Experimental Physics - III
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Lecture – 22
Topic – Experiment of Quincke's Tube Method

I will demonstrate that Quincke's Tube Method Experiment for measuring the magnetic susceptibility of paramagnetic material, one can do for diamagnetic material also. but in our laboratory we will use paramagnetic solve in form of solution.

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This is the experimental setup here you can just see. for this experiment whatever the things we need. We have arranged on this table. for this experiment as you know that we need magnetic field.

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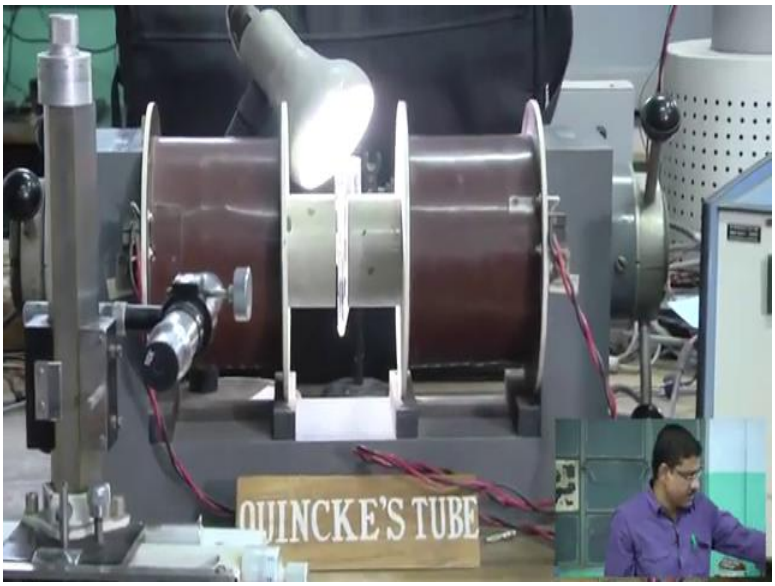

This is the electromagnet, this is the electromagnet, and you know how to use the electromagnet.

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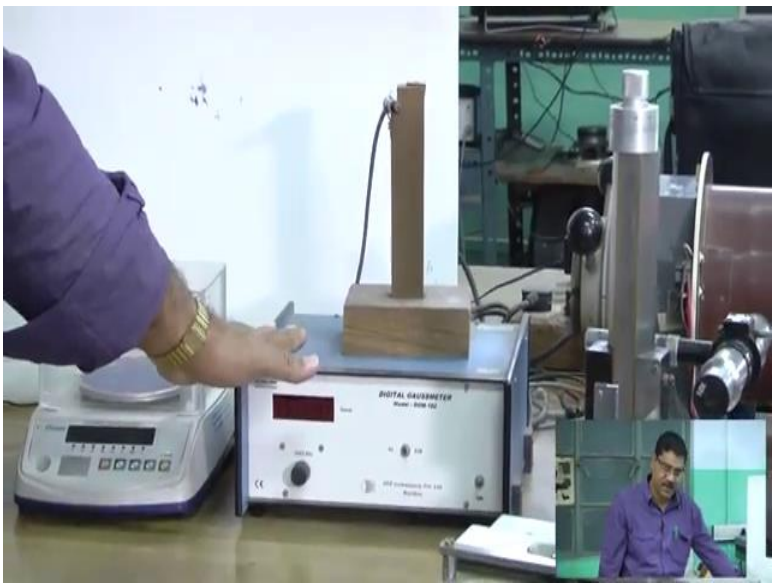

I have Hall probe and Gauss meter. this between pole pieces we have kept some gap distance, where we have to put our sample.

