Architecture 314
Structures I

Pinned Frames

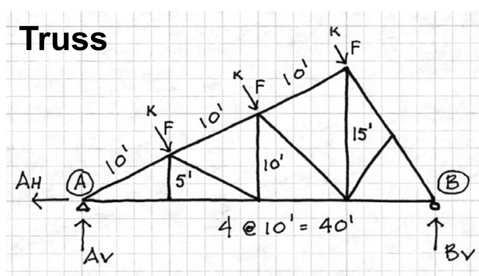
2-Force Members
Multiforce Members
Stability
Timber Frames

Das Spitzhäuschen. Marktplatz. Bernkastel-Kues

Pinned Frame vs. Truss

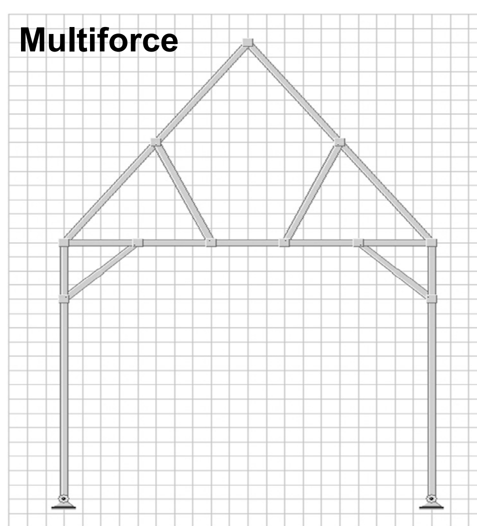
Trusses:

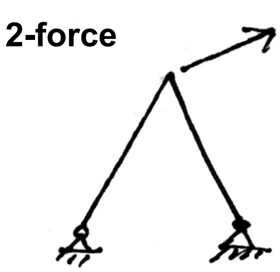
- 2-force members
- ridged bodies



Pinned Frames:

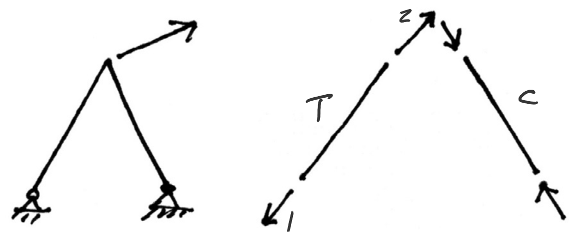
- 2-force or multiforce (axial or bending)
- ridged body or mechanism



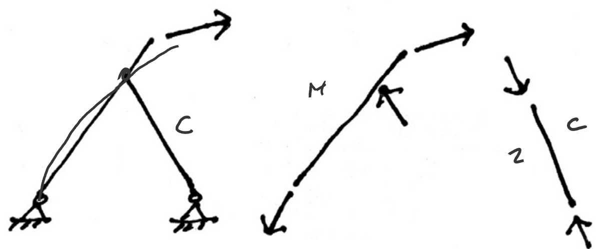


Frame Types

Frames with 2-force members (axial forces)



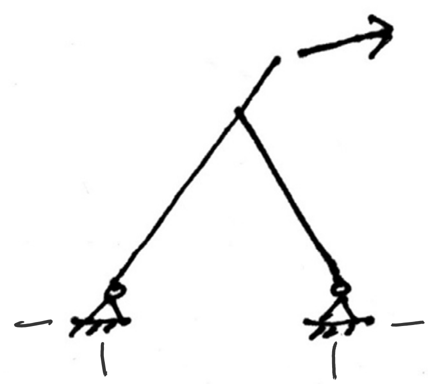
Frames with multiforce members (bending + axial forces)



Rigidity

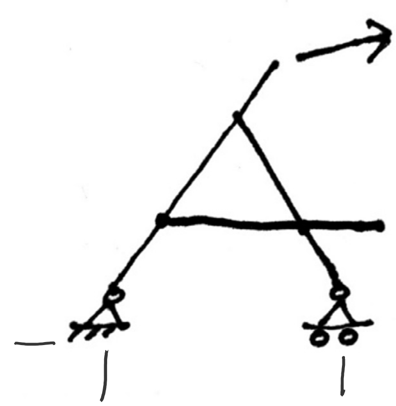
Nonrigid frames (require 4 or more reaction components for stability)

Without supports they collapse.



Rigid frames (only require 3 reaction components)

Remain a rigid body even without supports.



