Mechanics Of Solids
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Lecture – 05
Support Conditions

Welcome back to the course mechanics of solids. So, as we have seen in the next lecture that we are talking about equitation of equilibrium and free body diagram. So, we are basically discussing free body diagram with examples on modeling of typical supports and joints, conditions for equilibrium in 3D and 2D friction limiting and non limiting cases. So, these are the things we are just covering in this particular chapter.

So, basically in the last lecture, we have taken couple of examples to show how you can draw the free body diagram form a complicated system right. So, now, as you have seen most of the mechanical systems, whatever you see in day to day life they support they have some support on some other kind of material like, say suppose if I want to have a beam, that you generally see in day today life in different civil engineering structure that will be supported on say column right. So, these are columns. So, they are supported on the columns.

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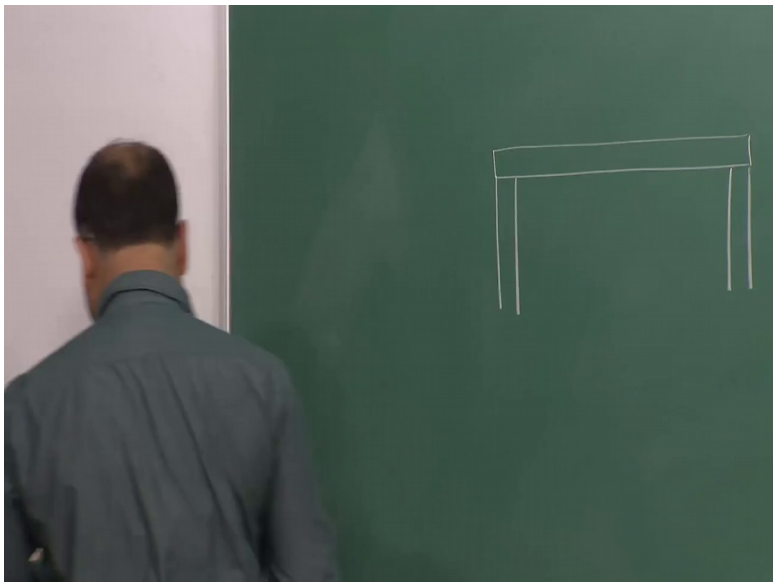

So, every system if you think about in the last lecture whatever we considered 2 balls right which is resting in the in a can right. So, the upper ball is getting support from the

can as well as from the ball, and that is why the support reactions got developed and we have seen that thinking the free body diagram. Similarly, the lower ball is getting the support from the can. So, that it is resting in equilibrium condition. And similarly we have shown when we are talking about the free body diagram of the can, then we talked about the support from the bottom of the can because the can cannot fly, can cannot be in the in the wide space right it should have some support. So, that it will give or it will satisfied the equilibrium conditions.

So, now we should know what are the different types of support we generally encounter, in mechanics. Apart from that you have different other supports, but mostly these supports we will talk about the, I will cover the whole range of problems. So, let us talk about the support conditions for different mechanical systems, support conditions.

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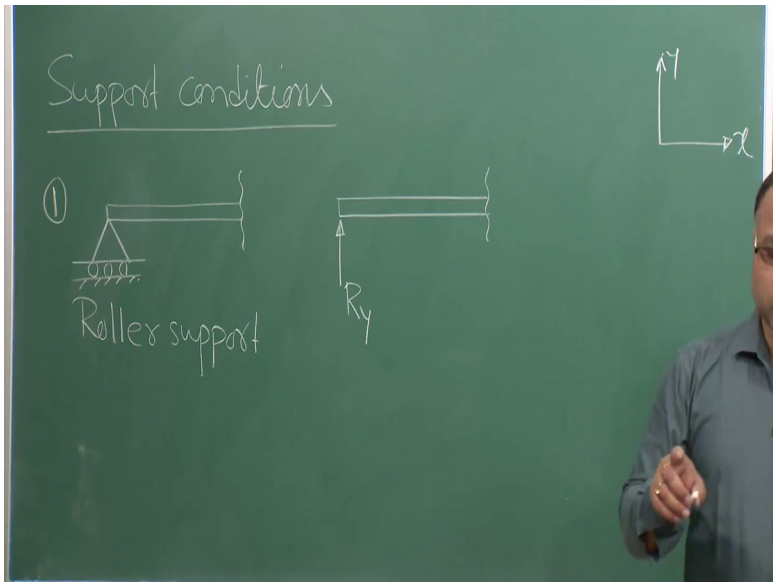

First one is suppose I have one beam which is supported like that. So, these are rollers fine. So, if I consider this is my x y plane. So, this beam is spanning in x y plane. So, this is the planar structure, you can say in the z direction we are not we are not considering at this movement. So, this support is known as roller support, as it is resting on rollers.

