Experimental Physics - II
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Lecture - 15
Determination of Focal Length of Convex Lens

Today we will demonstrate how to measure the Focal Length of a Convex Lens. In last two classes, we have seen how to measure the focal length of concave mirror and convex mirror.

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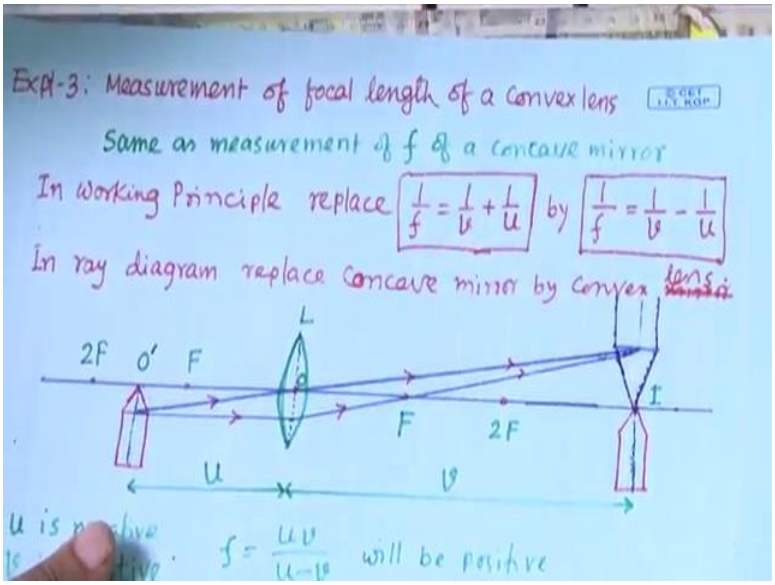

For measurement of focal length of a convex lens. this it is procedure is same as the measurement of focal length of a concave mirror. for concave mirror we have seen that or for mirror formula actually in working principle the mirror formula we have used that is 1 by f equal to 1 by u plus 1 by v right or 1 by v plus 1 by u.

Now, for this convex lens or for lens this formula has to be replaced by this 1 by f equal to 1 by v minus 1 by u. in concave or convex mirrors we use this formula, but for convex lens or concave lens the formula we will use that is 1 by f equal to 1 by u or 1 by v minus 1 by u right and in ray diagram we will replace the convex concave mirror by the convex lens.

What I am trying to say that, procedure is same only in working formula you use these; this lens formula as well as the ray diagram whatever we drawn in case of concave

mirror there just you place this convex lens. this ray diagram will be like this. you have a convex lens; now convex lens like concave mirror they are converging lens or converging mirrors.

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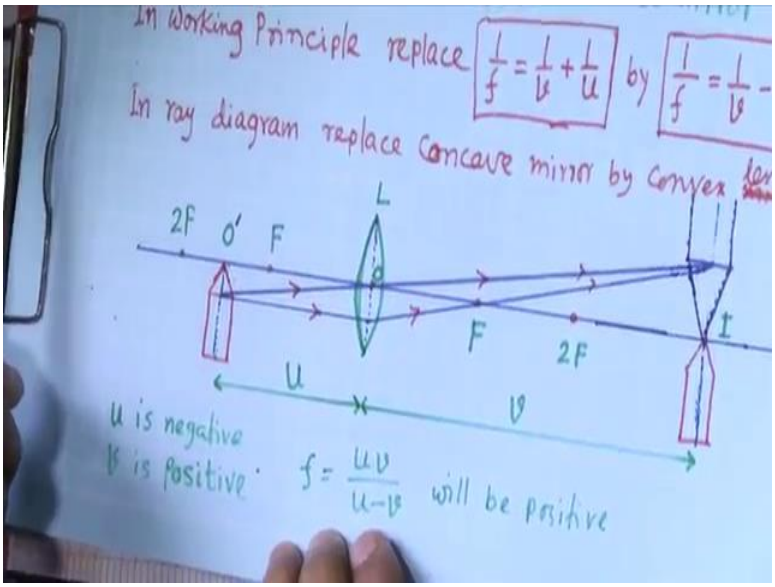

This lens produces the image whether it will be virtual image, or it will be real image, that depends on the distance of the object from the mirror.

