Trusses - Method of Sections

ME 202

Methods of Truss Analysis

• Method of joints (previous notes)
• Method of sections (these notes)

MOS - Concepts

• Separate the structure into two parts \( \text{(sections)} \) by \text{cutting} through it.
• Draw an FBD of the \text{section} that is on one side or the other of the \text{cut}.
• Use method for \text{non-concurrent, coplanar} systems.
• \text{Three} independent equations on the \text{section}.
• No more than \text{three} unknowns on a \text{section}.

Yes-Yes

The method of sections involves analyzing \text{non-concurrent, coplanar} force systems, and so uses \text{moment summations}. 
MOS - Steps

1. Draw a FBD of the entire structure.
2. Solve for the structure’s overall reactions.
3. Cut the truss to expose the force in a member of interest.
4. Draw a FBD of the section that is on one side or the other of the cut.
5. On the section’s FBD, if possible, write an equilibrium equation in which the desired force is the only unknown.
6. Repeat steps 3. - 5. as necessary.

Example 1

Use method of sections to find forces in all members as functions of the applied load, $F$.

\[ \sum M_A = 0 \Rightarrow C_x = \frac{5}{3} F \]

\[ C_x = C_y \Rightarrow C_y = \frac{5}{3} F \]

\[ \sum F_x = 0 \Rightarrow A_x = -C_x = -\frac{5}{3} F \]

\[ \sum F_y = 0 \Rightarrow A_y = F - C_y = -\frac{2}{3} F \]

\[ \sum M_A = 0 \Rightarrow F_{BC} = -\frac{5}{3} F \]

\[ \sum F_y = 0 \Rightarrow F_{AB} = \frac{\sqrt{34}}{3} F \]

\[ \sum M_B = 0 \Rightarrow F_{AC} = \frac{5}{3} F \]
Example 2

Use the method of sections to find the force in member BE.

\[ \sum M_D = 0 \Rightarrow A_y = 3 \text{kN} \]

Example 3

Use the method of sections to find the force in member BF.

\[ \sum F_y = 0 \Rightarrow \frac{8}{\sqrt{89}} F_{BF} - 30 \text{kip} = 0 \]

\[ F_{BF} = \frac{15}{4\sqrt{89}} \text{kip} \]

Example 4

Use the method of sections to find the forces in members UV, MV, EM and DE.
\[ \sum M_D = 0 \Rightarrow F_{UV} = -\frac{15}{4} P \]
Trusses - Method of Sections (MOS)

2 In previous notes, we have seen the method of joints (MOJ) for analyzing trusses. In these notes, we will see the method of sections (MOS), which is very different from the MOJ. There are several significant differences in these two methods.

3 If you study the examples that follow, the meaning of the concepts on this slide should quickly become quite clear.

4 One difference between the MOJ and the MOS is that in the MOJ, we do not use moment summations, except perhaps in finding the overall reactions supporting the truss, while in the MOS, we use moment summations very often.

5 For some simple problems, steps 1 and 2 can be skipped. One of the following examples will have this property.
6 A FBD of the entire structure includes reactions at $A$ and $C$. Because of the rollers at $C$, the force there is normal to the inclined plane. Because we know the force’s direction, we know the ratio of its rectangular components. So, the force there is only one unknown.

7 The order of these summations is such that each contains only one unknown. This completes steps 1 and 2. After finding the structure’s overall reactions, we cut through members $AB$ and $BC$ and draw a FBD of the section to the right of the cut. Note that the moment summation is about a point that is not on the FBD. There is nothing incorrect about that. Given the force in member $BC$, the second summation has only one unknown.

8 To find the force in member $AC$, we must make a cut that goes through member $AC$. Again, summing moments about a point that is not on the FBD gives an equation with only one unknown.

9 Steps 1 and 2 are to find the overall reactions. But we can avoid finding the reactions at $D$ if we cut the structure vertically between $B$ and $C$ and use a FBD of everything to the left of the cut. That FBD will have three unknowns, which are the forces in members $BC$, $EF$ and $BE$. 

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10 This problem illustrates a second difference between the MOJ and the MOS. In finding the force in a member in the interior of a truss, the MOJ requires that we analyze first one joint and then another until we work our way to a joint on which we can find the desired force. For a complicated truss this can require that we make many FBDs. But by using the MOS, we can often find the force in an interior member with only one or two FBDs.

11 If we were to use the MOJ for this problem, we could start at joint $D$ or joint $E$ and work our way to $F$ or $B$, where we could find the required force. But with the MOS, we can find the force with only one FBD and one equation. In this example, finding the overall reactions is unnecessary.

12 The required forces are in the members highlighted in green.

13 A FBD of the entire structure can be used to find the reactions shown at point $A$ on this slide.

The FBD shown here results from cutting the structure vertically between joints $U$ and $V$. Because the diagram has four unknowns, it is statically indeterminate.
On a statically indeterminate body, we cannot find all the unknowns from the equations of statics. But we need them all for this problem. How many of the unknowns would we need to have to make this FBD statically determinate?

14 The second cut exposes only one of the desired unknown forces, which is the force in member $UV$. Of course, it also exposes forces in members $MU$, $DL$ and $CD$, and so results in another FBD with four unknowns. While it may seem that making the second cut does not get us any closer to a solution, the following slide demonstrates otherwise.

15 For three of the four unknowns, the line of action passes through point $D$. By summing moments about $D$, we have a single equation with the only unknown being the force in member $UV$. Now, we can return to the first cut and have only three unknowns.

16 Given the force in member $UV$, we can find each remaining unknown with a single equation. Note that the final equation has only one unknown only because it is written after the previous two equations. Note also that each triangle in the truss is an isosceles, right triangle. This means that the angle theta is $45^\circ$, which simplifies computing the moments arms needed in the moment summations.
This problem illustrates a third difference between the MOJ and the MOS. Application of the MOJ requires little thought. By moving from joint to joint, analyzing every joint in the structure if necessary, we can eventually find the force in every member. With the MOS, we can usually find the force in any specified member with only one or two FBDs, but first we must see where to cut the structure to facilitate this. We also need to see what moment centers will yield equations with one unknown. The need to see which cuts and moment centers will lead us quickly to the desired result requires a higher level of thought than that needed for the MOJ.