Now, if I have this kind of support, then basically what will be coming to your mind. Now if I say this is the support means it will try to whole the structure. So, this is the structure the support will try to whole the structure in position. Suppose I am standing here right; I am standing on the floor. So, floor is giving me the support. So, that I am not

going inside the ground. So, that is nothing, but the support. So, every mechanical system if you consider you should have some support otherwise it will not withstand.

So, now if I, as I told you I am standing on the floor. So, my weight is giving some action on the floor. So, floor is giving some reaction equal and opposite reaction as per the newtons law. And that equal and opposite reaction basically will be in the upward direction say suppose my weight is acting in the downward direction. So, the reaction will be acting in the upward direction; that means, I am free to move in this direction like this, but I cannot move in the vertically downward direction because the floor is giving me the opposite and equal reaction.

What does it mean; that means, if I restrict anything any system or any component of the system if I restrict that thing from any movement. So, in that direction basically I will be give I will be getting some reactions am I right or not because I can move in the lateral direction or in this direction right in the in the frontal direction, because I do not have any reactions on those directions. Nobody is abstracting me nobody is restricting is my movement. So, that is why I am getting, I am not getting any reactions in those directions, but I cannot move in the vertical downward direction because of flow is giving me in the support or flow is giving me some opposite reaction.

So, for any support it will try to restrict some movement and try to allow some movement. If it restricts some movement then of course, you will be getting the reaction in those directions. I am and if it is allowing the movement in some directions. So, we will not be getting any reaction for these from the discussion. So far whatever we are doing now based on that we can say that. So, what we can say? We can say that a support will give me the reaction, if it restricts the movement in that direction and the support will not give me any reaction if it allows the movement in that direction fine fair enough.

So, if that is. So this roller support if you look at I have rollers here. So, the movement of this beam in the x direction that is the horizontal direction is not restricted by the support. The support is not restricting the horizontal movement of the beam therefore, I should not get any reaction in that direction as per our as per our discursion or as per our say whatever we have agreed.

But if you look at this beam cannot move in the vertical direction vertically upward or vertically downwards of course, this is the simplified figure. Generally, one more roller

support is generally put on the top. So, that the vertical movement either in the upward direction or in the downward direction; that means, either in positive y direction or negative y direction is completely restricted. So, if the movement is restricted in y direction then what should I get from the discussion, that I should get one reaction right.

Now, another thing is that suppose I am putting some load on the beam. So, this beam suppose, if you consider if you consider this is the beam this this part is a beam this is the support. Now this support is not allowing me the vertical movement, but it allows me the horizontal movement, but at the same time it allows me the rotation of the beam. So, beam can rotate with respect to this point it can rotate right, like this hinge. So, this hinge basically will give me the rotation. So, if it gives me the rotation. So, and rotation generally happened due to the movement. So, what we can get from this support because this is allowing the horizontal movement. So, there is no horizontal reactions. It allows the rotations. So, there for no movement reaction what it does not allow the vertical movement. So, therefore, there must be some vertical reaction.

So, once I want to show the free body diagram of this beam. So, the free body diagram of the beam will be like these. So, this is your beam. So, free body diagram means you want to separate the beam out from the system; that means, your replacing the support by putting some externally applied forces. So, what are the forces will be that they only the vertical reaction.

So, this is the typical behaviour of a roller support. So, whenever you will be encountering with roller supporting in this particular course immediately it should come to your mind how the reaction. So, will developed at the support because it is the allowing horizontal movement those therefore, no reaction in the horizontal direction it is allowing the rotation, therefore, no movement reaction at the support, but it does not allow the vertical movement. So, ther E for I should get one vertical reaction.

