Optical Methods for Solid and Fluid Mechanics
Prof. Aloke Kumar and Koushik Viswanathan
Department of Mechanical Engineering
Indian Institute of Science – Bangalore

Lecture - 10
Optical System: Lenses

Welcome back everyone. So, today what we are going to do is we are going to step into the lab one more time. Before we do, I want to give you an idea of what you are going to see in the lab. We are going to be discussing a very important topic which is lenses and for imaging lenses are obviously very important, they help you form the image otherwise you will not see the image at all.

Now when it comes to lenses the theoretical construct usually starts from the idea of very simple thin lenses. So, if you look up an book on optics what you will encounter is something called as the thin lens.

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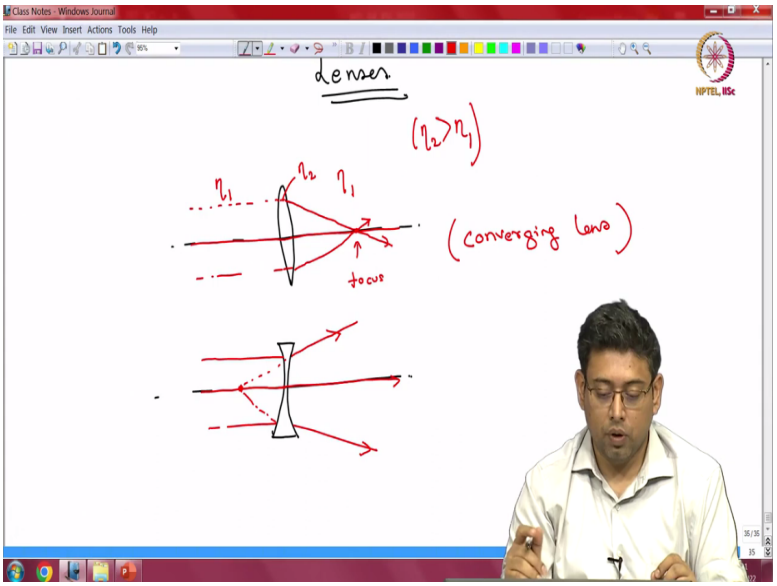

Now the thin lens is a simple version of what type of lenses we encounter today and the reason they are important is because in thin lenses the image that is formed by the optical system that can be understood simply. So, there are two wide widely used type of lenses one is something called as the convex lens and the other is the concave lens. So, this is for example the top image that I am showing you here.

This depending on what is the refractive index of the two medium so we are going to assume that this has let us say a refractive index of eta 1 and this is eta 2 and we are going to assume that eta 2 is greater than eta 1. In this particular case what this lens does is it acts on a plane wave front and it focuses it onto a point. This is illustrated by this particular diagram let us say we have three rays that are traveling parallel rays that have traveled to my thin lens.

Thin converging lens then the light that is passing through the optical axis that just passes unchanged whereas the light at the top is shifted or is bent so that it travels towards the center similarly for the light at the bottom and both of them are shifted so that they end up passing through a focused point so this is your focus. So, the converging lens as the name suggests converges the light that is why the name.

So, this is your converging lens and the diverging lens does sort of the opposite. So, if you have a plain wavefront coming which basically is a parallel set of rays here depicted by three parallel lines then again the light passing through the optical axis passes unchanged the light ray at the top this is now affected so that it actually diverges from its previous path similarly for the other one.

And this divergence is such that okay this is not a great diagram this should have been something like this. So, essentially this focal point now is a virtual focal point then do not actually these two light rays never really meet, but if you extend this towards the back of the lens this is sort of where they will meet. So, this two form very different type of images and they to do with different things to the light.

Now, these are the two most common lenses that you will encounter. Most imaging lenses, for example, if you have a DSLR lens or any other even if you are looking at a microscope lens you will mostly encounter converging lenses or a sequence of converging lenses obviously in a realistic scenario what we today have are set of many different lenses that are put together.

And when you change their lenses with respect to each other the overall properties of the optical system also change, but all these can be usually understood with respect to some of these simple elements of the converging and the diverging types of lenses.

