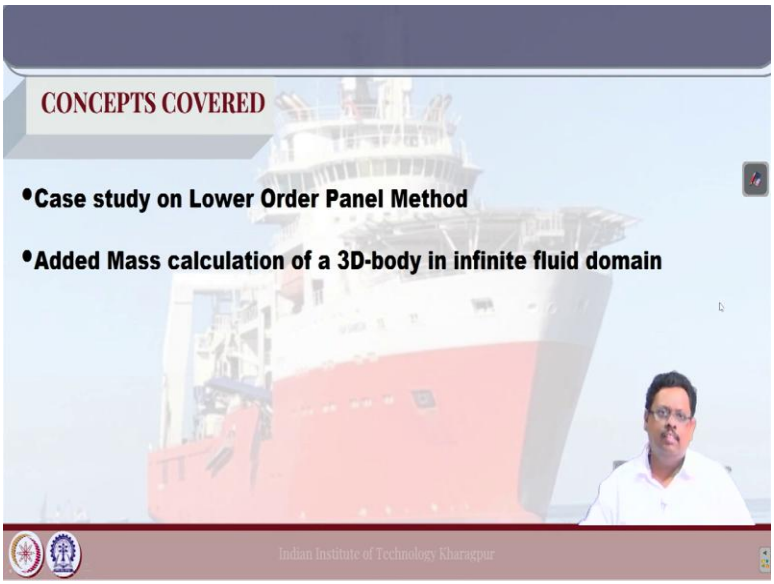
Numerical Ship and Offshore Hydrodynamics
Prof. Ranadev Datta
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Lecture - 18
Case Study

Hello. Welcome to Numerical Ship and Offshore Hydrodynamics.

(Refer Slide Time: 00:22)

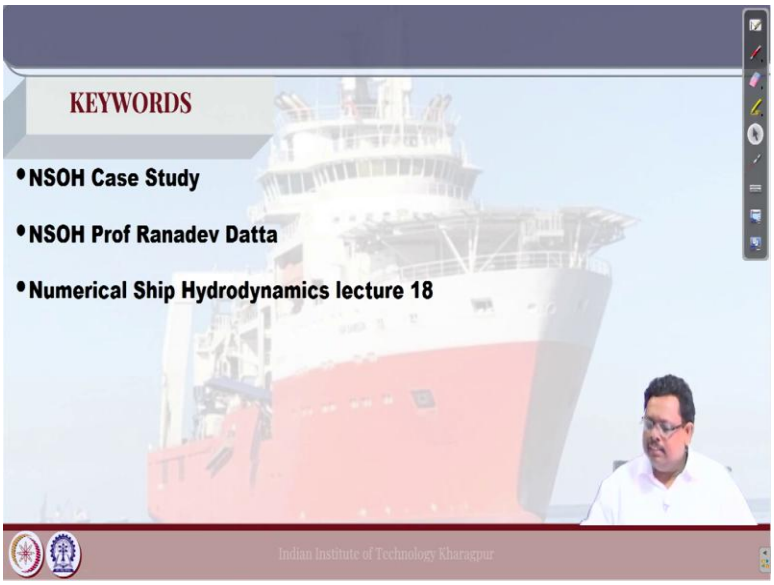


So, today we are going to discuss something called in a Case a Study on lower order panel method. So, if you remember in the last class we have discussed hypothetically I would say in more general way how to solve the radiation problem in infinite fluid domain. However, I see in my class that when actually you are try to code it then you will find many difficulties you will find many difficulties there are several challenges of coding the phase and that actually you know they do not get the solution so quickly.

So, what I decided to take a case study I take a general body I mean this particular take a body three dimensional body and then let us discuss how to proceed to write the code because it is very much expected in this particular course that you end up get getting some idea about how to code this problem. Because this course is numerical ship hydrodynamics if you do not code this then probably you do not get the full flavor of this course.