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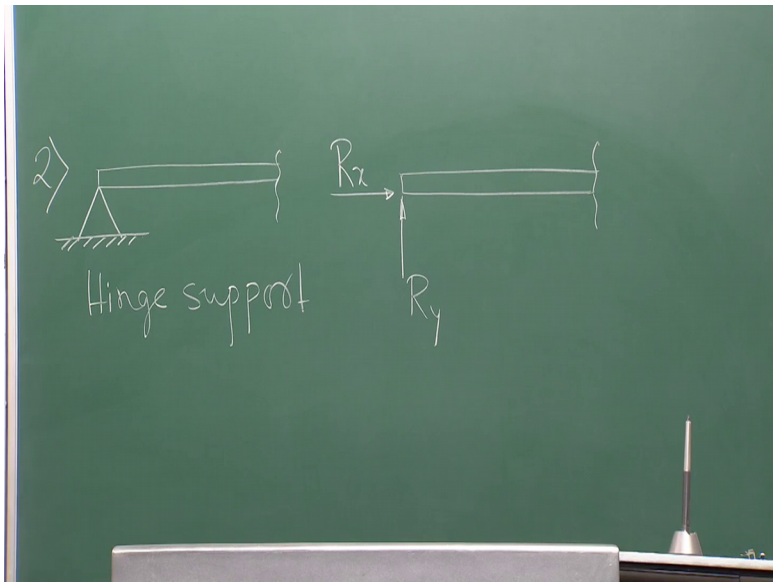

So, similarly the second type of support is hinge support take another beam. So, this is your hinge support. So, what is the specialty of this support? If I look at this support, this support is looking like roller support, but it is not the roller support. Why it not the roller support, if you look at this support it will not allow any movement in the horizontal direction, which is not like the case whatever we discussed previously for the roller support. So, it restricts the horizontal movement as well as it restricts the vertical movement, but what about the rotation it allows the rotation right. That is why I mean you generally you see this kind of support in the door right. If you want to open the door if you want to close the door the door can be rotated right door can be rotated with respect to the hinge at the end which is attached to the frame door frame right. So, door can rotate, but it will not come out from the frame or it will not go down from the frame. So, this is a typical example of hinge support.

So, if I want to draw the free body diagram of this beam. So, how should I draw it? This is the beam. So, it restricts horizontal movement as well as vertical movement. So, therefore, I should get 2 reactions Ry and Rx and what about movement there should not be any movement reaction because rotation is allowed fine.

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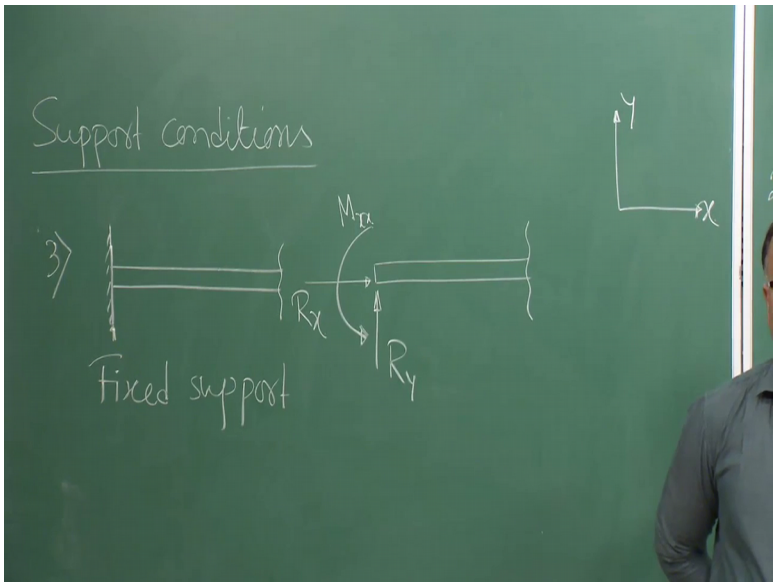

So, next type of support is. So, next type of support is fixed support. Next kind of support is fixed support. So, this support does not allow horizontal movement, does not allow vertical movement, as well as does not allow any rotation. So, there for I should gave because all the movements are restricted. So, there for I should get all the reactive forces. So, if I want to draw the free body diagram as per our discursion. I will get vertical reaction, I will get horizontal reaction and I should get the movement reaction.

