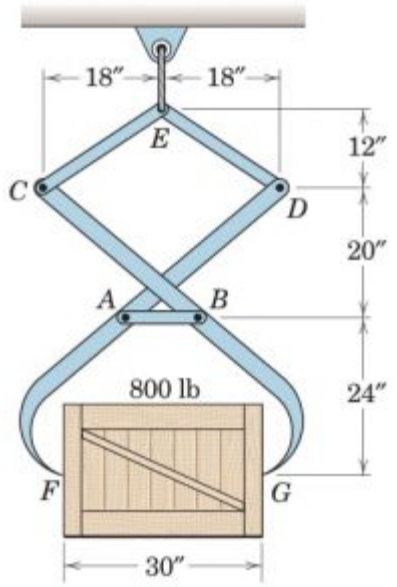
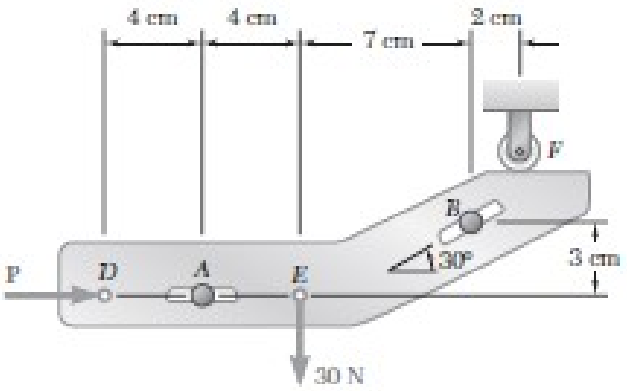
Practice Problems (Engineering Mechanics: ME102)

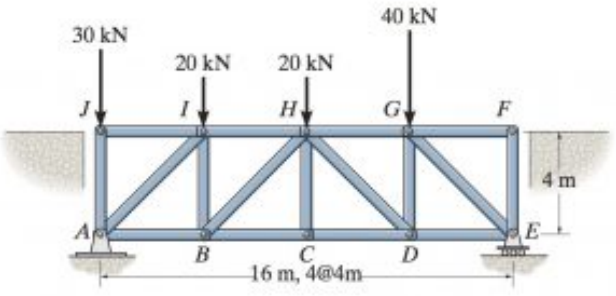
1. Compute the force in link AB of the lifting tongs which cross without touching.

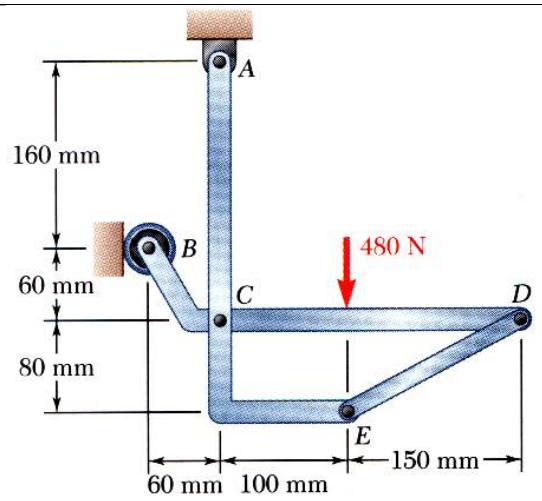
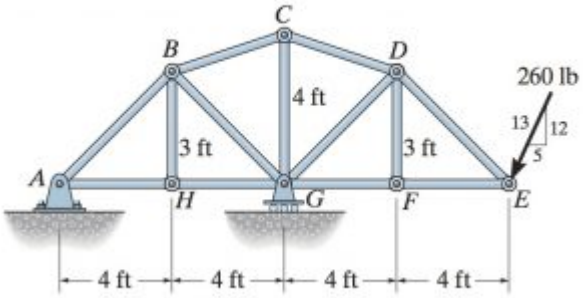
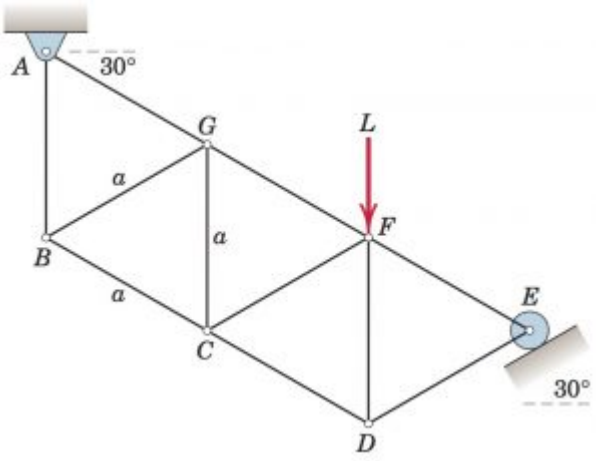


