

MECHANICS AND MATERIALS I

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Introduction to Statics vi

Analysis of Structures ii

Chap. 6

[Beer Johnston et al. 9th edition]

MECHANICS AND MATERIALS I

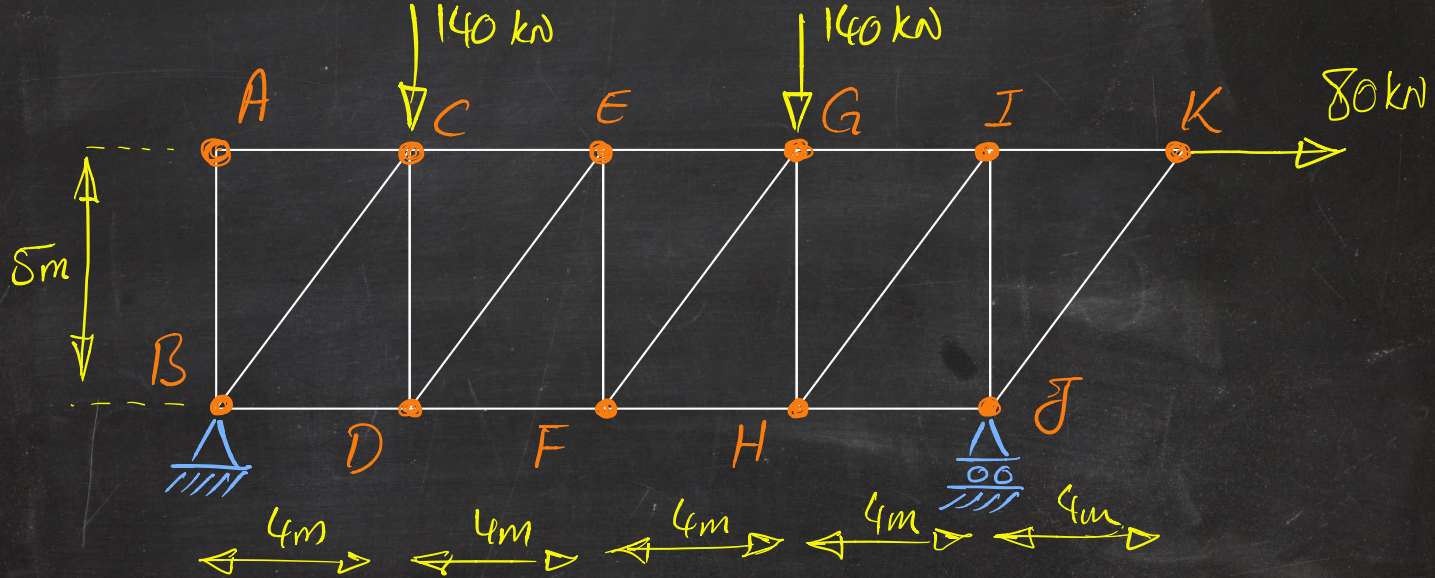
MECHANICS AND MATERIALS I

↳ METHOD OF JOINTS ↪ PAST TIME

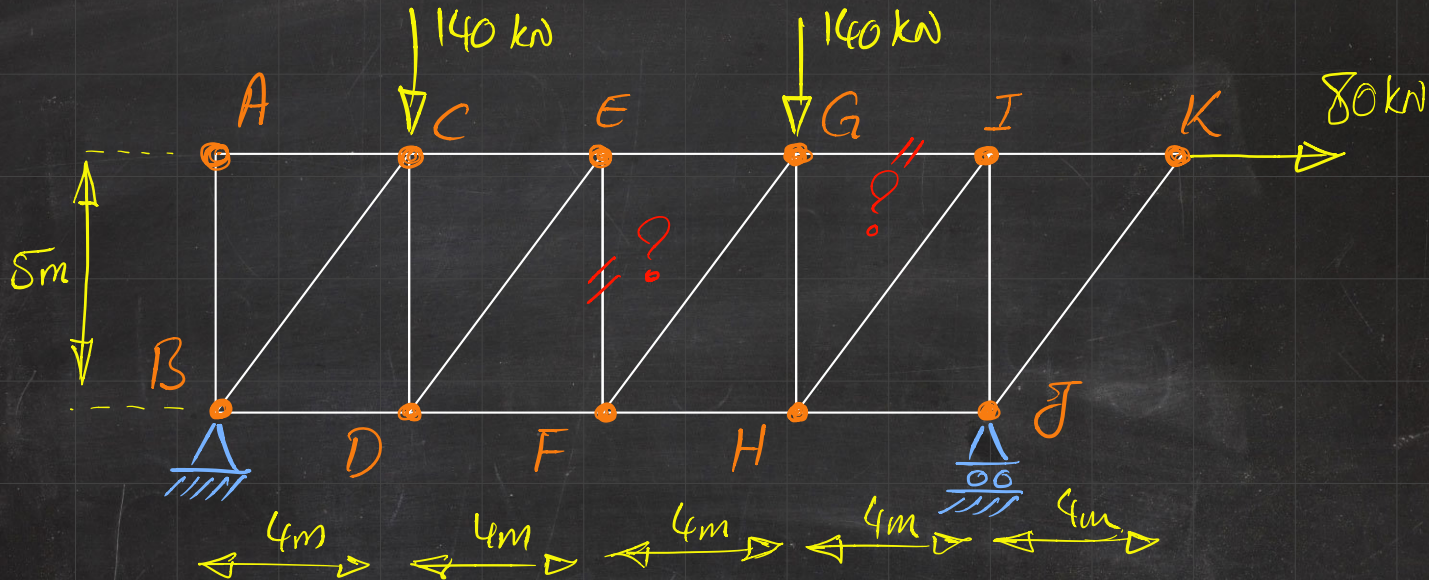
↳ METHOD OF SECTIONS ↪ TODAY

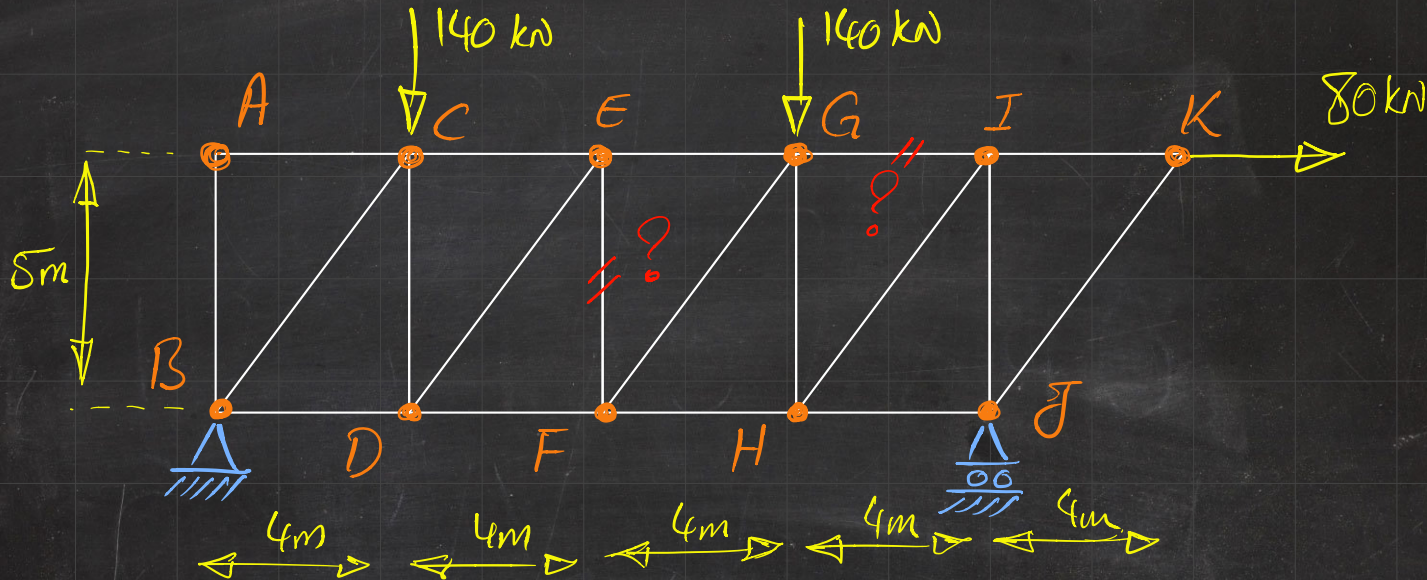
↳ LEARNING THROUGH EXAMPLES

Exercise 1 . [similar to ... P. 307 ... 6.2]



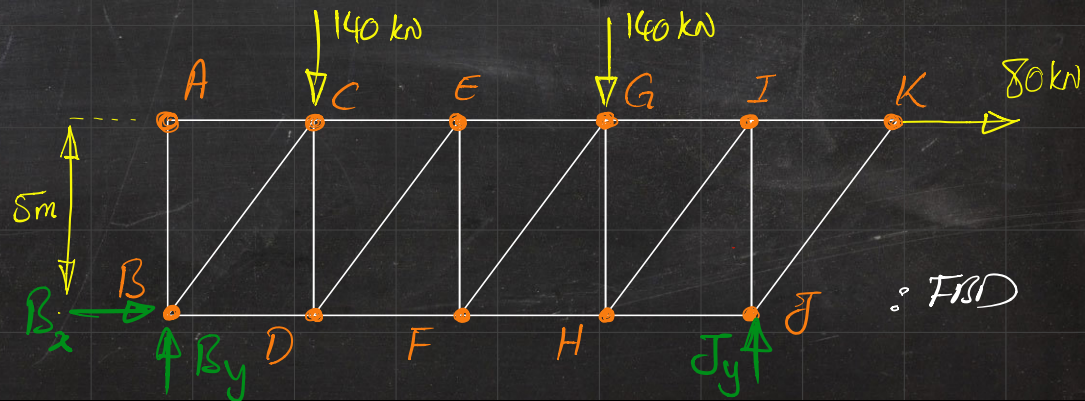
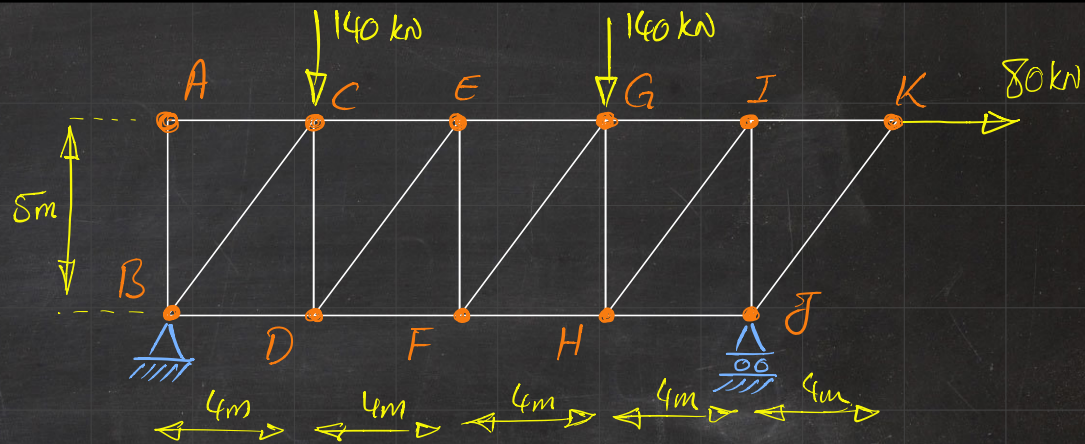
DETERMINE THE FORCE IN MEMBERS EF AND GI.





