Virtual Reality
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Lecture - 8-2
Lights and Optics (optical system of eyes)

So, for the last bit for this lecture, I want to talk about the eye, the human eye and how that lens imaging system works with regard to some several different cases. Some kind of not going to include the aberrations in this, but I am going to go into the other part.

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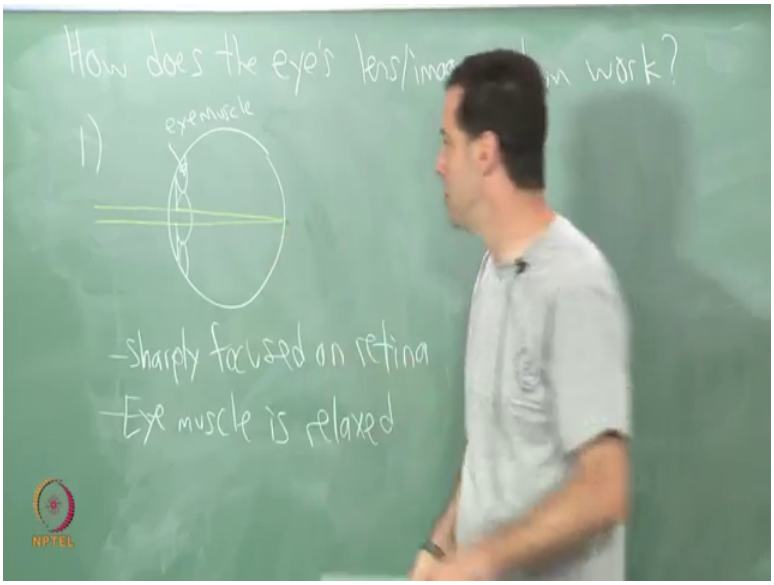

So, let me bring my picture that I have here back to the eye. So, this thing were curious about is how does the eyes, a lens, or image system, or optical system work, all right. So, I am going to go over four different cases that occur very frequently all right. So, this is so, here one case I will just draw the eye eyeball is a simple circle here, but you can remember that has more details from the picture, mines going to be rotated. So, that it is the eye is looking to the left. I will just make kind of a very simple eye example here. And put the lens here, and I will have some parallel rays coming in.

So, I have parallel rays of light coming in; my eye should be trying to comfortably take in some kind of image from that. And so, the optical system of the eye should cause these rays to converge onto the retina, right. Again, like I said the eye lens, the eye lens is not exactly shaped like the lenses, I have shown nor is the retina. So, everything here is

curved in a different way has somewhat different geometry, but a lot of the same principles are applying, there is just extra curvature here. Um I have a seen a lot of places a lot of books and other accounts where the human eye is modeled with the exact same level of mathematics as the as optical engineering books do for the lens systems that we tend to design.

So, but it would be nice to have that kind of boiled down in a nice simple clean algebraic way. But I have not been able to find that does not mean it does not exist. But certainly experts who work in human vision have models of these things, but it seems to be mostly appearing in literature that is difficult to access.

Alright so, in this case and we have like eye muscles here.

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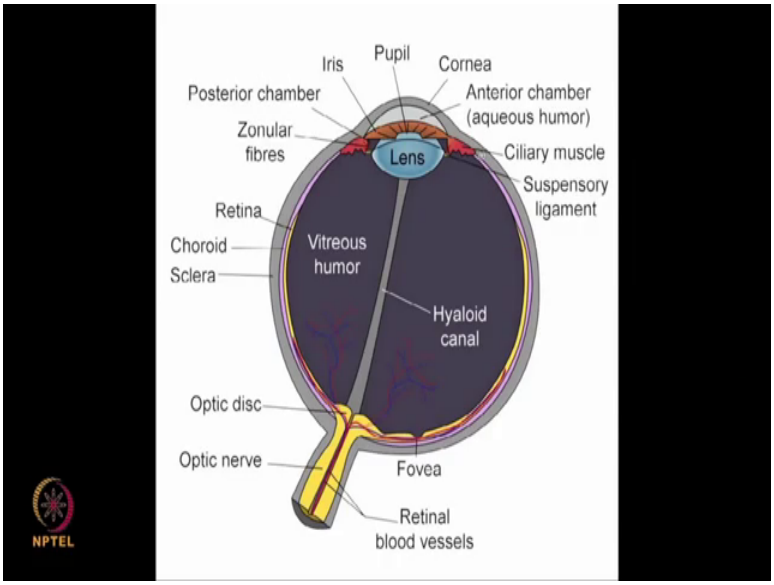

