Marine Hydrodynamic
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Lecture - 20
Irrotational Flow - A Bird's Eyeview

Today, let us welcome to this series of lectures in marine hydrodynamics. Today, I will give a brief review of all what we have been studied till now, because we started with basic flow description. Then we went to discuss about the two characteristics, basically assuming that the flow is incompressible, and then we talk about a verticity vector, after verticity we talked about into desianal motion, then we have talked about miscuss fluid.

In which non miscuss fluid the importance of perhaps several differences between the miscuss, and non miscuss fluid, various characteristics of the in visible flow. Then we have talked about the conservation of conservation equations, basically for emphasis it was un conservation of mass, un conversation of momentum, conservation of mass gives us a continuity equation. Then which says that total mass is conserved, on the other hand we have then we talked about earlier sequation motion. There we have talked, which is based on the laws of laws of conservation of momentum, basically the Newton's law of motion, second law of motion. Then afterwards we have talked about we have taken we have again assuming that fluid is a conservity field.

We are in the gravitational field is conservative and we have talked about the Bornallius equation and again we have seen, when in case of a when the motion is steady. We have seen that the gravitational head, floss pleasure head, plus the velocity gradient is the constant, when the motion is steady. Then we have talked about potential flow from potential flow plus, another some sun of tradition based of tradition compressible and irriodetional. I found that the existence velocity for a gel I such that q is equal to grad fie and in the (( )) satisfies law plus equation as the, which is obtained from the continuity equation. In a similar way we have talked about a equation of motion from the Euler's equation motion, which is suitable for in mission flow.

We have derived the, but only sequential motion. Then we have talked about streamlines stream function. Incase if streamlines, we have seen that that the streamline when the streamline psi is equal to the stream functions psi is equal to constant that gives us the

streamlines. That there is no flow across a streamline and that has given us the idea about streamline body. So, in the process in the polveni fit up flow description particularly most of the marine bodies or hydrodynamic bodies are considered are assumed to be streamline bodies, because that will help us that will reduce.

Because in a as we have told on the streamline there is no flow across the streamline, when the body is consider streamline that will be helpful in the design and also the flow will not be destroyed on there will be smooth movement of the object made is move in the fluid. So, in the process we have, because of this reason many are aero dynamical bodies or hydro dynamical bodies in the water there consider as treble line bodies. Then knowing very well about velocity potential and the stream function, we have moved to discuss the relation between them. That has given us about the relation between the velocity potential and the stream function.

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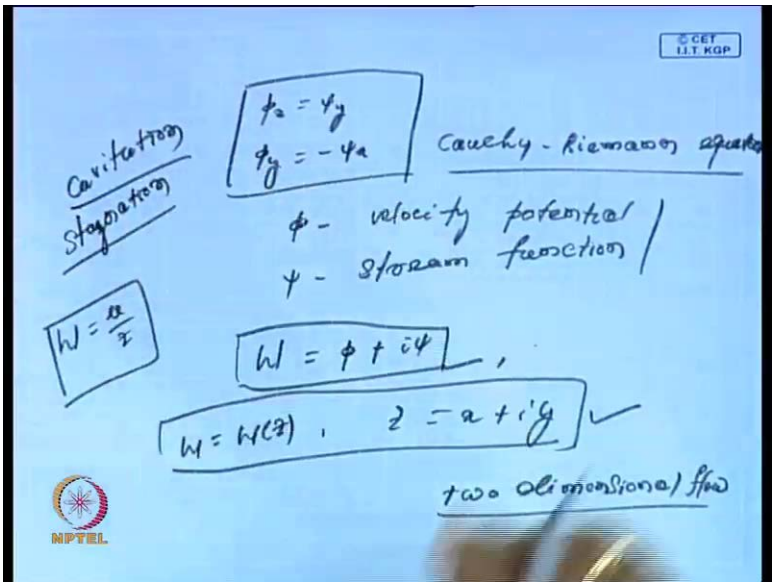

And that is the Cauchy Riemann equation that equation we have already seen, that how it is this is given phi x is equal to psi y and then phi y is equal to minus psi x. So, this was the Cauchy Riemann equation this was the Cauchy Riemann equation phi is the velocity potential and we have psi the stream function and in both the cases both phi and psi is satisfy the for a irrotous numbersion fie. Psi satisfy the law equation and we have seen that when the more sorry when the flow continuity equation has given us very good

understanding about the characteristics the fluid again, we have talked about because in incompressible.

