Noise Management & Its Control
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Lecture - 06
Key Terms in Acoustics

Hello, welcome to noise management and its control.

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Today is the last day of this week which is the first week of this course and we will continue our discussions on some of the important terms and terminologies associated with acoustic we have discussed what is the meaning of decibel; decibel scale sound pressure level sound intensity level sound power level and so and so forth.

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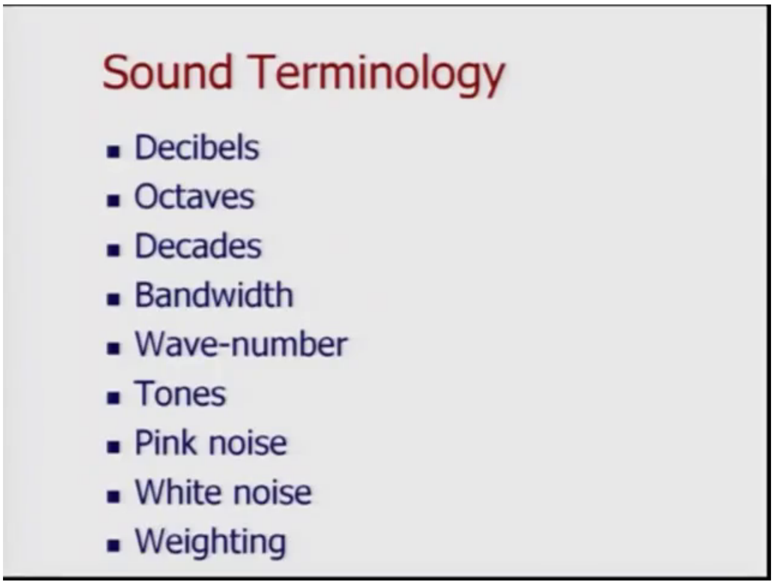

So, today; we will look at some other important terms which are used very often in context of acoustics and noise. So, we have already discussed what is a disable what we will learn today is a little bit about octaves decades bandwidth wave number tone pink noise and so on and so forth. So, let us look at tones and octaves.

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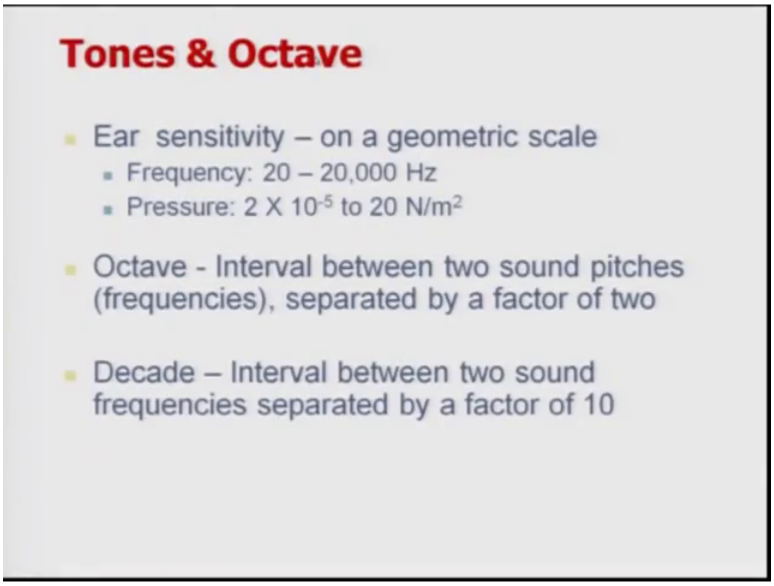

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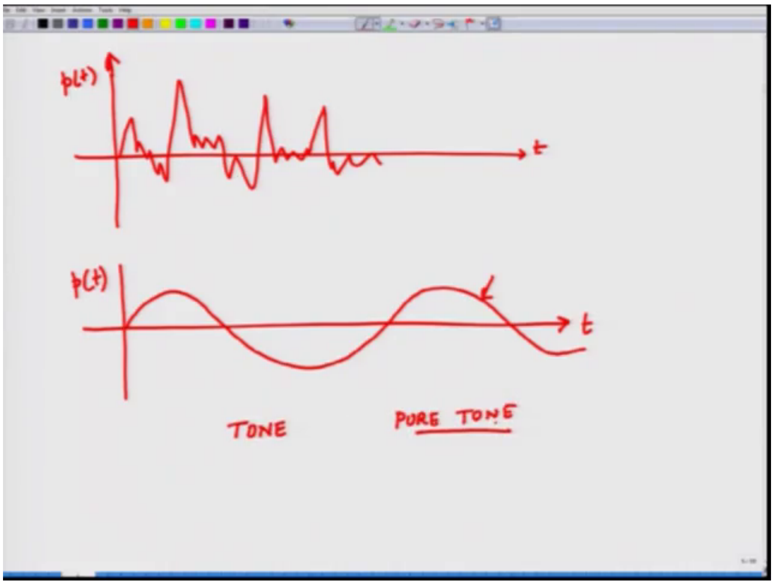

