

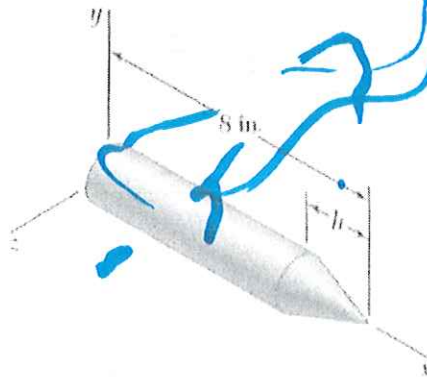
**FINAL EXAM**

**Open Book, Closed Notes, Do not write on this sheet, Show all work**

1. (25 points) A portion of an 8-in.-long steel rod of diameter 1.50 in. is turned to form the conical section shown. Knowing that the turning process reduces the moment of inertia of the rod with respect to the  $x$  axis by 20 percent, determine the height  $h$  of the cone. The specific weight of steel is  $0.284 \text{ lb/in}^3$ , and the volume of a cone is

$$V_{\text{cone}} = \frac{\pi}{3} r^2 h$$

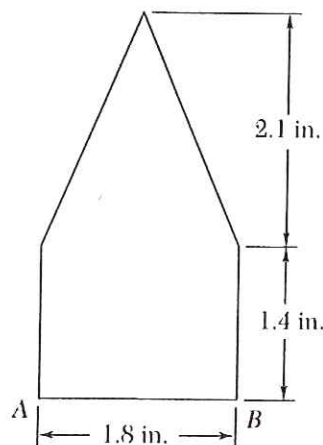
where  $r$  is the radius of the base of the cone, and  $h$  is the height of the cone.



11 GOT THIS RIGHT.

25  
 22  
 19  
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2. (25 points) Determine the moments of inertia  $\bar{I}_x$  and  $\bar{I}_y$  of the area shown with respect to centroidal axes respectively parallel and perpendicular to side  $AB$ .

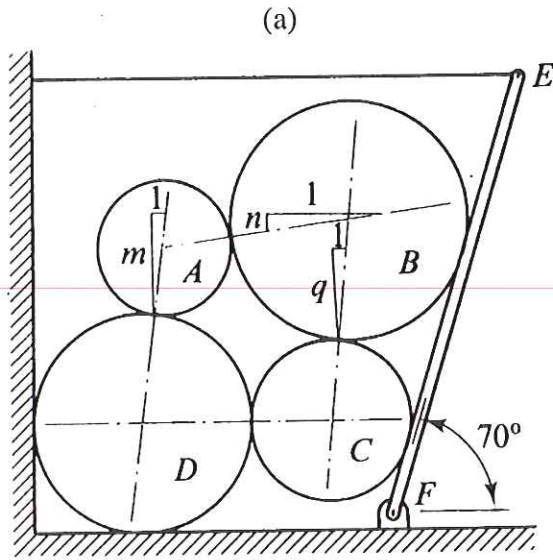


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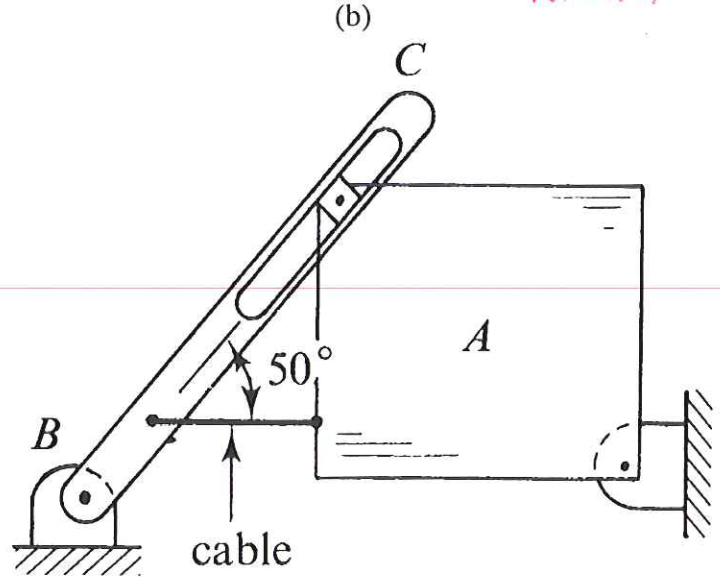
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3. (50 points) Draw the free-body diagrams necessary to solve the following situations.

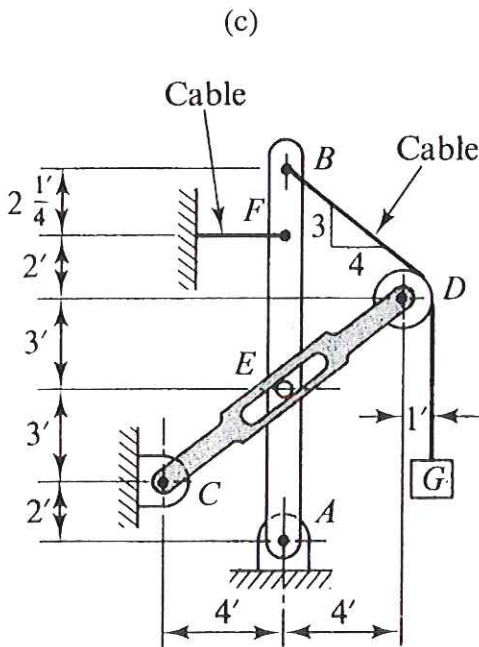
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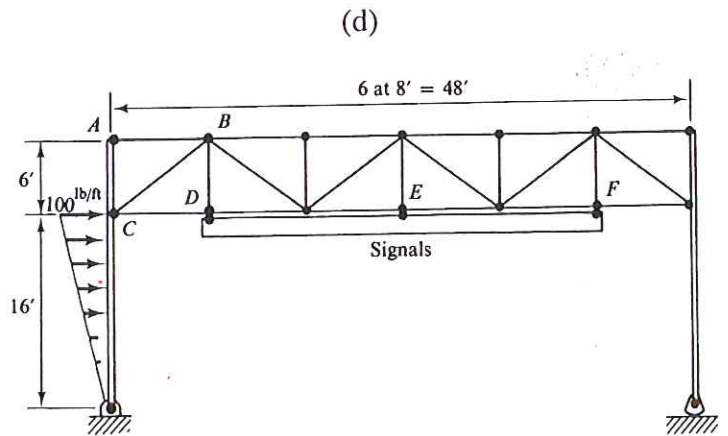
The pipes A, B, C and D weigh 30, 80, 40 and 60 lb, respectively. The pipes are stacked in the rack as shown. Draw a free-body diagram of member EF and pipe C.