Most of the flow related to the marine environment where we always assume that density is constant or d row by d t is 0 metal, total metal derivative is 0. The process from major analysis we have used as if the flow is potential in fluid is a homogenous density or in some or in general taken d row by d t 0. May be in the process we have divergent of q is 0 for a incompressible fluid we have taken. And then we have seen that both Laplace equation, Laplace equation is a satisfied in both the cases of the velocity potential as well as the stream function.

Then we have in the process we have seen that the characteristics of Laplace equation is followed very well to analyze last class of problem. One of the flow region of incompressible assuming that the flow is incompress fluid is incompressible and the flow is irrotational. So, in the process, because while we look at Laplace equation the only disturbance only singularity that comes on the boundary. As a result, but there is no flow similarity there is, because Laplace equation is analytic. Now, function is a harmony function both phi and psi is harmonic, when you assume the flow is irrotational and the flow is irrotational and the flow is incompressible. So, that is one of the benefit, but it has lead to other problems. So, since although we have solving Laplace equation in both the cases, but still the problem remains the difficulty remains, because of the various types of we introduced and the various types of flow is introduced by means, apart by means of the boundary.

Introduce certain object into the flow or may be the boundary and those objects in the flow or the boundary that brings a boundary surface and that makes the flow complicated. Like we have seen several examples, whether we have seen the flow in a open channel, we have looked into the flow past a aerofoil or hydrofoil or a flow past a cylinder. Even if you have seen the several cases of flow like sources, sinks, combination of a certain uniform in the presence of a flow source or a even if we have talked about what is this? So, all these things and again we have talked about conformal mapping before going to conformal mapping let me highlight by conformal mapping has come.

Because we have seen that the multi potential pi as well as the stream function psi and both satisfies the Laplace equation and the Cauchy Riemann equation. Then the, from the

theory of complexion (( )), we understood that we can always depend a complexion velocity potential w (( )). The remain equation then we have seen that we have introduced w and that we call the complexion velocity potential. So, that it becomes so we can express this in terms of a analytic function. So, the into gather and these way is only possible when the flow as 2 dimensional in nature with, because w is a function of a z and w is equal to w z where z is equal to x plus i y. So, major flow has been analyzed several flows have been analyzed and the assumption that z is equal to x plus i y.

So, that means, we have taken as if the flow is 2 dimensionally ledger. Another characteristics, the fluid when is assumed to dimensional nature and large number of problems have been analyzed base on this assumption. Then we have seen that how while talking about we have started with a very simple flows, we started with a uniform flow, then we have talked about sources sink double (( )), then we have talked about what texts we have talked about uniform flow started with a uniform flow. Then we have gone to various kinds of other simple flows like the flow by introducing several complex velocity potential. We have analyzed simple flows and we have seen the cross combination of these flows.

One of the advantages one of the advantages of this simple flow is that some of the flows may not in principal represent gives any physical relation of the flow, but when this flow have been combined together two or three flows have combined together. That has given a summary flow parton, which has, which are of practical importants. Like we have seen when we have analyzed the uniform flow past a cylinder. There are two things we have seen that one flow is a uniform flow, the in the valential direction the other is just by circle theorem we have added.

If we look at the double e t that in case of a double e t, we have taken in the case of a double e t. We have taken w is equal to mu by z and this has come from, basically combining two sources with suitable arrangement of a source and a. Then we have gone to several flow characteristics we have talked about stagnation and stagnous in flow we have talked about cavity formation cavitation theorem.

