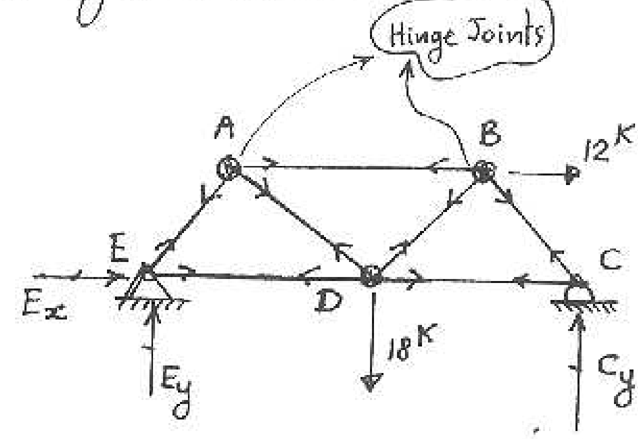
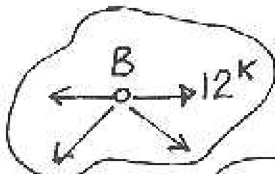
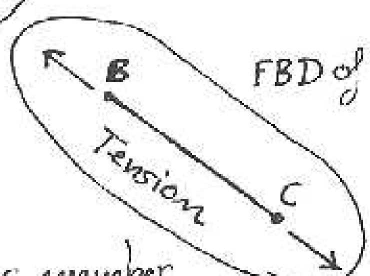
Chapter 6: Analysis of Structures



(A) Method of Joints

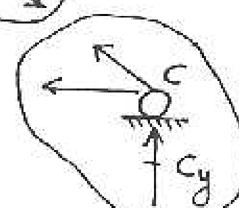


FBD of Joint B



FBD of member BC

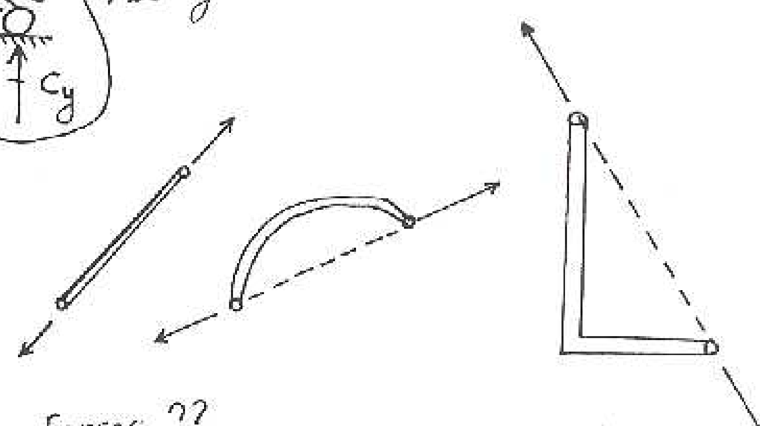
* Each TRUSS member is connected by 2 "hinge" joints



FBD of Joint C

* A "hinge" joint can transfer forces, but NOT moments

* Truss members can only carry AXIAL forces



(B) How To Compute Truss Member Forces ??

Step 1: Apply 3 equilibrium eqs. to find 3 unknown reactions

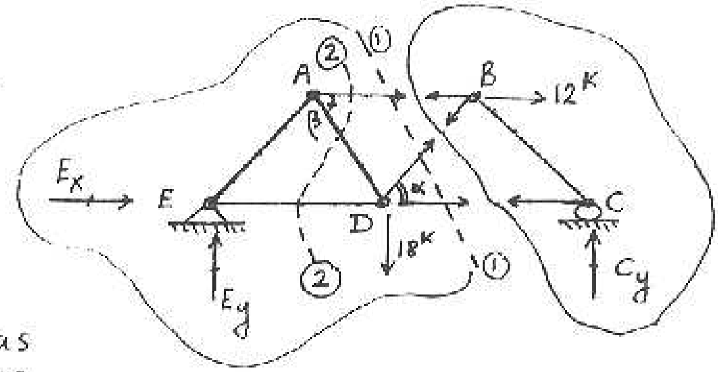
$$\Sigma F_x = 0 \quad \xrightarrow{+}$$
$$\Sigma F_y = 0 \quad \uparrow +$$
$$\Sigma M_{z\text{-axis}} = 0 \quad \circlearrowleft +$$