→ Step 1: FBD for entire structure
 ↓
 calculate supports reactions

→ Step 2: split the structure
 → Step 3: Equilibrium for each section

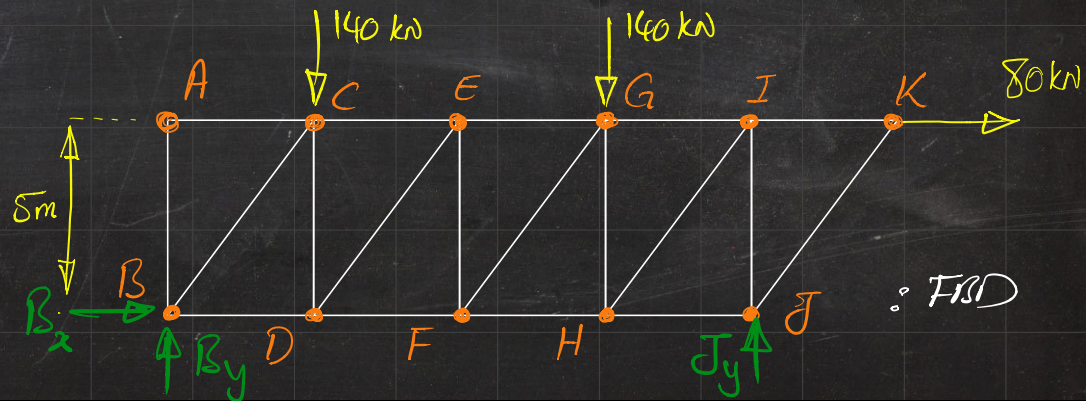
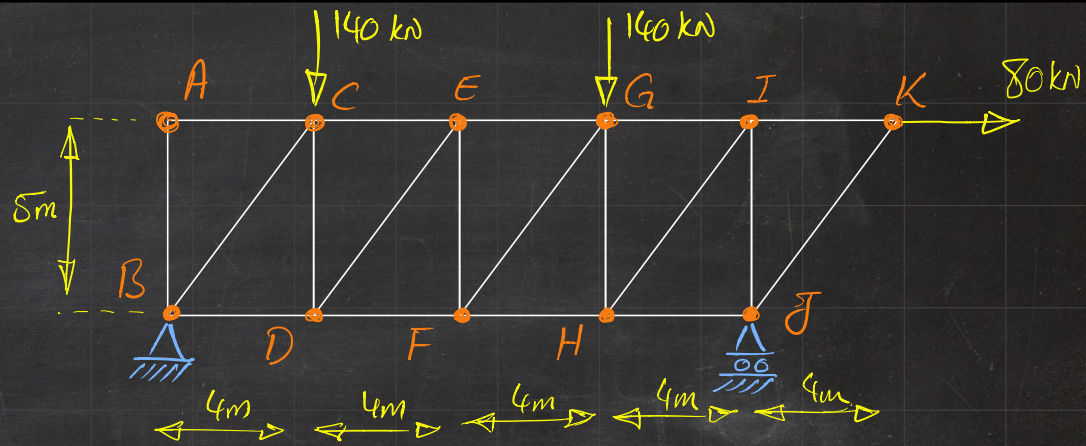


: FBD

$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_B = 0$$

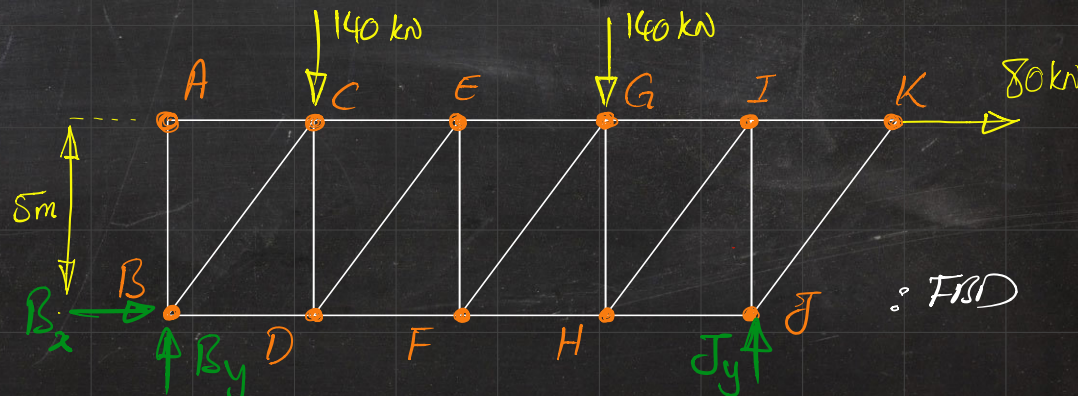
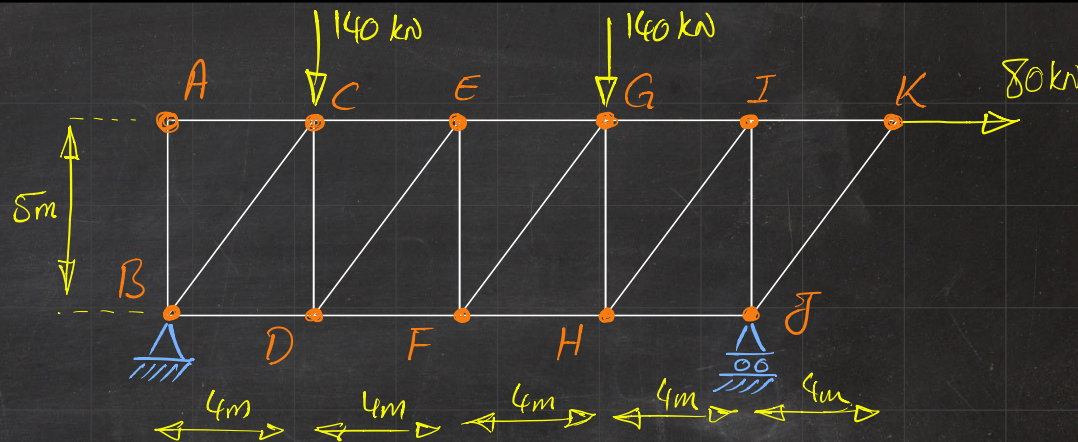


$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_B = 0$$

$$B_x + 80 = 0$$



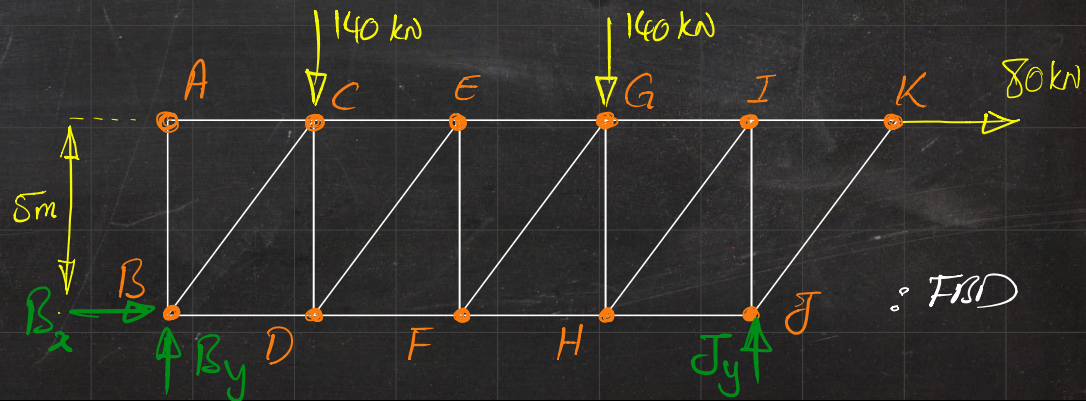
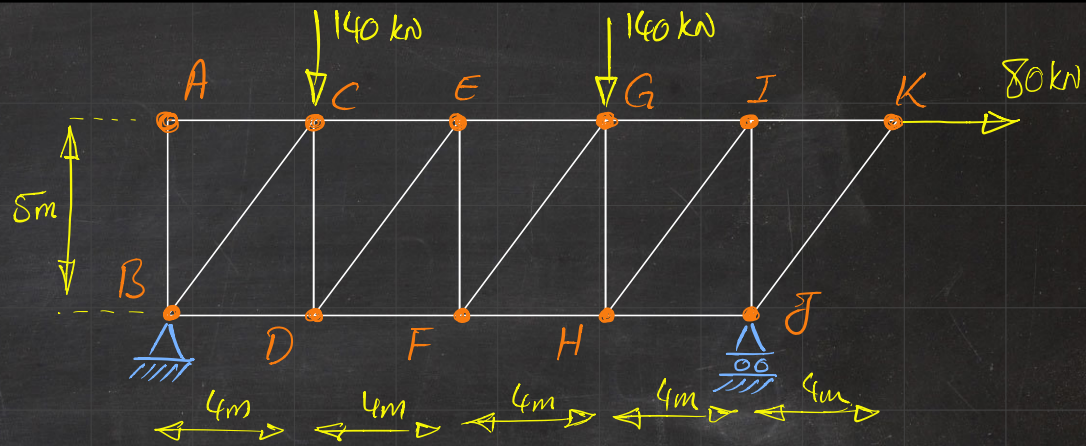
$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_B = 0$$

$$B_x + 80 = 0$$

$$B_y + J_y - 140 - 140 = 0$$



: FBD

$$\sum F_x = 0$$

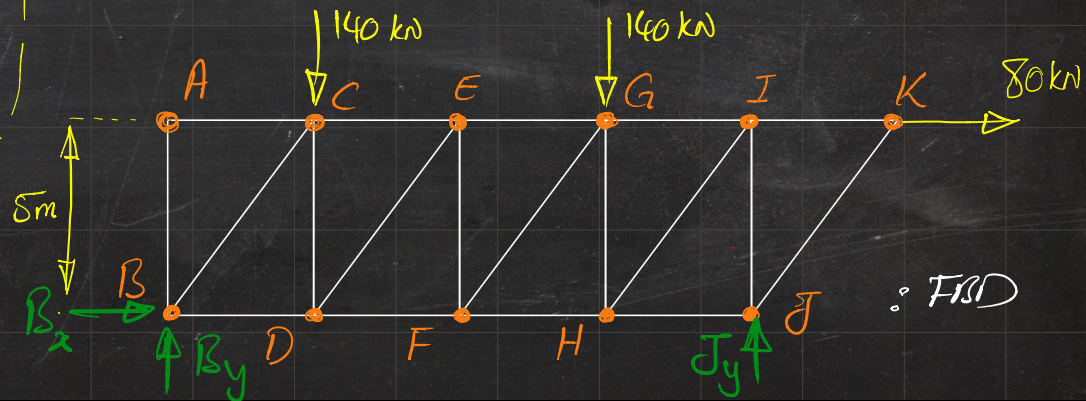
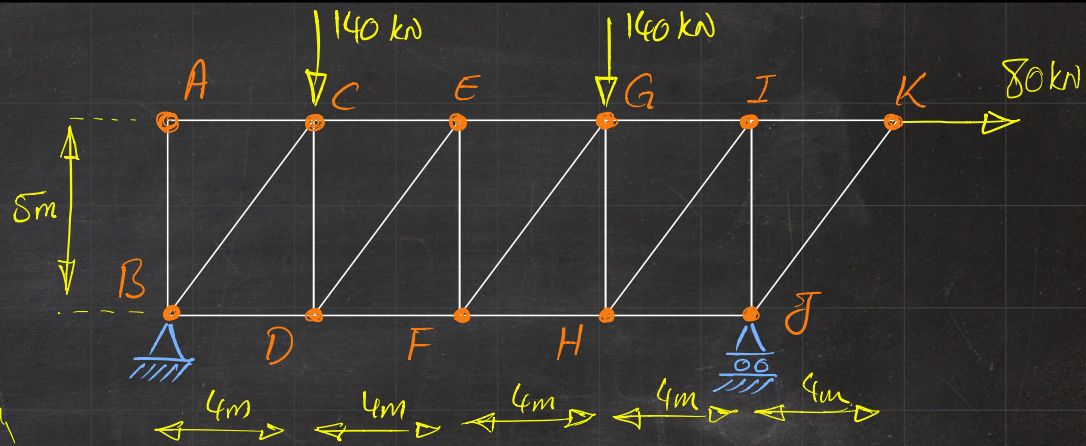
$$\sum F_y = 0$$

$$\sum M_B = 0$$

$$B_x + 80 = 0$$

$$B_y + J_y - 140 - 140 = 0$$

$$16J_y - 5 \times 80 - 4 \times 140 - 12 \times 140 = 0$$



: FBD

$$\sum F_x = 0$$

$$\sum F_y = 0$$

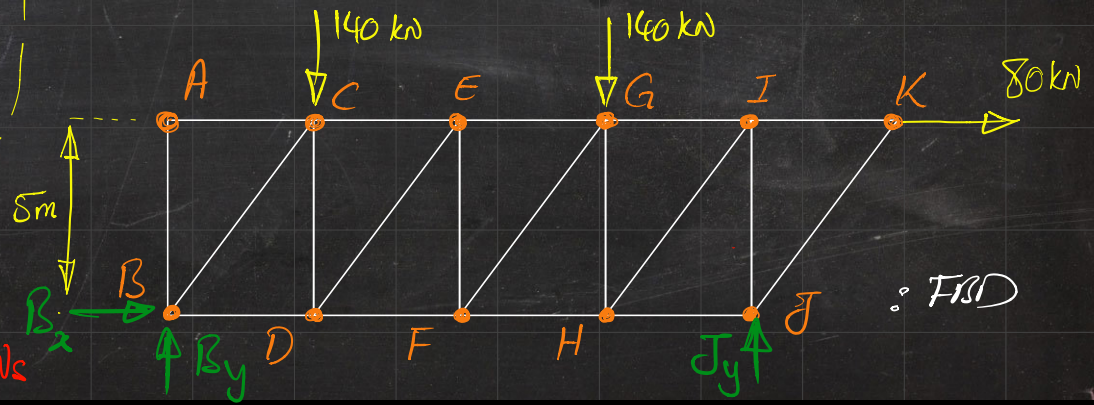
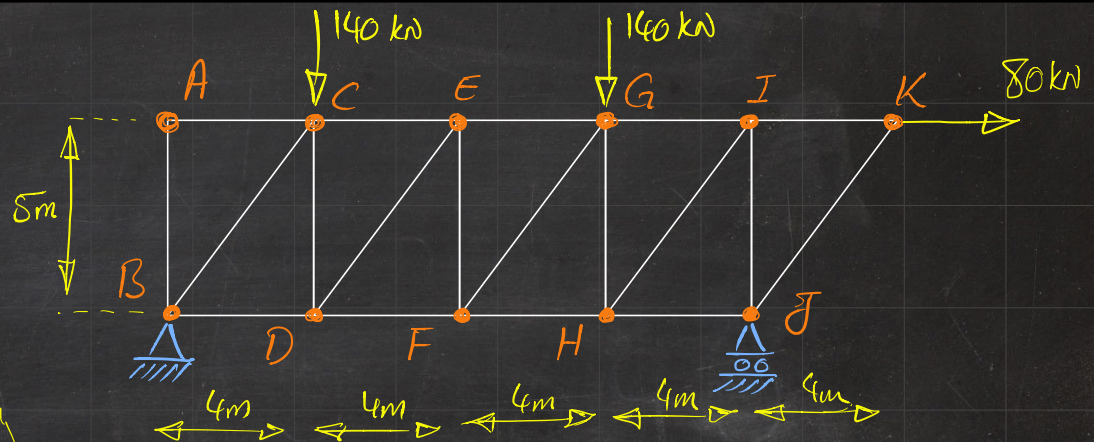
$$\sum M_B = 0$$

