Problem of the day

RULES AND EXPECTATIONS: This is just for fun and exercise. Enjoy it! Solutions will be posted shortly on the course website.

EXERCISE: A suspended ceiling panel is supported by three cables vertical cables. The panel weighs 500N. Determine the tension in each of the three cables.

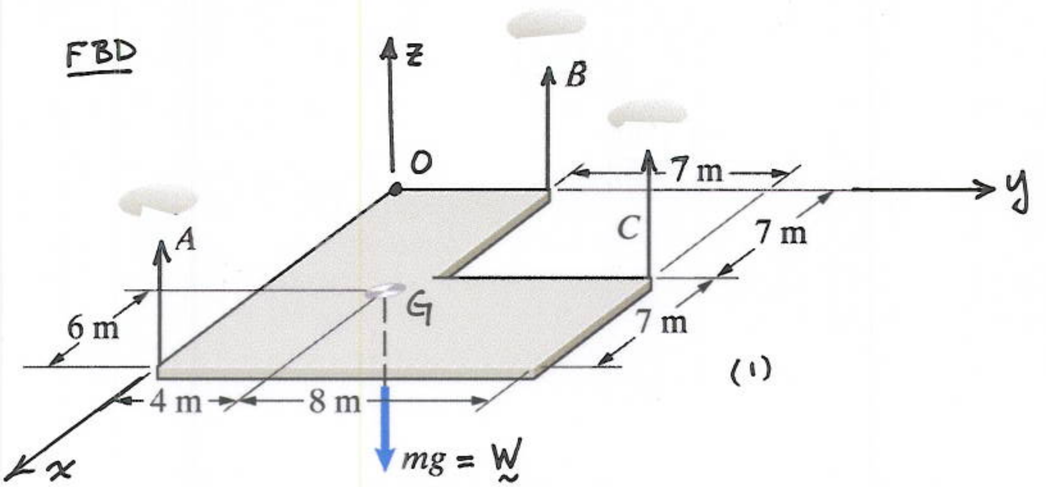


Figure: 05-18-27P5.93 - Problem 5.93

Equilibrium.

$$\Sigma \underset{\sim}{M}_O = \underset{\sim}{r}_{OA} \times \underset{\sim}{F}_A + \underset{\sim}{r}_{OB} \times \underset{\sim}{F}_B + \underset{\sim}{r}_{OC} \times \underset{\sim}{F}_C + \underset{\sim}{r}_{OG} \times \underset{\sim}{W} \quad (2)$$

$$\underset{\sim}{r}_{OA} = 14m\,\hat{i} \quad (3)$$

$$\underset{\sim}{r}_{OB} = 5m\,\hat{j} \quad (4)$$

$$\underset{\sim}{r}_{OC} = 12m\,\hat{j} + 7m\,\hat{i} \quad (5)$$

$$\underset{\sim}{r}_{OG} = 8m\,\hat{i} + 4m\,\hat{j} \quad (6)$$

$$\underset{\sim}{F}_A = F_A\,\hat{k}, \text{ etc.} \quad (7)$$

$$\underset{\sim}{W} = -500N\,\hat{k} \quad (8)$$

$$\Sigma \underset{\sim}{M}_O = 14m\,\hat{i} \times F_A\,\hat{k} + 5m\,\hat{j} \times F_B\,\hat{k} + (12m\,\hat{j} + 7m\,\hat{i}) \times F_C\,\hat{k} - (8m\,\hat{i} + 4m\,\hat{j}) \times 500N\,\hat{k} \quad (9)$$

$$= -14m\,F_A\,\hat{j} + 5m\,F_B\,\hat{i} + 12m\,F_C\,\hat{i} - 7m\,F_C\,\hat{j} + 4000N\text{-}m\,\hat{j} - 2000N\text{-}m\,\hat{i} \overset{set}{=} \underset{\sim}{0} \quad (10)$$

(10) $\cdot\,\hat{i}$:

$$5F_B + 12F_C = 2000N \quad (11)$$

$$-14F_A - 7F_C = -4000N \quad (12)$$

Use $\Sigma F_z = 0$ for third eqn:

$$\Sigma F_z = F_A + F_B + F_C - 500N \overset{set}{=} 0 \quad (13)$$

Solve (11, 12, 13):

$$F_A = 237N \qquad F_C = 98N. \qquad F_B = 165N \quad (14)$$

Problem of the day

RULES AND EXPECTATIONS: This is just for fun and exercise. Enjoy it! Solutions will be posted shortly on the course website.

EXERCISE: The weight W= 90 lb. Determine the internal force in bar AC, and whether it is in tension or compression. All joints are pin-connected.

