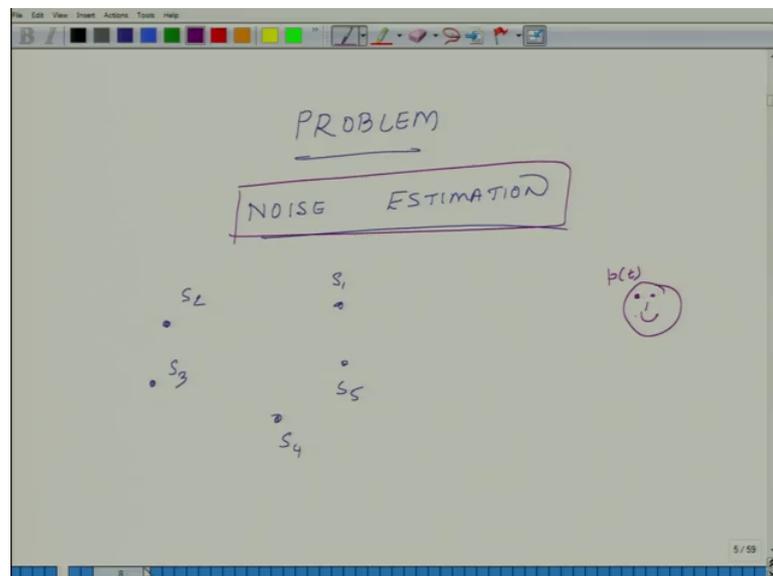


Noise Management & Its Control
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Lecture – 39
Noise Source: Terminology

Hello, welcome to noise control and its management. Today is the third day of the ongoing week which is the seventh week of this course and starting today, we will start moving in a different direction and over the next 2 weeks we will learn techniques through which we will be able to figure out roughly the sound pressure level at a point of interest due to the presence of different types of machineries now these machineries could be present either outside in a field or they could be present inside closed rooms. So, what is our problem; the basic problem which we are trying to address is noise estimation noise estimation?

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So, what does that mean suppose you have a closed room and you have all sorts of sources of noise. So, this is source one source 2 source 3 source 4 source 5 all these machines each of these machines is producing noise and I have a person here and we want to know what is the pressure level what is the pressure level at this location

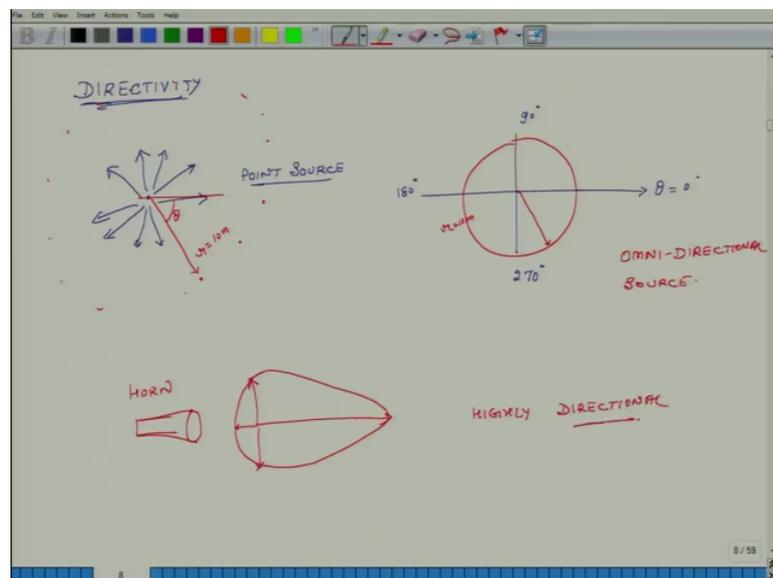
So, we have different machines and we know the distance between this source and this is a closed room we know all the details of the room how it looks like what kind of shape it

has what kind of materials it will be made up of and we also know what these machines are what kind of motors they have what kind of gears they have; do they have a fan, do they have a pump all this thing and based on all that we will try to calculate the noise level at this location.

So, this could be either inside a room or it could be also if there is no room and we are just outside let us say on a football field and on a football field we put a genset and some pump for making pumping out water from the ground and we are interested in figuring out what is the noise at this location. So, noise estimation that is our goal now before we start discussing how do we come to these estimates we have to learn one important concept because it will come very frequently when we are doing noise estimation and that concept is of directivity.

