Hydrostatics and Stability

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Module No. # 01

Lecture No. # 08

Problems in Integration

As I told you before, we have done the derivation of these Simpson's rules and trapezoidal rules. We will just extend Simpson's rule little bit and see some examples.

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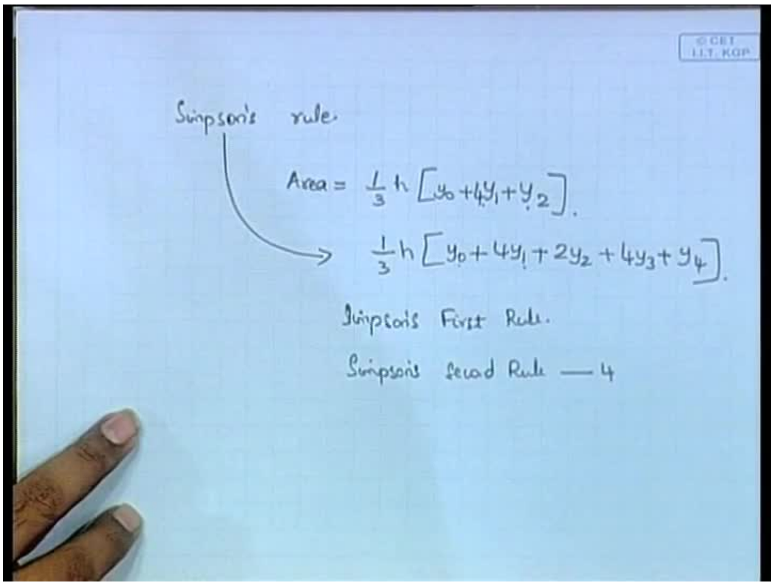

I have already defined that you can have your trapezoidal rule or a Simpson's rule. Now, some things that I probably did not tress on last time was when I saying about that the Simpson's rule, I said that the area is given by 1 by 3 h into y 0 plus 4y 1 plus y 2. If there are more terms, it will become 1 by 3 h if there are more terms 4y 1 plus 2y 2 plus 4y 3 plus y 4. So, you will get a Simpson's rule like this.

Now, you will notice one thing here, if you want to use this method. In this case, you are having three ordinates means as y 0, y 1 and y 2. In this case, you are having 1, 2, 3, 4, 5 and the thing is you cannot do this method, if you are having an even number of ordinates. It can be 3 or 5 or 7 like that because you cannot have a multiplier like a 1 or 4 or 2. It cannot end like that and it always ends as 1 4 and 4 1 and that it should always end like that. Something in between will be there, so it will always be an odd number and it should always be an odd number.

What do you do, if you have an even number of ordinates? The simplest way, which I suggest to do is use the trapezoidal rule. Trapezoidal rule has no such limitations that is you can apply to any number of it just 1, 2, 2, 1. So, it can be any number of 2s there. That is not a problem, but in real practice, this formula is actually known as Simpson's first rule. For completeness sake, I will just do the whole thing that is Simpson's first rule. This 1, 4, 2, 4, 1 is known as the Simpson's first rule

There is also something known as a Simpson's second rule. It starts with four ordinates and that means an even number of ordinates. I will derive this before that and there is something, which I left last time, which is very important. Suppose you are having half ordinates, we already said that if it is like 0 half 1, 1 and half 2 something like that. How will you solve the problem?

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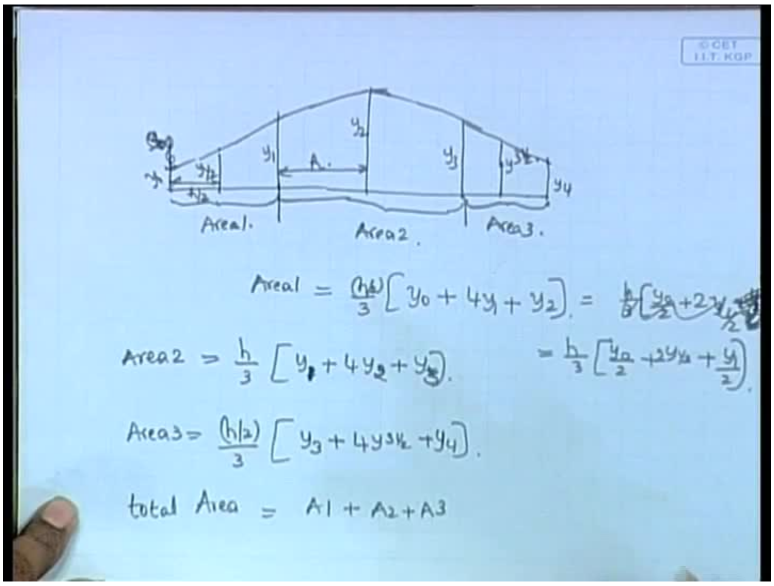

Let us just do one problem like that and remember you might not have this same problem. I might give 0, 1 by 4, 1 by 2 like that. It is just an extension of this and you know how to do the method. So, let us take this problem, you have y 0, y 1, y 2, y 3 and y 4. Here, you have y half, y 3 and half and let me just say this is y 0, just to make the smooth curve. It is something like this; this is the curve and you are now asked to find the area of this section. Now, we will use 1, 2, 3, 4, 5, 6, 7 and we can use the Simpson's first rule because it is 7.

This is the problem that we are having. So, you are having y half, your having half station and you are having 3 and half station. The simplest method is - you first take these three points and you find the area of that denoted as area of 1. You take these three points and you find the area of this area of 2. You take these three points and you find the area of this area 3. So, we have now split the whole problem into three sections and since, our goal is to find the area, we will just add these three areas. So, the first one is area 1, it is given by h by 3 into y 0 plus 4y 1 plus y 2. the basic Simpson's rule which we can write as no the thing is here. Now, let us call this separation as h; it is the distance between two stations that is 0 and 1 or between 1 and 2 or between 2 and 3.

So, obviously, the distance between 0 and half becomes h by 2. This is h by 2 and therefore, this becomes h by 2. It is actually h by 2 by 3 of y 0 plus y 1 4y 1 and that is the area of this section. Therefore, we can write it as h by 3 into y 0 by 2 plus 2y 1 plus y 2 by 2. Then, the area of the second section is the area of this, it is given by h by 3 into y 2 plus 4y 3 plus y 4 and that is very obvious. (( )) y 0 by 4 y half and sorry, I made a mistake. It is plus y. So, h by 3 into y 0 by 2 plus 2y half plus y 1 by 2. Area of the section two will be h by 3 into y 1 plus 4y 2 plus y 3. Then, area of the third section is h by 2 by 3 into y 3 plus 4y 3 and a half plus 1 by 4. So, we want have total area, which is area 1 plus area 2 plus area 3. We actually sum them. If I cannot write the values here because this is wrong so we have to actually sum it up