If object is at infinity, we will get image we will get real image and that will get at the focal point of this lens. Now if you if you reduce decrease the distance between the object and lens means if you are bringing the object from the infinity towards the lens. when this lens this object will be the distance will be greater than 2F or greater than radius of curvature of the lens, then the image will be shifted from focal point it will shifted away from the focal point.

In that case it will be between F and 2F. When you will bring to the object at the at the 2F then it will be at 2F image will be at 2F and all image will be real and virtual real and inverted one.

When this object will be between F and 2F, then this image will be behind the 2F behind the 2F and it will be real image and inverted one. when it will be at F object will be at F, then image will be at infinity when this object will be; so far whatever image I told; all

will be real and inverted ah. when the distance of the object is less than F it is between focal point and the and the and the and the lens then you will get erect and virtual image.

You will get erect and virtual image and we will get in this in this side. here in experiment. we will keep the object approximately at between F and 2F then we will expect that image will be beyond the 2F. if you to know the approximate focal length of this lens. just you can put the mirror you can put this, not mirror, this lens, below, say light it is that too far from this lens and then you will see this it will this light will focus at a point. that distance will be focal length approximate focal length.

Oh; one should one should find out that one and then you keep this your object more or less 1.5 times from the 5 times of the focal length at that distance more or less and then you try to see the image. image will form say here. now, how to find out the image position that is what we use parallax method. what is that method? I explained already for in case of mirror? you have to change the position of the of the object needle in such a way that the image inverted image you will see through this lens and the point of this inverted image and the point of the object needle tip basically.

First you should try to take them at the aligned take them aligned; that means, this 2 tip will coincide. first try to find out that distance now more or less that object image position will be there; now you have to remove the parallax. for that you just move your eye towards left and right and find out the position of the object that the; these two tip will not detach, they will move towards left and right together.

If they are not moving together, they are becoming detached and image and the image needle that tip they are relatively they are moving when you are moving your eye towards left and right; so that means, it is not the right position. you have to adjust these object position to not object position image needle position to find out the position where there will not be any parallax means they will not be separated on movement to your eye towards left and.

Then we will take the reading of this position of the object needle then position of the lens and position of the image needle. this is object distance u, and this will be the image distance v. Now we will change. for each object position, we will take three reading we will take three reading three observation basically. average of that observation we will take as a average position of this object needle image needle. then second set data we

will take just changing the position of the changing the position of the object needle say plus minus 2 centimeter plus minus 2 centimeter

From this position ok; say here whatever. shifted by 2 centimeter this side and repeat the experiment find out the position of the image needle record the data. next set of data you take thus this you take this object position on the other side by 2 centimeter and then repeat the experiment find out the needle position needle position object image needle position by parallax method and record the data. then if you will find out u and v and sign of u and v is for u it is negative and for v is it is positive.

Using this formula f equal to u v by u minus v you can find out the focal length of f and it will be positive. image is formed this side. this is the focal length distance that is the focal length of the lens.

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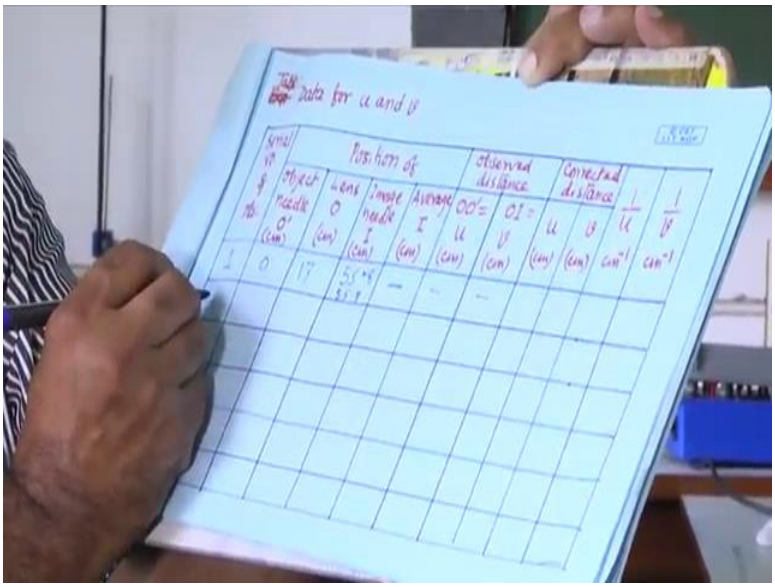

You need table to record, the data you need table to record the data. data for and u and v. here serial number of observation position of object needle, then lens, then image needle as I told image needle you take three observation then find out the average of that image reading. now, object distance is u and v O dash OO dash and O I that is v.

