Elements of Ocean Engineering
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Lecture - 8
Physical Properties of Water

Today's lecture is Physical Properties of sea Water, there are basically 5 parameters to be discussed.; first one is pressure then temperature then heat, temperature is obviously associated with heat in flux, and salinity and density.

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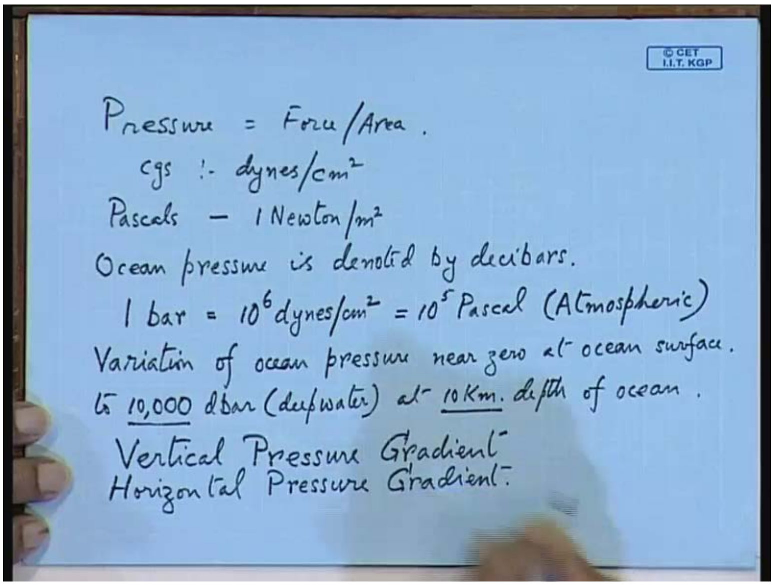

Now, the first you can see that the pressure, now in pressure is actually post for unit area, and normally in C G S or M K, C G S units these are given in dynes per centimeter square or it is measured in Paschal. So, which is nothing but 1 new ton per meter square, now pressure in the ocean, so ocean pressure is denoted in deci bars, so this is the unit of pressure by which oceanographers at familiar.

So, it is denoted by deci bar and one bar is there is your one atmospheric pressure, so this is equals to 10 to the power 6 dynes per centimeter square, so this is 10 to the power of 5 paschal, if you work out the numeric. So, it is 10 to the power 5 Pascal, and this is your atmospheric pressure, now variation of ocean pressure, so this is varies from near 0 at ocean surface to 10,000 deci bar is in deep waters, so this is the variation of pressure.

So, you can see 10,000 deci bar will be at around depth of surround 10 kilo meters depth at of ocean. So, whenever your engineering, when you object down below the especially in the deep waters, you have to take account of this huge pressure. So, order 10,000 deci bar means 1000 times atmospheric pressure, so that is 1 deci bar is 10 to the power of it is one tenth of an atmospheric pressure.

So, that is why actually for this large depths of 10 kilo meters, we are as yet I mean most of the countries are not yet developed, there submersible to go down to this large depth of submarines can go at based 1 or 2 kilo meters down water. This kind of landing of tremendous pressure is its self engineering, now this is, so far this is your vertical, there is they are two types of pressure. One is the vertical pressure gradient, and the other is the horizontal pressure gradient, so what are these two types of gradient, now what do they do, now your vertical pressure gradient.

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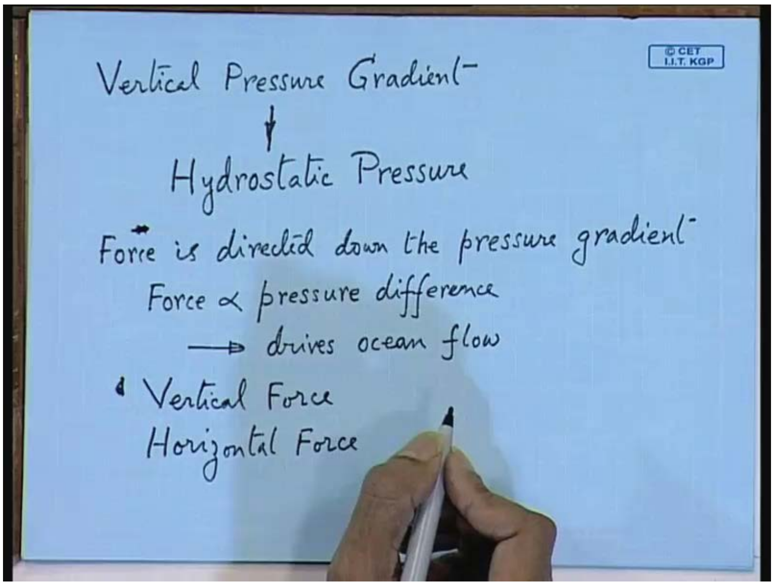

