Indian Institute of Technology Madras
NPTEL

National Programme on Technology Enhanced Learning

Video Lecture on

Convective Heat Transfer

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Lecture 8

Couette flow - Part

Let us start what I want to do is this quad flow I want to do it thoroughly I like this I assume hopefully you will also like this because it is a complete very what this can be done completely in the class starting from the beginning to the end by hand but that is not the only thing there are some very nice concepts which come out of it and this is one of the very few as always we say one of the very few exact solutions of the navies-stokes =s naval stock signals are very complex with certain assumptions definitely but when we do this also the flow is very simple one of the simplest flows actually.

I would say this is the simplest problem in convection it is a convection problem the simplest in convection you will see why it is so you will actually do it along with me I want you to do step by step starting from the beginning so today and tomorrow will completely a lot this I will ask you to do something at home later okay let us start this is a parallel plate problem basically usually we divide the problems is a flat plate problem pipe problem square debt problem care - what is it Bluff bodies this is a parallel plate problem point number one it we call it in literature quiet flow problem equipped flow problem so that is.

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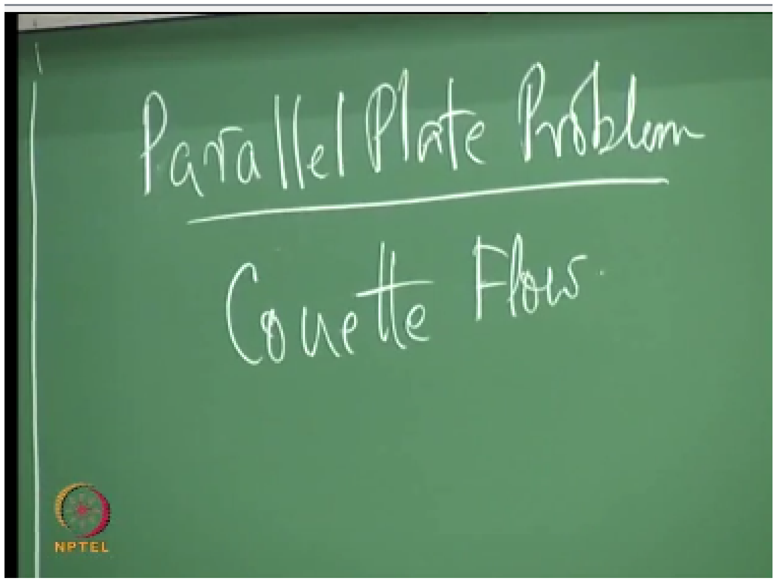

What in particular we are talking about a quick this was a this called couette flow in literature there was a I think it was a French person his name has been given we have tried what was his contribution is nothing great actually but it is effort that has a quiet flow it has a certain practical application which may look very trivial but it gives you a lot of information that's why I like this and hopefully you like it.

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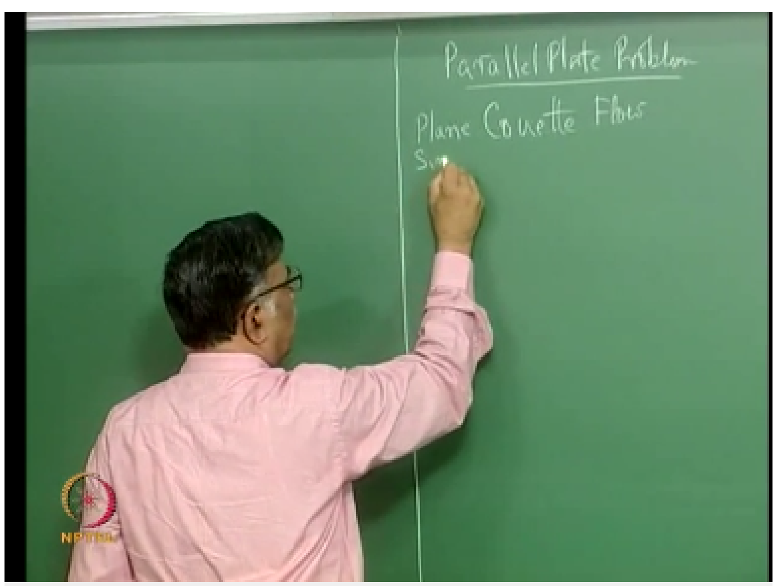

So I will also add a objective to this is called plain or simple quit problem objective of this is as usual to obtain velocity and temperature profiles and getting the province is not the end of the solution we would like to estimate calculate rate of heat transfer I will say in the system now then we will see what it is and then study this a little further study the results and see what comes out of it this is also a noise interpretation just getting the profiles that heat transfer is not enough then you have to look at the consequences of that study a little bit analyze when you do this for any problem then you know how to use it so simply.

Solving a mathematical moΔ through a core you will give that a nice profile that is not the end of it but know the results interpret them study them and then say okay that means you know what happens if I change this what happens if I change that why is this happening where is this possibly used how can I control the flow how can I control heat transfer that should come from the results part of it so it is complete solution involves the interpretation and study all solves and there is no end to that now we will start what is the very first step we will do it in steps when you want to study a problem in any problem but here in your talk about convection what is it I have simply stated overall title I have given.