So, what do we mean by a tone. So, a sound signal it could be complicated in shape. So, on the x axis, I am plotting time and on the y axis, I am plotting pressure as a function of time or it could be a simple sine wave for instance, if I have a straight wire in a guitar or a sitar and I pluck it, it will generate a nice single sine wave, it will vibrate at one particular frequency. So, in that case the sound pressure level will change like this. So, this is simple, it could be a sine wave or a cosine wave. So, if the sine signal sound signal is a simple sine and cosine wave we call that type of a signal as a tone sometimes it is also called as pure tone, but means the same tone.

So, a pure tone or a tone is a sound signal which can be represented by a single sine or a cosine wave. So, I can generate a 300 hertz tone, 400 hertz tone, 20000 hertz tone and so on and so forth.

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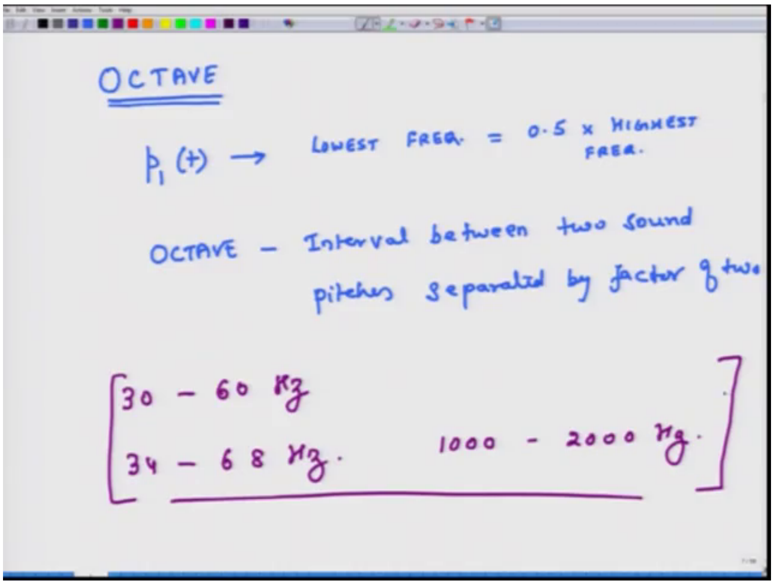

Next we will look at a term called octave and this is a very important term because it gets used very frequently in acoustics music noise vibrations and so on and so forth octave. So, let us say I have a sound signal we will call that p one is a function of time and it is a sound signal which is made up of all sorts of frequencies. So, I can generate frequency f 1, f 2, f 3, f 4 and it has all sorts of frequencies and I am just adding up all those frequencies together, but the condition is that the lowest frequency is equal to 0.5 times highest frequency.

So, I can make up a signal for instance I can create a signal or some instrument is being which is playing where the lowest frequency which it is producing is let us say 100 hertz and the highest frequency which it is producing is 200 hertz, then we will say that this instrument is producing sound in an octave. So, octave is interval between 2 sound pictures which is same as frequency separated by a factor of 2. So, example of octave I can set 30 to 60 hertz is an octave.

As long as the higher frequency and the lowest frequency they are off by a factor of 2 it is an octave another example could be 34 to 68 hertz; this is also an octave there are standard octaves and non standard octaves; this may not be a standard octave, but it is an octave because the ratio of higher frequency and the lowest frequency is 2 another octave would be 1000 to 2000 hertz; 1000 to 2000 hertz that is an octave. So, all these are octaves because the ratio of upper frequency and the lower frequencies of by a factor of

2. So, octaves are very frequently used in engineering terminology when we are discussing about sound; now; why do we use this term octave we will talk about it a little later, but as long as the ratio of higher frequency and lower frequency is 2; it is called an octave.

