And here as you know it we have considered it is a horizontal surface. So z_1 equal to z_2. That is what we cancelled out. And we are just substituting the mass conservation equation and the Bernoulli's equations to compute what will be the Q value. So once I know the Q value to estimate whatever will be the force component will going to apply linear momentum equations.

We are going to apply linear momentum equations. Let us apply the linear momentum equations for these problems. And always I encourage that, please start applying the Reynolds transport theorems, simplify the Reynolds transport theorems from linear, basic linear momentum equations to the simplification functions. That what need to be do it.

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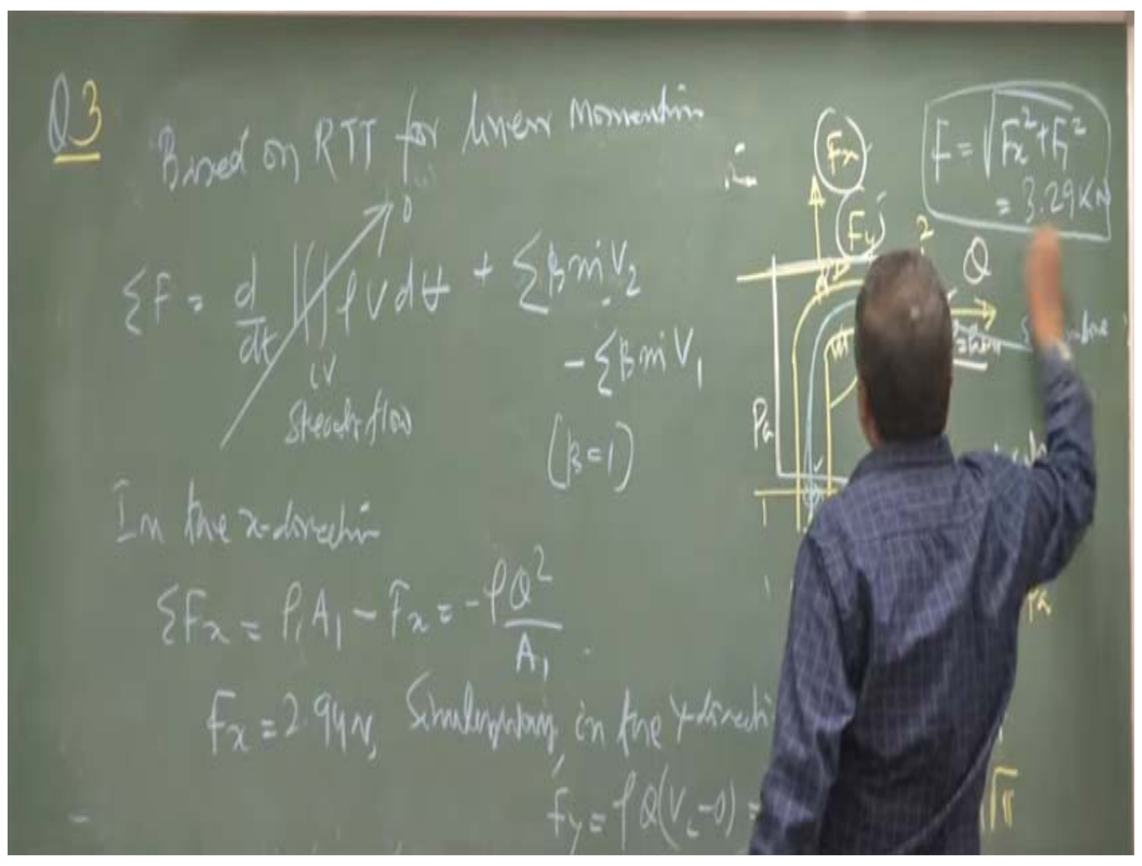

So based on Reynolds transport theorems, we can write for linear momentum equations. We can write that the sum of the force is acting is equal to same path, change of is equal to since it is a one inflow and one outflow, so we will have,

$$\sum \vec{F} = \frac{d}{dt}\int_{CV} \rho \vec{V}\, d\forall + \sum \beta\, \dot{m}\overrightarrow{V_2} - \sum \beta\, \dot{m}\overrightarrow{V_1}$$

So that is what is outflux, mass outflux. Sorry, this is what momentum outflux and this is what momentum influx components.

