Extended Body Equilibrium - Adaptive Map Worked Problem 4 Transcript

0:00

For this problem, we have member ABC, which is supported by a pin joint at A, a cable at B, and it supports a 300-kilogram weight at C. We are asked to determine all forces acting on member ABC. These include the gravity force, the tension force in the cable, and the x- and y-components of the reaction force at the base. This is an extended body equilibrium problem. Step one is to draw the free body diagram.

0:33

For the free body diagram, consider member ABC. Point A is at the base, point B is at the midpoint, and point C is at the far end. At point A, the pin joint provides an unknown force in the x-direction and an unknown force in the y-direction. These are labeled F_Ax and F_Ay. The axes are defined with x horizontal and y vertical. At point B, there is a tension force T in the supporting cable. At point C, the gravity force F_G acts downward. The gravity force is the weight of the 300-kilogram mass: 300 kilograms times 9.81 newtons per kilogram, giving F_G = 2943 newtons.

1:54

Next, add helpful dimensions. The entire member is 6 meters long. Point B is centered, so it is 3 meters from A and 3 meters from C. The forces F_Ax, F_Ay, and F_G are horizontal or vertical, but the tension force is at a 45-degree angle, perpendicular to the beam.

2:47

Now write the equilibrium equations: the sum of forces in the x-direction, the sum of forces in the y-direction, and the sum of moments.

3:06

In the x-direction, the forces are F_Ax and the negative x-component of the tension force. Because the cable is 45 degrees from horizontal, the x-component is T cos 45. The equation is:
F_Ax - T cos 45 = 0.

3:38

Extended Body Equilibrium - Adaptive Map Worked Problem 4 Transcript

In the y-direction, the forces are F_Ay, the positive y-component of the tension force T sin 45, and the negative gravity force 2943 newtons. The equation is:
F_Ay + T sin 45 - 2943 = 0.

4:11

For the moment equation, take moments about point A. This eliminates F_Ax and F_Ay. The tension force creates a positive (counterclockwise) moment. Its perpendicular distance is 3 meters. The moment from tension is 3T. The gravity force creates a clockwise (negative) moment. Its perpendicular distance is 6 cos 45. The moment equation is:
3T - 2943(6 cos 45) = 0.

5:50

Solve the moment equation first. Rearranging gives:
T = [2943(6 cos 45)] / 3.
Evaluating gives T = 4162 newtons.

6:56

Now substitute T into the x-direction equation:
F_Ax = T cos 45.
This gives F_Ax = 2943 newtons.

7:28

Next, substitute T into the y-direction equation and solve for F_Ay. After substitution and simplification, F_Ay = 0. There is no vertical reaction force at the pin joint in this case.

8:15

We have now solved for all three unknown forces: the tension T, the horizontal reaction F_Ax, and the vertical reaction F_Ay. These correspond to the forces at points B and A. Thank you for watching, and I hope to see you again.