Virtual Reality
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Lecture – 17-1
Audio (auditory perception)

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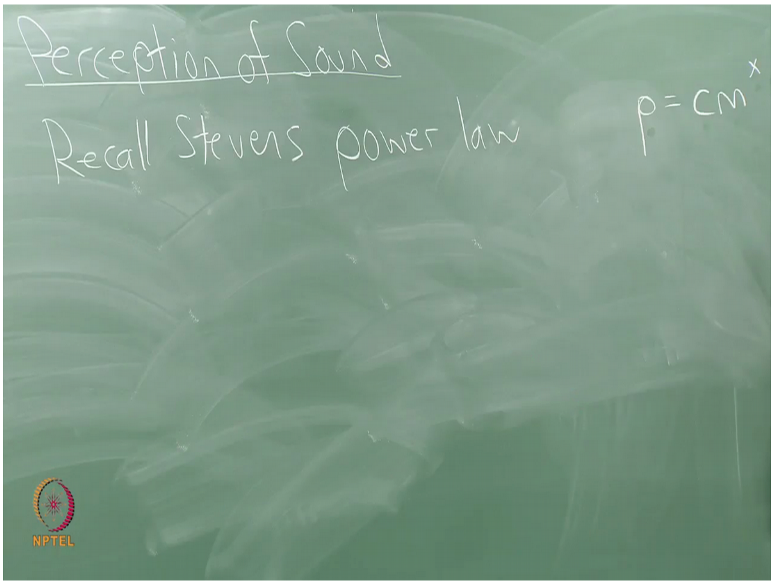

Remember for vision we had perception of motion perception of depth. So, we are up to the high level, now perception of sound. The way back near the beginning of the course, you may recall Stevens power law, which takes the magnitude of a stimulus and maps it to the perceived magnitude of the stimulus. So, let me make sure I get that, and it should be fine sorry let me change I just a little bit.

Let us say P the perceived magnitude of the stimulus is some constant times the magnitude and there is some exponent there.

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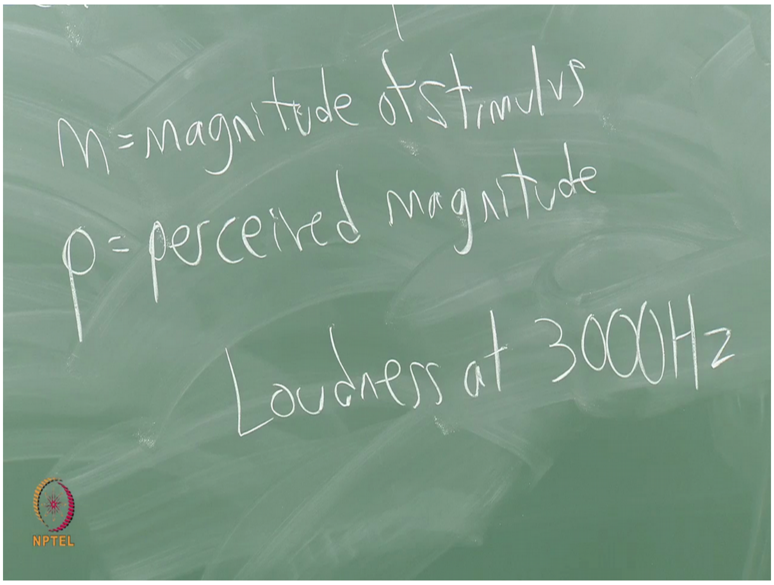

So, M is the magnitude of stimulus. And P is the perceived magnitude and so, one very simple example in the perception of sound where this becomes important is loudness, at a pier tone of let us say 3000 hertz.

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So, in this particular case we get a plot like this, where the exponent is 0.67. So, this is the magnitude of the stimulus and the perceived magnitude of the stimulus.

So, in other words if you double the magnitude of the sound, it does not necessarily get perceived as being double the magnitude in fact, it is significantly less than that. So, as the sound pressure waves get louder and louder, the incremental amount of extra loudness that, we perceive is significantly less. So, this is ends up being a nice example of Stevens power law in the context of audio perception.

