Noise Management & Its Control
Prof. Nachiketa Tiwari
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture – 45
Measuring Sound Power Level – Understanding Standard Octave Bands

Hello, welcome to noise control and its management. Today is the third day of the ongoing week and what we planned to do today is introduce the concept of standard bands and the reason I am going to talk about the standard bands before I start helping start working on how to figure out calculating the value of L p is that a lot times our noise data is reported in terms of these standard bands.

So, overall last 2 weeks what we have been doing is we have developed a relation between L p and L w for inside the room situation and outside the room situation and using that relation I can calculate the value of L p sound pressure level if we know the value of L w which is the sound power level, but to figure out the sound power level we have to understand this concept of standard octave bands because a lot of types the data whenever we calculate L w it is calculated for these a specific bands. So, that is what we will discuss and then starting tomorrow, we will start talking in detail about how to calculate sound power levels for different situations.

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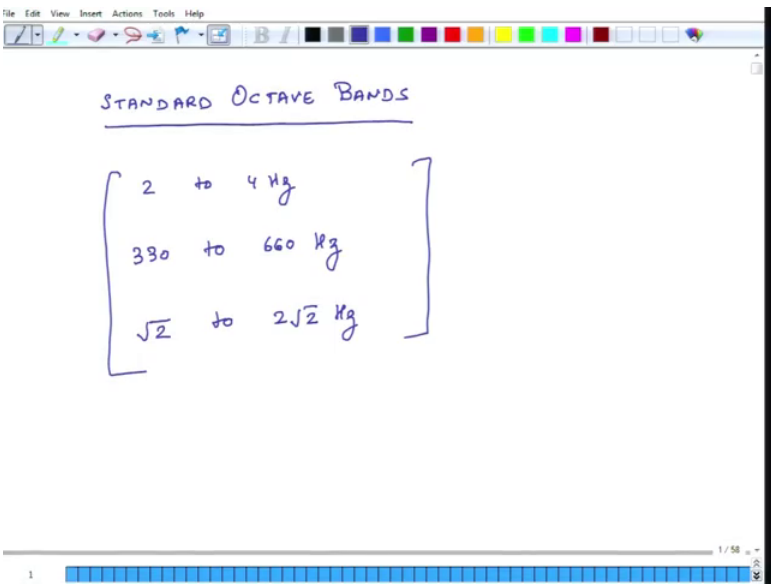

So, the theme for today would be standard octave bands. So, way back in this course we had defined; what is an octave? So, a band of frequencies where the upper limit and the lower limit are off by a factor of 2 that is an octave. So, an example of octave could be 2 hertz to 4 hertz, this is an octave. Another example could be 330 hertz to 660 hertz or you can have square root of 2 hertz to twice of that. So, the point, what I am trying to make is that as long as the ratio of upper frequency limit and the lower frequency limit is 2 it is an octave, but in engineering situations whenever we report our results or present share our data, we do not represent them in any arbitrary octaves rather we use some industry standard octaves. So, what are those octaves?

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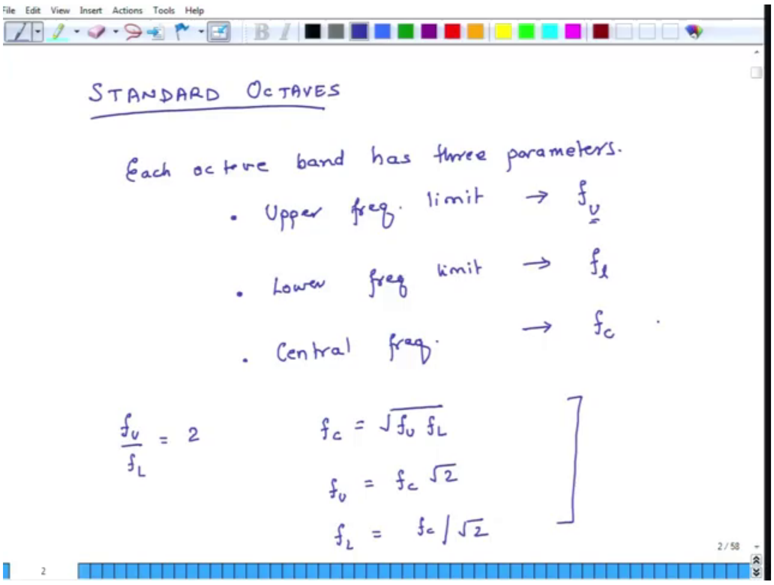

So, we will discuss standard octaves each octave band has 3 parameters the first parameter is upper frequency limit. So, this we designate as f subscript u and u is standing for upper frequency limit then it has a lower frequency limit and that is designated as f L and then it has a central frequency and there is a mathematical relation between all these 3 parameters. So, this central frequency is designated as f c.

