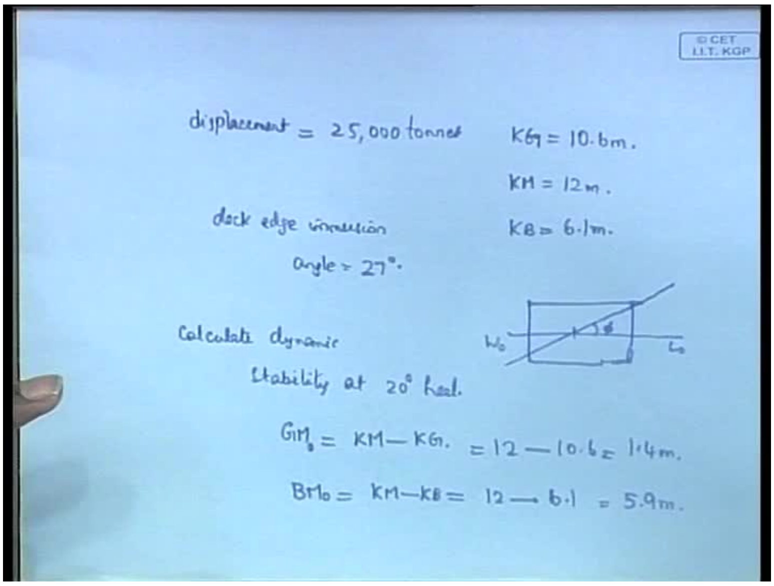
Hydrostatics and Stability
Dr. Hari V Warrior
Department of Ocean Engineering and Naval Architecture
Indian Institute of Technology, Kharagpur

Module No. # 01
Lecture No. # 22
Righting Stability – II

We will continue from the previous problem - there is another problem - it says that there is a vessel with a displacement of 25000 tonnes, some hydrostatic data is given, KG equals 10.6 meters, it gives KM equals 12 meters and KB equals 6.1 meters; this is the second type of problem where you are given your hydrostatic data and you are not calculating you are I or anything; now, you are also told that angle of deck edge immersion is 27 degrees.

(Refer Slide Time: 00:42)



The meaning of angle of deck edge immersion is, suppose you have a vessel like this - this is obviously your deck, you know that, this is your w 0 L 0; if it heels at this phi you know that this will be the deck edge and it will be immersed; this angle of phi is called angle of deck edge immersion; it is the angle to which the ship should be heel such that the edge of the deck will be immersed. As you can see from the figure it is straightforward.

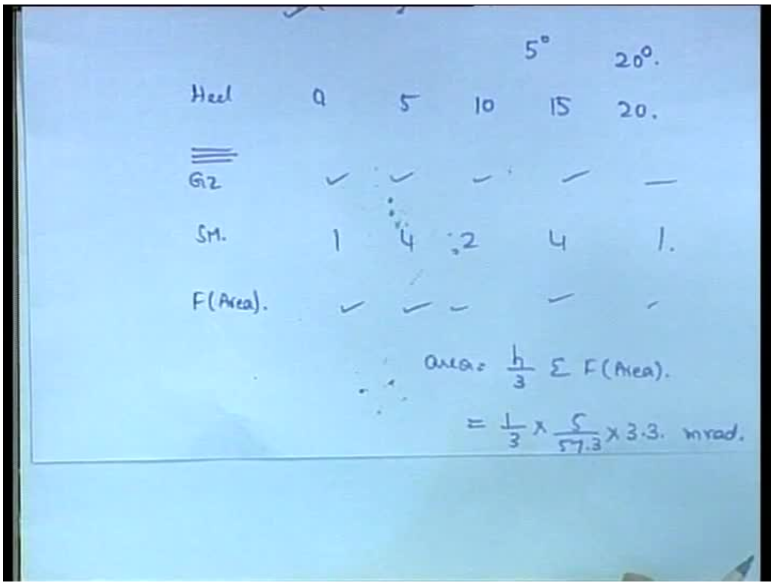
You are told that the angle of deck edge immersion is 27 degrees, now the question is calculate the dynamic stability at 20 degrees heel - that means, you are asked to find the dynamic stability up to 20 degrees - I guess thats what is meant. Yes, you are asked to find the dynamic stability up to 20 degrees; just as a word of caution - you will see that till your mid semester, in fact, whatever you have done it is simpler compared to what you are going to do after this - it is much simpler; there are lot of things after what you have done, the other the other one was just...mostly you knew Archimedes principle, a little bit of GM BM and all that - little bit not that much; it was much simpler because after that they have done dynamic stability; if you remember the classes...you will see that the ones coming after that like wind heeling arm, calculating the grains - those things are really very complicated; if you start doing the problem you will...complicated means there are a lot of things you have to remember.

First of all, the formula - all the load line regulations - you have to remember very clearly; grain regulations you have to remember clearly; that heel how it is done you have to know - if you remember I took one full class to do just the wind heeling arm, it was very confusing; you have to take some 1.5 lambda 0, lambda 0, 1.5 lambda 0 you have to draw a line. I am just cautioning you that your end semester would not be that simple - like your mid semester, it is it will be much more involved because if I ask you problems...this problem itself we can see that you have to know everything - what is dynamical stability, how to calculate dynamical stability and when you going to grains, wind and all that it becomes much more complicated; so, just be careful for the end semester.

The problem says calculate the dynamic stability at 20 degrees heel; first of all, you have to calculate your GM 0; GM 0 is equal to KM minus KG - this is straight forward, this you have to do; that will give you 12 minus 10.6 that is 1.4 meters this is your GM 0; then, you have to calculate BM which is also BM 0 which is equal to KM minus KB this is the second thing which will give you 12 minus 6.1 equals 5.9.

Now, the problem here is to find the dynamic stability; of course, you have to know that dynamic stability is the area under the GZ curve - that is the meaning of dynamic stability - not GZ curve, delta into GZ curve - delta is the displacement of the ship; delta into GZ - the area under that delta into GZ curve is what is known as the dynamical stability.

