Fluid Mechanics

Prof. T.I. Eldon

Department of Civil Engineering

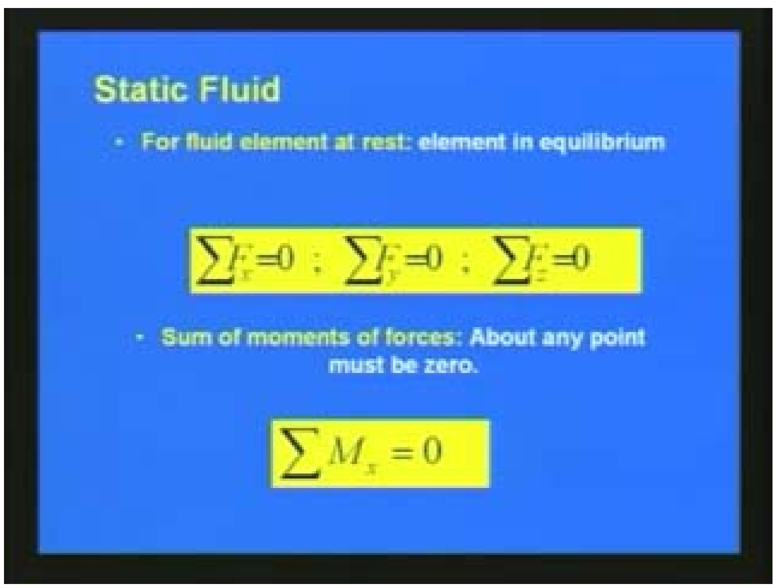
Indian Institute of Bombay

Lecture – 3

Fluid Statics

Welcome back to the video lecture on fluid mechanics. In the last lecture we were discussing about the fluid statics; we were discussing about the courses on lids and then the applications of theories from lid mechanics and we are started with the static fluid theories like on a fluid element rest.

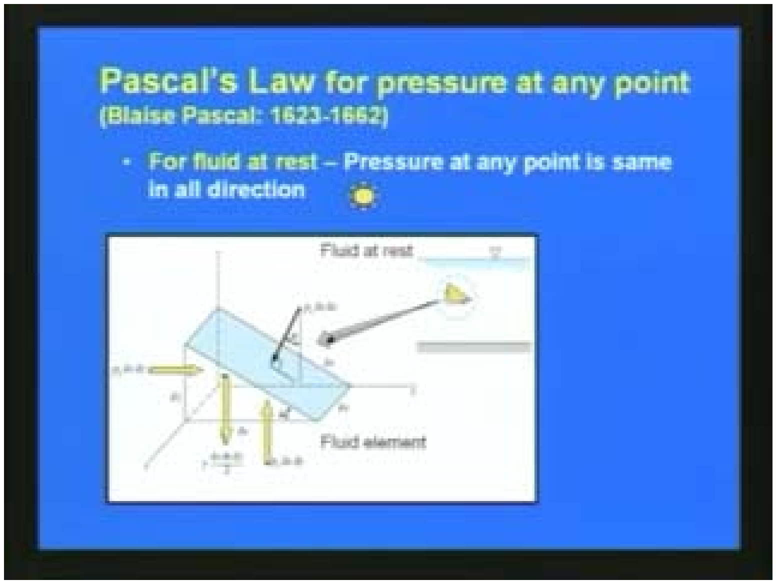
(Refer Slide Time: 1:49)



We have seen that the equation sigma f_x is equal to 0 sigma f_y is equal to 0 sigma f_z is equal to 0 at sum of the forces in xyz directions equal to 0 as we use in lid mechanics

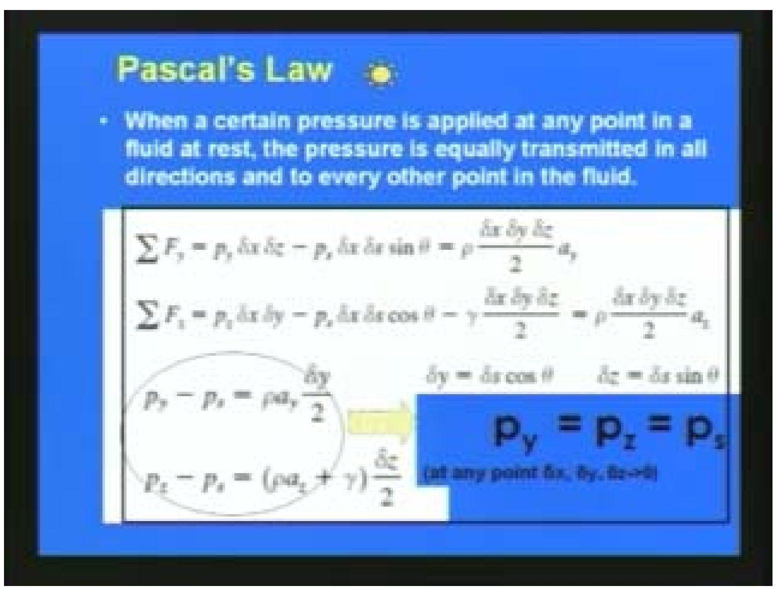
So similarly the sum of moments of forces sigma M_x is equal to 0 that also we have seen and we are defined the pressure.

(Refer Slide Time: 2:11)

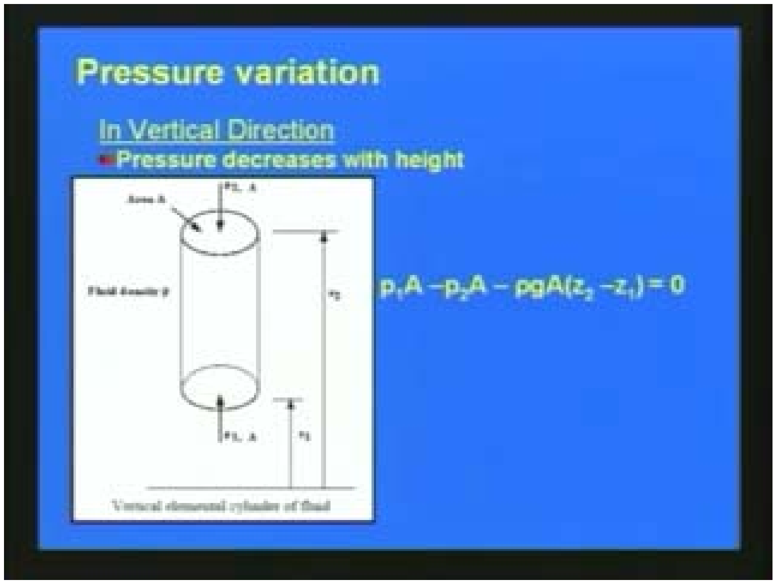


Also we have seen the applications of Pascal law for pressure at any point as we have seen the as for the pascal law pressure at any point is same in all directions that derivations also we have seen in the last lecture.

(Refer Slide Time: 2:21)

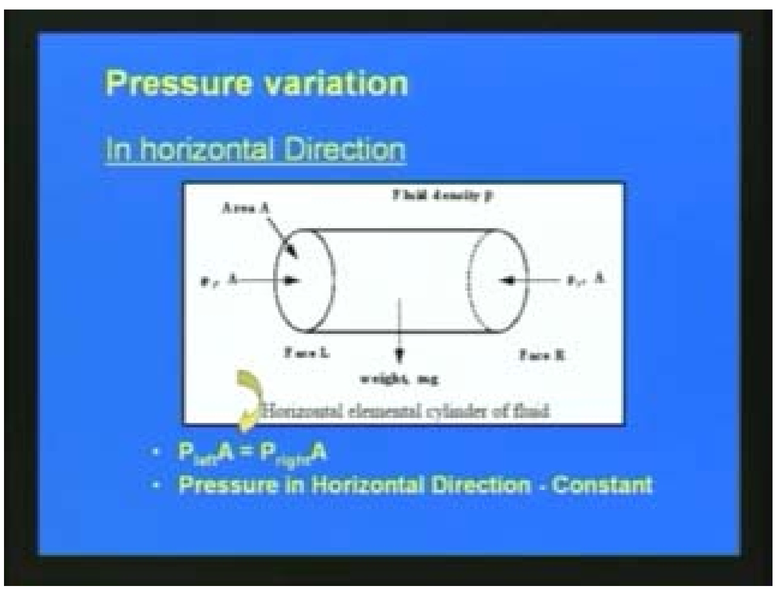


(Refer Slide Time: 2:23)

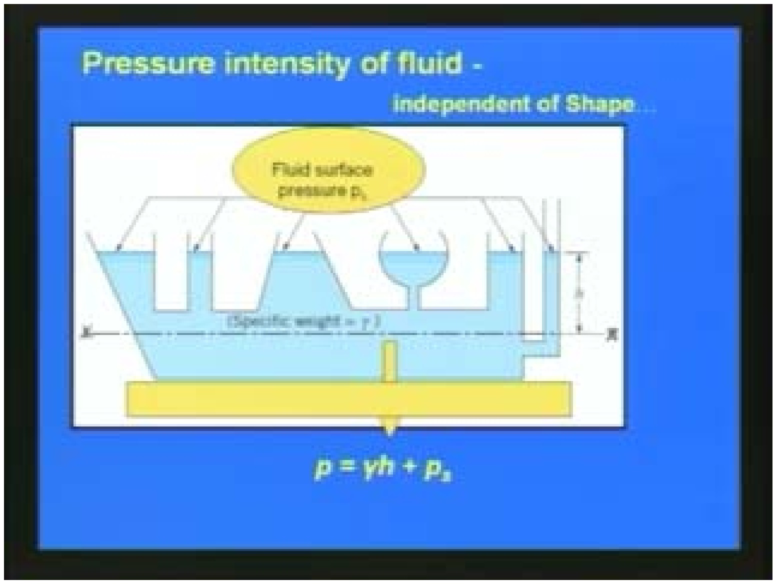


And also we have seen the pressure variation vertical direction and also the horizontal direction.