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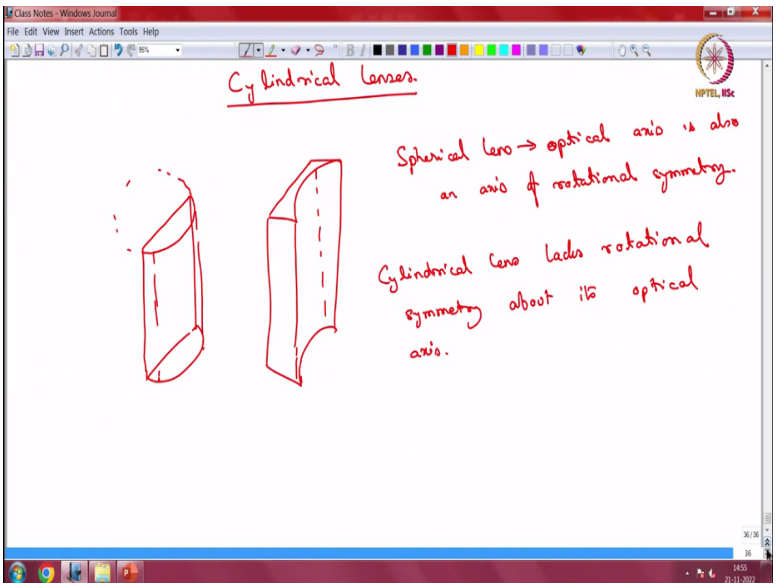

There is a one important type of lenses that you will also encounter called cylindrical lenses. Now in cylindrical lenses as the name suggests the lens is actually part of a cylinder. So, for example, this could be a cylindrical lens. So, this for example is a is a cylindrical lens. So, you can see that this if I had extended this further this would have been a sort of a cylinder right here.

But what you are doing is using part of a cylinder right here. Another type of cylindrical lens could be something this scenario where you have it is basically the negative cylinder. So, spherical lens lenses and mirrors are very common in today's in imaging systems. Cylindrical lenses are a little bit less common, but still they are encountered in different scenarios what makes a spherical lens in a cylindrical lens different is the role of the optical axis.

Now in a spherical lens the optical axis also serves as the axis of rotational symmetry so maybe I will just write this down for you. So, a spherical lens your optical axis is also an axis of rotational symmetry. Now in a cylindrical lens however the optical axis is not an axis of rotational symmetry. So, cylindrical lenses lacks rotational symmetry about its optical axis. So, cylindrical lenses have asymmetrical focusing properties.

Whereas a spherical lens will produce point focus for a point object a cylindrical lens produces a line for a point object. So, the image of a point object in case of cylindrical lenses is a line. Now you might want to ask how is this helpful? We will see that in PIV a Particle image velocimetry this property of cylindrical lenses to stretch out point into a line becomes extremely useful.

And we are going to use that for lighting for our case. So, cylindrical lenses are often employed in large scale PIV systems where beam of light is an input and you want actually a plane as an output. So, this is where we are going to see cylindrical lenses otherwise all the other lenses which will encounter, for example, in the microscopes or in as DSLR as lenses that go along with DSLR digital cameras those are all spherical lenses I am sorry I misspoke spherical lenses.

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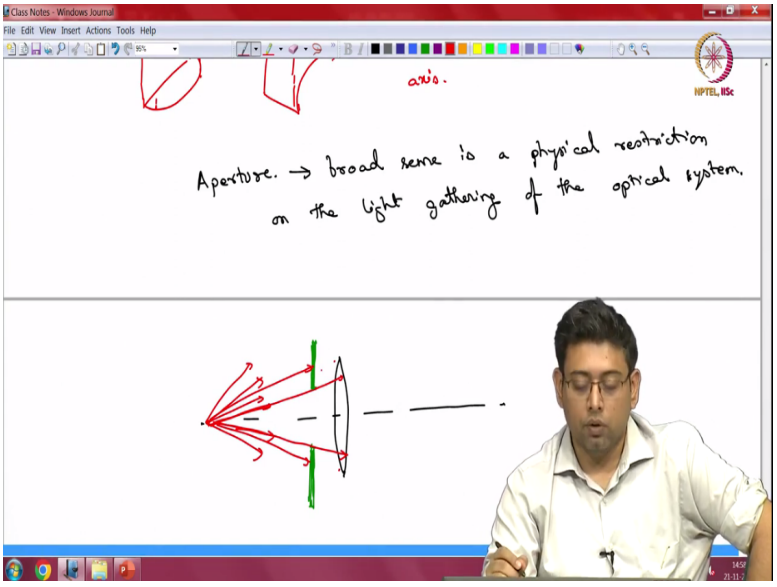

