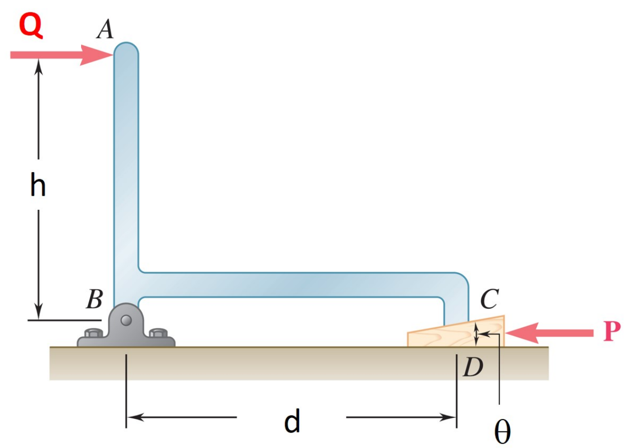
AEM 2011 Final Exam Monday, May 13

You may only use a simple calculator that does not communicate in any wireless manner. 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.

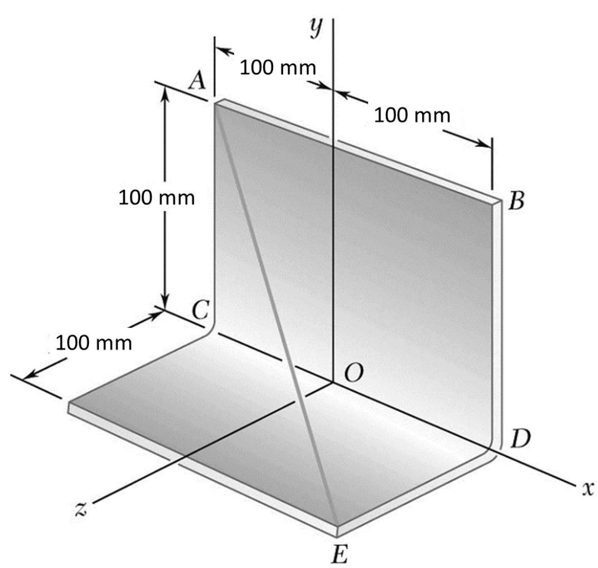
1. (14 points) The part ABC is supported by a frictionless hinge at B and a wedge with angle θ at C. A force Q is applied at point A as shown. The distance from A to B is h and the distance from B to C is d. The surface of the wedge is at an angle θ. Assume the part ABC and the wedge are massless. **Assume all surfaces are frictionless.**

   (a) Draw free body diagrams for the part ABC and for the wedge.

   (b) Assume Q is given. What is the force P required to maintain static equilibrium?



2. (12 points) The wire AE is stretched between corners A and E of a bent plate. The tension in the wire is 500N. Determine the moment about O of the force exerted by the wire on corner A.

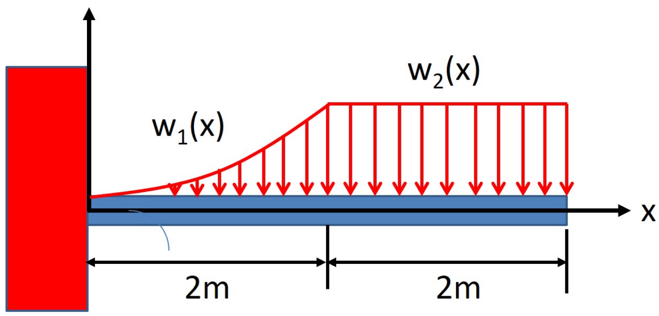


3. (15 points) Consider the beam with two distributed loads shown below.
The first distributed load is $w_1(x) = 2.5x^2 \frac{N}{m}$ for $0 \le x \le 2$m and zero elsewhere.
The second distributed load is $w_2(x) = 10 \frac{N}{m}$ for $2 \le x \le 4$m and zero elsewhere.

(a) What is the magnitude and location for the resultant force due to the first distributed load w_1?

(b) What is the magnitude and location for the resultant force due to the second distributed load w_2?

(c) What is the magnitude and location for the resultant force due to both distributed loads w_1 and w_2?



4. (15 points) Professor Seiler visited the Science Museum and constructed the truss shown below on the left. The geometry for the truss is shown below on the right. The truss is supported by pin at A and a roller B. A downward force $F = 1$N is applied at C.