(Refer Slide Time: 06:17)

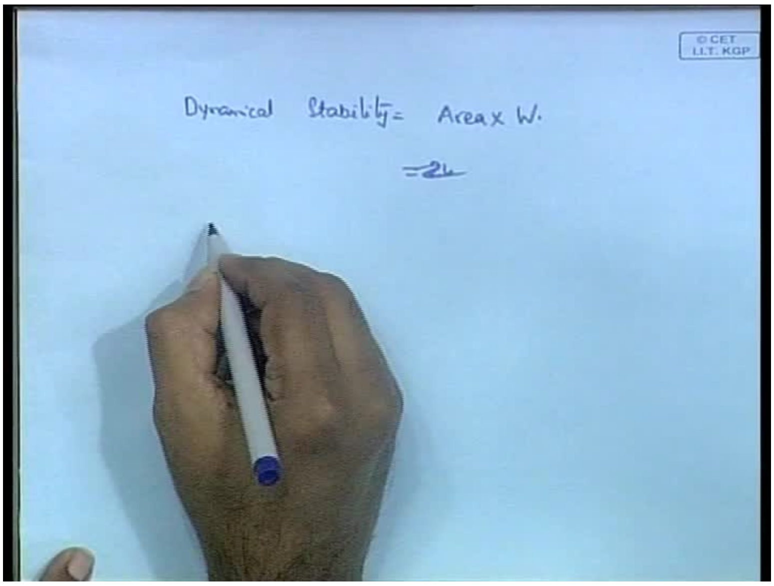


That means first of all you have to get your GZ curve, only then you can do your dynamical stability; in this problem even your GZ curve is not given, so you have to calculate the GZ curve - that is the only additional thing in this; so how do you calculate the GZ curve? You use the wall sided formula; you have to make your G Z table - in this case you have to generate your GZ table using the wall sided formula: GZ is equal to sin phi into GM plus half BM tan square phi; now, the usual way is you take 5 degrees intervals start from 5 degrees - in this case, you have to go up to 20 so 5 10 15 and 20 - you take four values and you make your GZ table like this.

Heel 0 5 10 15 and 20 - well, you just have do this whole thing - half BM tan square phi plus GM into sin phi that will give your GZ; that means you have to calculate that - do the calculations of GZ using this formula here and you will get GZ - all those values of GZ you get; then, you have your Simpson's multiplier 1 4 2 4 1 and function of area - same thing - that is the this 0 this I mean GZ multiplied with this Simpson's multiplier comes here each of these GZ multiplied with Simpson's multiplier is the function of area and once you have that your area is equal to h by 3 into sigma function of area.

Therefore, this is equal to 1 by 3 5 by 57.3 into all these things...5 degrees so 5 by 57.3 radiance into function of area - whatever it becomes, so many meter radians you will get. This gives you dynamical stability; this is the area and dynamical stability will be this multiplied with the displacement. Dynamical stability will be whatever area you are getting here multiplied with W.

(Refer Slide Time: 08:34)



That will give you, whatever...this will give your dynamical stability; there are different possibilities here - you are given problems in different types where you are...finally the main thing will be to calculate to see if it is satisfying the load lines regulation. Once you remember the formula in these kind of problems note that once it is....as far as you are concerned for the problems there are there are 3 types of regulations - one is for grains, one is for wind and one is for general.

Remember this - there are going to be.... for problems wise; when you are asked any type of question like - does it comply with regulations or anything like that... 3 formulas you have to....3 sets of rules you have to remember; why I am saying this now is because the next chapter or two chapters later there are going to be a whole serious of formulas; I will talk about formulas adopted by U K Navy, formulas adopted by the U S Navy, adopted by the German Navy - like that different formulas are going to come.

When you get the problem, I am not going to include those formulas - do not use those formulas because problems will be just based on these formulas; for the problems part there are 3 types of formulas required for 3 types of load line regulations required - one is the load line regulations using grain, so the moment you see grain anywhere in the problem - it is a ship carrying grains, a container carrying grain - you see that word grain anywhere you have to use those formulas not anything else.

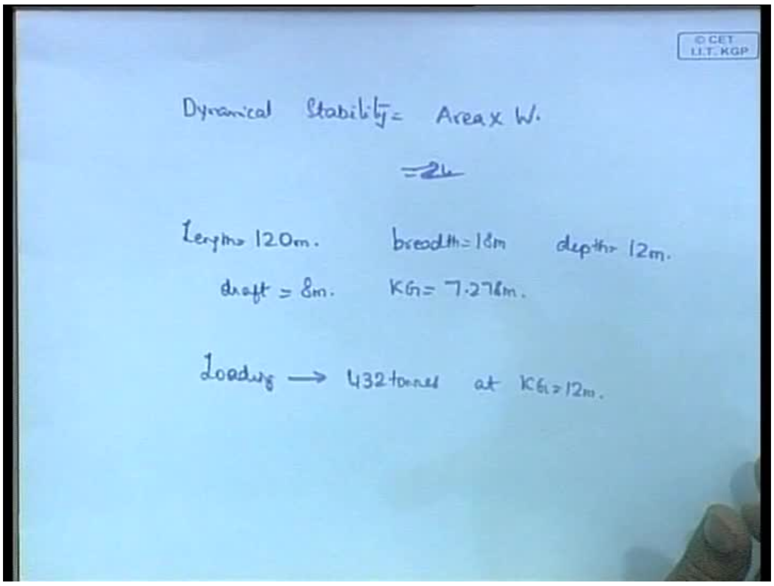
Similarly, number two is wind; the moment you see that the problem is to do with wind it is says - wind velocity is this find the heeling due to wind - anything to do with wind you have set of formulas that... I mean set of regulations that also I have told you already. Always use those formulas; if it is not either of these - anything else, any other kind of ship - whether it is fluid, anything that you you are not used to - if it is fluid or water or ballast they will say or anything - ore, no ore...probably better use grain then anything else you see you use these formulas - that is, the one I have said - the initial up to 30 degrees should be less than point naught 55 meter radians - that one.

There are 3 sets of rules, remember that; later all those thing that I am going to discuss probably two weeks from now those do not apply to problems, just remember that and keep that...I think there is one more problem; this is also....actually we haven't used that the deck edge immersion anywhere in this, right? Usually this deck edge, it is....no, in this problem that term was that 27 degrees was not used anywhere really

It's not used i mean, but you have to use it; if you remember, in the wind derivation when you are calculating the wind heeling arm and when you are - you will be - asked this kind of wind is acting or even if you are not told you have to....suppose you are asked see if the ship is stable as for as the wind is concerned; when you are asked a problem like that it is do with the heeling arm due to wind, which have done one full class; in that, if you remember, one of the criterion was that one of the angles should be less than the angle of deck edge immersion - one criterion was that, one of the rules was that; remember that.

That is why usually you have to...this is given - deck edge immersion is usually given to check one of the criterion - that is, one of the angles should be less than the deck edge angle - that is the use of that in this problem, but we are not using it anywhere.