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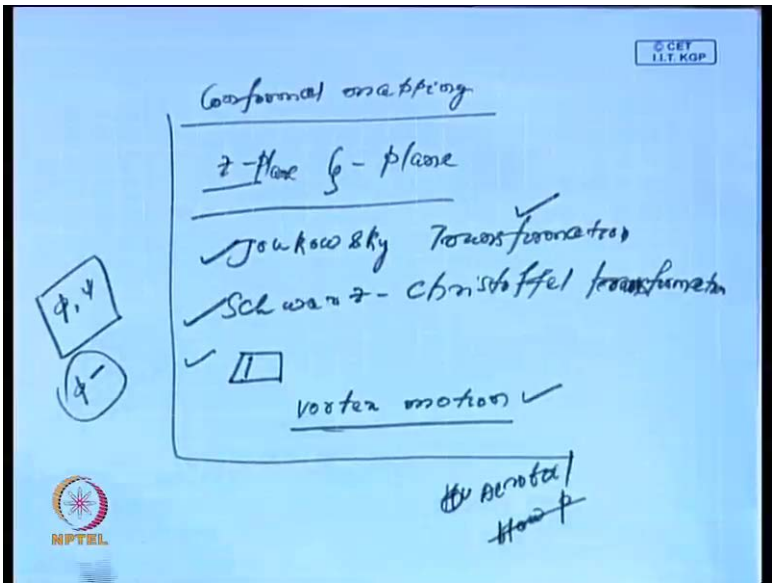

And then we have, when we have come to conformal mapping they are simplified sum of our analysis in the conformal mapping it has simplified most of our analysis, because we have already we have brought in compressible z. We have taken another example; eta and geta there are two plains we have talked here z plane and the geta plane.

And one of the some of the most important conformal mapping are the Joukowsky transformation we have. Then we have talked about Schwarz Christoffel transformation. We have Joukowsky transformation, Schwarz Christoffel transformation here. There is two important transformation, which we have talked about and we have seen the application of this transformation in analyzing several types of fluids. Then another characteristics, which come across the similarity in the flow, because we have as I said that we always look into when we look at a analytic particularly, when you look at a lapless equation we always look into.

The flow inside the boundary there is no disturbances, but inside the domain there is no differences, but always the disturbances all the changes in a pro characteristics comes, because of the lectorary boundary. There are several types of boundaries we have seen since there are if the boundary is very smooth. Then the proportion is very smooth, but the problem has come when we have a the boundary is not very smooth. Like we have seen in the case of a when a propastor waves or when we have seen in open channel flow when there is a substance in the surface of the boundary.

Again I will talk about when we have a analyzed a flow in the presence of sources sinks or double (( )), these because we have brought in symbolize in the flow pattern like we have seen in the case of a. What else we have seen near the origin r is equal to 0 the flow is singular, but the r is equal to 0 the flow is regular in a similar manner. We have seen some of the other application like, when we have look into some of the other applications like, vortex motion.

In this case also we have seen how you can combine a vertex the wire pool motion of a wire pool or when even if we have a vertex and a source combine together. The kind flow it has given initially one the two flow effects separate, but when you combine the two flows, which has given a very different type of flows in a similar manner. So, after these two dimensional flow, because we have seen that here that large number of flow has been characterized by these two dimensional flow.

Then the two things the velocity potential and the stream function side together of full problems we have seen that often problems it has been easy to analyze to understand the pro characteristics without even if knowing about the details about the velocity potential phi. In many situation the flow characteristics we have obtained just by always obtaining psi, basically the stream function and assuming that psi is equal to constant even that has given us the streamline and that has given the flow characteristics. So, in fact most of the problems we have done that again when we have gone to this.

In case of a, the last few classes we have already seen and how the k surface the rather I will say about when we have gone to the apply the Joukowsky transformation to the hydrofoil or aerofoil theory. Aerofoil or flow past a circular cylinder means, from flow past a circular cylinder or in flow past an elliptic cylinder. We have seen how complex well the algebra, but it has given nice transformation were helpful in a obtaining a very nice form of the solution. Again we have seen we have seen that very nice form of solution has been obtained by the just application of Schwarz Christoffel transformation.

