

ENGR-1100 Introduction to Engineering Analysis

Assignment Project Exam Help

<https://powcoder.com>

Lecture 23

FRAMES

Today's Objectives:

Students will be able to:

- Draw the free body diagram of a frame and its members.
- Determine the forces acting at the joints and supports of a frame.

In-Class Activities:

- Reading Quiz
- Applications

<https://powcoder.com>

Add WeChat powcoder

Analysis of a Frame

- Concept Quiz
- Group Problem Solving
- Attention Quiz



APPLICATIONS



Frames are commonly used to support various external loads.

Assignment Project Exam Help

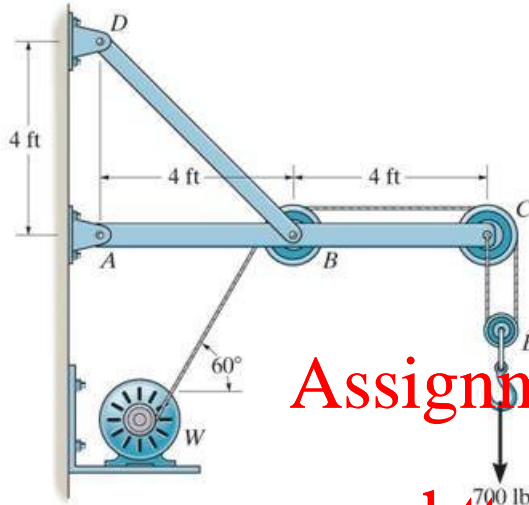
How is a frame different than a truss?
<https://powcoder.com>

Add WeChat powcoder

To be able to design a frame, you need to determine the forces at the joints and supports.

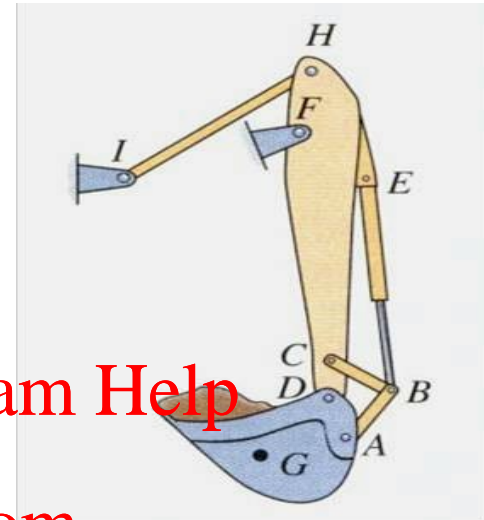


FRAMES AND MACHINES: DEFINITIONS



← Frame

Machine →



Assignment Project Exam Help

<https://powcoder.com>

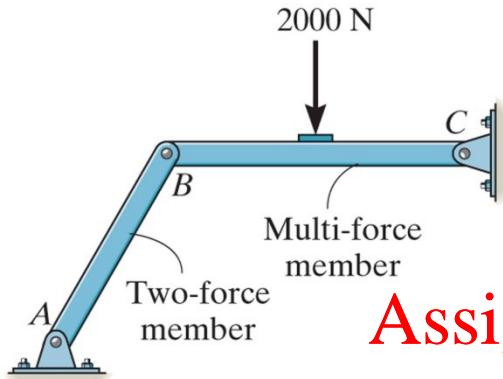
Frames and machines are two common types of structures that have **at least one multi-force member**. (Recall that trusses have nothing but two-force members).

Frames are generally **stationary** and support external loads.

Machines contain **moving parts** and are designed to alter the effect of forces.



STEPS FOR ANALYZING A FRAME



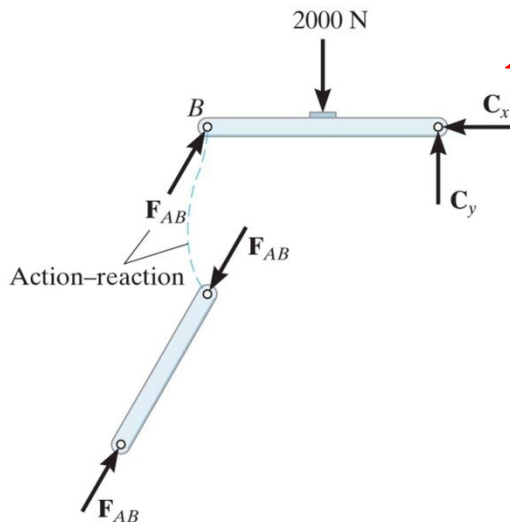
1. Draw a FBD of the frame and its members, as necessary.

