Hydrostatics and Stability

Prof. Dr. Hari V Warrior

Department of Ocean Engineering and Naval Architecture

Indian Institute of Technology, Kharagpur

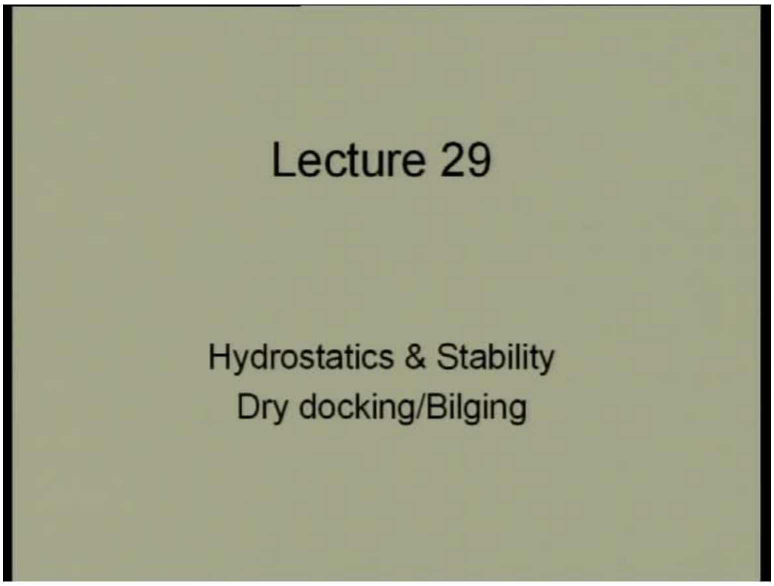
Module No. # 01

Lecture No. # 29

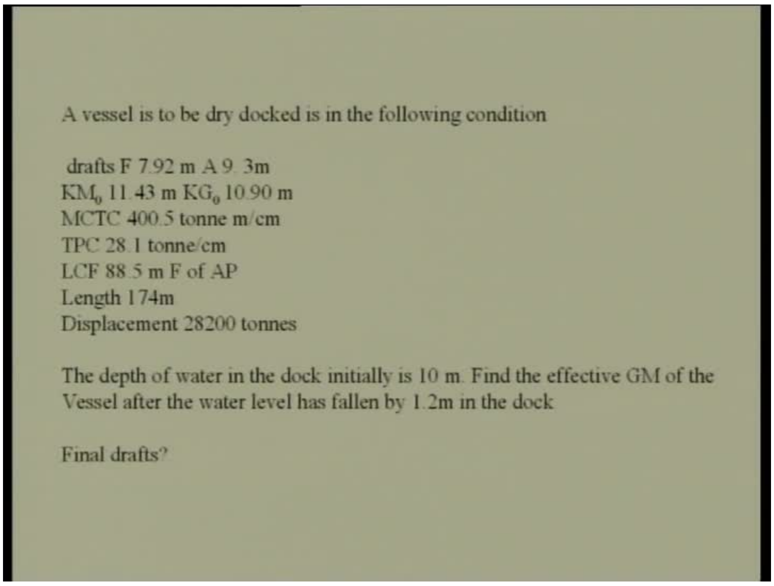
Bilging - I

This lecture we will just finish up on dry docking and then we will go into something known as bilging - I mean - we will come to that. There are a couple of more problems and some more sections on this dry docking. For instance, let us finish this problem.

(Refer Slide Time: 00:26)



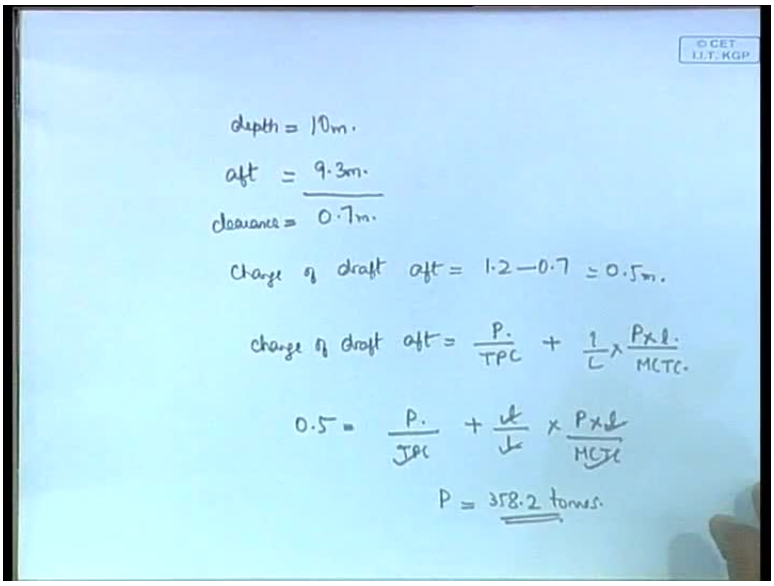
(Refer Slide Time: 00:46)



Now, you are told that there is a vessel which is going to be dry docked and it has the following conditions, its draft forward is 7.92, draft aft is 9.3 meters and KM 0 is 11.43, KG 0 is 10.90, MCTC is given, TPC is given, LCF is so much forward of AP, length is given and displacement is given. Now, in the dock the depth of water initially is 10 meter, find the effective GM of the vessel after the water level has fallen by 1.2 meter in the dock? So, water level has fallen by 1.2 meter and then, you are asked the final draft ,that is the question.

Slight thing which you might not think in this problem is, other things are very much similar to the previous problems, like you find the G 0, G 1, change in GM and you have to find the final GM in this case also. First of all you are given that the draft forward and aft, so you know the initial trim.

(Refer Slide Time: 02:26)



You are told that the depth is 10 meter and let us take the aft section, why do we take the aft section? It is because aft is deeper, means the draft is more it is always like that and in this case also its like that, so its 9.3 meters. Therefore, what do we see? We see that there is a 0.7 meter clearance.

Now, the only mistake that comes obviously when you do this problem is, you are told that, see the water level has fallen by 1.2 meter in the dock. Now, one thing you might directly do for instance is that, the change in draft in the aft position, how much would you consider it. See initially the depth is 10 meter and this draft is 9.3 there is 0.7 here, now it is dropped down by 1.2 meter.

Direct way of thinking would be that you will suddenly think this 9.3 has dropped down by 1.2 therefore, it will become some 8.1, understand what I am saying but, it does not fall like, that you understood.

(( )) In the dock the water level is falling down

Ok, you understood what I am saying

(( ))

It is a dry dock, what has happened there is water in it that is how a dry dock operates. Initially, there is water and what is done is, they have some ballast and they force the water out and water level is falling, so directly you might think that. Let us say, if it is 9.3 initially the draft, it will become 9.3 minus 1.2 but think of it. See, what will happen is actually when the water level falls the ship will come down - you understood that - and this aft will hit the ground. Once it hits the ground then that is true whatever remaining it will fall down; therefore, this 0.7 will come down just like that. Therefore, at that time also draft is 9.3 it comes down like this, its draft is still 9.3, it will come down and hit the ground and then, it will decrease by whatever is left as 1.2 minus 0.7 is 0.5, it will decrease in fact that is only the slight thing which you would not think of, other than that then this problem is straight forward.

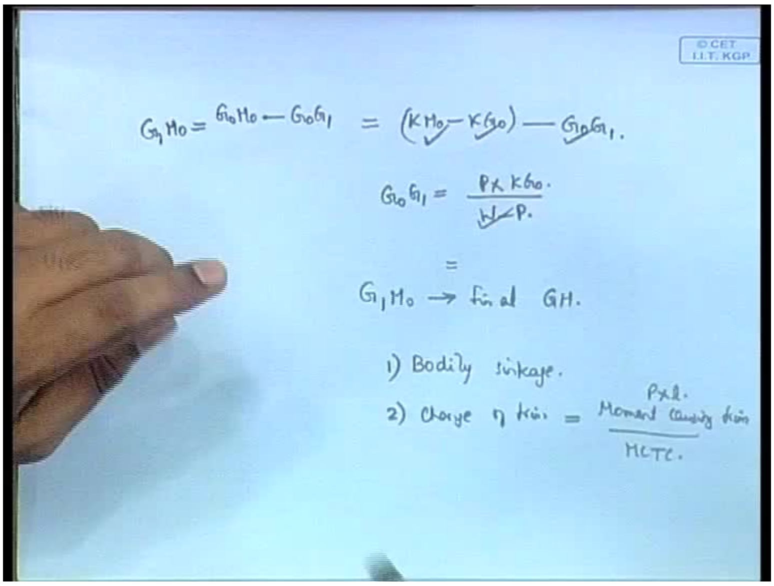
Now, we have this clearance of 0.75 therefore, we can say that the change of draft aft is equal to what? It is equal to 1.2 minus 0.7, it is equal to 0.5. Instead of just saying it is 1.2 meters actually, it is 0.5 meters that is the only trick in this problem. Now, you know that when you have a ship sinking or trimming totally, the total change of draft is given by change of draft aft there is a formula, it is the sum total of the sinkage plus trim that is the total change of draft.