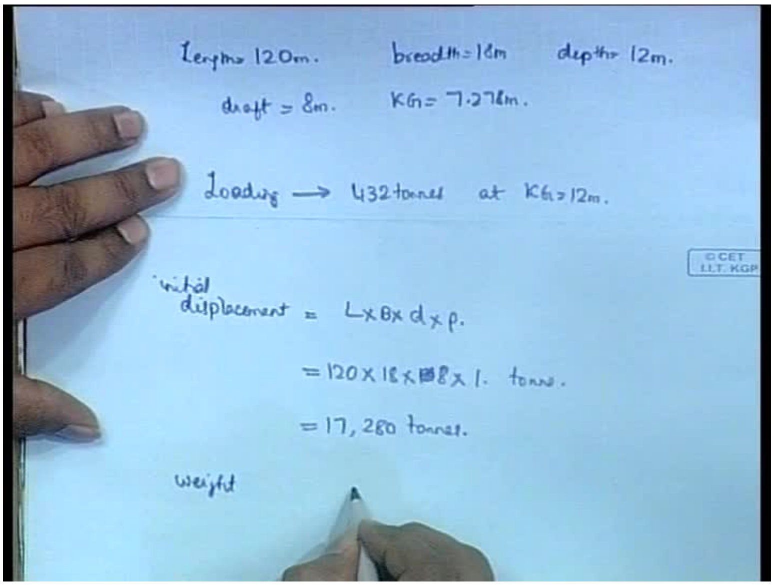
(Refer Slide Time: 13:01)



The next problem says, there is a box shaped vessel - again, it is the box shaped vessel - it has a length of 120 meters, it has the breadth of 18 meters, depth of 12 meters and it is floating at a draft of 8 meters - you are told that it has a draft of 8 meters in fresh water and it has the KG of 7.278 meter; you are told that a weight of 432 tonnes...now, what we are going to do is qw are going to load a weight - 432 tonnes is loaded at KG equal to 12 meters, so a weight of 432 tonnes is loaded at a KG of 12 meters.

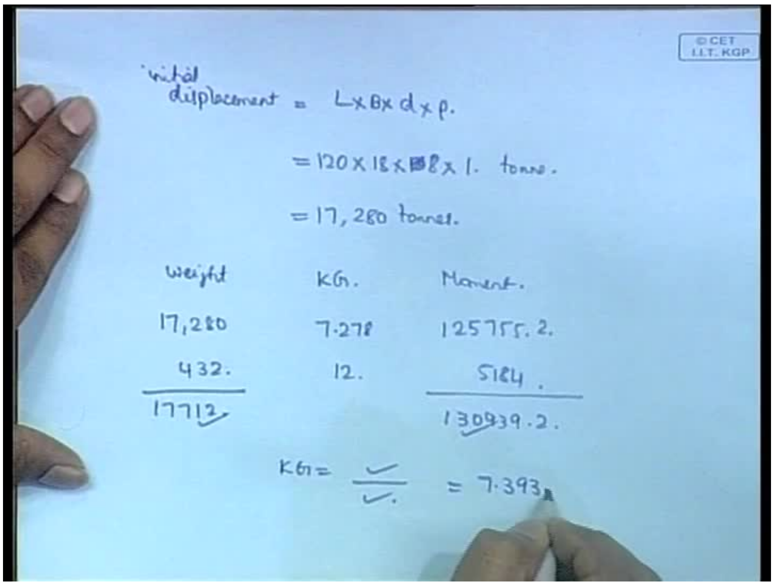
The problem will be like this most likely - it will say, find the dynamical stability of the vessel up to the angle of deck edge immersion; that means, two things - one, you have to first find the angle of deck edge immersion and then you have find the dynamical stability up to that angle - that means up to the angle of the deck edge immersion; you have to find the area under the delta into area under the GZ curve - that you have to find, that is the dynamical stability; let this be here, so this is the problem.

(Refer Slide Time: 15:01)



First of all, let us find the displacement of ship before the weight is added or that is the initial displacement; initial displacement of the ship is equal to L into B into d into rho; that is equal to 120 into 18 into 8 8 is that draft into 1 so many tonnes - this is the initial displacement of the ship - it comes to 17280 tonnes; this is the initial displacement of the ship before the weight is added.

(Refer Slide Time: 16:01)

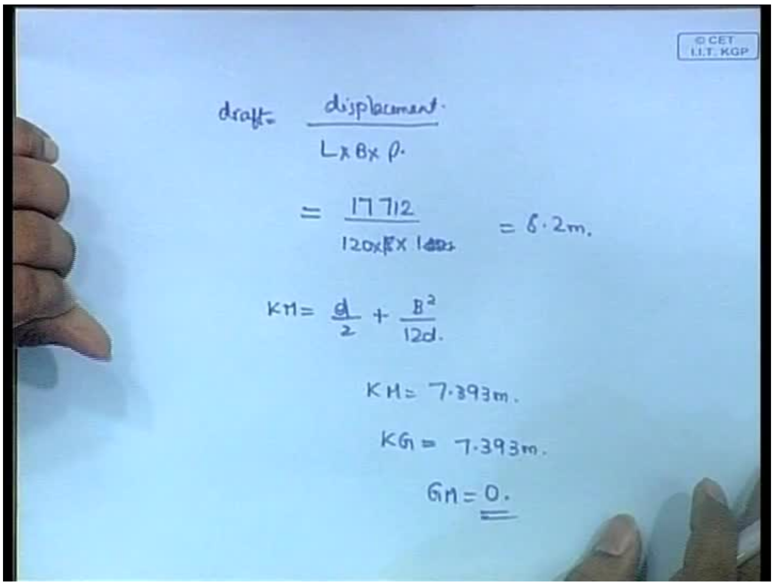


Then, we need to find....after the weight is added - weight added, then you have your KG, then you have your moment; the initial weight of the ship is 17280 tonnes and your

KG - remember your given KG is 7.278; therefore, your moment you multiply 755.2 will come there; then, you are told that you are adding a weight - you are told that a weight of 432 tonnes is loaded - this is added; you are told that your KG for that is 12 meters, so 12 - you multiply this you get something; you find the total moment sum this up and this will give you your total....this is just to find your final KG, as you know KG this will be this divide by this; you will get your final KG.

This gives you the KG once the weight has been added - this will give your KG; as I said before the previous thing once the weight is added to the ship it is draft will change - the ship will sink, the draft will change so you have to find the final draft; it is very easy.