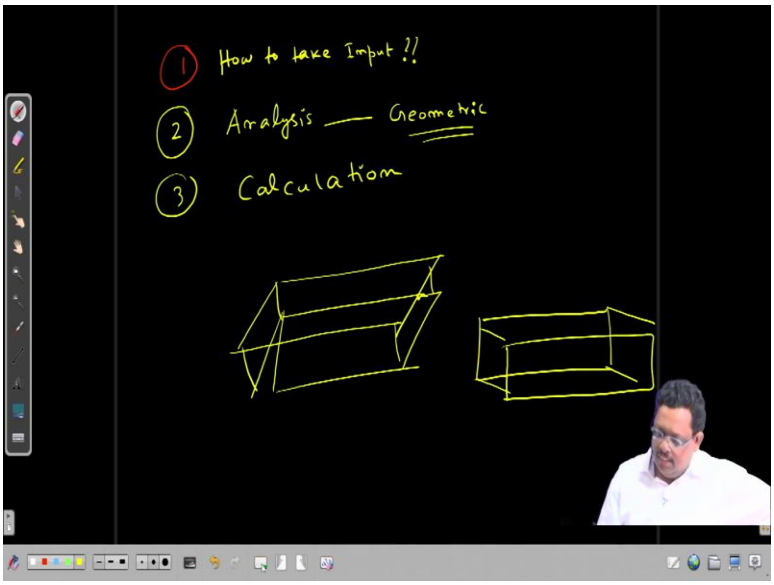
So, what we do is today we are going to discuss we take a. Let us take; let us take; let us take a in a rectangular barge I mean that it is not a box let us take a box type structure and try to find out that added mass in the infinite fluid domain ok.

(Refer Slide Time: 02:00)



And this is the keywords that you are going to use to get this lecture ok. So, let us see how we can attack this problem ok. Now, you see there is a in any type of coding actually you have you know three type of thing that you have to find out.

(Refer Slide Time: 02:23)

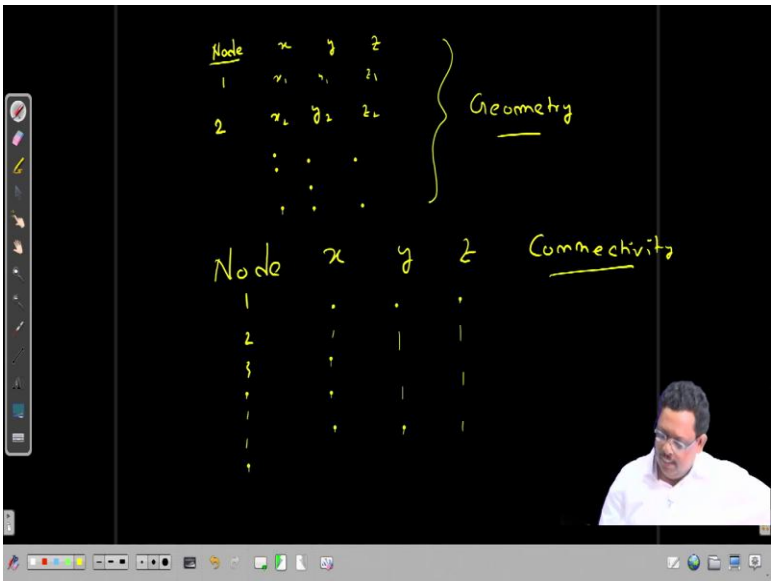


The first one is that like the first part is how to take the input parameters. How to take input parameters? Or what are the inputs basically. Now the second is the analysis. So, this involves lot of the you know the geometric thing it involve lot of geometric calculation the geometric things that you have to deal with lot of geometry you need to find out the normal you need to find out the normal to the body so many things discretization etc.

And then how we can do the calculation and how we can do the calculation that numerical technique or like how we can like at the end of the days you have to take the linear system equation. So, how can you convert the integral equation to the linear system of equation? That is the third part and of course, then the results. Now today what we are going to do is we can take let us say a box type structure.

So, we take a box type structure and with this idea I mean it is not that very good box ok. Let us do a better box ok I think this is better 1 ok. So, now, suppose you have this box type structure because we assume that is a infinite domain. So, there is no free surface right. So, you have to match the whole box. So, first challenge is how we can match this box right and how to take the input right ok.

