Experimental Physics - II
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Lecture - 17
Determination of Focal Length of Convex Lens by Displacement Method

In last four classes we have demonstrated, how to measure the Focal Length of concave mirror, convex mirror, concave lens, convex lens. We have used the parallax method means using the image needle. We were trying to find out the position of the image by parallax method.

Tip of the image and tip of the image needle so they will coincide and they will not be separated, when we are moving our eye towards left and. today, I will demonstrate another method for measuring the focal length of a convex lens, so that is a it is called displacement method. what is that displacement method? let me explain.

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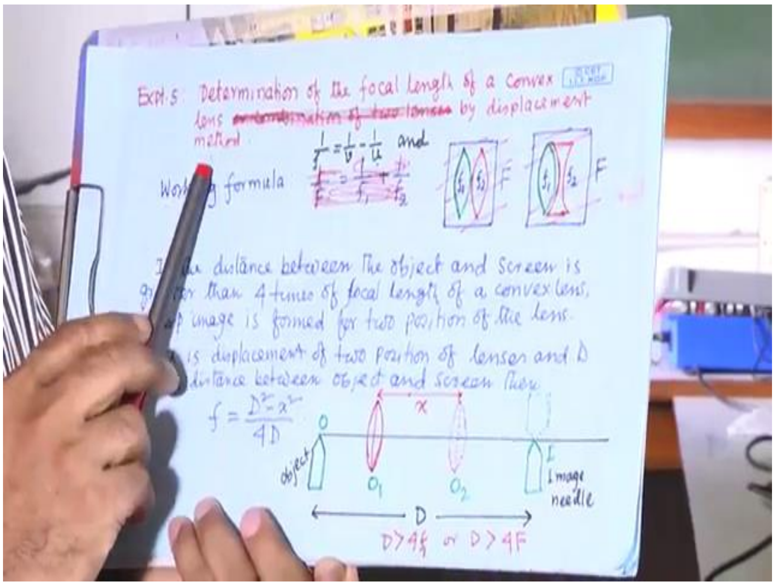

Determination of the focal length of a convex lens by displacement method. this formula working formula for this method or this lens formula is 1 by f equal to 1 by v minus 1 by u.

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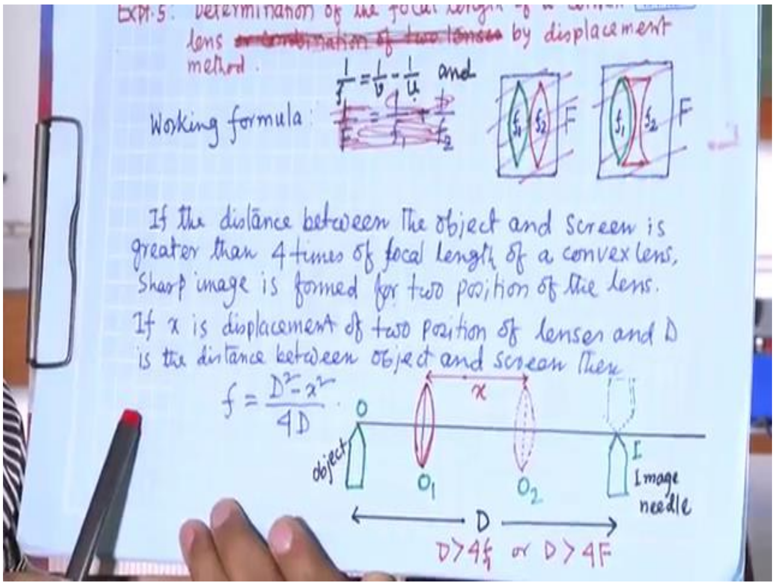

Now, displacement method is basically, if the distance between the object and the screen is greater than 4 times of focal length of a convex lens, sharp image is formed for 2 position of the lens. If x is the displacement of two position of the of lenses and D is the distance between object and the screen ok, then this focal length of the convex lens is equal to D square minus x square divided by 4 D. this is the working formula for this method displacement method.