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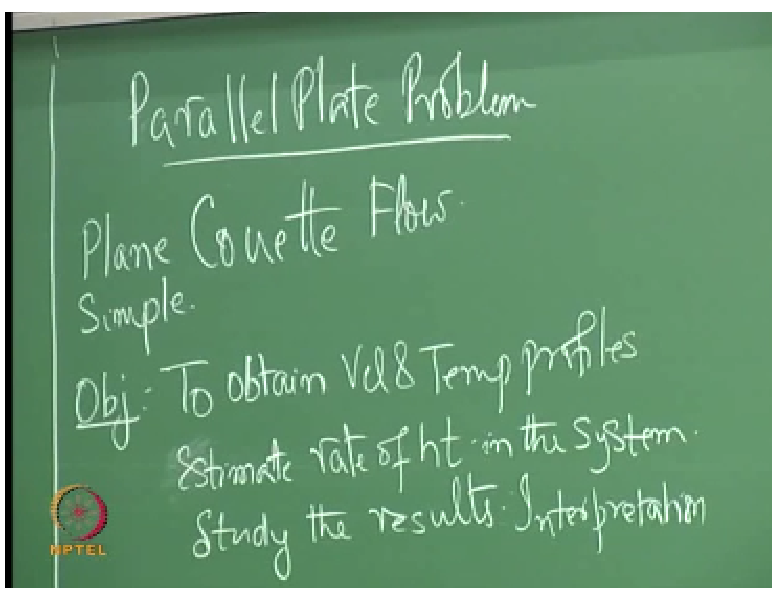

Parallel plate problem you must have an idea what they will write it down and it is called a plane or a simple quit flow when I when I knew that a jerk you should immediately think oh there should be something other kind of a code flow more complex not so plane not so simple obviously well we see now in any convection problem conduction radiation to order it what is the first when you want to study a problem what is the first thing that you do in our scientific methodology of not the experimental part scientifically okay I will give you a we are actually going to moΔ this let us say.

So what is the first thing that you write you should are pardon me they come friend yeah we are you sitting at the Infinity it is like way tending to infinity there they were =0 is vacant here huh tremendous resistance a heavy shear stress here okay yeah that you want to be free or all free stream people are okay, tell me now that is all I will not say anything more about it what is the first thing that you do you have to do what is it huh geometry then can you give me a different slightly better term jam boundary conditions will come later exactly that is.

Why I want to clear it out here boundary country how can you talk about boundary conditions without you want talking about the =s but before you talk about the = something else has to be no clear for clarity we write down diagram you said what geometry flow conditions can you combine all this and give one for me what is it say that it is okay, assumptions will come later we will do that I am now trying to identify and write down all these things are correct geometry you said diagram a flow description.

Okay fine in what you want it to write in words that you want to formulate correct formation okay I will just want to use a _ moΔ first we should have a tomato cuddle that's exactly the power it will come later okay so now comes the diagram geometry you are talking about we said parallel plates right parallel plates two penalties now we will define this space these are large bits in our real translator there are some words which give you some ideas which you should use large now what do what do you mean by plate being large pad is large what meaning do you make out of it.

Okay so very good very long you in one particular direction the other one is very long is length the other one is okay now I can also add this is thin why do we say it is thin plate we always should actually whenever we talk about solid I know we will usually you said thin plate because there could be thick plates also what is the difference between these two in terms of what you should consider in heat transfer then you have to consider the conduction in the thick plate also that becomes a conjugate problem kind of a thing thin means the entire that thickness is at one temperature.

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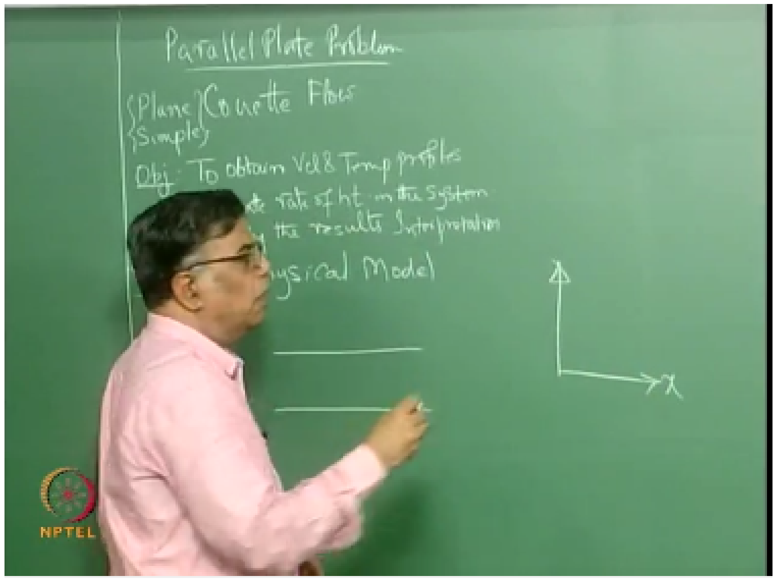

You can take it like that now very long and very wet so let us now have the coordinate system X Y for me this always you know in convection x and y these are the directions even if I go to free convection X along the surface or in the direction of the flow Y perpendicular X Y now I will also write this Z this is for the flow now if you take that in terms of the plate that means this X is very long so this is very long very long means it is infinity there are very simple things. I am trying to make it clear to my cell phone to you so how you can break it down X is infinity now.

We will not make Y infinity we will make Z infinity is perpendicular to the plane of the board so the example I usually give is this is the top plate the roof this is the bottom plate and they are extending in two directions infinite this is why this is a parallel plate prop actually this is a duct enclosure problem if you take this room into enclosure problem for walls and top and bottom but remove these four walls you get the parallel plate problem and therefore in the Z direction also it is now this is why I have to obviously say what is this let us say it is they are displaced there is a gap of L will not specify at this point how Much it is we'll just put it as here now varies the flow we said we have to define the flow you know where is the flow this is a very peculiar problem usually.

What you would do to put two parallel plates and then say flow is coming from the same know now I will say first of all what is there in between the two these two plates so now let us say there is some fluid we would not even say inner water the moment I say fluid so what is the number we are specifying so we say there is a fluid number well there is a fluid it has a certain pantry number meaning it has certain properties pressure and temperature come into the picture you see P by K new function of temperature.