$$B_x + 80 = 0$$

$$B_y + J_y - 140 - 140 = 0$$

$$16J_y - 5 \times 80 - 4 \times 140 - 12 \times 140 = 0$$

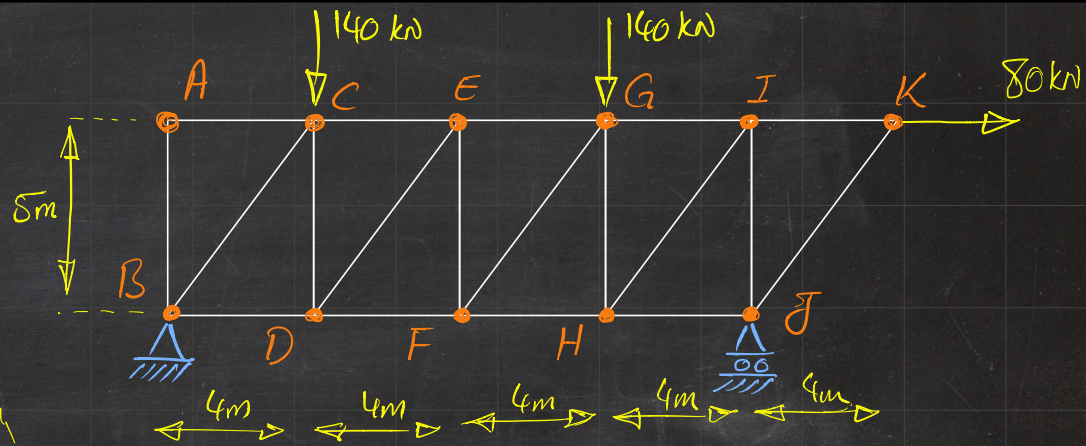
3 EQNS, 3 UNKNOWNNS



$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_B = 0$$



$$B_x + 80 = 0$$

$$B_y + J_y - 140 - 140 = 0$$

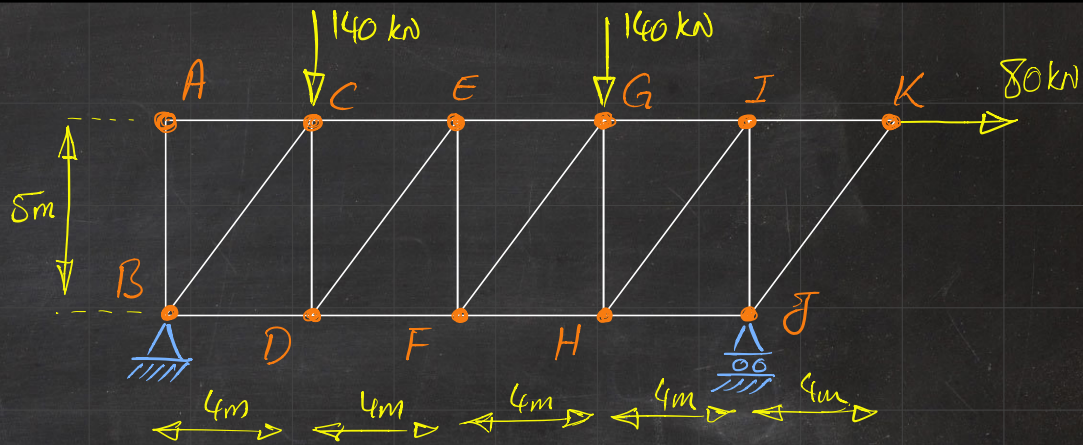
$$16J_y - 5 \times 80 - 4 \times 140 - 12 \times 140 = 0$$

3 EQNS, 3 UNKNOWNs

$$\Rightarrow \left\{ \begin{array}{l} B_x = -80 \text{ kN} \\ J_y = 165 \text{ kN} \\ B_y = 115 \text{ kN} \end{array} \right.$$

(Note: The diagram shows a red arrow pointing left from node B labeled 80 kN, which is equivalent to $B_x = -80 \text{ kN}$.)

$$F_{EF} = ?$$



$$F_{EF} = ?$$

↳

Cut the structure

such that F_{EF} and

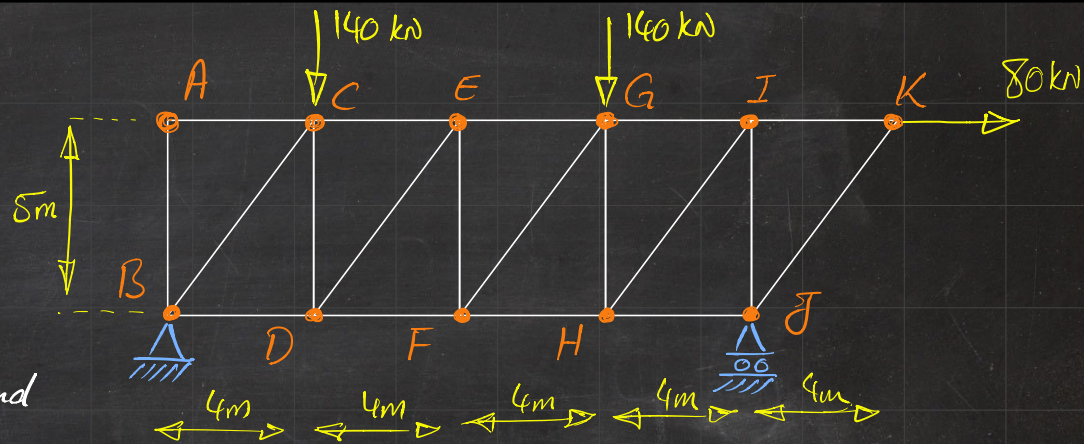
only two other unknowns remain!

↳

3 unknowns ↗

3 equations

$$\left\{ \begin{array}{l} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum M = 0 \end{array} \right.$$



$$F_{EF} = ?$$

↳

Cut the structure

such that F_{EF} and

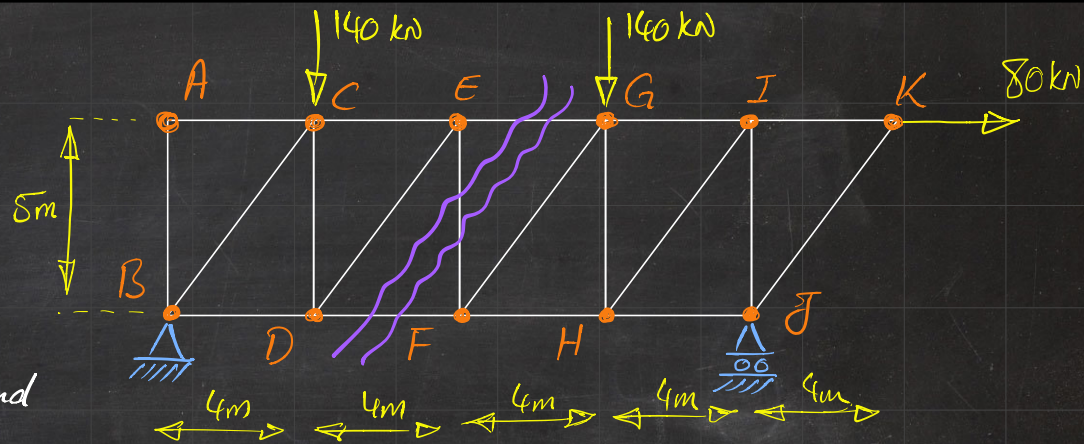
only two other unknowns remain!

↳

3 unknowns ↗

3 equations

$$\left\{ \begin{array}{l} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum M = 0 \end{array} \right.$$



$$F_{EF} = ?$$

↳

Cut the structure

such that F_{EF} and

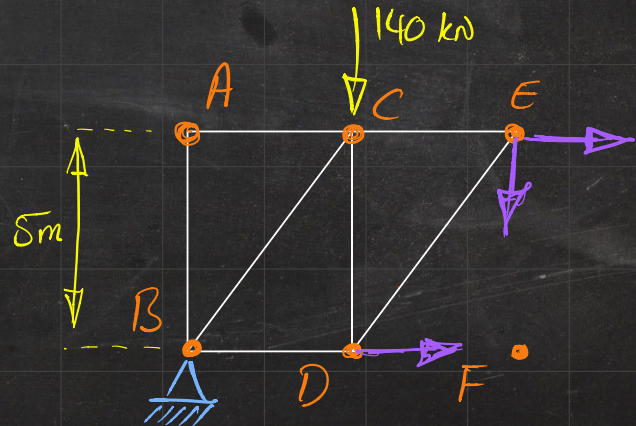
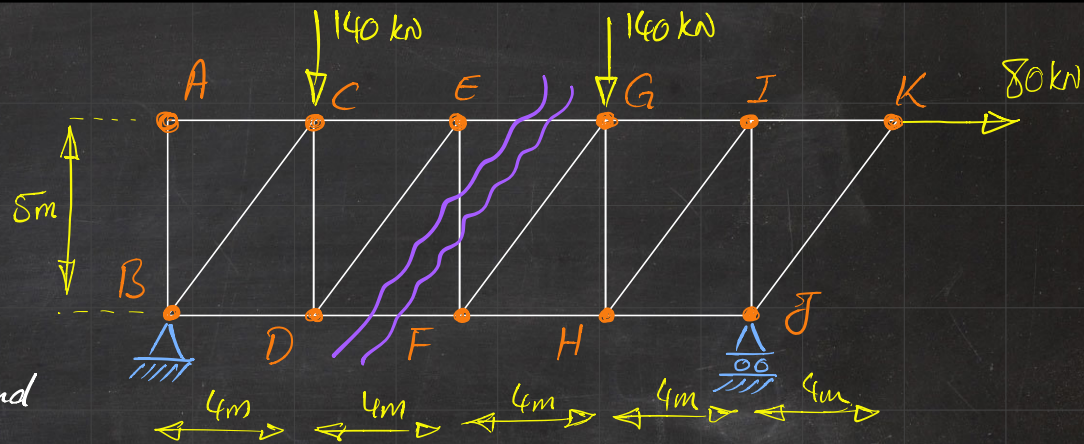
only two other unknowns remain!

