Noise Management & Its Control
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Lecture – 42
Noise Source: Role of Reflecting Surfaces

Hello, welcome to noise control and its management. Today is the last day of the seventh week of this course and what we plan to do today, is conclude our discussion on how to calculate the sound pressure level at a distance r, which is away at a distance r from a sound producing source, the sound producing force source is what we have discussed till. So, far is in an ideal situation, it is located in free infinite size, space, full of air and there are no reflecting surfaces, whatsoever in this whole space.

So, for this kind of a situation, the value of L p which we had discussed.

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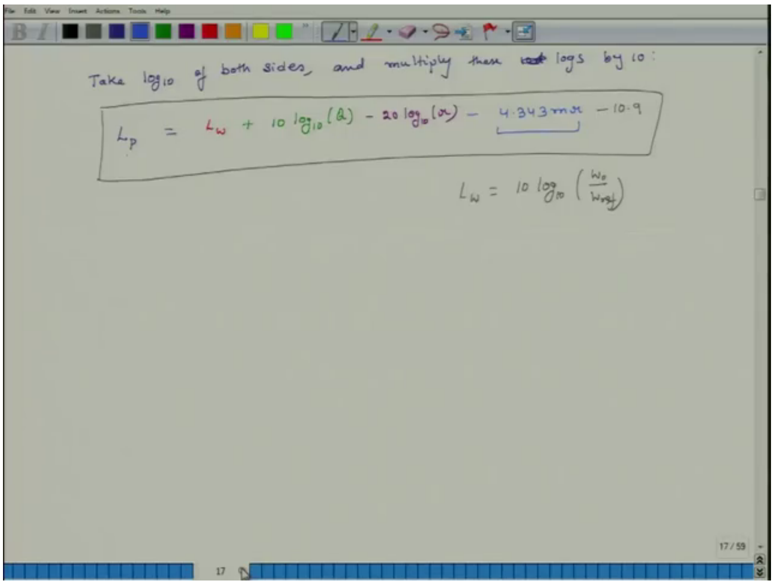

We had developed that relation and we will write that relation one more time. The relation is L p, which is the sound pressure level at

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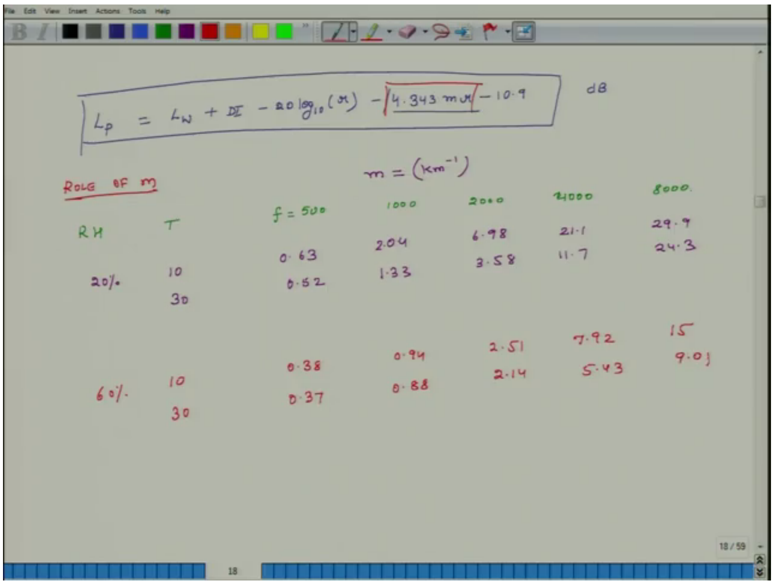

the location of interest is equal to the sound power level, L w plus 10 log of q which I called directivity index. So, we had defined this directivity index is 10 log, 10 of q and please note, the q is a function of frequency. So, it can change with different frequencies minus 20 log of the distance, how far the microphone is from the source minus 4.343 m r plus or minus a constant number 10.9.