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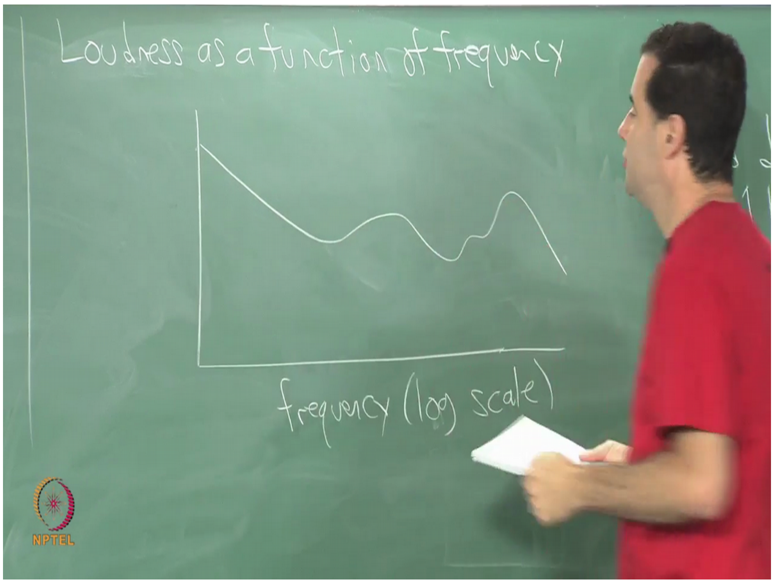

Here is another interesting result in the perception of sound, you can talk about loudness as a function of frequency, I will just do some rough idea of the plots here. So, we put frequency here 10 log scale, but I am not going to worry about the exact coordinates, I will just want to show you that there is a interesting shape to the plot.

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So, here is what I do? I take a sound at fixed amplitude or fixed dB fixed decibels at 1 kilohertz right. So, I have sound that I have a 1 kilohertz tone and you get a customed, if you are participating in this experiment you get a customed to the loudness of that. And now you listen to a tone at a different frequency and, you are asked to turn the loudness up or down until it sounds like it is just as loud as this based tone that make sense.

So, you are just trying to compare and say ok, I have I am may have a sound at a 2000 hertz, this ones at 1000 hertz and, I may have a sound at a 2000 hertz and may I have to tune it. So, that it seems like it is just as loud, but in terms of decibels we can measure scientifically exactly, whether or not it is the same loudness level.

And so, in this particular case the curves end up being quite interesting, I guess I will just draw there is like some kind of plot like this. Let us say so, it ends up being non constant. So, I just want to say that we have very unusual perception of equal amount of loudness it varies as a function of pitch. So, this would be a equal perceived loudness contour.

And finally, as I not finally, sorry but next as I mentioned before very early in the course there is adaptation.

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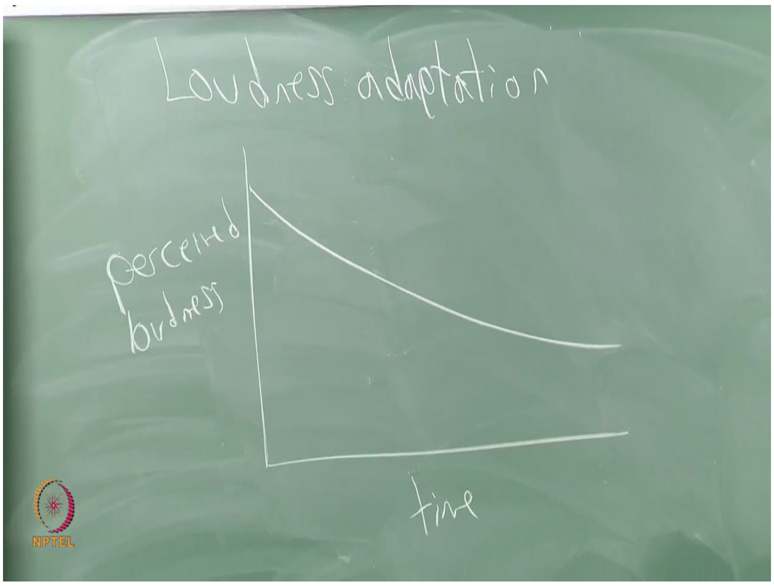

So, it may be the case that perceived loudness over time generally decreases, this also happens throughout the day for us, I do not know about you, but when I wake up in the morning, I am very sensitive to sounds if I was most was listening to some music the night before added a certain volume level, I wake up the next morning and I think wow I had it that loud how could that be you know. So, it seems to take some time for us to adjust to or adapt to loudness levels throughout the day.

