Fluid and Particle Mechanics
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Lecture – 21
Tutorial - 04

Hello everyone; today we will solve the problem on calculating pressure drop through an inclined pipe. So, first we will see the problem clearly. The problem states water flows downward in a pipe at 45 degrees and we will draw the schematic first.

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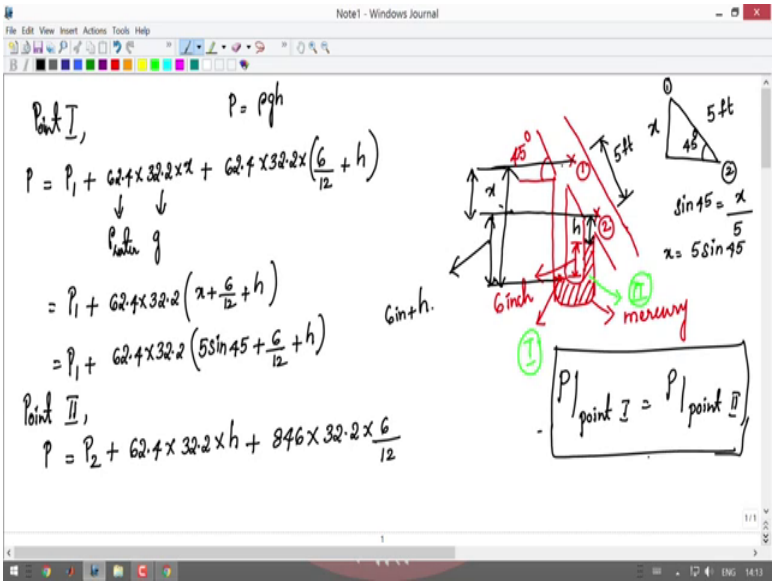

So, we have an inclined pipe and we have a point 1 here and point 2 here. To calculate the pressure drop between point 1 and 2 we are using an YouTube manometer, ok. And this angle is 45 degrees. So, this is what is given in the problem. And we are supposed to calculate the pressure drop between point 1 and point 2, point 1 and point 2.

So, the manometric fluid; we have is the mercury. So, the dash to region represents the manometric fluid; which is mercury and it is certain the reading in the manometric fluid shows us 6 inch, ok. So, yeah, so let me put this way. The point 2 is here. We know that manometric, we know that the YouTube manometer works on the principle of hydrostatic equilibrium, using that; first we will calculate the pressure at the point 1 and at the point, sorry, at the point 2. From the principle of hydrostatic equilibrium; we know that, the pressure at point capital I and capital II are same.

We will make use of, we will make use of that fact and we will calculate the pressure difference between the points 1 and 2. For that; first we will calculate, we will write the pressure at point I. So, the water is flowing in this inclined pipe, so for point I. So, sorry for point 1 if we calculate the pressure it would be P 1 plus the pressure whatever we have from.

So, the pressure exerted by the fluid; which is inbuilt in this region, and to do that region to calculate the pressure in that region; first we will make an assumption that, the distance between this point and this point here is h and this as x. So, I repeat that the distance between the point 2 and the manometric reading in the right limb is h. And the distance between the manometric limb reading in right side and the left side. The difference between the two manometric limbs heights is given as 6 inches in the problem and we considered that; the distance between the vertical distance between the point 1 and point 2 is x.

So, if we look at the left hand side; the fluid, which is above the manometric limb will give us a pressure on the point capital I here. So, P 1 is the pressure at point 1. And we have the water as a fluid from point 1 to in this entire region we have the water as a fluid.

So, for that; we have to calculate x and we should know the this distance ok. So, to calculate x; first we will see, we make a right angle triangle, so that x. And again in the question it is given that; the distance between point 1 and 2 is 5 feet. So, I just remade the part of this channel here which is a 5 feet distance that is between point 1 and point 2. And we know that the angle is 45 degrees. So, if we take sin 45, it would be side opposite to theta by hypotenuse that implies x equal to 5 times sin 45, sorry x equal to 5 times sin 45.

So, now, we know x and we already know this distance because it is just it is nothing but, 6 inch plus h. We will just keep this as h. We do not have to calculate h, we will see that y.

