Virtual Reality
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Lecture - 08
Light and Optics (imaging properties of lenses)

Great, welcome back, we are continuing onward in our discussion of light and optical systems. So, I went over basic properties of simple lenses, we have just talked recently about the eye, or human eye as an optical system. And we ended with explaining that the diopter of the eye.

I introduced the notion of diopter, which is the converging power of a lens or an optical system. And I said that the power of the human eye is nearly 60 diopters. I want to talk a bit about the imaging properties of a lens.

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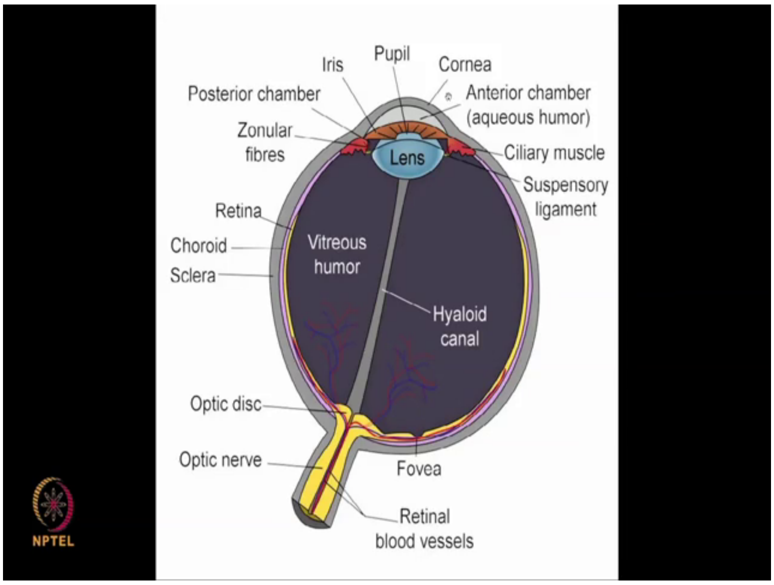

And you know just in connection with the human eye as I showed last time. Remember that the light comes in. It is refracted at many places across the cornea, through the boundary between the cornea and the outside air, the cornea and the aqueous; the aqueous on the lens and the lens and the vitreous.

So, An image forms on the retina all the way across this curved area here so retina starts roughly here; goes all the way around and stops here with the Fovea being the place of greatest acuity where, we receive the highest density of information. The part becomes very important, and it is one of the motivations there are others, but one of the main motivations for eye rotations that we perform.

So, we can change the location of greatest visual acuity. So, I want to talk a little bit about images and how they hit an image plane? Or in this case notice it is not going to be exactly what I am covering, because the engineered systems that we tend to make have focal planes. And we talked about fixed focal dif distances. Here, the retina is curved and so, there will be a curved region that will remain in focus on the outside world as a consequence of that. And so, mechanic gives of all of the geometry of that, but at least can explain what appears in standard engineering systems.

So, let us talk about the imaging properties of a standard lens.

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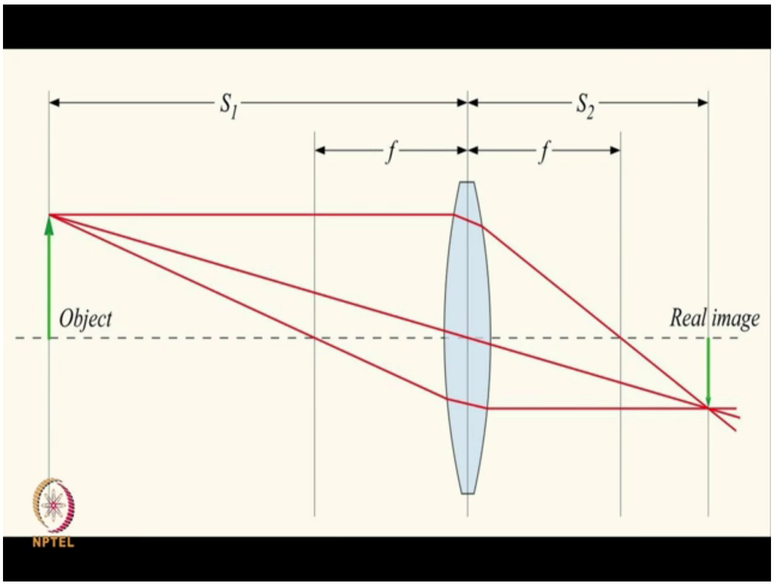

