Experimental Physics - II
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture – 19
Determination of Refractive Index of Liquid using Travelling Microscope

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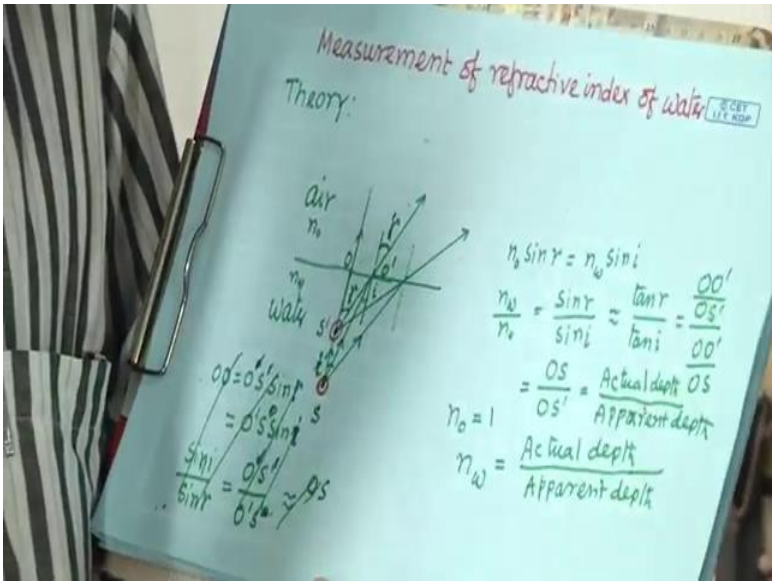

Today I will demonstrate very simple experiment how to measure the refractive index of liquid. We will take water; we will measure the refractive index of water. For this measurement, what principle we will follow like. you have water, and this is the interface of water and air; refractive index of air is, say n 0 and water is n w.

Now, in water if you have an object S, if you have an object S then if you see the image of this object from air; where you will see that image. image will be formed by the refractive ways. light will come from the water to the air there will be refraction at this interface. this is one rays perpendicular to the interface it will go refracted following without changing the direction. Second ray say this one is a second ray, ok.

is a denser medium or is a rarer medium it is a; if I to this is a incident angle. here I have taken r; actually, from other side we can say this is the refracted angle because like follows the reversibility principle. this ray this is the normal these angle will be no; I have taken this is the this is the normal. this is the incident angle I; this is the incident angle i this the refracted ray angle of refraction is r.

this is one refracted rays, and this is another refracted rays. from outside in air we will see that this light is coming from this point ok. if you if you extend backwards these two refractive rays they will meet here. this image will be formed at this place ok. apparently, we will see this height of the object inside water it has is decreased. that object apparently will see it has come up. if you take another ray al if you extend it refracted one, they will meet here.

this angular very small e p c; e p c put your eye here. following the Snell's law you can write n 0 sin r. Why I have written r? Ok. Yes, so because this is here is the sometimes confusing because, we are habituated to define the angle from air to water air in opposite. n 0 sin r equal to n w sin i incident angle here and corresponding refractive index; n w by n 0 equal to sin r by sin i; approximately if angles are small then you can write tan r by tan i.

tan r and tan i this angle are r and this angle is i. tan is O O dash by O S dash and for another case O S. O O dash by O S dash for tan r and for tan i O O dash by O S. so, these equal to O S by O S dash. actual depth divides by apparent depth. for air n 0 that is 1 n w is equal to actual depth divide by apparent depth. if we can measure the actual depth and the apparent depth of the object ok; then we can calculate the refractive index of liquid of water. for measuring this one we will follow the following step, we will follow the following step.

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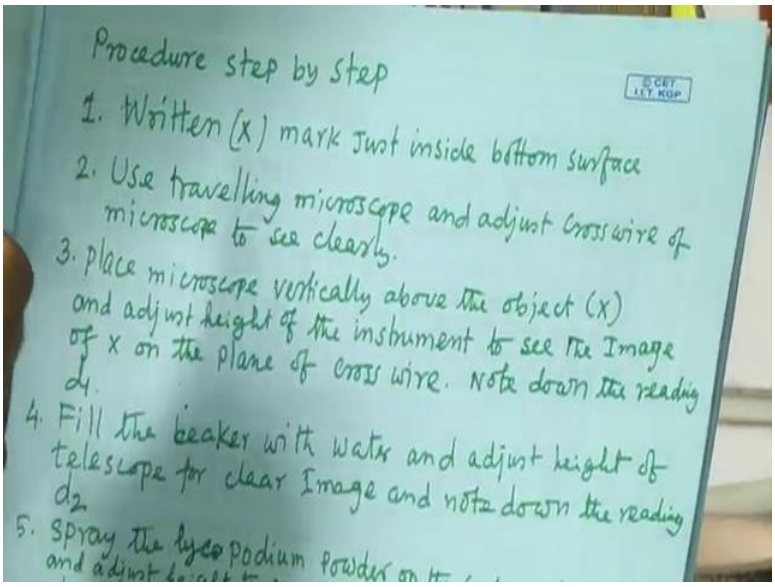