So, overall we have seen that there are large number of problems, which has been analyzed just under the assumption of that motion is two-dimensional in nature. But there are however, there is limitation and concrete almost all flow it cannot be analyzed one of the basic assumption of the two dimensional as another assumption of the flow disc problem in two dimensional nature. Although, there is large number problems we

have analyzed like the flow pastosphere. The flow pastosphere cannot be analyzed by using the two dimensional theory, when I used to take the course of the three dimensional theory. However, because of the complexity of the nature of the, because here one has to go to the spherical coordinate system and in the spherical coordinate system one has to then the problem will be more complex in nature. So, because of that in this course we are not going to the three dimensional problems.

In general, in fact and we have in this part of the analysis may be in some other course three dimensional flow patterns will be, but though there are specific problems, which can be analyzed that is, because of the complexity of nature. The problem the movement you have increasing the another valuable, because here we have we are dealing with the two variable x and y variable assuming that the flow is two dimensional in nature, but moment you add one more variable that is the shade variable then it becomes more complex to analyze the problem.

And in the process the simple analysis what we are able to do just in the two variable will not able to do, even if we have seen the problems certain problems are analyzed assuming the not only in the Cartesian co ordinate, but also in the cylindrical co ordinate assuming the into symmetric about the theta direction. So, in the process we have brought the down the problem to again in the in a problem of a the pole of coordinate and we have sorry cylindrical in the polar coordinate we have again, the only reformulated problem in the real direction and we are able to handle it easily.

All these problems, whatever we have discussed till now, as several application and all these are possible, because we had in most of the problem we have assumed that the flow is of potential type that means, flow is rotational fluid is incompressible and In fact another important result, which has given us insight the limitation about the miscuss flow that is the b r number paradox. When we calculate the uniform low past a cylinder, then we have seen that the total force that is acting on the cylinder is 0 and that has given us the paradox the Holom paradox, which is the real number paradox.

That again when we have again we will have an ideal to this flow pattern introduce to a circular introducive presents of rather we have introduce of flow past a cylinder in the presence of a circulation. Then we have seen a strength k we have seen that that provides

us a there is lift force, which has been developed and that gives us idea that in the presence of circulation there the flow a lift force, which is originated in the flow pattern.

On the other hand we have seen there is a lift And drag force both are becoming 0 in case of flow past a cylinder what is? That is what the De Almod paradox. And the De almod paradox is given us the idea that it is not enough or it is a sincere to study the discuss flow for a marginal class of problem were the potential flow will fell. Again the concept the introduction of the circulation of strength, certain strength when at strength as talked about the lift force and which has, which lift force, which plays a very significant role while we look at a body is moving in the fluid, whether it is in the water or it is in the air. And we have seen particularly more important when you one things of the aerofoil theory or the hydrofoil theory.

And that is y the theory of the results of Kutta Jouskawsky, which becomes more important is provide, although it is based on the potential theory, it gives a good understanding. It gives a good understanding about the lift force and the movement acting on the aerofoil or the or in the similar case in the hydrofoil. So, we have seen that and that as this is all these are one accept of the problem we are not yet just as similar here. What I am talking about? We are talking about just as in the flow is incompressible and produce a rotational.

So, when it has comes to the motion characteristics all these days we have talked about invisid fluid when it has come to calculation of force in the pressure. But in the next few classes rather we will spend more how the another equation of motion are the Bernoulli's equation of motion for a potential flow associated to the potential flow will play a very significant role. This is another accept of this and whatever we have talked with a understanding of the flow characteristics of a rotational motion.

A rotational motion for associate this compressible fluid and if we have assumed we will assume for the fluid is invisade. Then we will go to the details on the three surface hydro dynamics flow and that is the need to the theory of water ways. Before going to that again let me talk about, because while talking about the flow characteristics and the flow only boundary of the surface we have emphasized.

