Fundamentals of Acoustics
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Lecture – 70
Reverberation Time

Hello, welcome to Fundamentals of Acoustics. Today is the 4th day of the last week of this course and today we will discuss different concepts and it is known as reverberation time.

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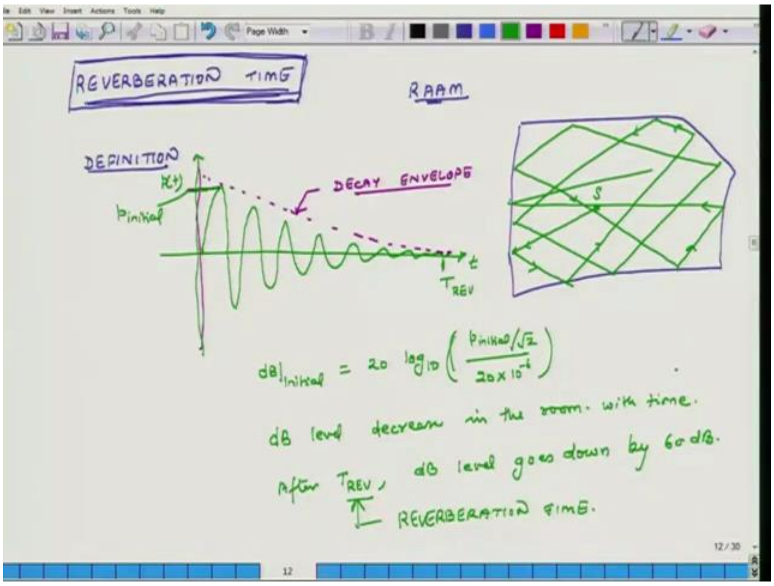

First we will discuss, I will give you context and then I will discuss in detail what is the importance of reverberation time. Suppose I pronounce the word RAAM r a m, but this A is long. So, I am writing it raam raam raam and I can pronounce the word either in open space. So, I am here and you are 20 feet away from me or 100 feet away from me and I pronounce it in open space. So, when I say raam, you are not there, there are no walls around in the region. So, that sound does not come sound does not get reflected and come to you. So, the only time you are hearing raam is when I pronounce it. So, initially you hear the sound ra then you hear the sound aa and then you hear the sound maa and after you have heard maa you do not hear anything at all.

In another situation suppose you are in a room or you are on top of hill and you say raam and what happens is that the sound comes from my mouth and the listener listens to it directly, but the sound also goes to a reflecting surface. So, if you are in a room which has the strong reflecting surfaces you also here the reflected raam and also the direct raam and sometimes it can happen that when you hear the directed the direct sound ra or the direct sound aa by that time the sound of r or ra it goes hits a wall and comes back to you. So, while you are is hearing the direct sound from me you are also hearing reflected sound ra. So, you are hearing two sounds at the same time ra and at the same time and because of that you your brain gets confused and it is not able to figure out what is it that you are listening and you do not understand whatever is being told.

This problem is because of these reflections, if there are no reflections then there is no problem, but if there are reflections and if the reflections are very strong then the intelligibility of the sound and it does not matter whether it is speech or music or whatever the intelligibility of the sound that is your understanding of the sound it can significantly degrade it can significantly degrade.

To measure the influence of this reflected sound, there is a parameter called reverberation time, there is a parameter called reverberation time. So, if the reverberation time is infinite it means that there are no reflections if the reverberation time is extremely small then the movement I you hear ra direct and reflected they almost come at the same time, but if it is somewhere in middle then it may interfere you with here perception.

That is why reverberation time is important, now we define reverberation time. So, consider a room. So, let us say this is a closed room and this is a source and it is producing some sound, let us say initial sound wave comes here. So, it gets reflected it gets reflected again it gets reflected again it comes here.

It keeps on reflecting forever and as it keeps on, this is the path of the sound, how it is getting reflected. So, what happens as sound gets. So, what is happening sound is starting from point s and it is traveling and while it is traveling some of that sound as it travels through here it gets absorbed because here absorbs some sound energy does not absorbs the whole lot of energy, but it absorbs. So, some of the sound energy gets absorbed as it is traveling in the air and a larger portion of the sound gets absorbed when it hits a wall especially if the wall is not perfectly rigid then an appreciable portion of the sound gets absorbed.

As sound keeps on traveling and it keeps on bouncing and it undergoes infinite reflections, its energy keeps on decreasing, its energy keeps on decreasing. So, if I plot in time and let us say I am plotting pressure and let us say the sound which is being produced is the pure sin wave. So, if after each reflection it will still remain a sin wave, but its amplitude it will keep on decreasing like this.

What I do is I can make a envelope and this is called a decay envelope decay envelope let us say when I n the beginning let us say this is the total pressure. So, let us call this p max I will not call it p max let us call it actually this is green. So, initial amplitude is p initial. So, what is the initial decimal value dB initial is equal to 20 log 10 and this is the amplitude. So, I have to divide it by I have to take the RMS value. So, it is p initial and because this is sin wave I divide it by square root of two divided by 20 times 10 to the power of minus 6. So, this is my initial decimal value in the room.

