Elements of Ocean Engineering
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Lecture - 7
Open Ocean – II

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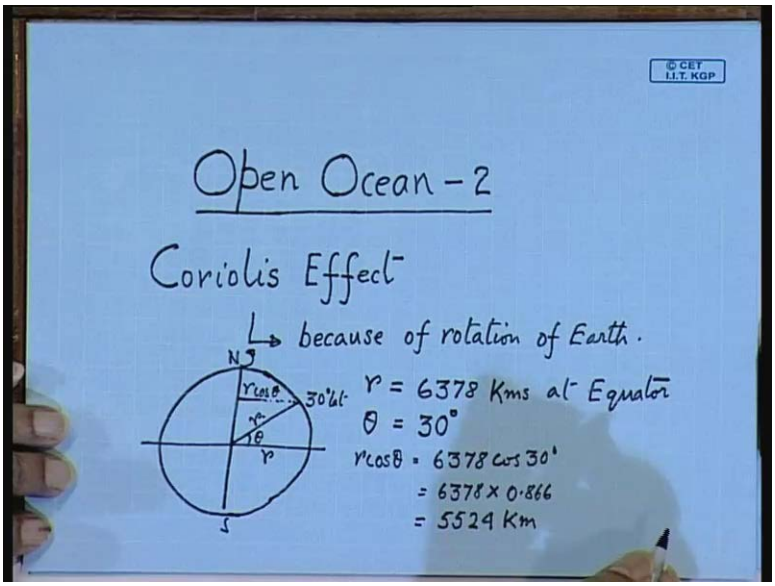

This lecture is Open Ocean II. Now, here I will discuss mainly of, first one is your coriolis force or this is called the coriolis effects. Now, you are mechanics class a most all come across this word coriolis, this is because of the coriolis means what, because of rotation of the earth. So, this is another cause for your current rotation of earth, here to know the mechanics know here actually you find the earth is having a spin, here my diagrams not perfectly wrong, see this your north pole, South Pole, so this is a spin. Now, because of this spin you will find that your having 2 radii, say theta is this angle say how much is this distance, so this is r cost theta, now you find out the angular velocity.

Now, r is equal to how much these 6378 kilometers at equator, now what is the value of your radius at theta is equal to 30, say as an example let us take the value of this theta, say theta equal to 30, so 30 degree latitude, so radius says r cost theta, so this is 6378 and cost 30 degree find out. So, this is 0.866, so this gives us 5524, so radius is shorter by

how much, say more than 700 kilometers, so find out this speed, speed east words after particle at equator.

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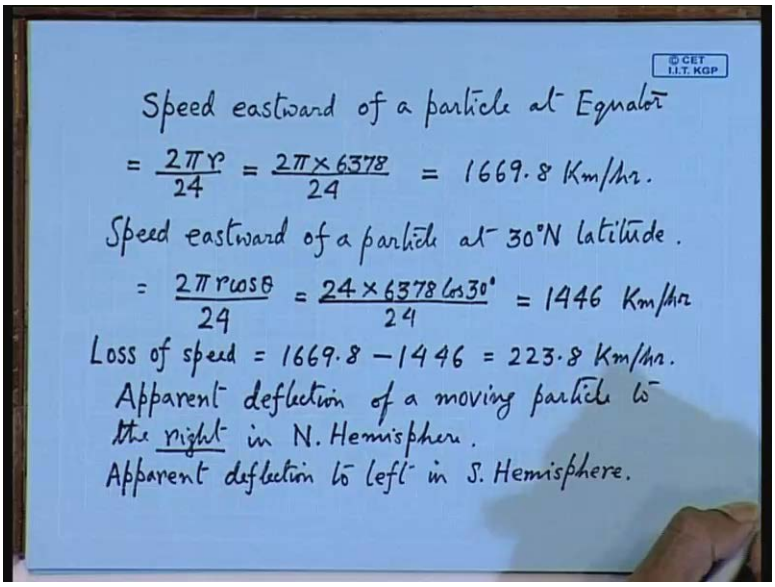

So, how much is that, this will be circumstances 2 pi r divided by 24, so at equator here rotating at this speed, which occurs down free. So, this is 2 pi multiplied by 6378 divided by 24, this works out at a 200 speed of 1669.8 kilometers per hour. So, this is what god is going to use not able to realize, velocity in the ((Refer Time: 06:29)), now what is the speed, you find out first speed east word of a particle that 30 degrees latitude or rather you write at 30 degrees north latitude.

