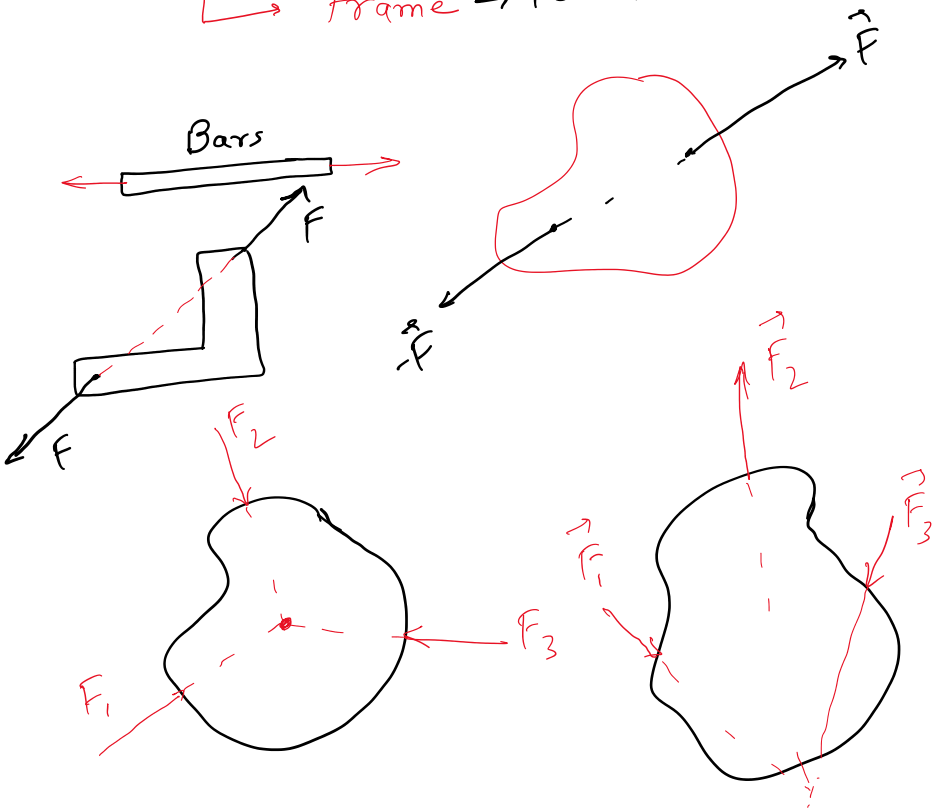
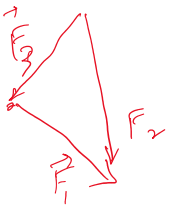
Structures

Wednesday, January 22, 2025 9:04 AM

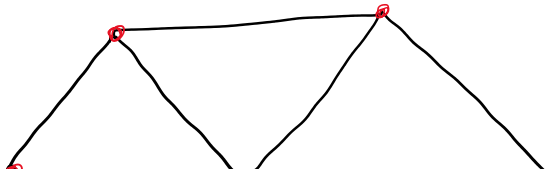
- Truss → Two force members
- Frame → Three force member

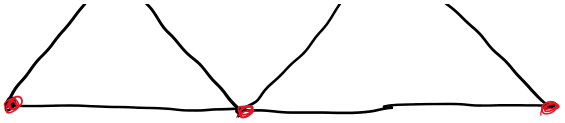




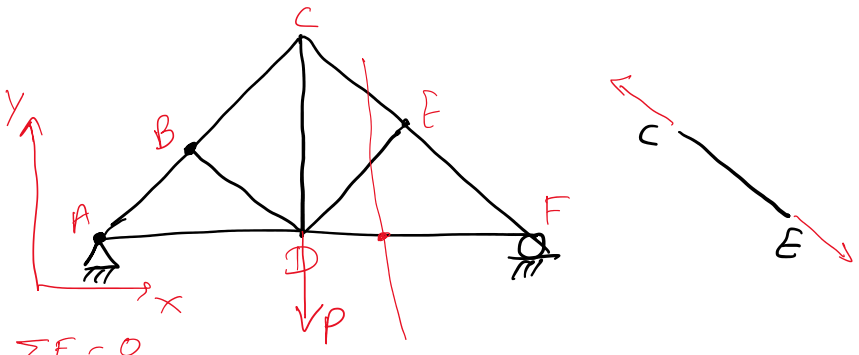
Truss

- Plane Truss
- Connected by frictionless Pins
- Each member have no more than two joints
- Forces are applied only at joints
- Weight of individual members are negligible.