So, this is in decibels and d i once again I said is directivity index and it is defined as 10 log of q just wanted to do a couple of things in this lecture. So, first thing we will like to explore is, what us the role of m in this whole thing, this is what we are interested in role of m. So, the role of m is. So, m we had discussed either you can express it in inverse of meter that is the unit or in kilometer inverse. So, let us look at some of the values of m. So, I am just quickly going to write down this table.

So, the first column is relative humidity. Second column is temperature in degree centigrade and then we have different frequencies. So, 500 1000 2000 4000 and 8000, these are central frequencies and the first case is R H is equal to relative humidity s 20 percent and we will see for two values 10 degree centigrade and 30 degree centigrade. So, what do the numbers look like? So, here m is in kilometer inverse 1 by kilometer that s the units.

So, what do these units look like 0.63 0.52 0.2 0.46 0.98 21.1 29.9 30 0.52 excuse me, 1.33 3.58 11.7 24.3 and the other one 60 percent relative humidity and again, we will look at the value of m at 10 degree centigrade and 30 degree centigrade. So, what do the numbers look like 0.38 0.94 2.51 7.92 15. So, it is 0.37 0.88 2.14 5.43 and 9.01.

Now, you would wonder, what do these numbers mean? So, let us do some quick calculations. So, suppose there is a machine and it is generating noise and it is as we have discussed in this case, it is there in free space infinitely, large free space. So, it just hanging in air and there are no reflecting surfaces and the machine is producing

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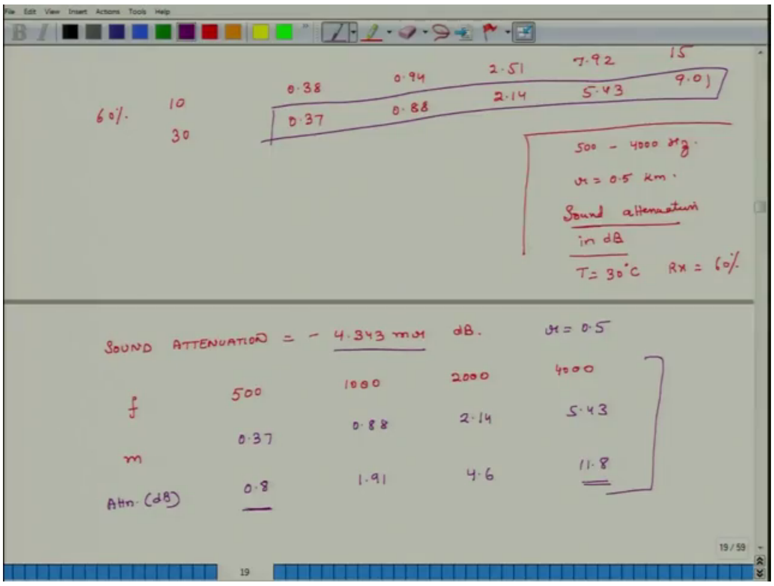

Noise and the nature of noise is that, it ranges between 500 to 4000 hertz. So, the there is a machine in space and is generating a lot of noise and it is producing noise at 500 hertz. All frequencies between 500 and 4000 hertz and what we are interested and suppose, the microphone is located away from the machine, let us say r half a kilometer away from the machine.

So, r is equal to half a kilometer 0.5 kilometers, then the question is how much sound is attenuated, because of this, because of air absorption. So, we have to calculate sound attenuation. Sound attenuation in decibels, this is what we are interested in finding it out and then finally, we assume that temperature is equal to 30 degree centigrade and relative humidity equals 60 percent. So, what do we do? So, sound attenuation equals how much minus 4.34 3 times m r in decibels.

So, we just make a quick table. So, for different frequencies, we will see how much sound is getting dissipated by. So, f is equal to 500 1000 2000 4000 and the values of m what are the values of m? We choose this row. So, values are m r 0.37 0.88 2.14 and 5.43 and attenuation in decibels, how do we calculate it, we just calculate this term 4.34 3 times m times r and r is equal to how much 0.5.

