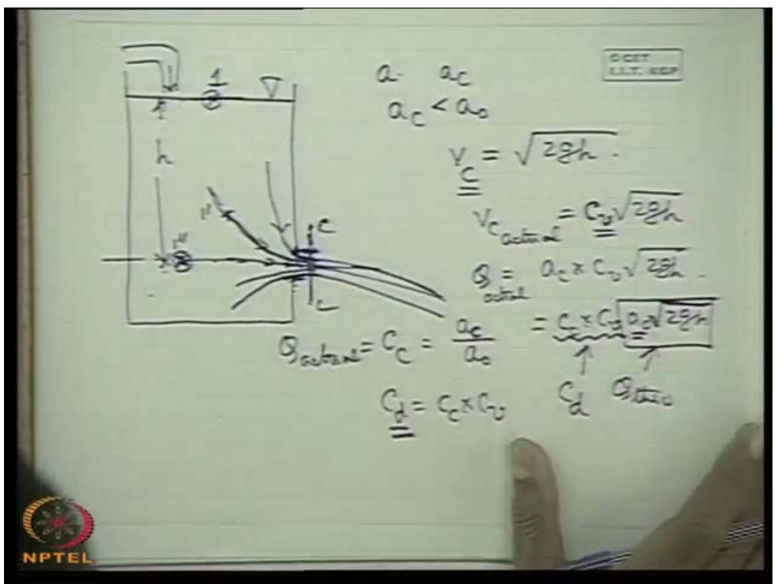
Fluid Mechanics

Prof. S. K. Som
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Module - 1
Lecture - 28
Fluid Flow Application Part –VII

Good afternoon, I welcome you to this session of fluid mechanics. Well last class we were discussing about the discharge through an orifice, what is an orifice we just discussed and what is the discharge through an orifice under a constant head.

(Refer Slide Time: 00:35)



So, let us recall little bit of the earlier discussion. Well if this is a tank where there is an orifice at the side, sorry this is wrong. So, this is the orifice, small hole there is no projection, small hole and if there is a constant head maintained, that means orifice, through orifice the water is discharged to maintain a constant head that means water inflow has to be there. So, under a constant head, head means that if I consider an axis line, gives the axis of the sharp edged orifice.

Then this height is h under a constant height from the axis of the orifice and if this orifice height, that means this height is much less compared to this head above the orifice; that means the height of the water surface from the axis of the orifice. Then we have found out by applying the Bernoulli's equation first of all we see that how the streamline contracts, that is the surface the we have recognized that streamlines are like this, they are contracting like this and ultimately they come to a section very close to the orifice, downstream to the orifice just after the orifice section is C C, where the cross-sectional area of the stream tube is less than the cross-sectional area of these orifice, if the cross-sectional area of the orifice is a, then at C C where this stream tube converges and then becomes again parallel, this is the minimum area section, let this section is C C after that it goes on falling because of the gravity.

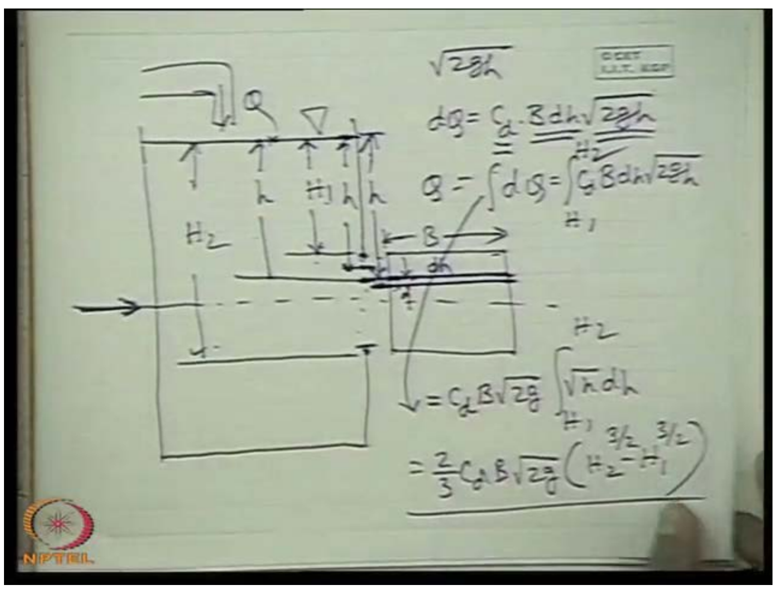
Then this area is a C then a C is less than a, this is the contraction now if we apply the Bernoulli's equation at any point on the free surface 1 and at any point on this section C C or at any point on a streamline, let the point may be 1 dash let the point may be here 1 double dash, one point will be here we will always get after using the Bernoulli's equation, the velocity of discharge at C C of the z that V C is root over 2 g h. Very simple, that means we can tell this potential energy compared to point 1 is totally converted into kinetic energy, that velocity for an ideal fluid without any loss. If we write this for this and this point, so this point is the pressure energy because this point in the same axis, so this point and any point at the C C plane in the orifice is at the same elevation level. So, therefore this is in the form of pressure energy, here the energy is in the form of pressure energy because of this height over the point up to the free surface.

So this is converted to the velocity so V C is equal to root over 2 g h, then we found out that this is the theoretical velocity. So V C actual, which is due to the friction of the fluid at the orifice h is less than this theoretical value and this is multiplied the taken care of by a factor C v that is known as coefficient of velocity whose value is less than 1 and value depends upon the height from the centre of the orifice, that is the head and the size of the size and shape of the orifice. So, therefore Q is equal to, Q actual will be equal to a c that means the volumetric flow rate into V actual that means C v into root over 2 g h.

Now, with a definition of coefficient of contraction as the area of the vena contracta to the area of the orifice, we can write a c in terms of, let area of the orifice as a o, o suffix for orifice c suffix for vena contracta section. Then we can write C c into C v into a0 root over 2 g h. This we designate as a theoretical volume flow rate Q theoretical, that means if there was no friction in the fluid so that the total potential head or pressure head at this point is converted into kinetic head and if there was no contraction of the streamlines then this could have been the theoretical discharge. This is multiplied by C c into C v, that is the coefficient of contraction and coefficient of velocity and this is combinedly known as coefficient of discharge. That means the theoretical discharge as defined by the orifice area multiplied by root over 2 g h, should be multiplied by a factor which is less than 1 to count for the actual discharge, this we discussed in the last class.

Now, here one thing, we assume that the orifice size is so small compared to the height above the orifice that means, if we consider a central line to the orifice so any point on this line or any other point along the height of the orifice, will have the same liquid head a that means with respect to this h there is no variation of the point, that is no variation in the head of the liquid at different points of the orifice. That means any point on its axis is a representative point of the entire cross-section of the orifice, so that we can tell the orifice the entire orifice is under the head h, so that the velocity at each and every point is uniform.

