Structural Analysis 1
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Lecture 9
Analysis of Truss - Method of Joints (Contd.)

Hello. So what we have been doing since last class is, we are trying to see some examples ofanalysis of statically determinate truss using method of joints. Let us continue with that.

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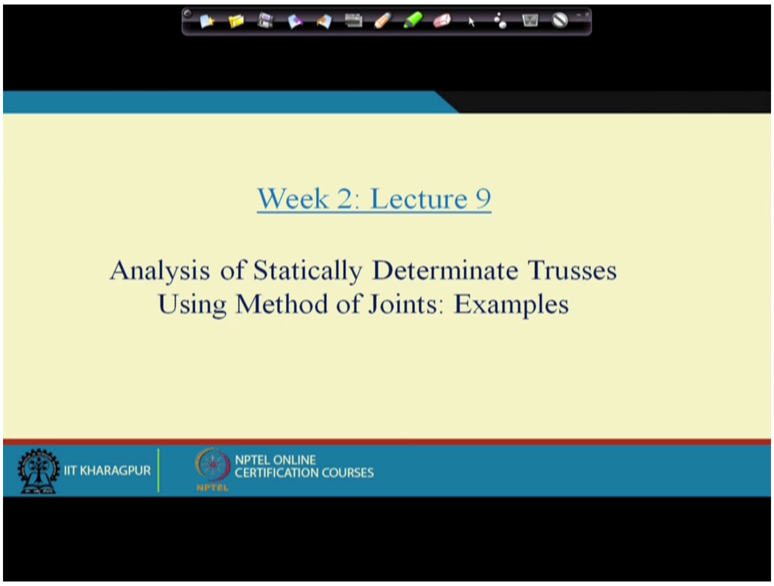

Nownext take this example.

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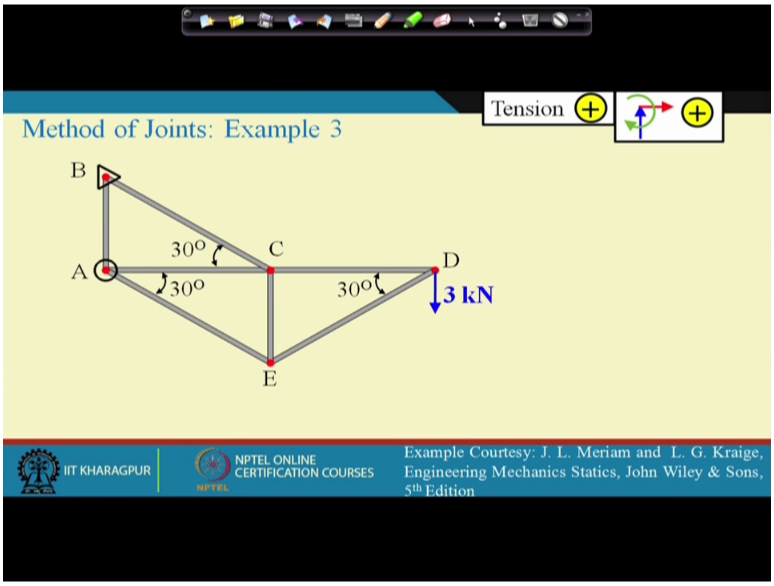

So we are going to solve this truss.

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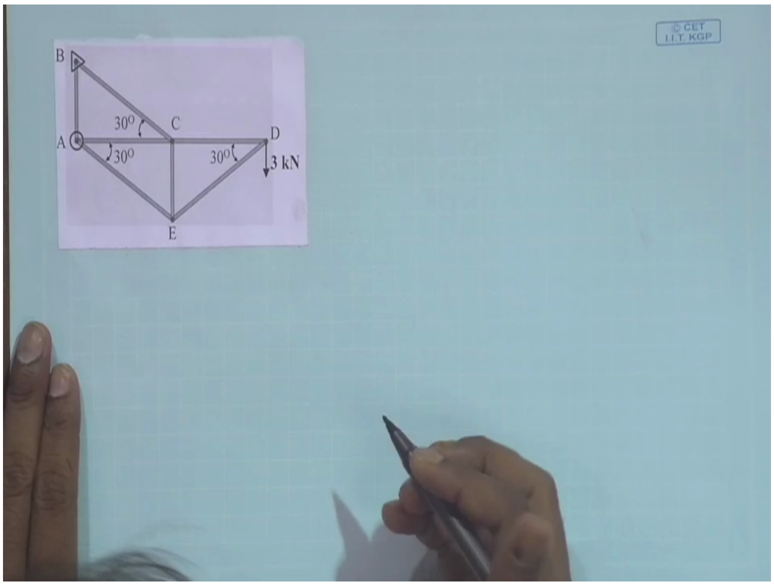

Now,first is, we need to determine the support reactions. So first let us see whether it is statically determinate truss or not.Number of reactions are, we have is3, here 2.

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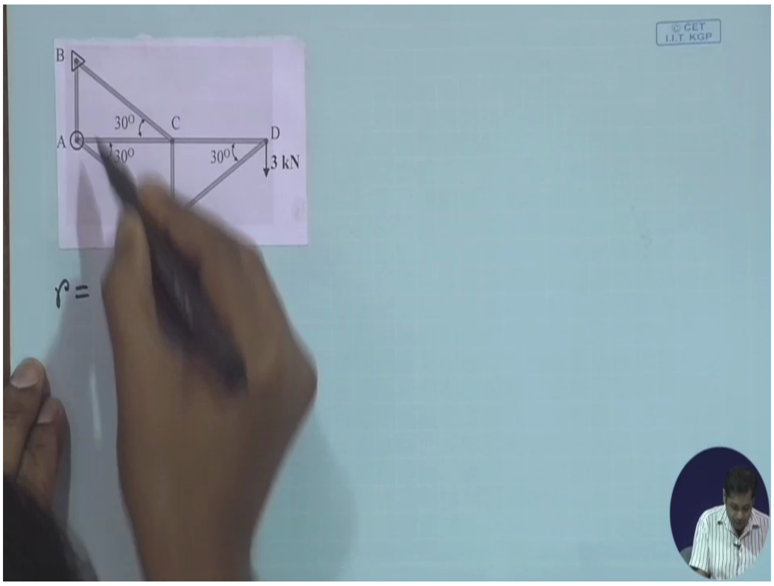

Let us draw the free body diagram of the entire structure first. So this is roller support we have. This is Ax and then this is Bx and By.

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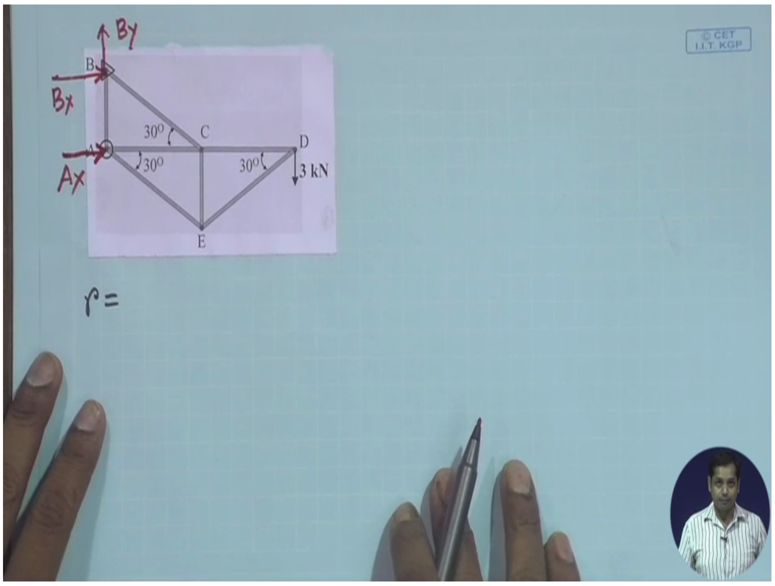

Again last class also I mentioned. Just to save the timeI am drawing the free body diagram of the entire structure and showing this reactions on this diagram itself. But free body means it has to be free from the support, right? So when you are (repl) replacing support by forces, don't show support and the reaction together in the same diagram. Okay, now so number of reactions are 3 and the number of members are 1, 2, 3, 4, 5, 6, 7. Number of members are 7.

