Hydrostatics and Stability

Prof. Dr. Hari V Warrior
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Module No. # 01

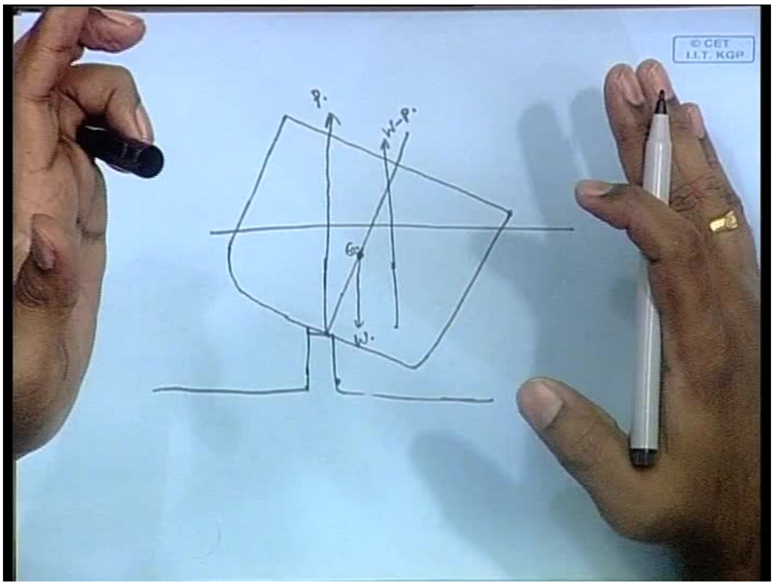
Lecture No. # 28

Dry Docking – II

So, in the last class, we are doing, we were talking about the dry docking, where we take a ship to the dry dock which will reduce, lower the water level, and consequently, finally, the ship will, I mean, the ship will keep going down, till it finally touches the bottom, and then, there is a reaction force which supports the ship. Consequently, the buoyancy force gets replaced by the reaction force completely, and then, they put these keel blocks, the whole, the things onto the ship is held firmly and then it is ok.

Then, the water, you do not need the water to hold the ship. So, now they were doing some derivations, which we did not complete yesterday in the last class. So, let us do the same thing. One part we did. The second part, we will we need to do that is consider this.

(Refer Slide Time: 01:24)



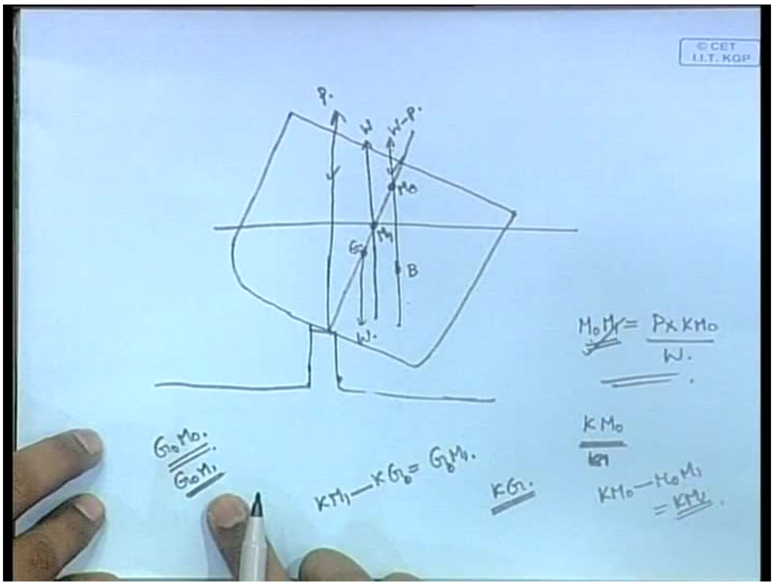
So, we are having a ship that is being dry dock. So, from here we are having the reaction force, from the ground p is a reaction force. Then, let us assume that this is the center line of the ship, therefore at this point, you have G. The center of gravity of the ship, at that point, the weight of the ship will act down w.

Now, there is a buoyancy force acting on the ship. We know that the buoyancy force will be given by w minus p. Now, this problem, the question in this there are two derivations right now which we did. One we completed in the last class, one which we did not do, now the two derivations. What is the purpose? The purpose is to find how much the GM changes-that means the metacentric height. How much the metacentric height changes as a result of this dry docking? So, that is the purpose of this purpose of two exercises.

Now, the thing is there are two ways in which you can see a change in GM. For instance, you can look at in two ways. One M can decrease, then lets K is fixed. Let us fix G. Now, there is a G, there is an M initially and in that is when there is no p that is when there action force from the ground has not come, there is a keel which is fixed always and there is a G and there is an M.

Now, the way in which we can change GM is for instance, suppose the M moves, then the GM can change. K is fixed but the GM is moving, so the GM can change. G is also fixed, I mean k is fixed, G is fixed, M is moving. Therefore, the GM is changing. Now, another possibility is K is fixed, M is fixed, G is moving. These are two ways in which your GM can change, now the two exercises or two ways in which you can look at the change in GM. I will explain what I mean by that for instance. Let us take the first one.

(Refer Slide Time: 04:05)



Now, look at this figure that is, we have the reaction force p and we have w minus p, the buoyancy force act. Let us say, this is B, which is the center of buoyancy. Here, w minus p is acting. Here, p is acting and G, now there is one. There are two ways actually in which you can view this p. For instance, p number, one way is that p can be viewed as an additional buoyancy force. It is not a buoyancy force, it is a reaction force but you can look up it as a force upwards anyway.

So, you can look upon it as an additional buoyancy force because the real buoyancy force actually becomes smaller, when you compare it with p. Therefore, this p can be compared as an additional buoyancy force acting at a different point. It is not acting at B, but it is acting at some other point. It is like a buoyancy force, that is number one. One way in which you can view p.

Number two, you have the weight of the ship is acting at G. That is the displacement of the ship acting at G. You can assume, that p is like a negative displacement. That is the second way to view it. See p is upwards, it is the force upwards. You can view it as it is a reaction force, anyway. It is not buoyancy, it is not displacement. It is not either of these, but this is the hydrostatics and stability problem. So, we are interested in buoyancy and displacement. So, two ways in which we can view p is, one, you view it as a buoyancy force acting at a different point, not at the center of buoyancy. Another view is it is a negative G, negative displacement. It is upwards. It is negative displacement acting at some other point. So, these are two ways in which you can view the same thing.

So, what happens as a result? First case, you have the ship, first without p and then, with p. What happens is that when, so you when this p comes, there are two buoyancy forces. Now, there is w minus p acting at the center of buoyancy, and there is p acting somewhere and a resultant of these two, it can be assumed to be acting at some of the centroid of these two. This is what we did in last class. We I will just explain quickly, what I did in last class also.

So, this will give you w acting somewhere in between the w minus p and p means there are two buoyancy forces. One here, one here and as this figure shows, there are two buoyancy forces, w minus p here and p here. So, you can assume that there is some total forces is, obviously w minus p plus pw acting somewhere in between, at the centroid of these two forces. Imagine there is a third force w, but that we are not considering right now. We are just saying, there are two buoyancy forces and at the centroid of the two buoyancy forces, the net buoyancy force will act. The total buoyancy force will act at the centroid of the two buoyancy forces.

So, at this point, somewhere in between, we know where it is because we know w minus p and we know w. So, we in we know w minus p and we know p. Therefore, we know where this w will act because there are two forces acting, its centroid you can find. When I mean that is what we put an x and y and we got the equation. Now, this is the first part. This is the first way of solving. Now, what happens as a result? What happens is that, when you have this w minus p, and an additional buoyancy force, your M, see your initial M is here.

