Noise Management & Its Control
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Lecture – 02
Introduction

Hello, welcome to Noise Management and its Control.

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Today is the second day of the first week of this course and what we plan to do today and also in the remaining part of this week is covered some of the important concepts and terms which are used in context of noise and acoustics. So, that is what you plan to do today. But before we start talking about some of the some of these specific terms and terminologies I wanted to show you a video.

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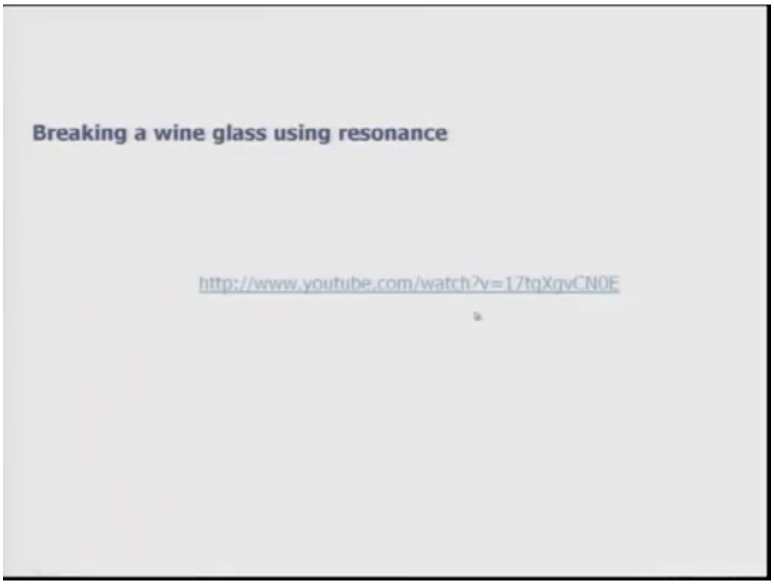

So, this is an interesting phenomena what sound can do it can do a lot of things, this is one interesting thing which can do and what you are going to see is that there is a glass you know a glass which is used to drink wine and that wine glass is being exposed to sound at a particular frequency. And while doing this experiment what they have done is that they have adjusted the frequency in such a way that the frequency is same as the resonance frequency of the glass.

So, when you know hit that glass with that sound, it excites resonance and at resonance glass vibrates a lot and because glass is very low damping properties its vibration is becomes uncontrolled and as a consequence it shatters. So, this is just an interesting experiment, but I thought it will be just in good so, that it gives you some interesting Knowledge and perspective on sound and gets you excited about sound.

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So, that is the glass and you see that it is being excited by this particular frequency and as we see in time its vibration is becoming larger.

Now, it is becoming its increasing in amplitude and then it gets shattered. So, we would not talk about this phenomenon in this particular course, but I thought it will be just interesting.

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To start this discussion with this interesting video.

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So, the first thing I would like you to understand is the meaning of two terms one is one term is vibration and the other term is a wave. Now lot of times we accidentally or sometimes because of inaccurate understanding we use these terms interchangeably.

But vibration means one thing and waves means something different they are related, but they are not same. So, what is a vibration and what is a wave. So, maybe in the next couple of slides we will try to understand the difference between what is a vibration and what is a wave.

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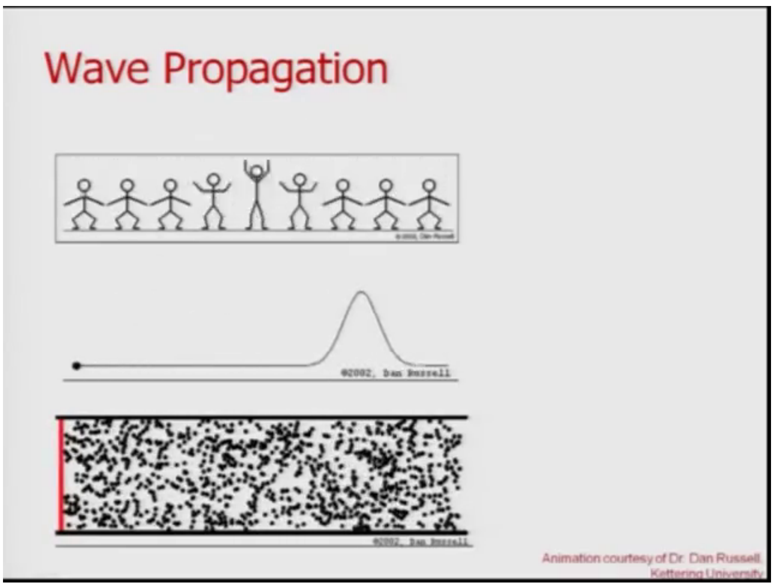