This term octave has been used since very old times since thousands of years it is not a new thing,, but in si system people said oh why do we have to use this o a factor of 2 because in si system system international things changed when they are off by a factor of 10 right for instance in a metre decimetre centimetre; centimetre times 10 is a decimetre decimetres time 10 is a meter metres times 10 is a decametre and so on and so forth, right.

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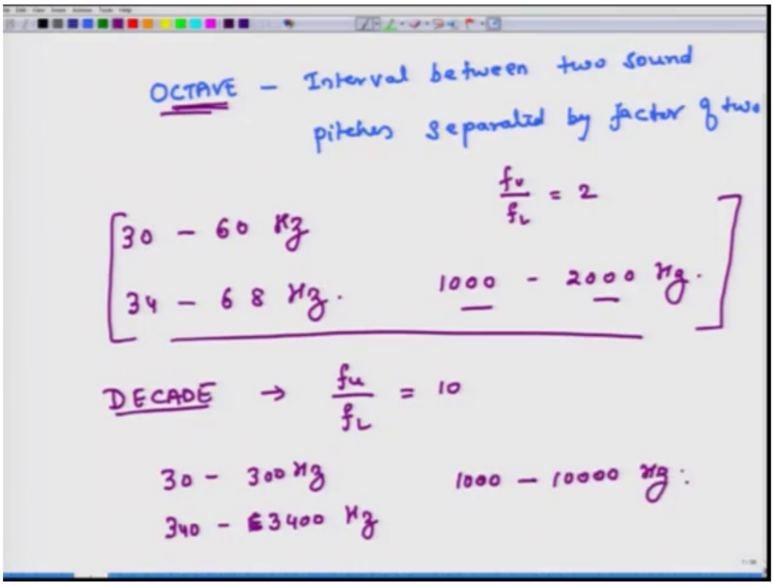

So, then in si system people came up with a the term called decade. So, this is also equally used decade in decade the ratio of upper frequency and the ratio of lower frequency is 10 in octave the ratio of upper frequency and ratio of lower frequency is 2 you would think in octave it should be 8, but it is strangely it is 2, but in decade it is 10 and so example of a decade would be 30 to 600 hertz or 340 to 3400 hertz; 30 to 300 hertz here or 1000 to 10000 hertz. So, these are all decades.

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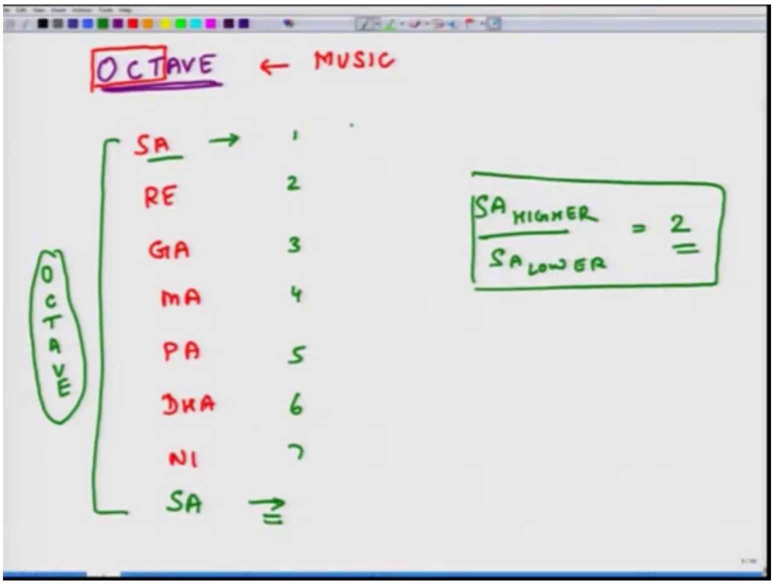

So, now, we will discuss a little bit further about octave and what we are we will try to understand is why is this term OCT because typically OCT means 8 octagon octahedron it means 8, but we will try to understand why is this used octave even though the ratio of frequencies is 2. So, this originally this term comes from music it does not come from engineering it comes from music and we will look at our Indian music system and we will also look at western music system and then we well figure out what is the how is it coming from music. So, in Indian music system we have 7 [FL] right.

So, what is the basic thing [FL]; these are the 7 [FL] and so, as you go from [FL] your frequency keeps on going up and then when you sing you say [FL] and then the next [FL], I will put it in a different colour. So, this is [FL] number one and this is [FL] number 2 this is the lower [FL] this is the highest [FL] the ratio when you say [FL] each person produces his own sound it may be some frequency maybe it is 500 hertz, but then by the time he reaches the next [FL] higher divided by [FL] lower the ratio of frequency is 2 typically if a person is doing a good job in singing then the ratio of frequency of higher [FL] and lower [FL] is 2 and why is it called.