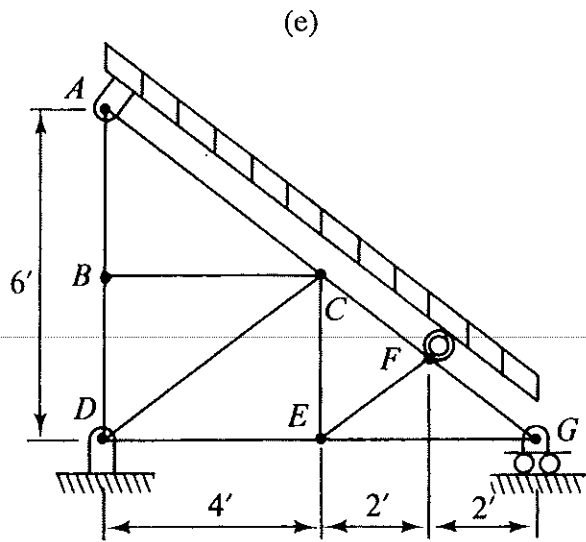
The body A has a mass of 120 kg and BC has a mass of 20 kg. Draw free-body diagrams of body A and of member BC.



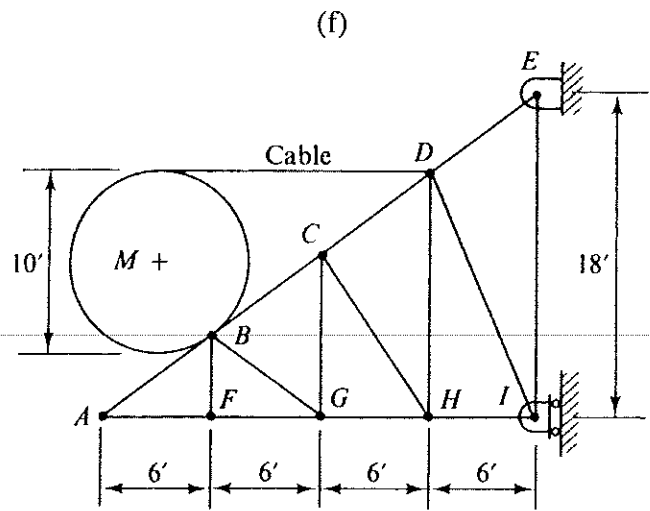
The body G weighs 1500 lb, and the weights of all other members can be neglected. Determine the force exerted by the pin at A on member AB. The roller E is pinned to member AB.



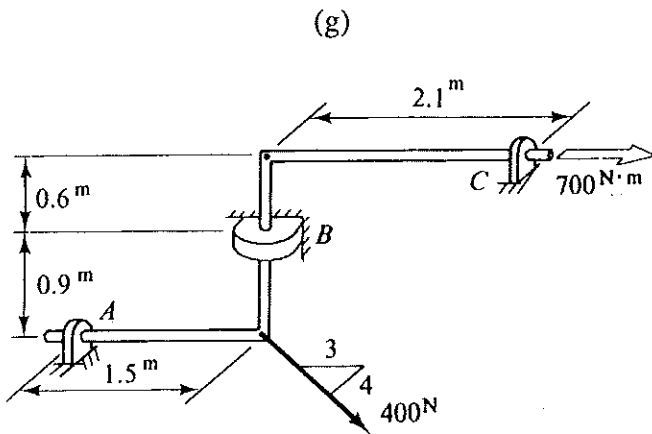
The signal truss is subjected to a distributed load and supports a signal which weighs 3000 lb. The signal is connected to the truss at joints D, E, and F, and the lengths of the connecting links are adjusted so that each one carries a third of the load. Determine the forces in members AB, BC, and CD using the method of sections.



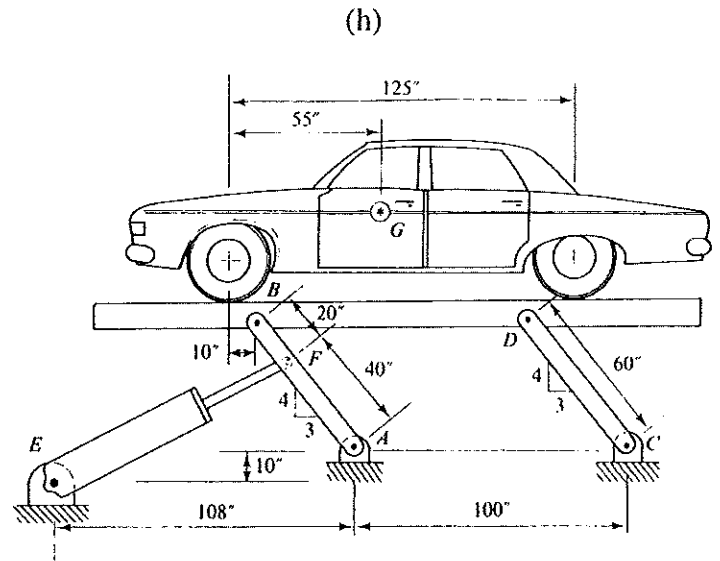
The gravel chute is supported by a truss at points A and F. The chute and contents, when full, weigh 300 lb per running foot. Determine the forces in members CE and EF of the truss.