Now, corrected distance as I told that corrected distance means if any index error is there. how to find out index error I explained I am now repeating. that if any correction is there then you should do that correction. I assume here that there is no index error. then

for plotting graph you can plot u v graph as well as 1 by u and 1 by v. as same as concave mirror and from there you can find out the from the graph you can find out the focal length. let me do the experiment let me do the experiment.

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This is the same optical bench this is the same optical bench it has it has meter scale meter scale. 0 to 0 to 150 centimeters 150 centimeters.

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Now, this one is convex lens. we put convex lens in a holder, lens holder and that we that holder we put on the upright. upright; that we can change the position of this it can move from the optical table optical bench.

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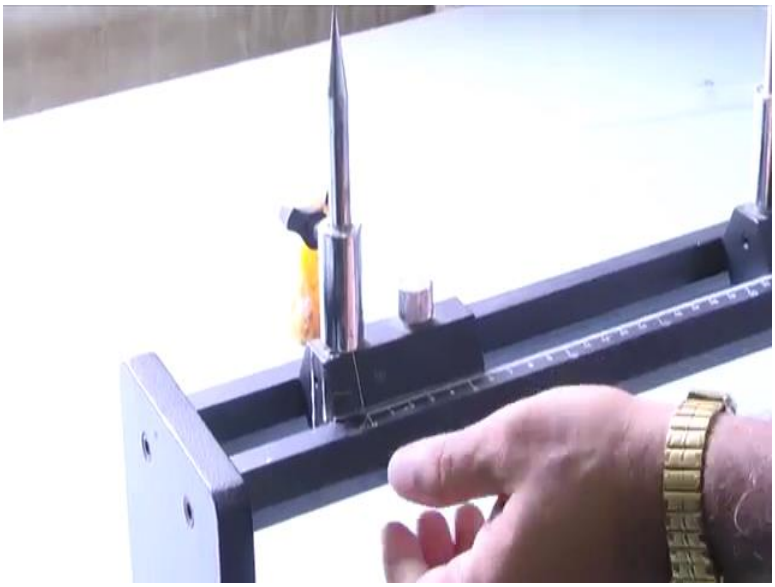

And this is the object needle. I fix that object needle at 0. index mark is coincide with the 0. let it be fixed and then these lens I have seen I think I will not repeat that one, but or I can do that.

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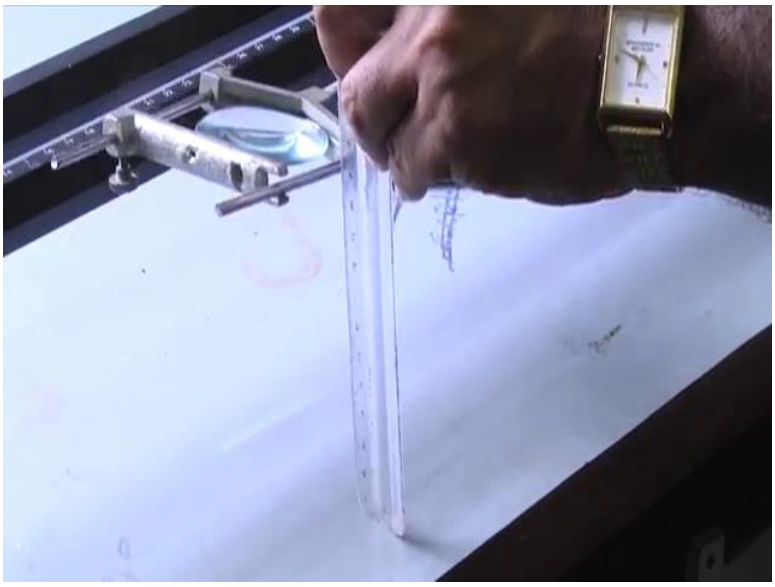

Initially what you should do? you should try to find out the approximate; yes, I can you see here.

This is the length of this; is the length of the focal length, it is around we have seen I do not have scale here, but I think I have a small scale. from here I can see it is approximately this scale is not good one, but this is this scale reading I can see 20 to 30 this side. approximately 10 centimeter approximately; 10 centimeter. then put it here and fixed it. to move it just you have to press it and just move it.

