Fundamentals of Acoustics
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Lecture - 02
Introduction

Hello, welcome to Fundamentals of Acoustics. Today is the second day of the first week of this 12 week MOOC on Fundamentals of Acoustics and what we plan to do today is to start introducing the topic of acoustics. And before we do that I would like you to look at a particular video.

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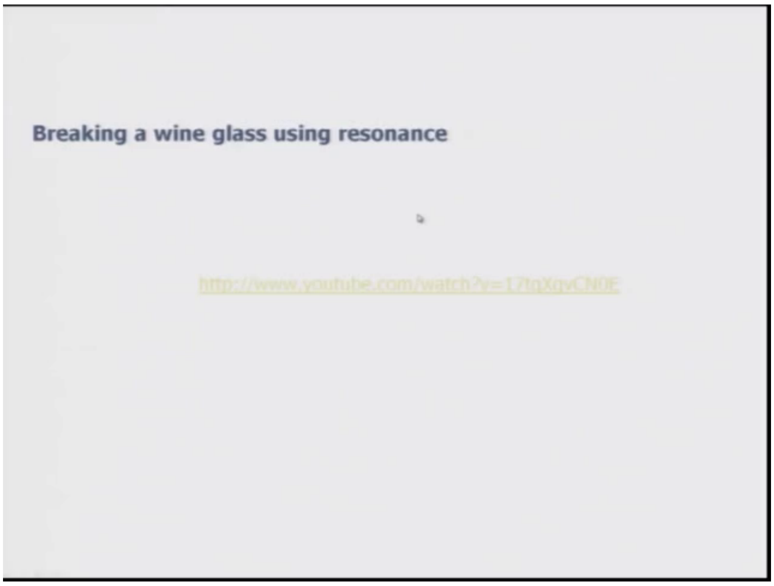

Now before we see the video I would like to talk a little bit about what is sound and what do we mean by the term Acoustics. Wherever we say that sound as propagated or I am speaking and the person let us say 10 meters away from me is listening to sound, essentially in an engineering sense; what that means is that when I am speaking in the atmosphere, my voice box is producing some fluctuations in the pressure and these fluctuations if there is a medium, they get propagated. So, they travel in medium in air or in water or in some other medium and then they reach the other person and that person's ear senses those fluctuations in the pressure and senses it as what we term as sound.

From engineering or a scientific stand point, sound is essentially propagation of pressure fluctuations in an elastic medium. Most of the times when we have sound, it is used for primarily for conveying information. So, when I am talking then that is the purpose of producing a sound that I want to convey some information with a person next to or away from me or in case I am playing some music, again I am producing some pressure fluctuations and some information is getting transmitted to the listener and in this case the purpose of that inter information is to provide him or her with some sense of enjoyment.

In another case, sound may also be used, sound is generated in some cases, sound is generated unintentionally and it is the original intent was not to produce sound, but because we cannot design machines effectively or perfectly then sound gets produced and in those cases when we have unintended sound, it is quite often referred as noise.

The second big category of sound is noise and in these cases we found that the type of sound and the amount of sound which is produced is as less as possible. So that is another one and in third category we use sound to manipulate objects. So, we can use sound to lift objects, we can also use sound to modify objects and in this case, what we will see is an example, where sound is being used to break a wine glass using the principle of resonance.

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This is a video from you tube and before we play if further what here, the person who has done the recording which is David Mehrania and Jimmy Segura from university of Southern California, what they have taken is wine glass and they are exposing it to sound of 8 particular frequency which matches the resonance frequency of the glass and as the glass gets excited into it is resonance mode, it starts vibrating at large amplitudes and after some time it cannot handle those large vibrations, so it cracks. So that is what the video is all about. So, there you go. So, this is one application of sound, but most of times when we are talking about sound it is essentially used to propagate information and convey information from point A to point B.

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The next thing we are going to discuss is understand the difference between the Vibrations and Waves. So, both these concepts are inter related, but it is important to understand the distinction between these 2 important terms.