(Refer Slide Time: 05:40)



But it is not so in case of a large orifice, if we consider a orifice like this, consider a large orifice that means a orifice like this a orifice like this, it is a very large with respect to the head over, that means let us consider a constant head is maintained by an inflow arrangement Q, an orifice is such that we define the H 1 is the height maintained that height of the free water surface from this top part of the orifice and from the bottom part it is H 2.

So H 1 and H 2 are different, earlier if we define some H 1, H 2 from the top and the bottom so these height is so small compared to h. So, H 1 and H 2 are very small, sorry very, very much equal. That means this height of the orifice is less, very small compared to height of the water surface from any point or any level of the orifice, but here the orifice is so large, I mean this is the height of the orifice, which is H 2 minus H 1. So, H 2 is much bigger than H 1, so H1 or H 2 are not very equal, that means the size of the orifice is comparable to the height of the liquid surface, free surface of the liquid above the orifice. They are comparable to H 1 to H 2, this is the height of the liquid within that case, what happens is very simple a simple integration.

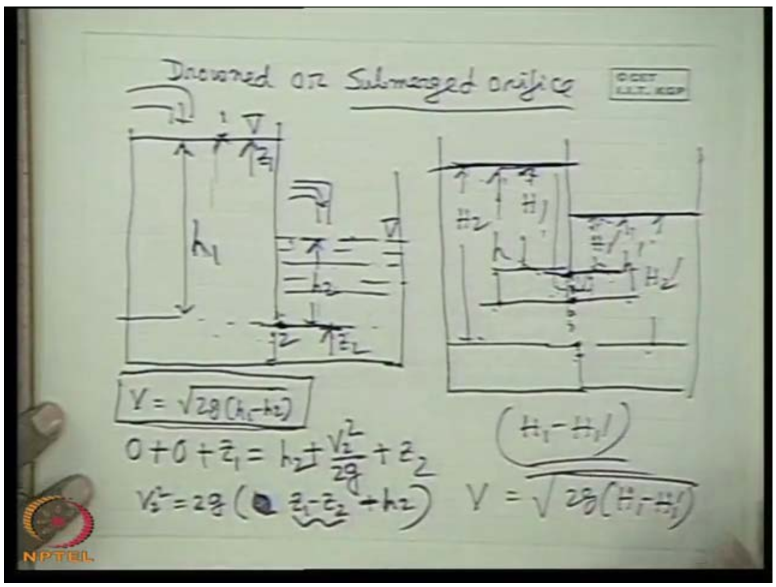
Let us consider the orifice to be if, you see from here a view a rectangular in shape that means whose width is B, then what happen difference is like this, if we consider an axis you can consider but difference is that each and every point the head of the liquid is varying. So, therefore, the velocity at each and every point will be changing, that means if we apply the Bernoulli's equation between a point here and a point here, we will get a velocity root over 2 g h, which is where h is this height, which is varying from point to point, which starts from H 1 from the upper point of the orifice and goes to H 2. So therefore, velocity at this point, at liquid particle at here will be much higher than the liquid particle here, so there will be a non-uniform velocity distribution.

So therefore, what we will have to do, we will have to integrate. The simple procedure is like that, we consider an instantaneous height, that means at any level that at any point. So, let this be the height h at this point and it has got, perpendicular to this direction if you take a view so a small elemental strip you consider. So, this is the h, alright this is the h and this you consider as d h, that means now you consider the discharge through a small elemental strip of the orifice which is at a height h from the free surface, this height is h, height h from the free surface, this is the height h and whose thickness is d h, that means whose area is B d h, a small strip rectangular strip. let dQ is the flow rate through it, what is the formula c d, now we know c d into a area of the orifice, what is the area of the orifice B d h into root over 2 g h. We apply the formula that coefficient of discharge into area of the orifice into root over 2 g h, where h is the head of the liquid that means the height of the free water surface from the orifice.

So, what happens the for this, we have to find for the entire orifice we have to integrate dQ, that means what, we will have to do, we will have to integrate this. C d B d h root over 2 g h, from H

1 to H 2 from H 1 to H 2. Alright, so if you carry out this integration it will be very simple, it is equal to C d is constant, if we consider C d same at all points, it is constant throughout the orifice. B is the width geometry of the orifice root 2 g h, it simply becomes root over h d h from H 1 to H 2. Simple, very simple school level things, 2third C d B root over 2g into H 2 to the power, what is that half, 3 by 2minus H1 to the power 3 by two. That is, this simple orifice is large it may not be a rectangular orifice, depending upon it’s geometry you can integrate accordingly, so this is the concept.

(Refer Slide Time: 10:07)



Now, another concept is that, what is meant by drowned orifice, what is meant by drowned orifice. What is meant by drowned or submerged drowned or submerged orifice, what is meant by that, very simple, now first let us consider a drowned orifice or submerged orifice of small orifice. Let us consider a very small orifice, compared to the head which is above the orifice, so from any point the head is h, so better we represent it from the axis, that means the height of the orifice or the area of the orifice is very small, height of the orifice is very small compared to this height, small orifice. Drowned orifice means that orifice does not discharge into atmosphere, it discharge into another water vessel that means other side, downstream side there is a pressure, very simple, hydraulics is very simple, this is hydraulics that means instead of discharging into atmosphere it is discharging into another tank where the height of the liquid, free surface of the liquid which we call head is h 2 from its axis. Then if we write the Bernoulli's equation from 1 to 2, now this is maintained that constant h 2, this is maintained at constant h1 for (( )).

So, flow will be from this tank to this tank always, but it has maintained constant because of the inflow, that arrangement we make, that is not very much concerned that how we make it, so the height of the 2tank maintained constant h 1 being more than h 2 the flow takes place from this tank to this tank. So, this orifice is discharging in this direction the flow takes place this way, so now if we write the Bernoulli's equation between 1 and 2, we will get that V, the velocity of discharge for an ideal fluid, 2 g h 1 minus h 2, can you get it, because you write the Bernoulli's equation very simple one. Bernoulli's equation pressure head is 0 p by rho g, taking the pressure head above the atmospheric head. Then V square by 2g 0. Let Z1 be the elevation head with respect to any datum, reference datum is equal to at this point what is the pressure head p by rho g, it is h 2 because pressure here is h 2 rho g.