Now, because initially your M is here, your M actually can be assumed to be at M1 now. When you assume that p is a buoyancy force, what will happen is that, the result is that you will see that your M has come down. Your mathematics will show that your m has come down.

Now, what has happened? G has not changed, G is still the same. So, your GM has decreased. This is the first part and we got an expression for this change in M. I would not do that again. M0 M1, it became like this, it came like this. This is M0 M1. This is the distance through which the metacenter shifts. Therefore, if you have our initial KM0 and I mean, K once you have the initial KM0, which is how do you get that. It is always got from the hydrostatic data. Hydrostatic data will always give you KM. So, KM0 means without any p that is actually once you consider the ship, there will be some KM. Note that K, a metacenter is always defined for a particular draft because if the draft keeps changing, your M will keep changing.

Basically, the metacenter is defined for heeling. So, you have ship like this. Initially upright and it heels, you know that when you pull. That concept is, we are clear now. At that point of B, where the center of buoyancies you draw vertical, where it hits the initial vertical that is called as the metacenter. That metacenter depends upon that draft at which it is exists and it is heeling. That is the draft at which it is heeling. That is what it depends on, and if the initial draft is here, there will be some value of M0. It will be here.

If the draft increases or decreases as it go up or down, your M0 will be at some other point. So, your KM0, which you call as there is no term for KM0 as it is or your metacentric height GM0, any of it will depend upon your draft. So, right now here, we have KM0. Suppose, you are given KM0 that is your hydrostatic. From the hydrostatic data, we have KM0. Once you have that, then using this equation, you can get M0 M1 provided you know p.

One way to find p is again from the hydrostatic data. That is what will happen that is, I will explain. That is what happens is that ship is initially put; I mean it is in the dry dock. There is some draft, it stays at some draft. Then the draft keeps coming down and finally, that due to the change of draft, there will be a change in volume in the displacement and correspondingly, a change in the up rest.

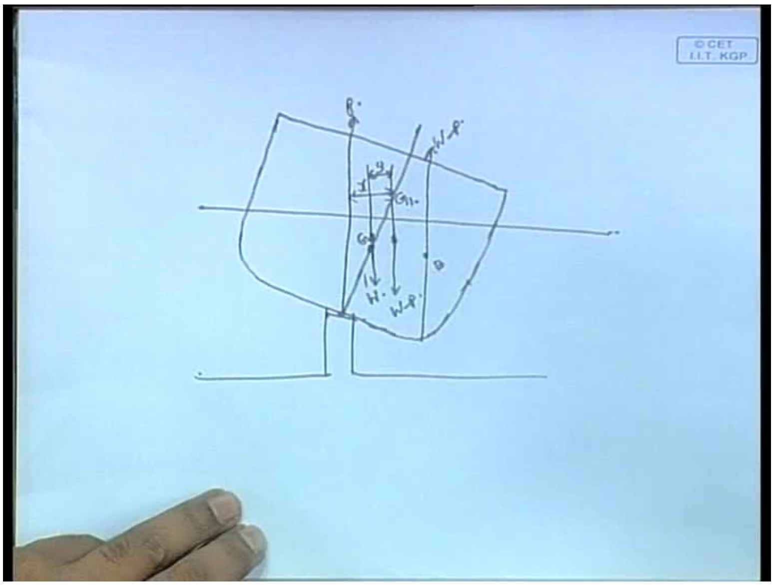
Now, that change will be bound or it will be taken up by this p. Finally, when it comes down, that difference will be taken up by p. That is the reaction force. So, suppose you see that the change in draft is something you that we will be given that. If we know, once we know the change in draft, we from the hydrostatic data, again we can find the hydrostatic curves. In fact, so that also, I will explain that is usually, you are given some curves which will say draft verses displacement.

So, once you are given, so for each draft, you will know what is the displacement of the ship? Once you know the hydrostatic curve, so that of course, you need to do this problem, but once you design a ship, you are going to design all that, so that initial design. Once you do all that, all this comes with you. This is known as the hydrostatic curves. The whole thing comes with you. So, you look at that, you find the displacement at each draft, so you find the change in displacement that draft you can always read. I mean any dry docking an easily change see the change in draft, read the change in draft, read the from the hydrostatic curve, find the change in displacement, find the change in weight that is p that will be bound that when that touches the ground that will bound by the weight of the keel block.

That will take the weight, so that is what this is. So, this is the first way of doing it. So, you know KM0 from here, you know KM0 M1 means the change in metacenter. So, if you do KM0 minus M0 M1, you will get your KM1. That will give you, and if you know the position of G, I mean if you know KG, then note that in this method of derivation, G is not changing. G is fixed. Therefore, this KM1 minus KG will give your GM1. In these derivations, we usually write it like this G0 because G is not changing at all. So, it becomes G0 M1.

So, there are initially, there was G0 M0 which was before the vessel touch the ground before dry docking or before the critical instant. I defined critical instant is the instant at which the ship touches the keel block.

(Refer Slide Time: 13:42)



So, before that, it is G0 M0. Then, it becomes G0 M1, according to our, this method of solving the problem. So, this will give your new position of GM. G0 M1 is your new

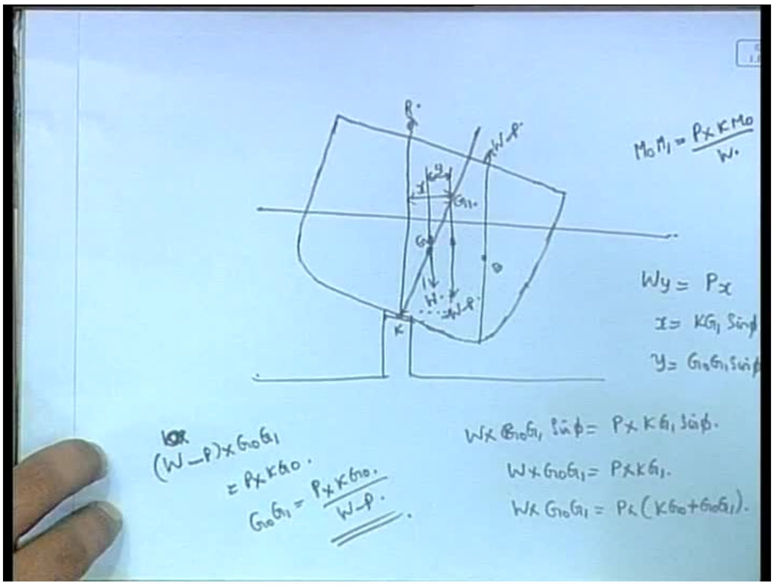
GM, and if this GM has become negative, you know that the ship has become unstable. This is first way of doing it. Then, the next way of doing the problem is same thing. I will do this, so this is the center line of the ship. Initially, you have G here, and you have the weight w acting. Now, what do we assume? We assumed that there are two ways. Now, we have of course, at this point there is B, the center of buoyancy and of course, there is w minus p acting here, but that is not, we are not bothered about the buoyancy part in this problem, in this way of definition.

So, what we are doing here is that we assume that p, which is the reaction force is like a negative displacement. So, right now we have two displacements. One is the weight of the ship acting down, and there is a negative displacement p acting somewhere to the side or acting here. There is a negative displacement. So, what do we have? We have a resultant which is w minus p, actually it will act somewhere. If you do it, you will see it will come here. Since, the forces are in opposite directions, will come here; w minus p will be a force acting here. Now, same concept has before, w minus p will be the centroid of these two forces w and p. We can take the distances as this as x. Let us take this as x and this as y. Then, so see what you have here is, this is your G0. In this particular case, what you have is, so before you have p coming, you just have w acting at G0. This is G0.