And number of joints J is equal to 1, 2, 3, 4, 5 joints. 5 joints. So m plus r is equal to 2j. So this is statically determinate truss.

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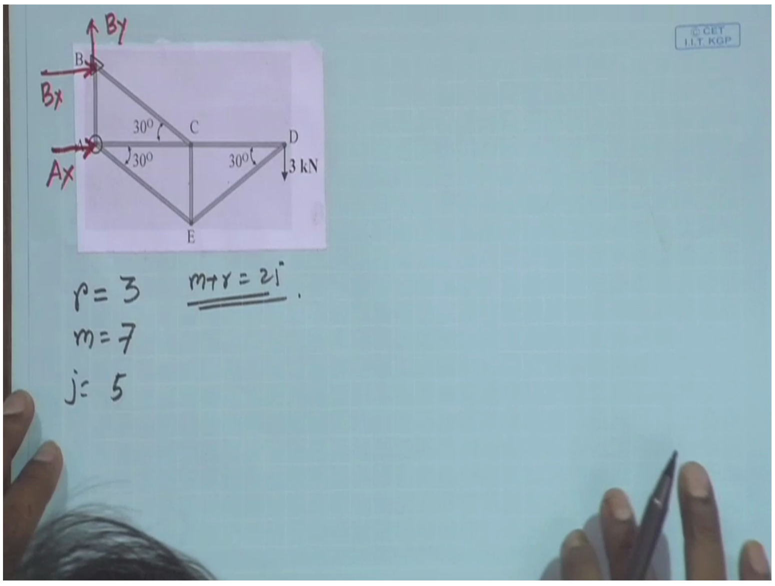

Now first let us find out the support reactions. Now if we take if y is equal to zero. Let's just, this is okay. On this free body diagram, if we apply the equilibrium equation, first is summation of Fy is equal to zero. Thisdirectly gives that By is equal towhat are the forces you have in Y direction? We have By and then downward 3 kilo Newton force. So By minus 3, 0. So By is equal to 3 kilo Newton. So this is okay.

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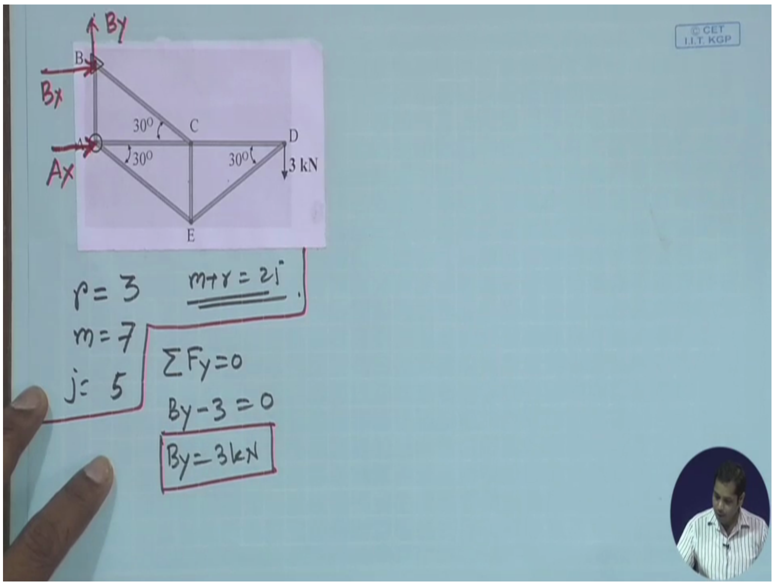

Now if I take moment about A is equal to zero. Say summation of moment about A is equal to zero. Now what are the forces we will contribute to this moment? Ax will not contribute, By will not contribute because the point A lies on the line of action of the B. Bx will contribute and this 3 kilo Newton load will contribute. Now the forces in Bx will be this distance into Bx. And then clockwise couple by this force is 3 into this distance.

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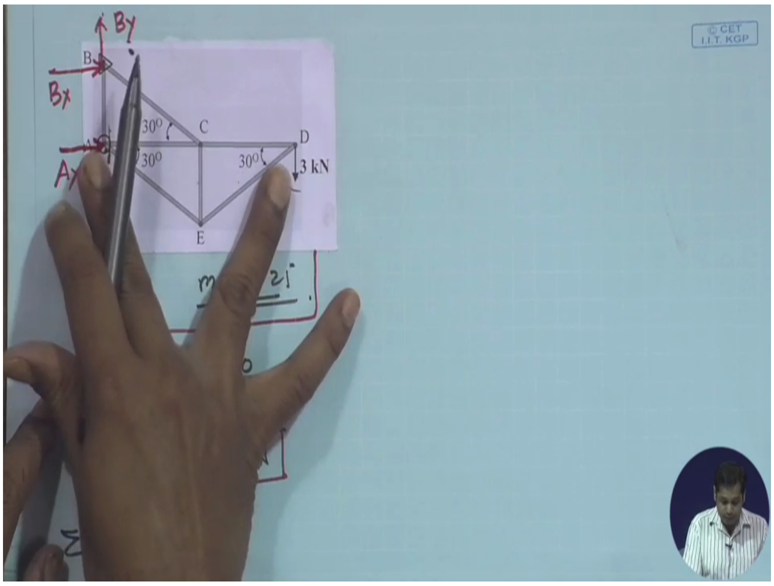

Okay, let us first write the distances. These distances are L, these are all L. These angles are 30 degree. So this is 2L by root 3 and this is L by root 3. Now summation of MA.M is equal to zero. It means let us write it here. Summation of MA is equal to zero. What it gives is Bx. Bx into L by root 3. This is positive because it is clockwise. Plus 3 into 2L, that is equal to zero and this gives Bx is equal to minus 6. This equal to minus 6 root 3 kilo Newton. So this is Bx, right?

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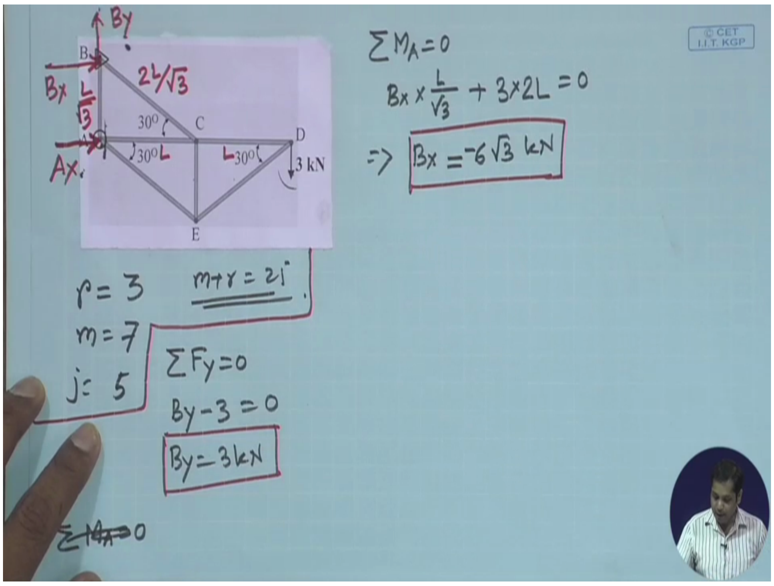

Now if I take summation of Fx is equal to zero.Then horizontal component are Ax and Bx. This gives us Ax plus Bx is equal to zero. You could have done like this. You could have showedAx in this direction and Bx in opposite direction. In that case it will be Ax minus Bx is equal to zero. Plus try to avoid that because when you draw the free body diagram, whatever sign convention you have fixed for your free body diagram, you please do that. Be consistent with that. This is equal to zero.

