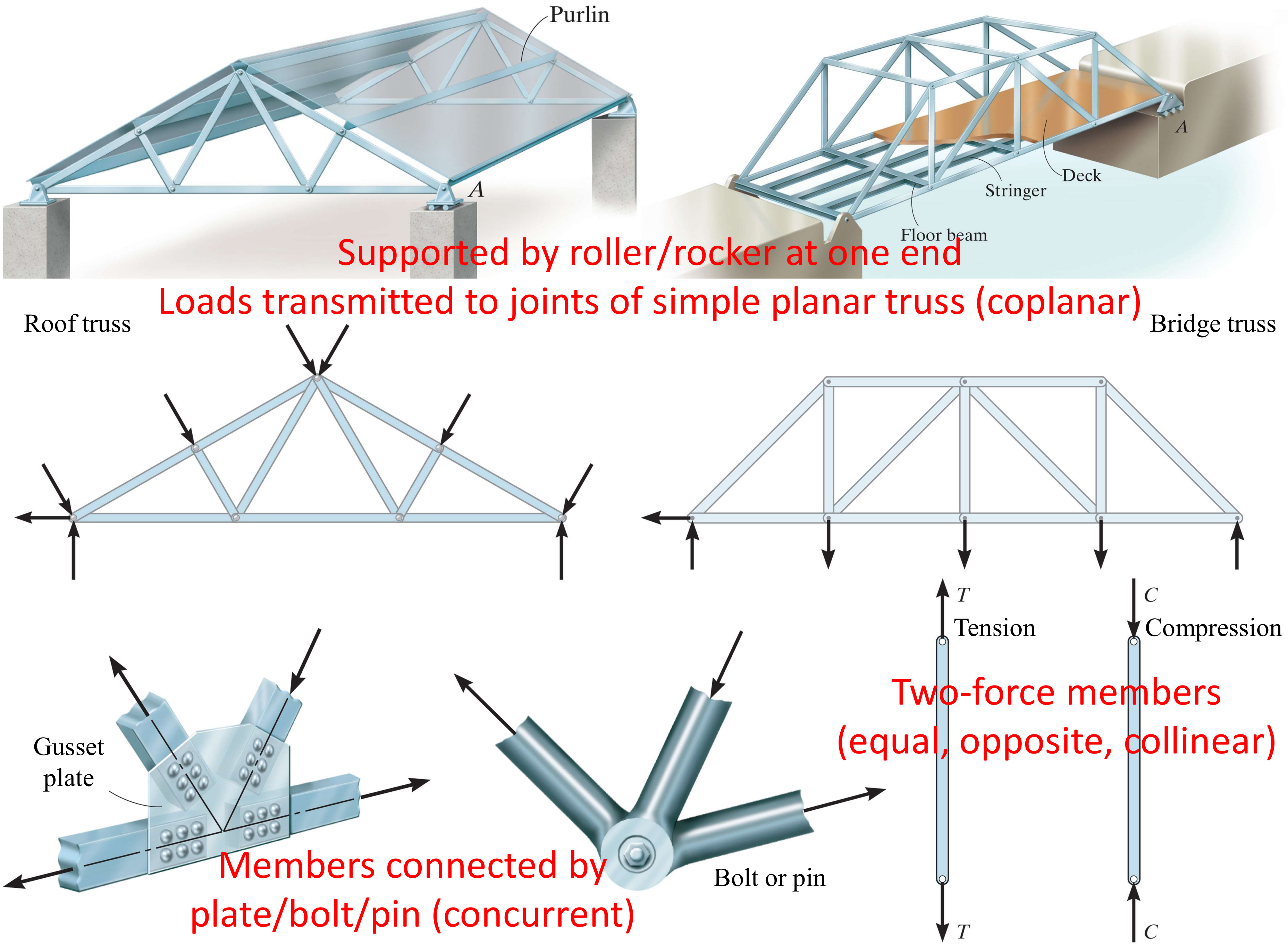
# Trusses

Hibbeler 14e: Sec 6.1-6.4

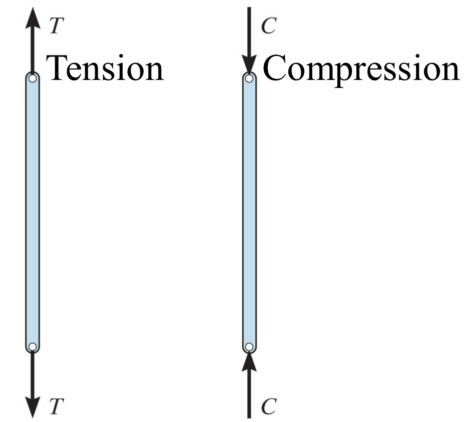

Purlin
A
Deck
Stringer
Floor beam
A
Supported by roller/rocker at one end
Loads transmitted to joints of simple planar truss (coplanar)
Roof truss
Bridge truss
T
Tension
C
Compression
Two-force members
(equal, opposite, collinear)
Gusset
plate
Members connected by
plate/bolt/pin (concurrent)
Bolt or pin
T
C

## TRUSSES

**Two-force members**

Structure composed of slender members joined together at their end points

**Assumptions** --- to determine force in each member




- Loads applied at the *joints only*; neglect member weight or apply half at each end
- Members connected by *frictionless pins*; joining members have concurrent center lines

