Applied Ergonomics

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Lecture – 11

So, welcome once again to just cognitive part. So, previously we have completed the introduction to the cognitive ergonomics and we just initiated about knowing about the human sensory system in which we have completed the vision path.

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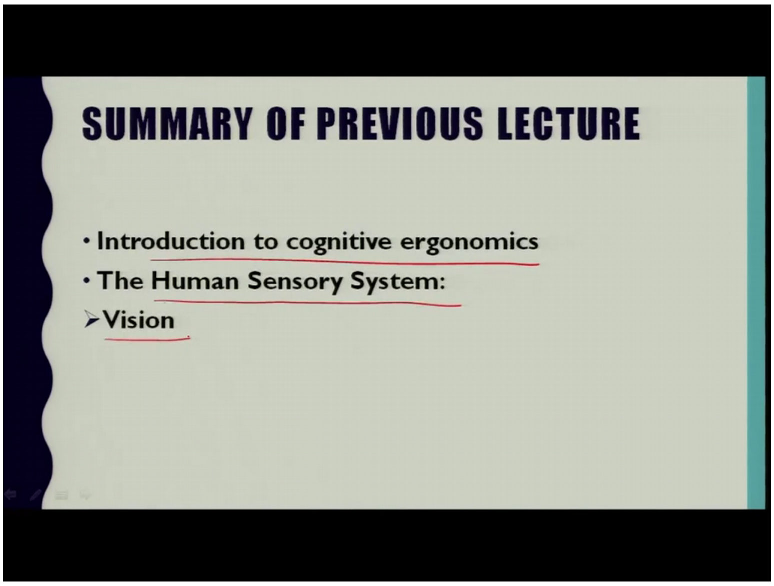

So, as just to recall of the fact that there are 5 human senses so we are in the process of completing all the 5 senses, how do they function and what are their involvement as for as our functioning of the human body is concerned. So, we have completed the vision now the next that we are going to cover is hearing.

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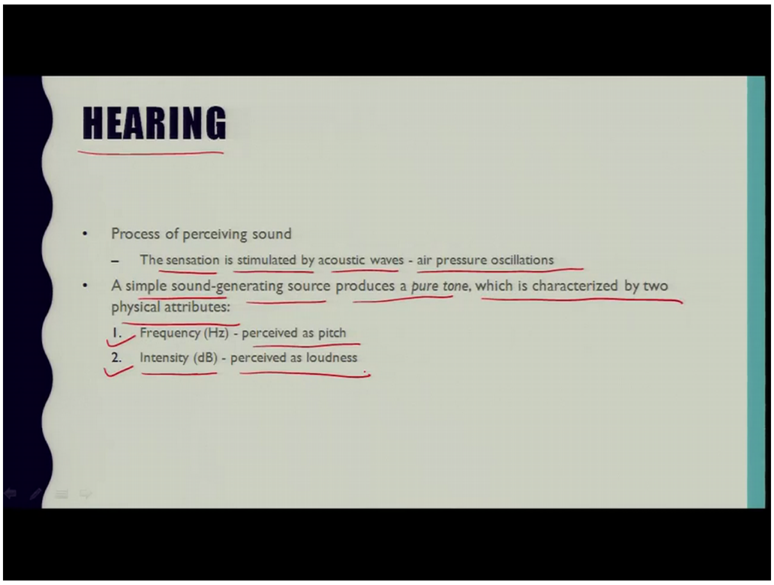

So, the first question, in fact, the answer is obvious that what is hearing?

So, hearing is the process of perceiving sound. So, whatever the sound waves are around us and if you are able to recognize that particular sound then it is hearing. So, it is the sensation that is a stimulated by acoustic waves air pressure oscillations. So, that is why, in fact, this mechanical energy is being a transmitted through the air by these special oscillations and simple sound generating source produces pure tone which is characterized by 2 physical attributes. So, basically there are 2 attributes of the sound that is a sound its sound frequency that is perceived as a pitch and intensity that is expressed in the decibel that perceived as a loudness.