(Refer Slide Time: 04:34)



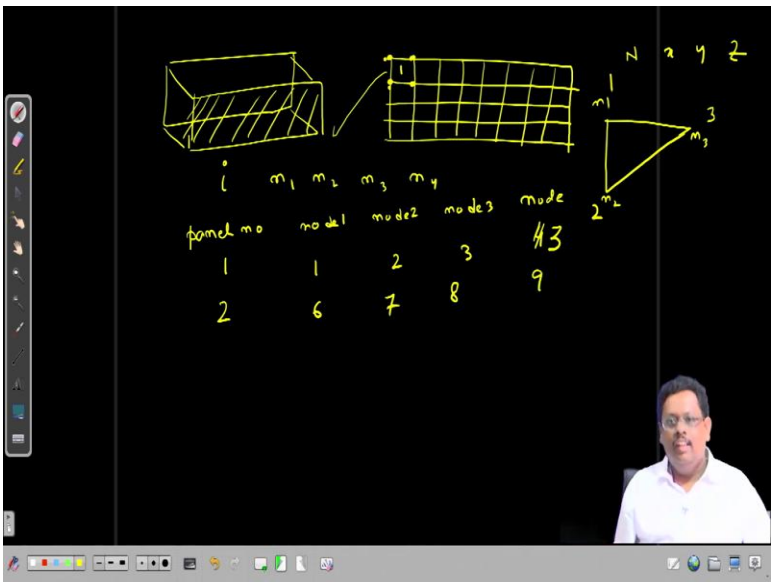
So, now here the best way to take the input like in terms of we can call there is a node with respect to some node alloy. So, it can take in a matrix form. So, first column may be the node and then you can take some x y and z right. So, then this is the x y z the

coordinate of the body. So, let us say node 1. So, there is some x_1, y_1, z_1. Then node 2 you have some x_2, y_2, z_2 in that way you are taking it.

And then the second one is this is something called your geometry file or you can store the geometry in this matrix form right. So, it has four columns, the first column is node. So, it is 1, 2, 3 etcetera this is integer and then you have the real number x y and z those all are real number. So, this is the matrix that you are going to take the data. But then you have to have again something called the connectivity.

Then what is the meaning of the connectivity? So, connectivity tells you that how these nodes are connected these points are connected to each other to make a panel.

(Refer Slide Time: 06:01)



Now here I just take this is your box I am just taking one phase out of it ok. Let us say this is your box and then I am taking let us say this phase out of this. So, if I write this phase. So, this how actually it looks like let us say this is the phase. Now, you know that in order to do the meshing definitely you have to have some panels. So, these are the panels.

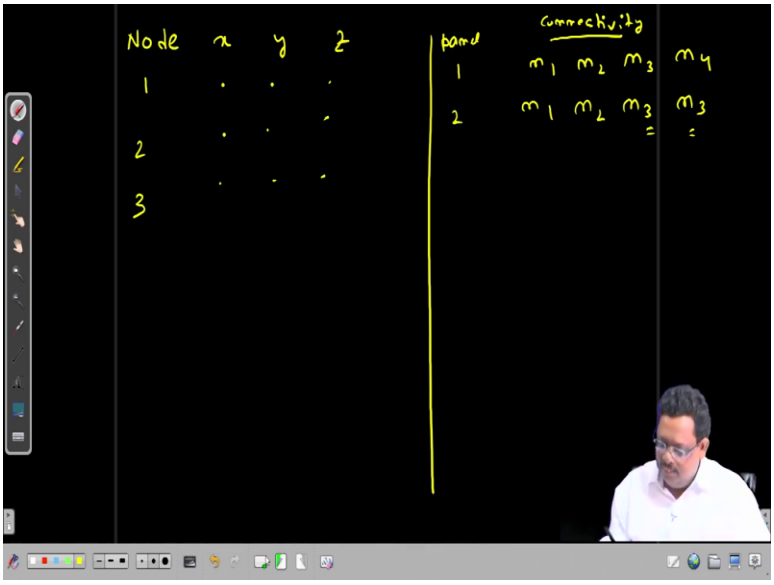
Now if you remember when you say the nodal analysis you are having here that integer N and then x then y and then z right. So, then this element have four data; one is your node number which is integer and associate this is the x y z coordinate. So, now you see here this rectangle it connected with this four node and definitely there is four node

number n_1, n_2, n_3, and n 4. And these four nodes actually makes this panel. So, then you can call this is the panel number i right.

So, it means that you can call this is the first index is your panel id or we can call the panel number this is the first index. So, you can take the first panel say it is 1 and it is connected with let us say this node let us say 1 node 1, node 2 let us say node 3 and then node 4. Now, node 4 sometimes normally where actually people go wrong. They do not know if there is a triangular element how to make the fourth node.

