

**Experimental Physics I
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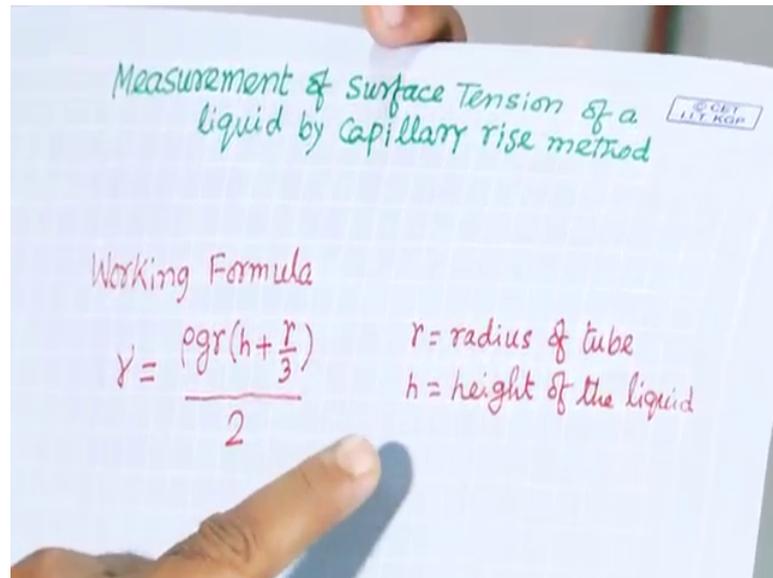
**Lecture - 29
Demonstration on the experiment of surface tension and data collection**

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So, this is a setup experimental setup for measuring surface tension of a liquid by capillary rise method. So, I have discussed about the working formula of this experiment. So, what was the working formula?

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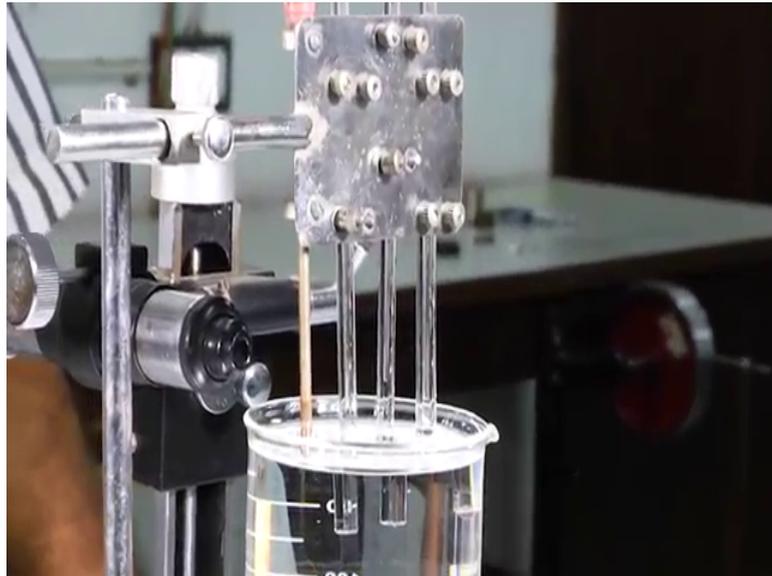
So, working formula was basically the surface tension is gamma equal to rho g r h plus r by 3 divided by 2, r is the radius of tube and h is the height of the liquid right. So, in this experiment basically rho is the density of the liquid. So, it is supplied with what need to measure and g is the gravitational acceleration, so that also known value. So, only r and h that we have two measure from this experiment. So, this is the setup for measuring this surface tension. So, here you can see we are using three tubes; we are using three tubes of different radius.

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So, what does it mean, it basically we are doing the experiment for three different radius. So, we could do one by one, but in this set up we have arranged of and in such a way that simultaneously we can do the experiment for different radius right. So, we will do this experiment for different radius that is basically here we have taken three radius. So, this three tubes having different radius and height of the water depends on the radius. If radius is smaller, height of the water will be higher ok.