So, that is most of your familiar with this, it is your vertical pressure gradient, gradient means the difference in pressure over a finite depth or a finite horizontal distance. Now, vertical pressure gradient is what, there is a difference in the vertical pressure is 0 hydrostatic pressure, which with your most familiar, this is the hydrostatic pressure. So, the difference in the a gradient is a difference in pressure of sometimes this is called pressure down in ocean of graphic terms we say, force is directed down the pressure gradient so; that means, wherever we have difference in pressure we have a force.

So, force is directly proportional to the difference in pressure or directly proportional to pressure difference. Now, there are two types of force, one is the there are balancing your hydrostatic pressure, that is your that is, so force is diagram proportional to, so what is this force do. It drives ocean force, ocean flow is defined by this force which is directly your difference in pressure, now there are two types of force that you will find one is a very, very this vertical force or vertical force another reason horizontal force. So, from the pressure, we will get these two types of force, one is the vertical force and the other is the horizontal force.

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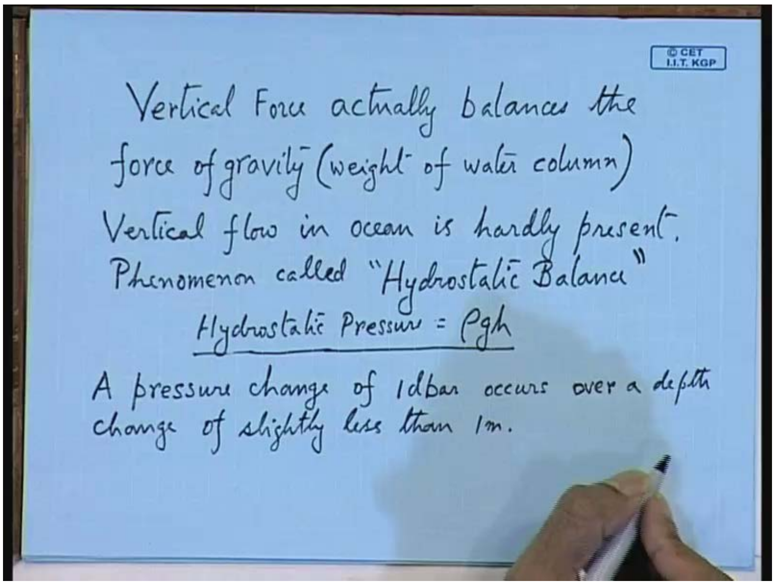

Now, this vertical force, you will not find great force taking place in the vertical direction, so vertical force actually balances the force of gravity, what is this force of gravity, that is the weight of the water column. So, net force in the vertical direction is somewhat 0, the ((Refer Time: 10:30)) is equal to 0, so there is no flow in the vertical direction.

So, vertical flow is hardly present or vertical flow in ocean is hardly present, and this phenomena is called hydrostatic balance, so your hydrostatic pressure is what, hydrostatic pressure all of you should know is equal to rho g h. So, this is actually supporting the water column or water mass, so hardly you will get any flow in a vertical direction, so this is called hydrostatic balance.

Now in the vertical direction this is hardly just for your knowledge, so a pressure change of one deci bar that is one tenth of a bar occurs, this is over a depth change of slightly less than 1 meter. And this is the numeric if you have a vertical flow, now coming to the horizontal flow, so horizontal pressure gradient so; obviously, the flow will only take place, if there is a difference in pressure of force.