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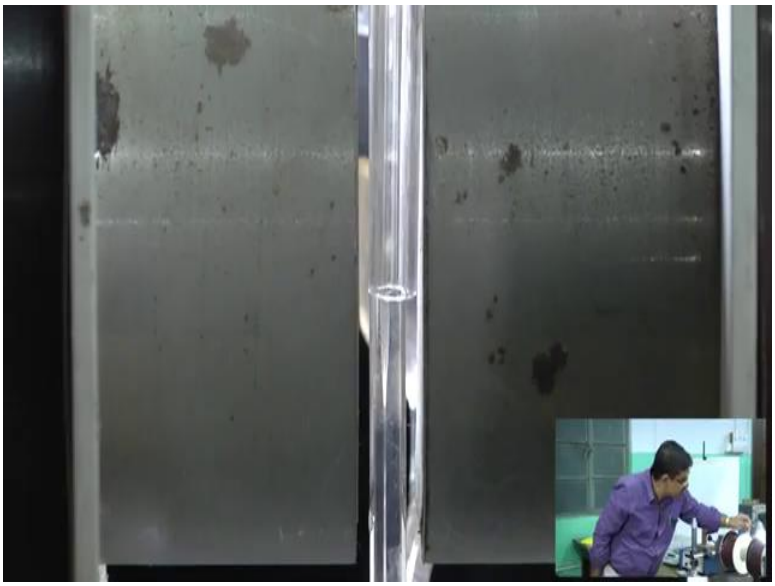

Here we have put our sample in Quincke's tube; I will show you that tube. but before putting that one has to use this gauss meters and we have for this air gap we have to calibrate the electromagnet. Means for different current what are the magnetic field that we will note down from this gauss meter and then a field versus the coil current.

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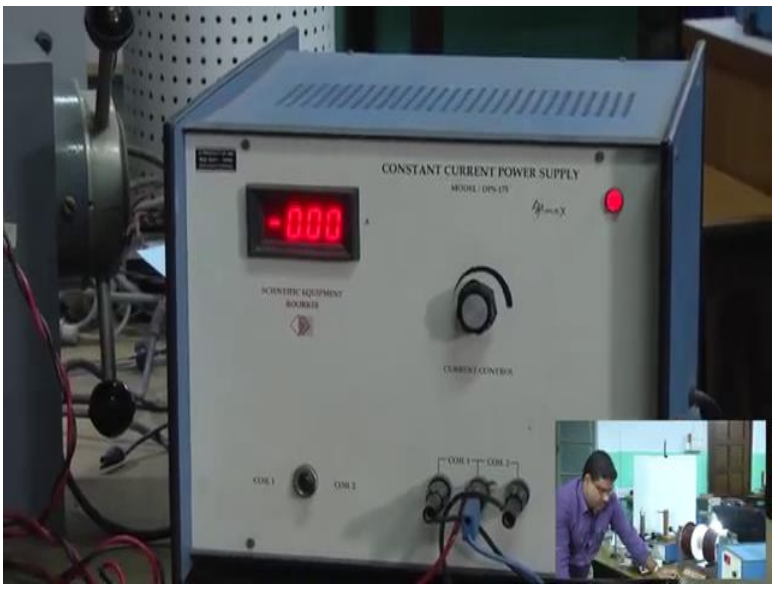

This we are telling coil current for magnetic field we have to; we have to plot and slope of the plot we will we tell this calibration constant. Using that constant, we can get the magnetic field for any current coil current. after calibration; after calibration we will start

experiment. In this experiment, what we need? We need we will take the liquid sample or solution in a tube called Quincke's tube.

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This is the form of this Quincke's tube this is, you will see u shape it is not u shape, but this is the shape of Quincke's tube. these tube these tube here it is the wider diameter and here smaller diameter, the reason is that when in these tube the liquid surface will change height. Other side we will expect that there will not be any change of the height.

That is why this we have taken I think maybe 10 times higher these diameter than the diameter of this one. reason as I told that we have so here this liquid surface height will remain same, when although here height will change due to the smaller. That change will be visible to us upper surface of the liquid will change in magnetic field. that is what we have to; we have to measure that height change we have to measure.

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Now we need solution we need solution, so here I have say here we have prepare solution.

