Transcript for Analysis of Frames and Machines - Adaptive Map Worked Example 1

(0:00 - 0:39)

Hello, so for this problem, we have ourselves a frame. So, this is a body, a structure, we've got connected pieces, and we've got ABC, CDE as two parts of the side of kind of this A-frame structure, and then we've got a cross member from B to D. So, we're asked to find all forces acting on all of the members. So, we're going to have forces that are kind of external forces down here at the base that are acting on the A-frame, and then all the parts of the A-frame have forces experienced between the pieces, like at point C, we've got ABC and CDE interacting at that point.

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So, the first step in all of this, any sort of problem, we need to look and see if we can analyze this structure as an independently rigid body. So, for that, we would separate it from the base, so we'd separate off the ground here and draw a free-body diagram of the whole A-frame structure. So, this thing is independently rigid, that means if I separate it from the base, it's still a rigid structure; I can't move parts independent of one another.

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So, I can analyze this as a rigid body. So, what I've done here is I've drawn out the start of my free body diagram. So, for this, I still have that 300-pound force, and now I'm going to look at where I have external forces acting on my A-frame.

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And so where I'm going to have those external forces is actually going to be at point A I've got a pin joint, so I've got possibilities for forces in the X and the Y, and at point E I've got a roller, and so this can roll back and forth, but I'm going to have a force in the Y direction. So, let's go ahead and draw in our forces. So, like I said I've got a pin joint here, so I've got a force that can act in, I'm going to call this A, FAX, and FAY, and over here I've got the roller so I'm only going to have a force in the Y direction, so FAY, and that is the only external forces I have acting on my body, and I've got my load force of 300 pounds of course.

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So, once I have this, once I've got my free body diagram, I can start drawing out my equilibrium equations. So, I go and do the sum of forces in the X, and the sum of forces in the X is going to be FAX plus 300 is equal to zero, sum of forces in the Y, I've got FAY plus FEY is equal to zero, and for sum of moments I'm going to do all of this about point A over here, so that's going to eliminate some of those forces in the moment equation. So, sum of moments about point A, and so the two forces that are in certain moments about this are FEY and my 300-pound force.

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So, FEY, I need to figure out the perpendicular distance, and so here I can look at my diagram, and I can see 60, 60, this would be another 60-degree angle up here, it's an equilateral triangle, so if it's two feet along this side, it's going to be two feet from A to E. So, my perpendicular distance, this is going to be a positive moment, using my right-hand rule, it's going to be two feet times the magnitude FEY, so two times FEY. Now I've got this 300 pound force that's going to exert a negative moment and cause clockwise rotation, so I've got to figure out the distance for that, so it's negative, and for my distance, let's go back to my original diagram, I need to find the perpendicular distance, so if I draw the line of action, what I need to find is this distance right here. And so if I look at this, I can see kind of a triangle, I'm going to have a right triangle right here, this is going to be 60 degrees, like so, and this distance right here, it's going to be, well I had two feet originally, and I take off .5 feet, so this distance right here would be 1.5 feet, so my distance over here is going to end up being 1.5 sine 60.

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So, minus 1.5 sine 60 times the magnitude of this force is 300 pounds. Alright, so once I have this, I can start solving for some of my variables. So, I can solve for, really quickly, I can solve for FAX, FAX is going to be equal to negative 300 pounds, and all the negative means is I assumed the wrong direction, so FAX is actually a 300-pound force going in that direction.

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And now I can go to my moment equation, FEY is going to be equal to 1.5 times the sine of 60 times 300 divided by 2, and that will give me a value of 194.9 pounds. Alright, so those are two of my reaction forces; the last one I need to find is FAY, and I can find that from my sum of forces in the y equation. So, FAY will be equal to negative FAY, so negative 194.9 pounds.

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And again, the negative number means I assumed wrong, so FAY is actually pointing down like that. So, now I have solved for the external reaction forces, the next thing I need to do is start solving for the internal forces. And to do that, I will need to break the whole thing apart.

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So, with my A-frame structure, I am going to have three different members. So, I have ABC, that is one side of my A-frame, CDE is another side of my A-frame, and BC is the cross member in my A-frame. So, I just figured out some of these values. I just figured out that FAX, I have a 300-pound force pulling right there, FEY was negative 194.9 pounds, and FE over here was positive 194.9 pounds.

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So, I have got some of those forces, now I need to draw in the rest of these forces that are acting, my unknown forces. So, the first thing I am going to notice is that BC, this member right here in the center, that is going to be a 2-force member, so it is going to be in tension or compression. So, I am going to assume it is in tension to start with, and I am going to draw in those forces.