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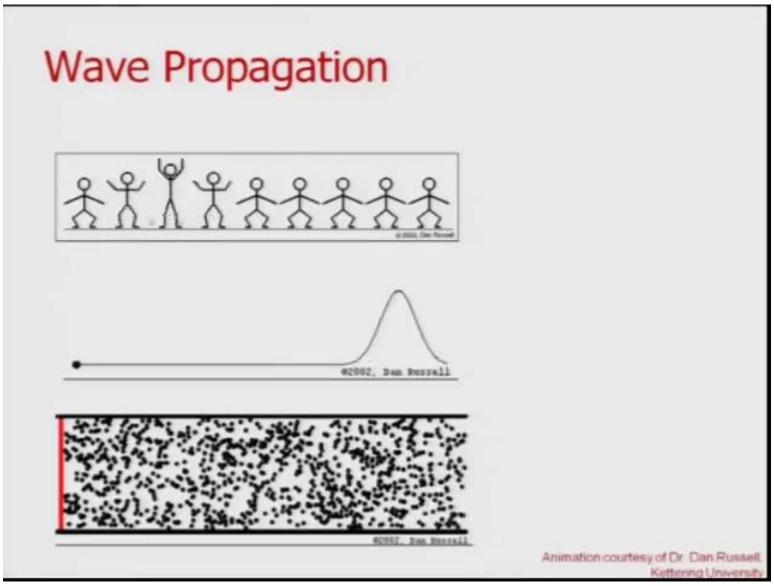

Let us look at this animation, the source of this animation is Dr. Dan Russell from Kettering University and further movement, we will just look at the animation which is on the top. So, what we have here is number of individuals arranged or sitting in a straight line and what is happening is that initially the first person is getting excited and as that person gets excited, he moves up and he moves down and when this person moves up and down that excitation gets transmitted to the person adjacent to him and once that information or excitation gets transmitted to the adjacent person, the other person also moves up or moves down and in this way, the excitation gets transmitted in the horizontal direction which we may call as the x direction while each person gets excited in the vertical direction.

While the direction of propagation of excitation is the horizontal direction, the direction of excitation of each individual is in the vertical direction. So, this is one way in which excitation can propagate in a medium. In this case, the medium is long row of individuals, but we can replace these individuals by individual particles. So, in that case, if we have a long row or a 1-D structure, made up of several particles, the particle may move up and down while the disturbance may get transmitted in the horizontal direction.

This propagation of disturbance from point A to point B in a direction is essentially known as wave propagation, while the excitation of the particle about its mean position is typically referred to as vibrations. So, the same phenomena is observed in the second animation which is this one and here what we have is a point or a large number of material particles in a row and the particles themselves get excited in the vertical or the y direction while the wave gets propagated in the horizontal or the x direction.

This type of wave propagation where the excitation of particles is at 90 degrees or is perpendicularly oriented with respect to the direction of the propagation of waves, this type of wave is known as a transverse wave because the propagation of waves is transversely oriented to the direction of motion of particles.

We have transverse waves, but we also know from our understanding of physics that there are other waves also and one of those waves is known as the longitudinal wave and the propagation of a longitudinal wave is schematically shown in this third animation. So, here we have a long tube which is filled up of lots and lots of air particles. So, we have air particles and then there is this red piston which excites these air particles at one end of the tube and these air particles when the pistons gets excited, they also get excited in the x or the horizontal direction and the disturbance in these particles propagates in the horizontal direction as well.

In such a case, the excitation of particles and the propagation of the waves is both in the horizontal direction and they are both aligned to each other in the same direction. So, these types of waves are known as longitudinal waves. These are longitudinal waves and the last point I would like to note is that both in longitudinal waves and in horizontal waves, you should note 2 important features, one is that the particles vibrate or move about their known mean positions, they themselves do not propagate over a long distances right as.

What we see? This excitation of the particle in transverse waves, it is also of that nature and we see the same thing that the particle by itself does not move from one end of the tube to the other end of the tube. So, the particles move about their mean position, but it is the wave which travels over long distances and it can travel over the entire length of the tube; in this case or the length of the row, in the case of transverse wave which we are seeing in this animation.