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This is the specific gravity bottle it is the 25 millimeter this one 50 millimeters. this bottle one of them one can take and this balance digital balance is there.

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We will first empty bottle we will measure the weight of this empty bottle. That I told the w 3.

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Now, w 3 or whatever I forgot the what I have used this empty bottle mass of empty bottle w 1 Now we will take water; we will take water in this bottle we will take water in this bottle I am not taking but you should take water in this bottle and then you put it, then whatever extra water it will come out and exactly what will remain so that is the 50

here 25 ml With water now again we will measure the bottle plus water, so that is w 3. Now what will do we prepare some we prepare the solution we prepare the solution ok.

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Here you can see this one Manganese sulfate. The ours sample solution of manganese sulfate we will take.

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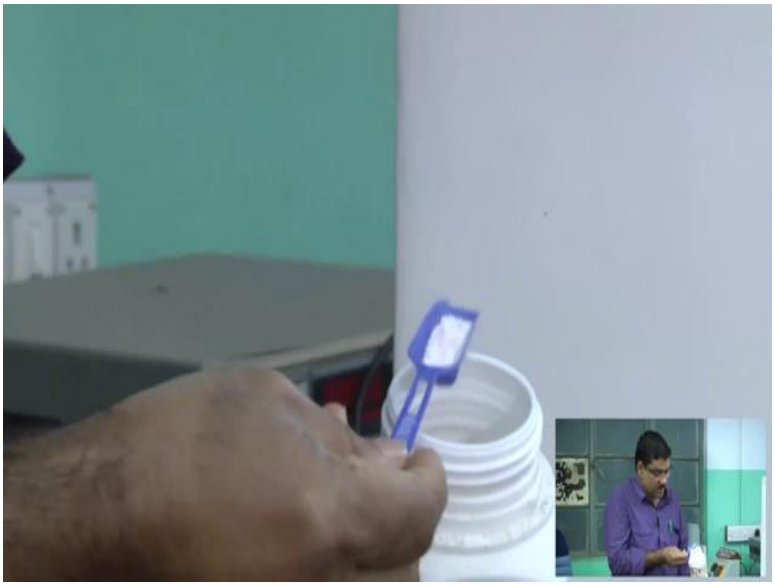

this is the powder kind of material powder kind of material yes, it is a white powder just yes it is the powder kind of sample we have to take this one prepare the solution; prepare the solution generally around I think this concentration we take around say 20 percent 10

to 20 percent this concentration of the solution we take. we will prepare solution and then again we will take that solution here and we will measures measure. This is bottle and solution this is equal to w 2 as I shown this in formula.

Now, you can find out the density of the solution. After preparing the solution and finding out the density of the solution from this formula density of solution from this formula ok.

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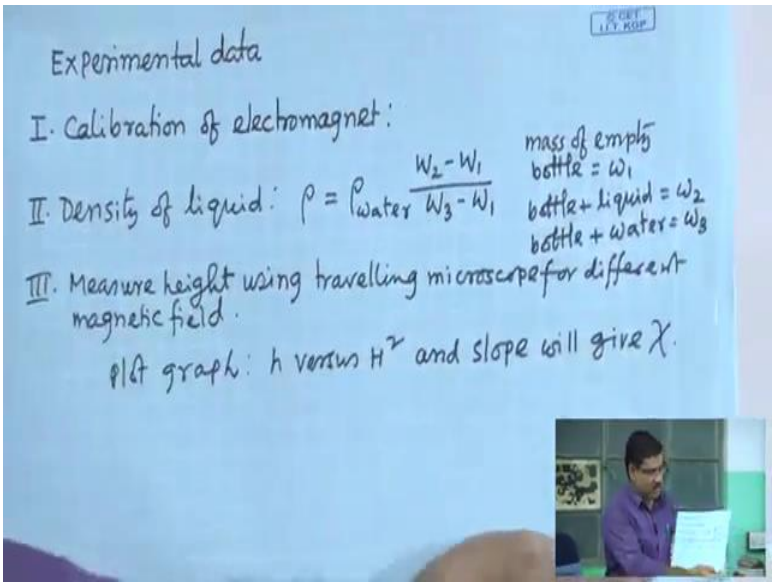

What are generally one can take 1 at 4 degree centigrade it is 1, but room temperature around 20. It will be slightly different from this one, but we can take 1 just from this weight measurement we can find out the density of liquid, because this we need. Now, calibration of the electromagnet after that density of the liquid we have prepare liquid, now that liquid we will take in this Quincke's tube.