Just remember some formulas like, you can go one by one, first you have to remember this thing change, it is trim is equal to moment divided by MCTC that moment producing trim divided by MCTC will give you the trim then, change of trim aft will be small l by capital L into t that will give you the change of trim aft. Now, the change of draft aft will be this plus that weight by TPC just know what are that signs that is all means if it is a weight added, if it is a weight removed you have to make it plus or negative that you can think.

So, the total change of draft aft is in this case p by TPC plus remember the trim itself is given by p into l by MCTC and therefore, the change of trim aft will be l by L into that so this is the expression for the change of trim aft, like there are a couple of things, there is a trim, there is a trim aft then, there is a parallel sinkage, there is a change of draft aft. Change of draft is a final thing which is sum total of the change in trim plus sinkage, this will give you the change in draft aft.

Now, we know the change in draft aft it is given as 0.5 meter; we have already calculated it. If you do that 0.5 you put this p, you know TPC; so TPC is known then, l is the distance of the center of floatation that is also given length of the ship is given p, we do not know again, l is the length of center of floatation MCTC is given so, MCTC is you know, L you know and l l you know.

(Refer Slide Time: 08:55)



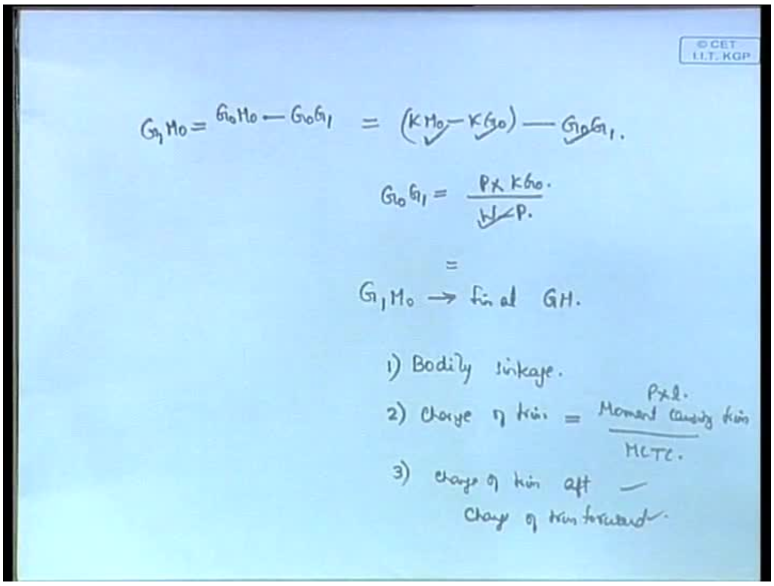
In this you solve for p, you will get p as some 358.2 tons this gives you the reaction force when it touches the ground. Now, the rest is actually very straight forward that is, you are asked to find your final GM that is, final GM is always got by initial G 0 M 0 minus G 0 G 1, this will give you your final GM.

Now, G 0 M 0 you will get by KM 0 minus KG 0 that will give you G 0 M 0 minus G 0 G 1. Now, you have the data KM 0 is given, KG 0 is given, so that is straight forward. Now, G 0 G 1 there is a formula we have already derived it, here G 0 G 1 is the change in G or the change in the metacentric height that is, p you have just calculated; KG 0 is known, w is the displacement of the ship, p is known, so we know everything.

So, you calculated G 0 G 1 and once you know this you get your final G 0 M 0. This is your G 1 M 0 which is your final GM this is one of the questions of the problem, this is one question. Then, if you are asked to find the final draft; final draft is always found by, you have find the bodily sinkage first, then you find the change of trim, then you find the change of trim aft, change of trim forward then you find that change of trim you add to the initial trim in the aft and the forward this method is always fixed when you are asked to find the final drafts this is the method, I will just write it down; 1, find the bodily sinkage; 2, you find the change of trim - change of trim is always the moment causing trim divided by MCTC, that changes according to the problem. This is always the formula but this changes according to the problem it sometimes becomes w into d by MCTC where, w is the weight added at a point d from the center of floatation.

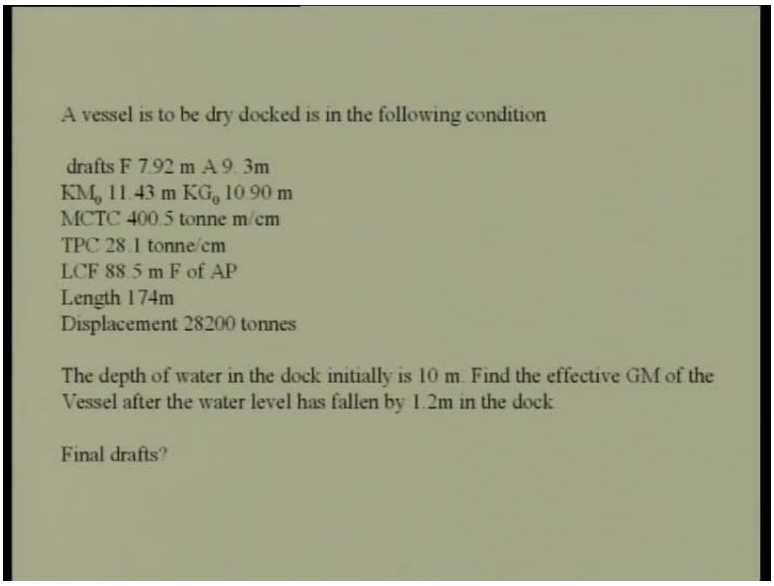
It could be w that is shifted a distance d inside the ship itself from one point to another we have done that is what. So, depending on the problem that moment causing trim will change but, as long as you know what it is you just have to find the moment anyway. So, w into d by MCTC in this case it becomes p into l by MCTC. In fact, this is the only 3 types of problems are there, one is when a weight is added at some point, that point at which it is added the distance from the center of flotation becomes d and w is the weight added, if it is removed then it is bodily rise it is just minus. Then the other possibility is a ballast or some fuel, we will say is removed from moved from one point let us say compartment 1 to some compartment 3 from aft of the ship to forward of the ship like that there the weight of the ballasted moved is w and the distance through which it is moved is d that is w into d always.

(Refer Slide Time: 12:31)



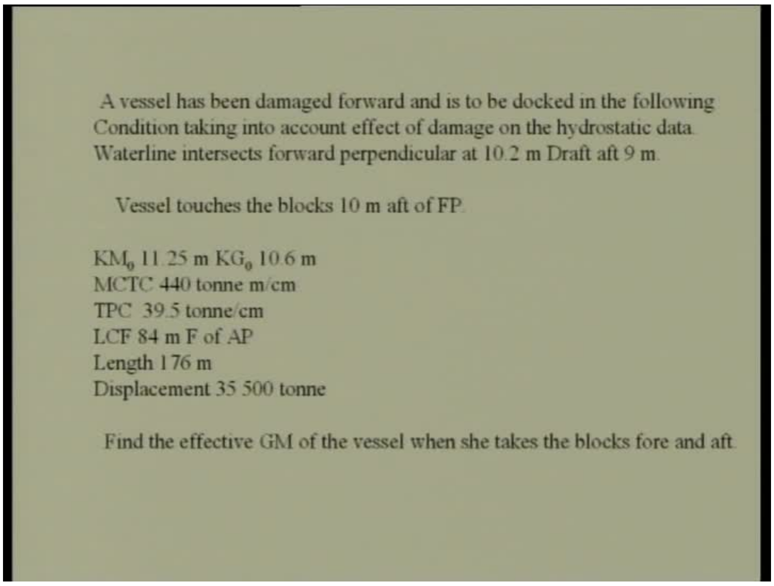
The other third possibility is this p into l when this p force comes the reaction force from the ground comes, so you have p into l l is again the distance between the aft perpendicular and the center of flotation. So, this you find the change of trim and then once you find the change of trim you find the change of trim aft, find the change of trim forward, so you find these two things.