So, f u divided by f L is 2 as an octave should be, but then what about the central frequency it is not the arithmetic mean of f u and f L rather it is a geometric mean. So, f c equals square root of f u times f L, this is the other relation and then because of this we can also write that f u equals f c times square root of 2 and f L equals f c divided by square root of 2. So, these are the ratios. So, every octave band has a upper frequency limit a lower frequency limit and a central frequency and the central frequency is off by the upper by a factor of 2 square root of 2 and it is off the lower one by also a factor of square root of 2. So, with this context in mind let us see; what are industry standard octave bands. So, I am going to show you a slide.

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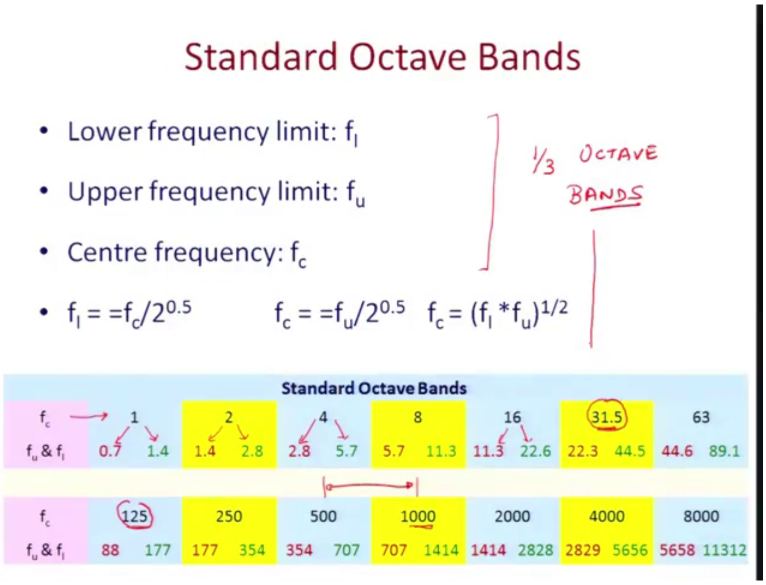

Where some of these bands are listed not all the bands are limited listed some of them. So, this is the central frequency for different octave bands. So, one octave band has a central frequency of 1, then the next band has a central frequency of 2, then 4, 8, 16, 31.5 and so on and so forth.

And this band has an lower frequency limit of square root of 1 divided by square root of 2. So, that is 0.7 and you multiply it by square root of 2, you get 1.4 same thing here. Now interesting thing to note is that when you go from 16 you multiply it by 2 you get 32, but the industry says no, we do not like 32; rather, we will like to use 31.5. So, the central frequency 1, 2, 4, 8, 16, they are all industry standard central frequencies, but the next centrals industry standard central frequency is 31.5 hertz, not 32 hertz; why we will see that later because when you multiply 31.5 by 2 you get 63 and then you multiply it again by 2 you should get 126, but rather we use 125 because we want to end up at 1000.

So, this is one variation; 31.5; if you just multiply it by factor 2 you will not get 31.5 and then the next variation is 125 and then again you go 255, 100, 1000 and then you again go further then you will get 2000, 4000, 8000, 16000, but then the next one will be not

32000, but 31.500 and so on and so forth. So, this cycle keeps on getting repeated. So, these are the industry standard octave bands. So, this is important to underrate. Now a lot of times the gap between octave bands may be too large for instance the gap between 500 and 1000, it is 500, hertz wide band. So, some people want to have finer results, you know, they do not want to just have a point data at 500 hertz and the next data point at 1000 hertz, they also want to have some 2-3 points in between.

So, with that requirement lot of times people use octave bands, but if people need more points on their graphs then they use one third octave bands they use one third octave bands. So, what are these octave bands here also the ratios are constant. So, just me give me a moment. So, we have discussed; what are octave bands; now we are discussing; what are one third octave bands?

