Transcript for Analysis of Frames and Machines - Adaptive Map Worked Example 2

0:01

Hello. For this problem, we have a frame - this is frame A-B-C over here. It only has two members in it: A-B, which goes downward, and C-B, which goes across. We have a six-kilonewton load about two-thirds of the way out on member C-B. We want to find all forces acting on each member of the frame shown below.

0:25

Normally, the first thing we would do is separate this from the wall and analyze it as a rigid body. But we cannot do that in this case because the body is not independently rigid. If we imagine separating the whole thing from the wall, there is nothing keeping it from being just two members that could swing independently of one another. Because of that, we cannot simply use the equilibrium equations for the whole structure. Instead, we need to break the whole thing apart and analyze it in pieces.

1:02

To do that, we break it apart, and I have drawn a free-body diagram of the two pieces here. We have member A-B and member C-B. I have placed the six-kilonewton force on member C-B. Now we need to identify all the unknown forces.

1:20

The first thing that helps with this problem is noticing that member A-B is a two-force member. It only has forces acting at point B and point A. With that in mind, we know the whole member is either in tension or compression. I will assume it is in tension. I will have force F_B down here and force F_A up here, and I know these forces act along the line connecting the two points.

1:59

This helps with member C-B as well, because I know that force F_B has an equal and opposite force acting on member C-B. The angle from the original problem is 60 degrees. Even though member C-B is anchored by a pin joint at the top, we only have one force to worry about because A-B is a two-force member.

2:39

At joint C, however, member C-B is not a two-force member. Where it is anchored to the wall, we have potential forces in both the x and y directions. I will call these F_Cx and F_Cy.

2:58

Now that we have the free-body diagram, the next step is to write the equilibrium equations. I will start with member C-B and determine the unknown forces.

3:18 - Sum of Forces in the X

F_Cx minus cosine(60 degrees) times F_B equals zero.

3:45 - Sum of Forces in the Y

F_Cy minus six kilonewtons plus sine(60 degrees) times F_B equals zero.

4:11 - Sum of Moments About Point C

Taking moments about point C allows us to solve for F_B. The six-kilonewton force creates a clockwise (negative) moment: 6 kN x 2 m. The vertical component of F_B creates a counterclockwise (positive) moment: 3 m x sin(60 degrees) x F_B. Setting the sum of moments equal to zero allows us to solve for F_B.

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Solving the moment equation gives $F_B = (2 \times 6) / (3 \times \sin(60 \text{ degrees})) = 4.6$ kN.

6:15 - Solving for F_{Cx}

$F_{Cx} = \cos(60 \text{ degrees}) \times 4.6 = 2.3$ kN.

7:01 - Solving for F_{Cy}

$F_{Cy} = 6 - \sin(60 \text{ degrees}) \times 4.6 = 2$ kN.

7:32

These values can now be placed on the original diagram: $F_{Cx} = 2.3$ kN, $F_{Cy} = 2$ kN, and $F_B = 4.6$ kN.

8:10 - Solving for F_A

The last unknown is F_A at the top of member A-B. Using equilibrium in the x direction for member A-B, we get $F_A = 4.6$ kN. This makes sense because a two-force member must have equal and opposite forces at its ends.

9:04

With that, we have solved for all forces acting on the two members. Thank you for watching, and I hope to see you again.