(Refer Slide Time: 13:28)



Now, aft is given by small l by capital L into total t like that then, final draft will be this bodily sinkage plus this change. The initial trim you know it is given draft is this your initial not trim initial drafts are given draft plus or minus bodily sinkage plus or minus the trim and that is how you find the final draft of the ship if it is asked.

(Refer Slide Time: 13:52)

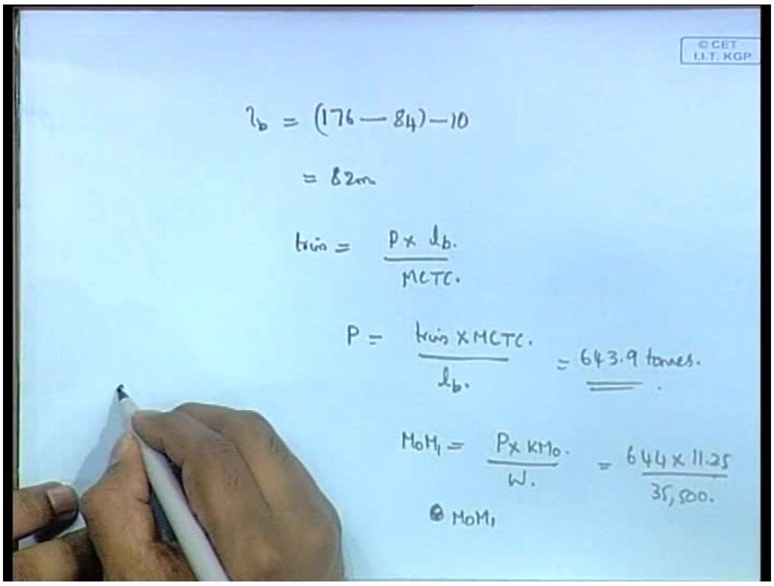


Then, now one problem is possible which is also same it just slightly different it is like this. In this problem instead of the ship coming and hitting at the aft perpendicular due to some damage condition the ship comes and hit somewhere in the middle, so that is the only difference in the problem. So, it does not dry dock at the aft perpendicular but it dry docks at some point in between. So, the only difference becomes that taking that distance from the center of flotation to find the moment it is no longer the distance to the aft perpendicular, it is the distance to that particular in fact that is the only difference we will just do it but, that is the only difference.

The problem is this, a vessel has been damaged forward and is going to be docked in the following condition taking into account the effect of damage. Now, you are told that water line intersects the forward perpendicular at 10.2 meters means that the draft forward is 10.2 meters and the draft aft is 9 meters. As you can see this is a damaged condition, the draft forward in this case is greater than the aft. So, it is not a normal condition, in general condition you do not see like that always you will see the aft more than the forward.

So, because of these condition while you are trying to dry dock it hits, the it says vessel touches the blocks 10 meter aft or forward perpendicular. So, actually it hit the front part not even the aft, it came and hit like this it is hit here first. So, that is the vessel touches the blocks 10 meter aft of forward perpendicular then, the hydrostatic some data are given KM 0, KG 0, MCTC, TPC, LCF length displacement, you are asked the final GM when the ship hits.

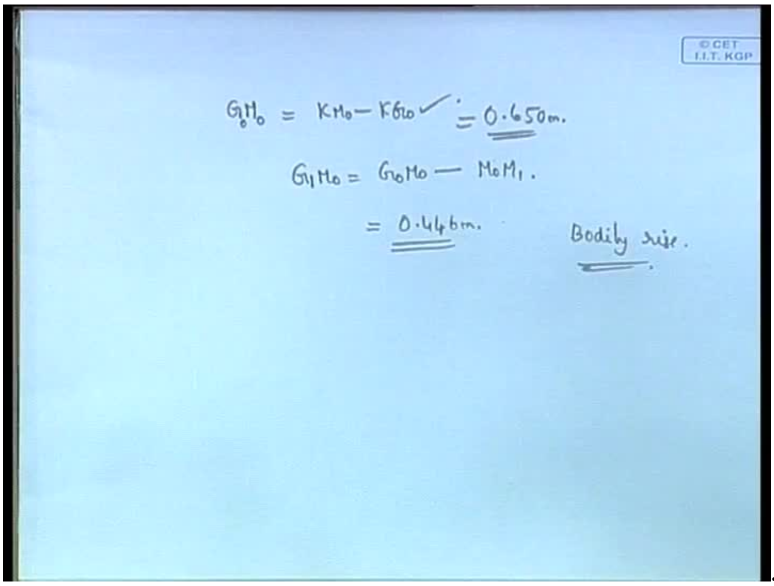
(Refer Slide Time: 16:25)



As you can see, the only difference in this problem; I am pretty sure you would have done this even if i had did not done this, because that is the only change. So, you have to find an l b - the new distance l b - which will be the distance between the center of flotation and the point at which the ship hits the block. So, in this case you are given that LCF is 84 meter forward of aft perpendicular, actually distances are given in this case from the forward perpendicular means vessel is, so you need the length. So, it will become like this length 176 minus 84 will take you to the LCF minus 10 will give you the distance between LCF and it is equal to 82.

Now, this is the distance between your center of floatation and your point where the ship hits. Therefore, your trim in this case becomes p into l b divided by MCTC, so you get your p which is equal to your trim into MCTC divided by l b, so you just do this you will get your trim it comes to 643.9 tones comes to this.

(Refer Slide Time: 18:08)



Then, you can do it two ways, either calculate it G 0 G 1 or you can calculate your M 0 M 1 whichever way, in this case if you do it this way M 0 M 1 can be taken as p into KM 0 divided by w which is equal to your here 643 points, which is 654 into KM 0 is given to be 11.25 divided by w displacement of the ship 35500 tones. This will give you your M 0 M 1, you are given with your initial GM - you are given KM and KG, so you know. Even though you do not need the initial portions of the course to do the last portions but, I do not think you can do any of these without remembering the previous things, because everything are like if I ask you what in the previous problem, what is the righting moment at 1 degree heel, you have to remember that it is delta into GZ, where delta into GM sin phi. Most of the important formulas are throughout the course that has to be remembered. What is TPC, what is MCTC that and all we did long back, all these formulas have to be remembered.

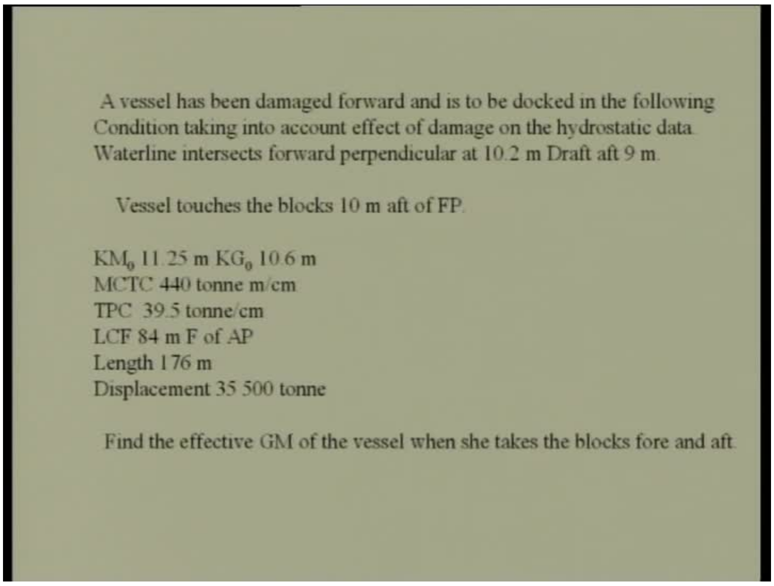
When you are reviewing these things also touch upon things like block coefficient, prismatic coefficient all because in this problem instead of giving things like displacement - I mean - the problem might be just give c b just to make sure you remember something from the previous section. So, you should also know all these important formulas should be remembered always plus the block coefficients all those.