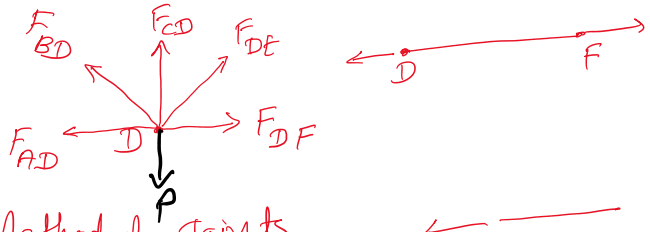


Analysis of Truss Structure



$\Sigma F_x = 0$

$\Sigma F_y = 0$

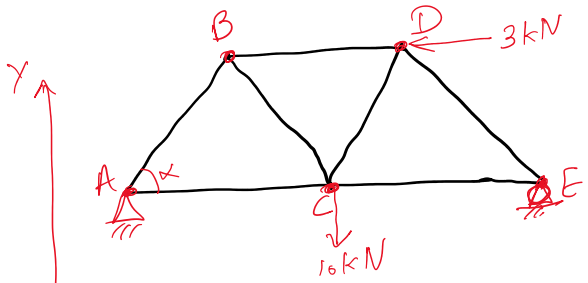


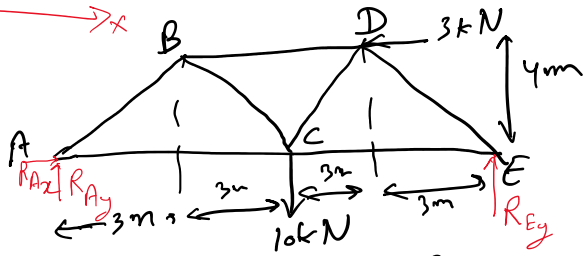
Method of Joints

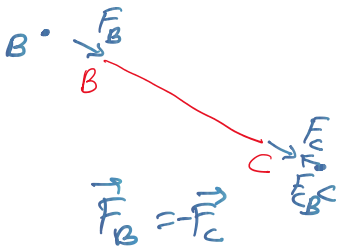
F

Method of section

Method of Joints



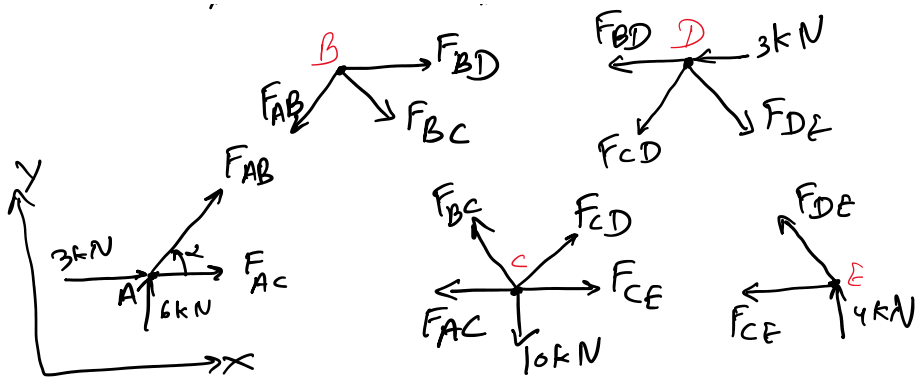




$\Sigma M_A = 0 \Rightarrow R_{Ey} = 4kN$

$\Sigma F_y = 0 \Rightarrow R_{Ay} = 6kN$

$\Sigma F_x = 0 \Rightarrow R_{Ax} = 3kN$



Joint A:

$\Sigma F_x = 0$

$3kN + F_{AB}\cos\alpha + F_{AC} = 0$

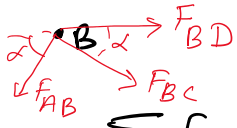
$F_{AC} = ?$

$\Sigma F_y = 0$

$F_{AB}\sin\alpha + 6kN = 0$

$\Rightarrow F_{AB} = ?$

Joint B:



$\Sigma F_x = 0$

$F_{BD} + F_{BC}\cos\alpha - F_{AB}\cos\alpha = 0$

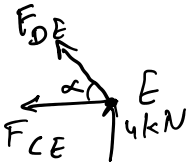
$F_{BD} = ?$

$\Sigma F_y = 0$

$F_{AB}\sin\alpha + F_{BC}\sin\alpha = 0$

$F_{BC} = -F_{AB}$

Joint E



$\Sigma F_x = 0$

$-F_{DE}\sin\alpha - F_{CE} = 0$

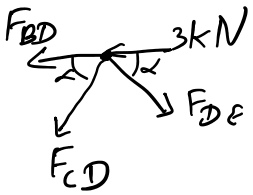
$F_{CE} = ?$

$\Sigma F_y = 0$

$F_{DE}\sin\alpha + 4kN = 0$

$F_{DE} = ?$

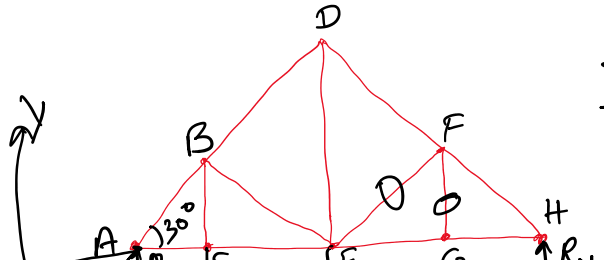
Joint D:



$\Sigma F_y = 0$

$F_{CD}\sin\alpha + F_{DE}\sin\alpha = 0$

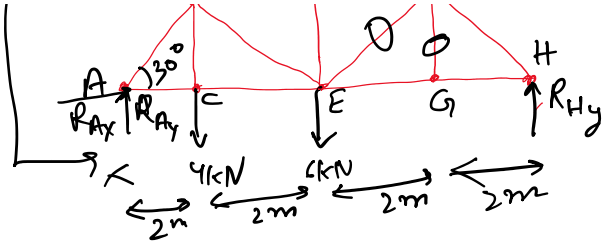
$F_{CD} = ?$



Joint G:

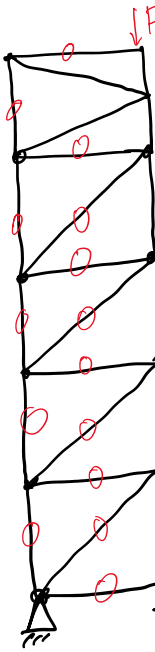
$F_{FG} = 0$

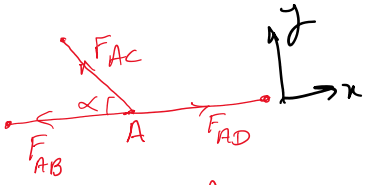
Joint F



Joint F

$F_{EF} = 0$





For joint A

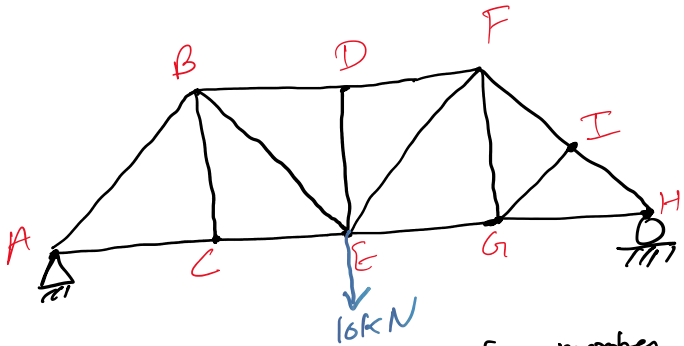
$\Sigma F_y = 0$

$F_{AC} \sin\alpha = 0$

$F_{AC} = 0$

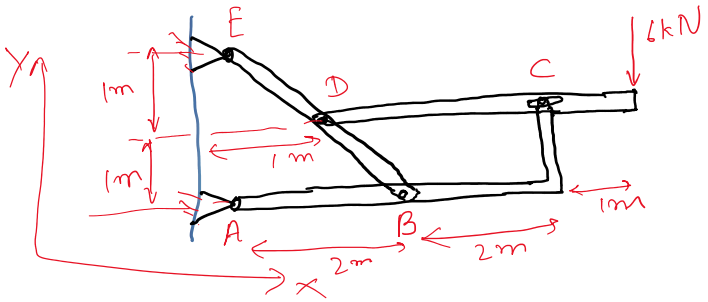
Sufficient Condition

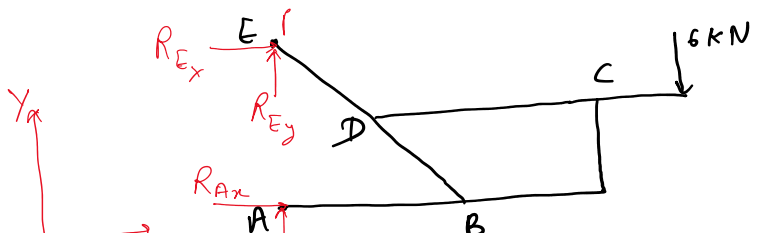
- Has 3 members connected
  - 2 are collinear
- No external force applied.