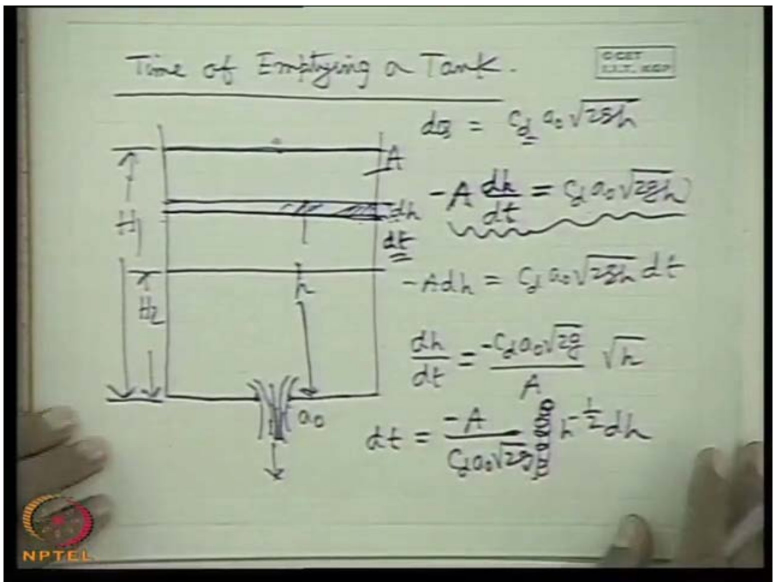
Because of this height of the liquid column, so very simple velocity which we want to find out V square by 2g, all in terms of the head. That means energy per unit weight meter, unit and then rest is it is Z 2. Therefore V 2 square is 2g okay, into h 2, Z 1 plus, so V 2 square by 2g is minus, h 2 I am sorry Z 1 minus Z 2 plus h 2 minus h 2 and Z 1 minus Z 2, that means the elevation head between this 2is nothing but h 1, that means ultimately you get V is equal to (( )) very simple, that means effective head causing the flow is h 1 minus h. Where this is the back head that means it is flowing under an effective head of h 1 minus h 2 so you will have to make it h 1.

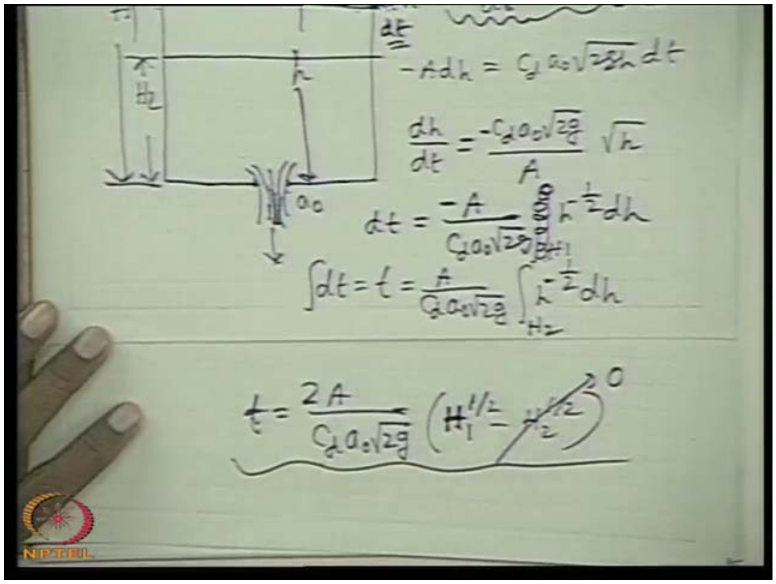
But in this case one interesting thing is that there is no difference between a large and a small orifice, thing is that if we have a large orifice for example this is a large orifice this is a large orifice, and let this side also, this is a large orifice let us this H 1 and this side let this is H 1 dash there is no difference between large and why, how I show you. Let this is H 2, that height of the water level from the bottom in this side and correspondingly this side H 2 dash, so entire orifice is under an effective head of H 1 minus H 1 dash, can you recognize it because this large orifice can be considered similar as a small orifice under an effective head H 1 minus H 1 dash. Why because here what happens when the head varies point to point, then whatever is added from this side is also added from this side, for example at this point what is the effective head causing the flow H 1 minus H 1 dash. What is the effective head causing the flow, H 2 minus H 2 dash that is H 1 minus H 1 dash.

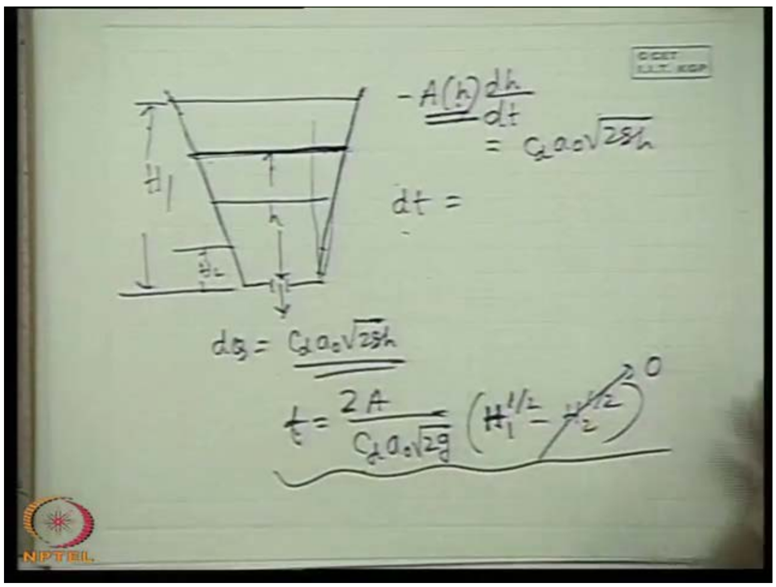
At any point the effective head causing the flow, let this is h and if this is h dash, then the effective head causing the flow at this point is h minus h dash, which is nothing but H 1 minus H1 dash, that means any increase in head from this side favoring the flow, a same way obstructed by the same increase in head in this side. So therefore, for a drowned orifice, a large orifice whose height is comparable to the head of the liquids above it can be treated as a small orifice under a drowned condition or under an effective head, which is H 1 minus H 1 dash that means difference of the water level from it is upper point, clear alright.

So this is a trick that if there is a large orifice and it is a drowned or submerged orifice it behaves as, that means the velocity through this is theoretical case is root over 2 g h 1 minus H1 dash, when there was no drowned orifice then the difference in head counted because downstream side head is uniform that is atmospheric pressure (( )) here the same head is added okay, it is very simple, drowned or submerged orifice.

(Refer Slide Time: 15:35)







Now, we will come to time of emptying tank time of emptying a tank, is an unsteady problem, so far we have discussed the discharge with a constant head, but if head is not maintained constant and there is for example, consider a orifice at the bottom of a tank centrally and if the initial head is H 1. Let us, this is a transient problem, unsteady problem that means we do not have any provision for inflow to maintain this head constant. So, what will happen the streamlines like this, let me draw the, that means what will happen. The water will be drained out through the orifice coming out so head will be decreased, so the problem is posed like that. What time will take for the head to come from H 1 to H 2.

Next example, what is the time taken this type of problem so it is very simple, so these orifice is under a varying head, therefore the distract is maximum when the height above the orifice is maximum, that means at initial level. Then as the height falls the discharge rate is reduced, let us consider an any instantaneous height h above the orifice, this bottom bottom plane h. So, in that case the discharge through the orifice, that means Q, discharge through the orifice Q is what.