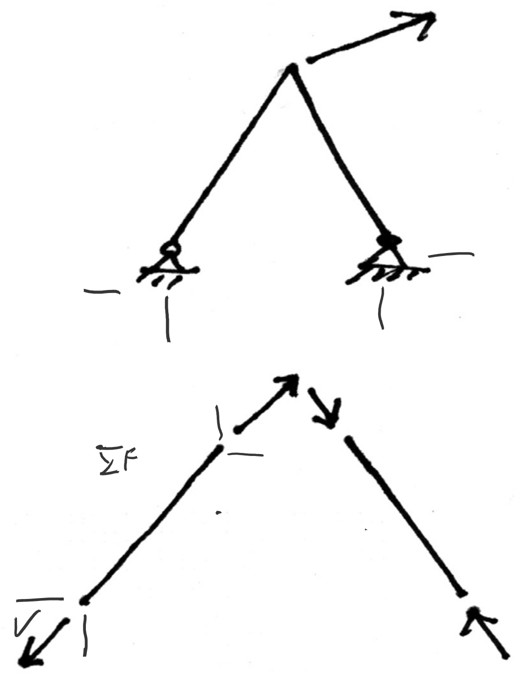
2-Force Member Frames

Procedure

1. Solve external supports
   - FBDs
   - Simultaneous equations

2. Cut FBD of each member

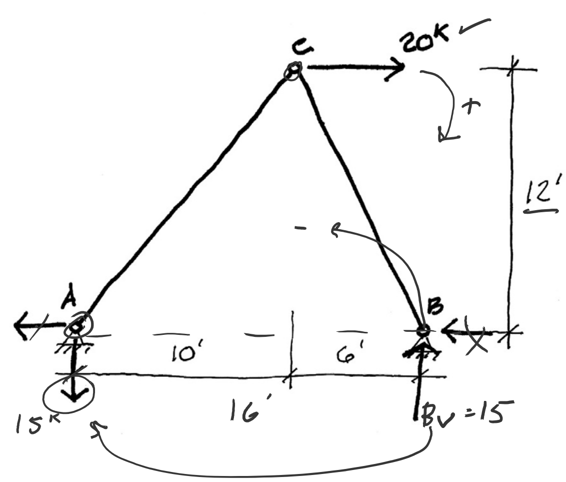
3. Solve member forces



2-Force Member Frames

Analysis

1. Solve external supports
   - FBDs
   - Simultaneous equations

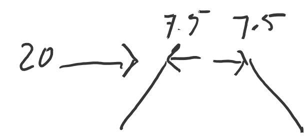


$$\Sigma M_{@A} = 0 = {}^{+}20^{k}(12') - B_v(16)$$
$$B_v = 15^{k}$$

$$\Sigma F_v = 0 = -A_v + B_v$$
$$A_v = 15$$

2-Force Member Frames

Analysis



2. Cut FBD of each member

For 2-force members the force components follow the slope.