So, to understand this you should look at the picture on the top at the moment do not focus at the picture the second picture or the third animation.

Just look at these you know this topmost picture and what you see here is a line or a row of people who are standing you know. So, several people are standing in one straight line and what is happening is that there is in the beginning all of these guys are sitting and then the first person gets excited, when this guy gets excited his excited excitation is shared by the person adjacent to him. So, the second guy gets excited and then that excitation gets transferred to the third person.

So, in this way the excitation travels in the x direction. So, if this is the x direction the horizontal direction. The direction of propagation of excitation is in x, but the x the motion each person is in the y direction the vertical direction. Now in a very loose sense you can argue or you can thing that the particle. So, let us say it considered that each of these persons could be a particle. So, the particle in this case is moving up and down while the disturbance is moving in the x direction.

Now, when we are talking about vibrations, vibrations are the most of the times we think in terms of vibration set point you know. So, there could be a point which may be moving around the mean position. So, vibrations happens around the mean position, but that vibration causes adjacent particles to get excited and the disturbance moves from one particle to the second particle to the third to the fourth particle and that direction of motion of the disturbance need not be same as the direction of the motion of the particle.

So, this disturbance when it propagates in a medium is known as wave, it need not be sinusoidal lot of times in this course we will talk about sinusoidal vibrations and sinusoidal waves, but it did it need not be sinusoidal it could be that just the excitation happens one and the wave travels out and that is it, but the vibration happens about a mean position.

So, the vibration of each particle is happening about the mean position. So, vibration is having happening in this direction vertical y axis and in the x axis the wave is travelling the disturbance is traveling. So, the n and as this disturbance is travelling what is happening? The kinetic energy of first particle gets transferred to kinetic energy you know to the second particle, then it gets transferred to the third particles and forth particle and so on and so forth.

So, energy its travelling in the x direction because of this wave phenomena, but individual particles their position does not change they are the mean position of the particles still remains the same it is not that particles at position one is finally, going to particle you know position number 10. So, particles are just moving about their mean positions, but the wave can travel very far this is something important to understand.

Now, this is in one way to look at it. So, now, let us look in the second picture and what you have here is a rope. So, it is a long rope and what I am doing is initially the rope is straight and then I excite the beginning of point of the rope and I exited in such a way that I move it upwards in the vertical direction and then I bring it down. So, the first point in the rope is getting excited in the y direction and that is all I am doing.

But because of that the adjacent particle gets excited, then after some more time the particle exit the adjacent to the second point gets excited and so on and so forth. So, the wave is travelling in x direction, but particles here also they are moving about their mean positions in y direction. So, this is another example where the motion of the particle and the motion and that propagation of the wave they are not in the same direction, but that.

So, the first picture shows that the second picture shows that, but that need not be always true. So, this is so far that let us look at the third picture. So, what do you have here? I have a long tube. So, this is a long tube and it is filled up with air and I can consider air as a very large number of small small particles. So, each of these, these small dots are particles of air and at the end of the tube, I have a piston which is in red and what I am doing is that I am just disturbing that piston a little bit in the beginning and when I am disturbing it the particle which is just touching the piston, it gets excited and it moves a little bit about its mean position and then its kinetic energy gets transferred to adjacent particles and then the second set of particle transfer their energy to the third set of particles.