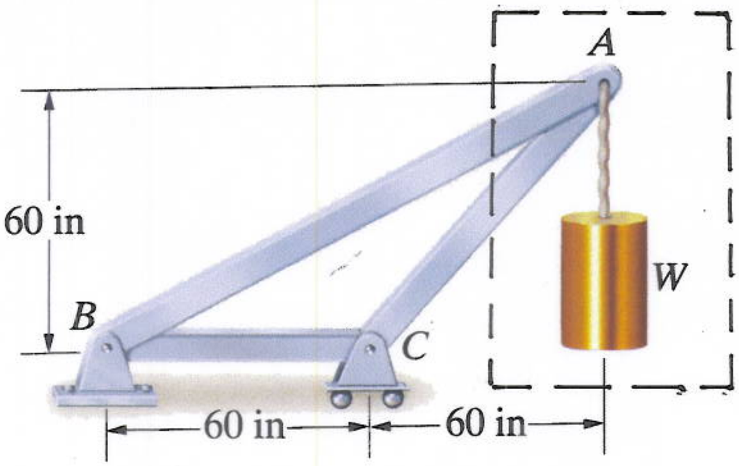
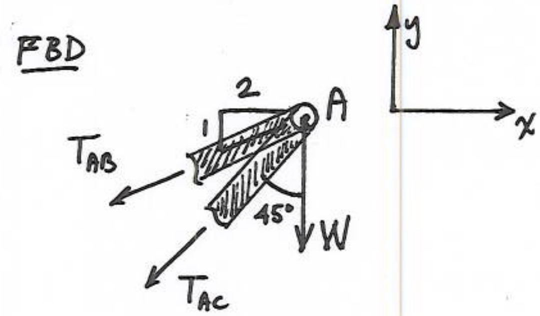
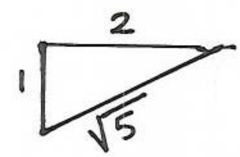


Figure: 06-11-11P6.3 - Problem 6.3





Equilibrium.

$$\Sigma F_x = -T_{AB}\frac{2}{\sqrt{5}} - T_{AC}\frac{1}{\sqrt{2}} \overset{set}{=} 0 \quad (1)$$

$$\Sigma F_y = -T_{AB}\frac{1}{\sqrt{5}} - T_{AC}\frac{1}{\sqrt{2}} - W \overset{set}{=} 0 \quad (2)$$

2(1) − (1) :

$$-T_{AC}\frac{1}{\sqrt{2}} - 2W = 0 \quad (3)$$

$$T_{AC} = -2\sqrt{2}\,W \quad (4)$$

$$\boxed{T_{AC} = 2\sqrt{2}\,W \quad \text{compression.}} \quad (5)$$

Problem of the day

RULES AND EXPECTATIONS: This is just for fun and exercise. Enjoy it! Solutions will be posted shortly on the course website.
After solving, try going through the *I've totally mastered this!* checklist:

1. Find a different way to solve it.
2. Make another problem of similar difficulty.
3. Make another similar problem that's harder. Explain why it's harder.
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5. Describe a problem from another subject similar to that this. (When you can do this, you've totally mastered the concepts here.)

EXERCISE: The weights have mass m= 30 kg. Determine the internal force in bar AD, and whether it is in tension or compression. All joints are pin-connected.

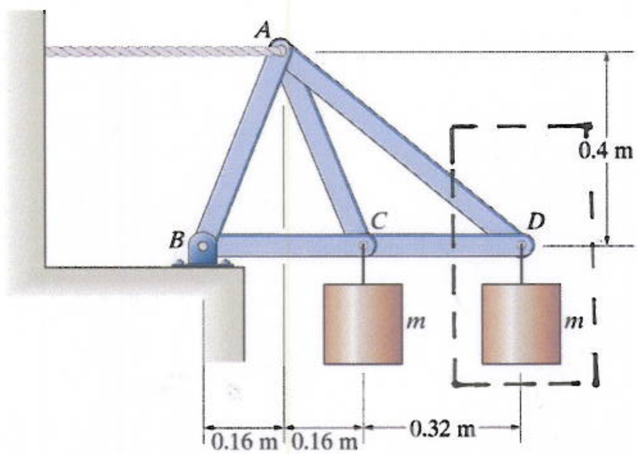
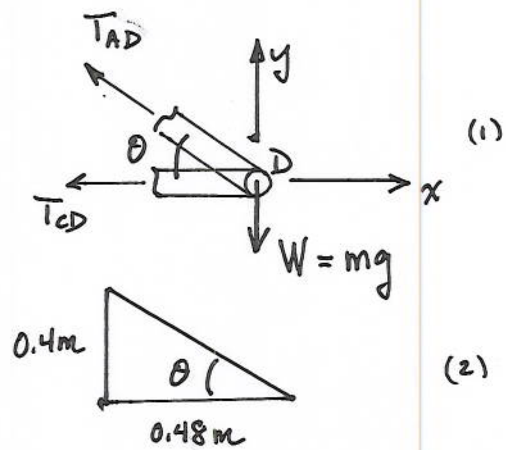


Figure: 06-11-13P6.5 - Problem 6.5



Equilibrium.

$$\Sigma F_y = T_{AD}\sin\theta - W \overset{set}{=} 0 \quad (3)$$

$$T_{AD} = \frac{W}{\sin\theta} \quad (4)$$

$$= \frac{W}{0.4/\sqrt{0.4^2+0.48^2}} \quad (5)$$

$$\boxed{T_{AD} = 459N \text{ tensim.}} \quad (6)$$

Problem of the day

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3. Make another similar problem that's harder. Explain why it's harder.
4. Explain how you solved the problem.
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EXERCISE: The bridge is supported by a pin support at A, and a roller support at H. All joints are pin-connected.

a) Determine the force within member BD. What could you change about the bridge design to reduce this load?

b) Determine the force in DE. Surprised?