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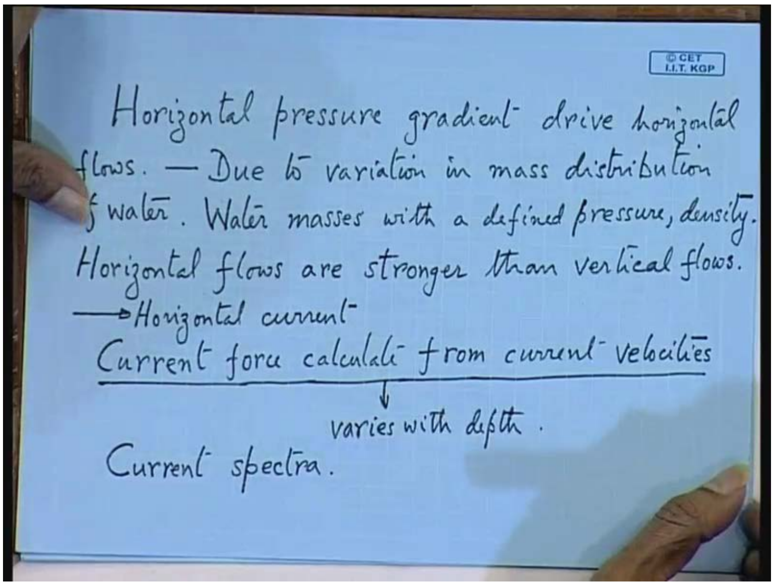

Now, horizontal pressure gradient as you can see from this known, you still have a pressure change over a depth, although it is balance equal hydrostatic balance, but still there is some force, they are in the vertical direction. Now, horizontal pressure gradient drive horizontal currents or we can write drive horizontal force, now this is due to variation in mass distribution of water.

So, that is where water is more dense, it will try to displace a less dense water, so normally be actually in oceanographers water masses the oceanographers, they identify water masses with a defined pressure or sometimes they say it will depends below pressure depends on density it also density. So, that is you have to segregate and demark it various water masses flowing in the ocean, and this is done by marking particular water masses with their cartelistic pressure and density.

So, in the oceanographic charts you will find this water masses and horizontal flows are stronger than vertical flows, so that is why in a any ocean in the calculation whether we say current. So, this is it is the horizontal current, so we do not consider the vertical current or rather we are more influenced by the horizontal current. So, in oceanographic studies or ocean engineering, we have to calculate how much is this strength of the current and from this we calculate the current force.

So, current force as to be calculator from current velocities, so this will find out how we do this later on and this whole thing varies with depth. Now, so we are more interested in calculation of current from that is the force of current, from current velocity that is varies with depth and normally. If you go into more complex calculations, you have to derive this forces from what is called it current spectra, one of this spectra analysis is more complicated right here not much bothered about this.

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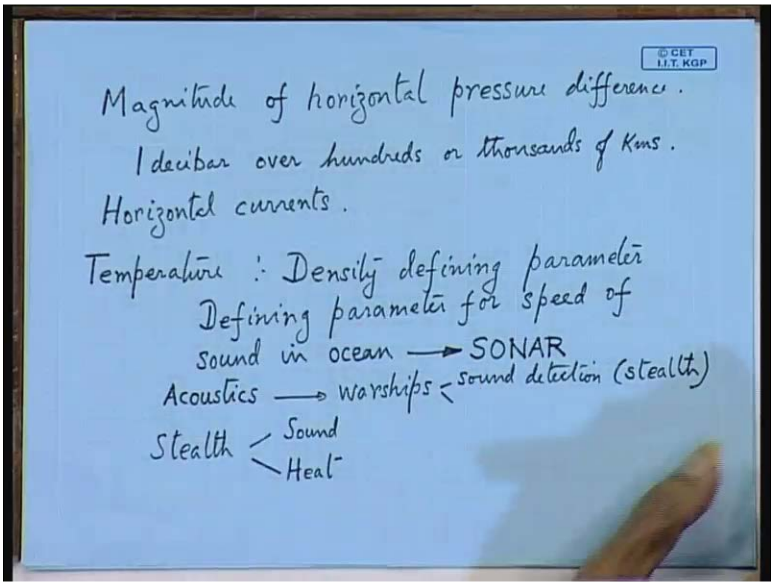

Anyway, so this is of the order the magnitude, you can write magnitude of horizontal pressure difference, so this is one deci bar that is one tenth of atmospheric pressure. Now, this extents over hundreds or even thousands of kilometers, where as in the vertical force this is mostly balanced by the weight of water, so hardly you find vertical force, but this actually this is the main driver for horizontal currents, so this is one of the aspects of pressure.

Now, the other parameter is temperature, so what does this ocean temperature do, so it is density defining parameter, so temperature changes density. Temperature of course, is directly proportion to your heating flux, might be your more heat, how this water will expands, and the colder region it will become contract. It will become, so in the colder regions density will be more rather, than in the equatorial region, so temperature is a density defining parameter.