(Refer Slide Time: 2:28)

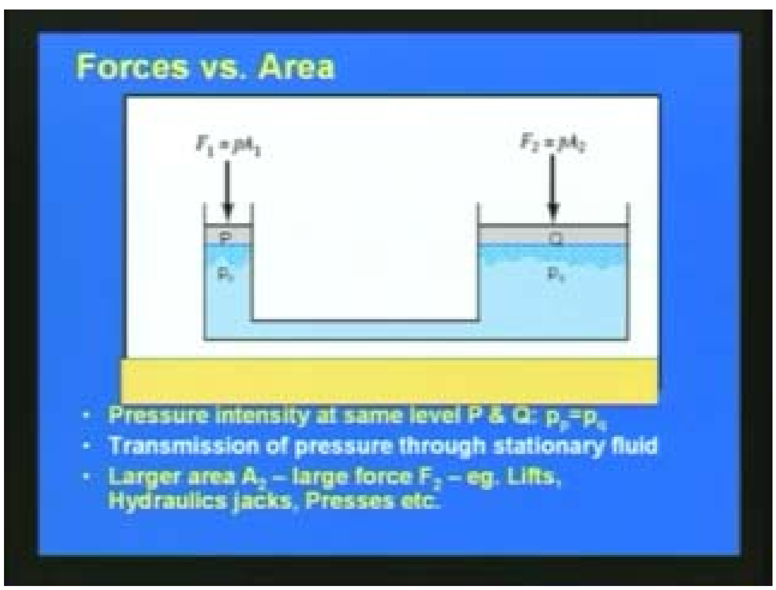


(Refer Slide Time: 2:30)



As we have seen in the last lecture, the pressuring density of fluid is independent of shape as we can see here it is on this excess line and then.

(Refer Slide Time: 2:42)



We have seen the application of the concept of force versus area, here as we have discussing the last lecture say here force F_1 on this side is p into A_1 and other side F_2 is equal to p into A_2. Since p is say on both side is the level p and q. p_p is equal to p_q.

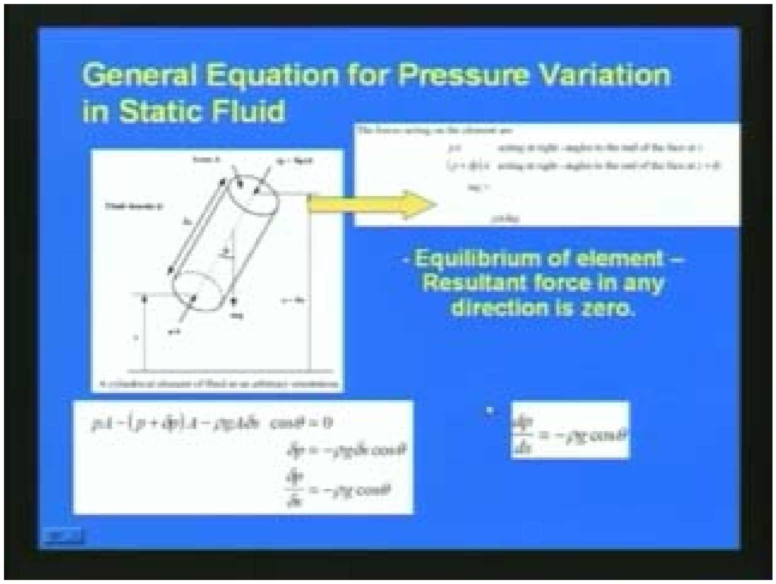
So, transmission of pressure through the stationary fluid is a large number of applications in many practical engineering areas like in use of hydraulic jacks, pressures etc.,

So here we can see that the force applied F is on this side is equal to p in to A_1 which with small force we can raise or we can get a large force F_2 is equal to p into A_2. So this application like as I mentioned hydraulic jacks or lifts pressures etc., are very much used in engineering areas. So now just one application here you can see a man can lift the car.

(Refer Slide Time: 3:46)

So here car is placed on this side and here is also the man is standing and you can see just with his weight due to application of this principle the car is lifting. So that is very much obvious from this animation. So, what is happening is the pressure intensity same on both sides but here the area is smaller. So with respect to that p into A_1 is much more force using that we can raise this p into A_2 which is very larger force. So, the car is raised as shown in this animation.

(Refer Slide Time: 4:30)



Now, we will discuss the general equation for pressure variation in a static fluid. So, for this purpose, we just consider as shown in this slide you can see here we consider a fluid element a cylindrical element of fluid at an arbitrary orientation like this we consider. So on this face of the cylinder the fluid cylinder say the pressure of the force is p into if the pressure intensity is p, force is equal to p into A and on the other side if the pressure is increasing delta p by delta p then on this side the force is equal to p plus delta p into A.

So, here for the fluid density is row and now here this instance is z and here z plus delta z the force acting on the element are p into A acting at right angles to the end of the face and z this as shown here and on the other side p plus delta A acting at right angle to the end of the cylinder element at z plus delta z and then there will be the weight of the element that will be mg.

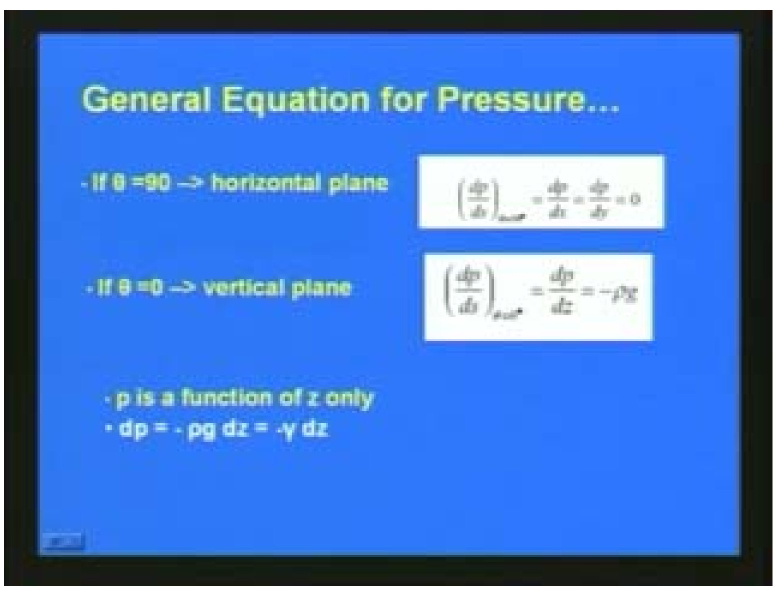
Now, we consider all this using the Newton second law, we can write p into A minus p plus delta p into A minus row g A into delta z cos theta is equal to 0 if we consider this direction. So that using the Newton’s second law that the force is equal to say the total mass into acceleration here with respect to this we can get at equilibrium of the element the result force in any direction is 0 as you have seen in the case of static fluid.

So using that principle we will get delta p is equal to minus row g into delta s cos theta or we get delta p by delta s is equal to minus row g cos theta as this theta is this angle with respect to this inclination with respect to vertical theta is represent vertical.

Finally, we get a general expression dp by dx is equal to minus row g cos theta as shown here, theta is this angle g is the acceleration due to gravity and row is the density of the fluid. So this equation gives the general equation for pressure variation in static fluid. So now we have considered an inclined element or cylindrical fluid element like this.

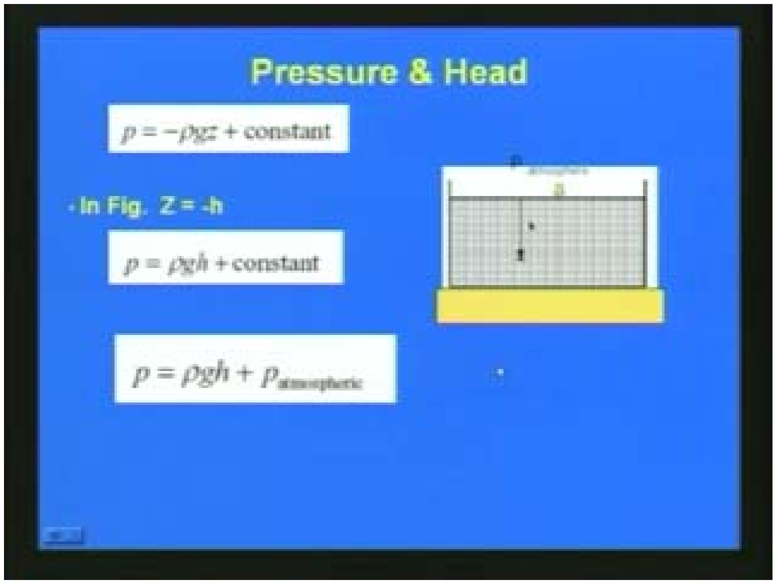
With respect to this equation we can write the general equation for any type of say whether horizontal vertical or inclined type pressure variation in static fluid. So now with respect to the general equation which we have derived now if theta is equal to 90, then on horizontal plane we can see that it dp by dx as theta equipped 90 is equal dp by dx that is equal to dp by dy is equal to 0 and with respect to the earlier figure theta is equal to 0 that means the plane is vertical So for a vertical plain like this.

(Refer Slide Time: 7:24)



So then the dp by ds is equal to minus row into g, here we can see that this is a small basin where we have stored me water. In the horizontal plane you can see that the pressure is 0 and in the vertical plane you can see that the pressure when theta is equal to 0 and dp by ds is equal to minus row g and here this p, the pressure intensity is a function of z only or we can write dp is equal to minus row g dz or where row g is equal to the specific weight So that we can write dp is equal to minus gamma dz, gives the general equation or pressure variation means static fluid.