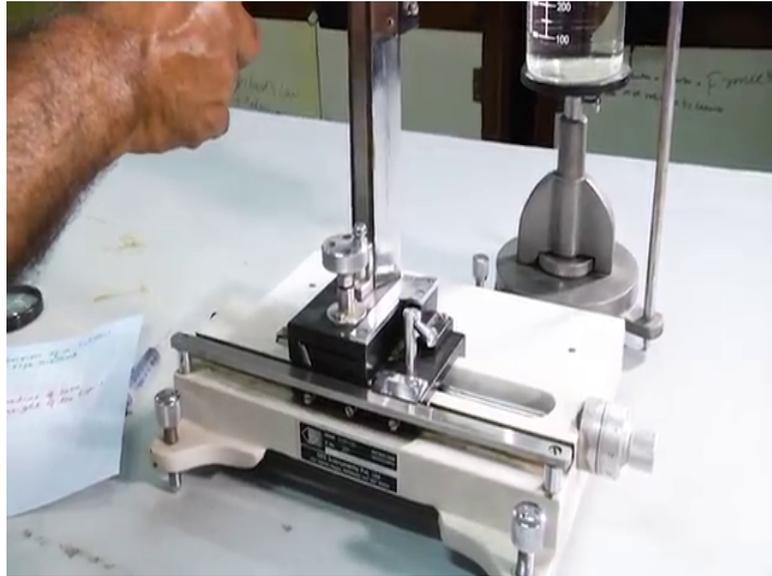
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So, and besides there is a needle, you see this end of the needle it is just touching the surface of the water ok. So, we want to measure the height and we want to measure the radius. So, first we will measure the height of the water ok. So, what is the height of the water? So, height of the water basically from the surface of the water in the beaker that where we have taken water, so that water surface from that water surface what is the height of the liquid column in the tube, so that we will measure.

So, for measuring this height we are using this instrument is basically the travelling microscope and already I have discuss about this instrument in previous experiment. So, again I will tell about this instrument. So, this travelling microscope have basically we can just moves this microscope basically in vertical direction as well as in horizontal direction.

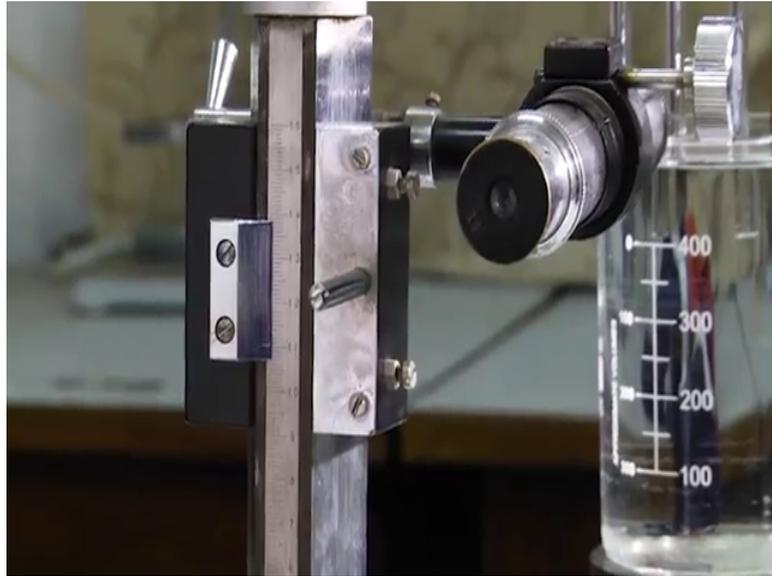
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So, it has two scale one is horizontal scale and another is vertical scale right. And this both scale it is basically equivalent to slide calipers. So, it has main scale as well as vernier scale ok. And Vernier constant of this one has to find out. So, how to find out that you know. So, here basically 49 division, here you can see this there are 50 division in vernier scale, so that coincides with the 49 division of the main scale ok.

