Fluid Mechanics
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Lec 34: Open Channel Flow

Good morning all of you. Today we are going to start a new chapters that is what is open channel flow is a just a application subjects what we learnt so far on fluid mechanics. As you know it we learnt about mass conservation equations, we have learnt about linear momentum equations, also the energy equations as we have the three equations with us as well as we also learnt to use the control volume concept for the integral approach. So, today we are talking about those tools those basic equations like mass conservation equation, linear momentum equations and energy conservation equations for open channel flow. It is very specific flow open channel flow. This is the applications of fluid mechanics what we learnt so far of about the control volume about these conservation equations.

How we can apply that once with a concept with a some simplifications what we are going to do it that is what I will discuss it. As the name implies it this is what the open channel flow that means we are talking about channel flow which is open okay. So more details I will commit. The basically in this there are a lot of advanced level of open channel books are there.

But I can suggest you to go through this F.M. White book which will be give it say very concise for the undergraduate levels the F. F. White book you can follow it or you can follow Senzel Simbala book and if you want to have a go for advanced levels okay which is there one of the course which we are floating it by me is river engineering okay.

So, so many a concept of open channel flow we discussed about that which we also followed open channel flow the books by Hanif Chaudhary. So, the basically what I am telling you is a introductory levels. So, we can read FM white book which is quite concept. conceptually is concise book you can read it you can read the Sinzel Cimbala book. But as I said it we are not introducing a new concept whatever concept you have learned how to use the control volume concept how to use mass conservation equations how to use the momentum conservation equations for open channel flow.

Open channel flow, if I talk about, I think almost all are familiar. Because if you look at most of the rivers, they have the curved nature. Most of the rivers we have the curved nature. which is we called Mandarin rivers, but why we do not know we do not look at that much details. But in open channel flow we can address that or when you have a this is what the river natural flow systems.

Let us go come with examples like a river flow as you know it river does not flow a straight path. So, it has a mandate seat as a curve curves that is what is a river flow. and similar way you can see this natural flow systems which is very complex. Today's world we have Google Earth Geo-visualizers you can see that how the complex river patterns. Anyway we are not discussing that or we try to make canal systems for So, you know it we construct the canals, we construct the drain.

storm water drainage systems okay which will have a more less having a series of junctions series of outlet. So if you look at that the flow can come this side can go this side this like this okay. So if you look at that there are main systems like canal the drainage system storm water drainage systems navigational channels okay as you can look at that the civilizations how we made the best navigation channels to so that way if you look at that these are all the open channel flow. of one channel flow okay. One side we have a natural systems okay and another side we have the man-made systems to for a drainage networks, the canal networks, navigational canal networks.

So if you look at that there are a lot of systems we build it to transport of waters or any solid waste through a drainage systems or the canal networks okay which is having a free surface. Basically we are talking about when we have free surface okay that means if I take a cross sections that means if I take a cross sections of a river or I take a cross section of main main channels okay cross section at the 22 and the 11 if I take the cross section like the 1 1 as it expected it is being a natural systems it could have a the free surface here okay for the section 1 1 okay. So this is the bed, this is the cross sections, this is the top width, this is where the top this is what perimeters as you know it okay. So this is the flow channels we what we have for the natural systems where the geometry may be the complex systems okay. But when you come it to the canals like for examples if I look it most of the times we canal I either you have you can see it any of the canals okay nearby.

So either it is a or a shape of rectangles okay. So it will have the flow depth, it will have the perimeters and you will have the top width. So more details will come in. So one is manmade the cross sections, another is the natural process what is making this the shape of the cross sections of the rivers. Though mostly what we are getting it the both the things the common is the free surface.

Common is the free surface. There is a free surface is there. that means at that locations the pressure is atmospheric pressures because it is a free surface the pressure will be the atmospheric pressures. So at these locations pressure is equal to pressure atmosphere this location pressure will be the pressure atmosphere. So let me I just reschedule it the concept that that means if I have a natural rivers and I have the free surface okay.

So I can put it like this. So this is the perimeters of channel. This is the free surface where the pressure is equal to P atmospheres okay. P equal to P atmospheres and here I have a canal okay maybe carrying the water maybe storm waters maybe sweats whatever be okay but it has a free surface. So that is the reasons it is the pressure is equal to atmospheric pressures, pressure is equal to the atmospheric pressure.