So all the reactions, all the reactions, because it is not allowing me the rotation it is not allowing me the vertical movement as well as horizontal movement. So, there for I should get the components of all the reactive forces here. So, now, this fix support you generally see in your day to day life like a beam is having the support on the column. So, beam column support or beam column junction you might have seen in your building or in any civil engineering structure is beam column structure is generally defined has the fix support. And where you get these roller and hinge support have you ever seen this. If you have you ever seen any Railway Cross Bridge or the classical example of the Howrah Bridge or something like that, there if you really look at the supports at the bottom you might get this kind of supports.

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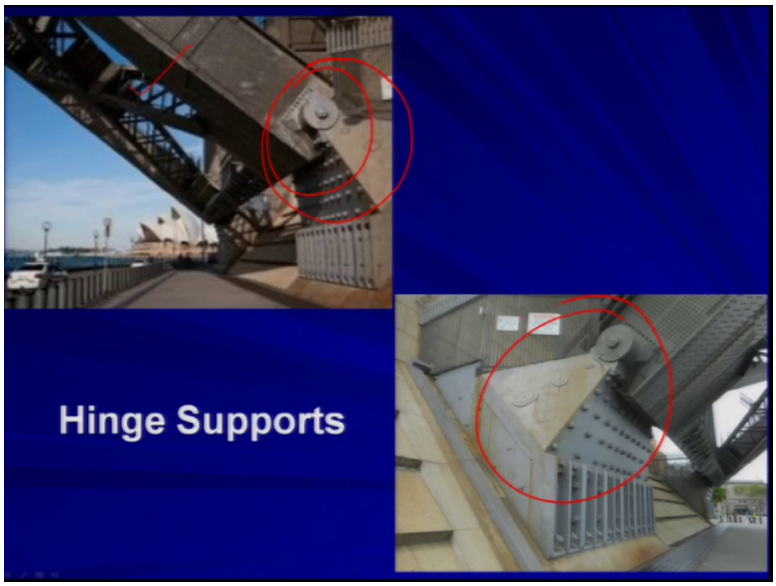

So, I will show you the typical picture of this kinds of supports. So, if you look at this figure. So, this is your hinge support if you look at this this is a huge bridge cross, cross will be coming later all what is cross and how we can define cross and how we can solved the cross. So, these things will be coming later all, but you might have seen that is railway bridge some steel cross railway bridge of the classical example is the Howrah Bridge - The Howrah Bridge classical example of the Howrah Bridge. So, that steel structure completely made of steel.

So, there you might have seen you carefully look at the supports you might see this kind of supports. So, this is known as hinge supports if you look at this is known has hinge support, it looks like whatever I showed you just now right from the from the fontal elevation this is the typical example of roller support, if you look at this it will try to allow the movement in the horizontal direction.

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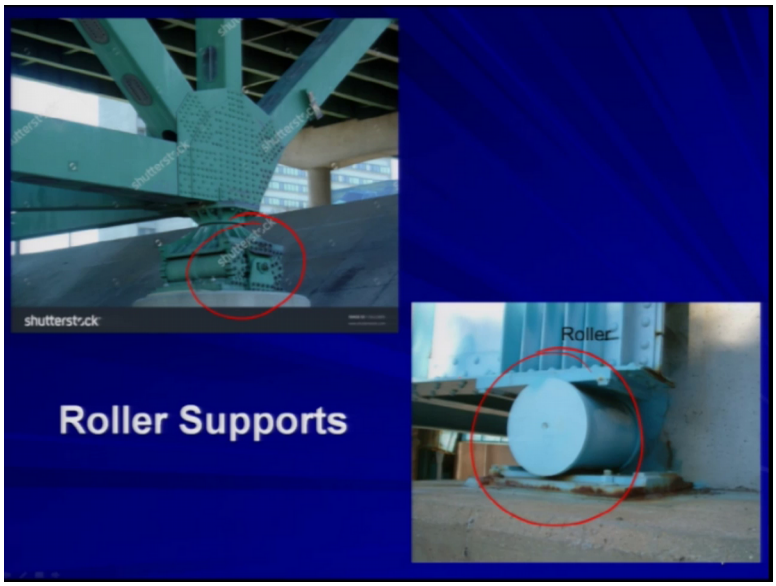

But it will not allowed the movement in the vertical direction. This is the typical example of the roller support, it could be huge I mean it is not the small thing right it could be huge it should sustain the load whatever is coming on that roller right.