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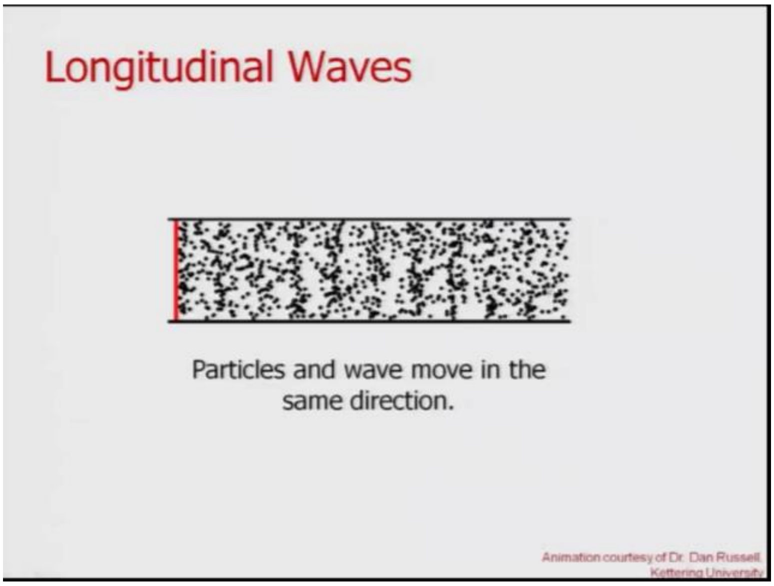

This is again the schematic depiction of longitudinal waves and we see that particles and waves are moving in the same direction, but the important thing to note here is actually there are 2 important things to note, one is that the particles do not move from one end of the tube to the other end of the tube, it is the wave which is propagating.

The second thing is that there is no reason to think that the velocity of the wave is going to be the same as the velocity of the particle itself. The particles then move at one particular speed or velocity while the wave moves at a difference velocity.

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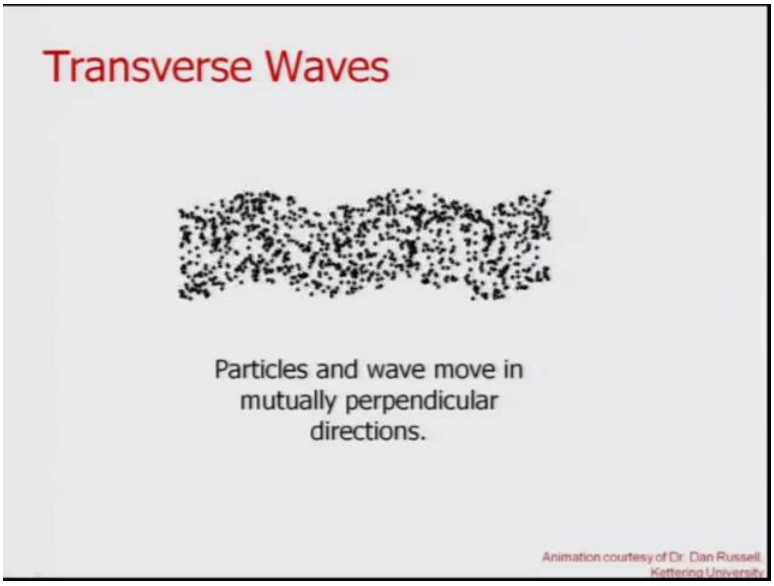

And we see the same thing happening in transverse waves that particles are getting excited in vertical direction and their velocity may not be necessarily same as the velocity of the wave in the horizontal direction.

The next thing we would like to look at is about sound. So, as I had said earlier that sound is essentially a pressure fluctuation in a medium – so when I am talking, my voice box is generating pulses of pressure in the ear and those pressure pulses get travelled and they propagate to the other end and that is known as sound.

