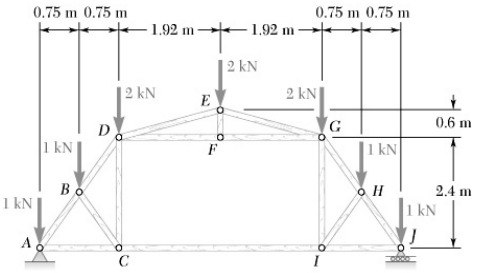
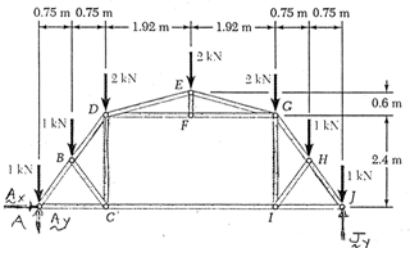



## PROBLEM 6.14

Determine the force in each member of the Gambrel roof truss shown. State whether each member is in tension or compression.

## SOLUTION

**FBD Truss:**




$\rightarrow \Sigma F_x = 0 \qquad \mathbf{A}_x = 0$

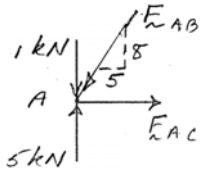
By symmetry: $\mathbf{A}_y = \mathbf{J}_y = 5 \text{ kN} \uparrow$

and
$$F_{AB} = F_{HJ};\ F_{AC} = F_{IJ};\ F_{BD} = F_{GH}$$
$$F_{CD} = F_{GI};\ F_{DE} = F_{EG};\ F_{DF} = F_{FG}$$
$$F_{BC} = F_{HI}$$

By inspection of joint *F*: $F_{EF} = 0$ ◀

**Joint FBDs:**

Joint *A*:




$\uparrow \Sigma F_y = 0$: $5 \text{ kN} - 1 \text{ kN} - \dfrac{8}{\sqrt{89}} F_{AB} = 0 \qquad F_{AB} = \dfrac{\sqrt{89}}{2} \text{ kN}$

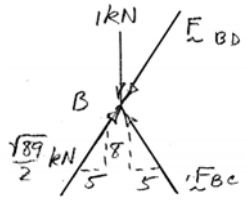
$F_{AB} = 4.72 \text{ kN C}$ ◀

$\rightarrow \Sigma F_x = 0$: $F_{AC} - \dfrac{5}{\sqrt{89}} \dfrac{\sqrt{89}}{2} \text{ kN} = 0$

$F_{AC} = 2.50 \text{ kN T}$ ◀

so $F_{HJ} = 4.72 \text{ kN C}$ ◀

Joint *B*:




$F_{IJ} = 2.50 \text{ kN T}$ ◀

$\rightarrow \Sigma F_x = 0$: $\dfrac{5}{\sqrt{89}} \left( \dfrac{\sqrt{89}}{2} \text{ kN} - F_{BD} - F_{BC} \right) = 0$

$\uparrow \Sigma F_y = 0$: $\dfrac{8}{\sqrt{89}} \left( \dfrac{\sqrt{89}}{2} \text{ kN} - F_{BD} + F_{BC} \right) - 1 \text{ kN} = 0$

Solving: $F_{BD} = 4.127 \text{ kN}$ so $F_{BD} = 4.13 \text{ kN C}$ ◀

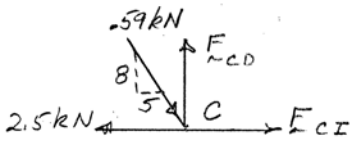
$F_{AB} = 0.5896 \text{ kN}$ and $F_{BC} = 0.590 \text{ kN C}$ ◀

so $F_{GH} = 4.13 \text{ kN C}$ ◀

and $F_{HI} = 0.590 \text{ kN C}$ ◀

## PROBLEM 6.14 CONTINUED

Joint *C*:




$$\rightarrow \Sigma F_x = 0: \; F_{CI} + \frac{5}{\sqrt{89}}(.59 \text{ kN}) - 2.5 \text{ kN} = 0; \qquad F_{CI} = 2.187 \text{ kN}$$

$$F_{CI} = 2.19 \text{ kN T} \blacktriangleleft$$

$$\uparrow \Sigma F_y = 0: \; F_{CD} - \frac{8}{\sqrt{89}}(.59 \text{ kN}) = 0 \qquad F_{CD} = 0.500 \text{ kN T} \blacktriangleleft$$

$$\text{so } F_{GI} = 0.500 \text{ kN T} \blacktriangleleft$$

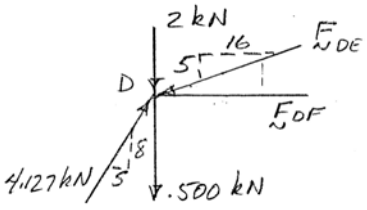
$$\uparrow \Sigma F_y = 0: \; \frac{8}{\sqrt{89}}(4.127 \text{ kN}) - 2.5 \text{ kN} - \frac{5}{\sqrt{281}} F_{DE} = 0$$

$$F_{DE} = 3.352 \text{ kN}$$

Joint *D*:

$$\text{so } F_{DE} = 3.35 \text{ kN C} \blacktriangleleft$$

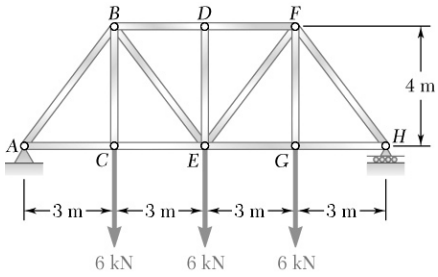
$$\text{and } F_{EG} = 3.35 \text{ kN C} \blacktriangleleft$$




$$\rightarrow \Sigma F_x = \frac{5}{\sqrt{89}}(4.127 \text{ kN}) - \frac{16}{\sqrt{281}}(3.352 \text{ kN}) + F_{DF} = 0$$

$$F_{DF} = 1.012 \text{ kN T} \blacktriangleleft$$

$$F_{FG} = 1.012 \text{ kN T} \blacktriangleleft$$

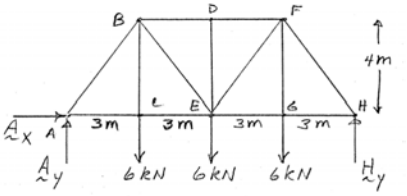



## PROBLEM 6.15

Determine the force in each member of the Pratt bridge truss shown. State whether each member is in tension or compression.

## SOLUTION

**FBD Truss:**




$\rightarrow \Sigma F_x = 0$: $\mathbf{A}_x = 0$

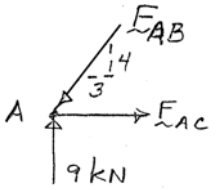
By symmetry: $\mathbf{A}_y = \mathbf{H}_y = 9$ kN $\uparrow$

and

$$F_{AB} = F_{FH};\ F_{AC} = F_{GH}$$
$$F_{BC} = F_{FG};\ F_{BD} = F_{DF}$$
$$F_{BE} = F_{EF};\ F_{CE} = F_{EG}$$

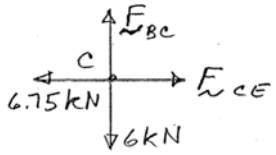
By inspection of joint *D*: $F_{DE} = 0$ ◀

**FBDs Joints:**




$\uparrow \Sigma F_y = 0$: $9 \text{ kN} - \frac{4}{5} F_{AB} = 0$ $\quad F_{AB} = 11.25$ kN C ◀

$\rightarrow \Sigma F_x = 0$: $F_{AC} - \frac{3}{5} F_{AB} = 0$ $\quad F_{AC} = 6.75$ kN T ◀