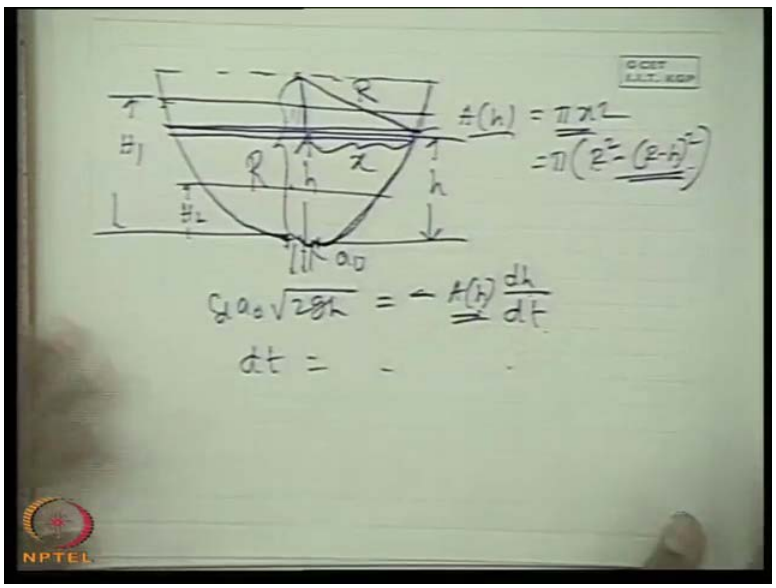
Let dq small discharge through the orifice is C d into orifice area is a naught into root over 2 g h C d, takes care of all the losses frictional losses and contraction and all this thing. So, if we consider d h is the decrease in the height, now this is the d h is the decrease in height for a time t or rather we can think in a various ways, when various ways. We can consider that if A is the cross-sectional area of the tank, so rate at which the volume flow rate is reduced in the tank is a d h d t and that must be equal to C d a naught root over 2 g h with a negative sign, why because h is decreasing with time, that means A d h d t is the rate at which the volume is decreasing in the tank. The volume flow rate is decreasing, that means it can be conceived this way that during a given interval of time d t the head has fall, the height has fallen by d h.

So, therefore the volume this has been decreased is minus A d h and this must be equal to the flow which has gone through the orifice, a 50 years back, explanation d t so ultimately A d h d t , but you should write straight in terms of the rate the rate of volume flow in the tank is A d h d t in terms of the instantaneous height of the tank and rate of the volume flow through the orifice is this, the equal this 2rate under continuity equation. So therefore, it becomes simply d h d t is minus C d a naught root over 2g, all the constant together into root h d h d t , is equal to sorry, is equal to minus.

So we have can found out time like this d t is equal to, so d t is equal to this, will be like this. A by C d a naught root over 2g into h to the power minus half d h with a negative sign with a negative sign, but sorry I am sorry, with a negative sign. Now, the time taken for the height to come from H 1 to H 2 can be written as by integrating d t is equal to, let that time is t then you just integrate these these are the constant A C d a naught root over 2g, integrate h to the power minus of d h. Now, from a initial height H 1 to H 2, so it should be H 1 to H 2. I take care of the minus sign so I write H 2 to H 1, that means if you integrate it this time taken will be simply A by C d a naught root over 2g. Now, this integration will be what 2minus, half plus, 1 half 2and H 1 to the power half.

So, this is precisely very simple, now if one has to find out the time of emptying, which I started time of emptying means H 2 is 0, so starting from an initial height H 1 that time of emptying that time will be this multiplied by H 1 to the power half, but here one thing is very simple the tank height, a tank area is constant or uniform. It does not vary with h, so integration becomes simple. There may be a tank of some geometry where the area may be a function of h, so there is no fluid mechanics, it is simply school level integration that means there may be an orifice in a prismatic tank, like that difference is that here the area that means at different head the area is changing. That means if you start with, let this is the H 1 the same problem if you pose the time of emptying or reducing the height from H 1 to H 2, whatever we do so same problem if you pose at any instantaneous height h.

(Refer Slide Time: 22:01)

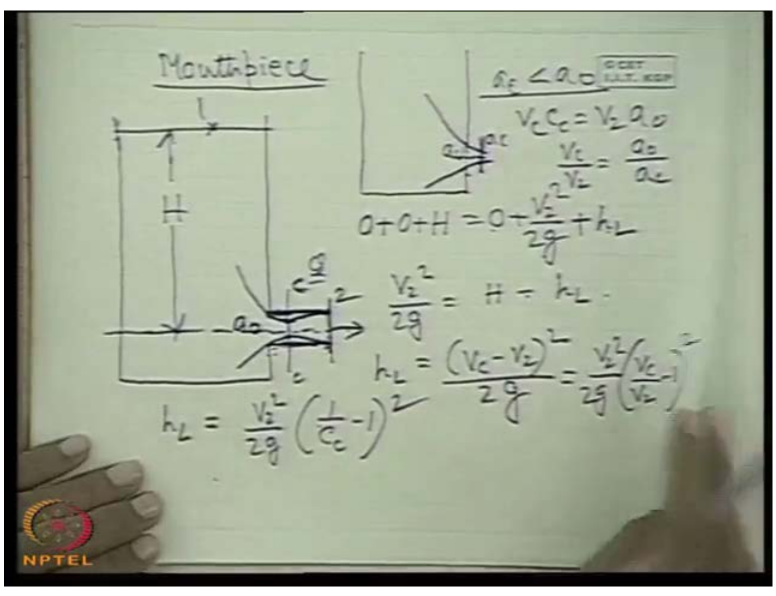


From this if you consider the area of the tank there that means, okay the through orifice the flow is same dQ is rate of flow is C d into the orifice area is same root over 2 g h, but the rate of volume flow rate at this level is minus A which is a function of h, A is changing A hd hd t which has to be made equal to C d a naught root over 2 g h that means you will have to take d t in one side and d h. So, A as a function of h only you have to incorporate there is no fluid mechanic, these you can find depending upon the geometry if this is a prismatic tank, say straight surface from the inclination something will be given in the problem. So that from the geometry you can express the area at this section as a function of h and can integrate it, there are several problems, standard problems.

One standard problem is solved in my book, there is a hemispherical there is a hemispherical vessel and there is a, this is the hemispherical vessel. Let, it is upper surface, let this is the centre of curvature for this hemisphere, hemispherical, which is the fluid is coming out. So, it starts with some H 1 and then it goes to another H 2 goes to another H2. What is the time taken, very simple at any instant you consider this as h so C d a naught this orifice area is a naught root over 2 g h, this must be equal to the area here, that means an elemental area here which is a as a function of h minus A h d h dt .