As time progresses the dB level decreases in the room why there is a decreases because more and more energy keeps on getting absorbed. So, dB level keeps on decreasing. So, once again what I am what I am doing I am taking this room in the room I am playing this speaker for some time let us say 3 second. So, sound is bouncing all over the place and then I stop it when I stop it at that very instant the pressure is high, but the sound does not become all of a sudden and sound come keeps on continuing to bounce at all the places and as it travels and bounces its amplitude keeps on decreasing.

This decrease happens something like this. So, dB level keeps on decrease in the time in the room with time and after certainty let us say at this time let us say this T and I call it T rev. So, after T rev dB level goes down by 60 decimals. So, if the dB level has gone down by 60 decimals then this T rev is called reverberation time. What is 60 decimals? It is essentially that T he energy or the power of the sound as gone down by a factor of 10 to the power of 6.

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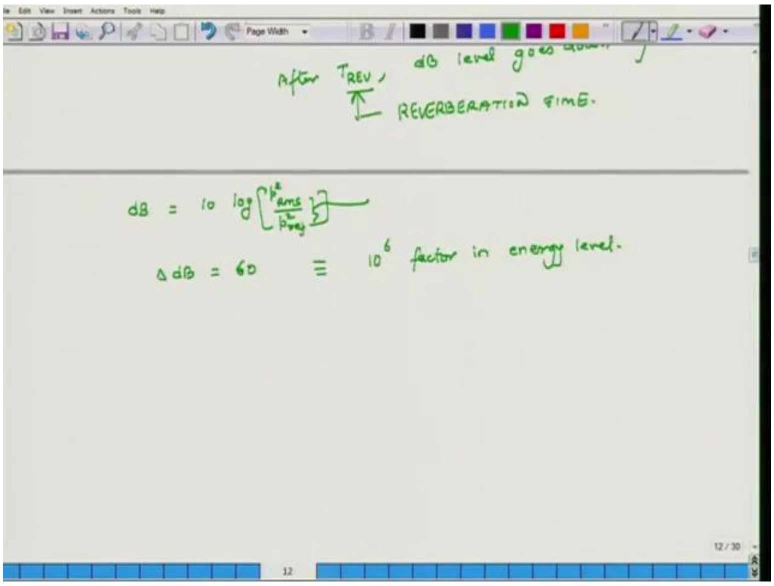

Why do I say that dB is equal to 10 log p square RMS by p ref square, this is the original ratio when I take square out, I get 20 log and this is not ratio of pressure. So, other, it is the ratio of square of pressure and a square of pressure is related to proportional to energy.

When delta dB is equals to 60 then change in the energy level is 10 to the power of 6. So, this corresponds to 10 to the power of 6 factors in energy level not in pressure level pressure level, it will be 10 to the power of 3, but in energy level it is 10 to the power of 6. So, what is reverberation time reverberation time I can define based on all this discussion is the time required for a sound in a room to decay by 60 level decimals, if it decays by 60 decimals and it occurs over a period of some time that time is known as reverberation time. So, that is what reverberation time is all about.

The next thing is how do we calculate reverberation time? Calculating reverberation time for this we use a particular formula. So, there are several formulas available, but the most popular formula is known is Sabine's relation. So, I will not derive that relation I will just write it T rev is equal to 55v over a prime c. So, what is v? So, if there is this is the room for which we are trying to figure out the reverberation time then V is the volume of room now remember this relation does not work for rooms which are rectangular in shape. So, if you have a room something like this, this formula does not necessarily work, but if you have some uneven surfaces suppose the ac is there. So, it makes it a little less square is a lot of such obstructions anything like that are there then this formula works fine.

So, V is the volume of the room and I can do that volume either in meter cube. So, I can use this formula either in food pound system or in SI system. So, if I am in SI system then I have to record volume in cubic meter or in British system, I have to do it in cubic feet the second thing is c. So, c is speed of sound and this is either in meter per second or in feet per second and the third thing is a prime and this is a constant for room and we will learn how to calculate this constant, but this constant it is either in its units are either square meters in SI system or in British system it is not feet square it is called Sabine's. So, it is not feet square, but in SI system it is meter square.

If I know V c and a prime then I can calculate T rev. So what do I do? So, now, I tell I explain how to compute a prime. So, a prime is given by another relation, a prime is equal to s, another parameter which depends on the room times log 1 minus alpha bar. So, this is my first relation this is my second relation. So, what is s? S is the surface area of room, it is internal surface area. So, wherever we are having reflections, all that surface area has to be calculated. So, its units are meter square or feet square and then finally, alpha bar alpha bar is absorption coefficient of room and this does not have any dimensions. So, if we have a room which is given I know how to calculate s, I have to just measure all the internal geometry of the room and I can calculate s, I know what is the value of c, I can calculate V the only thing is I do not know alpha bar.

In the next class we learn how to calculate alpha bar for the room because once we do that we calculate a prime plug that a prime in the relation for T rev and calculate the reverberation time. So, with that we conclude our discussion for today and in the next class we will continue this discussion and also learn how to calculate alpha bar for a room.

Thank you.