(Refer Slide Time: 8:25)



Now, we will briefly discuss the relation between the pressure and head. So for that purpose let us consider say a small basin of fluid or say here water is shown here. Now this fluid this is in static condition the pressure on the surface is atmospheric pressure as here shown in this figure.

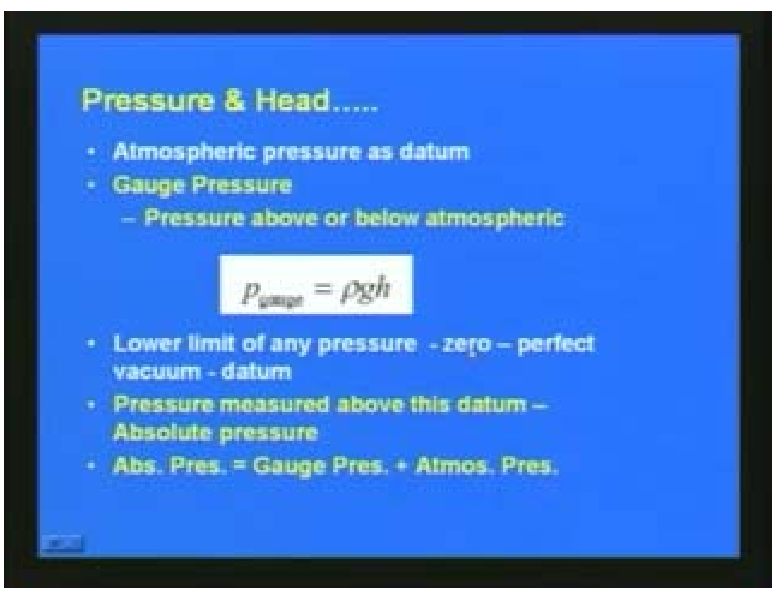
(Refer Slide Time: 8:53)

We can write p is equal to row in to gz and plus constant that means if any other than atmospheric pressure, generally atmospheric pressure can be consider as 0.

So that p is equal to row g into h but if we consider that atmospheric pressure then total pressure is equal to pressure intensity is equal to row gh plus p atmospheric.

So this gives a relationship between the pressure and the head as from in this slide.

(Refer Slide Time: 9:26)



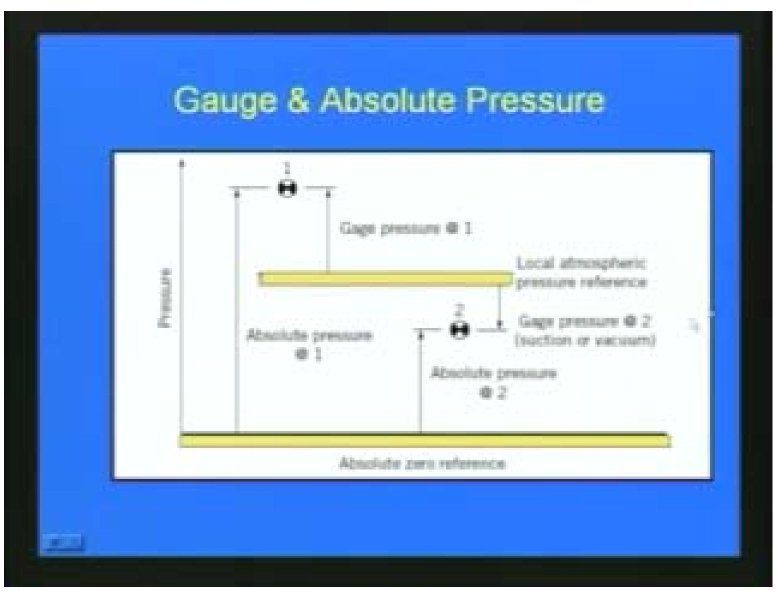
If you consider the atmospheric pressure as datum then we can say that the pressure above or below atmosphere that pressure is called the gauge pressure. So if we consider the atmospheric pressure as 0 or that is the datum, we can define the gauge pressure as the pressure above or below atmospheric pressure that the p gauge or the gauge pressure is equal to row in to gh as we have seen in the previous slide.

So as we know the lower limit of any pressure is 0 for the case of perfect vacuum or if you consider as datum, then pressure measured above this datum is called the absolute pressure.

So when we consider we can classify the pressure in to the absolute pressure or gauge pressure, the gauge pressure is the pressure above or below the atmospheric pressure.

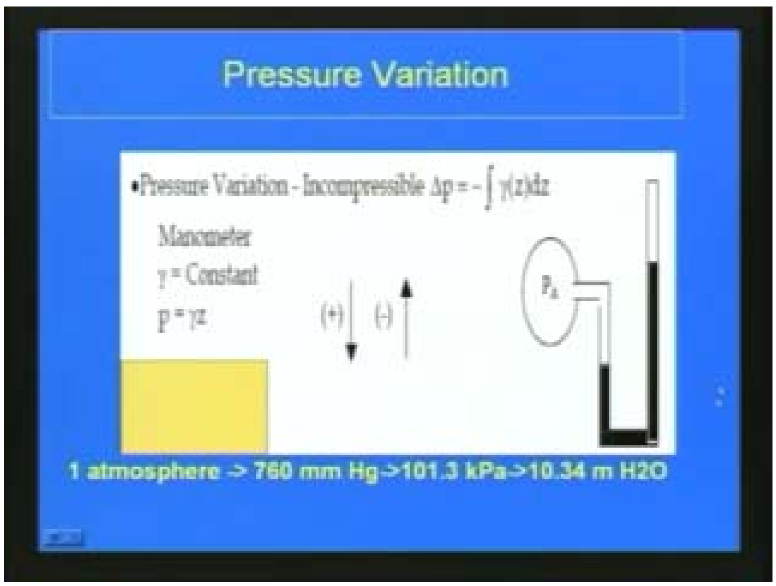
So let the equation is p gauge is equal to row into gh and at absolute pressure is defined as absolute is equal to gauge pressure plus atmospheric pressure or the datum which the absolute pressure. So the absolute pressure is equal to gauge pressure plus the atmospheric pressure.

(Refer Slide Time: 10:47)



So with respect to this, when we consider the various pressure like gauge pressure or absolute pressure or atmospheric pressure let us consider in this slide as you can see if this is the absolute 0 reference as far as the pressure measurement is concerned say if you consider say here the particular points say 1 then we are measuring as absolute pressure and if this line indicates the local atmospheric pressure reference then with respect to that when we measure the pressure at this particular point it is called the gauge pressure but when we are measuring with respect to the atmospheric pressure and the gauge pressure that pressure is used as the absolute pressure. So we can differentiate the pressure measurement with respect to either we are using the gauge pressure or the absolute pressure as shown in this slide.

(Refer Slide Time: 11:42)

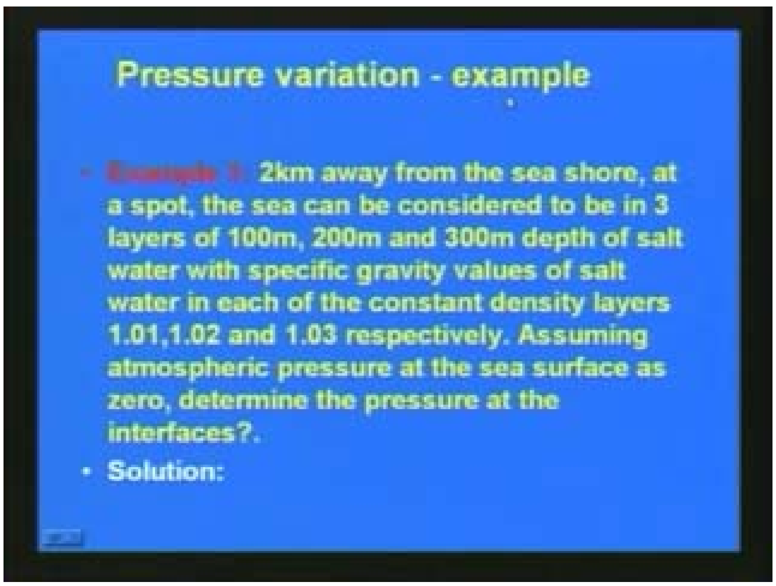


Now, we will further discuss about the pressure variation the pressure variation for incompressible fluid, you can see that as we have seen in the previous slide it is say row g your gamma into vz if you consider say from one point to another in the vertical direction. So we can just integrate this to get the total pressure variation you can just integrate gamma z dz.

Generally, we have to use a sign convention whether say the pressure above the atmospheric pressure whether it is positive or negative we can consider say we can put it whether it is increasing or decreasing the direction as positive or negative as shown here. So finally if you indicate as we have seen the previous slide we get p is equal to gamma into z. So this we can measure using a manometer like this the pressure variation can be measured say at a particular point p at A can measure with pressures. So we will be discussing about the pressure measurement later parts of the lecture, now we have seen the pressure can be say the gauge pressure or absolute pressure and then the atmospheric pressure.

So one atmosphere in the pressure is defined as say 760 millimeter of mercury or it is equivalent to 101.3 kilopascal or again that is equivalent to 10.34 meter of water quantum. So the atmospheric pressure is generally expressed as either 76 centimeter of mercury or 101.3 kilopascal or 10.34 meter of water quantum. So this equation gives the general pressure variations and then with respect to that atmosphere pressure the values are these values given here.