And here we can assume it the $\beta = 1$ and being a steady flow again, this part becomes zero, as it is a steady flow conditions. So you just have to compute the momentum flux, influx and the outflow. That what the net momentum outflux what is happening through this control surface. That is what will show us what are the force components in scalar component in x direction and the y direction.

So we will play along the x directions to get it. If I apply in the x direction, we will get it the sum of the force F x will be,

$$\sum F_x = P_1 A_1 - F_x = -\frac{\rho Q^2}{A_1}$$

So in this case, only this momentum flux components will come it. That what will be the minus rho Q square by A 1. Just to look it this is the momentum flux per unit area, momentum flux component what we have computed. That is the reasons Q by A is the velocity.

That is what is indicating here. And this is the P 1, the pressures, the A 1 is the area. And if I substitute these values, then we will get,

F_x will be 2.94 Newton.

Similar way if I apply in the y directions, I am not doing for the y directions detail equations. We will also get it the

$$F_y = \rho Q(V_2 - 0)$$

By substituting this value,

$$F_y = 1.7\ KN$$

So as we know this F x and F y value then we can compute resultant force which will be

$$F = \sqrt{F_x^2 + F_y^2}$$

$$F = 3.29\ KN$$

That is the value comes out to be 3.29 kilo Newton. This is what the solutions for this problem.

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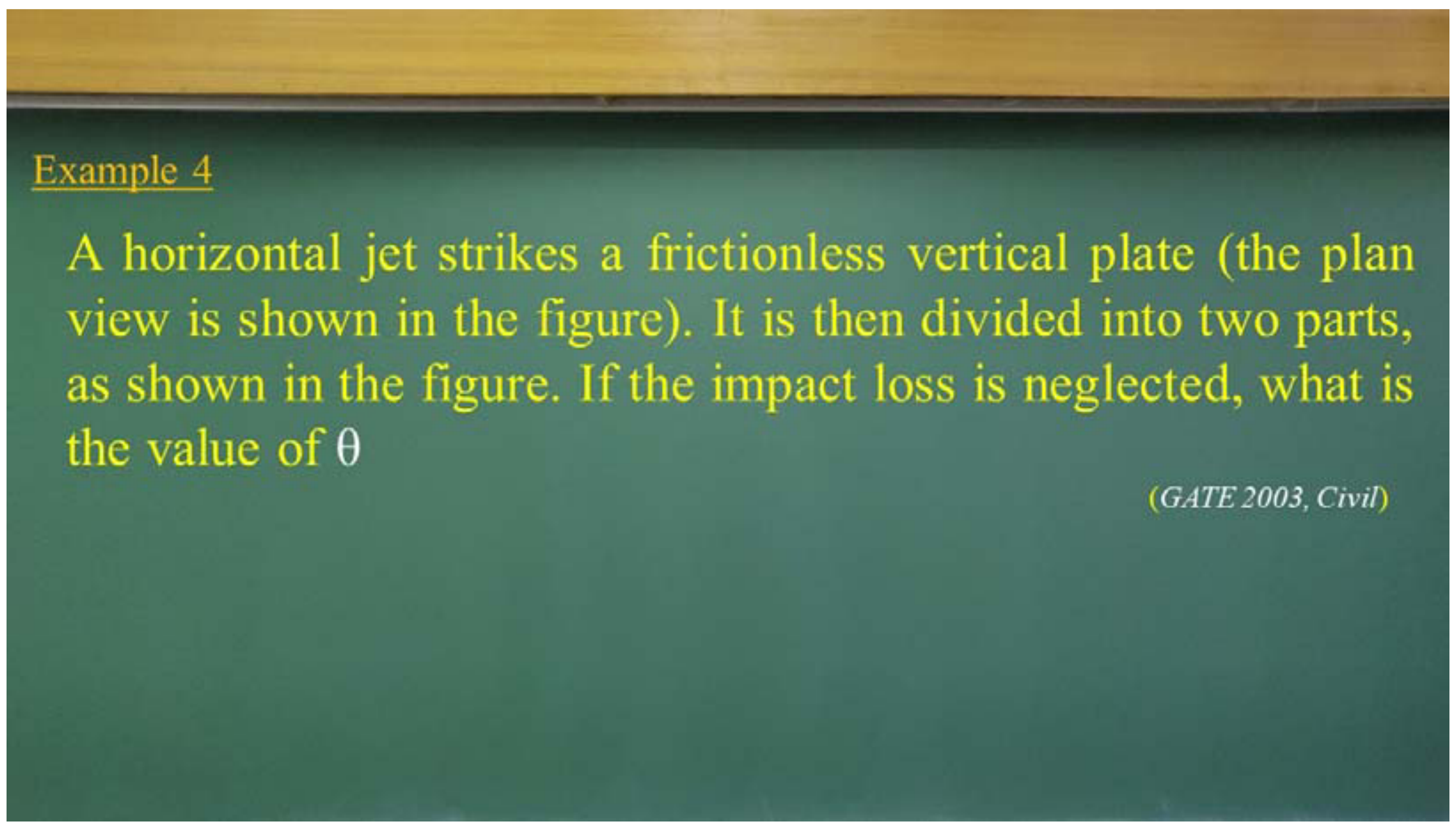

