Engineering Mechanics
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Module 02
Lecture No 21
Plane trusses III: calculating forces in a simple truss by method of joints

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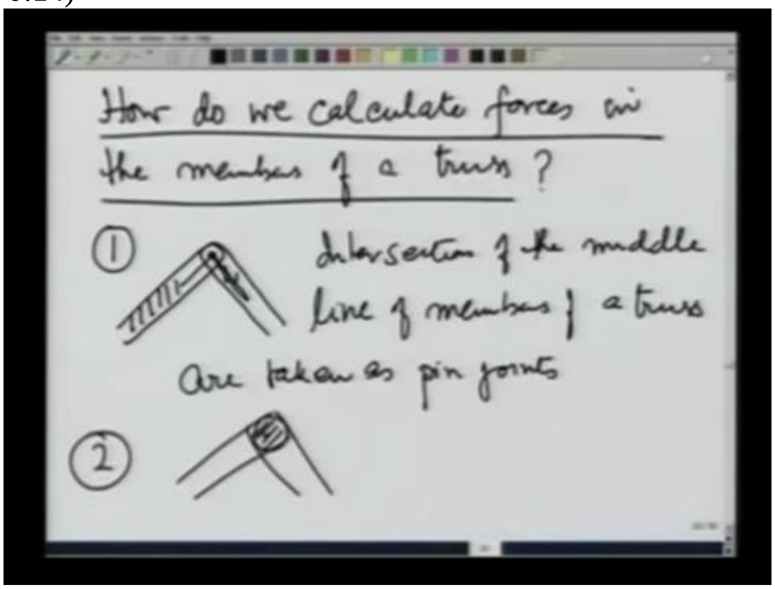

How do we calculate forces in the members of a truss. We are going to restrict ourselves to plane trusses which are the ones that I showed you and we are going to do our analysis under certain assumptions. Number 1, when these members which we take to be sort of rods but are wide enough, when the middle line wherever it cuts, we are going to to take that intersection as the pin joint.

So intersection of the middle line of members of a truss are taken as pin joints.And as a corollary, we are also any plate or bolting that can be done here, we ignore the torques arising because of that.

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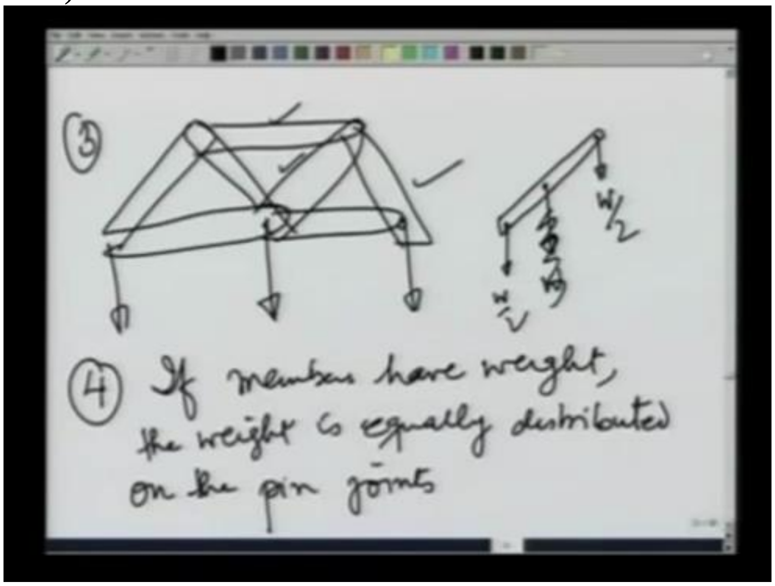

Next, we are going to assume that at any truss, all the load is going to be only on the pin joints. That is the next assumption. And finally, if members, that is these rods have weight, the weight is equally distributed on the pin joints. That is, if for example a member may have weight W, then I am going to say that this pin joint bears W by 2 and this pin joint also bears W by 2 of this weight.

So the weight is equally distributed on the pin joints. Under these are sometimes, we analyse the trusses. There are 2 methods of analysing the trusses and getting their, the forces on various members.