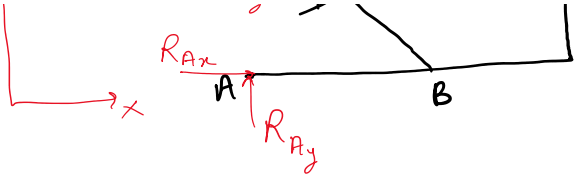


BC as zero force member

DE //







$$\sum M_E = 0$$

$$\Rightarrow R_{Ax} \times 2m - 6kN \times 5m = 0$$

$$\Rightarrow R_{Ax} = 15kN$$

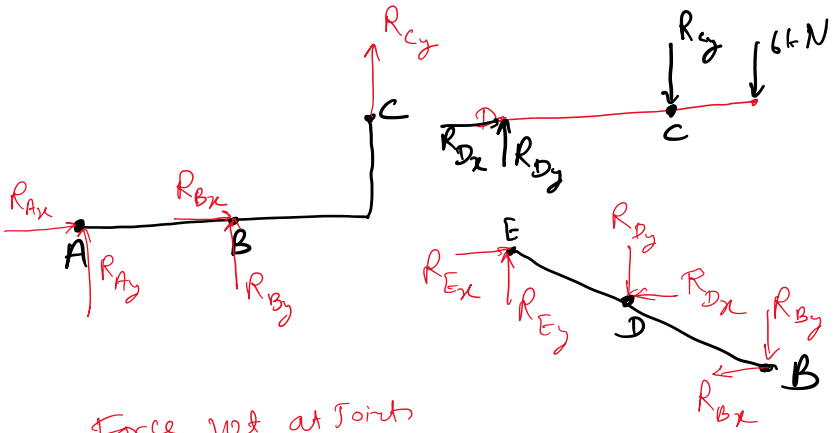
$$\sum F_x = 0$$

$$R_{Ax} + R_{Ex} = 0$$

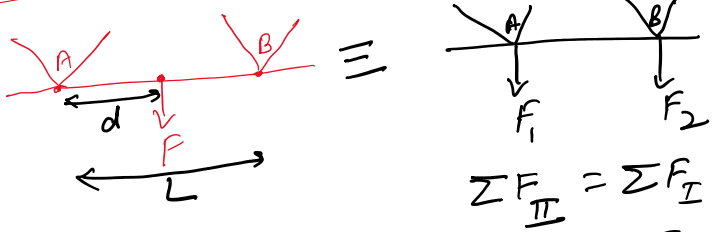
$$R_{Ex} = -15kN$$

$$\sum F_y = 0$$

$$R_{Ay} + R_{Ey} - 6kN = 0$$



Force not at Joints



$$\sum F_{II} = \sum F_I$$

$$F_1 + F_2 = F$$

$$(\sum M_A)_{II} = (\sum M_A)_I$$

$$F_2 \times L = Fd$$

$$F_2 = F\frac{d}{L}$$

$$F_1 = F\left(1 - \frac{d}{L}\right)$$

Static Determinacy

m = number of members

r = number of support reactions

m = number of members

r = number of support reactions

j = number of joints

number of equations = $2j$ for 2D Truss

$3j$ for 3D Truss

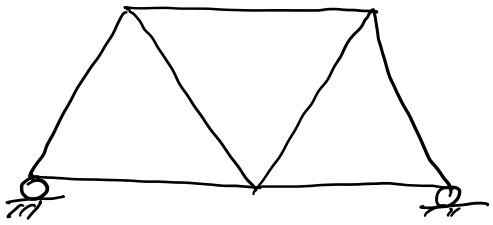
number of unknowns = $m+r$

$$m+r = \begin{cases} 2j & \text{in 2D} \\ 3j & \text{in 3D} \end{cases}$$

if $m+r > 2j$ ← Indeterminate

if $m+r < 2j$

if $m+r = 2j$



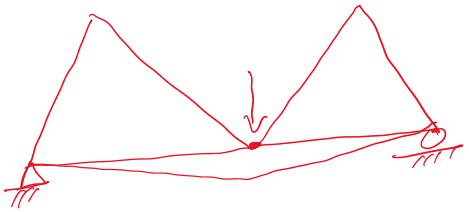
$m = 7$

$j = 5 \Rightarrow 2j = 10$

$r = 2$

$m+r < 2j$

Partial Fixity



$r = 3$

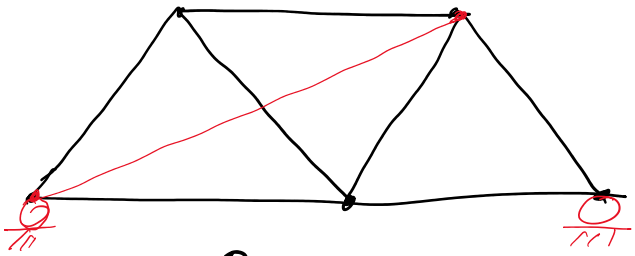
$j = 5 \Rightarrow 2j = 10$

$m = 6$

$m+r < 2j$

Not rigid

(Mechanism)