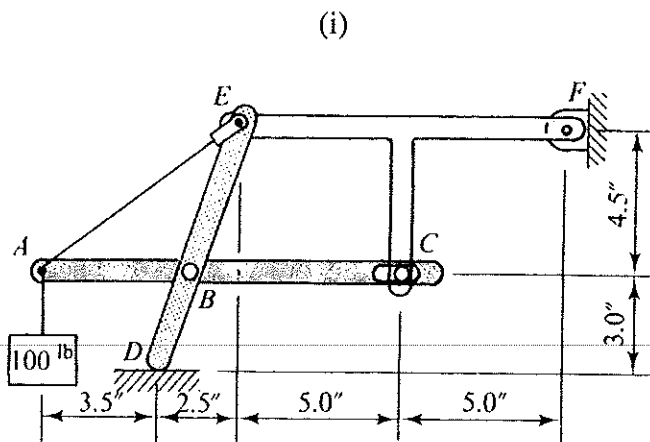
The 5000-lb drum  $M$  is supported by the truss and a cable which is wrapped around the drum and fastened to the truss at B and D. Compute the forces in members BC, GC, and GH using method of sections.



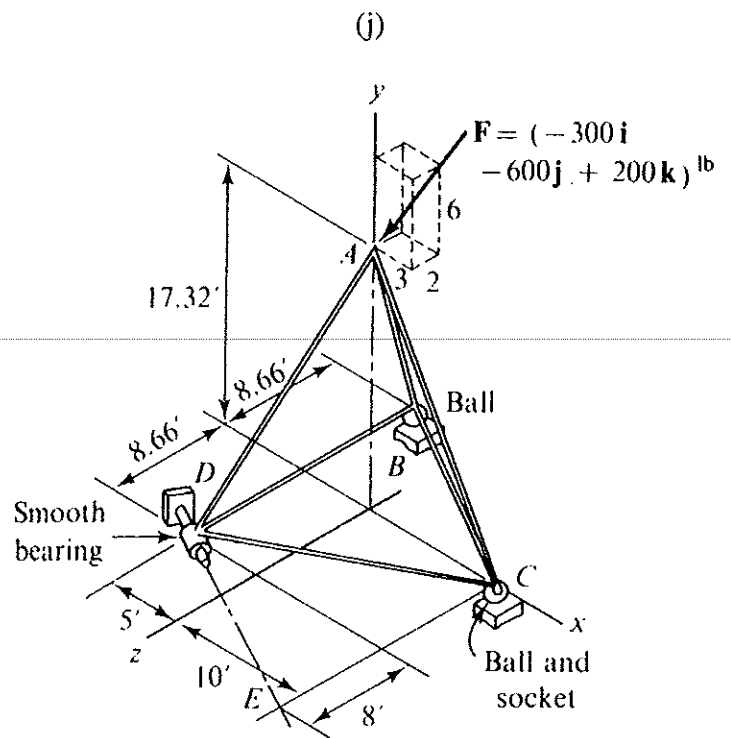
The bent rod is supported by three journal bearings at A, B, and C and lies in a vertical plane. The 400-N force is in a horizontal plane, and the vector of the 700-N·m couple is horizontal and in the plane of the rod. Determine the bearing reaction at A on the rod.



The hydraulic automobile hoist consists of two identical frames like the one shown. The hydraulic piston is centered between the two frames. A 4000-lb automobile is supported in the position shown (2000 lb on each frame). Determine the force on the piston rod EF on each of the two members AB, and the bearing reaction at A on AB.

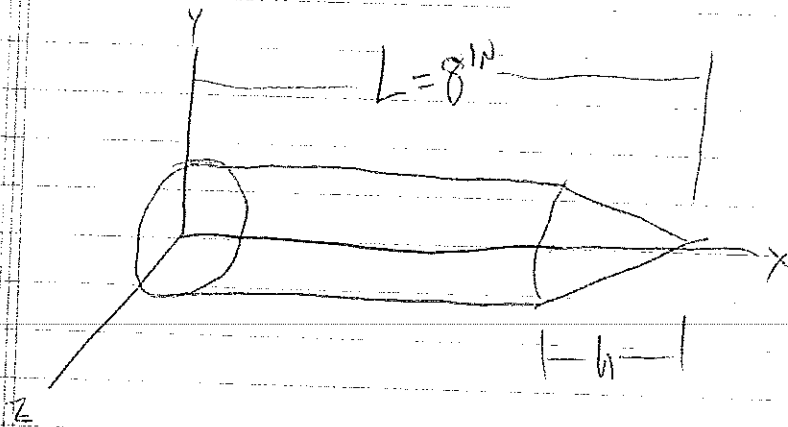


Determine the horizontal and vertical components of the reactions of the pins  $B$  and  $E$  on member  $DE$  of the pin-connected structure. Consider the point at  $A$  to be a frictionless pulley.



Determine the components of the reactions at  $B$ ,  $C$ , and  $D$  on the space frame. The pin  $D$  is parallel to  $DE$ .

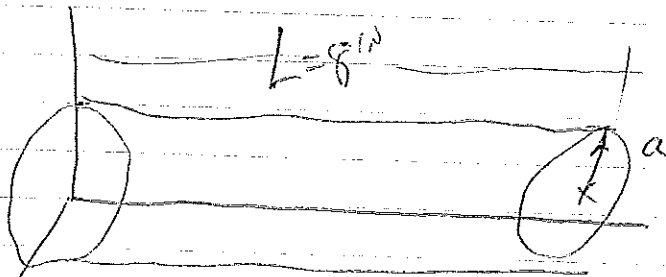
PROB. 3



$$D = 1.5 \text{ in}$$

$$(I_x)_{\text{CON.}} = 0.8 (I_x)_{\text{ROD}} \quad \text{FIND } h$$

FOR A ROD,



$$D = 1.5 \text{ in}$$

$$(I_x)_R = \frac{1}{2} m a^2$$

$$m = \rho V = \rho \cdot \pi a^2 L$$

$$(I_x)_R = \frac{\pi}{2} \rho a^4 L$$

FOR ROD/CONE,

$$(I_x)_{\text{CON}} = (I_x)_R + (I_x)_C$$

$$= \frac{1}{2} m_r a^2 + \frac{3}{10} m_c a^2$$

$$M_R = \rho V_R = \rho \pi a^2 (L-h)$$

$$M_C = \rho V_C = \rho \cdot \frac{\pi}{3} a^2 h$$

$$-\frac{2}{10} + \frac{1}{10} = -\frac{1}{10}$$

$$= -\frac{2}{5}$$

$$(I_x)_{\text{CON}} = \frac{1}{2} \cdot \rho \pi a^4 (L-h) + \frac{3}{10} \cdot \rho \frac{\pi}{3} a^4 h$$