so, procedure step by step read X mark just inside bottom surface of a beaker. we will take a beaker say at the bottom surface inside, inside bottom surface of the beaker; we will write some mark say X or plus or something or some circular drop ink drop, ok. Then we will use microscope, travelling microscope and we will focus the microscope to see the; actually, first you should focus the microscope to the cross wire.

And, then this you place this microscope, you place this microscope on the beaker to see this mark, this cross mark or plus marks. And, we have to adjust the height to see the image, to see the image of X on the plane of the cross wire ok. then when it is focus properly on the object ok, we will take we will note down the reading of the scale. that we will note down say this is d 1.

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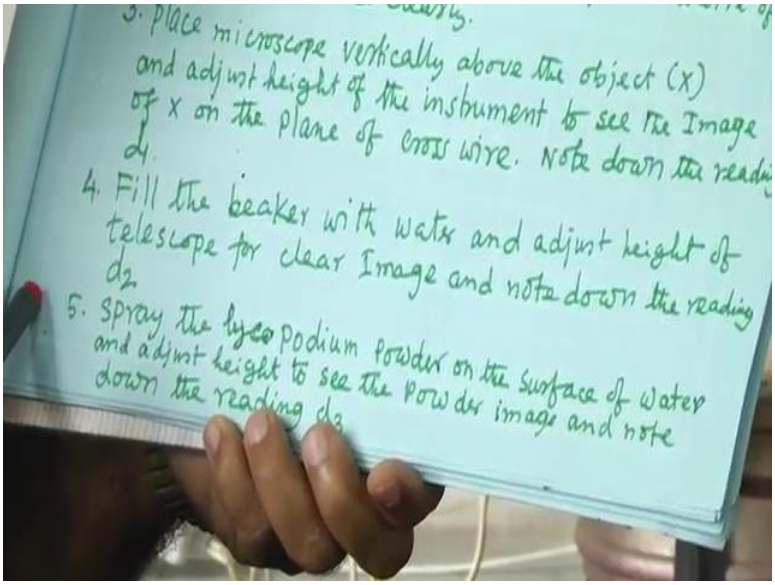

Then we will feel the beaker with liquid, in our case we will use water and again we will adjust the height of the telescope for clear image and again we will note down the reading of the scale that is say d 2. Then we will spray lycopodium or some chalk powder on the surface of the water and then we will adjust the height again to see the powder image and note down the reading. that is the water surface, that is reading for the water surface.

if that reading is 3 this is the water surface. Now, so what is the distance of the object from the water surface means what is the actual depth of the object. that we will get d 3 minus d 1 or d 1 minus d 3 and the image apparent height of the objects or the image.

that we will get from difference between the d 2 and the and d 3 then we will be able to calculate the refractive index, ok.

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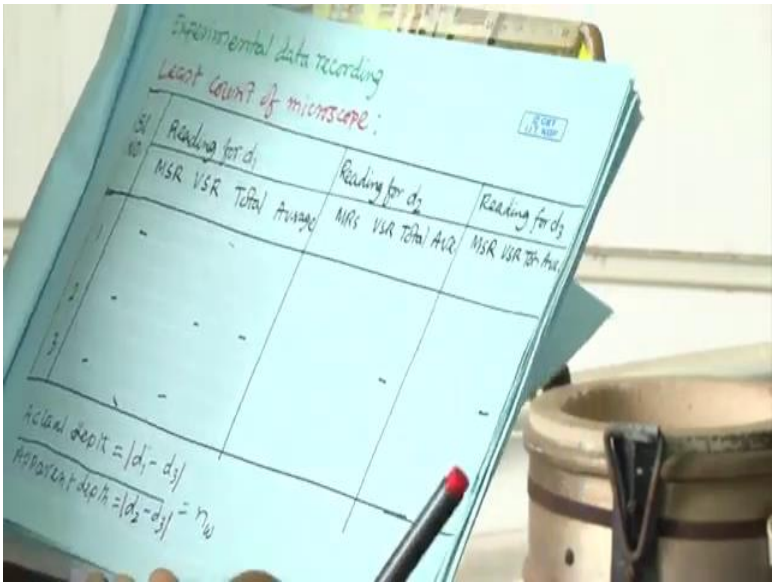

this table is very simple. we have to note down the least count of the microscope, we have to note down the least count of the microscope, ok. Then one column is for serial number, then reading for d 1; d 1 means this object depth. main scale reading, Vernier scale reading, then total, then we will take few observation, then we will we have to take a average.