CP function of pressure temperature public a function of temperature so present temperature is taken care of that gives you the fluid so if it's point if you say it is one it is a gas if it is four or five is water up to 10 to 20 it with hundreds and thousands it is oil 40 to 50 thousand is heavy oil point not one not one is a liquid metal that is fixed. Now so there are two parallel plates now we will define a little bit further what are these plates so now I am not saying there is a flow here how would then a flow exist now I say this top plate is moving bottom plate you can you know in convection you can have any kind of geometries and situations now you can try to solve them I will say the bottom is fixed this hatching for me is either it is a fixed plate or it is insulated in this particular case I am saying it is flat plate a fixed plate and there are two plates parallel to each other displaced at a distance L.

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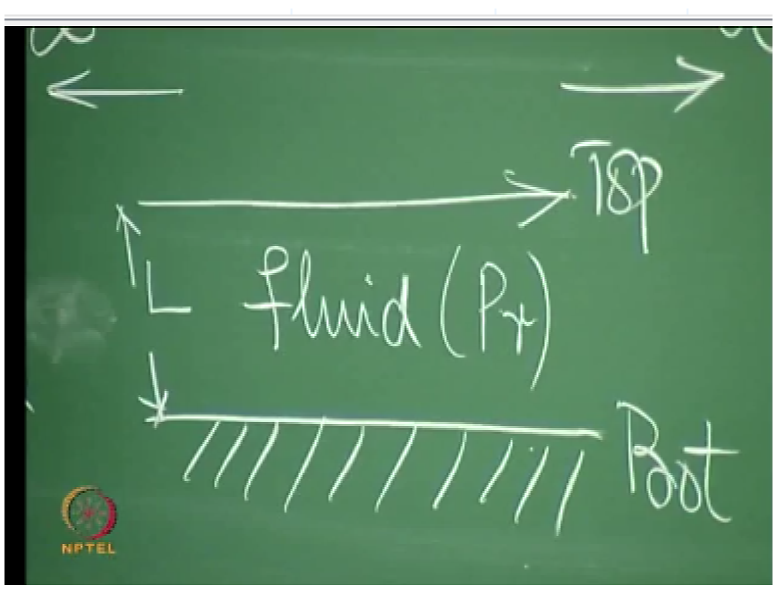

So we call this the bottom plate this is the top plate so the bottom plate is fixed the top plate is moving then I have to prescribe something it is moving with a velocity u1 one refers to the top plate 0 sub okay this refers to the bottom play subscripts later now anything else to be defined I am now computing the physical moΔ basically you have the diagram you have the flow means now I am saying in steady state by the way okay we will define it again the top plate is moving so it is not fixed it is not insulated bottom plate is fixed at this point in time for me to have heat transfer one would think that should be a temperature difference. So I will say this is at a temperature t1 this is a temporary a temperature t0 so now you say how we are prescribed the velocities and the temperatures anything has required for us to continue this physical moΔ is complete now two plates large X infinity Z infinity displaced at Y thin plates there is no imposed flow bottom plate is fixed top plate is moving one would think therefore there is a flow is induced.

Is different from imposed for me impose would be I put up I put a fan here or a compressor that would be inducing the imposing the flow but I think as you understand you can use whatever word you want bottom plate fixed top plate moving in the X direction this is very important also for us is a courtesan I have selected the Cartesian coordinate system okay now what kind of a fluid here no we will go one step ahead what kind of a fluid we would like to have here we cannot of course I will prescribe that you will prescribe we will say this in Newtonian fluid many a times we take the all these for granted.

I am trying to make it a little bit more so I do not think it is so simple you know it is known sometimes we make mistakes here also say Newtonian fluid meaning it follows that Newtons law viscosity tau = to M Δ u by Δ Y it is a Newtonian fluid this is the fluid number one - what kind of a flow we will now assume we will now say it is incompressible he is a fluid do you referred compressibility impressive incompressible to the fluid or a fluid flow you call him compressible fluid are incompressible fluid flow compressible fluid compressible fluid flow think about it we will now say it is incompressible this is I am prescribing is not an assumption at this point I am saying I want to study this incompressible waters in terms of flow what else I have to say ok steady.

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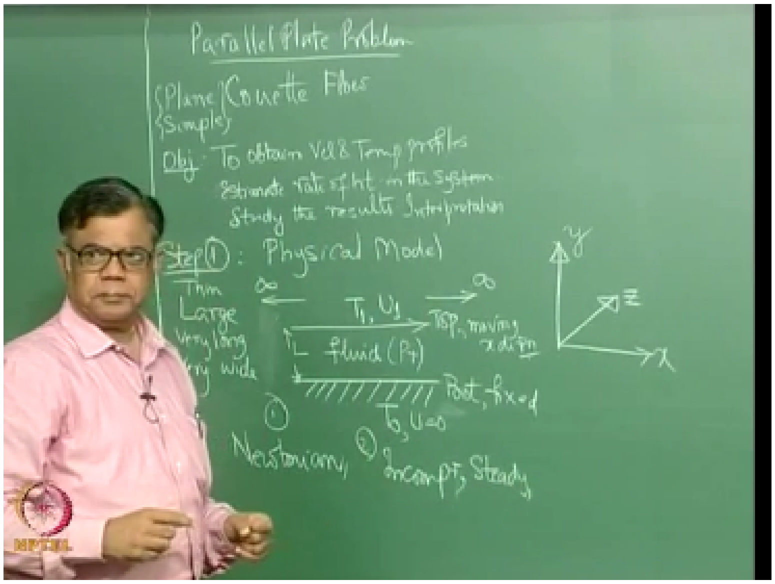

Let us enough huh is that enough a point from the coordinate system what is it that I have to write one two three so you have to say let us write down then what else very good something from the point of view of properties Oh Dean is we do not you know that term we do not use but properties either the properties are X are there Y you decide at the initial point all the earlier you put = when you write this point is very important because of the type of =s will change according to this.