So let us solve this another example which is example 4.

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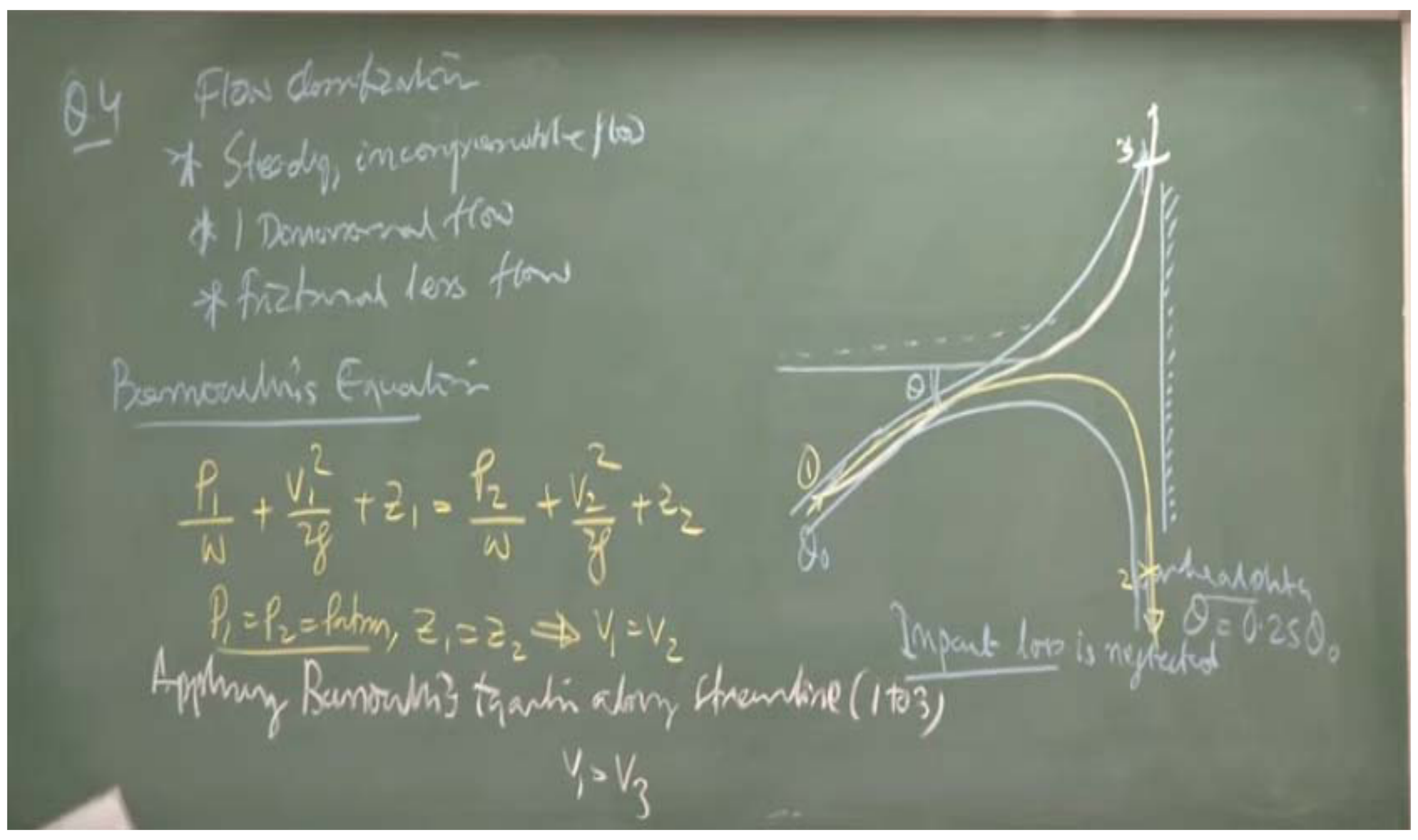