Then GM, in this case you have your G 0 M 0 is given as KM 0 minus KG 0, this you can calculate. Your final G 1 M 0 becomes G 0 M 0 minus M 0 M 1 there is a decrease in GM, this will give you 0.446 meter. So, this is your new GM your G 0 M 0 was 0.65 in case you are confused whether to add or subtract please remember that dry docking will only decrease the stability, it will never increase the stability that means your G M should never increase.

If you do not remember the figure the G came G went up or M came down whether it is going up or down at any rate you should make sure that the stability only decreases during dry docking. If you remember that you know the GM can only decrease and it keeps decreasing and then, it becomes 0 then it becomes unstable.

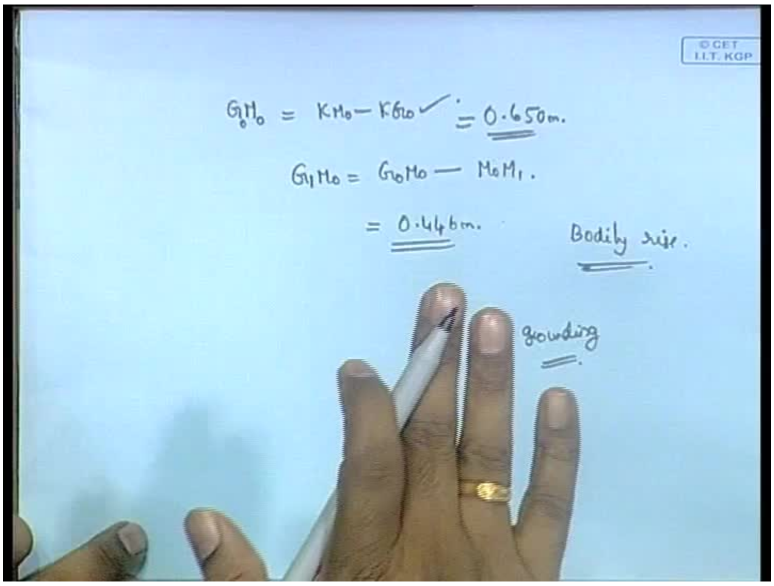
The same thing is if you are asked the final drafts same thing in trim, you find trim aft trim forward, in this case bodily sinkage - I think - it is a bodily rise see in this case remember it is not a bodily sinkage because this p is actually up, when it comes up it is up, so it is going to be a bodily rise not a bodily sinkage. Actually in that previous problem also when you are doing p by TPC plus that p by TPC will become negative. Let me see its subtracted, you have to just remember that please remember p. This is a bodily rise in this problem in dry docking and not sinkage.

(Refer Slide Time: 21:20)



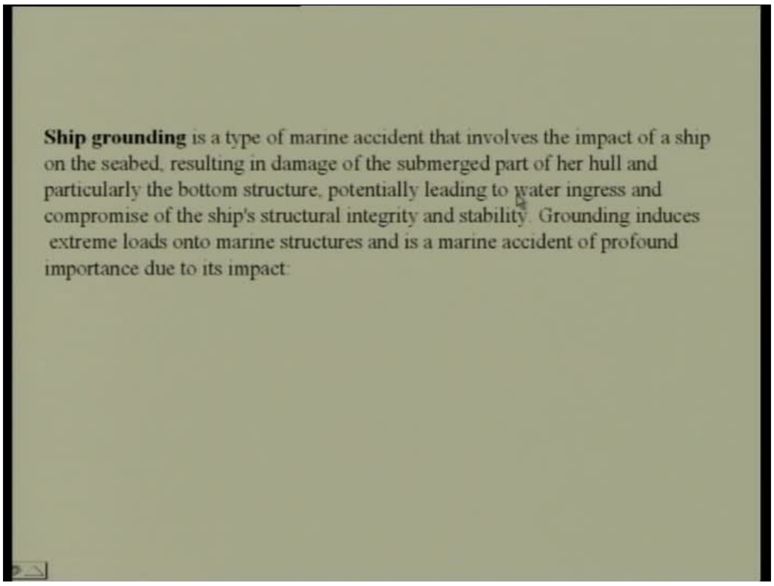
This covers the section on dry docking, so one small thing associated with dry docking is a phenomenon which we call as grounding. Grounding is like an accidental dry docking means suppose, that a ship is going in some shallow water and - you must have heard of tides - no tides suppose suddenly the tide falls means, the water level suddenly falls because of the tide change and the ship might end up hitting some rock below and means it will just come down and hit some point it, you do not know what that point is, it is like an accidental dry docking. So, it comes and hits there and it causes damage to the ship and it is really a phenomena associated with the damage of the ship that is called as grounding.

(Refer Slide Time: 22:13)



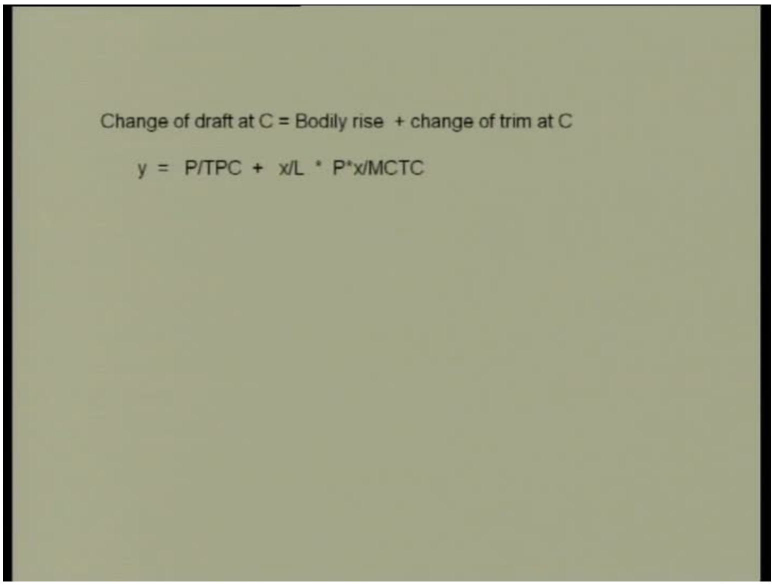
Grounding is caused in many way also in case a ship is damaged due to anything any process you call it grounding but, really the word grounding stands for the this process when it comes down hits some points. In fact if you just look at the internet or like news you will see all the time ship grounded near the some harbor ship, grounded near the coast like that the meaning is this grounded means, it is damaged and it is struck somewhere, so I will just the definition I just put here you can just read it.

(Refer Slide Time: 22:47)



Ship grounding is a type of marine accident that involves the impact of a ship on the sea bed which causes damage on the hull and on the bottom structure, so it can cause damage and it can affect the ships stability, integrity and structural soundness it will affect that so the ship is no longer safe to be used. The reason is because it is such a heavy load suddenly comes on some point of the structure it cause the structural damage I mean, you are doing marine construction and building you will have some idea of what will happen if some something suddenly strikes, so this is the grounding.

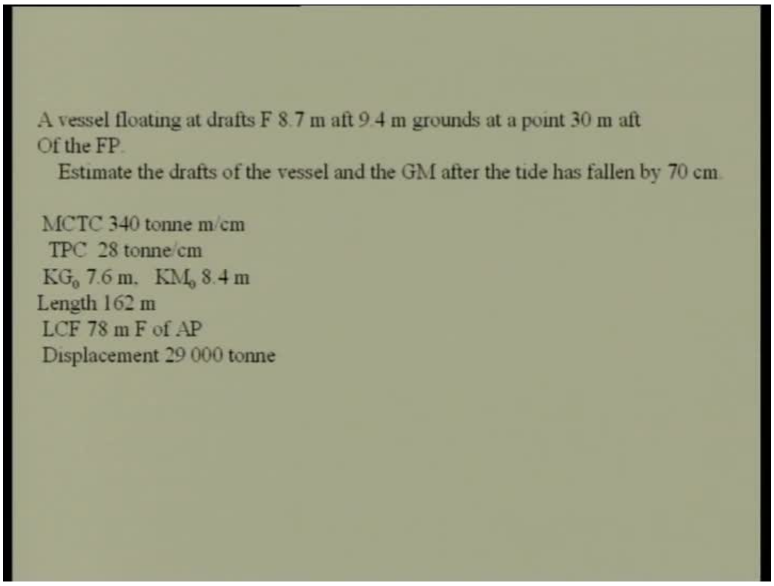
(Refer Slide Time: 23:33)



Let us suppose that the here that equation what it says is that change of draft at C, by C we mean the point where ship hits the ground that point is called C. Now, at that point the change in draft at C will be; I mean that is the common formula change of draft anywhere is given by this formula only, change of trim at C plus that. See in that the only thing is which looks new here is that x, this y is the change of draft at that point C and x is the distance of that point from the center of floatation.