Once you have this p coming, you are assuming that there is new displacement, which is a resultant of this whole initial. I mean this w, and the reaction force which is w minus p; it is acting at a slightly different point. It is acting here. This is G1 G0 and it is G1. Now, in this method of derivation, what has happen? Your G has moved up. So, actually it makes no difference. You will see when you do, the slight difference is there, of course, in the calculations but like 1, 1.2 meters, you will get difference. Other than that, you will see that when you do, the GM is using the two methods.

One in which you assume that, there is a decrease in the metacentric height because you assume that p is actually a buoyancy force or number two, you assume that p is a negative displacement. In that case, there is an increase in GM, increase in the point or a going upwards of G. G goes upwards, there is a new G.

(Refer Slide Time: 17:11)



Now, that either way, whether G goes up or M comes down, there is a change in GM. There is a decrease in GM that remains same, and it is just the way in which you look at it. Let us, I mean, let us derive this expression. Now, same thing, we say that now, as you can see w minus p is the centroid. Therefore, W into y will be equal to p into x. This is W, W into y is this distance p into x.

So, P into x is the moment causing like this. W into y is a moment causing like this, there in balance because this is the centroid at that point then. Now, it just a some like x. You can just look at this figure, you will see. You know what G0 G1 is. See you have to make these triangles.

This is K. You make this full triangle, so you get, look at this triangle. You will get this, KG sin phi and y becomes G0 G1 sin phi then. Therefore, w into G0 G1 sin phi equals p into KG1 sin phi or w into G0 G1 equals p into KG1 w into G0 G1 is equal to p into KG0 plus G0 G1. Therefore, w into or you can, I will just bring the w minus p into G0 G1 equals p into KG0.

Therefore, G0 G1 is equal to p into KG0 divided by w minus p. Now, what we get for a previous thing? We got, we saw that in the previous case, we saw that M0 M1 was p into KM0 divided by w. Now, at any write you need some, this we will see how to, we will do some problem to compare the values. So, this is two ways which you are doing the problem. One in which m comes down, one in which G goes up. Problem is the same; it is just two ways of doing the problem.

(Refer Slide Time: 19:56)

Draft	Disp. at 5 m draft	Disp. (W-P) tonnes	P (tonnes)	G_0G_1	KG_0	KG_1	KM_0	G_1M_0
5	17052	17052	0	0	11	11	14.08	3.08
4.5								
4.0								

Now, what I thought this time is that, these problems that I am having instead of my writing down all this, I will put it in the screen. So, you just read it like this. For instance, the first problem, I mean I did not write the whole problem. See, the problem says that you are given some ship that is to be dry dock. This I started in the last class. Now, see you are told that the initial, the ship is initially at the draft of 5 meter. So, it is at a draft of 5 meter, then displacement is at given at 17052 tonnes.

Then, what happens is that the p keeps increasing, the ship is being dry dock. So, slowly the weight of the ship or the displacement of the ship, the draft comes down. Therefore, the buoyancy decreases and the weight displacement w minus p, w minus p decreases. Now, or rather in this case, you can see that the p keeps increasing. I have not written down the value.

Now, this is the problem is that you are given the hydrostatic data. You are given KM. This without this, you cannot do. KM values are given like different values at different drafts have to be given. I did not write the whole value but that whole, there is the big table. So, like this 14 point naught 815 point naught 6 like this, the KM 0 will come for different drafts. Now, your question is to find out the draft at which the ship becomes unstable. Now, how will you figure out the ship is unstable? You will figure out by saying that at that point GM becomes negative, GM becomes 0 exactly. So, GM becomes 0. I mean when you are doing this table at some point, you will see that the values become negative.

Actually, you have to find it at 0. Exactly, so G1 GM becomes 0. So, you have to do that then. So, for that you need to find out, how the GM keeps decreasing. Now, this is a very straight forward problem. We have seen how the GM keeps decreasing. There are two ways in which you can solve the problem as we said last time. You can keep decreasing our M and find your new value of GM are you can keep increasing your G raising up your G and finding out the new values of GM.

In this particular problem they have actually trying to, I do not think there is anything like that. If you do that there is the slight difference.

First of all, actually you should get exactly same. It is because of errors in the values of see KM it is not always accurate means like here. You see this draft KM0 14 point naught 814.26 like this. There are not absolutely accurate that is the one problem which does both values and sees which I mean how close they are. The difference is of the, we will do it and see difference is of the order of, I mean I will give you 0.5270 meter GM and the other case, GM becomes 0.52395237 and 5239 something like that. So, at the very difference, it is both are same. It is actually we are doing the same thing because if you think of it actually you can see p is p in that derivation p is really a not a buoyancy force or it is not a negative displacement but it is something that can be seen as both. It is there is nothing wrong if you say that p is a buoyancy force because it is like a buoyancy force, it is acting somewhere up.

In the upward direction behaves exactly like a buoyancy force, so if you do the (()) and you know that initially the ship there is some at that point some there is some buoyancy force and when it is coming down means when the buoyancy force shifts wherever the buoyancy force is acting, wherever it is hitting the center line that is the metacenter.

So, it is the final metacenter. So, that is absolutely correct. There is no assumption in any of it approximation; there is no any approximation in either of these derivations.

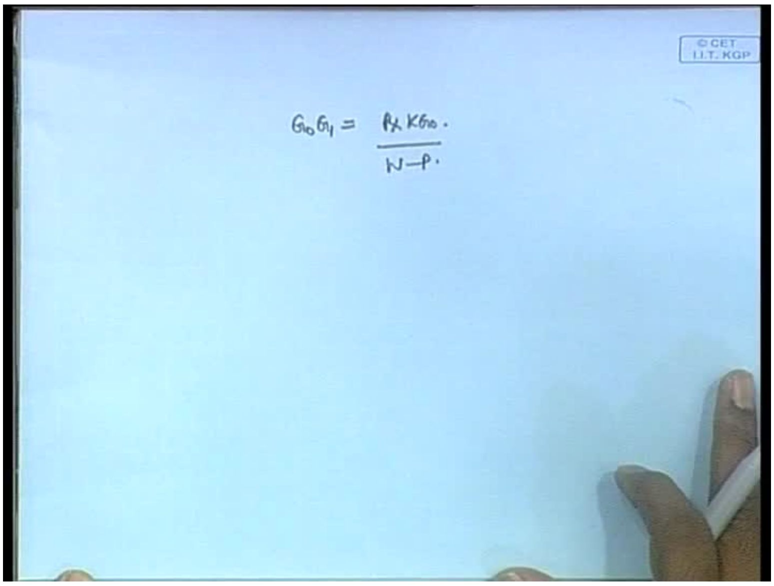
(Refer Slide Time: 24:15)

Draft	Disp. at 5 m draft	Disp. (W-P) tonnes	P (tonnes)	G_0G_1	KG_0	KG_1	KM_0	G_1M_0
5	17052	17052	0	0	11	11	14.08	3.08
4.5								
4.0								

So, both are absolutely correct. So, no such thing as which is better or thing but usually, they use this one KG better because the other one you need KM0 because hydrostatic data KG is known always because it is the very important thing. KM is not that commonly use, so because of that I would say that we will use this one KG instead of KM.