Since it is around 10; 12 centimeter focal length.

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I will keep object distance from the lens is 1.5 times. say let me keep this then I have to keep this lens is say 15 if it is 10 or 12. let me keep it at say 17. focal length is 10. it is 20 2F is 20. I am keeping the object distance 1.5 times more or less.

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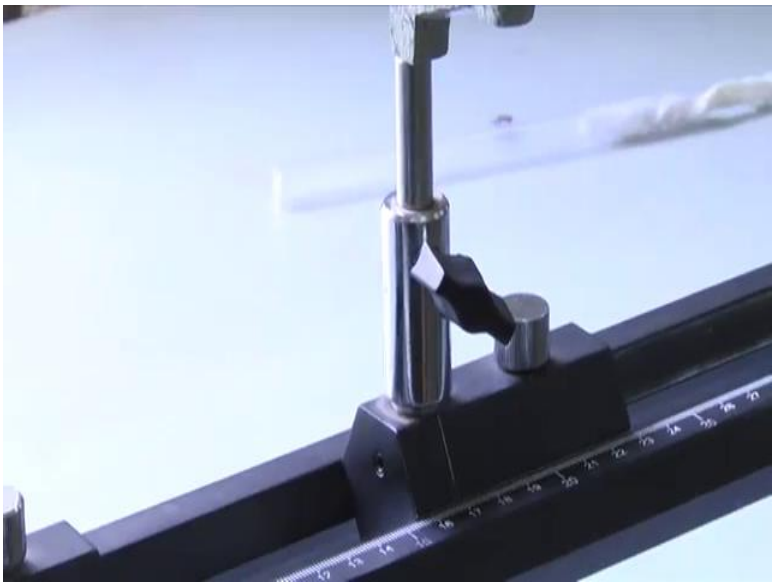

I am keeping here, and I should check the image whether it is one has to be very careful because this is very sharp it can hit your eyes.

Actually, I should also get very nice image of the yes image of the needle. I can it is within f. I can get the image now eye it is defocused. that way also one can guess that what is the yes focal length. I think it is disturbing. I have to remove this one object that is the; we will use as a yes this is the around f now it is started to be inverted, but yes, I got it; yes, I got it.

I am keeping approximately around say around 15 16 17; it is no problem I can see; I can see the image; yes, I can see the image. we will note down this position of the object needle and the position of the lens; it is around 17 now it is the 0.

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Now, I have to take this image needle, I have to take the image needle and first what I have to do? I have to change the distance and first that inverted image tip and the object this image needle tip should coincide.

Now it is not coinciding. if I take away and then it is going to coincide; yes, it is coincide yes at this position it coincides. now after coinciding I have to remove the parallax error. there is a parallax. I have to adjust the position. let move that way and see; yes, I am going close now, I have to come this side yes; it is reduced parallax is reduced now it is a more parallax, it is less. I should now I can move. this is the important for this experiment you know one has to have patient and find out and this cannot be unique position.

See it is really I am not yes.

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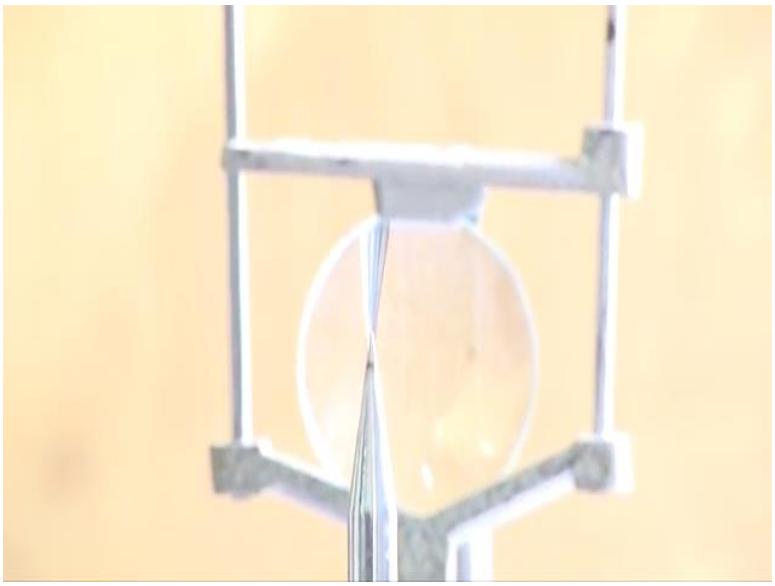

This is the position of image needle. I should note down the data observation 1 and then object needle distance here it is 0 and then this one is 17. one should yeah more or less I am taking; yes, I have to take one should not have parallax error.