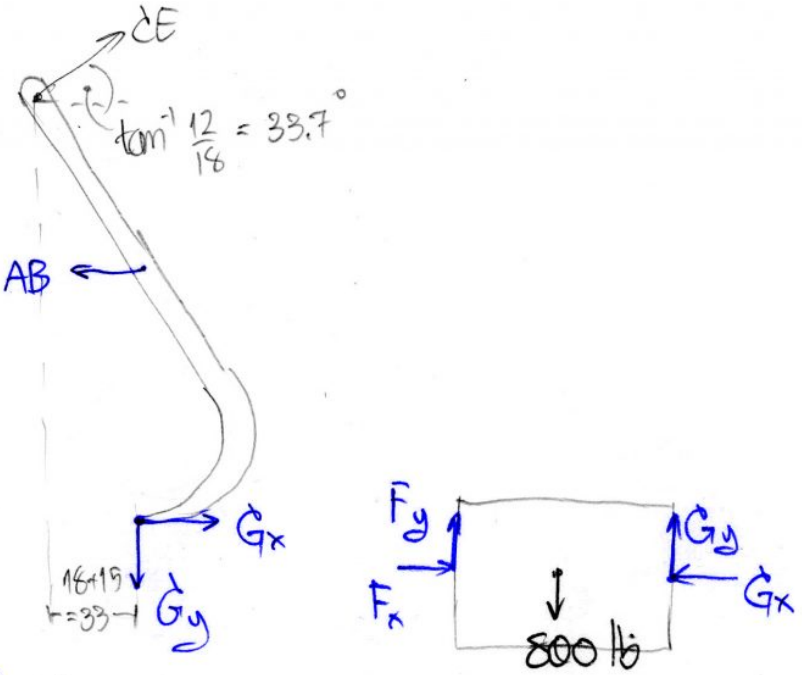
2. Two slots have been cut in plate DEF, and the plate has so that the slot fit two fixed, frictionless pins A and B. Knowing that P = 15 kN. Determine the (a) force each pin exerts on the plate (b) and the reaction force F



3. Using the method of joints, determine the force in members *EG*, and *ED*, and state if the members are in tension or compression.



4. Members ACE and BCD are connected by a pin at C and by the link DE. For the loading shown, determine the force in link DE and the components of the force exerted at C on member BCD.	
5. Find the force in member BG	
6. The truss is composed of equilateral triangles of side a and is supported and loaded as shown. Determine the forces in member CD.	



FG: $\circlearrowleft \Sigma M_F = 0$: $800(15) - G_y(30) = 0 \rightarrow G_y = 400$ lb.

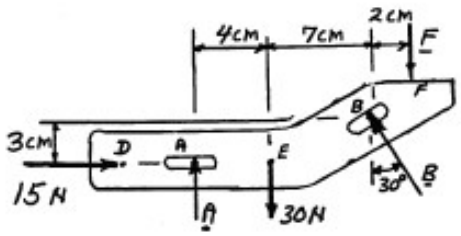
BCG: $\Sigma F_y = 0$: $CE\sin 33.7 - 400 = 0 \rightarrow CE = 721$ lb.