So, broadly we have already discussed directivity what it means, but now we will try to give a mathematical definition for directivity. So, so what does directivity mean?

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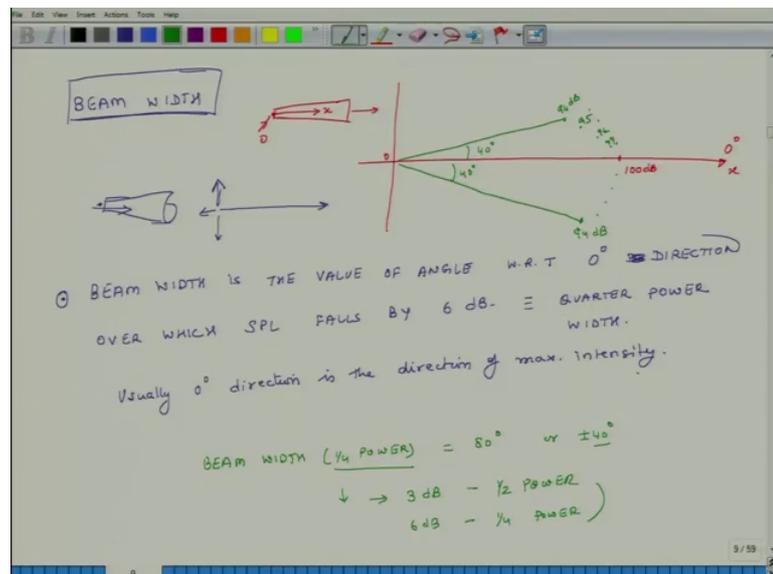
So, if you have a point source, it emits sound uniformly with equal intensity in all the directions. So, this is a point source it is a point source and if I; at a distance r if I measure this distance r using this angle theta. So, at a distance r if I plot the polar pattern, this is theta equals 0 degrees, this is 90 degrees, this is 180 degrees and this is 270 degrees and at a distance r, if I plot the sound pressure level. So, I can I can measure the sound pressure level at this location or this location this location like this you know at

different locations, but the r remains same then what I will find is that it is just a regular circle whose centre lies at this origin.

So, what this means is that? So, for this radius, let us say r is equal to 10 meters. So, for r is equal to 10 meters the amount of decibels which is expressed in terms of the distance from the origin it is same. So, it is a. So, this is an Omni-directional source this is an Omni-directional source, but you can have a different type of source suppose you have a source which is a horn you know a horn it is not a point source what will the directivity of this be like it will be the sound you would expect that the sound is going to be stronger in this direction and it will be weaker in this direction it will be stronger in this direction in the and it will be probably very small in this direction. So, if I make a directivity plot for this it may look something like this and this is just a very crude.

So, this horn; so, this is a horn this is highly directional. So, different types of sources could be either Omni-directional or they could be directional sources and what we want to do is now we want to quantify because later I mean we want to quantify how this directionality can be mathematically expressed. So, that is what we will discuss. So, there are 3 ways to quantify directionality.

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So, the first definition of directionality or quantification is through this term called beam width beam width. So, what does this mean? So, suppose we have a horn. So, you are blowing into it and it is producing this sound you will have louder sound in this direction

and lesser sound in this direction and maybe very small sound on the back in the negative direction. So, suppose this is our origin. So, what is this horn doing it is essentially throwing a beam of sound because the sound is not spreading uniformly in all the direction. So, for instance you have a beam of light; light is more intense inside the beam and then if you move away from the beam the intensity of the light is less.

So, similarly sound in this case as produced by your horn it is in a sort of a beam it is a beam of sound and we try to figure out how wide this beam is how wide this beam is. So, this is what is meant by beam width this is what is meant by beam width and we will make a more precise definition. So, suppose. So, what is; so, we will first define it. So, beam width is the value of angle with respect to 0 degree direction over which sound pressure level falls by 6 decibels falls by 6 decibels. So, this is actually known as quarter power width and we will explain all this quarter power width here usually 0 degree direction is the direction of maximum intensity. So, so again let us say there is a horn this is the horn and this is my x axis. So, this is. So, this is the origin. So, this is my origin and this is my x axis. Now when I blow the horn we would expect that the sound is going to be maximum in this direction right if you have right in line of the horn you will hear the loudest sound if you are away then the sound is going to.