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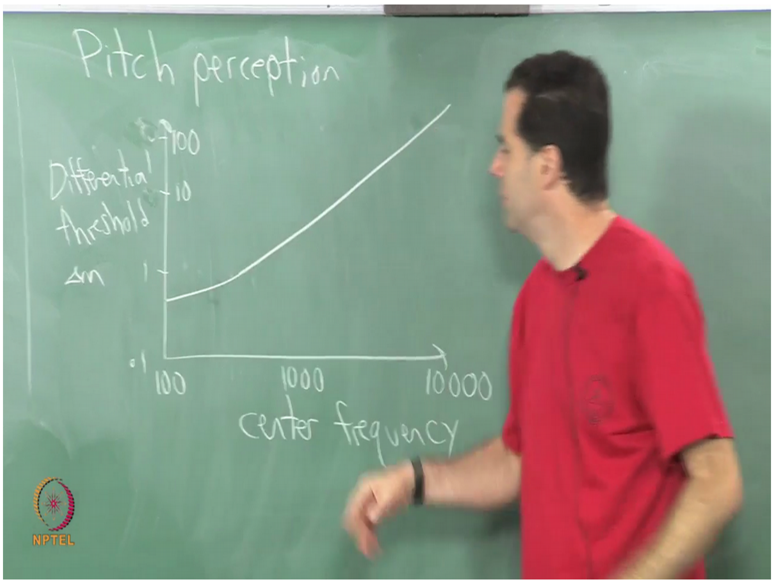

So, adaptation as well, here is another interesting result, pitch perception. And this makes use of a powerful idea from a psychophysics, which is called just noticeable difference, I need to point this out. So, right before getting into pitch perception let me mention just noticeable difference.

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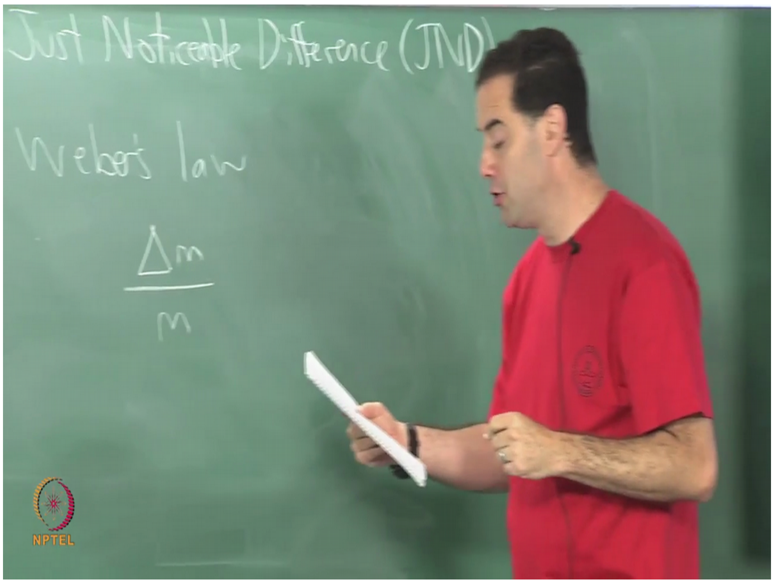

Just noticeable difference or JND. So, the question is in that case, if I have a stimulus and I have the ability to change it is magnitude how much do I have to change the magnitude by before, you notice there is a difference that is the question, what is the smallest amount is ask different now, I could do this in many ways I can do this by slightly changing colors, you know I could do this by changing brightness levels, in the case of a vision right, I could do this by changing the pitch I can do this by changing the amplitudes a lot of cases where, I have a a linear stimulus let us say, and I just want to ask the question when do you notice that it is different right that I have done something different to it.

So, this is a just noticeable difference and, here is one interesting general result called Webbers law, which if I look at the change in the magnitude of the stimulus divided by the overall magnitude of the stimulus.

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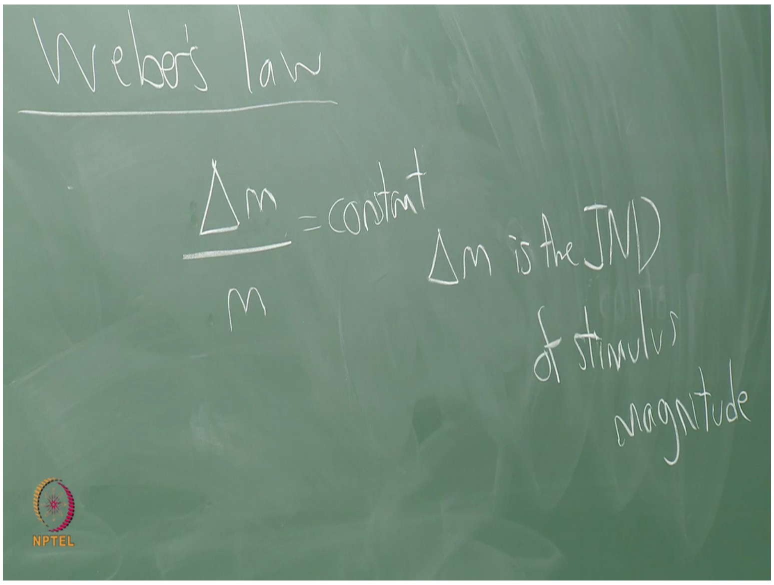

So and let us say delta m is the just noticeable difference that was obtained through some experiment. And so, suppose delta M is this small change that was the just noticeable difference anything smaller would not be perceived, then Webbers law says that this amount delta M over M is a constant, which means that if I were to all of a sudden cut the overall magnitude of the stimulus in half, then the delta t would cut in the delta M sorry would cut in half as well.