Now in case of rectangular you can have some different number four. However, if it is a triangular panel let us say this is the triangular panel. So, this is your node number n 1 and it is n 2 and n 3 you do not have the fourth node right. So, then in that case let us say it is 1 this is 2 and this is 3. So, in that case the fourth node we can take as 3 only. So, in that way actually you can connect all these panels. So, you can similarly it is a panel 2 some 6 7 8 and let us say 9 in that way it is. So, eventually what you have you have 2 input files right.

(Refer Slide Time: 09:10)



Or you can in one input file also you can do that in first input file you have the node number and corresponding to the ok let me write in bigger way. So, let us do it again. So, in the first file you have node with x, y and z and then you can connect node 1 some real numbers, node 2 some real number, node 3 some real number and then you can find out

here another geometry which tells you the connectivity. This tells you the connectivity it tells that your panel number.

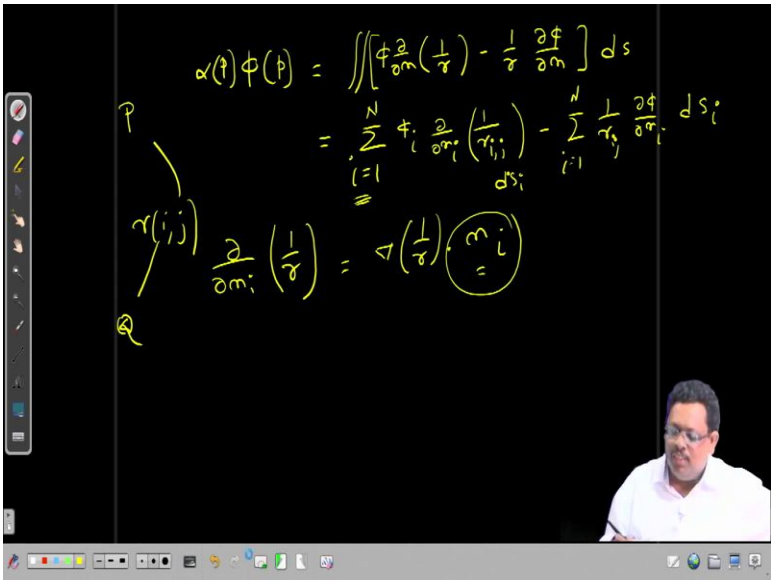
So, panel number 1 how it connect to the nodes which is n_1, n_2, n_3, n 4 all could be different or there is a possibility that n 1, n 2, then n 3 and n 3. So, that you have to be very particular that ok if it is triangular panel I can only take it to the right hand side. Now here is the second questions come like it is not that you know easy to say ok it is fine it appears it is easy, but actually not. Why?

I am telling you that when you do the connectivity you have to take care. So, many things that normally we do not really understand that this is how and then something go wrong like see the problem here in our domain is little bit it is more difficult because when your program is not giving results sometimes we really do not understand it is just because that theorem is wrong or a interpret the theorem is wrong or it is the logical error right.

Most if you deal with the data structure and if something wrong you can find over there may be it is because of some logical error perhaps, but here your physical understanding may be wrong your interpretation of the physical understanding to the coding may be wrong or it may be a logical error. So, you have to be very careful and we can afford any mistake on any point of time. So, when you do the coding be careful you are actually doing it rigorously or checking every aspect a priori writing the original code.

And the first point how to do it this to write this geometric file and read the geometric file in correct way and then when I say the correct way what is that correct way let me explain. Now, most of the time, you look at this physical problem, infinite fluid domain.

(Refer Slide Time: 12:17)