BY SLOPE

$\frac{6}{5} : \frac{15}{12.5}$

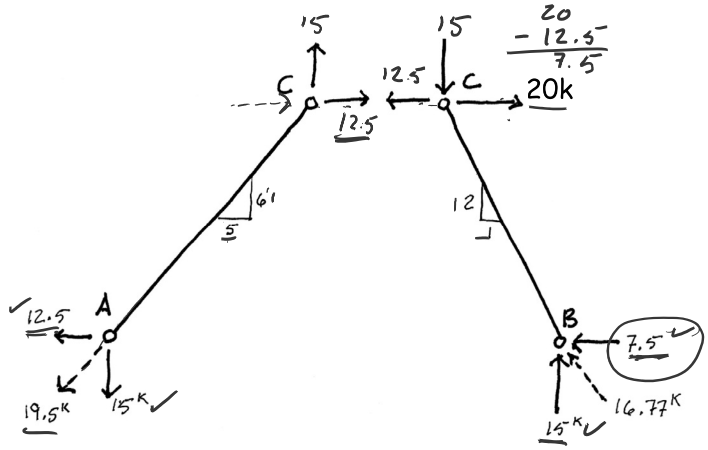
BY SLOPE

$\frac{2}{1} : \frac{15}{7.5}$

REACTION COMPONENTS

$B_V = 15^K \uparrow$

$B_H = 7.5 \leftarrow$



2-Force Member Frames

Analysis

3. Check member forces and balance forces.

LEFT FBD

$\Sigma F_V = 0 = -15 + C_V$

$C_V = 15^K$

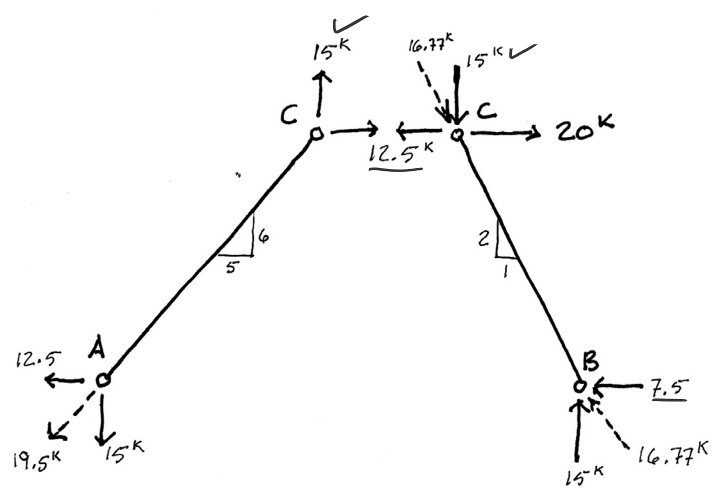
RIGHT FBD

$\Sigma F_V = 0 = 15^K - C_V$

$C_V = 15^K$

$\Sigma F_H = 0 = 20^K - 7.5 - C_H$

$C_H = 12.5^K$



2-Force Member Frames

Find the force in the shear legs assuming a point load of 20 **lbs**.
Members **2:1 slope** (63.4° at base)

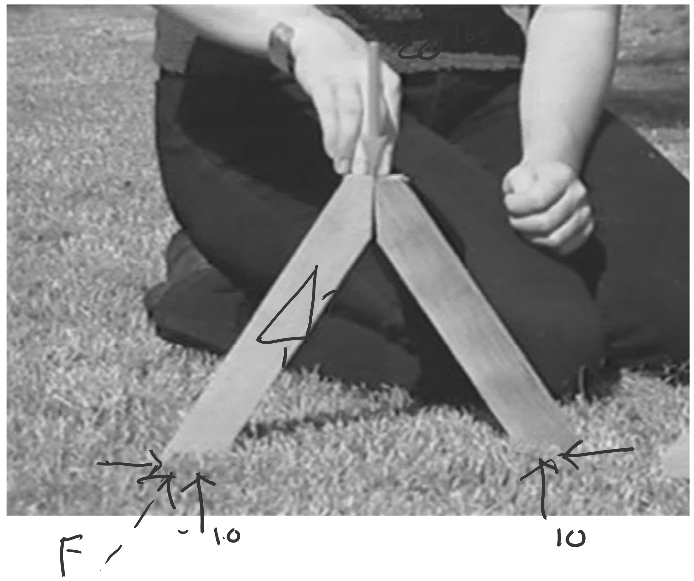
Determine the horizontal and vertical end reactions.

Reactions:
Horizontal __________
Vertical __________

Axial member force:
____

tension or compression?

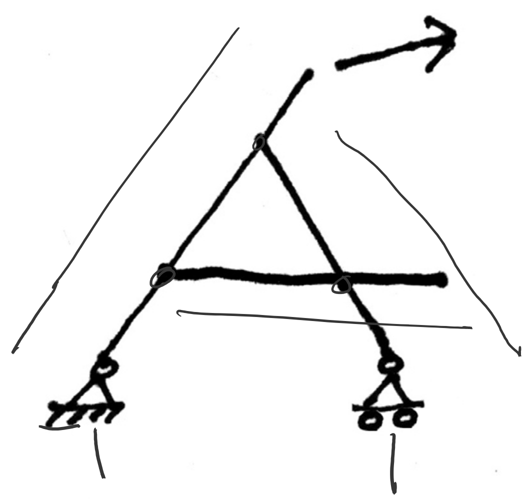
____



Multiforce Member Frames

Procedure

1. Solve external supports
2. Cut FBD of each member
3. Solve forces at joints.
4. Some members will be multiforce, they will be in bending.