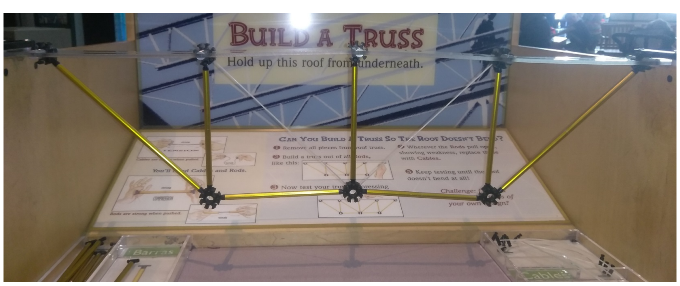
(a) Draw a free body diagram for the entire truss including reactions at A and B.

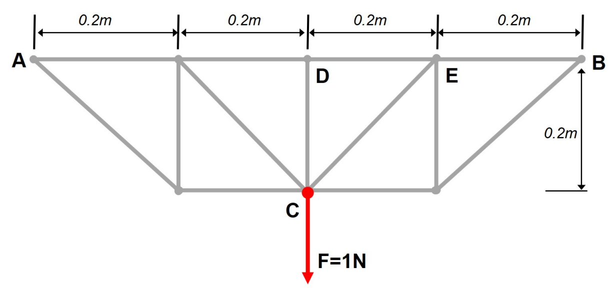
(b) Determine the external reactions at A and B required to support the truss.

(c) What is the force in member CE? Specify whether the force is in tension or compression.

(d) What is the force in member CD? Specify whether the force is in tension or compression.

(e) Assume the applied force is increased to $F = 2$N. What is the force in member CD?





5. (14 points) Consider again the part ABC and wedge as shown in Problem 1. **Assume there is friction at the surface between the wedge and ground. Also assume there is friction at the surface between the wedge and part ABC.** Assume the coefficient of static friction is μ_s a both surfaces. The force P is just sufficient to overcome friction and move the wedge to the left.

   (a) Draw free body diagrams for the part ABC and wedge.

   (b) The force P required to move the wedge to the left is given by one of the equations below. Select the correct answer and justify your answer.

$$P = \frac{Qh}{d}\frac{(1-\mu_s^2)\cos\theta + 2\mu_s\sin\theta}{\sin\theta - \mu_s\cos\theta} \tag{1}$$

$$P = \frac{Qh}{d}\frac{2\mu_s\sin\theta + (1-\mu_s^2)\cos\theta}{\cos\theta - \mu_s\sin\theta} \tag{2}$$

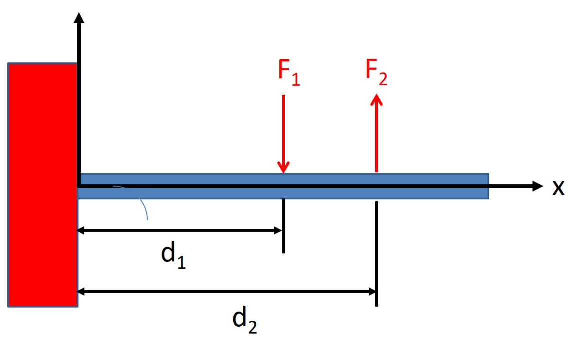
$$P = \frac{Qh}{d}\frac{(1-\mu_s^2)\sin\theta + 2\mu_s\cos\theta}{\mu_s\sin\theta - \cos\theta} \tag{3}$$

$$P = \frac{Qh}{d}\frac{(1-\mu_s^2)\sin\theta + 2\mu_s\cos\theta}{\cos\theta - \mu_s\sin\theta} \tag{4}$$

$$P = \frac{Qh}{d}\frac{(1-\mu_s^2)\sin\theta + 2\mu_s\cos\theta}{\cos\theta + (1-\mu_s^2)\sin\theta} \tag{5}$$

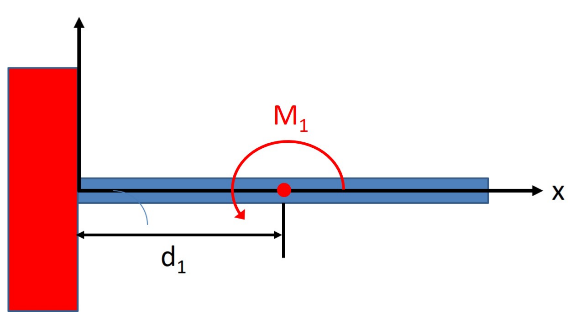
6. (15 points) Shear and bending moment diagrams:

   (a) The beam shown below has a downward force F_1 at d_1 and an upward force F_2 at d_2. You may assume $0 \le F_2 \le F_1$ and $d_2 > d_1$. The length of the beam is L. Sketch the shear force $V(x)$ and bending moment $M(x)$ as a function of the position x.