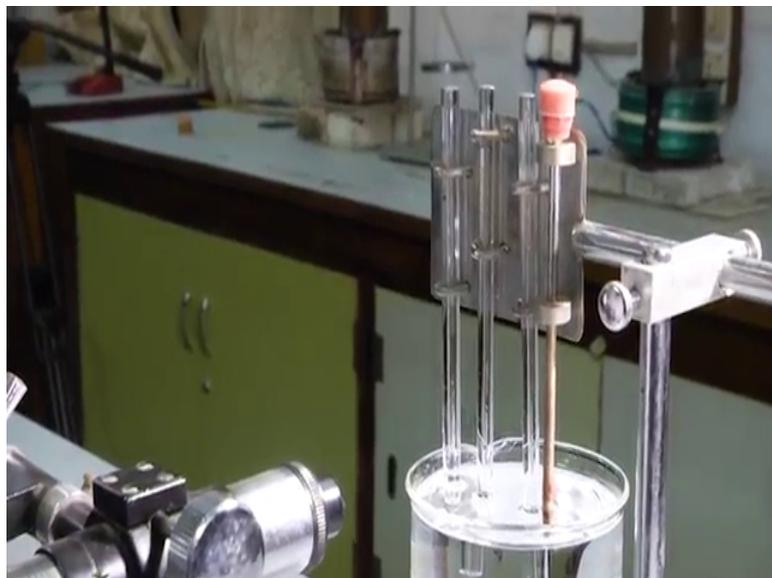
So, to calculate this Vernier constant we have to know the value of the one small scale division of the main scale linear scale, so that is basically here it is 0.5 millimeter. So, your Vernier constant will be 0.5 millimeter divided by 50, so that is that equal to 0.001 yes 0.01 millimeter and in centimeter it will be 0.001 centimeter. So, least count for this both scale for this horizontal scale as well as this vertical scale, so this least count is 0.001 centimeter. So, we have to note down this least count the basically Vernier constant.

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Now, let us now we have to measure the height of the liquid in the capillary tube. So, I have 3 tube, I have 3 tube of different radius.

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So, let us see the water column, the inside the capillary tube yes I can see, you see this height here this is the height of this liquid column in this tube. And here height is higher so that means, radius of this one is must be smaller. So, here this is the height ok and in this case height is this one. So, this is the tube having higher radius ok. So, these three heights, because of three different radius. So, we have to measure the height of this

columns from the surface of the liquid. So, to just to using this microscope to get the reading of this surface of the water. So, we have used one this needle at the end of the needle just, it is touching the water surface ok.

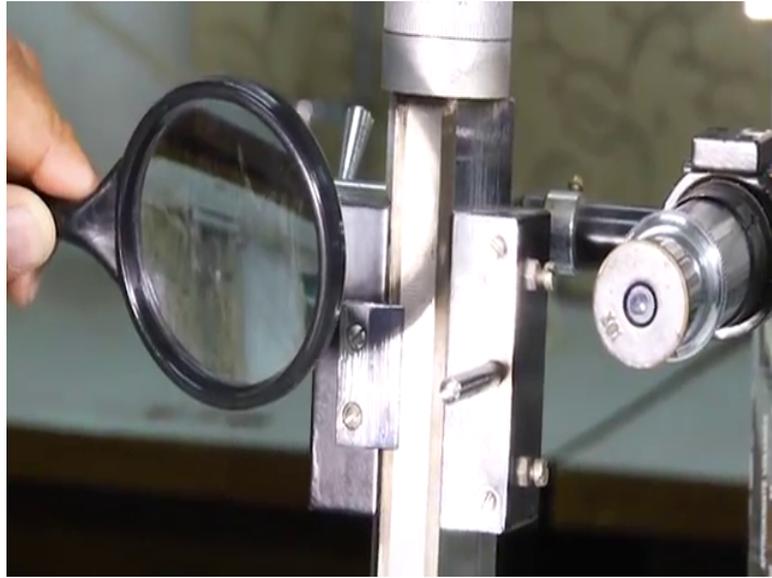
So, from this microscope first, we will focus at this end then we will note down this reading on the vertical scale and then we will move up this; we will move up this microscope. And focus at the top end of this liquid column; top end of the liquid column and then again we will note down the reading of the vertical scale. So, difference between these two reading is basically will be the height of the liquid column ok. So, for that I think can we just focus and so, I think here it is already focused.