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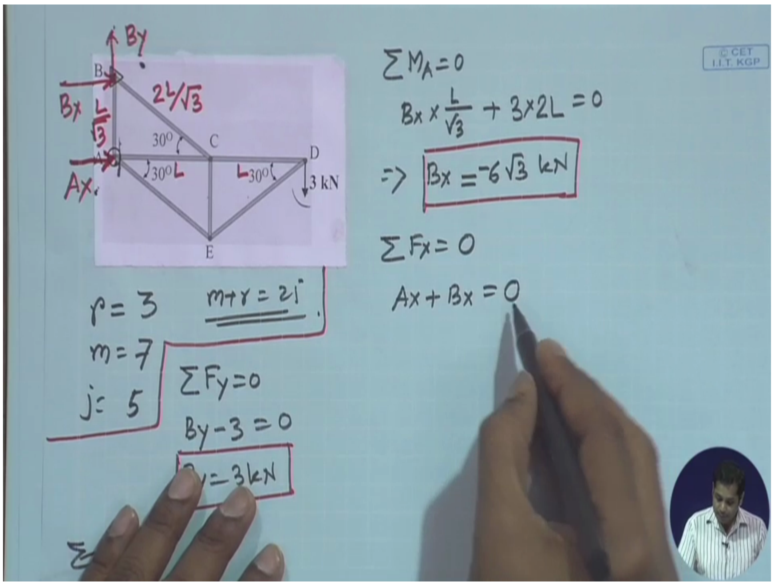

So this directly gives that Ax is equal to 6 root 3 kilo Newton. So this is the support reaction. So we have obtained the support reaction, right?

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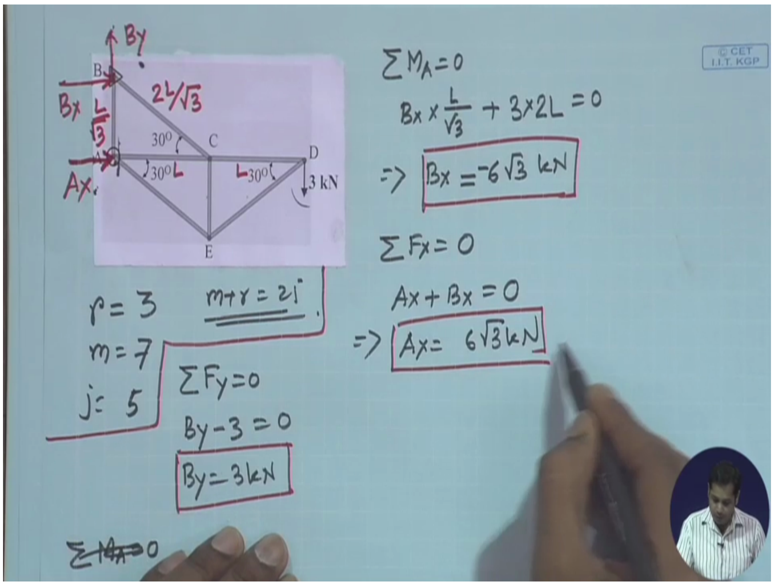

Now let usdetermine the member forces. Now let us identify which jointwe shall take. We cannot start with joint E, because joint E has 3 members. So 3 unknowns. Equations will be only 2. We cannot start with joint C because C has 4 unknown, 4 members. So we have only

2 equations. We cannot start with joint A as well because A has 3 unknowns. And equations are only available 2. So either we can start with joint B or we can start with joint D. In both the cases number of unknowns are 2.

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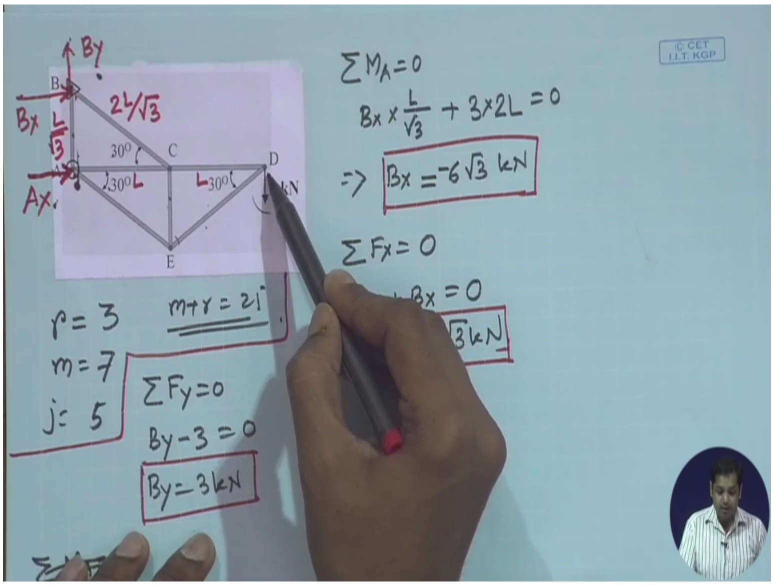

So let us start with joint D. Now what is the free body diagram of joint D? So this is your support reaction, right? Let us draw the free body diagram of joint D. So this force is Fcd and this force is Fde. And then another force 3 kilo Newton. This is D and this is Fbd of D.

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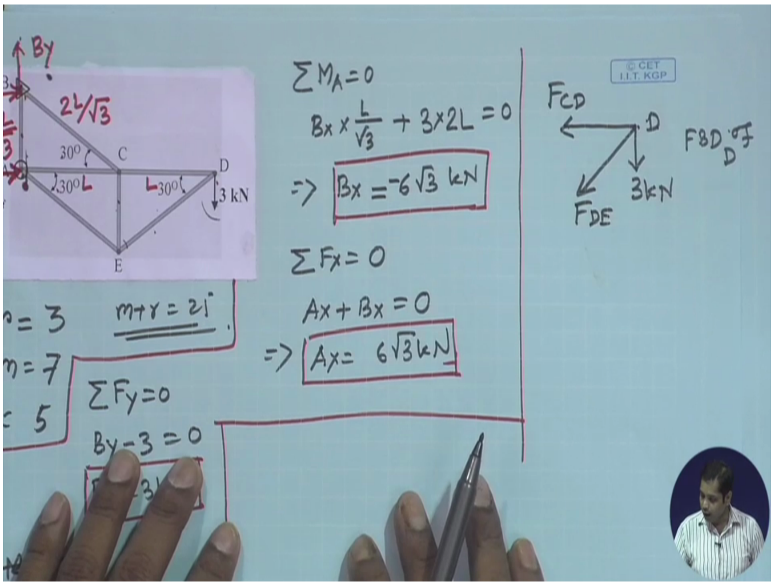

Nowtake summation of forces in X direction is equal to zero. Or take summation of forces in Y direction is equal to zero first. Then it gives Y direction component as 3 kilo Newton and component of Fde, this angle is 30 degree.

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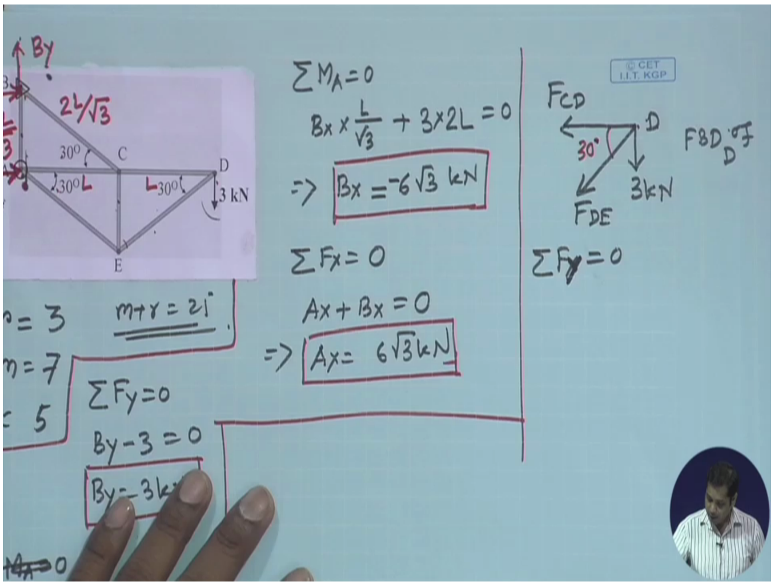

So what we have is Fde which is the vertical component. H is downward that's why I put negative sign here. And then minus 3 is equal to zero. 3 minus because it is acting downward. So this gives me Fde is equal to minus 6 kilo Newton. So Fde is obtained, right?