In this case there is a horizontal jet of the flow with angle theta strike on a vertical plate and the flow distributions here is Q naught is the flow is coming it and at this point the flow is equal 0.25 times of Q naught value. Then we try to find out what could be the theta value when the impact loss is neglected.

So if you look at this case, we can classify the flow, the flow classifications like the,

- steady
- incompressible and
- one dimensional flow even if it looks a two dimensional.

But as we will be resolved the force component in x and y directions we can make it as a one dimensional flow component. And frictionless flow component. That means the impact losses, no frictional component because of at this vertical plate that is what we have not considered. If it is that is the conditions, so first what we will do it we will apply the Bernoulli's equations for this case, the applications of Bernoulli's equations.

To apply the Bernoulli's equations we can draw a streamlines, we can draw a streamlines like this okay. That means this is my streamline. I am applying the Bernoulli's equations from this is the point 1, this is point 2. I am applying the Bernoulli's equations from this 1 to 2 as there is no frictional loss. So if I applying the Bernoulli's equation between 1 and 2, I can have same way I can write the Bernoulli's equations here, standard.

$$\frac{p_1}{w}+\frac{1}{2g}V_1^2+z_1=\frac{p_2}{w}+\frac{1}{2g}V_2^2+z_2$$

$$p_1=p_2=p_{atm}$$

$$z_1=z_2$$

$$V_1=V_2$$

Now if you look at this part as we have the water jet we can consider the P_1 equal to P_2 is equal to P atmosphere as it is a water jet problems. Only and it is just striking in a horizontal jet. So we can consider z_1 is equal to z_2. That what is indicate for us that V_1 is equal to V_2. Similar way if I draw another streamlines from 1 to 3. This is the three locations.

I will get it applying the, applying Bernoulli's equations along streamline 1 to 3, I will get it

$$V_1=V_3$$

. Now let us apply the linear momentum equations to compute it what could be the theta value where some of the force acting on these net force should equal to the zero case. That is what the conditions in this case if you just to visualize this problems, if I consider is a control volume like this. Since these are fixed one, the net force acting on this impact object is equal to zero.