Same way if you can talk about that I have a pipe but it is not fully So it is half filled okay. So if it is that the conditions the pressure at these locations also comes to the atmosphere. This is what we can understand very easily when you have a free surface or open channel flow the pressure at the top where the water depth start is which is designated by these symbols is a pressure is atmosphere. So if that is the conditions if you try to look it now we have only the two force components with us now because there is no pressure force okay because pressure is at the atmospheric levels, pressure is at the atmospheric levels. So we have a two forces one is gravity force, second is friction force that is two.

There is no surface pressure force components. We will discuss more that because there is no process. So that is what the difference between the pipe flow and the open channel flow. In pipe flow, we have a pressure. Pressure flow energy is there.

But when you talk about open channel flow, we have the only two forces. One is the gravity forces. Another one is the friction force. Where the frictions comes? The friction comes from bed or the perimeters. okay better the perimeters.

So that means what type of perimeters I have what type of roughness it has the same similar to the as we discuss in case of the pipe flow the roughness of the pipe flow that is what we discuss it the same concept will come it here because of the presence of the roughness in the perimeters of a channels it gives a resistance force it gives a frictional resistance force. the frictional forces is given by that. So that is reasons what type of the boundary what type of the materials are roughness is equivalent present here that is what will give you a frictional force and you know about the gravity forces component what will be there for the any flow control volumes we can find out the gravity force and we know what will be the friction forces because the friction force will come from the perimeters and at these atmospheric levels there is a no there will be drag forces but that air force is much much negligible okay air drag force will be much much negligible compared to the liquid what we are considering. So that means we nullify that. not only that as you know it we have no slip boundary conditions okay that is what we discuss in a very first class no slip boundary conditions.

The no slip boundary conditions imposes us the velocity near to this boundary will be 0 the velocity near to the boundary will be the 0. So, velocity near to the boundary because of no slip boundary conditions the boundary is fixed at the locations. So, the velocity becomes 0. So, you can now conceptually look it that we are coming to a very simplified problem as we have solved many difficult problems in earlier classes like integral approach the differential approach. But open channel flow is very simplified cases because there is no pressure force components there is a pressure is equal to atmospheres the no slip boundary conditions when we are imposing it the velocity near to the boundary the parameters will be 0.

So since it is a 0 that means I can draw this the velocity distributions velocity contours okay iso velocity contours I can draw the velocity contours I can draw velocity contours that means maybe this velocity is equal to 2 meter per second next maybe 1.5, 1, 0.5 meter per second. This is what the contours of equal velocities that is what you can be because near to the boundary velocity is 0. So you can have a velocity distribution like you can have a velocity for this case also you can have a velocity distributions like that is what I always encourage you to just draw the safe try to understand it how the velocity distributions are happening it okay.

So if you understand that the concept that means you understand many of the things. Now if you look at more introductions levels we are talking about also we will talk about the classifications of open channel flow, hydraulic radius for some common sections and we talk about the wave speed and flow power numbers which already we have discussed in dimensional analysis. Then maybe the next class we will talk about other component like specific energy, the critical depth and all but let us today class we will be confining up to the wave speed okay. More details I will discuss on that. Now if you look it as I already said it.

the basically we have the free surface boundary conditions okay. So once you have the free surface boundary conditions if I remember it basic pipe flow when you are solving a pipe flow that is the same things I am drawing it here. So when you have the pipe flow okay if you remember that we used to draw hydraulic gradient line and energy gradient line okay that is what we used to draw it of a pipe flow of if it is going like this if it is a z1 is a from a particular d terms that is what is datum head then you have a pressure head okay that is what is p1 by the pressure head rho g the pressure head then you start hydraulic gradient just top of that you start energy gradient lines. That is what we did it for the pipe flow and that is way we reflect the how the energy distributions losses are happening it are how the energy gradients lines are there each point of a pipe networks with a very simple representations through energy gradient line and hydraulic gradient line okay. But now when I am coming for the open channel flow this is what the pipe flow okay.

So if it is that if I have this so this is my free surface in a pipe in a channel flow okay this is channel flow okay this is a channel flow having a slope let be theta okay having the slope of theta so I have the channel flow. So if I consider a datum that means my pre-surface will be the hydraulic gradient line above of that I will have a energy gradient line. So that pre-surface whatever this is the flow depth let be the y is a flow depth z is distance from the data. So I have this and this is what v square by 2 g and you can have this kinetic energy correction factors okay that is what you can see that. So that means the difference between the technical is between the pipe flow and these one is flow energy is not there the pressure flow energy is not there when you talk about the open channel flow because of that your hydraulic gradient lines and free surface they they are the same they are the same.

