Mechanics Of Solids

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Lecture – 09
Method of Sections

Welcome to the course mechanics of solids. So, as we were discussing about the truss analysis of truss plane truss in the last couple of lectures. So, in the last lecture basically we have seen that how we can solve or analyze a particular say plane truss right. So, and we discussed about method of joints. And today will be discussing about the method of sections. So, method of joints I hope that you have understood that how we can proceed joint wise in the truss to get the solution means the member forces. So, those are basically the unknown forces and under the action of some external forces you can calculate or you can determine the member forces, if you analyze all the joints right. So, in the last lecture we have seen that. So, today will be talking about method of sections.

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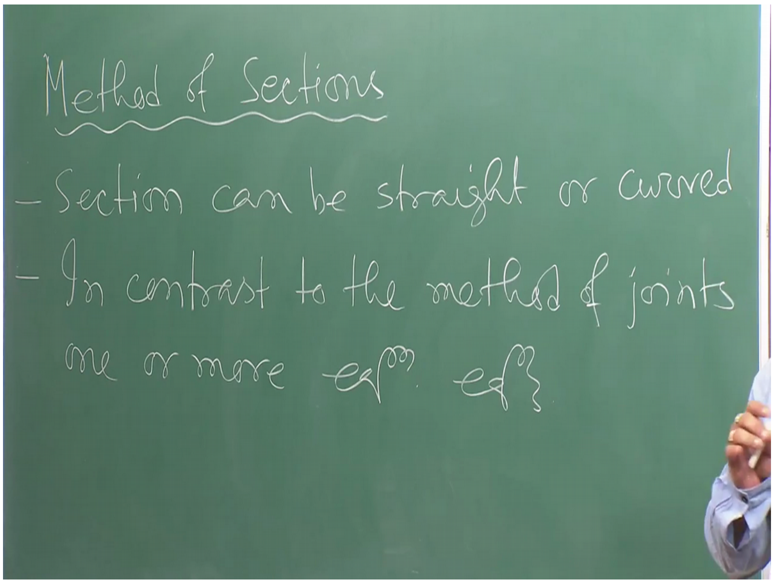

So first we should know what are the different properties are different say important is aspects of this method. So, first one is that the section from the name itself. It is very clear that we are going to choose some sections now there are some properties of these sections. So, first one is that section can be straight or curved. So, there is no restriction how we are choosing the section. So, there are several guidelines for choosing the section, but section can be straight line or curved. The next point could be in contrast to the method of joints one or more equilibrium equations. So, in method of joints you have seen that you have used the equilibrium equations. Or you have considered the equilibrium condition at each and individual joint right. So, in contrast to the method of joints basically here in this method you may have one or more equilibrium equations. So, here basically we will see later on that you can you can exploit the equilibrium condition with respect to the moment also.

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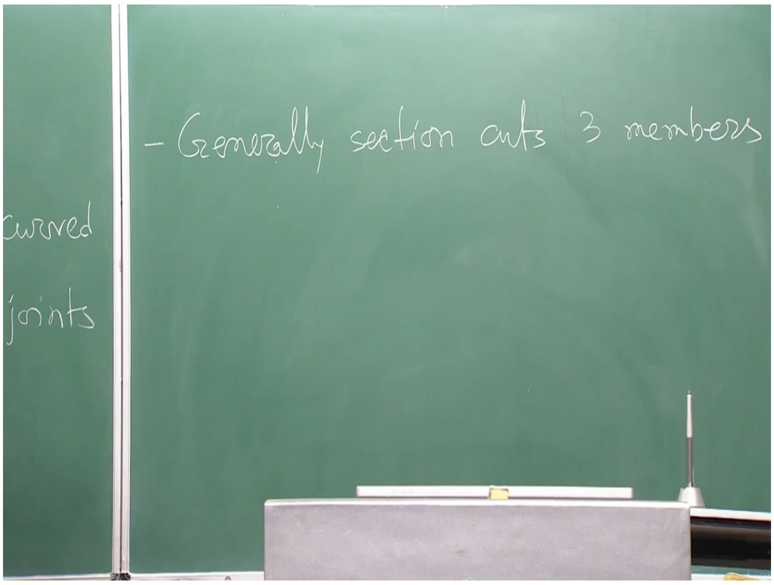