So, this is 2 pi multiplied by r cost theta you use spinning speed divided by 24, so this works out to be a how much, this is 24 6378 cos 30 degree divided by 24, this is 14461 kilometers per hour. So, this is that 30 degrees latitude so; that means, how much is the loss in speed, so that is loss of speed, so this is 1669.8 minus 1446 this is equal's to 223.8 kilometers per hour so; that means, a person which is who is that the 30 degrees north latitude.

So, you see a particle going towards the right arc 223.8 kilometers per hour, if you considered the 30 latitude to be stationary see here 45 fly pass like this, so that is what you are happening. So, now, that explains this direction of oceans current, so you see the direction of the ocean current to the north of the equator, best these if you through a stone from the equator, which direction it will go towards the right is not. So, that is the

clockwise movement of the current is taking place, because of the coriolis force, say if you through a particle from the equator go towards your left.

So, that is your anticlockwise spin there is a sub tropical ((Refer Time: 10:00)), so this the gives an explanation to the direction of the current. So, this is called apparent deflection of a moving particle to this you should always remember, to the right this occurs in the northern hemisphere, and apparent deflection to be left southern hemisphere, so this is your coriolis effect.

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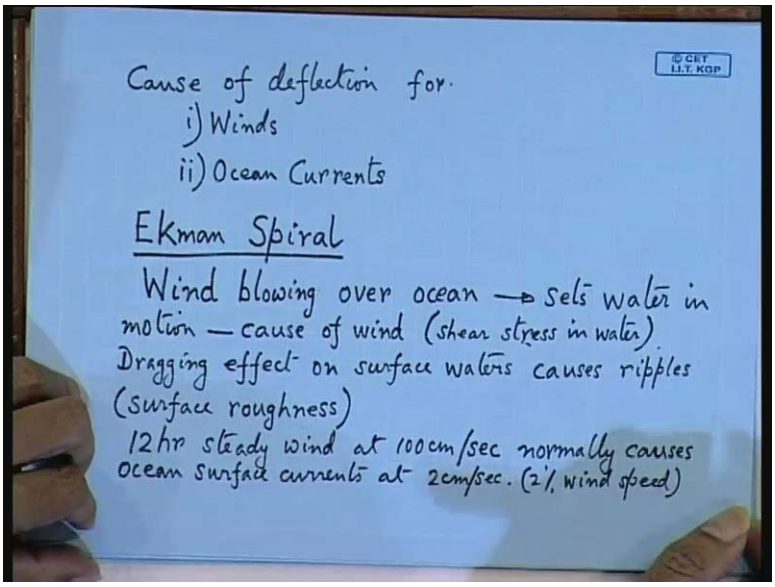

Now, if you want to study this in detail, now this actually deflects cause of deflection for both, cause of deflection for number 1, you write to winds and number 2 you write ocean currents. So, that is why the coriolis force is important, and especially this is affecting, in this diagram you can see this is affecting we are the equator is the region is the most affected by a coriolis force. This is the where the speed near equator is larger, now the last these your what is called the EKman Spiral, now this is caused by the wind.

So, major cause of the EKman spiral or explain what is this EKman spiral is, but this main cause is the wind, now this wind blowing over the ocean, this actually sets water in motion, may be read the mechanize, there is the cause of wind least stress. Wind actually causes a certain shear stress on the water surface, so you are water surface forms layers these layers moving its each other, so that is called a shear stress caused by wind rather you write shear stress in water.

This is caused by dragging effect on surface waters, so the wind actually somewhat takes to the water I dragged the layers of water, so this is a fictional force causes ripples. Now, ripples are named as surface roughness, so wherever you see ripples you will find, there is a light breeze blowing, which is causing the water to slidedans each other. Now, 12 hour study wind, at 100 centimeters, this is a 100 centimeters per second, normally causes ocean currents are other ocean surface currents at 2 centimeters per second, so this is roughly 2 percent of winds speed.

