Acoustics
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Module 6
Sound in Public Spaces and Noise Management
Lecture 8
Lumped Parameter Modeling of Transducers

When we started this course we had made three broad classifications, physical acoustics which was essentially about how sound propagates in air or in medium in general from point a to point b, then we had also talked about electro acoustics that was another big category which concerns itself with transformation of sounds into other forms of energy or other forms of energy into sound. And the third big area was psycho acoustics.

How the mic the human brain interpret sound and then so that was the introduction then we talked in detail about or somewhat in detail about physical acoustics we went through this plane wave equation, one dimensional equation and Cartagena and spherical coordinates, interference of waves, stuff related to physical acoustics then we moved into the area of electro acoustics and primarily in area of electro acoustics.

What we have talked so far is how is sound generated in Engineer's systems, in natural systems sound gets generated we have not talked about that but in Engineer's systems, systems which human being is devices and designs how is sound generated so we have talked about that, today we will still talk about electro acoustics but we will talk we will focus more on how is sound received or recorded .

Because that is important to understand from an engineering stand point for two reasons if I have a sound of quote and quote of a different of a specific type (then we will figure) we will explain what this type means then what kind of microphones should I use that understanding has to be there, the second thing is which microphones are good or not so good in a particular application we have to understand that.

So today we will primarily talk about microphones we will not talk so much in terms of how microphones can be design but how we can intelligently use microphones which meet our needs so in that context we will talk a little bit about the design at a little detail level but not we will not go too deep into the detail and then we will also try to map different types of microphones into different types of application.

Microphones essentially measure pressure or in some cases they measure pressure gradients differences in them, so in general these are two big broad categories of microphones pressure microphones and then pressure gradient microphones and then there is a third category which are hybrid which work on the principle of a combination of both of these pressure and pressure gradient, so we will start with pressure microphones.

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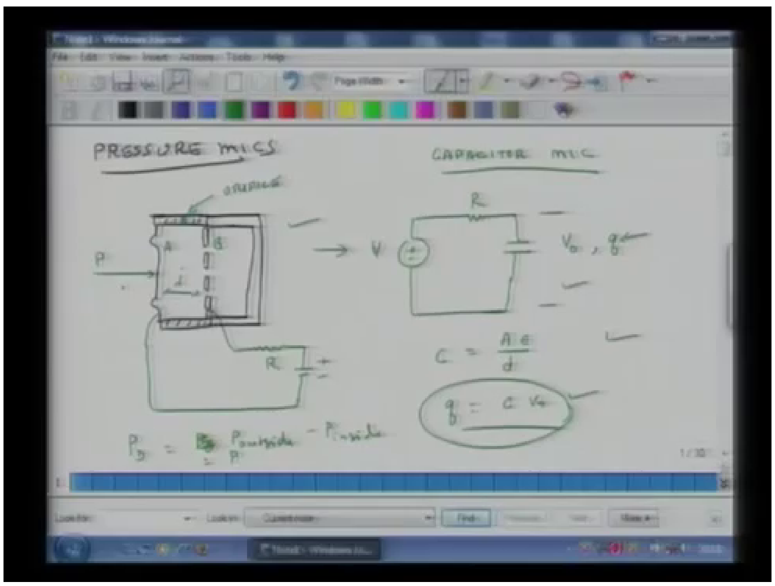

We will start with pressure microphones and within pressure microphones there are different types or categories of microphones there could be electro dynamic microphones, there could be condenser or capacitor microphones, there could be piezo electric microphones, there could be carbon microphones we will very briefly capture all of these but let’s start understanding how a pressure microphone works.

Essentially what a pressure microphone is, is that I have a casing and then I have a diaphragm which is attached to a suspension system, so this is my diaphragm this wiggly line represents the suspension system so the diaphragm can move in and out on the back side of the microphone now this diaphragm is could be metallic (or it could) it does not have to be metallic it’s a film, it’s a thin film on the back side I have a perforated surface.

Diaphragm in the back perforated surface they are electrically and then I seal this entire thing, also what I have is a small orifice here which is in green so I have diaphragm which is member a, I have a perforated screen which is member b, everything into an enclosed cavity and I have a small orifice which is here and my pressure wave when it hits it gives me a pressure it hits the diaphragm so the diaphragm receives some pressure ok.

The front membrane and the back membrane so what we are talking this is a particular type of pressure mic what we are seeing it's called a condenser mic, the front membrane and the back membrane are (conve) connected to a resistance which is very high in number, very high value of resistant and then I have a battery source which provides what I call polarizing voltage the diaphragm and the surface beam they are made up of dielectric materials.

So there they can store charge, electrical sense this entire thing looks like I have a dc supply a very high value of resistance and then these two flat plates are like capacitors, make a capacitor and what I measure is basically this parameter (wheel) v zero which is the voltage across is these two plates actually more often I measure the charge q, so these two plates they are separated by distance some nominal distance let's this distance is d.

So my capacitance is c equals area of the surface times permittivity constant over distance d right, now when a pressure wave hits it hit the diaphragm, the diaphragm moves in or if it is negative pressure then it moves a little bit out so what I am doing is I am sensing changes in this charge q and then I interpret that change in charge because my capacitance is changing right, my q is basically c times v not.

When capacitance changes charge is changing and I sense that change in charge and from that I interpret try to extract what is the pressure which the diaphragm is seeing so what I have drawn here is basically the electrical component of the circuit here also mechanical component of the circuit, you all have now the fundamentals to develop a mechanicals component of the circuit. Electrical and acoustics component merge into this thing and you can figure out.

When it sees a pressure p how does q change right, you can figure it out so I am not going to go into detail in that aspect but this is how the pressure microphone works (in a very) at a very basic level as you are developing the acoustic component bear in mind there is some cavity here so it has some springiness there is also a mass of the diaphragm, here also a stiffness of the diaphragm so all that has to be taken into a component.

When you develop the entire thing if you want to, someone may ask why do I have this surface be slotted and the essential reason for that is there could be some frequencies which may excite the resonance of surface beam, so then it does not behaves in a very controlled way so what the perturbations do is that they act as acoustic resistance so when you are developing, the acoustics are kept in into that resistive element and what that resistance does is it dams out the vibrations.

So this is capacitor mic, this is a capacitor microphone if my pressure goes up my charge increases linearly and what we see from this very simple analysis is that the change in charge does not depend on frequency is nothing which relates which is embedded in the frequency part of, frequency term is not embedded in this relations so q changes regardless if a pressure wave is hitting at 1000 hertz or a pressure wave is hitting at 50 hertz.

Or a pressure wave is hitting at 20,000 hertz if the value of that pressure is same q will change by the same amount so the response there's only one caveat that the size of this device has to be significantly smaller than the wave length of the frequency, wave length of the perturbation if I plot pd, pd is basically the pressure difference outside and pressure difference inside, inside it's atmospheric pressure because I have this small orifice.

Because when you move microphone from location a to location b you can take it in aircraft pressure can change, so I have the small orifice to make sure that the ambient pressure is same as whatever is the ambient pressure outside that is the purpose. So pd is basically p outside minus p inside right, which is basically p.