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This liquid we will take in this Quincke's tube, just put liquid; just put liquid in Quincke's tube. I have put more water more I think some air bubble is there here some air bubble is there.

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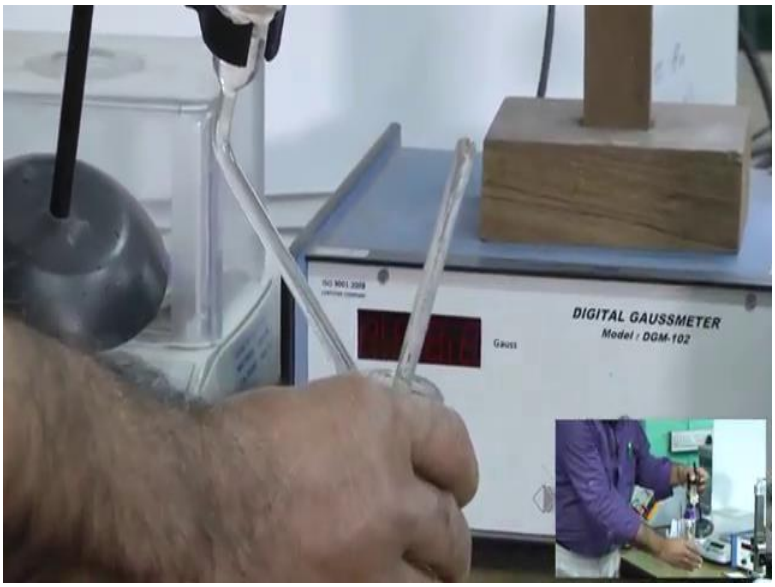

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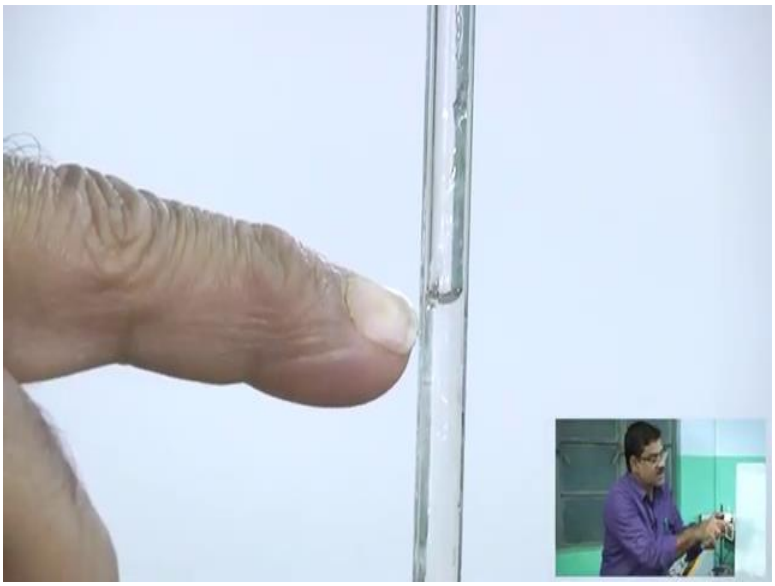

You can take out; we can take out here you can see this upper surface of this liquid. Now this tube us will this tube a smaller diameter one we will put this top surface of this liquid should be at the center of the pole pieces at the center of the pole pieces. Already we have so similar tube we have taken and already I have put; I have put here, I have put here we can see it

The upper surface of the liquid it is at this point, I can see here it is at this point at this height this is the liquid; this is the liquid and water that liquid surface is around here, this is the liquid surface ok, it is more or less at the centre of the pole pieces.