What is that so the properties for our problem are considered as I want the answers from you therefore, I am I want to have this interaction it doesn't matter if it takes time the properties are either actually there is a very important assumption that's how you write your you tell you all =s you write only then you can write those =s in that form I tell you I come to that continuum here in this particular case constant we mean with respect to the temperature and pressure not with respect to the time that is one way of doing it with respect to time the properties will change only if the pressure temperature changes.

With time we will leave it as it this constant property is not a very nice terminology from English point of view but that is used in literature constant with respect to temperature and pressure so properties would in change is what we have a kind of now you see this is the beauty and complexity of convection there is. So many things that you have to specify when you do this and then get the mathematical = and then put the boundary condition for every one boundary condition and this combination you will have one solution you will change one boundary condition we have a different solution keep the boundary condition same chain one term in the mathematical = solution are different and those =s depend upon this so if it is not incompressible you have a whole set of new =s where the properties as the ROIs which will goes into the derivative steady and city obviously you know laminar turbaned obviously you know 3 D 2 D 1 D single phase 2 phase. So when you look at flat plate nusselt = 0.332. Then I was half pronto 1/3 all this Must immediately compute two dimensional laminar incompressible constant property Newtonian fluid of course in all this give you that solution you change any one of these definitions of the problem your point three theta does not hold good so you cannot simply is a flat plate put point three two letters of pun you should know what is behind that particular solution okay this is the.

Yeah so I would like to take this up this is a very important boundary a condition which we assumed at the beginning there is a difference between assuming and defining the problem constant property could be an assumption but I am now trying to define but this is I am defining the problem here then assumptions will come in about the situation about the conditions then you simplify the =s ok now what I want you to do is the for me this is the full physical moΔ now this is I am considering this problem diagram is one of the aspects all these things you have to be very clear if you are it is better to write down.

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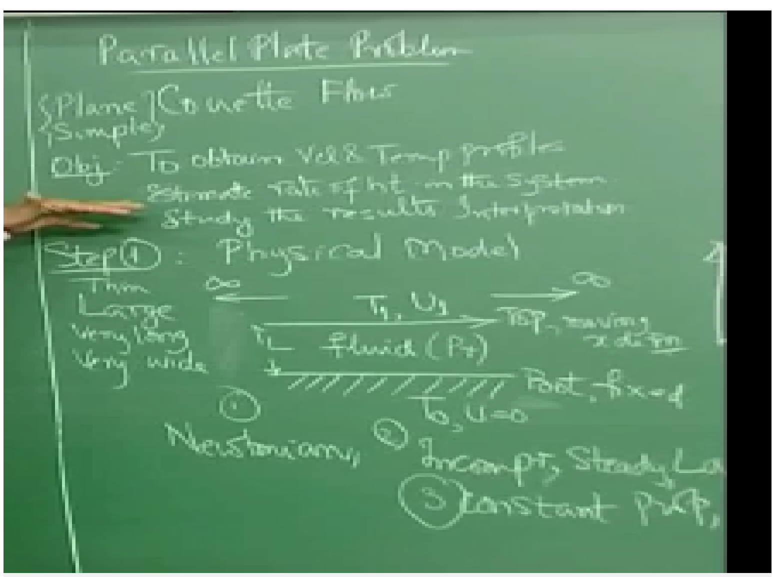

All ways so that you can push it to the next step so there is a physical moΔ so from physical moΔ you graduate to what should do you know get now the physical moΔ is ready now. So now we have to write down the math moΔ.

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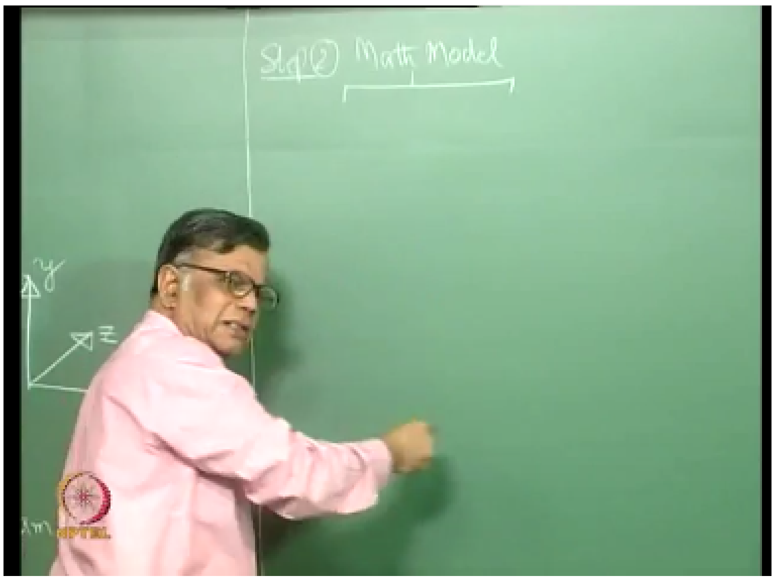

Math moΔ consists of two things what are these boundary conditions will come later first before the governing =s only boundary conditions. When you do this the mathematical moΔ is complete so do not think mathematic. when I say I do not think out of experience I am saying math welcome I will simply people write the =s and leave their boundary conditions to me only when you write the boundary conditions looking at the proper they =s. How many boundary conditions how many boundaries how many conditions so what is the order of the derivative then only the problem is now complete.

Hopefully it is now ready for the solution now so we will now get the mathematical you will get the mathematical moΔ for this what I want you to do is write down three dimensional for this situation the neighbor Stokes =s complete nervier is stokes =s we have not talked about boundary layers here we are not talking about a layer make a difference write down the complete nervier stokes =s continuity x component by component Z component energy no species start. As and when you finish you please tell me I like it continuity = three-dimensional laminar incompressible is very important here constant property cell give me the three-dimensional continuity = what is it that you say you are some of jumping ahead maybe I am a little slow give me the first three-dimensional continuity = for these conditions or is it if we try to be unsteady what would it be if it is incompressible. So this is also for incompressible it is a unsteady state also this is a = for unsteady you get only Δ Rho by Δ T in that term you do not get U,V,W there is only the property variation if it is incompressible if it is compressible flow only that will come in as a continuity = in incompressible flow Δ Rho by Δ T is 0 so Δ u by Δ X plus Δ V by Δ y plus Δ W by Δ Z = 0 is the continuity = for incompressible flow steady or unsteady talk now oh it is component now.