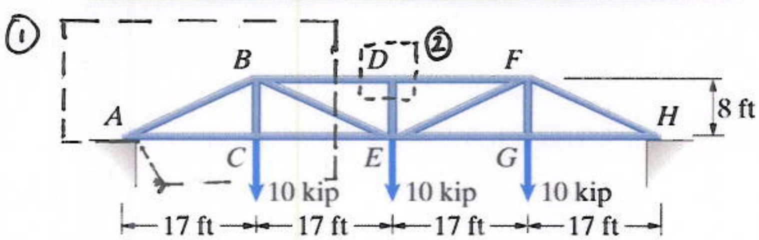
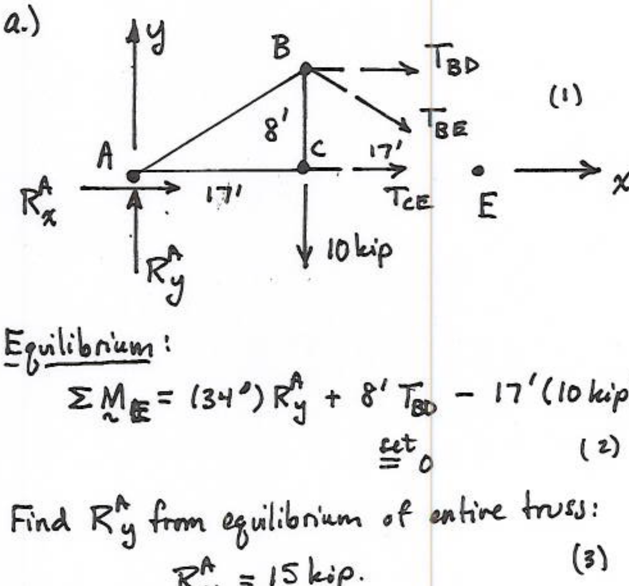


Figure: 06-11-15P6.7 - Problems 6.7/6.8

a.)



(1)

Equilibrium:

$\Sigma M_E = (34') R_y^A + 8' T_{BD} - 17'(10 \text{ kip}) \overset{\text{set}}{=} 0$ (2)

Find R_y^A from equilibrium of entire truss: (3)

$R_y^A = 15 \text{ kip}.$

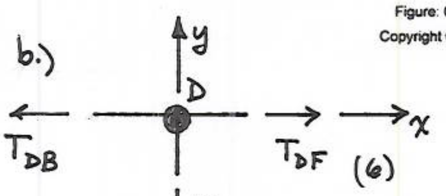
(2,3): $T_{BD} = \dfrac{170 - 510}{8 \text{ft}} \text{ kip ft}$ (4)

$= -42.5 \text{ kip}.$

$\boxed{T_{BD} = 42.5 \text{ kip compression.}}$ (5)

Increasing height above 8' reduces the compressive force in BD.

b.)



(6)

$\Sigma F_y = -T_{DE} \overset{\text{set}}{=} 0$ (7)

$\boxed{T_{DE} = 0}$ (8)

Problem of the day

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3. Make another similar problem that's harder. Explain why it's harder.
4. Explain how you solved the problem.
5. Describe a problem from another subject similar to that this. (When you can do this, you've totally mastered the concepts here.)

EXERCISE: Determine the GD internal force, that is, determine the internal force in bars GD, GE, and DF, and whether each is in tension or compression. All joints are pin-connected.

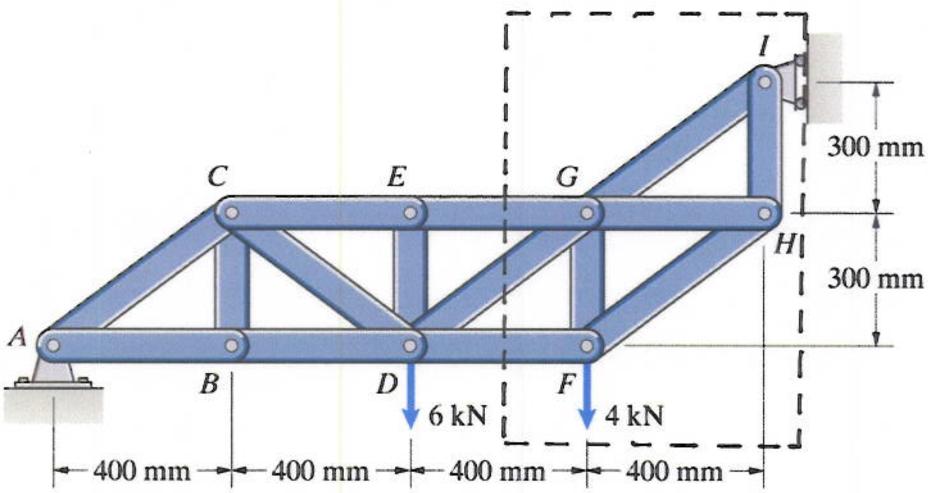
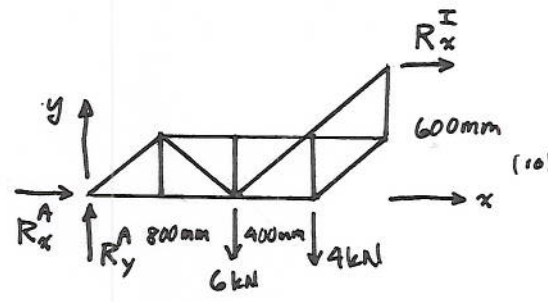
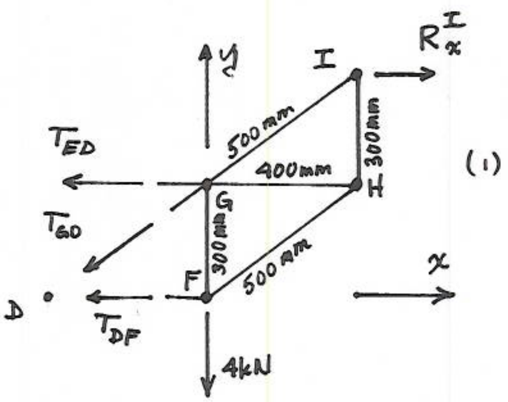