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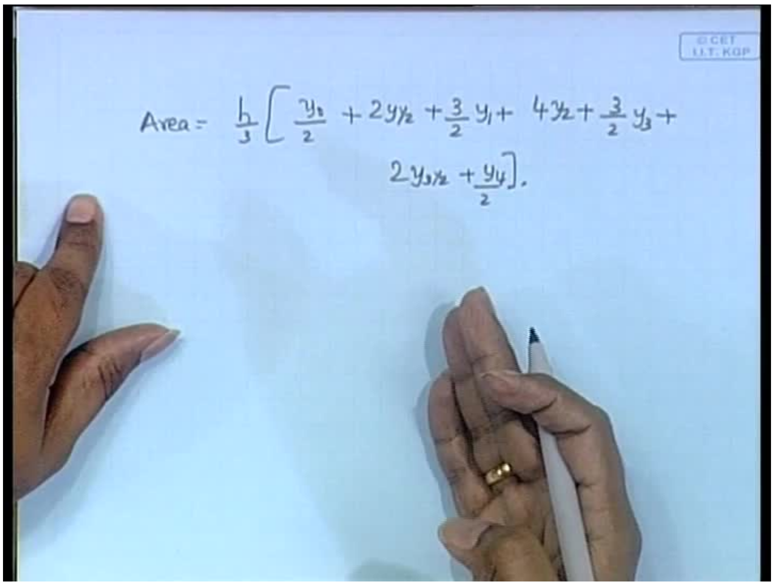

You will get a value, it will become something like h by 3 into y 0 by 2 plus 2y half plus 3 by 2 y 1 plus 4 y 2 plus 3 by 2 y 3 plus 2y 3 and a half plus y 4 by 2. So, you cannot really predict your answer. In this case, you can memorize this and that is a different thing, you can do that. You will not have the same number of ordinates and so you do not memorize any of this and that is not the goal.

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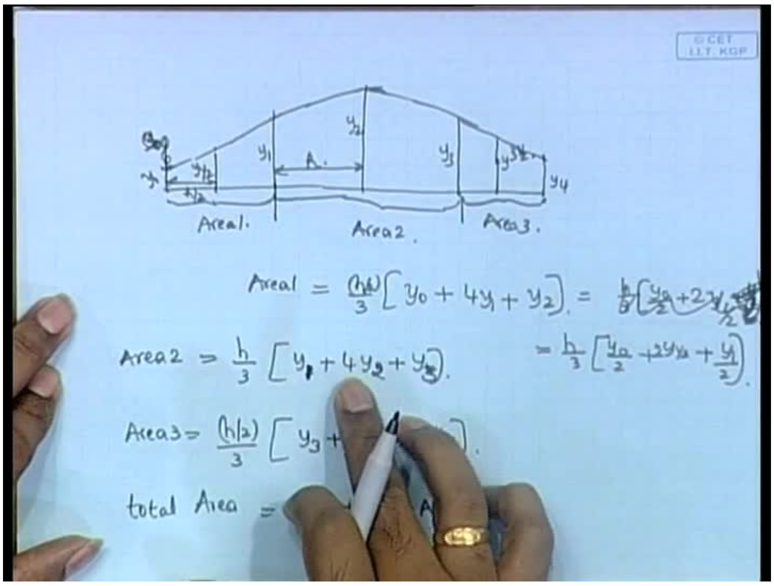

Your idea is just to do this summation. So, only thing to remember is this; h by 2 and this is h. Other than this, if all your y 0’s and all others are proper, you just sum up and divide it in such a way, because you are doing Simpson's first rule. So, always you take three ordinates and divide it. Then, you would not make any mistakes. You can divide into five and three like that. To get a better answer, it might be better to divide it in a group of three. It is the only thing to remember when you are doing Simpson's rule. So, put it in groups of three and you may get areas and sum up all the areas.

Now, you know how to do it, if you have 1 by 4 ordinate also same thing, so that derivation of the multipliers is a very important thing. So that is how you have to do for different multipliers, for different kinds of stations. If you have to do this thing, there is something known as Simpson's second rule, we will just mention it. If you want, you can do one thing. If you are having an even number of ordinates, you apply trapezoidal rules straight away, it is not wrong. This is just for you to know this Simpson's second rule. Since, this is not very important, I would not do the derivation. I will just tell you the method to do.

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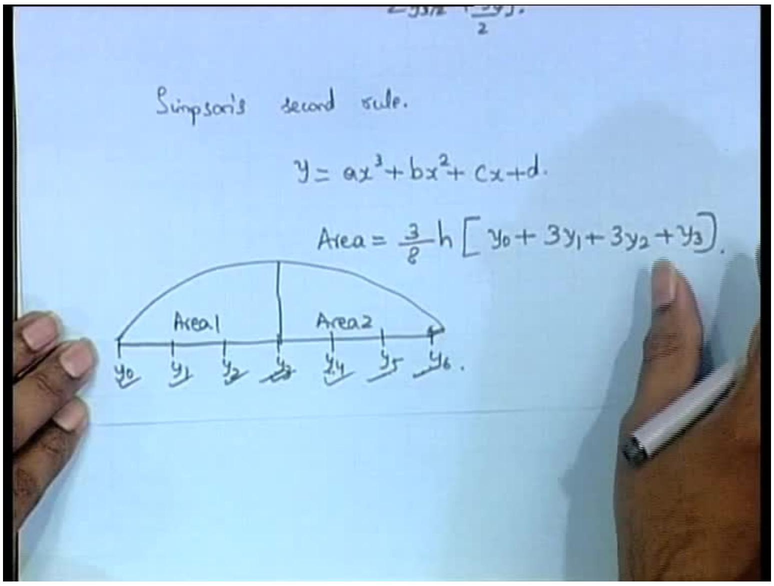

In this case, you are actually replacing this curve; y is equal to f of x by a third order polynomial. Last time, we used a parabola; a second order polynomial quadratic equation. In this case, it becomes something like a third order bx square plus cx plus d and the derivation is little long. So, we will skip that and we will just know this value. Its way of writing is equal to 3 by 8 h into y 0 plus 3y 1 plus 3y 2 plus y 3. So, this will give total area that you need to do.

For instance, if you have a problem like this and just to mention that is one means. Suppose, you have y 0, y 1, y 2, y 3, y 4, y 5, y 6 and you are having a system like this. Suppose, there is a curve and you are asked to find the area of this curve. What you do is you can divide into two regions. Here four ordinates and here four ordinates. Take, these four as 1 and these four as 1. You find the area of these sections and sum them up. That will give you the total area of this whole section. So, this is one method of doing. In fact, for all cases, you can just apply trapezoidal rule and make it simple. There is nothing wrong with that and you can do just this. What really is followed is that Simpson's rule. If you remember, we saw that the error is actually much lesser, if we use Simpson's rule. Obviously, you will get better accuracy and we follow that in real practice.

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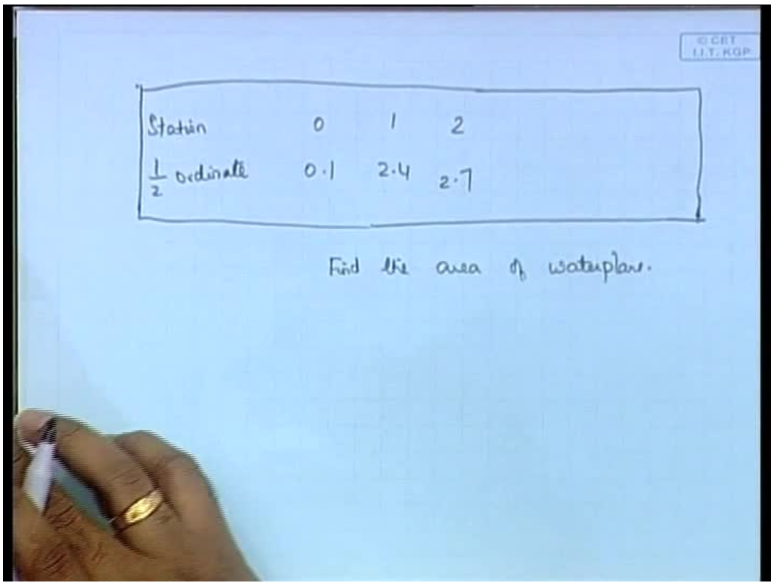

Now, I will do two or three problems, which will tell you, how not only to do the Simpson's multiplier, but that will also give you an idea of what exactly you must do, when given a table. You will see some tables and we have already drawn some tables. When you see those tables, what exactly can you get from the table? What values can you get? Suppose, you are having a table like this as stations and half ordinates, I have already explained the meaning of this to you. This is the station and these are the half ordinates at each point. At different stations, what are the half ordinates? Now, you are asked to find the area of water plane and these half ordinates are obviously at the water plane.

