Fundamentals of Acoustics
Prof. Nachiketa Tiwari
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture - 39
Interference of Sound Sources - Part III

Hello. Welcome to Fundamentals of Acoustics. Now we will extend this discussion further.

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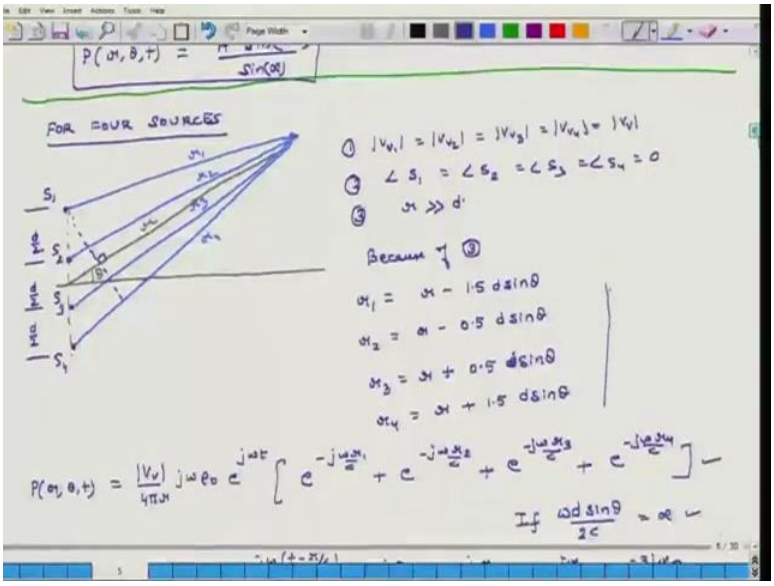

So, here I had 2 sources, now let us see what happen when I have 4 sources. So, first let us define the problem. So, I have 4 sources S 1, S 2, S 3, S 4; the distance between each of these is d over 2 and then there is a median line and these sources are S 1, S 2, S 3, S 4 and these are the distances. And I am interested in finding the pressure at a far field point. So, from S 1 the distance is r 1, from S 2 the distance is r 2, from S 3 the distance is r 3, and from S 4 the distance is r 4. And if I connect all these points, then the distance from the median line to the point of interest is r, and this angle is theta. So, here we say that volume velocity magnitude of V v 1 is same as volume velocity magnitude V v 2 is same as magnitude V v 3 is same as magnitude V v 4 is same as some common number V v; and also phase of S 1, is equal to phase of S 2, is equal to phase of S 3, is equal to phase of S 4 and this is equal to 0.

So, for such a situation first we will write down the expressions for r 1, r 2, r 3, r 4; r 1 is equal to again how do I calculate r 1? I draw perpendicular and so this is first assumption, second assumption is phases are 0 and the third assumption is r is extremely large compare to d by 2 or d. So, given the third assumption we can say that r 1, r 2, r 3, r 4 all these vectors are parallel to each other and the relation between r 1 and r 2 and r 3 r 4 is something like this. So, because of 3, r 1 equal's r minus 1.5 d sin theta, r 2 equals r minus 0.5 d sin theta, r 3 equals r plus 0.5 d sin theta and r 4 equals r plus 1.5 d sin theta.

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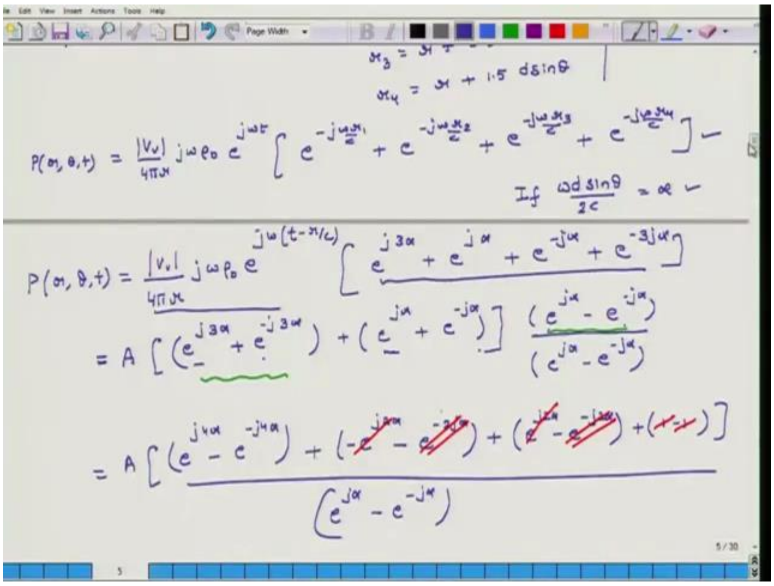

So, the pressure at point t which is p is a function of r theta and t will be the sum of pressures from all these 4 individual sources. So, the contribution from each source is V v divided by 4 pi r times j omega rho naught, times e j omega t and in the brackets it is going to be e minus j omega r 1 over c plus e minus j omega r 2 over c plus e minus j omega r 3 over c plus exponent minus j omega r 4 over c. Now in this relation we substitute expressions for r 1, r 2, r 3, r 4 and we can take r outside the bracket because it is common.