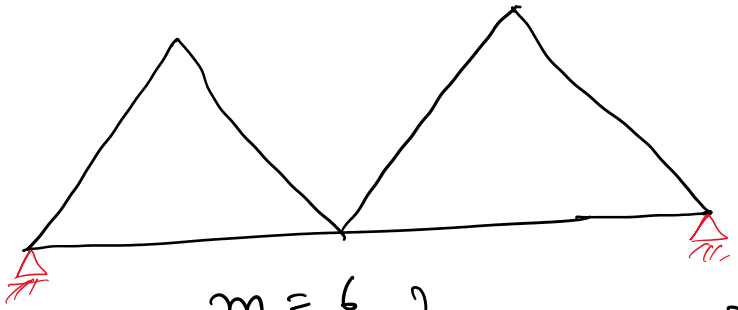


$m = 8$

$r = 2$

$j = 5 \Rightarrow m+r = 2j$

Partial Fixity

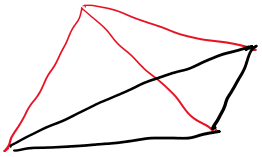


$m = 6$
$r = 4$
$j = 5$
$\Rightarrow m + r = 2j$

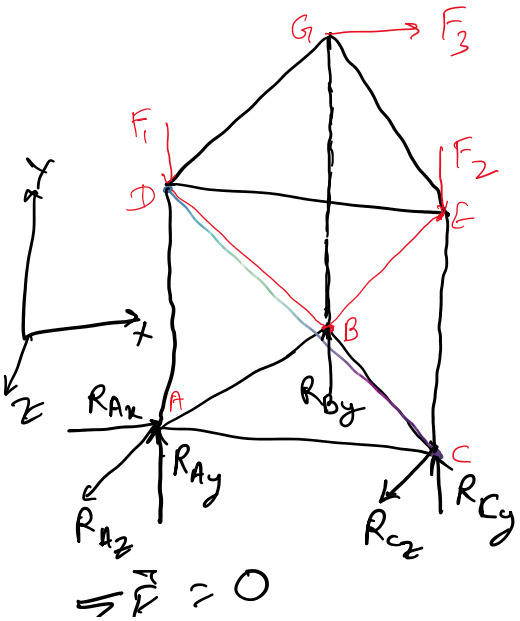
(Mechanism)

3-D Truss

- 3D structure consisting of 2-force member
- All member are connected to one another by frictionless ball-and-socket joints
- Forces are applied only at joints.
- Weightless member



Example



$\Sigma M_A = 0$

$\vec{r}_{B/A} \times \vec{R}_B + \vec{r}_{C/A} \times \vec{R}_C + \vec{r}_{E/A} \times \vec{F}_E + \vec{r}_{G/A} \times \vec{F}_G = 0$

$R_{Cx} =$
$R_{Cy} =$
$R_{\_} =$

$\Rightarrow \vec{F} = 0$

R_{Az} R_{Cz} R_{Cy} =

$\sum \vec{F} = 0$ R_{By} =

Method of Section

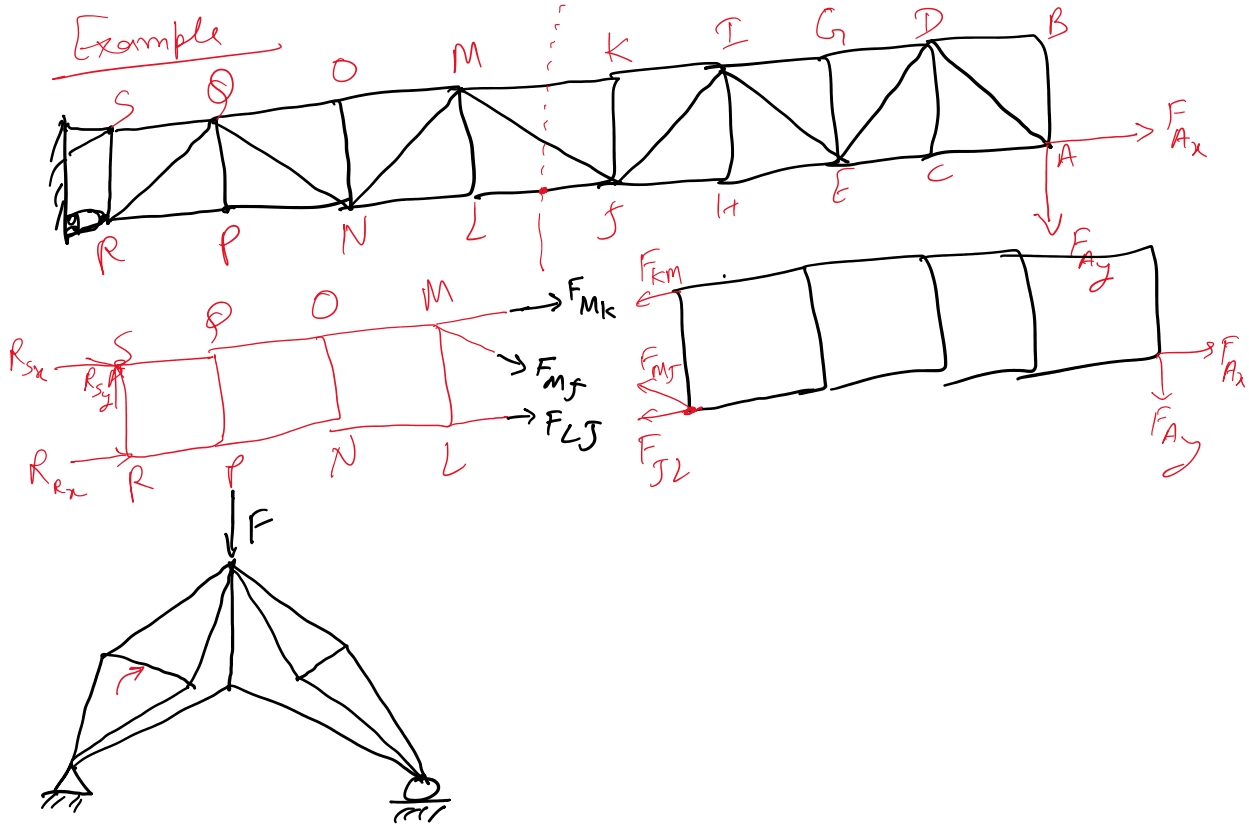
Cut the structure into Two parts such that it

