Virtual Reality
Prof. Steve Lavalle
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture – 7-1
Light and Optics (three interpretations of light)

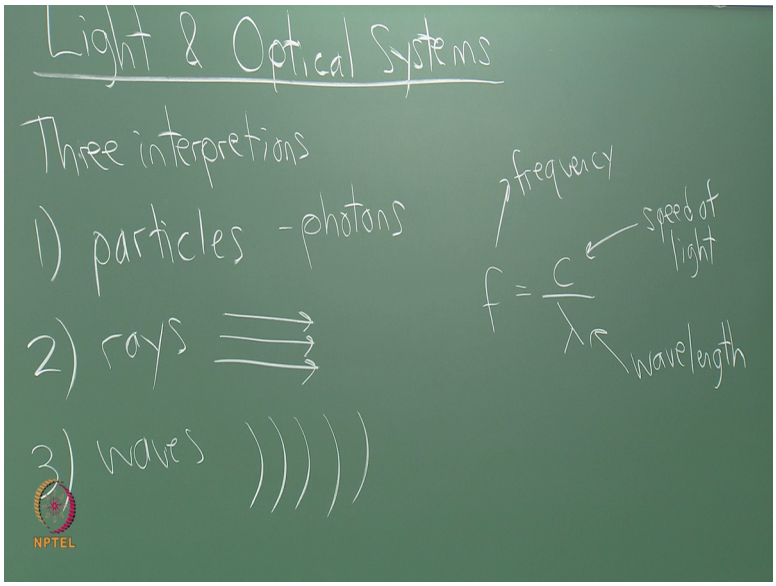
Note that the things we covered in the last lectures are just the math in the sense of its just a geometry and the algebra, the mathematics required to move points around in space.

So, today I want to talk about light and optical systems. So, I am going to be switching more towards the physics. Two reasons for that, one of them is if we want to go from math to computer graphics so that we can talk about rendering in artificial worlds or virtual worlds then we need to understand how light propagates or if we want to maintain any kind of alternate world using the alternate world generator we want to understand how light behaves and propagates in these spaces. So, that is one reason.

The second reason why is that these virtual reality devices that we build exist in the physical world and there are optical systems associated with them. So, we have to understand how that is working because the light ultimately goes from the engineered device into your eye hitting the retina as part of the presentation of the stimulus as I said right, it is an artificial stimulus that is being generated.

So, let us talk about this.

(Refer Slide Time: 01:28)



So, we will talk about light and optical systems. Well, first of all I will just starting off with the absolute basics I know you have all had physics before us from somewhere. We have three interpretations and we will find all of these useful in this class. So, three interpretations, one is light as a particle, in other words as photons and you may remember two more representations one of them is light as rays. So, we think about rays of light.

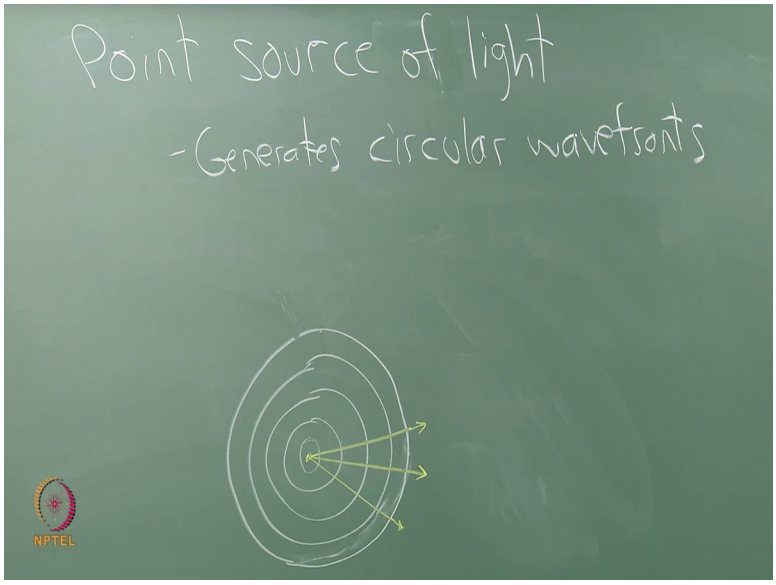
This representation is very popular among computer scientists for doing visibility kinds of calculations and computations. So, there is whole family of algorithms in computational geometry for example, called visibility algorithms in computer graphics there are what are called ray casting and ray shooting methods. So, rays of light become very important and at the same time waves are also important. So, like to think about propagation of ways. So, rays and waves are very closely intertwined very often in physics you hear more about the duality between particles and waves. But the rays perhaps are just another way to look at the waves which I will say in just a bit.

And also remember this, the frequency is equal to the speed of light divided by the wavelength, just very very simple formula that hopefully you remember from somewhere frequency in hertz, speed of light. Anybody remember what that is roughly speed of light in a vacuum.

Student: (Refer Time: 03:38).

Three times 10 to the 8th meters per second yeah that is right good. So, I guess I remember too, right or I cheated and I heard what you said wavelength right. So, once you know the speed of a wave in a medium this is just a general property of waves, once you know the speed of the wave and a medium you can relate the wave length through the frequency. So, you should be able to easily convert back and forth between those sometimes I might show you figures or plots that are using wavelength or frequency you can convert to the other one it is very straightforward assuming we know the speed. So, I want to relate rays and waves a bit here and then I will start to talk about optical systems.