$\circlearrowleft \Sigma M_G = 0$: $CE\sin 33.7(33) + CE(\cos 33.7(44) - AB(24) = 0$

$AB = 1650$ lb Ans

SOLUTION

Free-Body Diagram:



$\pm\ \Sigma F_x = 0$: $15\text{ N} - B\sin 30^\circ = 0$ **B** = 30.0 N ◺ 60.0° ◀

$+\circlearrowleft \Sigma M_A = 0$: $-(30\text{ N})(4\text{ cm}) + B\sin30^\circ(3\text{ cm}) + B\cos30^\circ(11\text{ cm}) - F(13\text{ cm}) = 0$

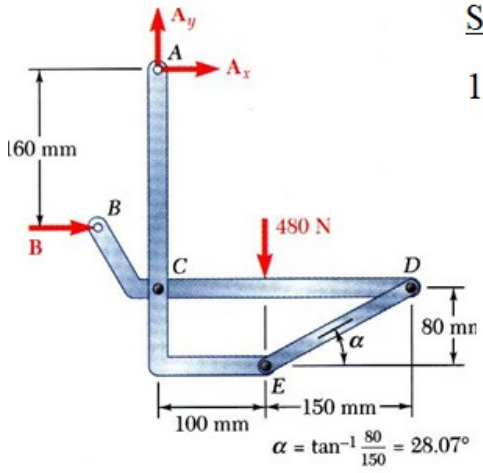
$-120\text{ N}\cdot\text{cm} + (30\text{ N})\sin30^\circ(3\text{ cm}) + (30\text{ N})\cos30^\circ(11\text{ cm}) - F(13\text{ cm}) = 0$

$F = +16.2145\text{ N}$ **F** = 16.2 N ↓ ◀

$+\uparrow \Sigma F_y = 0$: $A - 30\text{ N} + B\cos30^\circ - F = 0$

$A - 30\text{ N} + (30\text{ N})\cos30^\circ - 16.2145\text{ N} = 0$

$A = +20.23\text{ N}$ **A** = 20.2 N ↑ ◀



SOLUTION:

1. Create a free-body diagram for the complete frame and solve for the support reactions.

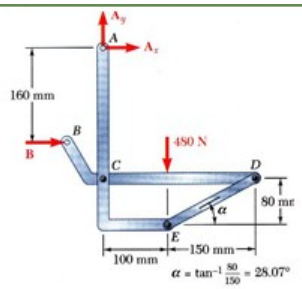
$\sum F_y = 0 = A_y - 480\text{ N}$ $\boxed{A_y = 480\text{ N}}$

$\sum M_A = 0 = -(480\text{ N})(100\text{ mm}) + B(160\text{ mm})$

$\boxed{B = 300\text{ N}}$

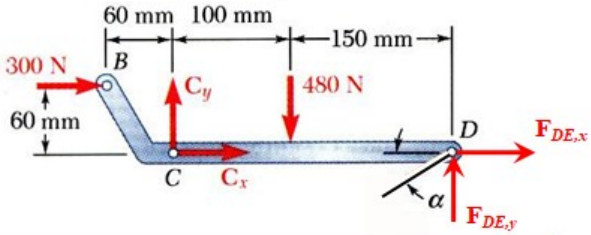
$\sum F_x = 0 = B + A_x$

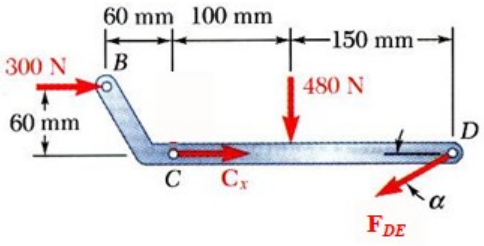
$A_x = -300\text{ N}$ $\boxed{A_x = -300\text{ N}}$