So, we are taking it in kilometers, because m is given in kilometers inverse, if m was given in meters inverse, then we would have taken r to be 500 meters. So, this is important to understand. So, attenuation is 0.8 decibels 1.91 decibels 4.6 decibels and 11.8 decibels. So, what do you make of it; essentially what it tells us is that, at low frequencies half kilometer away sound does not get dissipated as much pointed decibels is not a lot, but 11 decibels or 11.8 decibels at 4000 hertz, it means that the power has gone down very significantly, each time the power goes down by a factor of 10, you loose 10 decibels.

So, the power which is reaching half a kilometer away is 11.8 decibels less, which is lesser than 10 percent of the power, which was generated at the source at 4000 hertz, but at 500 hertz, virtually all the power is reaching out. So, at low frequencies the effect of air is negligible. If you look at 100 hertz or 50 hertz, this number will be even smaller, it will be negligible, but at higher frequencies, especially beyond 2000 hertz, air acts as a very strong filter and it absorbs a lot of sound, but at low frequencies does not absorb a whole lot of sound. So, this is the second thing and the last thing is that remember this relation is true, for what when the sound source object is located in free space and there are no reflecting surfaces anywhere around the thing.

Now, what if there are reflecting surfaces. So, the question is what if there are reflecting surfaces;

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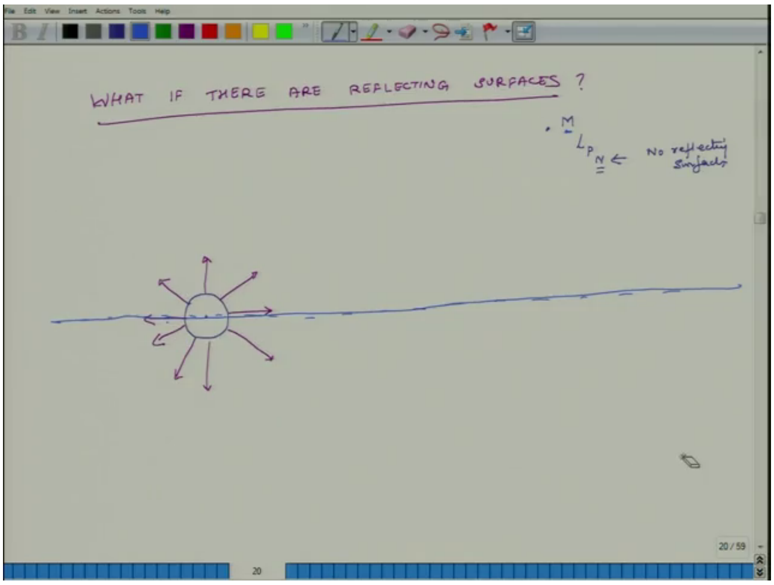

What do we do in such a case? So, we will answer that question and to answer that question consider this experiment. Suppose, I have a sphere, it is a perfect sphere and it is emitting sound and it is in free space, it is in free space and I am measuring sound at this location m where I have placed a microphone. So, there are no reflecting surfaces in the sphere in the world and I am measuring sound at this location and I say that the value of sound pressure level, here is l P and I will also put a letter N which means in absence of no reflecting surfaces, actually let us make this sphere a little smaller. So, that it is manageable.

So, it is a small sphere and the sound which is being measured by microphone M is L P N, where N tells us that this is the sound pressure level. When there are no reflecting surfaces, the sphere is hanging in free air and there are no reflecting surface anywhere in the whole universe and it is L P L. Now, consider this when sound is being emitted by this sphere. It is going in all directions; uniformly it is going in all the directions, in all the directions uniformly, in all the three dimension which means,

So, now just consider this imaginary plane, consider this imaginary plane which is mean made in by a dotted line. It just is splitting the sphere in the top half and also the bottom half right. The sound which is being sensed by this microphone m is because of what is it, because of the top half or of the, because of the bottom half it is because of the top half the sound which is being emitted by the bottom half is not going to the, to this microphone at all right. If there was some reflecting surface, here then it would reflect and come back, but because there is no reflecting surface at all, because there is no reflecting surface at all, the sound only from the top half is reaching the microphone, the sound from the bottom half is just going in the other part of the universe.