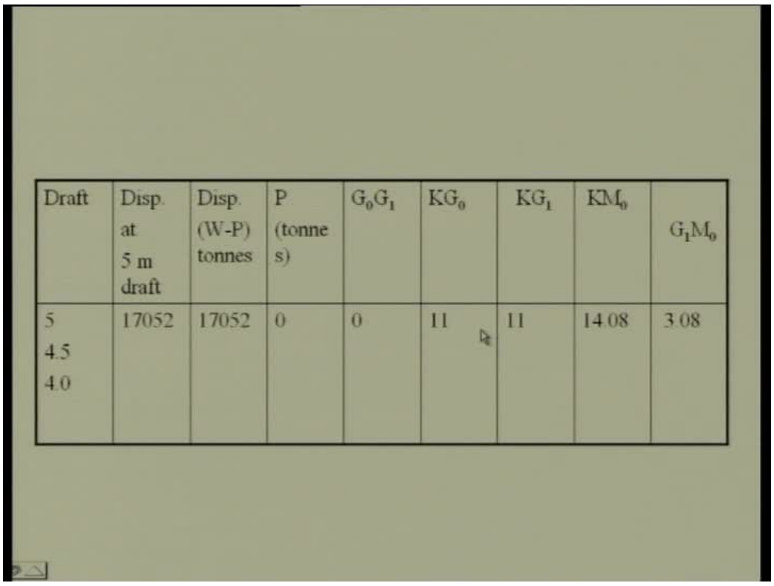
So, this formula is more useful than the other formula though both are same then. So, in this case, what do we have? We have displacement is given as you can see this column displacement at 5 meter draft 17052 this will remain the same all throughout because at it is 5 meter drafts. Then there is no really no point in this column as such but then this is p, p will keep increasing. 0 it becomes180020003000 5000 like that p keeps increasing and therefore, w minus p will keep decreasing. So, the value 17000, it will keep decreasing. It goes down up to in fact, up to 6000 at around 2.5 meter water line. It will be by the time it will become about 8000.

(Refer Slide Time: 25:26)



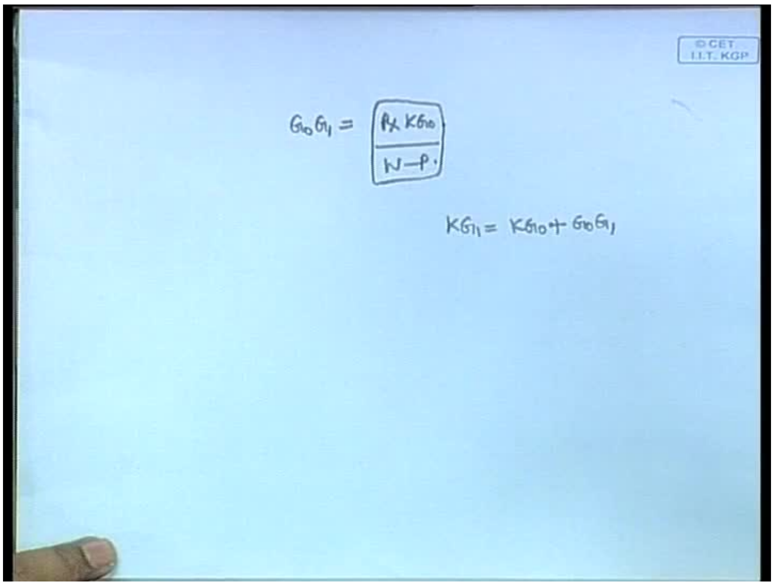
Now, the only thing here is to do this thing, this formula. This of course has to be given, KG0 has to be given. It the center of gravity of the whole ship that has to be given KG0 means when the ship is designed or when it is not dry, it is not about dry docking. When the ship in its usual condition, what is its G0 that we need to have. It is given in this problem is as 11 meter and KG1 is your new KG which keeps varying as the draft keeps changing.

(Refer Slide Time: 26:01)



Draft	Disp. at 5 m draft	Disp. (W-P) tonnes	P (tonnes)	G_0G_1	KG_0	KG_1	KM_0	G_1M_0
5 4.5 4.0	17052	17052	0	0	11	11	14.08	3.08

(Refer Slide Time: 26:09)



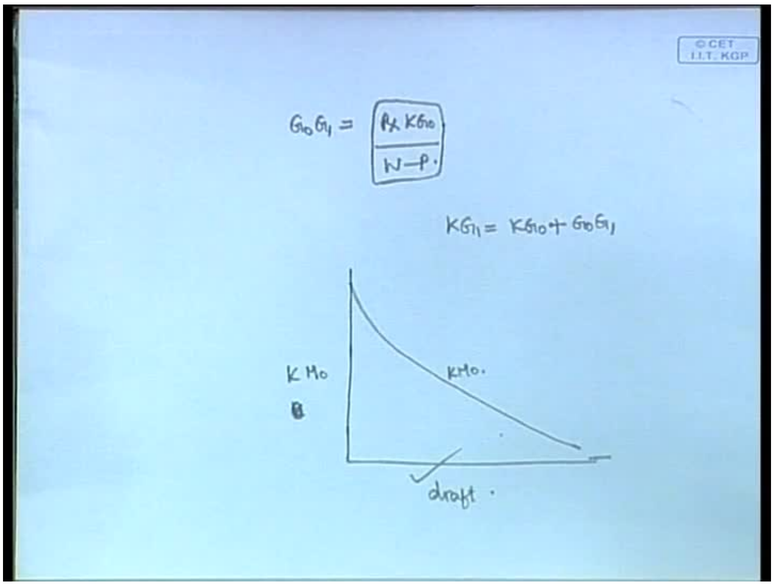
So, as the draft keeps going down, G keeps going up and as a result, your KG1 which is equal to KG0. No, sorry G keeps going up exactly, so KG0 plus G0 G1. So, your G1 keeps going up or G keeps going up and therefore, your KG1 keeps becoming KG0 plus G0 G1 and at any point G0 G1 is given by this formula. P into KG0 by w minus p everything we know that is the only p is again I told you p is the displacement at every draft.

So, this needs the hydrostatic curve. Again, you look at the hydrostatic curve. You have the draft. For that draft, you read the displacement from that curve. From the hydrostatic curve, you can read it directly. So, when the draft keeps decreasing, your displacement will keep changing or total displacement will keep coming down. It becomes w minus p and therefore, from that you get this w minus p at each.

The thing is that you keep doing at the steps like draft. You change from 54.5 43.5 like that keep changing it in steps. As the rest of it, the other one will also keep changing in steps and you put it in this table like this and so you keep doing this. Now, see this KM0. Please note, KM0 is also not it might seem as if the KM0 is the constant for a whole column. I should probably have written a couple of more values but this KM0 is not a constant for the whole table because KM is defined as a value that is another thing.

KG for instance does not depend up on the draft in that sense because it is the weight of the ship. G is that does not change but those are some of the advantage of the second method compared to the but KM will change it depending on the draft M will be at some point and when you change the draft M will shift. It will come down or go up. We can actually I will draw this figure, it looks like this.