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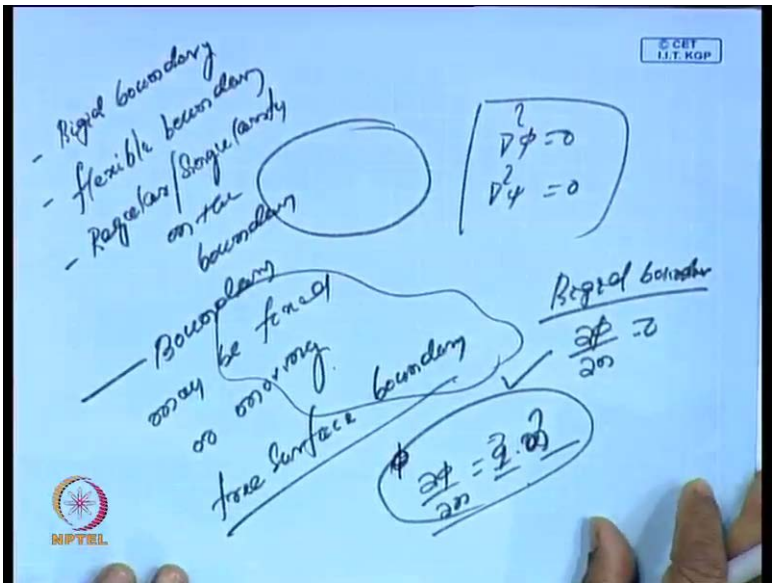

What happen? When we have a fluid, because I was just talking about the leave about the boundary, because you have you may have a Laplace equation satisfied by the ammoliate potential or the stream function when we have any boundary. So, there are couple of boundary that I always talk of rigid boundary, we can talk of rigid boundary, which is we can talk about a flexible boundary or boundary may be regular or we have singularity boundary. Then another accept is that the boundary may be moving or fixed, fixed or moving a potential flow we have seen we have also seen in the boundary rigid associated with various boundary.

If the flow is in the boundary surface, if it is rigid and flow is a potential type, then we have del by del n is 0. On the other hand if we have seen that the boundary is moving then we have seen fie del pi by del n equal to q dot u q dot n at… So, that means if this is the q is the speed at which the particle is moving a body is moving n at is the normal derivation. Then we have seen that this also gives about a moving boundary then again, but what has happened there is another kind of boundary that is the free surface boundary. So, what will happen here? When you think about free surface boundary particularly this comes when you analyze problems.

Associated with this is a, this gives us a new class of problems when you look at that is y I say that in the next few classes we will talk about free surface.

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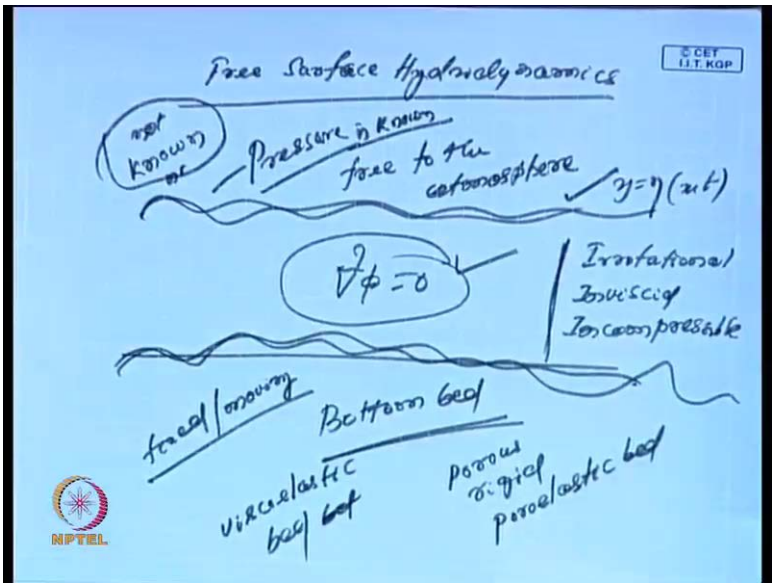

The main broadly, we will talk about free surface hydro dynamics. Basically here, when we in this case what will happen that means, I have a surface, which is free to the here free surface. Means I will say that surface is free to the atmosphere. So, this surface is not a fixed surface unlike you say bottom bed, bottom c bed, which is beast it can be also moving, because when there is moment of a seri moment of the bottom of the surface.

The sea surface can also may not be a fixed one, fixed or moving. So, this is the here the bottom bed can be also, because the unlike equation, very rigid, fixed, but bottom bed are a rigid having a rigid bed. So, this surface also can be the there are, so many questions comes the surface need not be uniform it can be it can be of any shape. Then here we may have a rigid bed in the bed may be porous, the bed may be rigid, that is when sometimes we in the it comes to the atom bed. Sometimes we call it we call it as a poroelastic bed, sometimes this a way vircirlar analyze of c bed as a square elastic bed.