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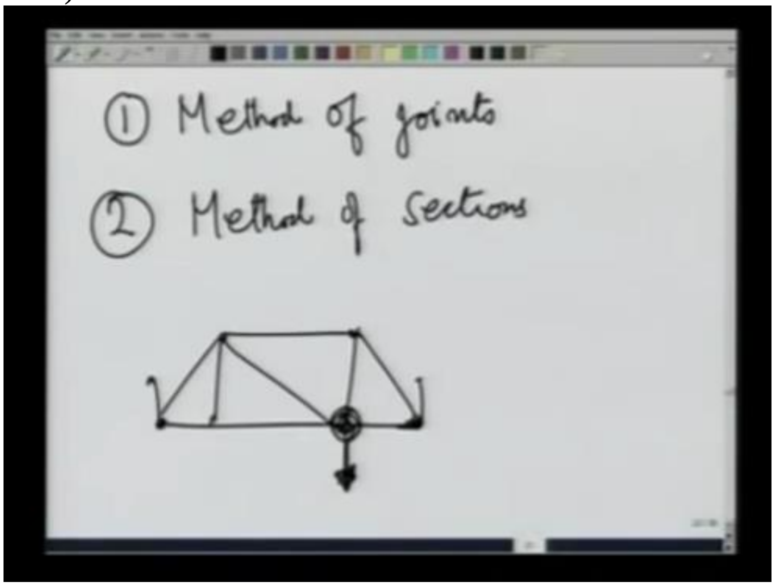

One is known as the method of joints and the other one is known as the method of sections. You have already seen and already gotten a glimpse of method of joints when I analysed a very simple truss earlier. What is done in method of joints is that each point, each joint of the truss is not in equilibrium under the applied forces. So if I have a truss like this and it is loaded, then we start with a point where the load is and see how that point is in equilibrium.

That gives us the forces in the various members that are commented with that point in terms of the applied load. In case you have more sources than you can solve for in this case, then you go, you 1st solve for the reactions at the fixed points and then because there are only 2 members at those fixed points, you can solve for the forces in those members and then go on to the next joint and so on.

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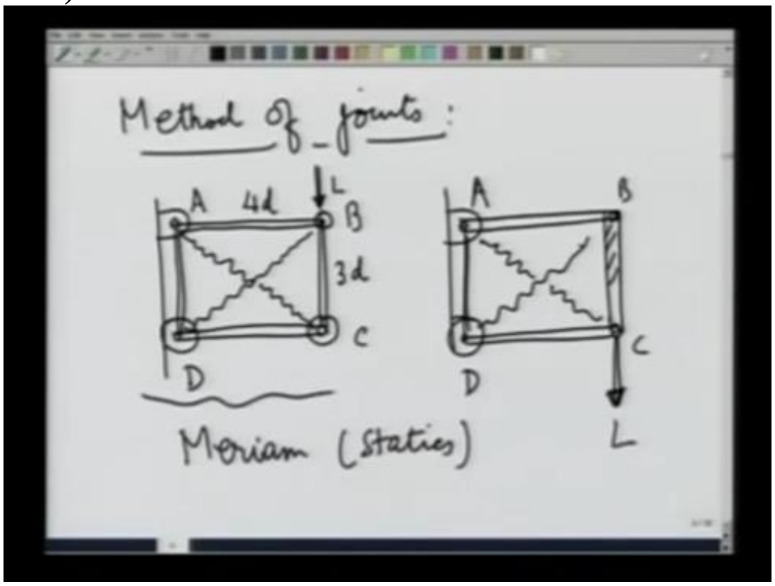

I am going to demonstrate the method of joints through several examples. As the 1st example, let me take a system, a simple system which is made of 4 rods. One fixed pin joint here. This is a rod. Another rod like this. The pin joint here. 3rd rod like this and this is on a roller, 4th rod here. And there are 2 ropes along the diagonal. Let me call this system A, B, C and D.