So, this entire collection of frequencies is called an octave and why is it called an octave because every eighth frequency. So, this is one 2 3 4 five six seven and the eighth frequency is twice of the first frequency. So, that is why it is called an octave.

So, this terminology this is it comes it is the same thing this terminology it is in Indian music in Indian music every 8th note is twice of the first note. So, that is why it is coming as octave and the same thing is true in western music system also same thing is true in western music system also. So, this is the fundamental reason why we use this term octave because every node eighth node is twice of the first node and since.

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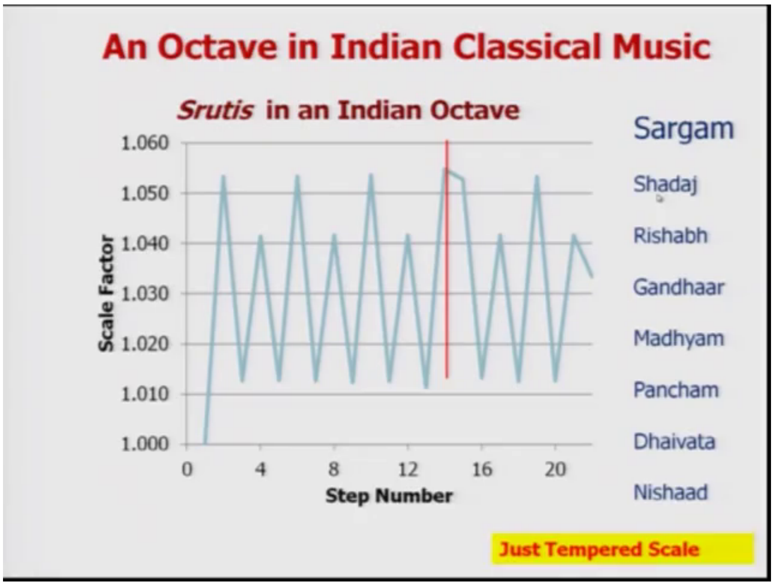

We are talking about music. So, I will not talk about this graph, but just this these terms [FL]because I am it will be interesting to know that they are not they are actually shorts names for actual words. So, [FL] actually the actual name of [FL] is [FL] the [FL] the actual name for that [FL] is Rishabh [FL] the actual name for that is Gandhar, [FL] the actual name for that [FL] is Madhyam, [FL] is Pancham [FL] is Dhaivat and [FL] is Nishad.

So, Shadaj, Rishabh, Gandhar, Madhyam, Pancham, Dhaivat and Nishad; these 7 [FL] or 7 tones in modern thing because they are pure tones they are known collectively as [FL], they are known collectively as [FL] and the term octave comes from music because every eighth note is twice of the first note in terms of frequency. So, that is about octaves the second thing I would like to say is that just as we figured out that if I try to plot pressure on the y axis on a linear scale, everything will not fit because the range of pressures is very large 10 orders of magnitude similarly our ears can sense frequency as low as 20 hertz and as high a 20000 hertz that is the hearing range.

If I want to plot all these frequencies on a single axis let us say each 20 hertz is one cm then; that means, that I need 1000 centimetres to represent 20 hertz to 20000 hertz. So, again it is a very large range. So, that is why whenever we plot frequencies on the x axis that also we plot on a log scale. So, on the x axis a lot of times we plot frequency and that is on a log scale and on the y axis we plot pressure that is also on a log scale. So, lot of graphs which we generate for acoustics they are on a log scale, this is important to understand.

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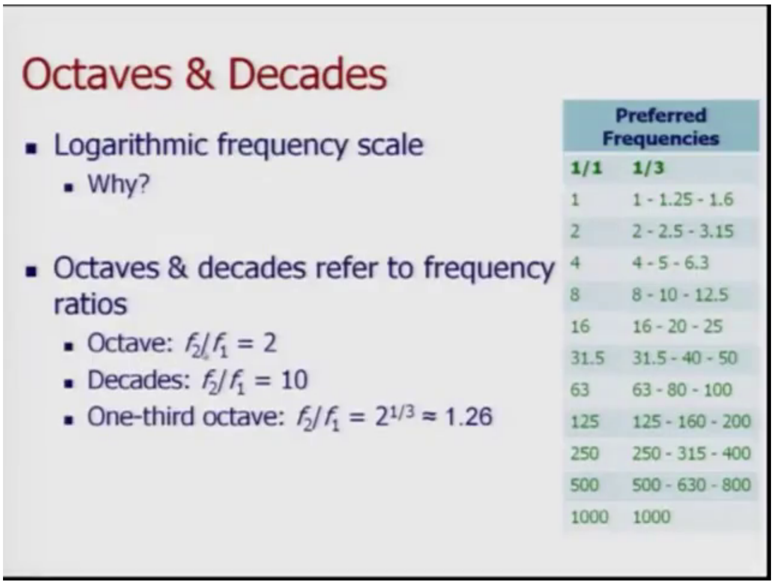

