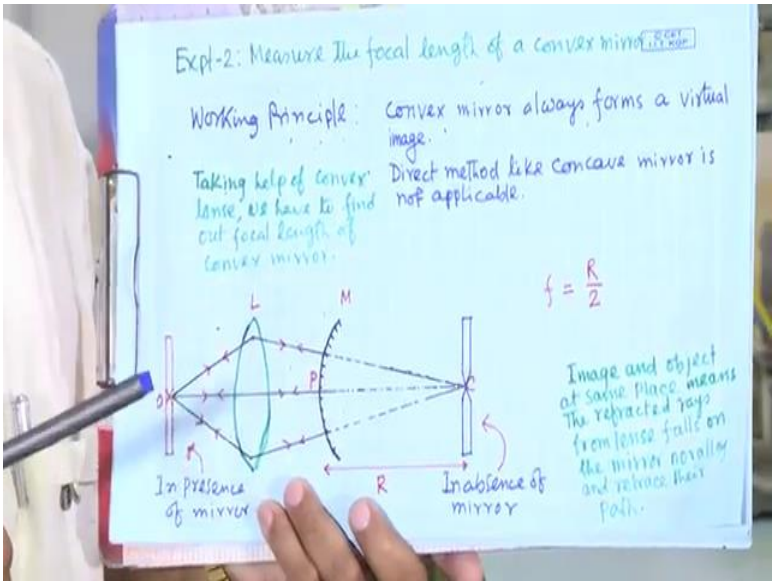
Experimental Physics - II
Prof. Amal Kumar Das
Department of Physics
Indian Institute of Technology, Kharagpur

Lecture – 14
Determination of Focal Length of Convex Mirror

Today, we will demonstrate how to measure the Focal Length of Convex Mirror. In last class I have shown you how to measure the focal length of concave mirror. Today we will do the same things for convex mirror.

(Refer Slide Time: 00:53)



Measurement of convex mirror, focal length of a convex mirror. working principle is not same as the concave mirror. in concave mirror we get the real and inverted image, but for convex mirror all the time we get the virtual image. Concave mirror of course, if the object distance is a less than focal length, then only we will get the virtual image; otherwise when distance object distance is greater than f, then all the time we will get the inverted real image ok, so that means real image we can actually put on the screen, you can see the real image on a screen, but virtual image we cannot put on the screen.

Measuring the image distance is difficulty, you cannot put the image on a screen, so that is why directly we cannot measure the focal length of a convex mirror. As we can do for the concave mirror, so that is why this method is an indirect method and for concave that

was the we tell the direct method. for this case taking help of convex lens or we can find out the focal length of the convex mirror.

Now look at the; look at the diagram. in this diagram in this diagram there is a lens, convex lens right, there is a mirrors and here this is the object needle, this is the object needle O object needle. Now, here is the image inverted real image, how we are getting this image say, so this on the tip of the needle rays are going and refracted or converge the light, converge the light after the lens ok, converging the light from the lens.

Now, if mirror is not there; if mirror is not there, so these ray will go this ray will go and meet at this points, so that means due to this lens we will get the image at this point. you know this for convex lens we will get; we will get the real inverted image; real inverted image ok; real inverted image. Now, due to the lens, when this object is here object is generally is the its distance object distance is greater than focal length of this one. It is between f and 2 f, there we keep ok, then we will get the; then we will get the inverted real image and that is the position at this place.

Now, without mirror then object then this is the object needle, so image needle I can put here; image needle I can put here using the parallax method. I can find the position of the image as I have shown you during the measurement of the focal length of the concave mirror, so that same way one must find out the position of the image using the image needle. We must just remove the parallax then that position will be the today also I will show you this is without the mirrors only because of the lens.

Now, if I put a lens between after the if we put the mirrors convex mirrors after the lens then if I move if I just move this mirrors to and fro then and look image. there is no function of this one, now I cannot see this one. So now, it is a mirror is here, so I must see the image from this side. Earlier I was seeing the image from this side, now I must see the image from this side because light will be this light it will not reach here that is why I must put it here dotted line.

