2.001 - MECHANICS AND MATERIALS I
Lecture #2
9/11/2006
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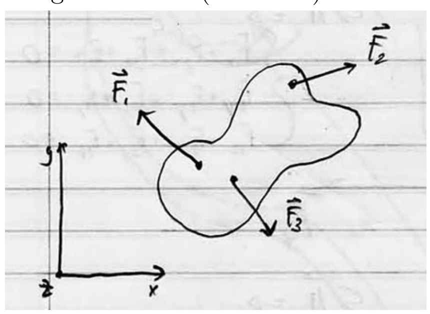
TOPIC: LOADING AND SUPPORT CONDITIONS

STRUCTURAL ANALYSIS
Tools we need:
1. Recall loading conditions (last time)

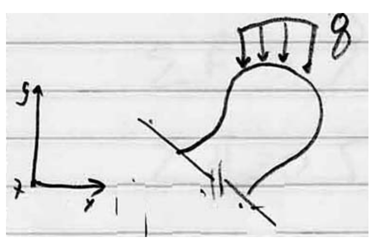


a. Forces - ("Point Loads ") Point of Application
Magnitude
Direction

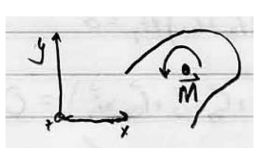
b. Moments
From forces applied at a distance from a point.

2. Recall equation of static equilibrium (last time)
$\sum \vec{F} = 0 \Rightarrow \sum F_x = 0, \sum F_y = 0, \sum F_z = 0$
$\sum \vec{M}_0 = 0 \Rightarrow \sum M_x = 0, \sum M_y = 0, \sum M_z = 0$

3. Distributed Loads - Force per unit length

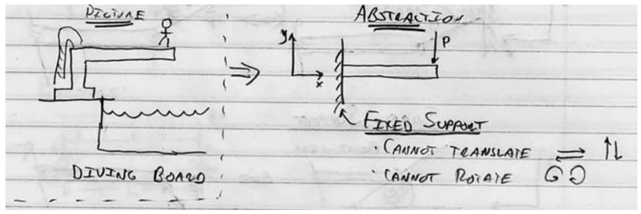


4. Concentrated Moment - Moment applied at a point (EX: Screwdriver)



FREE BODY DIAGRAMS

Draw like a mechanical engineer

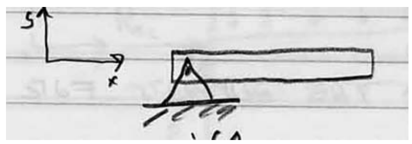


Fixed Support

Cannot translate horizontally or vertically.

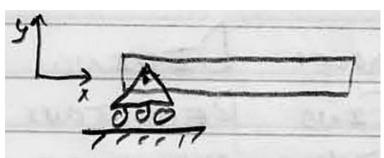
Cannot rotate.

Pinned Support



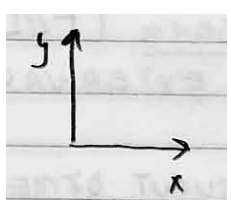
- Cannot translate.
- Free to rotate.

Pinned on Rollers



- Cannot translate in y.
- Can translate in x.
- Free to rotate.

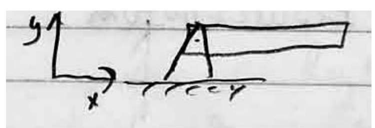
REACTIONS: (Forces applied by a support)



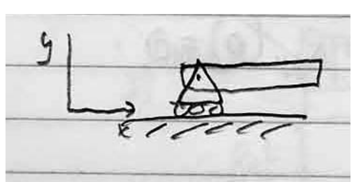
No $\rightleftharpoons \Rightarrow$ can apply R_x.
$\uparrow\downarrow \Rightarrow$ can apply R_y.
No rotate $\Rightarrow$ can apply M.

