Human Factors Engineering

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Lecture - 44
Octave bands and examples

Welcome friends to this lecture on Human Factors Engineering. We have been delivering these lectures for quite several weeks. My friend Professor P K Ray, he must have talked about the measurement and evaluation of physical environment. In fact, he must have talked about the environment itself. What I will be discussing today is the measurement and evaluation of physical environment.

Well, before we go into details, I would like to take back to our initial lectures in which we discussed what human factors engineering is and how it is so important in the present context? Whether you talk of a service sector, you talk of a production manufacturing system or you talk of any crowded environment where people are there including the hospitals where we are supposed to maintain lot of silence.

Now, this is one part of the game when we are talking of the human factors engineering, we are talking of the human being, we are talking of the machines or the equipment or other gadgets around, we are talking of overall environment. The environment varies from location to location, system to system, task to task and from industry to industry, services to services.

Now, question is how do we take care of this environment? We also talked about elimination level, which are the constituent of the environment, we talked about people in the environment, how they become part of the environment while other people are working on the equipment. There are other adjacent people who are working on other equipment they do become environment for the person in question or a system in question.

Therefore, these immediate environments, outside environments and connected environments need to be explained properly and understood properly. While we talk of the human, machine and environment we just give a clarity that while the immediate equipment or equipment, gadgets etc. which are in the vicinity of the operator they are taken as the immediate environment.

The environment where noise being created from the same system in which the person is working or any other location where the person is working, he is getting the sound or the noise. Then it may also happen that some of the equipment which has been given or creating some sort of noise. It is also complete illumination level which is available there.

We can think of the thermal environment which is there in which the task is being carried, it could be very low temperature, it could be high temperature, it could be a well-maintained temperature for the body of the person to perform the task. We have seen the glacier locations where people are still working and doing their job the security persons particularly, therefore, the environment has been of varying kind when you are talking of human factors engineering and when you want to check best is obtained out of the human machine system, we have to take care of all the three components. For example, the human- you have to take care of the human physical capabilities and limitations, its mental capabilities, its tenacity, its level of understanding of a particular system, its level his or her level of preparedness about a particular system and situation.

And then we are talking of the equipment or other portions or other attributes which are there in the environment. And then we talked of the physical environments like thermal, we are talking of a velocity a of air, we are talking of noise or sound and any other thing which is creating sound, etc.

Now, I will be dealing with some of the important parameters for example, we will talk of how to measure and evaluate noise, sound level, we will also talk of the elimination level. We will go into details Octave Bands and Examples.

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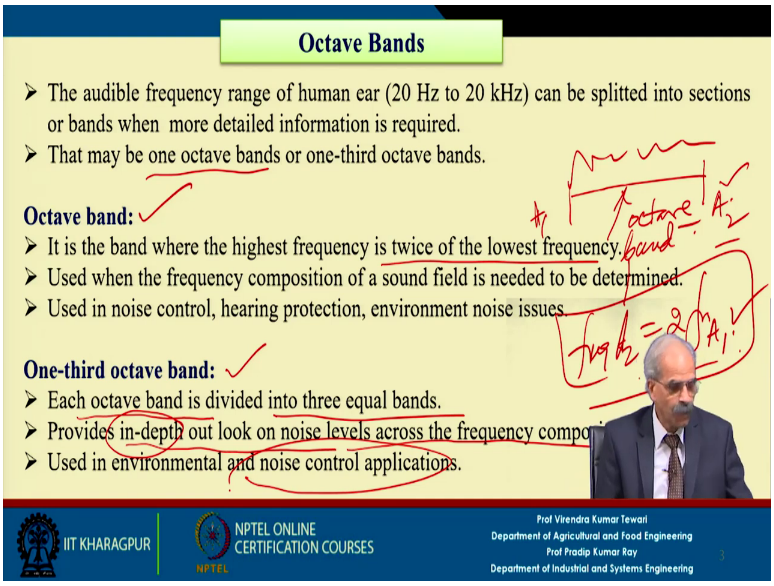

Now, sometimes when we get random sounds where the frequency is varying from a lower to a very high the audible frequency range of a human ear is about 20 hertz to 20 kilo hertz which can be split into sections of band more detailed information is available.

That may be one octave bands or one-third octave bands.

