Fundamentals of Acoustics
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Lecture – 66
Loudness

Hello, welcome to Fundamentals of Acoustics. Today is the last day of this week which is the 11th week of this course and what we planned to do today is extend our discussion on loudness and yesterday specifically we had discussed the idea of loudness level and we stated that the unit of loudness level is phons.

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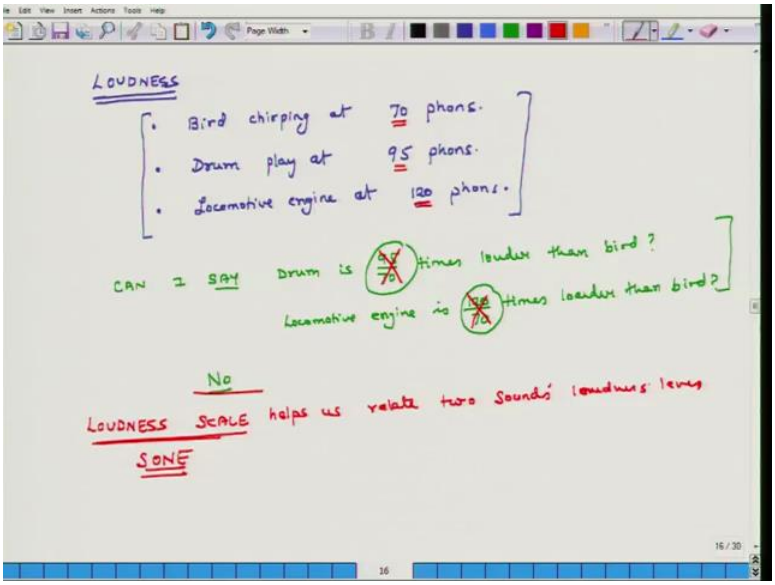

Today we will introduce a new concept which is loudness itself, loudness and first I wanted to illustrate how is this different from loudness level? So, consider 3 scenarios 1 is that there is a bird and it is chirping at 70 phons, how do we know that it is 70 phons? We say that it is 70 phons because if I play a sound 1000 hertz, sound at 70 decibels, people will say that this sound is as loud as this bird, it is 70 phons. In the second case we play a drum and it is playing at it is a 95 phons and in the third case we have a locomotive engine at 120 phons.

Now based on the discussion earlier, we know that how do we get to these numbers? We know how we got to 120 phons, we know how we got to 95 phons and how we got to 70

phons, but can I say that drum is 95 by 70 times louder than bird? That we do not know, we have not explained that if the difference is 25 phons, how louder is the sound a versus sound b, I can also not say or for that sake locomotive engine is 120 by 70 times louder than bird, I cannot say that. But perceptually if you ask that to if this sound louder than this sound not only the person says yes it is louder, but he will also if he is careful enough he will also say yeah, it feels may be it this sound is double twice as loud as this sound those statements people do make.

What is this factor? Is this the right factor or is this a wrong factor? It turns out that the answer to both of these questions is no because these are wrong factors. So, even though we know how to calculate phons, I just cannot take the ratios of these 2 phons and say that sound a is x times louder or softer than sound y. So, loudness scale helps us relate you know to sounds loudness levels this loudness scale the loudness scale is measured on a scale called sone or sone and if I can convert this phons into sones then I relate 2 sound 2 sound sources. So, how do I do that?

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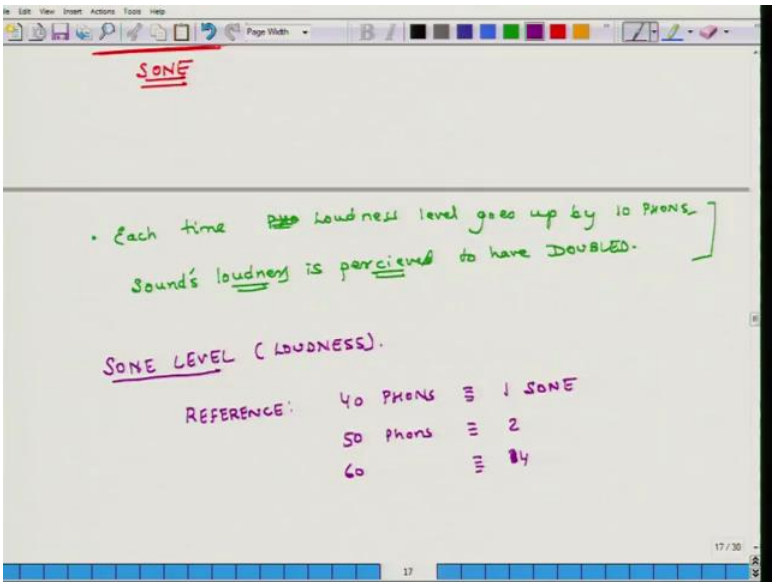

What people have done is they have done a lot of perceptual experiments and people have found that each time loudness level goes up by how much? 10 phons, sound's loudness is perceived to have what to have doubled. It is important too. So, this is how did I say that this is based on a lot of perception experiments. So, you play a sound at 10 phons and then you play a sound at 20 phons and you say what do you think about these

2 sounds. So, a lot of times people say that the sound has doubled, loudness has doubled then you play it at 30 phons and then they say sound loudness has gone up by a factor of 4. This time you got 10 decibels. It goes up by a factor of 4.

With that understanding based on perception, people have crafted sone or sone level and this measures the loudness and here you can compare. So, our reference sound level is what? It is 40 phons, they correspond to 1 sone then 50 phons become; they correspond to 2 sones, 60 corresponds to 4, you are right, 4. So, this time it goes up by a factor of 2.