So:

Need R_x, R_y, M



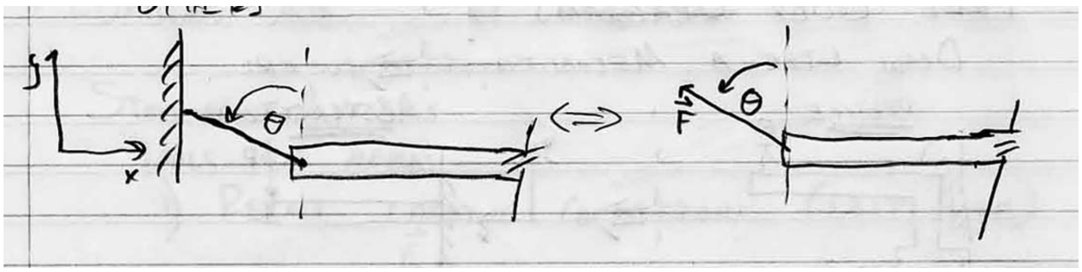
Need R_x, R_y



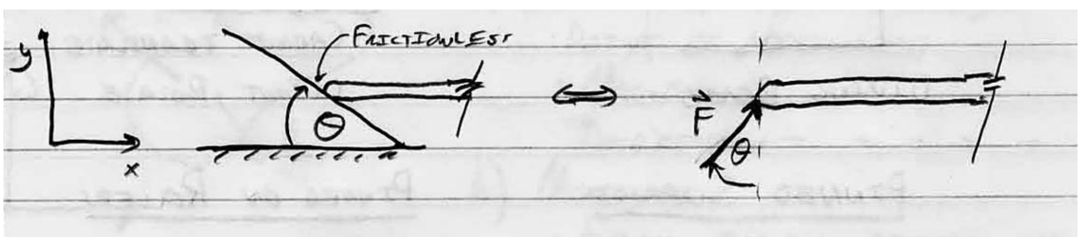
Need R_y

OTHERS:

CABLE:

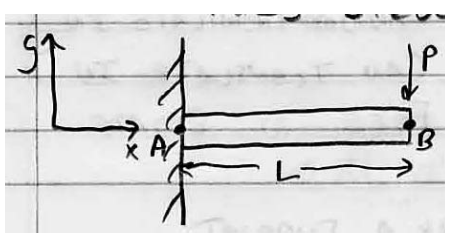


SMOOTH SUPPORT:

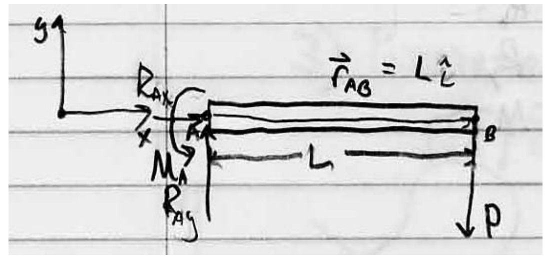


EXAMPLE: DIVING BOARD

Find reactions from the supports for this structure.



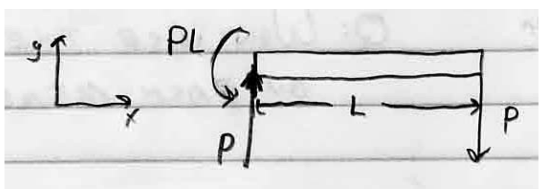
1. How to draw a Free Body Diagram (FBD)
   i. Remove all external supports.
   ii. Draw all relevant dimensions.
   iii. Depict all external forces and moments.
   iv. Coordinate system.



2. Apply the equations of equilibrium.
   $\sum F_x$: $R_{Ax} = 0$
   $\sum F_y$: $-P + R_{Ay} = 0$
   $\sum M_{Az}$: $M_A - LP + (R_{Ax})(0) + (R_{Ay})(0) = 0$

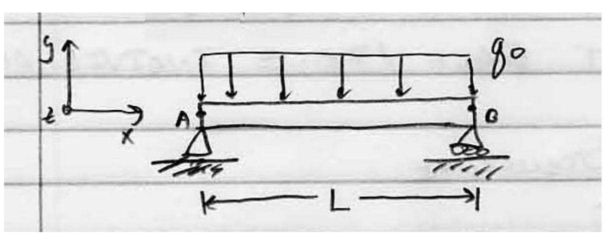
3. Solve. $R_{Ax} = 0$
   $R_{Ay} = P$
   $M_A = LP$