This length is 4D, this length is 3D and we load the system once at point B by a load L and another loading is done at point C same L. These are 2 ropes. A, B, C, and D and in both the cases, I want to know the forces developed in these rods or members and these ropes. I should also mention here that this problem is taken from the book of Meriam. This is quite a nice problem because teachers ask quite a lot of things in one problem.

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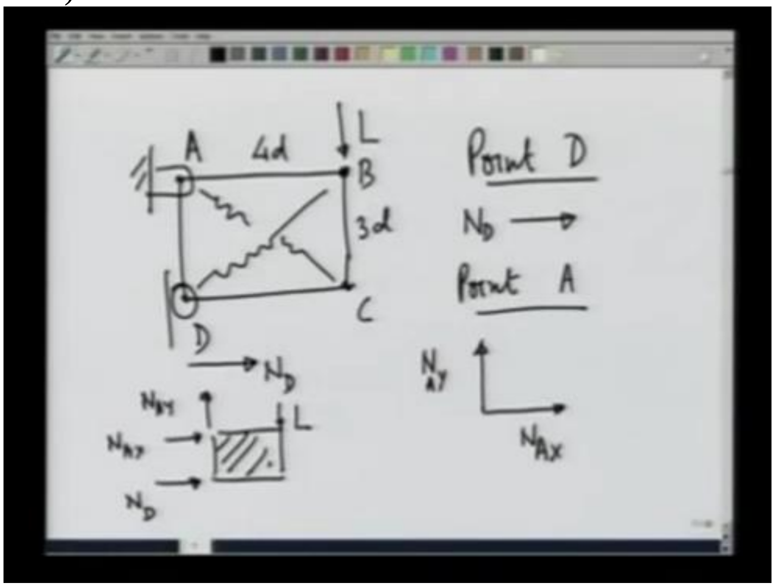

So let us 1st take this particular case where we have let us make it in a very simple manner, these points, this is on a roller, this is on a fixed pin, this is a rope, this is a rope, this is the load. This is 4D, this is 3D. Now on the point, this is A, B, C, D. On point D there will be only a reaction in the horizontal direction. Let me call it ND on the entire system. So ND in horizontal direction.

On point A, there is going to be a reaction in the vertical direction. Let us call it Ny NAY and horizontal direction NAX. This is if I consider the entire system as a whole. So on the entire system, if I make a free body diagram, this is a load L, this is a reaction here ND, there is a reaction here in the vertical direction NAY and there is a reaction here in the horizontal direction, NAX. Since there are only 3 external forces, ND, NAX and NAY, these can be determined very easily. It is a two-dimensional problem.

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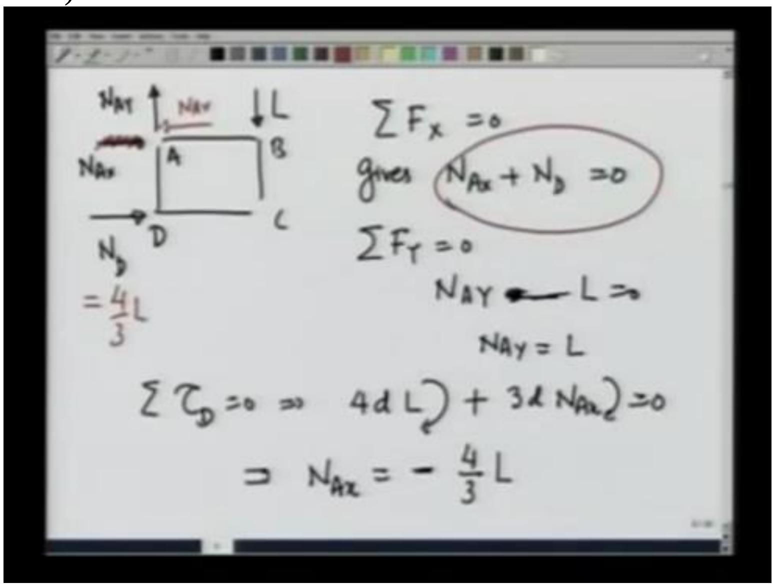

So let me make it again. There is a load L, ND, NAX, NAY. Summation Fx equal 0 gives NAX + ND equal 0 and summation FY equals 0 gives NAY equals - L. Sorry I should write NAY - L equals 0 or NAY equals L. That is it is vertically upward direction. Summation torque about D, this is point D, A, B, C is equal to 0 gives 4D times L clockwise lures 3D times NAX also clockwise, should be 0.