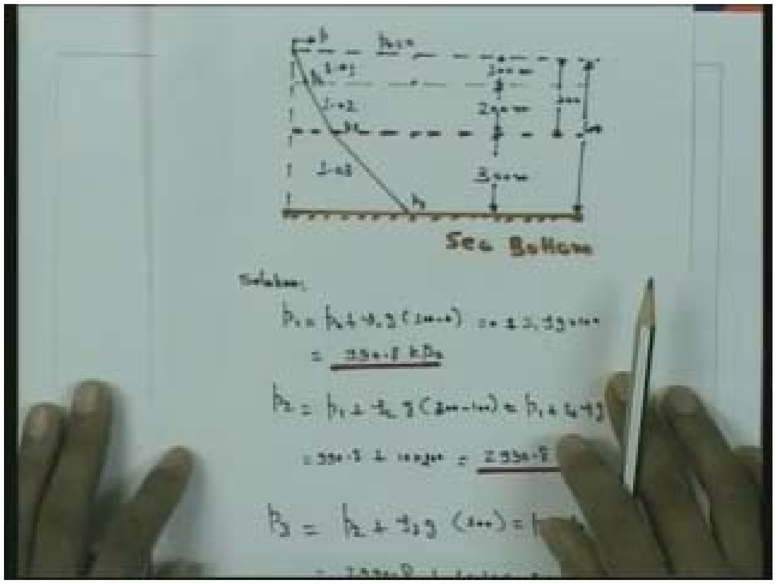
(Refer Slide Time: 13:45)



Now, with respect to the pressure variation we will demonstrate or we will discuss a small problem here. So here the problem statement is first example, 2 kilometer away from the sea shore at a spot the sea can be considered to be in three layers of 100 meter, 200 meter and 300 meter depth of salt water with specific gravity values of salt water in each of the constant density layers as 1.01, 1.02 and 1.03 respectively. So, assuming atmospheric pressure at the sea surface as 0 determines the pressure at the interfaces.

So here I would demonstrate this problem with respect to this figure here, you can see if the sea shore is on this side we are considering two kilometer away from the sea shore at a particular spot here you can see three layers.

(Refer Slide Time: 15:38)



So first layer is about 100 meter and second layer is 200 meter and third layer is 300 meter and this is the sea bed or sea bottom.

So now the atmospheric pressure can be consider as 0 and at this particular spot the specific gravity values of salt water each of the constant density layer are event for the first layer the density is 1.01, the second layer the density is 1.02 and the third layer the density is 1.03.

So we have to determine the pressure at the various interface you can see here there is one interface and here the second interface and here below the at the position also we have to determine the pressure. So we can just utilize the equation which we have derived earlier. So the solution here you can see say even we want to determine this p_1 the pressure at this interface. So that will be equal to the surface pressure the atmospheric pressure here p_1 is equal to p_0 which is the atmospheric pressure plus row_1 g, row_1 is the density and g is the acceleration gravity that this is the specific weight of the liquid at this layer.

So row_1 into g this that is 100 meter if you are measuring the depth from the surface this is at this particular position where we are measuring the p_1 it will be p_1 will be at this location. So that will be obtained as p_1 is equal to p_0 plus row_1 into g into 100 minus 0 since the depth is 100 meter this location p_1 is equal to p_0 plus row_1 into g, row_1 g is the specific weight into 100 minus 0 since we are measuring the datum as on the surface.

So from there only the measuring, that is equal to since atmospheric pressure as per the problem it is assumed as p 0 is equal to 0, 0 plus s_1 into row g into 100 here it is given as 1.01 as the specific gravity of the first layer or the constant density layer as 1.01g is 9.81 into 1.01.

So finally multiplied by 100 we get 990.8 kilopascal, at this location the pressure will be 990.8 kilopascal. So similarly now we will determine the pressure at position say here this interface between layer 2 and 3, at this location p_2 is equal to here this location the pressure will be the pressure with respect to the top layer p_1 that we have to add plus the specific gravity or the specific weight of this liquids in this layer.

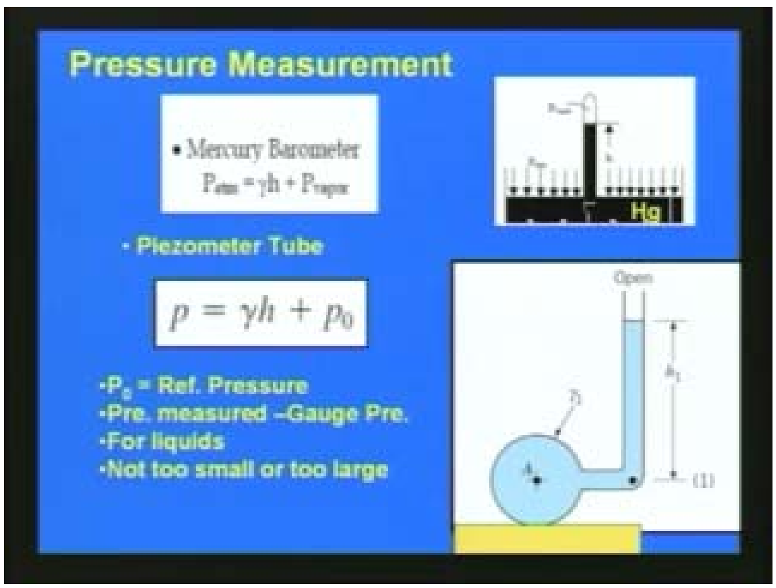
So that is given as row_2 into g that is the specific weight with respect to this layer and then multiplied with respect to this layer thickness that is equal to the total distance from the surface to the bottom of this layer is 300 meter.

So 300 minus 100 meter is the depth of the first layer row_2 g into 300 minus 100 that is equal to p_1 plus s_2 row into g where the s_2 is the specific gravity of the constant density layer of the second layer is 1.02. So, row is 1.02 multiplied by g 9.81 into 200 this gives the total pressure at this is the interface between layer 2 and layer 3. So that total p_2 is equal to p_1 we have already determine as 990.8 kilopascal that plus this equal to s_2 in the row g is about 10, so 10 into 200 total pressure at this location will be p_2 locate here will be 2990.8 kilopascal.

Similarly, we will determine the pressure at this bottom of the sea p_3 is equal to the total pressure at this layer, two layers, first layer and second layer that is all determine as $p_{2.}$ p_2 plus this layer thickness layer thickness total see that is say 600 meter up to here is 300 meter so 600 minus 300 depth will be 300 meter it determine this pressure here p_2 plus row_3 into g or into s_3. s_3 is given as 1.03 that multiplied by this depth 300.

So that is equal to the previous p_2 we have already determined as 2990.8 that plus this value is this value is 10.104 into 300 that gives 6022 kilopascal. The pressure at the bottom of the sea at this location will be 6022 kilopascal and the interface between layer 2 and layer 3 will be 2990.8 kilopascal and between layer 192 even will be 990.8 kilopascal. So using the general equation which we have derived earlier you can determine the pressure variation like we have illustrated in this particular problem.

(Refer Slide Time: 20:37)



Now, we will go to the next topic is pressure measurement, especially fluid mechanics is very important since say various pressure is one of the most important fluid property. So we have to determine the pressure in various cases especially when we consider any kind of fluid flow problem whether is static or dynamics but now we will be discussing which static here we will be discussing how to determine the pressure or how we can measure the pressure for various cases. Various types of equipments or various types of gauges are available for measurement first one is called a mercury barometer.

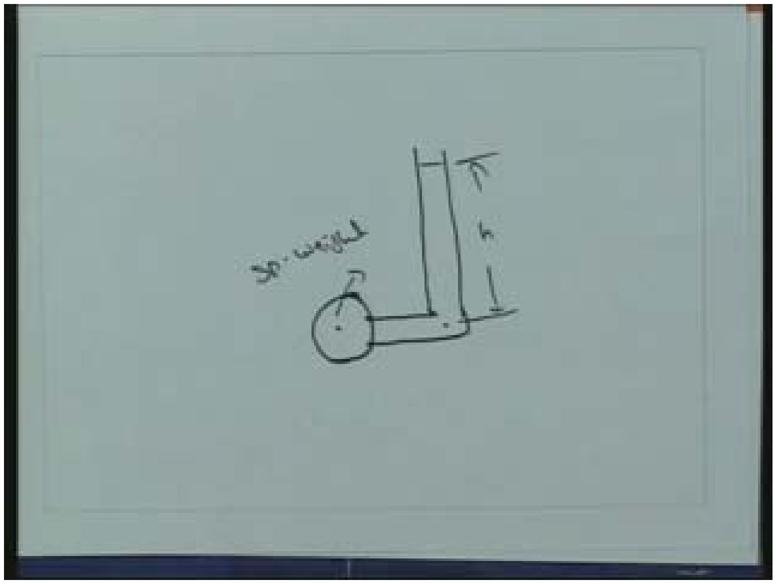
So here we can see in this slide the mercury barometer the pressure is measured as especially this mercury barometer used for atmospheric pressure measurement we can see that the pressure will be varying from say at sea level it will be one say it will be maximum then it will be reducing say or the top of the mountain.

So we have to measure the atmospheric pressure at various levels or various position we can say mercury barometer like this. So we are say small base in the mercury based and then a small tool we can see here using this mercury barometer here the mercury is used. So the atmospheric pressure is measured as this gamma this depth gamma multiplied by this specific weight gamma multiplied by this height h gamma h plus if any the pressure that us the atmospheric pressure using a mercury barometer. So this is the way which we generally measuring the atmospheric pressure. Now we will discuss the other pressure measuring equipment.

One of the simple moisture pressure measuring equipment is called a piezometer tube.

So here you can see if we have want to measure the pressure in a pipe like this are in a tank or in the position where we want can introduce a small piezometer tube. So a piezometer is just like a tube where we can introduce it on particular location this small tube this is called a piezometer and then this can be connected to various location say like if you want to connect if you want to measure the pressure in a pipe then you can just put like this. Finally, we will be determining the water column the height here and then with respect to the equation which we have derived earlier we can get or we can measure the pressure.