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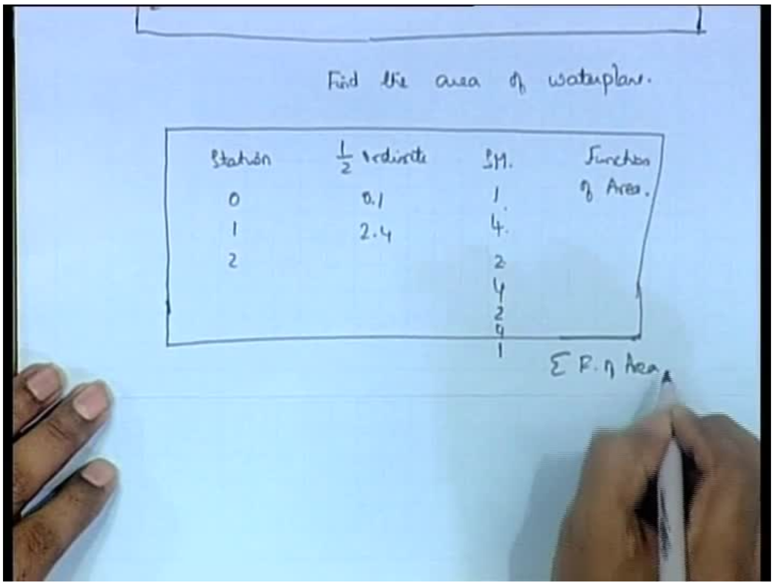

You have a ship; you have a water line somewhere. You are asked to find water plane area. You are given y's at different points. When you sum up the y dx, it will give you the area of this. It is the area of the water plane. So, there is no need to solve, you make the table. This is the standard format of the table for any problem like this station half ordinate. I will write SM for Simpson's multiplier and this is the function of area. This is the way in which you make the table. You have a table like this with stations, you give the ordinates here half ordinates are given like this.

In this case, there is 1, 2, 3, 4, 5, 6, 7 coordinates. You can apply the Simpson's first rule. It is odd number and you can do this. For this problem, it comes like this as 1, 2, 3, 4, 5, 6, 7. You find the function of area here. It is this half ordinate into this Simpson's multiplier. So, you sum up the half areas and sum up the total sigma function of area.

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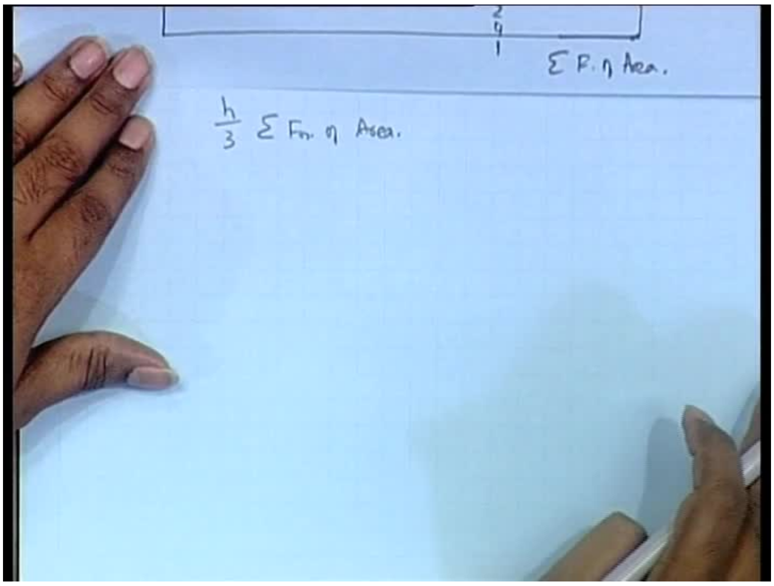

You apply this formula h by 3 into that. Here, h will be the distance between the stations that is given. We are told that vessel is 90 meters and it is divided into 7 stations that mean 6 equal regions. So, 6 equal parts that is 90 by 6 and you do that. So, h by 3 into this summation will give you the total area of the water plane. This tells you not just that how to find the Simpson's rule, but that also tells you from the half ordinates, you find the water plane area. Actually, there are many things like this. From the half ordinate, you can find the water plane area, then similarly from the y's.

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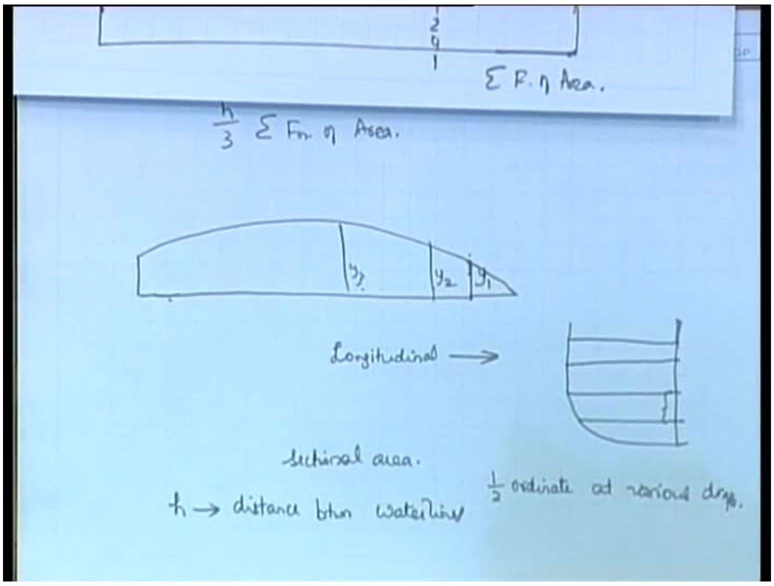

Let me draw this here. This is the ship; assume the length of the ship. This is the longitudinal direction of the ship. If your given half y's, it is enough. Let us call this as y 1 and the ship is like this. In this particular problem, you are given y 1, y 2, y 3 and you are finding this water plane area. Similarly, another problem can be, you are given a section and let us just take the half.

You know the section and you are given these lengths. What does it mean? It means the half ordinates are in each draft. This is the half ordinate at various drafts. You have told that this is a draft of 0.25 meter; this is the half ordinate. So, what you get? You are actually getting sectional area, y. What will be your h? It is the distance between the water lines. So, h will be the this line distance. It will just be a distance between the water lines. This is one area you can get; this is another area you can get. There is no point doing the problem.