   (b) Assume that the forces have equal magnitude: $F_1 = 100$N downward and $F_2 = 100$N upward. Also assume that $d_1 = 1$m, $d_2 = 1.01$m and $L = 2$m. Sketch the shear force $V(x)$ and bending moment $M(x)$ as a function of the position x.

   (c) Finally, consider the beam shown below with a pure moment $M_1 = 1$Nm at $d_1 = 1$m. The length of the beam is $L = 2$m. Sketch the shear force $V(x)$ and bending moment $M(x)$ as a function of the position x.



7. (15 points) The beam shown in the left diagram below has length $L = 10m$. The beam has a downward force $F_1 = 100$N at $d_1 = 2$m and an upward force $F_2 = 50$N at $d_2 = 4$m. The resulting bending moment at location z is given by:

$$M(z) = \begin{cases} 50z & \text{for } 0 \leq z < 2m \\ 100 - 50(z-2) & \text{for } 2 \leq z < 4m \\ 0 & \text{for } 4 \leq z \leq 10m \end{cases} \quad (6)$$

The beam cross-section, shown in the right diagram below, is a "T" shape the given dimensions. The origin of the (x, y) axes is at the centroid of the beam cross-section. You can make the simplifying assumptions discussed in class to do parts (c), (d), and (e).

(a) What is the largest bending moment and at what location z does it occur?

(b) What is the moment of inertia of the beam cross-section about the x-axis?

(c) What is the largest stress in tension and at what location (y, z) does it occur?

(d) What is the largest stress in compression and at what location (y, z) does it occur?

(e) The beam is made of high-strength A514 steel which has a yield stress of $\sigma_y = 700 \times 10^6\ N/m^2$. Will the beam yield (i.e. deform) due to the given bending moment? Justify your answer.

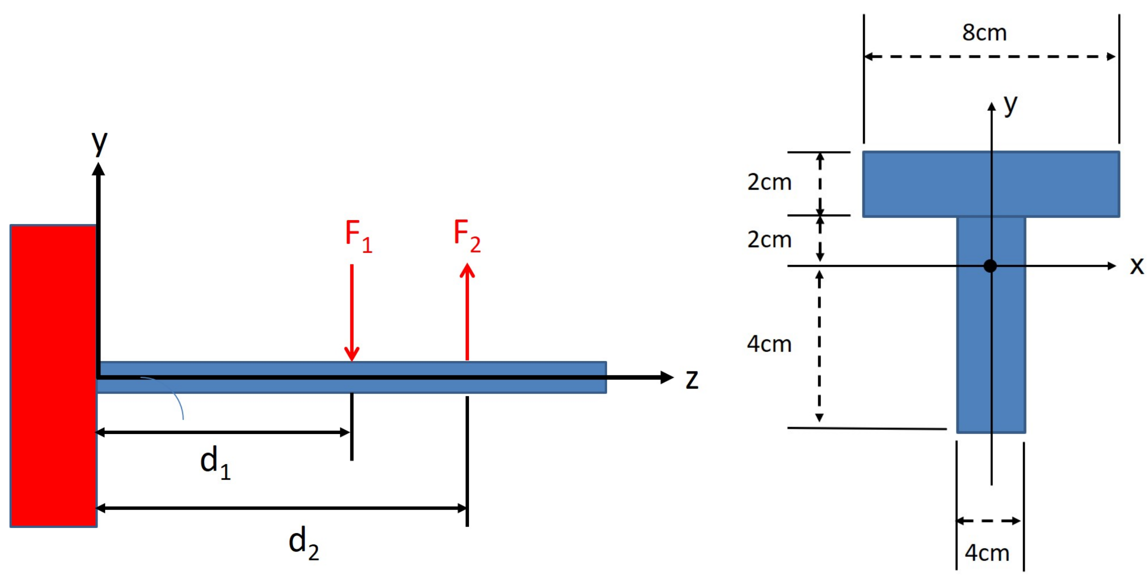


Figure 1: Bending moment diagram (Left) and beam cross-section (Right)