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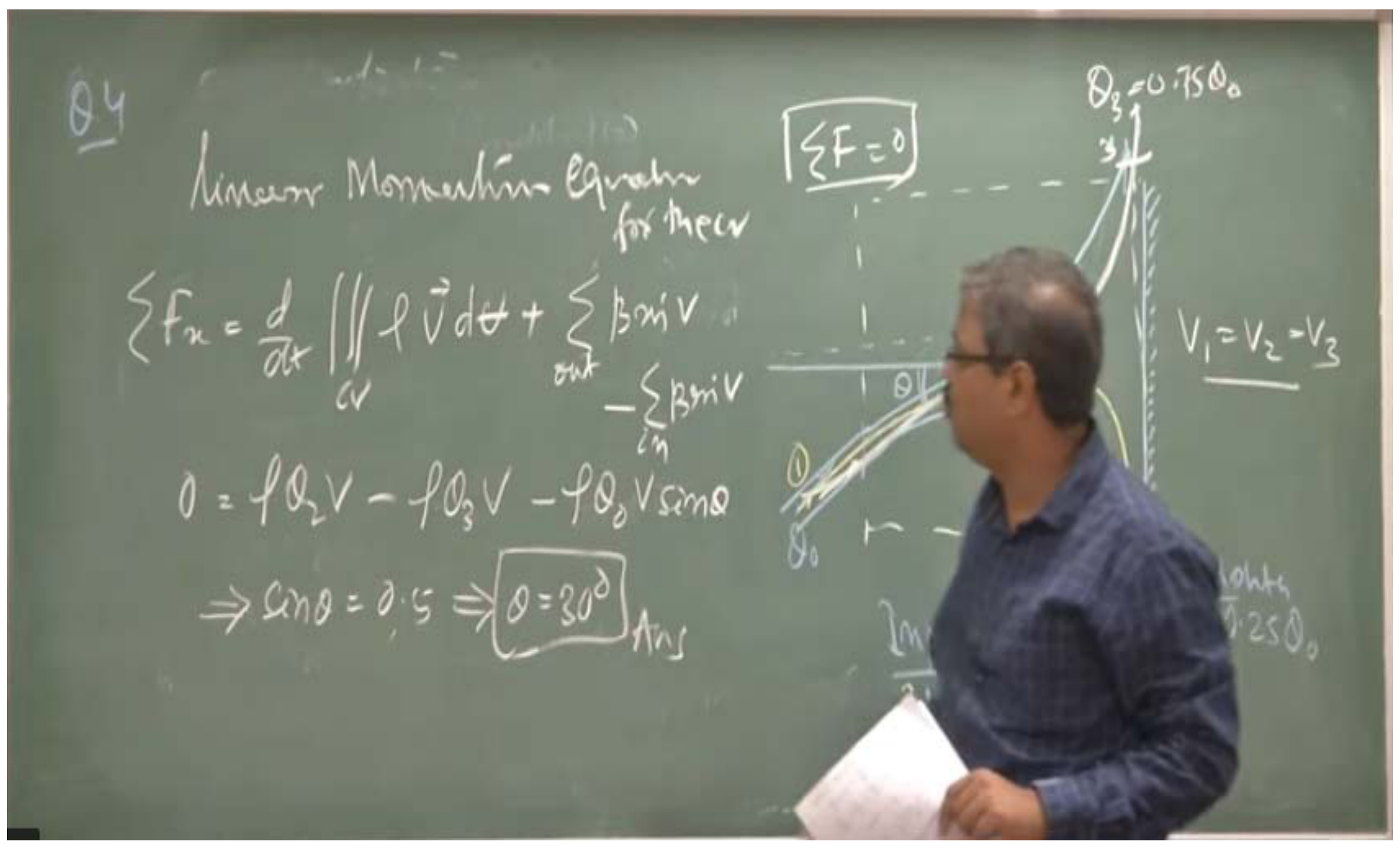

If that is the conditions we can easily apply linear momentum equations to find out at what theta value the sum of the force acting on this should equal to zero. That is the problems what we are looking for that. So let us I write the linear momentum equations, linear momentum equations for the control volume.

If you write the linear momentum equations that force component the sum of the force acting on the x direction that what will be equal to,

$$\sum \vec{F} = \frac{d}{dt}\int_{CV} \rho \vec{V}\, d\forall + \sum_{out} \beta\, \dot{m}V - \sum_{in} \beta\, \dot{m}V$$

That is in, this is what is out. If you look at these values as the sum of the force is equal to zero, if I put it

$$\rho Q_2 V - \rho Q_3 V - \rho Q_0 V \sin\theta$$

That is what if I just substitute the Q 2, Q 3, and Q naught as this. If this is a Q_0 flow is coming it and this is 0.25 Q_0as the continuity equations for Q 3 is equal to 0.75 Q_0, okay. If I just substitute these values, then we will get,

$$\sin\theta = 0.5$$
$$\theta = 30^\circ$$

it the sin theta is equal to 0.5. That is what indicates theta is equal to 30 degree. This is what the solutions. This is what the answer.