Now, it is also a defining parameter for sound speed, so all is all linked actually, it is a defining parameter for speed of sound in the ocean, because was the water is becomes more verified, because of the higher temperature. Obviously, there is difference in density, and this will that is the transmission of sound is directly proportional to your density of water, or density of any medium through which it is passing.

So, this is actually taken care of by instruments called sonar, so sound is a important means of communication believe the ocean surface, or in deep waters the manner of transmission of sound is a several study all together that is covered in acoustics. And more this is particularly of importance to the warships or naval operations, because they employ all this tactics of warships, they employed tactics of detecting sound, so detects warships sound detection is very important, from the point of a stealth.

So, the those of you were going to the navy or interest in warship design; that means, they have to figure out this the sound signature of the warship. Sound an basically is stealth property is comes from, there two aspects of stealth, sound how can you detect anything in the ocean one is why sound and other is there detected by heat or inferred radiation.

Anyway so this is not too much into detail of this, now defining parameters for speed of sound, so temperature is directly influencing your density, and because of change in density it influence your sound proportion. Now, temperature difference in the ocean is also quite large, as we have seen in that the difference in pressure can be as high as how many 10,000 deci bar is not it of 0 to 10,000 deci bar is a variation in pressure and temperature difference in the ocean.

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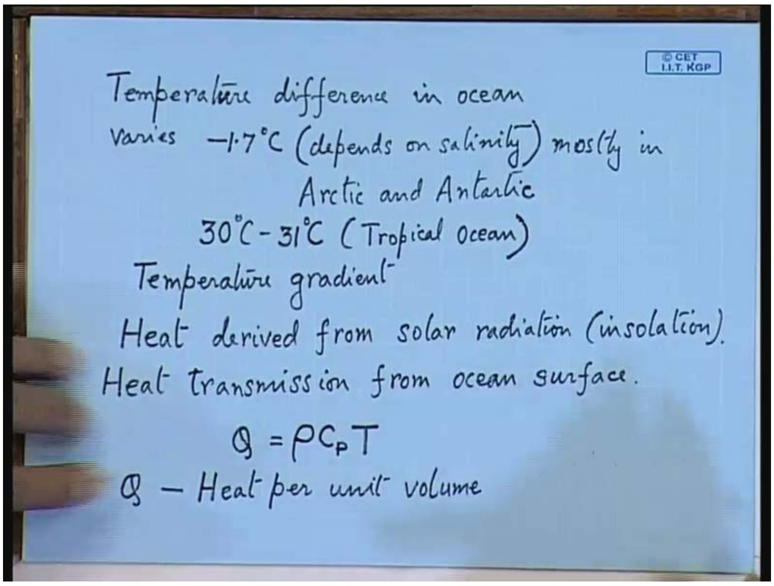

So, whatever it is happening in the ocean is on a massive scale, so this varies from below freezing minus 1.7 degree centigrade, now this depends on salinity, so this mostly you will find near the Arctic and Antarctic region. So, temperature is below freezing; that means, you have the solve there is a lot of salt in the water, now this can go high to 30 degree centigrade 30 to 31 degree centigrade this you find where that is tropical ocean.

So, you can see there is also large difference in the this is called a temperature gradient, there is a temperature gradient in the ocean both the horizontal as well as in the vertical direction. So, these changes your density of the ocean, now coming from temperature is the difference is in temperature is because of heat, now heat the ocean is deriving from I have talked about this in your earlier class from solar radiation, so that is called insolation.

Now, how to measure this heat or heat transmission from the ocean rather you write ocean surface, so the equation is the quantity of heat, it is normally you will find in British thermal units. So, this is your rho is a density of sea water and you have to find out the specific heat, C P is the specific heat, and T is your temperature in degree Kelvin.