Like we did the previous problem we saw what happens when the ship dry dock at a point which is not at the at the aft perpendicular, so the same thing that the x is that distance from the center of floatation to the point to C means, C is the point where it hits the ground or the whatever rock or something, so this is the expression for the change of draft at C.

(Refer Slide Time: 25:01)



This problem will explain that is, suppose you have a vessel floating at draft forward 8.7 meter aft 9.4 meter, it suddenly grounds at a point 30 meter aft of the forward perpendicular. Estimate the draft of the vessel after the tide has fallen by 70 meter.

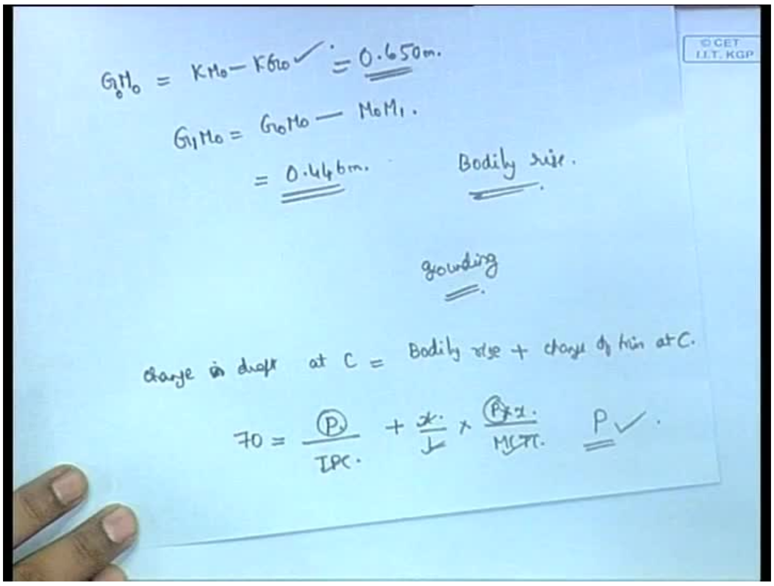
What has happens is, it has grounded due to some reason and then the tide is falling by 70 meter the only thing you need to know here is, see even though the tide has fallen by 70 meter, you cannot say what is the change of draft at any point on the ship other than at that point where it is grounded, you see why that is, because the ship is like this. Now, if the water level falls it can go here up or down like this therefore, you really cannot say what is the change of draft at any of these points I mean this point but, this point you can say here it cannot go up or down.

Therefore, if the water level falls by 70 centimeters the change of draft at this point you know, it can only be 70 centimeters but, at any other point you cannot say, you can calculate it using our formulas and all that change of trim change of using those formulas, but you cannot say directly it 70 meter it is not 70 centimeters it is like that previous problem again, you have to know slightly that the water level how it changes that is the only thing.

(( ))

At C it will be initial draft minus 70 centimeters exactly, but it is not true at any other point. Any other point you have to consider the trim into account, so that is all the problem is actually the same as the previous problem.

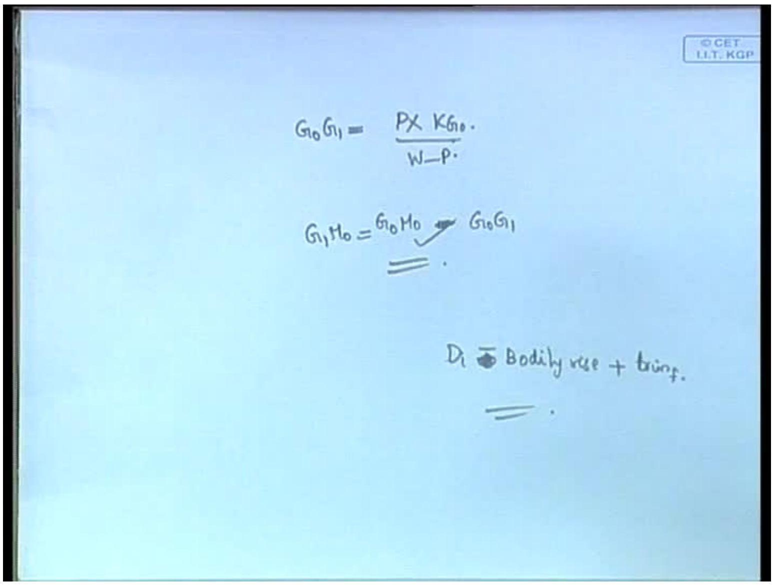
(Refer Slide Time: 27:17)



Now, in this case what do we know that the change in the draft of the vessel at C is 70 centimeter that is given because the tide has fallen by 70 centimeters, so change in draft at C is seventy centimeter. The change in draft at C is given by the formula bodily rise plus - so this will be negative - plus this thing change of trim at C.

Now, change of draft at C is given in this problem 70 centimeter that is equal to bodily rise which will be given by p divided; by we do not know p here means we do not know what is the reaction from the ground here, so p by TPC; TPC is known for the ship it is given form the problem and at the only point is that we need to know that where it is grounded that is given in the problem the ship is grounded at a position 30 meter aft of the forward perpendicular so that is given, so you know what is x, x is the distance between the center of floatation and the point where it is grounded.

(Refer Slide Time: 29:06)

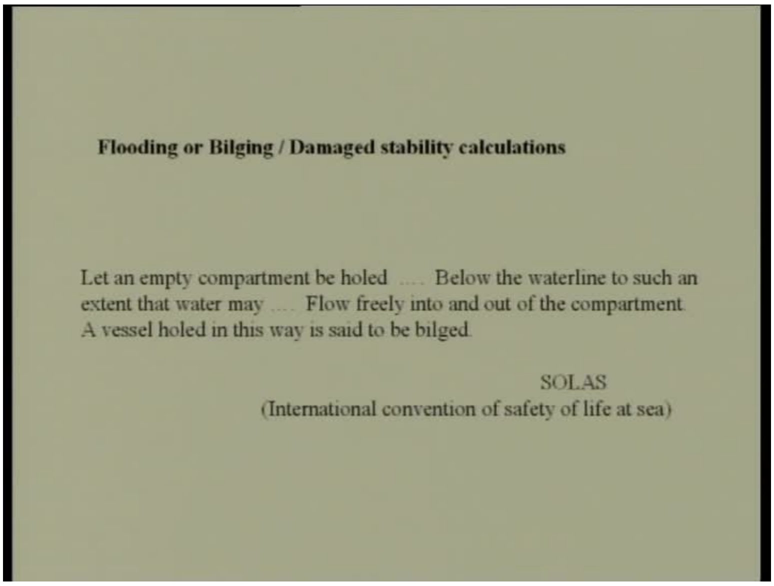


So, x divided by L, this is actually at that point change of draft at that x divided into total trim, total trim is given by p into x divided by MCTC. Here we know x, we know the length of the ship, we know MCTC, we know TPC and therefore, your only problem comes to finding p. Therefore, the reaction force from the grounding at the point C due to this grounding and once you know p we can find the change in GM by using the formula G 0 G 1 is equal to P into KG 0 divided by w minus p. So, this formula will give you G 0 G 1 which is the change in GM now from this you know G 0 M 0 this we get from your previous expression KM 0 minus KG 0, so you get G same formula G 0 no G 0 M 0 minus G 0 G 1 will give your G 1 M 0 so you know your final GM.