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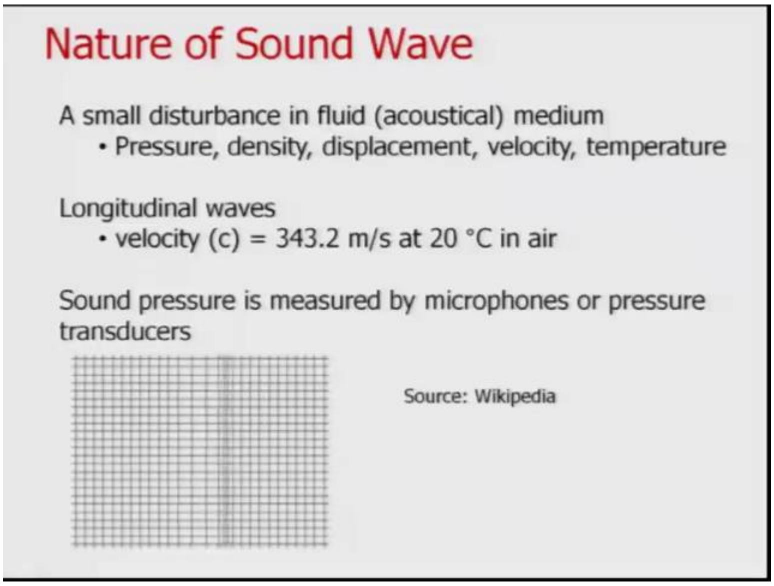

That is essentially what is mentioned here, if that sound is essentially a small disturbance, especially in context of this particular course, we are looking at disturbances which are very small. So, this is a small disturbance in fluid medium and this disturbance can be of pressure, it can be of density, displacement, velocity or temperature and when these fluctuations happen, then sound gets propagated.

The other thing to note is that the sound waves propagate at standard temperature and pressure conditions in air at a speed of 343.2 meters per second and they are typically measured through microphones or pressure transducers and the animation here is again showing, how sound is getting propagated in the horizontal direction. So, this is the one dimension transmission of sound wave. Since we have defined sound as a small disturbance in fluid medium, we will like to quantity that that what is small.

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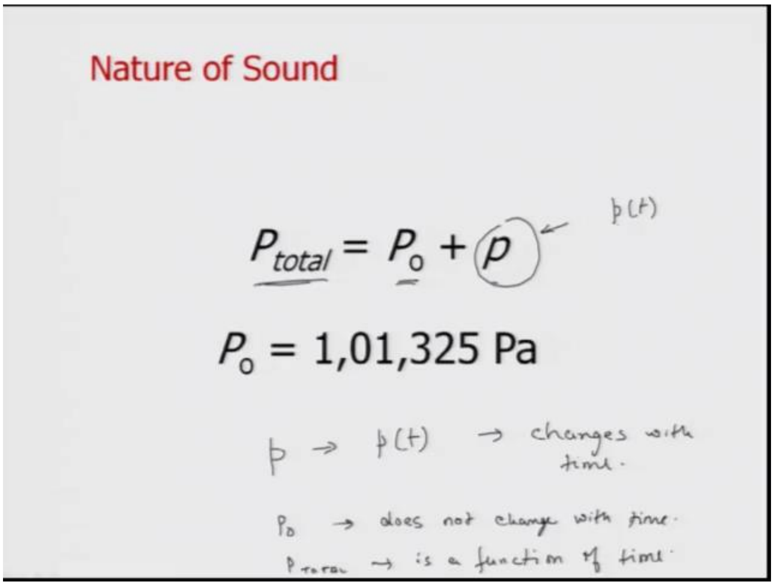

If there was let us say, I am in this room and if there was no sound in the room and I was not speaking or talking and there was no machinery or fan or any other motion occurring in the room then the total pressure or the pressure in the room will be P naught which is essentially atmospheric pressure and the standard value of atmospheric pressure is 101.325 kilo pascals. So, if there is no sound fluctuation, no pressure fluctuation occurring in the room, there is no sound in the room then the pressure in the room would be 101.325 pascals.

That pressure I call it P0, now in such a room, if I enter and I start talking then the pressure in the room will start going a little, it will start fluctuating and that fluctuation I am terming it as lower case p or small p and this p is essentially a function of p a, a function of time. So, p is essentially a function of time. So, it changes with time. So, it is important to understand P naught does not change with time and the total pressure in the room which is this is again a function of time because it is the sum of P naught and p. So, p total is a function of time.

When we take measurements on sound, typically we do not measure P naught, we do not measure even p total, most of the times when we take measurement on sound, we are actually measuring p and as a function of time. So, this is something important to understand.