↳

3 unknowns ↗

3 equations

$$\left\{ \begin{array}{l} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum M = 0 \end{array} \right.$$

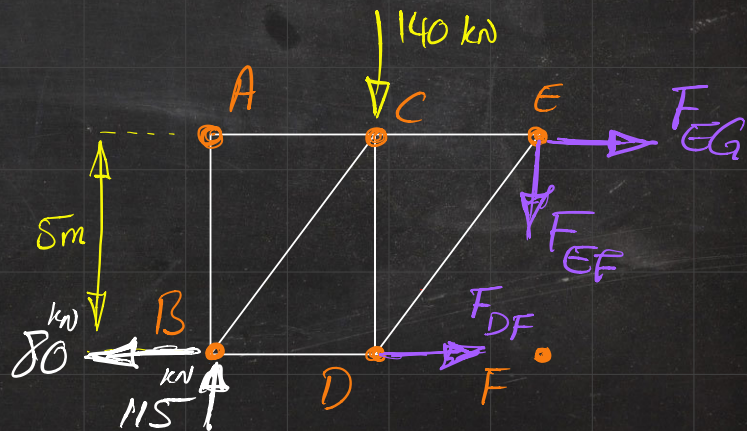
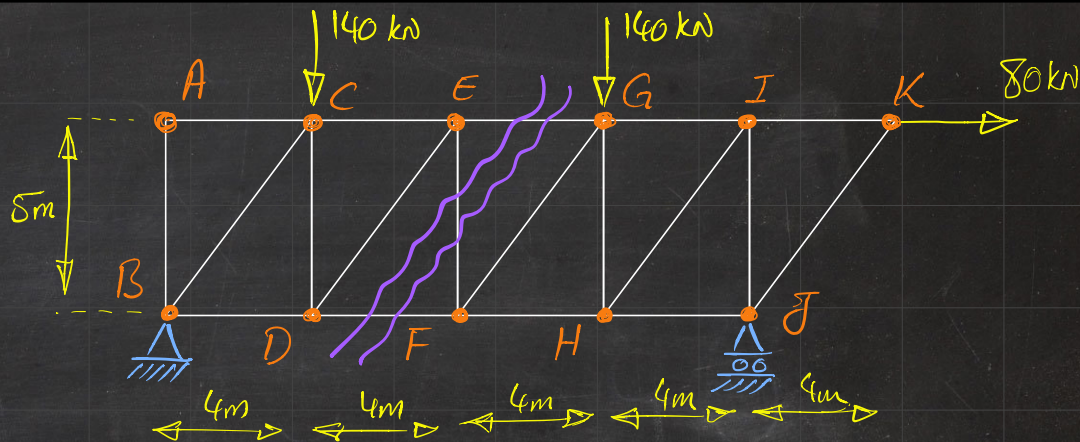


$$F_{EF} = ?$$

$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_B = 0$$



$$F_{EF} = ?$$

$$\sum F_x = 0$$

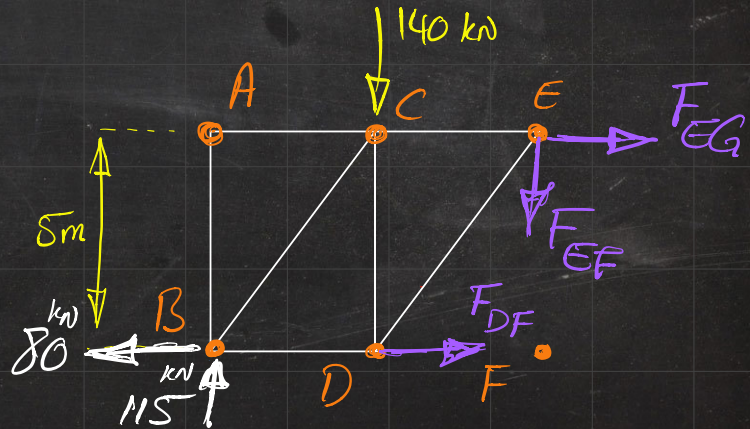
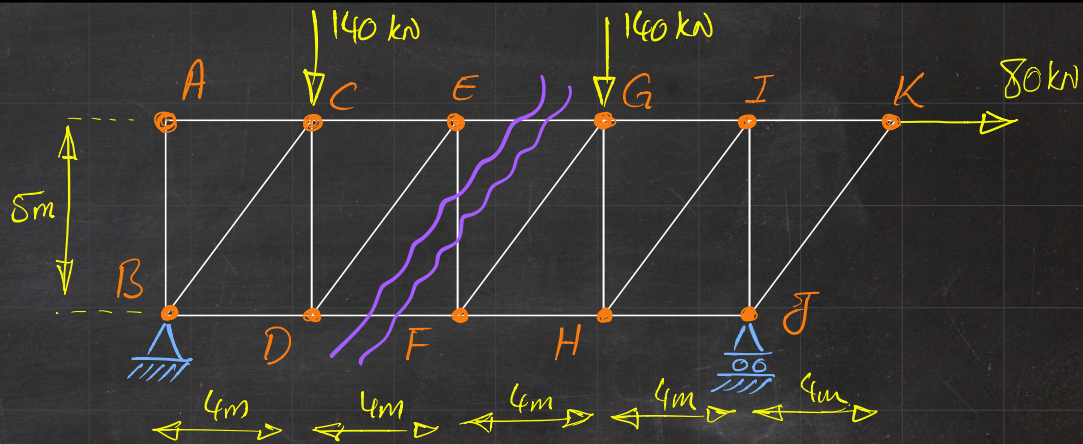
$$\sum F_y = 0$$

$$\sum M_B = 0$$

3 EQUATIONS

3 unknowns

↳ F_{DF} , F_{EF} , F_{EG}



$$F_{EF} = ?$$

$$\sum F_x = 0$$

$$\sum F_y = 0$$

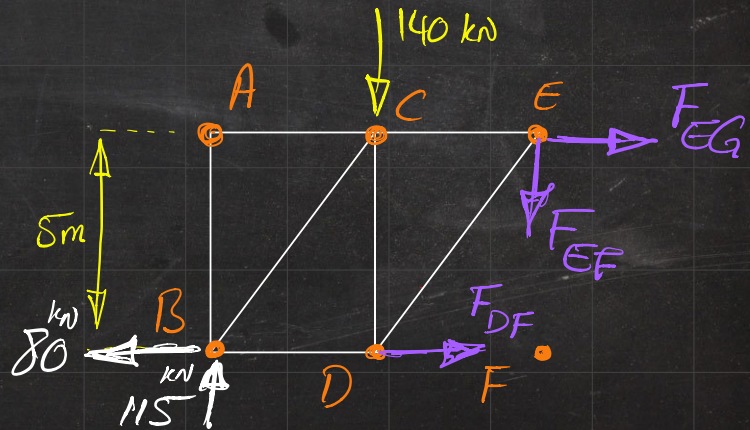
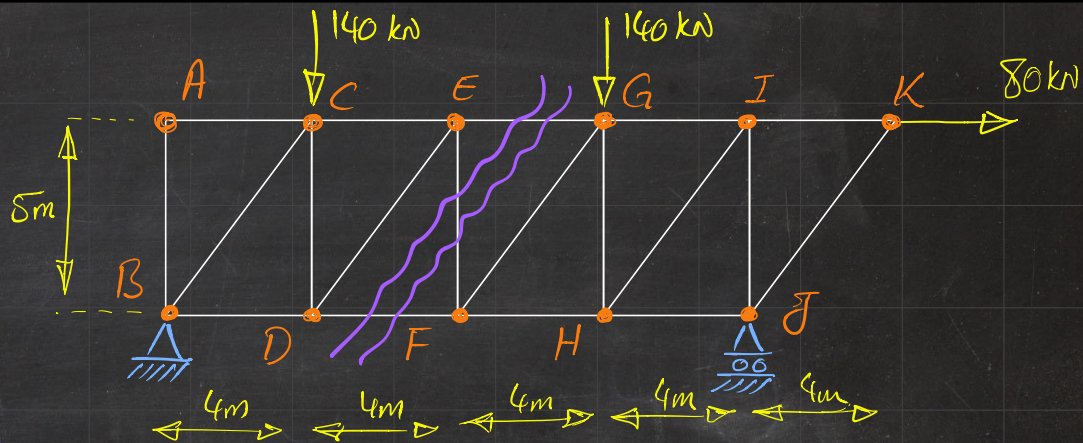
$$\sum M_B = 0$$

3 EQUATIONS

3 unknowns

↳ F_{DF} , F_{EF} , F_{EG}

WE WANT ONLY ONE



$$F_{EF} = ?$$

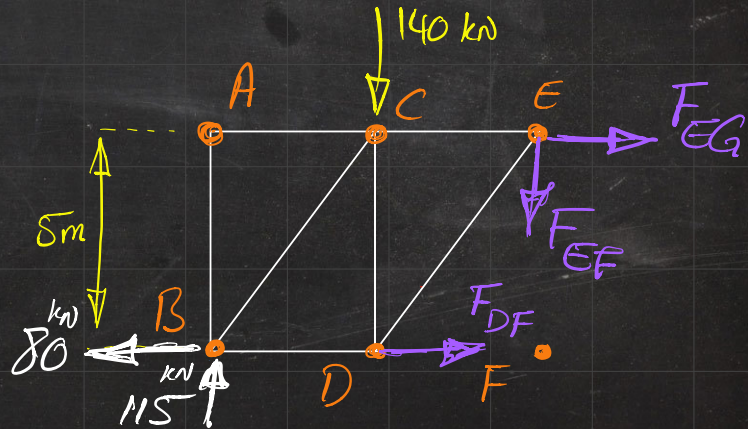
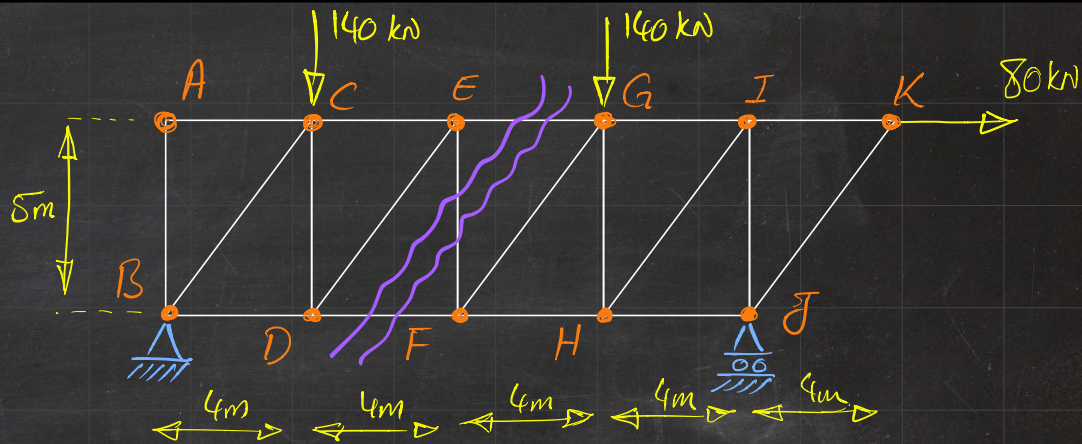
$$\star \sum M_F = 0$$

$$140 \times 4 - 115 \times 8 - F_{EG} \times 5 = 0$$

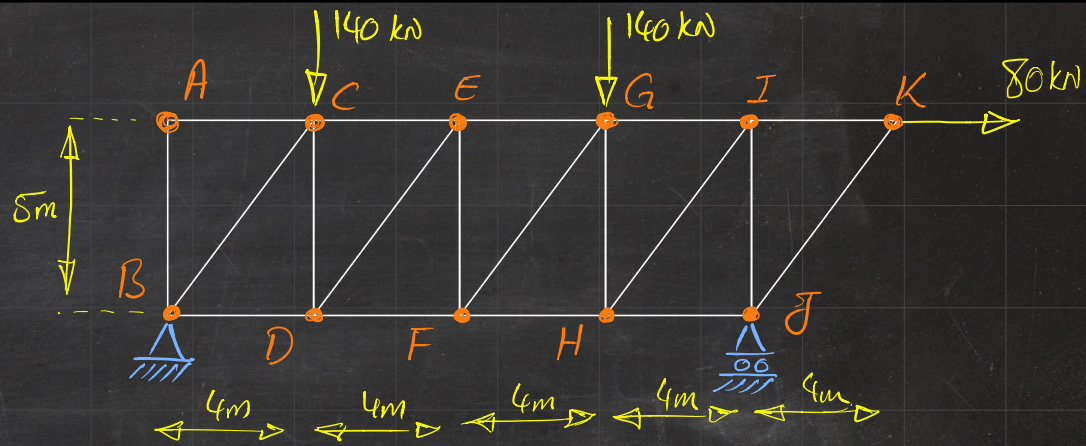
$$\Rightarrow F_{EG} = -72 \text{ kN}$$

$$\star \sum M_D = 0 \Rightarrow F_{EF} = -25 \text{ kN}$$

2 EQUATIONS, 2 UNKNOWN



$$F_{GI} = ?$$



$$F_{GI} = ?$$

↳

Cut the structure

such that F_{GI} and

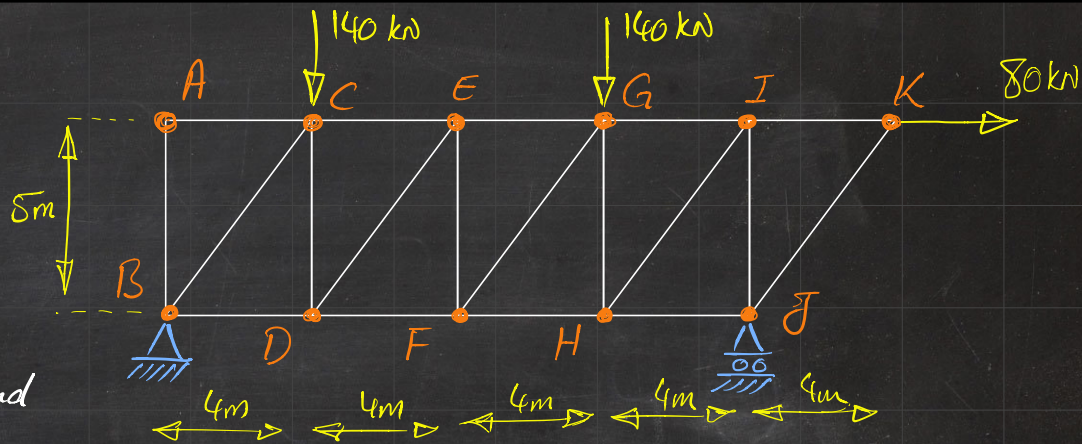
only two other unknowns remain!