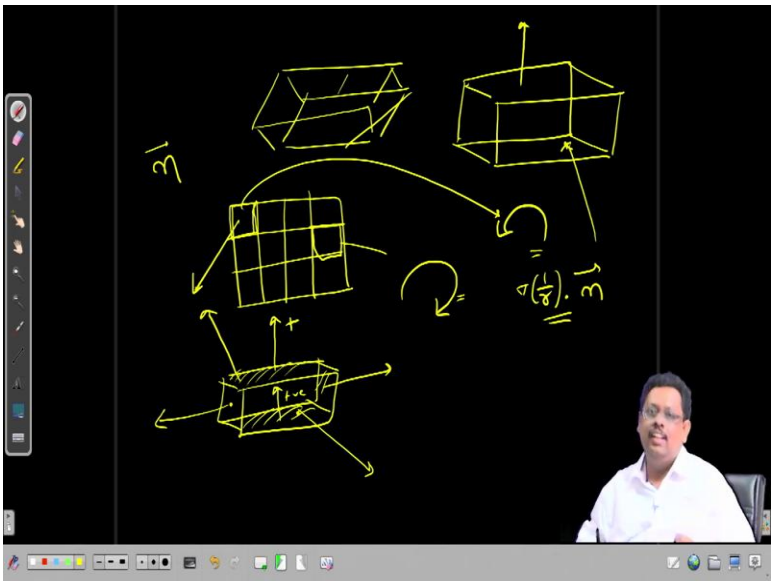
And let me write the integral equation which is $\alpha(p)\phi(p) = \iint\left[\phi\frac{\partial}{\partial n}\left(\frac{1}{r}\right) - \frac{1}{r}\frac{\partial\phi}{\partial n}\right]ds$. Now, if you remember this that we discretize as follows it is summation. Let us say i = 1 to n is the total number of panel then it is ϕ_i right and then it is we call it is the functional value it is $\frac{\partial}{\partial n}\left(\frac{1}{r}\right)$ now it is you known ok.

So, I should make it let me make it j or let us say let us I mean what I try to say that when you call that r (i, j) now here in this case I am taking j as my the field point P and I as my source point Q that you have to understand. Like because this summation is over i. So, when you do the summation it is definitely over the body. So, I is the index for the you know the surface and j may be the index for the field point.

So, it should be r(i, j) right and then you are doing minus again I just replaced by summation i = 1 to n, 1/r(i, j) and then it is $\frac{\partial\phi}{\partial n_i}$ into of course, you have to multiply by the area. So, it is ds_i this is also ds_i. So, this how we discretized if you remember the last class. Now here the important point is this $\frac{\partial}{\partial n}\left(\frac{1}{r}\right)$ is nothing, but $\nabla\left(\frac{1}{r}\right).n_i$ and here all problem comes when you do the numerically. What kind of problem it will come?

$$\frac{\partial}{\partial n_i}\left(\frac{1}{r}\right) = \nabla\left(\frac{1}{r}\right).n_i$$

(Refer Slide Time: 14:45)



See here when you when I do this analysis I think this is better box or else ok. Since we what I am trying to tell you that how we define your normal $\vec{n}$. Now, here it could be two type; one is either it is outward to the body which is inward to the fluid or sometimes which is inward to the body; that means, outward to the fluid. Now you cannot mix up both the things. You have to take either 1 either it is outward to the body or inward to the fluid or it is inward to the body I mean outward to the fluid anything.

But what is happening when you do the meshing we forget to take care these things. Why? I am telling you the very I mean that is exactly related to the connectivity that you are doing. Now suppose if you take this ok. And now you randomly you use the connectivity ok. Now suppose if you make a convention is anticlockwise this is your convention and definitely are getting the normal in this direction. However, but you need to maintain this exactly for all mesh.

Now, suppose if you connectivity it is for this particular thing you make the connectivity in it is counter clockwise this direction then suppose here if you do the connectivity in the in a clockwise direction then the direction of normal over here and the direction of

the normal over here will the different and then when you do this integration that is $\nabla\left(\frac{1}{r}\right).\vec{n}$ when you do this integration then you will get the erroneous result ok.

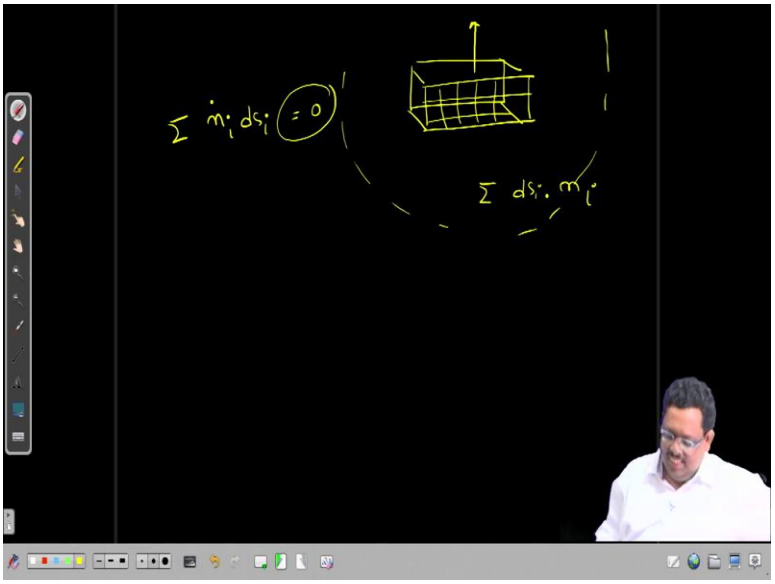
In fact, you know if I in this way if you try to calculate the you know the any component like you I mean here like statically it should be balanced right is it not. Now if you are if you go wrong then you do not get the total the total force is 0 without oscillating the body you should get it right. Like ideally speaking if you do not apply anything then this body does not experience any external force.