Octave band: It is the band where the highest frequency is twice of the lowest frequency. It is Used when the frequency composition of a sound field is needed to be determined. Used in noise control, hearing protection, environment noise issues.

One-third octave band: Each octave band is divided into three equal bands. Provides in-depth outlook on noise levels across the frequency composition. Used in environmental and noise control applications.

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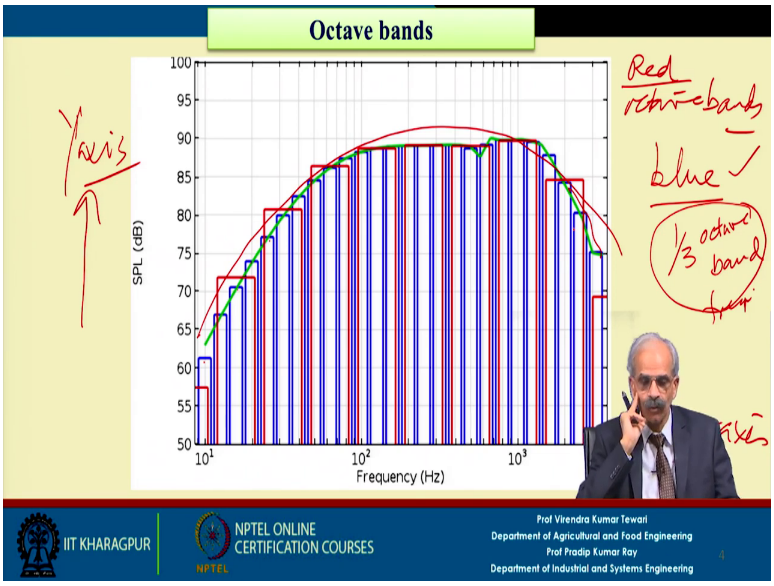

Now we are showing you particular consideration of how frequency in hertz presented in this level and the sound pressure level in dB is presented in the y axis here, and frequency is given in x axis. So, you can see here that the frequency varies from 10^1 to 10^2, 10^3. And similarly sound pressure level which is given in decibels in y-axis.

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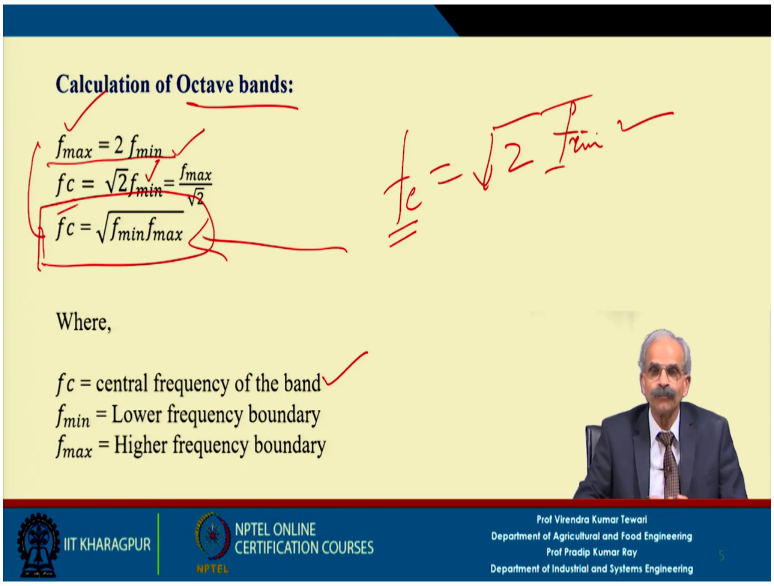

And then we talk here calculation of octave bands then

Calculation of Octave bands:

$$f_{max} = 2 f_{min}$$

$$fc = \sqrt{2} f_{min} = \frac{f_{max}}{\sqrt{2}}$$

$$fc = \sqrt{f_{min} f_{max}}$$

Where,

fc = central frequency of the band

f_{min} = Lower frequency boundary

f_{max} = Higher frequency boundary

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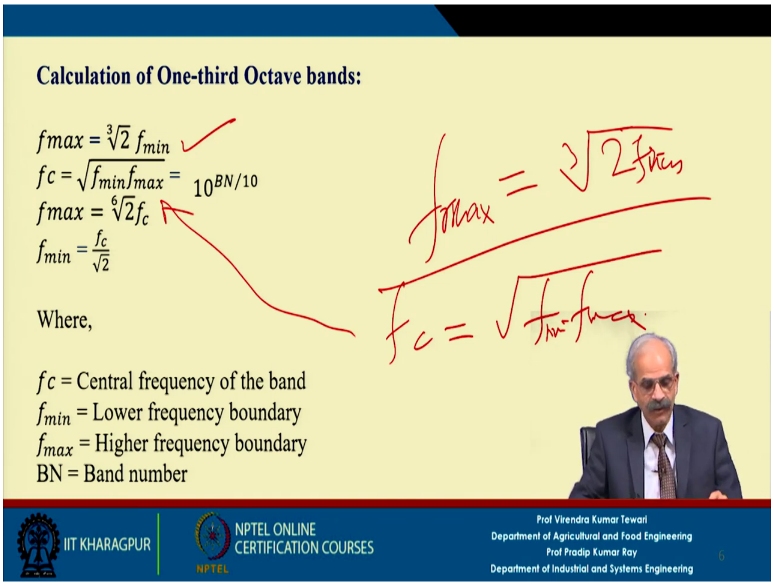

So, when we go to the next slide, we see that how do we calculate one third octave band.

Calculation of One-third Octave bands:

$$fmax = \sqrt[3]{2}\, f_{min}$$

$$fc = \sqrt{f_{min} f_{max}} =$$

$$fmax = \sqrt[6]{2} f_c$$

$$f_{min} = \frac{f_c}{\sqrt{2}}$$

Where,

fc = *Central frequency of the band*

f_{min} = *Lower frequency boundary*

f_{max} = *Higher frequency boundary*

BN = Band number

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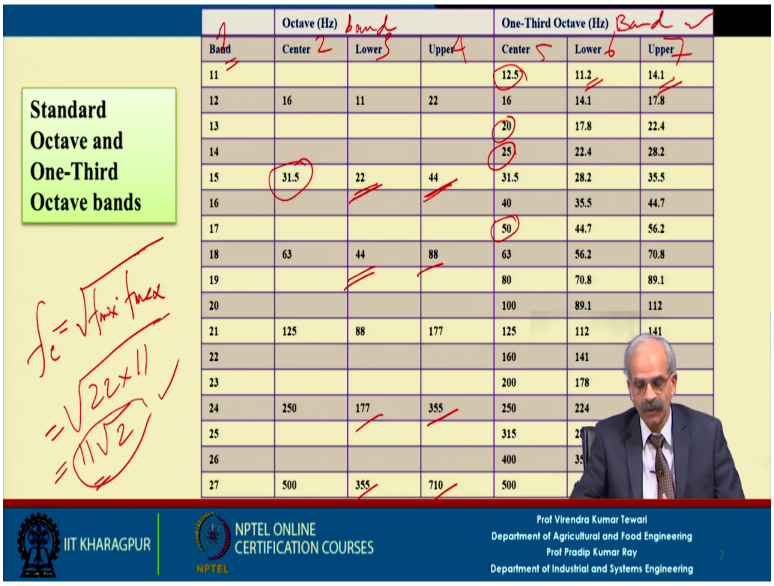

Here, a table has been created exactly the way we did those examples of central frequency for an octave band and central frequency of one third octave band. How do we get those things? If you see here in the on this table, we have 1, 2, 3, 4, 5, 6 and 7 columns. In these seven columns what are given- band number, the centre frequency, the lower frequency and upper frequency of the octave frequency.

Then one third octave band. When we are talking of the octave band, these are the band. These are the band numbers. When you talk of a particular band number, what is the octave band frequency? Lower frequency, upper frequency, and the centre frequency. Similarly, when you talk one third octave bond what is the lower frequency, what is the upper frequency which is indicated in column 6 and 7.