(Refer Slide Time: 17:52)

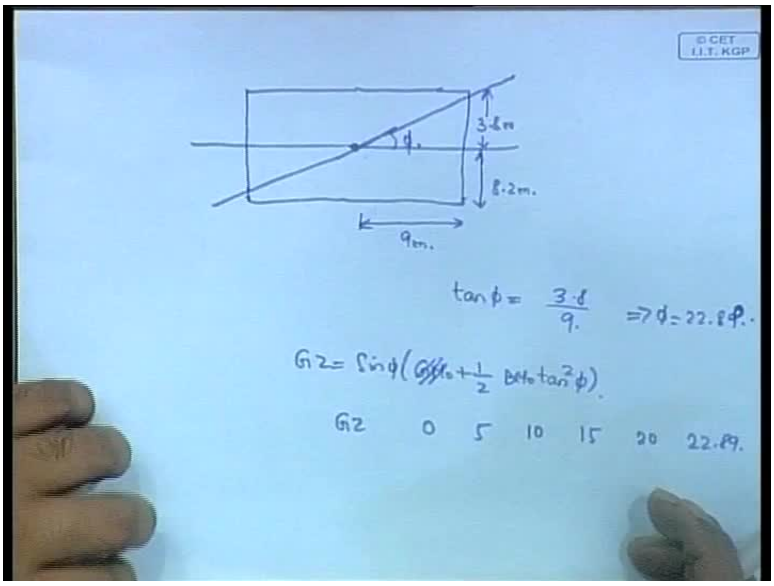


You can do...the final draft will be the final displacement divided by length into breadth into rho; this will give you final displacement - we have calculated 17 7 1 2 divided by 120 into 18 into L into B into rho one point naught 25 in this case it is 1; just for your information the density of salt water is one point naught 2 phi into 10 cube kilo gram per meter cube and the density of pure water is - fresh water is - 1 into 10 cube kilo gram per meter cube; in all these cases, in these problems in this course you will write it as 1 ton per meter cube always; that is the density of sea water is 1.025 tonnes per meter cube; that is your density.

Then, this will give you draft it is equal to 8.2 meters - this is the final draft; draft has increased from 8 meters to 8.2 meters; you are told that this is a box shaped vessel so again we can use this formula - KM is equal to d by 2 plus B square by 12 d; remember, for this d you have to use 8.2 meters and not 8 meters because you are finding the KM once the weight has been loaded, provided the weight is...now it is... just to give a problem as such there is nothing more to it - you have a ship, you added weight, once the weight is added now let us find the final KM; you have to find the final draft - draft is 8.2 meters here - this 8.2 plus this thing this will give you KM equals 7.393 meters and KG is given, KG we just calculated.

K G it turns out it also come down to 7.393 meters which means that KM is equal to KG; this is a particular type of problem, we did a special case if you remember where GM is equal to 0 this is that case KM has become equal to KG - by coincidence KM has become equal to KG, such that GM is equal to 0; now, the question is how do you find the angle of deck edge immersion from the data given, let us see.

(Refer Slide Time: 20:34)



It is a box shaped vessel and you are told that the draft is given - we want this, remember we want this phi; now, you are told that this draft is this - is final, so this is 8.2 meters; then you are told that the depth of the ship is 12 meters therefore this is 12 minus 8.2, 3.8; it is not difficult, right? This you know - this is your b by 2, b by 2 is...breadth is given 8 meter so this is 9 meters; it is now very easy to calculate deck edge immersion - you can see the tan phi is equal to 3.8 divided by 9, that is all; that will give your angle of deck edge immersion.

Your question is find the dynamical stability up to the angle of deck edge immersion; so, right now you have calculated your deck edge immersion - that is the first thing; your problem is calculate the dynamic stability, which means that you have to initially formulate your GZ table; formulating the GZ table - the only way is using the wall sided formula here because you are not given the k n; there are only two ways is to calculate the GZ table - one, you should be given the GZ table, two, you are given the k n curve or the k n table from which you can derive your GZ table, three if you are given neither of these, then from the wall sided formula.

We are given neither of these so you use the wall sided formula - this is the wall sided formula and this we use; we just calculate the so for you are asked for till in this case this came to be...implies phi equals to 22.89; this is...provided you have this you get your deck edge immersion angle to be 22.89 degrees; your problem is to now to find your area under the GZ curve from 0 to 22.89; you have to find the area in a step, so, let us see - you can do it as 0 5 10 15 20 and some other way to calculate from 20 to 22.89 like that the best thing is do like this 0 to...no since you are doing wall sided formula you might ask... you can as will do 22.89; you put phi equals 22.8 so you do it like this GZ as 0 5 10 15 20 and 22.89.

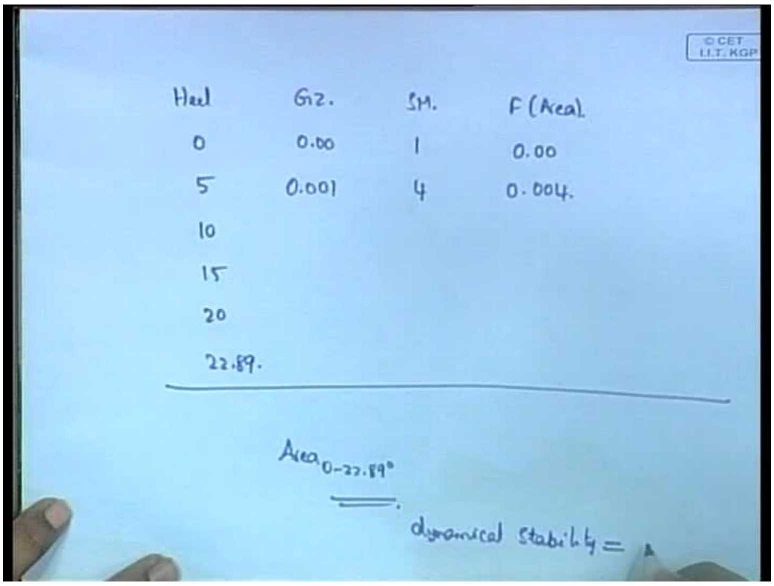
Simple, you just put it here and you find the area under that - so GZ we have. This has one specialty - this problem - you remember that GM 0 became negative in the problem - 0 becomes 0 in this problem.

GM was 0 so this is gone - it is simplified; it becomes sine phi into this thing half BM 0 tan square phi; BM has to be calculated - BM, that BM - again, same way I by del - this is a box shaped barge, you know how to calculate I, you know how to calculate del.

I by del...once there are... two again in the same thing if you are not given any information about BM like you are not given the hydrostatic data you have to look at the problem - you must be given that this is a box shaped vessel or at least that the shape of the vessel is something - that it of some general shape.

But, that is not enough to calculate KM; you will be given that it is a box shaped vessel, otherwise it is becomes too difficult; it will be given that it is a box shaped vessel then you know how to calculate BM I by del; I is for a rectangle, you know B cube L by 12 and del is the volume of the ship - total volume of the ship - which you can calculate by displacement of the ship divided by the density of sea water - that will give you the not the total volume of the ship sorry it is volume under the water - volume under water is the displacement so this will give you GZ.