we have to keep object and screen at a fixed distance and that should be greater than four times of focal length of the of the lens. Now, if we move this lens between these object and screen so for a one position, we will get sharp image of the object on the screen. we have to note down that position and then if you move again you will get another position, for that position of the lens you will get again the sharp image on the screen. this is displacement of this lens for getting the sharp image twice on the screen.

this x we have to find out and position of the screen and the object are fixed. So that distance we have to note down, so that is d. now, using this formula we can hand out the focal length. keeping the screen at different distance say 5 centimeter more distance or yes, 5 centimeter 10 centimeter from the from this position. we can take three-four sets of the data and we can find out the f and average f you can get.

how this formula has come? I think this is the twelfth class task you know.

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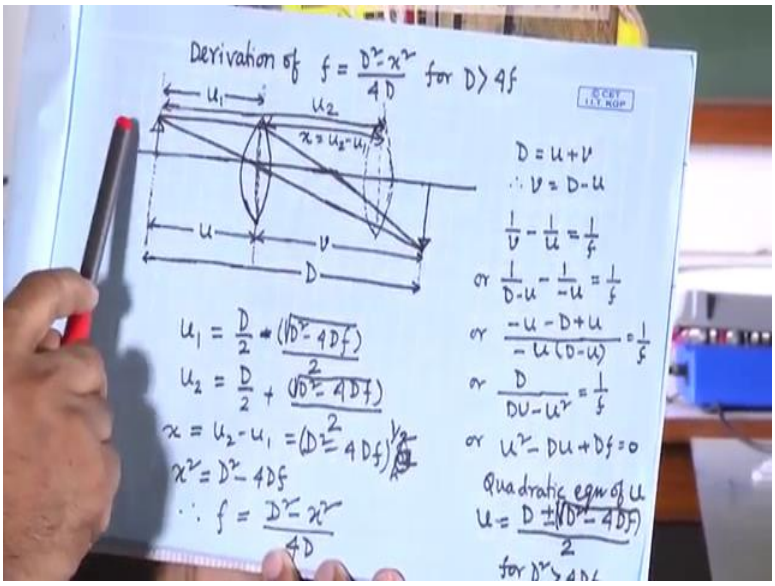

this is a homework, I can show you how it has come, but I do not think I need to explain more, because this is the image, this is the object, and this is the this is the image screen position. this is a position of the lens. distance of this lens or the distance of the object from this lens is U and this distance of the screen from this lens is so that is the image distance V. for this position of the lens we are getting the image on the screen.

Now, if you find out the second positing of the of the lens from where you are getting the again image at the same place so; that means, the object distance will be this, object distance will be this and image distance will be this. whatever the case D, this total distance D it can be u plus v. v equal to D minus u. in this formula 1 by v minus 1 by u equal to 1 by f. we can replace v by D minus u. then you simply each then you are getting quadratic equation of u; quadratic equation u of u; that means, you will get 2 or solution for u.

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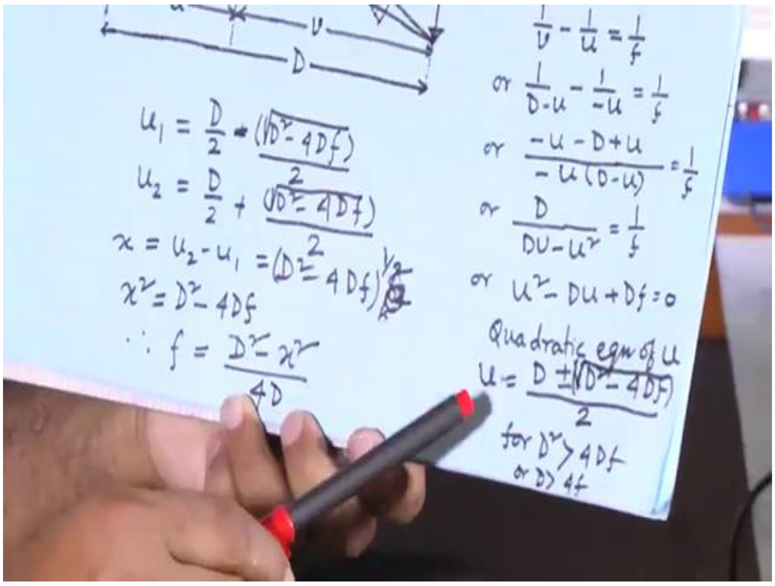