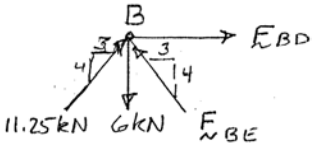



$\rightarrow \Sigma F_x = 0$: $F_{CE} - 6.75 \text{ kN} = 0$ $\quad F_{CE} = 6.75$ kN T ◀

$\uparrow \Sigma F_y = 0$: $F_{BC} - 6 \text{ kN} = 0$ $\quad F_{BC} = 6.00$ kN T ◀

$\uparrow \Sigma F_y = 0$: $\frac{4}{5}(11.25 \text{ kN}) - 6 \text{ kN} + \frac{4}{5} F_{BE} = 0$

$F_{BE} = 3.75$ kN C ◀




$\rightarrow \Sigma F_x = 0$: $F_{BD} - \frac{3}{5}(11.25 \text{ kN}) - \frac{3}{5}(3.75 \text{ kN}) = 0$

$F_{BD} = 9.00$ kN T ◀

From symmetry conditions above

$F_{FH} = 11.25$ kN C ◀

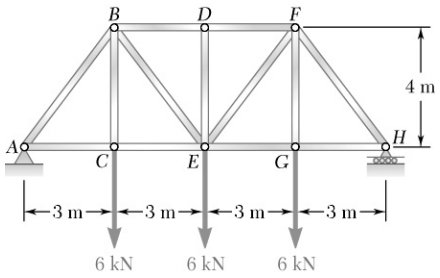
$F_{GH} = 6.75$ kN T ◀

$F_{EG} = 6.75$ kN T ◀

$F_{FG} = 6.00$ kN T ◀

$F_{EF} = 3.75$ kN C ◀

$F_{DF} = 9.00$ kN T ◀

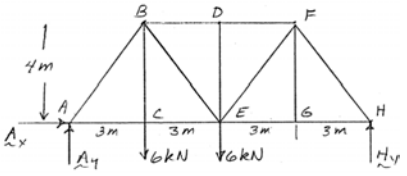



## PROBLEM 6.16

Determine the force in each member of the Pratt bridge truss shown. State whether each member is in tension or compression. Assume that the load at *G* has been removed.

## SOLUTION

**FBD Truss:**




$$\rightarrow \Sigma F_x = 0: \mathbf{A}_x = 0$$

$$\circlearrowleft \Sigma M_A = 0: (12\text{ m})H_y - (6\text{ m})(6\text{ kN}) - (3\text{ m})(6\text{ kN}) = 0$$

$$\mathbf{H}_y = 4.5\text{ kN} \uparrow$$

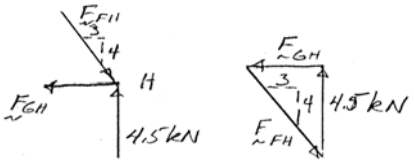
$$\uparrow \Sigma F_y = 0: A_y - 6\text{ kN} - 6\text{ kN} + 4.5\text{ kN} = 0$$

$$\mathbf{A}_y = 7.5\text{ kN} \uparrow$$

**Joint FBDs:**

$$\frac{4.5\text{ kN}}{4} = \frac{F_{GH}}{3} = \frac{F_{FH}}{5}$$

Joint *H*:



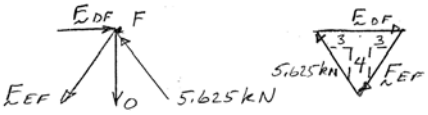

$$F_{GH} = 3.375\text{ kN} \qquad F_{GH} = 3.38\text{ kN T} \blacktriangleleft$$

$$F_{FH} = 5.625\text{ kN} \qquad F_{FH} = 5.63\text{ kN C} \blacktriangleleft$$

By inspection of joint *G*: $F_{FG} = 0 \blacktriangleleft$

$$F_{EG} = F_{GH} = 3.38\text{ kN T} \blacktriangleleft$$

Joint *F*:



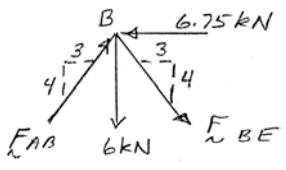

$$\frac{5.625\text{ kN}}{5} = \frac{F_{EF}}{5} = \frac{F_{DF}}{6} \qquad F_{EF} = 5.63\text{ kN T} \blacktriangleleft$$

$$F_{DF} = 6.75\text{ kN C} \blacktriangleleft$$

By inspection of joint *D*: $F_{DE} = 0 \blacktriangleleft$

$$F_{BD} = F_{DF} = 6.75\text{ kN C} \blacktriangleleft$$

Joint *B*:




By inspection of joint *C*: $F_{AC} = F_{CE}$ and $F_{BC} = 6.00\text{ kN T} \blacktriangleleft$

$$\rightarrow \Sigma F_x = 0: \frac{3}{5}(F_{AB} + F_{BE}) - 6.75\text{ kN} = 0$$

$$\uparrow \Sigma F_y = 0: \frac{4}{5}(F_{AB} - F_{BE}) - 6\text{ kN} = 0$$

$$\Sigma F_y = 0: \frac{4}{5}(F_{AB} - F_{BE}) - 6\text{ kN} = 0$$

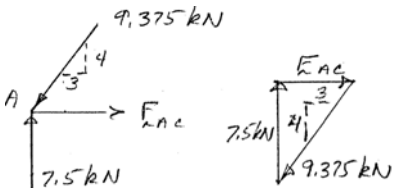
## PROBLEM 6.16 CONTINUED

Solving: $F_{AB} = 9.375$ kN so $F_{AB} = 9.38$ kN C ◀

Joint *A*: $F_{BE} = 1.875$ kN $F_{BE} = 1.875$ kN T ◀

$$\frac{F_{AC}}{3} = \frac{7.5 \text{ kN}}{4} = \frac{9.375 \text{ kN}}{5} \qquad F_{AC} = 5.625 \text{ kN}$$

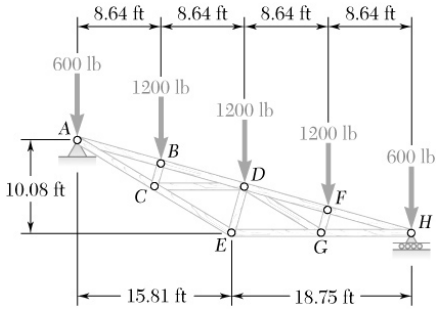
$F_{AC} = 5.63$ kN T ◀







From above $F_{CE} = 5.63$ kN T ◀

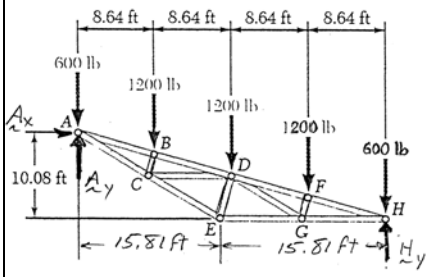



## PROBLEM 6.17

Determine the force in member *DE* and in each of the members located to the left of *DE* for the inverted Howe roof truss shown. State whether each member is in tension or compression.

## SOLUTION

**FBD Truss:**




$$\rightarrow \Sigma F_x = 0: \mathbf{A}_x = 0$$

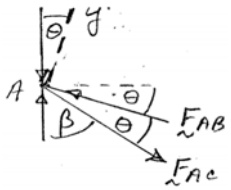
By load symmetry $\mathbf{A}_y = \mathbf{H}_y = 2400 \text{ lb} \uparrow$

Note: $$\theta = \tan^{-1}\frac{10.08}{15.81 + 18.75} = 16.26°$$

$$\beta = 90 - 2\theta = 57.48°; \quad \alpha = 180 - \beta = 32.52°$$

**Joint FBDs:**

Joint *A*:



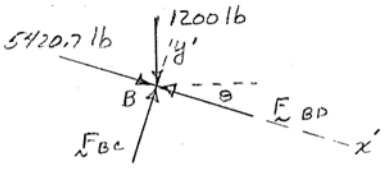

$$\nearrow \Sigma F_{y'} = 0: (2400 \text{ lb} - 600 \text{ lb})\cos\theta - F_{AC}\sin\theta = 0$$

$$F_{AC} = \frac{(1800 \text{ lb})}{\tan 16.26°} = 6171.5 \text{ lb}; \qquad F_{AC} = 6.17 \text{ kips T} \blacktriangleleft$$

$$\searrow \Sigma F_x = 0: (6171.5 \text{ lb})\cos 2\theta - F_{AB}\cos\theta = 0$$

$$F_{AB} = 6171.5\frac{\cos 32.52°}{\cos 16.26°} = 5420.7 \text{ lb}; \qquad F_{AB} = 5.42 \text{ kips C} \blacktriangleleft$$

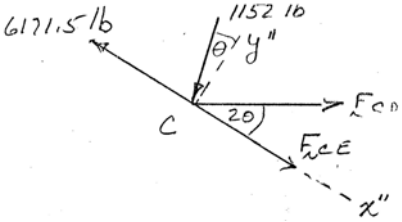
Joint *B*:




$$\searrow \Sigma F_{x'} = 0: 5420.7 \text{ lb} + (1200 \text{ lb})\sin\theta - F_{BD} = 0$$

$$F_{BD} = 5420.7 + 1200\sin 16.26° = 5756.7 \text{ lb} \qquad F_{BD} = 5.76 \text{ kips C} \blacktriangleleft$$

Joint *C*:




$$\nearrow \Sigma F_{y'} = 0: F_{BC} - (1200 \text{ lb})\cos\theta = 0 \qquad F_{BC} = 1152 \text{ lb}$$

$$F_{BC} = 1.152 \text{ kips C} \blacktriangleleft$$

$$\nearrow \Sigma F_{y''} = 0: F_{CD}\sin 2\theta - (1152 \text{ lb})\cos\theta = 0$$

$$F_{CD} = 1152\frac{\cos 16.26°}{\sin 32.52°} = 2057.2 \text{ lb} \qquad F_{CD} = 2.06 \text{ kips T} \blacktriangleleft$$

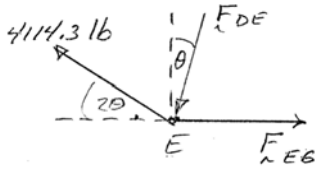
$$\searrow \Sigma F_{x''} = 0: F_{CE} + (1152 \text{ lb})\sin\theta + (2057.2 \text{ lb})\cos 2\theta - 6171.5 \text{ lb} = 0$$

## PROBLEM 6.17 CONTINUED

$$F_{CE} = 6171.5 - 1152\sin 16.26° - 2057.2\cos 32.52°$$

$$= 4114.3 \text{ lb} \qquad F_{CE} = 4.11 \text{ kips T} \blacktriangleleft$$

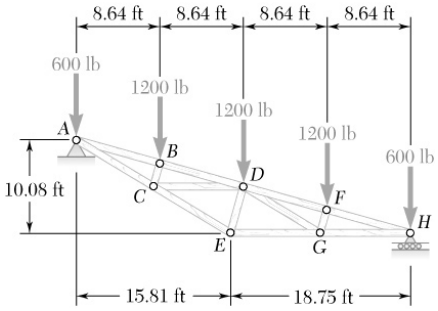
Joint $E$:




$$\uparrow \Sigma F_y = 0: \left(4114.3 \text{ lb}\right)\sin 2\theta - F_{DE}\cos\theta = 0$$

$$F_{DE} = 4114.3\frac{\sin 32.52°}{\cos 16.26°} = 2304.0 \text{ lb} \qquad F_{DE} = 2.30 \text{ kips C} \blacktriangleleft$$

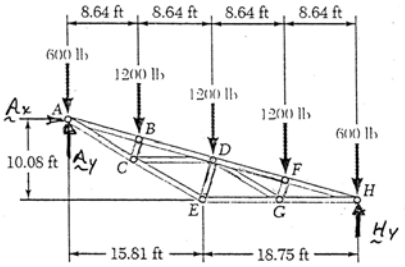
## PROBLEM 6.18




Determine the force in each of the members located to the right of *DE* for the inverted Howe roof truss shown. State whether each member is in tension or compression.