So, the pressure at point 1 is P equal to the pressure at point exactly, sorry the here it is not the point 1 its capital I. Pressure at point capital I equal to pressure at point 1 plus the pressure exerted by the fluid in the region with an height of x which would be 62.4 times 32.2 times x. Where 62.4 is density of water and 32.2 is the g in fps units. And we know that P equal to rho gh.

So, this is the pressure at 62.4 into 32.2 into x is the pressure exerted by the fluid in this region; which is in the by the fluid, which is at an height of x. And then, we will calculate the pressure in the remaining section in from the left hand side and it is 62.4 times 32.2 times 6 inch. We will convert that to feets; now 1 feet equal to 12 inch.

So, it is a 6 by 12 feet plus h. So, it is P 1 plus 62.4 times 32.2 times x plus 6 by 12 plus h; where x equal that implies P 1 plus 62.4 times 32.2 times. x we have calculated it as 5 times sin 45 plus 6 by 12 plus h. Similarly we can calculate pressure at point capital II.

. So, the point capital II does have two fluids above it; water, we will write that. So, pressure at point II equal to capital II equal to; pressure at point 2 plus pressure exerted by the fluid with an height of small h that is water. So, we will take the density of water which is 62.4 in fps units times 32.2 which is the acceleration due to gravity in fps units times h plus; we have an we have the manometric fluid the mercury for an height of 6 inch.

We will write the pressure exerted by the mercury of height 6 inches. For that, we need to use the properties of the mercury; which is the density. So, the density of mercury is 846 times. So, we know that the acceleration due to gravity is 32.2 times and 6 inch. The height is 6 inch; which is converted to feets and that is 6 by 12.

So, this is the pressure at point II. And from the principle of hydrostatic equilibrium; we know that, the pressure at point capital I is equal to pressure at capital point II. Pressure at point capital I equal to pressure at point capital II and.

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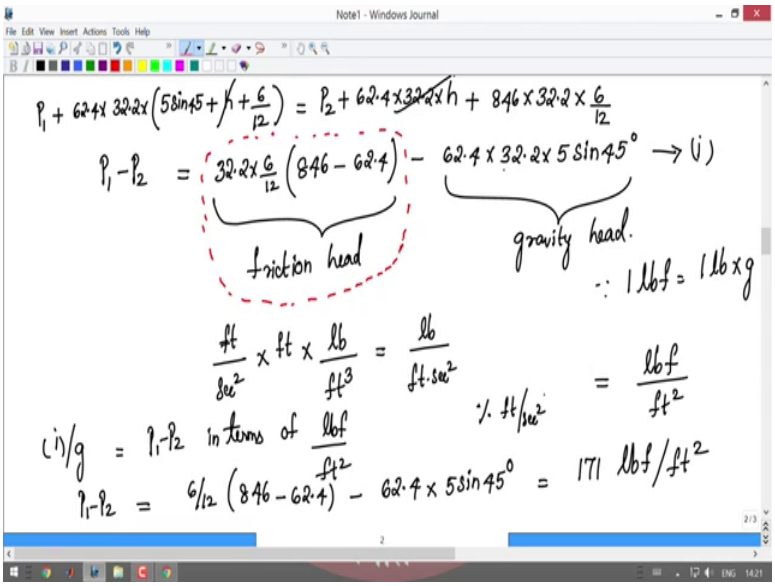

So, what we know is P 1 plus 62.4 times 32.2 times 5 times sin 45 plus h plus 6 by 12. This is the pressure exerted that pressure exerted by the fluid at point 1; which is equal to P 2 plus 62.4 times 32.2 times of h plus 846 times 32.2 times 6 point 12.

The LHS corresponds to the pressure exerted by fluid at point capital I. And RHS represents the pressure exerted by the fluid, water plus the pressure exerted by the mercury at point 2. So, now, we need to calculate P 1 minus P 2; which is equal to, so yes. 32.2 times 6 by 12 times 946 minus 62.4 times. And this term gets cancelled with this term and we will left with 62.4 times 32.2 times 5 times sin 45, 45 degrees.