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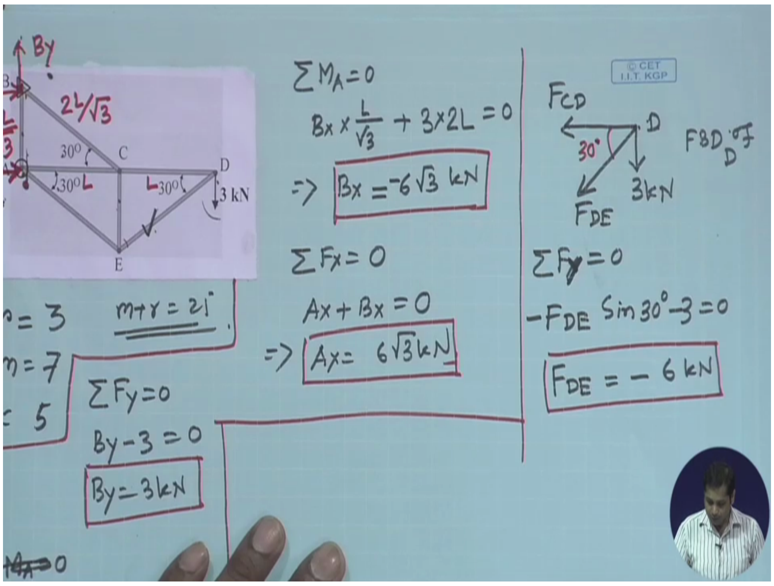

Now in the same equation if we take summation of same free body diagram, take summation of Fx is equal to zero. Thenwhat we have? We have Fcd minus Fde cos 30 is equal to zero, right?. This is again negative.

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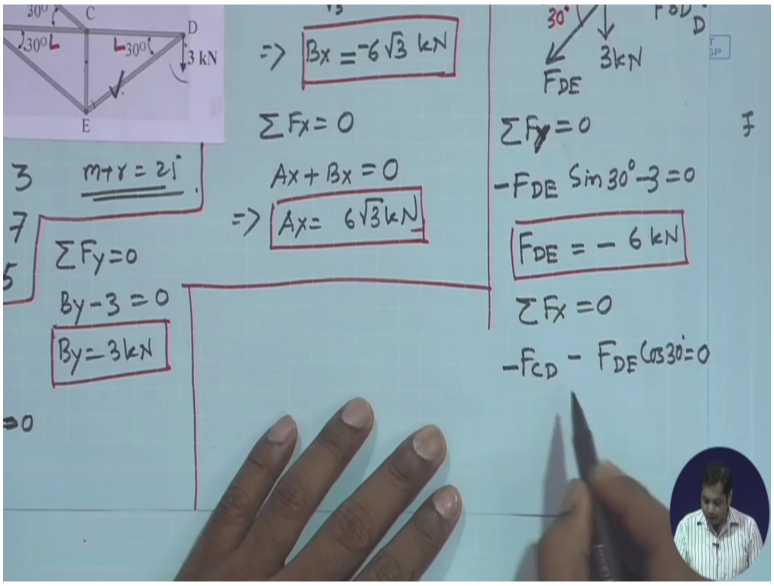

Both are negative becauseas per our sign convention, both are in this direction and the component of this is also in this direction. Per our sign convention is this direction is positive.

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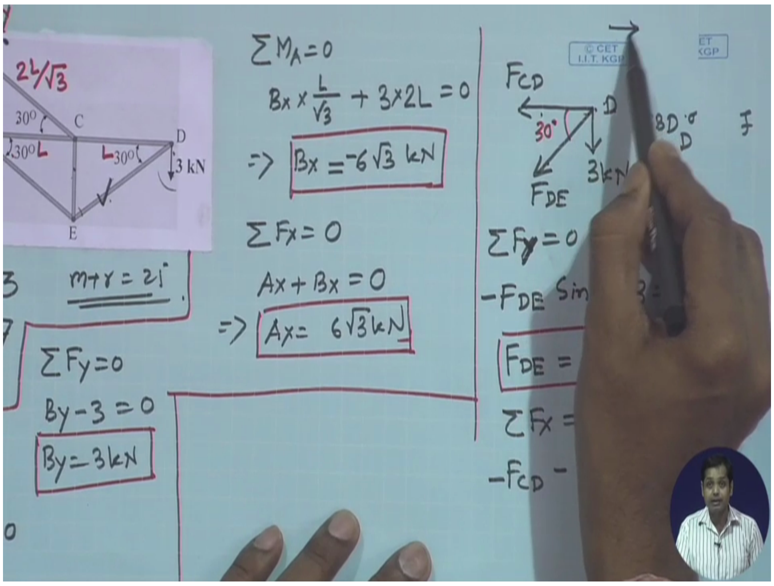

Now Fde is already obtained 6 kilo Newton. And from this equation we can get Fcd is equal to uh 3 root 3 kilo Newton. So Fcd is determined. So this is determined, right?

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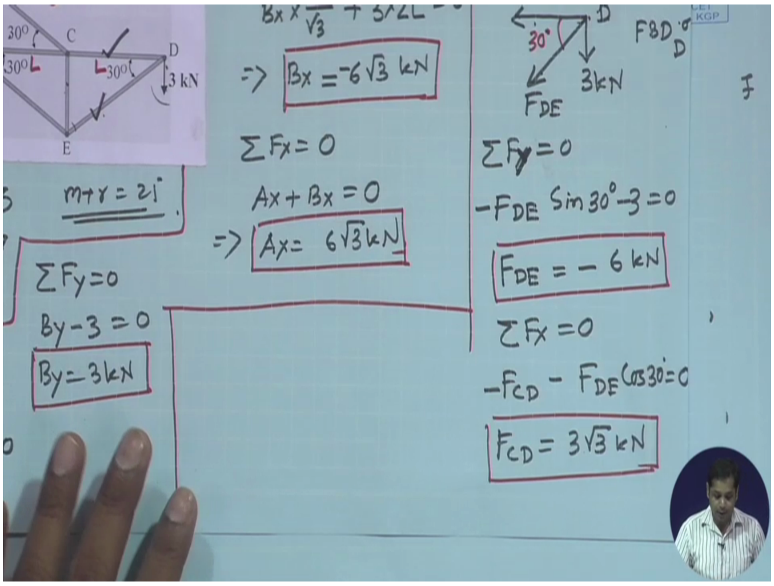

Now let's see what joint. We have already obtained the member forces in these 2 member forces. Let us see now which joint to take next. Joint C still has three unknowns. It has originally 4 unknowns. But one is already computed. So still it has three unknowns. So we cannot take next joint C.Joint E, originally it has three unknown. But now this is known to us. Member forces in member ED.

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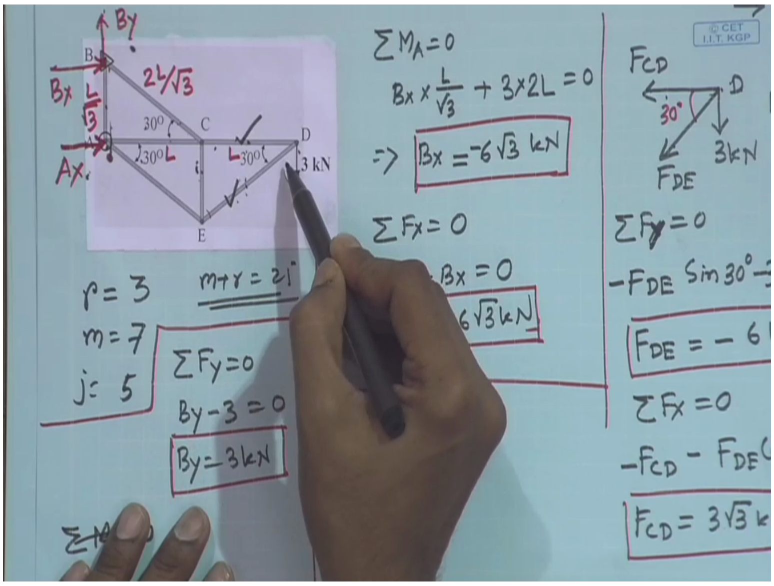

Now only unknown it has is these 2. Member forces in this and member is this. So let us uh draw free body diagram of joint E. Now joint E will be the free body diagram Fbd of E, right? Now Fbd of E will be this, this and vertical component like this. All these angles are 60 degrees these angle are 60 degrees angles are 60 degree. This is Fed, Fae and then Fce.

