Virtual Reality
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Lecture – 9-2
Human Vision (light intensity)

So, I think it is nice to look at several cases in terms of light intensity.

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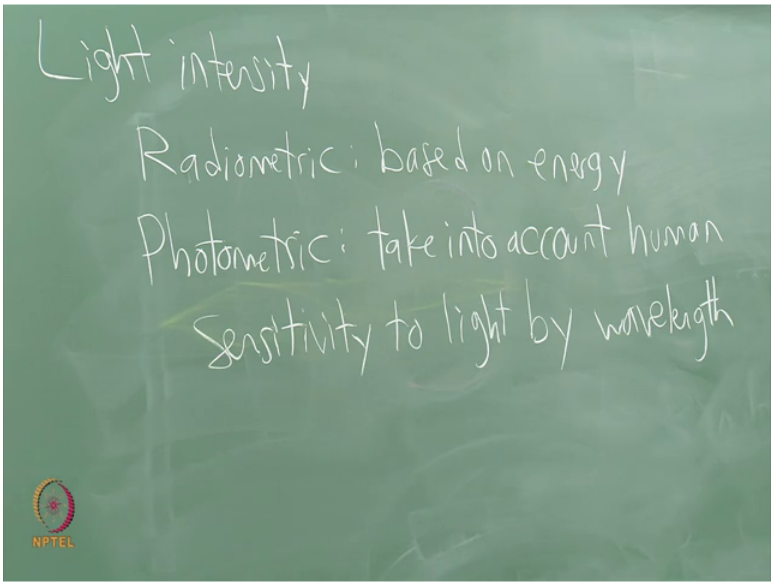

Now, first of all I say when we talk about the intensity of light, one of the most natural kinds of measures might seem reasonable to us, especially for engineering people is a radiometric measure, which is based on energy, and what is instead used when we talk about perception of light, when we talk about light in the context of human vision, we use what are called photometric measures, which take into account, human sensitivity to light by wavelengths.

Which is exactly related to these photoreceptor, sensitivity plots that I showed you right. So, so there are measures, that that take this into account and that is what we will use a photometric measures, rather than a raw physics, that makes sense because it the it the visible spectrum is special only to us right, and many other animals but the visible spectrum for other animals changes quite a bit as well for example, there are some birds that have photoreceptors that can measure ultraviolet light, and then they end up with beautiful patterns on their wings that are in the ultraviolet spectrum, and they can see that. So, for them that is the visible spectrum.

So, if the birds were making measures, but these particular birds they would use something different, but this photometric units are based on a humans, and I will use just a common unit here of luminance called candelas.

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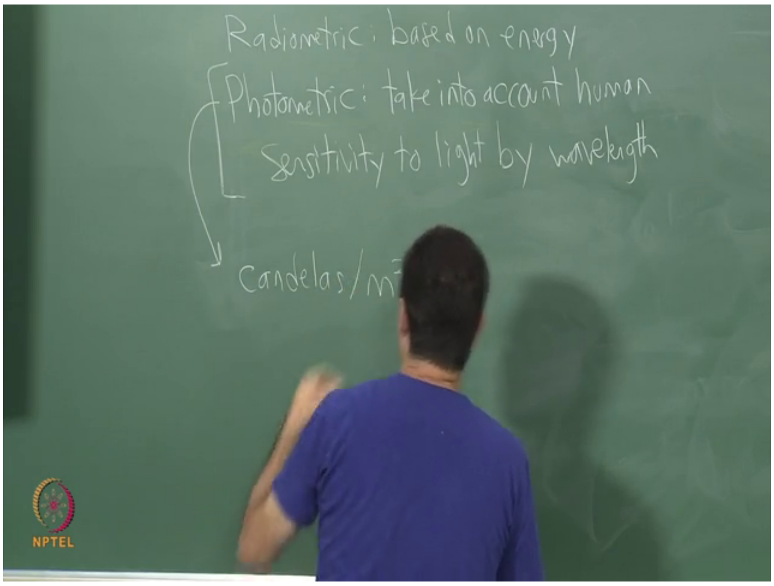

Which is based on the light and roughly speaking is based on the light emanating from a candle. So, I will use candelas per meter squared as a unit of radiating light, and I just want to give some examples which these appear in the major textbook, and then lot of the surrounding concepts of what I am talking, about here also appear in there in a chapter 6.