Hints:

a) Identify any two-force members,

b) Note that forces on contacting surfaces (usually between a pin and a member) are equal and opposite, and,

c) For a joint with more than two members or an external force, it is advisable to draw a FBD of the pin.



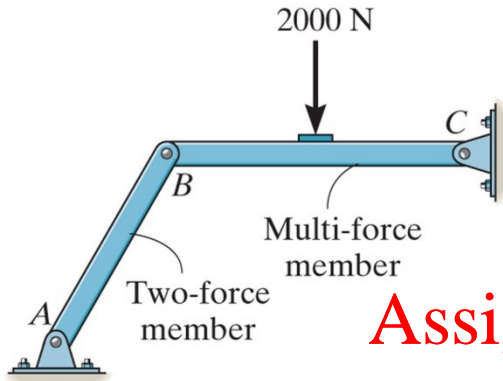
Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder



STEPS FOR ANALYZING A FRAME

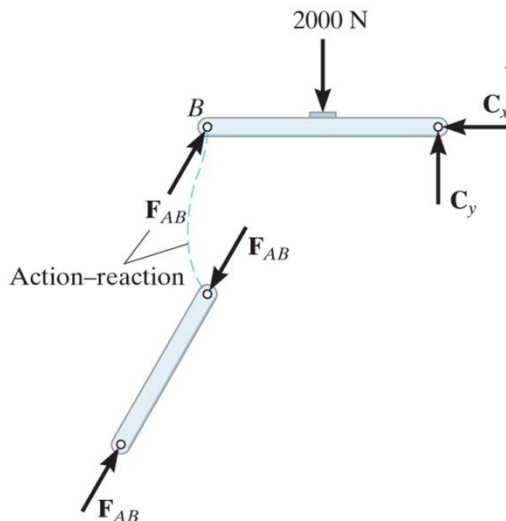


2. Develop a strategy to apply the equations of equilibrium to solve for the unknowns. Look for ways to form single equations and single unknowns.

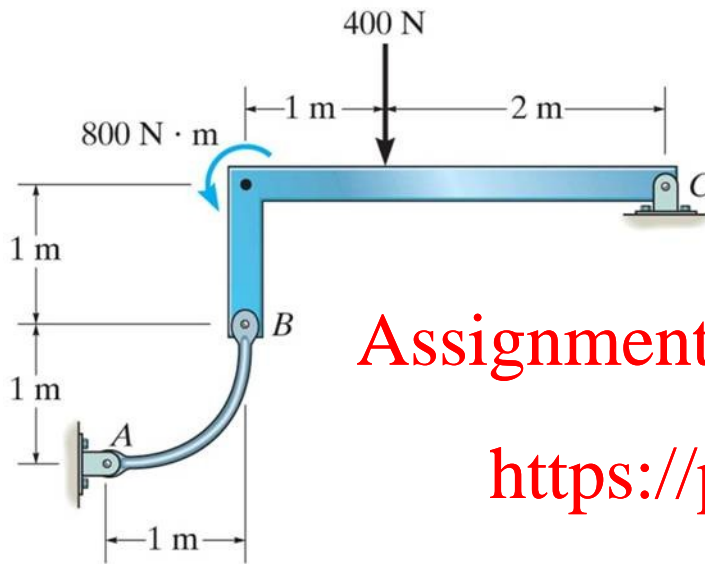
Assignment Project Exam Help

<https://powcoder.com> Problems are going to be challenging since

there are usually several unknowns. A lot of practice is needed to develop good strategies and ease of solving these problems.



EXAMPLE



Given: The frame supports an external load and moment as shown.

Find: The horizontal and vertical components of the pin reactions at C and the magnitude of reaction at B.