↳

3 unknowns ↗

3 equations

$$\left\{ \begin{array}{l} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum M = 0 \end{array} \right.$$



$$F_{GI} = ?$$

↳

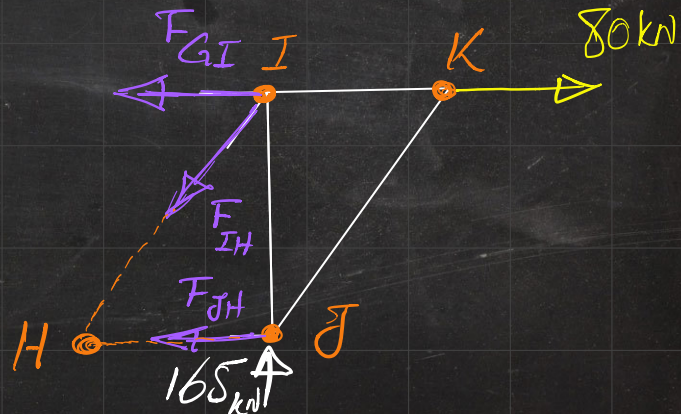
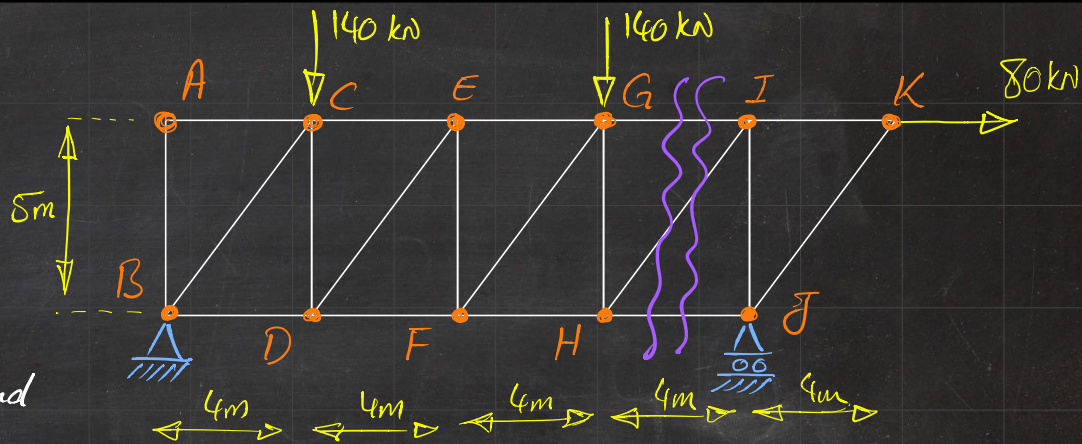
Cut the structure

such that F_{GI} and

only two other unknowns remain!

↳

$$\begin{array}{l}
 3 \text{ unknowns} \rightarrow \\
 3 \text{ equations}
 \end{array}
 \left\{ \begin{array}{l}
 \sum F_x = 0 \\
 \sum F_y = 0 \\
 \sum M = 0
 \end{array} \right.$$



$$F_{GI} = ?$$

↳

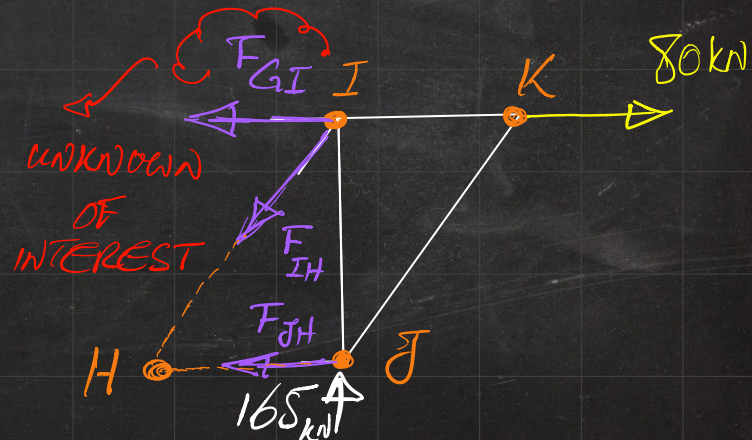
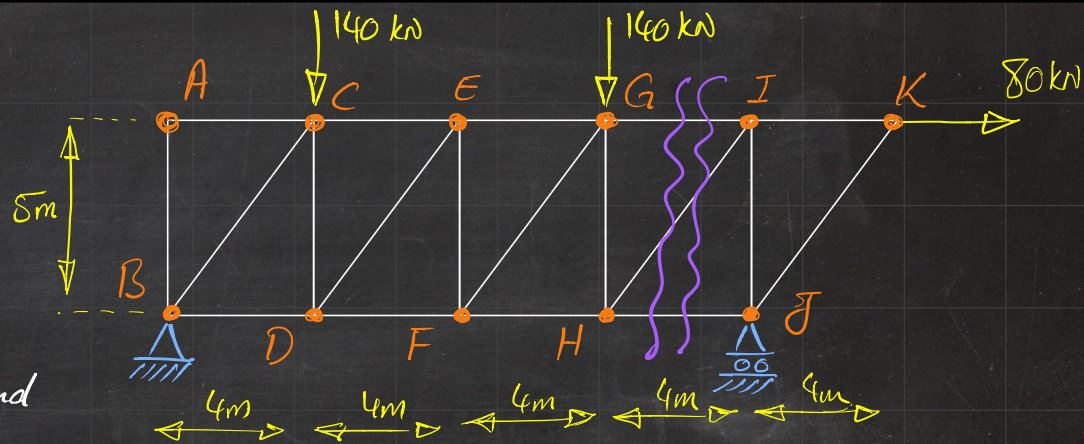
Cut the structure

such that F_{GI} and

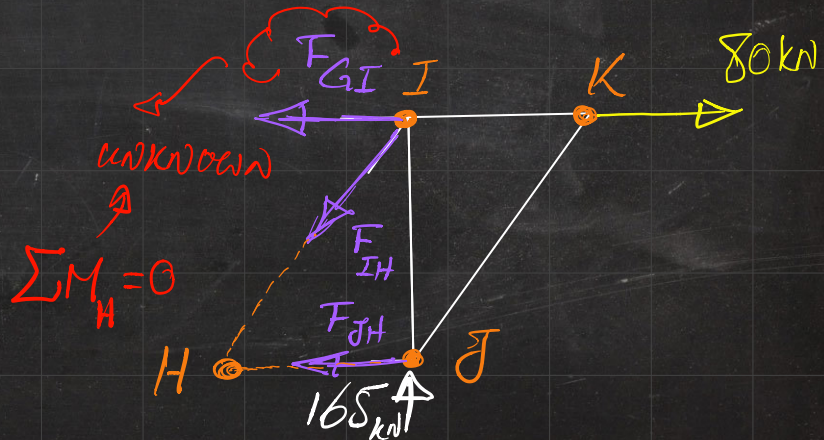
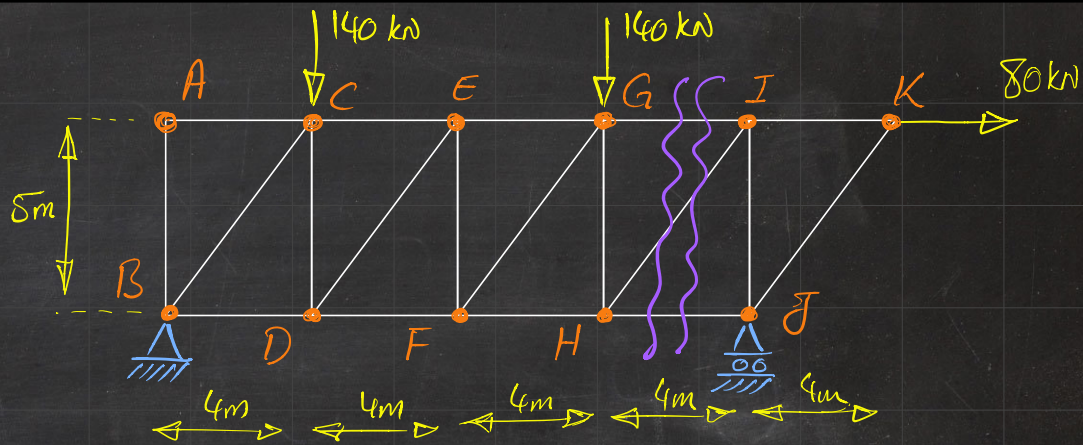
only two other unknowns remain!

↳

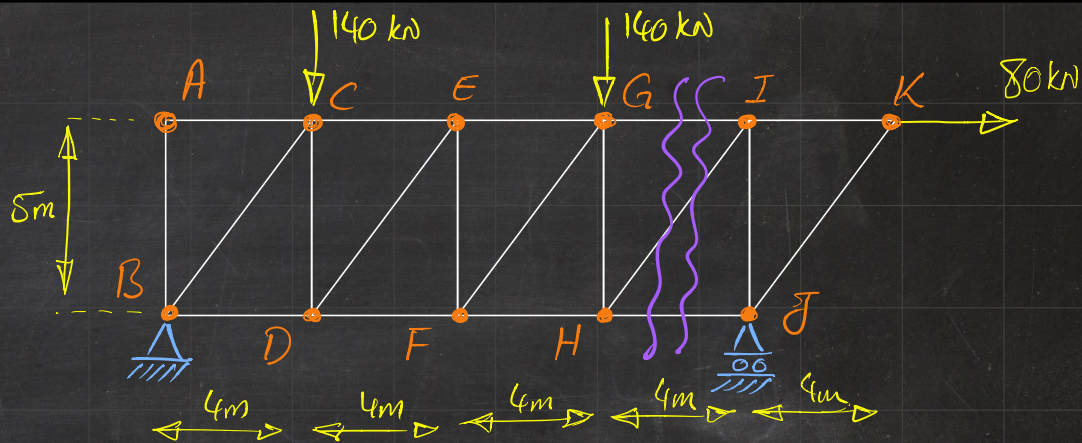
$$\begin{array}{l}
 3 \text{ unknowns} \\
 3 \text{ equations}
 \end{array}
 \rightarrow
 \left\{ \begin{array}{l}
 \sum F_x = 0 \\
 \sum F_y = 0 \\
 \sum M = 0
 \end{array} \right.$$