Then the third point is that generally section cuts 3 members. So, you will be choosing the section in such a way that it generally cuts 3 members. More than more than 3 members you should not cut, but of course, this is this is the general statement. So, sometimes you may cut 4 members or maybe more than 4 members. So, that depends on the in on the truss configuration, that even if you cut 4 members still you can get the solution, but most of the times, if you want to get the solution then you should have the section which is cutting 3 members maximum 3 members. Because you can you can explore 3 equations of equilibrium to force equilibrium like summation of F x equal to 0 summation of F y equal to 0 and moment equilibrium like summation of moment with respect to some point is 0. So, there are 3 equations. So, therefore, generally the section should cut 3 members. 3 members means there will be 3 unknown forces, which are going to be determinants. So, these are few aspects of method of section, now let us let us see how we can proceed. So, we will take one example of truss.

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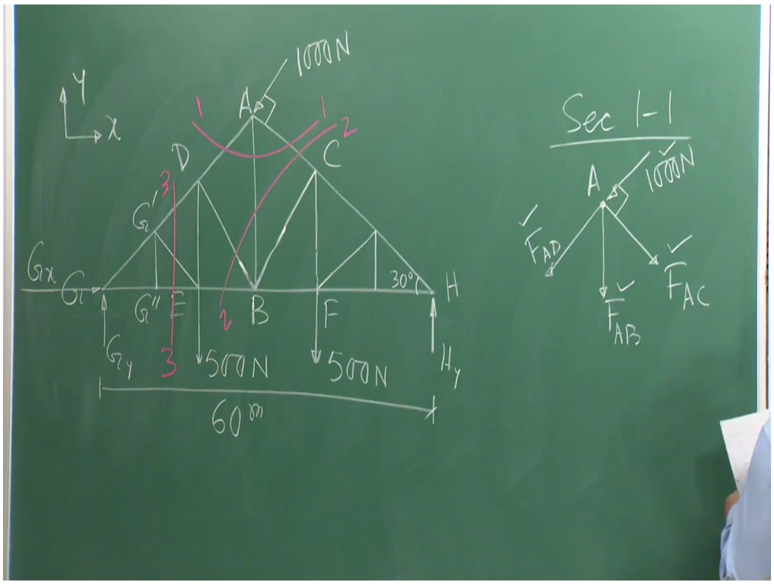

So, let us take this truss, this is a roller support. So, this is one simply supported truss plane truss at G and H. You are having supports at G you are having hinge support and at H you are having roller support and there are 3 externally applied forces on this truss. One is 1000 newtons at A which is acting perpendicular to the member AC, and then there are 2, 500 newton concentrated force at joint E and F. And this span all this span is I mean are equal. So, G G double prime G double prime E, E B all are equal the total span of the truss is 60 meter. So, just for the sake of illustration we are showing this we are not going to solve each and individual numerical values. So, now, in this truss basically, if you look at by using your method of joints you can solve this. There is no issue, but the main problem is that in method of joints as I told you that method is little bit cumbersome or little bit say laying the process.

Suppose if you want to find out are the member force A B what you need to do in method of joints you have to start from say joint G and gradually you have to proceed from joint G to G prime then G double prime and. So, on and up to say a or B whatever joints you consider and then you find out the unknown force A B or if you can move from H and then you can gradually move to member A B. So, this is a lengthy process, but the method of section if you want to find out the member force A B very simply, you can get it now in this method of section what is my first job first job is to draw the free body diagram. So, we are not violating the first step. So, the first step is that to draw the free body diagram.

So, if I want to draw the free body diagram. So, basically what we can do? We can remove the supports and we can put and if this is by x y coordinate system. This is H y and this is G y and G x. So, these are the support reactions. If you remove the support conditions, you will be getting the support reactions. And now it will show you the free body diagram of the whole truss fine. And now you are well equipped to find out the support reactions how you can find out the support reactions just to exploit the equilibrium conditions and you will get 3 equations summation of F x equal to 0 summation of F y equal to 0 and moment with respect to any point G or point H you can find out the support reactions fine. So, that is just for sake of completeness, I am telling you, but rest of the I mean next point onward we are not going to discuss, how to find out the support reactions. So, automatically you know that you are supposed to find out the support reactions at the first moment.