$$f_c = \sqrt{f_{min} f_{max}} = \sqrt{22 \times 11} = 11\sqrt{2}$$

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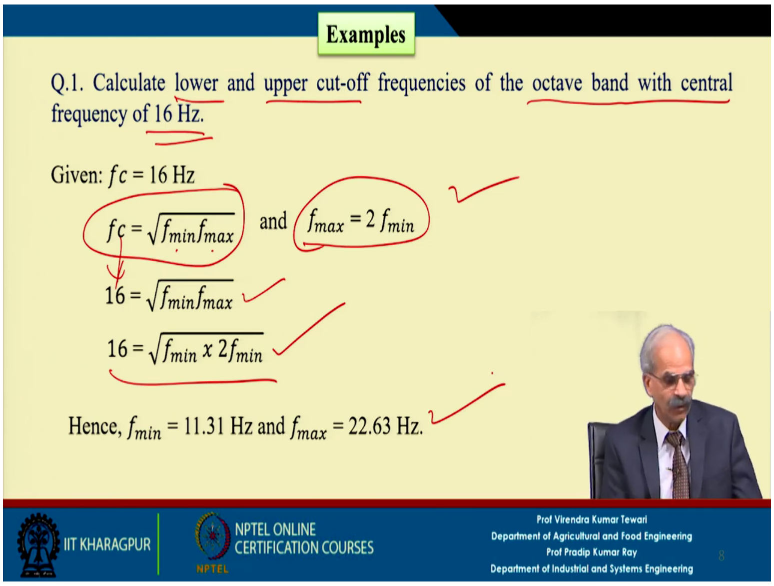

Q.1. Calculate lower and upper cut-off frequencies of the octave band with central frequency of 16 Hz.

Given: f_c = 16 Hz

$f_c =$ $\sqrt{f \quad f}$ and f_{max} = 2 f_{min}

$16 =$ $\sqrt{f \quad f}$

$16 =$ $\sqrt{f \quad x\, 2 f}$

Hence, f = 11.31 Hz and f = 22.63 Hz

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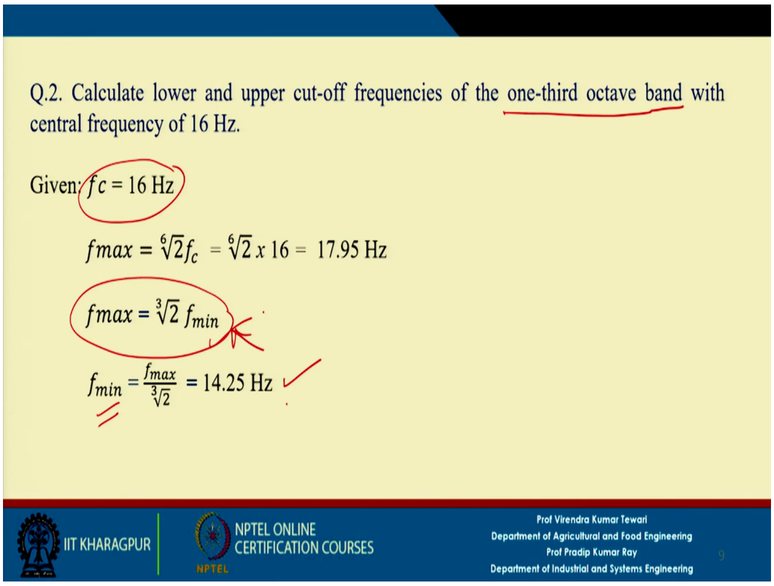

Q.2. Calculate lower and upper cut-off frequencies of the one-third octave band with central frequency of 16 Hz.

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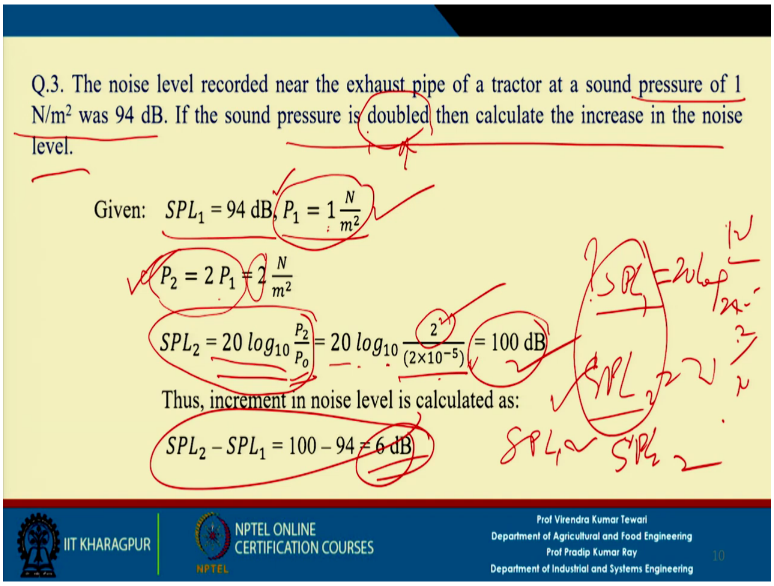

Q.3. The noise level recorded near the exhaust pipe of a tractor at a sound pressure of 1 N/m^2 was 94 dB. If the sound pressure is doubled then calculate the increase in the noise level.