So, I can also say that only the half of the sphere is responsible for producing this L P N the lower half is not responsible for producing L P N right. If there was another microphone here then the lower half would produce l p n, but because the microphone is located in the top half, only the top half of the sphere is responsible for producing L P N right. Now, consider another thing. So, now, what I am saying is that, here this blue line was a imaginary dotted plane, which partitions the sphere into a top half and a bottom half.

Now, instead of an imaginary plane if I split this sphere into a top half and a bottom half, what will happen to L P N, will it remain the same or will it change, still the lower half is emitting sound which goes to the lower half of the universe and it never comes back. So, it has no influence on the reading of this microphone and the top half the sound from the top half is still reaching the microphone right. It is still reaching the microphone and because of this the microphone reading is not changing everyone understood.

So, what; that means, is that if I split a sphere into a top and a bottom half, the lower half has no influence and I introduce a reflecting plane, going through the center of the sphere that has no influence on the reading of the microphone right, not because it is going through the center of the sphere, if the reflecting plane was here, then it would influence the reading.

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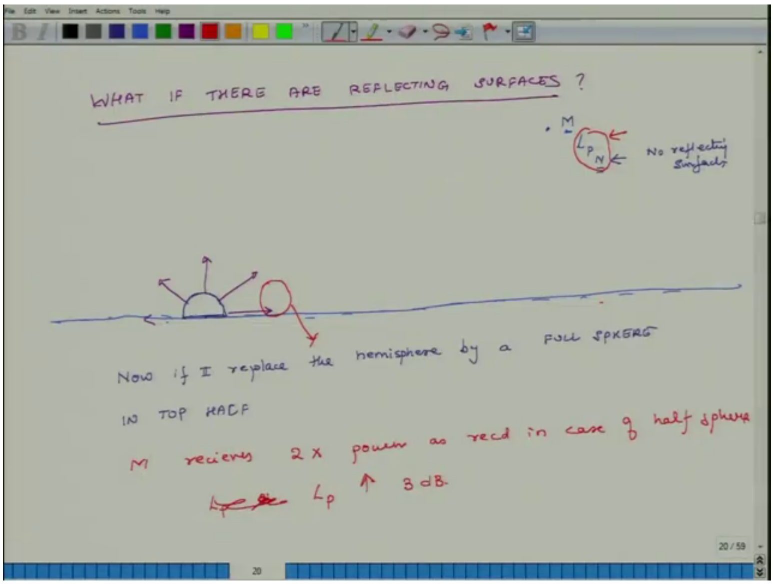

But because it is going through the center of the sphere it does not have any influence on the reading of the microphone which also means that instead if I have a universe which has a top half and a bottom half plane I do not need a whole sphere to produce the same sound pressure level, rather I just need a half sphere right. I only need half of the sphere to produce L P N, because the lower half is not being utilized agreed.

So, I only need half of the sphere to produce L P N. Now, if I have this type of a universe, where there is a top half and a bottom half and they are separated by a reflecting plane and in such a situation now, if I replace the hemisphere by a full sphere in top half, what does that mean, that instead of a hemisphere in the. So, initially right now, in the top half there is only half of the sphere. Now, what I am doing is I am putting the whole sphere on the top, I am putting the whole sphere on the top, what does that mean that will mean that this thing will get twice as much as energy right, it will get twice.

So, here was getting energy, which was sufficient to create L P N only, because only half of the sphere was there, but now, I have put the whole sphere. So, energy from here cannot go down, all that energy, it will get multiplied by because of this reflection and the microphone receives two times power as received in case of half sphere right. So, in this case, if it gets two times as power what will happen to this sound pressure level, it is 10 log of power divided by reference power.

So, L P or you can also call it. So, L P goes up by 3 decibels, because 10 log of 2 x log of 2 is 0.3 10 times 0.2 is 3. So, if I have one reflecting plane going through the middle of the sphere and the whole sphere is above that reflecting plane, then my sound pressure level goes up by a factor of by 3 decibels. Now, this is only for one reflecting plane, now consider another case.