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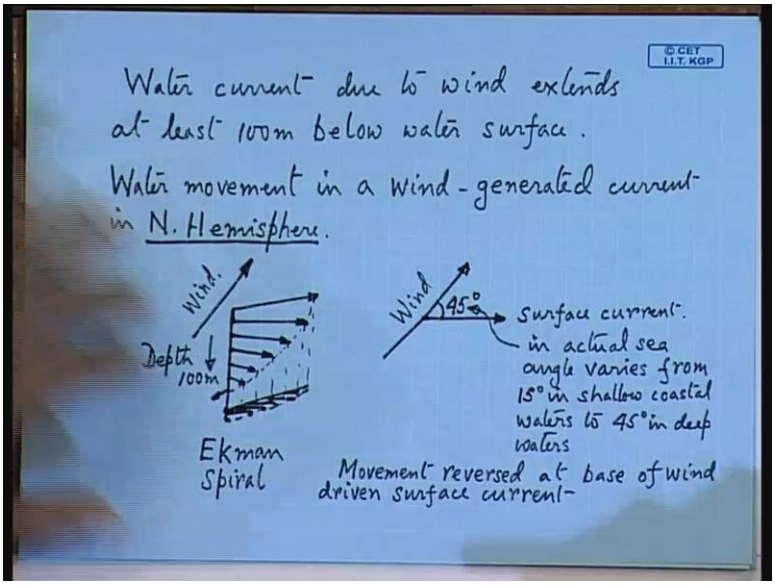

So, this is the cause of ocean surface current, this is an example and the depth of influence of this wind driven current is, so water current due to wind, extends at least 100 meters below surface. Now, here is a diagram of water moment, now this occurs in the northern hemisphere or either you write in a wind generated current in northern hemisphere. Why already the northern hemisphere used by the diagram, you can tell me.

Now, if you take a vectorial spread, there is a that you wind is going in the direction, then surface currents will go like this, if you go deeper down into the water, what will happen to this current. There is the current vector will gradually decreased, know the vectors will get reduced in length, but also it will changes in the direction you can see like this, has as you go deeper down to the ocean the current vector, actually diminishes in size.

Now, you go on down below then after a certain depth, see 100 meters that is the influence of the wind, you will literally find the direction of current is opposite to your surface current like this. Now, if you join these ends you find that, you are getting us sort of spirals you take the projection of these vectors at a piece of paper, you find you will get a curve like this. So, these are the projections, this will all come from this point, so this is called a EKman spiral.

Now, if you draw this surface wind pattern, you will find the direction of wind is in this direction, now surface currents you will get 45 degrees to the direction of wind. So, this you are wind direction, and this one is the direction of surface current, now in most cases it will be 45 degrees, but this angle readies. So, in actual sea angle varies between 15 degrees in shallow coastal waters, why to 45 degrees, in deep waters during shallow coastal waters deep guests affected by the a bottom friction. So, you have less; that means, the friction is higher so; that means, your lesser angle bottom friction is not their 15 to 45 degrees, in deep waters use sees 45 degrees.

Why the direction is to the right, because this is in the northern hemisphere, you are water mass is affected by coriolis force, so even if you have a wind direction in this. So, the current will not follow the wind direction, but it will be deflected to the right by an angle of 45 degrees. So, down below this water I think the maximum depth of influence is 100 meters, so this depth you can right is 100 meters. So, these vectors will decreasing, because of the sheer of the various layers of the water, so this is the less affected by wind, this is a down below it is going to opposite direction, so movement reversed at base of wind driven surface current.

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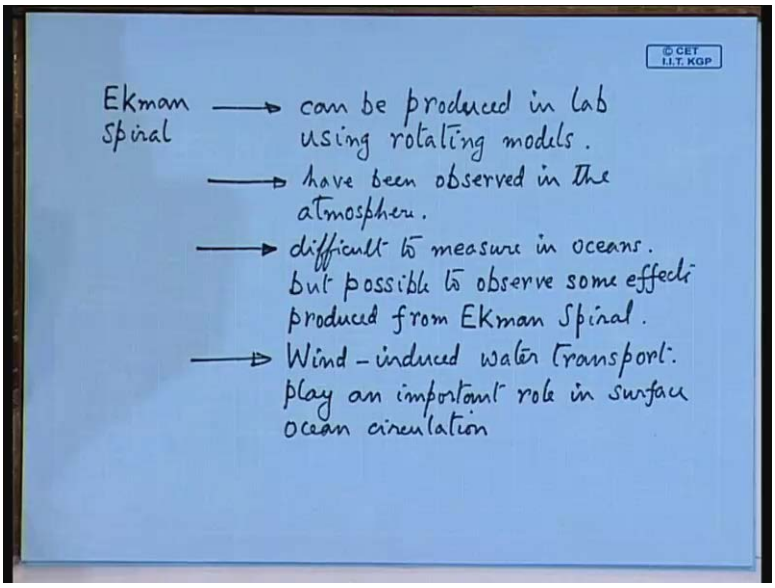