Now, we have to find out h for a very hemisphere, it is very simple if this is h already i have done it, so therefore this is a circular cross-section. So, this area will be if I define this as x, this is equal to pi x square and this x from the geometry, see this is the radius of the hemisphere which will be given the geometry of the tank and this part is R minus h. This is also R because of it is a hemisphere, so this is equal to pie into R square minus R minus h whole square.

(Refer Slide Time: 23:58)



So, you can find out x as a function of h, R is constant so therefore h as a function of h you put it and then take t at the one side d t and integrate this function of h from H 1 to H2 take care of the sign and get the answer. That is all, so this is the unsteady problem that means when the orifice is discharging under a varying head, which is the practical problem of emptying a tank; that means the water level in the tank falls down as the orifice is placed or orifice is opened.

Alright now last part I will discuss the mouthpiece, what is a mouthpiece, mouthpiece; now it has been found that by attaching a short length of pipes cylindrical length of pipe at the side instead of an orifice. A short length the discharge is enhanced as compared to an orifice that means if there was an orifice, sharp edged orifice, what could have been the discharge. The discharge will be more if instead of that orifice if we attach a short projected part, short of a cylindrical cross-section, very short which is known as mouthpiece. What is the physical mechanism for it, why the discharge is increased, what happens is that this contraction which takes place is again filled up. So, therefore when the discharge is taking place then it is full flow.

Let the area a naught is same as the orifice, if we consider an orifice what could have happened in case of an orifice, if there was an orifice this area could have been just like that. I just show you if there could have been orifice, what could have happen this. So therefore, the area a c gets reduced from this a naught. So, therefore the reduction of area contraction is not taking place, it expands the tube and then finally flows. So, therefore there is possibility of enhancing the head, enhancing the discharge Q, but there is a question. Let us consider a short height that, that's the head or the height of the free water surface is same for all points and we take a representation as the axis. Now, the question is that okay, I understand here contraction is there here, also contraction takes place but this is again refilling the tube.

A short portion is there so that when it comes out it is fully filling the a naught, that means the effective flow area is a naught where, here effective flow area is a c, which is less than the a naught, a c is less than the a naught and the way we define the coefficient of contraction c, c as a c by a naught, but at the same time due to contraction there is some loss if I consider the short section so that the friction we neglect then at this but we cannot neglect the losses due to contraction which we have discussed this is the contracted area c, c, so whether the loss counterweighs the discharge rate or not let us see and it has been found. It can be proved theoretically that discharge rate is enhanced by refilling the liquid in the tube that means to increase or expand this stream tube, so that the effective flow area becomes the total area of the mouthpiece a naught even if there is a contraction loss okay.

Let us see, now this is the section, let two, let this is the section 1 and we write the Bernoulli's equation, let us write the Bernoulli's equation here pressure head is 0 atmospheric pressure. We take 0, let us now consider unnecessary Z 1, Z 2 this axis is the datum. So, velocity is 0 h h is this now at 2pressure rate is 0 atmospheric discharge and this is the velocity which we are finding out. Now, let us forget about the friction, first of all friction part we neglect and it is a short tube, when you will compare with an orifice we will consider frictionless orifice also, so that do not worry comparison will be at the same basis but loss, this loss you have to consider h l, that loss is due to contraction. So, therefore you see V 2 square by 2g is equal to h minus h l alright.

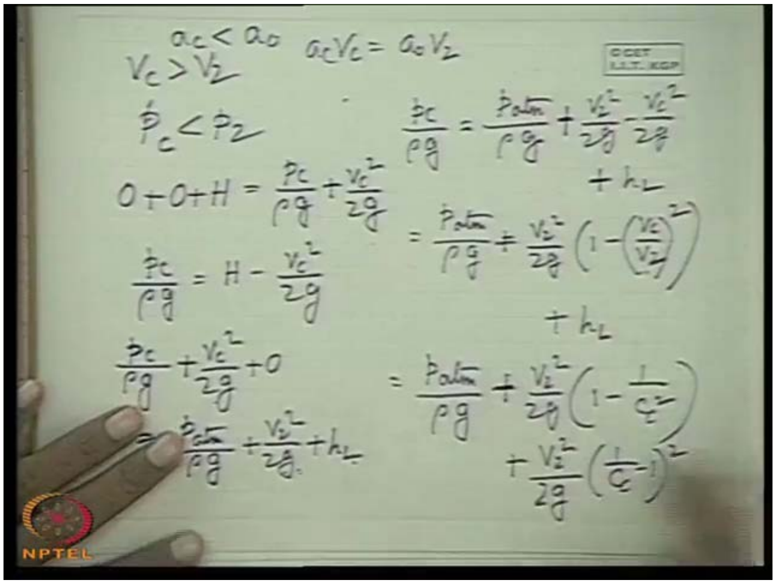
So, what is h l now you tell me, what is h l. So, 0 plus V 2 square by 2g plus h l, what is h l if you recall h l is, it is due to the contraction. Actually the contraction loss is due to the expense and itself, I told it repeatedly and this is nothing but V c minus V 2 whole square by 2g. We have deduced it earlier that it is the loss due to expansion, not due to contraction. After contraction when the stream tube expands, so it is just the loss due to expansion of the stream tube that means V c minus V 2 by 2g whole square. That means if I take this V 2 square by 2g, common. Then it is V c by V 2 minus 1 whole square.

Now, V c by V 2, if you see here the continuity equation V c into C c is equal to V 2 into a naught. The continuity between this 2sections, therefore V c by V 2 is what, a naught by a c, that means 1 by C c C c. Definition is a c by a naught that means, we can write h l is equal to v 2 square by 2g 1 by C c minus 1 whole square. So therefore, if we place this here what we get, if we place H 2 here that means it goes this side, therefore V 2 square by 2g into 1 minus 1 by C c minus 1 whole square. I take this here h l plus, very good plus is equal to h okay, this is okay.

Now, I write here therefore, V 2 is equal to, now if I take this as K, which is very important what is K K is equal to 1 plus 1 by C c minus 1 whole square. This is k that means this coefficient of V 2 square by 2g that V 2 is root over 2 g h. Okay, then what is the discharge Q area is a 0. Here area is full a naught, there is no contraction a naught into, oh god, divided by under root K. I am sorry, so Q naught into root over 2 g h by under root K that means we can tell that C d for mouthpiece is 1 by root over K, this acts as the C d for mouthpiece into a naught root over 2 g h.