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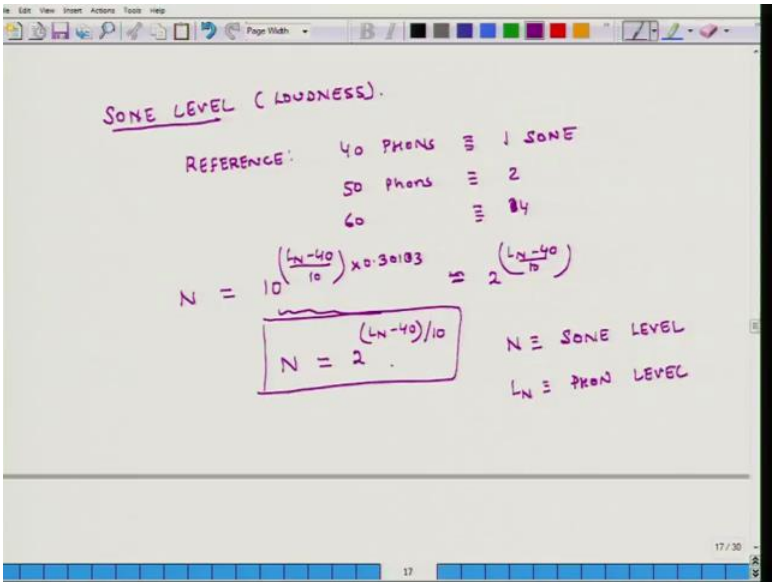

In general I can write it as n equals 10 to the power of L N minus 40, this is a formula into 0.30103 and this is equal to, if I, what is 10 to the power of 0.3? What is log of 2.3 or 0.30103? This is actually log of. So, this approximates to 2 L N minus 40 divided by 10.

In an approximate sense, I can say N equals 2 to the power of L N minus 40 divided by 10, let us explain this relation, where N is what? Sone level and L N is phon level. So, using this formula if I know L N, I can calculate N.

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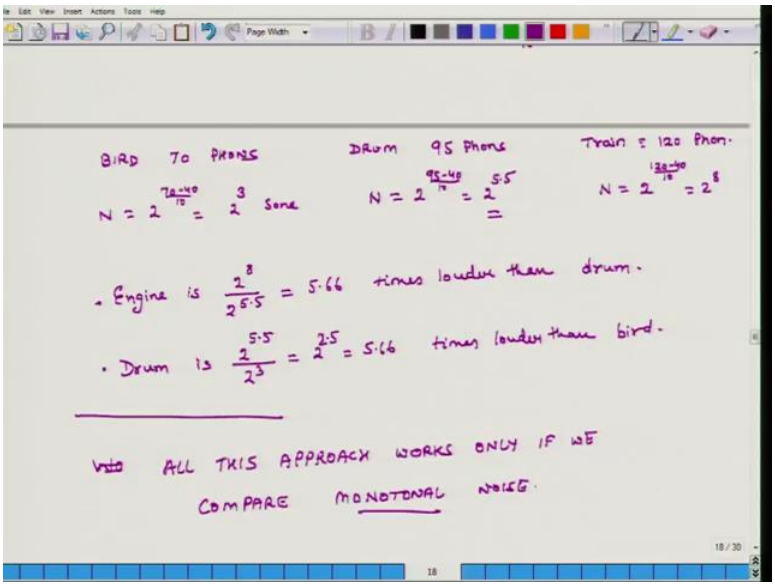

Now with this understanding, let us answer these questions. What was the bird? Was it 70 phons? Then we had drum, it was at 95 phons and then train, it was at 120 phons, we can calculate their sone levels. So, for bird, n is equal to 2 to the power of 70 minus 40 divided by 10. So, that comes to what? 2 to the power of 8 sones, here n equals 2 to the power 95 minus 40 divided by 10. So, that is equal to 2 to the power of 5.5 sones. You can calculate these numbers and in case of train, N is equal to 2 to the power of phon sorry this is 70 minus 40 is 30, 30 divided by 10 is 3 and here it is 120 minus 40 divided by 10, so it is 2 to the power of 8 sones.

So, how loud is each sound with respect to other? So, engine is 2 to the power of 8 divided by 2 to the power of 5.5 and that comes to 5.66 times louder than what? Than the drum and the drum is 2 to the power of 5.5 divided by 2 to the power of 3. So, this becomes how much? 2 to the power of 1.5 and that is a still a 5.66, I have just picked up numbers. So, that these ratios are same.

Drum is 5.66 times louder than the bird. So, in this way we can compare 2 sounds and we can say that sound a is x times louder than sound b using the sone scale, but to compute the sone scale first we have to figure out the phon scale and phon scale we can figure out if we using those equal loudness contours, we can figure out the phon scale because all we had, we had to do is first we have to see what is the decibel level for the sound, from that decibel level and a particular frequency we can compute its phon level

once we know the phon level, we can compute the sone level and we can compare 2 sones, but all this works.

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2.5, so, it may be 2.5 so, but all this is based on a premise that the sounds have only single frequency, only then we can do these comparisons. Now if the sound is having lot of mixed frequencies then all this approach does not work, then we have to go to some more advanced methods which we will not cover in this lecture. So, all this approach works only if we compare monotonal noise, what is that mean that if the noise has only single tones then we can compare sound a versus sound b and do all that. But if sound has all sorts of noises then things become more complex.

So, that concludes our discussion for today and also for this week and I hope you have learnt something useful over this week and will start once again in next week which will be the final week and till then have a great day, bye.