Audio System Engineering
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Lecture – 01
Introduction

Good morning. So, we start about the course, course is Audio System Engineering. And this course will be mainly deal with that the audio systems, not exactly the systems, I will cut cater this course to more or less acoustic design and that part. So, the course audio system engineering, whole course will be cover by ten hours lectures. So, if you see that once you think about what is audio, audio system engineering? First we have to think about, what is audio, if you see that you have heard about audio signal, audio is not coming out. So, in audio basically a sound, a sound is generated or a sound wave audio wave means sound wave.

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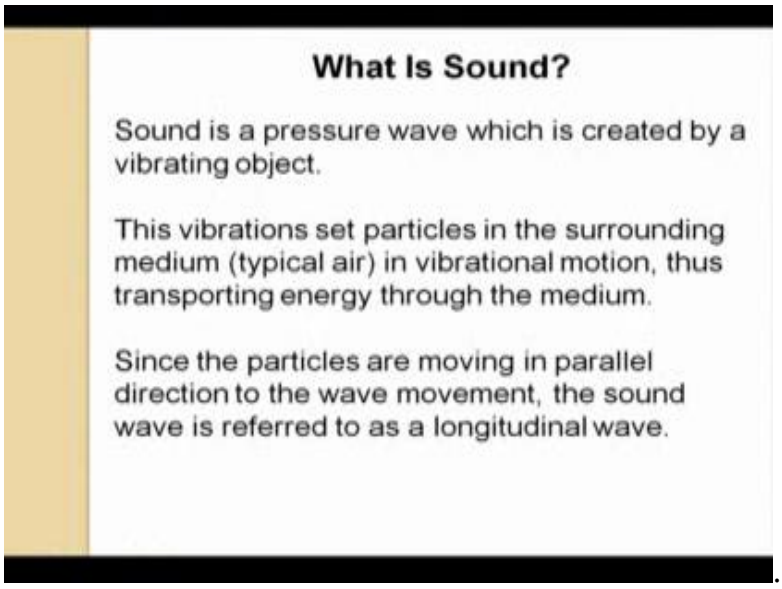

So, if I discuss what sound is, think about first what is sound so what is sound the sound is the pressure wave which is created by a vibrating object. You think about it if I strike in the table, a sound is generated that means, all way the sound is created based on some vibration without vibration sound cannot created, so source of the sound is vibration. Now, how this sound is travel to me, how this sound is propagated then, this vibration has to be propagated in some way. So, this vibration, once I strike in this here the

vibration is created. So, these vibrations set a particle that if it is vibrating surrounding particles are moving, so those movement transport energy from one point to another point that is how the sound wave is propagating

So, if I think about that sound system engineering, first we have to think what is the source of sound is said source of sound is nothing but a vibration of a mechanical object mechanical vibration. Then you say how the sound wave is transmitted that has to be known. So, this course will covered that if you see this whole course will cover the fundamentals of vibration and how this vibration can be automatically model that is its equivalent electrical circuits that is sound system engineering.

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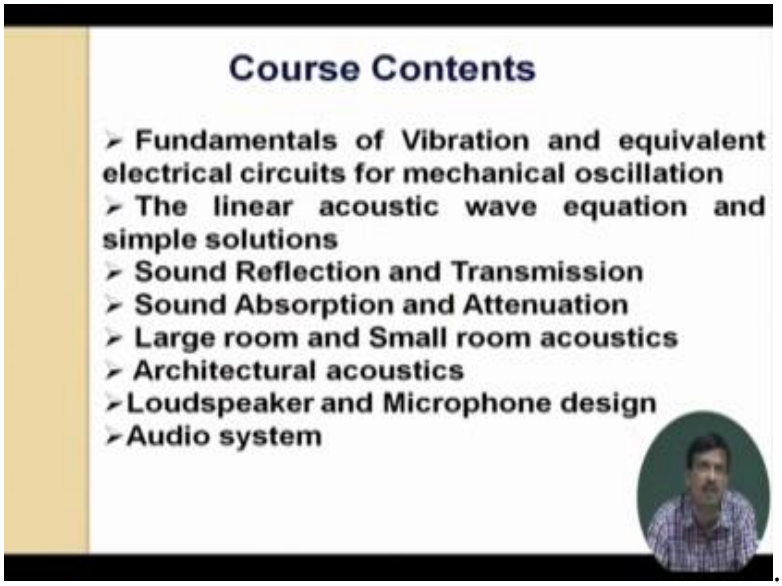