So that means whatever you line we are getting it the free surface flow that is what is representing the hydraulic gradient lines. So if we know the velocities so I can estimate the anarchic gradient lines. I can estimate the energy gradient lines that is what I can estimate the energy gradient lines. So that is what I think as I said it the free surface is coincided with the hydraulic gradient lines and the pressure is constants along the free surface as I discussed the same way it is there. There is a no slip boundary conditions as I discussed it.

that the wall shear stress develops along the wetted parameters which varies along the wetted parameters more detail okay more detail just let me explain it that what is telling is that when you have this lady I have a natural systems okay having the river cross sensors like this okay it is river. So it is saying that no doubt the velocity at these points along these parameters as a no slip boundary conditions will be the zero will be the zero and the flow is three-dimensional lectures okay three-dimensional lectures as well as except very few cases like for example for open channel flow when you have very thin sheet flow maybe during the rainfall beyond that all the flow most of the flow turbulent flow okay. Turbulent flow okay except few conditions that the flow will be the turbulent flow. And we will be discuss about that what the flow characteristics in terms of subcritical, critical and supercritical. This is analogous to the supercritical this is just analogous to the subsonic, supersonic and sonic.

conditions what you discuss about the compressible flow. So same way incompressible flow in open channels where the gravity force dominates it we classify the flow into three categories subcritical, the critical and the supercritical. As we discuss very beginning of dimensional analysis we use the flow proud numbers for classifications of these like flow proud numbers if is equal to the 1 then is a critical if it is a greater than 1 is supercritical less than 1 is subcritical. So the basically we can have a different classifications of the flow we will discuss more details. why we need it subcritical supercritical and the flow conditions.

As well as let me what we are discussing is that we get the frictional forces we get the the shear stress acting over the surface that is what the wall stress that is developed along the wetted surface that is what is the part is wetted part varies along the wetted perimeter at a given cross section. That is what is a variability is there as you can understand how the shear stress distribution And if I make it very simplifications that just want to put it for this one channel flow if it is having theta slope this is the bed level and I have the free surface if I simplified it okay that is what we do it many of the cases okay. the three-dimensional flow which to approximate to the one-dimensional flow if I can approximate it okay. That means we are just talking about that the flow is happening in these directions only okay mostly this the longitudinal directions that is what the flow dominating it and if that is the I have the velocity v then I can say that v varies along this x directions and if my y is the flow depth so y also varies with a x directions and the area of flow is also varies with x directions for steady flow. okay for a steady flow if I approximate it okay I do not consider other dimensions that my the velocity of the flow the average velocity of the flow in the x directions that is what is going to change it the area of the flow is going to change it the depth of the flow is going to change it which is more interest for us but if there is a unsteady flow unsteady flow that means most of the times we also encountered the unsteady flow with a one-dimensional approximations we are z b x and t y x and t and area x and t okay that is what we discussed lot okay.

So it will have commit a dependence function of the space and the time. So basically the flow varies along the direction in most of kinds. So the velocity distribution in generally the three-dimensionals that is what I discuss it. The magnitude of the flow resistance depends upon the viscosity of the flow as well as it depends upon the wall roughness what type of roughness factors are there. So the basic idea comes from this open channel flow that is what let me because as I said it very beginning this is very introductory levels with a very simplified way I am going to deliver these lectures but if you are interested for advanced level anyway you are the courses are there in open channel flow courses are there on river engineering.

So, now let me I come back to that as I sketch it very beginning that this is what when you conduct a lab scale experiment. Scale experiments any flume type of experiment which we have shown the flume experiment in analysis and similitudes the same continuity with that. So we can measure the velocity distributions in a open channel. So you can have the instruments to measure the velocity. As you measure the velocities in any rectangular channels as it expected it the velocity of maximum velocity will not be at this this is the lab scale experimental data okay.

That is what I emphasize is okay this is what experimentally verified it this is the distributions happens it. So that means you will get it the velocity distributions like this okay velocity distributions like this okay again I am repeating it this may be 2 point meter velocities in terms of meter per second. So this is 1.5 this is a 1 this is 0.5 and along the boundary you know it the velocity is equal to 0 okay.

but we observed from experiment that if is the y is the depth then the maximum velocities occurs about 0.2 times of y or 20% of the flow depth from the top surface that is what the experimental findings that is what the experimental finding about this velocity distributions that means it is we can easily get the velocity distributions from velocity distributions from experimental data set this is not a difficult. And since it is a turbulent flow it is a velocity distributions will come from is a logarithmic velocity as we discussed in the boundary layer concept and all. So velocity distributions also will follow the logarithmic velocity distributions. But what we are not worried about more about the velocity distributions of these classes these two classes but that more we are towards to understand it what is the general natures of the flow okay.