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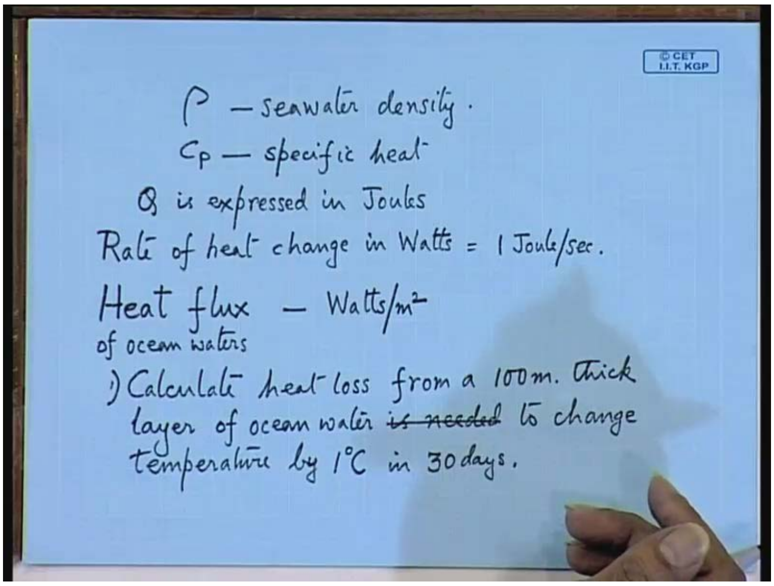

Now, this q is denoted as heat per unit volume rho is sea water density C P is specific heat, now in this equation, heat is not expressing British thermal unit it is heat quantity of heat is expressed in Joules q is expressed in Joules. That is your unit of energy, for as wrong this is not in British thermal, we discussed in Joules and rate of heat change with which you are interested, rate is expressed is in Watts. Now, what is the unit of watts this is one joules per second, now here is a small problem by which we can find out the heat, was sometimes in ocean graph e j call it heat flux.

Heat flux is the favorite name given to the heat transmission from the ocean, and this is measured per-unit time, heat flux is given in watts per meter square, so heat flux of the of ocean or rather you can see of ocean waters. Now, this is an example, calculate heat flux or rather calculate heat loss, now from a 100 meter thick layer of ocean water is needed to change temperature by 1 degree centigrade. So, temperature change is 1 degree centigrade in 30 days that is there as take respect to be 1 month, now you use the previous equation.

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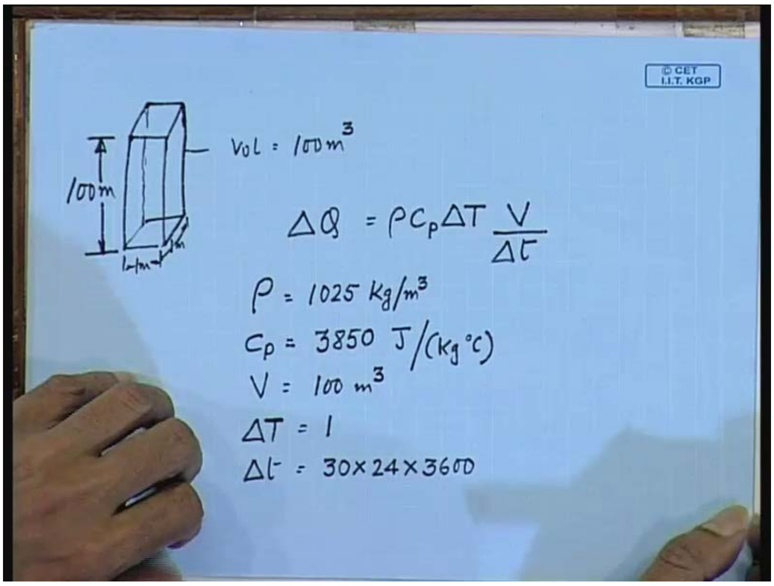

Now, you are first you calculate this, so whereas have a graphical group of the volume of ocean water, so how much is the depth, so depth is 100 meters, and we have to calculate over this a heat flux is what are the units is given in watts per meter square. So, you calculate this volume of heat that this volume of column of water is given, so this is 100 meters and this dimension is 1 meter for, so what is the volume. So, volume of this is 100 meter cube, when that expression for cube that we have written down just, now, so that is given per-unit volume is not it there are cube expressed in unit volume.

So, you can write the though in the problem, you have to calculate in 30 days, so per second, how much it is the rate, so you calculate delta q delta q will be rho. This rho and c p are both are constant, your delta t is how much, so 1 degree multiplied by you have to multiply by v, that is the volume of this column water and divided by the time interval that is delta t, so this is your formula. So, heat change you calculate heat change how much is this coming, now in this equation you take rho that is the density of sea water this is 1025 k g per meter cube.