(Refer Slide Time: 23:31)

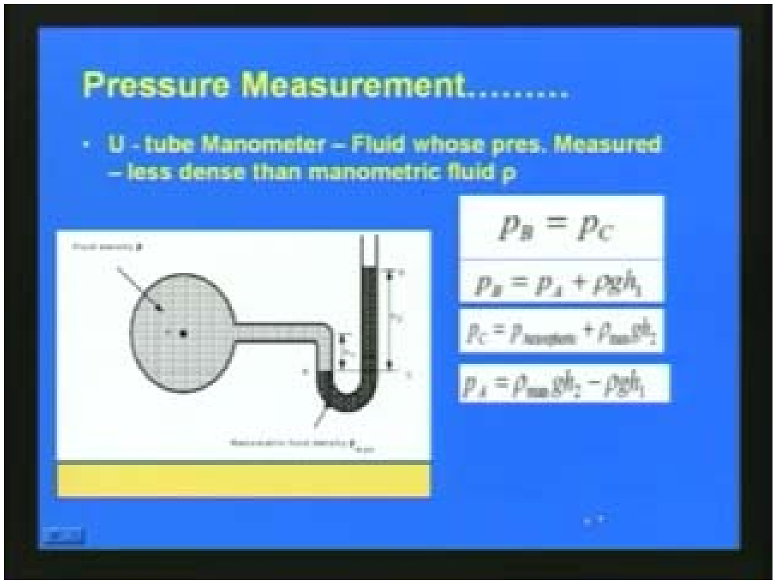


As you illustrated in this slide using a symbol piezometer, piezometer is connected here and then it is open to the atmosphere, the depth is the raise to the pressure in this pipe or the container there will be raise in pressure or raise in water column or liquid column water or what ever the kind of liquid which is consider raise in liquid column here than it is h_1 here and then the piezometer from the piezometer you can return in the pressure p as gamma into h plus p_0 where p_0 is the reference pressure say for example if it is open then we need it can be atmospheric pressure which can consider as 0 and pressure measured is the gauge pressures here the we are measuring the gauge pressure.

So, the piezometer can be used in many cases like especially for liquids. The disadvantage of piezometer is that we cannot measure too small pressure, it is difficult to measure or when the pressure is very large we cannot measure, that is the disadvantage of this piezometer. The advantages is very simple, we can directly connect to the pipe or container or in a system and then see the pressure at the particular location as demonstrated in this slide.

So the pressure measurement is using piezometer using the simple equation and what we are getting is the gauge pressure.

(Refer Slide Time: 25:08)



So as we have seen this use of same piezometer has some disadvantage which we cannot measure the pressure very accurately, it cannot give a small variation in pressure or we cannot measure large pressure. So another type of equipment we generally used in laboratories and another place is called U tube manometer. So the pressure measurement using U tube manometer here the fluid whose pressure is to measure we can see that here a U tube like shaped in U shape and then there will be a manometric fluid inside in this U tube.

So you can see here this is the manometric fluid of density row manometer, here you can see and then it will be a dense fluid and then what will be doing is there we have to measure the pressure accurately we can connect this U tube like this here, we are measuring the pressure in this pipe or a container like this.

So we are connecting this U tube like this with respect to the since due to the pressure in this pipe or the container the liquid in the manometer liquid in this manometer U tube manometer will be rising like this. Now with respect to this we will be measuring generally this raise h_2 and also this variation h_1 we will be measuring using scales with connected scales. So from the principles let we say the pressure at this location b and c should be same if you use that principle p_B is equal to p_C as shown in this slide, here with respect to this we can write p_B is equal to pa that means the pressure here pa plus row in to g that means row is the density of fluid in this pipe.

So row into g is the acceleration o gravity row into g into h_1 that gives the pressure at this particular location p_B. So that is with respect to p_A the p_B is equal to pa plus row g h_1 similarly we can find the pressure at the location c that is obtained as p_C is equal to there will be a since here the manometer is open to atmosphere.

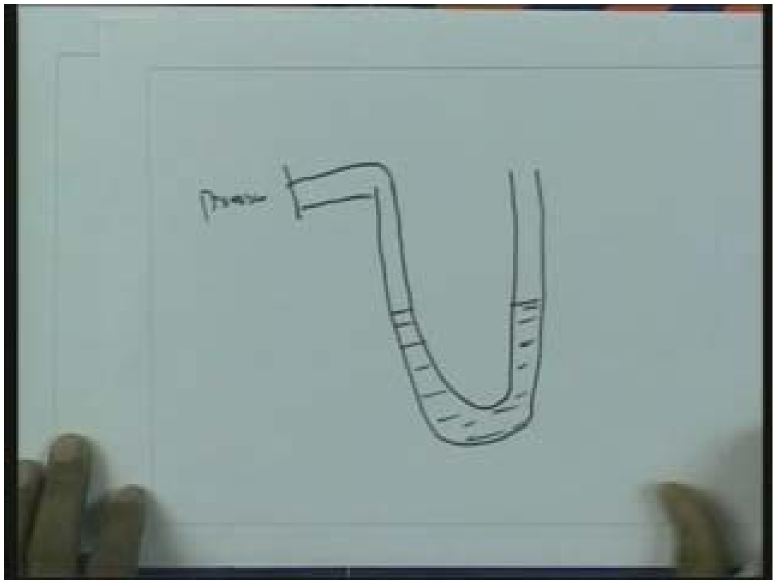
So this we have to consider the atmosphere pressure if you have neglecting all with considering a 0 density, then we know to consider but here if you consider p atmosphere then p_C is equal to p atmospheric plus the row manometer that means the density of the the manometer liquid multiplied by g in to h_2 this height of liquid which we are measuring.

So p_C is equal to p atmospheric plus row manometer into g into $h_{2,}$ now our aim is to measure the pressure at this particular location here this point A.

So to measure the pressure at this particular location A, p we can use this principle p_B is equal to p_C look at this then we will get and if you assume p atmospheric is equal to 0 then we get the pressure is equal to the density of the manometer liquid multiplied by g the acceleration between gravity and this depth h_2 which we measured and then minus row, row is the density of fluid in the pipe row in to acceleration due to gravity multiplied by this depth h_1. So this gives the pressure pa that means the pressure at point is equal to row in manometer g in to h_2 minus row in to g into h_1

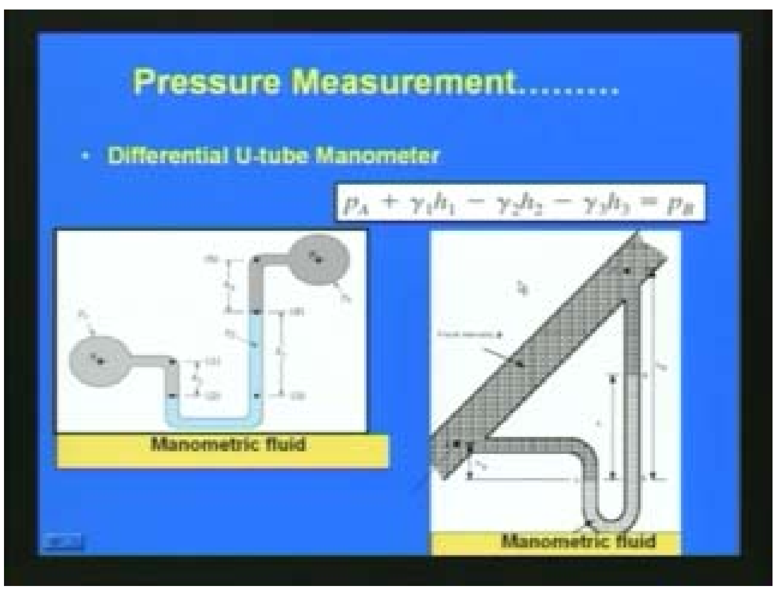
So the basic principle of manometer here is you can see that here we have just a U type pipe like this here we put some liquid either it can be mercury or any kind of liquid and then we can connect this through a another pipe where we have to measure the pressure So this is the point there will be measuring this is the simple principle used the case of manometer.

(Refer Slide Time: 29:39)



Now, the pressure measurement using the manometer you can use it in different ways.

(Refer Slide Time: 29:45)



So first one is the last slide just only one limb of the manometer is connected to a particular location where we want to measure the pressure and now if you want to measure the pressure differentially that means between two position say here A and B

So for that when we use this manometer, U tube manometer, it is called the differential U tube manometer

So here we are determine the pressure at the pressure difference between A here this location A and this location B. The one limb of the U tube manometer connected to the pipe flow or the container at here through a pipe line this and other limb of the manometer is connected to the second pipe or the container and say with respect to this location B.