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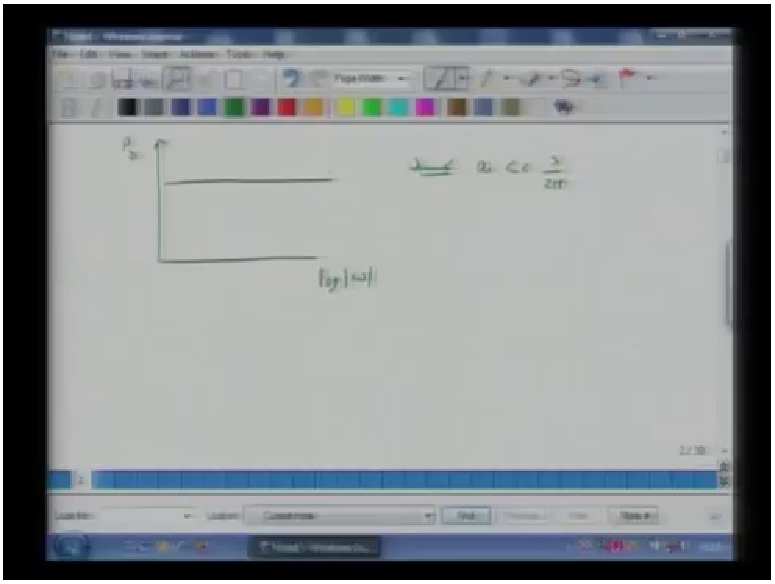

So my prop pd verses log of omega as long as my lambda my size of the object which I can represent. By this dimension a is significantly small than lambda over 2 pi then my response curve is a flat curve.

So a device of this type gives me of fairly straight response curve over I can make this range as much as I want by just discallation in the size of the microphone to whatever value I like so this gives a very linear response over an extended figures.

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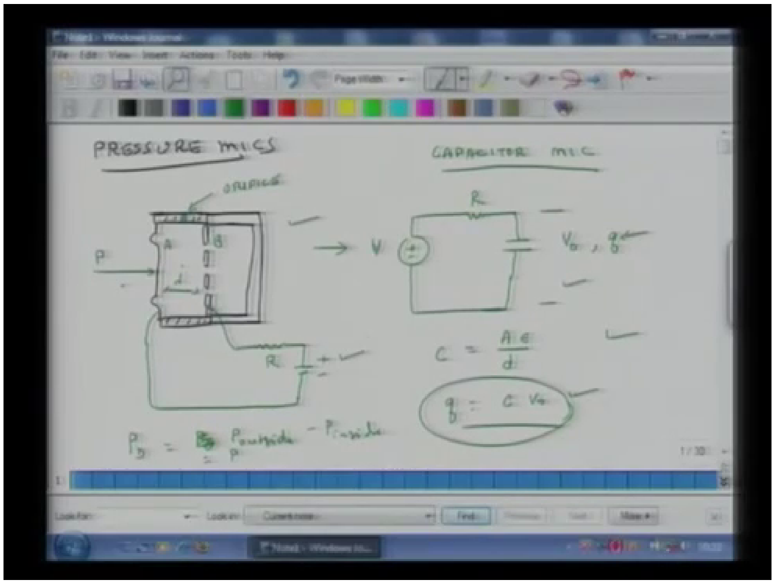

But because I have to have this charging battery in it, this is an expensive device. This is, I have to provide a polarization voltage and to make that happen that requires lot of money. So this makes things very expensive. Also the tolerance is required in construction of this kind of equipment are very tight, this particular type of a pressure microphone is expensive to make, so this is one type of a pressure microphone which is called a capacitor microphone (it will the) it will change with the vibration and what's it.

If I am putting a pressure regardless of whatever frequency it is let say it has a value of 5 Newtons per meter square then my member will just move in accordingly by same amount, rate of change in charge will depend on frequency but not the charge, but that's why we are measuring charge (so the rate) so ya we are not measuring current we are measuring the charge which is integrated quantity.

So that will not depend on frequency that's nothing, so they engineer diaphragm in such a way you cannot make the diaphragm also perforated so they have to, you have to engineer diaphragm in such a way that now as you keep on shrinking the size of the diaphragm to make things smaller to meet the frequency, it also automatically starts between more and more stiff but yes engineering diaphragms if you want to measure it up to 20,000 hertz.

The full band audio band then engineering it is not easy yes, so it's a very difficult thing but in theory you can make things as small as possible and in that will give you linear response, inherently in the mechanic subsystem there is nothing which says that the responsible beam not straight as frequency change, that's all. (So the second type of) so this is in a very broad sense this is a pressure microphone.

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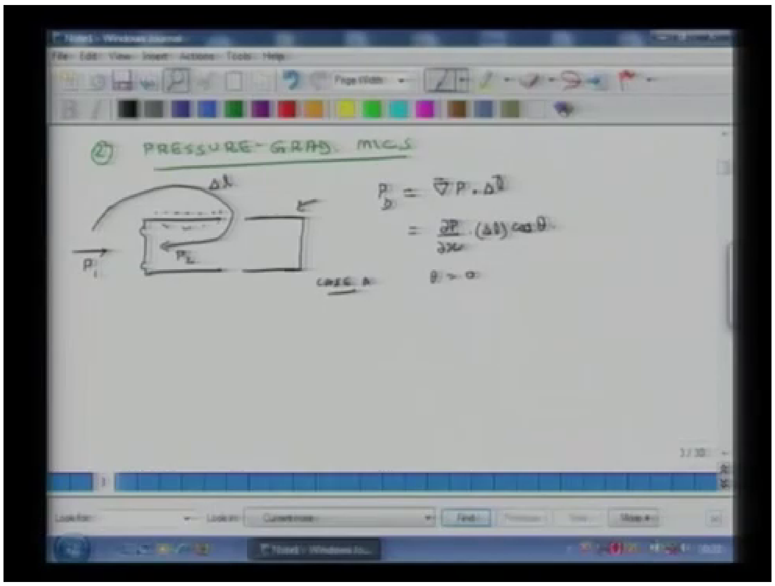

What we are measuring is changes in pressure the second big category is pressure, gradient microphones, these microphones are also called by some people is velocity microphones and we will see that a little later why they are called velocity microphones. In general the way these mics work is that you have again a tube so you have a diaphragm and here this kind of a tube which is not long now my pressure wave is coming from this side.

Let's say this is called p one this pressure and this has fairly wide slots so unlike a small orifice for equalization of pressure what you have here is a fairly wide gap which can enter into this tube or a cavity so the pressure can sound also travels like this and let say this length is delta l the length l so let say this pressure on the inside which is when it hits the diaphragm is p two sound travels delta l distance more for pressure p two.

Because it has to go inside and hit it so there's a change in pressure associated with some delta l so essentially what we are measuring here is the pressure gradient, so pd which is the difference in pressure is mathematically we can say gradient of p times delta l it's a dot product to these two vectors where p one is pressure outside the tube near the diaphragm, p two is pressure inside the tube near the diaphragm, delta l is the distance difference in distance travelled by the two waves.

And it's a dot product because when you have a gradient it's a vector and it has some directionally associated with it. So this delta l has to be aligned with that gradient so this is essentially del p over del x constants if I am only in thinking about x direction times delta l which is scalar times co sin of theta, yes but we have to take it's dot product so in this case if the direction of p one is same as this length of this length.