$$= \frac{\pi}{2} \rho a^4 L - \frac{\pi}{2} \rho a^4 h + \frac{\pi}{10} \rho a^4 h$$

$$= \pi \rho a^4 \left( \frac{1}{2} L - \frac{2}{5} h \right)$$

$$= \pi \rho a^4 \left( \frac{5}{10} L - \frac{4}{10} h \right)$$

$$(I_x)_{\text{CON}} = \frac{\pi}{10} \rho a^4 (5L - 4h)$$

$$(I_x)_{\text{CON}} = 0.8 (I_x)_{\text{ROD}}$$

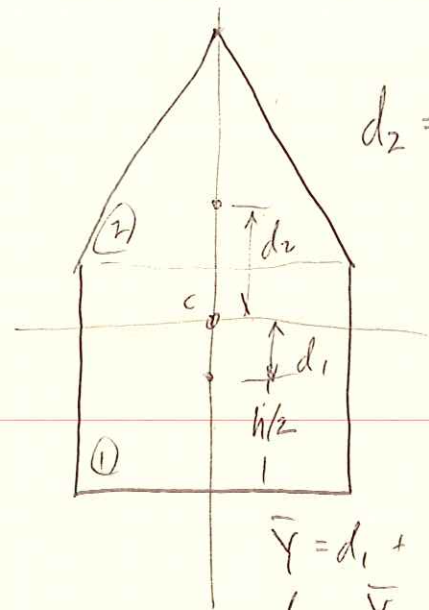
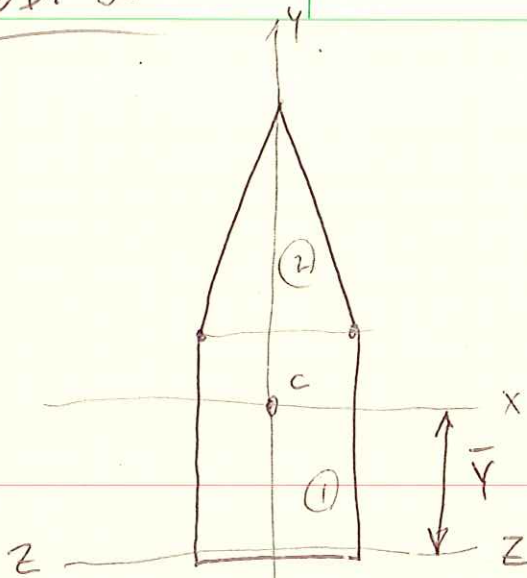
$$\frac{\pi}{10} \rho a^4 (5L - 4h) = \frac{4}{5} \cdot \frac{\pi}{2} \rho a^4 L$$

$$5L - 4h = 4L$$

$$4h = L$$

$$h = \frac{L}{4} = 2^{-1} L$$

PROB. 2



$$d_2 = (h - \bar{y}) + \frac{h}{3}$$

$$\bar{y} = d_1 + \frac{h}{2}$$

$$d_1 = \bar{y} - \frac{h}{2}$$

FIND  $\bar{y} = \frac{\sum \bar{y}_i A_i}{\sum A_i}$

AREA 1:  $\bar{y}_1 = \frac{1}{2}(1.4 \text{ in}) = 0.7 \text{ in}$ ,  $A_1 = (1.8 \text{ in})(1.4 \text{ in}) = 2.52 \text{ in}^2$

AREA 2:  $\bar{y}_2 = (1.4 \text{ in}) + \frac{1}{3}(2.1 \text{ in}) = 2.1 \text{ in}$

$$A_2 = \frac{1}{2}(1.8 \text{ in})(2.1 \text{ in}) = 1.89 \text{ in}^2$$

$$\bar{y} = \frac{(0.7 \text{ in})(2.52 \text{ in}^2) + (2.1 \text{ in})(1.89 \text{ in}^2)}{(2.52 \text{ in}^2) + (1.89 \text{ in}^2)}$$

$\bar{y} = 1.3 \text{ in}$

FIND  $I_x = I_{x,1} + I_{x,2}$

$$I_{x,1} = \bar{I}_{x,1} + A d_1^2 = \frac{1}{12} b h^3 + b h d_1^2$$

$d_1 = 1.4 \text{ in} - 1.3 \text{ in} = 0.1 \text{ in}$   $d_1 = (1.3 \text{ in}) - \frac{1}{2}(1.4 \text{ in}) = 0.6 \text{ in}$



PROB. 2 CONT.

$$I_{x,1} = \frac{1}{12} (1.8^{1N}) (1.4^{1N})^3 + (1.8^{1N}) (1.4^{1N}) (0.6^{1N})^2$$

$$I_{x,1} = \cancel{0.8368} \quad 1.319 \text{ IN}^4$$

$$I_{x,2} = \bar{I}_{x,2} + A d_2^2 = \frac{1}{36} b h^3 + \frac{1}{2} b h \cdot d_2^2$$

$$d_2 = (h_{\text{REC}} - \bar{Y}) + \frac{1}{3} h_{\text{TRI}} = (1.4^{1N}) - (1.3^{1N}) + \frac{1}{3} (2.1^{1N})$$

$$d_2 = 0.8^{1N}$$

$$I_{x,2} = \frac{1}{36} (1.8^{1N}) (2.1^{1N})^3 + \frac{1}{2} (1.8^{1N}) (2.1^{1N}) (0.8^{1N})^2$$

$$I_{x,2} = 1.673 \text{ IN}^4$$

$$I_x = (1.319 \text{ IN}^4) + (1.673 \text{ IN}^4) = 2.992 \text{ IN}^4$$

$$I_y = I_{y,1} + I_{y,2} = \cancel{\frac{1}{12} b^3 h} + \cancel{2 \left( \frac{1}{12} b h^3 \right)}$$