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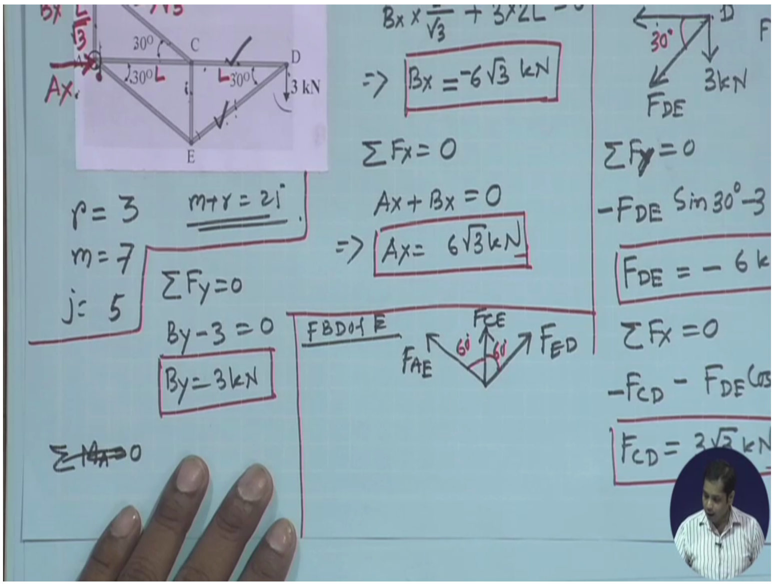

Now if we take summation of Fx is equal to zero, it gives us Faesin 60 minus, this is plus Fed sin 60 is equal to zero. And this gives me Fae is equal to Fed. So forces in this member and forces in this member are same. Now this member already we have determined Fed. Fed is already determined minus 6 kilo Newton. So this we can write Fae is equal to minus 6 kilo Newton.

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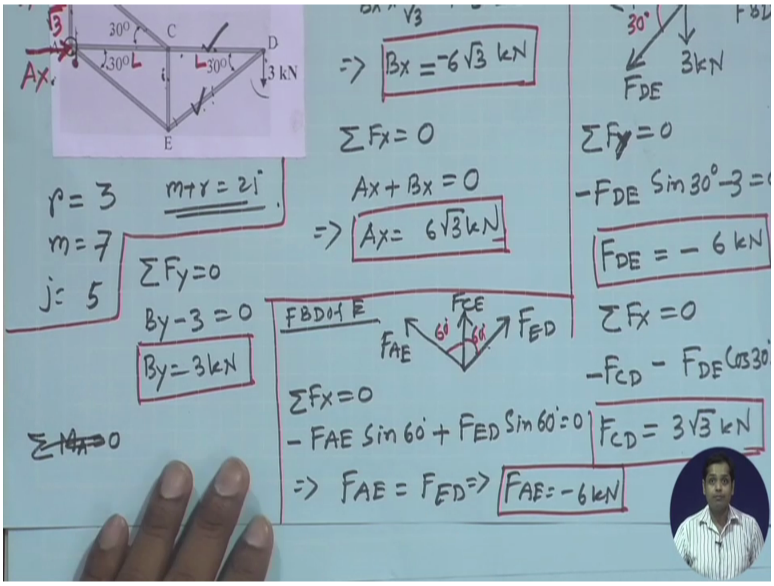

Now next what we have to take? Next we have to take the forces in verticalcomponent. So vertical component will be component of this and this and the force in members C itself.

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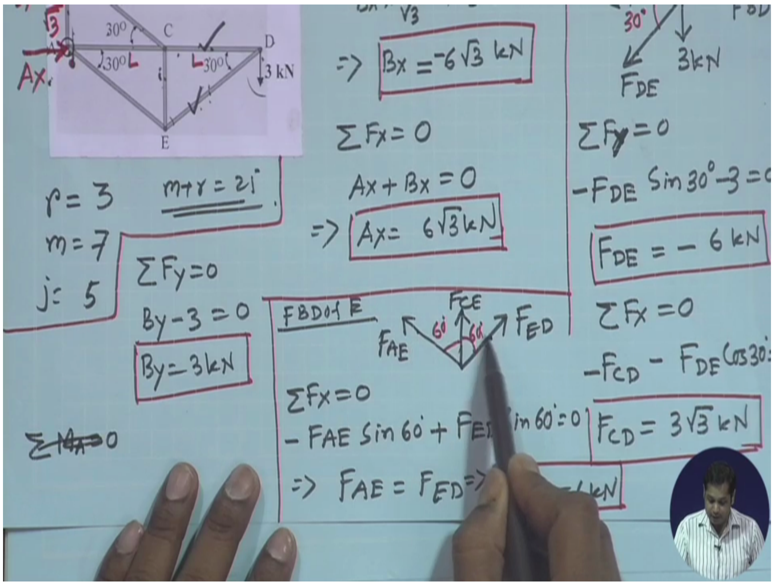

So, let us once again draw the free body diagram of this. It was Fed and it was Fae and the force Fce. This is 60 degree, this is 60 degree. If you take summation of Y is equal to zero, then we get Fce is equal to 6 kilo Newton. I am just writing the final result because it is just some algebraic operation. So Fce is equal to zero.

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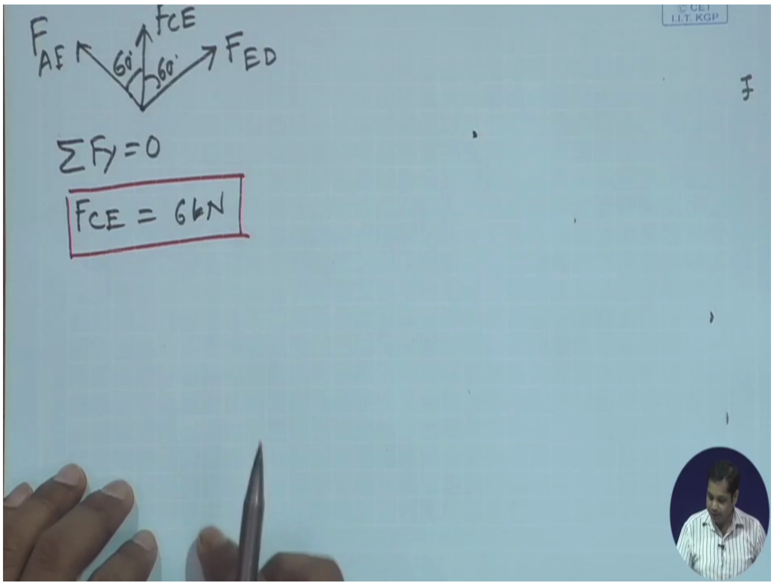

Now in this case we have determined this forces,right? Now next what we can do? Next we can take free body diagram of joint B to determine this force and this force. Free body diagram of joint B if I draw, Fbd of B. Then the free body diagram will be, this is and then this, horizontal reaction Bx and vertical reaction By. And this will be Fba and Fbc and this angle is 60 degree.

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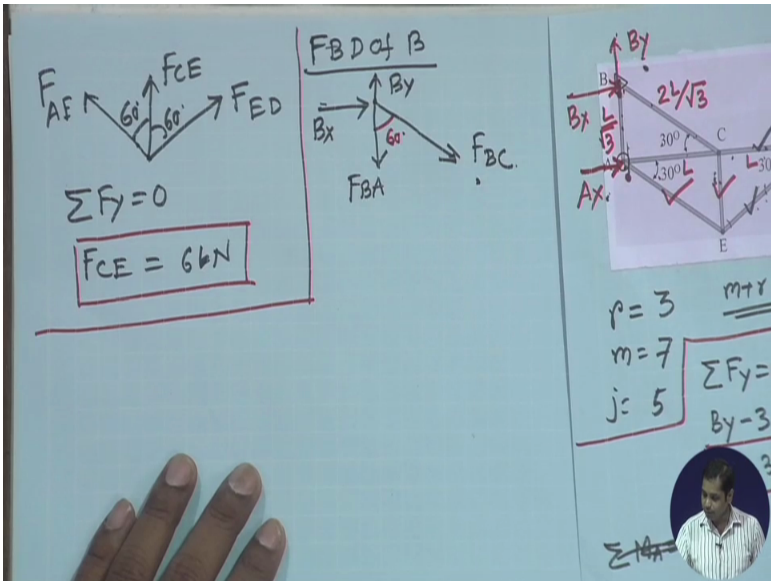

Now if I take summation of Fx is equal to zero, then it gives me, what are the forces we have? Bx is positive. Then plus Fbc sin 60 is equal to zero. Bx already we obtained. Bx is equal to minus 6 root 3. This is support reaction. And so if I minus 6 root 3 plus Fbc root 3 by 2. This gives me Fbc is equal to 12 kilo Newton. So Fbc is determined.