So, again in this case the energy is traveling in x direction, but the particles are also moving in x direction. But again they are not moving from beginning of the tube to end of the tube the particles move about their mean position a little bit, but the energy travels along the length of the tube. So, in the first two cases what you see is that the direction of particle motion and direction of wave motion are different, in the third case you have the direction of particle motion and direction of wave motion they are same.

So, this is something important to understand and in the third case is how sound travels. So, when sound travels it needs air it needs a medium. So, when I speak initially wave when I am speaking or there is a loudspeaker, then close to my throat or to the loudspeaker air gets excited, then those particles transfer energy to the next set of particles then to the third set of particles and so on and so forth.

So, I am just standing here and I disturb the air and that disturbance travels as a wave outwards away from me and the speed at which it travels is known as the speed of sound. Let us look at another slide, but before we look at this slide I will go back to this and what this slide shows that all these three pictures show is that wave. The wave travels both in space what does it mean because it travels in space it means that disturbance initially gets generated at a you know at the origin then it travels to the next point then it travels to the next point and so on and so forth.

So, wave travels in space you know and this is a one dimensional wave. So, it is travelling only in the x direction and it also travels in time. What does it mean that are at different positions of x the disturbance occurs at different points of time you know. So, at the x is equal to 0. So, suppose this is my origin, then at x is equal to 0 the disturbance in this case is happening at time t is equal to 0, but if I will move a little bit further down then the disturbance arise at little later point of time.

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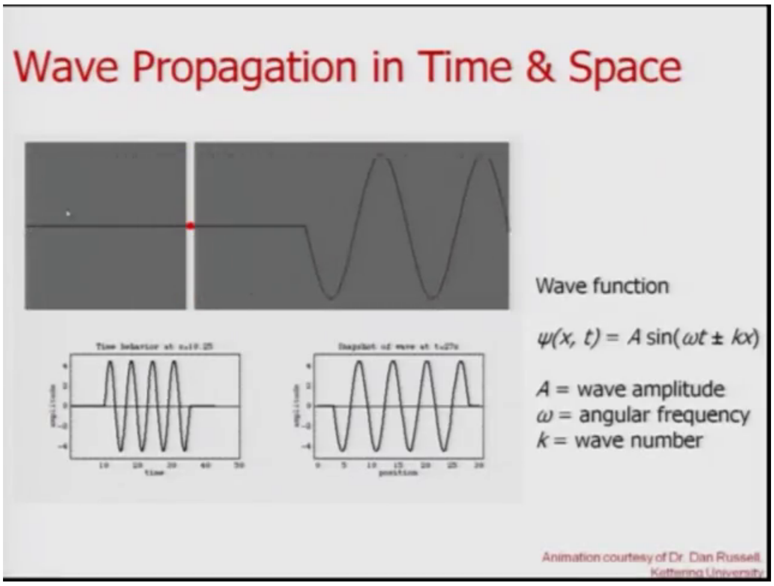

So, when we are expressing waves, we express it as a function of both the space and time. So, this is what is shown in this slide.

So, what we are seeing here is a wave. So, right now there is no wave and this is a particle and then wave is getting generated. So, we will again stop for a moment. So, in the beginning there is no wave then waves starts at this point and it propagates and it hits this particle. So, the particle gets excited about its mean position and then wave keeps on getting it and then it stops. So, the particle stops and this is how it happens. So, now, let us look at the second graph and it says on the x axis we are plotting the time behavior at x is equal to 10.25 seconds some number ok.

So, what is that we are plotting? We are plotting the amplitude of the motion of the particle this red dot at for different values of time for different values. To let say the location of the particle is 10.25. So, it says. So, what this graph shows is how is particle motion changing in time x axis is time y axis is amplitude and what it shows is that initially it is not moving and then when the wave hit it hits it the red particle moves up and down and then once the waves stops coming to it then again it becomes 0. So, this is the time behaviour of the particle.

Now other wave to see a wave is that, you have a wave travelling and then you at a particular time you take a picture of the wave and see what are the positions of particles at the dif at the same point of time. So, this is what you are seeing in the second graph. So, on the x axis you have position, position means different values of x and in the y axis you have amplitude. So, initially there is no disturbance and then you take a picture at 20 is equal to 27 seconds and so we will see it again.