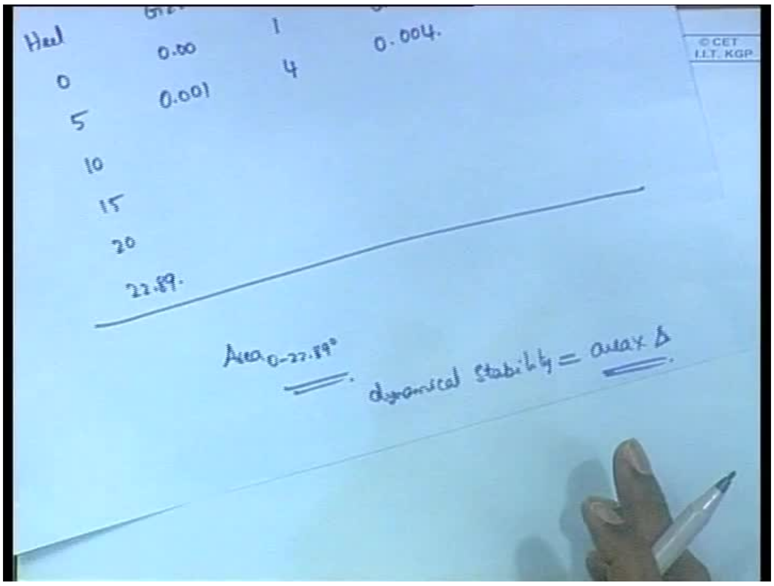
(Refer Slide Time: 25:40)



You formulate your GZ table; here they have calculated same way yes; you make your table like this; you will you have to make the table - heel, GZ Simpson's multiplier and function of area; like that for 10 15 20 and it you might as well do for 22.89 and you find the area from 0 to 22.89 degrees; 1 4 2 4 is Simpson's rule and once you have the total area you just have to calculate the dynamical stability as...

Once you have that, dynamical stability becomes your area - which you have calculated - into your delta, the displacement - that is in tonnes, so you will get your meter square tones and that will give your dynamical stability. Is it meter square? No, meter area is GZ meter meter radians, right? So, tonnes meter radians - you will get it like that and that will be your dynamical stability.

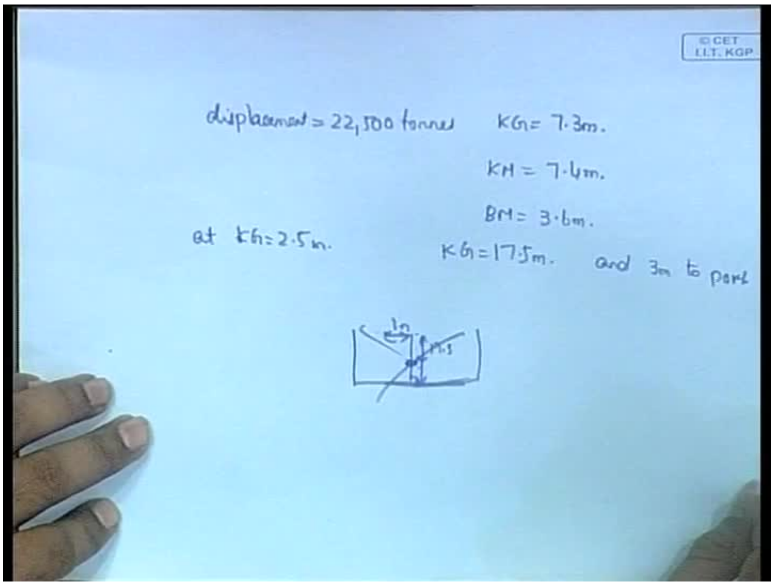
(Refer Slide Time: 27:37)



That gives you your dynamical stability up to the deck edge immersion; here, we all we found out is how to find the deck edge immersion that is very straight forward, using just geometry you can get that; next is, if you have to know for a box shaped bar how to find KM, how to find BM - two things, because nothing will be given - that formula has to be known; how to calculate the KM and the BM - two things.

Of course, there is no difference the only thing is in this case you get GM to be 0 there is no special formula or anything to be applied here; in that formula, for wall sided formula GM become 0 so it becomes simplified - problem becomes simplified. They have one more problem, that I will do.

(Refer Slide Time: 28:47)

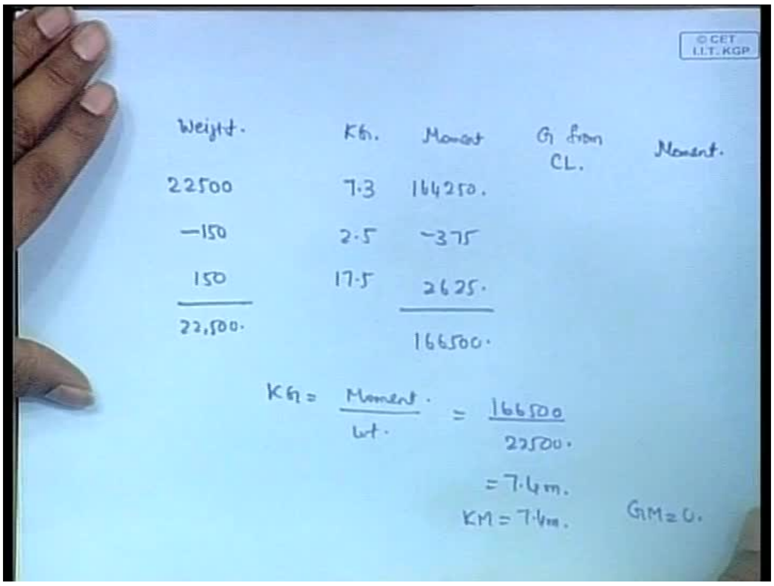


It says a vessel has a displacement of 22500 tonnes; you are given that KG is 7.3 meters, KM is equal to 7.4 meters, BM is equal to 3.6 meters; in this problem - it is the second type - you are given the hydrostatic data, you do not have to calculate I, you do not have to calculate KM, nothing - everything is given KM is given, KG is...you are given the hydrostatic data.

There is a lift, which...I mean, there is a crane which lifts 150 tonnes of weight from the ship at a.... initially at that center line at a KG of 2.5 meters - from this point, from KG of from height of KG of 2.5 meters along the center line a lift is lifting a weight to a height of KG equals 17.5 meters and 3 meters to the port; what the problem says is like this - let us say that this is the center line from here something from the center line is lifted and it is lifted to the port; it is lifted from 2.5 meter KG to some 17.5 meter height to the port side 3 meters - so 3 meters like this to 17.5 meters up there; it was initially at 2.5 meters, that is the problem.

You are asked to find the list because of this; crane is lifting a small weight from the center line and shifting it to port - not just to the port, up and to the port, like that - there is a problem; you are asked to find the list as a result of this shift of weight.