This is the total pressure that we are supposed to calculate. And we have two parts here. This part of pressure drop is coming from the fact from friction. So, this is called as the friction head and this is coming from gravity head, ok. And now, for the question if you see the question clearly; it is asked to calculate the P 1 minus P 2 in terms of lb force per in square. If you look at the; now we will just look at the units of this P 1 minus P 2. So, we have 32 minus 2; which is feet ok, I will write it down here. 32 minus, 32.2 is feet per second square times 6 by 12 is actually it is, it was in inches and we have connect converted that to feet and 846 minus 624.

These corresponds to the densities of mercury and the densities of the water. So, the density is in fps units; it returned as lb for feet cube. So, finally, we have ended up with lb per phi times second square. But, we were we are asked to calculate the pressure difference in

terms of lb force per in square. To get lb force per in square from lb per phi time second square.

We will multiply this with g; gravitational acceleration due to gravity which is feet per second square. And finally, we will end up with lb force per sorry, so we will divide it more, we will divide it with feet per second square. So, we will end up with lb force per feet square, yes. Because, 1 sorry, because 1 lb force equal to 1 lb times g. So, we already have lb here, so we divided it with g; that is a unit the units of g are feet per second square. So, we have got lb force per feet square.

So, in this, if we in the above equation I; if we divide I with g in fps units. We will get P 1 minus P 2 in terms of lb force per feet square. We already, we have said that 32.2 is a value of gravitational due to, acceleration due to gravity in fps units. So, we will have P 1 minus P 2 equal to 6 by 12 times 846 minus 62.4 minus 62.4 times 5 sin 45 degrees. This comes out to be 171 lb force per feet square yes.

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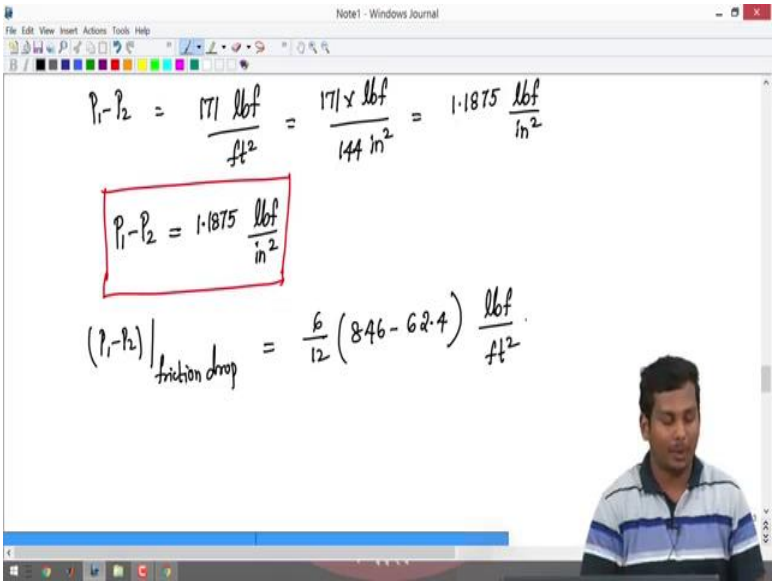

So, we have got P 1 minus P 2 as 171 lb force per feet square. But, in the question; we are asked to get the pressure difference in terms of lb force per in square and, yes. 1 feet equal to 12 inches. So, lb force per 12 square 144 times in square which is equivalent, which is 1.1875 lb force per in square. So, the pressure difference P 1 minus P 2; that we are supposed to calculate is 1.1875 lb force per in square. So, this is the final answer; P 1 minus P 2 equal to 1.1875 lb force per in square.

And later in this same question; we are asked like, what is the pressure drop due to friction only between 1 and 2 in lb for force per in square? So, the yeah, here we said; we have the pressure difference in the system, because of friction, which is termed as friction drop. This part corresponds to the pressure drop due to friction between 1 and 2. Does the manner, and next we are ask; does the manometer reading correspond only to friction drop?

So, so P 1 minus P 2; due to only friction drop will be this term 6 by 12 6 by 12 times 846 minus 62.4 yes, that is lb force per feat square. Does the manometer reading correspond only to friction drop, why? You know, the manometer reading corresponds to both friction drop as well as the gravitational height. So, that is about the problem.