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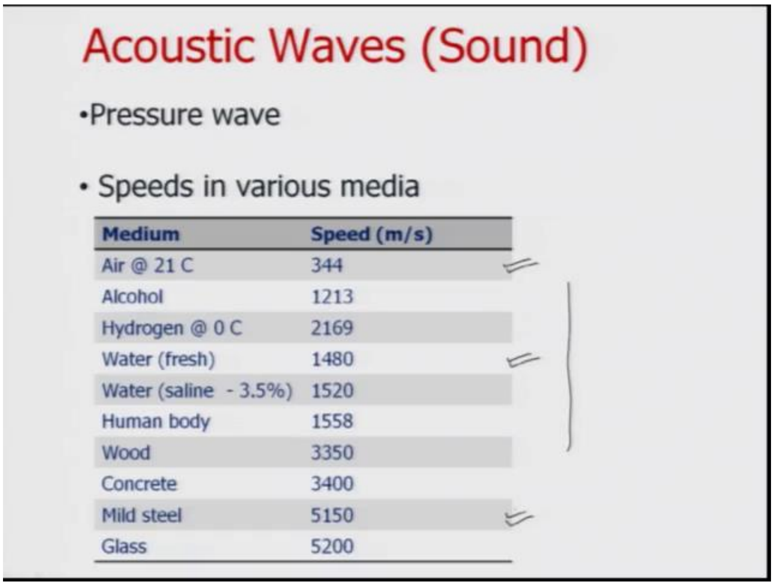

Medium	Speed (m/s)
Air @ 21 C	344
Alcohol	1213
Hydrogen @ 0 C	2169
Water (fresh)	1480
Water (saline - 3.5%)	1520
Human body	1558
Wood	3350
Concrete	3400
Mild steel	5150
Glass	5200

Now, I had mentioned that sound travels at a speed of 343 or some meters per second, this is the speed of sound in different media. So, if we change the media and temperature and pressure conditions, the speed of sound varies or changes. So, this is the speed of sound at 20 degree centigrade. In air 344 and in alcohol, in hydrogen water, in saline water, say in sea water, in human body, in wood, concrete, mild steel, this is how sound propagates, these are the standard speeds of propagation of sound.

It is important to have some physical understanding of what is the speed of sound in different media and if not for other media. It will be important to keep in mind, this particular value; 344 meters per second, which is the speed of propagation of sound in air and also for water which is around 1500 meters per second.

And maybe if you later, if you start getting interested in sound propagation in solids then this is the third number which you may want to internalize that the propagation of sound in steel is about 5000 meters per second.

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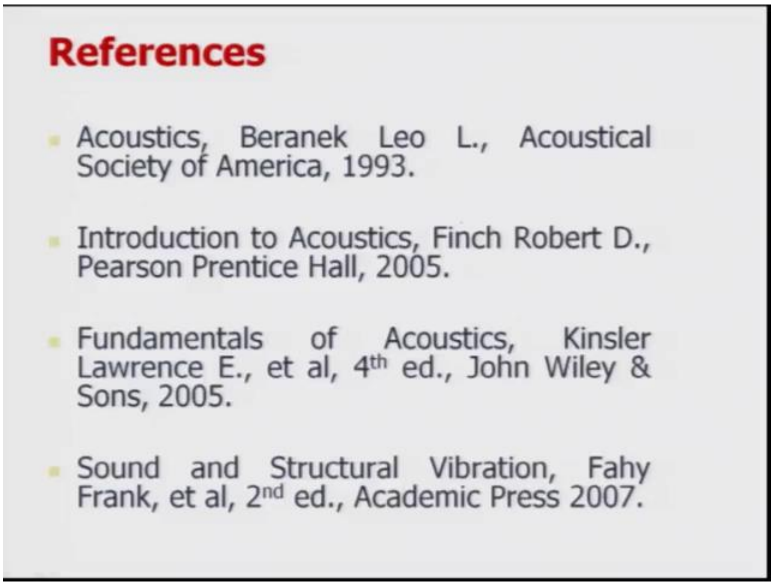

Near about 340 meters per second, water; it is 1500 meters per second and in steel it is 5000 meters per second. So, these are the references and it is important to use these references as we move forward in this course. So, this completes our discussion for the second module and I look forward to seeing you tomorrow and continuing this discussion forward.

Thank you.