$$\cancel{I_y = \frac{1}{12} (1.8^{1N})^3 (1.4^{1N}) + \frac{1}{6} (2.1^{1N}) \left( \frac{1.8^{1N}}{2} \right)^3}$$

$$I_y = 0.9356 \text{ IN}^4$$

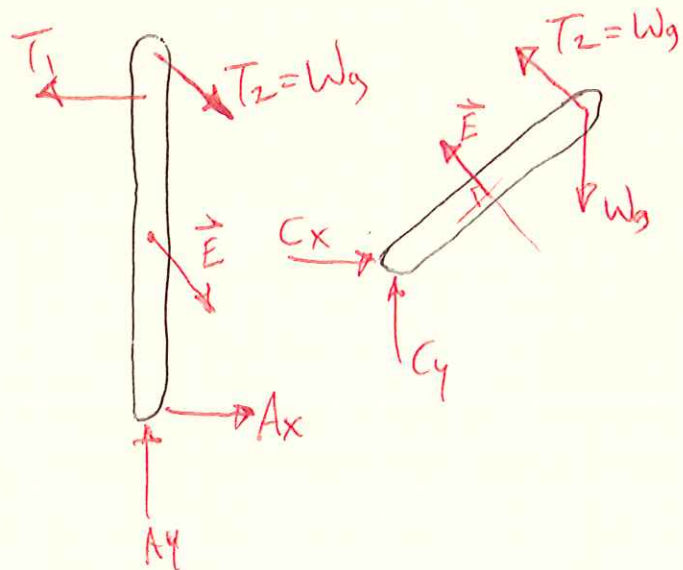
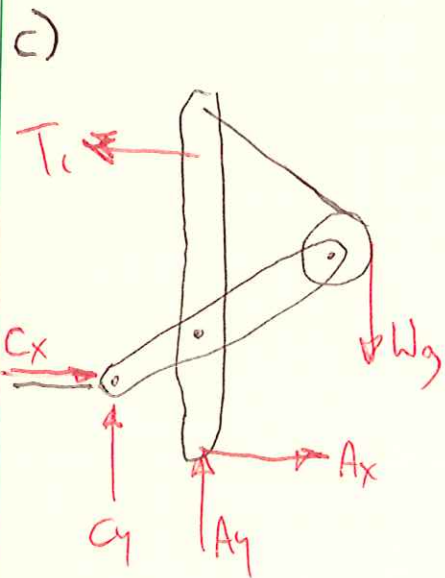
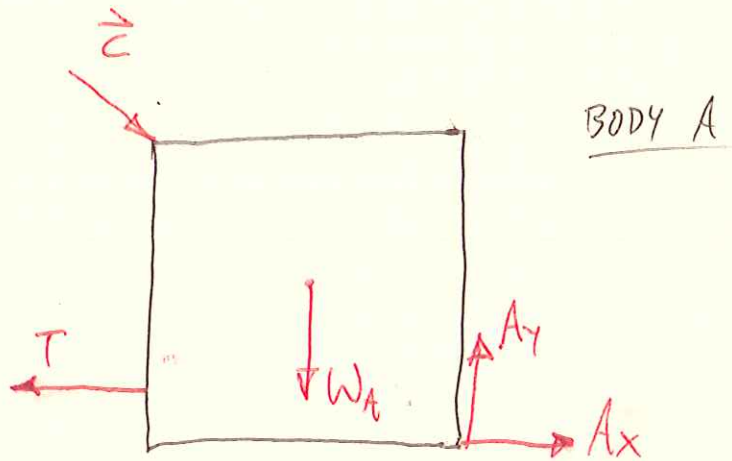
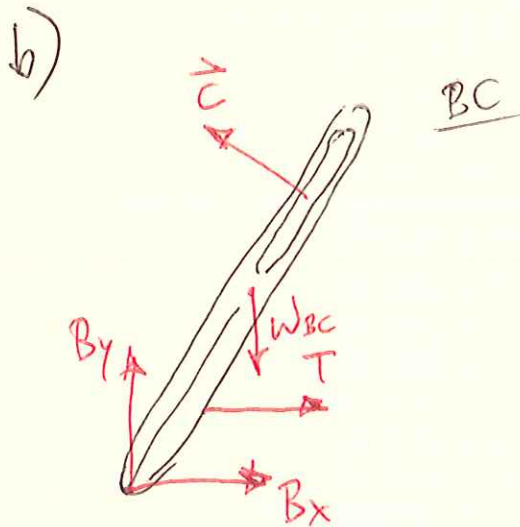
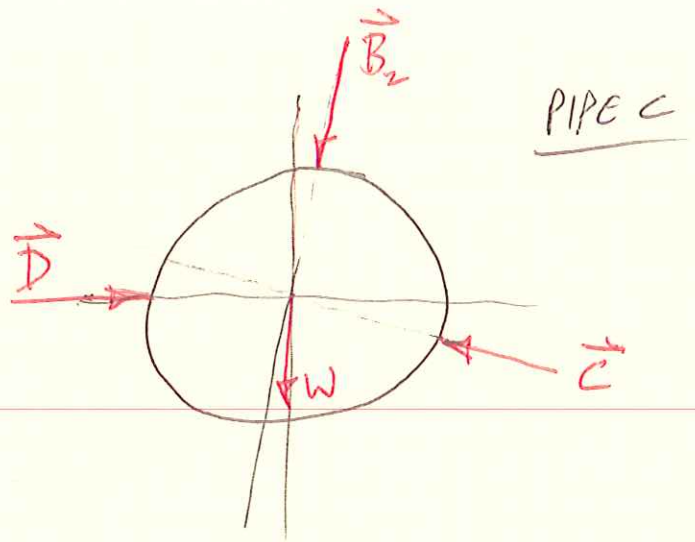
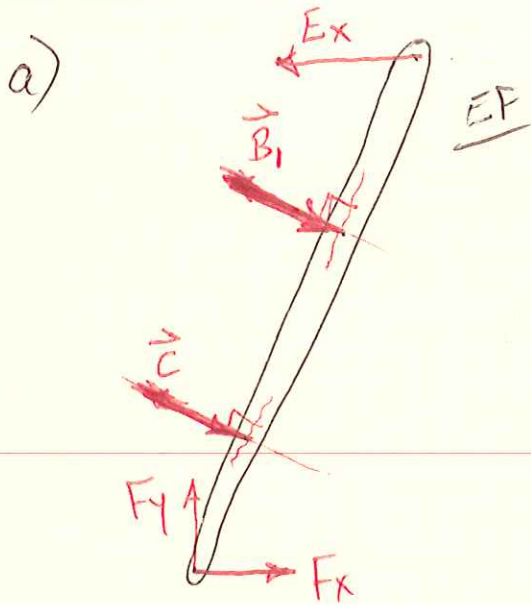
$$I_{y,1} = \frac{1}{12} b^3 h = \frac{1}{12} (1.8^{1N})^3 (1.4^{1N}) = 0.6804 \text{ IN}^4$$