We write momentum we will start giving number space momentum = please x-com Pinot huh no you okay we will write it because although I have said here and steady a steady at this point we will send steady and then make it straight good ok give me this please quickly you do you by duo X so by = to what - Plus no you are ok I'll say the X component of the body force but I've divided. Everywhere, by row right this one by and E Z components please completely write.

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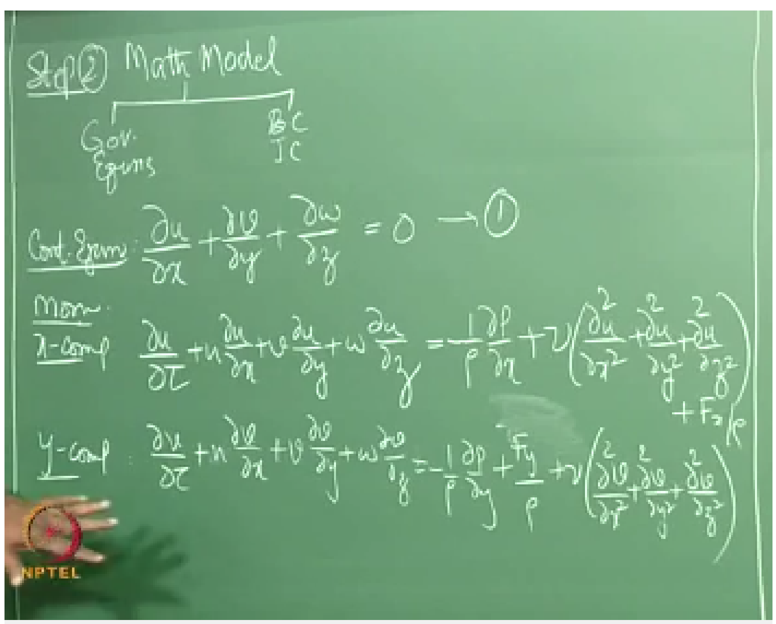

There are two terms our inertia terms pressure body force and the viscous weight for W also three components you have written write the energy = can you tell me one by one terms energy huh yeah notify Plus this is very easy to write u Δ T by Δ X V Δ T by Δ y plus W Δ T by Δ

Z you are you all promised it as though I always princess that Δ   you understand okay koru is = to what now here α.

 This is a grad square T actually anything else write the complete energy = for incompressible then we will make assumptions huh sometimes we write Phi sometimes M Phi if you do not write M Phi and write Phi in the definition of Phi would have included M here that M you can take out take it away from that okay huh yeah I thank you is that all anything else there are actually two more terms one is a compressibility term.

 But we have said incompressible otherwise you shred the compressibility term β comes into picture compressible expansion coefficient. So write down Q triple prime by so this is two three one two three four no species = now actually you have to solve these certifications three-dimensional this is the complete naïve is stokes = or what we have written for this particle situation.

 Now we may yeah this can be done with them operating with our boundary conditions of course for UVW TP and everything only on a big computer you can do this and not analytically even they were approximate by the integral method may or may not work here almost definitely how to go to it basically what becomes a DNS you know direct numerical simulation. But we will see we will avoid it. So tell me we will make some simplifications now this is step number.

Okay to a simplification we have not yet completed the mathematical moΔ now I will give you now this is a parallel plate example I am giving now if I want to consider the flow somewhere in the middle of the speed in this portion. So physically what would you told you interpret how do I ask this question I want the flow although I have talked about two plates I want to talk about the flow only in this region what am i implying actually when I say that I am but sit no I did not communicate the question properly I am interested only in the flow between these two plates but only here means now tell me what I am trying to negate okay let me put it the other you may hint I want only in this portion here instead of taking the entire plate that is why we are given the example.

 we have used the word large actually now I'm coming to that when you say large plate in the majority of the plate zone what is it that you can negate entry effects and once you correct once you actually there is no entry here there is no entry but let us take it that way entry when you say entry another thing is exit on only on one side on both sides but there is no entry here knows it so we would very correct now we would say in the so-called X direction we call this the ends of the plate.

N and in the other direction we call it the edge so, there is a end two ends and two edges now we will say if I want to consider the flow only here the effects at the entry and exit I mean again how do you neglect now mathematically how do you neglect entry and exit effect on both sides what would you what would you say in terms of mathematical terms.

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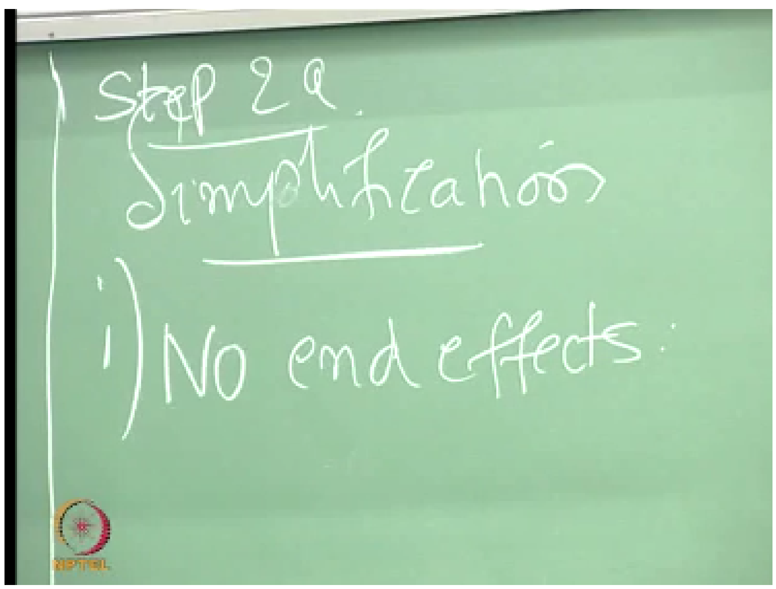