So, this is your mass per meter cube, and ah the specific heat that is c p is given as 3850, so this is Joules in given in joules per k g degree centigrade. Now, your equation is dimensionally right or wrong, you first check that now v is a volume given in v is in we are getting v is how much 100 meter cube and delta t is 1. Capital T that is your change in temperature what is the change in time that is your small delta t, so the change temperature that is 1 degree centigrade is occurring in 30 days, so per second if you do, so you divided by delta t. So, this will be 30 into how much 1 day is how much 24 into 3600, so now, you calculate.

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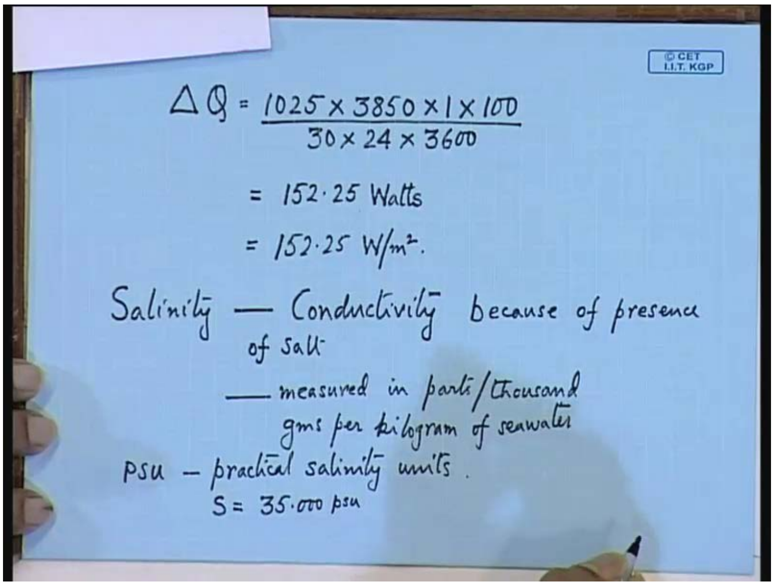

So, delta cube if you calculate this heat flux, it is coming as 1025 into 3850, if it is multiplied by 1, volume how much we are getting that is 100, so divided by 30 into 24 this is into 3600 we are getting. This is delta t is given in second, and this if you have a calculated you can work out in my calculation this comes to 152.25 watts, so it is a not pretty small is not it, more than 100 watt bulk.

So, this is happening in what we need of time per second you will getting, so this is the units will be this is passing through 1 meter square, what we have calculated is per meter square. So, this is 152.25 watts per meter square, so now, imagine how much for energy the water, anyway, so this is you are the heat is a problem in the heat. And next is the salinity, if you look at this diagram of you have this already given the graphs, that is your pressure change, now salinity is actually linked with conductivity, why, because of presence of salt.

And this salt is actually is not given I think it is Nacl, now salinity this is measured in parts per 1000, now on the lane as definition this is grams per kilogram of sea water. Now, there is lot of controversy regarding this, so now, the present tendency is to denote salinity in what is called p s u, if you look into your oceanographic book this is called practical salinity unit.

Normally, you will find in the literature, they write like this s is equals to 35.000 p s u that is called practical salinity unit. Now, this is based on there is parameter called chlorinity, you will not go into the details of this just for your knowledge, I am telling you the salinity is expressed in terms of chlorinity.

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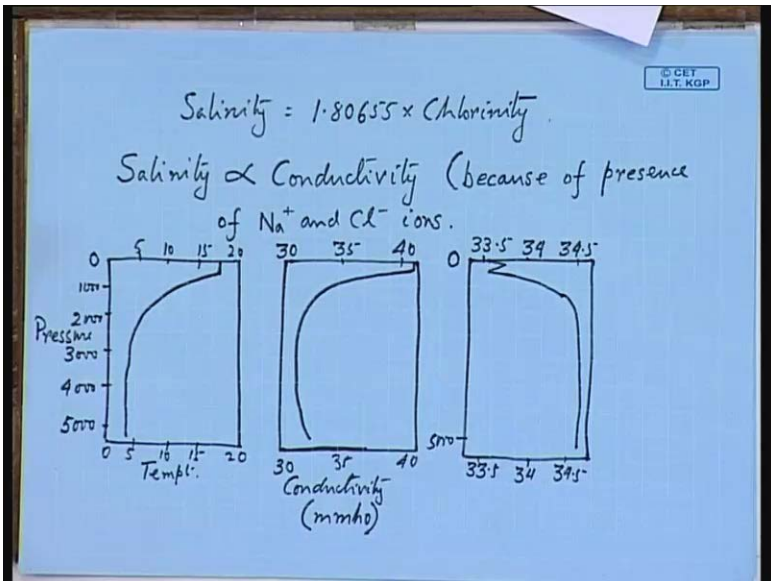