Then how this sound wave is propagated so I said sound wave is nothing but a acoustic wave that the properties of how the mechanical oscillation is propagate in a medium is called acoustics. So, this acoustics wave, how his acoustic wave is propagated in the medium that is called linear wave acoustics wave equation that is means we have to derive how acoustics pressure wave or how acoustic energy is travelled from one point to another. So, mathematical derivation of those properties is called acoustic wave equation.

Now, if you see may be is it linear or is it non-linear, so it may be non-linear or it may be linear, so here we restrict ourselves up to linear acoustic wave propagation. Why, if you think that sound generated by a crowded auditorium, the intensity of that sound is still

obey the linear wave equation, but if you see the example explosion of a bomb, instantaneous energy of the bomb explosion is such a way or such huge that it cannot be expressed by a linear acoustic wave equation. So, we are not interested to go there. So, this course is only deal with the linear wave equation and sound wave propagation using that thing. So, we are have to interest to study is that sound propagation of to lets auditory of that or you can say the stadium – packed stadium humming noise that also huge intensity, but how that is propagated. So, we are talking about that thing.

Then if those are the sound intensity, think about, if I produce a sound here, the sound strike to the wall. Now, how the wall is reflect that sound or how the wall is transmit the sound inside the wall is called sound transmission phenomena, so we have to know that phenomena also. Suppose, for a practical example that we want to that inside that auditorium should be sound proof from external sound source; that means, suppose I design an auditorium and I should not want the outside sound should come inside, and inside sound should go outside. Now, if I want to restrict that things, you have to phenomena, how sound is transmitted in the medium, how sound is reflected by a medium.

So, as you know any sound or acoustic wave without media cannot transmit, because if it is transmit then explosion which is happening that above the earth that mean that you cannot heard it, because in that region there is no medium. So, without medium sound cannot travel that is why that sound is not coming in our earth, so we are not getting that sound. So, any acoustic wave if you want to propagate then it requires a medium. Now, once it requires a medium, how the wave is propagated in the medium is mathematically described by the wave propagation equation. How the wave is reflected by the medium, transmitted by the medium, observed by the medium or attenuated by the medium that is called sound reflection, transmission, absorption and attenuation.

So, if you see in large, now that I know that I know the sound absorption, transmission and attenuation. Then what I requires, suppose I want to design a acoustic rooms or I say recording studio, sound you heard about that sound recording studio. If you go to that any recording studio, where the song is recorded where that the cinema dubbing is happened, if you see the special kind of room, why this special kind of room is required. Why cannot be it is done in here, that means, we want to reduce the if you see that I produce a sound if that is that sound I want to record, I should not want that

environmental noise could crop the sound. So, I want to reduce the environmental noise. If I want to reduce environmental noise, that means, sort of some sort of acoustic treatment I should made in the room, so that external sound should not come inside the room or internal sound should not go outside the room.

Similarly, if you want that suppose I want to build a huge auditorium, now if I speak in the stage, the last row cannot heard it, cannot heard it, then we put some microphone. Once I put some microphone, if the auditorium is huge then there may be a chance of echo. So, I want to reduce the echo, I want to optimize the sound intensity, so that every seat in the auditorium must listen that sound, so; that means, I want to create a sound field inside the auditorium such that the intensity at every point must be more or less equal. So, that kind of treatment I want, so those are called large room and small room acoustics. Now, large room acoustics, you heard about that somebody said you know the reverberation time of this auditorium is two seconds. So, what do you mean by reverberation time?