So, see this is the beam some beam or some structure which is carried by this roller supports. So, it will allow the movement in this direction, what it will not allow any movement in this directions. So, this movement is not allowed. So, these are some typical photos. So, that you can absorb or you can understand that what are the different types of support we are talking about.

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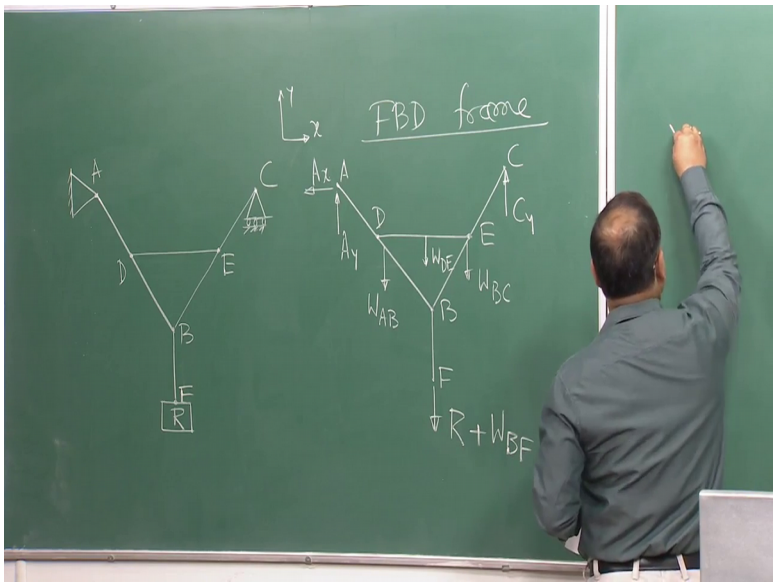

So, now, with this bit background of the support conditions, now will try to draw the free body diagram of it typical structure. Say let me draw that, this is one hinge support. This is a roller support. This is A from load R is acting at the bottom this point is B. This is CDE and F. So, this is a kind of frame you might of seen made of steel or wood or whatever all these members. So, these are joints these are all joints.

Now, how many members we have in this frame. We have AD one member, DE another member, EC another member, DB another member, EB another member and BF. So, 1 2 3 4 5 and 6 there are 6 members which are connected by some friction less pin. Which we are connected by some friction less pin and we are assuming that thing we are analyzing that system. So, this all joints are made of friction less pin. It could be pin joints it could be rivets or it could be bolted you might of seen that thing in different frames right frame structure if you look at anyway. So, we are not going to analyze the frame right, now will see how we can analyze the truss at the time will talk about this thing in more detail.

However I want to draw the free body diagram of this system. Now if you look at this system generally these members. So, what are this members AD BC and all these 6 members. So, this 6 members how it will behave and what are the different forces it will take. So, those things we have not talking about at this moment because we have not equip to do that at this stage, but I can draw the free body diagram because right now, I

know the support conditions. So, if I want to replace this support I know how to replace those things and then I can draw the free body diagram. So, if I want to draw the free body diagram of the frame whole frame FBD of frame then basically this is the frame. So, this is the; this is C and this is D, this is E, this is B and this is F.

So, this is the whole frame I am taking it out. So, when I am taking it out from the actual system, then it should be the support conditions must be replace by the forces. So, in this hinge support what are the forces will be getting the reactive forces one horizontal another on vertical right. If I say this is my x y plane. So, I can simply right, I do not know the direction. So, do not think about the direction too much you may ask. You may ask me why I am showing ax in this direction. Let it be in the opposite direction I do not have any problem, because I do not know the actual direction. So, that will be coming later on when will be actual analyzing the structure you correct direction.

So, right now this direction is arbitrary I mean I am just putting that thing arbitrary. You confused different direction there is no problem, but all in thing is that only thing you have to remember that we will come to that point. So, we are replacing the reactive forces here. Similarly, at C this is the roller supports, only vertical reaction right. Other vertical reaction and at point F. So, before that this AB will be having weight if I consider the weight of the member. AB is a member same and DE is a member well. I mean in the problem what I am seen here in the problem I am considering AB is one member another one member is BC. So, BC is the whole member AB is a whole member. So, they are connected by DE at this 2 points.