Step 2: At each joint which has 2 (or less) unknown member force(s), apply 2 (force) equilibrium eqs. to find 2 (or less) member force(s)

$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$

Step 3: Repeat step 2 until all (or few desired) member force(s) are found.

(C) Method of Sections



This method is useful if one has interests to compute only few selected (not ALL) member forces, such as member forces AB, DB and AD ??

step 1: Apply 3 equilibrium eqs. for the entire structure to find 3 unknown reactions

step 2: Make an "intelligent & honest" cut section ①-①

- The cut should go through member(s) that you have interests
- The cut should NOT go through more than 3 members
- The cut must be completed, it should NOT end prematurely

Then, decide "which side" of the cut to draw FBD, say LEFT side!

Step 3: Apply 3 equilibrium eqs., using LEFT-FBD:

$\sum M_{@D} \overset{+\circlearrowleft}{=} 0 \Rightarrow f_1(F_{AB}, E_x, E_y) = 0 \Rightarrow$ (solve for F_{AB})

$\sum F_x \overset{+\rightarrow}{=} 0 \Rightarrow f_2(E_x, F_{DC}, F_{DB}\cos\alpha, F_{AB}) = 0 \Rightarrow$ (solve for F_{DC})

$\sum F_y \overset{+\uparrow}{=} 0 \Rightarrow f_3(E_y, -18^K, F_{DB}\sin\alpha) = 0 \Rightarrow$ (solve for F_{DB})

Notes: The remaining member force F_{AD} can be found by:

* Apply Method of Joint @ joint A: $\sum F_x = 0$, $\sum F_y = 0$ } solve for F_{AD}; F_{AE}

* or, make another cut section ②-②, use LEFT-FBD, and

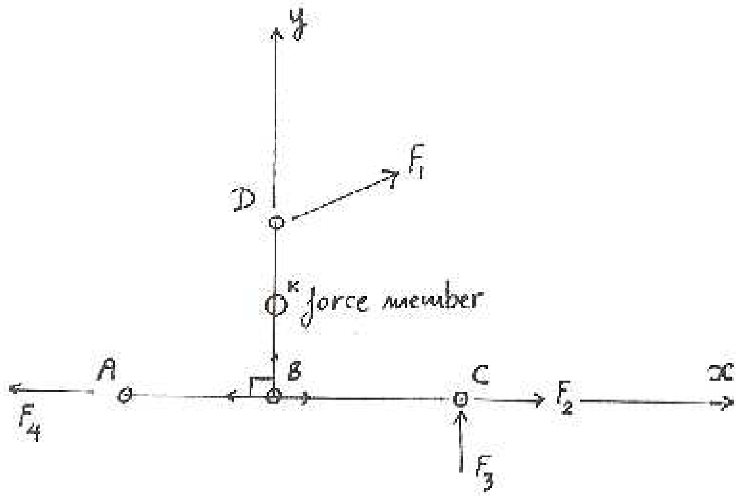
$\sum M_{@A} = 0 \Rightarrow f_4(\cancel{F_{AB}}, \cancel{F_{AD}}, F_{ED}, E_x, E_y) = 0 \Rightarrow$ solve F_{ED}