Then basically literally the delta l will be this length plus this length right twice that (())(18:08). So now what we will do is let's look at a scenario when this whole device is at an angle from p one and let say what it does to us in this case which is case a theta is zero.

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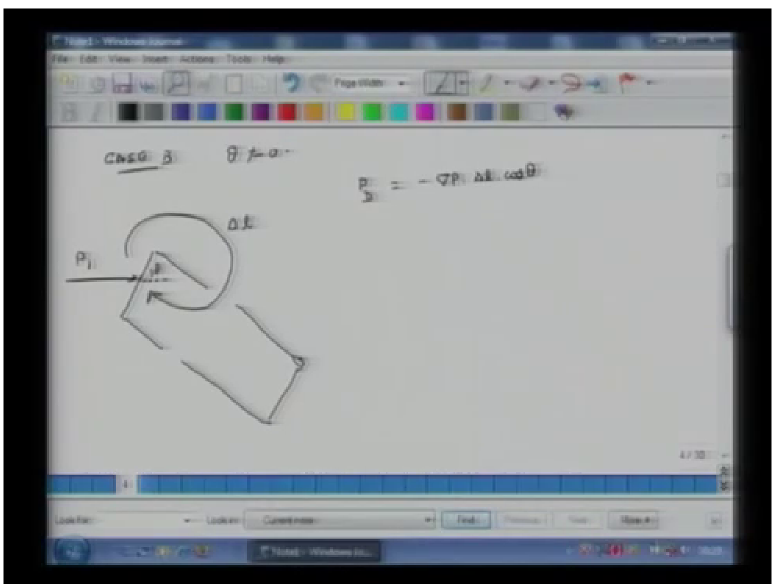

But what we will look at it is another scenario so case b theta is not equal to zero, I will have to make a rather long big drawing is so that things are visible.

I have to make a gap that's my p one my delta l is associated with this path, this angle is theta my pressure difference is minus gradient of p times delta l times co sin of theta.

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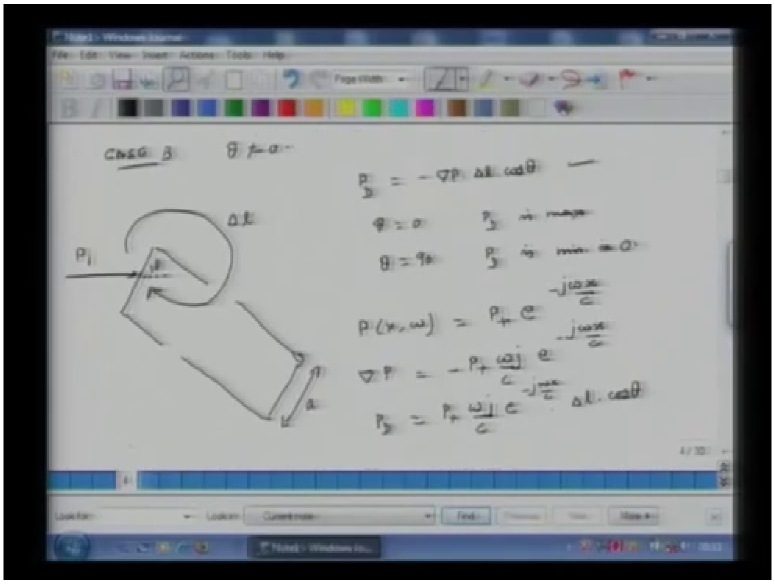

Why did I, I have negative gradient of p because I mean if I look at it physically if p two is larger than listen I have to define a coordinate system, this is my coordinate system so going forward is positive x if p two is larger than p one then the displacement in the membrane will be negative x direction right.

So for positive gradient p I have negative x so that's why I have a negative delta p so pd is minus delta p times delta l times co sin of theta, again the standard things that the size this, this dimension a has to be small compared to the wave lengths we are going to measure all that has to be cleared for theta equals zero pd is maximum for theta equals 90 degrees pd is minimum which is zero, so in this kind of a contraption I am measuring the movement of the membrane.

Which is basically a consequence of the difference in pressures attributed to a delta l so that's why it's called a pressure gradient microphones, p p now x omega is p plus e minus j omega x over c, I am assuming in this particular relation that I have a forward travelling planer wave, there's nothing with no reflection happening. So this now p negative term. So gradient of p is minus p plus omega j over c e minus j omega x over c.

So my pd is minus I am using this relation minus gradient of p so its gives me so minus minus terms become a positive p plus omega j over c e minus j omega x over c times delta l times co sin of theta.

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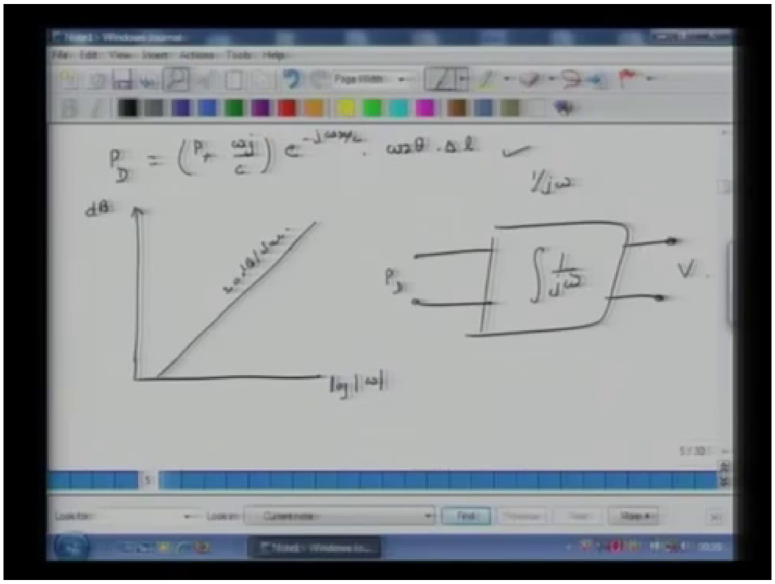

So I will just rewrite this relation pd equals e plus omega j over c e minus j omega x over c times co sin of theta times delta l, so if there is no reflection when basically p one is same as p plus right, if I am trying to plot pd and I do a boat plot.

So I have a log omega here I am plotting decibels for pd how will the curve look like for a given value of x the question is see at this point x is defined wherever my wave is hitting the microphone x is defined so x is not changing theta is not changing, for a given value of x and theta if I change the frequency how does pd change what will be the curve look like it will be a flat line or positive slope, negative slope what will it be.

It will be positive slope omega there is nothing positive here, negative here, will be something like this right, ya and this will be some I think it will be continued, so that’s my transfer function so clearly this is not a, so for different frequencies if I am measuring pd for the same amount of pd same magnitude of pd if I measure it at 100 hertz the signal measured in terms of voltage when the membrane moves will be one.

If I measure it at 1000 hertz which is a decade apart the signal measured will be 20 decibels less right, because of this relation so I don’t like this and that is coming essentially because of this omega j over c term, how do I get rid of this term what I can do is I can integrate this line, so omega j over c goes away so (e) I can multiply this by one over j omega so the omega term goes away or in electrical terms they use this word called integrator.