As an engineer, I should know what is the physical meaning of reverberation time. How it is calculated for a given specification of an auditorium, of a cinema theatre. If you visit any Dolby digital hall, yes, you have many of you visited that Dolby digital hall. If you visit Dolby digital hall, you see there is a some kind of acoustic, some kind of particle board are fixing inside the wall, back side there is a huge blanket is why it is required, those things we have to know. Those things are called acoustics properties of sound room that may be a large room acoustics that may be a small room acoustics. If you see very practical example, if I put a microphone without the cover of that, but sponge cover what will happen, if you see it will create a bust kind of energy. So, if I want to reduce that energy, suddenly we put a sponge cover just top of the microphone and it reduces. How it is reduce, you have to know that things.

So, we have to know the how the acoustic properties are deals, how the auditorium is design, only acoustic parts, how the acoustic part of the auditorium is design, so that are architectural acoustics. Even today think about, I want to design my drawing room to get the feeling of 5.1 channel loudspeaker you know that 5.1 channel Hi-fi music system. So, I have to know if I want that 5.1 channel real effect, how do I place my loudspeaker. If I you have seen that you have a five loudspeakers you have given in 5.1 channel audio system, where to fit. If I put all in front of me, am I getting the 5.1 channel effects, so

where I put that place that microphone in my drawing room, and what should be the minimum size of the drawing room to get that effect. So, all those things as an acoustical engineer or sound system engineer, I should know that things. So, those things will understand we deal this course.

So, this course only deal with how to calculate the reverberation time, how to find out the minimum free path, how to find out the various acoustics parameters like intelligibility of acoustics parameters like percentage (Refer Time: 11:49) those things how we find out. So, all those things we will deal with this course. So, we will start we will touch that architectural acoustics. Now, think about it, why I require a ram kinds of things in auditorium, forgot about the visualization part. Is it is there any issues in sound part also, yes, we have make the ram because of everybody can see the stage that is one part; another aspect is that that also effect in sound also. To getting the proper sound in every seat, I required a certain kind of ramping, so that part also we will discuss in architectural acoustics.

If I put a two parallel wave, parallel wall in an auditorium, if you see any auditorium, does not have any parallel wall. If you visit Kannadasan auditorium in IIT or you visit all in cinema hall anywhere, you see there is no exactly parallel wall. So, why it is not there, there is a acoustical reason. So, those reasons will be discussed in this course. So, we discuss about the architectural acoustics.

Then loudspeaker and microphone design. I will talk about something on basic principle of loudspeaker and microphone design and acoustic transduction. What is acoustic transduction that means if you see you know that if you produce a mechanical sound here, if I want to convert it electrical sound, I put a microphone here. So, what is microphone is doing, it converts that mechanical vibration to electrical signal. Similarly, if I supply a electrical signal to the loudspeaker, it produces a acoustical vibrations so; that means, electrical to mechanical vibrations. So, this transduction will be discussed and then we will discuss how that loudspeaker and microphone basically design, what are the different kinds of loudspeaker is available in the markets.

As an engineer, somebody told you sir, this loudspeaker is very good, if you visit in an audio markets and you see you want to buy a 5.1 channel music system then they said see that sir loudspeaker specification it is very good loudspeaker, you heard about the

Bosch, Bosch's loudspeaker. Why it is very good, what are characteristics I should look for a good loudspeaker? So, design is one part, another part is be you aware about the loudspeaker specification, so that I can say this loudspeaker is technically good after examining the technical specification, I will certify that this loudspeaker is good. Suppose, you want to design an acoustic system, audio system for your institute or you want to design seminar room acoustic system, you go to the market and want to buy a loudspeaker. If you buy one loudspeaker, you will say my loudspeaker is good. As an engineer, I should see of that the specification, and I should understand each of the meaning of the specification and then I should certify yes this loudspeaker is good. So, we will study about that specification during the loudspeaker design.