a. cuts the bar of interest and

b. cuts at most 3 bars and

c. One of the two parts must have all loads known
   i. loads are the externally applied load
   ii. reaction forces that you calculate using the FBD of the structure.

d. Solve eqⁿ of equilibrium.



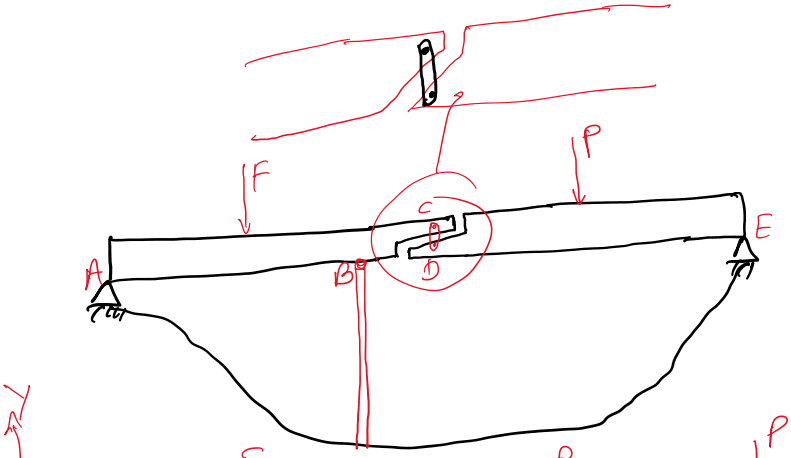
Frames

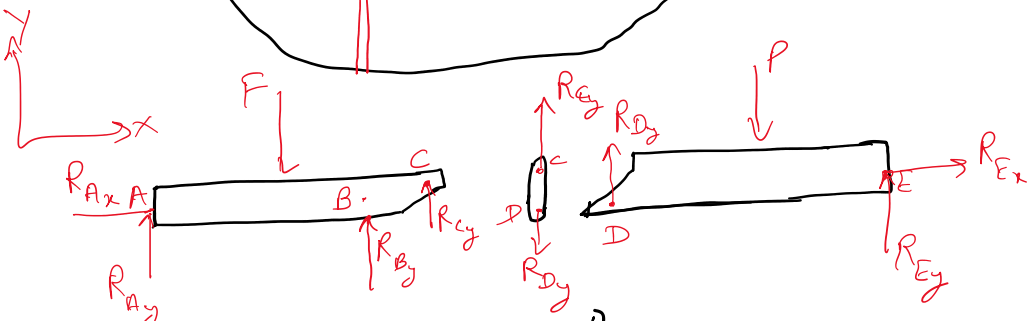
A structure with one or more 3-force or multi-force members

Rigid body

multi-force

Rigid body





$\Sigma F_y = 0$

$R_{Cy} = R_{Dy}$