Fundamentals of optical and scanning electron microscopy
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Module – 02
Lecture – 10 continuation
Tutorial Problems related to optical microscopy

Hello everyone, welcome back to this Material Characterization course. In the last class, we just looked at some of the problems involving the basic principles of optical microscopy. In today's class also we will continue that tutorial class, and I would like to solve two more problems and then we will move on to the next topic. So, the problem number six, problem number five.

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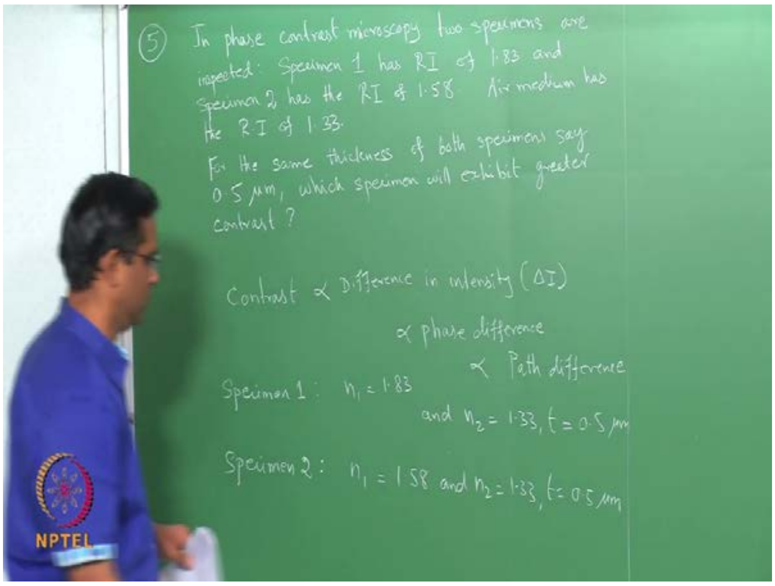

So, this problem is involved in the phase contrast microscopy principle. In a phase contrast microscopy, two specimens are inspected. Specimen 1 has the refractive index of 1.83, and the specimen 2 has the refractive index of 1.58, and the air medium has the refractive index of 1.33. And if you assume that for the same thickness of the both specimen say, would 0.5 micron which specimen will exhibit greater contrast. So, what is that, I hope you will remember the formula which one should be used.

So, let us start with contrast as we have discussed in the one of the class that contrast is a difference in the intensity, that is you can write contrast is proportional to difference in intensity that is delta I, which is proportional to phase difference and the phase difference is proportional to path difference. So, this how we have to connect all this phenomenon. Contrast is proportional to difference in intensity which is related to phase difference and which is again related to path difference. So, we can write for a specimen 1, and then specimen 2 we can write. So, we can write like this for specimen 1 as well as specimen 2.

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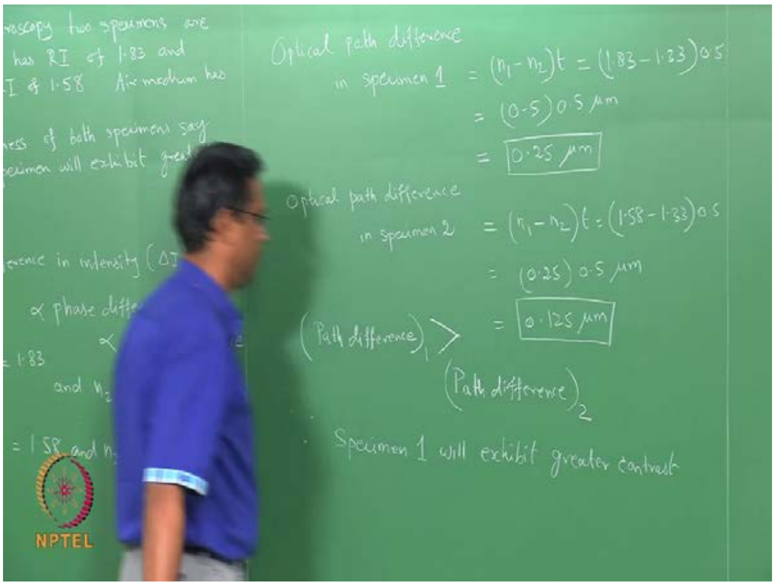

Now, we know the formula for optical path difference. So, for the case of we can say in specimen 1, equals we can say n 1 minus n 2 times t. Which is nothing but - so we simply substitute this values of n 1 and n 2 for a specimen into this formula. The path difference is the difference in the refractive index times the thickness of the medium. So, you get the path difference of a specimen 1 is 0.25.