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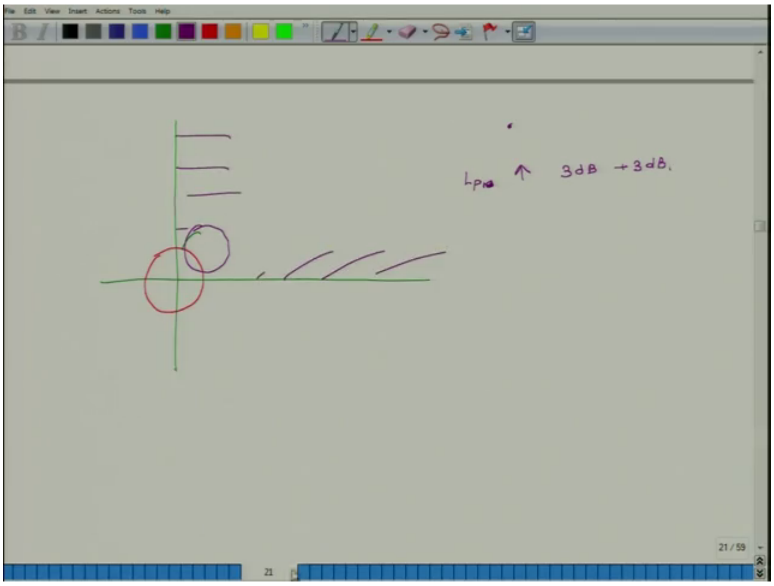

So, you have no reflecting plane and now in I introduce one reflecting plane, but there is no reason I can also have another reflecting plane, an example of a reflecting plane would be.

So, you have one reflecting plane is this another reflecting plane is this and I have a sphere located here in this case and here I have my whole sphere is located here, if there was no sphere, only one fourth of a sphere was sufficient to produce L P N, but now, because I have put the whole sphere between the 2 reflecting boundaries, my L P N. Now, my L P it goes up by how much 3 decibels plus 3 decibels, because 3 decibels, because of reflection from this surface and 3 decibels, because of reflection from this surface do you understand this. So, this is when you have two reflecting surfaces and your object is close to the corner of the intersecting two planes and finally, you could have even three reflecting surface.

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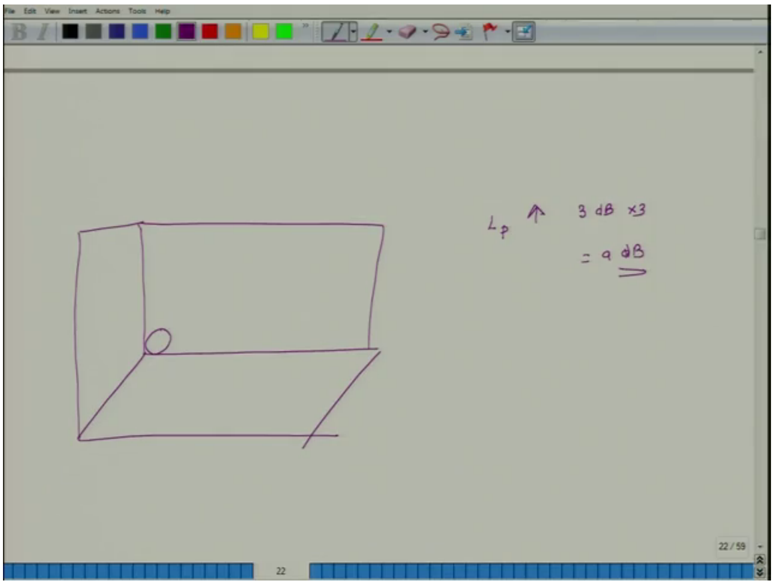

So, you can have this and this and your object could be here. In this case L P would go up by 3 decibels into 3 is equal to 9 decibels, what would be the physical situation you have one reflecting surface, which is this ground and the reflecting surface, which is a vertical wall, third reflecting surface is perpendicular to it and your sphere or the source is located at the intersection of all these three things. So, if. So, in absence of any reflecting surfaces, this is the relation which we use, if this object is placed on one reflecting surface, then all the energy will be prevented from going to the bottom half of the universe, and all that energy will again get reflected (Refer Time:22.40). So, if there is only one reflecting surface. So, this is when no reflecting surface is, if this object which is emitting w watts is placed on one reflecting surface, then I have to increase my decibel level by three more and if it is located at the intersection of two reflecting surfaces then, I have to increase my decibel level by 6 extra decibels and if there are three reflecting surfaces like this then I have to increase it by 9 d B.