So, suppose you are 10 meters away from the horn, it could be anything 10 meters, 5 meter whatever and 0 degree direction is that. So, that is what it means 0 degree direction is the direction of maximum intensity. So, first we have to figure out what is a 0 degree direction. So, this is the 0 degree direction. So, in the in context of horn it is along the line of the centre of the horn that is the 0 degree direction there the sound will be at the maximum level now let us say this is. So, this corresponds to let us say 100 dB, then I keep on measuring for different values of theta.

So, let us say this is 20 degrees, this is 10, 20, 30, 40, 10, 20, 30, 40; these are different values of theta and here what I find is that in the 10 degree direction it is 99 decibels in the at 20 degree angle, it is 90 eight decibels at 30 degree angle, it is 95 decibels, it could be anything and at 40 degree angle, it is 94 decibels.

So,. So, this is 94 dB, this is 95, this is 96, this is 99 and so on and so forth. So, this is 40 degrees and similarly it may be symmetric around 0 degree axis or it may not be depends on the source, but in case of horn it will be symmetric. So, this is again 94 dB at 40

degree angle. So, what does that mean that if I go away from 0 degree and 40 by 40 degrees the decimal value who falls from hundred to 94 and on this other side also when I go move by 40 degrees decimal value falls by 6 decibels the radius does not change the distance from the origin does not change the radius has to remain constant, then I will say that beam width and which type of beam width quarter power band width quarter power width is equal to 80 degrees or I can also say plus minus 40 degrees in this case 80 degrees or plus minus 40 degrees because the power level has gone down by 6 decibels.

Now, why do I call it quarter power I call it quarter power because when I go down by a factor of half that corresponds to 3 decibels and when; so, this is half power and when I go down by a factor of one fourth it is 3 plus 3. So, it is 6 decibels that is one fourth power. So, the beam width if I am using this quarter power standard is defined when the pressure falls by 6 decibels. Similarly there is half power bandwidth and in case of half power bandwidth it is the amount of theta you have to go from the 0 degree axis when the power falls by 3 decibels.

So, that is the beam width. So, this is the first way to measure directivity of a source a source which is extremely directional it will have higher bandwidth or lesser bandwidth not bandwidth it will have more beam width or lesser beam width, it will be lesser beam width it will be very sharp right. So, sources which are very sharp they are which are have they have very thin beam width Omni-directional in case of Omni-directional it does not make sense, but you can because you do 360 degrees and it still does not fall right, but as a source becomes more and more Omni-directional this beam width it increases as the source becomes more and more directional its beam width becomes more pointed and more sharp.

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DIRECTIVITY FACTOR (Q)

$$Q(f) = \frac{I}{I_{REF}}$$

IDEAL SOURCE \rightarrow produces N watts of sound energy.
 \equiv Ref. source $\equiv S_1$
 I_{REF}

I want to find out the DIRECTIVITY OF A REAL SOUND SOURCE. (N watts)
 S_2

$Q(f)$ will change with θ .

Normally we assign 0° direction to that orientation when I is max. and we usually measure $Q(f)$ in such 0° direction.

So, this is the first measure of directivity, the second measure of directivity is directivity factor by the way before we talk about directivity factor beam width it can change from one frequency to other frequency for instance a source could have be pretty much Omni-directional at very low frequencies especially if its size is very small compared to the wavelength, but at high frequencies maybe it becomes more and more directional. So, beam width let us call this bw is function of frequency it changes from one frequency to other. So, may be it will have a 40 degree beam beam width for 2000 hertz, but for 5000 hertz may be the beam width could be only 10 degrees, it could be that. So, it is important to understand that whenever we are talking about directionality or directivity it is very strongly dependent on the frequency of interest.

So, directivity is often also expressed as Q and again Q is a function of frequency and this is defined as the ratio of I divided by I REF and we will explain what this means. So, suppose there is a source located at this point x, let us say it is an ideal source it is an ideal source and it produces. So, it is a point source monopole and because it is a monopole it produces what kind of waves it is spherically symmetric waves. So, this source and ideal source is Omni-directional; it is Omni-directional and let us say. So, it is an ideal source and it is producing n watts of sound energy. So, each second it generates and sound and all this sound it spreads equally and uniformly in all the directions. So, that is my reference source. So, this is my reference source now. So, this is my source I

will call it S_1 and I am interested in finding out directivity factor. So, if my microphone is here at a faraway point and I am interested in finding out the directivity factor.