(Refer Slide Time: 04:24)

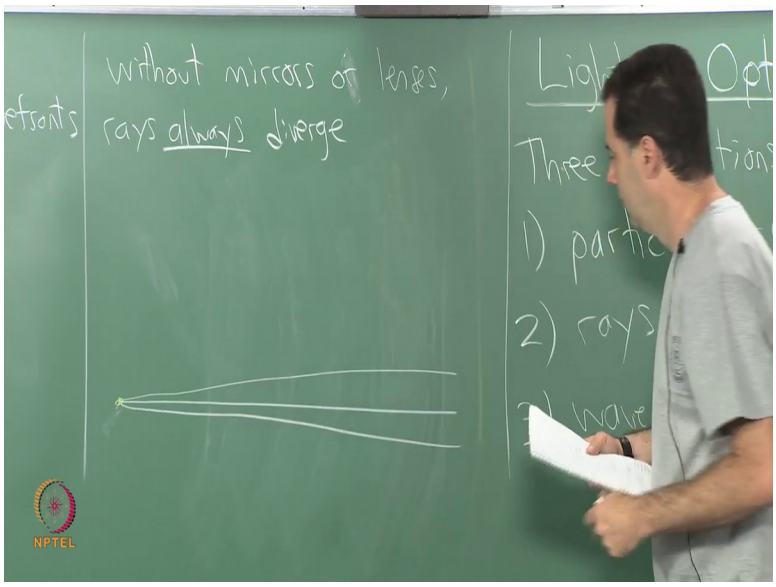


So, let us think about a point source of light. So, we started a particular point as the name suggests and then we can think about waves propagating outward from that. Try to draw a circular wave fronts for as long as I can no guess I am already starting to mess up that should be far enough and so, we have these waves coming out. So, generates circular wave fronts assuming that there is no other obstructions right. So, we just have a point light source and were propagating through maybe a vacuum or the air which is closed in terms of propagation and the speed of light is only slightly lower in air and then we may think about rays of light the rays are perpendicular to the wave fronts.

So, whenever we consider rays of light and we draw this just think about them also corresponding to the way that the wave fronts are propagating right and, so at any given point a long array orthogonal to that should be the wave front that is propagating along

all right. So, these two representations 2 and 3 are very closely intertwined and. So, if I start drawing pictures of lenses with rays of light going through them, think also about how the waves are propagating.

(Refer Slide Time: 06:26)



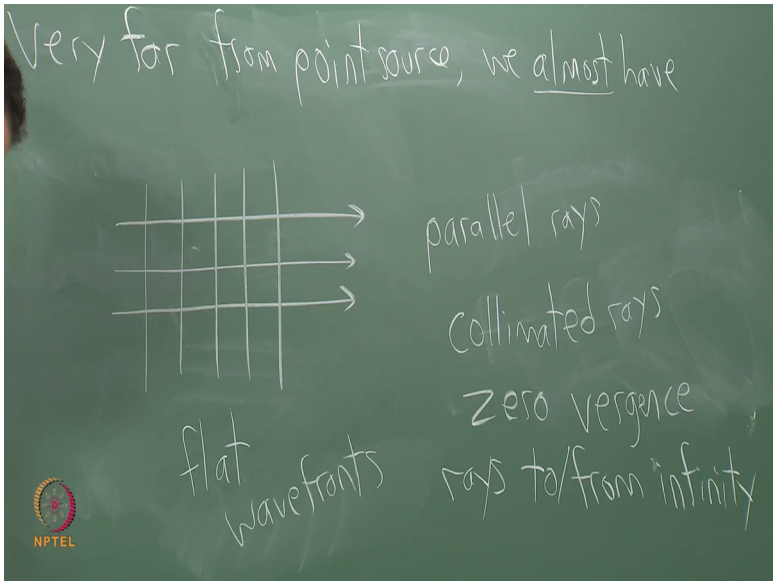
Now, one interesting thing about the physical world is that without mirrors or lenses the rays always diverge, all right. So, we could get we could get very far away from the source of light and the wave fronts are propagating way up when we get over here we are imagining these rays of light propagating out. They are still diverging right, no matter how far away we go they are still diverging do you agree with that.

Yet at the same time when we talk about optical systems everyone likes to talk about parallel light rays. So, I just want to point that out that parallel right where light rays are in some sense a kind of fiction unless you start using mirrors and lenses right away to fix that. But very often we pretend that we have a light source and we have parallel rays coming in and what is true about it only is that it is an approximation all right. So, what we often mean when we make a drawing and we claim there are parallel rays is that the light source is so far away that we may as well assume that the rays are parallel and if that happens what are the wave fronts look like.

So, they should be perpendicular and parallel as well. So, the parallel wave front case, we have when were very far away from point source then we almost have and you know

the almost is important here that said it is not exactly right, parallel rays and what you might consider to be then flat wave fronts right.

(Refer Slide Time: 08:22)



So, the wave fronts should be curved in a circular way, but the radius of curvature keeps going down right, on the radius of curvature keeps going ups now radius of curvature goes which way let us see up or down, up sorry goes up and when it tries to tend toward infinity right then these look like lines, right. So, the circles are getting bigger. So, the radius is getting larger alright.

There are several names for parallel rays and just want to point out what these are, several names that you will find around if you look at other literature. You can also call them collimated, people say collimated light or collimated raise the situation is also called zero vergence, and also called raise to or from infinity which seems to make sense, right. If you could get infinitely far away in some kind of limiting case which as far as we know does not happen in our universe how do we know and experience anything like that when then the mathematical model would be correct all right. Questions about that?