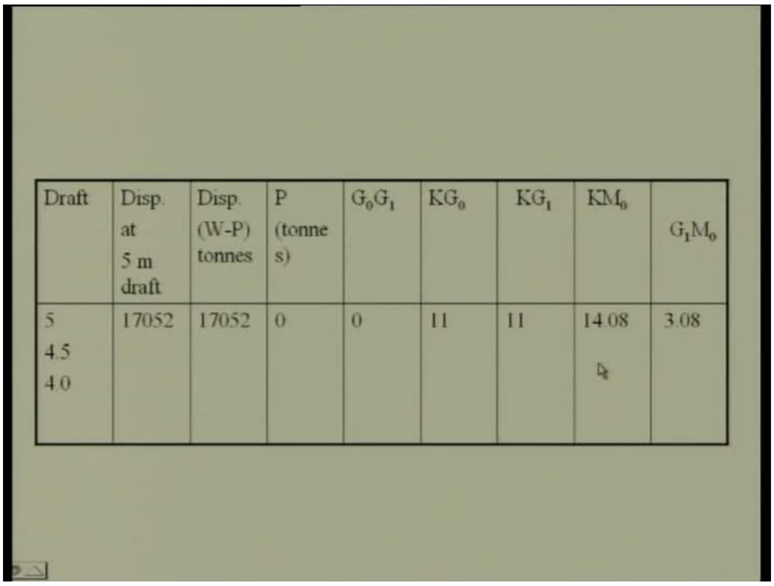
(Refer Slide Time: 28:29)



So, KM0 are all these values. KM0 it is actually comes down like this. No, it is KM0 that is good that is the good point but I will it is KM0 because M0 means when the ship is in up right condition, ship can be in an upright condition at different drafts. It is a different draft but in the upright condition that is the meaning of 0. There are two processes happening here. One is heeling that is what metacenter is really associated with it and the other one is the change of draft change of draft. I mean all that you did previously was just dealing with heeling. There was no draft was all fix. We never talked about draft at all. That point I mean there was draft but no change this time. M 0 means 0 heeling that is all.

Here, the draft is changing. So, it is that is what, so KM0 comes down like this. So, this is how your KM0 will vary. So, as your draft keeps increasing, your KM0 is actually coming down. Then, so this kind explains how the KM0 comes and that is how this table also says KM0 will actually change. So, correspondingly here what is happening? The draft is decreasing, therefore KM0 should increase. So, KM0 will keep increasing 14 point naught 8 at the end, it becomes 28.8.

(Refer Slide Time: 29:58)



Draft	Disp. at 5 m draft	Disp. (W-P) tonnes	P (tonnes)	G_0G_1	KG_0	KG_1	KM_0	G_1M_0
5	17052	17052	0	0	11	11	14.08	3.08
4.5								
4.0								

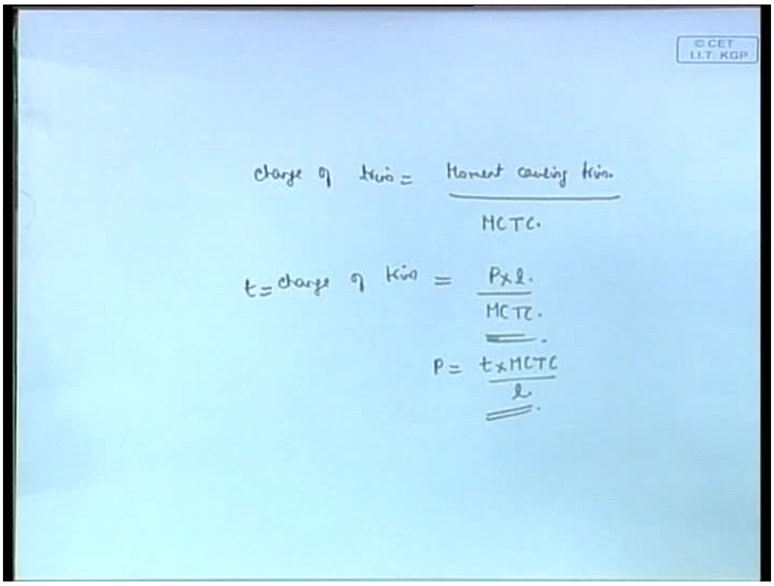
So, KM0 will keep increasing, so this is your problem. I mean this is quiet straight forward. This is the process of dry docking. This is how you calculate. Now, the others are just problems which just with some twist and all that is that we can do we will do. Now, one more thing is that I have already told you a ship is always mostly trimmed by this stern.

Now, we are going to kind of combine the two. We have already done trimming. Now, we are going to combine trimming with dried docking or when you are dry docking if you remember. In trimming, we talked about a change in density and that produces a change in draft as if you remember that produced a trim just like that. This is also a change in draft due to a different reason. This also produces a trim. Now, we will just do at the instance of dried docking as I told you before the dried docking. I mean in general shift move like this means the stern is down, then goes up. Always in general, the ship is always like this and when it is dried docking also, it is like this. So, it comes down like this. So, in general in 95 percent of cases this will hit the ground first. So, this is where the ship first hits the keel block.

Now, when that happens, let us at that instance the critical instance which we call. So, when it keeps coming down, it will hit. So, at that point there is a p acting here. It will be acting only at that point, it is only this point as hit.

We further the simplicity purposes for our purposes we will assume it is half perpendicular. So, the half perpendicular hits the ground first and at that point the p acts up and therefore, what will because of this that there is some trim going to happen. We always define change of trim is equal to the moment causing trim divided by MCTC. That formula you just memorize. That is it is very straight forward and it is, so this one change of trim is equal to moment causing trim divided by MCTC.

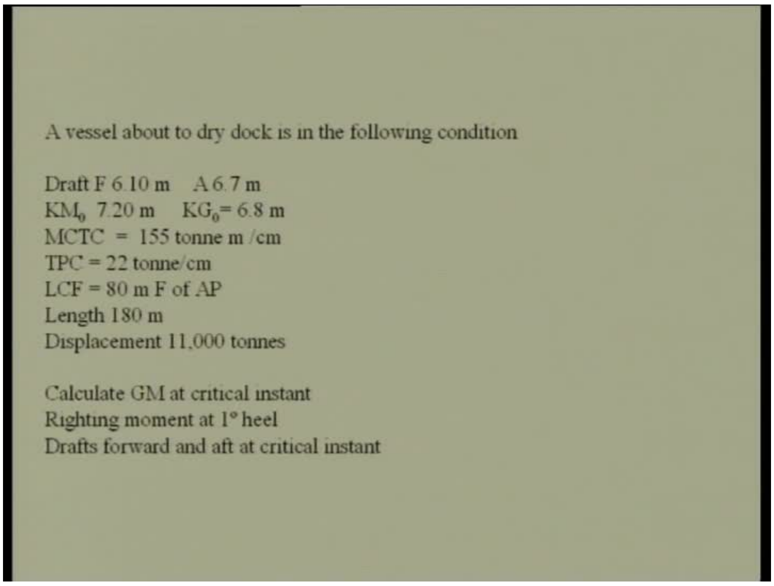
(Refer Slide Time: 32:32)



So, the new moment that comes here I mean the new force that comes here, actually this p. So, this p will give you the new moment. So, what will remember moment is always taken from the center of floatation that is how we have defined it. Therefore, the new force that has come is p at a distance of we usually defined that distance of the center of floatation as small l. If you remember that derivations in the previous chapter small l represents the distance between the half perpendicular and the center of floatation. So, the distance between p and the center of floatation is small l, therefore a moment causing trim in this case is becomes p into l.

So, the change of trim becomes p into l divided by MCTC. This is a particular case and for the purpose of this course, you can assume that if you have a problem where you have dried docking combine with trimming, always you will have this thing the half perpendicular hitting and this thing whole this formula whole and you have the change of trim given by this formula change of trim is given by this formula P into l by MCTC. Now, so this is usually written as t, I think t is equal to or just t into MCTC by l.