So now once you know the support reactions. Now basically you can choose different sections. So, let us take the sections the first section say as I told you section can be straight line or curved. Here section 1 1 is curved line. And it generally section cuts 3 members right generally section cuts 3 members. So, it is cutting 3 members this is one member 3 in 2 member and 3 members. So, it is satisfying all the conditions whatever we have discussed for method of section, similarly, I can choose some another section say let us say this is another section 2, 2 I want to show that all the times you need not to cut or need not to take the section which is cutting all the 3 members you can you can even take a section which is cutting 4 members, but some proper or some specific configuration.

So now if you look at section 2 2. Basically it is cutting 4 members member B E member B d member A B and member AC. So, 4 members are getting cut by section 2. 2 similarly one more section I am considering. So, these 2 sections are curved one more section I am considering that is section say 3 3. And that is nothing, but a straight line now what to do with this sections I am cutting the sections fine, but what to do with the sections that we will be discussed. Now if you take the sections like that basically our job is to take once I take the section, I can take the right hand side or the left hand side of the section and we can analyze that part the left hand part or the right hand part to find out the unknown forces. Now if you look at section 1 1 and then for section 1 1 if you consider then what and if I take the upper half upper part of the section, 1 1 then basically what we get this is joint a from joint a, A D force is acting F A D then joint a F A B is acting and joint a F AC is at and this is the force thousand newton is acting perpendicular to the line AC. So, this is the free body diagram of the upper part of section 1 1.

Similarly, you can draw the free body diagram of the lower part of the section 1 1. So, what I am doing by taking the section I am taking out some part of the of the truss, and I am analyzing separately that part to get the unknown member forces. So, now, similarly section 2 2, let us let us draw the free body diagram of section 2 2 which is or may be section 2 2 is cutting the truss in 2 parts right. And part the left hand part. So, we will be taking is a right hand parts.

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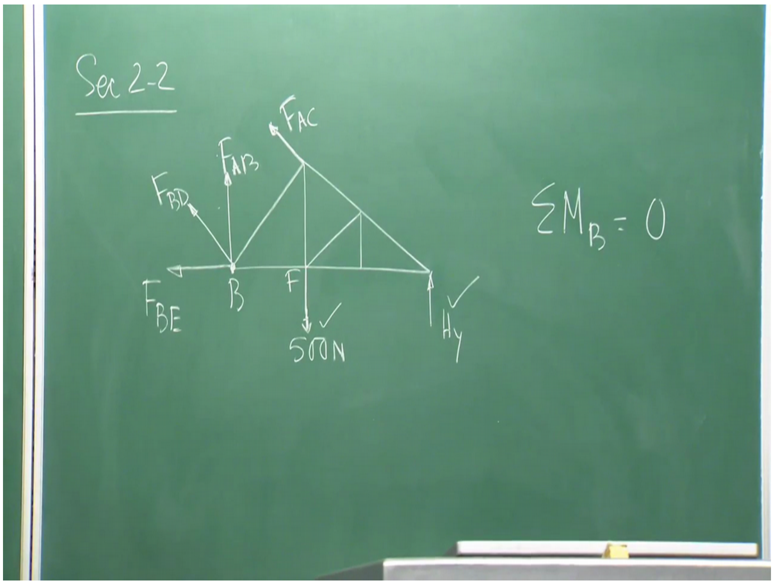

So, let us say if we take the right hand side of section 2 2. How to look like. Let me draw it and then I will explain. So, this is the right side of section 2 2, if you look at the section 2 2 is cutting 4 members as I told you member AC member A B member B D, and member B E right. So, these 4 members are getting cut by section 2 2. So, if I am taking the right hand side or the right part of section 2 2. Then basically you look like this. So, that is my free body diagram of the right hand side right hand side of section 2 2. So, this is your if you consider section 2 2. Now you may ask me that why I am considering the right hand side. So, there is no hard and fast rule you can choose as per your convenience or as per your actually requirement. You can choose the right hand side or the left hand side there is no issue you can choose even left hand side.

now if you I mean now how you will find out the member forces. Now for example, that is for example, I am not going to solve the whole problem. For example, you know H y this is the force is known to you that is extremely applied force. Now these member forces are completely unknown to you right. You do not know these member forces agreed. So, what I can do now if you look at there are 4 unknowns right, there are 4 unknowns, but how many equations are available with you equilibrium equations 3 2 force balance and one moment balance summation of F x equal to 0 summation of F y equal to 0 and moment balance. Now by seeing the configuration as I told you though the section is cutting more than 3 members, but depending on the configuration you may get in the solution, now for this problem I deliberately took this problem to tell you that it is not I mean compulsorily or mandatory that all the times the section should cut more maximum 3 members anyway.