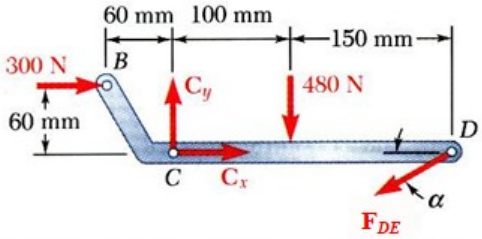


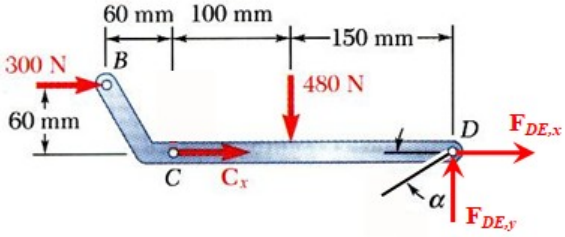
SOLUTION (cont.):

2. Create a free body diagram for member *BCD* (since the problem asked for forces on this body). Choose the best FBD, then discuss your choice with a neighbor. Justify your choice.



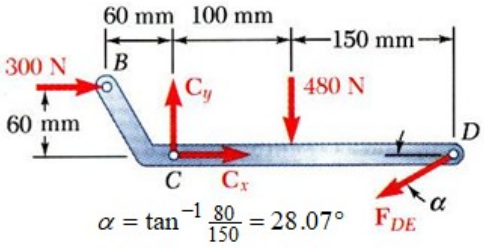






SOLUTION (cont.):

3. Using the best FBD for member *BCD*, what is the one equilibrium equation that can directly find $\mathbf{F}_{DE}$? Please discuss.



$$\sum M_C = 0 = (F_{DE}\sin\alpha)(250\text{ mm}) + (300\text{ N})(60\text{ mm}) + (480\text{ N})(100\text{ mm})$$

$$F_{DE} = -561\text{ N} \qquad \boxed{F_{DE} = 561\text{ N } C}$$

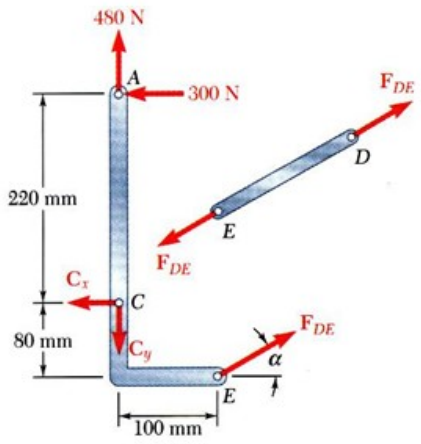
- Sum of forces in the *x* and *y* directions may be used to find the force components at *C*.

$$\sum F_x = 0 = C_x - F_{DE}\cos\alpha + 300\text{ N}$$

$$0 = C_x - (-561\text{ N})\cos\alpha + 300\text{ N} \qquad \boxed{C_x = -795\text{ N}}$$

$$\sum F_y = 0 = C_y - F_{DE}\sin\alpha - 480\text{ N}$$

$$0 = C_y - (-561\text{ N})\sin\alpha - 480\text{ N} \qquad \boxed{C_y = 216\text{ N}}$$



- With member *ACE* as a free body with no additional unknown forces, check the solution by summing moments about *A*.

$$\sum M_A = (F_{DE}\cos\alpha)(300\text{ mm}) + (F_{DE}\sin\alpha)(100\text{ mm}) - C_x(220\text{ mm})$$
$$= (-561\cos\alpha)(300\text{ mm}) + (-561\sin\alpha)(100\text{ mm}) - (-795)(220\text{ mm}) = 0$$

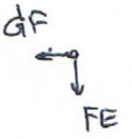
(checks)

Q7 $m + 3 = j$

$9 + 3 \quad 2(6)$

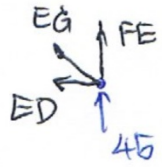
$12 = 12$ ∴ this structure is statically determinate.

$+\circlearrowleft \Sigma M_A = 0$: $20(4) + 20(8) + 40(12) - G_y(16) = 0 \Rightarrow G_y = 45$ kN

point F: 

$\Sigma F_x = 0$: $GF = 0$. ★

$\Sigma F_y = 0$: $FE = 0$ ★

point E: 

$+\uparrow \Sigma F_y = 0$: $45 + EG\sin 45^\circ + FE = 0$

$45 + EG\sin 45^\circ + 0 = 0$

$EG = -45\sqrt{2}$ kN.