4. Check

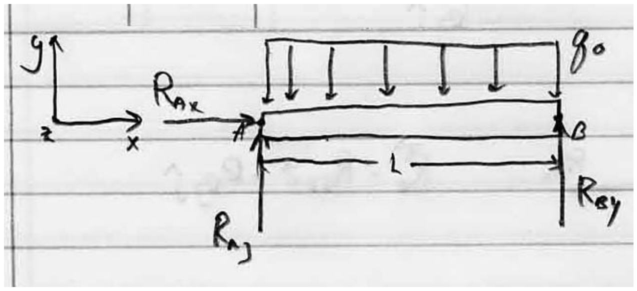


⇒ looks good!

EXAMPLE:



Draw FBD.



Apply equilibrium.

$\sum F_x$: $R_{Ax} = 0$

$\sum F_y$: $R_{Ay} + R_{By} - \int_0^L (-q_0)dx = 0$

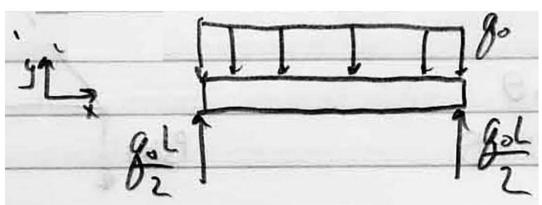
$\sum M_A$: $R_{By}L + \int_0^L (-q_0)xdx = 0 = R_{By}L - \frac{q_0 L^2}{2}$

Solve. $R_{Ax} = 0$

$R_{By} = \frac{q_0 L^2}{2L} = \frac{q_0 L}{2} \Rightarrow R_{By} = \frac{q_0 L}{2}$

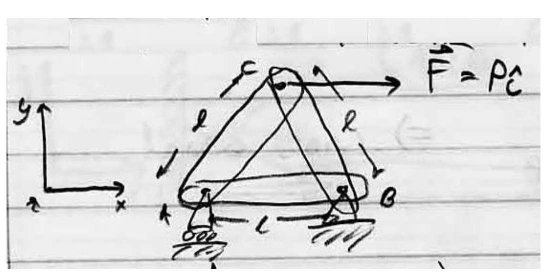
$R_{Ay} + \frac{q_0 L}{2} - q_0 L = 0 \Rightarrow R_{Ay} = \frac{q_0 L}{2}$

Check.



$\Rightarrow$ looks good!

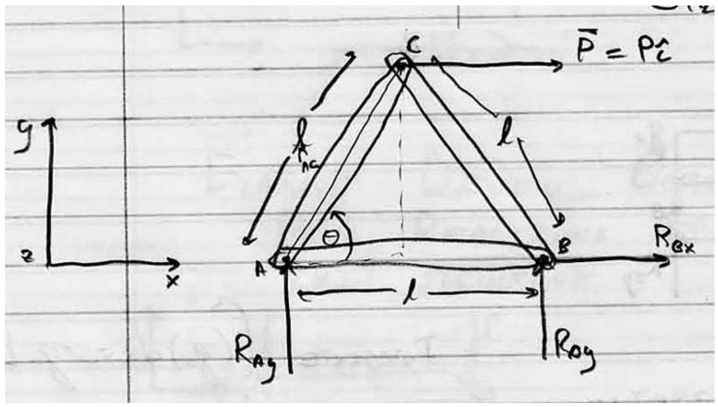
EXAMPLE: PLANAR TRUSS



Q: What are the forces on each member?

Approach:
Look at whole structure.
Look at each piece individually.

FBD of Whole Structure



$\vec{R_B} = R_{B_x}\hat{i} + R_{B_y}\hat{j}$

Equations of Equilibrium:

$\sum F_x = 0$

$R_{B_x} + P = 0$

$\sum F_y = 0$

$R_{A_y} + R_{B_y} = 0$

$\sum M_A = 0$

$R_{B_y} l + (P)(-\sin\theta)l = 0$

OR

$\vec{r_{AC}} \times \vec{P} + \vec{r_{AB}} \times \vec{R_B} = 0$

Solve. $R_{B_x} = -P$

$R_{B_y} = P\sin\theta$

$R_{A_y} = -P\sin\theta$

Check.