$$I_{y,2} = 2 \left( \frac{1}{12} b h^3 \right) = \frac{1}{6} (2.1^{1N}) \left( \frac{1.8^{1N}}{2} \right)^3 = 0.2552 \text{ IN}^4$$

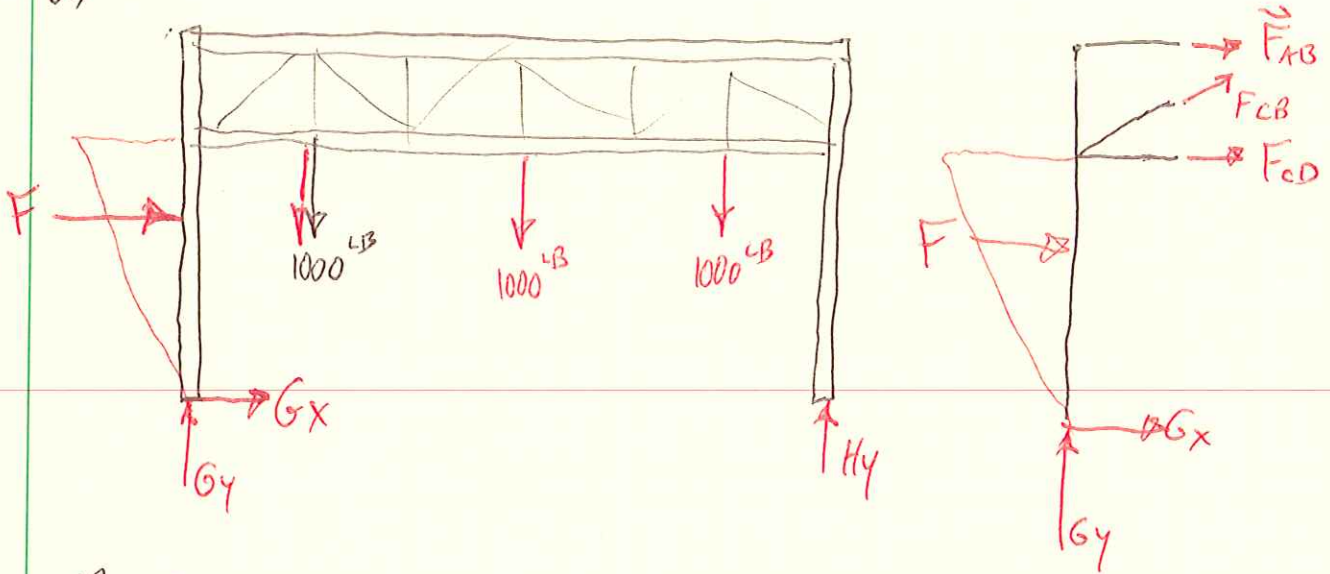
$$I_y = 0.9356 \text{ IN}^4$$



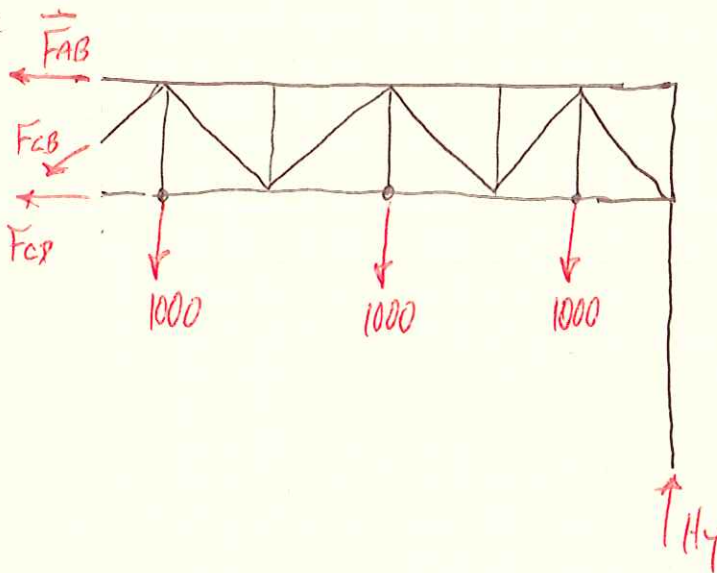
PROB. 3



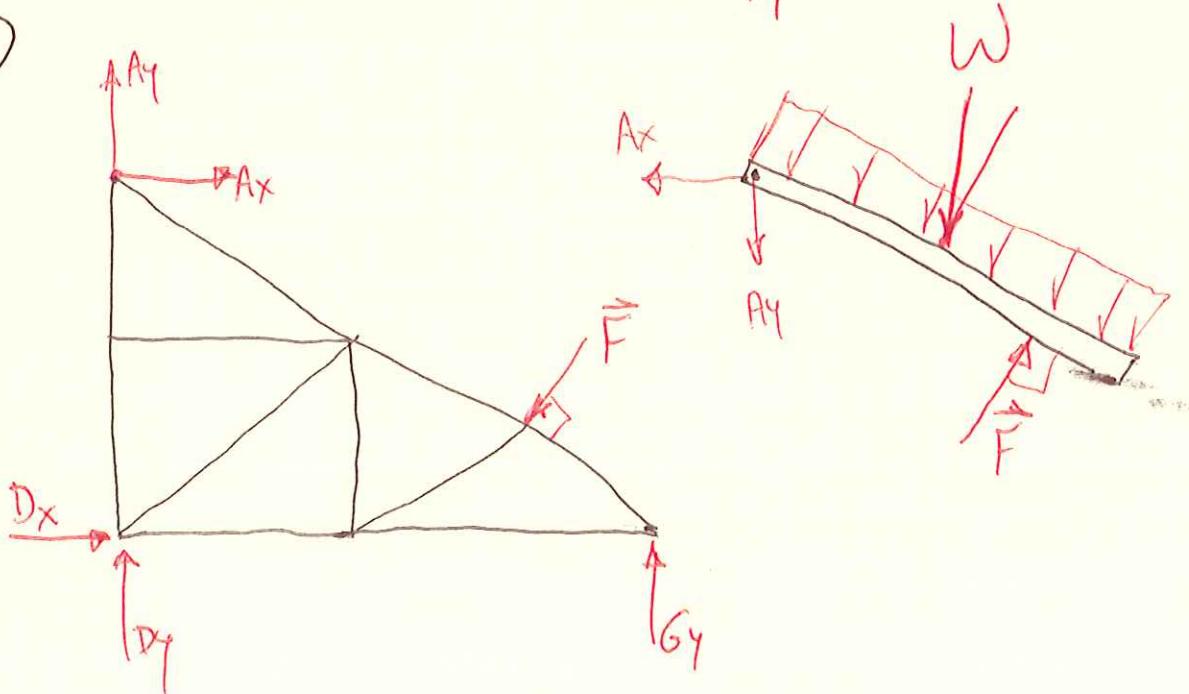
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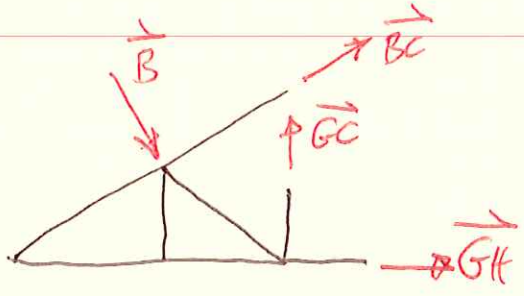