So, it is really the percent difference let us say in the in the in the stimulus magnitude that seems to be at the thresholds of perception, I am so, this is a common law that seems to occur a very frequently in these types of just noticeable difference experiments.

Let me go back to the case of pitch perception and, mention this interesting experiment which I find this result surprising. So, you start off with a pure tone, you have a center frequency. So, I generate a pure tone I will make a logarithmic scale here. So, I will put it at 100, 1000 and 10000. So, I start off here with a pier tone, I generated at that frequency and then we start varying the frequency and we try to determine, when you the subject can actually tell that it is a different tone right. So, I may give you random tones and I ask you to press a button is this the same or different.

Student: (Refer Time: 09:53) does not it matter the time (Refer Time: 09:55) change.

The time over.

Student: Yeah.

In what sense?

Student: Pitch change.

Oh.

Student: Stimulus over all very long duration, it may need not be possible (Refer Time: 10:06).

I think it is very interesting observation. So, so that is right you may not if I present to you a stimulus today, and now we come back tomorrow and I say is this at the same level, I bet that would make a much larger delta M. So, that is that is reasonable so, this as a it is formula, it does not it is its not saying a delta M is going to be the same across all of these. So, let us just hold time fixed and then say this law holds. And most of the time in these kind of experiments, the one stimulate one stimulus is presented right next to the other temporarily. So, they are very short in time, but you are right your ability to remember how close those were, that ends up that ends of involving memory let us say.

Student: It will gradually change the (Refer Time: 10:49).

In these types of experiments usually it is one and then the other um, but that is a very good point. So, in this particular experiment here, what we have is the differential threshold in other words the delta M, and what I find surprising. So, we have like 0.1 hertz here, 1 hertz 10 and 100. So, leave a lot of room for my axes here, I will put it on this side.

The plot is about like this, which means that we are in the range of a few 100 hertz, we can perceive a tone difference of 1 hurts, that is quite incredible and it is amazingly sharp. So, but then as the frequencies get higher it gets more difficult. So, I find that really interesting, all right.

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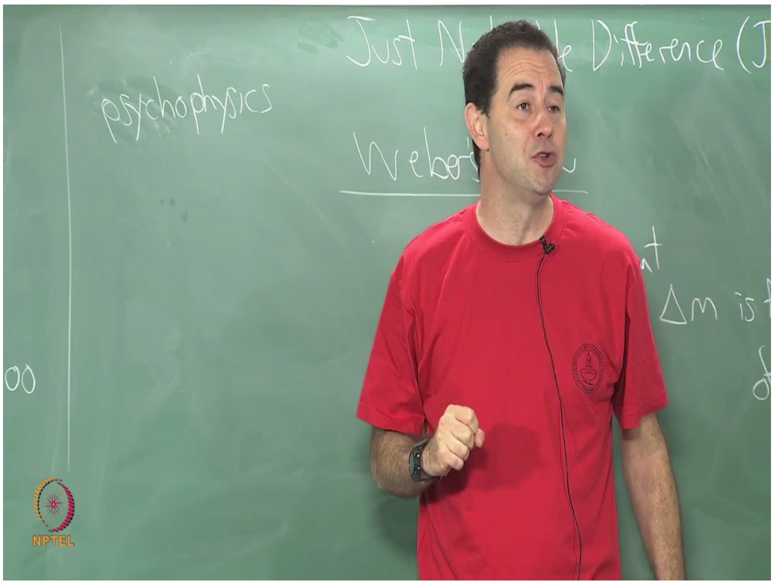

So, these are just some basic audio perceptions you know I cannot talk about things like perception of scale or perception of the shape of objects and things like that right, we do not have these kind of this level of complexity as we have for vision, but in this gives some idea of perception it also is remind you of something that is very important, which I am encourage you to look up more about this I do not have enough time in this course, but to look up psychophysics.

Which is the science of connecting stimulus to perception, around you want we want to understand we have a stimulus coming in, we want to understand the perception coming out. If you are building virtual reality systems, it is very important to understand what the user is going to perceive based on the stimulation that you are providing and so, there is there is an entire field literature devoted to this and entire methodologies for designing experiments that involve human subjects. So, that you get the right results out you do not have artificial bias and other problems that are introduced to run.

So, this is worth looking up and studying in conjunction with this course especially, if you are interested in doing user studies to do the to determine whether or not you have done the right thing, all right have done something sufficient for your task, or whether or not you have made a comfortable virtual reality experience all right.