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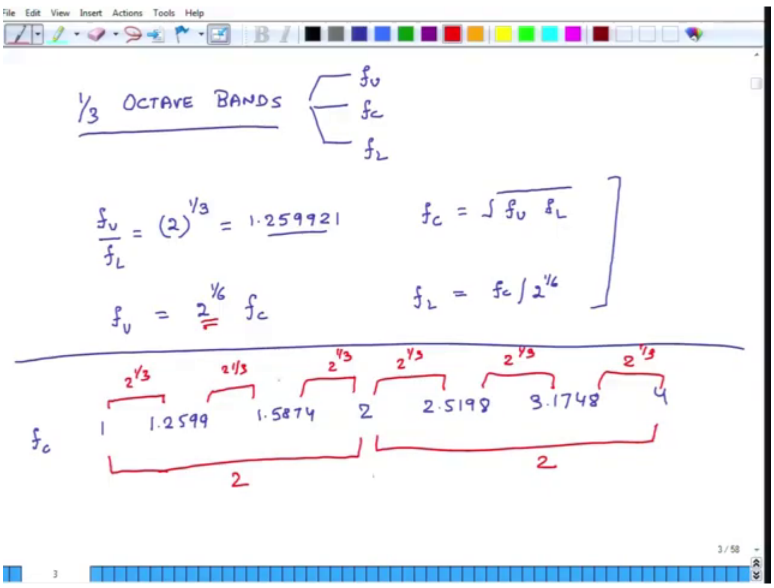

So, one third octave bands and these are also. So, first we will discuss in general and then we will talk about industry standard one third octave bands. So, once again each of these octave bands has an upper frequency limit a lower frequency limit and a central frequency and what is the mathematical relation f u divided by f L equals cube root of 2 its cube root of 2 and if you do the math it comes to 1.259921. So, that is typically the ratio, but it is not exactly that all the time and then your central frequency is still the geometric mean. So, it is f u times f L square root of that.

So, it is not an arithmetic mean of the top and the lower thing and then f u equals 2 to the power of 1 over 6 times central frequency and the lower frequency is f c divided by 2 to the power of 1 by 6. So, if we want to use some industry standard octave bands or one third octave bands this is how we. So, what we will do is we will list the central frequencies f c. So, let us say we start from 1 hertz, then the next central frequency will be one times this factor 1.2559, then I multiply again.

So, so this is the first one, then this is the second one, then I have 1.5874 and then if I multiply 1.5874 by this factor; I get 2, then I get 2.5198. So, I am just multiplying every time by 1.259921, then I get 3.1748 and then I get 4 and so on and so forth. So, what is this? So, this is off by a factor of 2 to the power of 1 by 3; again 2 to the power of 1 by 3. Now these are all central frequencies for each octave band if I have to compute its lower and upper frequency limit I have to multiply and divide by it 2 to the power of 1 by 6. So, these, but then if you look at; so, so these all these successive ones are off by a factor of 2 to the power 1 by 3 and then if you look at every third central frequency it is off by a factor of 2.

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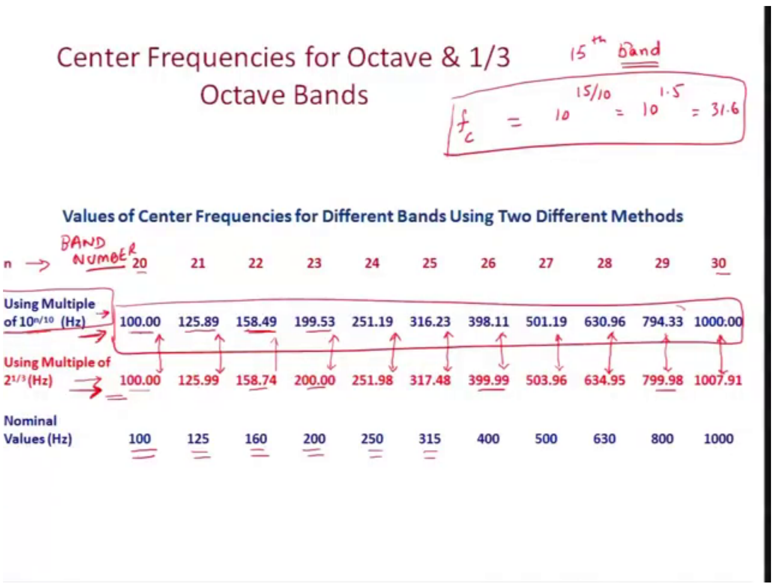

So, this is how it works out; now let us look at an interesting slide, we will look at this slide patiently. So, what does this say it is say values of central frequencies for different bands using 2 different methods and what are those 2 methods we will talk about it in a while and then there is this number called n we are not going to discuss this number n right now, but first let us look at this red row. So, what do we have let us say we start with 100 hertz; we multiply it by 2 to the power of 1 by 3, we get 126 or 125.99, then we get this then we get 200 and then we get 400 and then we get 800 and so on and so forth. So, this is one method of computing the central frequencies this is one method of computing the central frequencies.