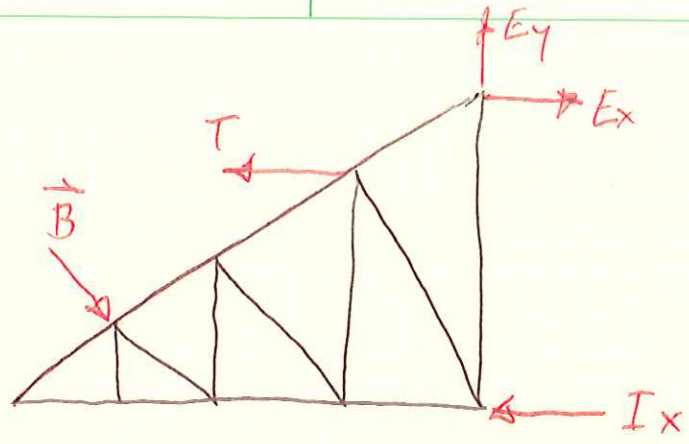
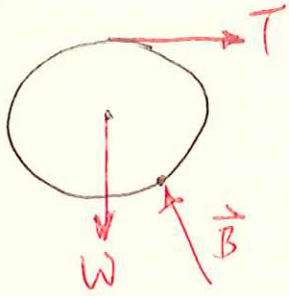
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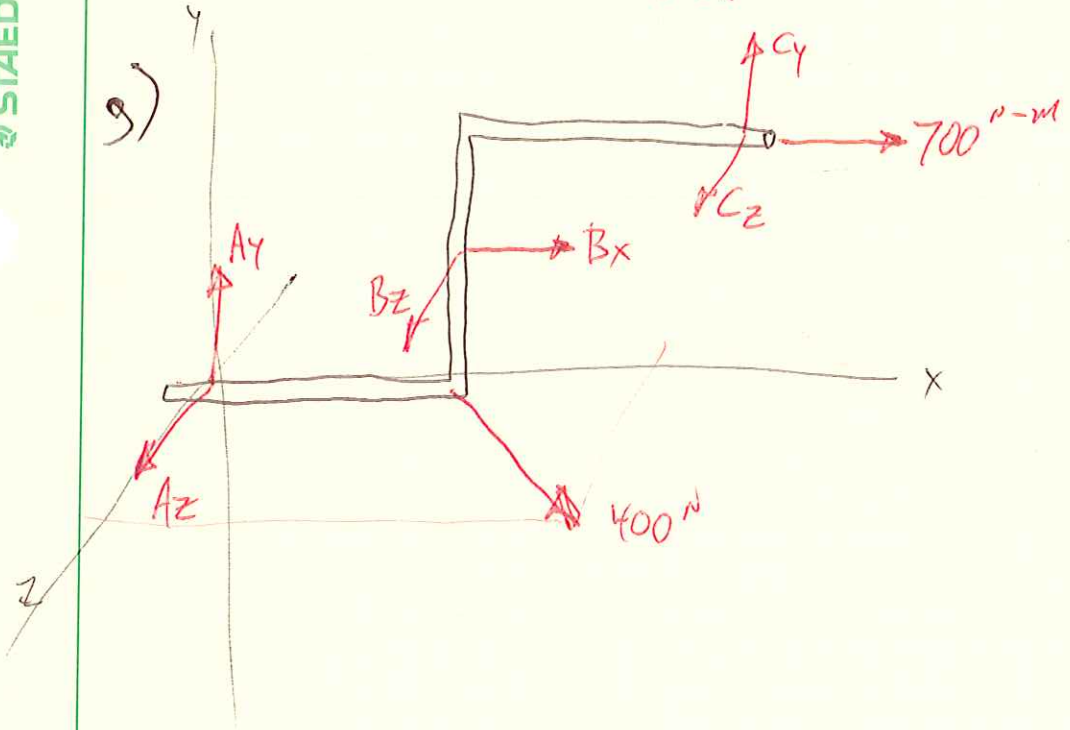
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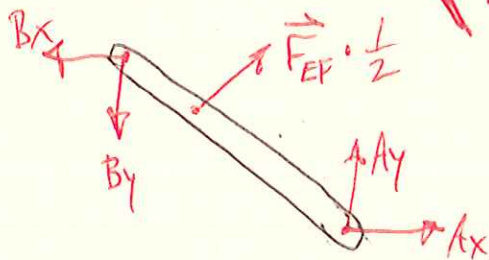
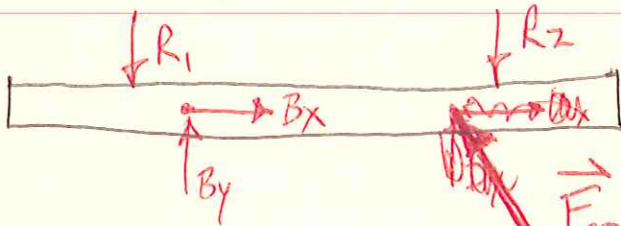
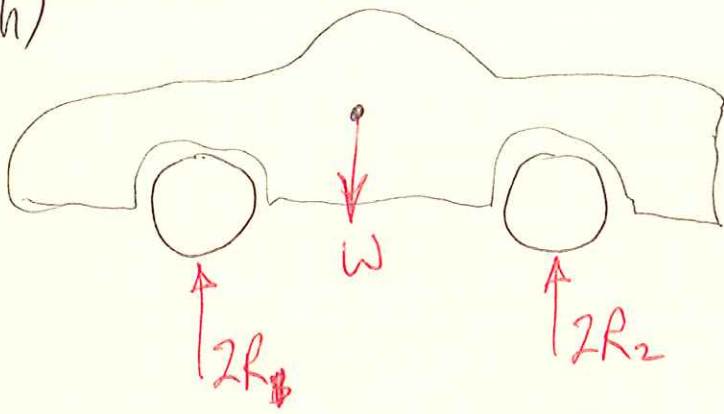