u 1 and u 2 u 1 and u 2. this is the one position of the lens. this distance u 1 and second position of the lens that is the u 2. u 2 minus u 1 is x, u 2 minus u 1 is x. x equal to u 2 minus u 1, we can do from here, you subtract it you will get this. from this relation f equal to D square minus x square by 4 D. this is the working formula for our experiment.

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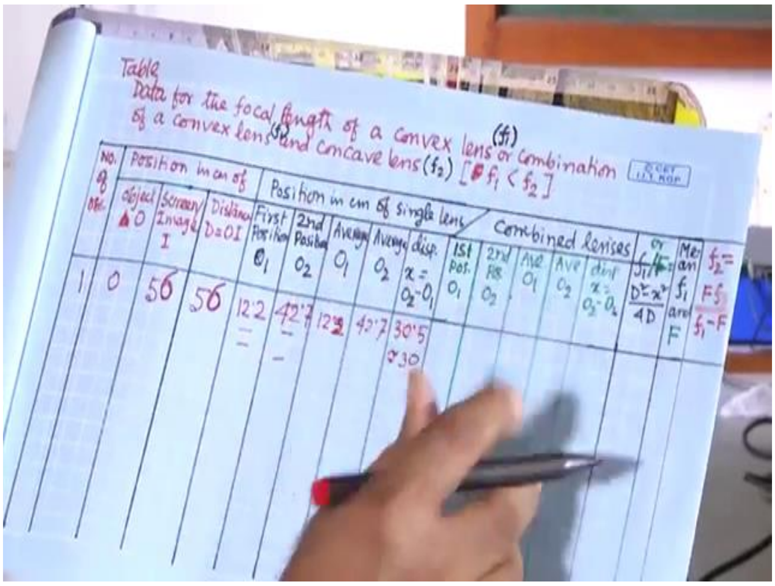

for our experiment we will use the table, this table. actually I make the table. it can be single lens or it can be combination of two lens, but here I am discussing only for single lens; one can do the experiment same way using the combination of lens either, they are in contact or they are separated by distance D. Number of observation the position in centimeter of object and screen . So, this from this position, you can find out the distance between the object and the screen that is capital D equal to OI.

now, we have to put the lens and find out the find out the position find out the position in centimeter in case of a single lens. for first position you have to note down, for second position you have to note down. observation generally for each case you can take three observation three observation and average of O 1 for first position, average of O 2 for second position and then displacement you can find out x equal to O 2 minus O 1 O 2 minus O 1. for combination of lens also one can do, but I think same way one has to do I will skip it. you can find out the focal length, you can find out the focal length using the formula D square minus x square by 4 D either for single lens or for the combination of lens.

both we can do if you can do this single length and then combination of the another, if you combine another lens with this with this single lens whatever we have used. from this table you will get the you will get the focal length of the single lens and from this table you will get the focal length of the combination or focal length of the combination lens. if that is capital F. you can find out the focal length of the second, focal length F 2 of the second lens.

but that part I will keep as I told. that is I am leaving on you. it is your homework you can find out, but here I will demonstrate, how to find out the focal length of a convex lens, single lens by displacement method. let me demonstrate the experiment.

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here actually I need screen earlier, I was using the image needle and using the parallax method to find out the position of the image, but in displacement method, we cannot we cannot use the image needle ok, because in this method we have to find out the two position of the lens. For that position of the lens how, how I will find out the position of the lens? Seeing the image, sharpness of the image I can find out the two position of the lens.

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that is why I have to see the image directly, then only I can I can use this method displacement. here this is a screen, and this is a needle. On needle actually, I have put a wax I have put a small wax. I will lighten it and then this is basically, our source object and then we will see the image of the candle on the screen and we will try to get the sharp image of the needle. it will be inverted.

for another thing for these two position for first position near to the near to the lens, near to the object so we will get larger, we will get magnified image and for the far distance we will get very small, diminished image. that from theoretically, one can check it find it.