(Refer Slide Time: 31:23)



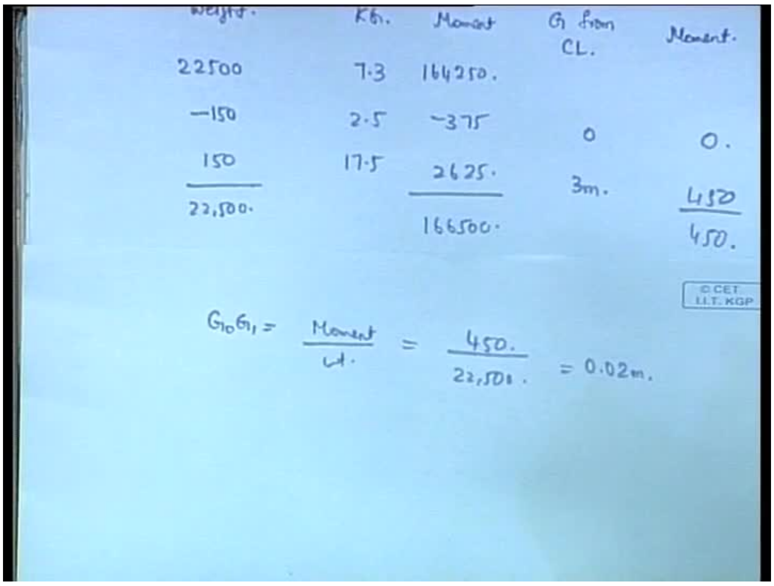
For such a problem this is a usual method; you have the weight KG moment, then distance from center line, then the moment - this is the moment for the horizontal motion and one is the moment for KG; initially, you have the weight 22500 tones and you have told the KG - this you can calculate; let us just do this one, let us forget about the horizontal motion let us consider the vertical motion alone to calculate the KG alone.

What are we doing? We are shifting a weight of...it is said - it is 150 kilogram - 150 tonnes; a weight of 150 tones is removed from a height of 2.5 meters and it is put at a height of 17.5 meters; there is a minus 150 tones at 2.5 meters and there is a plus 150 tones at a height of 17.5 meters - this is straight forward, 2625.

This gives you the net moment 166500 and this gives you the net weight; from this you can get the net KG that is equal to moment by weight; net moment divided by the total weight which gives you 166500 divided by 22500, that will give you 7.4 - this is the first thing; if you see the problem you are given the KM also; right now, you calculated KG you are given the KM as well you will see that KM is also given to be 7.4 - same problem, you are having GM equal to 0 - it is a 0 GM problem.

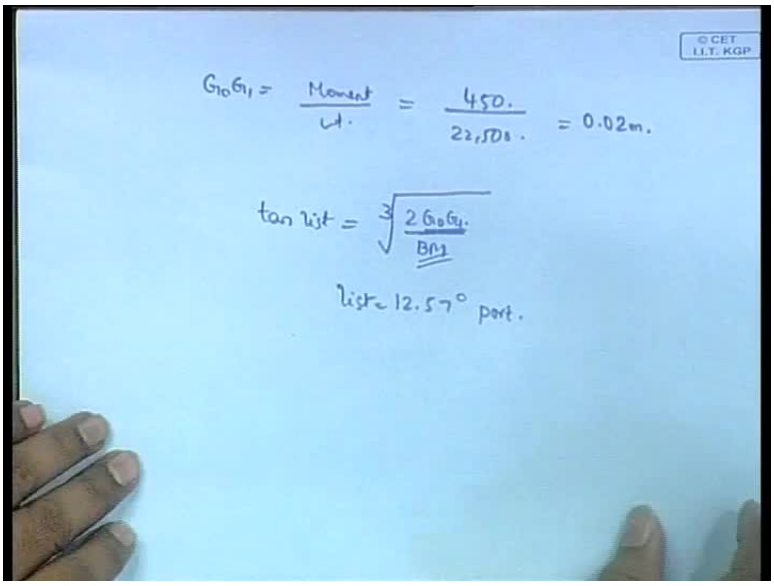
To do this we need one more thing - this is the first part, then you have to do this as well that is you have to find how much it is moving in the horizontal - the horizontal moment; this is to find the shift G 0 G 1 - that is, the shift in the G 0 in the horizontal direction because of the shift of the weight in this direction; from the center line - it is initially at the centerline at 0 - at 0 x it is at the 0 and then it is moved to port some distance - 3 meters and as a result of this you know that the center of gravity of the ship, the whole ship, itself will shift a little to the left side - to the port side it will shift.

(Refer Slide Time: 34:31)



Let us see how much that will shift, that is also straight forward only; initially, the weight is at the center line so its distance from center line is 0 - moment from here is 0 and then it is put at a new point 3 meters to the port; this becomes 450 so this is this. Now, your G 0 G 1 is you are shift in the center of gravity of the whole ship as a result of the shift in the small weight inside the ship; that is, G 0 G 1 is equal to the moment divided by the weight - weight of the whole ship, that will be 450 divided by 22500 that gives you 0.02 meters; this will give you the this is the G 0 G 1 or the shift in the center of gravity of the ship as a result of this shift of weight.

(Refer Slide Time: 35:32)



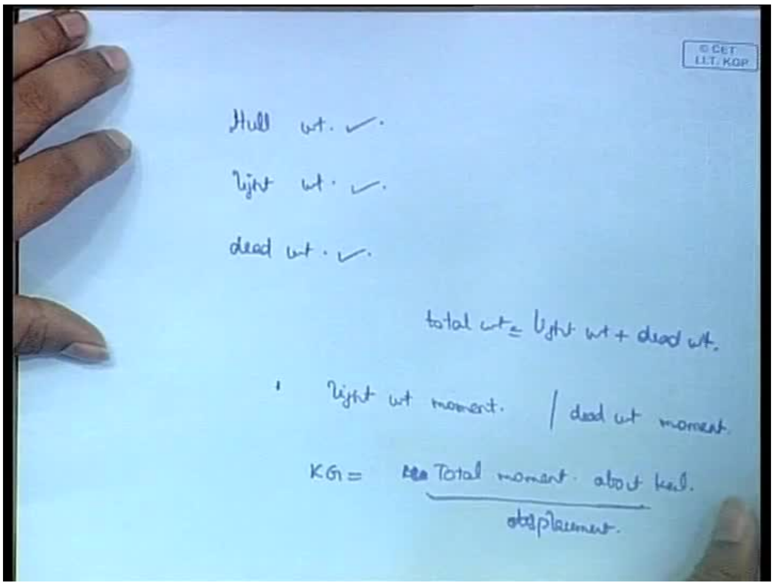
If you just look back there is a formula we have done when the particular case - that is, the weight has been shifted from one side to another side and GM is 0; we derived an expression for tan of phi or tan of that angle list it was given like this - cube root of ....this no need to derive it as such but it becomes like this; we have derived this expression, of course, for the exam, let us see if something like this comes; I doubt if you can derive it as such...yeah it is...of course, if you can derive it, it is okay; but, you will have to remember some things.