Now, what do I do? So, Q_d is called directivity factor it is measured by I and I_{REF} . So, if it is a point source then it will be Omni-directional, right, it will be Omni-directional now suppose I have a machine or a small sound producing object. So, I want to find. So, I want to find out the directivity of a real sound source. So, let us call that S_2 and let us designate it something like this some complicated shape S_2 . So, this reference source is S_1 .

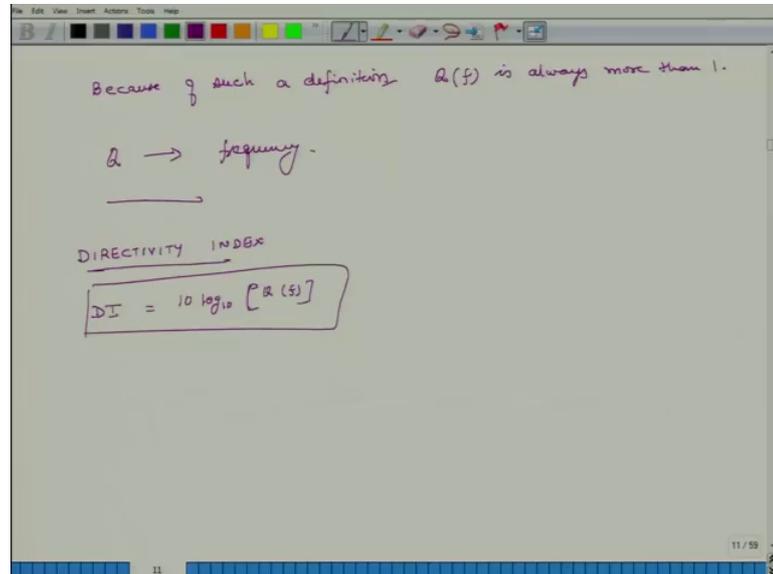
So, what do we do what we do is first I put my microphone at that desired location and at the place where S_2 is going to be located at the same location I first put an ideal source and I measure the sound intensity at this using this microphone. So, that gives me I_{REF} that gives me I_{REF} . So, I; you understand. So, I put an ideal source which is Omni-directional and at this microphone location I find out the pressure and using mathematical mathematical formulae I can calculate I_{REF} easily and then what I do is I replace S_1 by S_2 .

So, in the second step I replace S_1 by S_2 and then what happens the sound does not spread uniformly in all the directions. So, again I find the value of I and I calculate the ratio and I calculate and then that is how I figure out the value of directivity now this directivity will change it will change. So, this may be 0 degree direction this may be some other theta and. So, it will change. So, directivity Q_d will change with theta it will change with theta, but normally we assign 0 degree direction to that orientation when what I is maximum normally we do that when I is maximum then we assign that direction as 0 degree direction and we usually measure directivity in such 0 degree direction. So, what does that mean that if a sound source is Omni-directional then what will be the value of directivity it will be one it will be one because I intensity of the Omni-directional source and of this real source it will be the same.

Oh; by the way this real sound source should also produce same power level and watts. So, the total watts is the same. So, if I am in the; if the actual source S_2 is Omni-directional then my Q_d will be one if the source is not Omni-directional, but it is directional then Q_d will be more than one or less than one it will be more than one

because in the 0 direction I have the direction for maximum intensity and that will be always more than the intensity produced by an Omni-directional source.

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So, because of this; because of such a definition because of such a definition Q_f is always more than one. So, always more than one; so, this is directivity once again Q depends on frequency it is a function of frequency and the third parameter is directivity index. So, that is DI? DI equals $10 \log_{10}$ of Q_f . So, that is directivity index ok

So, these are the 3 ways to measure directivity one is through beam width second one is through directivity factor and if I just take the log of their activity factor and multiply it by 10, I get a directivity index. So, for an Omni-directional source what is the value of directivity index for an Omni-directional source directivity index will be 0 and directivity will be one for directional source directivity will be more than one and directivity index will be non zero. So, this and it because it is more than one what does that mean if it is more than one then directivity index will be what log of one is 0 log of anything more than one is a positive number right it is a positive number.

So, directivity index will be a non zero number and it will be also positive it will be a positive number. So, that concludes our discussion on directivity and starting next class we will start discussing the basic problem which we have talked about. So, or actually we will do one more concept as to how sound gets absorbed in air. So, that is the other thing we would like to learn and then we will start discussing about our basic problem

which is which is what we had described earlier this is the problem which we will try to address.

So, that concludes our discussion and I look forward to seeing you tomorrow till then have a great day, bye.