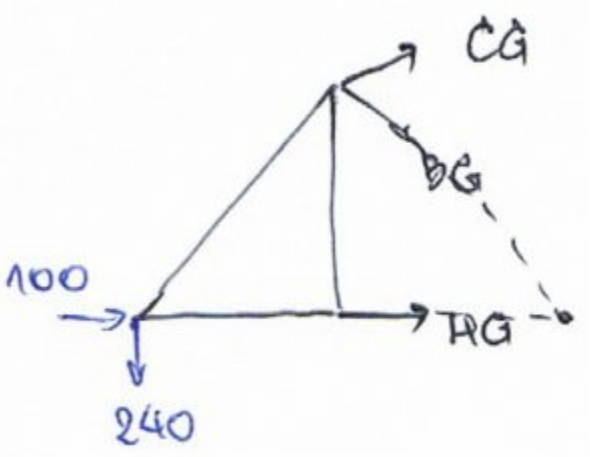
$+\rightarrow \Sigma F_x = 0$: $-EG\cos 45 - ED = 0$

$-(-45\sqrt{2})\cos 45 - ED = 0$

$ED = 45$ kN.

$\therefore F_{EG} = 45\sqrt{2}$ kN Compression

$F_{ED} = 45$ kN Tension Ans



$\circlearrowleft \sum \vec{M}_G = 0$;

$\circlearrowleft \sum \vec{M}_G = 0$; $-240(8) + CG\cos 14^\circ (3) + CG\sin 14^\circ (4) = 0.$

$CG = 495$ lb.

$\circlearrowleft \sum \vec{M}_G = 0$:

$260\left(\frac{12}{13}\right)(8) + A_y(8) = 0.$

$A_y = -240$ lb.

$= 240$ lb $\downarrow$

$\uparrow \sum F_y = 0$; $-240 + 495\sin 14^\circ - BG\left(\frac{3}{5}\right) = 0$

$\rightarrow \sum F_x = 0$:

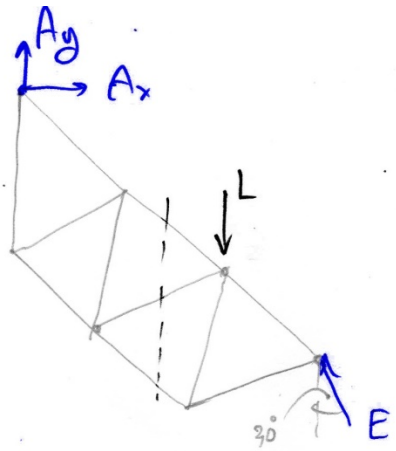
$A_x - 260\left(\frac{5}{13}\right) = 0$

$A_x = 100$ lb $\rightarrow$

$BG = -200$ lb.

$\therefore F_{BG} = 200$ lb Compression.

a)

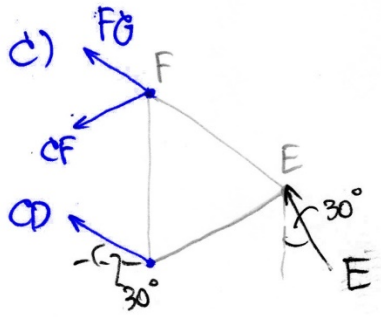


b)

$\circlearrowleft \Sigma M_A = 0$: $L(2a\cos 30) - E\cos 30(3a\cos 30) + E\sin 30(3a\sin 30) = 0$

$E = \frac{2\sqrt{3}}{3}L$ Ans

c)



$\circlearrowleft \Sigma M_F = 0$: $-E\cos 30(a\cos 30) + E\sin 30(a\sin 30)$

$CD\cos 30(a) = 0$

$CD = \frac{\sqrt{3}}{3}E = \frac{\sqrt{3}}{3}\left(\frac{2\sqrt{3}}{3}L\right)$

$= \frac{2}{3}L$ #

$\therefore F_{CD} = \frac{2}{3}L$ tension Ans