Now let us do some mathematics in slightly different way. So, what we are doing is we are starting with hundred and we multiply 100 by this factor 10 to the power of n by 10 and this n in this case is 20. So, if you do this math you get 125.89, then you again multiply this 100; 100 by 100 to the power of 22 by 100 you get this number 158.49 and then you get 199.53 and so on and so forth.

Now, when you look at compare these 2 numbers of course, this is exactly the same this is slightly off this is again. So, these numbers are very close to each other it is just happens like that it is not that there were some; it just happens that these numbers are pretty close to each other. So, in and the good thing or the interesting thing about this is that each time you increase n by 100 you end up with a factor of 10. So, if you go from 20 to 30; I have increased n by 100 and I end up at 1000 hertz. So, I am starting from 100 hertz and I end up at 1000 hertz.

Again I go increase it by 100; I end up at 100-1000 hertz. So, instead of using this people use this in the industry to compute central frequencies because this is a repeatable, it is just cyclical thing and the intermediate frequencies are pretty close they are pretty close to this 2 to the power of 1 by 3 factor method. So, this is what people tend to use and this n is known as band number. So, so this is industry standard band number. So, someone asks you; what is the central frequency of 15 octave band. So, if the question is what is the central frequency of 15th band, then how will you compute it you just do this 100 to the power of 15 by 100 is equal to 100 to the power of 1.5 and you do the math I think it will come out to be 31.6 hertz.

So, the moment someone says the band number you can calculate using this relation the central frequency and then you multiply and divided by 2 to the power of one by 6 you get its upper and lower frequency limits and so, this is how central frequencies according to international standards are computed they are computed using this band number method and if people are not interested in wandering about the second place of decimal then they just round it. So, the nominal values of 100, 125, 160, 200, 250, 350 and so on and so forth, but this method it gives us the; it is it uses band number to compute the central frequencies of different octave bands.

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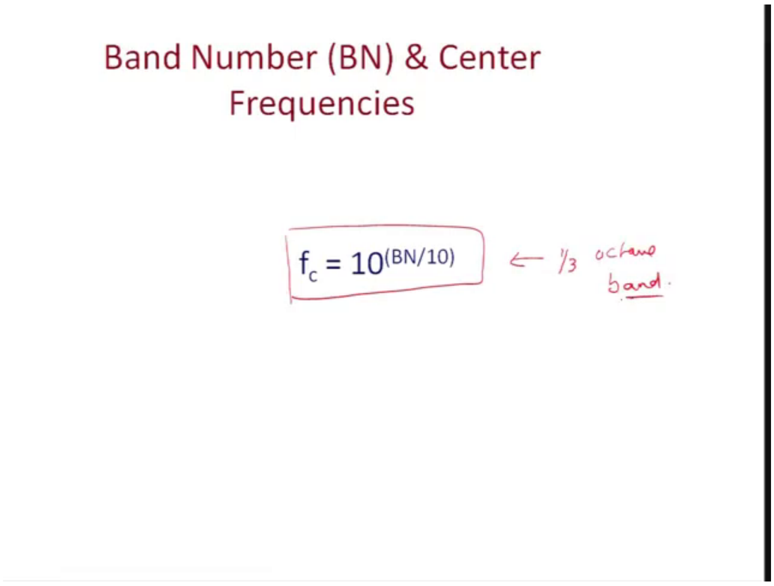

And then let us look at finally, this. So, this is what I wanted to say the central frequency is nothing, but 100 to the power of band number divided by 100, this is how central frequency for any one third octave band can be computed; this is for one third octave band, but each time you skip 3 bands you end up with an octave, right.