Analysis

1. Solve external supports

Get vertical components by summing moments.

$$\Sigma M_{@A} = 0$$

$$+20^K(12') + 15^K(20') - B_v(20') = 0$$

$$B_v = 27^K \uparrow$$

$$\Sigma F_v = 0$$

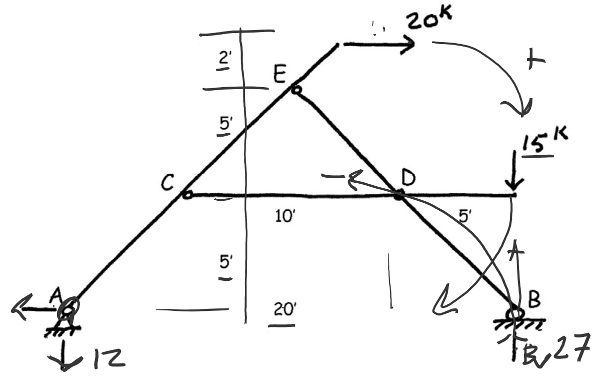
$$-A_v - 15^K + 27^K = 0$$

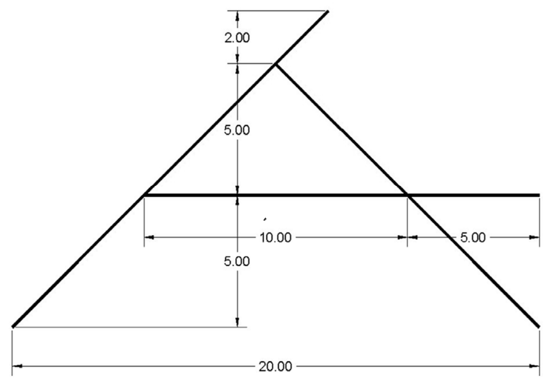
$$A_v = 12^K \downarrow$$

$$\Sigma F_H = 0$$

$$-A_H + 20^K = 0$$

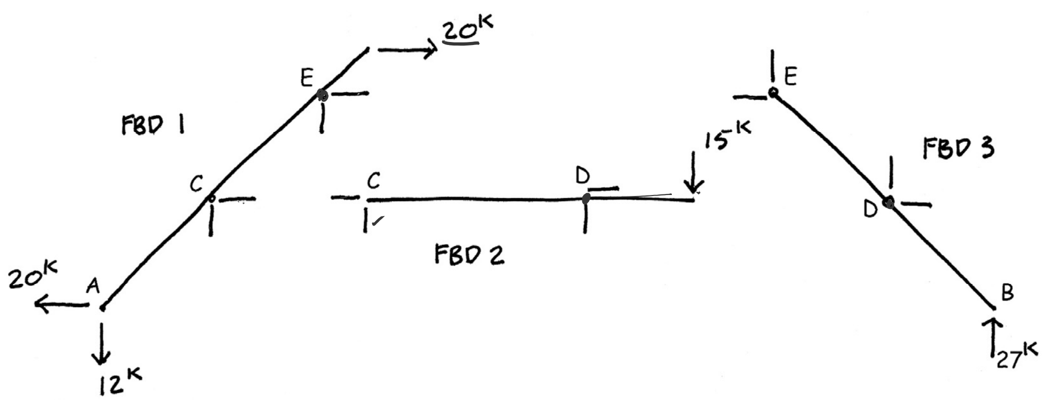
$$A_H = 20^K \leftarrow$$





Analysis

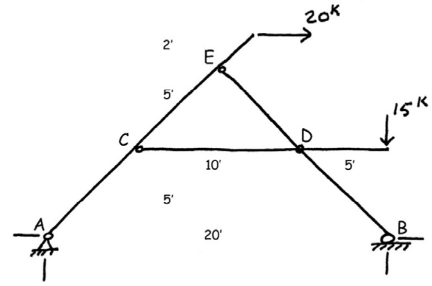
2. Cut FBD of each member

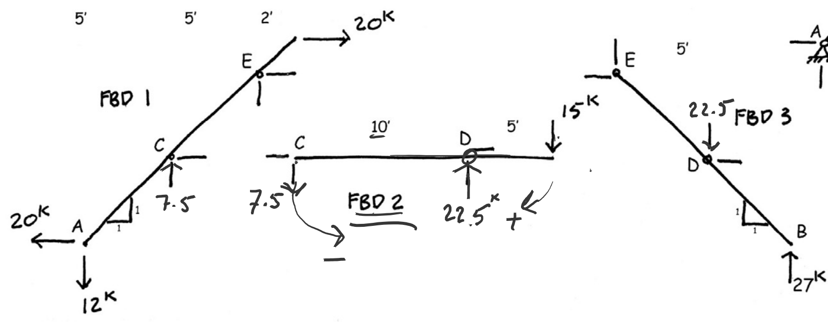


- Work between the FBDs using 3 equations of statics.
- End force components can be solved as axial and normal forces.
- The normal forces are "shear" forces and result in moments or "bending" forces.
- Not all systems are statically determinate and may then require other methods.