If there is a pressure difference between A and B let means between the positions this pipe and second pipe the we can write the equation as p_A the pressure at this location p_A we can using scales we can measure the depth as 1 here as shown in this figure and also we can measure this depth h_2 here say where the manometer liquid is raised So this is h_2 and then we can measure this depth h_3 with respect to this point B this h_3 can be also measure finally we can write the equation as the A plus gamma one h_1 minus $gamma_2$ h_2 minus $gamma_3$ h_3 is equal to p_B

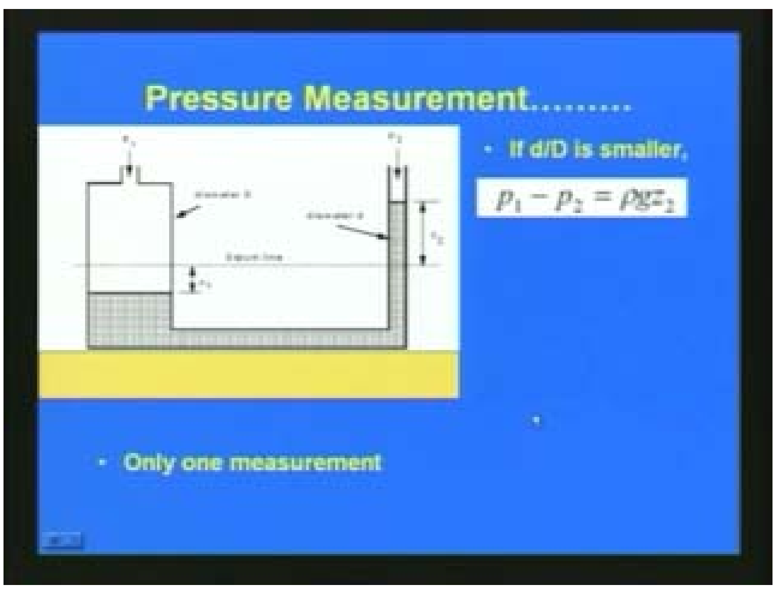
So this is the equation which we use for the differential U tube manometer, since we know the this specific weight for the density of the liquid in this first pipe and also know the specific weight for the density of the manometer liquid and we also know the density of specific weight of pipe two for this container.

So with respect to this h_1 h_2 h_3 are already measured we can get the pressure difference between A and B using this equation. If there is the same pipe line if you want to measure the pressure between this position and the earlier position that means between A and B here you can see the say the fluid density is same we can connect the manometer both the links like this say first link can be connected to this location and second link connected to the second location and then this difference can be a h_1 h_2 h_3 can be measured as in the previous space and then finally this equation can used to get the pressure difference between point A and B as demonstrated in this figure.

So now using the U tube manometer we have seen how to measure the pressure at a particular location as say here in the previous slide and then again we say here seen here at a particular point if you measure of the pressure this shown be this shows the slide shows how we are doing and then the second case you have seen if you want to measure the pressure difference between two boils or between say two pipe lines are between to container or between two locations any type of locations we can use the manometer like this or in a single pipeline with the pressure difference between two points can be measured like this by connecting the two links of the manometer at two locations we want to measure the pressure difference and then we can use this pa the points of A and B then p_A plus $gamma_1$ h_1 minus $gamma_2$ h_2 $gamma_3$ h_3 will be the $gamma_1$ is the specific weight of the first pipe, $gamma_2$ is the specific weight of the manometer liquid and $gamma_3$ is the specific weight of the fluid in the second pipe.

So, we can see that using the manometer the major difficult here is that we have to do many measurements here; we have to measure to see the pressure difference three measurements we have to do p h_1 h_2 and h_3. So if the measurements are not very accurate then the results will not be accurate, so more over many measurements are not good why determining the pressure very accurately.

(Refer Slide Time: 34:23)

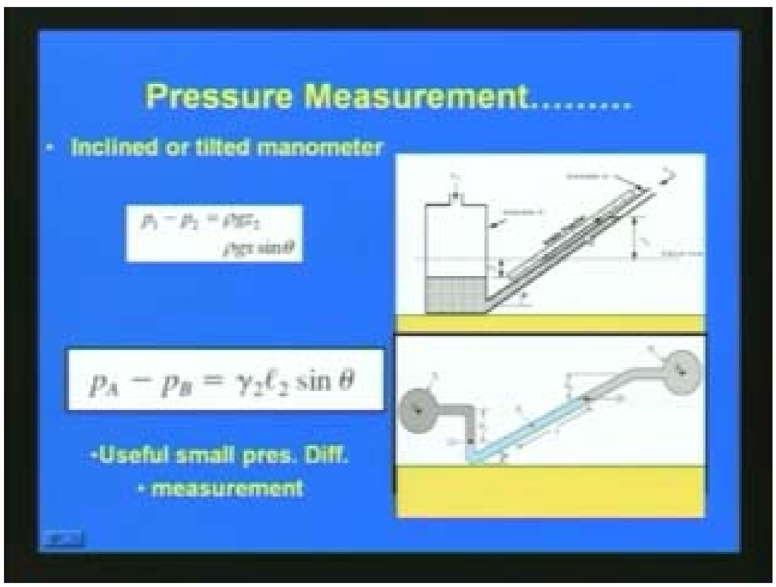


So, this kind of problems if we consider a manometer or this mechanism like this where the diameter d is much larger compared to the diameter D on this line.

So this line which is d by D is very smaller, then we can see that with respect to this say if you measure this Z_2 is measured then between this p_1 and if you wan to measure the pressure difference between p_1 and p_2 then we can see with respect to this figure we can write the equation p_1 minus since d by D is very small.

So if d by D is smaller, then we can write the pressure difference as p_1 minus p_2 is equal to row g in to z_2. So in this case we are measuring only at this location only z_2 is only measured and equation is p_1 minus p_2 equal to row g into z_2 so that advantages only one measurement, but it is less accurate than what we have seen in the earlier cases.

(Refer Slide Time: 35:32)

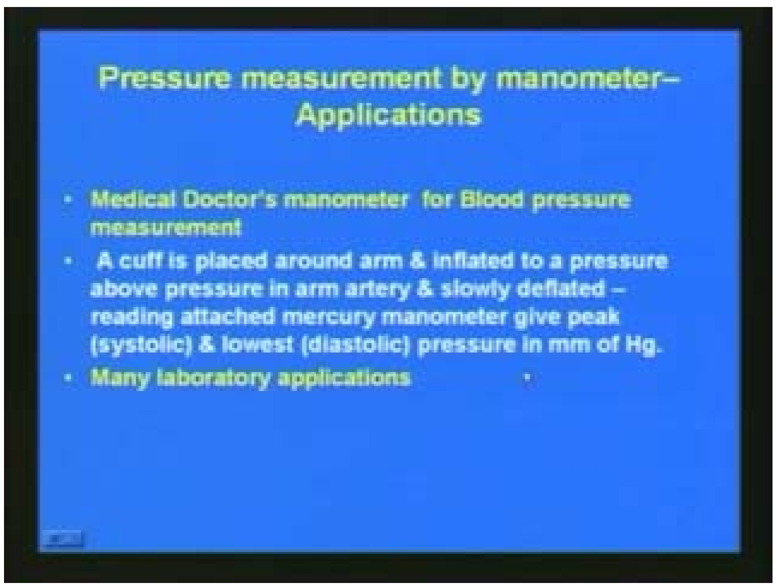


And also say some times you can use the inclined or tilted manometer that may be more accurate compare to the earlier one which we say they are till inclined or tilted manometer is demonstrated in this figure here. So you can see here say now if you want to measure the pressure say p_1 here and then if the pressure here is p_2 then the pipe with a manometer liquid like this. So with respect to this figure we can write the equation as the pressure difference is p_1 minus p_2 is row g z_2 that is equal to we can measure using a scale like this So that is equal to row g x sine theta where theta is this angle and x is the measured distance with using this scale here.

So that is called a inclined manometer or we can also have a tilted type of manometer like this where we are connected we are connected this manometer to pipes location A and B and then p_A minus p_B will be this l_2 is this distance measured from measured between this level and this level and $gamma_2$ is the specific weight of the manometer liquid inside and then p_A minus p_B is equal to $gamma_2$ l_2 sin theta with respect to this figure.

So this kind of inclined or tilted manometer is useful to measure very small pressure on the pressure difference. So it is better than the previous one which we are discussed since it can measure through more accurate accuracy from there to be earlier one.

(Refer Slide Time: 37:15)



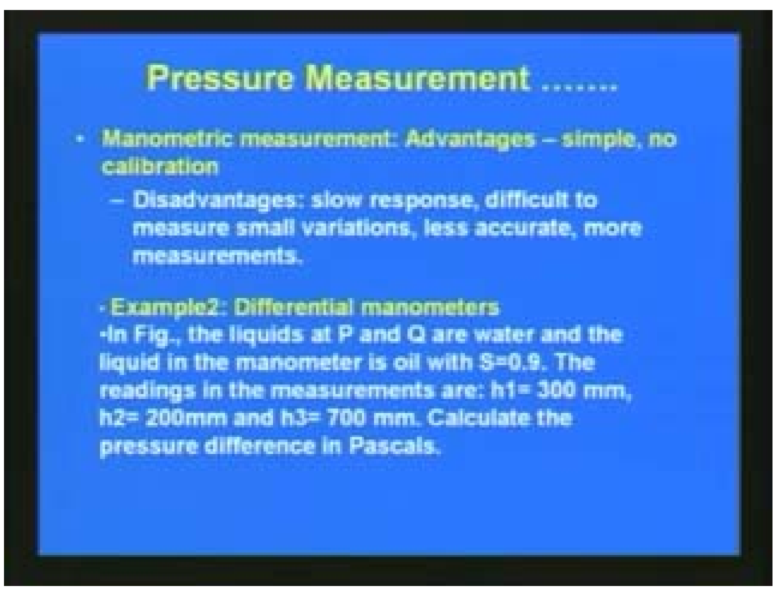
So now this manometer can be used for many applications say one of the generally used application is the pressure measurement by medical doctors, they use this manometer for blood pressure measurement.

So all of you do experience how they are measuring the pressure the doctor is measuring the blood pressure what they are doing is a cuff is placed around arm and then inflated to a pressure above pressure in arm artery and the slowly deflated you can see that me using some mechanism they are inflating or the inflating in the arm artery and slowly deflated reading attached mercury manometer to give peak and peak ions called systolic and the lowest is called diastolic pressure in millimeter of mercury

So here also a manometer use which gives the pressure and this also you can see that this small u tube type manometer. Also this manometer we can use in many kinds of say especially in laboratories we generally used manometer for pressure measurement But now a days this manometer since it will be have to measure the scales and then the accuracy may not be to the level which we require in many of the sophisticated problem then we will be using for say we will be going for mechanical type or other kinds of manometer.