So, you take a picture and what you see is that the position of different particles at different positions this is how it looks like. So, typically because of this as we discussed wave depends on the disturbance depends on x as well. So, this is why we have a wave function and a lot of times we use this symbol psi. So, psi equals is a function of x and time, it is some constant A times sin omega t and you can have either a plus or a minus times k x. It depends in the how the waves travelling if the wave is travelling in forward direction then the symbol will be minus kx. If the wave is travelling in the negative direction then it will be positive kf.

So, A is known as wave amplitude, omega is known as angular frequency and k is the wave number. So, what is omega angular frequency? It is 2 pi times frequency which is f. So, omega equal 2 pi f and k is the wave number and wave number what do you mean by that? It is basically 2 pi divided by lambda which is the wavelength. So, wave number is 2 pi over lambda and angular frequency is 2 pi times frequency. So, these are important terms you should understand.

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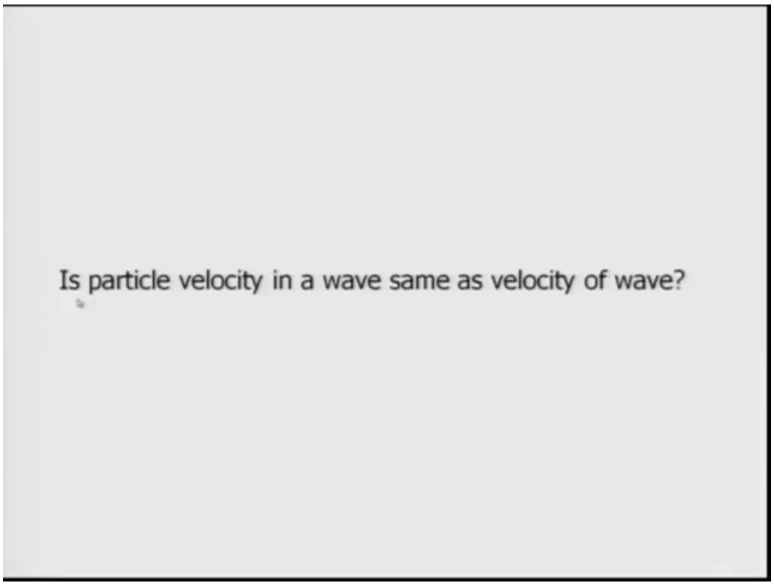

Again we will ask the same question again in waves particles are moving and also energy is travelling in a particular direction. So, the question is particle velocity in a wave same as velocity of the wave. So, you have velocity of the particle and then wave is moving in this direction, are these two velocities particle velocity and party and wave velocity are they same, they need not be the same I mean we will see the same thing here. The particle moves at some velocity in some direction and the wave travels with some other velocity and in some even with the different magnitude and different direction.

So, the magnitude of the particle velocity and the magnitude of wave velocity need not be same and also the direction of particle velocity and direction of wave velocity also need not be the same. Now we will look at some of the interesting sound waves or not sound waves different types of waves which are present in nature. So, in your high school physics and even in your earlier B-tech or be programs you may have heard of this term called longitudinal waves.

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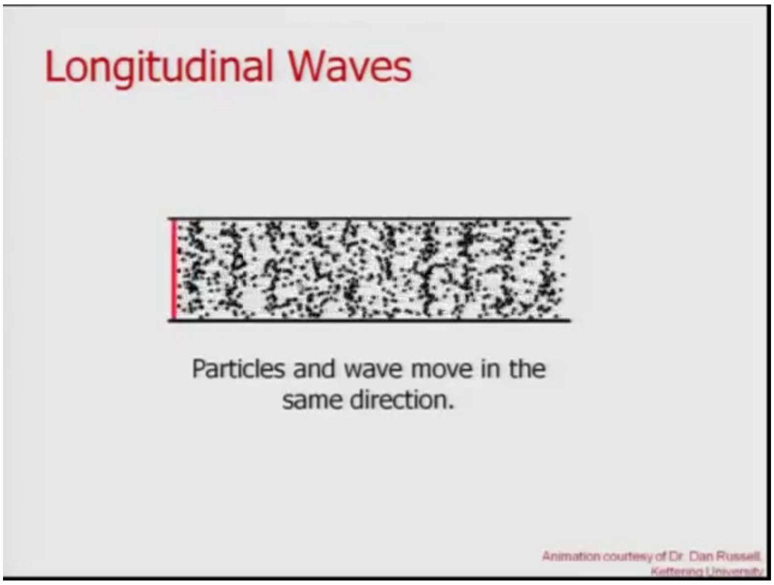