Similarly, we can do, so now you have a two values belonging to specimen 1 and then specimen 2. So, now, you have to think how do we interpret this values. So, what is that the path difference exhibited by specimen 1 is greater than path difference exhibited by specimen 2, so obviously, you know how to relate this with the contrast. So, therefore, specimen 1 will exhibit greater contrast. So, it is a very simple problem, but in order to bring the idea of a phase difference and it is useful.

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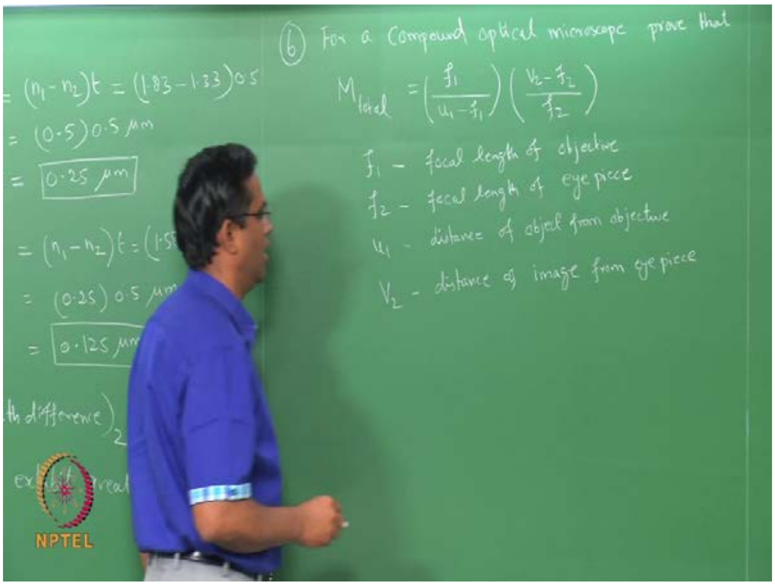

We will now move on to problem number six. So, the question is for a compound optical microscope, prove that M total that is total magnification is equal to f 1 divided by u 1 minus f 1 times v 2 minus f 2 divided by f 2. Where f 1 is focal length of objective lens, f 2 is the focal length of eyepiece lens, u 1 is a distance of object from the objective, v 2 is the distances of image from the eyepiece. So, before you make an attempt to solve this kind of a derivation, you better go back and look at the ray diagram what we have discussed in the class, for a compound optical microscope. If you remember or recall the ray diagram then it is very easy to derive this.

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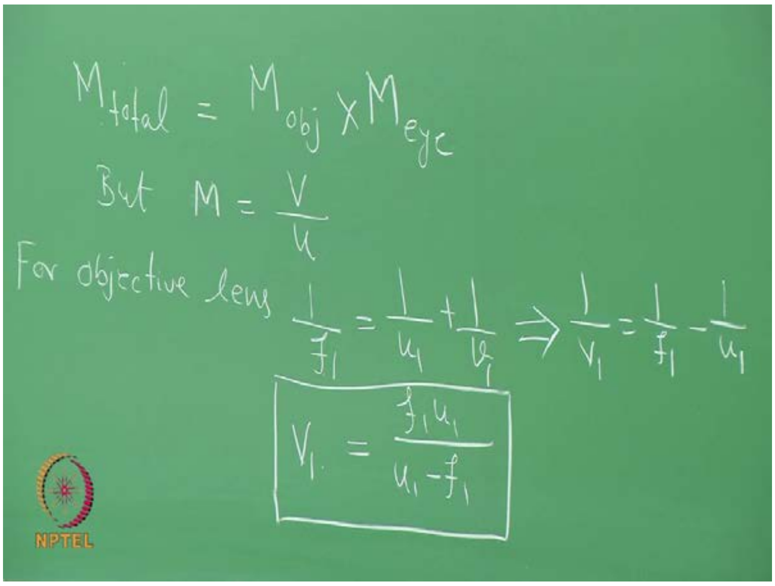