Similarly, same cases applicable for microphone also. If you see somebody told you Zura microphone is very good, Bosch microphones are very good and this microphone very costly, I do not know why it is so costly. There is you can find out microphone is five hundred rupees and I can find a microphone with 1 lakhs rupees. So, what is the difference? So, if I see the specification of the microphone sheet, I should as an engineer I should able to tell that is why those of the technical points that is why this microphone is very good for this kind of audio capturing, this microphone is very good for this kind of audio capturing. So, you can certify why this microphone for this purpose, why this microphone for this purpose. So, using the microphone design not only we try to design the microphone means we should know how the microphone is designed, but also we should understand, if I see the technical sheet of the microphone, I should know each and everything, so that also will be covered.

So, then I will talk about the audio system means amplifier, how the microphone is connected to the amplifier, what are the different kind of connector is available, why this connector of this type, have you heard about this x l r connector, there you heard about R C A connector. So, why, why those connectors are evolve and how they, why this connector is very good. So, connection diagram then amplifier, acoustic audio amplifier you heard about. I am not design the audio amplifier, because this is the part of purely electronics engineering, so I have skipped it a design of audio system audio amplifier. But we should understand if a microphone is connected to the audio amplifier what are the connection point, what are points I should check for an audio system so those things

will be discussed. So, this is more or less coverage of the audio system engineering course.

So, first I try to mathematically understand the theory of sound, how the sound wave is generated, how the sound wave is propagated, and then we understand how the sound wave is transmitted in a medium, how it is reflected, observed, transmitted, refracted all those properties we got it. Then we go for the architectural acoustic, what is large room, volume acoustic, and what are the acoustic parameters like the reverberation time, mean free path, standing wave how it is generated, node all those things and then we go for the acoustic treatment or acoustic design of an auditorium.

So, more or less this course is not only beneficiary for the electronics student, but also it is beneficiary for who are studying civil engineering, and architecture. Many of time, all of you are ignoring these points, sometimes you ignore that acoustic point of that when design the architecture. So, if you attend this class, if you know the basic acoustic properties of architectural design then at least you can apply those things when you design the civil diagram for an auditorium and other things. So, this is the more or less course coverage.

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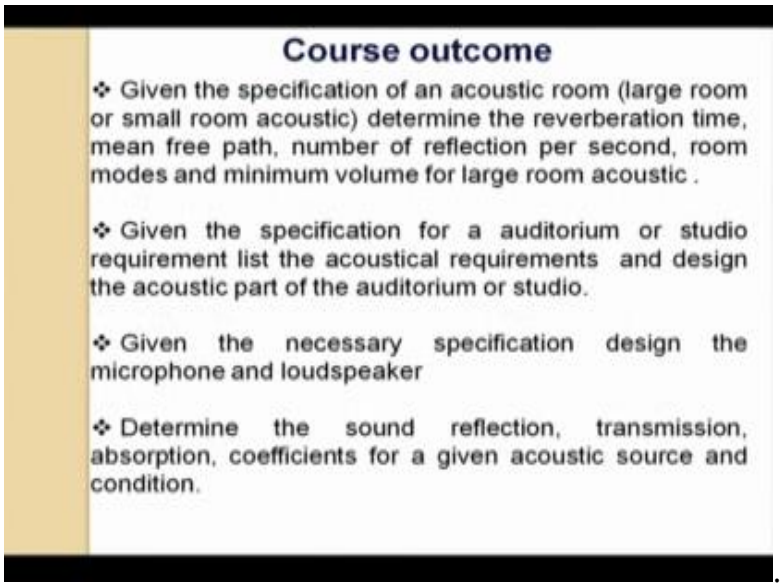

Then why you study this course. If you see, in my opinion every course that why we study this course only for the credit, that I will I want some two credit, three credit, no. The purpose of this course is that you are attending this course, you want to know or you

want to develop certain skills on audio system. It is not that you know what is reverberation time. If you do not know, how to apply it then that knowledge does not have any effect. So, if you say what should be the outcome of this 10 hours course, after you attending whole ten hours lecture, assignment, all the examination, what skill as a teacher, I look for you and as a student what skill you want to develop using this course.

