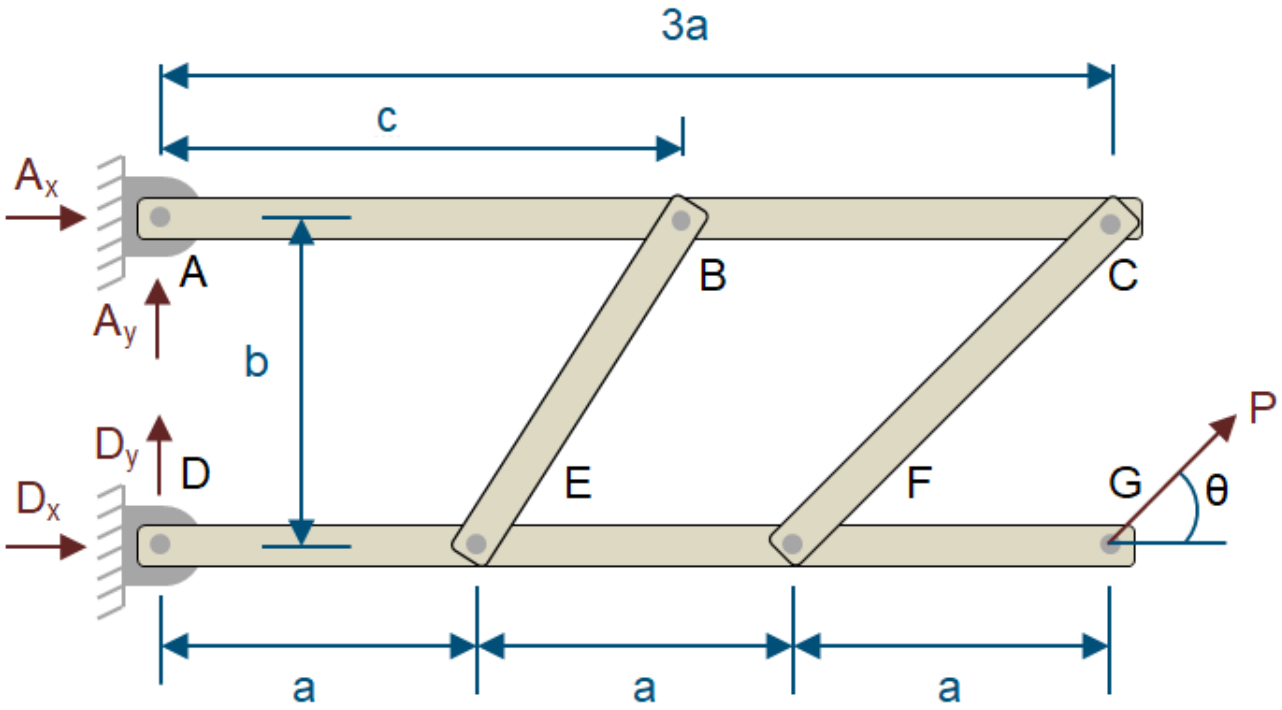
Forces in a 4 Member Frame

Introduction

This frame is subject to a load P at point G. This application will determine the forces at the supports and in members BE and CF.



Since the frame is in equilibrium, the sum of horizontal forces, sum of vertical forces, and sum of momentum about a point is zero. This allows us to identify the unknown forces in a system.

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> restart:
  with(Units[Simple]):
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Parameters

Load and load angle

> $P := -800\ \mathrm{N}$:

$\theta := 30.0\ \mathrm{deg}$:

Lengths

> $a := 0.3\ \mathrm{m}$:

$b := 0.4\ \mathrm{m}$:

$c := 0.5\ \mathrm{m}$:

Analysis

Sum of the moments about A

> $sum\_moments\_A := b\,D_x + b\,P\cos(\theta) + 3\,a\,P\sin(\theta) = 0$

$$sum\_moments\_A := 0.4\,D_x\ \mathrm{m} - 637.1281293\ \mathrm{J} = 0 \quad \textbf{(3.1)}$$