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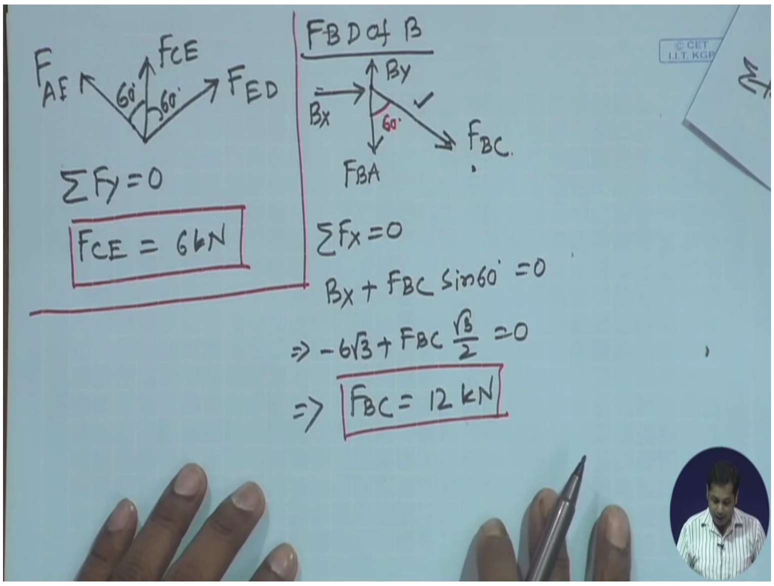

Let's calculate Fab. Fab we can calculate by applying summation of Fy is equal to zero, right? If I take Fy is equal to zero the equations are By minus Fba and then minus component of Fbc cos 60. And then if I substitute all this. Bc is known, By is known. Only unknown is Ba and from this if I substitute all the values, Ba we get is minus 3 kilo Newton.

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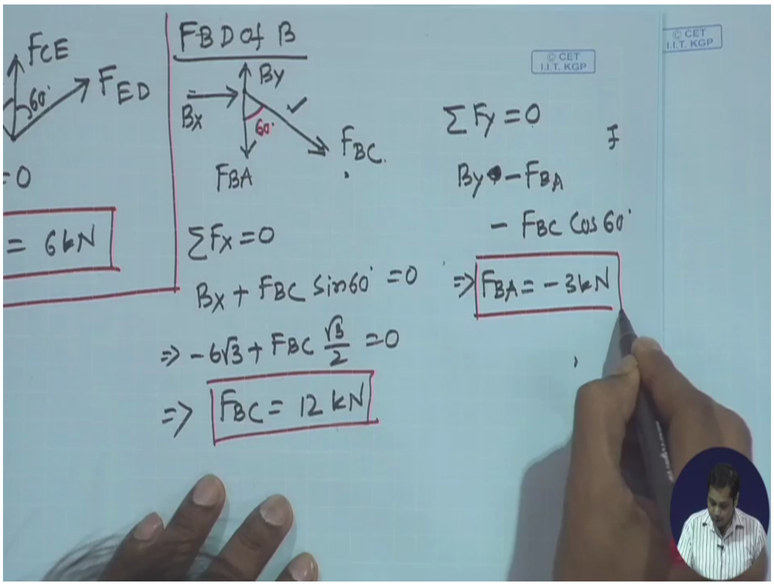

You see now this is also known. This is now known, this is known. Only thing left is this member.

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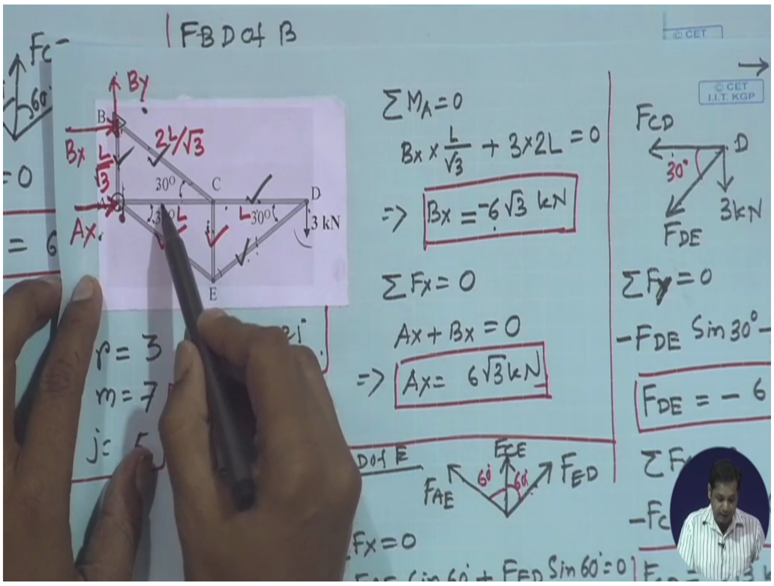

Similarly you can draw the free body diagram of this joint and find out the forces in this member.. The forces in this member Fac will be5.2 kilo Newton minus. So this is method of joints.

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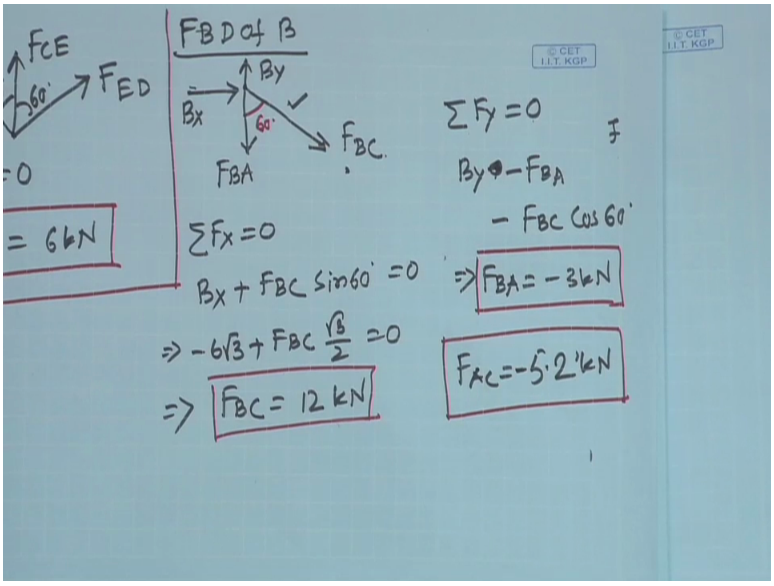

So now similarly once you have all the member forcesyou can draw the member force diagram of the truss. Just quickly one more example. There is a specific purpose of this example. You see herewhat we need to determine is, we need to determinethe member force in member CD, right? Now this is the problem.