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Needle image it is 55 point; I can see 55.8; ok point 8as I told this is not the unique position. one should again one should again try to find out the better position take 3-4 observation take 2-3 observation now it is 55 point I can see 4; 55.4. take three observation and then find out the average of that one. then you will get the u and you will

get the v and then second you should what you should do? Second observation second set of data you take. you change the position you change the position of the either needle object needle or the lens.

I will change the; that means, u I am changing. let me keep at say 19 keep at 19 and then I will keep other side this 15 or keep at 15 and then 15 it was 17 earlier. now, 15 I will again find out find out the yes now it is the. I have to change the position and find out the yes. what happens? I kept at it is 15; that means, this u value now it is it is close to the f.

If object is at f it is at infinity now. if it is greater than f. it is coming image will come towards from the infinity towards the lens. if distance is now it is less than earlier distance. image needle it is expected that this image will be away from the lens compared to earlier one when the distance was 17. Now distance is 15. earlier whatever this it was 55 point something. it should be higher than that this reading should be higher than that. that you can you can come from the theory of the lens you can guess you can assume that one.

It should not be less than 56. this is very important for this experiment you know. one should find out yeah more or less I am getting here.

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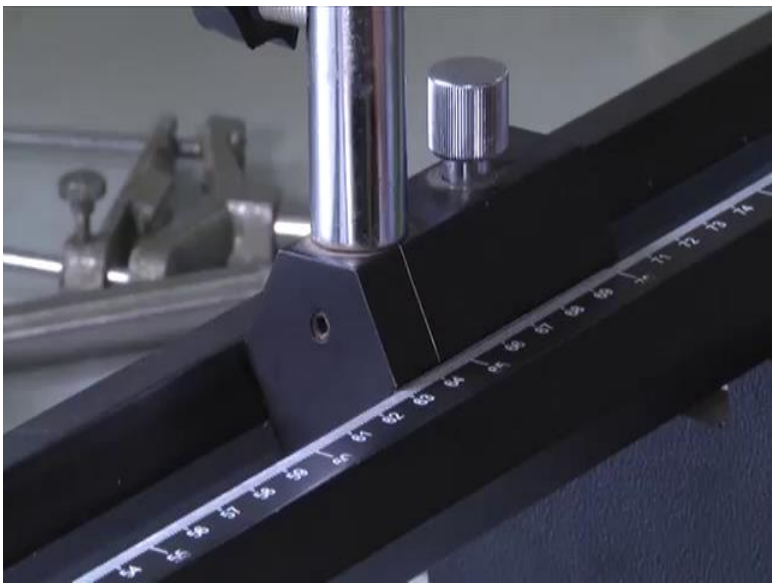

Now reading is 64 point 64 point around 6; 64 point around 6. this is the 0 position this is the 15, this is the 64.6 then you take more 3 reading find out. then you put at 19 lens you put at 19, it is 0 this third one.

You can take you can take not only this 3 reading. you can take more reading say 21, 23, 25. this a you should have 5 6 7 reading because we have to plot graph. when you will get this u and v and corresponding 1 by u and 1 by v. now, we plot graph that same way as we have plotted for concave mirror.

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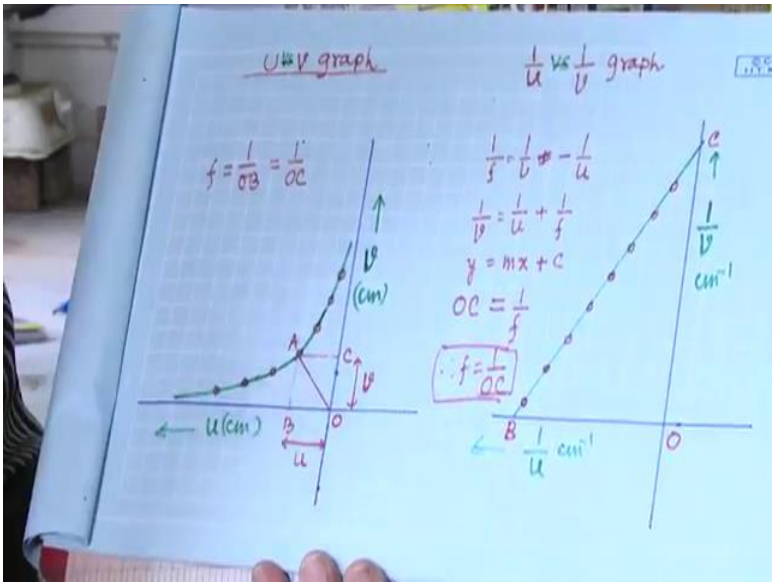