And, then reading for d 2 means for image and then reading for d 3 that is for surface. then you can calculate the n w refractive index of water. that d 1 minus d 3 or d 3 minus d 1 divide by d 2 minus d 3 or d 3 minus d 2. actually, you have to one can keep this mod then what about you take difference that does not matter.

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let us see the setup for this experiment. this is the setup for the experiment, I need only one microscope travelling microscope and I have a beakers. And beakers; there is a you can see this there is an object this is marked say it is a S, it is a some marking at the bottom of the beaker, inside bottom. that that is our object.

in travelling microscope, you know that there are three scale: one is along these direction, another is along these direction and other one is along the height ok. at present we have set the x and y direction for putting this microscope on top of the beaker, we will not; we do not bother about the shifting, but initially one has to shift along x and y direction. at present only we will deal with this height with this scale ok.

in this scale you can see here it is it will work like a screw gauge because, here this is the linear scale, this is the linear scale and this is a circular scale, ok. it has 100 division circular division and if I rotate where a 0 position, 0 position is I think it is the 20. Yes, 0 position is other side, here I can see here it is the 0 position ok. If I rotate let me take the 0 position here; I think yeah this is the 0 position, ok. here what is the reading that I have to see? I can see the reading that is it is a 2.5or 25 millimeters.

if I rotate once then we have to shift, let me rotate by 100 division ok. So now, its reading is a is I can see this is 2.4, 24 millimeter so; that means, for a one complete rotation for 100 division; linear scale that is this change is 1 millimeter. least count will

be you have to note down least count for this scale that will use for measuring for doing the experiment.

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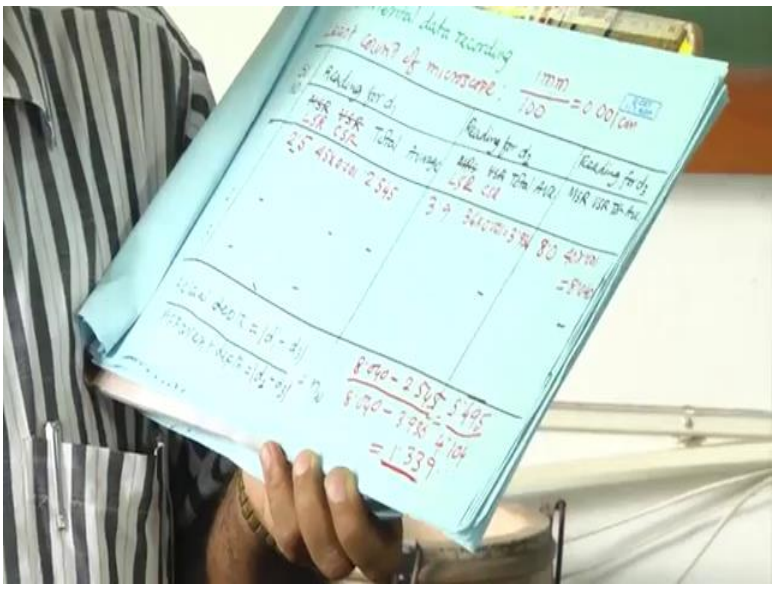

one smallest that is 1 millimeter for 100 circular division. you will get 0.01 millimeter then 0.001 centimeter. that is the least count for this microscope for this scale; vertical scale this scale only we will use. next let me now I have to focus the object that mark whatever is there.

that it is an almost focus we kept it focus position, but I change, I have to go other way. to get the clear pictures, sharp pictures, sharp image; we have to I think I should; now it is becoming hazy. I have to go other way; no, it is not better; it looks better. what is the reading? Ok. But I think this is not enough, I have to know it is ok; let me fix here and then find adjustment I can do to this with this, yes this it is a nicely focused.

I have to take reading. reading is now is the 2.5 centimeter and this one is 45 ok. this reading I will note down; I will note down this reading this main scale reading or linear scale reading in this case, ok. it is a, you can write linear scale reading it is the in which unit you should use centimeter we have used. we will use this 2.5 and Vernier is 45 into 0.001 it is total will be 2.545. I am not taking another you should take two-three observation try to focus two-three times and take the reading. then find out the average of them, but I will take this one reading.

Next, I will go for the, I will put water I have water it is so I think slightly I reduce yes, I think it is fine, slightly more I will reduce fine this could be fine. this water I have poured into the beaker and then put once more here, ok. Let me see I have placed properly, yes now it is a hazy. I have to focus once more ok. I will loosen this one, this screw and codes adjustment I should do; whether I have to take upward down that I have to check, yes, I have to take up, yes.