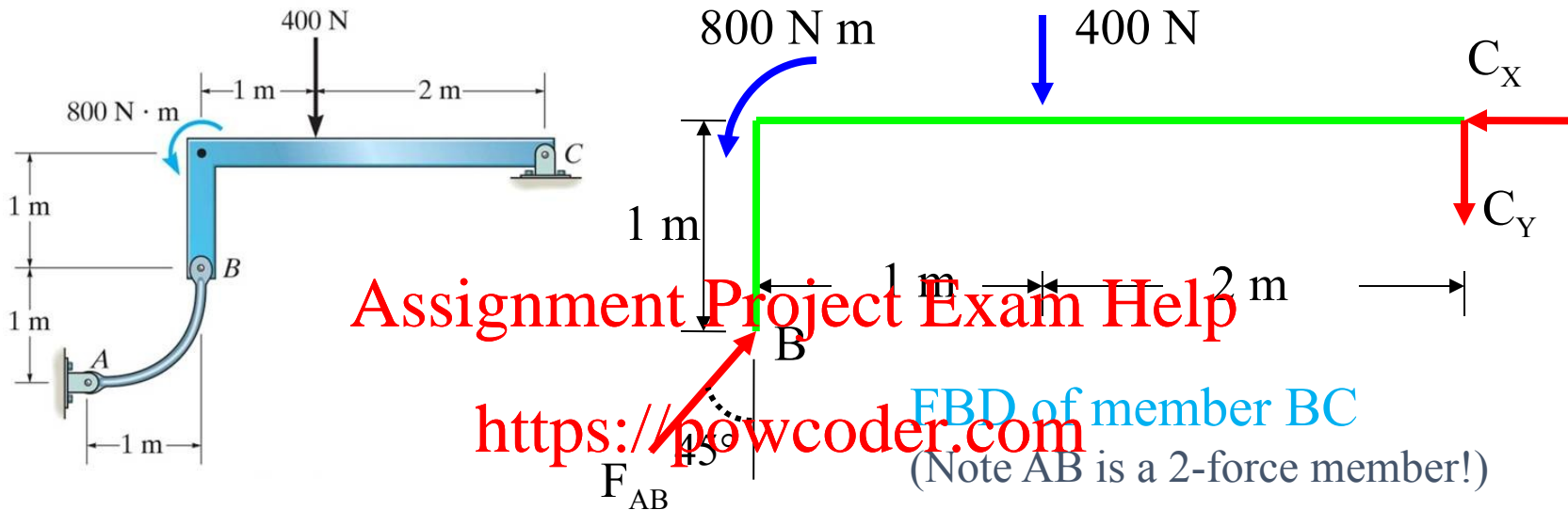
<https://powcoder.com>

Add WeChat: powcoder

- Draw FBDs of the frame member BC. Why pick this part of the frame?
- Apply the equations of equilibrium and solve for the unknowns at C and B.



EXAMPLE (continued)



Add WeChat powcoder
Note that member AB is a two-force member.

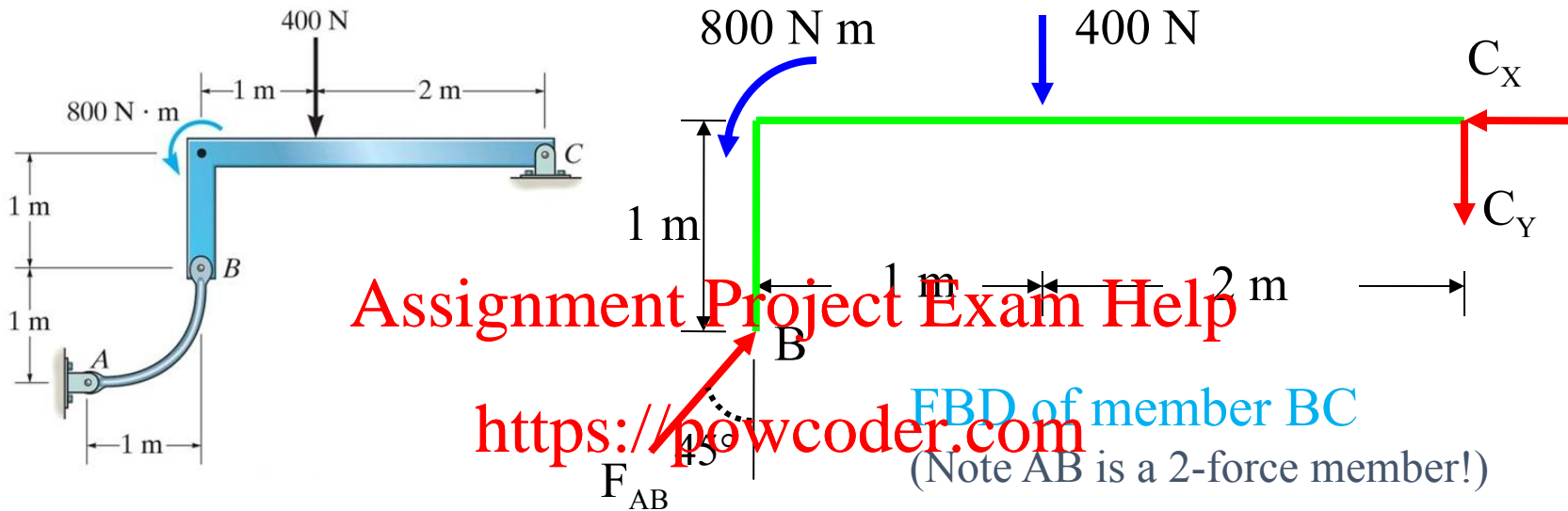
Equations of Equilibrium: Start with $\sum M_C$ since it yields one unknown.