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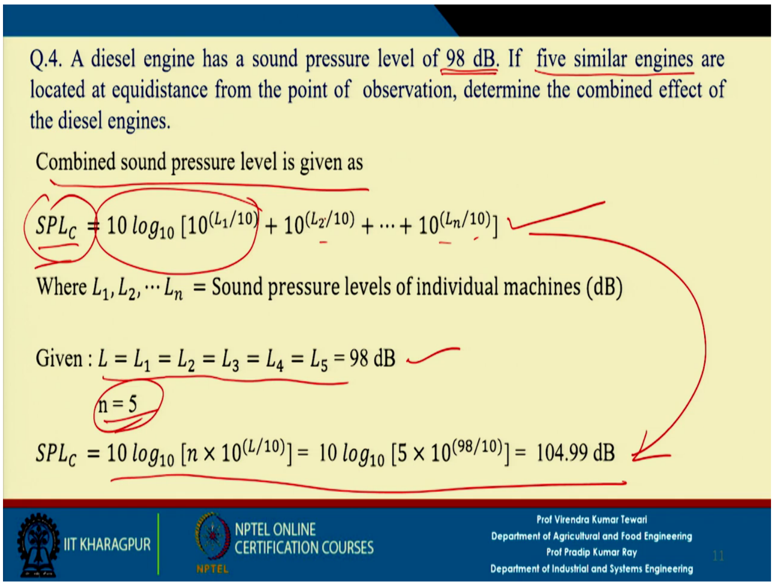

Q.4. A diesel engine has a sound pressure level of 98 dB. If five similar engines are located at equidistance from the point of observation, determine the combined effect of the diesel engines.

Solution:

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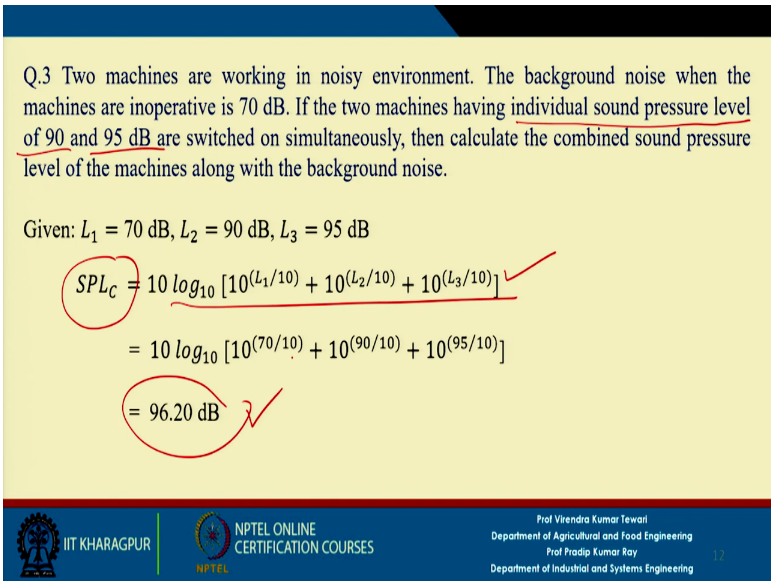

Q.5 Two machines are working in noisy environment. The background noise when the machines are inoperative is 70 dB. If the two machines having individual sound pressure level of 90 and 95 dB are switched on simultaneously, then calculate the combined sound pressure level of the machines along with the background noise.

Given: L_1 = 70 dB, L_2 = 90 dB, L_3 = 95 dB

$$SPL_C = 10\, log_{10}\, [10^{(L_1/10)} + 10^{(L_2/10)} + 10^{(L_3/10)}]$$

$$= 10\, log_{10}\, [10^{(70/10)} + 10^{(90/10)} + 10^{(95/10)}]$$

$$= 96.20 \text{ dB}$$