So, therefore, you know it should be you know it should be statically stable in equilibrium condition. Now if see if your normal here is outside and if your normal here is inside and if you do not take care of these things, then it is not cancelling out when you do this may be the pressure is here and pressure here is same. Now when you calculate the force this will get let us say positive force this will also gives you the positive force.

So, therefore, your force is not balancing. So, you do not get 0. Similarly, this is the direction of the normal in this phase. So, this phase should be this way otherwise it won't balance. So, here this is the direction of the normal in this phase. So, that should be the direction of the normal in that phase understood. So, this is the basic idea of doing the connectivity.

So, you have to understand and you have to really judge before you start writing the original coding you have to verify that your connectivity is fine and you are getting the normal in uniform direction either it is inward to the fluid or it is outward to the fluid.

(Refer Slide Time: 19:13)

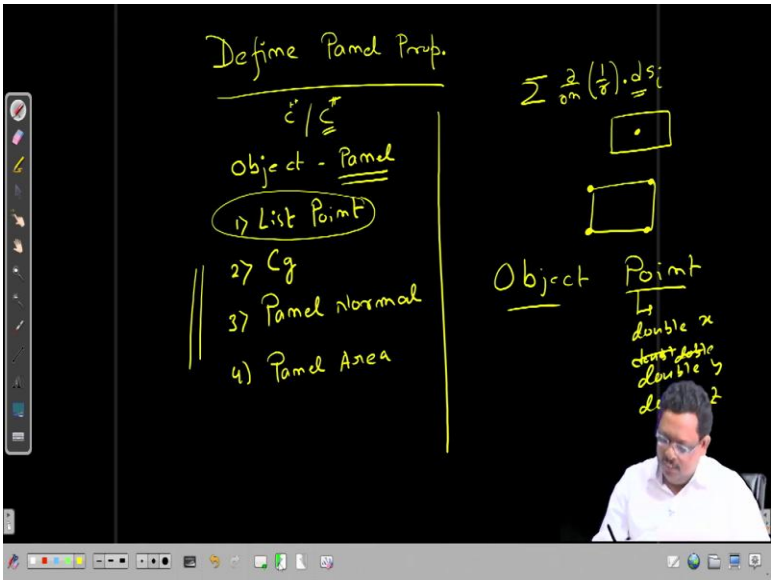


Normally what we do is normally we take the normal is you know outward to the fluid and inward I mean sorry inward to the fluid outward to the body. So, normally we define the normal in it is in inward to the fluid you see this body surrounded by the fluid only in infinite domain. So, therefore, we are considering it is inward to the fluid not outward. So, understand. So, this is the something that you need to take care when you know even start writing the original code. We have not even started the code right. Here we are just discussing that we are not doing anything wrong when we start I mean read the geometry and interpret the geometry.

Because this is the most important part that you are going to do. So, when you are done with this now suppose your connectivity is fine. So, and that you have to check manually there is no other way to check like one way to check that you can make the pressure to be constant. You just you can let us take that you simply do that you know that $n_i ds_i$. You just sum it up in that in all distance and if you do that then you should get that equal to 0. This is the check right. $\sum n_i ds_i = 0$.

So, what I said that if you do the paneling you know this area of the panel let us say and then you simply multiply this area with the normal vector n_i and you just sum. Now if your normal is correct then you should get it is equals to 0. If it is not equal to 0 then you have problem ok fine. So, let us go ahead let us go ahead next. So, now, we understand that we read the geometry accurately right.

(Refer Slide Time: 21:17)



Then what you need to do that you need to define some panel property. Now when I say the panel property the panel is you know each panel what type of property. Now here actually we can make some difference between two type of coding something based on the object oriented coding right. Like C, C ++ , C sharp, java.

So, somebody is doing the object oriented programming we can say and somebody using the MATLAB code which is not really I do not know whether object oriented not. But here you know you can define the object if you are going in C or in a C plus plus or let us say C sharp you can make your own structure.