In such a problem you know only two things they will be interested in one will be to find the GM that you have already calculated, the other will be to find the final drafts, aft and forward. You know the draft at the C, you need to find the draft aft and forward because of this. So, that is very simple again you know what is the trim? p into x by MCTC; you can find the change of trim aft small l by capital L into that trim t that will give you your change of trim aft. Similarly, you can find the change of trim forward then, you find the bodily sinkage or bodily rise, so you are told that it is floating at the draft forward and aft, so you know the initial drafts. So, initial draft plus bodily sinkage or in this case it will be minus, so the bodily rise plus the final trim that is all. So, this will give you this problem of grounding. So we have more or less covered the section on dry docking and grounding; grounding is dry docking only except the dry docking is done by us and the grounding is an accidental process

Dry docking is always done at the aft perpendicular if the ship is not damage. So when a ship comes I mean we will know whether it is damaged or not most likely it might be damaged but, if it is not heavily damaged it will be like the stern side will be down and the forward side will up in most cases. So, once you have that when the water level comes down most likely the aft perpendicular will touch the ground unless it is heavily damaged and it is like this as in the other problem. Then of course, some other point will hit and it can be dry dock like that, so this is the whole process of dry docking and now we will go into the next chapter.

(Refer Slide Time: 32:15)



There are two names used to describe this process one is called as flooding or damaged actually there are three word to described the process one is flooding is the word you call it damaged this is a new chapter. I am starting the new chapter, its described either as because there are two books I am following right now, one is the berence book and other is that other book.

The first book calls it flooding, this books calls it bilging both are the same process. Some books calls it damage stability calculations that is also the same thing. So, same thing is described as flooding processes when you study hydrostatics and stability any book on that you will see it described either as flooding process or as damage stability calculations or as bilging calculations. So, three things represent the same thing, all of which the meaning is this as the screen says that is let an empty this is as describe by SOLAS - I do not know I think I have said it - SOLAS means, Safety Of Life At Sea that is SOLAS, you have done in marine construction there you would have done lot more, may be you have seen that.

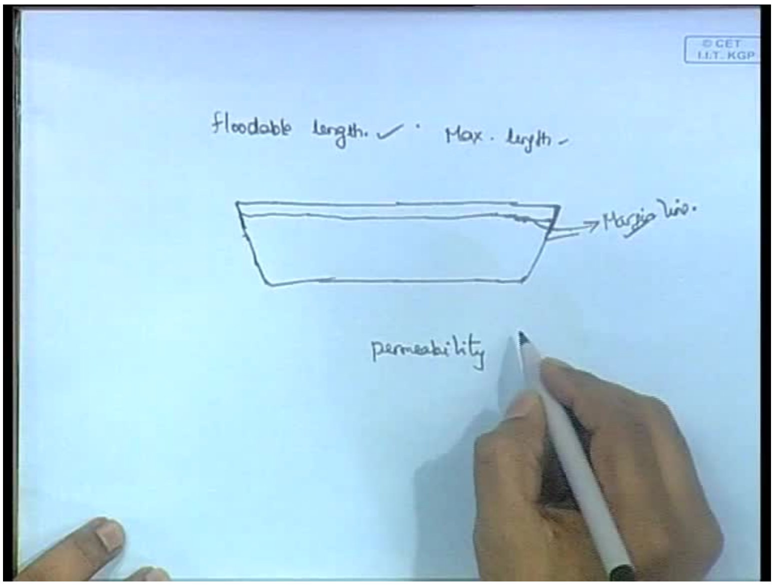
See, there is something called as SOLAS Safety Of Life At Sea that is a convention astarted after the titanic disaster, so they that is when they started 1915 or something they started in London. Now it is a big regulatory body it is called the international convention of safety of life at sea, now what they say about flooding is like this.

Let an empty compartment be holed below the waterline to such an extent that water may flow freely into and out of the compartment a vessel holed in this way is said to be bilged. So, as the name itself suggest you have a big vessel and let us say that its divided into some five compartments and suddenly some compartment either the end somewhere its developed a hole in it and that compartment is partially or fully filled with water and that is why you call it flooding, so it is flooded with water. Just because one section is holed that does not mean the ship has to sink there is no such a thing, because see the compartment you know that they are water tight they would not they will prevent water from entering unless it is a very heavy break it is like the titanic or something it is not going to sink as such.

This will cause damage and water let it keeps come in now what we do is, we do the damage stability calculations and see what is the stability of the ship in such a condition and we go as far as checking to see how many compartments can be holed before the ship sinks totally.

So, this is the whole concept as in this chapter. Now, some important things that is needed that is before we go in to the processes of doing the no let us wait this is this can wait for some more time that is Before we go in to the we need to know some terms.

(Refer Slide Time: 36:43)



The first term is bulk head, you know what is bulk head you have done bulk heads, we can call it compartment it is what separate them compartments bulk heads are there. Then there one word that we use is the floodable length as the name itself suggest floodable length means that it is the total length of the ship that can be flooded without the ship sinking, that is the definition for floodable length that is what it means.

Now also let us define something like this length - not breadth - total length of the ship that can be flooded. We are looking at it I mean if you have total length of the ship like this then and it is divided into compartments we are seeing the total length that can be flooded or that can be broken or amount of damage that can be

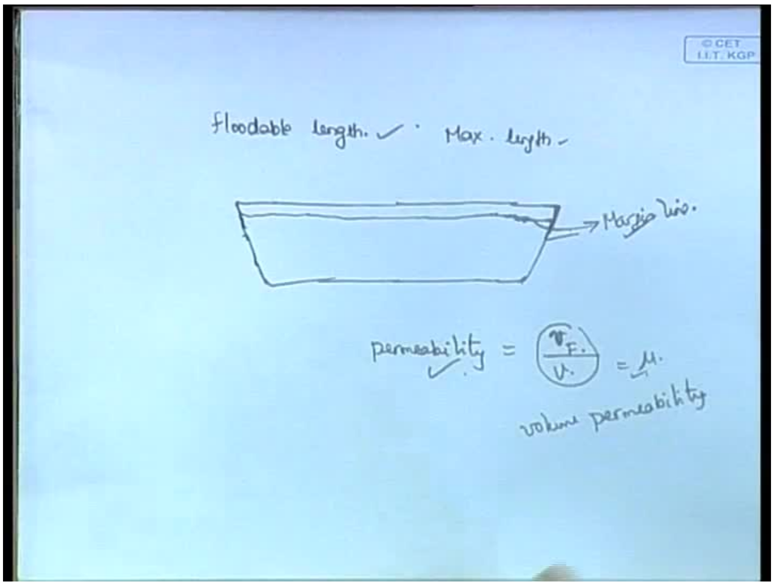
Compartment 1 and 2 will be different from compartment 2 and 3

Yes, that is true actually it is defined as the maximum length that can be flooded. Yes, it is the maximum length that can be it is true if it is flooded here will be different from what is flooded here that is true. So, it is the maximum length that can be flooded which means you basically taking the safest region, so that will be where you have the maximum length, the more crucial regions you can have only lesser length that is true, so it is the maximum length, maximum length that can be flooded.

Suppose, the ship is flooded by some method the waterline up to which the ship can go up without, I mean the maximum waterline up to which it can go up safely is known as a margin line somewhere here. So, the maximum height up to which it can go up is the max means, the waterline can come up to here and without the ship completely sinking that this line therefore, is known as a margin line.

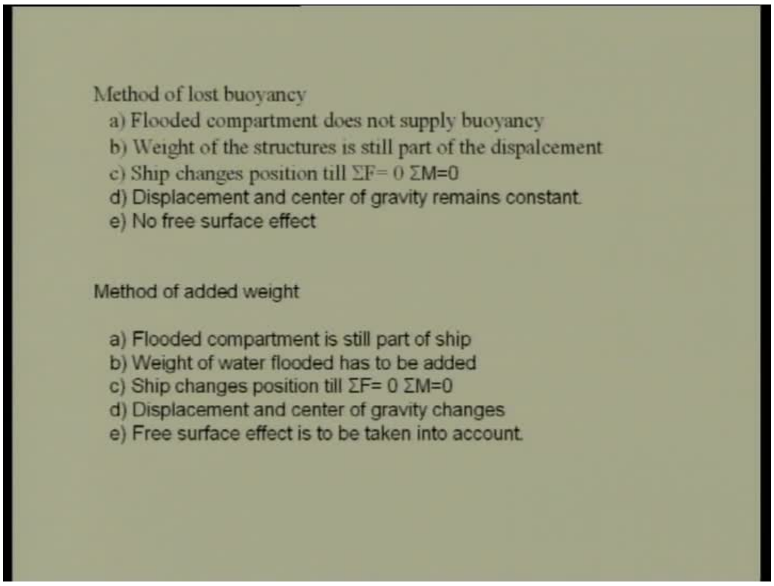
Another term that is used is this, we need floodable length and one more thing is a word called permeability. The word is used in many context, even in naval architecture it is used many places. In this particular, the meaning is that you have a compartment which has a volume v, you know that there will be different things in the compartment. Therefore, the amount of floodable volume is never v, always less than v therefore, we say that the ratio of the floodable length to the actual volume of the compartment is called as permeability.