So, AD BD they are not separate members. So, has as it is shown in the problem. So, AB is a complete member. So, in the previously whatever will talked about, now, basically we have AB one member BC another member DE another member, 3 member and BF. So, 4 members instead of 6 whatever we just talk instead of 6 basically depending on the problem, I mean you can have different members we can have 6 members, but at this problem whatever I show that these are 6 4 member (Refer Time: 25:20) anyway. So, that is not a problem.

So, if you consider AB as a whole member. So, the weight of the member AB that is WAB is can be assume to act along the center of gravity of the member fine similarly WDE is acting here similarly WBC is acting here. And at point F you have already force

R pulse WBF. So, this is the free body diagram of the whole frame. Now I want to draw the free body diagram of individual members, I mean, So, from the macro system, I am coming to the micro system then from the micro system, I am going to the Nano system something like that if you try to try to map like this.

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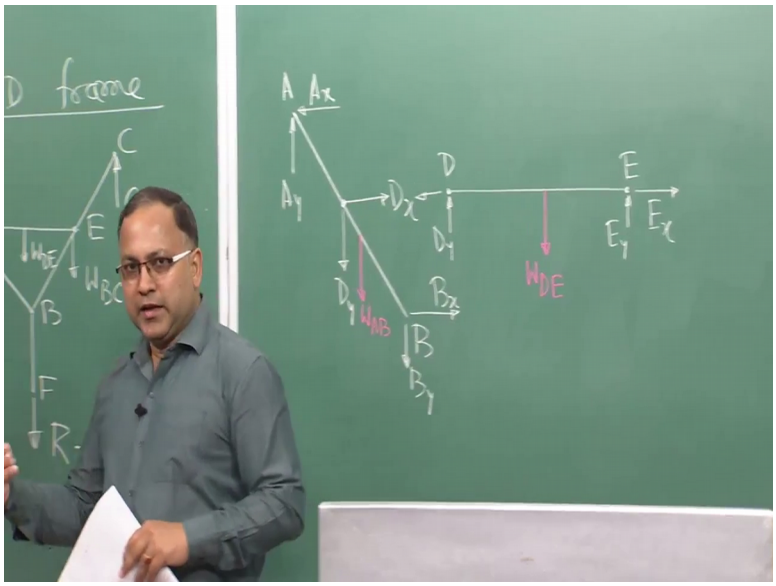

So, now, I want to draw the free body diagram of each and individual member. Let us draw that. So, this is my AB member I have AX, AY here.

Now, this is the joint as I told you B is the joint. Now I do not know the direction of the force at this joint. Because the joint will develop some support, because the joint is giving some support right for the member AB, AB is getting hinge like these 2 supports A and B right. So, at A I have a defined the forces because that is the hinge support this B is a pin support or there some joints.

In the joints I do not know the direction of the force in which direction it will move, it may along AB it may, but take some other direction I do not know line of action in of the force is not known, but I can resolve whatever line of action is there, but I can resolve that force in 2 components, one is along x direction another one is along y direction. So, that thing I can simply show by and bx again I am telling you repeatedly that I do not know the direction of Bx and By, Bx could be in this direction by could be upward direction that could be, but I do not know I am just writing that thing arbitrarily that will

be coming from the analysis when you are analyzing the actual structure then it will be coming automatically.

Now, at point D, D that member is getting supported at point D and B. So, at point D, we will be getting some reactive forces again I do not know the line of action of that force. So, I can resolve simply Dx and Dy and of course, I have I can use the different color for the wet of course, I have WAB. So, this is the free body diagram of the member AB, similarly I can draw the free body diagram of member de this is the member de in that member. So, here actually one thing we have to remember, now at point D, because it is in equilibrium. So, whatever direction of Dx is shown here on this member it should be exactly opposite and equal otherwise, it will not nullify or cancel each other right. So, these thing only you have to this is your Dx and Dy, I have shown by vertical downward. So, it should be upward.

This seeing only have to remember now if you choose Dx here, in this direction here Dx will be in this direction. So, that only you take care rest of the things will be coming automatically from the analysis you not to think about that. So, do not scratch your head by the selective of or selection of the direction of the forces. Similarly, for E and showing here - Ex and Ey, and of course, the load is acting WDE.

Anywise I will stop here today. So, in the next class will continue with the free body diagram of the other members.

Thank you very much.