So, this is roughly 1.80655 times chlorinity, so the present convention is be denote salinity in terms of chlorinity of seawater, now coming to the diagrams which we have discussed. And this salinity and chlorinity they are also linked with another term, which is called conductivity of seawater, so this is because of a presence of salt. So, seawater in ionized to a large extent now, so because of this you will get conductivity that used can conduct electric current, so be careful.

So, if you look at the graphs, you get like this you need to some extent in your earlier class, now this is the pressure, so pressure variation 5000 here is given. Pressure variation is also 0 at this surface, and your temperature is given from 0 to 20, so this is somewhere around this is 5, this is 10 15, you know the same nature of the graph you come here, that is your surface zone, and in the end it becomes more stable after 5000.

Now, here also you will find there is another graph called conductivity, there are variation in conductivity, now conductivity the unit is inverse of you are raising ((Refer Time: 48:40)). So, this varies from conductivity variation skill, nothing this is deal with pressure, pressure variation is this is 1000's, this is 2000, this is 3000, 4000 and 5000, same scale you take as pressure variation. Now, the conductivity variation will be says 30 and this is 35 this is around 40, whether you find that it is nearly the same graph, with this slight curvature of the bottom, this is 30, 35, 40.

And conductivity is expressed in what are the units, it is an I think in this case is micro on ((Refer Time: 50:04)) micro mho's, electrical raised can be measured in ohm's over h m s we just it will be mho's and all these salinity. So, the average thing we can get all the conductivity around 35, anyway, so the salinity gradients, now conductivity is actually used in ocean engineering purpose, can you tell me how you can use to your own advantage.

So, this 0 this is coming some around 5000 we are getting, so average salinity is how much, so average salinity you will get 34.7, so this is 34 and somewhere it is 34.5, so this is 33.7, so this is 34 and this is 34.3. So, I think it will be the reverse of the all 2 graphs, this is a variation of salinity, now the last one now salinity you as I told you where it is used.

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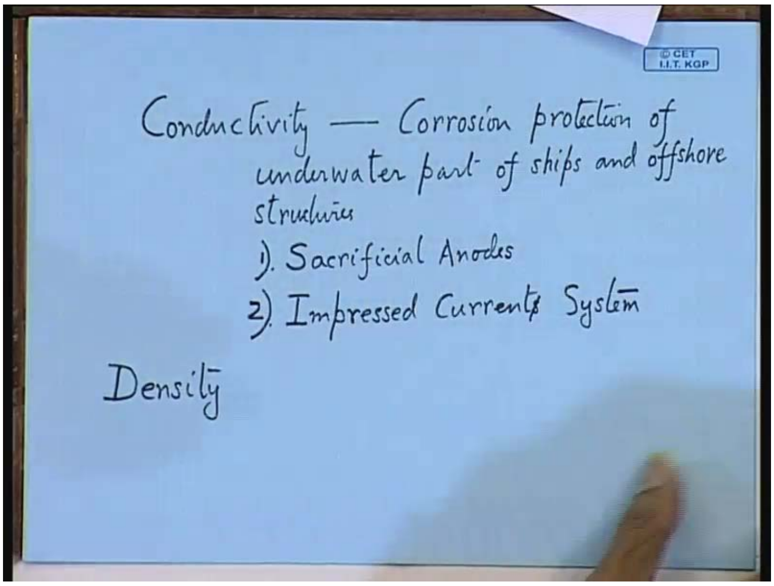

Now, this conductivity of seawater, because of salinity is used in what is called corrosion protection of underwater part of ship, and offshore structure. Now, I am not going to details, but if you ask your professor would give you production, there are two types of system. You come across number 1 is by means of sacrificial anode, that is your zinc and rather is by what is called impressed kinds system, where you take help of the conductivity of seawater.

So, these are the two methods of corrosion protection of the underwater all of this structure, impressed current system, so next class I will tell you about what is this. What significance you having, because of density of variation of density, now how it is expressed what are the units, so after this will go to calculation of weight.

Thank you.