So now, light will be reflected from this mirror and they will come back; they will come back and either they will this reflected rays from this mirror they will form the image either virtual or real depending on the; depending on the angle of the refraction, whether it is diverging or converging generally it is diverge.

Now think that if I try to find out the image at this place, where the object is there if I try to find out the image at the same place where object is there and for getting that one if I just adjust the position of the mirror and I will get a certain position, I will get a particular position where for that position I will get the image exactly on the object. How it is possible? It is possible only when the light will come back; light will come back following the same path. Light was going out from this and in same place I will get image if I get the reflected light in same path. it will face back it will back facing the same path when it is possible? When light will fall on the mirror perpendicularly right only then it is possible to retrace come back with the following the same path.

For this position of the mirror when I am getting the image at the same place of the object right then I can tell I can think that the light from each point light from each point on the mirror. they are; they are; they are falling normally on the mirror and they are coming back. It is possible only when; it is possible only when if you this is the; this is the centre of curvature of the mirror; centre of curvature of the mirror. as if from centre of curvature this all line if we draw, they are perpendicular on the mirror because they are the radius, radius of curvature.

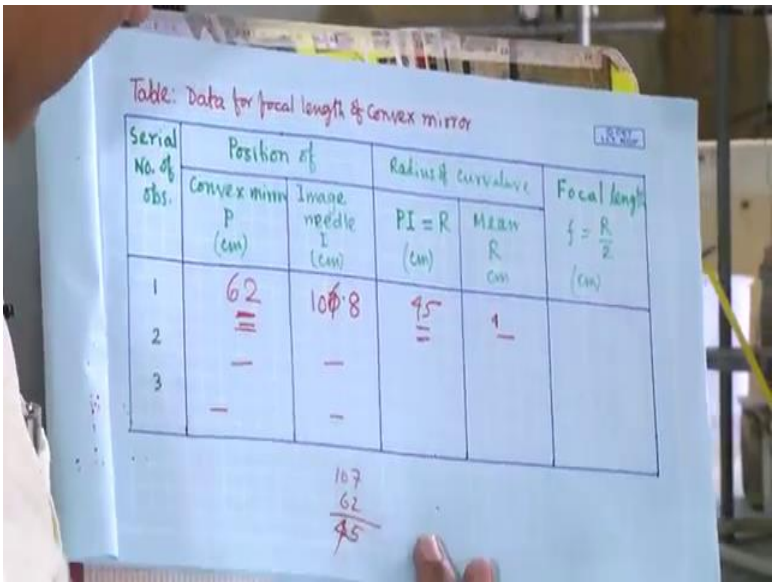
They are perpendicular on the mirrors, so if light falls along this line; that means, it is falling perpendicularly. it will reflected back following the same path. Now of course, in lens always the reversibility's is all the time it follows the reversibility if its incident light is this and this refracted this if you reverse it incident light is this then refracted will be rather once. it follows the reversibility. from here it is clear that if you find out the proper position of the mirror, so that you are getting the image on the same place of the object.

Then this mirror centre of the mirror will be that one, where, we got the image of the image from the lens of that object. here this position here in absence of mirror if mirror just if we take out, this is the image position. Now, if you put mirror here ok, so next position will be so adjust adjusting the position of the mirror you will get a particular position when the you will get the image position here. in presence of the mirror image you will get here.

In this practical what I must do. I must; I must find out the position without mirror. I must find out the position of the; position of the image of the object due to the lens this I must note down and then without disturbing object and the lens. Now, I must put mirror

here and find out the position of the mirror, so that I am getting the image on the top of it ok, then I must note down this position of this mirror. now this distance mirror to this, this images lens image distance that is nothing, but the radius of curvature of the mirror. focal length will be R by 2, so I must note down only this two position.