So, this is your based the direction is reversed, if you want to study the EKman spiral you can do laboratory tests, so can be produced in lab using rotating models. Now, this is also observed in the atmosphere, but it is difficult to measure in oceans possible to observed certain effects produced from EKman spiral. So, in the open ocean, so have hardly you see the EKman spiral, which is difficult to observed, but you can make out that it is existing over there, because of the existence some kind of effects, which I will tell you now.

Now, as a result of this EKman spiral, what we are getting is a wind induced current or rather where wind induced water transport. There is a mass transport of the water, and this play an important role in surface currents or surface ocean circulation, so surface currents are largely created by winds and the depth of influence is 100 meters, and there you will find the direction to be reversed.

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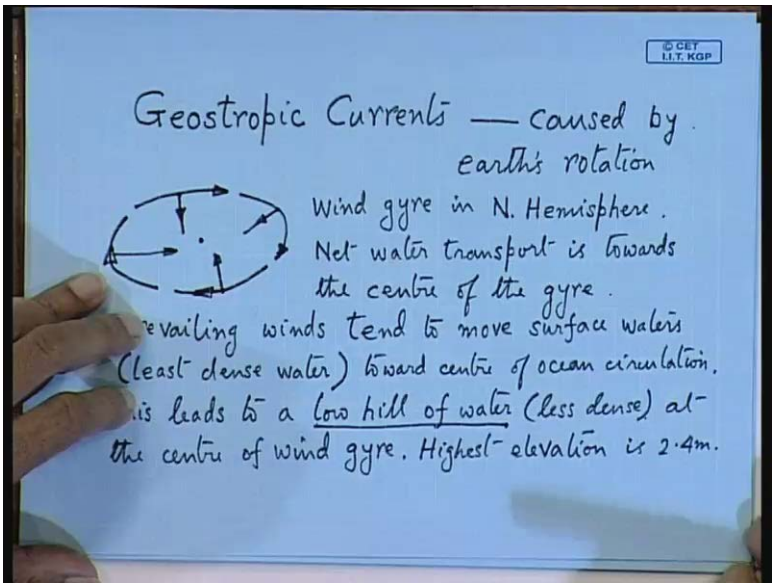

So, what is the effect of this coriolis force, coriolis force also gives rise to the current, that is called geostropic currents, so this is caused by earth's rotation, the EKman current is caused by wind, geostropic current is caused by rotation. So, now, if you wind is going in a close loop what will be the direction of current, so this is called a wind gyre, and this you take in the northern hemisphere, say wind gyre as been form in a northern hemisphere.

So, in this direction what is the direction of net waters transport, as you write surface current is there, you are net water transport will be perpendicular to the direction of wind, that is have not written you marked in this direction diagram. So, this will be 90 degrees, this is net water transport, there is the result in this all these vector in your EKman spiral, vectors from this surface to vector at least down below 100 meters.

You take the result in it will go in this direction 90 degrees to the direction of the surface wind right, whereas you surface current is, so many 45 degrees to the wind by this is only wind defaulters, and the shallow water. This will be 15 degree, so mechanics of somewhat, where will be different, so what are the talking about, this is the other one that is the wind, so what should be the direction of the net water movement.

So, obvious this will be your net water movement will perpendicular to direction of the wind, so it will come in this direction. Now, this gyre is a close loop again net water transport that is coming from the gyre will be coming this dash, so which direction all the

water is going, so are your water is collecting towards the centre. So, this is an example of the wind gyre in northern hemisphere, so prevailing winds, so net water transport is towards the centre of the gyre, so very interesting, so the water surface is not as flat as you see.

So, prevailing winds tend to move surface water tend to move surface waters, now it will move only the least dense water, surface water is least dense that is the density may be good deeper down than the water increases in density. So, the least dense waters towards centre of ocean, centre of the gyre that towards centre of ocean circulation, so this is one is what is here happening. Now, as a result of this leads to a low hill of water, so the water mass as a accumulated at the centre of the gyre, so low hill of water as been created, less dense at the centre of wind gyre, highest elevation you write is 2.4 meters.