$$\left(\sum M_C = F_{AB} \sin 45^\circ (1) - F_{AB} \cos 45^\circ (3) + 800 \text{ N m} + 400 (2) = 0 \right.$$

$$F_{AB} = 1131 \text{ N}$$



EXAMPLE (continued)



Assignment Project Exam Help

<https://powcoder.com>
 (Note AB is a 2-force member!)

Add WeChat powcoder

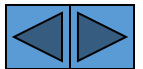
Now use the x and y-direction Equations of Equilibrium:

$$\rightarrow + \sum F_X = -C_X + 1131 \sin 45^\circ = 0$$

$$C_X = 800 \text{ N}$$

$$\uparrow + \sum F_Y = -C_Y + 1131 \cos 45^\circ - 400 = 0$$

$$C_Y = 400 \text{ N}$$



READING QUIZ

1. Frames and machines are different as compared to trusses, since they have _____.

A) Only two-force members

B) Only multforce members

C) At least one multforce member

D) At least one two-force member

<https://powcoder.com>

2. Forces common to any two contacting members act with _____ on the other member.

A) Equal magnitudes, but opposite sense

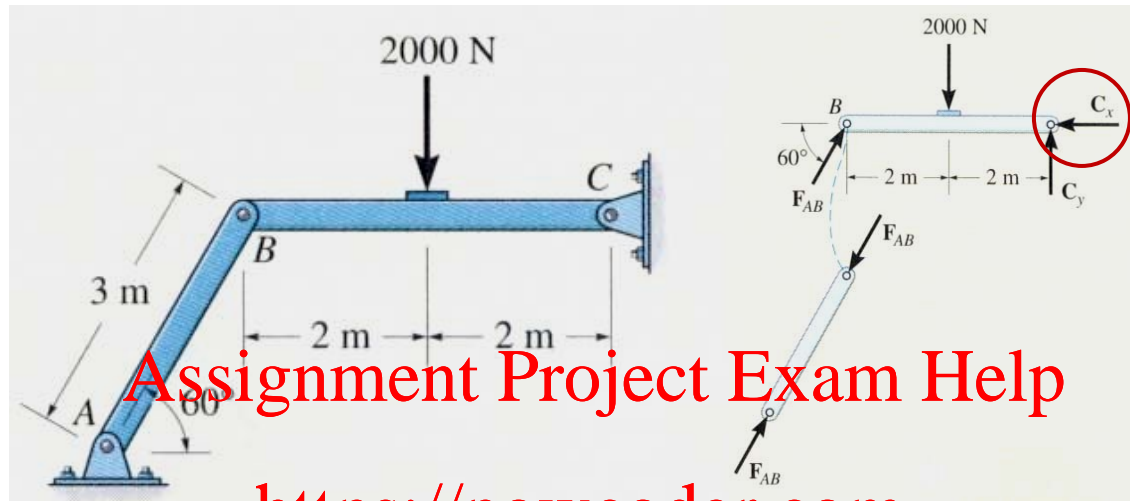
B) Equal magnitudes and the same sense