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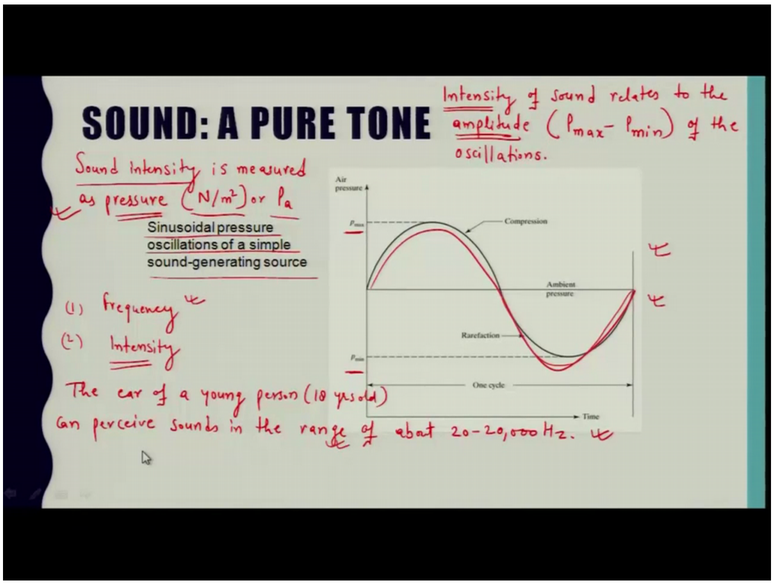

A simple sound generating source produces the sinusoidal air pressure oscillations that is illustrated in this figure. So, these are the sinusoidal pressure oscillations of a simple sound generating source, pure tone such as the that is showing been shown in the figure that is characterized by 2 physical attributes, first is frequency which is perceived in hearing as the pitch of sound and second is intensity of the sound, which is perceived by the listener as the loudness. So, the frequency of a pure tone is the number of cycles per second or it is also abbreviated as a hertz. So, this is one complete cycle so the number of cycles per second if they are passing. So, it is its frequency and that is shown in this figure also that the upper region is known as compression and the lower part of the oscillation is known as rarefaction.

So, in that the intensity of the sound relates to the amplitude. So, intensity of the sound is expressed in the form of amplitude of the oscillations and that amplitude can be expressed as a in the form of P max and P minimum. So, difference between the maximum pressure and minimum is its amplitude of the oscillations and 2 terms intensity and amplitude are often used interchangeably. So, this particular sound intensity is expressed in, basically the sound intensity is measured as a pressure and the unit can be there by taking as a Newton per meter square or Pascal, it is a very common units that you are aware of passenger engineer.

So; however, the range of the sound pressure is so large that is from the threshold of human hearing is about 0.00002 Newton per meter square to the upper limit of hearing at about 20 Newton per meter square. So, as the matter of knowledge that I am going to write one sentence that is a very useful information that is ear of a young person, let us say 18 years old can perceive sounds in the range of about 20 to 20000 hertz. So, in series with that if you want to measure the sound intercity so basically it the sound intensity is generally measured as a pressure. So, we have to define the sound pressure level to express the decibel, amount of magnitude of decibel that we have to if you have to measure. So, we have to measure with the help of this pressure level.

So, now we need to learn that how can we calculate the sound intensity which is measured in terms of pressure.

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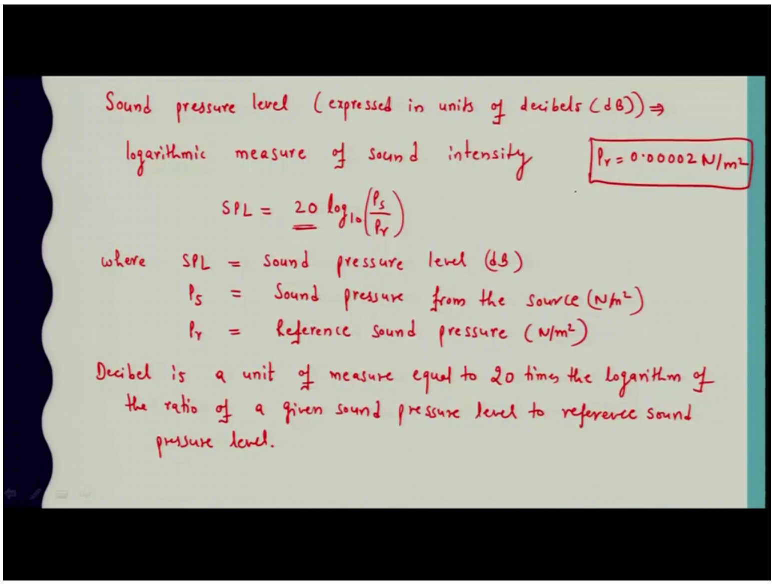