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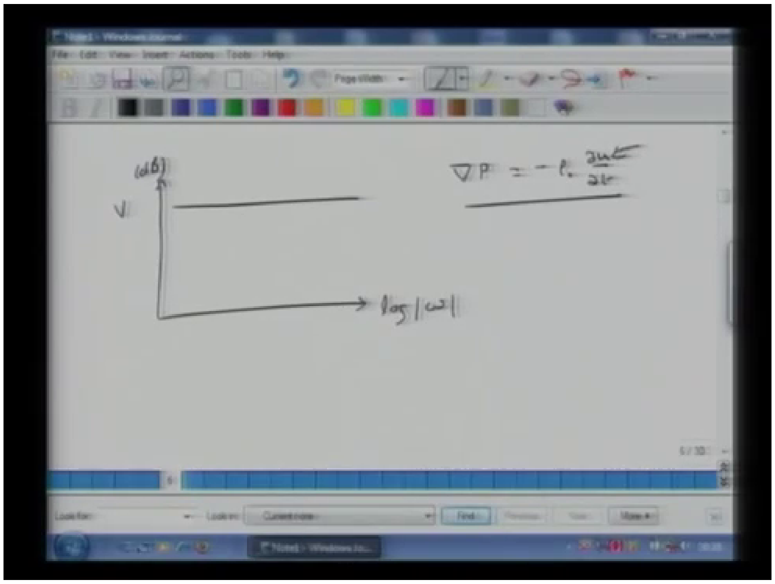

So my input is pd and whatever voltage I am getting is after integrating it so I get rid of this so once I integrate it my response curve becomes, how will be the response curve look like if omega term goes away so what will happen it will become a flat straight line right, Shailendra did you get it, x is fixed all what I am plotting is the transfer function of pd with I am plotting a transfer function of pd with respect to the incident wave.

So this e minus jx term gets eliminated so I get a flat straight line, I am being a little sloped yes so this is voltage so I get a flat straight line so this is how pressure gradient microphones (they are also called pressure gradieve) they are also called velocity microphones because we know that from Newton's law I think this is the relation right, so they are also measuring basically velocity.

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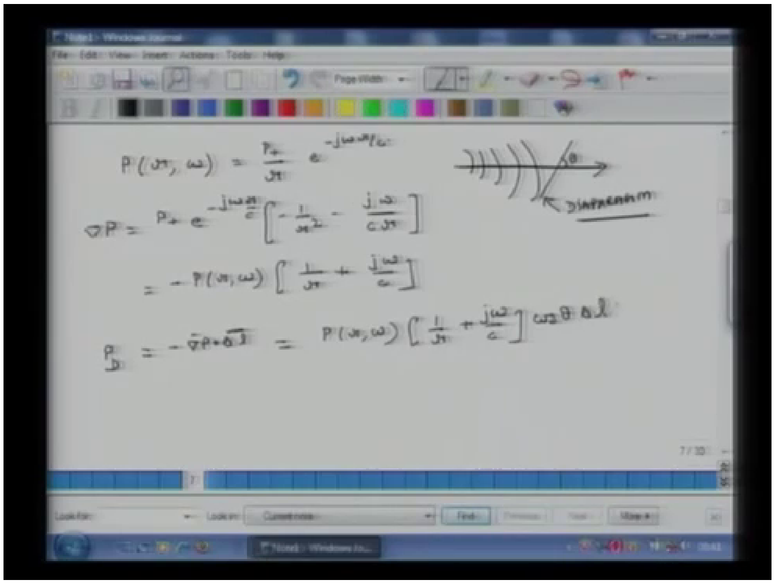

Especially after you have done the integration, that's why we are called velocity microphones but in the truest sense they measure pressure gradient, this is the response for a plane wave and once I integrated this is the response for a plane wave of a pressure gradient microphones, but in real application suppose I am speaking and it goes you it may not be a plane wave (you may be) you don't know whether it's a plane wave or it's a spherical wave.

So let's also see how it responds this kind of a contraption how it works further spherical wave so for a spherical wave the wave front forward going without any reflections wave front is p plus over r e minus j omega r over c and let say my wave front is such these are spherical waves in this direction in the orientation of the diaphragm is like this, this is my diaphragm so my gradient of p is what p plus e minus j omega r over c times minus 1 over r square minus j omega over cr.

Which I can simplify as minus er omega times 1 over r plus j omega over c so my pd which is the difference in pressure is minus gradient of p times delta l is the dot product which is pr omega times 1 over r plus j omega over c co sin of theta delta l.

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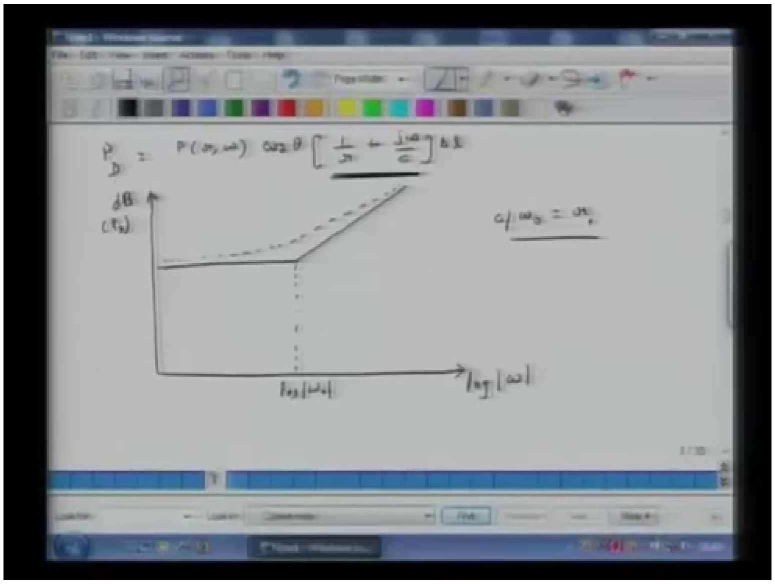

So I will rewrite this because I am going to do a board plot here is pr omega co sin theta 1 over r plus j omega over c delta l if I plot in decibels because of this particular term how will my board plot look like.

This is log omega this is decibel for pd, a board plot has a low frequency accent rode and a high frequency accent ode what is the low frequency accent ode going to look like, it will be a flat line and the high frequency accent rode it will have a positive slope perpendicular (28:59 to dot product) and the actual curve will look something like the cross over point will be such that this is log omega not where omega not is equal to r.

