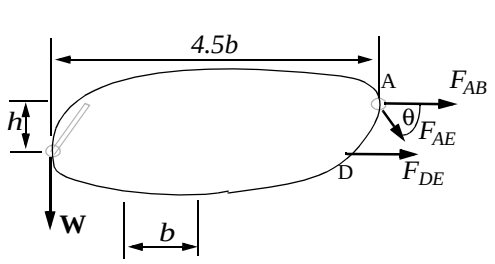
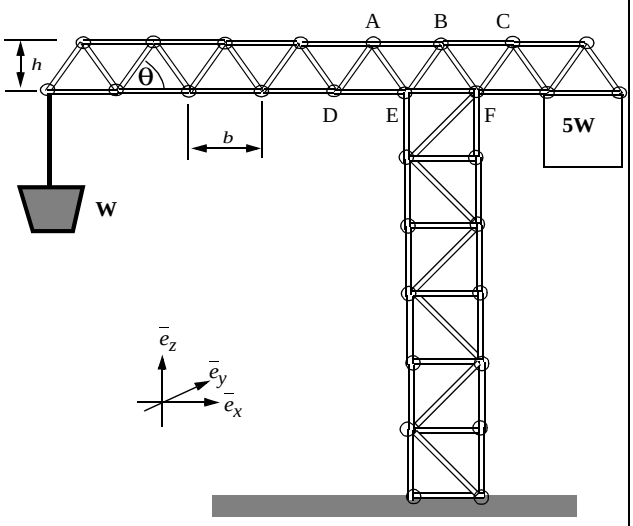
Class Exercise #1
1.101 Structures Work

The figure shows a truss structure. Draw a ***single*** free body diagram which, in applying the requirements of static equilibrium, will enable you to determine the forces in members ***DE***, ***AE***, and ***AB*** in terms of the suspended weight ***W***





Resultant Force = 0

$\vec{e}_x$: $\quad F_{AB} + F_{AE} \cdot \cos\theta + F_{DE} = 0$

$\vec{e}_z$: $\quad -W - F_{AE} \cdot \sin\theta = 0$

Resultant Moment = 0 (about A)

$\sum M_y \cdot \vec{e}_y$: $\quad -(4.5b)W - hF_{DE} = 0$

The solution of these three equations for the three unknown member forces is:

$$F_{AB} = 5\left(\frac{b}{h}\right)W \qquad F_{AE} = -\frac{W}{\sin\theta} = -W \cdot \sqrt{1 + (b/2h)^2} \qquad F_{DE} = -4.5\left(\frac{b}{h}\right)W$$

Note:

- That F_{AE} and F_{DE} came out negative means that the forces act in the opposite direction to that which I assumed at the outset. I assumed the three members were "in tension"; the member forces are all shown pulling on the nodes (A and D). Hence the nodes are pulling back on the members so they are in tension. One student stated it this way: "I had assumed the forces F_{AE} and F_{DE} in the *wrong direction*". Note that it is *not* wrong to do so, however. You can associated the sign of the unknown with the magnitude of the unknown. So don't waste time trying to figure out the direction of an unknown internal force (or component of stress for that matter).
- The member forces are all proportional to the external load.
- The forces in the horizontal, top and bottom members *AB* and *DE* are significantly bigger than the force in the diagonal member *AE* (for *b/h* of order 1). If $b = 2h$ ($\theta = 45^o$) we have:

$$F_{AB} = 10 \cdot W \qquad F_{AE} = -1.4 \cdot W \qquad F_{DE} = -9 \cdot W$$