So, we have the standard kind of simple lense, as we have been talking about here. And I am going to stop drawing pictures on the board now, and just utilize these pre-drawn pictures. So, we have a converging lense, and imagine there is some object that is distance S1 away from the lense appearing in front of it; if we put this object exactly away at infinity, right.

We move this object really far to the left so that it is infinitely far away we get our parallel lines. And then the image or the focal plane appears exactly at the focal length.

But we can bring the object in closer. So, instead of being at infinity it is at distance S1, and then it is can a take longer for the rays to converge, because the object is closer. But in some cases, they will eventually converge, and they will form an image that is further away than the focal distance which is distance S2. So, the expression for this is 1 over S1 plus 1 over S2 is equal to 1 over f the focal length. And notice in this picture that S1 and S2 are greater than f.

For this particular case, we say that on the right side we obtain what is called a real image. I am going to make a distinction between real image and virtual image on the next slide. But this is called a real image which means that, if we were to place a sheet of paper or a screen here then an image of the object would actually appear there. The light hitting it would form a representation or as kind of rendering if you like on the screen in the focal plane.

So, we call that a real image. It should be sharp in focus, everything should work out very nicely like that. And if I pull the object away suppose, I hold the screen fixed, and then I take this object and start moving it forward or back a bit, then this image will go out of focus.but I could then move the screen to get it in focus again. And I do that according to this formula. Does that seem fine? If this is a nice kind of scenery check, if that is S1 equals infinity or take the limiting case, where S1 tends to infinity, then what is 2 in this case?

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F which is good, right? Because that is what is supposed to happen. So, if we have S1 equals infinity; that means, the object here has been dragged all the way to the left forever, as far as one can go and then some. And so, in that particular case, this should converge in a limiting case to S2 equals f the focal length. So, I just want to point out that relationship, that even though we made a big deal out of the focal length, the focal point, this focal plane; all these things we made an a big deal out of that.

It is very important, but there is also a range over which the lense can be useful and can produce real images, correct? And the same thing is happening in your eye. It is just that it is curved. So, same in some way, let us say it may have that is similar because of the curvature of the retina. And in this case, there will be a surface; a 2-dimensional surface of locations where, you get perfect focusing on to your retina of a real image. There will bein fact, a real image that appears on your retina.

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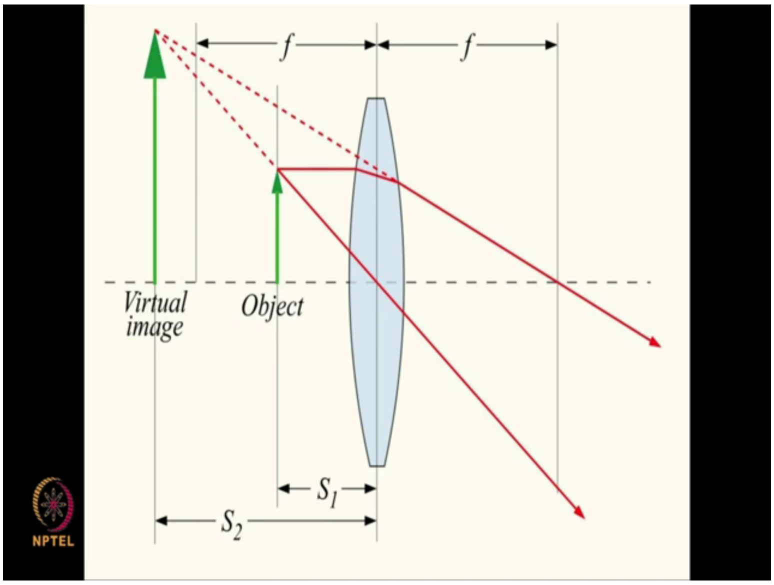

If you get to another case, where let me just draw a simple example here. There may be no solution of this equation.