Now, what I will do I have to measure the height change of these of this upper surface of this liquid. we will use this travelling microscope, travelling microscope you know that you can move it; you can move it along these direction ok, along horizontal direction as well as you can move vertical direction. here you can move in vertical direction; you can move in vertical direction.

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There are scale horizontal scale vertical scale and then we have the; we have the and we have Vernier scale here circular scale we have circular scale ok.

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This one we will use for measuring the height. this is the.

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We will focus this we will focus first we have to focus this top surface top surface of this liquid. I can focus it but I will not show you. I have to take at appropriate height and yes I have to take at appropriate height I can see liquid this way I have to; I have to focus this upper surface of this liquid.

Now, that reading I have to note down from here and corresponding that scale see with the cycle change it. From here, so least count you have to find out I think you it is not difficult one it is easy for one rotation how much it is changing. that you have to know then now this is a 100 divisions are there and if variation is generally it is a 1 millimeter 1 millimeter divided by100, so 0.01 millimeter will be the least count for this travelling microscope.

Now initially we have to take this reading and then now magnetic field is 0 ok, at 0 field this is the label initial reading of this upper surface. Now, I will I will not use, but we have to use because I want to show you how this height is increasing with the magnetic field that I want to show you. Now for each step just increasing the magnetic field in each step, you have to take; you have to take reading of this upper surface.

Now, that difference of these reading in presence of magnetic field minus the initial reading, so that we will be give you the height h. that we have to measure as a function of magnetic field, means in this case as a function of coil current. Coil current will give

from here constant current power supply from calibration curve you can find out corresponding h.

Let me I let me just shift it from here, because if I do that you will not be able to see in video. So now, you see I will change the magnetic field and you can check that you can check that I will also try to indicate from here. I think I will go to the other side that I this may be helpful or just I will sit and do it then it will not be obstacle.

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Now, I am changing the; I am changing the magnetic field I think it will obstacle. let me go other side; let me go other side So now, I am changing the magnetic field; I am changing the magnetic field putting current see putting current and check that.

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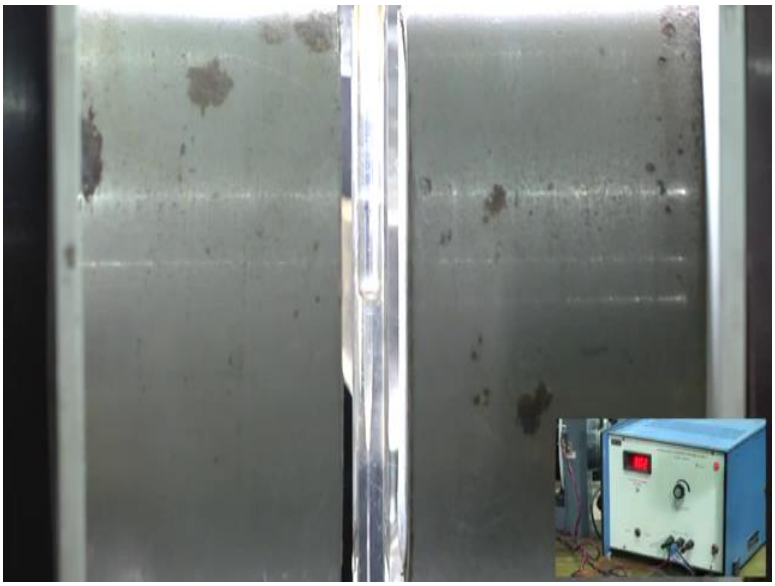

Now I have put some current just, if I change the current very quickly. Just to show you; just to show you that change of height. I will quickly I will change the magnetic field then it is it will be easy to show you in video.

just I am changing the; I am changing the magnetic field, mean coil current you see that height is changing; height is changing. hopefully it is visible height is changing. I am increasing the magnetic field and height should change; height should change so now, what you have to do? You have to now I have maximum current 3 here 3 ampere I have given you are we will see that height is the upper surface has gone up. So but procedure is that I will just change the magnetic field in step.