So, the first step is we know M total is equal to objective and eyepiece. So, this we know, magnification - total magnification is equal to magnification achieved by the objective lens times the magnification achieved by the eyepiece lens. So, we also know that from the ray diagram we can write v by u. So for objective lens, we can write 1 by f 1 equal to 1 by u 1 plus v 1. So, this can be written as 1 by v 1 is equal to 1 by f 1 minus 1 by u 1. So, what I have written is one objective lens, the lens equation you can write 1 by f 1 equal to 1 by u 1 plus 1 by v 1. So, you can rearrange this to this form, then from there you can write an expression for v 1. So, we can derive an expression for v 1 from this like this.

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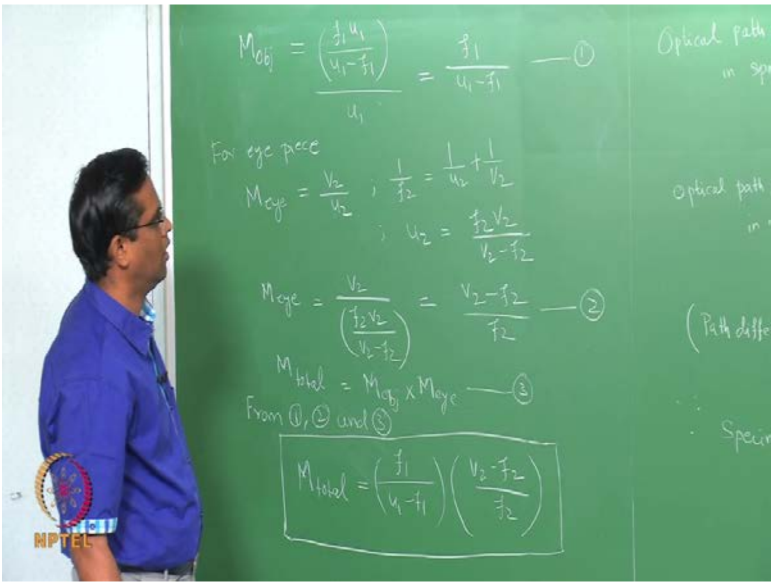

Similarly, you substitute that v 1 in this equation that is for M objective is f 1 u 1 divided by u 1 minus f 1 by u 1. So, you write like this f 1 divided by u 1 minus f 1. So, this you can consider as one equation one. What I have done is basically this is the equation - basic equation; and from this lens equation, we can obtain an expression for v 1, and then I am simply substituting this into this and then I am getting these kind of an expression. Similarly; for an eyepiece, let us assume that u 2 and 1 by f 2 equal to 1 by u 2 plus 1 by v 2. And we can assume this similar expression, you substitute this. So, you get this kind of an expression for a magnification of eyepiece.

So, now we can compare 1, 2 and let us consider this as 3. Magnification total is equal to magnification of objective. So, let us write like this. I will rewrite this here for a convenience. And then from 1, 2 and 3, we will be able to write M total equal to the expression this what we have asked in the question. So, what you have to remember is, again I am telling you, before you try to solve this a small derivation, look at this ray diagram of the compound lens, what we have seen in the class, then you correlate this magnification of objective lens and magnification of eyepiece lens geometrically, and verify them. And then look at this expression, then it is it will be very a simple derivation.

So, with that I want to stop this tutorial class. And we will move onto the next topic on scanning electron microscopy, and then we will also would take up a couple of tutorial classes involving some of the basic principles after going through the theory and the working details of the SEM.

Thank you.