$$F_{GI} = ?$$

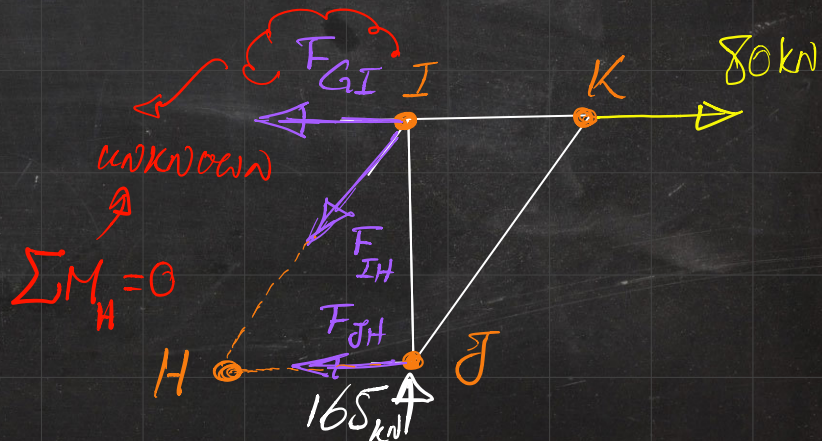


$$F_{GI} = ?$$



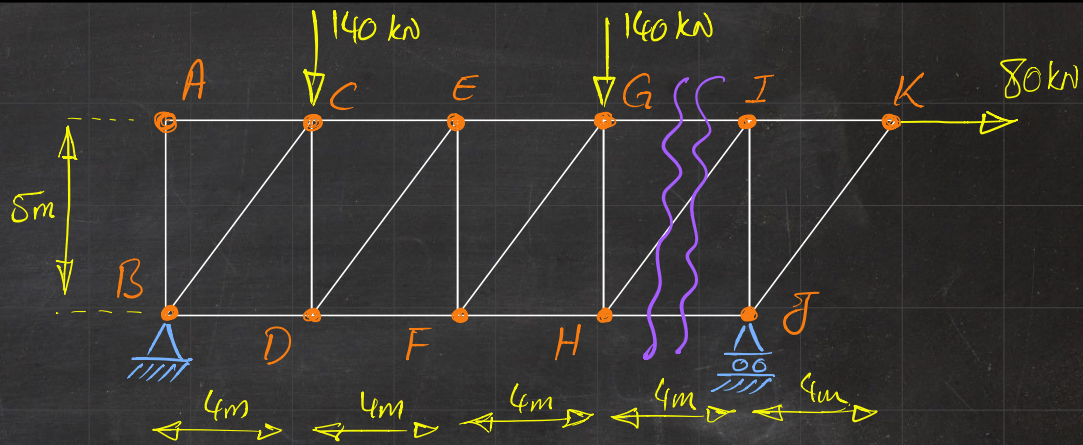
$$\oplus \sum M_H = 0$$

$$4 \times 165 - 5 \times 80 + 5 \times F_{GI} = 0$$



$$\sum M_H = 0$$

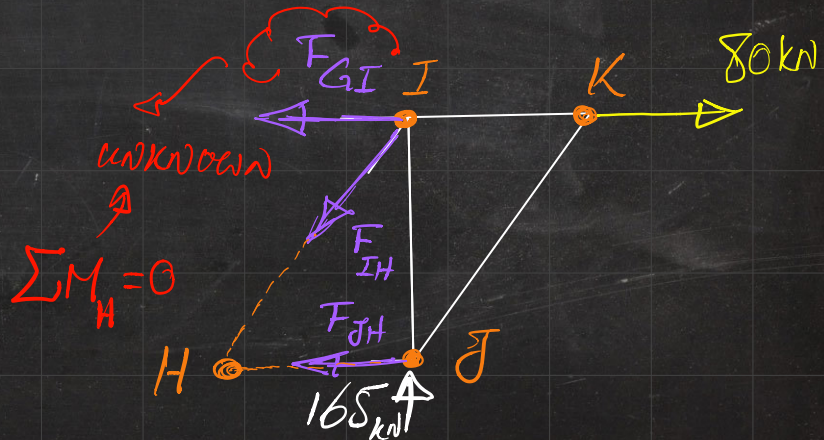
$$F_{GI} = ?$$



$$\oplus \sum M_H = 0$$

$$4 \times 165 - 5 \times 80 + 5 \times F_{GI} = 0$$

$$\Rightarrow F_{GI} = -52 \text{ kN}$$



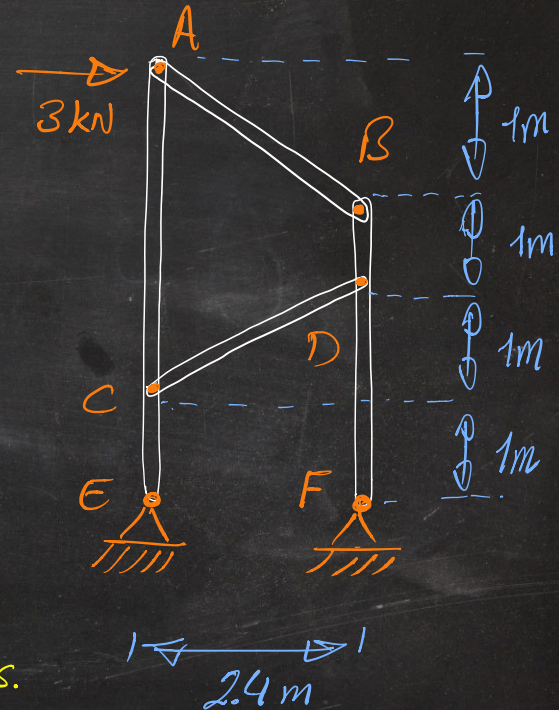
$$\sum M_H = 0$$

Exercise 2 . [similar to ... P. 322 ... 6.6]

DETERMINE THE FORCES ACTING ON
THE TWO VERTICAL MEMBERS OF THE
FRAME.

THE CONNECTIONS AT A, B, C, D, E, F
ARE PINS.

↳ Apply forces only but no moments.



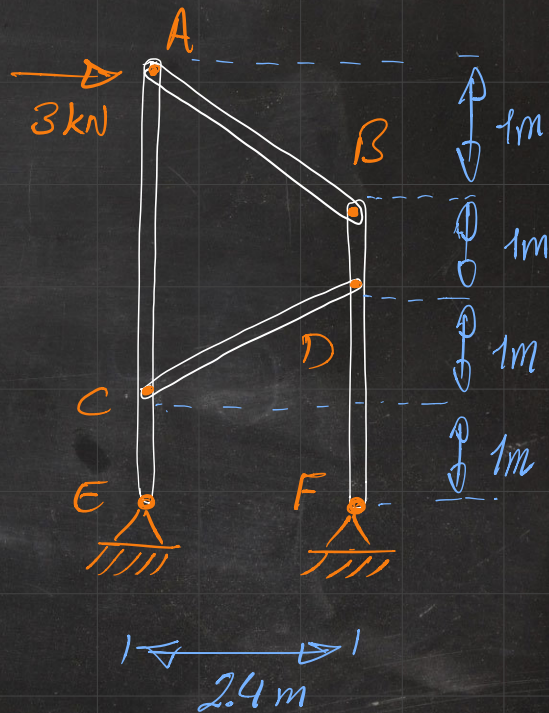
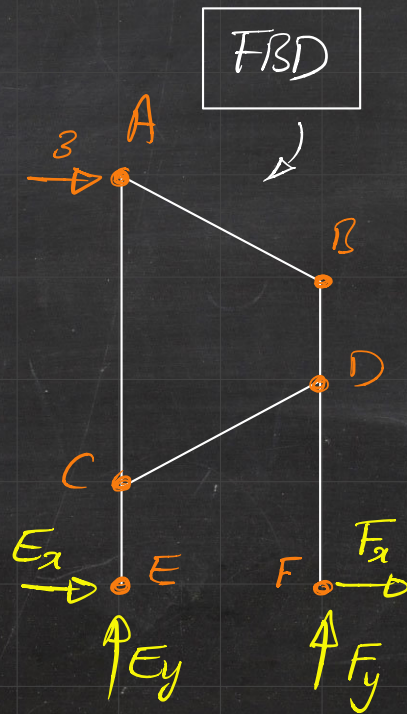
⇒ 4 Unknowns!



The supports reactions
cannot be determined
from FBD of the entire
system!

↳ 3 Equations

⇒ Write 3 Eqns. ⊕ Split



$$\sum F_x = 0$$

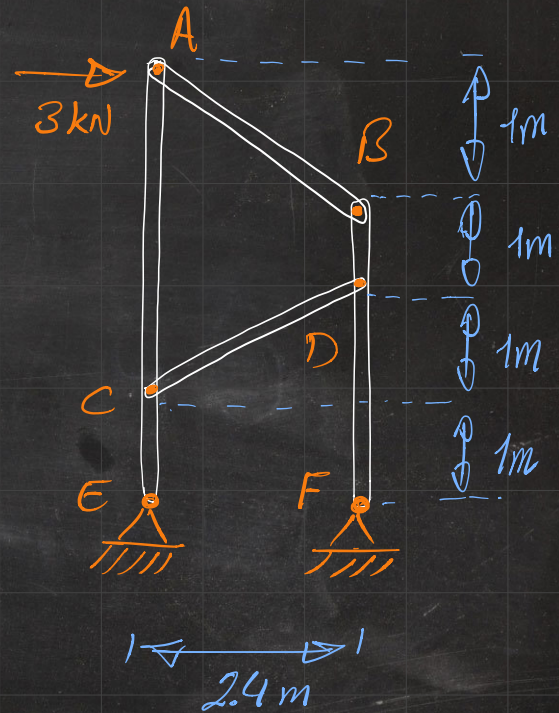
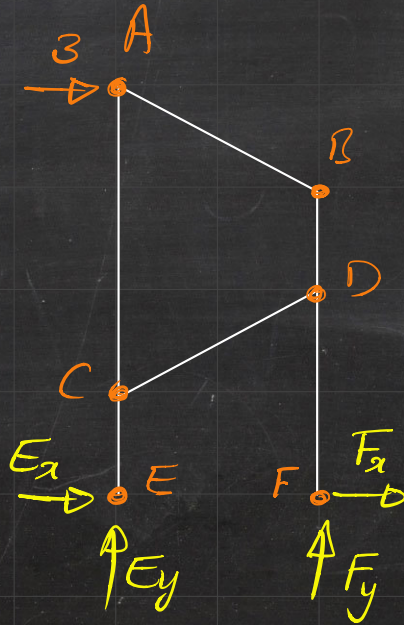
$$E_x + F_x + 3 = 0$$

$$\sum F_y = 0$$

$$E_y + F_y = 0$$

$$\sum M_E = 0$$

$$-4 \times 3 + 2.4 F_y = 0$$



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

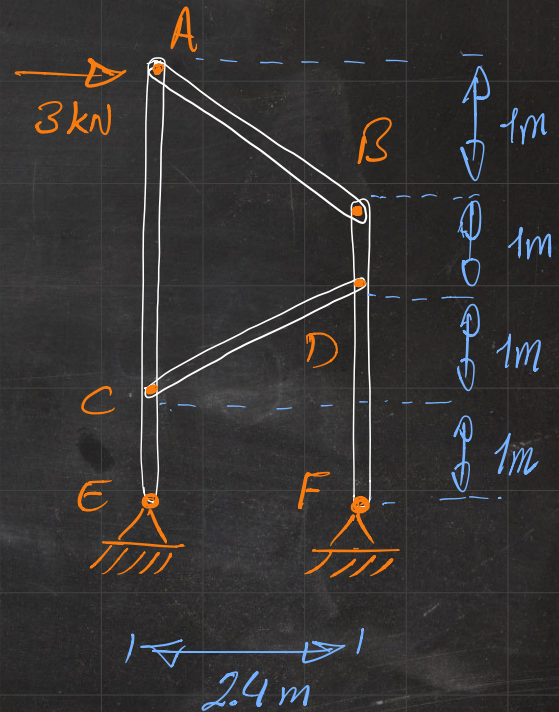
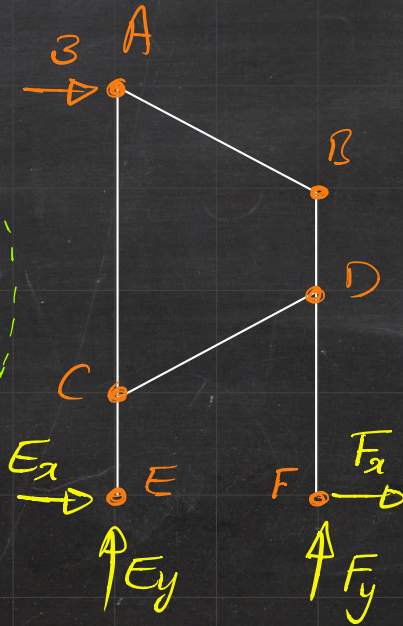
$$\sum F_y = 0$$

$$E_y + F_y = 0$$

$$\sum M_E = 0$$

$$-4 \times 3 + 2.4 F_y = 0$$

$$\left\{ \begin{array}{l} F_y = 5 \text{ kN} \\ E_y = -5 \text{ kN} \end{array} \right\}$$