> $D_x := fsolve(sum\_moments\_A, D_x)$

$$1.593 \times 10^{3}\ \mathrm{N} \quad \textbf{(3.2)}$$

Sum of the forces about A

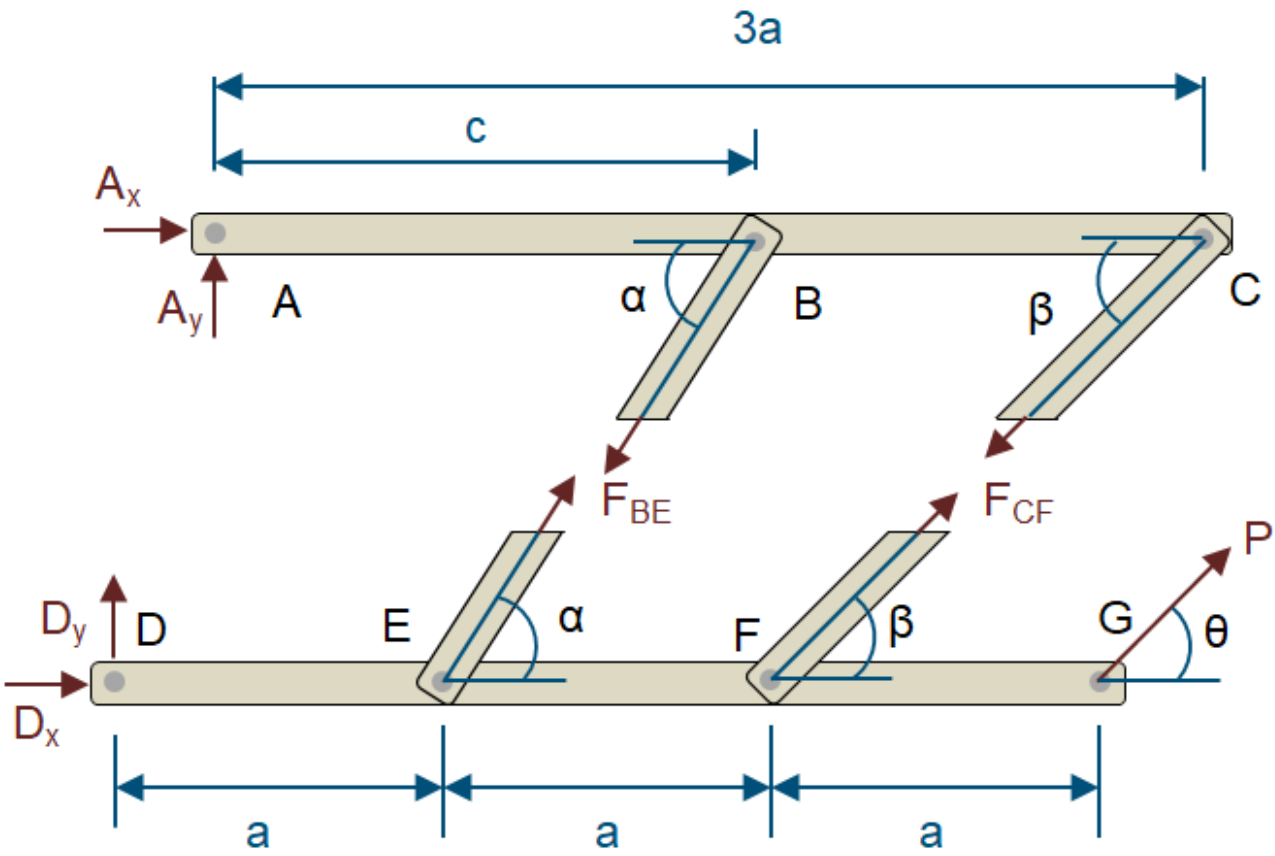
> $sum\_forces\_A := A_x + D_x + P\cos(\theta) = 0$

$$sum\_forces\_A := A_x + 900.0000000\ \mathrm{N} = 0 \quad \textbf{(3.3)}$$

> $A_x := fsolve(sum\_forces\_A, A_x)$

$$-900.00\ \mathrm{N} \quad \textbf{(3.4)}$$

The forces on BE and CF must be equal (but opposite in sign) for the members to be at rest. Split BE and CF like so



> $\alpha := \arctan\left(\frac{b}{c-a}\right)$

$$\alpha := 1.107148718 \quad \textbf{(3.5)}$$

> $\beta := \arctan\left(\frac{b}{a}\right)$

$$\beta := 0.9272952179 \quad \textbf{(3.6)}$$

Four unknown forces remain: Ay, Dy, F_{BE} and F_{CF}

> $sum\_moments\_ABC := c F_{BE} \sin(\alpha) + 3 a F_{CF} \sin(\beta) = 0;$

$sum\_moments\_DEFG := a F_{BE} \sin(\alpha) + 2 a F_{CF} \sin(\beta) + 3 a P \sin(\theta) = 0;$

$$447.21 \times 10^{-3} F_{BE} + 720.00 \times 10^{-3} F_{CF} = 0.00$$

$$\left(268.33 \times 10^{-3} F_{BE} + 480.00 \times 10^{-3} F_{CF}\right) \text{m} - 360.00 \text{ J} = 0.00 \quad \textbf{(3.7)}$$

These two equations are solved for F_{BE} and F_{CF}

> $fsolve\left(\{sum\_moments\_ABC, sum\_moments\_DEFG\}, \{F_{BE}, F_{CF}\}\right)$

$$\left\{F_{BE} = -12.07 \times 10^{3} \text{ N}, F_{CF} = 7.50 \times 10^{3} \text{ N}\right\} \quad \textbf{(3.8)}$$

> $assign(\%)$

Member ABC

> $sum\_forces\_ABC := A_y - F_{BE}\sin(\alpha) - F_{CF}\sin(\beta) = 0$

$$sum\_forces\_ABC := A_y + 4799.999998\ \text{N} = 0 \quad \textbf{(3.9)}$$

> $solve(sum\_forces\_ABC, A_y)$

$$-4.80 \times 10^3\ \text{N} \quad \textbf{(3.10)}$$

Member DEFG

> $sum\_forces\_DEFG := D_y + F_{BE}\sin(\alpha) + F_{CF}\sin(\beta) + P\sin(\theta) = 0$

$$sum\_forces\_DEFG := D_y - 5199.999998\ \text{N} = 0 \quad \textbf{(3.11)}$$

> $solve(sum\_forces\_DEFG, D_y)$

$$5.20 \times 10^3\ \text{N} \quad \textbf{(3.12)}$$