So, intended skill at the aimed of the course should be the given the specification of an acoustic room. Suppose, I provide you a specification of acoustic rooms, you should able to determine, the reverberation time, mean free path, number of reflection per second, room modes, minimum volume for large room acoustic has all the acoustic parameters you should avail to calculate if the specification of an acoustic room is given. So, this is the one outcome, so; that means, you not only know what is reverberation time or definition of reverberation time; you should able to calculate the reverberation time for a given specification.

Next thing is that give the specification for a auditorium or a studio requirement. Suppose, somebody gives you, I require this kind of auditorium that that many number of seats that many what is the maximum sound and you design that acoustic part of the auditorium. So, as a engineer, I should able to design the acoustic parts of the auditorium what kind of acoustic treatment I should put in the stage, what kind of acoustic treatment I should put in the wall, what I should tell the civil engineer that if you want the good acoustic, you should keep this, this, this point before you construct the auditorium. That's should not be many parallel wall, there may be a this kind of volume, so all those things you should able to understand and design that auditorium.

Then there is I come out that, I design the auditorium, how do you measure the auditorium is very good, how do you know the auditorium is if you see that there is a theatre in London with on that day without microphone, people can heard, even you should you see that acoustic of the (Refer Time: 21:28) Lucknow. If you see if you produce a waves or a sound in a portion, it can travel long distance, but generally sounds cannot travel. So, they produce acoustics structure of that that monuments such a way that sound can travel long distance. Then you can say how you measure the acoustic quality of that auditorium. There is a different kinds of measurement; you heard about the percentage of ALCON, there may be (Refer Time: 22:00) of the sound, so all those

parameters I will define in this class, and you should able to apply those knowledge, when you design an auditorium.

If I after this course, if you visit in any auditorium, your mind should creates some questions this auditorium is good this part, this auditorium not good in this part, these can be made good if I do this kind of things. Once your mind is that kind of question is asking then my course is fulfilled. So, at the end of the course, you should able to make curiosity, or you can if you say I will able to find out this is the acoustic problem, so let us try to solve this problem. So, I will to solve those kinds of acoustic problems then you understand that sound system engineering course. Then you set the given the necessary specification design the microphone and loudspeaker. This is one part.

One part is that I provide a specification. I can say this microphone can be designed like this way. You may ask sir, we are not designing any microphone earlier as you said, because we may not be the manufacturing joining the manufacturing industries, it is . You do not you are not actually design the microphone, but if you study how the how to design a microphone, you apparently know if a microphone is given to you, and how to read the technical specification of that microphone.

What are the meaning of each of the point, which is mentioned in the datasheet of the microphone and loudspeaker, so that is both side you should able to do. Either, I give you the specification you should design; or I provide you a microphone and that datasheet, you should interpreted each and every point. And you can measured that yes sensitivity of microphone is claim minus 50 dB, yes this microphone is minus 50 dB, I can measure it by creating this kind of experiments, so that kind of expertise I want you when I taught about the specification design of microphone and loudspeaker.

Then determine the sound reflection, transmission, absorption, coefficients for a given acoustics source condition. Somebody told you sir, why I required a concrete wall between the auditorium and the control room, I have put a control room – small control room may that side, I can make a simple partition of a gypsum board, why I required a concrete wall. So, you have to explain that if you produce a sound in the auditorium, this sound should not go in the next room. If I put an concrete wall, so; that means, I have to know how the sound wave is transmitted, how the sound wave is transmitted through the concrete, how the sound wave is transmitted through the gypsum board, how the sound

wave is transmitted through the any particle board, whatever you have said. So, those things you have to know, you have to understand clearly that yes this way the sound wave is transmitted; that means, how do you measure the understand, understand I cannot measure, why there you understand or not things.