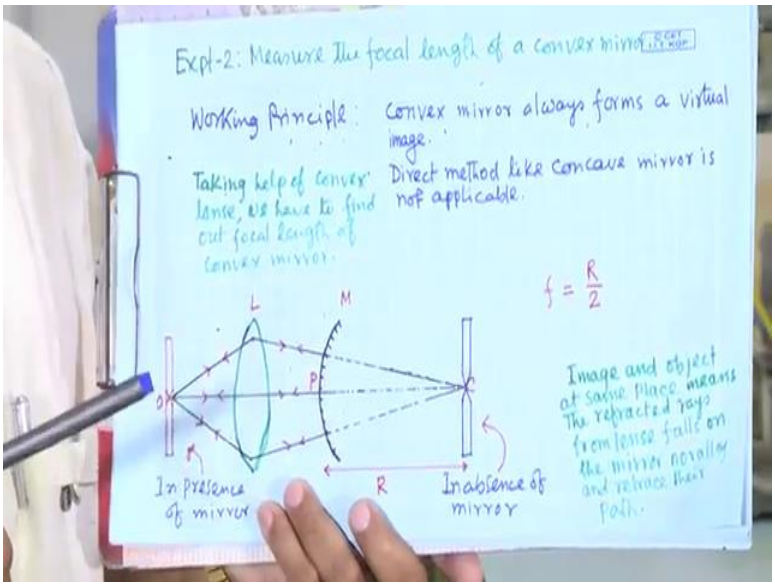
(Refer Slide Time: 14:19)



I think I have a table data for focal length of convex mirror. position of convex mirrors, I must note down. And image needle position of the image needle, I must note down right, if we note down these two position, so P I that what about difference of this two position will give radius of curvature. you can take three readings ok, just adjusting the mirror position ok, you can take three readings and find out the mean of this R and from there you can find out the focal length or you can do the three sets of experiment, you can do the three sets of experiment, just one experiment you are doing for a particular position of the object.

Now, just second set you can take this just change the object position by 2 centimetre or plus minus 2 centimetre, two more sets of reading you can take. And then you must find out the focal length for each case, R radii mean radius of curvatures, so from there you can find out the focal length.

(Refer Slide Time: 15:54)



That is the experiment so remember these sequence first without mirror I must find out the position of the image due to the lens. And then I will put lens and mirrors, concave mirror, convex mirror and I will try to find out the position of the mirrors to get the image on top of it. unfortunately, in camera I cannot show this, this co-incidence and this parallax method, but I will show the step how to do the experiment. this is the same optical table as last time we have used.

(Refer Slide Time: 16:47)

This is the mirror, convex mirror. We want to measure the focal length of this convex mirror. let me keep it here; let me keep it here.

(Refer Slide Time: 17:07)

Now, this is the; this is the lens convex lens.

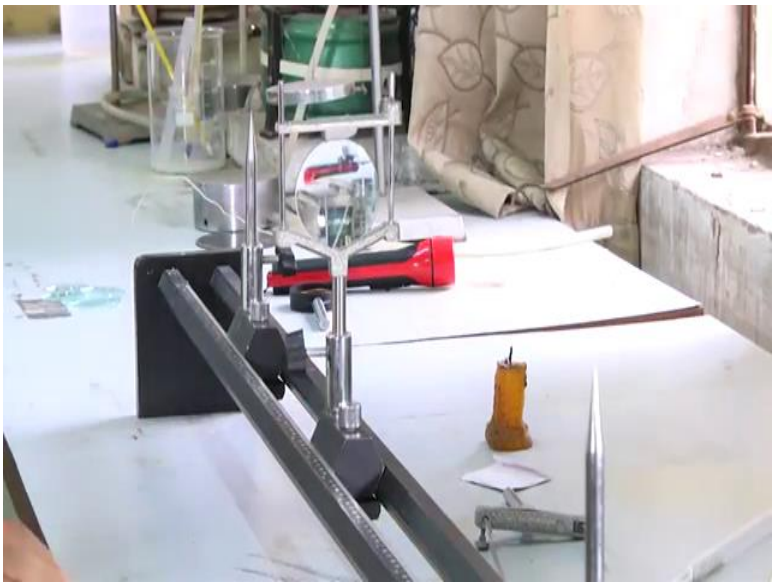
(Refer Slide Time: 17:16)

and this is the one needle; so, say this is the object needle.

(Refer Slide Time: 17:23)

And another needle I need to get the position of the image, so this the image needle.