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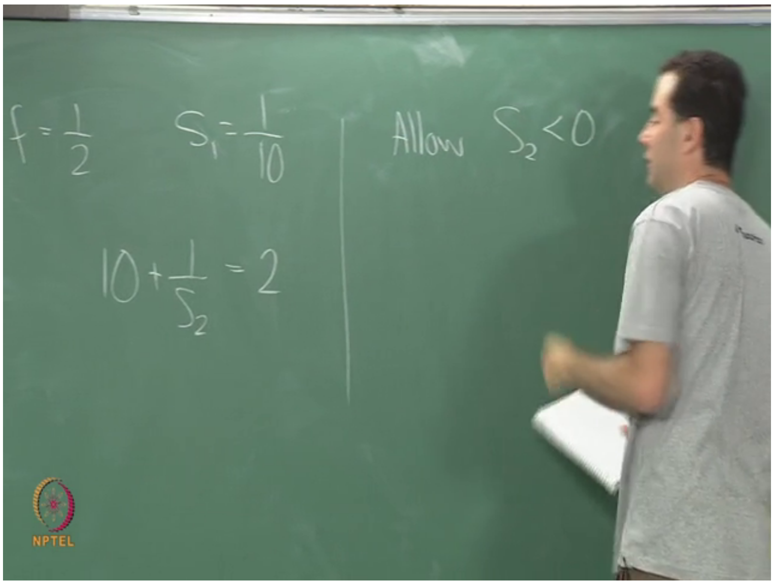

So, it may be that for example, maybe I have focal length it could be one half meter. And I say S1 equals 1 10th. So, I get 10 centimeters away from the lense. Then if I try to solve this equation here I get what? 10 plus 1 over S2, I am trying to figure out where this image would appear.

In fact, then go back a slide this is what well I mean you say I am trying to get this to work out, I want to figure out what S2 is going to be. So, I make the focal length be 1 half, I make S1; where place this object be very, very close. I put it very close to the lense. It is so close that the rays are diverging a lot. This lense isn't may be powerful enough to converge them back. They are just too far spreading. If I do that I get this and there is no solution, right?

This tells me that the lense cannot converge the rays. Now if it cannot converge the rays, what if it just does whatever it can so it may converge them some amount, it may change the divergence a bit, and do a little bit of converging. But it is still over all the ray is diverge after hitting the lense. We can still do this trick that we did for diverging lenses, which is work backwards, and see what the rays would converge to on the left side of the lense, and we get a picture that will look essentially like this. And in this case, we are allowing S2 to be negative.

So, we allow S2 to be negative. And we still get a solution for this. And this corresponds to a very familiar process called magnification, all right? Pull all the lense, and put it up very close to something and it appears to be larger; however, that is just an appearance to us. And in this case, we call this larger object that we get.

So, again, if you if you looking into the lense from this direction now, we put an object up very close to it, but from this perspective the object appears to be very large, right? So, that is magnification. We are using the same kind of lense. There is nothing different about it, other than just where I have decided to place the object and where I have decided to view the object from.

Now, there is one more maybe slightly confusing thing about this which should point out. If you decide to use a magnifying glass to look at an object of close, there is still a real image being produced somewhere. This process is still happening in your own optical system of your eye. So, when you see the object appearing very large looking through a magnifying lense as it hits the retina, just pay attention to that is still going to be a real image.

So, ultimately, I have to when looking at this picture here, and if your eye is over here on the right side looking through this magnifying lense, it is still going to converge the rays anyway so that it produces a real image on your retina, right? But it gives you the illusion that this object is much larger. I just wanted to point those things out. Any questions about that?