So the basically this problem you try to understand it that Q is not given. The velocity is not given it. We are first we have to find out what could be the velocity distributions. In this case because of water jet you can get it that by applying these Bernoulli's equations we find out that the velocity at V_1, V_2, and V_3 are all are equal.

Once you have that assumptions, you substitute in a linear momentum equation to compute what will be the theta equal to 30 degree. That means you apply the linear momentum equations over this control volumes, as there is no force is exerting on these. The net force is equal to zero. That is what we are applying it and compute it the component what we are getting it.

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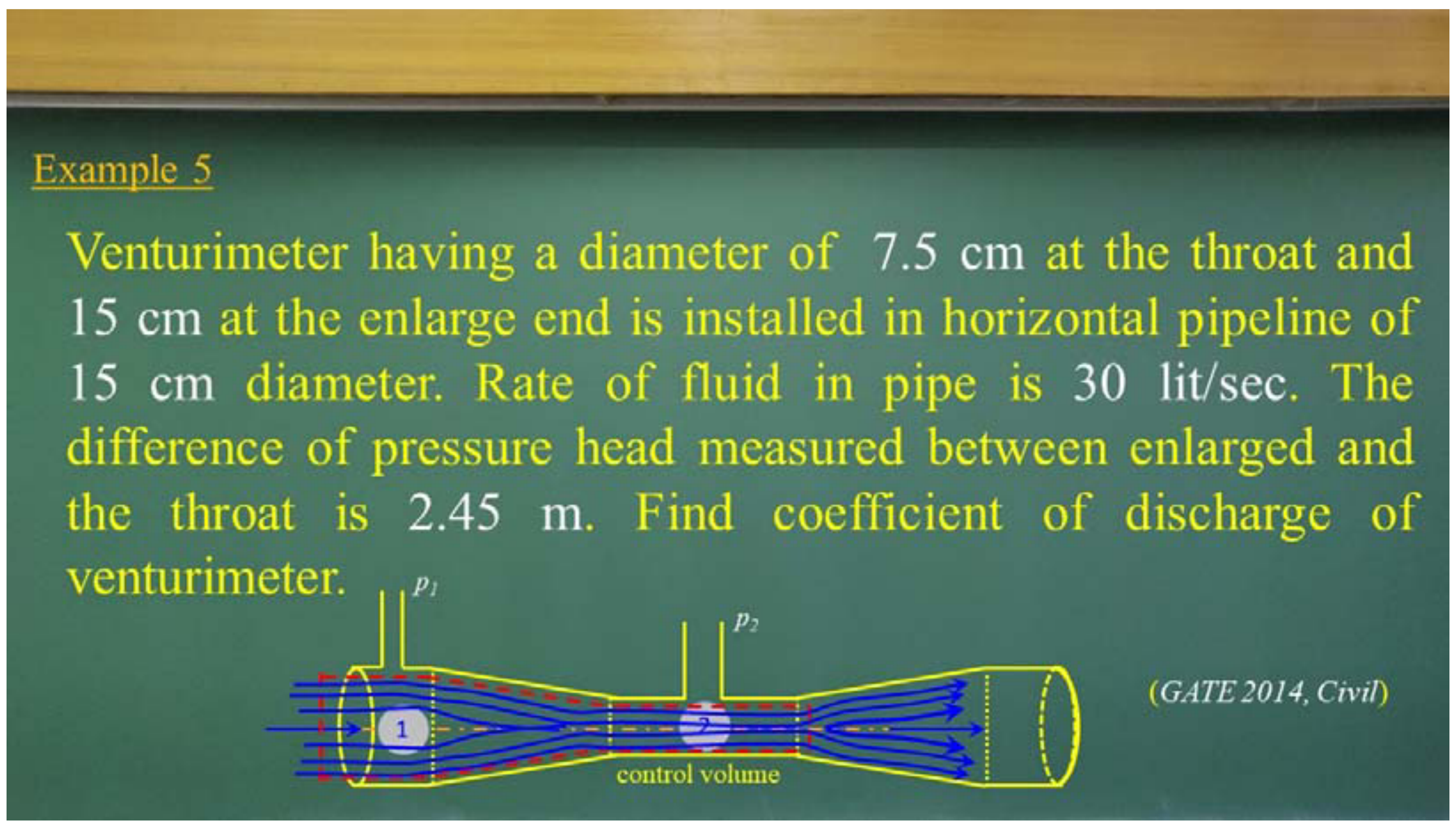