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let me lighten it. this is my object, and this is my screen. Now, let me see the find out the position, we can see this I can see the image here, but it is a defocused. I will I have to find out the focused image on the screen yes, again going through the defocus I exactly yes.

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We can see the inverted image inverted image of this candle. I have to note down this position in my in my table, I will note down the position. observation one ok, observation one this position of the object is 0, I kept it 0 and then screen position I have kept it at 50 screen position. I have kept it at 50 centimeters ok, the reading. Now, this lens position; lens position, I can see 12.2, I can see lens position. this is distance is D capital D is 50 and then first position of lens, I can see this is 12.2.

Now, I will find out the second position, I will find out the second position. Now, you see is the defocused is defocused, I am going and then now, I am it is the now, it is focused, one I am getting, but smaller one. you can see smaller one again, going to be defocused.

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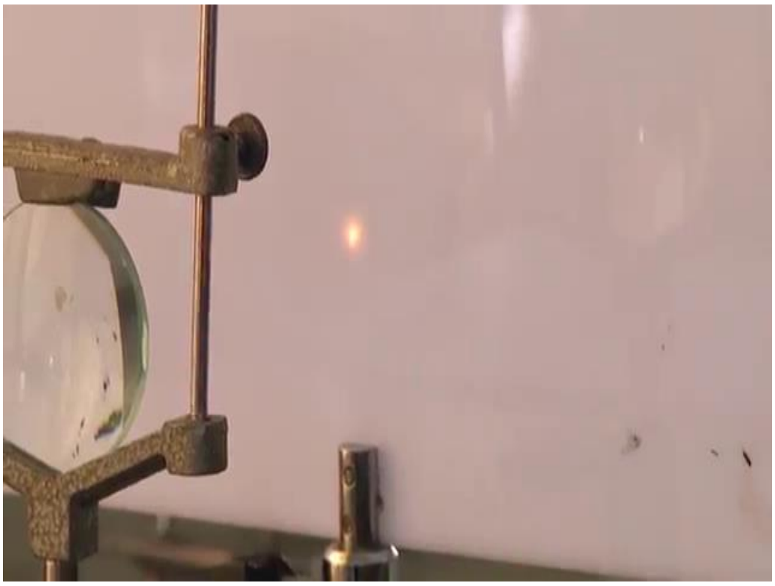

yeah, I think this position, I can take this position I can take ok, this position I can take. that is why basically, it is not it is not the unique position. actually, one should take three reading for these also for this position one take, what is the position here? It is the 42.7, it is a 42.7 ok, I can see 42.7. you can just move and take two more observation and I am not going to take, but you should do that, then you take the average one this is 12.5 12.2 and this is 42.7.

now, I am getting displacement x O 2 minus O 1. I can see this is 5 and then it is I can see it is 0 or 0 and then 3 30.5, it is the 30.5. approximately say it is 30, for calculation it will be here. Now, D square minus x square divided by 4 D see, if I calculate what I am getting? The capital D is 50 and x is 30.

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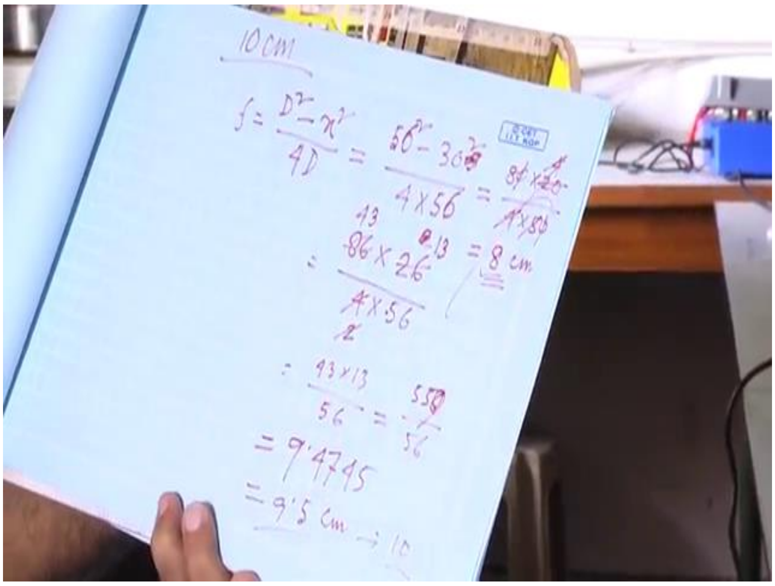