(Refer Slide Time: 34:41)



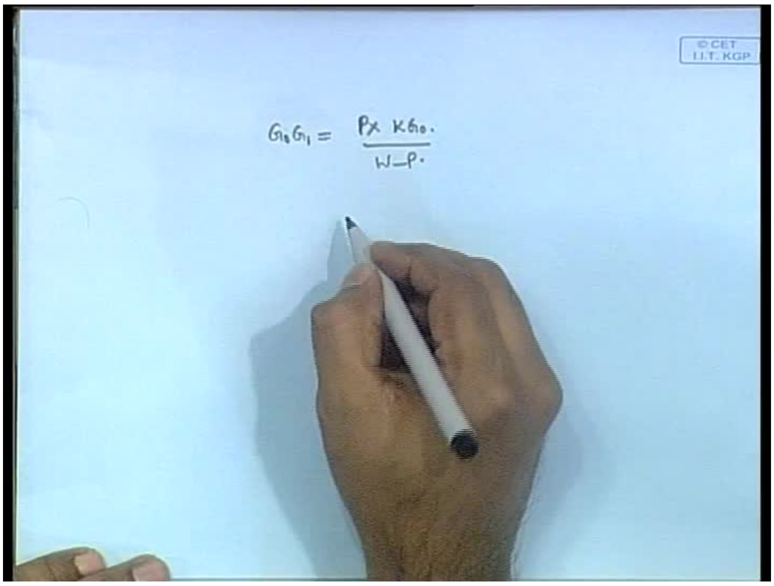
Now, we have some problems. I change I put the problems up in the screen. Now, I will put here and read this. Now, this is the problem. So, a vessel is now about to dry dock and it is said to be in the following condition. You are given that the draft forward is equal to 6.1 meter, draft aft is 6.7 meter, oh this is the particular case.

Draft forward is more than draft aft, then KM 0 is 7.2 KG 0 is 6 point. These have to be given. You have, these are the hydro static data, then MCTC is given, TPC is given longitudinal center of floatation is 80 meter forward of aft perpendicular length is 180 meter and displacement is 11000 tonnes. So, you are told that there is a critical instant when the ship hits actually, no it is correct only. Sorry, that is draft forward is 6.1 and draft aft 6.7, so aft is more I do not know why I got. Anyway, so alright. So, length is 180 meters, displacement is11000 tonnes, you are asked to calculate your GM at the critical instant.

So, the question is the moment you are asked to find GM, you know what you have to find. You need to find that G0 G1. Definitely, that means you have to find the change in G. The initial GM you can easily see from that look that data, I mean look the problem itself. Your given your initial case a KM0, you have your KG0. You can find your G0 M0. So, that is directly given. You have to find a final GM which is written as G1 M0.

This see we are not changing M, here M0 we are not changing, here we are changing G1 M0.

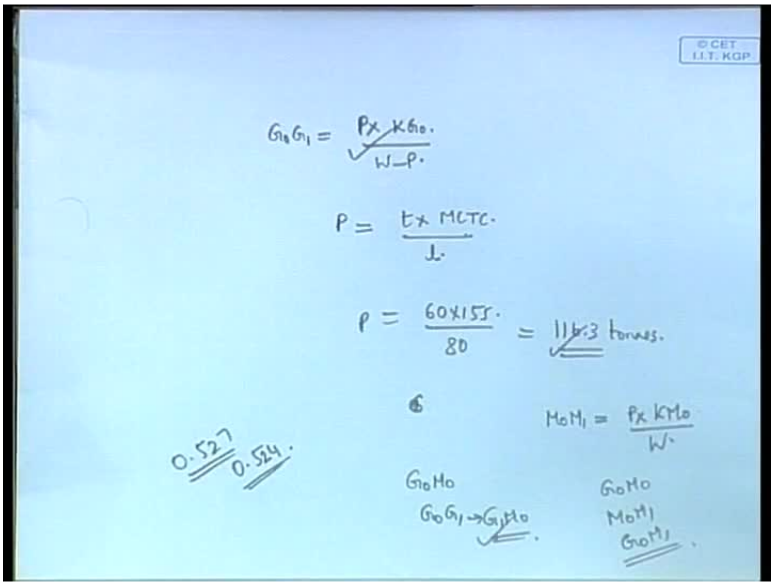
(Refer Slide Time: 37:01)



Therefore, our problem is to find G0 G1. Now, you need to find your G0 G1. G0 G1 is always given by this formula p into KG0 by w minus p. Now, as you can see we need to find in this problem KG0 is known w, we need to know p. So, we do not know p. Now, how can we find p? It is as you can see looking at the problem aft is below, therefore it is going to dry dock like this at the critical instance, when it touches here p will come here acting here. So, p into l by MCTC will give your trim. Now, what we can do is that, no it is not the assumption. See the ship will go like this only.

So, you know what is that going to be. The trim you are given, the trim the initial trim is given draft aft I mean aft is 6.7 and forward is 6.1. So, the difference is that trim you know the trim and therefore, you can find p like using this formula p equals t into MCTC divided by lt is the initial trim. Then what they have? We assume here is that see that ship trims like this. It comes and hits here and then the trim becomes 0.

(Refer Slide Time: 38:02)



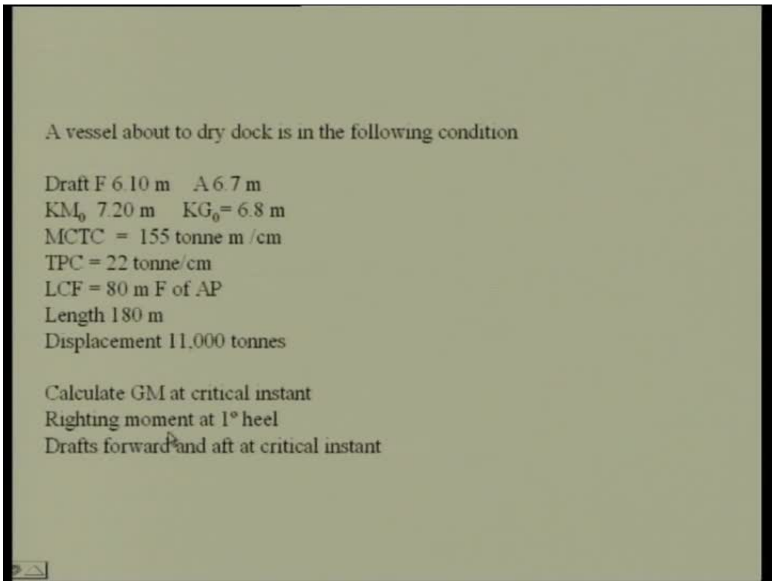
It comes like this, it hits here and then it becomes, so the change of the trim is the current trim. That is the problem. How the problem is done? I mean that is how you do this kind of problems when it is trim. It initial comes like this change of trim is current trim. That is how the problem is done. I mean that is how you do this kind of problems when it is trim, so when it trims. It initially comes like this, hits here and then sits down.

So, the change of trim is equal to the trim is equal to t into MCTC by l. So, this gives you p. This is the critical instance. When p is this, touches here and then it is just and therefore, at that point t into MCTC by l will give you p that you can just do. In fact, it will give you so you are given your trim is 0.6 meters. So, 60 into 155 divided by 80 becomes 116.3 tonnes. In this problem, now you can then once you know p, you can do this. You can get this G0 G1. Now, they have also done using that other method where you do M0 M1 instead of.