So, like that, but what happens when It comes to the free surface, the free surface one of the things if I say for equal to theta is of free surface and this free surface is not a known surface. The surface is not known, but what happens on the free surface? The pressure is always known pressure is known. So, that leads to a new class of problem, because there is a surface the boundary of the surface is not known. Although, we have saw in the fluid domain and again I see simple we have seen the flow is incompressible. We have seen that the flow is in rigid in deep one of these irrotational motion flow is flow is

irrotational. We have a inviscuid (( )) even if on the these assumptions we also we solve here the last equation, but still the complicity comes, because on the free surface the boundary wise is equal to eta it is a self (( )) at wary. Whereas, the pressure is misguide on this boundary and in minutes, which is also if you say that this is a moving boundary. So, we can also lead to a similar problem that the bottom boundary did not, because of this completes and again the surface boundary is if you look to the detail the surface boundary surface boundary. We can spare highly non-linear and this non-linearity on a free surface that means, here we are solving lap equation, but as a potential flow, but our boundary highly non-linear.

Another cuspate, which I like to remind here that, because the demine, because the surface will the lap equation is a linear equation. If the boundary condition is linear on the boundary condition is more, there is no singularity, there is no non-linear surface often super position principle helped us in super poising many solutions or many problems together. And then making the original problem a complex one and analyzing the problem in a suitable manner, which gives nice characteristics of the flow and which are more applied. So here also when the problem becomes in the free surface, so will see also that there will be several cuspate of the problem in a bodies in the water.

Once if been a fully linearism of a problem will still able to get a good cuspate to a real life problem and that approximation simple, because rather the problems will be highly applicable it is, because will solve still plus equation and under the assumption of the generates conditions. That is once the conditions (( )) various characteristics can be couple together particular super post together.

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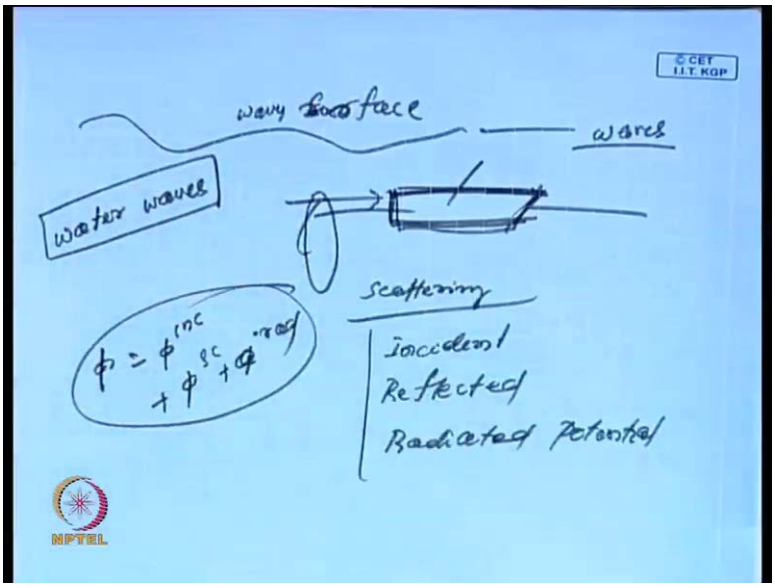

Various problems associate to flow can be super post together to the (( )) if I say that I have a body or let us see the motion of a ship anything, which is moving in water if the body is a east. Then That will give me a problem of scattering problem, because when there is a water it will come that will be incident potential there will be incident potential incident way in the ocean and there will be a reflected way, what this ship will be moved? Moving the body will be isolating than will have a radiation potential. So, in the first series what will happen than, because propagation whole square you can always find the total potential pi as a (( )) of the incident potential plus scatter potential to the radiator potential. This is not only in case of a sea in mini we have analyze the flow.