C over omega not equals to the (referen) wherever I am placing the microphone and how far it is from the spherical source that here I have still not integrated now here in hardware either you integrate it or you don’t integrate it, so in case of plane waves I had decided to integrate it because it gives me a flat response so let see what it does in this case;

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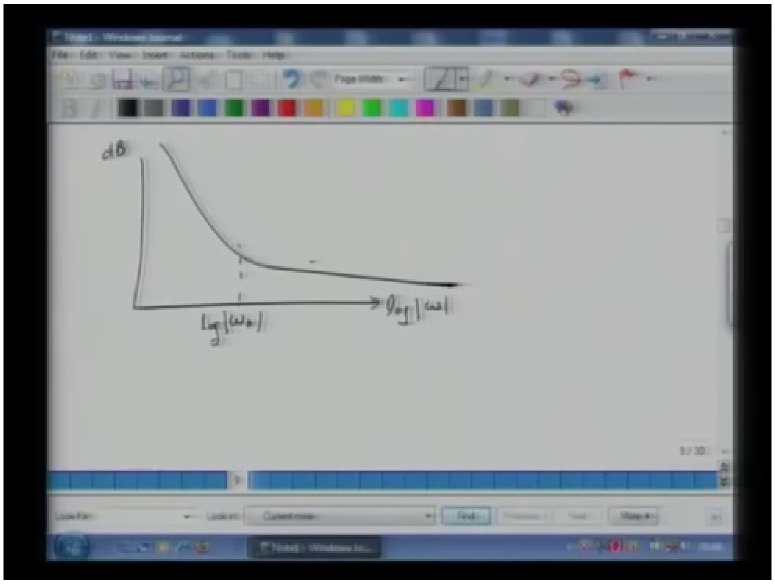

So once I integrate it basically my actual response curves looks like this. Basically the way you get it is you divide this whole bracket it term by (omega) j omega so this is again my decibels log omega this break point which is going to be somewhere here is going to correspond to omega not, above a certain point it starts between flat, I mean this is going to be an accent ode I should more careful something like that becomes fairly flat but at low frequencies you see is (())(30:33)

The other thing we have not talked about is that there is a cosine theta term in both the spherical as well as the plane wave expressions what that means is that if my microphone is placed in the direction of the incident wave it will see maximum amplitude if it is placed at 90 degrees it will see zero value.

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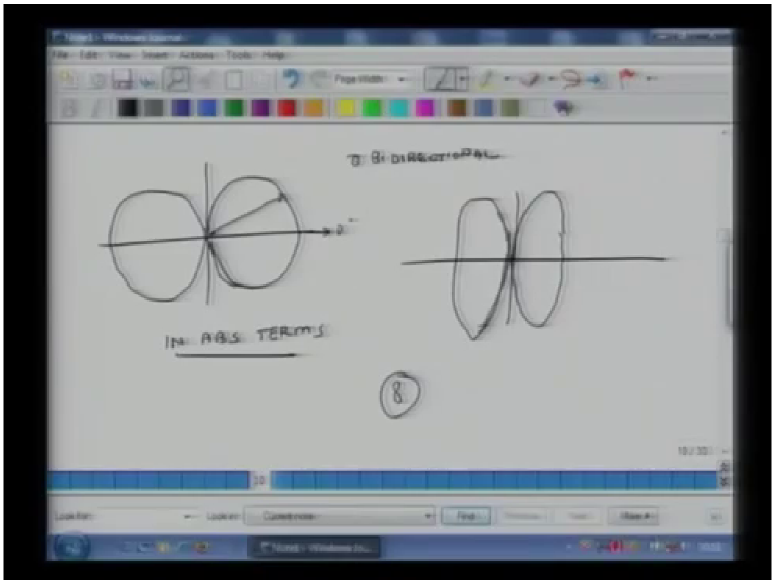

So I draw a polar plot and on a linear skill the curve looks like this these are suppose to be equal circles. If this is a back drawing but these are suppose to be equal circles. So this is zero degrees the radius represents the magnitude, I don't want to confuse this, this length represents the magnitude.

So at zero degrees the microphones will be very sensitive to incident pressure waves at 90 degrees (it will have) it will not record anything and (at minus 9) at 180 degrees it will again start recording at maximum level, so the response here is by direction that is the first thing.

Other thing is that in most of the cases (you hardl) unless you are really really far away from (a ray) a radiating you know single source (in most of the) unless you are really really far from you know point sources suppose I am speaking unless you are really far away from me this point source acts as a spherical source we have talked about it earlier so in most of the cases a microphone measures sounds immunating for point sources.

With act as (radiate) readily propagating sources and what that means is that if I place this microphone very close to the source what will be the measurement it will faithfully record high frequency data because the response curve is flat in this zone.

But it will record low frequency information at a higher decibel level, now when I play the same sound track in reality suppose I am speaking my low frequency sound.

Or you know information gets recorded at a higher decibel level high frequency (get regard) gets recorded at (33:29 code and code normal level) when I play the same sound track again I will sound like a person who has more base, this is a trick a lot of singers use that if they want to have a lot of their heavy voice they use this trick, they use these kind of microphones and place microphone very close to their mouth you may have seen it like that.

Actually a base enhancing technique also a lot of discussions when you hear on radio you will see that you will feel that the person who is speaking he has a very heavy voice it's because of this artifact of machine, so this is the polar plot in absolute terms and if I plot the same thing in decibel terms the polar plot looks a little steeper, it looks like a butterfly something like this because the shape of these pictures is like a figure of eight.

These microphones are also called figure 8 microphones this is in general cordless, so we have talked about microphones which measure pressure, microphones which measure pressure gradients

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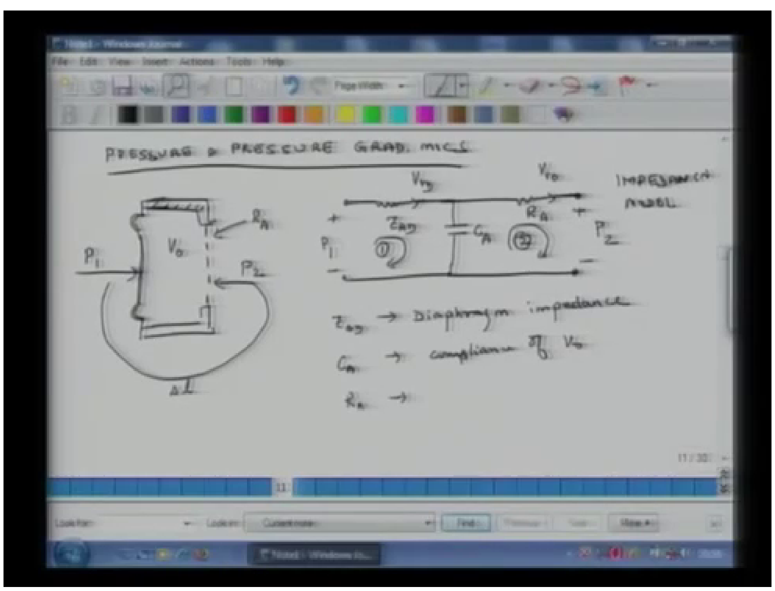

Now there is a third category which rely on both so these are called some guys call it pressure gradient microphones type two but that's not a very popular term but it's pressure and pressure gradient microphones.

So the construction looks something like this so again I have a diaphragm, so I have a suspension system this is suspension stiffness here in these two wiggly things there is a fairly rigid diaphragm and then there is a cavity of volume v not which is filled with regular air and on the other side I have a perforated screen which offers an acoustic resistance ra my pressure wave hits air in the pressure p one and the same pressure wave hits on the other side at a level p two.

And that length is delta l so I can construct a simple 4 point network for this for just the electrical acoustic portion of this thing so this is called Zab I will explain what this terms mean this is ca this is ra pressure so Zab is the overall impedance offered by the diaphragm ca is associated with the compliance of this cavity of volume v not, ra we have already defined it's acoustic resistance p one is pressure outside the diaphragm, p two is pressure just outside the screen.