So, what are these waves we will just have a very quick recap. So, what are longitudinal waves? Here the particles and wave move in the same direction. So, if this is my longitudinal axis x direction is the longitudinal axis, then particles also move in the longitudinal direction and waves also move in the longitudinal direction. So, that is why they are known as longitudinal waves because both the motion of the wave and motion of particle it is in the longitudinal direction along the in the direction. So, this is one type of wave.

So, sound waves typically travel like this especially in air, sound travels as a longitudinal wave sound also travels as a longitudinal wave in water. In solids sound has different types of methods of propagation, it can travel in a longitudinal way it can also travel in a transverse way. So, there the phenomena is more complex, but in fluids typically air water sound travels as a longitudinal wave the same may not be true for solids. Then we have seen another term in our earlier classes and this is transverse waves. So, what is so special about transverse waves?

So, why do we call this transverse wave? So, let us consider the x axis as the longitudinal direction x axis we call it the longitudinal direction then the y axis will be transverse to the longitudinal direction right and typically when whatever is normal 90 degrees that is known as transverse direction.

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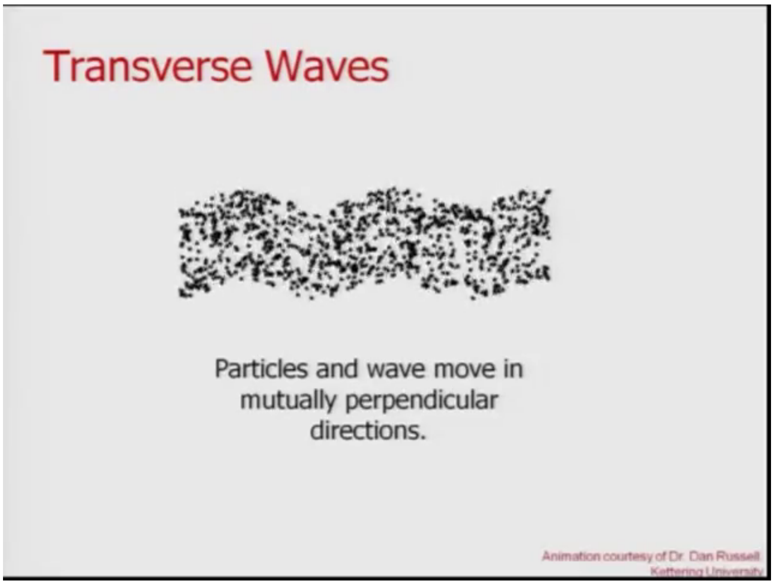

So, if here x axis as longitudinal y axis as transverse. So, what do you see here? Here the particles are moving in the transverse direction and the wave the disturbance is travelling in x direction, disturbance is travelling like this.

But the particles are moving in y direction. So, particle motion is transversely oriented to the direction of wave motion that is why they are known as transverse waves. Particle motion is transversely oriented to the direction of wave motion or wave propagation. So, that is why they are known as transverse waves.

So, your first example is where particle and wave propagation they are in the same direction here particle and wave are at 90 degree, but there is no rule that only these two types of waves should exist. So, there are some other types of waves also. So, consider this wave.