(Refer Slide Time: 40:22)



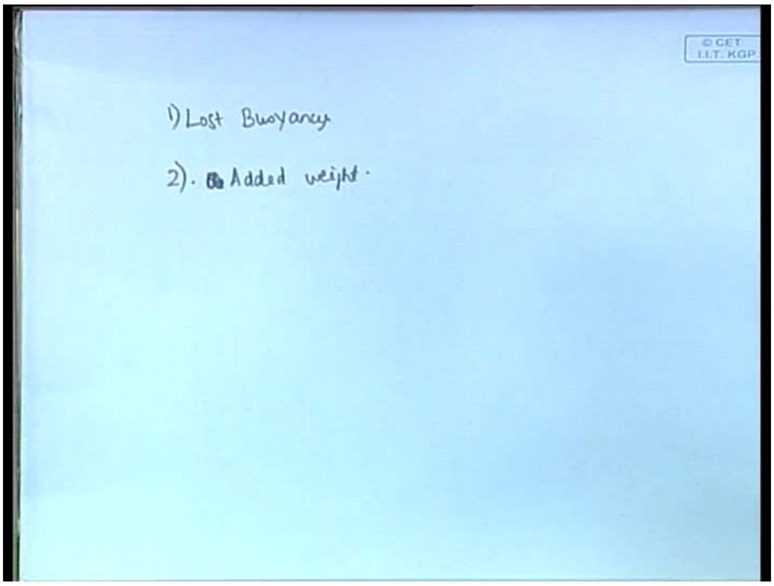
The floodable length let us call it as v F, so v is the total volume of the compartment this will include things different things are kept like there will be different kinds of constructions in the rooms that will reduce the floodable length. So, this ratio is a word called permeability this is mu and the usually when we talk about permeability we talking about volume permeability though of course, there are times when you read the literature you will surface permeability also means, you are talking about surface area in that case.

(Refer Slide Time: 41:19)



Mainly we talk about only volume permeability means the total volume that we cannot be using means, the total volume that we will not use for flooding. Now, will go in to the calculation of the damage stability. This calculation of damage stability has two main methods in which you can do it, please remember this two methods because name if you remember you will get an idea of how to do that problem and at least the name should be very important because people keep talking about it, this is an important section like if any of you take up a job in shipyard or anything this an important section, because you will always be coming across damage, in fact that what shipyard do most of the time. You are not going to be building ship all the time, you be repairing ships, it will be like damage ships keep coming, what you do is you need to know this damage stability calculations.

(Refer Slide Time: 42:19)



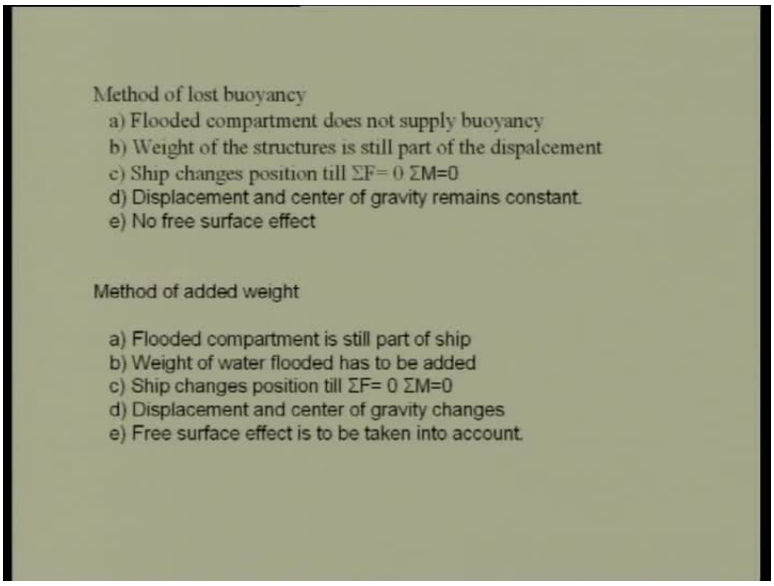
Two methods are very famous in this section and these two methods are usually defined as method of lost buoyancy - I am repeating please remember these two names - and method of added weight these are two ways in which you can calculate damage stability or flooding.

Now, when a ship first of all you have the ship suppose that some section is now damaged or some compartment is damaged, so what happens? Water has enter into the compartment. Initially what do we have? We have some weight of the ship something inside the ship lot of items inside the ship and this weight acts down and the volume itself produces a buoyancy force upwards that how it is usually.

Now what happens? Water has entered such inside, the weight of water and the volume of the compartment get cancel out each other. There are two ways in which we can solve this problem, what we can do is that, see in that section the weight and the buoyancy are cancelled out each other. What you do is, you assume that in the method of lost buoyancy - this is the first method, the other method we will describe later - method of lost buoyancy, we assume that, that section is really not a part of the ship any more.

When you do that because that was a part of the ship and there was a buoyancy from that. Now, water is there, that water balance the weight of the buoyancy from that section therefore, it is like that is no longer there you can neglected it, the total that region is remove completely, so the ship is without that compartment that is how you do proceed with the calculations.

(Refer Slide Time: 44:28)



So, something we can directly read, this is the method of lost buoyancy. You can say that the flooded compartment does not supply buoyancy, so this directly means that is not part of the ship any more. Remember the weight of the structures in the ship does not change that, buoyancy is lost that is all and weight of water is lost means, the weight of the water that is entered is cancelling the buoyancy, whatever is there in the ship is there that means the weight is not - is it clear because this should be clear.

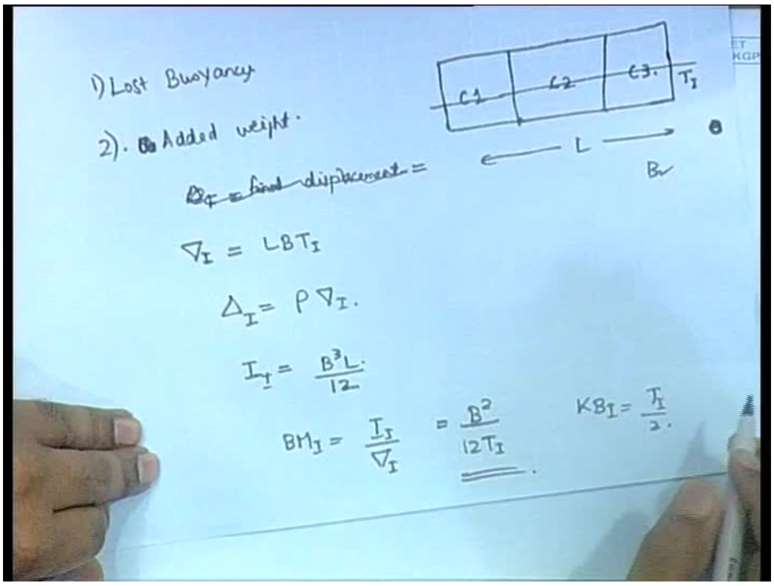
What has happened is the ship as such there is no change, water has entered and water has cancelled out the buoyancy therefore, there is no more buoyancy of that part, water is an additional thing but, whatever weight is there inside it remains as such, in ship nothing is changed except that buoyancy from that section is lost, so that is what it is.