And this is what kind of model is this, is this impedance model or mobility model because my pressure is the across variable. So let say my volume velocity which the diaphragm is seeing is vvd and volume velocity which the screen is seeing is vv not, two relations here vvd. So I am basically considering this loop, loop one and then there is another loop, loop two ok.

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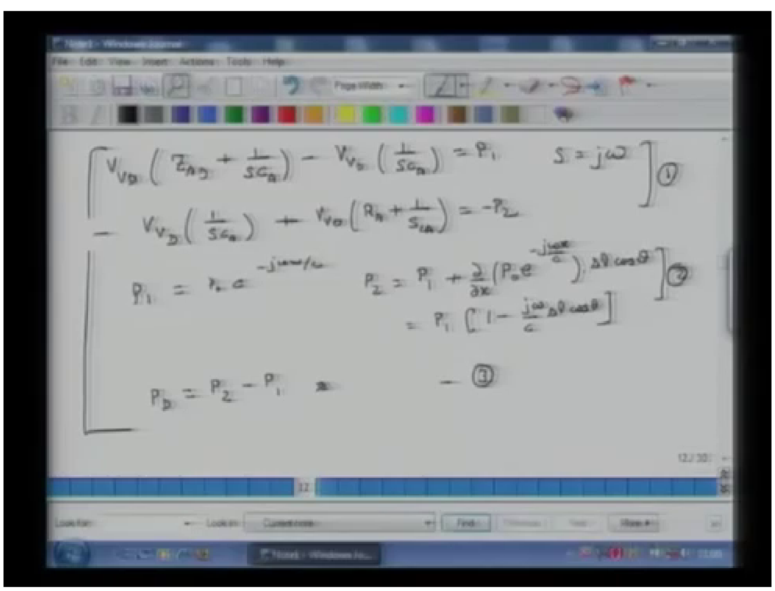

So my p1 is vvd times zad plus vvd times 1 over ca minus vvo times ca right so I will write that relation vvd times zad plus one over sca minus vv not times one over sca equals p one s is my (comple) j omega and similarly for the second loop my relation is vv not excuse me vvd times one over sca plus vv not acoustic resistance plus one over sca equals minus p two, so let say this is my re ration one.

So if I know p one and p two then I can figure out vvd and vv not, I know everything else in these two relations so what I will do is in next equation set of equations I will try to compute what is p one and p two, so p one is my incident wave p zero e minus j omega x over c I am assuming again flat one dimensional wave without any reflections and p two equals p one plus del over del x p not p minus j omega x over c times del l co sin theta.

So this becomes p one, one minus j omega over c del l co sin theta, so now I know p one and I know p two I can plug these in one, this is equation two so if I do so I can from two I can figure out what is vd and vv not and I also know that pd equals p two minus p one pressure difference between the two sides of the system and so this is there.

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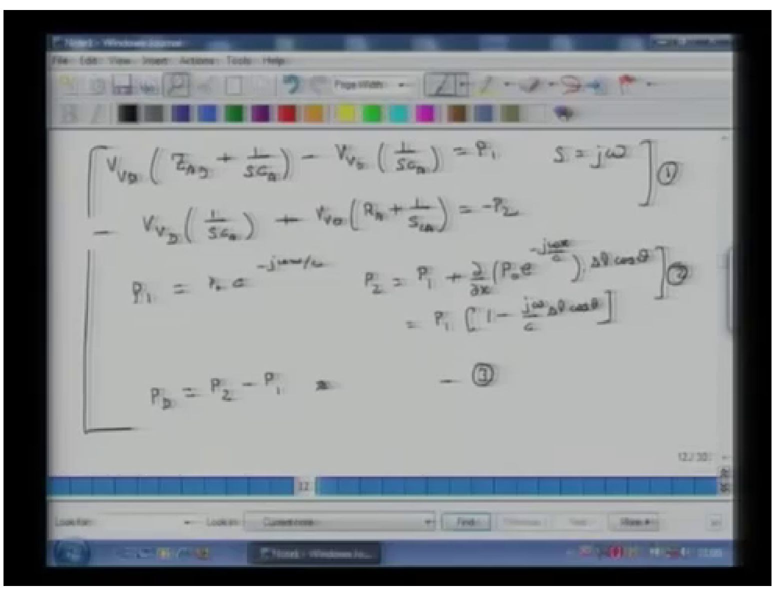

So if I do mathematics with all these three equations at the end of the day I mean this is just regular math.

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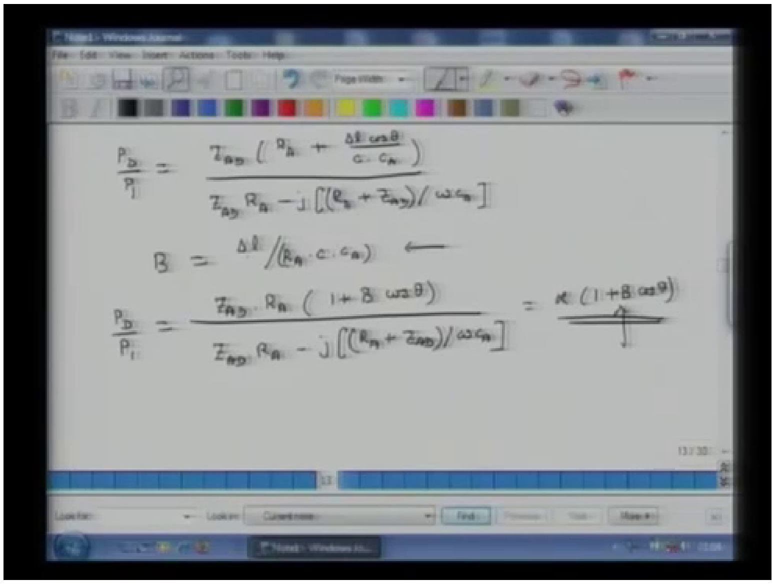

I can find the ratio pd over p one is this is a long term zad times ra plus del l co sin theta over velocity of sound times acoustic compliance the entire thing divided by zad times ra minus j ra plus zad divided by omega ca so you can play with these three relations to get pd over p one and you end up getting this thing now just to make things (little) look a little simple I define a quantity b such that b is delta l over ra times c times ca.

So my pd over p one becomes zad times ra one plus b co sin theta, alpha one plus b co sin theta where alpha is this entire term besides one plus b cos theta, so in case of a pressure differential mic we had just co sin theta in the term here we have one plus some constant times co sin theta, so pressure differential mic was by directional just because of co sin theta terms, here I have the flexibility to play with b.

B is basically delta l ra I cannot change c velocity of sound but I can change all other parameters delta l ra and ca and depending on a how I change it I can change the directional pattern of this (pressure) pressure and pressure (da) this combination mic in whatever way I want it to be within the realm of feasibilities.