I think we will apply point it is a 3. 3 milliampere so if you take in 0.20 then 0.2 ampere 0.4 0.6, so then you will get around 15 16 data. That we have to; we have to plot that height versus the h square and from that plot, we will find out. So now, again I will show you just I will decrease the magnetic field and you see this height will now decrease.

During increasing as well as during decreasing you can measure the height; you can measure the height for. Then you can take average of these two or you can separately you can plot the data h versus; h versus; h square magnetic field square h that is the height of the liquid change of the height of the liquid.

Now I am decreasing the magnetic field, you see that you see this I am decreasing the magnetic field, so this surface liquid surface is going down. now, it is a field is almost 0 yes. So now current is 0 field is 0. Height is decreased ok; it has come back to this hopefully into original position. then actually what you have to do you have to use this one then focused focus to this; focus to this upper surface of the liquid in this column; in this column.

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Now, I will apply this field say 0.2 as I told 0.2 ampere ok.

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For that, I have to again a processor I have to put at the processor I have to put at the upper surface of the liquid. Now, then I have to take a reading I have to note down this reading.

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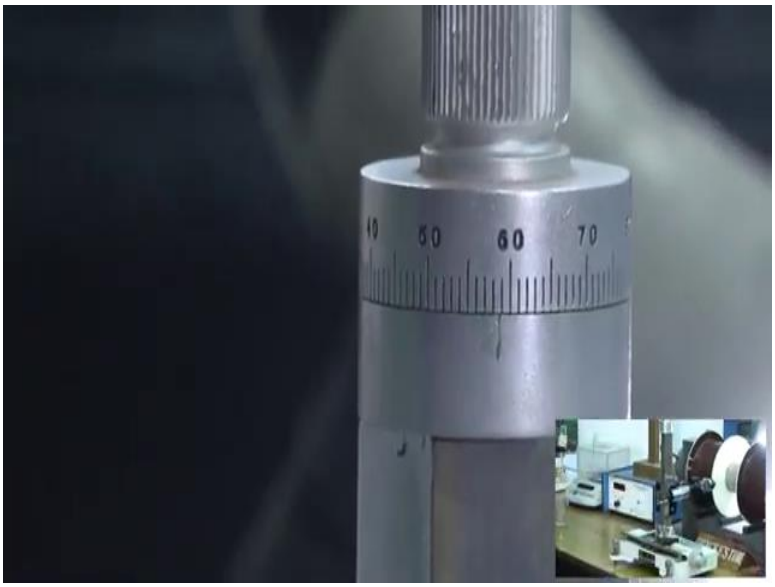

Now, again I will change the magnetic field I will go for 0.4 I will go for 0.4 ok.

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Now, corresponding magnetic field from the calibration curve we will get. Now for the spin what is the height again I have to see and I have to I will rotate it one I will rotate this one and processor should match with this upper surface of the liquid ok.

Again, I will take not a horizontal scale I have to take reading from this vertical scale, because I am using this vertical shifting. Whatever the reading you have to note down you go up to 3 milliampere not milliampere ampere, so you will get around 15 16 reading.