This is why this is to just to compare. It become the formula is this p into KM0 by w. KM0 is given, so p is known and therefore, w is also known. So, this will give your M0 M1. Now, the two ways in which you can solve is, now you have your G0 M0. You have your G0 G1. So, you can find your new G1. New GM which is your G1, M0 from this you find this. This is your problem. Now, other thing is you know your G0 M0, then you know your M0 M1. Then, you sum them up and get your G0 M1.

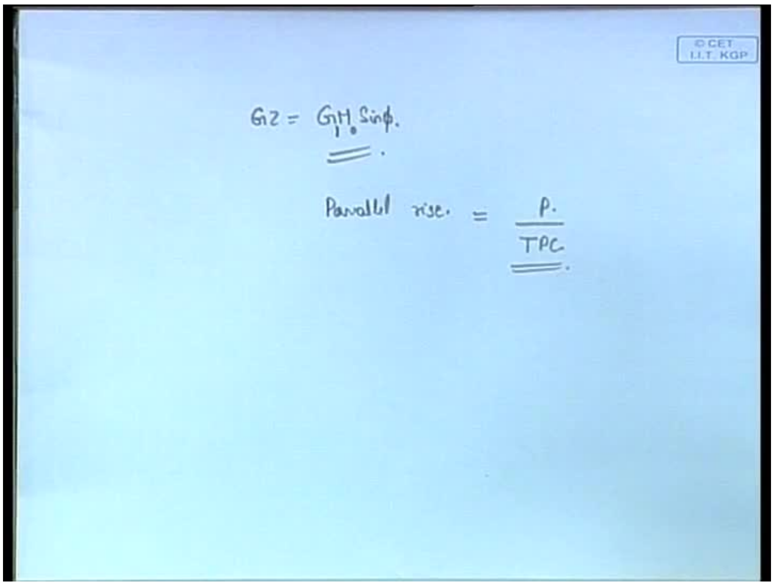
So, these are two ways in which you will have G0 M0 initially. Then, you have G0 M1 or G1 M0. Either of these two, so actually that is slight difference between two. Then, the other one is. So, these two, this much difference are between the two 0.527 and 0.524.

(Refer Slide Time: 41:24)



So, that becomes it is very small. It is negligible on most because that much of error will be there in a hydrostatic data. Anyway, you would not get that accurate anyway. So, it is just now in this problem we can see, you are asked the second question is righting moment at one degree heel. Now, it has turned at that point. Let us assume that it has a one degree heel at that point. What is your righting? How will you find the righting moment? Anyway, righting moment has only one formula. You do it using GZ; you need to know GZ that is all.

(Refer Slide Time: 41:58)

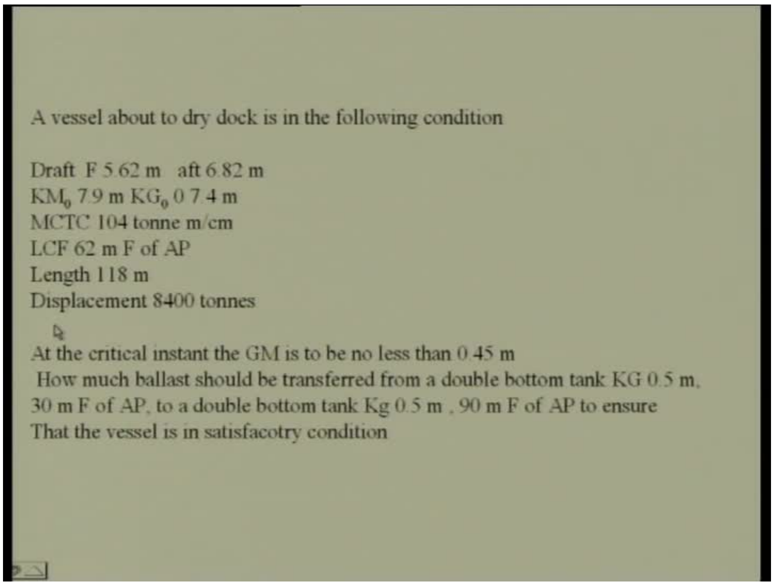


So, GZ is and you just need to know the formula. We need to put it as G1 M0 sin phi that is all GM sin phi. You just need to know, which GM it is. This will give your righting moment, righting arm. From that, you get the righting moment, so this you need to find out again. If you do the two methods, that is the slight difference, I mean two methods means, when you use your two G1 Ms like 100.2 and 100.5. There is slight difference in the answer. That does not matter. That is, then how will you find out?

The moment it touches when p comes, what will be your bodily change in the weight? Bodily change in the displacement at f means, at that we call parallel rise or parallel sinkage. It will actually be the rise in this case because p is coming upwards. Now, what has happened there is, a force p acting upwards. At this instance, there is the force p acting upwards and when a force p is acting upwards, what will be, it will just p by TPC. There will be a change in the parallel sinkage, p is the force acting and TPC is given.

So, parallel rise or sinkage will be given by p by TPC. This will give you a bodily rise or sinkage and that is all. Then, I think we can do the next problem.

(Refer Slide Time: 44:06)



then this problem states that it is a small difference it is that point where the last aft touches the keel block when where are you used there is ones light assumption like that I will check why that is? I will tell you in the next class then.

This problem says that a vessel is about to dry dock in the following condition, you are given the draft forward and draft aft then KM0 is given. KG0 is given, MCTC is given, LCF is given, 62 meters forward length is 118 meters displacement is given.

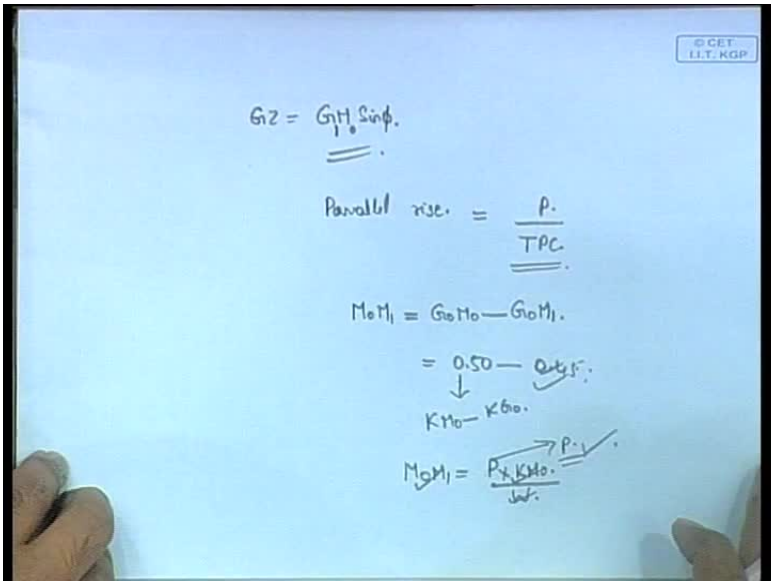
Now, you are told that at the critical instant, your GM should be 0.45 meter. In order for that happen, how much ballast should be transferred from a double bottom tank with a KG of 0.5 meter, 30 meter forward of AP to a double bottom tank with the KG of 0.5 meter, 90 meter forward of AP to ensure that the vessel is in satisfactory condition. Problems are more or less similar. I mean, the question is more or less similar or always what need to find, it is mostly in, actually all the problems they are taken, I will say that. Then, the problem becomes, so you are in this case. So, you are given your initial trim.

We have the draft and forward and aft. Then, do you have p here? Let us see, G0 M0 minus G0. Do you have your M1? Here, M1 KG0, actually this problem is slightly more simple in fact. See you have your KM0 and KG0. That mean G0 M0, you know now you are told that your GM should not be less than 0.45 meter that means you can assume a final GM to be 0.45 meter that is how you do it. So, that means you know your G0 M0 and know your G1 M0, therefore you can find G0 G1 directly and actually, using that formula you can go backwards to find p.