Analysis

3. Solve member forces





FBD 2

$$\Sigma M_{@D} = 0 = -C_V(10') + 15^k(5')$$

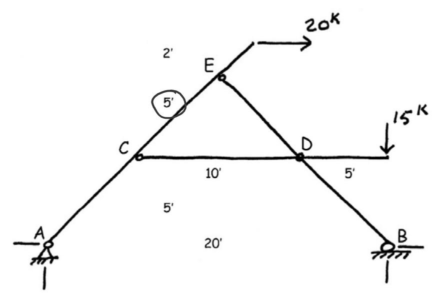
$$C_V = 7.5^k$$

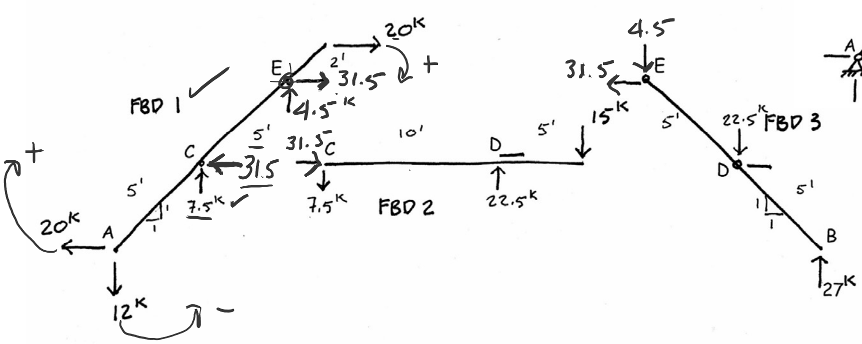
$$\Sigma F_V = 0 = -7.5^k + D_V - 15^k$$

$$D_V = 22.5^k$$

Analysis

3. Solve member forces





FBD 1

$$\Sigma M_{@E} = 20^k(10') - 12^k(10') + 7.5^k(5') - C_H(5') + 20^k(2') = 0$$

$$200 - 120 + 37.5 - C_H(5) + 40 = 0$$

$$C_H = 31.5^k$$

$$\Sigma F_V = 0 = -12^k + 7.5^k + E_V$$

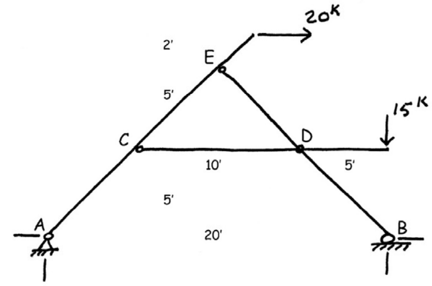
$$E_V = 4.5^k$$

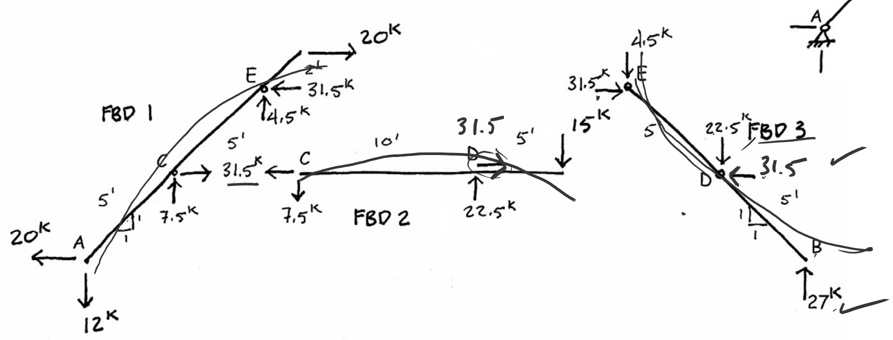
$$\Sigma F_H = 0 = -20^k + 31.5^k - E_H + 20^k$$