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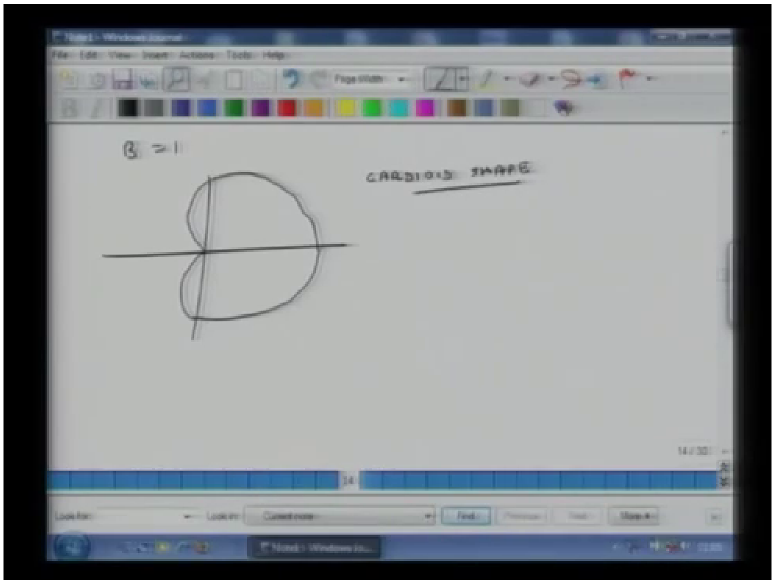
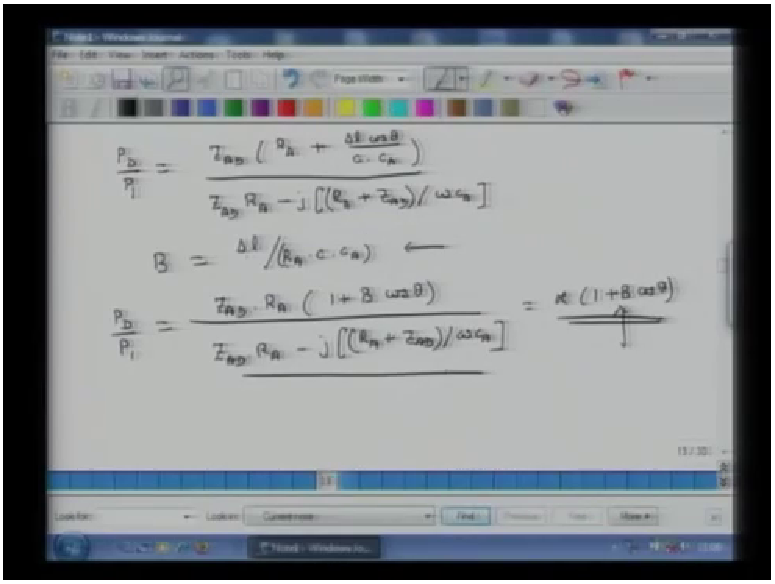


Let us assume that let say that b is one we can assume we can construct a mic with specific parameters such that b comes to one.

So in that case my polar pattern looks something like this, some day I have to take a class in drawing, this is called a cardio edge, so you get different form factors for this cardio edge shape based on how you play with b, essentially what this shows is that if I have mic winding towards you it will sense your sound and if I am opposite you behind the mic it will not sense my sound, so this is also a directional mic.

But I can change the shape of this by playing with b. (In differe) I mean to a certain extent so we have seen a pressure mic how it operates and what kind of features it has then we have seen a pressure gradient mic and then combination of pressure and pressure gradient mic, ((Refer Slide Time: 45:57)



I forgot to mention one thing that why is this called a combination mic or a pressure plus gradient mic and the reason for that is that in the process when we are developing this entire relation somewhere in the middle,

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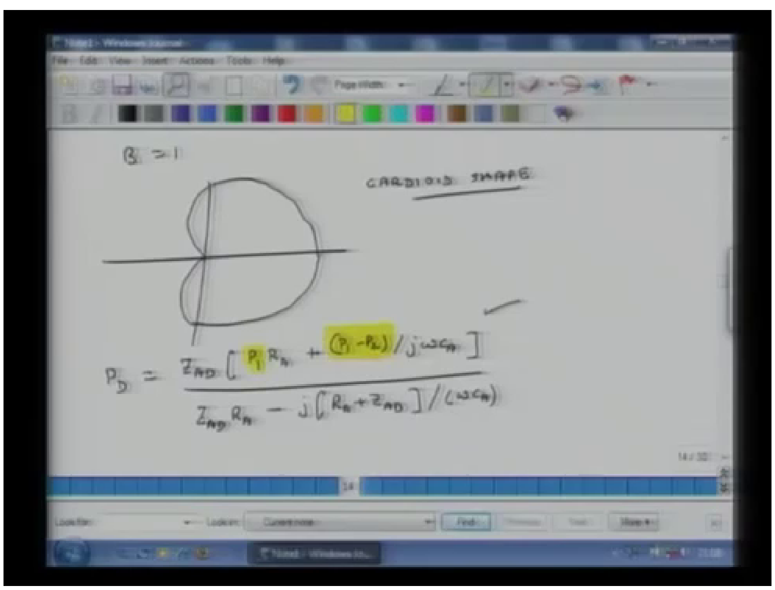

we will come across a term where pd will be something a longish expression zad p one ra plus p one minus p two over j omega ca, basically if you the way you get this is if you solve for v and v not and then find pd from there you get this relation.

And what this shows is that pressure differential is a function of depends on p one minus p two and it also depends on p one, that's why it's combination.

So from a mathematical stand point this is what I wanted to cover today so now in next (25) 20 to 25 minutes what we will do is we will just in a subjective sense we will go over we now understand at a basic level how different types of mics works how based on their designs they can be directional in specific directions, so based on that what we will do is we will discuss different type of microphones and how they are relevant for specific application.

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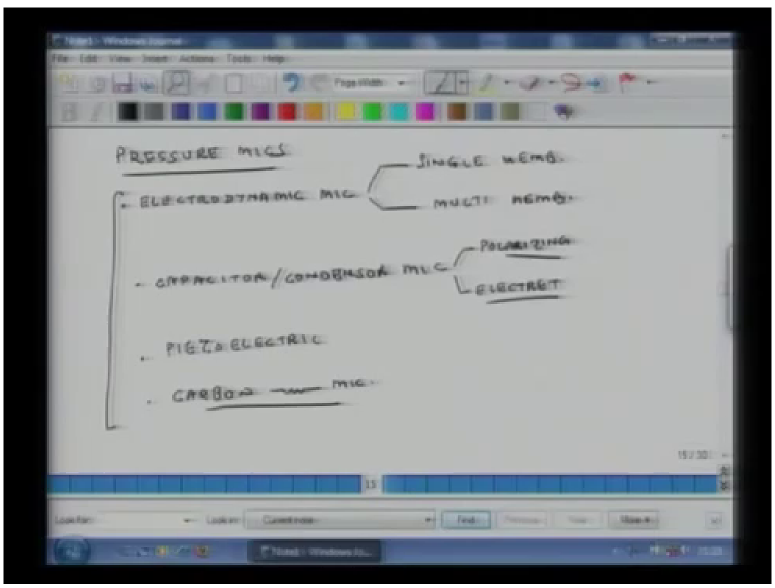

We have pressure mics and they are to three four broad categories, one is electro dynamic mic, (an electro dynamic) so in pressure mic they have several categories first one is electro dynamic mic think about this if you have a transducer a speaker which we discussed in last several lectures instead of exciting it with a voltage if I don't excite it with a voltage but I just throw sound energy again.