I will write here you came up with the right answer physically no end effect huh means what I will do I have to give you a hint what kind of derivative terms you can negate you negate this then so that I will set the gate I will say no edge efforts what would you negate huh bah-bye that means ladies and gentlemen no ladies here the flow is really three diamond in this box for example you know we're in there is goodness there is a three-dimensional corner this is a two-dimensional coordinate here you have the two flows if there are flows interacting to give you those two-dimensional three-dimensional effects especially.

Three-dimensional but if you take somewhere here a simple flat plate now you can take this as a flat plate flat plate need not be horizontal flat plate can be vertical and then the flow can come here in the majority of this area if you leave out the leading edge as you have known and the trailing edge you say those effects you can put in a BahΔ air flow you cannot do that in fact that flow or Y X = to 0 that is a leading edge thing that creates a lot of problems actually and especially where numerical if you are going to solve numerically. What is the condition that you are going to put at X = to 0 is a big problem y = to 0 is no problem X = to 0 what it is a singularity situation there ok no end effect no edge effect now I will say one more thing only G effect only G as a body force you know what this least leads to.

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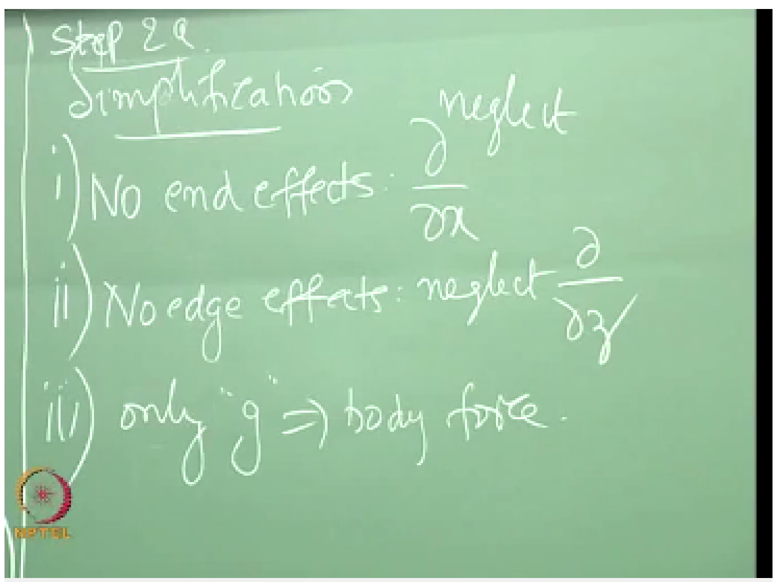

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What are the other body forces yeah then in an actual player that is good but in our applications in mechanical engineering for example body force acts on every molecule of the volume surface forces are actively on the surface. So pressure and viscous a body force acts on every molecule one is G huh no miss Casey the surface huh Fermi you know that is also surface normal spaces normal and viscous is act only on the surface I will give a hint a turbine go further ahead the earth is rotating on its own axis and rotating around the Sun what forces come into picture . Coriolis forces so electromagnetic forces Coriolis forces centrifugal centripetal all of them act on every particle therefore they are called body forces the body the entire body otherwise their surface forces so here we will take the simplest G and therefore it is a natural force G.

Okay know as and when we go further we will make other simplifications with this huh can you now simplify this we are now still doing the mathematical moΔ please simplify this see what =s do you get now get me 4 =s with all these assumptions that we have made take the take the first take the app ID you are right you are right thank you we also take study very nice start from the continuity = simplified no end effect. So what is it that can be neglected no effect there is no assumption on this so the continuity = now is Δ V by Δ y = to 0 psi dot right go to the X component place so I will say Δ   V by Δ y = to 0 then X component Δ u by Δ X Δ u by Δ Z now this is a problem we will come back Δ.

Square by Δ X square Δ Z Square this is not there now we will say Δ P by Δ X is 0 exact because we are not imposing the flow with a pressure difference from outside the inertial terms and miss customs are taking care of each other that is what is keeping the flow. So and also we are saying no adjacent so all Δ by Δ X is canceled so steady state no write down the expression now what is the X component momentum there is not a boundary layer thing there are no modern assumptions.

This navies-stokes =s with certain geometry flow and some assumptions we have made like no and effect on a edge effect so what is this Δ square huh give me give me the entire expression that you got here we know you by do u Y is = to now before going further we will make a small thing now here look at the continuity = Δ u by Δ y = to 0okay we will do it later leave it leave it we will come back later so this is five we will come back later. So we will = further simplify it then write down the Y component it is very interesting same thing here Δ.

V by Δ tau Δ V by Δ u by Δ X will go Δ V by Δ Z will go okay we will we will invoke a boundary condition and do it I wanted to write it later but we will do that tell me the boundary conditions on V at y = to 0 please write down at y = to 0. What is we why we = to 0 script doesn't come under v4 we V = to 0 is purple go to the plate so for V = to 0 what should be the assumption that we have to make are the condition that we have to specify there are no perforation so there is no V component means it is a solid plate it is impermeable plate please that we should have written here.

actually I could have written right there now just so there is no B comment but is that right just because it is a impermeable plate you think there is no V there is another condition where for impermeable plate there could be we you are saying we if it is there are holes and then you put in air or whatever the fluid suction or blowing is not there but I would like to state that we could be there even for my impermeable plate under certain conditions.