In this particular section there are two types - for instance, one, when you have an angle of loll there is a set of formulas - it is better if you remember it I think and another is when G M equal to 0 - there also you have a set of formulas and that is to be remembered.

These are the special cases that I have said because even in the problem....even in the exam lot of people kept asking me how do you find the KM or because...many people are asking that; that means, you are not reading that problem it is said that is a box shaped barge, that means, that formula has but for this exam I told you everything.

These are one of those types of problems where you have to remember that it is a special case where we have derived formulas for it - like for the box shaped barge; this will give the you tan of list; here, you have calculated G 0 G 1 and BM yes hydrostatic data is given - BM is given, BM is equal to KM minus KB, that will give you BM; this will give you... so this will give you list equal to 12.57 degrees to port; because, of course the weight is shifted to port so it will list only to the port; that is that problem, this is one section over.

(Refer Slide Time: 38:57)



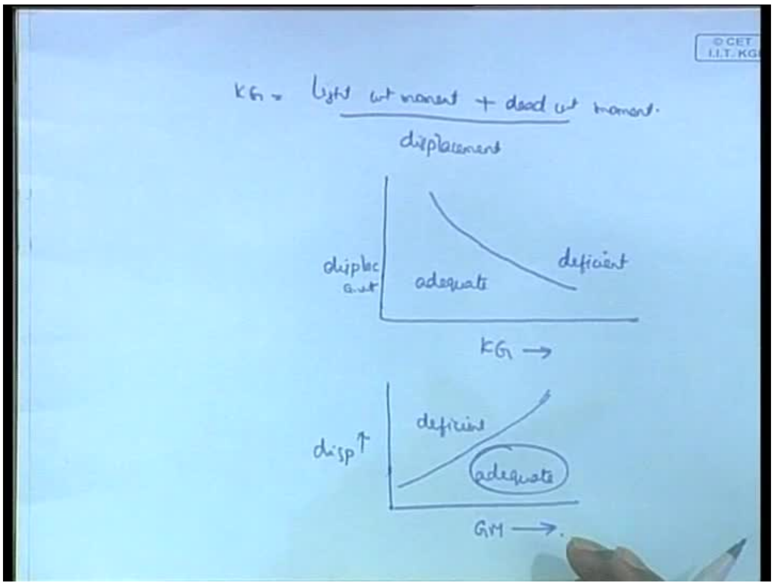
I have already told you there are...we talked about two types of weights in general in a ship they are light weight and dead weight; of course, there is something called hull weight also before that since I’m saying it I will tell everything; first we will talk about hull weight; hull weight in general means just the hull, nothing else, but the hull; you take the ship you have the hull there is nothing inside the ship as such except for those structures, except for the walls - like it is an empty building - like that; just the hull, that is known as hull weight weight; it is mainly the weight of steel which is going to make the ship.

Once you add propellers and some appendages to it - you have rudder propeller and all those things you add to it - once you add that you get some more weight that is known as the light weight; it still does not have lot of contents of the ship; the next thing is called the dead weight - everything else is added - the cargo, the ballast, the fuel, fresh water personnel, machinery everything so all those things are added to the ship and you get the dead weight of the ship; it is not the sum total - what is added is called the dead weight, light weight is hull weight plus propeller, dead weight is not the sum of all this - dead weight is just the additional thing all the cargo, fuel, fresh water the sum of the all that is called dead weight.

Total weight of the ship we usually say it is light weight plus dead weight is the total weight of the ship; now, we can talk about different types of moments as well - we have talked about moments about the keel, we have done that many times; to find KG, if you remember, when in the last problem we did you you are finding in the net KG, once a weight is added.

Initially, the ship is there you add some cargo you find the final KG, for that we are doing some moment - one moment is coming like a weight into that KG; that moment we called it as two things - one, if it is for the light ship itself it is called a light ship moment and if it is for the weight in it is called a dead weight moment, so it becomes light ship moment or the light weight; these are moments associated with KG means something into KG of that; for example, if it is the light weight of the ship whatever is there - for example, if it is the wall a - bulkhead, what you call weight of that into KG of that, that will give you one moment associated with that - that moment is called light weight moment; if it is the dead weight, if it is let us say cargo - weight that I am putting there and taking out, it is called a dead weight moment.

(Refer Slide Time: 42:39)



Therefore, we define KG to be the total moment or the total moment about the keel because it is KG divided by the total displacement; total moment about the keel divided by displacement - this is you KG and you usually write it in this format - you say that KG is light weight moment plus dead weight moment divided by displacement; also, you know that, in general when you increase KG, G will go up - G and M will come closer together and GM should be...wait KG is increased it will become more or less stable? Less stable - so, it will become less stable so as you keep increasing GM will become smaller yeah so will become less stable; if you keep increasing your KG your ship will become less and less stable ; note that, here, the light weight moment is the moment of the light ship it is self - that cannot be changed, the ship is already made you cannot do anything.

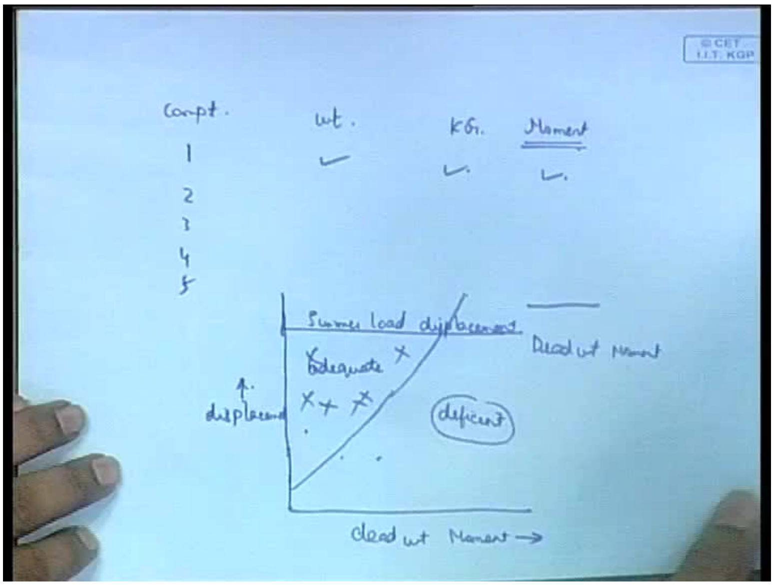
The idea should be to reduce your dead weight moment so as to increase the stability of the ship; therefore, you end up drawing something like this I mean we have to have some kind of criterion when we say that this is about dead weight moment; you say that you can increase the dead weight moment to some value and you increase the beyond the value the ship starts becoming unstable or maybe is not unstable but it is dangerous - it is in the dangerous zone.