Once again octave in an octave f 2 over f 1 is 2 in a decade f 2 over f 1 is 10. Now I can make any octave you know thirty hertz to sixty hertz 31.5 hertz to 63 hertz and so on and so forth, but my octave will be different than your octave will be different than his octave,, but as engineers we like to standardise things.

So, there are some preferred octaves. So, what are those preferred octaves these are the preferred frequencies one hertz to 2 hertz to 4 hertz to 8 hertz; these are standard octaves which a lot of times we use in engineering. So, 1 to 2, 2 to 4, 4 to 8, 8 to 16, 16 to 31.5, 31.5 to 63 and then from 63 I do not go to 126; I make a small shift and I go from 63 to 125 because I want to end up at 1000. So, I 125; 125 to 250; 260. So, these are standard octaves. So, in engineering whenever we plot our results we use these standard octaves to plot our result. So, we have talked about noise I mean tones we have talked about octave.

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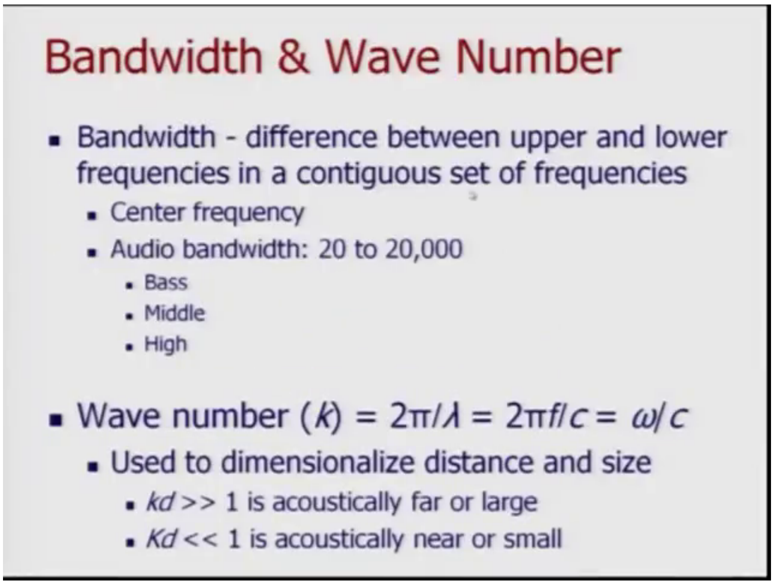

Another term is bandwidth. So, what is bandwidth? So, if there is a bunch of frequencies the difference between highest and lowest is called bandwidth.

So, each band has a higher frequency limit a lower frequency limit and a central frequency and the central frequency is f high f upper times f lower the square root of 2 then another term we use is wave number lot of times it is designated as k and that is nothing, but 2 pi over lambda where lambda is the wavelength and then the last 2 terms which we will talk about noise. So, we have already discussed tone; what is tone? it is a purely sinusoidal wave.

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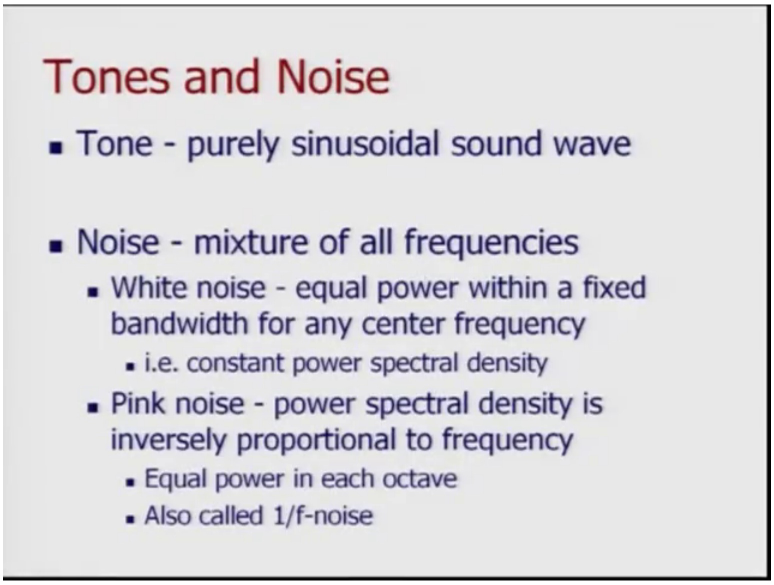

