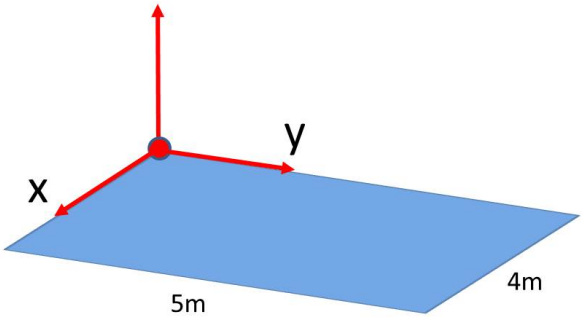
AEM 2011 Exam #2 Friday, April 18

You may only use a simple calculator that does not communicate in any wireless manner. Pagers, cell phones, and all other communications devices must be turned off during the quiz. All work (free body diagrams, algebra, etc) is required to receive full credit.

1. As discussed in class, my neighbor built a shed last summer. The shed collapsed under the weight of the snow as shown in the figure below (left). The geometry of the roof (before collapse) is also shown below (right). Before the collapse, the height of the snow was distributed by $h(x, y) = (0.2y + 0.5)$m for $0 \leq x \leq 4$m and $0 \leq y \leq 5$m. The density of settled snow is $300 \frac{kg}{m^3}$.

   (a) (20points) What was the total force on the roof of the shed (before it collapsed)?

   (b) (10points) What is the x location for the centroid of the distributed snow force?



2. A Caterpillar 325C Excavator is shown below (left) along with a simplified diagram of the movable arm/bucket (right). The bucket carries soil of weight $W = 30000N$ at point F. The arm is attached to the vehicle by pins at A and O. You may assume beams OB and CD are rigid two-force members that are attached by pins. Beams $ABCE$ and DEF are rigid multi-force members. The locations of the various points in meters are:

$$\mathbf{r_A} = 0\mathbf{i} + 10\mathbf{j}, \quad \mathbf{r_B} = 5\mathbf{i} + 20\mathbf{j}, \quad \mathbf{r_C} = 10\mathbf{i} + 23\mathbf{j}$$
$$\mathbf{r_D} = 30\mathbf{i} + 35\mathbf{j}, \quad \mathbf{r_E} = 28\mathbf{i} + 30\mathbf{j}, \quad \mathbf{r_F} = 25\mathbf{i} + 10\mathbf{j}$$

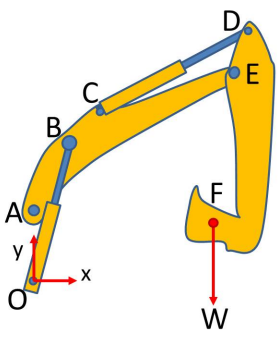
   These vectors are given in the coordinates with origin at O.

   (a) (20points) What are the external reaction forces at A and O required to maintain static equilibrium?

   (b) (10 points) Draw free body diagrams for each of the beams (OB, CD, $ABCE$, and DEF). Internal forces between beams, e.g. the forces at point C, should be drawn consistently between your diagrams.

   (c) (10 points) How would you solve for the reaction force at pin C? You only need to briefly describe the approach and you do not need to actually solve for the answer.

   As noted above you may assume OB and CD are 2-force members to simplify your work.



3. Last weekend was not warm but Professor Seiler was determined to go for a swim after our long winter. The diving board at his local pool is shown below (left figure). The board is pinned at A and supported by a rolling joint at B as shown in the simplified diagram (right figure). Assume Professor Seiler stands on the last 0.3m of the board and his weight is 7500 N. You may assume the diving board is rigid.

   (a) (10 points) What is the force density $w(x)$ on the board due to the human in units of N/m? You may assume the weight is uniformly distributed over the last 0.3m of the board.

   (b) (20 points) The reaction forces on the board at A and B are $\mathbf{A} = -8062N\mathbf{j}$ and $\mathbf{B} = 15562N\mathbf{j}$. Sketch the shear force $V(x)$ and bending moment $M(x)$ as a function of the position, x.