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So, you have to so in middle. So, we have focused it at this end. So, if I see, I can see this it is a convex type of end, we can see through microscope, because in microscope we get this is basically inverted image. So, basically here this curvature I on the top surface of the liquid column is basically this concave type, but in microscope I am seeing it is in convex type. So, this cross wire of this microscope I have said at the just top surface of this convex edge ok. And then I will take readings so, it is already set. So, this reading you have to take here you can see this is the 0 of this Vernier; this is the 0 of the Vernier. And this reading is yes it is I can see it is the 11 point something is difficult to see for me.

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But I think using the yes so, using the magnifying glass, I can take reading, yes, it is basically 11.0, yes and slightly it is between 11.0 and 11 point it is the 11 yes is 11.0 and 11.1, it is in between this two reading. So, now we have to find out the number of divisions ok, which division of Vernier scale coincide with the one line of the main scale so that we have to find out. As you know this how to find out, so this fine. So, this is a one has to take basically reading ok. So, here its slightly difficult to just take, but this is the way, as you know this we have to take reading, yes you take in Vernier slide calipers.

So, this is the one reading of one so for this middle tube ok. So, then we can take this same way, we can take this reading for the other one, I can move I think this way can you please just set to the next one ok. So, we will set to the next one, we will focus to the next one ok yes. So, we are focusing to the next one. First we just move the travelling microscope horizontally. And then we are adjusting the vertical height; we are adjusting the vertical height to just to focus that I think this we are focusing this one here; we are focusing this one here ok and yes then we have to yes we are focusing yes.

So, this fine adjustment, fine this height you can see. So, through the microscope if I see yes, it is the it just nicely focused and processor coincides with the upper surface of the concave edge of the liquid column. So, now we will take this same way here as I showed this we will take the reading.

Now, this reading is it looks to me it is 10 point yes it is 10 point, yes it is 10.123, it is 10.3, this reading is between 10.3 to 10.35 ok. So, now from Vernier scale, one has to the Vernier constant is Vernier constant is 0.001. So, we will find out the Vernier divisions which coincides with the main scale lines ok.

So, we will find out the reading for this tube ok. So, this way again this other one also we have to take reading. So, these three readings we will get for this three, this three column in three tube ok. So, now, we will take the reading of this water surface. So, basically the we will focus at the end of this needle. So, can you please focus at the end of the needle this microscope yes here. So, you are focusing basically needle using the microscope travelling microscope and it takes slight its takes sometimes to focused it, because you have to move horizontally and then you to adjust vertical scale. So, here mainly I am showing you how to use this travelling microscope to focus this liquid.

So, in this case we have focused this cross section is at the end of the needle so, needle end is touching the water. So, this is the basically this now we can take this reading is basically is the is around 10 point I can see 10 point, 10.1 its around 10.1 yes this is 11 this is the 10 10.1. So, now you have to take Vernier scale reading and find out this what is the reading for this needle end ok? So, this is the needle end, this is the same for all three tubes.

Now, to find out the height of this water h as I showed in working formula, so this earlier this top of the water surface in the tube that if we tell this is the h_2 and this water surface reading or needle and reading if it is h_1 , so your height of the water will be h_2 minus h_1 ok. So, same h_1 will be subtracted from this all three other readings. So, we will get height for three radius, so that we have to note down ok. So, this way we have to measure the height of the liquid column in the capillary tube.

So, this is one parameter thus we have measured ok. So, I have data, I have taken data. So, I will discuss how to analyze the data and find out the surface tension or calculate the surface tension. So, next we have to measure the radius of the tube. So, I have three tubes so, it has different radius. So, I have to measure the radius of the tube. So, there are two methods to measured it; so, one method is just we can put mercury into the, we can put the mercury into the this capillary tube.