Figure: 06-13-16P6.45 - Problems 6.45/6.46





(1)

$\Sigma F_y = -T_{GD}\frac{300}{500} - 4kN \overset{set}{=} 0$ (2)

$T_{GD} = -\frac{20}{3} kN =$ -6.67 kN (3)

$\Sigma M_G = -T_{DF}(300mm) - R_x^I(300mm) = 0$ (4)

$T_{DF} = -R_x^I$ (5)

$\Sigma M_D =$

$\Sigma F_x = -T_{ED} - T_{DF} + R_x^I - T_{GD}\frac{400}{500} = 0$ (6)

$T_{ED} = 2R_x^I - T_{GD}\frac{4}{5}$ (7)

$= 2R_x^I + \frac{20}{3}\cdot\frac{4}{5} kN$ (8)

$T_{ED} = -26.7kN$ (9)

—— // ——

Find R_x^I: Use (10):

$\Sigma M_A = R_x^I(600mm) + 6kN(800mm) + 4kN(1200mm) \overset{set}{=} 0$ (10)

$R_x^I = -16kN.$ (11)

$T_{GD} = 6.67kN$
compression

$T_{DF} = 16kN$
TENSION

$T_{ED} = -26.7kN$
T_{ED} IS IN COMPRESSION.

Problem of the day

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EXERCISE: Determine the axial forces in members AD, AB, DE, and DG. Model all joints as pin-connected, and model the supports at A and I as roller supports.

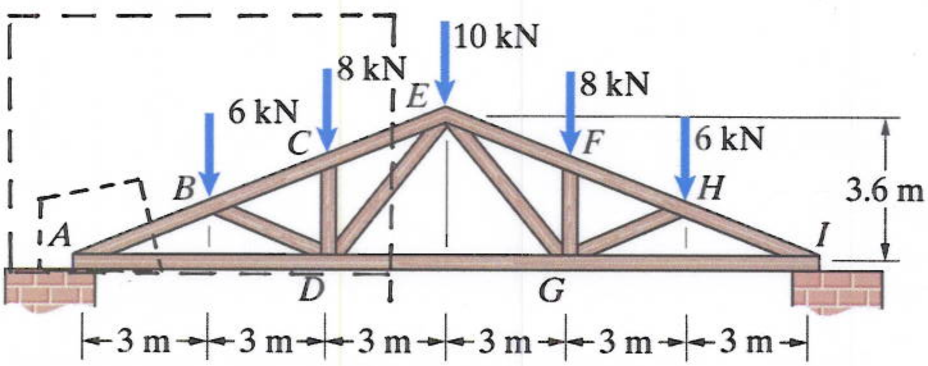
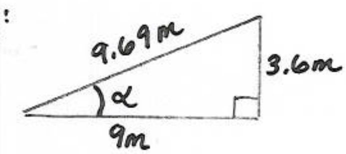


Figure: 06-11-31P6.25 - Problem 6.25

$\Sigma M_I = [(6)(3) + (8)(6) + (10)(9) + (8)(12) + 6(15)]$ kN-m $- R_y^A(18m) \overset{set}{=} 0$ (5)

$R_y^A = 19$ kN (6)

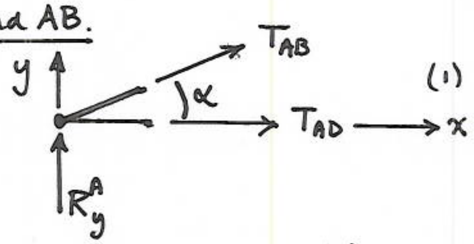
Need α:



(7)

$\sin\alpha = 0.3714$; $\cos\alpha = 0.9285$ (8)

AD and AB.



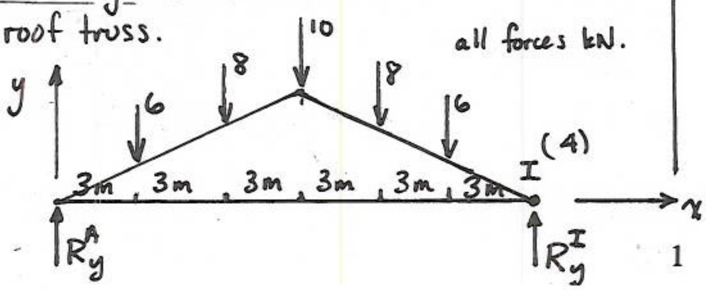
(1)

$\Sigma F_x = T_{AD} + T_{AB}\cos\alpha \overset{set}{=} 0$ (2)

$\Sigma F_y = T_{AB}\sin\alpha + R_y^A \overset{set}{=} 0$ (3)

Need R_y^A. Use box around entire roof truss.

all forces kN.

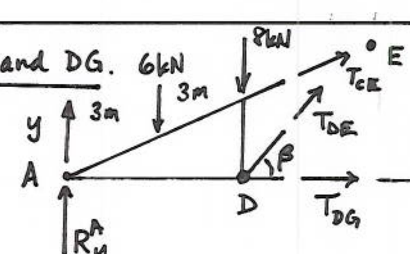


(4)

(3,6,8) $T_{AB} = -51.2$ kN (9)
IS IN COMPRESSION

(2,8,9) $T_{AD} = 47.5$ kN (10)
IS IN TENSION

DE and DG.