if I calculate using that formula, calculate using that formula f equal to D square minus x square divided by 4 D. measurement what I have done? This is 50 square 50 square minus 30 square divided by 4 into 50. this is A square minus B square. a plus b is 80 into A minus B is 20 divided by 4 into 50 here, I can. let us take out 0, this the this is 4 and this 4 get. it is the 8, if I am getting 8 centimeter.

approximately I have done, and I am getting it is 8 centimeter. you should take two more, three more observation and find out the actually, it is a it is not 8, it is it should be around 10, it should be around 10. it is 10, it was 30.5 basically, I think I have not done mistake in calculation, we have 30.5 yes. it will take 30.5 x square, so it is a higher. it will it will be smaller it will be smaller; I do not know then it may be if it is higher than this difference will be lower. this may go down anyway. just approximately, I just find out that is a 8 centimeter, but this lens is approximately 10 centimeter, but it may not be the, it is 10 centimeter, it can be 8.

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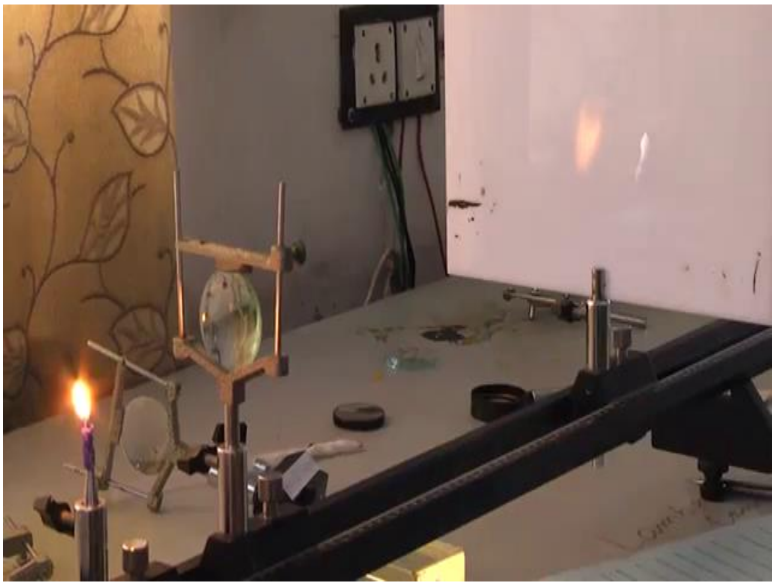

this is the way one has to actually find out the you see, so again, if I do experiment again, if I do experiment yes, I will take this position. Now, it is again 12.3 earlier, it was 12.2.

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Now, it is coming 12.3. 12.4 it is coming around that point ok around 12.4. second time I will see this it is 43.5 it is coming. one mistake I have done here, I can see it is not 50, it is 56 that is the mistake I have done. that is why the result was come, it is not 50, I can see it is it is 56.

it is screen distance is 56 hm. the screen distance is 56. I think that is the mistake I did. that is why result was like; I mean these value twice I checked, this is more or less this this is 30.5. approximately 30, you can take or 30.5 also approximately 30. in calculation actually, we have to make it 56 ok, this we have to make 56. if 56 let us take 30. it will be 86 if it will be 86 into 6 2 26 divided by 4 into 56. it is a 2 13 no, it will not go. I think it is the is the 13 and then it is 2, then this is 4 3. it is a 43 into 13 divided by 56.