What is says is it that the flooded compartment does not supply buoyancy. Now, you can see that weight of the structures is still part of the displacement of the ship then, as I go to d that is once you have. So, since the weight of the ship or the position of anything in the ship hasn't changed what has happened is displacement remains same and center of gravity has not changed because none of the items in the ship we are changing.

In nutshell I am putting the whole concept of of lost buoyancy and added weight. If you want you can take this down because it is not written this clearly in the book just these are the important points of lost buoyancy and added weight. Since we assume that the compartment is no longer a part of the ship that water that has entered is also not a part of the ship, so water is also not part of a ship and buoyancy is not a part of the ship that much we have cancelled out that is not a part of the ship. Therefore, there is no such concept of free surface effect.

Free surface effect means due water that has entered that compartment remember when water enters the compartment you know what is the free surface effect that free surface will come and it will when it goes slants up it will produce. Since this part is not consider part of the ship and that water is also part of the ship free surface effect does not come into this calculations. This is more or less the main points of added buoyancy actually when we describe things detail it will it will become very clear, because there always is a slight confusion in this but, it is very straight forward.

(Refer Slide Time: 47:52)



So this is the method of lost buoyancy we can just Therefore, what we can say is that delta final, which is the final displacement is equal to one minute oh i sorry this is added weight because I made it because the displacement does not change in this so I haven’t explained added weight still we will just do the lost buoyancy right now

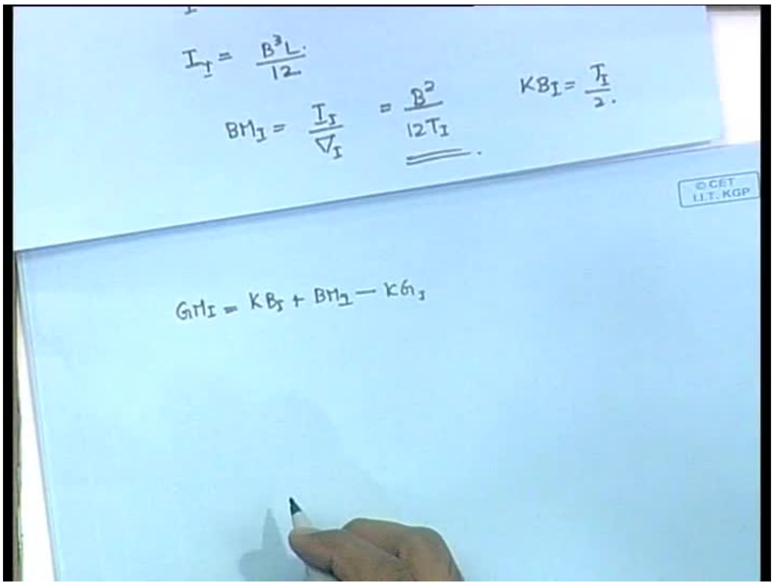
Let us do this, initially we have delta 1 delta initial del initial is your We will do one thing, let us take a very simple case like a box - let us take a box like this. Let us divided into 3 compartments; compartment 1, compartment 2 and compartment 3. Let us suppose it has a draft of t initial T I - I stands for T initial.

Let us assume that this middle compartment gets flooded, so C 2 is; this has a length L and it has a breadth B things actually become much more simple when you do these box shape things, like I all those things we can calculate very easily, so we use this for the time being, so we have length breadth and draft T I.

So, the initial displacement of the ship is given by LBT I which is l whatever you have your LBT I and the mass displacement or weight displacement is equal to rho into del I, this will give you, you can call it delta I, this is the weight of the ship.

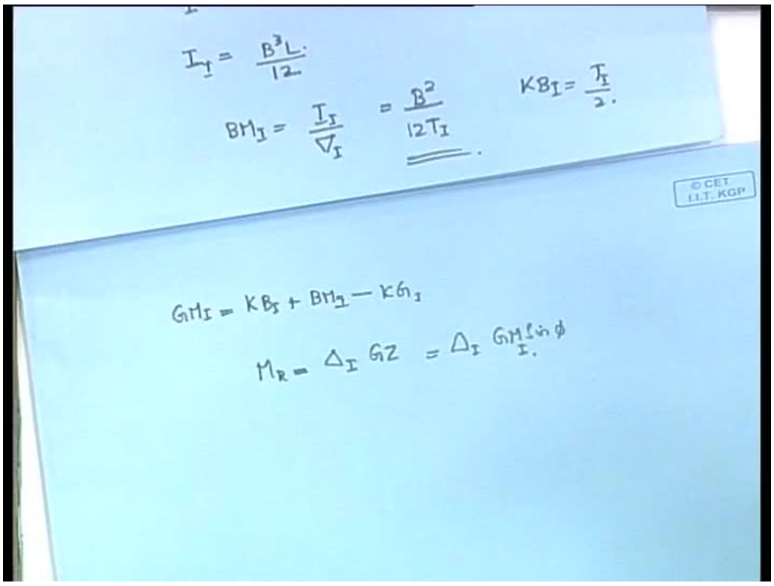
This is before the ship has flooded we are doing it two ways, same thing I will do it finally, we are doing the method of lost buoyancy. First, we will just describe the steps you know all these steps but, still I will do this. So, delta I is known, suppose I need to calculate the moment of inertia about the center line I is defined as I initial is equal to B cube L by 12 and the initial metacentric radius BM initial is equal to I initial divided by del initial.

(Refer Slide Time: 51:31)



You know this because it is a box shape barge it should be B square by 12 T I, so this will become BM, this will give you your BM initial and position of your center of buoyancy initially will be T I by 2. Now, your GM initially will be KB, initially plus BM minus KG, this will give you your initial GM which will KB is T by 2 T is the draft T by 2 will give your KB, BM is got by I by del that will give your BM and KG; KG in this case is just a half if we have not given the depth, well I think the depth is also given probably.

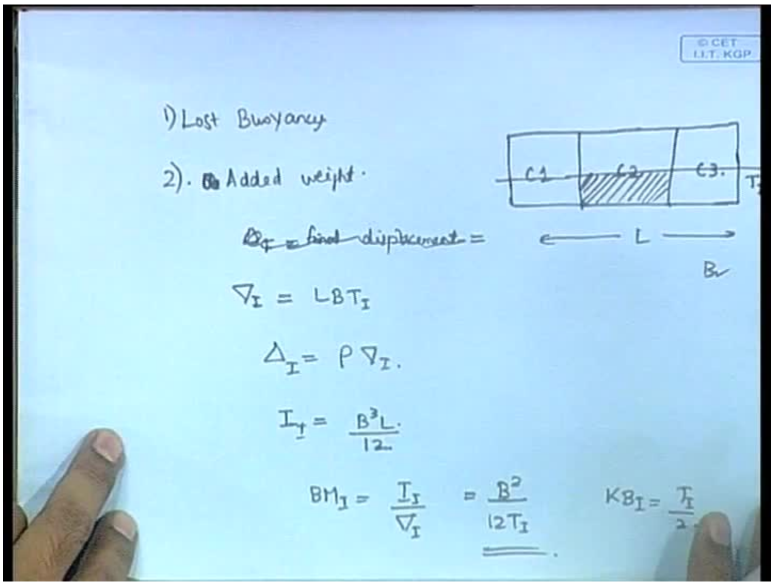
(Refer Slide Time: 52:38)



Depth is also given and therefore, KG actually they haven't written KG, it is the half, it is somewhere exactly in between. Now, one more thing I will just we need to know, here is the righting moment in this, this condition is given by M R equals delta initial into GZ which is equal to delta initial into GM sin phi or GM initial sin phi, so this will give you your initial righting moment.

Now our next purpose is, once you consider the method of lost buoyancy what will be all these things you start from del actually, that I have already said del is the same we are not changing the we are not assuming that the weight of the ship has changed, so delta is same.

(Refer Slide Time: 53:27)



Then, I will change, we will see now the next problem is, when this region is flooded means, we assume this much is flooded. Then, we do the problem and we see finally all these things. Finally, we have to find the righting moment in the case when we have to find GM and then finally, the righting moment when the ship is flooded in one of the compartments.

After we finish this method of lost buoyancy I will start with the method of added weight and then, we will see that both these method heeled exactly the same result is whatever you are doing it is the same thing is doing, so the same result will get. Now, I think I will stop here the next section is little long, we will do it in the next class.