This is the mouth piece Q, now what is the Q for leave it ,what is the Q for orifice Q for orifice, is C d into root over 2g, under the same head now C d. We can write as C c only, why because here also I want to neglect the friction that means C d is equal to C c into C v, we make C v is equal to 1 fluid friction we neglect, but contraction is there so C d is equal to C d. So, therefore here C d is equal to C c, now if I can prove that 1 by root K is greater than C c under all conditions, then I can prove that mouthpiece always enhances the flow rate. This can be proved, this as simple school level mathematics that for values of C c less than 1 1 by root k is greater than C c or 1 by k square is greater than C c square, okay you see that this can be always proved or you can prove that other way, K square, this one K square is less than K, sorry then we can write K is less than 1 by C c square. Alright, so provided I can prove 1 by root K is greater than C c and 1 by root K is always greater than C c for small values of C c. How can it prove, how can you prove it, let us prove, like it this is the K let us reform it in this way 1 by root K is greater than C c, I will have to prove that means, I will have to prove K is less than 1 by C c square K is less than 1 by C c square.

(Refer Slide Time: 33:59)



One line proof, you just break it 1 then plus 1 minus 2 by C c alright plus 1 by C c square 2 minus 2 by C c, 2 by C c is greater than 2 2 minus 2 by C c means this is a negative. So, 1 by C c square minus something, so K is less than 1 by C c square, very simple, one line proof because for all values of C c less than 1, because 2 by C c is greater than 2 2 minus 2 by C c plus 1 by C c square. So, therefore K is always less than 1 by C c square, so this prove is not given in my book, but i have written exclusively that for all values of C c less than 1 this one. So, this is proved that mouthpiece enhances the, well the discharge rate. Any question please, I think this is so simple that it.

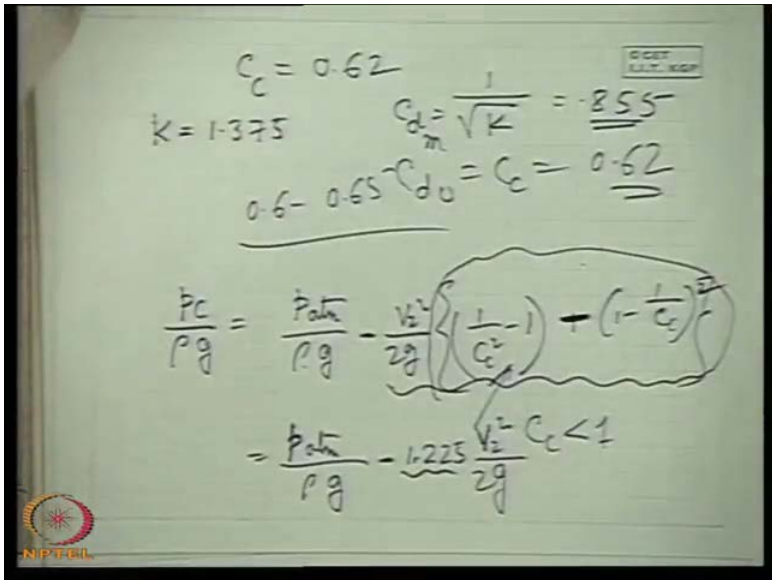
Now, one dangerous thing is there, can you tell me what is the dangerous thing? Now here, you see whenever there is a contraction that means here the velocity if you compare V 2 and V c V c is greater than V 2. Because a c is, because a c is smaller than a a naught. So therefore, p c is less than p 2 and what is p 2 p 2 is atmospheric pressure that means if there is an atmospheric pressure discharge and if there is a area where in the upstream, where the pressure is lower or there is an smaller area in the upstream, where the velocity is higher than the discharge velocity there is a change. That the pressure will be chance means obviously there is a pressure will be lower than the atmospheric pressure. So, therefore it is proved qualitatively or physically that the pressure at the vena contract a is lower than the atmospheric pressure, so we can find out these vena contractor pressure by applying the Bernoulli’s equation either between point 1 and 2 or between this point c 1 and let a point c, here between point 1 and c or between point c and 2.

Alright let us write point 1 and c, you write 0 plus 0 plus h is equal to, what the point is under question is p c by rho g plus V c square by 2g. Alright, so p c by rho g is equal to, but I think this will not held, we want to find out how much it is less than the atmospheric pressure. So therefore, you write between this 2points, so forget it so you write p c by rho g plus velocity head V c square by 2g plus let this line is the datum line 0 and you equate it with the 2at any point in this section, this will be the atmospheric pressure. Let I, write the p atmospheric that means p c I express in their absolute rho g plus V 2 square by 2g plus h l.

Well if we do so then you can write p c by rho g is equal to p atmosphere by rho g minus V 2 square by 2g minus V c square by 2g minus h l. Now this can be written as p atmosphere by in terms of C c only, so very simple you just take h l now this I can write V 2 square by 2g minus V 2 square by p. Atmospheric pressure plus V 2 square very good, minus plus V 2 square minus V c square by plus h l, very good so p p c by rho g is p atmospheric by rho g minus V c square by 2g V 2square by 2g plus h l, very good, now minus V 2 square by 2g, one plus V 2 square by 2g, 1 minus V c by V 2 okay whole square, alright plus h l.

What is h now, this can be written as p atmosphere by rho g minus, this is the discharge what is V c by V 2 again, V c into a c is equal to a naught into V 2. So, V c by V 2 is 1 by C c. So, 1 minus 1 by C c square, 1 by C c V c by V 2 okay, plus what is h l h l, why not we see here V 2 square by 2 g h. What happened, very good C c minus whole square.

(Refer Slide Time: 37:15)



Now I can write p c by rho g, all plus p atmosphere by rho g cut the minus V 2 square by 2g (( )) this minus (( )) 1 by C c square minus 1 and plus 1 minus 1 by C c 1 by C c minus 1 whole square, this is V 2 square by 2g minus. So, I have taken the minus so it will be minus I am sorry minus 1 by C c whole square.

So, now this can be also told, I have also shown that it is positive quantity, so that this is always less than p atmospheric by rho g, that I leave is, leave you as an exercise that I have shown for all values C c less than 1. This is a positive quantity now, I tell you a representative value if you take C c is equal to 0.62, then you get the value of K, this one if I come to this value that here if you see that root over 2 g h, where I deduced the earlier one V 2 is yes. So, root over 2h by root over K, the value of K if you recall, the value of K this is the value of K 1 plus 1 by C c minus 1 whole square with the value of C c is equal to point six 2the value of K is 1.375.