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

2 Unknowns
1 Equation

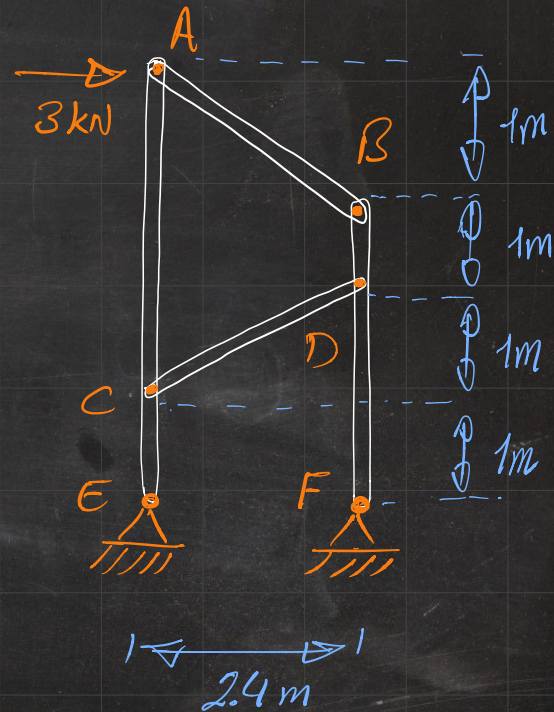
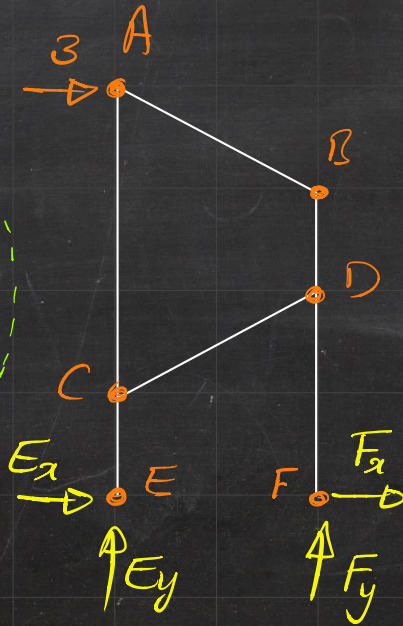
$$\sum F_y = 0$$

$$E_y + F_y = 0$$

$$\sum M_E = 0$$

$$-4 \times 3 + 2.4 F_y = 0$$

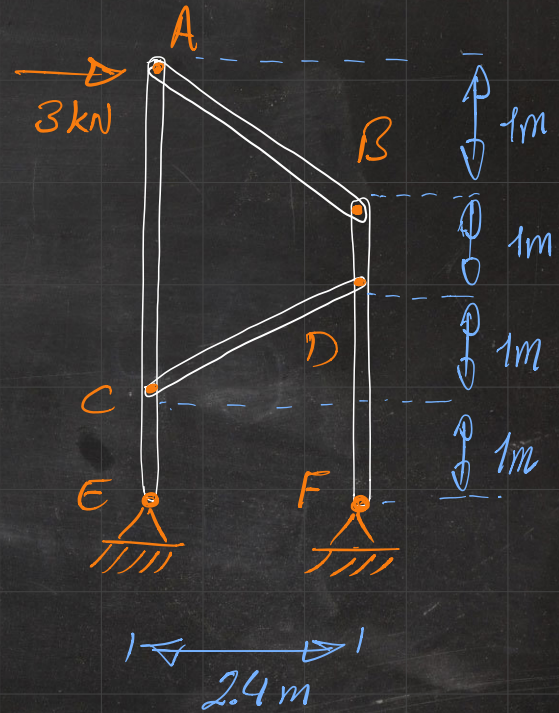
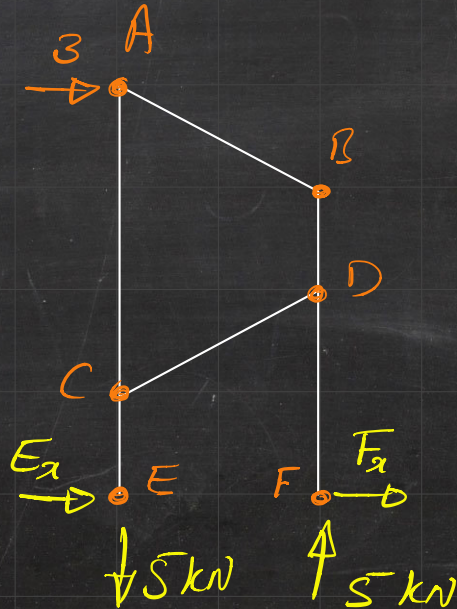
$$\left\{ \begin{array}{l} F_y = 5 \text{ kN} \\ E_y = -5 \text{ kN} \end{array} \right.$$



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

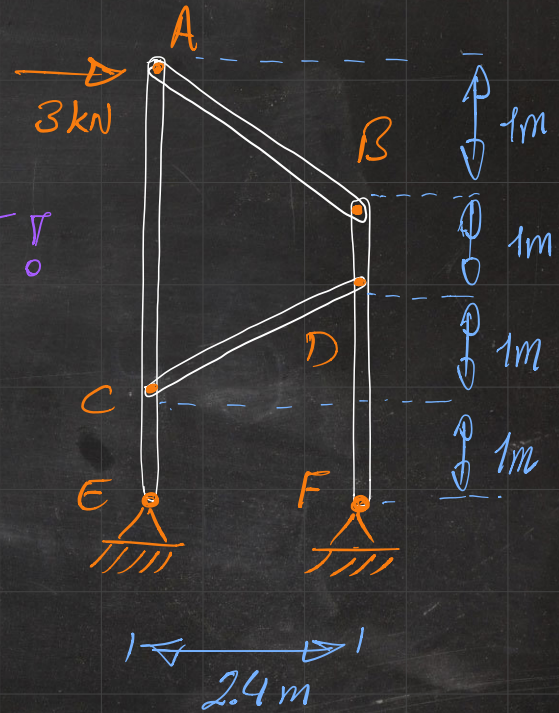
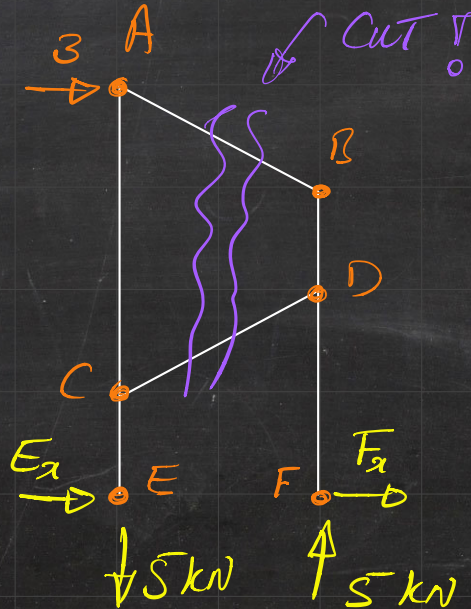
2 Unknowns
1 Equation



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

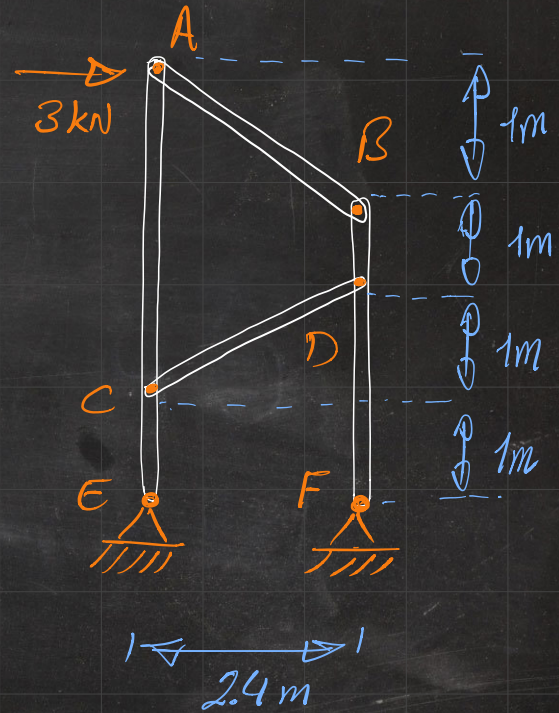
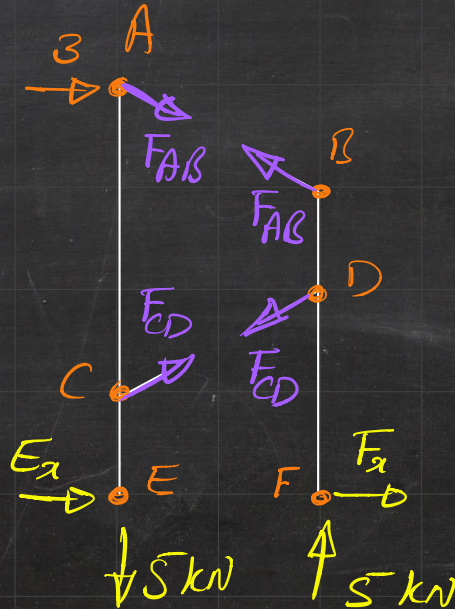
2 Unknowns
1 Equation



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

2 Unknowns
1 Equation



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

2 Unknowns
1 Equation

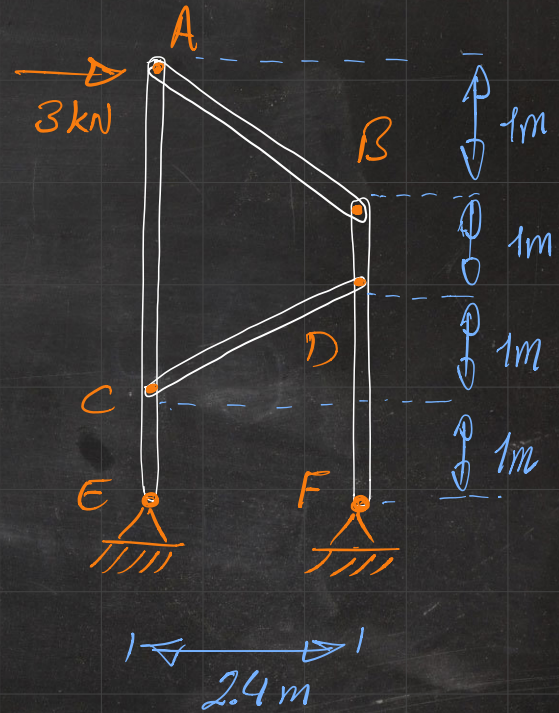
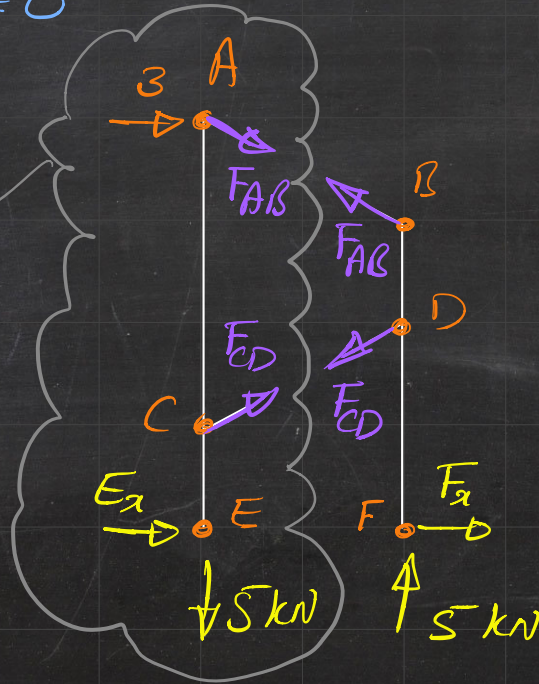
3 Unknowns

F_{AB}
 F_{CD}

E_x

3 Equations

$$\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \\ \sum M = 0 \end{cases}$$

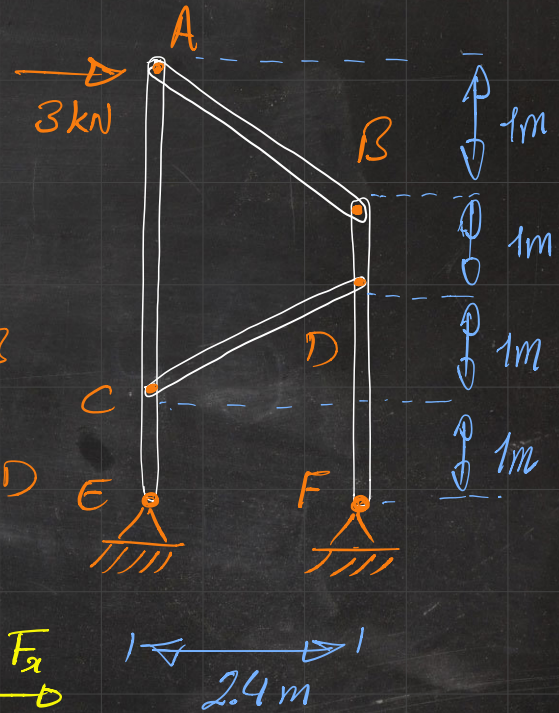
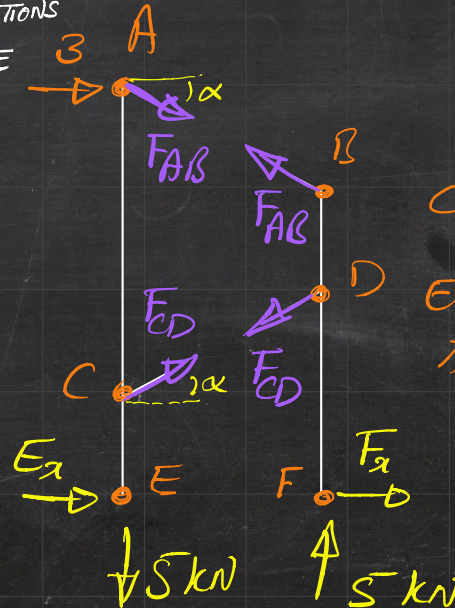