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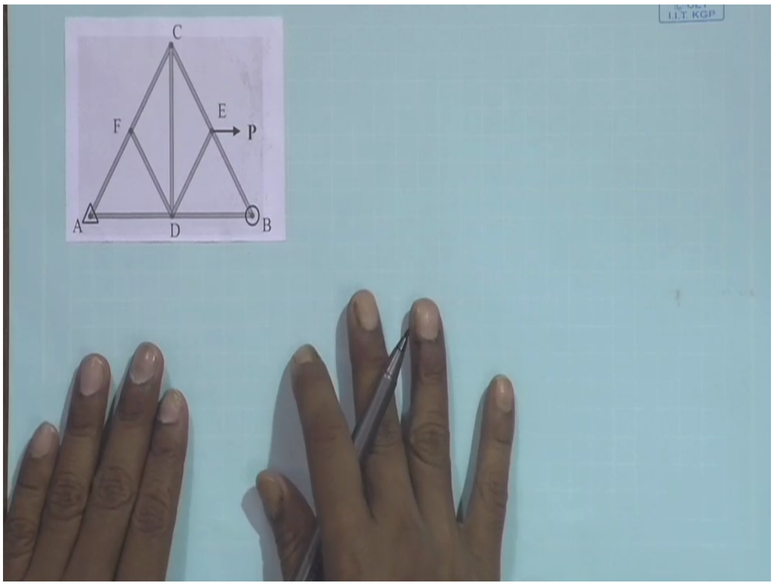

Suppose if I, because you are discussing method of joints today,suppose if I have tofind out the force in member CD using method of joints. Now what we have to do is, first we need to find out the support reaction. Once we know this support reaction, we can take this joint and determine the force in this member and force in this member.

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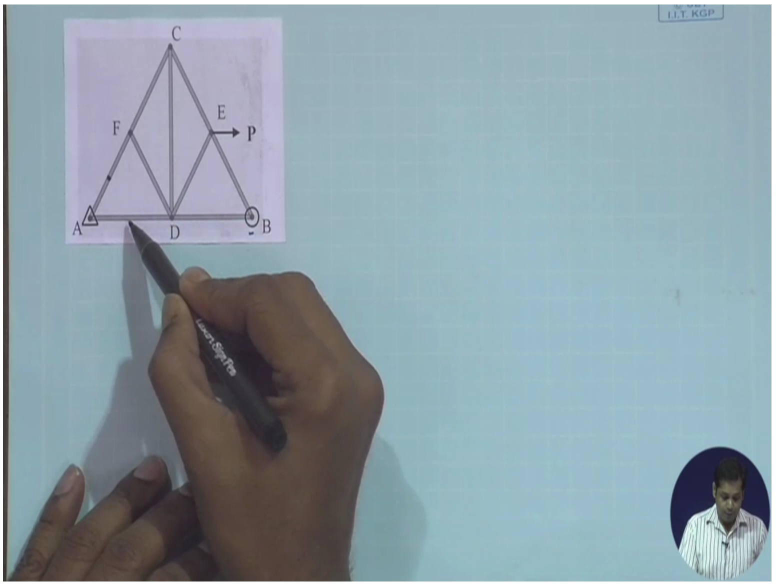

Once we know the force in this member, we need to take this joint to determine force in this member and force in this number.

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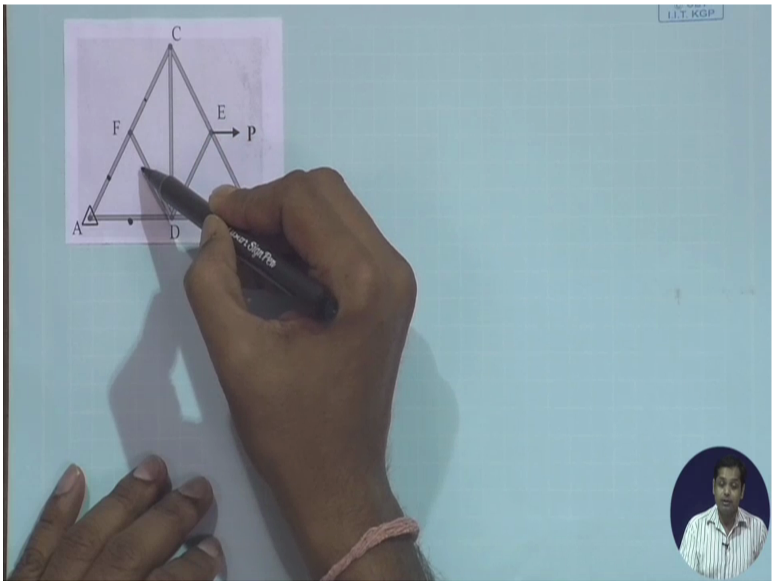

Once we know the force in this member, we can take this joint to determine force in this member and force in this member.

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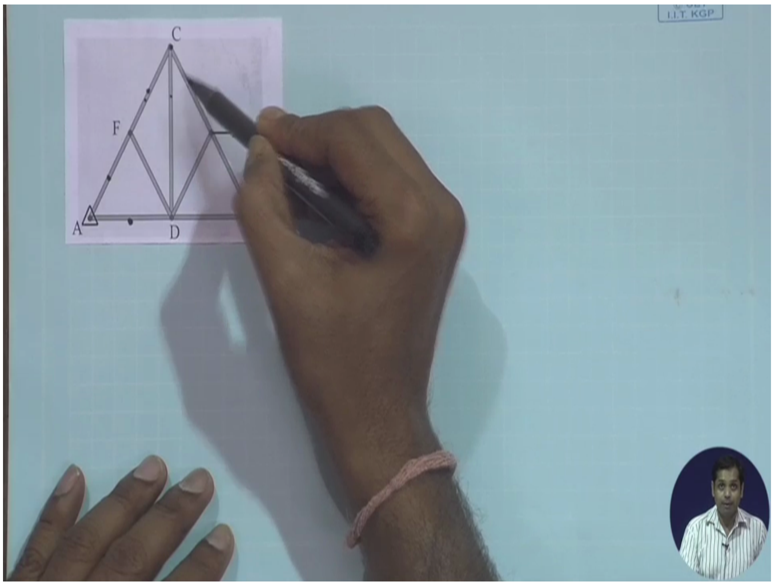

If you go this way, this way is also similarthing we need to do. So in order to get the member force in CD, what are the operations we need to do? We need to determine the support reactions, then free body diagram, one joint, apply equilibrium equation, second joint, apply equilibrium equation and third joint, apply equilibrium equation. Similarly here also we need to take 2 or 3 free body diagram to find out member force in CD.

Now is there anyotherway we can determinethe forces in this members. Let us see how we can avoidusing so many free body diagram of joints to determine the force in memberCD. Firstnow if I break the structure, supposefor instance,suppose if I break this structure here.

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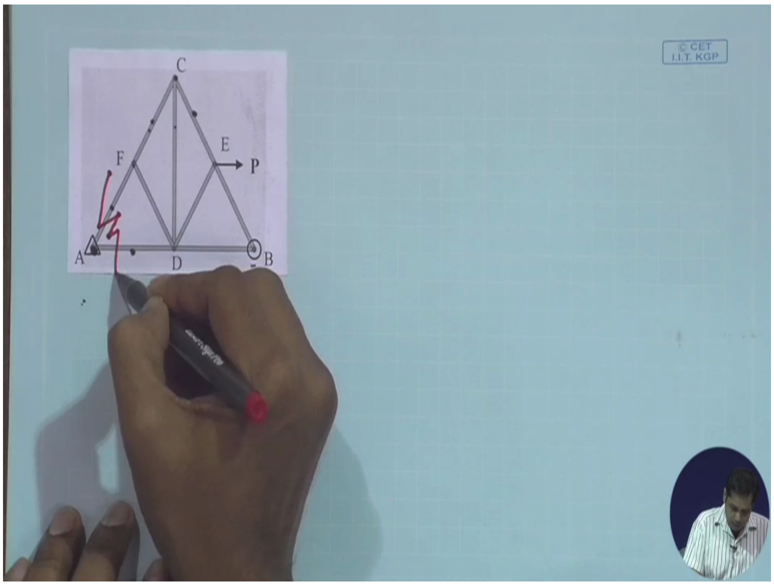

So now I have two part in this structure. One part is this and another part is this. What will be the free body diagram of this part? If I draw a free body diagram of this part and free body diagram of this part. Free body diagram of this part will be, you seenow this line breaks only member AF and member AD. All other members are remain unaffected, right?