That means what we are looking at that if I know these velocity distributions which is from the experimental data most upon things what we are looking it that how much of energy losses happening it okay. That is what is our audit okay. We are not bothering about the velocity distributions because anyway it is a open channel flow. For undergraduate levels here we are talking about more details that how much of energy losses happen as we estimated for the pipe flow. We have estimated within Mori chart and with a lot of examples we just demonstrated how to estimate the energy losses.

Same way if you have a network of open channel flow then we have to try to understand it how much of energy losses happening it for different conditions okay. So one cases there are the classifications one is a uniform flow as we discussed for a flow classification there I am not going detail. Now if you look it as I discuss it that we talk about natural channels. artificial channel and open channels okay it is it is name of the open means one of the side is open. So that is it is have not having cover at the top I think these definitions is not without any cover that is definition is not that correct but I will tell it that wherever you have a free surface even if I have a pipe flow If I have the free surface that is the conditions is the open channel flow it is not related to the covers okay.

Anyway that is maybe a simple way to explaining you not going through this pressure is equal to the atmospheres and the pressure flow energy is not significant in this case that is the reasons maybe it is come that but let me not we have these the cover does not matter it okay. we go for very simple cases like prismatic channels okay like many of the times when you have a man-made cross sections okay man-made cross sections. okay we try to make it the same cross sections okay and the constant bed slope that is what when you laying out a canals okay. So mostly you try to make it the cross sections will be the same okay as well the bed slope will be more less the constant okay so that is what the prismatic channels okay. Then we have a the cross section directly proportional to any of the power depth of the flow this is exponentially channel and if traversal channels are non-expansion channels okay that is basic definitions okay.

Now if you look at that I think we already discussed about the steady flow that means when you have a flow velocity the flow depth if it is a y and discharge energy losses all either they are the function of space or the time okay if it unsteady flow both it having the both space and times. Like for example is a dam breaks okay when a dam breaks happens it this unsteady flow but if you go the same discharge you flow in a channels. So, we can after certain times of the transitions then we will have the steady flow. So, steady flow is a very simple approximation what we do for open channel flow, but real life conditions when you talk about even if a channel flow or the river flow mostly they are the unsteady flow. mostly they are the unsteady flow but we are approximating to making a steady flow okay for but nowadays we have a for the river models like this we have a HECC RSA.

So we can use detailed unsteady flow analysis that is what is possible but anyway this is bit undergraduate levels and as I will tell it that how things are there. So let me have a there is a two again simplifies is that the uniform flow okay uniform flow. This is what the depth slope cross sections velocity all remain constant okay. So that means all are the constants okay that is what is depth slope cross sections all are velocity all are constant. How does it happens if it is just happens when this some of the force acting on the system should be 0 like a terminal velocity of anywhere free flying object you attend a velocity which is will be terminal velocity the same concept.

If you have a long open channel flow there may be a stress you will see that the net force acting on this a control volumes becomes 0. There is no acceleration node is accelerated okay. Those the reasons will have the depth slope and cross section and velocity will be constant. So then the flow what we call uniform flow. So basically it is a theoretically possible to have a uniform flow but very rare case we can see it in natural conditions the real uniform flow because attending the concept that some of the force acting on a systems is equal to 0 as I am explaining that when you throw drop a balls it attains a critical terminal velocities okay that is the same way net force acting on the systems is 0 that is what it happens it the same way we talk about the uniform flow attains it when you have there is no significant change in depth, slope, velocity and cross section okay that is very specialized conditions okay.

Otherwise you have the flow which we will discuss is non-uniforms it varies with and we also classified between two things is rapidly varied flow and gradually varied flow okay. So if you just look it rapidly varied flow that means rate of the change of any flow parameters is if it is very significant very high order. that what is roughly varied flow but the any of the parameter depth, velocity, slope if I am not changing it energy slopes is not changing that drastically that abruptly okay. gentle change of this properties are there then we call gradually varied flow. As we have discussed that mostly we have the turbulent flow except a few of very very rare case to have a laminar flow.