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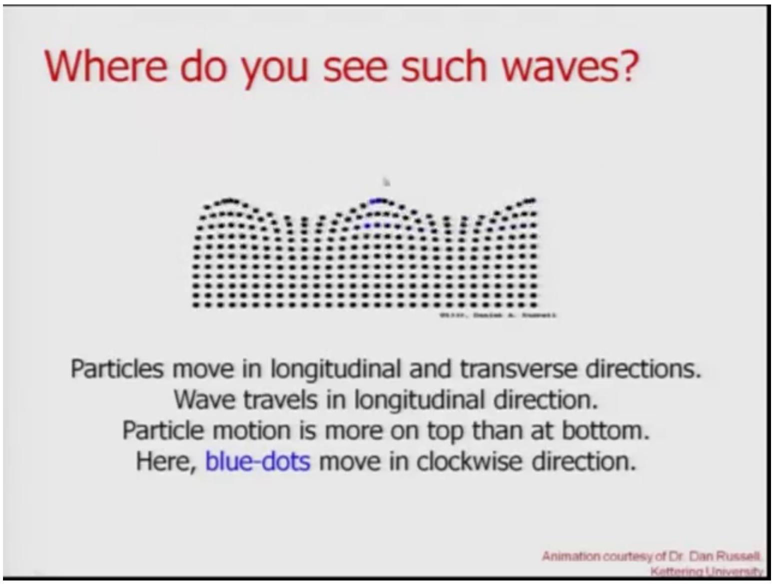

So, this is the another type of wave now here it is a different type of wave here the propagation is happening in this direction let us say this is direction, but what about the particles you look at this blue particle, which is on the top this blue particle is moving in a circular way right it is moving in a circular way and then you look at this blue particle the second blue particle which is inside the surface, this is also moving in a circular way.

But the radius of motion of the lower blue particle is smaller than the radius of motion of the top blue particle. So, when you go down inside these particles are also moving, but they are moving very little, but all these particles are moving in a circular way and the it is what counter clockwise or clockwise direction, all the particles it is blue they are moving in a clock wise direction. You may wonder where do these types of waves exist and all of you have seen these types of waves, if you throw a stone in a pond you will see these types of waves get generated.

And if you put a small colour dot or if you know air at a particular location in water and if you can observe the motion of that dot in, you will see that that dot moves in a circular way and as you go down in side water at deeper locations other particles also move, but the amplitude becomes less and in this case what the waves transverse radially outwards. So, wherever is the location of disturbance initial disturbance I throw in a pond some stone.

So, the waves emanate they originate from that point and they move radially outwards.

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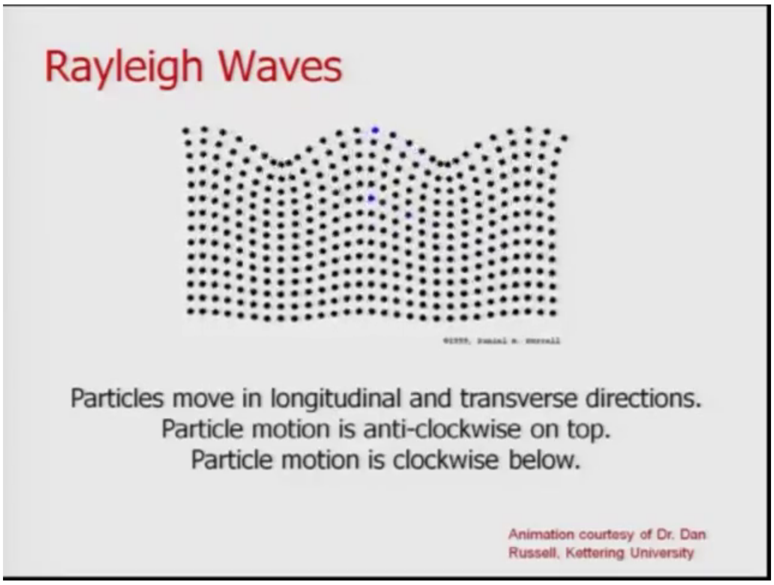

So, these are we can call them waterways and then this is another type of wave these are known as you Rayleigh waves. Here the top blue dot is moving anticlockwise and the lower blue dot is moving in a clockwise direction. So, these types of waves are known as Rayleigh waves.