And so, we have eye muscles which, you see them in this in the picture here as it says ciliary muscle here. So, these have the ability to change the dioptre of the lens. And so, in the usual case we have rays coming in from infinity what say and you get sharply focused on the retina and the eye muscle alright.

So, this is this is what happens in the normal case suppose you have no corrective vision of any kind and the most relaxed setting should be that light that is coming from a from a source that is an infinity parallel rays coming in should produce a nice image on your retina without your eye having to any kind of work. So, no extra sort of energy

expended. So, that is kind of the simplest case. Now here's something else that might happen.

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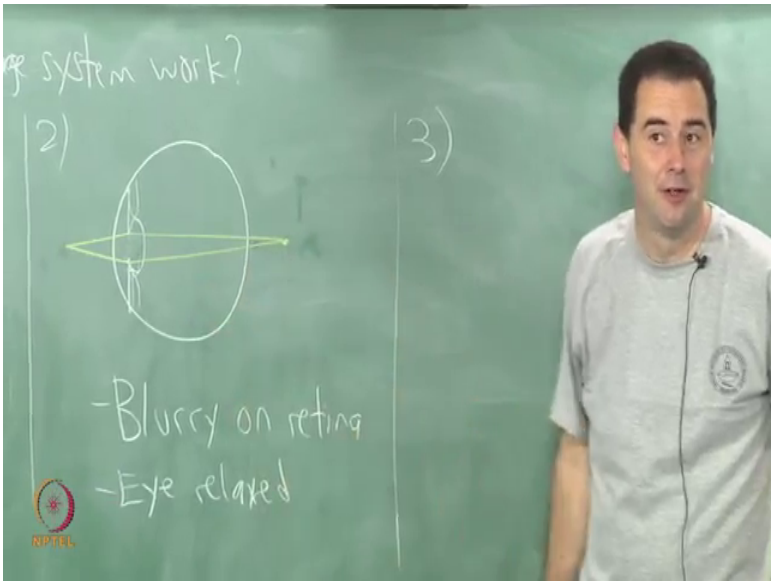

So, try to make same picture, making the eye muscle appear relaxed again. So, should look about the same looks like I have drawn it a little bit thinner here let me fix that. So, do not mean to do anything unusual to it. So, the lens should look about the same. Now suppose that the rays is coming in are not parallel. So, something has been placed the objects then placed a little closer to the eye.

So, that the rays are not parallel. So, coming in like that. And now because of that, let us suppose that they are they they there far enough away. So, that convergence still happens, but it happens too far back. Remember, that we could place it. So, close that it would never converge anyway, but let us suppose that we placed this source close enough we do not have parallel rays.

So; that means, if you remember I talked about the imaging power of lenses right we have the nice formula with s 1 and s 2 and we are trying to figure out where the image is going to appear. So, if we do this, then perhaps the image appears back here, right. So, what should what should we do in that case what would we see blur I guess right. So, we do not have a sharp image one possibility would be to have a squeezable eyeball, right.

So, that maybe if the eyeball could squeeze it could move the retina back here, right. It would that be nice another way to do it is to squeeze the lens to increase the diopter to bend the race so that it fits perfectly on the retina. So, this case, case number 2 is blurry on the retina and the eye muscle here is still relaxed. Number 3, which is a wonderful thing if it still works for you, is that your eye will change the shape of the lens and handle this situation, right so, that you could for example, read a book up close or read your smart phone up close.