So that is what I again I am repeating it very very rare case will have a laminar flow very very rare case will have a uniform flow. also the some cases we can simplify the steady. Otherwise the flow what we consider it all its flow unsteady turbulent okay non-uniform and also we talk about maybe most few of mostly it is also the subcritical flow we design it. So, the basically what we are looking it unsteady, turbulent, non uniform and the subcritical flow that is what is the basic classifications of most of the flow in open channel. Now if you look at a very simple cases to classify between all these flow systems again I am to sketching this part as I said it is very long channels is there then is a drop is there then we have the channel okay.

So that means sometimes you do it okay to change the slope in a canal we make a drop here this is what the drop structure okay so it is a drop structures if it is a very long panels we may be attending a uniform flow okay uniform flow UF. So as I discussed earlier that these the flow conditions where a net force is acting is 0. So that means the gravity force and the friction force both are equal each others that is what you can happen it in case of uniform flow. As there is change of the grades okay from these two slopes definitely you can understand it if I make a free streamlines of a free surface flow I will have a flow comes like this Then it will have a flow like this then it will have a this type of things okay just flow will come like this. So if you look at that this is what uniform flow after that the slope is changing it but very gradually as it is changing in gradually we say gradually varied flow.

that is what that is the gradually varied flow. But that means the flow depth the velocity or basic parameter of the flow is the depth velocity all these terms they they have a functional relationship but that variations are low gradually changing it that is what it has there then gradually it is a changing that part. So we can classify it as a gradually varied flow but after that if you look it the slope has changed and there is could be a formations of hydrologic jump we will talk about that in later on okay so the little some sort of jump structures will come it as the flow is there. So that is the reasons we will have the change of your velocity is very rapidly. So that is what is rapidly varied flow it is very rapid. So if you look at the v the h is very rapid after that again you can have a gradually varied flow or you can come to the uniform flow.

So that is the flow patterns. So the basic idea again I have to tell it that please sketch like a streamline you are used to have a sketch the streamlines for any flow patterns. Similar way when you have a stuck interactions between two any open channel flow try to sketch the free surface lines okay. If you can really sketch the free surface line then you can understand the flow how what type of flows are happening it exactly the same way as we discuss about the stream flow stream line drawing what we used to do it. So free on open channel flow we should draw the free surface lines approximate free surface lines. So if you can draw the approximate free surface line we can understand it where you uniform flow happens when which is the reasons a gradually varied flow happens which are the reasons the roughly rapidly varied flow happens gradually varied flow then uniform flow.

So you can have a approximations of this flow in the three category. So that like for example of a uniform flow we can easily understood it because this is a there is no acceleration, no de-accelerations, no change of the flow depth, no change of any of the flow parameters characteristics that means some of the force is equal to 0. So this is a very simple cases. we can solve it to equate the basic parts okay. Some of the forces is equal to 0 that means gravity force is equal to friction force. But if you look at the gradually varied flow and these this is also we can simplified it for rapidly varied flow but just we have to classify the flow as we is to do it for any other cases like subcritical, critical, unsteady, steady.

gradually varied flow, rapidly varied flow okay that is you can with respect to the change of these flow characteristics the velocity, depth, energy slope, the shear stress okay all if are changing it okay and what is the rate of the change with respect to the space if I define it that is what we are defining it. uniform flow, gradually varied flow, raffled flow okay that is I could I think you could understand this is very easy things as I said it earlier we have gone through very complex subjects this is very easy subject for us now the again in the definitions what he says that just raffled varied flow the flow depth is changes markedly over a relatively short distance in the flow directions. So that is a flow past a open gate that is what it happens is that if you have a gate in and you are just lowering a gate okay that is what you are doing it as you are lowering the gate if this is the free surface so there will be rapidly varied flow and there will be a hydraulic jump.

will come with more details okay. So there will be the flow chance. So these are the reasons we will talk about the rapid varied flow but these are the reasons what we can talk about gradually varied flow followed by you will have a graduate varied flow. This is what we have the free surface that is what is we have the free surface that is what I am just sketching it. So as you are Gradually varied flow the flow depth changes gradually that is what is of a long distance along the channels okay. So this this is a gradually varied flow that may be this distance is much longer to change of the slopes okay.

Follow typically a rapid varied flow and uniform flow. So it is a like we call about laminar boundary layers and turbulent boundary transitions. The gradually varied flow happens intermediate between a rapid varied flow and the uniform flows okay. Basically we are talking about because as I said it we made it a very simplified case of one dimensional case okay which I think is some 90s, 20s or 30s okay. These concepts are well built almost 100 years back okay that is the reasons.