So, what I get is P r theta t is equal to V v divided by 4 pi r j omega rho naught e j omega, t minus r by c and in the brackets what do I get? I get so if I define if d sin theta over c omega d sin theta is equal to alpha, if I define it like this and I plug this relation and these relations into this overall equation, then what I get is e to the power of j 3 alpha plus e to the power of j alpha plus e to the power of minus j alpha plus e to the power of minus 3 j alpha. So, this is defined as A and in parentheses. So, I will reorganize this, I will call it exponent j 3 alpha plus exponent j 3 alpha, but there is a negative here plus exponent j alpha plus exponent minus j alpha.

And what I do is again multiply and divided by a common term which is e j alpha minus e minus j alpha divided by e j alpha minus e minus j alpha. So, one I do the multiplication what do I get? There are 4 terms here 1 2 3 4 in the larger bracket and 2 terms in the smaller bracket in the numerator. So, I will get 8 in different terms. And if I do all the mathematics correctly what essentially I get is, e to the power of so first what I will do is I will multiply this by this entire thing.

So what I get is, e to the power of j 3 alpha times j 4 alpha j alpha is exponent j 4 alpha and then when I multiply 3 alpha now minus 3 alpha with minus alpha I get minus exponent minus j 4 alpha. And then I get if I multiply 3 alpha with minus alpha, I get minus e j 2 alpha and if I multiply with j alpha I get e j 2 alpha and if I lets step back a little bit otherwise this will be too fast. So, I multiplied e j. So, this is 4 alpha minus e to the power of minus j 4 alpha, then when I do the other multiplication, I get minus e to the power of j alpha minus e to the power of minus 2 j alpha and then I get a third bracket which this is e to the power of j 2 alpha minus e to the power of minus j 2 alpha, and then finally I get 1 minus 1. And in the denominator I get e to the power of j alpha minus e to the power of minus j alpha. So, in this 1 1 cancels out, this e to the power of j alpha cancels out with this term and this term cancels out the other term.

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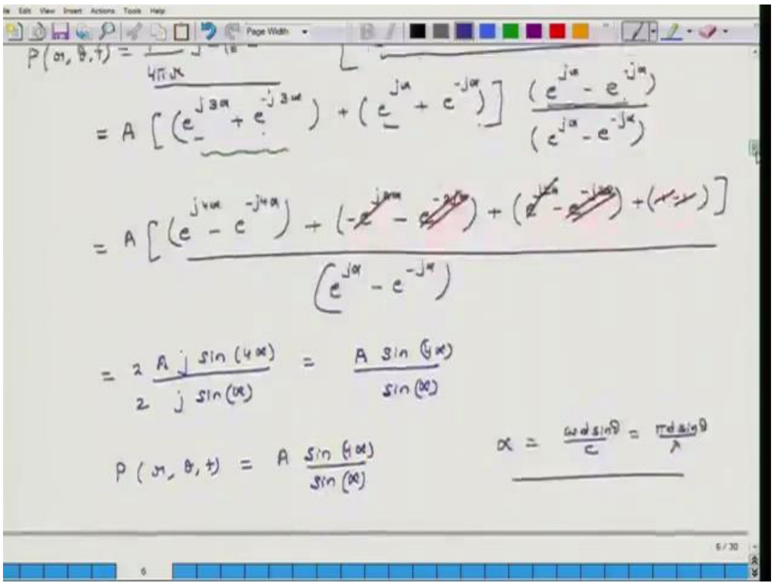

So, I can left with A j sin 4 alpha divided by A j sin alpha and of course there is 2 there. So, 2 j 2 j cancel out and I am left with A sin 4 alpha divided by A sin alpha. So, if there are 4 sources, then pressure at a point P is equal to A sin 4 alpha divided by sin alpha and what is alpha? Here alpha equals so it defined earlier, it is omega d sin theta over c and if you replace omega by so this is actually 2 c and if you replace omega by 2 pi f, then this becomes pi d sin theta over lambda. So, that is the definition of alpha and in this expression A should not have been in the denominator that was by error so that is the expression.

So, what we have done is, we have developed expression for 2 sources and 4 sources; similarly we can develop expressions of 6 sources 8 sources and so 8 sources and so on and so forth. So, in the next class we will actually generalize this relationship and then we will see where does it take us.

So, with that I am concluding our discussion for today and we will meet once again tomorrow, and continue our discussion.

Thank you.