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And then we have to measure the length of the mercury, we have to measure the length of the mercury column.

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So, I have mercury also, but basically yes I have mercury. So, this mercury, yes this is the mercury ok. So, this mercury I can put inside this capillary tube. So, using this you see needles medical needle. So, we use for taking blood from the body ok. So, this we can use, but I then we will basically measure the length of this mercury. And then we will take weight of the mercury of this mercury.

And from there basically if you know the density of the mercury, so weight of the mass of the mercury will be m equal to $\rho g h$ basically. So, mass will be $\rho g h$; $\rho g h$ means here ρg its no it will be mass will be equal to this volume into density, yes, so volume into density. So, volume of this mercury will be area cross section area that is πr^2 into this height or length of this mercury column. So, if it is h , so $\pi r^2 h$ that is the volume into ρ , so that will be the mass ok. So, that mass we will use balance to measure the mass of this one ok. So, from there we can basically calculate the radius of this mercury tub. So, this is one way one can find out the radius of the capillary tube.

But, here we will use another method. So, that I will explain I will show you. So, basically we will use this microscope to measure the radius of the capillary tube. So, from this micro through this microscope you can see clearly this hole of this tub. So, this cross wire I can put at the edge of the hole. So, this left side of the hole left edge of the hole so, this basically inner sight inner diameter I want to measure or inner radius I want to measure.

So, whatever hole we will see, this crosser vertical crosser I put at the left side, left edge, then we will take this reading. And then I will set this cross wire vertical this cross wire to the right of the edge ok. So, then so this is basically I have to take from vertical, so form horizontal scale. So, two reading I will get from left and this from right ok. So, from this horizontal scale; from this horizontal scale and if you take deference of these two reading then you will get the diameter of the this capillary tube that is inner diameter of the capillary tube of course, from there you will get the radius ok.

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So, can you please just so just we remove the this water beaker. And just turn this tube in 90 degree in 90 degree ok.

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Now, we will focus the hole, we focus the this tube. So, we will focus each tube, for each tube I have to measure the diameter or radius. So, we are focusing now the middle one ok. So, in microscope basically that is we are using microscope this smaller things, we can see in bigger way ok. So, this hole in microscope basically small hole, but you will see very looks like very big one very nicely I can see.

So, this portion now set at the left edge of this hole ok. So, now, I have to take reading. Again I have to take reading from here from vertical from this horizontal scale. So, here also horizontal scale this I have this 0, 0 and from here basically, you can take this reading it is the 14 point something. So, that accurately you have to take this read this reading from Vernier constant. So, one can find out this total reading. So, Vernier reading as well as this main scale reading, so total reading for this left edge of this hole.

And then I will move towards the other side to just now vertical cross wire I am setting to the other edge ok, yes, it is now at the other edge. So, now, again I have to take reading for this position ok. So, difference between these two reading is basically radius of the not radius, it will be diameter of this tube. And half of this diameter is basically the radius of this middle tube ok.

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So, same way one has to measure this one radius of this one and also the radius of the other one ok. So, for three tubes, we will find out the radius using this travelling microscope. So, for this case we are using the linear horizontal scale of this microscope. And for measuring the height you have seen that we have use the vertical scale of the microscope ok. So, now we have data. So, we have basically three sets of data. So, in working formula this I have shown you this we have to measure height and radius.

Now, experiment generally we repeat all the time we repeat. So, here we repeated simultaneous measurement we have done. So, here we have varied the this diameter of

the tube. And height we cannot vary, because it depends on the height depends on the radius of the tube. So, we varied the radius of the tube and for three radius, we have measure the height so, we have three sets of data.

Now, we will calculate for each sets of data this surface tension and then you have to take basically of this three data, then that will be the final result. And I will discuss about the about the data, how to record the data and how to calculate and finally, how to calculate the basically these error percentage error or most probable error for this experiment that details I will discuss in next class.

Thank you for your attention.