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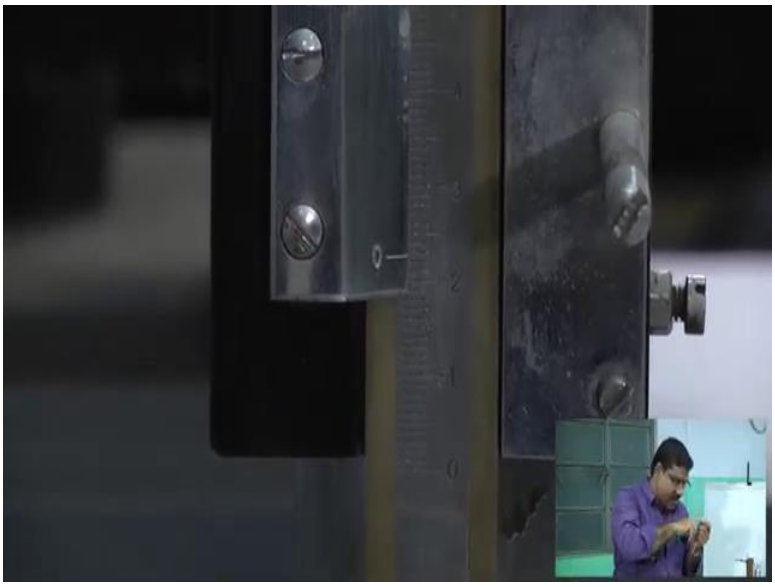

Now, again from there when you will decrease the magnetic field then also, you can just take measure the height and this will give you the complete data for height versus magnetic field. Then as I told we would plot, we will plot this.

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As I told that we have to plot the we will plot the h versus h square and from that slop we will get the; we will get the from slope h versus h.

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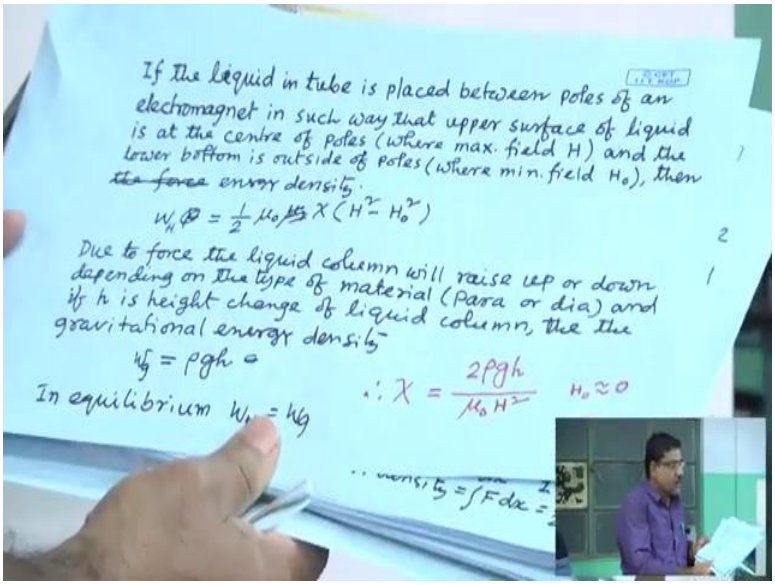

So h versus H square, so slope will be this mu 0 chi by 2 g h mu 0 chi by 2 rho g. we know mu 0, we know rho density and we know g that slope from that slope putting this value of these rho g and mu 0 we can find out the chi, that is susceptibility of this liquid. here when we are applying the magnetic field then height is increasing going up. It is the physical paramagnetic solved paramagnetic sample, if it is diamagnetic sample so there you will.

When we will apply magnetic field then we will see the height will decrease. Whatever say increasing or decreasing that is the metal, but you have to find out this height change with the magnetic field and same way one can plot and find out the chi. this height decreasing, that means this chi that will be it will be negative So height is decreasing, so one negative sign will come negative slope we will get.

That the indication of that is the indication of the diamagnetism. this is the technique which is used for measuring the diamagnetic or paramagnetic property of the material and there to that is that sample has to be in liquid form either sample is itself a solution or if you have a solid sample then you have to prepare solution. For this experiment, solution of the sample is required and you can perform the experiment for measuring the susceptibility of diamagnetic or paramagnetic material.

In addition, similar experiment one can do for solid sample. This is another method, so that also I will discuss we have experiment in a laboratory that I will demonstrate in next class.

Thank you.