(Refer Slide Time: 17:33)



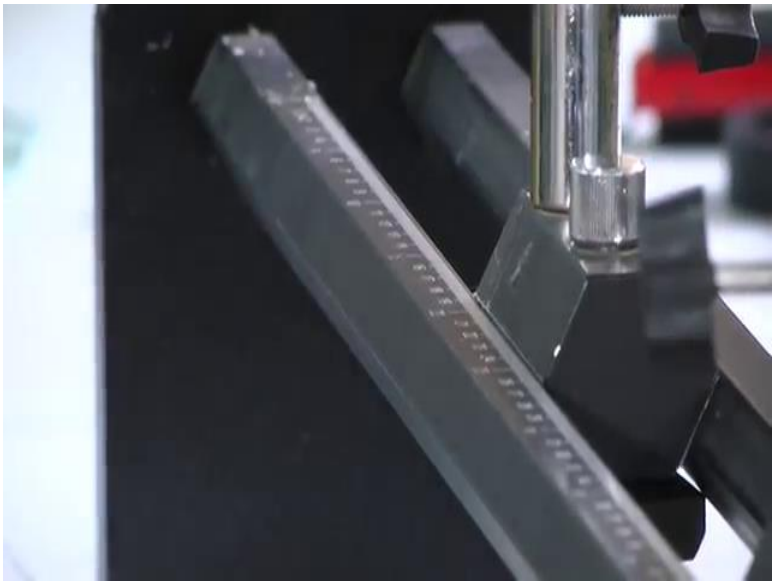
Put this convex lens, in the tables to make it I think I will. this focal length of this lens is approximately it is we know this is around 20 if it's better to know the approximates focal length of this of the lens or mirror, so then we can do your experiment. here that how to find out again you can see if it is within the f, so you will get the image of this needle, object needle as a virtual image and it is a erect one.

Now, if you change the position of the lens and then when you will cross the f ok, so then you will see that is becoming inverted. during the changing from erect to the inverted there you can approximately you can guess that it is this focal length is what is the magnitude that you can find out. in this case I think this one must be careful, because I any way let it be there. I can see now I think I will remove this one, let me see the image of the yes, I can see inverted image, so to guess the yes.

(Refer Slide Time: 19:41)

Now, I can see this very, I can see the; I can see the erect image of this one.

(Refer Slide Time: 19:51)



So that means, it is focal length is greater than now it is at position of 20 and it is position is 36 that means, 16 ok, so that means, its focal length is greater than 16. it is then if I take just increase and then increase yes, it is becoming started to be inverted. what is that position, so here I can see this is 46, so 20 and 46, 25; so, it is focal length is around 20, 20 around 20, 25 in that region.

I must keep this lens position greater than focal length. this is the approximately position for the focal length. I will keep it at the higher distance than this position and I will see the inverted image, I will see the inverted image yes, I can see the inverted image; so, I can see the inverted image. I am keeping approximately say it is around this distance 20, I would like to keep at 50 ok, around this 30 difference if this focal length of this one is 20 or between 20, 25, so I kept it as 50, it is at 20 that means this distance is object distance is 30 greater than focal length.

Now for this position, for this position I will try to find out the image yes, I can see clearly image position, so for that image needle I must use and parallax method, parallax method. I can see the clearly, I can see the yes, I close my left eyes and seeing through the right eye ok, I can see so I have to yes, decrease the so to tip of this image and tip of the first I have to try to make it coincide, tip of the image and tip of the yes, it is coincide; it is I think slightly up I will take yes, yes, so now, I can see that both tip coincide. Now, I must remove the parallax, I must remove the parallax.

I think I must fix it. And then yes both tip at this position now slight yes, so this position I found, this position I found that, this position I found that this tip of the image and tip of this object, image needle they coincide and this parallax that is also removed for this position. now I have to note down the; I have to note down this position of this image right, I have to note down the position of this is the, I think, position of the convex mirror and image needle. Now, image needle this one, so this is say 107 so I will write 107; approximately 107, I can say 106.8 centimetres ok, so I must write.

(Refer Slide Time: 25:53)

Now, what I must do without disturbing them, I must put this mirrors. I have to put this mirrors and now, I have to find out the position of the mirror, so that I can see the image, I can see the image or at this position at the object position; object position, so that means from the object wherever the light going, so reflected one will come will retrace the same path. It will retrace the same path only when it will be reflected from the mirrors it will perpendicularly or the incident rays will fall on the mirror perpendicularly and then it will be reflected also perpendicularly right, so then image and object will be in same position.