$$E_H = 31.5^k$$

Analysis

3. Solve member forces





FBD 2

$\Sigma F_H = 0 = -31.5^K + D_H$

$D_H = 31.5^K$

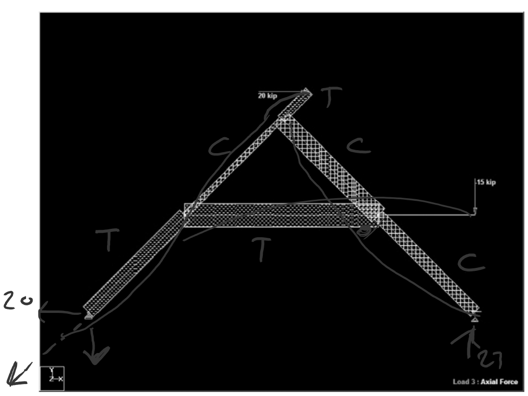
FBD 3 - CHECK

$\Sigma F_H = 31.5^K - 31.5^K = 0$ ✓

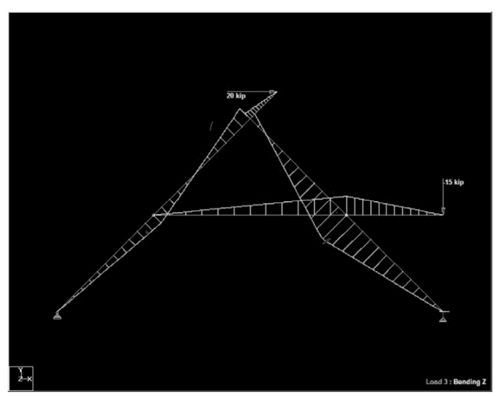
$\Sigma F_V = -4.5^K - 22.5^K + 27^K = 0$ ✓

Analysis

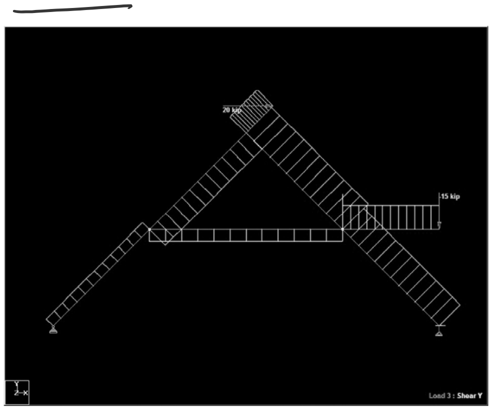
4. Determine multiforce members



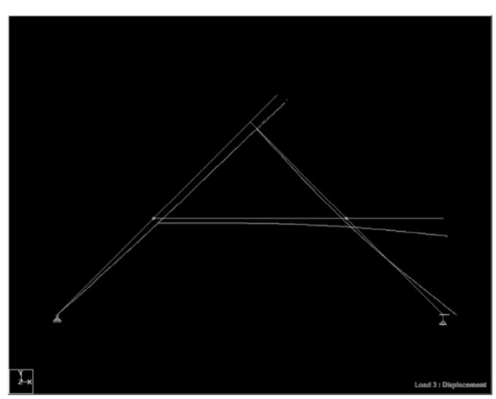
Axial Force



Bending Moment



Shear Force



Deflection

Riverbend Timber Framing

https://www.riverbendtf.com/

Marty Birkenkamp

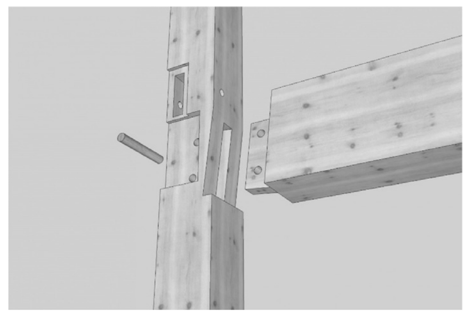
Riverbend
TIMBER FRAMING

Pariseau Barn

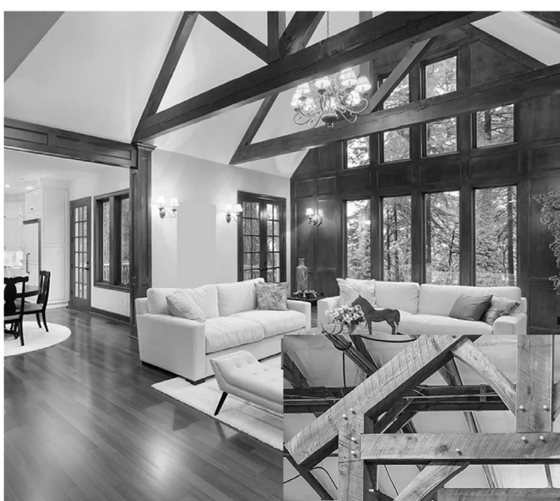
Example

Pariseau Barn Example

Motise and Tenon Joint



Highland Timber Framing - https://www.highlandtimberframing.com/



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