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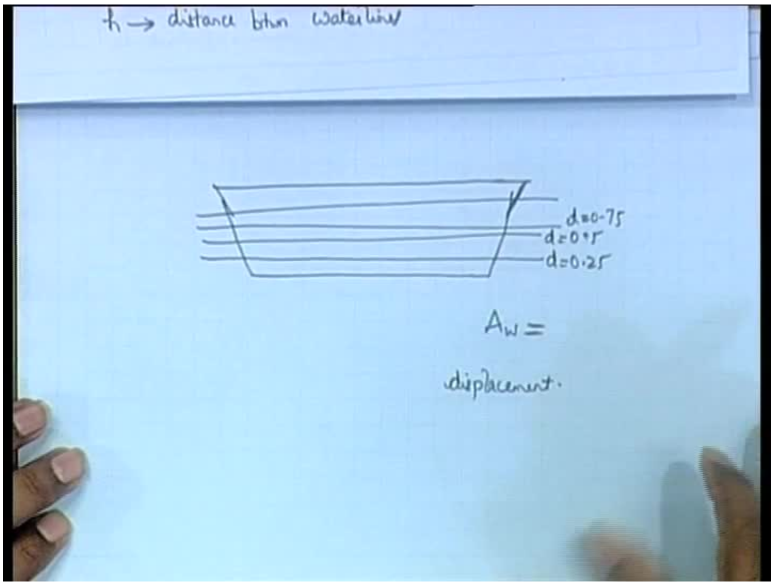

Another possibility is - half ordinate is given and you have to find the area that is not important, we have done that. Another thing is - you could be given at different drafts, it means a ship at different drafts that is at different cross section or different water planes. What is the water plane area? These are different drafts of 0.25, 0.5, 0.75 like that. You are given different drafts, what is your water plane area? This is always written as A w. A w means water plane area. So, water plane area at different drafts are given. What can you get from Simpson's multiplier? You can get the displacement. So, your h becomes the distance between the water lines, which is for the different drafts given. So, this is the third possibility and this is third type of region.

I think, these three are the main areas calculated using the Simpson's multiplier. The next possibility is to calculate I - moment of inertia. We have already done a problem similar to that. So, I think this is enough for the integration.

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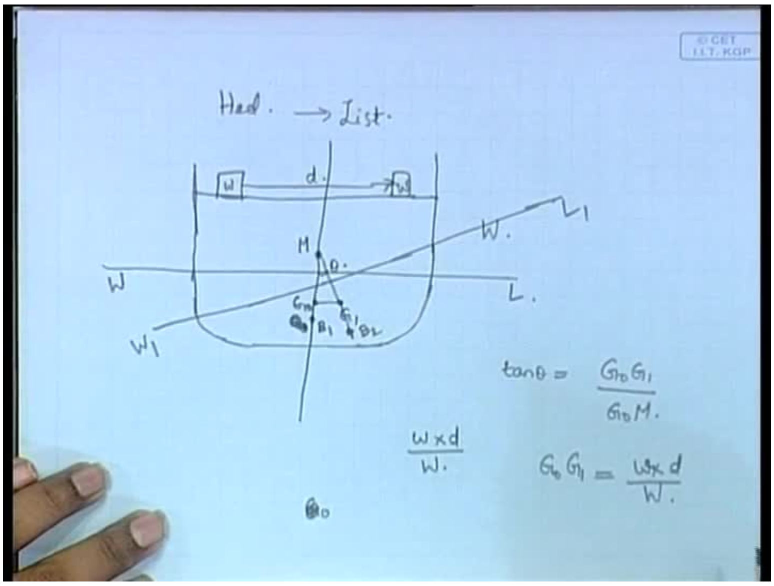

Now, we will go into couple of problems. First, we will do about heal, which is also called as list. We are going into this problem and let us look at some aspects dealing with center of gravity for the time being. It is not with the center of buoyancy, but with the center of gravity. For instance, we have a section of a ship; this is your water line. Now, the problem in this case is - you are given that the total weight of the ship is capital W and let us suppose that there is a small weight on the ship small w that is displaced from this point. Initially from here, it is displaced to this point that is w is shifted to this point.

Now, first of all, the body itself is shifting a weight. The center of the gravity of the whole ship will also shift little bit because, it is only a small weight. It shifts as it moves to a new point. Initially, without shifting it is at G 0 and after the shifting, it is at G 1 because the body has shifted in this direction. G also will shift in that direction and this is the G of the whole ship. For this case, let us derive some relations. What will happen, if there is a shift of weight? The whole ship will actually incline heal. Let us say that the body has healed like this; W 1 L 1 and because of that G has shifted here. The center of buoyancy has shifted here B 2 B 1. Actually B 1 and B 2 will be a straight line. So, more or less it is just the drawing and G will shift to G 1.

Now, let us call this angle as theta. Tan theta will be G 0 G 1 divided by G 0 M. Now, what will be the shift in the center of gravity of the whole ship, because of the shift of a small w through a distance? Let us call this distance d; we have already derived. If you have system of M 1 plus M 2 and we shift just M 1, how much will the center of gravity of the whole system shift? We have seen that it will be w into d by W in this case. Therefore, G 0 G 1 will be given by w into d by W.

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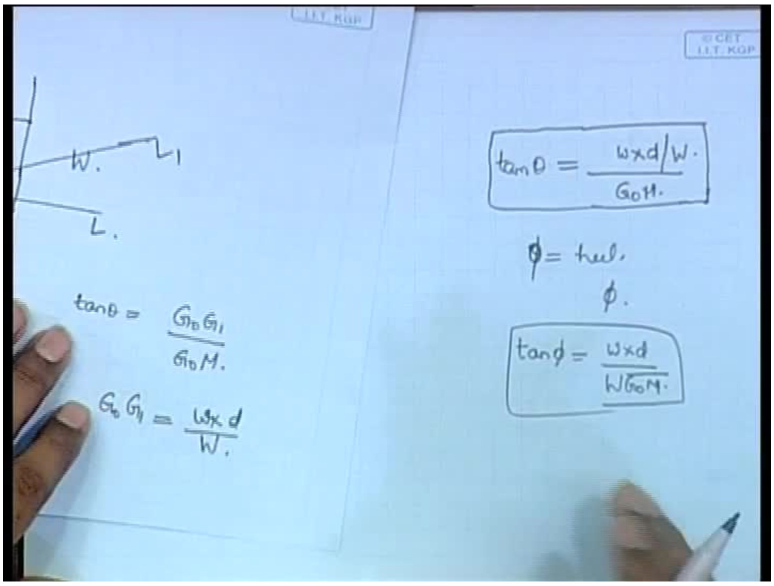

Here, tan theta equals G 0 G 1, which is w into d by W divided by G 0 M. Now, this is a useful formula. There is a small change that is this theta actually represents the heal only. This is the angle through which the body heals. I said in the beginning that for heal, we will use only phi. This book has used theta, so note that this is actually your phi. Till now, I have said that everything will be dealt as phi and so we can use phi. The concept is that tan phi will be given. From this, you can get angle of heal. If a body is shifted from one point to another on the ship because of… If you know the distance that it shifted and weight of that body, you can find the angle through which the whole ship will heal because of the shift. So, w into d is given by this and the only thing we need to know is G M of the ship.