So, reflecting surfaces also make the sound more directional, because they reflect and send the energy in a particular directional. So, just very quickly, we will see one last slide for today, that because of the presence of reflecting surfaces also there is an additional directivity factor.

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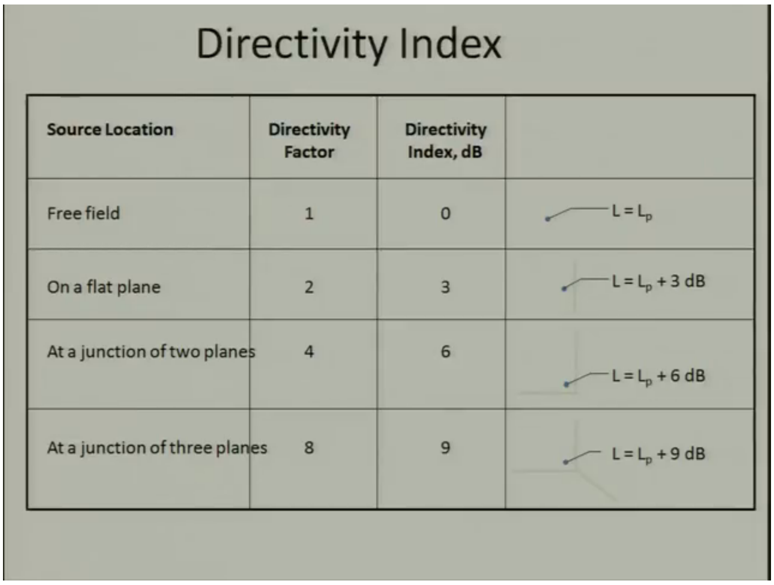

Directivity Index

Source Location	Directivity Factor	Directivity Index, dB	
Free field	1	0	$L = L_p$
On a flat plane	2	3	$L = L_p + 3$ dB
At a junction of two planes	4	6	$L = L_p + 6$ dB
At a junction of three planes	8	9	$L = L_p + 9$ dB

So, if it is in a free field, free field means no reflecting surfaces, whatsoever then whatever L p. We are calculating, that is fine from the formula, which I had expressed earlier, if I have a flat plane and my sound producing object is located on that flat plane then, I have to add 3 more decibels.

If there it is at the junction of two planes then I have to add 6 more decibels and if my sound producing object is at a junction of three objects, three mutually perpendicular planes, then I have to add 9 extra decibels. So, what you have learnt is now, that initially what we learnt was how to calculate the sound pressure level in absence of any reflecting surfaces and now if we, but remember and now once we have reflecting surfaces and remember when we say reflecting surfaces, they should be perfect reflecting surfaces it is not that they are like sponge, there had been sound hits. They absorb some energy and only reflect a part of the energy.

They have to be rigid walls, rigid flat shiny walls. So, whatever energy comes none of that energy gets absorbed by the surface. All the energy gets reflected, if it is ground swale and things like that it is not a perfect reflecting surface, but we have perfect reflecting surfaces in presence of one reflecting surface. We add 3 to this equation, if 2 reflecting surfaces, we add 6, if 3 we add 9, but that is again the situation when we have perfectly reflecting surfaces.

So, this gives you an overall idea, how to compute L p in, when the object is outside a room. In the next class, what we will do is we will do a similar activity and we will figure out how to compute sound pressure level L p, when the sound producing machine, whose voltage is w watts is located inside the closed room. So, that concludes our discussion for today and we will meet next week, till then have a great weekend bye.