## SOLUTION

**FBD Truss:**




$\rightarrow \Sigma F_x = 0$: $\mathbf{A}_x = 0$

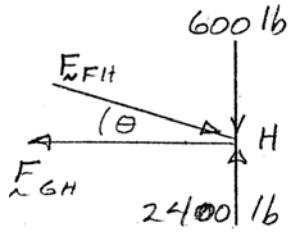
By symmetry of loads $\mathbf{A}_y = \mathbf{H}_y = 2400$ lb $\uparrow$

Note: $\theta = \tan^{-1}\dfrac{10.08}{15.81 + 18.75} = 16.26°$

$\beta = 90 - 2\theta = 57.48°$

**Joint FBDs:**

Joint *H*:



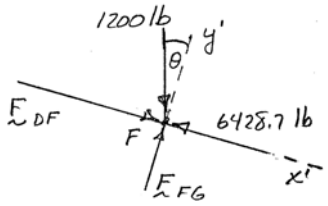

$\uparrow \Sigma F_y = 0$: $2400 \text{ lb} - 600 \text{ lb} - F_{FH}\sin\theta = 0$

$F_{FH} = \dfrac{1800 \text{ lb}}{\sin 16.26°} = 6428.7 \text{ lb}$ $\quad F_{FH} = 6.43 \text{ kips C} \blacktriangleleft$

$\rightarrow \Sigma F_x = 0$: $(6428.7 \text{ lb})\cos\theta - F_{GH} = 0$

$F_{GH} = 6428.7\cos 16.32° = 6171.5 \text{ lb}$ $\quad F_{GH} = 6.17 \text{ kips T} \blacktriangleleft$

Joint *F*:




$\nearrow \Sigma F_{y'} = 0$: $F_{FG} - (1200 \text{ lb})\cos\theta = 0$ $\quad F_{FG} = 1152.0 \text{ lb}$

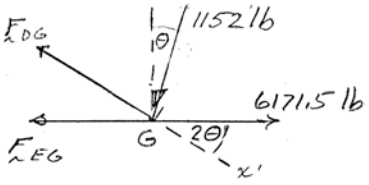
$F_{FG} = 1.152 \text{ kips C} \blacktriangleleft$

$\searrow \Sigma F_{x'} = 0$: $F_{DF} + (1200 \text{ lb})\sin\theta - 6428.7 \text{ lb} = 0$

$F_{DF} = 6428.7 - 1200\sin 16.26° = 6092.7 \text{ lb}$ $\quad F_{DF} = 6.09 \text{ kips C} \blacktriangleleft$

## PROBLEM 6.18 CONTINUED

Joint $G$:




$$+\uparrow \Sigma F_y = 0: \; F_{DG}\sin 2\theta - (1152\text{ lb})\cos\theta = 0$$

$$F_{DG} = 1152\frac{\cos 16.26^\circ}{\sin 32.52^\circ} = 2057.2\text{ lb} \qquad F_{DG} = 2.06\text{ kips T} \blacktriangleleft$$

$$+\rightarrow \Sigma F_x = 0: \; 6171.5\text{ lb} - 2057.2\cos 2\theta - F_{EG} - 1152\text{ lb}\sin\theta = 0$$

$$F_{EG} = 6171.5 - 2057.2\cos 32.52^\circ - (1152\text{ lb})\sin 16.26^\circ = 4114.3\text{ lb}$$

$$F_{EG} = 4.11\text{ kips T} \blacktriangleleft$$