But a lot of times we hear that oh this is noise and nose has a precise engineering definition it is not like a regular term. So, what is noise? Noise is a sound signal which has all sorts of frequencies present in it now in which proportion they are present, it can vary.

So, there are different types of noise there as there is one. So, 2 commonly used noise signals are white noise and pink noise 2 types of noise there are other types of noise also,, but in our course we will talk about pink noise and white noise in both of these noise white noise and pink noise all frequencies are present,, but the proportion in which different frequencies are mixed is different. So, what is so special about white noise in white noise you have equal power within a fixed bandwidth equal power within a fixed bandwidth and pink noise you have equal power in each octave what does that mean. So, I will explain that. So, let us say we are going from 20 hertz to 20000 hertz.

So, whether it is white noise or a pink noise all frequencies between 20 and 20000 hertz will be present in white noise as well as pink noise,, but in white noise the energy between 20 hertz to let us say hundred and 20 hertz will be same as energy between 120 hertz to 220 hertz equal bandwidths 20 to 120 to 200 to 320. So, in every steps of 100 hertz the energy is same equal in pink noise it is different it is 20 to 20; whatever is the energy is same as 40 to 80 and that is same as 80 to 160 and that is same as 160 to 320. So, did you understand this? So, that is the main difference in white noise the bandwidth is equal and in each bandwidth it is same amount of energy in pink noise you have same energy in octave you have same energy in octave and that can be also mathematically computed and all that detail is here.

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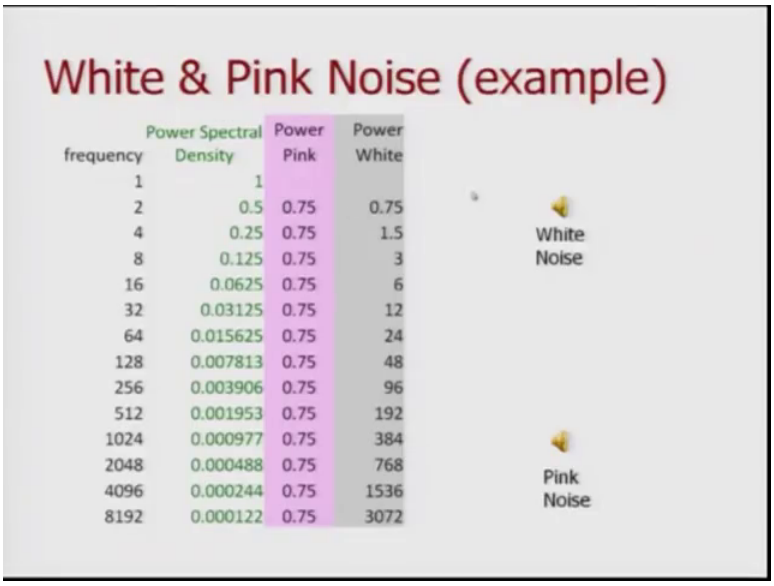

frequency	Power Spectral Density	Power Pink	Power White
1	1		
2	0.5	0.75	0.75
4	0.25	0.75	1.5
8	0.125	0.75	3
16	0.0625	0.75	6
32	0.03125	0.75	12
64	0.015625	0.75	24
128	0.007813	0.75	48
256	0.003906	0.75	96
512	0.001953	0.75	192
1024	0.000977	0.75	384
2048	0.000488	0.75	768
4096	0.000244	0.75	1536
8192	0.000122	0.75	3072

And what I will do to close today’s lecture is actually place sample of white noise and pink noise. So, that you get a feel of how does white noise sound like and how does pink sound like. So, this is white noise I will play it once again and this is pink noise.

So, lot of times people fail file find that pink noise is not as irritating as white noise this is sharper this has lower frequency it has lower frequency more the proportion of lower frequencies is more this is sharper it is more scratchy. So, with this, I would like to conclude our discussions for this week and we will meet once again next week till then have a great time, bye.