(11)

$\Sigma M_A = T_{DE}\sin\beta(6m) - 6kN(3m) - 8kN(6m) = 0$ (12)

→ $T_{DE} = 14.3$ kN TENSION (13)

$\Sigma M_E = T_{DG}(3.6m) + 8kN(3m) + 6kN(6m) - 19kN(9m) = 0$ (14)

→ $T_{DG} = 30.8$ kN TENSION (15)

Problem of the day

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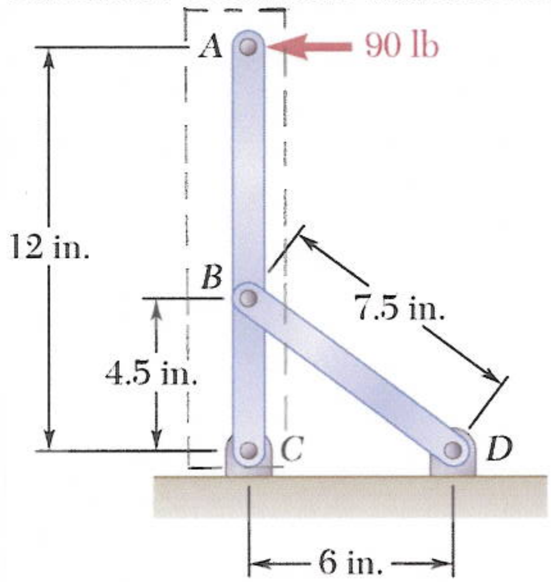
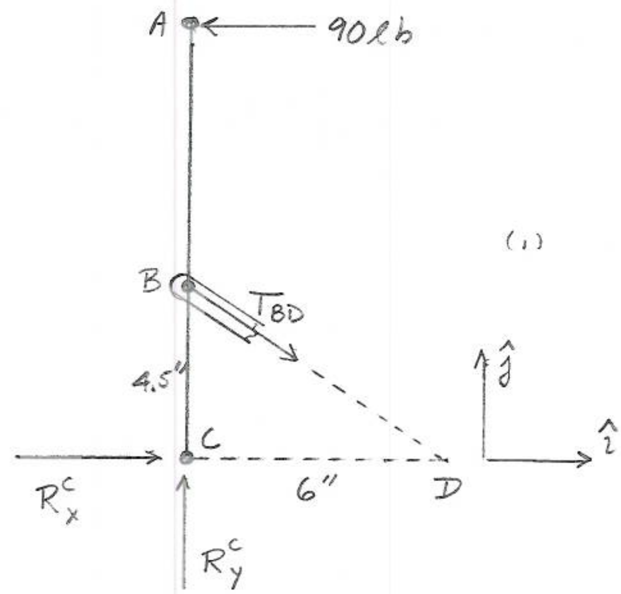
EXERCISE: Determine the axial forces in member BD and the reactions at C.





Note: Since BD is a two force member, its internal force is purely axial, i.e. $\vec{T}_{BD}$ is directed along BD.

ABC, however, has 3 forces applied. Therefore $\vec{R}^C$ need not point along ABC.

Equilibrium.

$$\Sigma M_C = (90 lb)(12 in) - T_{BD_x}(4.5 in) = 0 \quad (2)$$

From figure (1): $T_{BD_x} = T_{BD}\frac{6}{7.5} = \frac{4}{5}T_{BD}$ (3)

(2,3) $$T_{BD} = \frac{90 lb\,(12 in)}{\frac{4}{5}(4.5 in)} = 300 lb \quad (4)$$

$$\Sigma F_x = R_x^C + T_{BD_x} - 90 lb = 0 \quad (5)$$

$$R_x^C = 150 lb \quad (6)$$

$$\Sigma F_y = R_y^C - T_{BD_y} = 0 \quad (7)$$

$$R_y^C = 180 lb \quad (8)$$

Problem of the day

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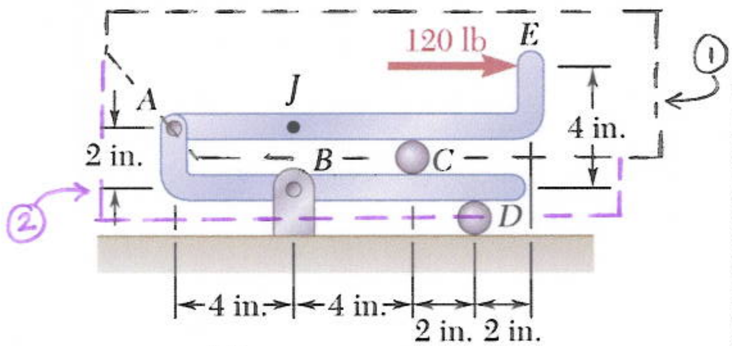
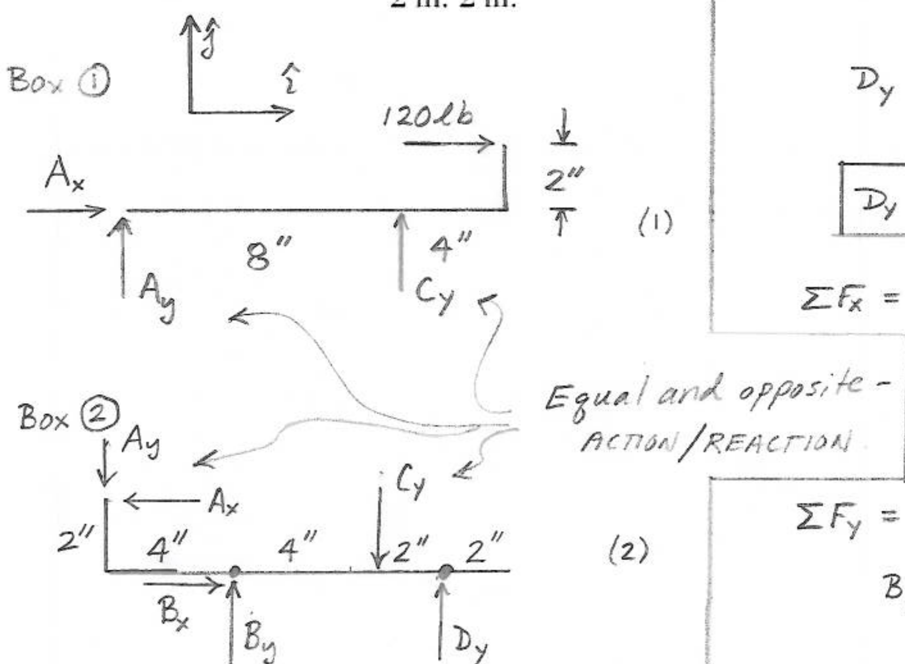
EXERCISE: Determine all the forces acting on member ABCD resulting from the applied 120 lb load.