And this implies that NAX equals - four third L. And - sign tells you that it is direction, let me make the good direction with red. It should be this way. So this is NAX. And from this equation that NAX + ND equals 0, ND also comes out to be in the right direction four thirds L. So now we know the forces, external forces on the system.

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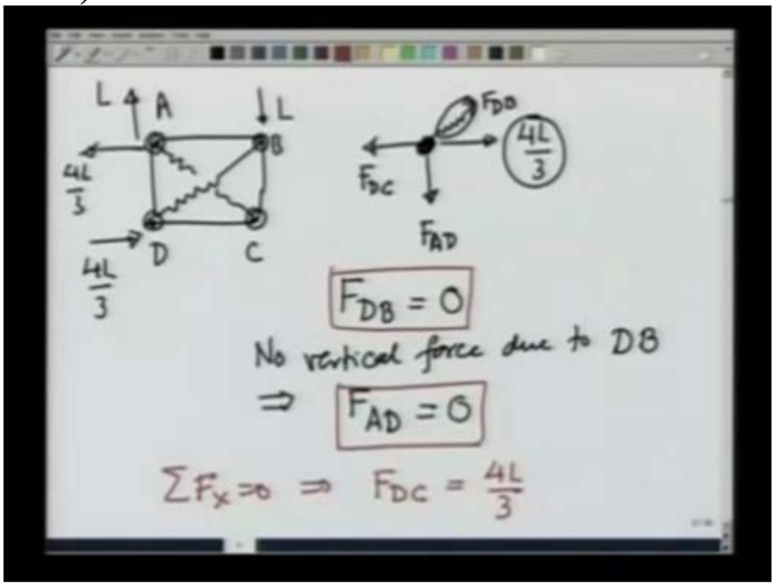

What we have is L here at point C, point A I have a force acting towards left, 4L by 3, force acting towards vertically up, L, I have a force acting on this joint in this direction, 4L by 3 and I want to calculate other forces. This is point C, this is point D. Let us take the joint D or pin at D and see what the forces on D are. Now we are really using the method of joints. Each joint we are going into bring into equilibrium by applied forces.

At point D, there is a force in horizontal direction 4L by 3. There is a force and now I am anticipating that the force by rod DC is going to be towards left FDC. There is a force by the rope. Now since this is a rope, it can apply only a tensile force. I mean the rope can exist only under tension, not under compression. So it will not support a compressive force. So it can apply only a force in this direction F let us call it DB.

And there is a vertical force due to rod FAD. Now one can see that this joint is under a force 4L by 3. So this is going to be pushed to the right and if it is going to be the push to the right, the rope is also going to be pushed in. But rope cannot sustain any compressive force. So FDB is going to be 0. That means, there is going to be no vertical component of force due to element DB. This also implies that FAD is equal to 0.

So we have found 2 forces FDB which is 0 and FAD which is 0. Let us now consider the forces in the horizontal direction. Since FDB is 0, summation FX equals 0 gives me FDC equals 4L by 3. And positive sign tells me that I have already I have found the correct direction. Since the rod is pushing, rod DC is pushing the point out, the rod DC is under compressive force. So this is compressive.

