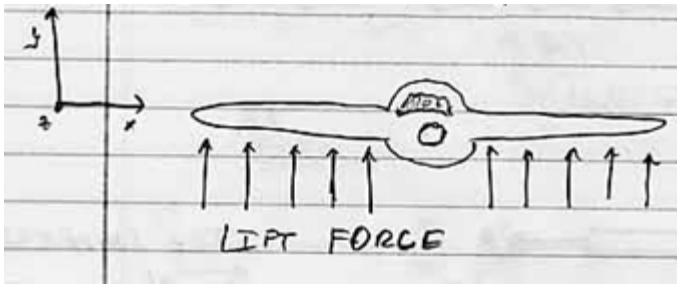
2.001 - MECHANICS AND MATERIALS I
Lecture #5
9/20/2006
Prof. Carol Livermore

TOPIC: FORCES AND MOMENTS TRANSMITTED BY SLENDER MEMBERS?
When will a structure fail?

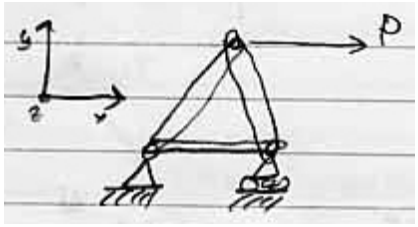
Recall:

1. What can the structural elements tolerate?
2. What forces and moments are experienced in the various parts of the structure?

EXAMPLE: Airplane

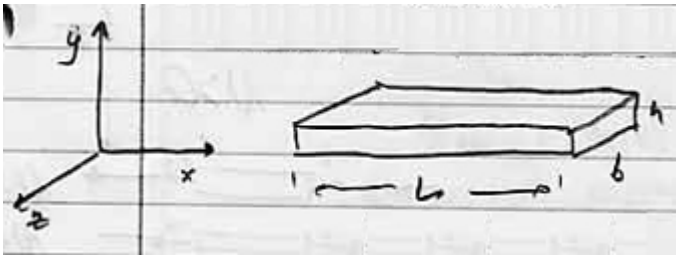


EXAMPLE: Truss



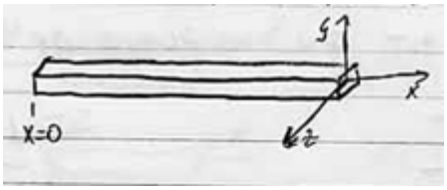
SLENDER MEMBERS

Long, skinny structural elements

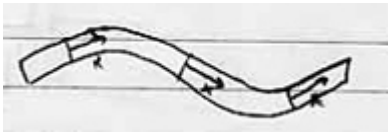


$$L >> b, L >> h$$

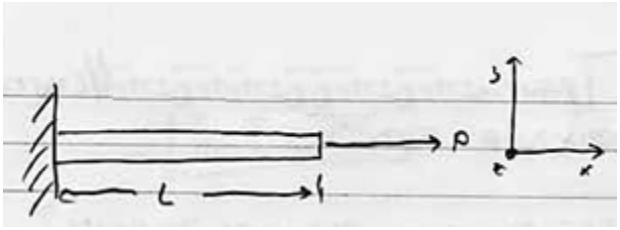
EXAMPLE: Skis, Golf Clubs, I-Beams



Local axes follow the beam.

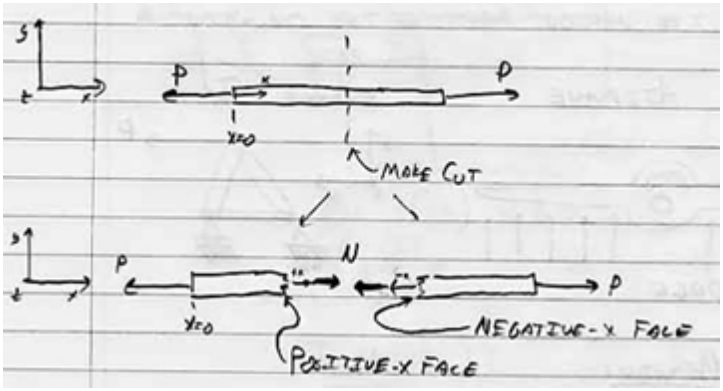


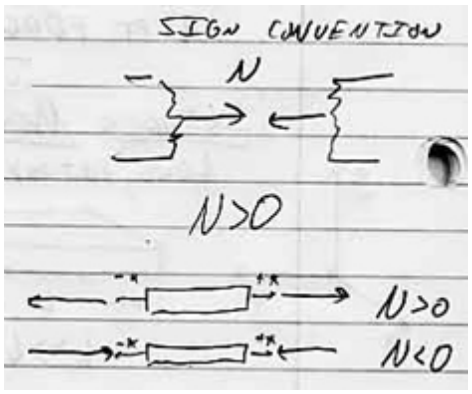
AXIAL FORCES:



Forces that act along the axis of the slender member.