C) Different magnitudes and the opposite sense

D) Different magnitudes and the same sense



CONCEPT QUIZ

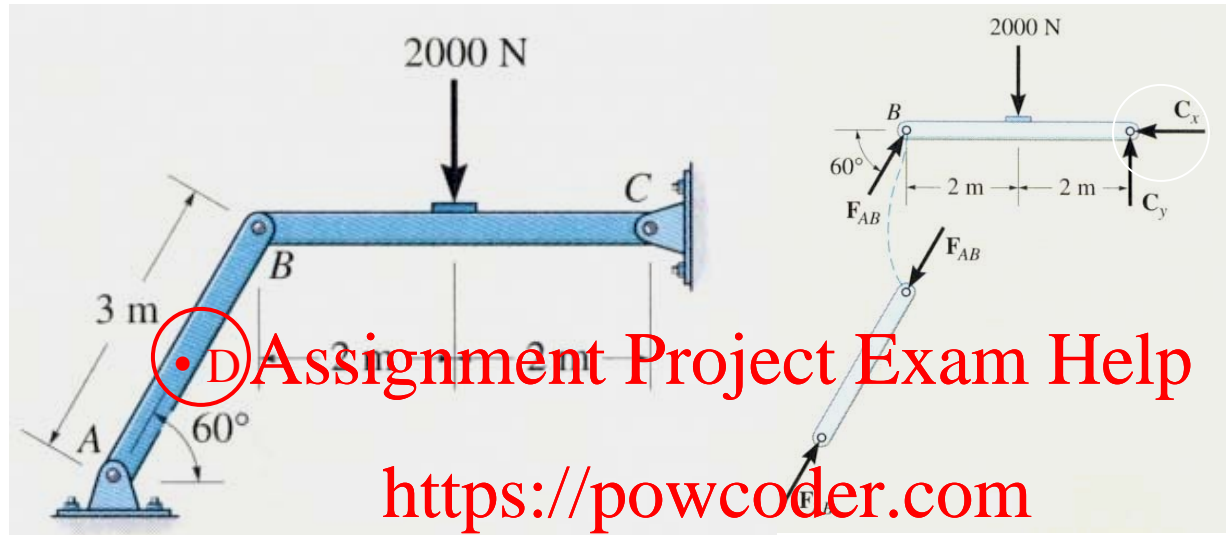


1. The figures show a frame and its FBDs. If an additional couple moment is applied at C, how will you change the FBD of member BC at B?

- A) No change, still just one force (F_{AB}) at B
- B) Will have two forces, B_x and B_y , at B.
- C) Will have two forces and a moment at B.
- D) Will add one moment at B.



CONCEPT QUIZ (continued)



2. The figures show a frame and its FBDs. If an additional force is applied at D, then how will you change the FBD of member BC at B?

- A) No change, still just one force (F_{AB}) at B.
- B) Will have two forces, B_x and B_y , at B
- C) Will have two forces and a moment at B.
- D) Will add one moment at B.



ATTENTION QUIZ

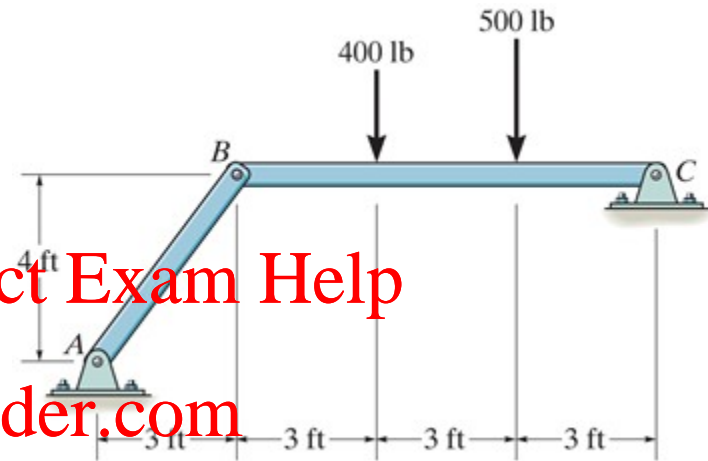
1. When determining the reactions at joints A, B and C, what is the total number of unknowns in solving this problem?