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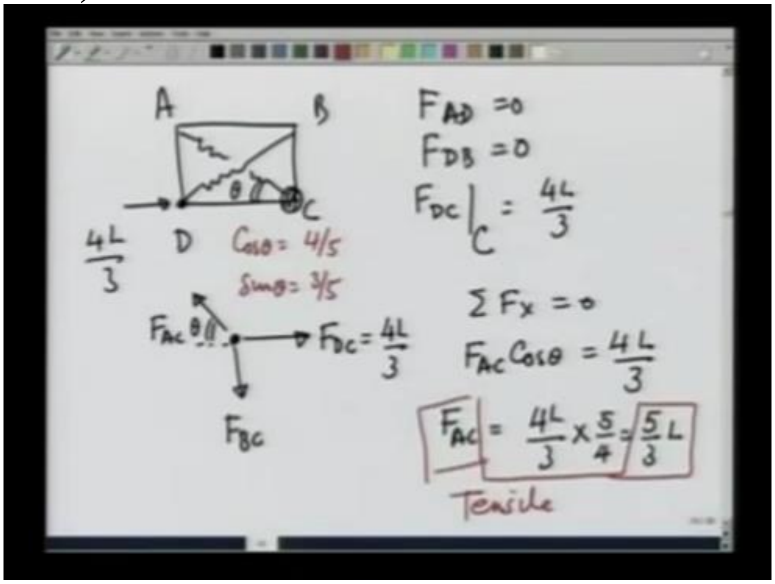

Let us move on. So what we have found in this that at point D there is a force 4L by 3 and A, B, C, D, FAD is 0, FDB is 0, FDC is compressive 4L by 3. Let us now look at point C. Point C is under a force FDC which is 4L by 3. There is a force and I am already anticipating the right direction FAC pulling it in. That means AC rope is under tension. And remember again, AC is a rope.

So it can support only tension, no compressive force. And there is going to be a force FDC. This angle is let us say theta. This is theta so that let me write in different colour, cosine of theta is four fifths and sine of theta is three fifth. So summation Fx equal to 0 on point C gives me FAC cosine of theta equals 4L by 3. So FAC 4L by 3 divided by cosine theta. So that is 5 over 4 and this gives me 5 over 3. That is the tension tensile force on the rope.

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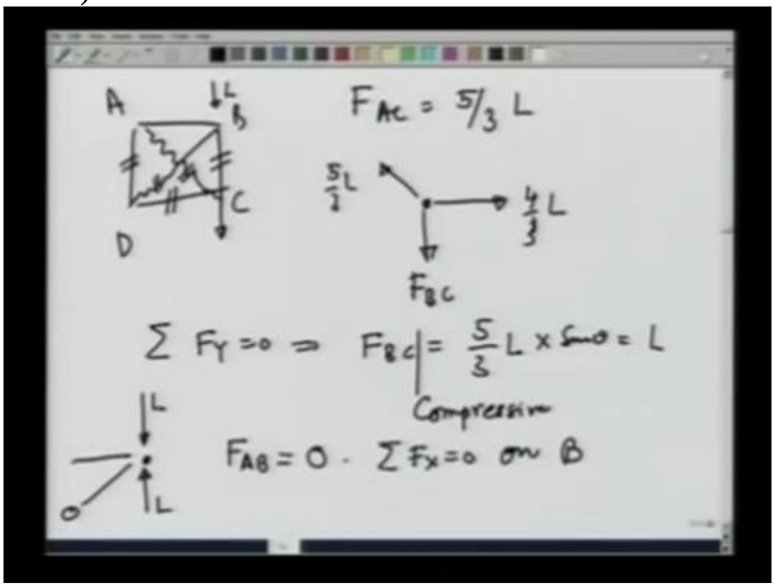

Now similarly if I do summation FY so again let me make the picture. A, B, C, D. We have found FAC to be five thirds the load. This is the load. At point C, this is five thirds the load. This is four thirds the load and this force is FBC. Summation FY equal to 0 gives me FDC equals five thirds L times sine of theta. Sine of theta we have already calculated is three fifths and therefore this comes out to be L.

So FBC is pushing it down and that means FBC is, the rod is being compressed so it is compressive. So we have found force FDC, we have found force FBC, we have found force FAC, we have found force FAD, we have found force on FBD. The remaining forces are forces only on FAB. Let us now look at point B. The joint B is under load L. Then, it is being pushed by FBC by L.

There is no force, 0 force due to the rope and therefore FAB comes out to be 0. This follows from the condition, summation Fx equals 0 on B. So now we have found all forces and let us see again by checking at point A whether all the forces are consistent.

