Truss structures and frames

Truss structures can be incredibly difficult things to handle, and the only way to be able to handle them well, is to practice a lot. But we're going to try to state some general things about them anyway.

1 Cutting

When calculating with truss structures, it's always the trick to make the right cut. By doing this, you cut the structure in 2 or more parts, and every part must be in equilibrium. The advantage of this is that the internal forces of both parts can be ignored, and only the forces acting on the parts itself (which aren't many, as long as you've made the right cut) have to be calculated with.

So the important question usually is, where to make a cut? It all depends on the truss structure, which comes in a variety of shapes, and on the variable you need to calculate. So I can not give general rules about it. It is however important to make a cut in such a way, such that there are as few unknowns as possible.

2 Important things to remember

Something you should remember, is that you can only cut through two-force members! Other members have a normal force, a shear force, and a bending moment, but two-force members can only have a normal force, which makes them ideal for cutting through. Note that a two-force member is usually a bar between two hinges, certainly not containing any hinges or half-hinges itself.

However, another important and rather logical rule is that, if you need to know the tension/compression in a member, you should always make at least a cut through that member once, because otherwise, you won't have any equation with that unknown (which you must calculate) in it.

And the third important rule is to always assume there is tension in a two-force member. If the size of the tension turns out to be some negative number, you automatically know there is compression, and you also automatically have the right sign for the compression in that force. It's quite convenient. But more about this is said in the chapter "Using signs".

3 Looking at hinges

Next to cutting through two-force members, another way of calculating forces in members is by looking at the hinges. For every hinge, the equilibrium equations $F_x = 0$ and $F_y = 0$ apply (note that no bending moments can act on a hinge). So you have to look for a hinge, of which you know all the forces acting in a certain direction, except for 1. Then by using the equilibrium equation, that unknown value can be calculated. By doing this over and over again (sometimes even up to 30 times in a problem) it is possible to find the force in every member in the entire structure. This can be an especially handy method for structures containing only two-force members, despite the fact that it is a lot of work.

But if non-two-force members are connected to a hinge, the situation can get difficult. The best advise is to avoid such situations. But if this is impossible, it is important to know that non-two-force members exert both a force tangential to the member, as a force perpendicular to it. Those forces can sometimes be found by applying the 3 equilibrium equations ($F_x = 0$, $F_y = 0$ and $M = 0$) on the non-two-force member. But such situations are best to be avoided.

4 0-force members

Next to two-force members, also 0-force members can be present in a truss structure. Suppose that there are 3 two-force members (members A, B and C) connected to a hinge, of which members A and B point in the same direction. If you take the sum of the forces on the hinge in the direction perpendicular to A and B, you will find an equation saying something like $kF_C = 0$ (where k is any constant unequal to 0, depending on the angle between C and A or B). Thus F_C is zero, and C is a 0-force member. The first thing you can do, when looking at a truss, is detecting 0-force members. However, when there are hinges present to which non-two-force members are connected, the situation gets different, and this trick can often not be used anymore.

5 Planning

But what is most important while calculating with trusses (well, preferably before calculating) is to plan. This is so important, that I made this a separate paragraph. Don't write down any equation before you have a clue how you can solve the problem. Ask yourself questions like "*if I make a cut there, what kind of equation do I get? What variables does it contain? How many of them do I know? Can I easily find the variables I don't know?*". This is quite similar to the planning part in "Solving a problem in 7 steps", which you might want to read, if you haven't already.