I do not want to focus more but let me as a text you have. So but now we have a technology with us it is not like we talk about the cases which are very simplified cases but just time to highlight it that hundred years back there was no computers. So methodologies were more a conceptual form work. Now they have introduced a new concept to look at that one is called hydraulic radius because as I sketching these different cross sections okay because in pipe flow you may have the circular or this square pipe flow but in natural rivers in case of different canal structures or drainage structures. So we need to have a hydraulic radius concept okay. So if you look at that a simple concept of hydraulic radius okay that means is A by P P is the weighted parameters excluding the top surface which are the the surface which is the free surface if you excluding the length of that.

So area is area of the flow cross sections okay that is what is it is equivalent to a meter dimensions okay you can just put it okay is a radius we define it A by P A by P. So what does mean by that I just have a very simple examples that if I have a rectangle channels y is my depth and b is my width okay. So area will be simple things area will be b into y okay simple geometry. weighted perimeter p will be b plus 2y.

So y from this side as well as y from this side so b plus 2y. So hydraulic radius will be the a by p which means the b by y b plus 2y okay so b by y by b plus 2y. if y is much much less than the b as compared to a river systems okay b is much larger maybe around 200 meters or 300 meters y will be 3 meter or 4 meters if you have that the conditions. So that means this part can become 0. So r will be close to the y. That means if I extend the b, making more and wider and widers, my radius will be the only depth.

My radius will be the only depth. So you try to understand it if I just make a widest okay my radius will be only the depth that is what is converting it. So that is the way a simplified hydraulic radius we are propose it for a open channel flow because that is what is because we are synchronized with your power pipe flow. So we to make it the similar type of concept that is the reasons the concept of hydraulic radius has come in because always having mind that we are trained for the pipe flows that is the reasons we want to have a edge equivalent. the open channel flow we are making it as equivalent to the pipe flow that is the reasons we introduce a hydraulic radius okay which will be the area by the weighted parameters and as becomes wider and widers the hydraulic radius will become closer to the depth that means you can draw a arc okay of r y that is what is equivalent the radius is given to us. So if you trying to this because we always look it to find out this characteristic lengths okay that is what is we need to compute this Reynolds numbers of the flow that is needed rho v characteristics length here we consider the hydraulic radius by this mu.

So this is the characteristic length okay for edge equivalent to the pipe flow we have using the d so we are not using the diameters of the pipe we are using the edge equivalent edge analogous to the pipe flow we introduce a hydraulic radius concept. in the hydraulic radius concept we use that is to estimate the Reynolds numbers. Most of the times just your things when you say that flow is turbulence okay do not talk about is a laminar flow. The flow Reynolds numbers is goes much beyond the critical Reynolds numbers of the open channel flow is 500 okay. As equivalent the hydraulic diameters when you put it again we are putting in a 4 times okay that is the reasons please do not have a confuse with diameter and radius should have a 2 times but as equivalent as you have put it that is the reasons 4 is coming to here okay.

So diameter is a 4 times of this so that is the reasons in a pipe flow you know that the critical Reynolds numbers to define the turbulent flow is the 2000 but for open channel flow we have the critical Reynolds numbers is just 500 because you can make it the 4 terms is there to make it equivalent replace. So we introduce a new concept of hydraulic radius hydraulic diameters as to make it the pipe flow and the open pressure are the similar type okay to analyze this. Many of the undergraduate course questions they ask basic things even if your gate or engineering service okay how to estimate weighted parameters, where to estimate the area, what is the r, and what is the diameters. So this is a simple for a different geometry you have a diameter at the client strength levels you know it for different geometry for different depth you can always estimate it what is a hydraulic radius. This is what I was talking about that when you have a thinness you will come it to the y in a circular channels you can express in terms of theta that is what angle theta and you have a radius r.

So you can represent weighted parameters you can vary up the flow then you can get the hydraulic radius. So it is basically theta representation same way we are looking at theta part is here. to defining the hydraulic radius what will come it in terms for a trapezoidal channels which is includes the weighted parameter of this as well as this and we try to just find out the hydraulic radius or hydraulic diameters okay for different flow geometry. These are the questions I think is from gate questions which is gives us that to estimate find out which is the different 4 channel with a different sections, circulars, rectangulars and triangulars, trapezius and you have to find out which in terms of hydraulics ready. I think it is not a big issue and always you can compute hydraulic radius and finally you find out the solutions what will be the 4, 1, 2, 3 okay.

So it is a very simple things just to have to understand that to estimate the area, flow, perimeters and estimate the hydraulic radius. okay so with this let me I conclude today lecture.