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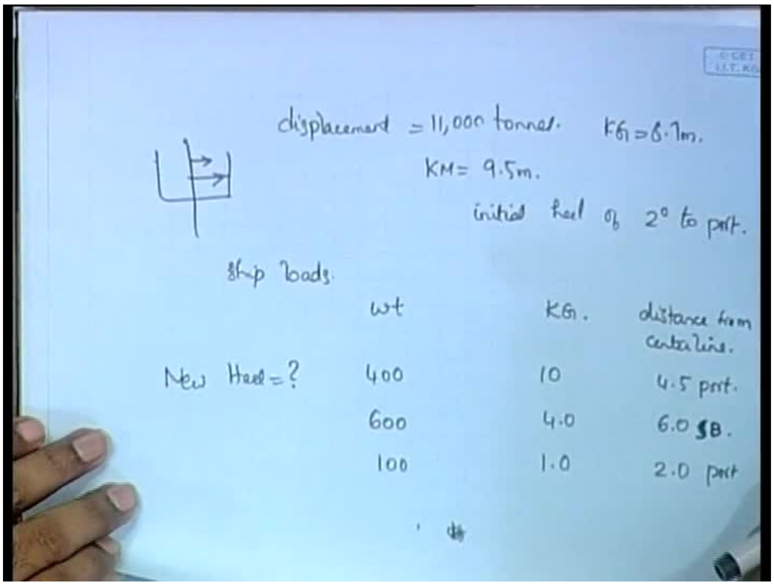

Now, we can do one problem that gives you an idea of this. I will read out the problem, so that you understand how the vessel is displacing 11000 tones. So, the meaning of that is that the displacement of vessel is 11000 tons. It has a KG of 8.7 meter, it has a KM equal to 9.5 meters and it is said that it has an initial list of or an initial heal of 2 degrees to the port side. So, port is in this side and it is healed like this. You are told that the ship loads. Now, what we are going to do is we are going to add new loads to the ship. So, the ship loads are like this. Now, you are given a couple of details. First of all, you are told that ship is loading first 400 tons. It is loaded at a KG of 10 and that means the KG of that load is given at 10 meters, then the distance from the centerline. What does it mean? It means this distance and this is the centerline always.

When you have a ship like this, this is the centerline of ship and this distance is the distance from the centerline. KG is this distance and you are given this distance. Why do we need this distance? It is actually to find G 0 G 1; it is the horizontal distance through which g has shifted. The problem is we have to find the vertical distance through which G has shifted, then you also need to find the horizontal distance through which G has shifted to get G 0 G . If you know G 0 G 1, then you can get tan phi. You will know how much it has healed and that is the problem you are asked. Initially, it has this heal, but after you load, what will be the new heal? So, this is your question. This is port and this is star board.

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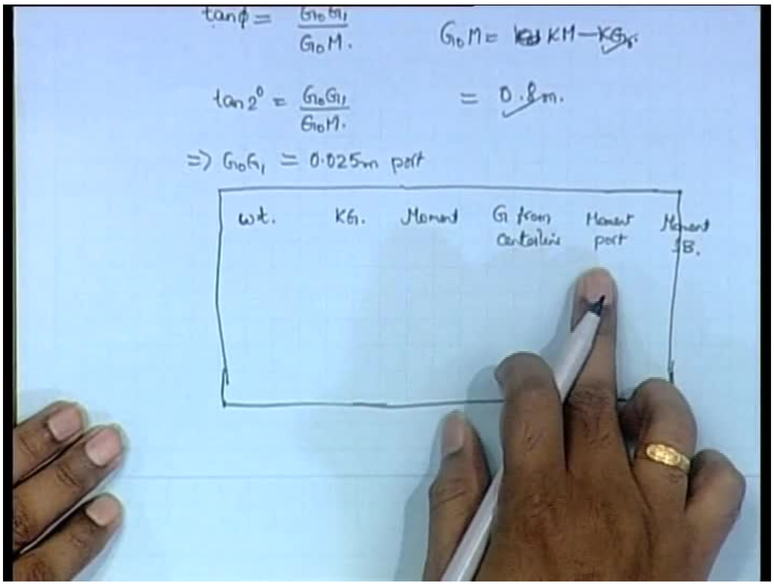

The initial case that is before you are loading this, new weights tan phi can be given as G 0 G 1 divided by G 0 M. Now, how will you find G 0 M? Remember, G 0 always means before the experiment or whatever, you are doing before. So, this represents your initial case, but note that this is not an upright case. In the initial case itself, the ship is in a healed condition. You are adding loads and it becomes even more healed. You are asked what is the new heal? So, this is tan phi and now, how will you find G 0 M? G 0 M is straightforward; you use your KM minus KG 0 and this will give your G 0 M. So, these two are given.

Initially, the shift KG is given and that is your KG and KM is also given. This is the problem and so you are given KG. This is your KG 0 (Refer Slide Time: 32:51) and from this, you are given KM. From these two, you can get G 0 M from K M minus KG 0. So, from this, you will get 0.8 meters and this gives your G 0 M. Now, we have come to this problem - tan phi is equal to G 0 G 1 by G 0 M. Now, we have derived this and we know G 0 M, we know tan phi. This is initially before the loads have been added. So, this is already given that it is a list of 2 degrees in the port side. So, tan of 2 degrees is equal to G 0 G 1 by G 0 M and this will imply that G 0 G 1 is equal to 0.025 or something meter port.

The value of G is at a distance of some meter to the port side. So, actually, it is healed like this and not like this. G is somewhere here, G is little distance away from the center line. This is your initial condition and now, we have solved your problem. We have added loads to it and you are asked to find out what are the new values of heal. In a way, all the problems that you are going to do are going to be making such tables with different kinds of data. You always make such tables, some kind of summation of areas or volumes and in this case, it is moments.

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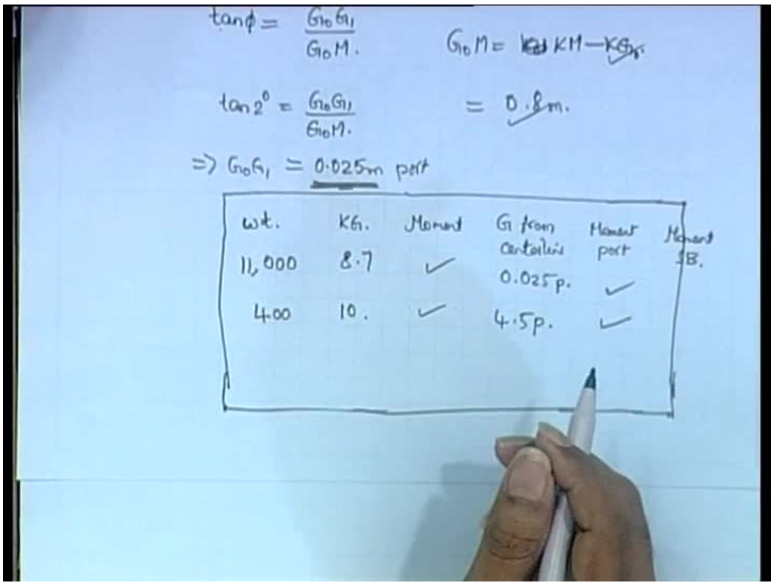

Now, I have made a whole table like this. You have weight, KG moment. Now, G from centerline means the distance of G from center line of that particular load. The moment of this is due to this weight and because of this distance between the center line and G, there will be moment acting. That moment is given by this. If it is on the port side, I will write here. If it is on the star board side, I will write here. Remember, if this is the ship, this is the centerline. One is port one, one is star board. G is anyway acting down and it is acting. I mean the moment acting on the port side will cause it to tilt like this. Moment acting to the star board side will cause it to trim like this or to the heal like this. So, it is opposite in sign. That change in sign is to take care of that. We are putting it as two columns. Here, there is moment in port and moment in star board. Finally, you just subtract them and you will get the final heal.

