Fundamentals of Acoustics
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Lecture – 65
Loudness

Hello. Welcome to Fundamentals of Acoustics. Today is the fifth day of the eleventh week of this course. And, today and tomorrow we will talk about a different concept in context of acoustics and that is known as Loudness.

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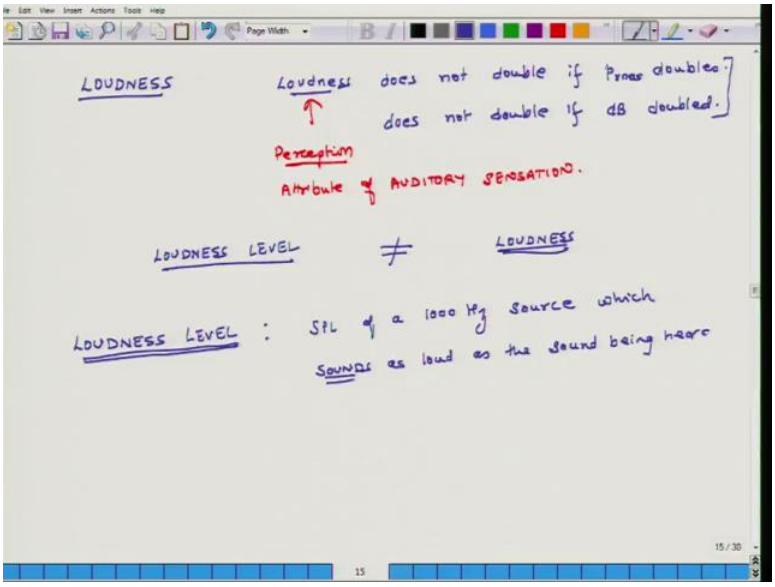

Now, loudness does not double if p rms doubles, this is the first thing to note. That if I double the p rms loudness does not double. What is loudness? It is a perception. So, if you double the pressure and you ask the person has the sound gotten doubled he will say no, it has not doubled. Second thing, loudness does not double if dB gets doubled. So, you are playing initially a sound at 40 decibels and you ask the person that when you double the sound decibel level to 80 you ask him has the sound doubled; you will say no it has not doubled it has gone up by much higher factor.

So loudness; and this is based on perception, so this is a perception thing. So, it is an attribute of auditory sensation. And there are types in context of loudness which will help us quantify whether loudness has doubled or not. So there are two terms; the first term is

loudness level this is one term, and the second term is loudness itself. So, please note loudness level and loudness remain two different things, and we will discuss that.

But it is important, so those are not the same. In engineering world in regular language we may mix them up, but when in an engineering sense when I say loudness level it means something different. So, first we will talk about loudness level. What is loudness level? So, first we will define it. It is the SPL, sound pressure level of a 1000 hertz source which sounds as loud as the sound being heard, I will explain this.

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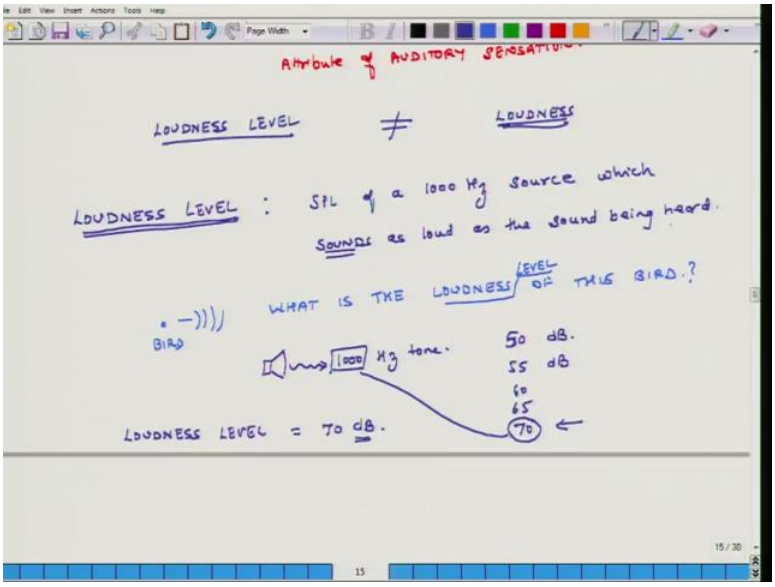

So, consider a bird, so when we make this as a bird and it is producing some sound. And I want to say; what is the loudness level of this bird. So, the question is what is the loudness level of this bird? Now remember this bird is not producing it is sound at 1000 hertz it may be something different 1700 hertz, 2000 hertz, 5000 hertz I do not know, but it is producing; every time it talks or it is tweets let say that it produces the same loudness level.