So, there are several types of waves it is not that we have only longitudinal and transverse wave several types of waves. These types of waves occur especially when earthquakes happen in component of those waves are Rayleigh waves and they have this type of situation.

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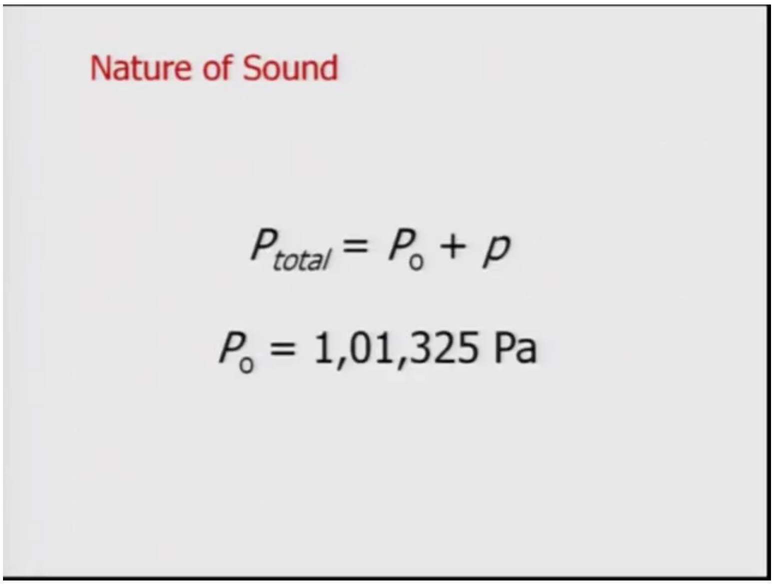

So, there the soil or earth particles move like this. So, the next we are going to discuss is the nature of sound. So, we have discussed different types of waves and in the next thing we are going to discuss is the nature of sound. So, we have to understand what is the meaning of this term called sound we here all the time.

What is sound when i. So, consider a situation that I am sitting in a room and you are also in a room and there maybe a television there may be some other machines, but let us say that there is none of these machines or me we are none of these things are generating any sound whatsoever. So, there is absolutely zero sound in the room and there is no air flow happening in the room also.

So, if that is the situation then in the entire room at every point in the room, the air pressure will be constant and what will be the value of that air pressure especially if I am at mean sea level and if the temperature is normal then it will be one atmosphere of pressure, that will be the pressure of air. Now when I talk in that kind of a situation then the pressure in the air it gets disturbed. So, when I talk the pressure gets disturbed.

So, initially it was one atmospheric pressure which is 105 101.325 kilopascals and then when I talk it gets disturbed. So, sometimes that pressure goes a little up and sometimes the pressure comes a little down. So, that disturbance of pressure is known as. So, that is can be expressed mathematically in this formula. So, if there is no sound in the room the only pressure we have in the room is P 0 or P naught and value of that P naught is

101.325 kilopascals or 100 and 1000 1.01 lakh pascals if there is no sound in the room and when I start talking or there is a noise source a sound source in the room and this pressure gets disturbed and this disturbance I express as small p or lowercase p.

Now, this lowercase p will change with time because when I am talking sometimes I am talking loudly sometimes I am talking softly. So, this [FL] p or little p is a function of time and it will also vary in space, because when I talk sound propagates outwards. So, this little p is a function of time as well as position. So, little p is a function of time and position this P naught is does not depend on time and position and then the total pressure at every point will be P total it will be P naught plus little p. So, P total is also a function of position and time.

So, I have not explicitly written here, but you should remember P total changes with time and position, little p changes with time and position, but P naught remains constant. So, a lot of times when we say that our sound is being generated what we are interested in figuring out is what is this value of little p. If I can value if I can measure the value of this little p then I can say the sound level is so many pascals. So, that is what we mean by sound in an engineering sense.

So, I think this concludes the discussion for today, we will continue this discussion in the next class also, but I hope what you have understood in today's class is different types of waves what is the meaning of wave, how is it different than vibration different types of waves and what is the basic fundamental nature of sound.

Thank you and look forward to seeing you tomorrow bye.