So, this sound pressure level which is expressed in units of decibel that is d B so it is expressed in the logarithmic measurement or logarithmic measure of sound intensity. So, the formula is SPL equals to 20 log base 10 P s upon P r where SPL equals to sound pressure level that is expressed in d B that we have mentioned in the first sentence of this is right and this p as equals to sound pressure from the source that is expressed in Newton meter square and P r is the reference sound pressure which is expressed in Newton per meter square.

So, as indicated in the equation and by definition as well this decibel is a unit of measure equal to 20 times the logarithmic of the ratio of given sound pressure level to a reference sound pressure. So, the usual a reference level is the threshold of hearing so which is taken as 0.00 basically four times 0 to Newton per meter square. So, this is the reference we often used to take while solving a particular problem. So, to account for positive and negative oscillations about the average atmospheric pressure value the sound pressure is averaged using the root mean square technique.

So, now we will try to learn that how can we calculate the decibel level that is a sound pressure level of a particular ah acoustic wave. So, just we will try to have one example and then we will proceed to understand the anatomy of ear.

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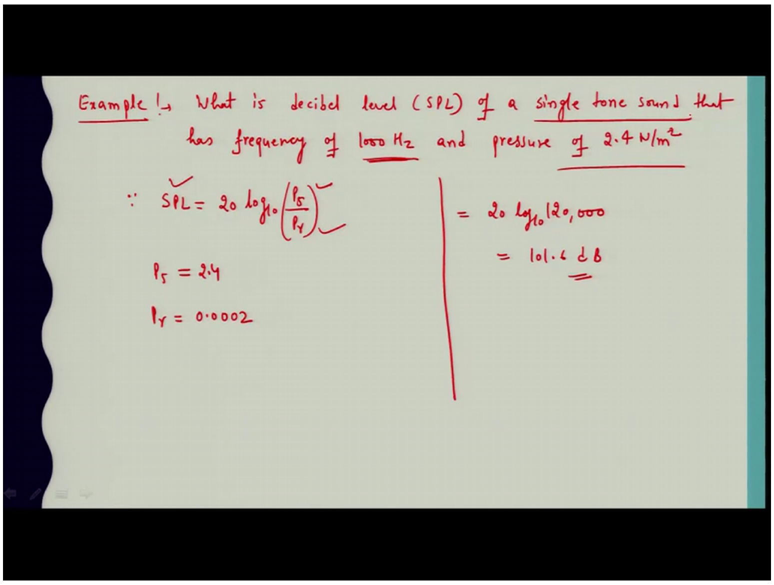

So, first we will solve an example like if you have to calculate the disable level of single tone sound that has frequency of 1000 hertz and pressure of 2.4 Newton per meter square. So, how do we calculate this? So, we have the formula which I have expressed in the previous slide which is sound pressure level can be calculated as 20 times log off distant and log of P s to P r.

So, now the value of the pressure source is P s is given as 2.4 and as a reference we have to take the value of P r as 0.000 to so as a method of fact that sound intensity is unaffected by the frequency although the perception of loudness may be affected by the pitch of source. So, our computation do not include this particular value and we will not considered this 1000 hertz in our calculation. So, only the things required to calculate SPL is P s and P r. So, in this we will calculate with the values that has been shown here. So, in this way we can calculate as 20 log base 10 and this will something will come out as 101.6 decibel.

So, this was all about the single tone sound, but most sounds are more complex than a single tone and include multiple frequencies and intensities.