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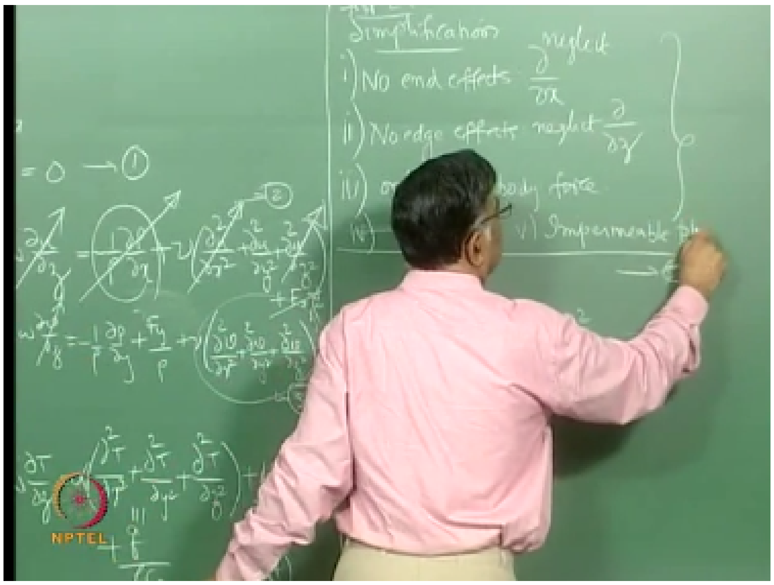

You know this you know the answer I want you to give me I will give you two minutes give me a physical situation that is a comic songs are seven impermeable plate there is no a component there particular to the impermeable plate there is no weak on there that means at the one it is there in the boundary layer at the wall we are talking about at y = to 0 we are talking about okay you have a water body our reservoirs Madras or is always which you do not have water you know water then there is a flow or then there is a wing what happens that is the solid surface actually impermeable surface rather.

What is surface but now there is a big component that we component is actually vibration that is occurring now can you go further and say something else too maybe at least definitely. One other situation two situations maybe one situation the operation is one related to that something else you see it all the time in our refrigerators yeah there is a condensation that is the boundary condition your dues there is a V there so impermeable plate V = to 0 because there is no going on suction but also there is no V = to 0 because there is no condensation and evaporation even with a solid plate.

Okay so now we will do that impermeable plate on the other hand can I use some other term for us to say V = to 0 some other term not evaporation no boiling you know condensation any other generally accepted term. I can say no this thing okay we will do that. So we = to 0 we have not yet formulated the problem but it is okay now take that V = to 0 at the wall both ones take this continuity = you have written D Δ V by Δ y = to 0 so what is the consequence of this if you apply the boundary conditions on V for this.

What is the consequence of that just look at that we = to 0 at the bottom plate y = to 0 please write down y = to L also V = to 0 DV by = to 0 therefore ,What is the conclusion out of this? V = to 0 where everywhere V = to 0 there is no B component at all because at y = to 0 V = to 0 actually y = to 0 I should not write V 0 we should sell V W = 0 and Y tending away = to L also V W = to 0 and this = together this component 2x forum continuity = and the boundary conditions tell you V is 0 everywhere is a very important physical interpretation we = to 0. Everywhere now you use this what is the Y component see what happens with the = here what happens sorry use it even for the X component first we = to 0 so what is the X component = now huh please dos square that's it there's momentum = what have you done in one shot all the convective terms are gone viscosity is there but because of our this noodle square u by Δ.

Y square = to 0 actually but now it has come down to this square you but actually Δ square u by Δ Y square Δ V by Δ Y I want you to do another thing it is only in the y direction that every = is coming along now this is we Δ V by Δ Y Δ square u by Δ Y square you can as well write this as change the dough to that is it so now it is coming into an order differential = here see how you have simplified that entire one of them call X component now go to the y component.

Whatever I component I had to do that V = to 0 everywhere so that you can simplify this but what remains here in the Y component there is a something still remaining pressure on now so write down that expression and tell me a solution. For this just write down the Y component and the solution is written there if Y is only body force is G so what is that DF y is the Y component of the body force what is the force there yeah give me the variables there in terms of variables. So Rho G and in what direction is Rho G on the Y direction upward and downward so it should be Rho G prefixed with a so now get the = and automatically will get the solution find out what it is one by Rho DP by = 2 or G so what is the solution for that Δ ta P = to my what is that = let us say that is a solution.

Y component is Δ ta P Δ ta B means within the boundary layer within the fluid layer P - P naught or whatever u is = to - Rho G H or G Y there is one more solution required that's the solution - Rho G Y so component has given its own the momentum = has given its own solution you don't have to solve it anymore. So Δ ta P = to - Rho G actually you get it as Y so it simply says very correctly also - actually so it is reducing p2 - p1 is reducing mean speed as you move away from the surface the pressure is reducing now look at the Z component very quickly yeah you have it give me the Z component = 1050 and you have to go Z component Δ W by Δ tau 0 all Δ by Δ X is all Δ by Δ Z s.

So what is it what is the = you ready you have an = still what is that Rho square right now invoke again the boundary condition what is w at the one what is bottom wall what is W at the top at y = to 0 W = to 0 at y = to n w is 0 so W is 0 complete the sentence every way quickly do the energy = can you do it. It is 1051 I have written down here so we will do this Δ ta by Δ ta is.