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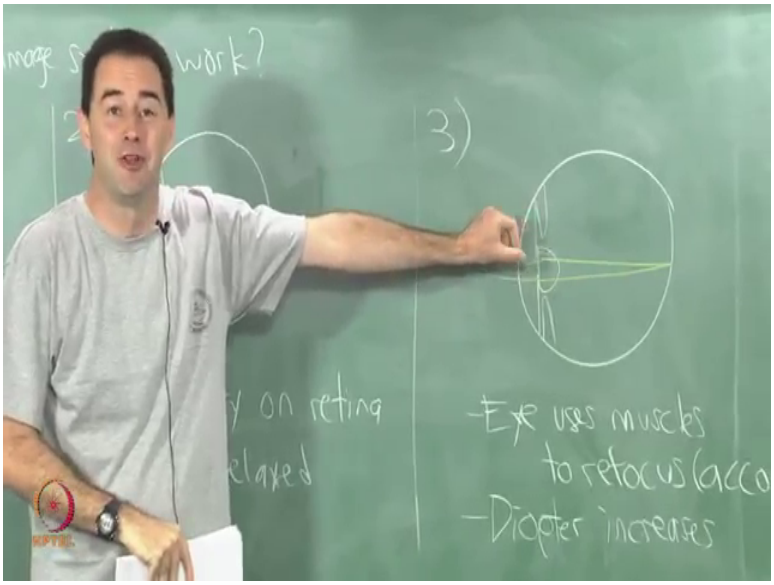

Draw the eye again here. In this case, the lens will be controlled to look a bit thicker let us say muscles coming in doing their work. And so, in that case suppose we have the source at about the same distance as it was before here. Then because of the increase in diopter we have been able to make the rays converge perfectly onto the retina.

So, the eye uses it is muscular power to refocus; which in vision science is called accommodate. So, it is very important to know this term accommodation, right. Accommodate just means a focus or refocusing of the eye and in this case as I said the dioptre. So, the optical system of your eye has a range of diopters actually, right. So, you have the ability to see things up close and focus sharply on them in addition to seeing things very far away. Normally, when you relaxed you see things very far away. As we get older we tend to need reading glasses and the reason why is because this mechanism becomes broken.

So, I have I am I am in my late 40's I have lost about 30 percent of my ability to do this. So, I now have to hold things a little bit further away, but I do not yet need reading glasses. In about 2 years of probably need reading glasses to read. So, that is just the facts of life, you notice that small children seem to be able to put things up very close and focus on them.

So, so, that means, that that I mean the range as we are younger the range is the largest and it tends to decrease over time, but but across our 40 s typically on average it falls off very fast. There are also many other kinds of difficulties we may have. Um it could be the case that for parallel rays. It might be that they tend to focus early before the retina, right. And then you can get a lens that causes divergence to fix that. And then you will move it to the right place right.

So, you should be able to see a little bit of what the job of the optometrist is now, right. It is adding some lens to the system here that performs the correct convergence or divergence to make sure that you keep hitting the retina, and if your eye lens is also still functioning the muscles are still functioning. So, you can change then it gives you a suitable range so that it it corresponds as close as possible to the feeling of normal vision, right. There is a special case of reading wanting to see sharpness up very, very close, closely and that may require an extra set of glasses or an extra set of lenses if you have bifocals or something like that it would motivate that.

