final reading and positive error get subtracted from the final reading ok.

So, in this in case of vernier scale; so, how to find out the 0 error? So, I think I will show you. So, when you will take at 0 position; I will loosen it take it at 0 position, then when you take the 0 position and then you have to see if it cross minus error or plus error positive or negative error. Now you have to see this which division of the vernier scale coincide with the main scale. So, if you see this say 25th division of this vernier scale coincide with the one line of the main scale.

So, your error will be 25 into the vernier constant that will be the 0 error; now it will be plus or minus depending on whether 0 of the vernier scale, it is at the right of the 0; of the main scale or it is left at the 0 of the main scale ok. So, that way you one can find out the positive and negative error for this vernier scale.

So, I think I will stop it here and then I will continue in next class.

Thank you.