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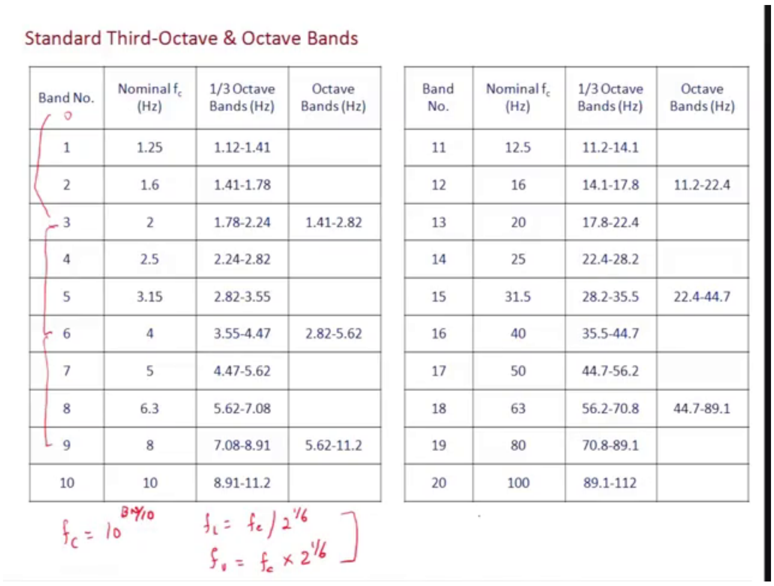

Standard Third-Octave & Octave Bands

Band No.	Nominal f_c (Hz)	1/3 Octave Bands (Hz)	Octave Bands (Hz)
1	1.25	1.12-1.41	
2	1.6	1.41-1.78	
3	2	1.78-2.24	1.41-2.82
4	2.5	2.24-2.82	
5	3.15	2.82-3.55	
6	4	3.55-4.47	2.82-5.62
7	5	4.47-5.62	
8	6.3	5.62-7.08	
9	8	7.08-8.91	5.62-11.2
10	10	8.91-11.2	
11	12.5	11.2-14.1	
12	16	14.1-17.8	11.2-22.4
13	20	17.8-22.4	
14	25	22.4-28.2	
15	31.5	28.2-35.5	22.4-44.7
16	40	35.5-44.7	
17	50	44.7-56.2	
18	63	56.2-70.8	44.7-89.1
19	80	70.8-89.1	
20	100	89.1-112	

So, what we will do is we will close this discussion on octave bands by looking at this chart and here I have computed using band numbers different central frequencies. So, I have started from one and I have gone till 20. So, band number one it corresponds to central frequency of 1.2; 125 hertz and it has a higher frequency limit and a lower frequency limit lower is 1.12; how did I get that it is 1.25 divided by 2 to the power of 1 by 6. So, here f L is f c divided by 2 to the power of 1 by 6 and f u equals f c times 2 to the power of 1 by 6.

So, for these different band numbers which I have calculated and f c is what 100 to the power of band number divided by 10. So, I have first I have calculated different band central frequencies from that I have used these relations to compute upper and lower frequency limits and then I see that each time my band number increases it goes from 1 to 3 you know it increases by 3; it I get a factor of 2. So, 3, 6, 9; of course, it should not be here oops; this should come from 0, if band number is 0, then it starts with 1. So, this is how this goes and band number of 20, I end up with 100 hertz.

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Standard Third-Octave & Octave Bands

Band No.	Nominal f_c (Hz)	1/3 Octave Bands (Hz)	Octave Bands (Hz)
21	125	112-141	89.1-178
22	160	141-178	
23	200	178-224	
24	250	224-282	178-355
25	315	282-355	
26	400	355-447	
27	500	447-562	355-708
28	630	562-708	
29	800	708-891	
30	1000	891-1120	708-1.41k

Band No.	Nominal f_c (Hz)	1/3 Octave Bands (Hz)	Octave Bands (Hz)
31	1250	1120-1410	
32	1600	1410-1780	
33	2000	1780-2240	1.41k-2.82k
34	2500	2240-2820	
35	3150	2820-3550	
36	4000	3550-4470	2.82k-5.62k
37	5000	4470-5620	
38	6300	5620-7080	
39	8000	7080-8910	5.62k-11.2k
40	10k	8910-11200	
41	12.5k	11.2k-14.1k	
42	16k	14.1-17.8k	11.2k-22.4k
43	20k	17.8-22.4k	

Band number of 100 I end up with 100 hertz at 20, I end with 100 hertz band number of 30, I end with 1000 hertz 40, 100, 1000 hertz and so on and so forth. So, these are industry standard one third octave bands and industry standard octave bands.

So, this closes our discussion on octave bands and also the discussion for today starting tomorrow, we will start exploring different systems which have which generate sound and for those different systems we will start figuring out how to compute sound pressure levels or sound power kevels for different systems. So, with that we close the discussion for today and I hope you have a wonderful day.

Thank you.