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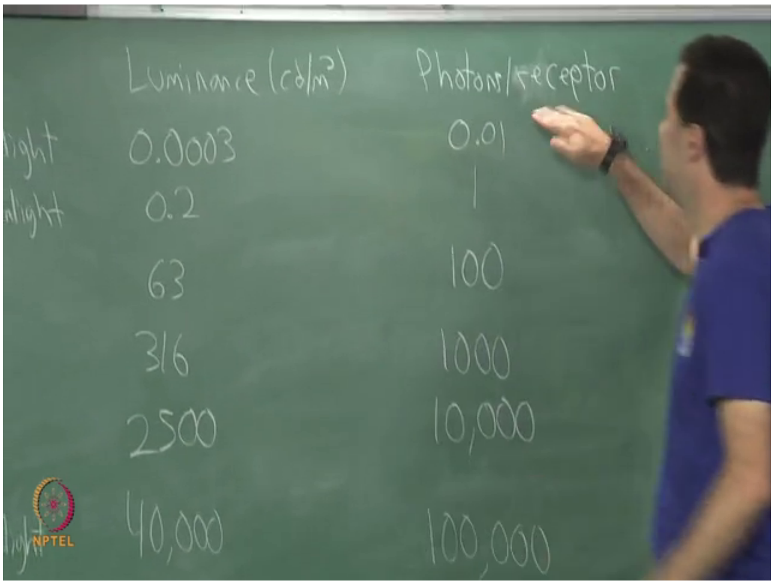

Let us look at the, right here luminance, and how many photons receptor how many photons land in a single receptor, at a certain level of luminance, and I will just give some cases here a paper in star light as the weakest. So, were outside there is no moon in the sky, there are no clouds just stars and you hold out a piece of paper, and I assume you are not near the city or anything like that right. So, imagine is very, very dark you just have a piece of paper, this course found corresponds and of course, it is hard to reproduce us exactly.

But this corresponds roughly to I think this table is nice for comparative purposes, this corresponds roughly to 0.0003 candelas per meter squared, which in terms of photo photons hitting your photoreceptor, you will get about 0.01 per second. So, not very much just maybe barely above some noise threshold if you are lucky. So, that is the lowest end, and then we have paper in moonlight, this goes up to 0.2 and you get about 1 photon for receptor.

So, to illustrate the enormous range over which your photoreceptors seem to be useful, looking at a computer monitor this is about 63 candelas of course, it depends on a lot of factors, but then you get a 100 photons photoreceptor room light which of course, again there is variation here, but 3 1 6 and it is about a thousand-blue sky. So, looking up at the blue sky about 2500, sure it depends on where you are at in the world and finally, paper in direct sunlight. So, if you sit outside imagine here in Chennai sitting outside trying to read a book or something you know perfect white paper hitting the sunlight that is very, very bright.

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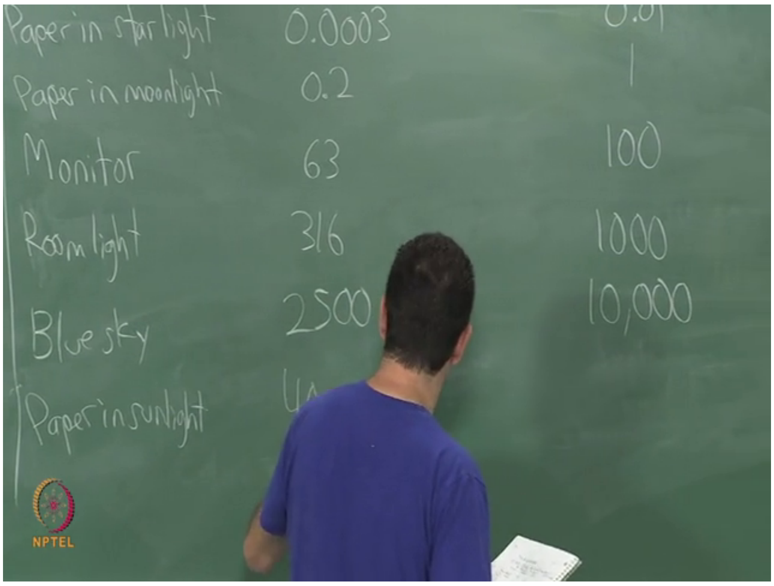