Now, let me use the calculator, let me use the calculator to find out. this is the 1343 into 1343 into 13 into 13 then divided by 56 divided by 56, we calculate divided by 56. it is a again equal to, this I do not know this calculator. this 5043 into 13 equal to 556 559 divided by 56, then equal to, but unfortunately here, it is 559 by 56, then answer I want 559 calculator 5 59 divided by 56 answer, I think I will use another something wrong.

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559 divided by 56 equal to yes, it is coming 9.47 4745. it is a 9.5 centimeter approximately 9.5 centimeter. that is why it was earlier; it was coming 8 because I did mistake it should not be so this focal length of this one as for company is telling that is 10 centimeters. our measurement is coming 9.5.

now, if you take 30.5 or if you take more observation it may go close to the 10 or whatever you will get that is your measurement value. this is the very useful method simple method displacement method, but you need screen and I think yes, for that you need the real image, which you can see on the screen ah. that is the condition to use this displacement method.

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now, with this one if I put another lens, if I put another lens and this two lens, either the they can be in contact or they may have some separation. then the ever the focal length will be combination of this focal length f equal to 1 by f 1 plus 1 by f 2 minus d by f 1 f 2.

what is the d? d is the separation between these two lens. changing the separation of these two lens, you can find you can get the variable focal length of this combination. that is the advantage of this one. this experiment also one can demonstrate using this method.

I am not going to repeat that one. You can measure the focal length you can find out the equivalent focal length of these two and from there one you have measured already for second one, you can find out that is focal length of the second one.

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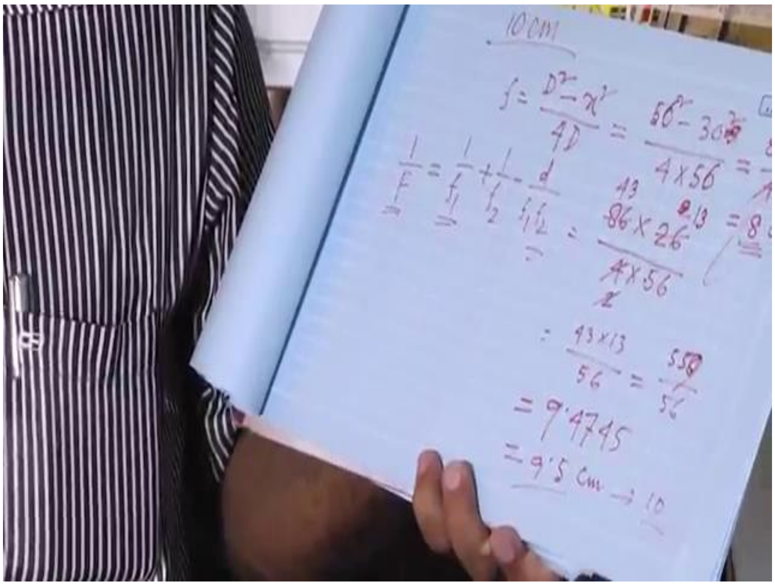

if you get this one, from this method basically, you will find out this one ok, for one if you know. other one also you can find out. this other one it can be concave lens, this can be also concave lens ok, for concave lens directly using this one cannot find that only condition that concave lens that focal length it should be greater than the focal length of the convex lens.

ultimately then if it is focal length of convex lens is less than the focal length of the concave lens this resultant one it will be converting lens concave lens. it will form the real image; it will form the real image and you can see on the screen.

this is another method; we use for measuring the focal length of convex lens or combination of the lens. Combination of the lens also as we to find out the focal length of the concave lens we have to take help of the convex lens ok, because concave lens it form the virtual image that you cannot see ok, you cannot put on the on the object ah, image needle .

That is why we need to get this help of the convex lens, but I showed you another method. from here using this combination method combination of the lens and using the displacement method you can find out the focal length of the convex lens or you can find out the focal length of the combination, you can find out the suitable distance, for which distance ah you should keep this two lens so that you can get your desired focal length for some purpose. This is the displacement method we use in lab, apart from the that parallax method. I will stop here.

Thank you for your attention.