First, you are told that we have the ship that is 11000 and your KG is given to be at 8.7. Therefore, you find the moment and there is no need to do it. Now, we have calculated the position of this G from the centerline this distance as 0.025 to the port side. We will write it as p, because this moment is to the port side. What is this moment? This moment is actually the moment causing it to incline into the port direction. It is given by the weight into this distance. So, this will give you the moment here. You add the different weights for instance and I will just write the first one as 400. Here, KG's are given as 400, 10 and 4.5 port. We will write it as 400 and this becomes 10. You get the moment, this is the product of these two is 4.5 port. Again, you will have a moment to the port.

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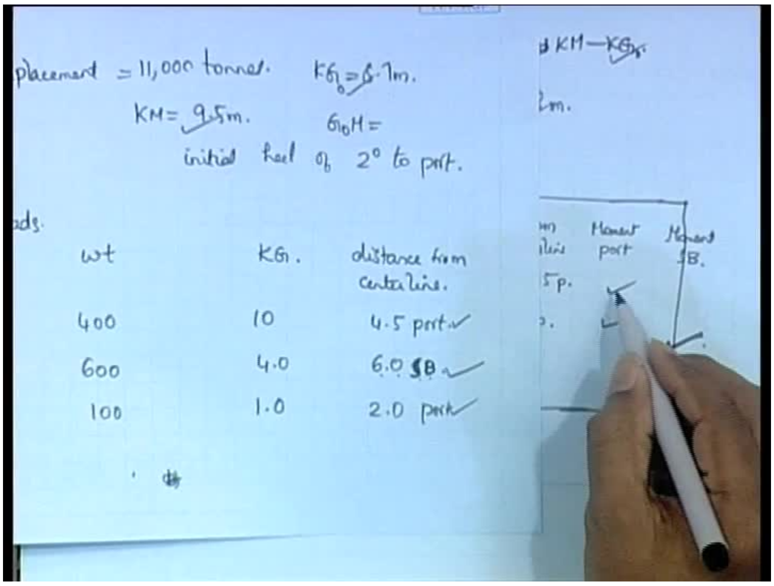

All these weights, you have to write. This one is on the star board side, this will actually come here. The third one is 6 meter to the star board side and so this will come here in the part of the moment. These two are ports will come here. Eventually, you have four - 1, 2, 3 and one for the whole ship. Now, how do you find the total? What exactly do we need to find first? We need to find KG 0. It is not KG 0. KG 0 means initially before the loads are added, once you add the load, it becomes KG.

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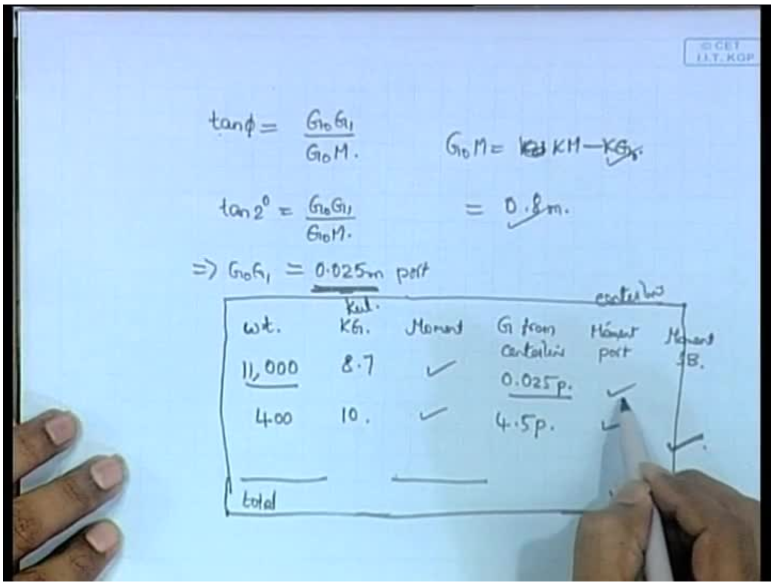

Now, different loads added at different points. What is the new position of your KG? You have the moments here, these moments divided by the total weight. Is it clear or is it confusing?

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Which, about the centerline?

(( ))

There are two moments here. We have taken this moment about the centerline and this moment is taken about the keel.

(( ))

Which one of them? Both are using 11000. This will be 11000 into this. It will give you this. Moment means you have the center line here, I am saying that this 11000 tons displays so much distance away from the center line. So that weight into this distance will cause it to heel like that that is the moment about this axis.

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Now, a lot of confused looks.

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Actually, I am calling it moment, but it is not really moment. What we are doing is we are finding the net KG for that moment. It is like, there is one weight there; one weight here; there is one weight here. Now, because of this, what will be the net centroid of this whole weight? This product is what I am calling as moment and that is all, it is not a moment vector that you are thinking. We are not doing that here. In the inclining case, it is the moment.

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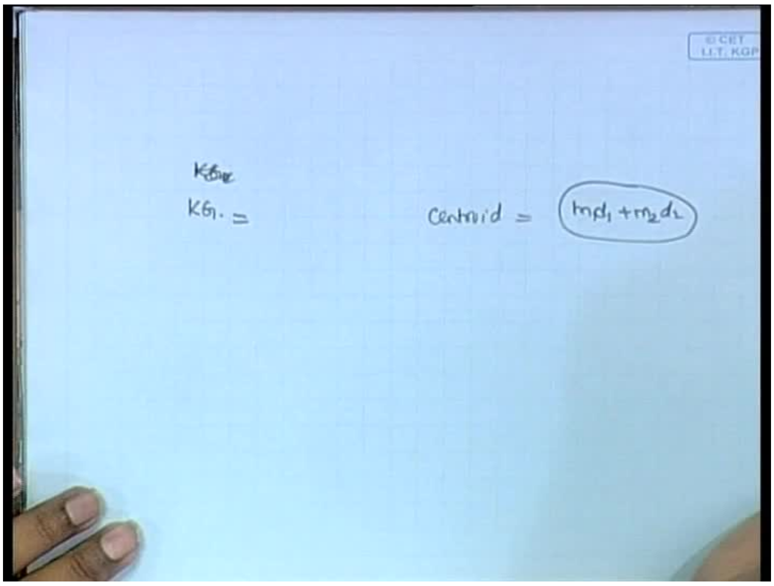

What I am saying is I will tell you, when we are always finding a centroid, we always do m 1 d 1 plus m 2 d 2 like this. So, I am calling this as a moment. That is a good question. So, this is how you get the total weight. This total weight is got, after all the loads have been added.

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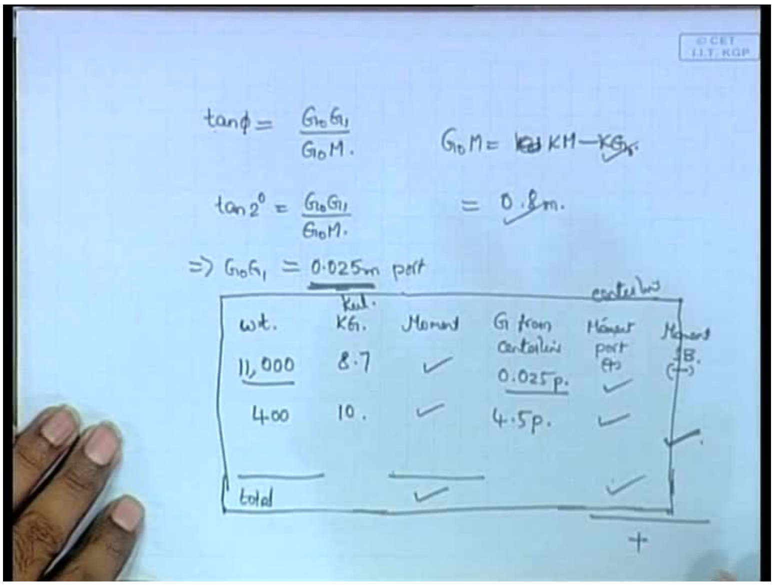

You have the total moment here; this moment is to find the KG. You have weights at different points; you are just finding where the net adds. So that is KG at different point. This is just to find that KG and this is actually what you are thinking. We are talking about real moments; it is a vector in that sense. One moment is causing it to heal like this and one moment is causing it to heal like this. We are finding the summation of that and that moment is the net healing or healing to the star board or port side that is the net.