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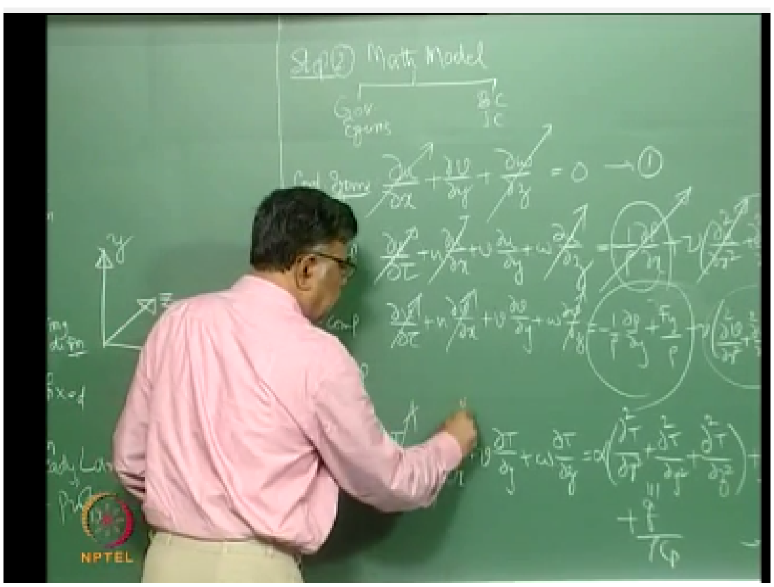

0 Δ T by Δ X is 0 V is 0 here Δ T by Δ Z is 0 w is 0 Δ Square t by Δ X square is 0 Δ Square t by Δ Z square is 0 and now we will put one more condition here no internal heat

generation. Will now add so that goes up Phi is full of derivatives can you write down you know you Must have it somewhere at the back and Δ u by Δ X whole square plus Δ V by Δ Y whole square plus Δ W by Δ Z whole square Multiplied by 2 that single terms all squares then two terms come into picture you have it please right now and then invoke this no idea fact no side effect simply I will give that to you as a small exercise do that and obtain the energy = though all that we have written here as simply Δ C Square t by square plus M by K B u by D u whole school where is this du by whole square coming from the viscous dissipation everything else.

Cancels out there I have already put D I should not have done it but I already mention you will see that all the derivatives are only function of Y therefore instead of do you can simply make them into a DS so you have d square DV by D = to 0 d square u by square = to 0 this is the solution already.

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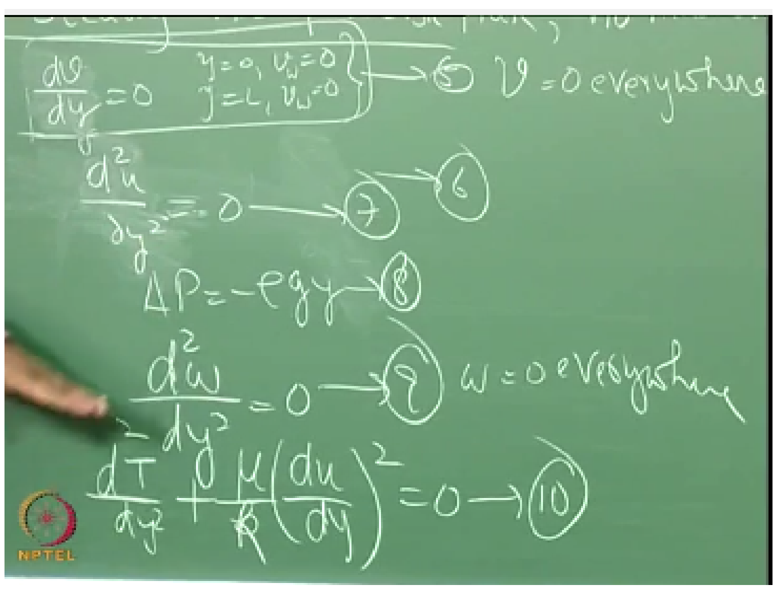

This is d square W by square = to 0 d square t by square plus M by K du by D whole squared = to 0 we never made an assumption any other assumption with viscous dissipation I have maintained that. That is very important from that you will get a lot now what is it there therefore you have to solve this is already taken care of this is solution B = to 0 everywhere this is V = to 0 everywhere sorry W = to 0 everywhere this is already solved so finally ladies and gentlemen the only two =s you have to solve is d square u by square = to 0 d square t by square plus M by KD u by D whole squared = to 0 please put the boundary conditions at y = to 0 for u v and t and y = to 0 T is T not please okay now this is this is completed the =s the mathematical moΔ is not complete till you write the boundary conditions please write the boundary conditions at y = to 0 U is 0 V is 0 we have given the reason why it is so and W is 0 T = to T naught y = to L u = to u 1 now what is this condition called I did not mention you know that when I put y = to 0 u = to 0 and U,Y = to L u = to u 1 what is the condition I am invoking physical condition what is it called no slip condition.

This is where all the problem starts for us if there were to be slipping I mean wonderful then that would have been an ideal fluid the Ombud principle would have worked the real fluid the problem is this is creating the entire boundary layer problems later that one condition then what about the temperature y = to 0 T = to T naught y = to L T = to t1 what is this condition called the other one was no slip condition what is this condition called now we have taken it to be isothermal not Chi so thermal plates yeah I did not mention.

Please write down isothermal plates that is a one boundary condition that I am talking about writing down y = to 0 T = to t0 and y = to L T = to t1 corresponding to low slip condition there is an M for it there is no slip means it is attached other it was slipped now temperature in a very similar way may we use another word okay I'll tell you huh perfect contact is verifying perfect contact condition you can call it very nice.

So we also call it as no temperature jump condition the perfect contact is verified no problem now when you write all these boundary conditions these 2 =s ladies and gentlemen you have now completed the mathematical moΔ we have to go for this step four which is the solution I will do it tomorrow but I want you to solve the momentum = there is no problem try to from the momentum = solution try to solve the energy = we will do it tomorrow we'll finish it and I want to calculate the heat transfer system our thank.

Couette flow – Part 1

End of Lecture 8

Next: Couette flow – 2

Online Video Editing / Post Production

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Funded by
Department of Higher Education
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