So the question is; how do we say, how do we measure it is loudness level. Actually what is the loudness level, I missed this term what is the loudness level of this bird; this is the question we have to answer. So what do we do? We say we listen to this bird and then the micro speaker and it produce a 1000 hertz tone. And in step one you produce a 1000 hertz tone at 50 decibels, and then you ask the listener is this tone as loud as the

bird- the answer is no. So, you ask him is that the bird louder or lesser, so he says that bird is louder.

So the next thing is you do 55 decibels, again 1000 hertz tone and you ask him is this tone as loud as the bird- he says no. So, you go up further, so you go to 60, 65 and may be at 70- the person says that yes this tone is as loud as is a bird. So, then the loudness level in this case is equal to 70 dB. The level of sound pressure level, corresponding to 1000 hertz tone, so remember 1000 hertz tone is a secret number it is a reference number in measuring loudness level; the level of sound pressure corresponding to 1000 hertz tone which is perceived to be similar as that of the sound in do you heard which is that of a bird that is called loudness level.

In this case it works out to be 70 decibels. So, let us look at a graph.

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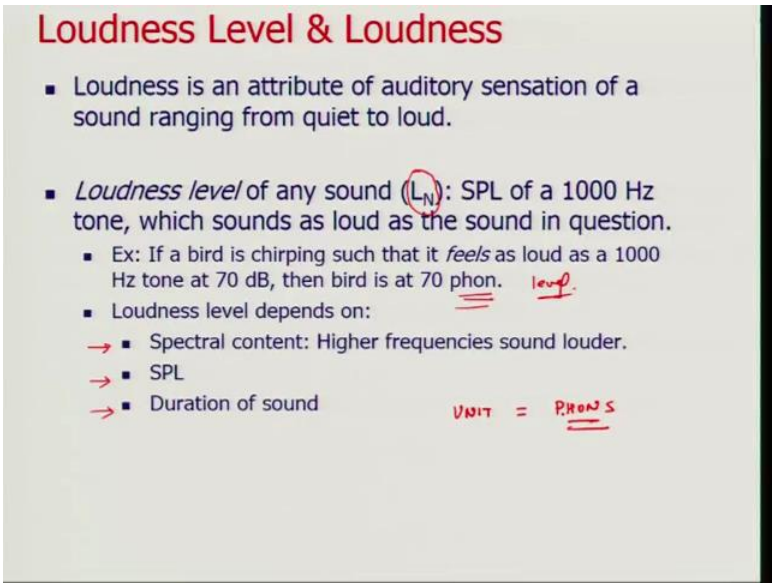

So what is loudness? Loudness is, we are just recap recapping it is an attribute of the auditory sensation; what is auditory, whatever you are listening; auditory sensation of a sound ranging from quiet to loud.

And loudness so it is expresses as L N, it is the SPL sound pressure level of a 1000 hertz tone which sounds as loud as the sound in question, and this is the same example. If a bird is chirping that it feels as loud as a 1000 hertz tone at 70 decibels, then we say that it is loudness level is 70 decibels or actually the unit is phons. So, we say that the bird is at

70 phon level. Suppose there is a drum and we are applying it and we want to measure it is loudness level, then we hear the drum and then we produce which tone 1000 hertz tone and keep on increasing it. And suppose we perceive that at 80 decibels of the 1000 hertz tone it is sounds as loud as the drum when we say that the drums loudness level is 80 phons.

So unit is phons; now this loudness level it depends on three things. It can change with frequency our reference is always 1000 hertz, but at lesser frequencies loudness level goes down significantly. It can change with SPL and it also of influenced by duration of sound; higher frequency sound louder.