So, what I give I provide you some sound acoustic source specification, this is the acoustic source, now you have to measure, how much amount of this acoustic source will be transmitted from one room to another room. So, those are the called the sound reflection, transmission, absorption, and how to find out those coefficients for a given source, given medium all kind of things I will cover. So, those are the course outcome. So, I believe that nobody all you just read that course and pass the exam, I do not want, everybody must develop that skill, yes, I attend the sound system engineering course, and I have specifically I have a skill how to measure a reverberation time of the auditorium.

Specifically I have a skill, how to find out that the transmission coefficient if the sound wave is generated in air and transmission on this medium. And I have a skill; if I have seen the specification of the microphone I should know which microphone is better and why it is better. And I should able to communicate these things with my organization or with my client and I should able to explain them as a client side also. So, those are the skill, I want from audio system engineering course. So, this is the basic coverage and outcome of the course is.

Now, those outcomes, those are the course outcome; that means, at the end of the course those skills I should have. Now, how these course outcomes will be fulfilled, throughout the course if you attend, one-by-one outcome, I will develop on viewing. So, it is not that you have to follow my whole lecture like that if you see that yes, I have already have this outcome, please try to solve that some tutorial which I will provided to you that if you able to solve that things; that means, you have a little bit of understanding of that things.

Now, if you have any doubts that yes sir I do not understand physically or without clear on your mind that - yes, I have understand everything on this things you ask question. So, I will encourage all of you to interact with me on that day if you have any doubt in any point during in my lectures. There may be some errors in during my lecture also, it is there, it will be there, and there will be some error. I want all of the you should once you

watch that video, you should able to identify those errors and communicate to me, yes sir here is my I understand that there should be some error then I should clear that error and that process you understand yes this is the case which I want to explain you. So, that means, it is not a one way communication, I just give you some if you search in the Google, design of microphone and loudspeaker, you get thousands of process, enough material, I do not require to supply you the material, but you have to require that the within that material, if I read this material, what skills I should develop.

So, I want try to develop you some skills that society give you some problem can I solve this problem using if I if I say somebody of you ask that yes have you done that audio system engineering, yes sir I have done audio system engineering course. Then somebody ask you, see at the Kalidas auditorium, I found that sound is not that good, there is some hazy sound noise is coming out. Then if you able to technically identify what is hazy noise, how it is generated, if you see many time, when you connect a laptop to an amplifier, suddenly a noise is coming that is continuous noise is coming, how to solve that noise, how to reduce that noise. An audio system engineer, I should able to tell, yes sir, that you are left of ground and this amplifier ground is not proper that is why the noise is coming. If I make them, not only explaining, if you able to solve that problem then you are the proper audio system engineering student.

So, all through my lecture, whatever after that I will take the lecture on board, I will because I will I will use some mathematics also, I will describe sound vibrations, mechanical vibrations then acoustic wave propagation all are the mathematical derivation that can be available in the book also. But during the derivation of that mathematical equation, I will explain some physical phenomena towards that mathematical equation. So, you have to clearly know, any mathematical derivation when you want to derive, you should know why I do this things, if you do not know the physical significance of that mathematical derivation then you are not developing your skill. You can remember the derivation and give the exam, but in my end, my paper even in IIT also, when I take the exam, I never provide any derivation on the end term papers, because derivations are available in the books, but same derivations how use that derivation to solve the practical problem is the skill.

So, I may use mechanical oscillation, but suppose in mechanical oscillation, if you not able to explain why if there is some two bumpers, why there is a speed limit is

mentioned, when you not heard that you are not done that mechanical oscillation course. So, if you understand the mechanical oscillation clearly, then you should able to clearly explain why before any bumper in the road a speed limit is mentioned, what physically happen if I cross a bumper with a high speed, so that you should correlate with the mechanical oscillation. If you are able to correlate, then you understand that things.

So, this is my first lecture to motivate you and provide you what should be the course coverage of audio system engineering.

Thank you.