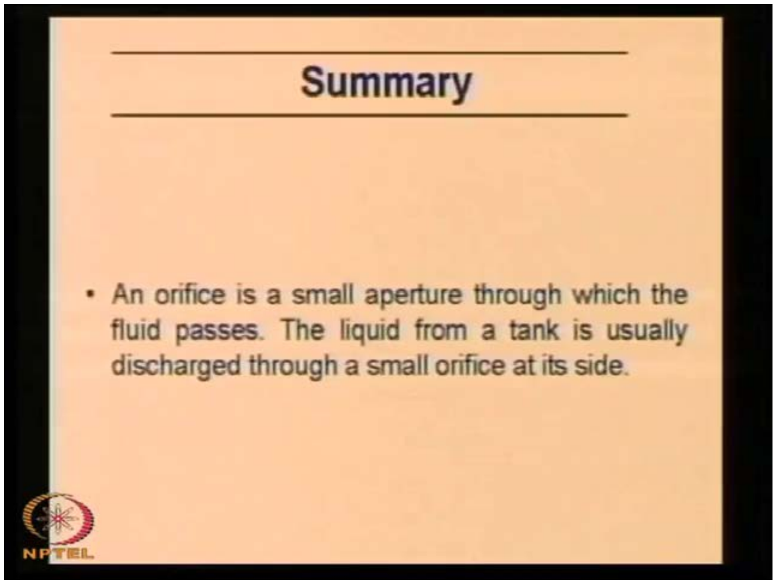
So, c d which is 1 by root over k for mouthpiece become 0.855 and C d for orifice is, C c that is 0.62, 2very important thing and if you put that value 0.62, here you get this is a representative value C c usually lies between 0.6 to 0.65.

So, minus 1.225 roughly the value is like that V 2 that means this will be lower than the atmospheric pressure by 1.225 times the discharge velocity, here so therefore, we see by attaching a mouth piece that means a short portion cylindrical, portion, short portion. So, the discharge rate will be increased, but thing is that why I am telling a short portion, if instead of that we give a very long cylindrical part projected, discharged may not be increase, why this is because frictional loss, frictional loss will be more that means apart from this contraction loss there may be more frictional loss so that the actual velocity of discharged will be much less than root over 2 g h plus all those. So, these h l will increase much that is why a short because sharped edge orifice friction is very less, C v value usually lies between 0.9 to 0.95, so therefore we must have a very short piece which is just sufficient to expand this stream tube alright.

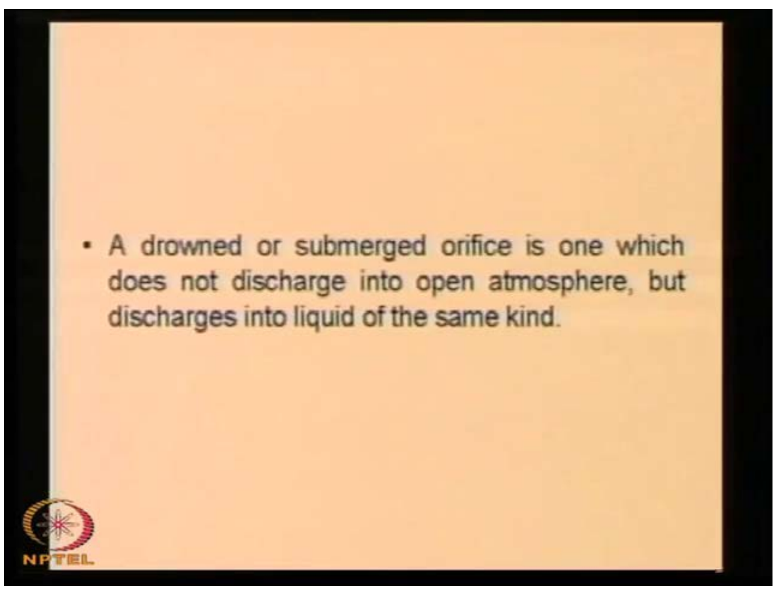
So, this is a very important statement sometimes it is written in the short portion, what is the meaning of the short portion because in the field of science the words used are not redundant there is no use ah there is no scope of using more adjectives and all this thing, so each and every word has got its implication. So today, yes I conclude this talk, so we have completed the application of Bernoulli's equation. If we look back the beginning, we have first recognized the Bernoulli's equation that is the pressure head plus the velocity head plus the kinetic head, first the datum head the potential head then the 3 components of mechanical energy remain constant everywhere in the flow field provided the flow field is irrotational but for a rotational flow field it is constant only along a streamline.

Then after that we recognized a solid body rotation that is a forced vortex, what is a free vortex and irrotational vortex. Pressure distributions in forced vortex and a free vortex then we we recognized the different losses, siphon then probably siphon, we started siphon what is the principle of siphon, how the siphon work then different minor losses, losses due to expansion, contraction. Then the concept of static pressure, stagnation pressure, pitot tube, application of pitot tube, then the discharge through orifice and mouthpiece, this we discussed so today I conclude this chapter, Tomorrow, next class I will start the incompressible viscous flow thank you.

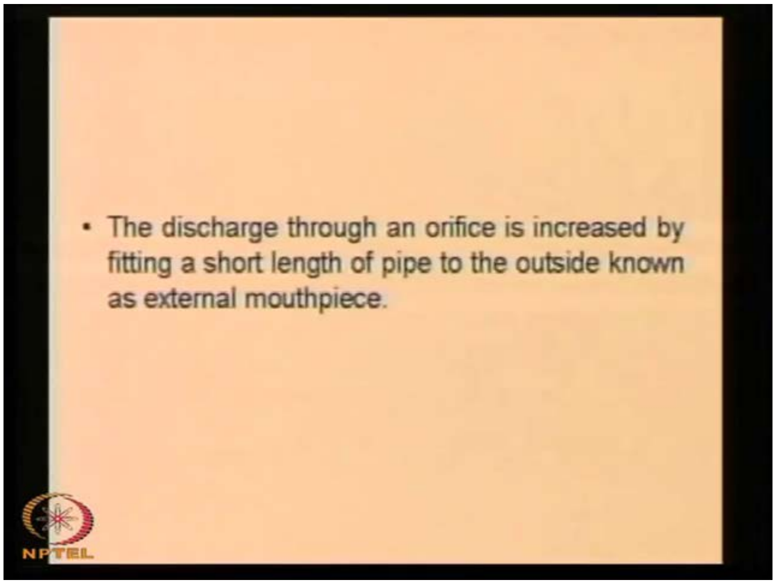
(Refer Slide Time: 41:53)



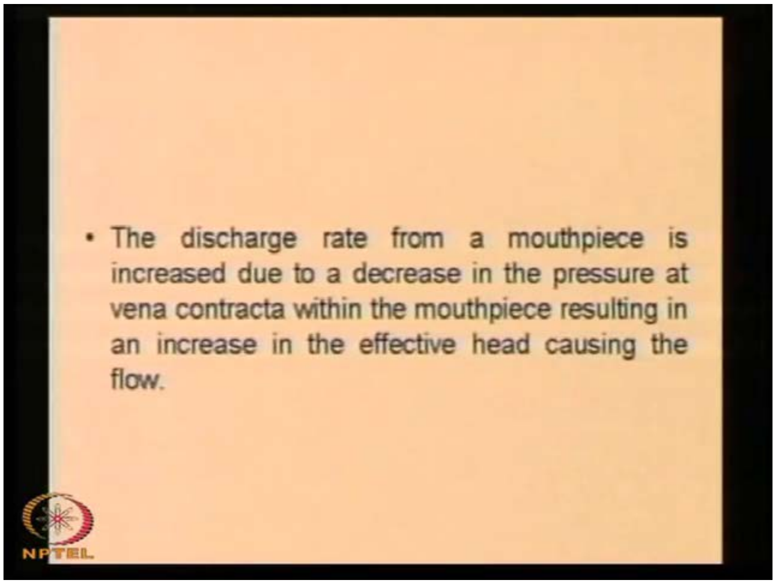
(Refer Slide Time: 42:46)