A) 6

B) 5

C) 4

D) 3



Assignment Project Exam Help

<https://powcoder.com>

Add WeChat powcoder

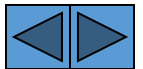
2. For the above problem, imagine that you have drawn a FBD of member BC. What will be the easiest way to write an equation involving unknowns at B?

A) $\sum M_C = 0$

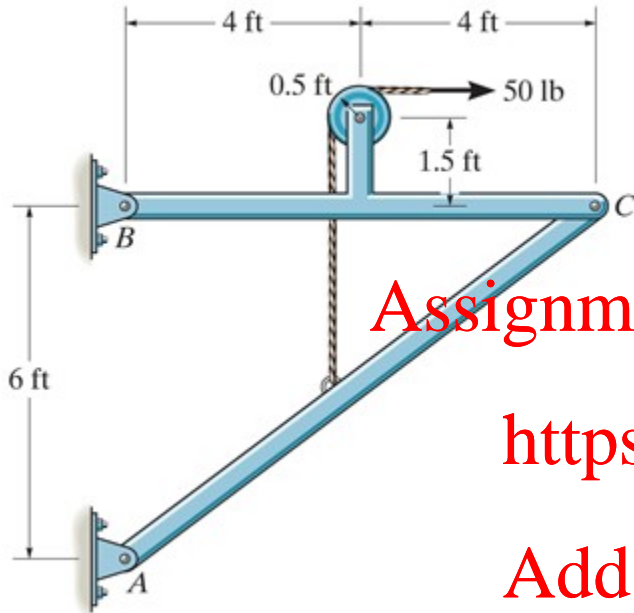
B) $\sum M_B = 0$

C) $\sum M_A = 0$

D) $\sum F_Y = 0$



GROUP PROBLEM SOLVING



Given: A frame supports a 50 lb load as shown.

Find: The reactions exerted by the pins on the frame members at B and C.

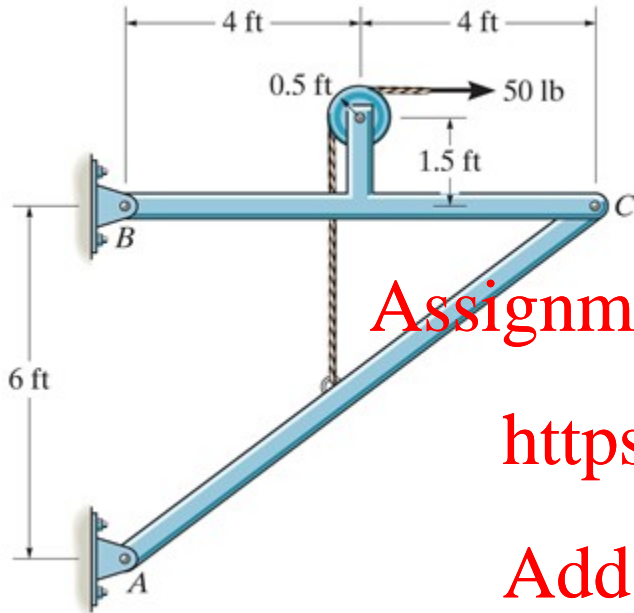
<https://powcoder.com>

Plan:

Add WeChat powcoder



GROUP PROBLEM SOLVING



Given: A frame supports a 50 lb load as shown.

Find: The reactions exerted by the pins on the frame members at B and C.

<https://powcoder.com>
Plan:

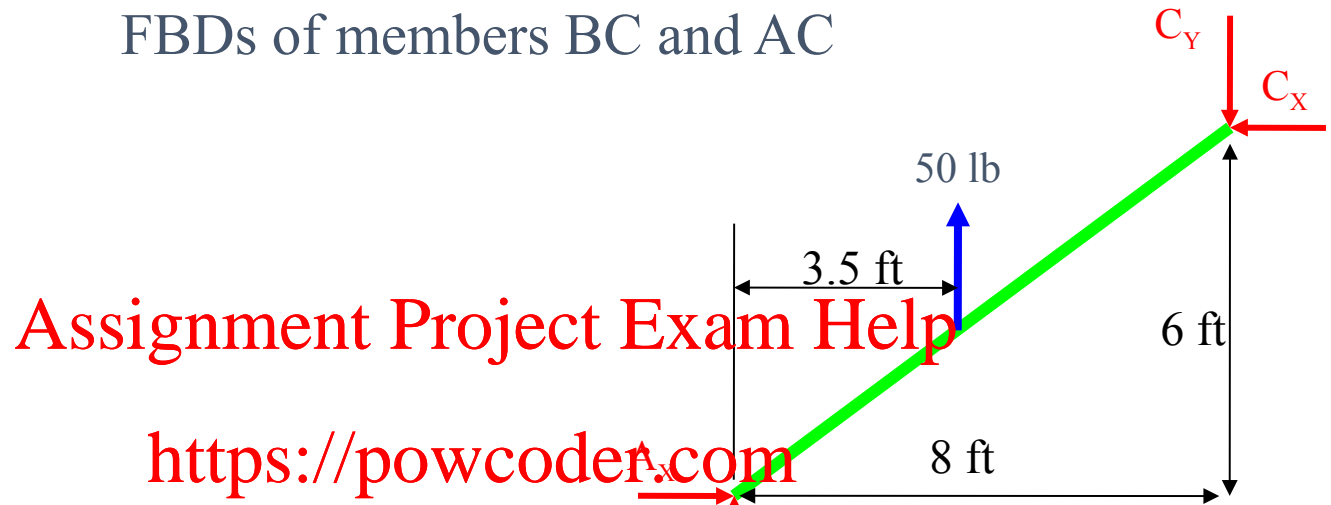
Add WeChat powcoder

- Draw a FBD of member BC and another one for AC.
- Apply the equations of equilibrium to each FBD to solve for the four unknowns. Think about a strategy to easily solve for the unknowns.



GROUP PROBLEM SOLVING (continued)

FBDs of members BC and AC



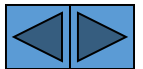
Applying E-of-E to member AC:
Add WeChat powcoder

$$\curvearrowleft + \sum M_A = -C_Y(8) + C_X(6) + 50(3.5) = 0 \quad (1)$$

$$\rightarrow + \sum F_X = -C_X + A_X = 0$$

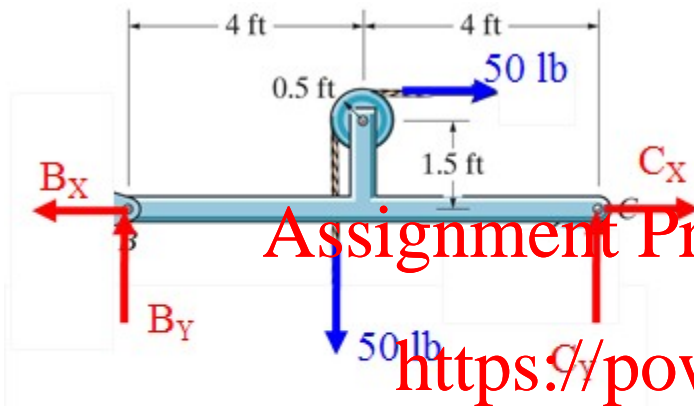
$$\uparrow + \sum F_Y = 50 + A_Y - C_Y = 0$$

Starting with this piece is not super useful! Why not?



GROUP PROBLEM SOLVING (continued)

FBDs of members BC and AC



Assignment Project Exam Help

<https://powcoder.com>

Applying E-of-E to member BC:

Add WeChat powcoder

$$\curvearrowleft + \sum M_B = -50(2) - 50(3.5) + C_Y(8) = 0 ; C_Y = 34.38 = 34.4 \text{ lb}$$

From Eq (1), C_X can be determined; $C_X = 16.67 = 16.7 \text{ lb}$

$$\rightarrow + \sum F_X = 16.67 + 50 - B_X = 0 ; B_X = 66.7 \text{ lb}$$

$$\uparrow + \sum F_Y = B_Y - 50 + 34.38 = 0 ; B_Y = 15.6 \text{ lb}$$

If you start with this piece, then the equations for AC will be simpler!