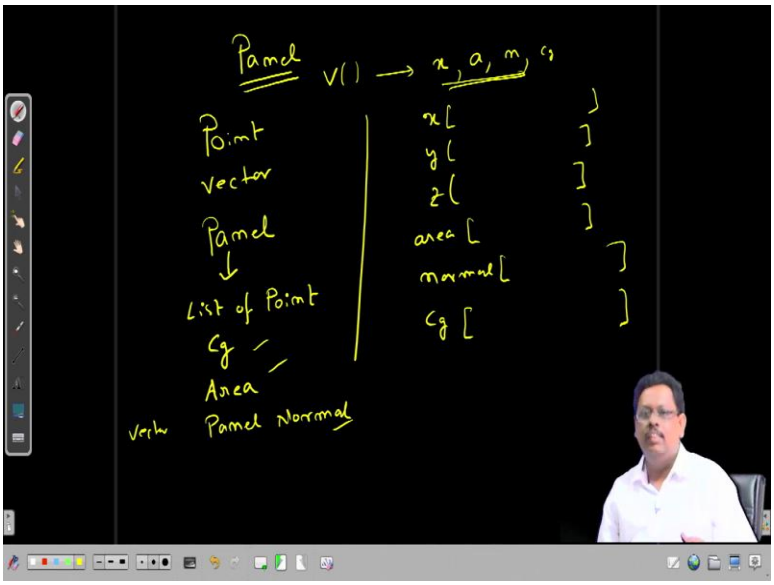
So, let us let discuss the both. Now you have to define some you can define in case of you are doing let us say C sharp. So, you can define some object as panel. Now in this panel object what is the thing you need to do? Now remember this formulation which is summation which is $\sum \frac{\partial}{\partial n}\left(\frac{1}{r}\right) ds_i$ right you have to remember this one right.

So, then I understand in this panel it must have and then if it is a lower order panel method you have to know what is the centroid. So, this panel better to have the information about the four corners, four coordinates. So, it you can define another object here as point right and this in object point you can have only this double x double y and double z. So, this is your structure of the panel right ok.

So, now here in panel you can take the list of point. Number 2 is a the Cg that you can calculate from the list of point. Third one is the panel normal and then fourth one is the what more is left it is the panel area. You know if you have these three thing probably you really do not need the list of point right. But however, it is better to have this with you.

So, now the next thing that you are going to do is that you are going to use define a object which is called the panel and in this object you are putting all these values.

(Refer Slide Time: 25:10)



However, if you are doing the MATLAB coding, you cannot define an object like panel. So, in that way you can define some vector right in this vector that you can define some vector and that vector you can use as the many columns. So, in that vector let us say some you can define some vector V and this vector also in this vector you can store all this property like that that coordinate the x and also the area a the normal the three component of the normal and also the centroid Cg.

So, you have to remember that you can define all these vectors in case of a MATLAB coding. But however, in case if you do the object oriented coding then you can actually define an object panel and in this panel you can define all this particular thing right. So, in case of a object oriented trace programming you can define some concept of point and then you can define some concept of the vector that is the object you can create also you can create the some concept of panels right.

And inside the panel you can define the list of point you can take which is the four corner point also thus the Cg or centroid again this is a point and also then you can call the a double which is area; that means, area of the panel and also you can define a vector which is the panel normal that you have to now this you need to get through your geometric data that you are stored right.

So, how to do this? How to get this you know that Cg, area panel number everything maybe we can you know we can discuss in later classes ok. And in case of a MATLAB they can define a vector for points like x some arrays and then you can define some y of some array they define the z of some array they can define this area some array they can define the normal this is some normal this is also a vector and then can define the Cg also with a vector.

So, today actually then we discuss that how to take care about the geometry and then how to structure structurally how to you know do this you know the basic parameters you are going to set. Now still we are not attacking the original problem right we are not yet solving the problem that we are going to discuss in the next class ok. So, for today we understand. So, now, this is a case study so, is you can call this as case study for finding out the radiation problem of a box type structure in finite fluid domain ok fine.

So, in the next class I am going to discuss how we can get the normal from given geometry and then how to get the get the Cg the area and how to integrate the things how we can make the matrix all these things we are going to discuss in the next class ok.

(Refer Slide Time: 29:00)

So, till this point.

Thank you.