You know G0 G1, so you go backwards to find p and once you know p, you can find how much trim will happen when it touches at critical instant and so, you know your final trim. You know your initial trim. What is question is to find the ballast to be transferred. Then, now you know your final trim and you know your initial trim. So, you know change of trim and you know the change of trim is equal to moment change in trim divided by MCTC.

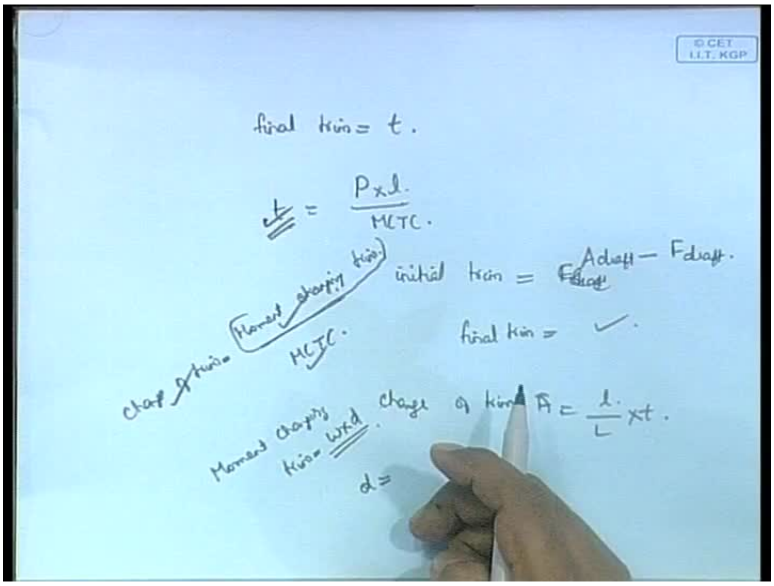
So, you know you find the moment change in trim and the moment changing trim is w into distance moved, that is all. W is the weight that is given here. No, that is a question here. W is the question. You are asked to find the d. No, d is given and you have to find w. The problem just goes like that. So, I will just quickly write the steps you do, M0 M1 which can be found.

(Refer Slide Time: 49:04)



You can do it using this formula. Anyway, G0 M0 minus G0 M1, you can write it either like is or using G0 G1 is the same thing, is equal to your initial G0 is given 0.5. This you get using actually all these formulas. If you know, then these problems can be done, KM0 minus KG0. This thing minus G0 M1 is given as 0.45. So, this can be done quickly. Then, we use the formula M0 M1 is equal to p into KM0 divided by w that is also. Now, here we know, M0 M1 w KM0, so you find out p.

(Refer Slide Time: 49:58)



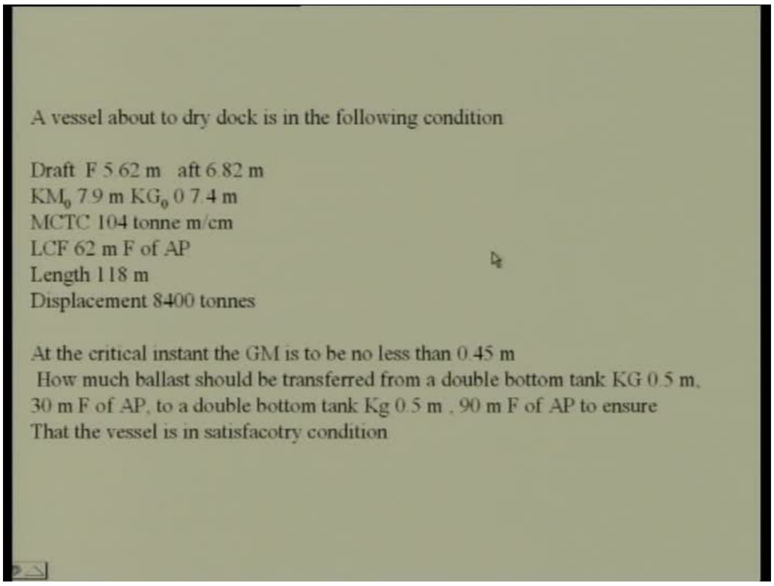
So, we know p. Now, we are finding that the final trim if let us assume, it is t then p into I mean t is equal to p into l by MCTC. Now, from this you know p is known. One is known, the final trim. You can find the final trim. This is calculated now. You know your initial trim, I mean these things, it will be clear till trim is equal to forward draft. I mean, it will be aft draft minus forward draft. This will give your initial trim. Both of these are given initial draft in the aft and in the forward are given.

So, aft draft minus forward draft will give your initial trim which is the present trim, the final trim. If the GM is satisfied, is given to be this. We do not know after forward, but we know the total. How will you find after forward? If you want to find, there was another formula. Once you have the total, how do you find the aft and forward drafts? That is what we had a formula like this. Yes, change of trim forward. I think this is aft. Aft is equal to l by L into total t.

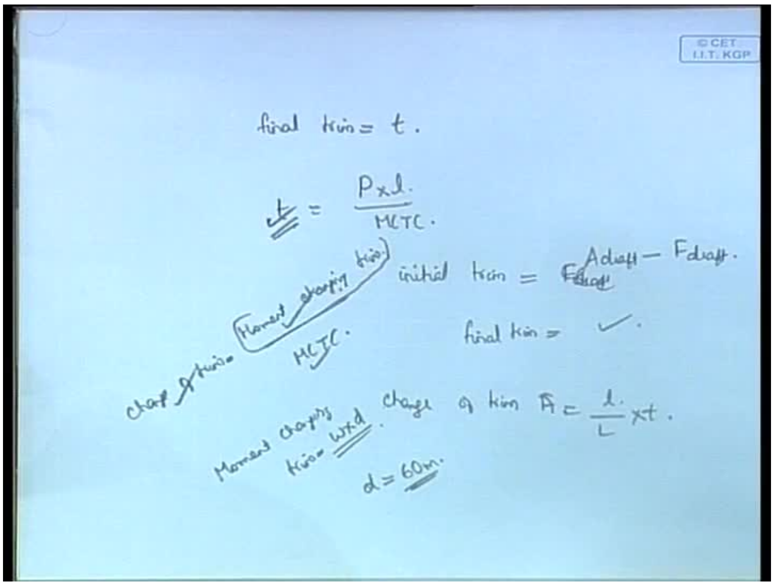
This formula was there, so if you use this change of trim aft. Is this and change of trim forward? Is FI mean capital L minus small l by capital L into t, there will give your change of trim forward? Then, you can find that forward and aft trim. Then, now once you have this, you use the formula change of trim is equal to moment changing trim divided by MCTC. Therefore, you know this. So, you can calculate that moment changing trim. Once you have that moment, changing trim moment, changing trim is equal to w into d.

So, d is the distance through which the ballast has to be transferred, that is given as in this particular problem, it is transferred from. See when you are given this problem, like it says, this is an extra information KG of the tank. I do not think we need that. KG of the thing is not needed.

(Refer Slide Time: 52:48)



(Refer Slide Time: 53:07)



So, you are told that this is not needed. This is additional, so you need this 30 meter forward of AP to 90 meter forward of AP. So, the distance through which is moved is 60 meters forward of, it is moved 60 meters. Therefore, 60 meters into, therefore that is all.

So, d 60 meters, so w into d will give you. So, this will give your answer. So, I think I will stop here. Alright.

Thank you