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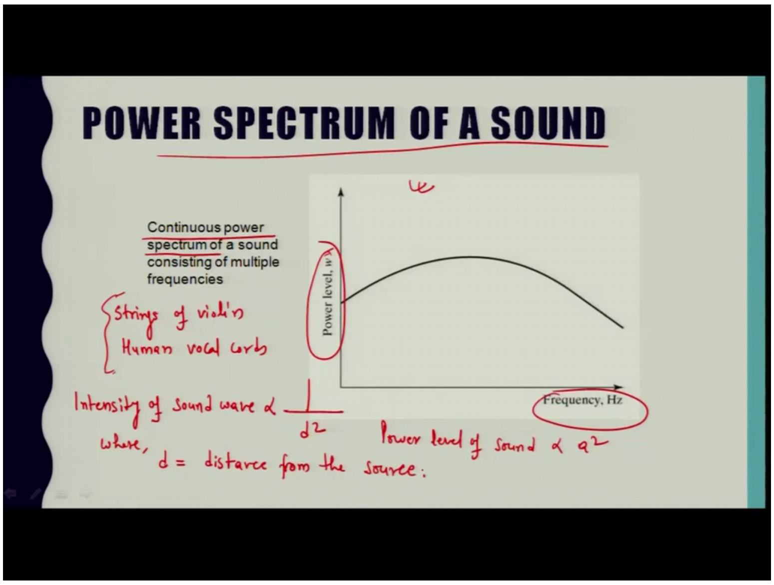

So, sound sources are basically a vibrating surfaces such as if you have seen the violin. So, strings of violin the dye from of acoustic loudspeaker or human vocal cord. So, these are the examples where the multiple tools are involved in one particular sound. So, human vocal cords. So, sound is also produced by turbulent fluid flow such as roaring serve or if you have a observed the police men's vessel that is also an example of sound containing multiple frequencies. So, that sound containing multiple frequencies and intensities can be plotted as a continuous power spectrum which indicates the power level and basically a, this particular graph is indicating the power level for various frequencies that make up the sound.

So, here the power level up sound is the square of the amplitude and as a general fact we know that intensity of the sound diminishes as the distance from the sources goes on increasing. So, the sound intensity is also measured from the listeners perspective and it is not the not a power measurement of sound source. So, the physical relationship is that, that intensity of a sound wave varies inversely as the square of the distance from the source. So, let us say if we are taking d as a distance. So, d is the distance from the source.

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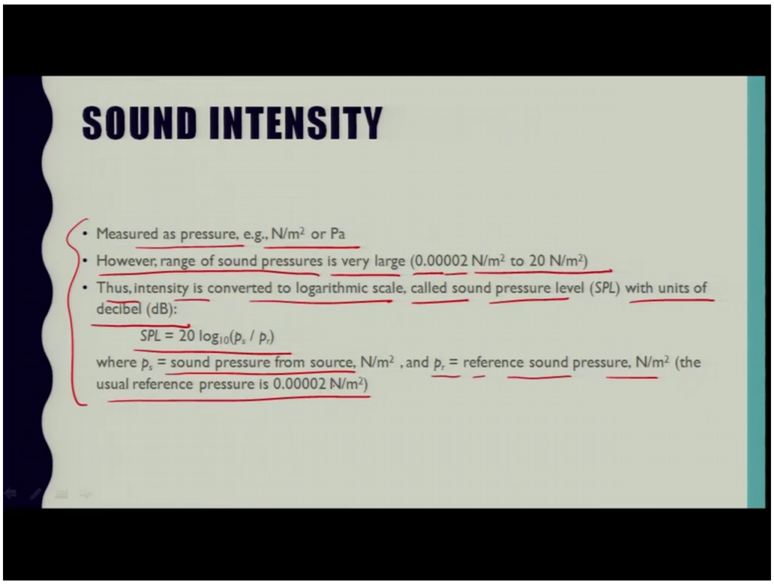

So, as a generalized way that we have covered in the previous slide just a brief summary of that so sound intensity is measured as a pressure which is expressed in the Newton per meter square and Pascal. Range of sound pressures is very large that is 0.000 to Newton per meter square to 20 Newton per meter square does intensity is converted to logarithmic scale called sound pressure level with units of decibel that is SPL equals to 20 times log base 10 P s upon P r where Ps is the sound pressure from the source and P r as the reference sound pressure and the usual reference pressure is taken as 0.4 time 0 to Newton per meter square.