Flow of characteristics in the presence of mini such of stales, we can always combine them together. The solutions basically the (( )) will be the super whole good that will help us solving many problems in this. Another aspect of these the surface of a problem is that this leads to y a free surface as an advantage it always comes at the surface, which is nothing but a wave re surface and this will lead to the generation of waves and what we say we call this we lead to an area. What is the call the area of water waves?

In fact, among all the waves electronic waves in a electronic waves x ray waves you particular waves we have seen then cell membrane, cell membrane and remembering that remembering there is way probable that is a string. There is way probable we have Compton in Compton is we have particularly in Compton square.

But here, out of the all this ways what row of is the most unit, because here what happen in the while analyzing for as related to auto mobiles often we come macros problems, which are in the on bounded. And when we will look at problems in the on bound in the main particularly they have to specify the radiation condition of the fire fill condition. We have seen in our previous analyses it is that when use to analyses the flow past a cylinder.

We always is analyses that as if the flow is uniform along the horizontal flow is uniform along x axis all. So, there are is also analyses in the flow is fluid is at rest active we already talk to about fluid is a rest at infinity. So, that means, when a I have to analyses is flow in a bounded that means, go when a which is infinity extended or bounded.

Then, I have to describe some kind of the behavior of the flow for behavior at infinity at the for a far field. In fact a that lest to we have seen in case of the radiation of full radiation fund problem summer field radiation condition. So, this lot of net when we have the even of we solve transformation and particularly or what are where is we this traditional condition give is a type of a, which is not non all the fall field. Then this as another comlexity it is the problem, because the fire field able each talk non of very like.

We the phase of phase the surface boundary surface in only water the water surface in not non not fire. Similarly, here the fire field conditions what non not of fire. In fact those fire full condition often gives us information about the nature of the kind of problem we have deal with, because like if you look at the scattering of able, if by if take water of Barier. Then the (( )) be a barrier will give us the replace and transmutation co opecient and that talk about the lecture of the talking the reflective characteristic of dissipates, characteristic of those structure. So, often we need to know in the process of often in the solutions we need to often on understand the physical phenomena at is associates it. Again there are structures, which will be looking to where will look at.

The other the boundary surface other the boundary flexible in nature flexible boundary online. The casa of resignation boundary, the privoles is not at easy when will think of flexible boundary. In case of flexible boundary we have seen that today this is another area, which is come of that is the area of hydrolosity. It is a (( )). This is basically, the area of the mutual of the introduction hydrodynamic and the elastic process that as lift to area. There one us to almost every problem and on rest consider and if the hydrodynamic

force and interact elastic process and they are, which was, which is pesions in rest and many problems, which a bring earlier.

Handle and to the assumes of the body of the regent body is all to relation many theories or bring generalist and other (( )) Because of today we are looking into structures, which is very large in nature, because of largeness of the structure, we are seen that the body result body analyses is not very helpful areas. The (( )) has to be taken to account in the process hydromantic and the analyses, becomes in the much more important. Again, I will talk to you another accept of the problem that is, basically when is comes to the surface problem there similar rapport from the linearity.

What will happen? If we have the non the linear bounded condition when you have the liner bounded condition that means, the preaseph condition is non liner and without liner each the problem. Then very few problems, which has been we are able to get solutions and infect today in measure part of the analyses associate (( )) on the based on the liner theory where we find several applications. What in comes to non liner? Be a theory, the theory is very fast and in almost all the cases efforts all be analyses efforts all be may to a seem that the a seem the problem is liner in nature to liner as the problem.

I the Process the similar theory is we will come to all this we are started with theory is we theory, airy wave, then we talk about to stokes and times of the waves we have cnoidal wave theory a strength or and some theory. Then we have solitary wave theory and many wave out of the structure final torn of the theory of first order of the theory is sometimes save as the airy wave.

So, with this understanding the coming series of lectures will who in detail to talk about what waves? Basically, will introduces the theory of what waves and when is come to the theory of what waves? There will measure imposes will give and once measure imposes will given the liner theory.

And the movement we had a full flow and then we are process, we are being another phenomena associate to do with weep. So, that two things the wave theory associate and along with few flow makes the problem or complex like. You look at let us look at the problem in a very flow patron a we have look at few patron in airy.