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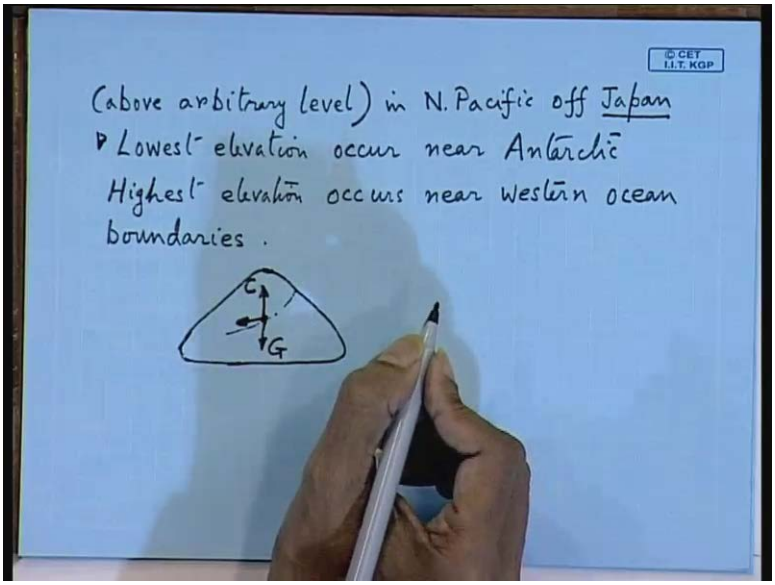

So, that if exceeding your man side, highest elevation is 2.4 meters, this is about arbitrary level, and this occurs in north pacific of Japan. These of course, the highest elevation the other this you will have result, and the lowest is given has lowest elevation occur near Antarctic. Now, highest elevation occurs as in this coast of Japan, so you write highest elevation occurs near western ocean boundaries.

So, Japan is towards the west to the pacific, so boundaries land and if you look at the mechanics you find a place low hill of water. So, this is us the direction of moment of the water bodies, this is the particle of, so this is acted upon a gravity force g is acting

downwards on the particle. And your centre point, because of the rotation of earth centrifugal forces is act towards the centre, and if you take the resulting you will get the direction like this. So, the part of the particle we will be somewhat, and this para, so that is geotropic current. Now, because of the wind driven current you have two aspects, which are caused by wind.

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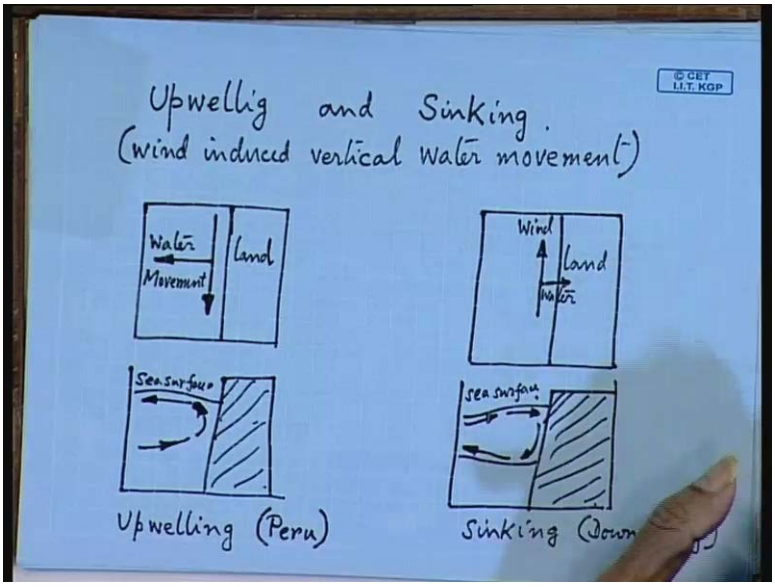

One is called up welling, as opposed to this you have sinking, down welling, so these are caused by wind induced vertical water movement, so this these the dynamics of your up welling. Say you are a mass of land on the right hand side see here beach or a share, so this is your landmass, now you are wind is going in this direction, now you are taking in the northern hemisphere. So, the deflection of the water will be towards the right, that is you are surface waters, so net water movement will be towards the right the northern is here.