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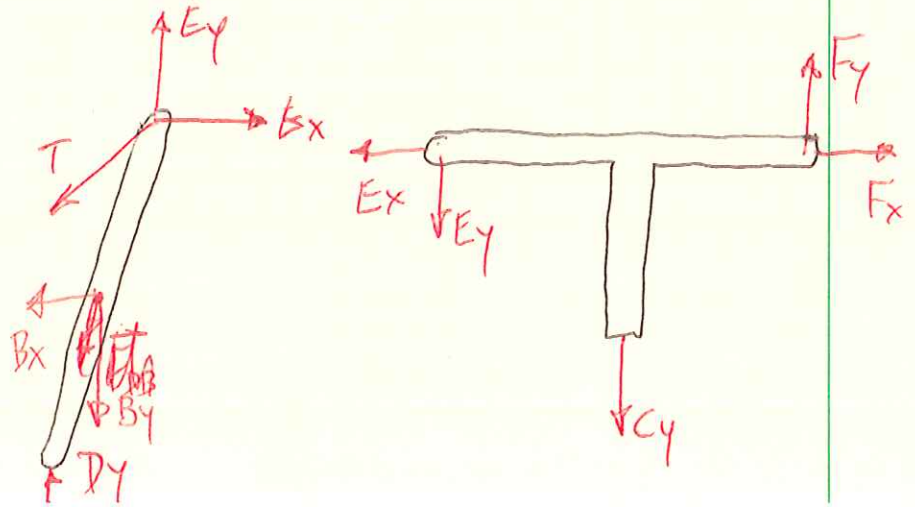
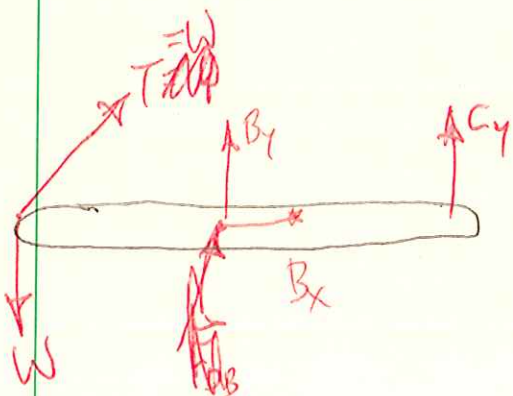
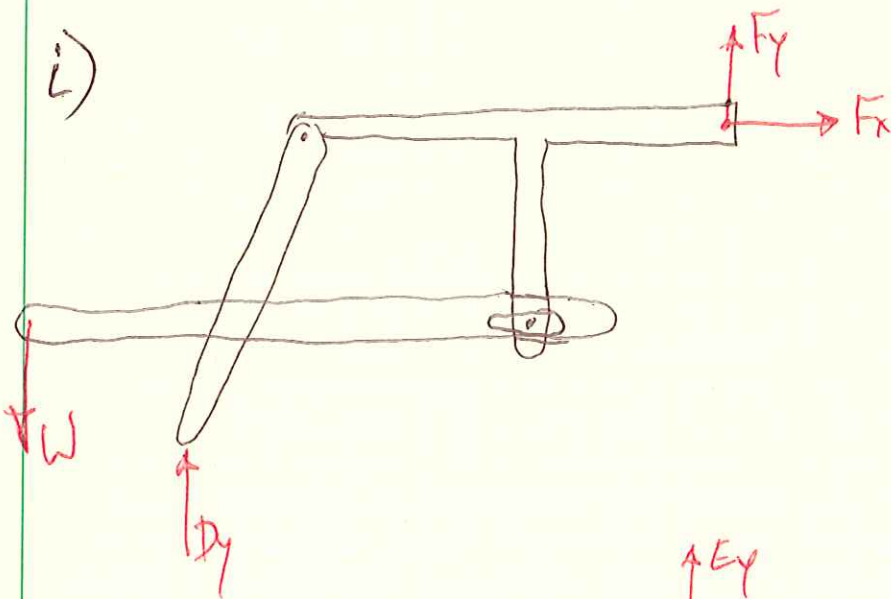


PROB. 3 CONT.

h)



i)



PROB. 3 CONT.

i)