In this case v is positive as I as I showed you v is positive v is positive and u is negative.

For concave mirror v and u both was negative now here this is the positive and this is the negative. you have value of u and corresponding v you plot you will get this type of curve. Now same way u from this curve itself. you know where when v will be equal to u or where this object is at 2F object is at 2F and image also you will get at 2F. whatever u v you are getting. that is ah. your f will be; f will be OB. this is u and this v when they are equal no this will be this will not be f it will be 2F it should be 2F OB equal to OC right OB equal to OC.

When you get image and image and object at the same distance when it will be at 2F means at radius of curvature. other one also I think I have written wrongly. this has to be 2F will be equal to; sorry, why it is O.

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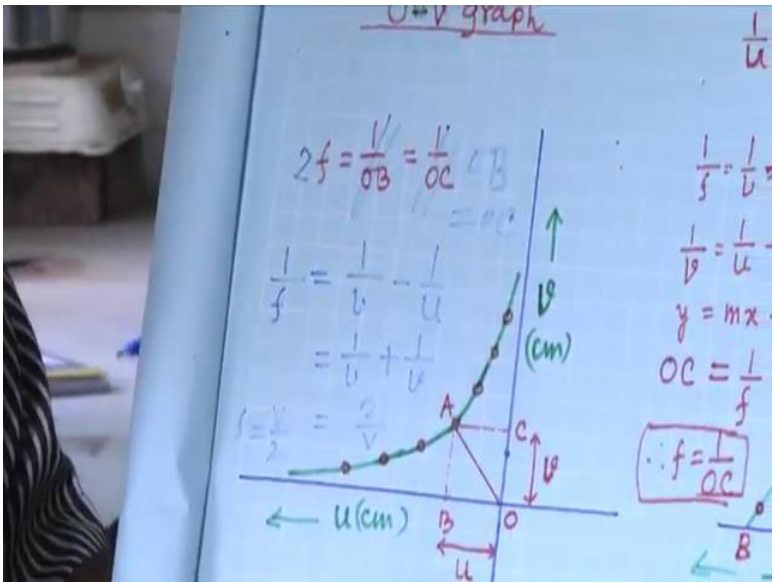

What is the formula? 1 by f equal to 1 by v minus 1 by u. when v and u are equal v and u are equal. this you can write, and sign will be opposite sign right v is positive u is negative. it will be 1 by v. plus say 1 by 1 by v same distance u equal to v

This will be 2 by v 2 by v. 1 by f equal to 2 by v. f equal to f equal to v by 2 f equal to v by 2 what is v; v is OC or OV. here I have written wrongly because 2F is equal to not 1 by 1 by V. equal to OB equal to OC equal to OB or equal to OC. f will be half of its f will be half of OC or half of OB. Similarly, if you plot 1 by v versus 1 by u. here y equal to mx plus c.

OC that is the interaction intersection on the y axis. that will be 1 by f that will be 1 by f intersection at c. whatever OC value you are you will get. that is 1 by f. f equal to 1 by OC whatever because here it is 1 by v. here it is v. that is; why it is the 1 by OC, but not here 1 by OC. I did mistake. I corrected it. now, f equal to whatever this you will get OC.

1 by OC will be the f. using the graphical method one can find out the focal length. then one should find out the error in the calculation. how to calculate error you know I am not going to discuss that one. in next class I will demonstrate how to measure the focal length of a concave mirror sorry not mirror concave lens.

Then I think we will know how to measure the focal length of mirror: concave mirror and convex mirror as well as lens: concave lens and convex lens. For convex lens this is the method. In next class I will discuss for concave lens. I will stop here.

Thank you.