Wave we always look at as if the match of moving, but particular some moving, because from an into another, but in the casa of when we have look at the same wave in version. Here we have two things, we have the more important in the wave a part from, because here the way part this negligible when you have a learning wave in rest we talking about the water flowing in a channel a canal (( )). But in the case of the measure analyses the saving in the accept the how to a analyses is a done a some phase of phase imparities negligible.

In the other hand in the case of in hydrodynamics analyses particular you have look at those in water arrow we always give much in phases. On the acceptable and this wave, so that description or the understanding of the physical characteristic of the weep along with discourse makes the problem all complex. There are many branches of marine hydrodynamics or other is engineering, which get is many passions, because of this analyses. If it is look of the areas like see of hydrodynamics we are the (( )). And particular look at the curses a look at calculating this wave resistance on weasel or another moving body or in we have look at calculating.

The wave fluid on or (( )) structure or understanding how the weep structure interacting in cases of a large porting body. All this things the one rest not only understand the wave characteristic on as to understand the characteristic of the structure of the self and along with the characteristic the for patron. So, because simple problems, which when put together has given to if gives rest to solution to and last class of problem, which air of uploading the nature or of large a important to varies install of application. So, this understanding again, I will say if it comes to I will just a little more a put modeling, because next class will come, because to the detail and talk about modeling. When a talk about modeling particular it today we see there are several models or physically models other when it is physical models.

But here, there are two (( )); one is physically realization we always call it is a give a mathematical models problem. Then we have experiment model testing is done experimental model, so what a we always the numerical often is numerical model. And then sometimes we have, so when one us to say that areal a more accurate (( )) of the model because then we have of observational data analyses, observational data analyses. So, a model is physical model or a model we say that the this most of prepare in the experimental model, the numerical model and the observational data. They all gives and

other they three results associate this model the (( )). Then will say this is one of the most one of the most will in physical model or that give some more accurate realization other problem.

But often it is very easy sometimes people say they are all the, they are debets non go to the divides sometimes people say that in easy to mathematical model or a sometimes people say, it is very easy to make a experimental model. All the they large debit on this, but always doing an experiment and model is very difficult one of problem, because a of develop if and for large any problems. Today, because of the availability high per computer you can always make a mathematical model. Accordingly that is expending numerical model and this numerical model, if you can validate which observational data then several observational data. Then we fill that or model is immaculate one.

There is although there is a good amount of analysis associated with this numerical model, because you have a model you always look at a numerical you always look at a numerical in the conversion test of the solution. Conversion of the solution associated with the model. Then we look at the convergence this solution we also look at the weakness unique characteristics. But in many real life problem today, real life if we look at many ocean problems that are analyzed and then numerical where they go on testing one result to another and then because of the complexity of the nature.

Complicity of the ploglam of a very difficult to study to this kind of analyses the conversion analyses or the uniqueness analyses, but still several methods are adapted, which gives a better realization problem at hand. And another accept is the experimental model, experimental models are always not possible for all class ploglam, because it is not only physically many times it is impossible to do experimental models for like today. If look at the (( )) it becomes highly there are various explicit formula, which are which are there in the let rich to understand.

This (( )) after lot of model test (( )), but still n r getting the what exactly happening in a (( )) at the show line. So, in all things will comes as part of a fiscal model, but one has two will try in a fiscal model to if the three things we can do mathematical model then numerical similar model and then experimental refection along with observation data analyses. All this three of four things to gather is a more accurate retaliation of a physical problem, but and should be proper. If it has a very good understanding about all this four

accept the study, then it will be very easy for him to say whether model is a more accurate or not.

Because (( )) not able to analyze the converges ion of solution of a large number of (( )), in which this background… In the next class only will start talk about introduction will talk about was physically, the what waves, the develop the theory of what waves and then try to work out few simple problems and was try to understand how various types of wave? What are the various types wave exists? What are the, how there are the classifieds? How the theories are developed? And then try to analyze some other simple wave problems? That is that we come across day today life and which are of also interest to the wear in technology are in the industry when this background on waves and with the summarizing all just small review. How fall, what all we have been study in the last (( )) of lecture. I will stop here.

Thank u very much.