Equilibrium in box 1

$$\Sigma F_x = 120\ell b + A_x = 0 \quad (3)$$

$$\boxed{A_x = -120\ell b.} \quad (4)$$

$$\Sigma M_A = C_y(8'') - 120\ell b(2'') = 0 \quad (5)$$

$$\boxed{C_y = 30\ell b} \quad (6)$$

$$\Sigma F_y = C_y + A_y = 0 \quad (7)$$

$$\boxed{A_y = -C_y = -30\ell b} \quad (8)$$

Equilibrium in box 2

$$\Sigma M_B = D_y(6'') - C_y(4'') + A_x(2'') + A_y(4'') = 0 \quad (9)$$

$$D_y = \frac{30\ell b(4'') + 120\ell b(2'') + 30\ell b(4'')}{6''} \quad (10)$$

$$\boxed{D_y = 80\ell b.} \quad (11)$$

$$\Sigma F_x = B_x - A_x = 0 \quad (12)$$

$$\boxed{B_x = A_x = -120\ell b.} \quad (13)$$

$$\Sigma F_y = -A_y - C_y + B_y + D_y = 0 \quad (14)$$

$$B_y = A_y + C_y - D_y \quad (15)$$

$$= -30\ell b + 30\ell b - 80\ell b \quad (16)$$

$$\boxed{B_y = -80\ell b} \quad (17)$$

Problem of the day

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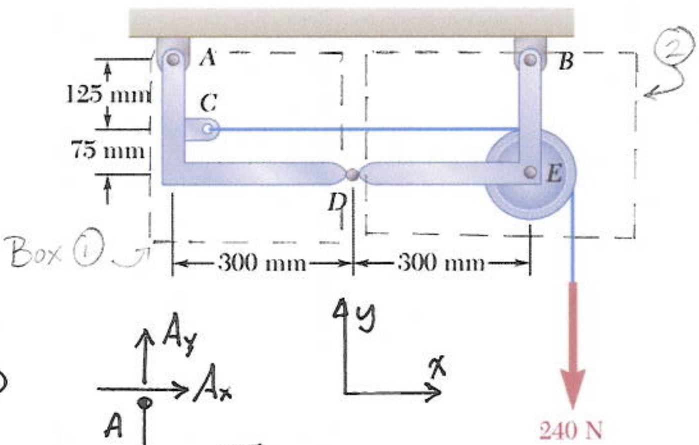
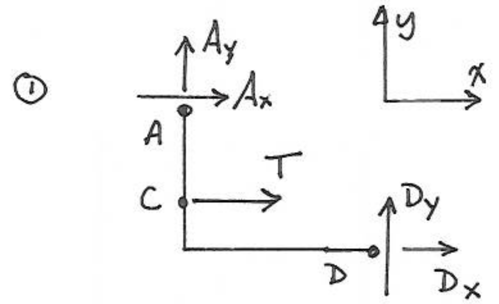
EXERCISE: Determine the reactions at A and B, and the contact forces at D resulting from the applied 240 N load.

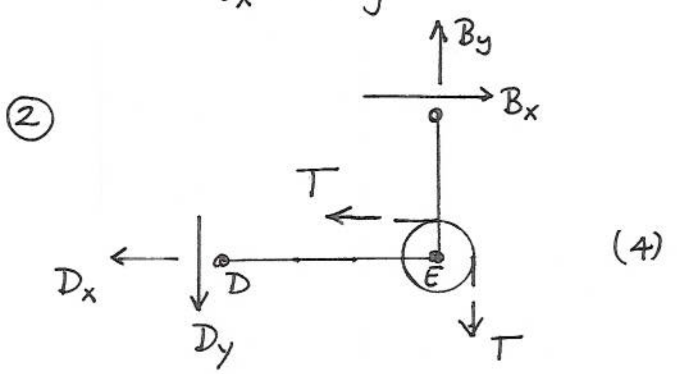




(1)

$$\Sigma M_A = (125\,mm)T + D_y(300\,mm) + D_x(200\,mm) = 0 \quad (2)$$

$$\rightarrow \; 8D_x + 12D_y = -5T \quad (3)$$



(4)

Note: D_x and D_y point in opposite directions in (4) and (1), as they should!