The example 5, which is a very simple problems on venturimeter as given in this figure.

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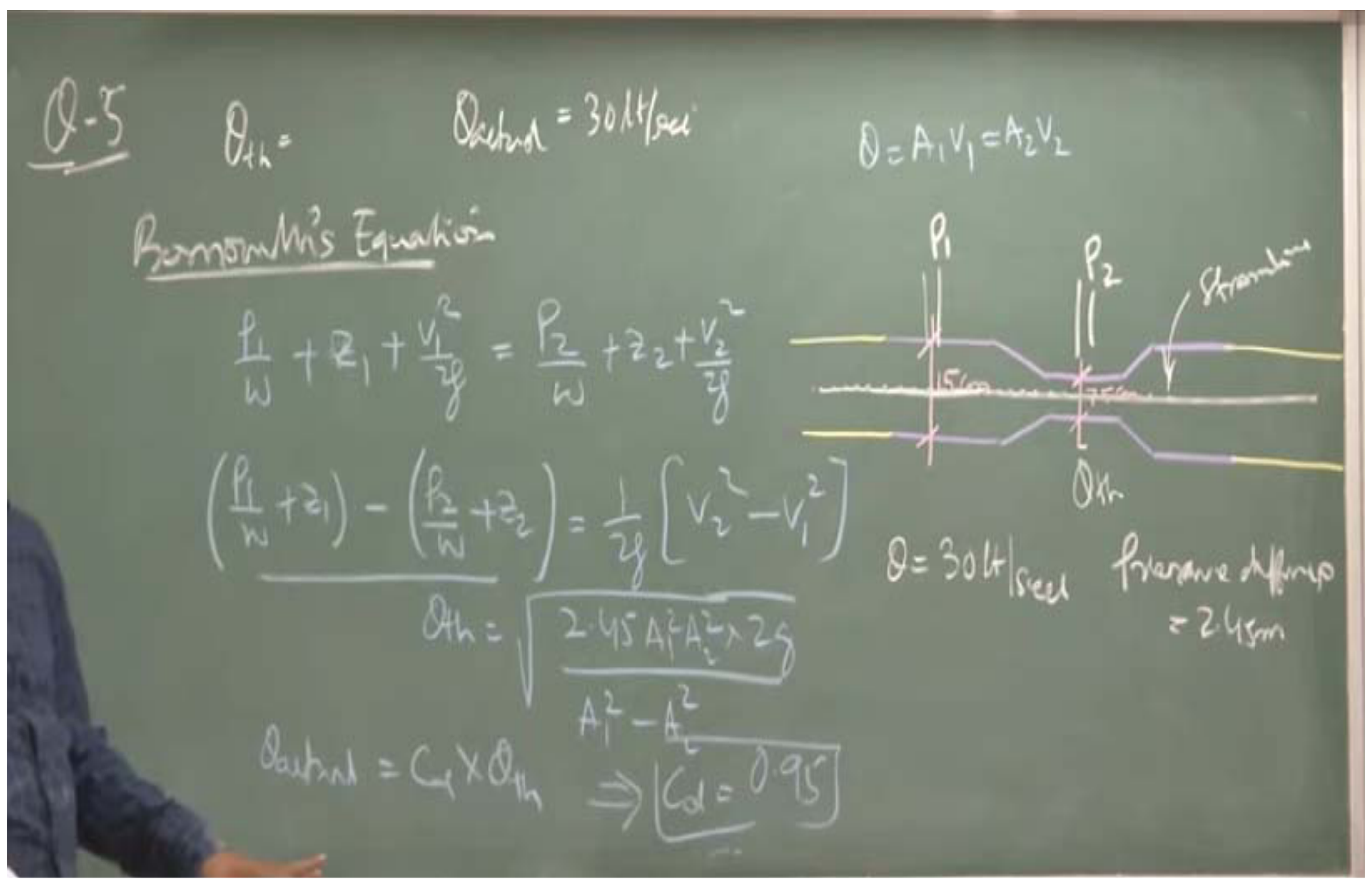