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I am just going to call this one FC, and this one FB, like so. And so I know that is a 2-force member there, and that is going to help me in my analysis, it is less forces I need to deal with, I know that they are acting horizontally like that. I need to draw in the pair that goes with this, so if FB, if we have got a force FB pulling this way on our 2-force member, we have to have an equal and opposite force where it is connected up here.

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So, we would have force FB at the two joint B connection pieces right there. Same thing with FC, we have got an equal and opposite force pulling on this member CDE, so CDE is pulling on member BC in that direction with a force FC, and then BC is pulling on CDE with a force FC in that direction, equal and opposite. Alright, and the last part is I have got some forces up at C. So, I am going to assume I have, I am just going to draw in forces like this, it doesn't really matter what you choose for the first one, I am going to have FCY and FCX, and over here, this is the important part, I need to draw them equal and opposite.

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So, at the other point C, I am going to have a force pointing down, so I am going to call this one FCY again, and if I was pointing to the left before, I have to point to the right this time, so I have got FCX on this member. And with that, we have got all of the forces acting on our free body diagram. So, the last part I need to do is basically choose a member and start writing out the equilibrium equations for that member.

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So, I am going to start with member ABC. So, I want to do the sum of forces in the X, sum of forces in the Y, and sum of moments. For sum of forces in the X, I am going to have negative 300 plus FB minus FCX.

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And that whole thing is equal to zero. For sum of forces in the Y, I am going to have negative 194.9 plus FCY, and that whole thing is equal to zero. Now for sum of moments, I need to choose a point.

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So, sum of moments, and I am going to choose point C. So, I don't know FCX, FCY, if I take the moments about that point, it will make my calculations easier, there will be less unknowns. So, sum of moments about point C is going to end up being equal to force times distance for this force, this force, and this force. So, let's start with FB.

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FB has got a distance of, we need to figure out this distance here, the perpendicular distance. And that distance is going to end up being equal to 1 times the sine of 60. So, the distance is going to be 1 times the sine of 60 times FB, and that's going to be a counterclockwise rotation it would cause, so that's a positive moment.

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Next, I am going to look at my 300-pound force. So, the distance here is going to be 2 times the sine of 60. This would be a negative moment; it's going to cause a clockwise rotation, so minus 2 times the sine of 60 times the magnitude of my force, 300 pounds. And then last, I've got this 194.9, that would cause a counterclockwise rotation, so that's a positive, and my distance is going to be this distance right here, the horizontal distance, so that distance will end up being equal to 2 times the cosine of 60.

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And the magnitude of my force is 194.9. So, that's all my forces, now I go back, sum of forces is equal to 0, now I need to start solving my equations. So, let's go with the FCY first. FCY is simply going to be equal to 194.9 pounds. Simple enough.

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Now I can go and I'm going to solve my moment equation, so I can solve that for FB, FB is going to end up being equal to negative 2 times the cosine of 60 times 194.9 plus 2 times the sine of 60 times 300 all over... Sine of 60, and that ends up being equal to 374.9 pounds. And then finally, if I do sum of forces in the X, I can solve that FCX is going to be equal to

374, this value right here, 374.9 minus 300, which is 374.9 pounds. Alright, so we've got three of our unknowns just through analyzing member ABC.

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So, I'm going to go back, and I'm going to draw in the values for some of these numbers. So, I now know that FB, the magnitude of that force, is this 374.9. And that is also acting on member BC. Up here, FCX, I found that number to be 74.9 pounds, so I've got 74.9 pounds here.

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And FCX over here will also be 74.9 pounds. They're pulling opposite directions. Finally, FCY, that was 194.9 pounds.

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So, this is pushing up, or being pulled up, with a force of 194.9 pounds. This other member here is being pushed down by the first member with a force of 194.9 pounds. Alright, so when we look at all of this, we notice that we've only got one force left unsolved.

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So, that's FC right here, or sorry, this should be, that is not joint C, this should be joint D, or BD, and this should be FD, FD. So, FD, I've got a two-force member, and I can kind of quickly assume that it's going to be 374.9. The way I'd prove that is for member BD, I've got sum of forces in the X is going to be equal to negative 374.9 plus FD is going to be equal to zero, and FD is just going to be equal to 374.9. And so with that, we've solved for all of the forces acting on our members. So, we split it all up into different pieces, and I've got both the external forces down here at the base and the forces that are kind of internal to the whole A-frame structure.

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So, with that, we've solved our problem. Thank you for watching, and I hope to see you again.