$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

2 Unknowns
1 Equation

BALANCE
EQUATIONS
ON
ACE



$$\sum F_x = 0$$

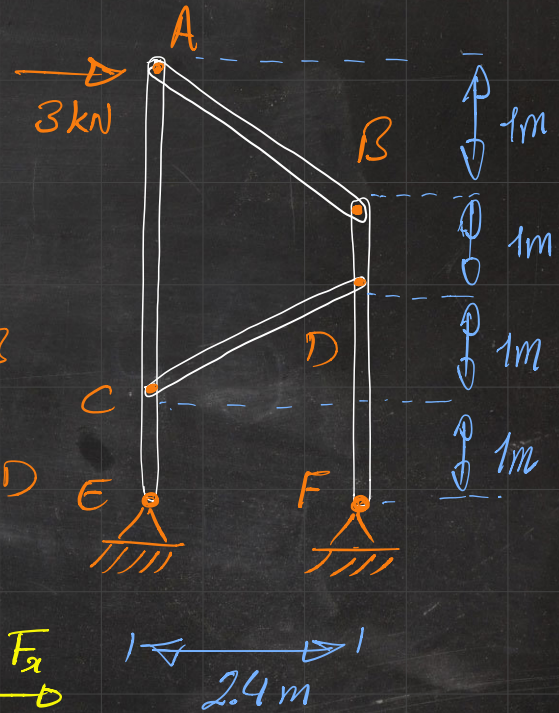
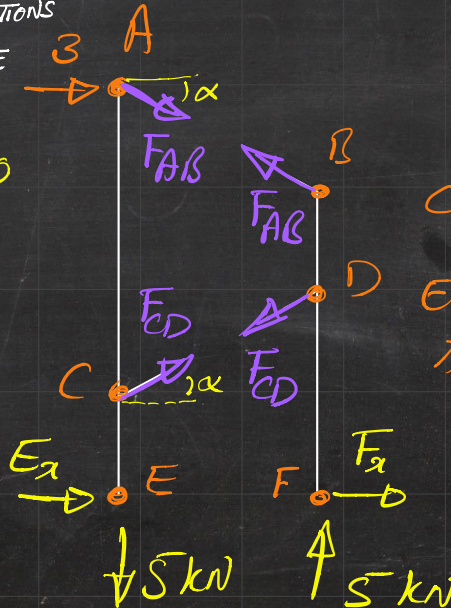
$$E_x + F_x + 3 = 0$$

$$\sum F_x = 0$$

$$F_{AB} \cos \alpha + F_{CD} \cos \alpha + 3 + E_x = 0$$

2 Unknowns
1 Equation

BALANCE
EQUATIONS
ON
ACE



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

$$\sum F_x = 0$$

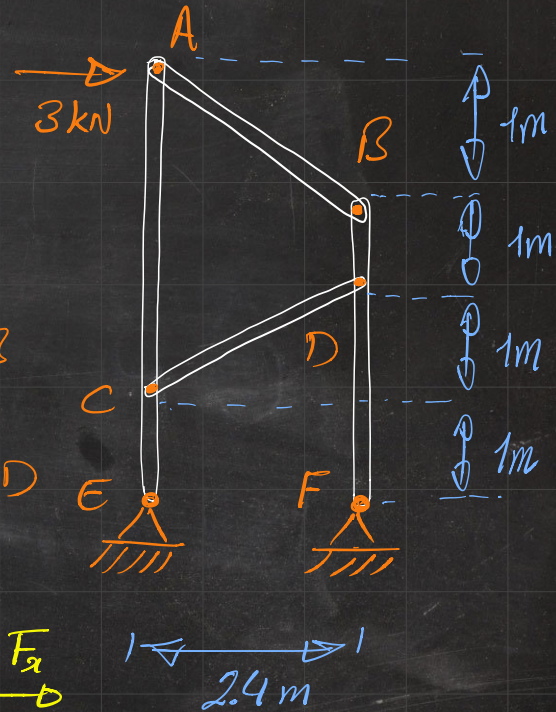
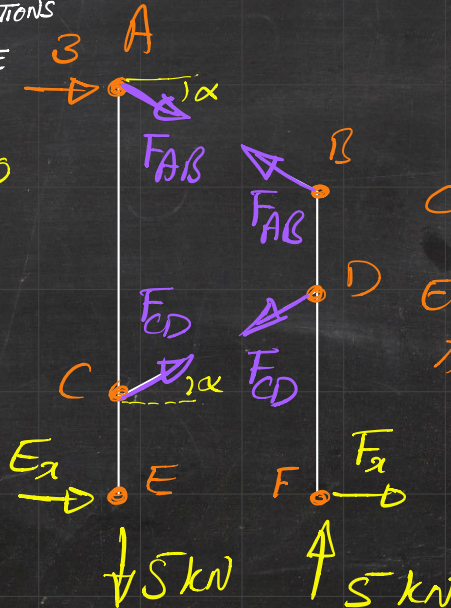
$$F_{AB} \cos \alpha + F_{CD} \cos \alpha + 3 + E_x = 0$$

$$\sum F_y = 0$$

$$F_{CD} \sin \alpha - F_{AB} \sin \alpha - 5 = 0$$

2 Unknowns
1 Equation

BALANCE
EQUATIONS
ON
ACE



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

$$\sum F_x = 0$$

$$F_{AB} \cos \alpha + F_{CD} \cos \alpha + 3 + E_x = 0$$

$$\sum F_y = 0$$

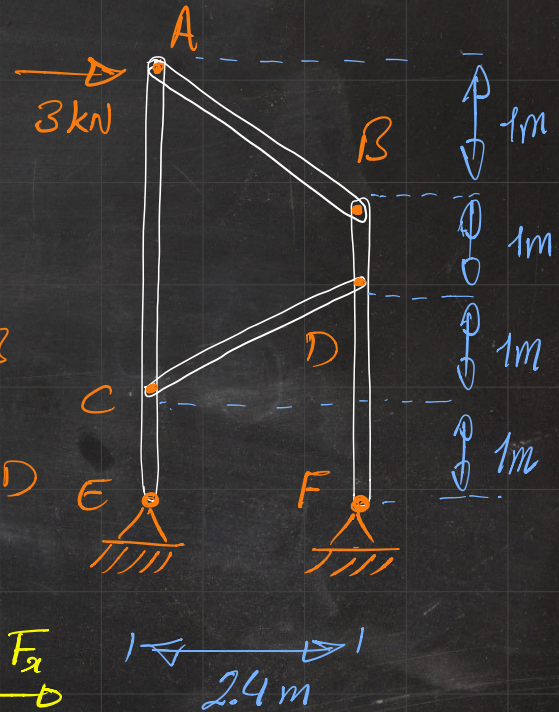
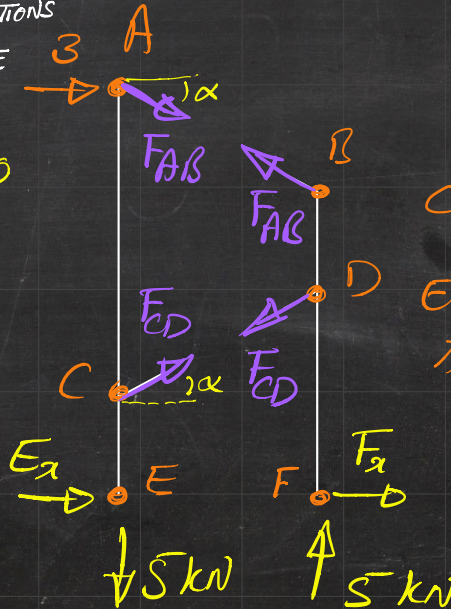
$$F_{CD} \sin \alpha - F_{AB} \sin \alpha - 5 = 0$$

$$\sum M_A = 0$$

$$F_{CD} \cos \alpha \times 3 + E_x \times 4 = 0$$

2 Unknowns
1 Equation

BALANCE
EQUATIONS
ON
ACE



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

$$\sum F_x = 0$$

$$F_{AB} \cos \alpha + F_{CD} \cos \alpha + 3 + E_x = 0$$

$$\sum F_y = 0$$

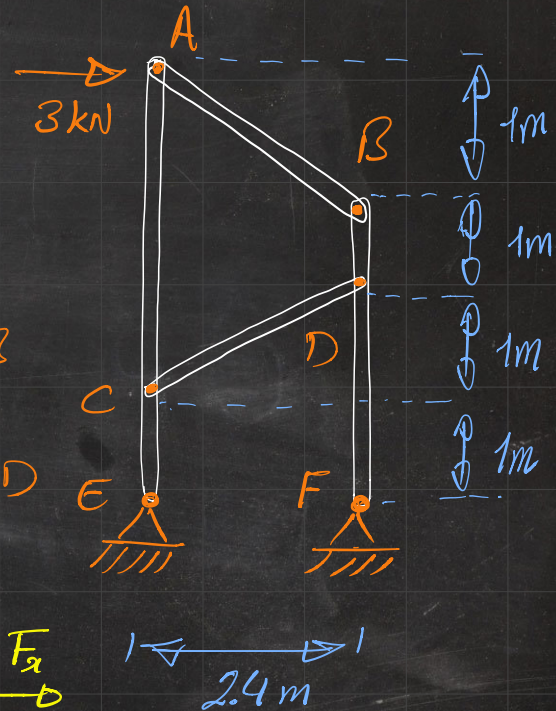
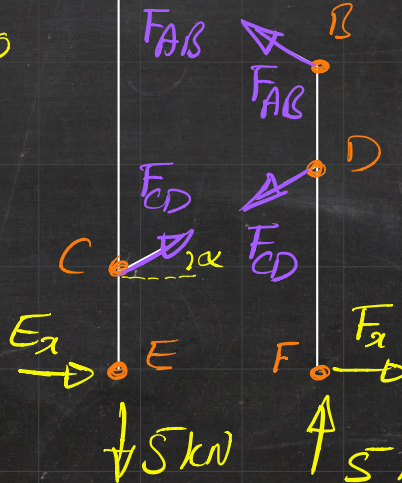
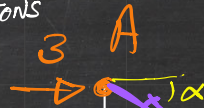
$$F_{CD} \sin \alpha - F_{AB} \sin \alpha - 5 = 0$$

$$\sum M_A = 0$$

$$F_{CD} \cos \alpha \times 3 + E_x \times 4 = 0$$

2 Unknowns
1 Equation

BALANCE
EQUATIONS
ON
ACE



$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

$$\sum F_x = 0$$

$$F_{AB} \cos \alpha + F_{CD} \cos \alpha + 3 + E_x = 0$$

$$\sum F_y = 0$$

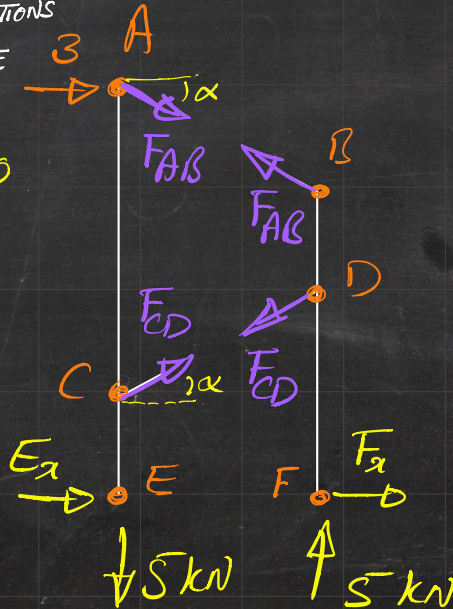
$$F_{CD} \sin \alpha - F_{AB} \sin \alpha - 5 = 0$$

$$\sum M_A = 0$$

$$F_{CD} \cos \alpha \times 3 + E_x \times 4 = 0$$

2 Unknowns
1 Equation

BALANCE
EQUATIONS
ON
ACE



$$E_x = -5.4 \text{ kN}$$

$$F_{CD} = 7.8 \text{ kN}$$

$$F_{AB} = -5.2 \text{ kN}$$

$$\sum F_x = 0$$

$$E_x + F_x + 3 = 0$$

BALANCE EQUATIONS ON ACE

2 Unknowns
1 Equation

$$F_x = 2.4 \text{ kN}$$

$$E_x = -5.4 \text{ kN}$$

$$\sum F_x = 0$$

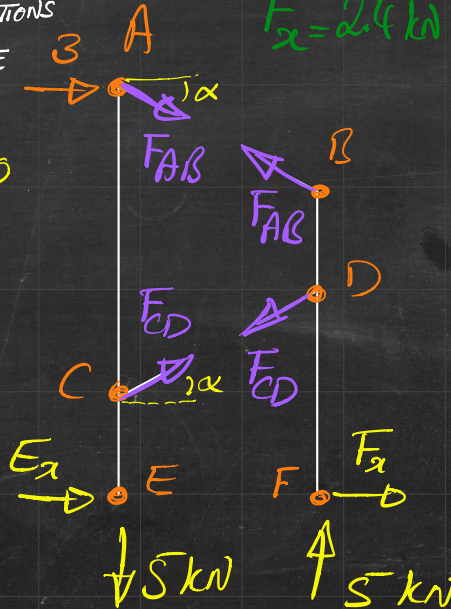
$$F_{AB} \cos \alpha + F_{CD} \cos \alpha + 3 + E_x = 0$$

$$\sum F_y = 0$$

$$F_{CD} \sin \alpha - F_{AB} \sin \alpha - 5 = 0$$

$$\sum M_A = 0$$

$$F_{CD} \cos \alpha \times 3 + E_x \times 4 = 0$$



$$F_{CD} = 7.8 \text{ kN}$$

$$F_{AB} = -5.2 \text{ kN}$$

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