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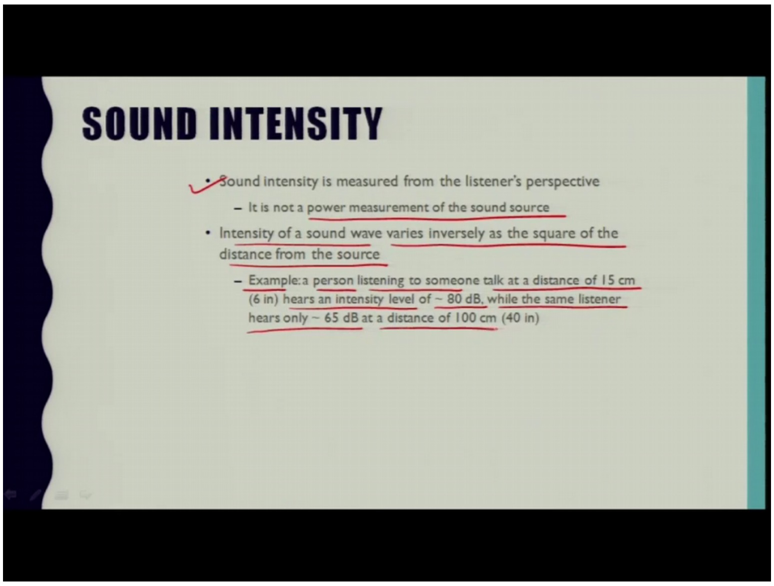

And the sound intensity is measured from the listeners perspective it is not a power measurement of sound source, intensity of sound wave varies inversely as the square of the distance from the source for example, a person listening to someone talk at a distance of 15 centimeter that is 6 inch hears and intensity level of 80 decibel while the same listener hears only 65 decibel at a distance of 100 centimeter.

So, with this it is clear that sound intensity is dependent on the listeners perspective. So, now, there is some defined decibel level for various sounds that we can we observed on the daily basis or while doing our job.

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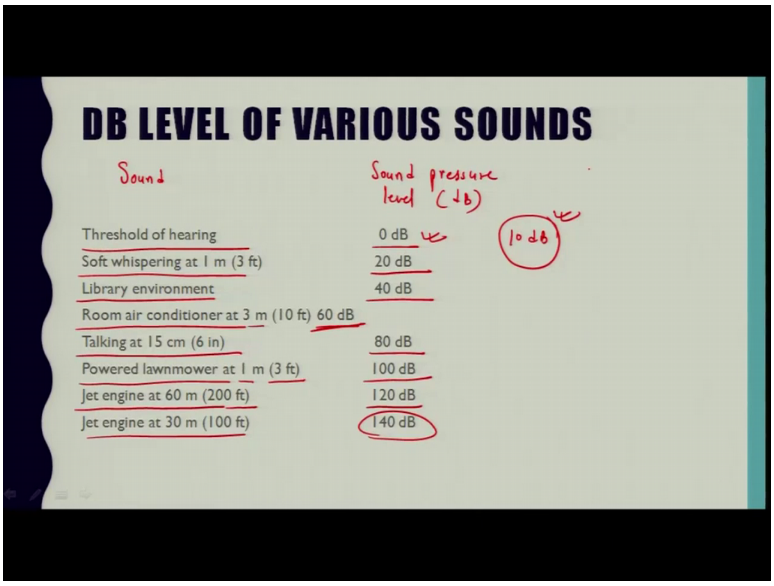

So, a proper control of the decibel level is required in order to create proper ambient for smooth functioning or for any kind of job performance. So, this is also ergonomical factor that the sound near us should be within a pressure prescribed limit. So, that it could not adversely affect the performance of a worker. So, here threshold of hearing is 0 decibel. So, basically here are the types of sound and here is the sound pressure level that is expressing in decimal. So, threshold of hearing is 0 decibel, normal breathing will give you 10 decibel very normal breath just a sound industry of 10 decibel is there.