Now, more or less I found it is a yes now I have to adjust I have to focus properly, yes, I should it is shaking bit, while yes, it is focused nicely. So now, I have to take this reading, I have to take this reading. What is the reading? It is now three point; this I can take 3.8 and this one is 36; 3.8 and 36 but I do not know here it is 5 6 7 8. I can take 3.9 it is called fusion, there should down be parallax error you know; it should be 3.9.

for d 2 again this one should write circular scale reading similarly here linear scale reading ok. that is what I told I forgot 3.9, yes 3.9. 3.9 and other one is 36 I told, 36 circular scale reading 36 into 0.001. your total will be 3.936 ok. two more two-three more observation one should take. Then now I will take reading for d 3 means on the surface, reading for the surface ok.

I will use just some chalk dust; I will use some chalk dust yes. Just it should be visible, the surface should be visible, ok. Let me check whether I should give more, or I can see the dust chalk, dust on the surface. I have to take more height; I think I should give more dust; I cannot see you should not, but there is no (Refer Time: 26:04) ok. I should not give again too much because, then height will change. yes, I can see, I think it will be here somehow is just a I have come down.

it should be up, but it looks I am finding to get the checked to get the dust for focusing it is. it is I do not know dust no, I do not know dust is more or it not focused, it not focused. I think I can get this place, let us see I think this may be the place it is, but something I should; I do not know some beakers it is not, yes.

this I think here I will get, actually this problem I am facing that. yes, I think this is the place. Yeah, I think I because it white as well as a it is now water become it is not clear water. I think I have put more dust but this more or less I could focus at this point. this reading is.

Student: (Refer Time: 37:39).

8 reading is 8 and this one is 40; 8 centimeters and 40; 8 centimeter this reading it is a 8 centimeter and this one this 40 into 0.001 it will be 8.040. if I use this this d 1 minus d 3 actually what this 8.040 minus d 3 minus d 1 actual depth that is a minus 2.545 divide by 8.040 minus 3.936, ok.

this will be equal to this 5 then 5 9 then 6, this is 4 and then this is 5 divide by this will be 4 0 0 9, this is a one point this 9 this one, this 4 this 4. 4.5 I have to use this calculator now, it is a on this 5.495 495 divide by 4.014, 4.104; 104 equal to.

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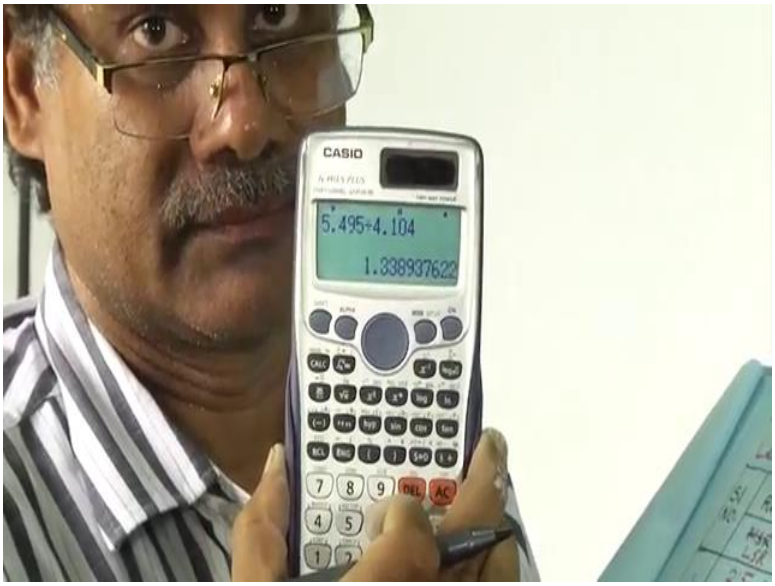

I got this is the value; is the value, I got one point; how much? 1.3389, I got this equal to 1.339 some other. it is you see this how accurately we are able to measure this you know this refractive index of water is 1.33, for glass we take 1.5 and for water it is 1.33.

here 9 is there, but up to this second is well point, ok. it is exactly this what about real value in literature. some simple experiment we are able to measure this refractive index of water ok. it is nice that I was able to focus properly; one has to try. so take few observation and take average you may get even better result; it is between 3.33 and 3.34.

You can get even better than this result. Then one should do this error calculation etcetera. You know how to do that; I have described for some experiments. I will not repeat for these experiments. It is a very simple experiment, nice experiment and how

easily we can get very accurate refractive index of liquid; instead of water you can take other liquid and you can measure it. I will stop here.

Thank you.