If you take the moment equilibrium with respect to B point is equal to 0. Then basically from B point there are 3 member forces are getting out or than getting emerged right F B E F B d and F A B. All forces are getting out from joint B. So, if I take the moment equilibrium with respect to point B, immediately the moment of these forces will be 0 right. So, which one will be left out F AC. So, so moment of force F AC with respect to point B moment of force 500 newton with respect to point B. And moment of force H y with respect to point B, and if you take the algebraic summation of these moments you will be getting the unknown force if you see fine. So, once you know F AC then basically if you come here in section 1 1. So, now, earlier case you had 3 unknowns right now you know F AC, because here actually the situation is lying in such a way that you are considering the method, as good as method of joint right. So, only one joint is considered, but as I told you in the previous lecture that from one joint if you have 2 unknowns then basically you can solve because if you consider the method of joints at each and every joint you have 2 equations of equilibrium summation of F x equal to 0 summation of F y equal to 0.

So initially you are not able to find out the member forces if you consider section 1 1, but once you know section I mean F AC from section 2 2, once it is obtained then basically if you come back here. Now it is known to you this force is also known to you because that is external applied forces. So, therefore, you will be knowing these forces F A B and F AC in that way actually you can solve the whole truss.

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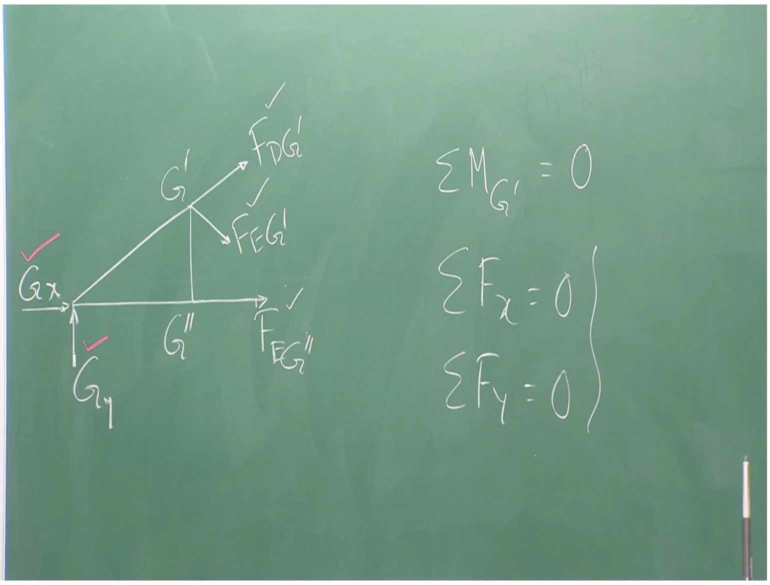

Now, let us talk about section 3 3 how what information will be getting from section 3 3. So, we are taking the left hand side of section 3 3. So, let us draw it that is G x G y they are known forces. This is your G prime G double prime as shown in the figure this force is F E G double prime. This force is F E G prime. And this force is F D G prime. So, what are the known forces your known forces are this force this force. So, these are the known forces right from the support reactions you know these forces. So, what are the unknown forces all member forces. Now you see section 3 3 is satisfying all the conditions, whatever we just talked about right that it is cutting maximum 3 members. So, member D G prime member E G prime and member E G double prime they are cutting.