That there is a venturimeter with having the diameter of 15 centimeters is reduced to the 7.5 centimeters, which is installed on a horizontal pipeline. And the rate of the fluid passing through this, the Q is equal to 30 liters per seconds, Q equal to 30 liter per second. And the pressure difference between this throat and enlarged part.

$$\frac{p_1}{w} + \frac{1}{2g}V_1^2 + z_1 = \frac{p_2}{w} + \frac{1}{2g}V_2^2 + z_2$$

$$\left(\frac{p_1}{w} + z_1\right) - \left(\frac{p_2}{w} + z_2\right) = \frac{1}{2g}[V_2^2 - V_1^2]$$

That is the pressure difference between P 1 and P 2 as we can find out the pressure difference as given here the pressure difference is equal to 2.45 meters in terms of the water head, in terms of the water head. We have to find out what is will be the discharge coefficient of this venturimeter. So again we can have a draw a streamline, draw a streamlines.

This case, we can take a the centrally flow part which will be a streamlined part this. And along the streamlines, we can apply the Bernoulli's equations to find out what could be the Q theoretical value. In this case, we try to find out the question numbers 5, the solutions what we are looking it what could be the C d value, if I know the Q theoretical and we know Q actual as it is given here is equal to the 30 liter per second.

$$Q_{th} = \sqrt{\frac{2.45 \times A_1^2 A_2^2 2g}{A_1^2 - A_2^2}}$$

$$Q_{actual} = C_d \times Q_{th} = 0.95$$

So the basic idea is here to apply the Bernoulli's equations along this streamlines. If I apply this Bernoulli's equations, Bernoulli's equations as we apply on along this the streamlines, it can easily we can write it the same form. Since in this case, whatever the Q amount of the flow comes it, the Q will be the

$$Q = A_1V_1 = A_2V_2$$

because one inflow, one outflow conditions for this control volume.

So we can write

Q equal to A_1 V_1, A_2 V_2. And since it is, we know the pressure difference between these two points, that is the reasons we can easily compute this pressure difference between two point as it is measure it. This is what the pressure difference is measure it. That is what will be equal to just rearranging the terms you will get it,

$$[V_2^2 - V_1^2]$$

So this is given to us. In terms of Q we can write it this values. See if I do that part then I will get the Q theoretical value from this equation in terms of A_1 and A_2. That is what more detail, after substituting this value will comes out to A1 square A2 square into 2g by A1 square minus A2 square. This is what the Q theoretical value. That is what the Q actual is equal to C d Q theoretical value.

So as the Q actual is given the C_d will be Q theoretical we are getting from this. You know this value of A_1 A_2 value as the diameter is given to us 2.45, 2g all the value is given to us. So we can compute the C d value which comes out to be 0.95 for this case. So this is a very simple problems using this venturimeter problems where you have to apply the Bernoulli's equation, mass conservation equations and we remember it, it has this needs the pressure difference measurements.

You need not to compute the z_1, z_2 because its pressure difference measurement is given to us. So we are not looking for whatever will be z_1, z_2. Whatever the pressure difference measurement that is what will come it and we can substitute to compute the C d value. So with this let us conclude the solving on the blackboard some of the GATE questions. Thank you.