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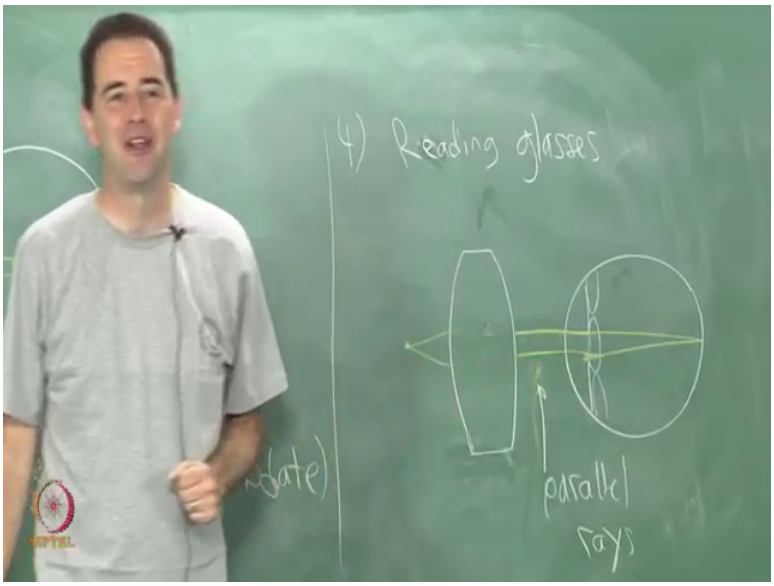

So, that would be the other case, which is reading glasses we are in this case, trying to make that look some metric just a simple converging lens. Now I put my I put my reading glasses, here the reading glasses lens, I put that in front of my eye I have my thin lens here that cannot be thickened any more because it is broken, let us say. And now I have my nearby source.

Again, I wanted to read this thing up close. So, the light is diverging, but then it goes through the lens, and comes out looking parallel. So, you have to, and it is kind of hard to get this from the way I have drawn it, but it should come out parallel. So, that then when it across through here it could converge the back of the retina and be just fine right. So, it should all match up nicely here.

So, here they should be the parallel rays, so that when you have something up close you are trying to read a book let us say it is very close, but after it goes through the reading glasses, it feels like it is infinitely far away, but with very, very big letters, right. And that is comfortable then so that your eye muscle can be relaxed it may be relaxed forever not working anymore, and then you will be able to read comfortably, right. So, that is what reading glasses are doing in this case ok. And you know you may still have some range of utility in here, in which case you just need a very light prescription of reading glasses and has Refer Time: 12:17) case further you will need stronger reading glasses. Any questions about that ?

So, I think it is very interesting to understand this, and those of you you know and who have been experimenting in the lab and you you are wearing glasses you have questions, why isn't it working for me, what can we do about it, right? So, this should help you to understand maybe what can and can not be done. So, there is some there is one more part which I think I will save for next time, but it is what happens in a head mounted display right. So, what happens there? I will give you just a hint of it here, there is a screen appearing here, it is very close to your eyes.

So, the lens is going to behave very much like reading glasses, it is gonna make those rays look parallel when it comes out. It is one common choice. So, that it appears to you like the screen is infinitely far away. So, it is like sitting in the open air theater, but the screen is infinitely far away and fills your entire field of view, with perfect clarity. So, that is how it should feel to your eyes.

Which I think should be fairly relaxing and comfortable. Other problems of flickering, and pixels, and brightness and all that that may be a problem ok, but optically for your system it should be comfortable, right. It should feel like you are just relaxing and looking at something that is far away like the amounts. And that that that is how it that is how it should appear. Questions about that?

Now, because of things like spherical aberration some of the other kinds of aberrations things might not be in focus. Especially, when you get to the periphery your eyes may try to redo the focus at the periphery to try to fix it maybe they can maybe they can not it depends on how everything's been placed and the capabilities of your particular eyes, alright questions? Comments? So, it is a next lecture we are going to be taking a closer work at how the human eye works, looking at the structure of it a little bit of the the biology a little bit of the neuroscience, how all the wiring happens, and we will start off by thinking of it as an optical system.

But then we have to get all the way up to a higher level brain functions to try to give you some kind of overview of that I am not going to drag you through all of neuroscience, but I am just some bits of that, so that you have a clear understanding of what the eye is doing, what it can do, what it can not do, and and get a kind of a feeling for the work that is automatically happening all the time, when you just comfortably see things in the world.

You do not realize how much your brain is working to fill in missing information, and to account for flaws in our own vision system. So, it is fascinating and it is very important and critical to developing virtual reality systems. That is, it.

Thanks.