Now I have to I can see the yes, I can see the image, so I have to adjust the position of the mirrors at to yes, I can see so I have to find out the position, where I can so this image will; image will coincide with the tip of this object one. Slightly away I should see yes I can see image, but it is not coincide, so I think slightly move yes, I can get this is the position has looks to me is the yes, coincides slightly more I have to take no, yes, no, it is separated, yes so I can see it is coincide with this with the tip of the object, and the tip of the image on the same line. Then also I should see the parallax that still slight parallax is there slight parallax is there no, so I must come closer yes, let me check yes slightly moves yes, not slightly moves yes, slightly move will turn and see.

(Refer Slide Time: 30:35)

Now, I must go other way slightly. Now, it is nice, so there is no parallax. now I must note down the; I must note down the position of the position of the mirror. It is the around it is a 6 the 62, it is a 62. P I so difference between these two this 62 and this 106 or 107 approximately, 107 and 62 so how much you are getting, 4 45, so this P I is 45, P I is 45.

Still you have chance to adjust, adjust the mirror take this mirror position 2, 3 position ok, 2, 3 position, keeping this needle that one is fixed. you will get 2, 3 value ok, so you take average of that one average of that one, so this way we can do another as I told that you just change the object distance by plus minus 2 centimetres say change it is a 20, so keep it at 18 and you have to remove the mirror, then from the lens you have to find out this position of the image needle.

Note down the position then again put the mirror find out the position for seeing the image at the object position, so that way you can second observation you can take and then again you take this if earlier it was 18, now put this one a 22 ok, 22 and repeat the experiment, so you can take the third sets of data and for each set of data for each set of data you should; you should take the 2 or 3 data, for changing the adjusting the position of the mirror and then take average of that one average of that one here, so that column is not I have made, but one can made or just either average you can make here or average you can make here, so that reading let it be there.

Then for second set you take, third set you take, and you find out the average of that this mean R and corresponding focal length you will calculate. this way one must find out the focal length of the convex mirror ok, so one must build up skill to see the image position and how to find this image position. (Refer Slide Time: 34:16)

One has to; one has to remove; one has to remove the parallax; that means, first what you have to do this here you have image needle say and then image real virtual image you have to see through the mirror or the lens and you have to change the position of the image needle and try to find out the position, so that this image tip will come on the tip of the needle image needle.

Now, you try to adjust the position of the image needle, so that there will not be any parallax means, so if you move your, so if you move your, so they will be separated if you move your eyes, so they will be separated ok, so if you change the position of the image needle. for a particular position you will see this both are moving same way ok, so that is very important one has to find out this position then this experiment is very easy, so that is the critical to find out this that position. And other things that about index error I have not discuss.

(Refer Slide Time: 35:54)

index error here, whatever index marking is there we are taking this reading, so but this marking may not be this what about the lens we have put here, so that middle of the rays optical centre of the lens may not be this center.

(Refer Slide Time: 36:02)

And also tip here we have to tip may not be at this coincide with this mark ok, so that is why that index error generally, so it takes a rod sharp two end are sharp and take the distance of this and this between these two here and then. what is the distance that rod length, so that rod length will measure from this scale, so that whatever the length rod

length here we are getting distance between these two and whatever here reading we are getting depends of these two reading and this reading here, if both are same then index error is 0, if there is a difference it should be same, if there is a difference plus or minus, so that will be the index error. And when we are taking the reading, so that index error that you must subtract or add with your reading. we must correct the reading.

I assume that this we do not have an index error, so that is why that part I have not included in the table, but in principle one should check it. yes, so we have learned that how to measure the focal length of a mirror that is whether it is convex mirror, or it is a concave mirror. concave mirror directly you can measure without taking help of convex lens, but for convex mirror directly you cannot measure, so you must take help of lens, convex lens and then you must measure, so that is the indirect method. I described both the experiment. Next, I will describe how to measure the focal length of a convex lens as well as of a concave lens. Let me stop here.

Thank you.