If you are softly whispering at a distance of 1 meter or 3 feet sound pressure level is 20 decibel, library environment should be of a 40 decibel, room air conditioner at 3 meter it gives you the sound pressure level of a 60 decibel. If you are talking at 15 centimeter it is 80 decibel powered lawnmower learn more at 1 meter or 3 feet it is of 100 decibel, jet engines at 60 meter which is at 200 feet it will give you the 120 decibel and jet engine at 30 meter will give you the higher that is 140 decibel. So, although sound intensity is a ratio measure as indicated in the previous equation that decibel scale allows 1 sound to be compared to another sound as a difference rather than a multiple.

So, this was all about the sound, some sounds are there and their corresponding decibel levels at a given distances.

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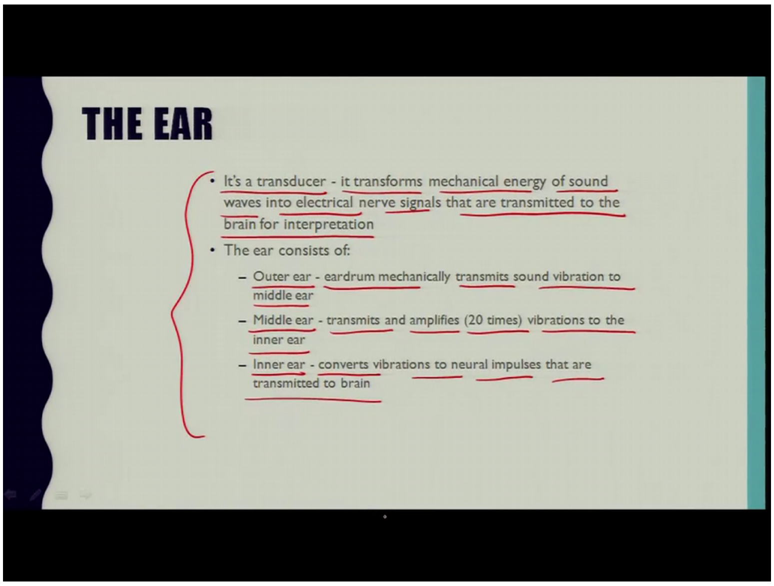

So, now we will discuss about the anatomian operation of the eye that as very much essential in order to make an ergonomics, ergonomist aware of the information processing system. So, in that ear is one of the important role playing. So, here we are going to start about understanding of the ear. So, ear is basically it is a transducer, what it does? Its basic function is to transform mechanical energy of a sound waves into electrical nerve signals that are transmitted to the brain for interpretation. So, to complete this function ear consists of 3 primary component first is outer ear, second is middle ear and third is inner ear.

This particular outer ear what it does? So, ear the mechanically transmits sound vibrations to the middle ear, middle ear what it does? It transmits an amplifies about 20 times vibrations to the inner ear and this inner ear converts vibrations to neural impulses that are transmitted to the brain.

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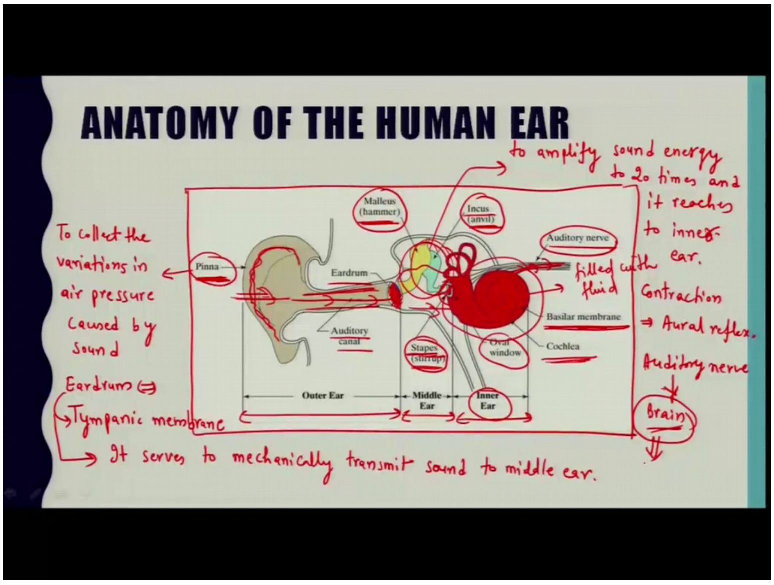