Now if I want to find out the forces the member forces unknown member forces, what we can do? We can simply take m G prime equal to 0 that is the moment equilibrium with respect to joint G prime. And if I make it 0 then basically the moment of these forces F D G prime and F E G prime will be 0. So, only force will be left out that is F E G prime E G double prime. So, therefore, we can find out F is the G double prime right. So, once it is known then we can take summation of F x equal to 0 summation of F y equal to 0. So, from these 2 equations we can get these 2 forces. So, initially we got this forces now we have got these 2 forces. So, all the 3 forces are now known to me. So, in that in that process. So, there is no there is no maximum number of sections you can choose N number of sections. So, by choosing different sections you can simply get the member forces. You can jump on that particular section you take the free body diagram of that particular section left hand side right hand side upper part lower part or whatever right and then you exploit your equations of equilibrium. And then finally, you will get the unknown member forces I hope it is clear to you right.

So now with this basically we can conclude the truss problem or analysis of truss, will take some example numerical example. Later on to understand the truss problem or to see how we can get the numerical values of the member forces. Now will move to the next topic that is friction this friction is mostly known to you from your previous background that friction is very much discussed in the course of physics, just to recapitulate or just for sake of completeness of the discussion we are going to discuss about friction.

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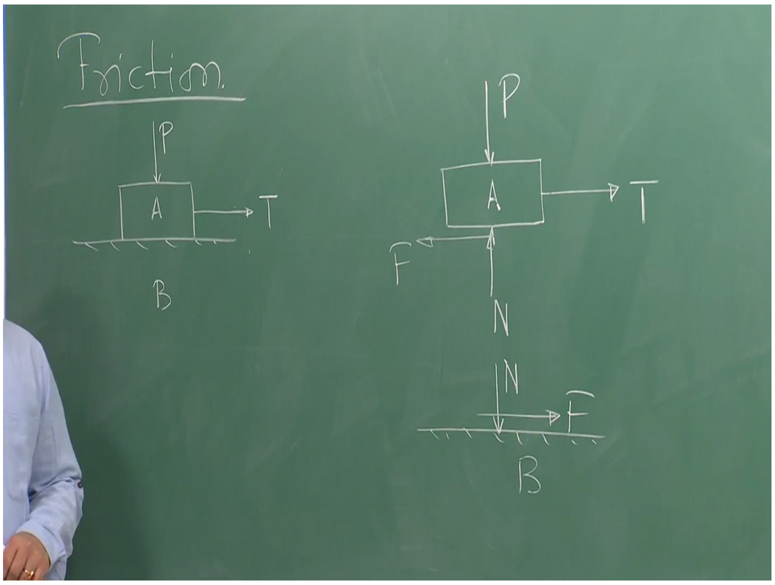

Now friction is nothing, but the interface response interface response means suppose, I want to slide block A over the surface of B. And this block is under the force of say p and I am just trying to pull this block t with a force T. So, that it will slide over the surface B, now at the interface between block A and the surface B some forces will be getting developed which will try to resist this sliding movement and that force is nothing, but your friction right.

So now you are well equipped to draw the free body diagram. So, we will draw the free body diagram of block A as well as surface B let us see how we can draw it. So, block A the free body diagram of block A will look like this. This is your block A one vertical force is acting. And this is the horizontal force which is acting, I want to I want to apply some horizontal force to slide the block A over surface B. So, these are the forces are shown here now few forces are not shown what are those forces now block A is resting on surface B. So, therefore, B surface will give some action or the if you if you call that action or reaction whatever. So, some vertical force of course, that is a reaction because block A, is a, is I mean I mean placed over surface B. So, the B surface will give some opposite reaction and that reaction say N.

Now when I am trying to slide block A over B as I told you as you know that some frictional force will be getting developed and that frictional force is opposite to the direction or movement that you know from your physics these frictional force is say f. So, this is the free body diagram of block A. Similarly, you can draw the free body diagram of surface B. This is your surface B. So, what are the forces are acting on surface B. This N is the reaction developed at the interface because the block A is placed or resting on surface B. So, therefore, you are getting the reaction. So, you will be getting opposite and equal action on surface B.

And F force that is the frictional force is acting at the interface between block A and B right. So, therefore, F is acting in the opposite direction of the movement of block A. So, therefore, you will be getting a force F, which will be acting like this. So, this is the free body diagram of block A. And this is the free body diagram of surface B so; that means, we are separating out each individual component from the whole system.

So, I will stop here today. So, in the next class we will continue with friction, and then we will take some numerical examples to help you to understand what we have learned so far in this particular course.

Thank you very much.