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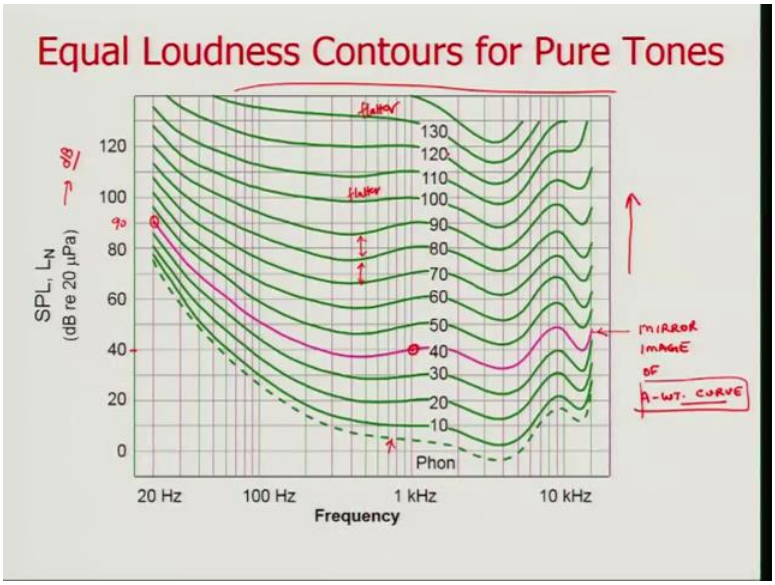

Let us look at this graph. So, on the x axis I have frequency and on the y axis I have L N. So what does that mean? Let us consider this pink graph. And let us start at 1000 hertz. So, that is my point 1000 hertz. So, at 1000 hertz and let say a 1000 hertz this pink thing corresponds to 40 phons. Why, because at 1000 hertz the decibel value is 40. So, 1000 hertz phon equals SPL. So, it 40 decibels and also 40 phons both of them are same at 1000 hertz.

Now, suppose I play some sound at let say 20 hertz which is this point, then I have to play it at 90 decibels so that it is sounds same as a 40 phons. And what is the reference for that 40 phons for decibels at 1000 hertz. In a sense this curve is inverse, not inverse on mirror image of what, A -weighting curve.

A -weighting curve it is not exactly same as A -weighting curve because this is a little more accurate, while we are doing A -weighting mean you have smoothened something so that calculations are important, but this is more. So A -weighting if I just take a just mirror image around this axis then the A -weighting curve will look similar to this. So, this is one thing. So, what we see is that the loudness level changes. I have to add more and more decibels for the sound to sound as loud as it is sounded at 1000 hertz as I reduce my frequency. So, as my frequency goes down I have to produce more decibels to make it sound at the same level at 1000 hertz this is one thing.

The second thing is that as you go up in frequency, no not an up end frequency in the; so this is your decibel level right. So, as up go in the decibel level this change is not that much, so you have to 40, 50, 60; so you have to 40, 50, 60 changes are similar the difference between these two curves and these two curves are same. But what happens? As I go above 100 decibels this curve becomes flatter, as I go to 130 it becomes even more flat. That is why in last class when we were talking above 100 decibels the weighting curve starts shifting, and we go for which weighting, the C weighting, but most of times because we do not use decibels in excess of 100 we do not worry about it.

So, in terms of weighting most of a weighting is used in most of the situations very rarely we go for C weighting. But when we are talking about loudness contours we see that as I reduce the frequency from 1000 hertz to downwards I have to add more decibels if we want that it as to sound as loud as at the reference frequency which is 1000. And also if I increase the overall decibel level and if the decibel level, and if the decibel level is in particular more than 100 then is compensation these loudness contours become somewhat flatter. So, here this is at 0 it is very steep, but that 100 is much more flat. So, this is the second important observation.

And the third thing is, that this loudness level also depends on the duration of exposure a sound. But that is something we will not talk today, but in general loudness level it depends on frequency, you have seen that it also depends on SPL, and the third thing is we have not discussed but it is important to be aware of is it also depends on duration sound. And the unit of loudness level is phon.

So, that concludes our discussion for today. What we will do tomorrow we will discuss another concept. So, what we had said was that we measured loudness in terms of two

attributes; one is loudness level and the unit of loudness level is phon, and the second thing is loudness. So, we will discuss this loudness as a concept in tomorrow's lecture. So, till that have a great day and we will meet tomorrow. Bye.