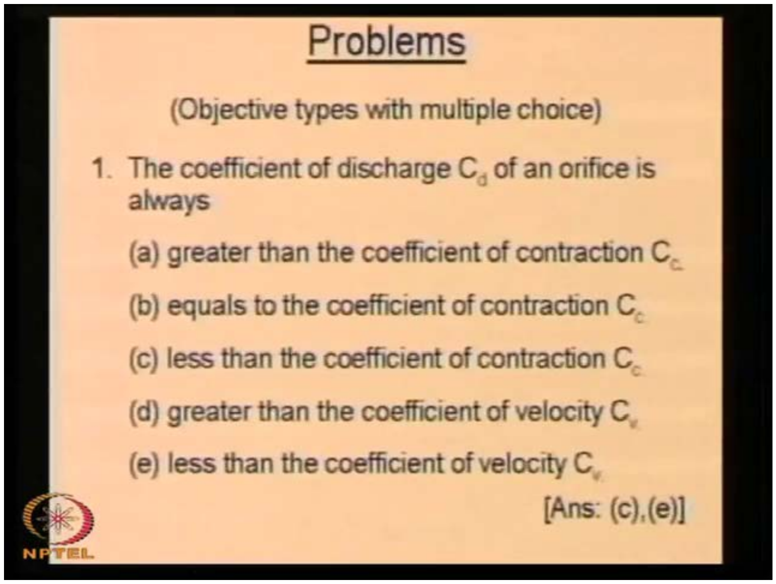
(Refer Slide Time: 43:40)



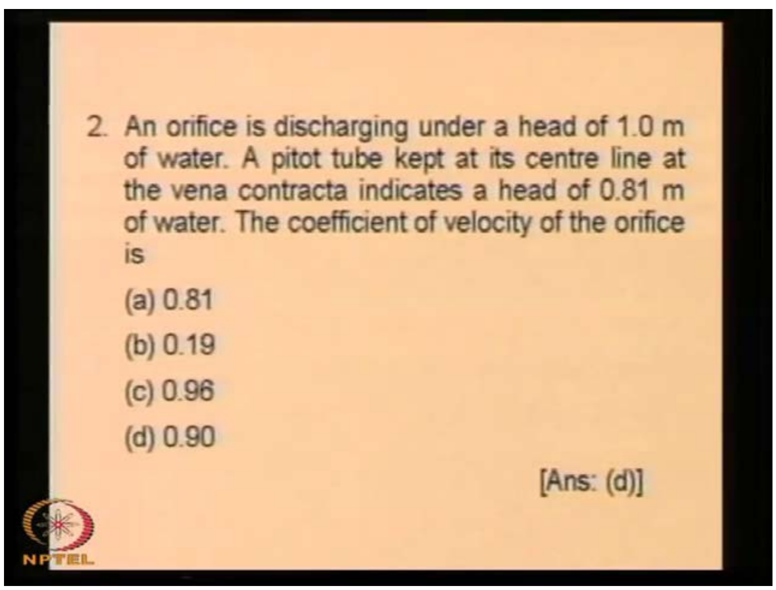
(Refer Slide Time: 44:33)



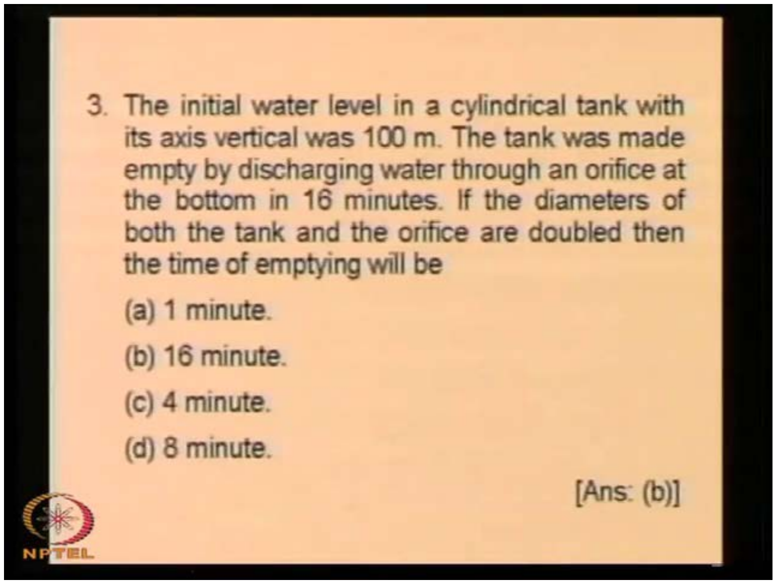
(Refer Slide Time: 45:26)



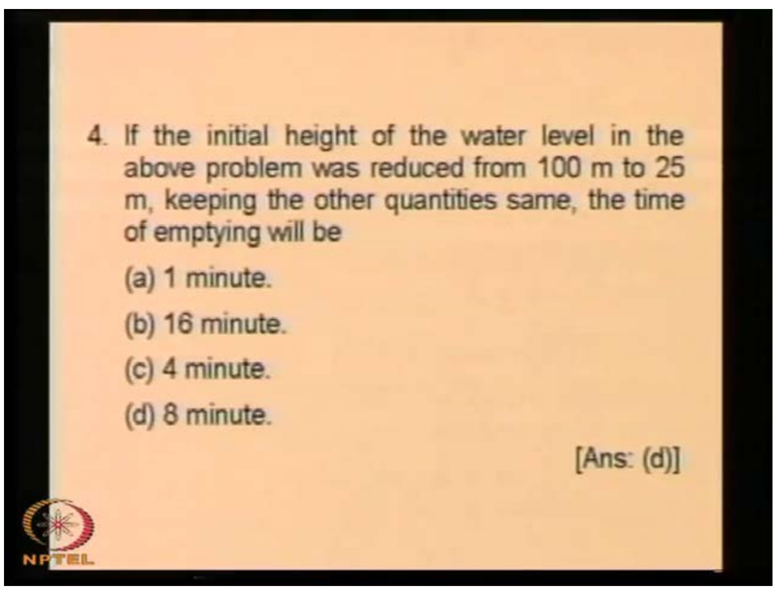
(Refer Slide Time: 46:20)



(Refer Slide Time: 47:11)



(Refer Slide Time: 48:05)



(Refer Slide Time: 48:57)