In (4):

$$\Sigma M_B = -T(125mm) - T(75mm) + D_y(300mm) - D_x(200mm) = 0 \quad (5)$$

$$\rightarrow \; -8D_x + 12D_y = 8T \quad (6)$$

Use (6) and (3) to find:

$$\boxed{D_y = \tfrac{1}{8}T = 30N. \quad (7) \qquad D_x = -\tfrac{13}{16}T = 195N \quad (8)}$$

In (1):

$$\Sigma F_x = A_x + T + D_x = 0 \quad (9)$$

(8): $$\boxed{A_x = -\tfrac{3}{16}T = -45N} \quad (10)$$

$$\Sigma F_y = A_y + D_y = 0 \quad (11)$$

(7): $$\boxed{A_y = -\tfrac{1}{8}T = -30N} \quad (12)$$

In (4):

$$\Sigma F_x = B_x - T - D_x = 0 \quad (13)$$

(8): $$\boxed{B_x = \tfrac{3}{16}T = 45N} \quad (14)$$

$$\Sigma F_y = B_y - T - D_y = 0 \quad (15)$$

(7): $$\boxed{B_y = \tfrac{9}{8}T = 270N} \quad (16)$$

Problem of the day

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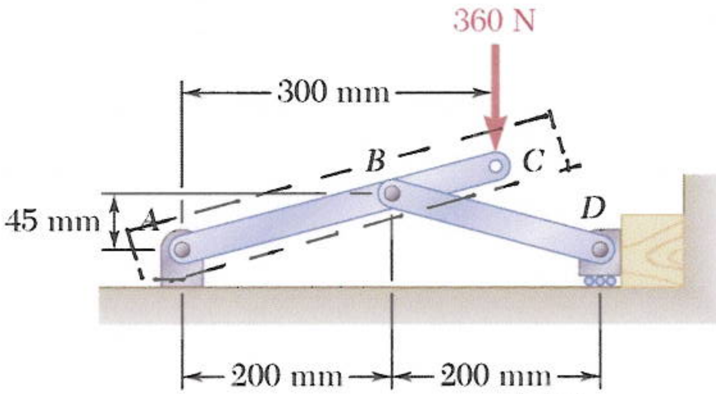
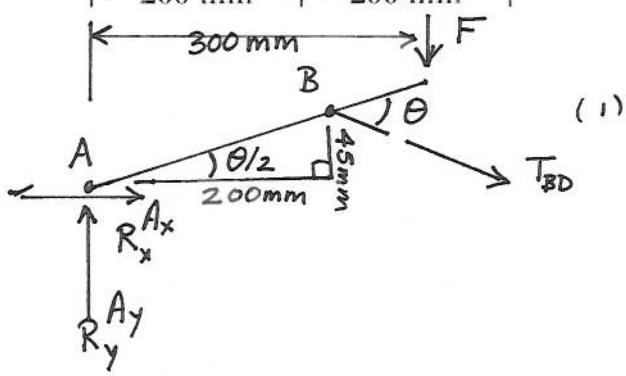
EXERCISE: The device shown is a "toggle vice". Determine the force exerted on the block at D and the force exerted on ABC at B, by the bar BD.





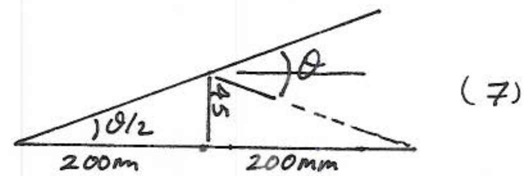
$$\Sigma M_A = -F(300mm)\hat{k} + \vec{r}_{AB} \times \vec{T}_{BD} \stackrel{set}{=} \vec{0} \quad (2)$$

$$\vec{r}_{AB} \times \vec{T}_{BD} = -\|\vec{r}_{AB}\|\,\|\vec{T}_{BD}\| \sin\theta \hat{k} \quad (3)$$

$$\|\vec{r}_{AB}\| = \sqrt{(200mm)^2 + (45mm)^2} \quad (4)$$

$$= 205mm \quad (5)$$

$$T_{BD} = \|T_{BD}\| \quad (6)$$



$$\tan\frac{\theta}{2} = 45/200 \quad (8)$$

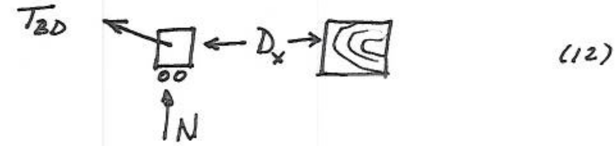
$$\sin\theta = 0.4283 \quad (9)$$

$$\vec{r}_{AB} \times \vec{T}_{BD} = -T_{BD}(87.805\,mm)\hat{k} \quad (10)$$

(10) in (2):

$$\boxed{T_{BD} = -\frac{41}{12}F = -1230N} \quad (11)$$

At D:



$$D_x = -T_{BD} \cos\frac{\theta}{2} \quad (13)$$

$$\boxed{D_x = 1200N.} \quad (14)$$

Problem of the day

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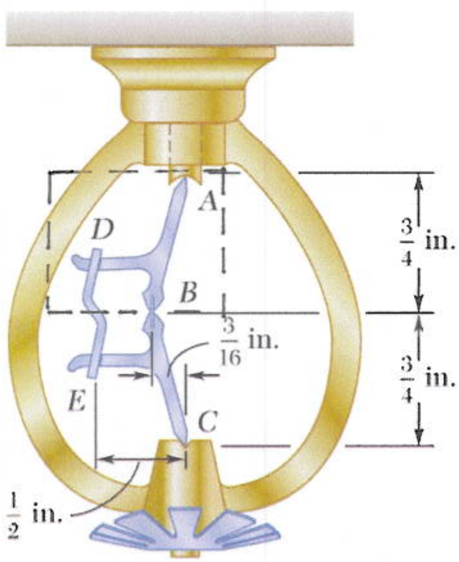
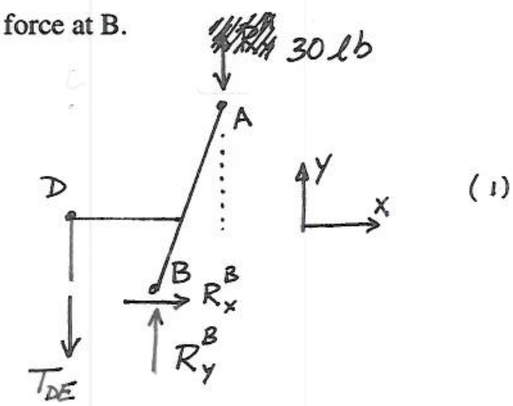
4. Explain how you solved the problem.
5. Describe a problem from another subject similar to that this. (When you can do this, you've totally mastered the concepts here.)

EXERCISE: Shown is a fire sprinkler, like those on the ceilings of many public buildings. When the fusible link DE is broken, the sprinkler is activated. In its off state, water pressure exerts a force of 30 lb on the plug valve at A, which is held in place by the (intact) fusible link DE. Elements ABD and CBE are connected by a hinge joint at B.
Determine the tension in DE (pretend it's straight) and the contact force at B.





$$\Sigma M_B = T_{DE}(1/2'' - 3/16'') - 30\,lb(1/2'') = 0 \quad (2)$$

$$T_{DE} = 30\,lb \times \frac{1}{2} \times \frac{16}{5} \quad (3)$$

$$\boxed{T_{DE} = 48\,lb.} \quad (4)$$

$$\Sigma F_y = R_y^B - T_{DE} - 30\,lb = 0 \quad (5)$$

$$\boxed{R_y^B = 78\,lb} \quad (6)$$

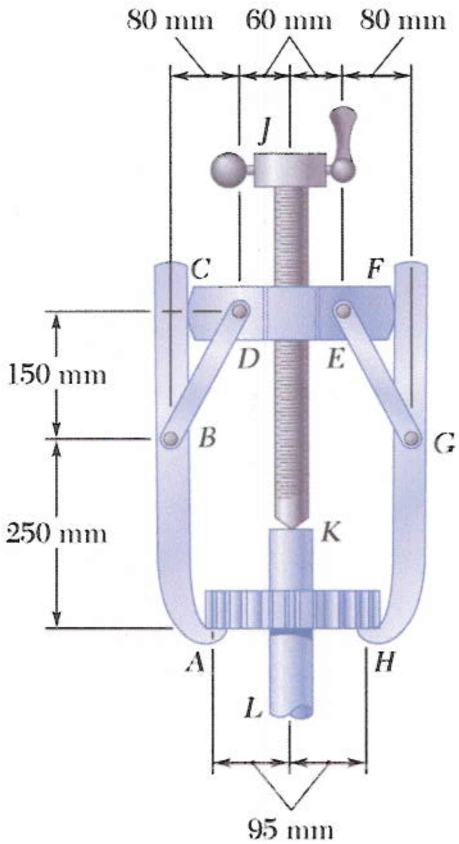
$$\Sigma F_x = \boxed{R_x^B = 0} \quad (7)$$

Problem of the day

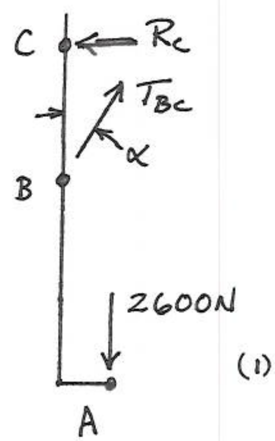
RULES AND EXPECTATIONS: This is just for fun and exercise. Enjoy it! Solutions will be posted shortly on the course website. After solving, try going through the *I've totally mastered this!* checklist:

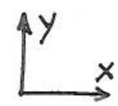
1. Find a different way to solve it.
2. Make another problem of similar difficulty.
3. Make another similar problem that's harder. Explain why it's harder.
4. Explain how you solved the problem.
5. Describe a problem from another subject similar to that this. (When you can do this, you've totally mastered the concepts here.)

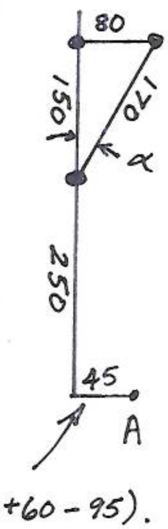
EXERCISE: The gear puller works by screwing the center rod (JK) through the crosshead (CF). This action pushes the axle KL off the gear AH. Suppose that a force of 5200N is required to push the axle through the gear. Determine the forces acting on ABC.



all dimensions mm.







(2)

$$\Sigma M_B = -(2600N)(45mm) + R_c(150mm) = 0 \quad (3)$$

$$\boxed{R_c = 780N} \quad (4)$$

$$\Sigma F_x = -R_c + T_{BC}\sin\alpha = 0 \quad (5)$$

(2): $\sin\alpha = 80/170$ (6)

(5,6): $T_{BC} = R_c/\sin\alpha = (780N)\frac{(170)}{80}$ (7)

$= 1657.5N$ (8)

$$\boxed{T_{BC} \approx 1660N} \quad (9)$$