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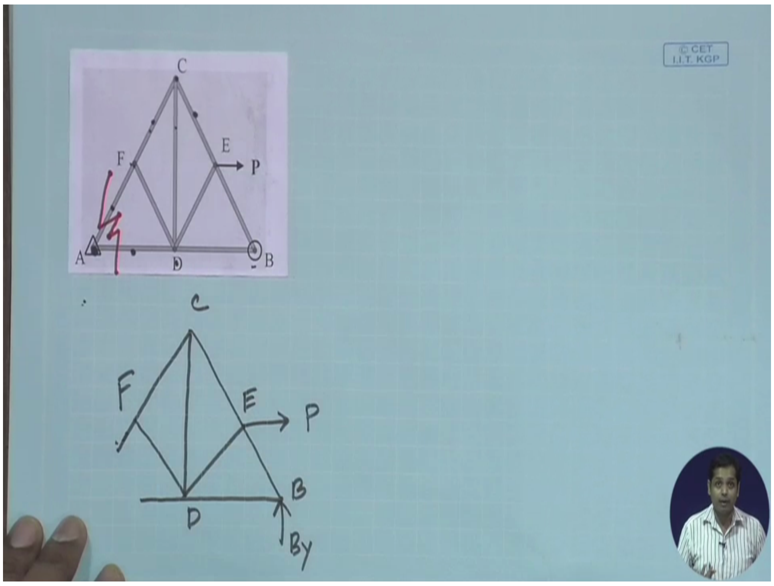

So this is the, this part of the structure. Now since this member AF and AD is broken now, so that has to be represented. It was originally continuous, that has to be represented by forces. So this force will be Ffa and this force will be Fad. So this is the free body diagram of this part of this structure.

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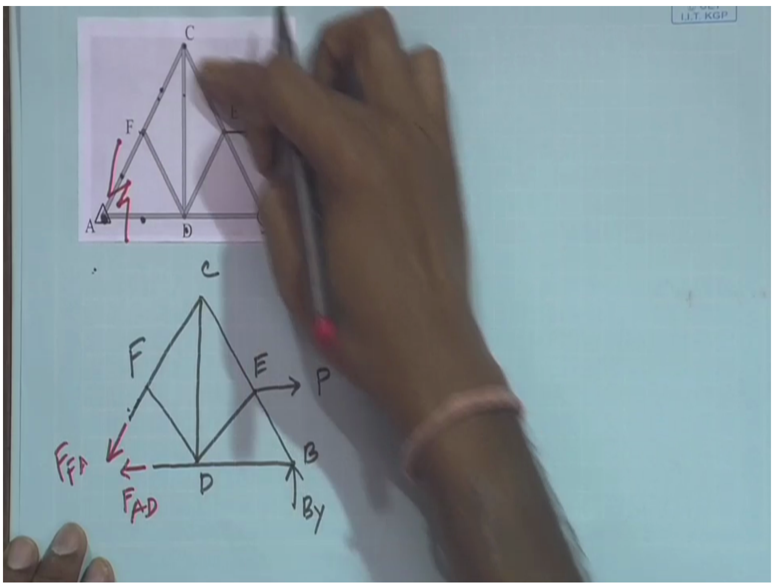

Similarly I can draw the free body diagram of this part of the structure. What was this part of the structure? This part of the structure was only this AF and AD is broken. So this is A and this is the support reaction Ay, Ax and then this is Faf and Fad.

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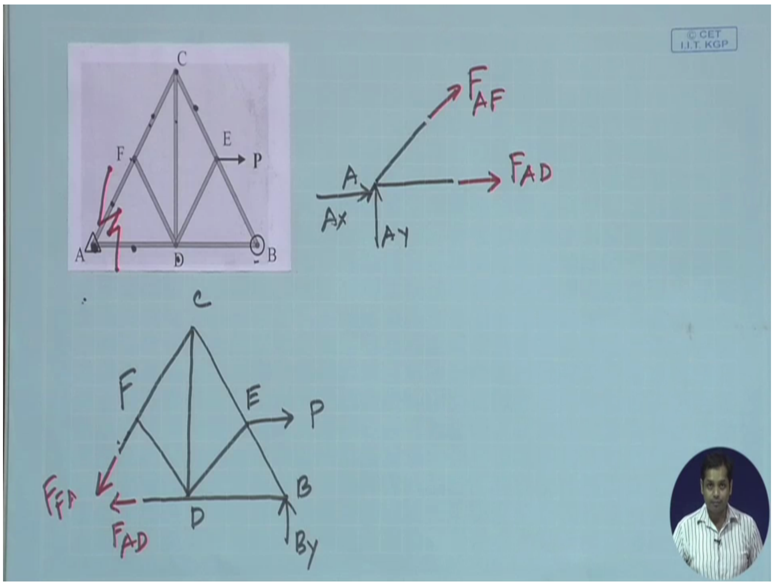

Now what is the difference between what we have just now done and the method of joints we have discussed so far is, in this case what we have done is we take a section from the structure and this is the free body diagram of one section, this is a free body diagram of the other part of the section.

Now instead of drawing the free body diagram of the joints and apply the equilibrium equation on those free body diagram, we can also take several sections and draws a free body diagram of the sections and apply the equilibrium equations on this sections.

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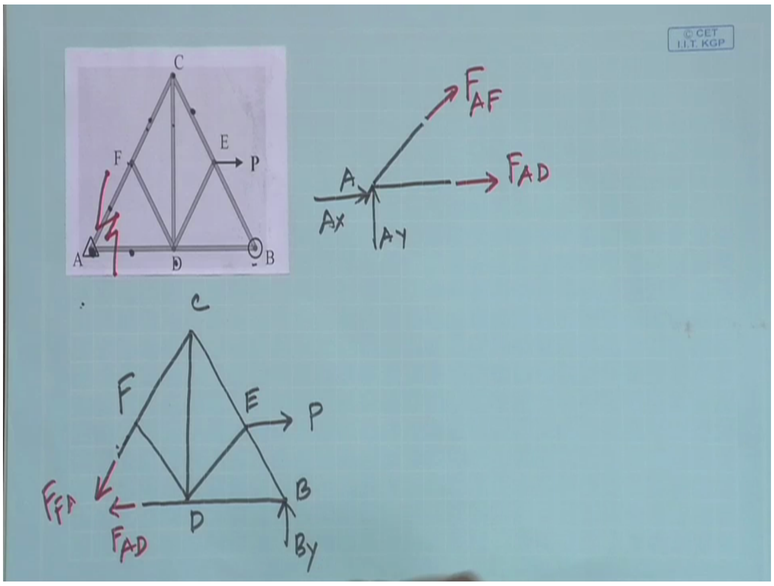

Now this method is called method of sections. Now what we will do is, we will stop here. Next class we will start with the same problem, this problemand then see using method of section, just now which is demonstrated here, using method of section finding member force inCD becomes much easier. So next class we will do is, we will discussanalysis of statically determinate trussusing method of sections.

We will start with this example. We will start with demonstration of this method of section. We will start that with this examples.

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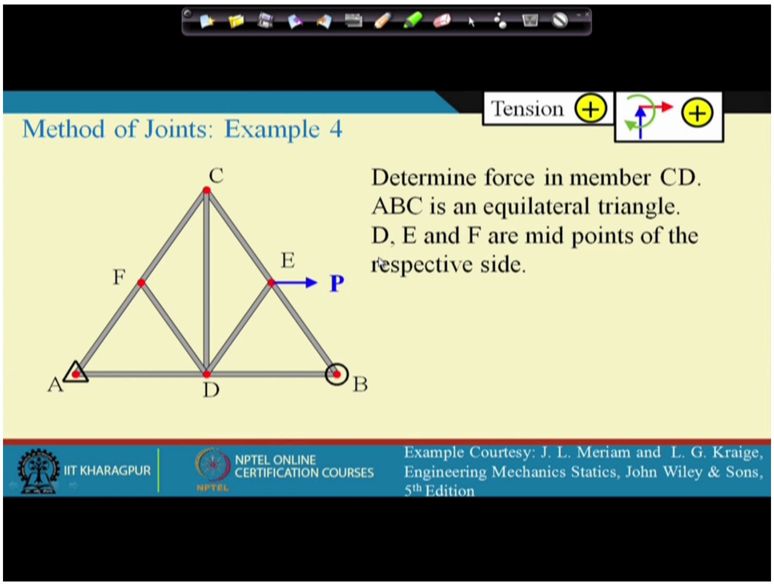

We will stop here. Thank you.