Suppose, you added these four quantities and you ended up with some value with a plus sign and that is very important. We have put this as a positive and we have put this as a negative. If you get this as a plus sign, it has healed to the port side. On the other hand, if you get it as negative, it has healed to the star board side. Now, we have to find the KG. So, KG will be just this total moment divided by this total weight. So that is done there and that is quite easy.

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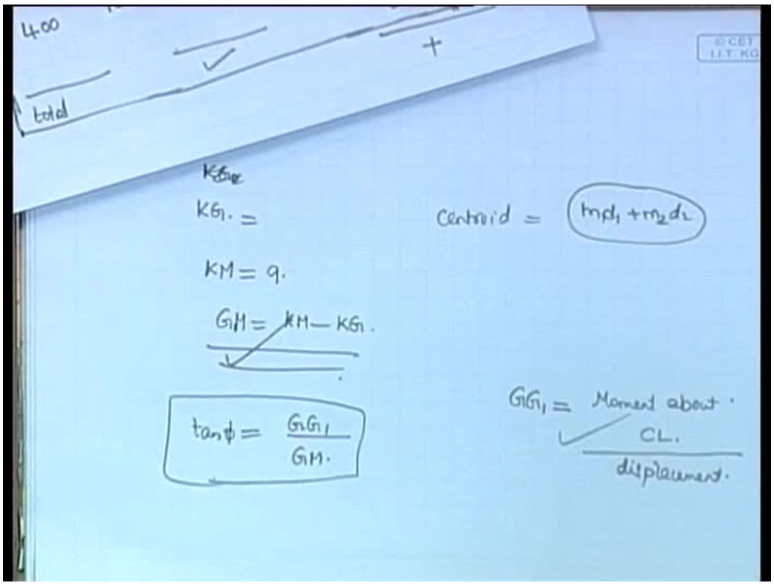

KM is given and again, KM does not change. It is because, it is just a tilting of weights, KM has not changed and it is the same thing. New GM is equal to KM minus KG. This will give you new value GM.

Now, you have to find what is your GG 1. It means what is your net horizontal movement of G? How will you get that? You have the net horizontal moment and you have the total weight. When you divide the net horizontal moment divided by the total weight, it will give you the net horizontal movement of the G. So, GG 1 moment about the center line; note that this is again about the center line is divided by the displacement. So, you just do that and you will finally apply the formula tan phi is equal to GG 1 divided by G M.

Note that we have calculated G M. Here, we have calculated GG 1 using this formula. So, to do that we need both these moments, you have to calculate G M. You need this to calculate GG 1 and once you have this, you can get tan phi. It is a very simple formula and you can just apply this. So, this is how you find out the new heal due to a weight being shifted.

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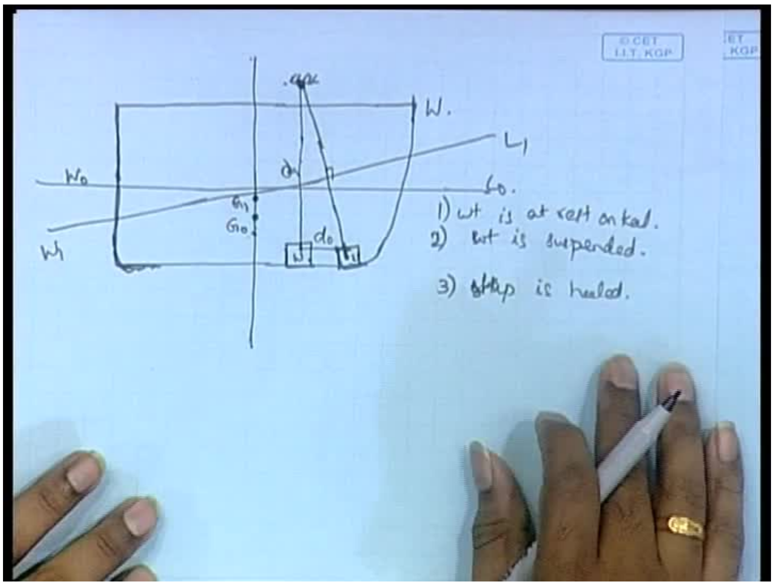

Now, there is a slightly different problem. In this problem, there is a weight of the whole system as W. Let us call this a small weight sitting here as small w. Now, the problem is you are going to hang the weight here. It is going to be suspended and becomes like a simple pendulum. This weight is suspended here.

Now, this is a very important experiment because, we will do that in the next class, something known as inclining experiment. It is used to find the KG of the ship. The beginning is like this, first in this problem, what we are doing is - we have this weight and we are suspending the weight somewhere here. It does not matter and let us say, height d or this height is called d 1. This is the height of d 1 from the base to the keel of the ship. So, here it is suspended somewhere.

Suppose, the ship heals due to some mechanism and because of this, what will happen? This pendulum will remain straight and that means the ship has healed. The pendulum will actually remain straight. It will be like this and this is your new W 1 L 1. So, pendulum will actually be in the new figure. It will look like this and it is hanging. So, it will be like this. Note that this will be perpendicular to this. Pendulum will always be hanging straight; it will look like this, horizontally. Actually, this is in the ship only. If the suspension point is outside the ship, it is on the ship. Let us say, lift on the ship is due to the weight, which is not going outside the ship. Weight is still on the ship, so w is still there.

In this figure, this has displaced horizontally through a distance d 0. Now, our problem is to find out some relation between all these three. Initially, this weight is remaining here at w in the keel. Let us say that the center of gravity is here. G 0 is the moment and you hang it. You will see that it acts as if the weight here is no longer the weight is here. You can think logically that because the weight is hanging there, the force is acting here. Therefore, G of this weight is actually shifted there, which will imply that the G of the whole ship will actually go up a little bit. So, this G 0 will go up here to G 1.

What happens? The ship has healed. So, there are 2 steps - the weight is suspended first, the weight is at rest on the heal, then the weight is suspended and the third is the ship is healed. Now, the ship is in heal because of the suspension or anything. Ship is healed because of some reason or some external force acted. Ship healed, because of which, the inclined weight shifted. Now, because of this, the G 0 shifts to G 1. When the ship heals and inclines, this weight goes horizontally. You have seen here a distance d 0 is gone horizontally. Therefore, this will move here somewhere. We cannot say exactly and let us say as G 2.

Now, the important thing is we are assuming a very small heal. It has not healed much. This is not a very large angle or a very smaller angle. So, it is somewhere like this G 1 and it has shifted there. Now, we are using a little bit of intuitive thinking that is see this figure shows that you have this weight shifted here. Now, look at this G and you see that the movement of this G should be really proportional to this movement of the weight itself. Therefore, it will follow, but that derivation is too complicated. You will see that these two triangles will be similar. It will similar because one is actually proportional to the other. G is actually moving directly proportional to the movement of weight. So, you will have these two triangles, where the angles are subtended by d 1 and d 0.