So like gauges that will be discussing next slide before that let us see the major advantage of this manometer. So manometer measurement, the advantages it is very simple there is no need of calibration it can just say if there is a U tube with a manometer liquid we can just connect to the location where we want and then that will just using a scale you can measure the height and that you give directly the pressure or the pressure difference. So it is very simple and knows your calibration but some of the disadvantage here are say this slow responsity if we want to measure the response using a manometer is very low.

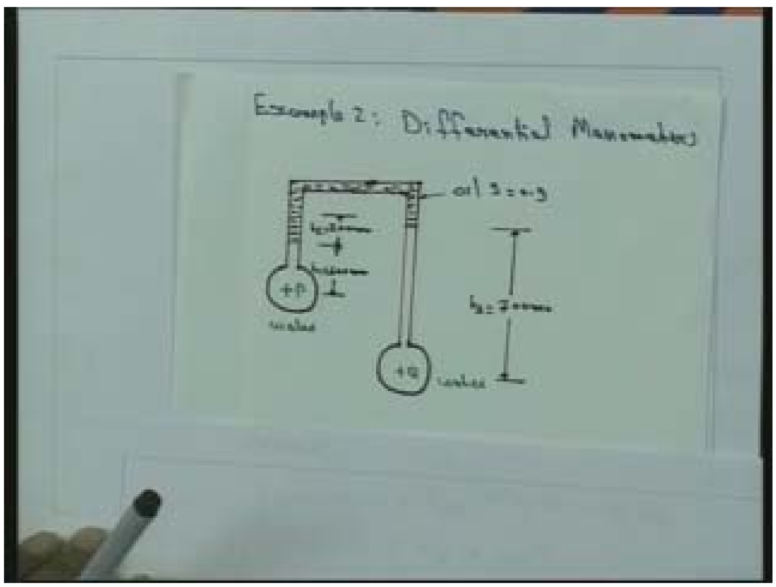
(Refer Slide Time: 39:30)



then it is very difficult to measure small variations if there is with respect to a small temperature raise if there is a small raise in pressure this kinds of differences it will difficult to observe using a manometer also and it is not accurate since we have measuring it using a scale.

So the accuracy is also less and we have to do as we have seen to three times use a scale and then measure the heights and all then we have to use this equations. So these are some of the disadvantages of this manometer type of pressure measurement. Now we will discuss a problem um for differential manometer how we can use a differential manometer we are getting the pressure. So in this problem here in this figure we can see here the problem

(Refer Slide Time: 40:30)



So the problem is say in figure the liquid at p and q or water in the liquid in the manometer is oil here there is a manometer you can see it is U tube manometer in the other direction in the inverse position. So we want to measure the pressure at p and q this is two pipelines going in parallel at p we want to measure the pressure which is the pipe p is containing water and q also containing water.

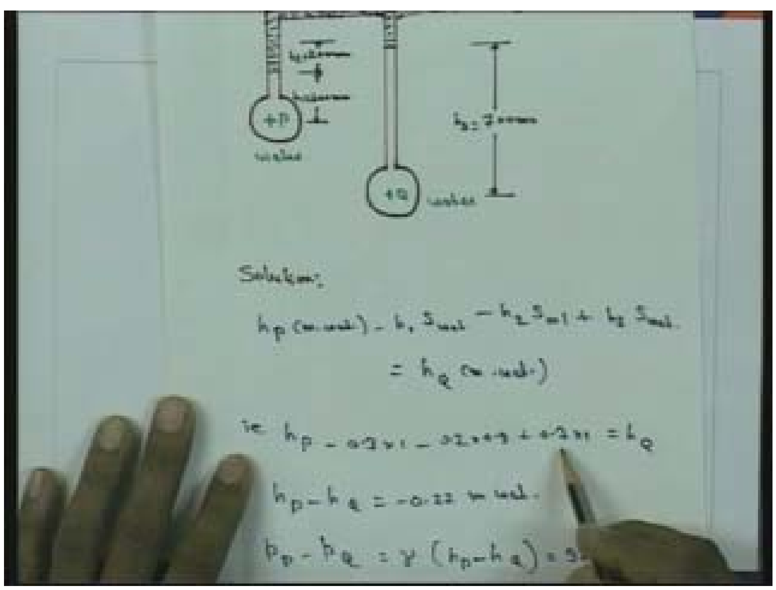
So you want to measure the pressure difference between p and q, the water and the liquid in the manometer water is there in the pipes and the liquid in the manometer oil with specific gravity of 0.9 and the reading in the measurement h_1 is equal to here h_1 is equal to 300 millimeter and h_2 is equal to 200 millimeter and this h_3 is measured as 700 millimeter, we have to find the pressure difference in Pascal's.

So to solve this problem now already we know this h_1 h_2 and h_3 and we want to find the pressure difference between p and q in Pascal and then the density or the specific gravity of oil in the manometer is also even.

So with respect to this figure we can write the pressure say at location p can be written as in terms of h_p in terms of meters of water minus h_1 this height multiplied by specific gravity of the specific water and this is manometer liquid minus s_2 into the specific weight of oil s into s oil, specific weight of oil plus h_3 specific weight of water.

So this is equal to h_p the pressure at location q in terms of meters of water, now using this equation which can write hp minus this 300 millimeter 0.3 into one the specific weight of water 0.31 minus 0.2 into 0.9 the specific weight of the oil is given as 0.9 with respect to the water 0.9 times of water.

(Refer Slide Time: 43:14)

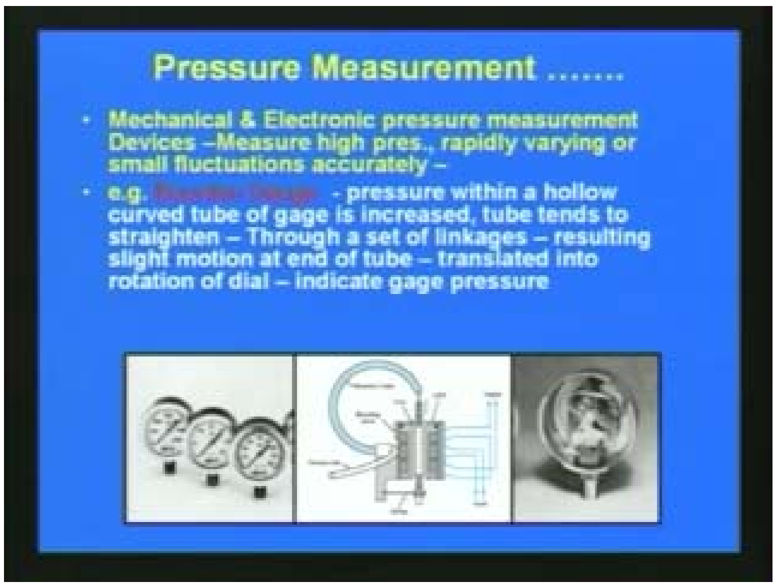


So 0.2 into 9 plus this is again this h_3 is water 0.7 into 1 that gives hq the pressure difference between p and q is hp minus hq is equal to minus 0.22 meter of water this can be we have, we want to get in terms of Pascal.

So p the pressure difference in between p and q can be written pp minus pq is equal to this specific weight of water can be specific weight multiplied gamma in to hp minus hq

So this gamma equal to row into g this is equal to 9806 Newton meter cube into minus 0.22. So this is equal to 2157.32 Pascal or 2.157 kilopascal. This way using a differential manometer we can determine the pressure difference between p and q. So now we have seen using a manometer.

(Refer Slide Time: 4:19)



How we are measuring the pressure whether it can be a simple manometer connecting to only one location or it can be differential manometer to find the pressure difference connecting on both links of the U tube manometer that you get the pressure difference and then we have seen inclined or tilted type of manometer say and then we have seen the advantages and disadvantages of manometer. So as I mentioned earlier this manometer using manometer the pressure measurement is [44:49] since we have to measure the height and then using me equations to convert now a days we have this mechanical and electronic equipments for measurement of pressure.

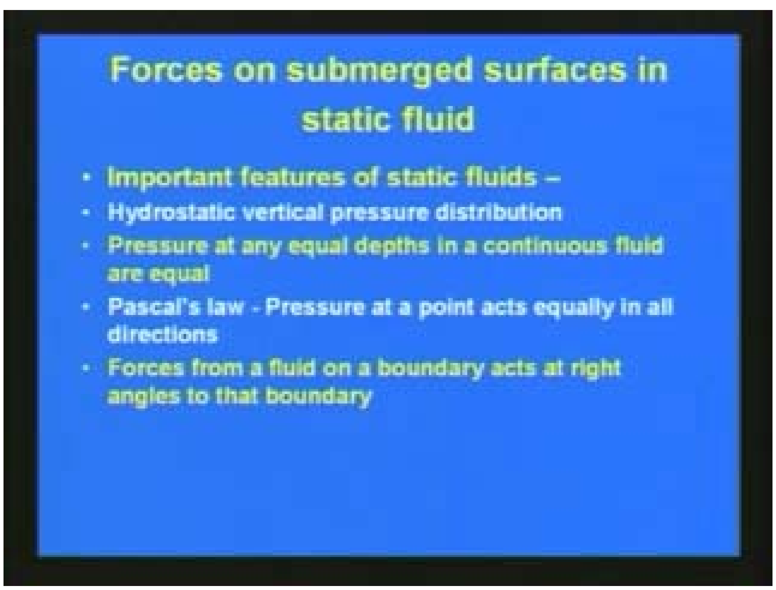
So the advantages of the mechanical and electronic pressure measurement equipments are it is very fast, low pressure can be measured and rapidly varying or small fluctuation can be also obtained accurately.