Like this... usually you will see a drawing like this - this is displacement and when...that means your KG should be low; you will see a margin line drawn like this and all those KG (s) is less than this value or these are adequate; this is dangerous or deficient. You might see a graph like this in some.... in the initial design stages when you have to say that the ship is...when you are checking whether the ship is stable or unstable you will see such graphs which say adequate or deficient.

All those KG (s) which are below are safe beyond that line it is dangerous; this graph might not be drawn with respect to KG it can be drawn with respect to GM, but it becomes slightly different GM should be as large as possible; this same figure - it is actually the same figure - KG it is...what we have done is that we have changed that KG to KM minus KG - we just changed to GM; obviously, the figure will shift - the region which was adequate will become deficient like that because GM has to be as high as possible; this region is adequate and this region is deficient.

These are two curves that you might see in your design; you will be told that you should have a stage when you should be in this region - you should always be in this region and...so you calculate and you say that this is either in a stable region or an unstable region like that; this problem is just an application of this, I will just tell you what this is - I will just say this problem; it says that there is a vessel which discharges 15000 tonnes, that means the displacement of the vessel is 15000 tones; you are told that some loading is done on it for instance there is a...in the cargo number... hold number one 4000 tonnes you are given the KG hold number two 3000 tonnes; you are given the KG equals 6.5 like that you are given different values; the problem is you have to check with the chart - I just drew it here, this is a chart like this - you to look at this chart and say whether the ship is stable or not.

(Refer Slide Time: 48:03)



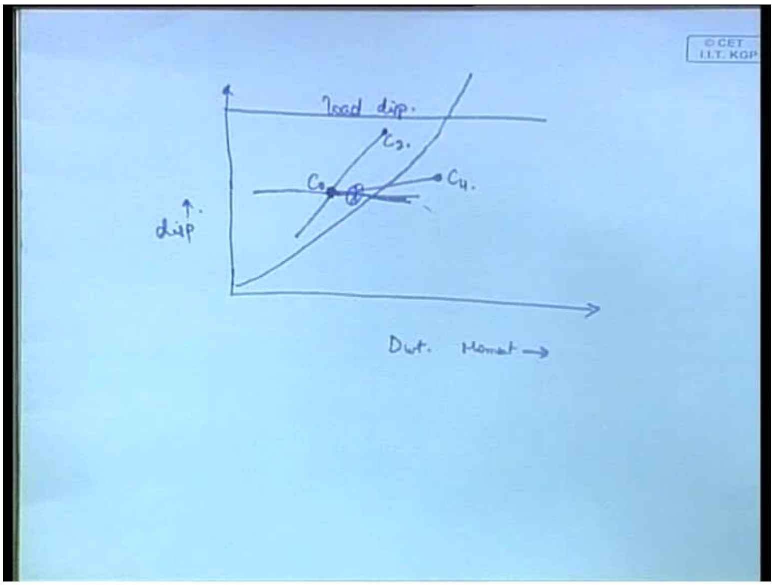
What you need to do is - in such a problem - I will just write this thing; let say this compartment, then weight, then KG, you have the moment; what you do here is this moment is actually giving you your dead weight moment; for each compartment one you are given what is the weight there, you are given the KG - what you should do is multiply the two and get the moment you sum of all the compartments - all the compartments you sum up you get the total dead weight moment.

In fact, here there is a chart given like this which says displacement versus dead weight moment; as you can see here, as the dead weight moment increases in the right side - as you go along the right side - dead weight moment keeps increasing, as the dead weight moment keeps increasing KG keeps increasing, as KG keeps increasing the ship becomes less and less stable; after this particular line this curve the KG becomes...the dead weight moment....the ship becomes exactly deficient - the ship become deficient.

What you have to do this, in this problem is you look at all the total dead weight moment and you look at the displacement of the ship - read, where is it lying? Is it here? Is it here? Is it on the line? Then, you say whether the ship is deficient or not.

I mean you are not going to be facing such kind of problems because that means such charts have to be given that long big charts - I do not think we will do that and you might end with something like this - some....you will see a line like this which says - summer load summer load displacement, which means that you usually cannot go above this that means that is...there is a always limit on every ship; the water line of every ship - the draft of the every ship cannot be increased infinitely; the whole... there has to be a fixed amount of free board always - that is all fixed; there is range but there is a limit, you cannot go beyond that.

(Refer Slide Time: 51:03)



This is that limit - summer load displacement is that limit; therefore, your ship...you cannot increase your dead weight moment such that limit is exceeded that is not possible; you cannot have beyond this line, horizontal line, you cannot have - beyond that region is not allowed.

If you have to say that ship is...for that particular condition the ship is okay, it has to be somewhere here - you have to get it here, anywhere else it is going to be a problem. Then, one small thing I will just complete and stop that is it is nothing much it is just...

You are having displacement versus dead weight moment; you are just looking at... here you will have line like this which is called as summer load displacement or load displacement - something like that - cannot cross that; usually you will have a position where you are at let us call the C 0, the ship is initially here; there are different directions in which it can go; what we are doing is, some weight is added to the ship.

Note that, whenever some weight is added to that ship its dead weight moment will only increase; so, in this it will go to the right - this line, if you draw line from here to final state it will go to the right - it can go here, this is one possibility C 2; if you have this curve like this you can...this is the limiting curve - beyond this is it is inadequate here it is adequate - so, this condition is ok.

We can say that C 2 is stable state - that is one possibility; then, it can go here sometimes if you keep increading the dead weight moment it can go to some state C 4 - which is an unstable state, so here it is not adequate it is deficient; another possibility is you can change the dead weight moment without changing the whole displacement of the ship itself - from one you are moving to another; so, the displacement of the ship is not changed but you are moving from one point to another point as the result the moment has changed; you can move like that you will go like this horizontally - displacement would not change it will go in this fashion and after a particular value it crosses and it becomes unstable, till then it is ok

These are different stages and just to complete, in case you are removing a weight or you are taking away a weight will go down in this curve will just come down; here the dead weight moment is decreasing it will come down like this and...displacement is also decreasing because you are removing a weight so it will come down; similarly, you can change your dead weight moment like this also without...this will become more stable - without the changing the displacement you are changing the dead weight moment ship become more stable.

These are the different possibilities; I think I will stop here. Thank you.