FBD

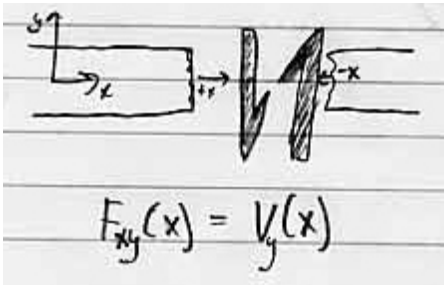


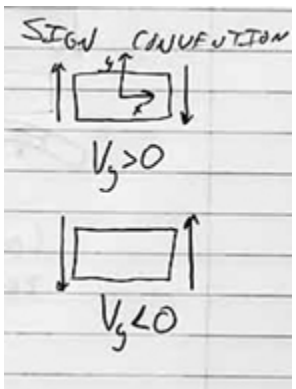


$F_{ij}(x) = N(x)$, i: face, j: direction, x: location

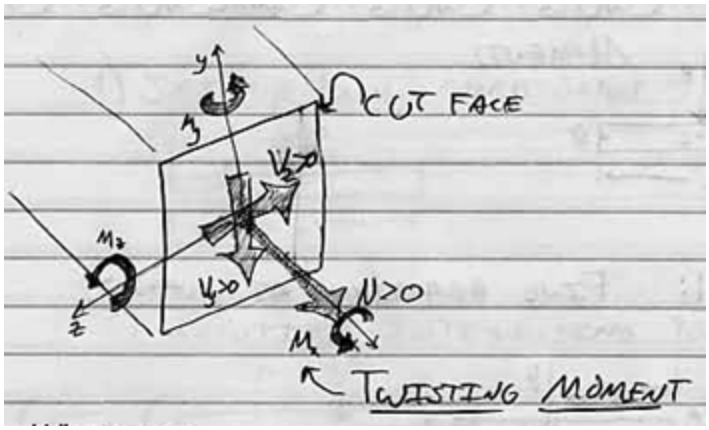
SHEAR FORCES:

Forces that act in the plane of a face.

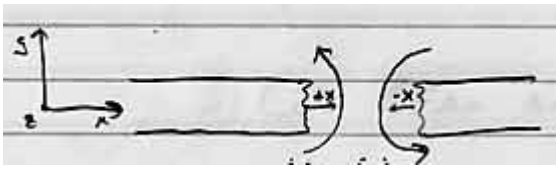




Summarize Internal Loads:



Moments:

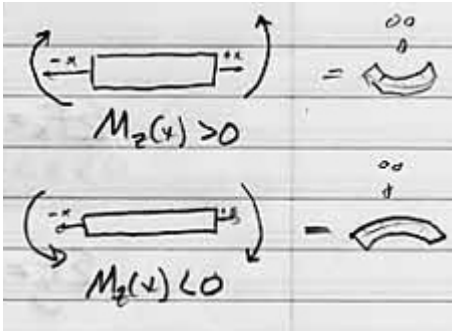


$M_{xz}(x_2) > 0$x: face, z: axis, x_2: location

$$M_{xz}(x) = M_z(x)$$

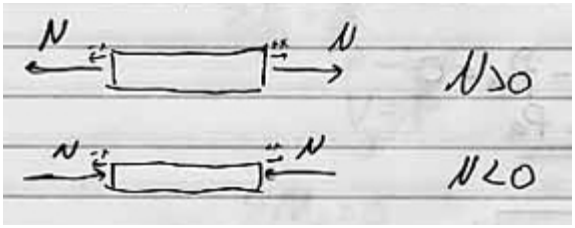
Bending Moment

Sign Convention

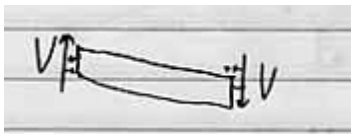


Summarize sign conventions

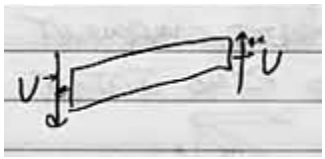
$N > 0$
$N < 0$



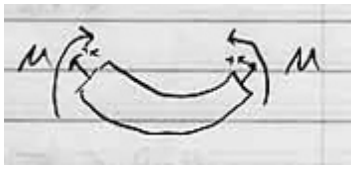
$V > 0$



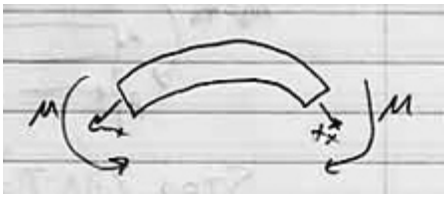
$V < 0$



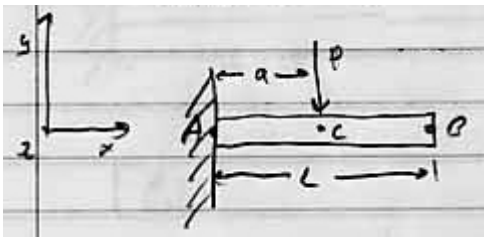
$M > 0$



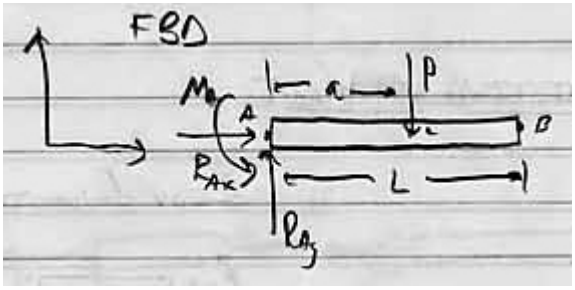
$M < 0$



EXAMPLE: Calculating internal forces and moments



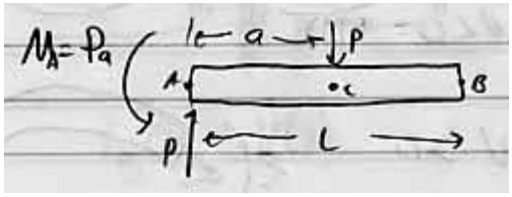
Step 1: Find reactions at supports.



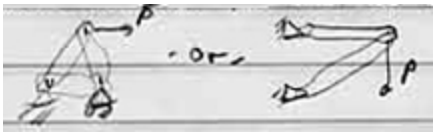
$$\sum F_x = 0$$
$$R_{A_x} = 0$$

$$\sum F_y = 0$$
$$R_{A_y} - P = 0$$
$$R_{A_y} = P$$

$$\sum M_A = 0$$
$$M_A - Pa = 0$$
$$M_A = Pa$$

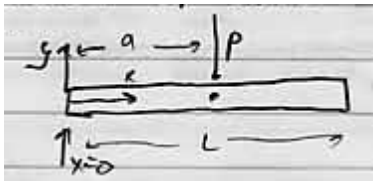


Step 2: If you have a multi-component structure, you will need to find joint forces too.

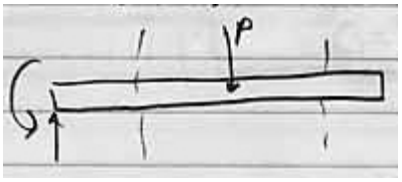


Step 3: Find internal forces and moments.

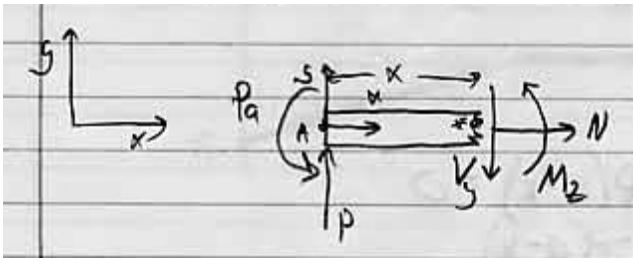
1. Set up local coordinates.



2. Identify interesting points.



3. Cut beam and do FBDs.



For $0 < x < a$

$$\sum F_x = 0$$
$$N = 0$$

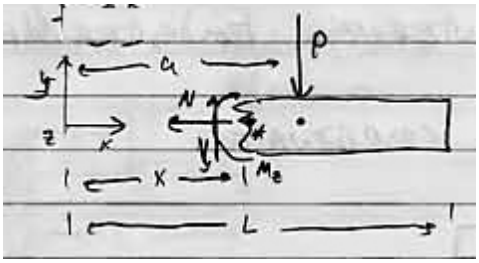
$$\sum F_y = 0$$
$$P - V_y = 0$$
$$P = V_y$$

$$\sum M_A = 0$$
$$Pa + M_z - Px = 0$$

$$M_z = Px - Pa = -P(a - x)$$

OR (From the other end)

FBD



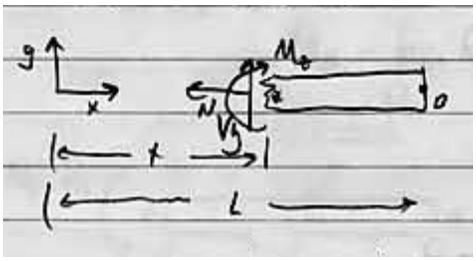
$$\sum F_x = 0$$
$$-N = 0$$
$$N = 0$$

$$\sum F_y = 0$$
$$-P + V_y = 0$$
$$V_y = P$$

$$\sum M_* = 0$$
$$-M_z - P(a - x) = 0$$

$$M_z = -P(a - x)$$

Note: This is the same as before.
For $a < x < L$



$$\sum F_x = 0$$
$$-N = 0$$
$$N = 0$$

$$\sum F_y = 0$$
$$V_y = 0$$

$$\sum M_* = 0$$
$$-M_z = 0$$
$$M_z = 0$$

Step 4: Plot result and sanity check.