So a pressure waves hit the diaphragm what will happen the diaphragm is going to move and that will induce current in the voice well right that is how an electro dynamic mic works, it's basically an inverted acoustic transducer, some people also call it moving coil microphone because the coil is moving, an electro dynamic mic can have one membrane but a membrane if it is this large it will have its own modes (which will be) which can be below a certain threshold.

So some mics some more fancy mics of electro dynamic category they have several membranes to get our extended frequency response for the system so this itself can be single membrane and then multi membrane, this is fairly commonly used mic because it is a pressure mic is it Omni directional or is it bi directional or in one direction, it's an Omni directional senses pressure doesn't matter how the mic is oriented right.

It will just sense the pressure at that point it's not sensing pressure differential, (in theoretical) from fairly theoretical stand point it should not have sensitivity to direction see you have a microphone like this in all it is sensing is pressure acting on this membrane, (so if I) pressure acts in all direction set of point right, pressure gradients are direction specific, if I make it like this pressure is still acting inside.

Electro dynamic mics are fairly Omni directional so if a place of an Omni directional mic and there is a crowd they can doesn't matter where the person is sitting if you have a round table discussion you put a microphone in center, people all around it their sounds would be picked up by the microphone also by nature of their construction these microphones are resistant to moisture which is an important thing.

So and they are fairly an expensive tooling so they are very widely used, the second one is capacitor mic or condenser mic, we discussed this earlier today right where we are actually measuring the charge on the capacitor now within this there are two types polarizing and non polarizing or others also call it electret, so in polarizing we have seen in the earlier part of today's lecture you have to put an external battery to provide a initial charge.

Polarizing charge across the two capacitive place that makes things very expensive the polarizing type of mics big are failed very accurate and also they have a very flat frequency response because when we did a very basic analysis we saw that the relationship between pressure and omega is of a flat line right, by the way electro dynamics mics may not have a flat frequency response as flat as capacitor slash condenser mics.

Because as we saw the response of a regular speaker it's not flat it has different bands, so electro dynamic mics behave in terms of frequency response similar to speakers we were on polarizing mics, now electric mics they do not have a charge provided by an external battery source rather what they have is that the two parallel place are essentially made of dialect materials and they have charge deposited on them to begin with.

How do they do it, what they do is that when the thing is being made you take a dielectric material and then it is heated up when things are in heated state above a certain threshold the (polarizing) polar molecules in that dielectric materials they can move back and forth so they heated the polar molecules have a propensity of freedom to move and orient themselves and in such a state they apply the manufacturing process.

Such that an external electrostatic field is applied, so you have a positive and negative so you have a positive and negative and electrostatic field is passing through between the field you placed a film which is made of dielectric material in a heated state so these polar molecules orient themselves accordingly ok, in that state then the thing is full so then the molecules own revert back to whatever are the orientations.

So then you have a permanent charge build up on both the plates we have a positive charge and negative charge build upon both the plates so that makes things less expensive so because of this electric mics probably today are the most popular microphones in the world so they are really cheap and this can be mass reduce because basically a lot of these films are like pieces of plastic cheap plastic and they deposit charge on them through this process.

A drawback of these is this that over a period time this charge starts dissipated because of heat, moisture and other but again (these are also have) these also buy from a theoretical stand point they have a fairly flat frequency response if you make them small enough you can enhance the frequency spectrum of the microphones to as much as you want we are very reliable they are still not as good as the polarizing type of microphones.

And it's not that you cannot make these microphones as good as the polarizing microphones but when you are doing a large scale production processes you have to maintain bigger tolerances because production process have wide tolerance they want to have as wide tolerances possible so once you make things in very large volumes the quality or the fidelity of an instrument goes down.

If you make one at a time and pay a lot of attention to every single piece you will do a better job. So because of that reason because they are mass reduced, in general they don’t have as higher quality as the polarizing microphones but again they are Omni directional and these guys are used in a lot of applications, is a microphone here setting here in this tablet in your cell phones you have an electric most likely you have an electro mic.

Computers almost all places where you have you need very small microphones these things are setting here ok, so that is condenser the third one is piezo electric, again this is also a pressure mic but what it does it senses pressure by due to when pressure gets exerted the crystal generates a voltage that voltage is sensed so that is a third category,

The fourth one is carbon resistance, this is a kind of (())(57: 09) term but earlier specially (in non) in lot of analog telephones you would have these mics and the way they operate is there is a small button in the device which is packed with carbon granules as the pressure wave hits a surface of this button it presses.

So the resistance of the carbon granule changes accordingly in some predefined way that’s resistance change is sensed by uh the electronics and that it’s recorded or converted into some. So it was used a lot in old (telephone) type of telephones fairly those black telephones you may still see some of them black and all and also in recording industry they use it. So this is these are four major types of pressure microphones.

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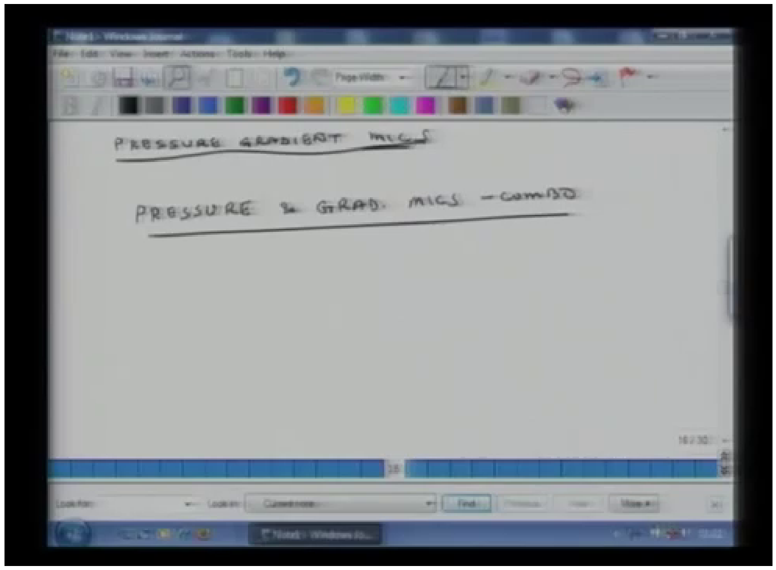

Electro dynamic capacitor, piezo electric, and carbon let's look at pressure gradient mics ok, these are directional we have seen through the mathematics specifically they are bi directional.

So at zero degrees and 180 degrees they have maximum response at 90 degrees the response is virtually zero given that if you have a public address system and the requirement is that the microphone should be able to pick up the voice of let say the speaker and the voice of the crowd which is on front side you know people tend to use these type of microphones, so it's depends on the nature of the requirement.

While these microphones are used you have to pay more attention to the frequency spectrum you have to pay attention even in pressure mics I mean what is the frequency band but here we saw that the frequency spectrum is booming at low frequencies and flat at high frequencies so one has to be careful as I mentioned earlier lot of singers also use it for the special features that these microphones tend to produce more booming sound at low frequency.

And then the third category we talked about is pressure and gradient mics combo. So again here you have the advantage of directionality and these mics as a special gradient mics again both these are very frequently used in broadcasting systems because of the directionality feature in auditoriums suppose you have play happening on the stage or you have a bunch of singers you don't want this noise or the sound of the audience to get picked up by the microphone right.

So you will use a combination of some of these types of microphones.