$\sum F_x = 0 \Rightarrow f_5(E_x, F_{ED}, F_{AD}\cos\beta, F_{AB}) = 0$

$\sum F_y = 0 \Rightarrow f_6(E_y, F_{AD}\sin\beta) = 0$

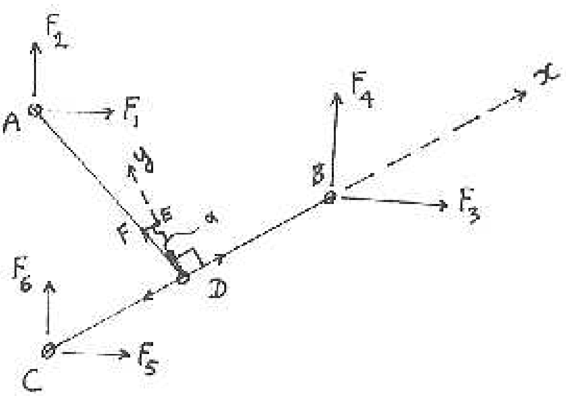
} (solve for F_{AD})

(C₁) Quick Ways To Determine Zero-Forces In Truss Structure



At joint B:

$\sum F_y \overset{\uparrow +}{=} 0 \Rightarrow \boxed{0 = F_{BD}}$



At joint D

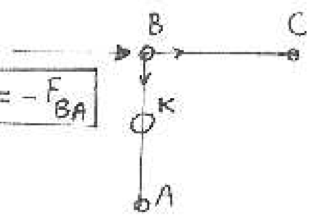
$\sum F_y \overset{\nwarrow +}{=} 0 = F_{DF}\cos(\alpha) \Rightarrow \boxed{F_{DF} = 0}$

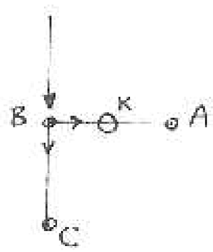
Rules

« If we have 3 TRUSS members joining @ a common joint (say Joint D), and if there is NO FORCES applied @ the common joint D, If 2 of the members form 180° angle (such as members DB & DC), then the remaining member (such as member DF) should have zero-force! »

At joint B:

$\sum F_y \overset{\uparrow +}{=} \boxed{0 = -F_{BA}}$

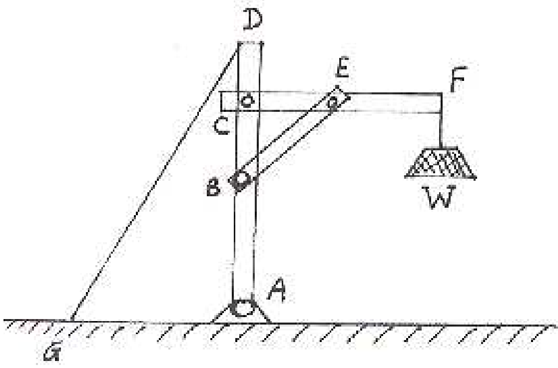


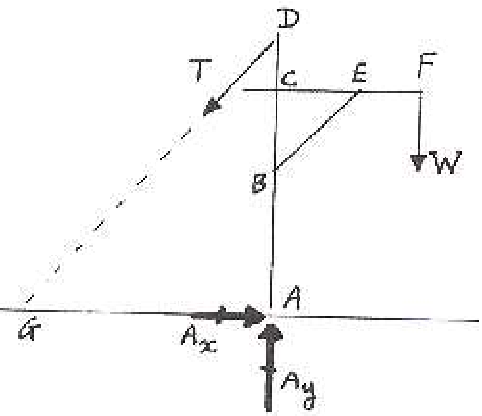


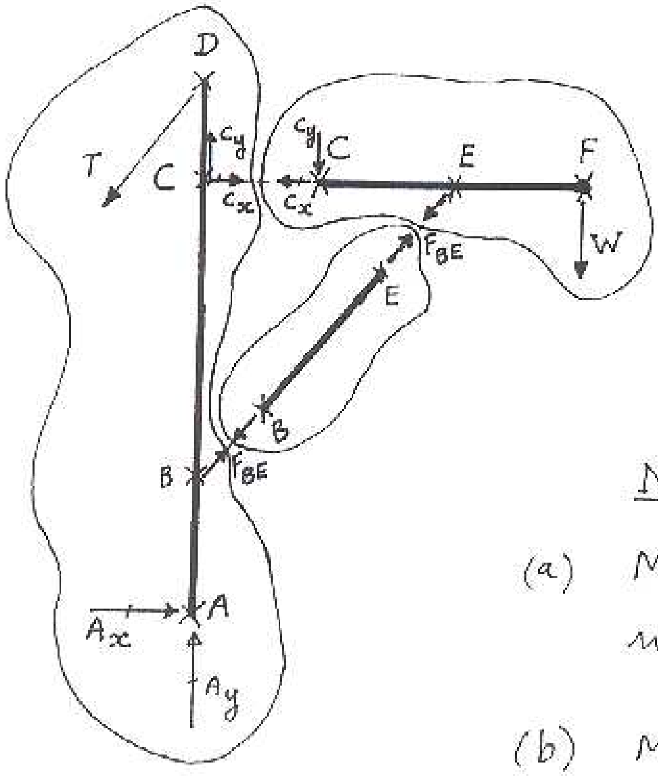
At joint B:

$\sum F_x \overset{\rightarrow +}{=} \boxed{0 = F_{BA}}$

(C_2) Multi-Force (Beam, Frame) Members







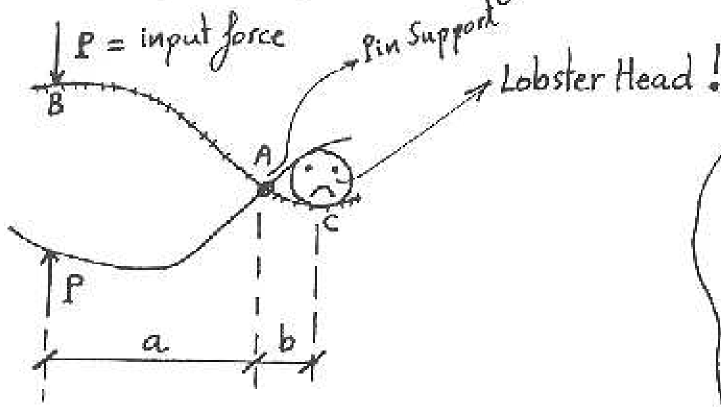
Notes:

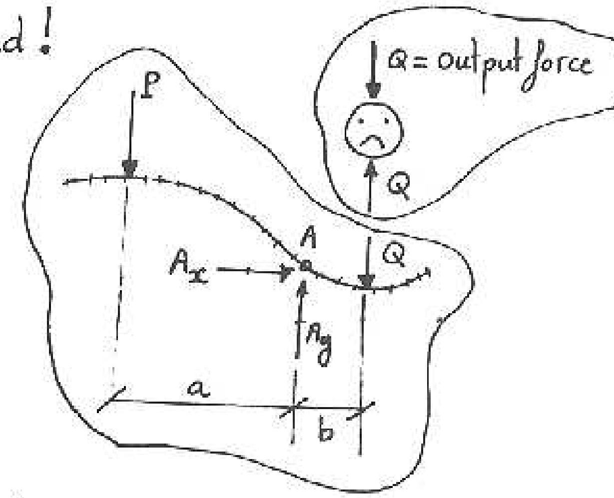
(a) Members AD and CF are multi-force members

(b) Member BE is a 2-force (axial) member

(D) Machine Design (i.e. Cutting Plier)

To transfer, modify "INPUT" force into useful "OUTPUT" force :





FBD of ....

* Lobster Head
* Upper Part of Cutting Plier

From Equilibrium :

$$\sum M_A \overset{+\circlearrowleft}{=} 0 = +Pa - Qb \Rightarrow Q = P\left(\frac{a}{b}\right)$$

Output Force = Input Force * (Magnified Factor)

For "machine's" usefulness, we want $\left(\frac{a}{b}\right) \gg 1$; or $a \gg b$ (!?)