Now, if you look at the cross section, you will find that the situation is like this, for this is your land cross-section, you are wind is coming in this direction, and the sea surface you are net water transport is going towards the right, so what is happening to the down below this. So, you moving your surface water to the right, also you are generating some kind of rack warm and you are bottom waters are going to come up to the surface, and because of this wind.

So, this is the phenomena, which is called this is your sea surface, so this phenomena is called up welling. So, in this actually bottom waters are driven to the surface, because of displacement of the surface water that these a moving surface water away from the shore, you are causing some kind of a rack warm and your bottom water is also coming up. So, this phenomena is called up welling, and opposite of this is called sinking, now both this phenomena taking place in the northern hemisphere.

So, this is your landmass, now you tell me which direction, the water will go your wind will going sea in the reversed direction from bottom to top. So, this is the direction of wind than what will happen, so northern hemisphere you are net water transport we will towards the right, so water is going to moves towards the coast. So, this is your water, this is I will written in the land portion, now if you look at the cross-section of the shore, you will find this is your land, so wind is going away or going in the opposite direction got your net water transport is towards the land.

So, water will tend to pile up towards the land, so that direction of flow will be towards the beach or shear, and this water from the surface is going to push the other water is down, so like this, so this is your envelop. So, this is your sea surface is bearing in the opposite direction, so this is called sinking or sometimes in some books you find this is called down welling, so which one is favorable up welling or down welling.

So, in the previous case, that is in the up welling case you find the bottom waters are coming to the surface so; obviously, this is good for the aquatic annuals or fishes in or the bottom various food, food is going to circulate. So, fishes can come up to the surface or they are own feed, and then go back and this case opposite is happening like that.

Now, these up welling actually takes place to a large extends in the peru coast, and that you can have fishing grounds, so oceanography is also required for fisheries, is one of the reason, so with these finished this physical oceanography. Now, the next is the you have some time, I thing I have to go because of this clock set by this people you know, so that we are given warm let us talk for a few minutes.

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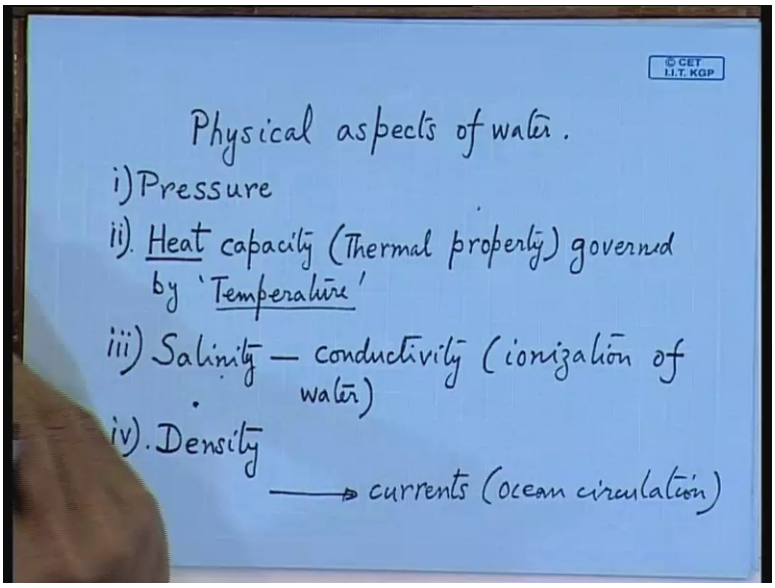

Now, physical aspects of water, now water as what is the heat redirection capacity of water, so first is number 1, of course is pressure. Water has pressure, number 2, number 2 is what, heat rather you write heat capacity, so this is called thermal property, there is a thermal property of water, which will discuss. Now, heat and thermal property are governed by temperature, so you can use this temperature to your own use, so heat causes rise of temperature.

They last property that is affecting all of us is number 3, you write salinity, now this salinity influences conductivity in the water, rather you can write ionization of water particles, after salinity is what the last one density. So, water has sea water basically, this 4 properties are important, there is pressure, heat, salinity, and density, you will study this in our next class. So, this particularly 1 and 4, the affect of course, salinity is also influences density, these are affect what is called ocean circulation. Currents ocean circulation is caused by this parameters also, so next class we will see how this influences gyre coriolis.

Thank you.