Another topic to quickly discuss before we step into the lab is the idea of an aperture. Now an aperture in a very broad sense is a physical restriction on the light gathering capacity of the optical system. So, how would you want to make one. So, for example, if you have a lens let us say and you have an object here that is sending out light rays in every possible direction then in the regular case this light would be intercepted by this lens.

And then this is going to form an image, but what you can do is you can put a geometrical obstruction such that this light ray can no longer pass. So, only my rays that are passing through this opening will pass all the other rays will be obstructed so these rays are obstructed. So, this is an example of an aperture now we will see that an aperture we do have a manual control over apertures this is a obstruction that you have placed or the user has placed deliberately in the path of light.

And this can be placed before the lens or after the lens and or different places before the light is finally let out of the optical system. So, that also gives you different types of apertures for

example a back aperture or a front aperture, but this is going to be important with respect to how the optical system gathers light. Now two things this is aperture usually does in an optical system is that it limits the field of view.

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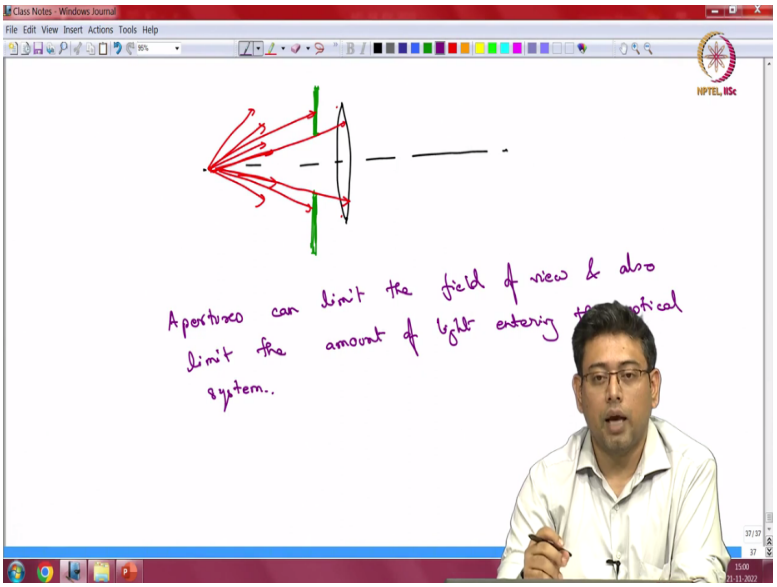

So, apertures can limit the field of view and also limit the amount of light that is coming to the system; so the amount of light entering the optical system. So, if I make my aperture smaller and smaller, for example, in this particular case I can make it smaller and smaller the image becomes dimmer and dimmer because less and less light is processed by my imaging system.

Whereas if I make my aperture bigger and bigger is more light that is falling into my optical system and hence the image also will become brighter and brighter and it also has some amount of effect actually it has a pretty good amount of effect on the focal depth and that is not something that we are going to go into because we are not going to go into a whole lot of geometric optics here.

But if you want to read up on geometric optics you should you can try reading up on lenses and apertures, but for us right now we are interested in just understanding these different terms and what we will do is we will step into the lab we will see some of these common lenses. We will also see how you can control the aperture using a camera and we will see how what effect it has on the image there. So, with that we will stop here and i will see you in the lab. Thank you.