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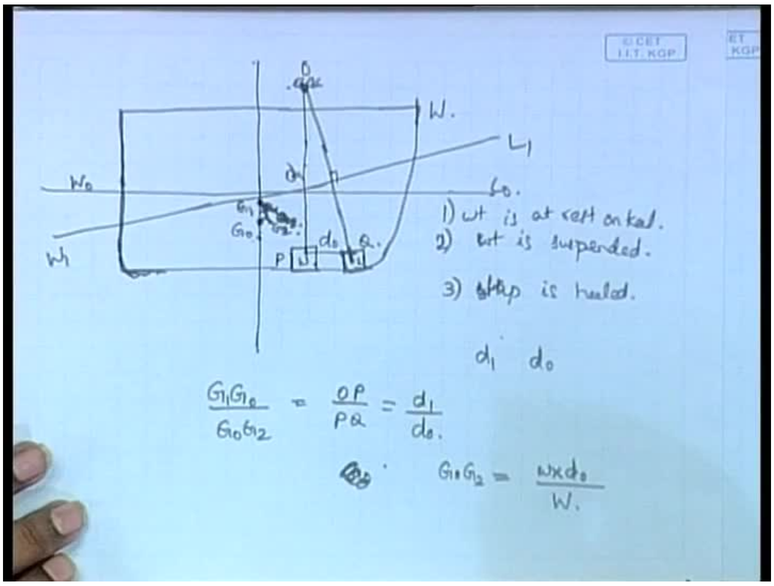

Here, you have some distance G 1 G 0 and G 1 G 2. The angle will be same and you will have something like G 1 G 0 divided by G 0 G 2. So, I will just call them as O P and this as PQ. We said that the two triangles are similar. So, you have G 1 G 0 by G 0 G 2 is equal to OP by PQ, which is equal to d 1 by d 0. Now, what is the horizontal distance through which the whole center of gravity of the ship will shift, if a small weight is shifted? It is the same formula and the same concept, so this is G 0 G 2. There is the shift because of the weight shifting through this distance. What will be that shift in the center of gravity of the ship? It is G 0 G 2. Let us say that w is the weight of the small mass that is w into d 0 divided by capital W of the ship.

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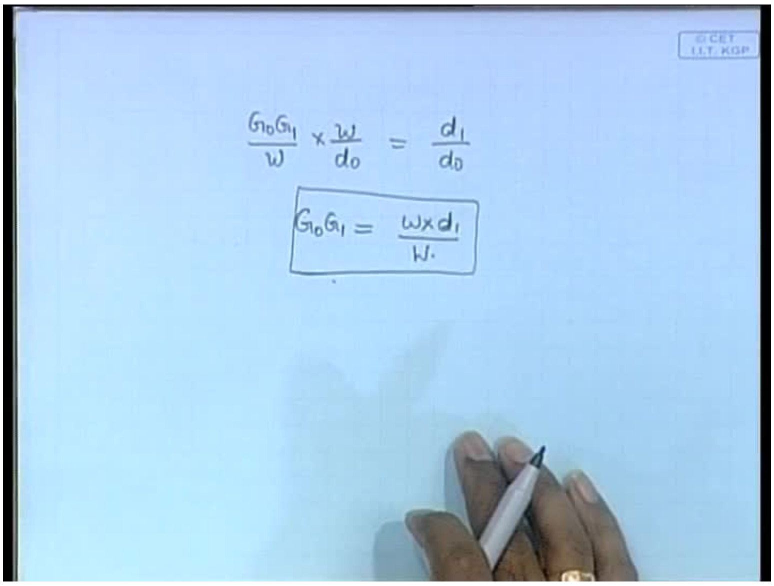

Now, you have G 0 G 1 divided by w into w by d 0 equals d 1 by d 0. It comes directly from the previous equation. Therefore, you get G 0 G 1 equals w into d 1 by W. Now, this is actually representing your G 0 G 1. What is G 0 G 1? It is the shift in the center of gravity of the whole ship due to the suspension of the mass. Initially, it was on the keel itself. You suspended the moment and the body was suspended still. Remember that it is suspended on the ship itself. Actually, it will be different, if it suspended outside. If it is suspended outside, it will be like the weight being removed. In this case, it is as if the weight is moved from here to there. Because of that movement G 0 will shift from G 0 to G 1. Slightly, it will go up and that distance is given by this formula.

Now, by doing such problems, we will see that we can get the center of gravity in a very nice fashion. There is a problem associated with this also. I will just explain quickly the parts of the problem. This problem is similar to what we did last time. It just says that you have a ship; actually the thing is probably I should explain and I will do that in the next class.

There is a statement that says lift is to be discharged into a lighter, at that time the derrick will be plumbed 12 meter star board of the center line and head of the derrick will be 29 meter above the keel. Thus wordings are little strange because you do not know what a derrick is. You do not know what is a lighter. So, such things I have to explain. We will do this problem in the next class.

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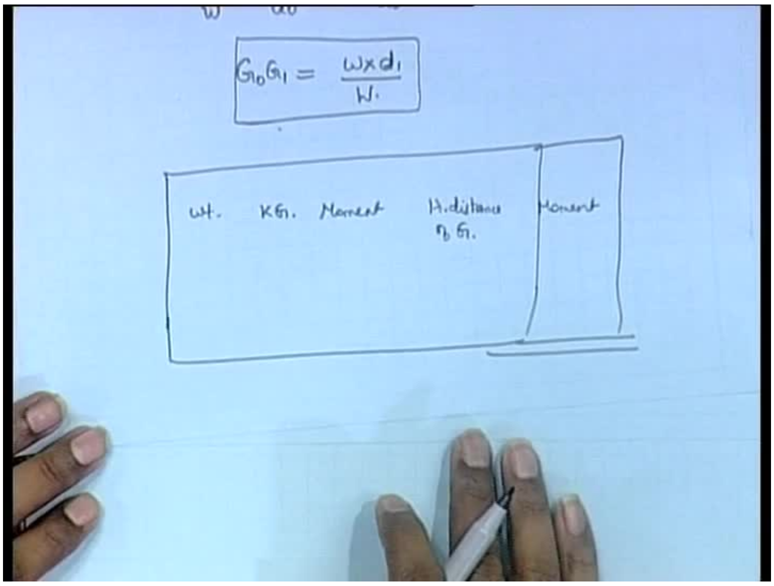

You should know the way of doing. You should always draw the table. Please do not do write continuously like KG 1, KG 2. Please draw the table and do it, otherwise mistakes are very common. So, weight will be there, KG will be next, moment will be next. This much is needed to get your new KG. In any case, some weight will be added somewhere or some weight will be removed somewhere. The concept is going to be the same thing and this is always written like this. From this, you can get the net KG.

In these problems, you need one more thing that is horizontal movement of the G. You will have that horizontal distance of G from the center line and then you will have the moment. You can do two things: you can put the port moments as positive, the star board moments as negative and just do it or you can put different moments and do that. A concise way of doing it is a port moment, you put it as positive and star board moments as negative. In one table, you make the whole… and this moment divided by the total weight is… Suppose, this is the problem and you just have to solve, it is just written in a different fashion. So, make this table whenever this is a fashion. At any rate, make a table. Any calculations to do with KG, KB or anything, you start with a table. Thank you.