So here in this slide we can see different kinds of mechanical type on the left hand side you can see different kinds of mechanical type of this kinds of say the pressure measuring gages and it is enlarge portion say whether it can the electronic type is also shown here.

So what we are doing is we can just put this particular location and that will through put sometimes it will directly give the value of the pressure as a Pascal or low Pascal or which unit we are looking for and one of the most commonly used gage for pressure measurement is called bourdon gage here this figure shows the bourdon gage in this the bourdon gage the pressure is measured say by using a say you can see here a hollow curved tube of gage is used this tube tense to straighten when the there is a pressure.

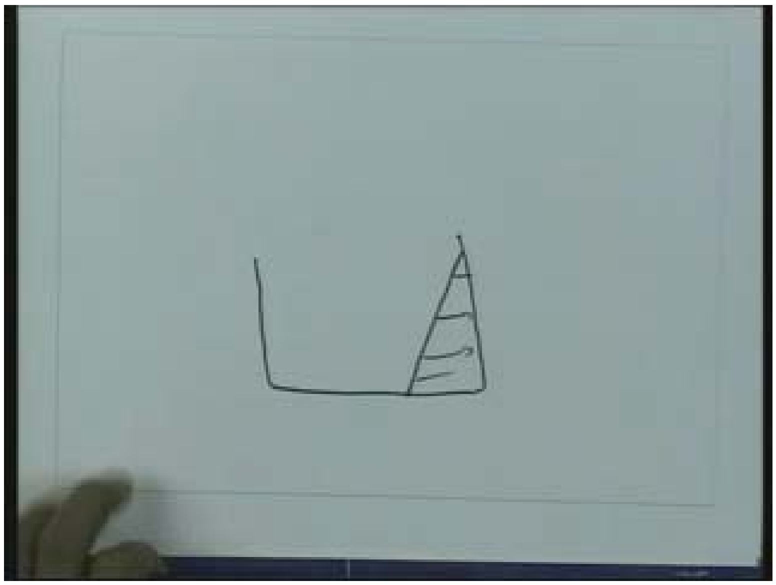
So set of linkages as you can see in this see bourdon gage through a set of linkage that is connected to here that a slight motion at end of tube that is translated into rotation of this dial here and that indicate the gage pressure directly So directly this rotation is translated into the gage pressure reading and then we can directly get the reading, so instead of using the manometer or piezometer type pressure from measurement. Now a days we are generally using the pressure measurement using the mechanical or electronic type from pressure gagging equipment like a bourdon gage as we are seen. So now we will in detail discuss about the forces on submerged surface is in static fluid.

(Refer Slide Time: 47:19)



So we have already seen some of the theory related to this important feature of static fluid which we have discussed so far is say the first one is hydrostatic or vertical pressure distribution, we have already seen what is the hydrostatic pressure distribution. So if you consider a the small basin or tank of water like this the hydrostatic pressure distribution linear pressure distribution.

(Refer Slide Time: 47:38)

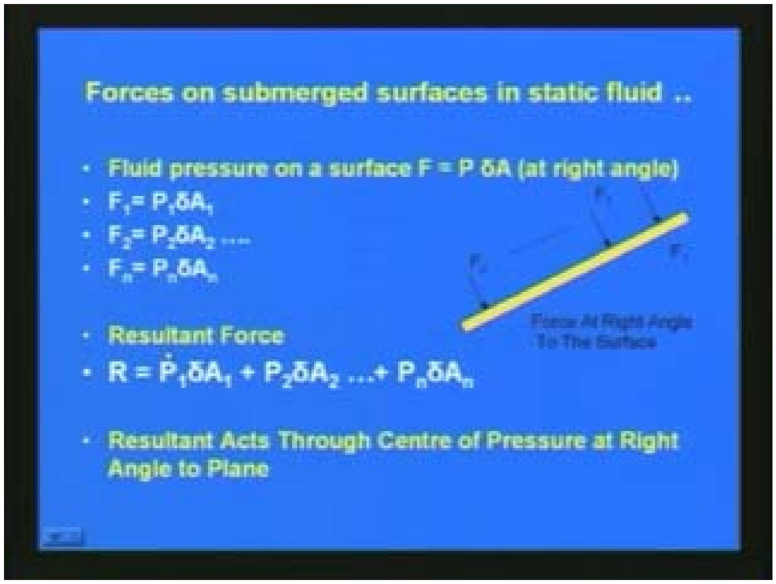


We have already seen that is one of the important feature which will be using and then the second one is pressure at any equal depths in a continuous fluid are equal.

So say if we consider the fluid in this basin or container the pressure at any equal depths say here if you consider here or this location or this location pressure at equal depths the continuous fluid are equal and then third important feature which we are discussed is Pascal law.

So according to the Pascal law we have see the pressure at any point at equally in all directions and then the last point is from forces from fluid on a boundary access straight angle to the that boundary. So forces are acting a right angle to the boundary this all important features we have already discussed based up on this features. Now, we will be discussing the forces on submerge surfaces in static fluid. So first let us consider an inclined plane like this.

(Refer Slide Time: 48:47)

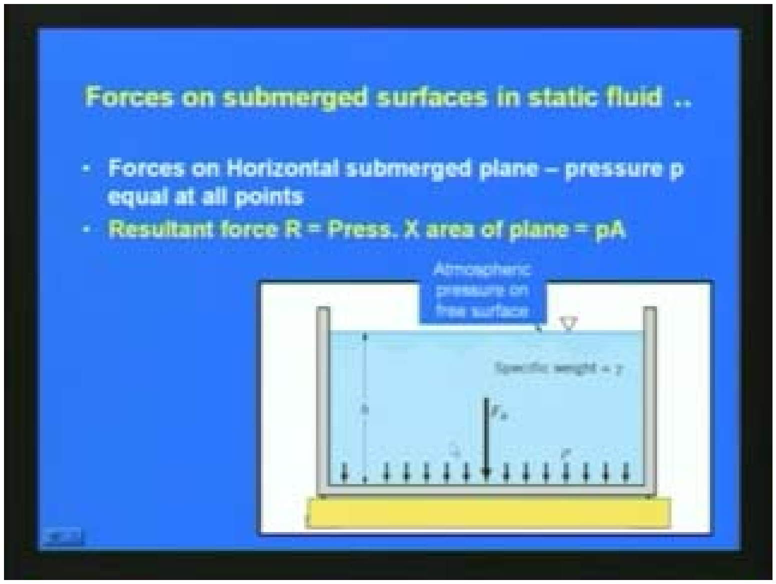


So forces as we have see forces at right angle to the surface, the full pressure on a surface is obtained as F is equal to p in to delta A. So if we consider here a small type of water then we are considering a small inline plane like this then the pressure say at various loca6tion F_1 F_2 like that we can with respect to the slide we can see the say f_1 is equal to p_1 in to here F_1 is equal to p_1 in to delta A_1 and F_2 is equal to p_2 into delta A_2 so like that at various location F_n is equal to p_n into delta A_n.

So that resultant force we can write the total force is equal to resultant force this R is equal to p_1 into delta A_1 plus p_2 into delta A_2 plus p_3 into delta A_3 like that plus pn delta An. So this gives the resultant force and generally as we discuss the resultant force acts through a center of pressure at right angle to the plane with respect to this plane we can just find the center of pressure where the total resultant force is acting.

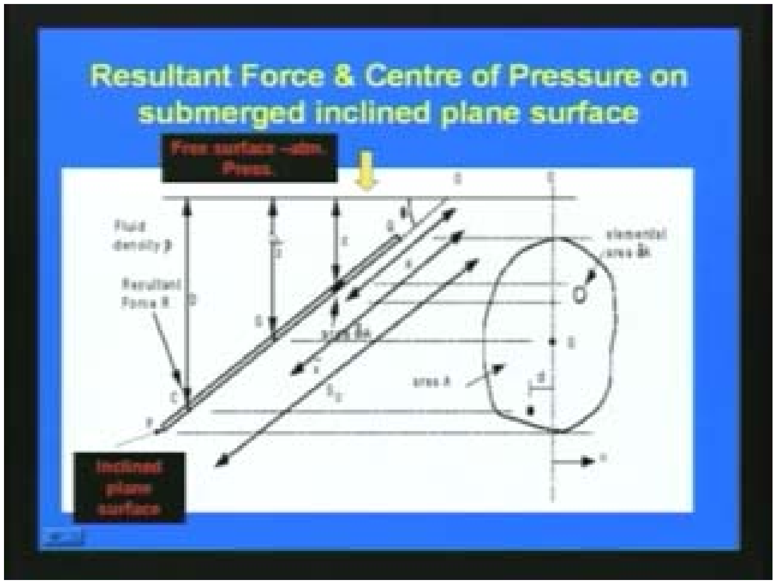
So the force on submerged surfaces we can determine like say the resultant force and we are determine the center of pressure.

(Refer Slide Time: 50:13)



And then now we will see the forces on submerged surface fluid again say in a horizontal submerge plane. So if we consider a small tank like this which we have already seen here at the bottom say is horizontal the resulting force is equal to the force on horizontal submerge plane pressure intensity p it is equal to all points that we can write resultant force R is equal to pressure into area plane or that is equal to p into A. So if we concerned atmospheric pressure here as 0 then the resultant force in the case of a horizontal submerged plane is equal to small p into A. So similarly we will consider now.

(Refer Slide Time: 50:58)



Resultant force and center of pressure on submerged inclined plane surface here this inclined plane surface say here you can see this is a tang of water and then an inclined plane is considered like this and now we want to determine the resultant force and center of pressure on submerged inclined plane surface. So this we will discuss in the next lecture.