So, paper in sunlight which gets up to a 100,000. So, that is quite a range when you look at it I like this this photon for receptor idea, this concept and so, I am going from 0.01 up to a 100,000 per receptor. So, at that point they get very, very saturated, I lived in Finland for a while and I think of a snow blindness too, as well or you have this remember we talked about the reflectance of snow last time. So, you can imagine snow in sunlight extremely bright, maybe a few of you haven’t seen snow in sunlight before I am not sure, let us see someday you will see that if you haven’t. So, one thing I want to talk about is, because of the way rods and cones are divided up and they have different functions, we end up with 2 different kinds of vision modes, one is called a scotopic vision, I am gonna write it on the other side of the board afraid I am running out of space over there. So, scotopic vision and the other one is called a photopic vision.

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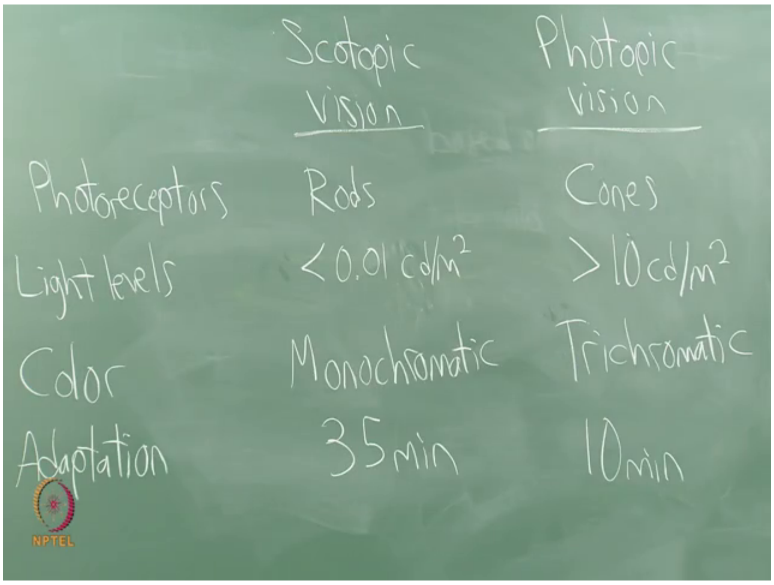

So, these are 2 different modes of vision operation, that we have 2 different kind of modes that are that our vision systems get into the dominant photoreceptor. So, if you want to add the word dominant, their dominant photoreceptors for scotopic vision are the rods, and the dominant photoreceptors for photopic vision are the cones, and for light levels typical light levels for scotopic vision, are less than 0.01 candelas per meter squared, and photopic is greater than 10 candelas per meter squared, of course there is some intermediate regions so, there is a gradual transition from one to the other in actuality brought down, but that the extremes are very clear what is going on.

So, as far as color perception goes, when you are in scotopic vision mode, it is monochromatic, and in photopic mode it is trichromatic, based on the r g b sensitivities of your a cones trichromatic, and there is the adaptation period in order to switch modes it takes about 35 minutes to go, fully into scotopic vision mode this seems reasonable right. So, if someone shines some bright lights or you been around the light for a long time, you go outside how long does it take before you can see really well in the dark, right may maybe after a few minutes you are already improving.

But if you want to get completely end a scotopic mode about half an hour, if you have ever done some work with telescopes trying to look at the stars at night, it takes quite a while before you can really see everything perfectly about half an hour, going in the other direction it is about 10 minutes to adjust, pupil dilation is also a significant part of this as well right so, when you are in a scotopic vision mode your pupils are dilated taking in as much light as possible. So, this is also another adjustment the eye is doing yet another degree of freedom in the optical system right, roughly speaking 90 percent of our neurons are devoted towards photopic vision so; that means, we are day time animals, maybe that is no surprise right were not old or bats or something like that. So, so were basically designed to survive to do the things we need to do to survive during daytime, and then were a lot more vulnerable at night right, but not completely vulnerable thanks to scotopic vision. So, so we have like 10 percent dedication to that.