So, this is the whole anatomy of the human ear, here now we will try to understand the various parts of this particular human ear. So, this as you can see from this figure that outer ear is up to this and this is the portion of the middle ear and this is inner ear. So, this whole complete, it is the complete anatomy of the human ear. So, now, we have to understand the functioning of this the different component of the ear.

So, this outer ear consist of the pinna p i n n a and auditory canal and ear drum. So, this outer ear consist of 3 components this pinna auditory canal and ea drum, this pinna is the external part of the ear consisting of where is this random structures whose purpose is to collect the variations in air pressure caused by sound. So, this pinna the role of is to collect the variation in air pressure caused by sound and you will be thinking that why this irregular shape has been created in your ear. So, the outer side of the ear that is pinna its irregular shape combined with the fact that there are 2 ears also provide some sense of the direction from which sound is coming.

So, this particular irregular shape is also giving you direction that it is giving direction to the air pressure. So, in this way this sound is coming inside and that incoming sound is channeled through auditory canal to the eardrum. So, this is the passage through which this particulars incoming sound is approaching towards ear drum so this particular portion is ear drum. Now ear drum which is also called tympanic membrane so this particular ear drum is also called tympanic membrane, this is a very thin membrane that vibrates in response to the sound received which is coming through the auditory canal.

So, this is very sensitive and it serves the purpose of transmitting the mechanical sound to the middle ear. So, ear drum is also known as tympanic membrane and it also serves to mechanically transmit sound to middle ear, now this middle ear consists of 3 small bones called the hammer, malleus, incus that is as a anvil and steps that is instead up is also known as instead up to these 3 bones are the major component of this middle ear. So, the purpose of this particular chain that you are seeing is to mechanically transmit and amplifying the amplify the vibration of ear drum to the over window of the inner ear and this particular is the oval window, this particular thing is a oval window and inner ear is consisting of basilar membrane and cochlear.

So, because of the relatively large size of the eardrum the mechanical leveraging applied by this particular chain, the sound energy is amplified in this region. So, this particular and the hammer anvil and stirrup is used to amplify the sound energy up to 20 times and it reaches to the inner ear. So, in addition to 3 bones the middle ear also includes 2 small muscles that contract and response to intense noises, this particular contraction is known as oral reflex. So, the contraction happens when large sound coming to the middle ear. So, the contraction is known as oral reflex and it reduces the energy transmission to the inner ear, this particular middle ear is helping to protect it against the harmful and excessive loud noises.

Now, the sound energy is reaching to the inner part. So, the inner ear what is doing it is having a spiral shaped organ corgi cochlea. So, as you can see this red portion it is a somewhat is parallel in shape and that particular cochlear that begins at the oval window from here the spiral shape is begin to happen and this particular portion is known as cochlea. So, this particular organ is filled with fluid, is filled with fluid the mechanical action of the steps that is this on the oval window causes the fluid to vibrate and this vibration is transmitted to basilar membrane which is a thin membrane running the length of the organ.

So, when this because of the fluid vibrations the basilar membrane is stimulates sensory hair cells which are present along its length and those vibrations or in fact, this stimulation of sensory hair cells send signals to the brain with the help of this auditory nerve. So, the signal is being transmitted from hair cell and the sending neural impulses with the help of auditory nerve to the brain. So, auditory nerve is helping neural impulses to reach to the brain for further interpretation. So, different senses are responses, responsive to different frequencies and this allows the brain to make an appropriate interpretation of sound touch. So, in this way this particular anatomy has been covered and now I would like to end with this anatomy of the operation of the ear in the next lecture we will try to cover auditory performance as well as other sensory elements.

Thank you.