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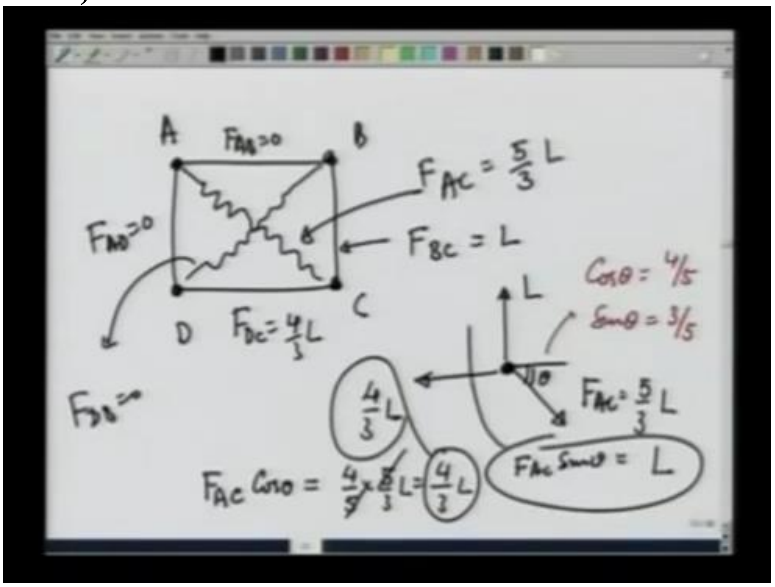

So what we have found on this frame A, B, C, D, FAB is 0, FAC is five thirds L, FDC is four thirds L, FBC is equal to L, FAD is equal to 0 and FDB is equal to 0. With these forces, let us see if point A is under equilibrium. Remember, we found that on A there is a force in this direction which is four thirds L, there is a force upwards which is L and now I know because of the tension in the rope, there is a force FAC which is five thirds L, this angle is theta.

Recall again that cosine of theta is four fifths and sine of theta is three fifths. If everything has been solved correctly, point A again should be in equilibrium. So FAC cosine thetaZ cosine of theta comes out to be four fifths times five thirds L which is four thirds L. And this force is going to balance this force out.

So horizontal forces are 0 and FAC sine theta comes out to be three fifths times five thirds L which is L and this force is going to balance out this particular force. And therefore point A is in equilibrium and we have solved the problem correctly.

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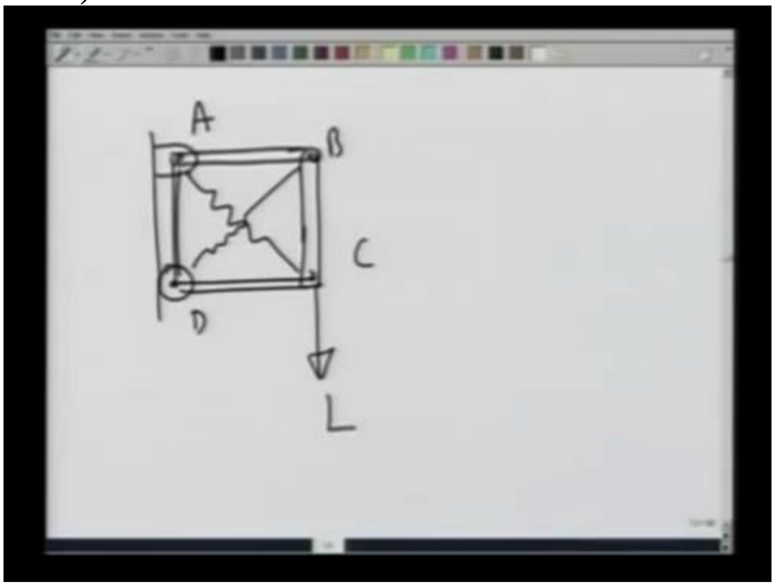

For the 2nd part where the system is loaded differently, that is the load is at point C, I leave this for you to account. In the next lecture, we will be taking slightly more complicated and bigger examples and see how method of joints helps us in solving the problems for trusses.