**Free-body diagram (FBD)** --- must draw for solving problems!

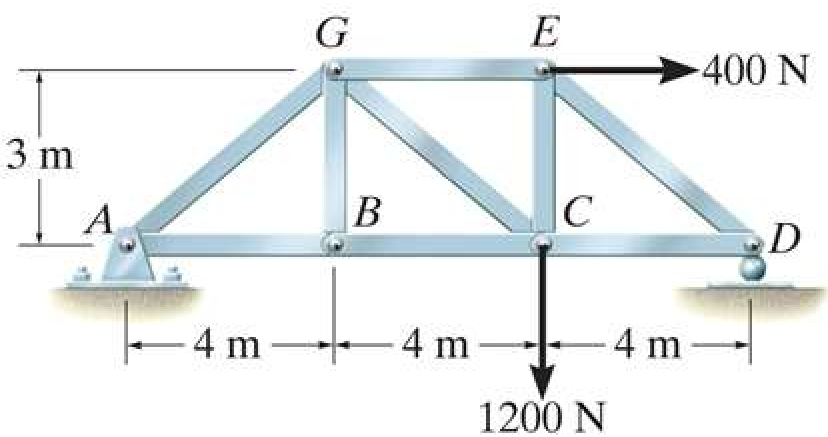
- Whole *truss* to solve for *support reactions* only if needed
- Isolate *joint* or *section* to solve for *member forces*

**Equations of equilibrium for 2D** --- must write for solving problems!

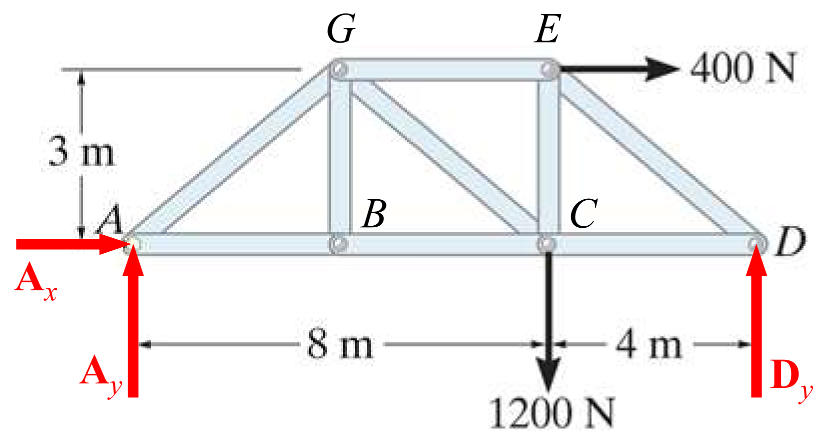
- CONCURRENT --- $\sum F_x = 0\,,\ \sum F_y = 0$
- NON-CONCURRENT --- $\sum F_x = 0\,,\ \sum F_y = 0\,,\ \sum M_z = 0$

## EXAMPLE: EXTERNAL REACTIONS

Non-concurrent: $\sum F_x = 0, \sum F_y = 0, \sum M_z = 0$




### FBD of whole truss
consider as one solid body




Sum forces in the x direction to solve directly for $A_x$

$+\rightarrow \sum F_x = 0;\ \ 400N + A_x = 0$ $\qquad A_x = -400 = 400N \leftarrow$

Sum moments about A to solve directly for $D_y$

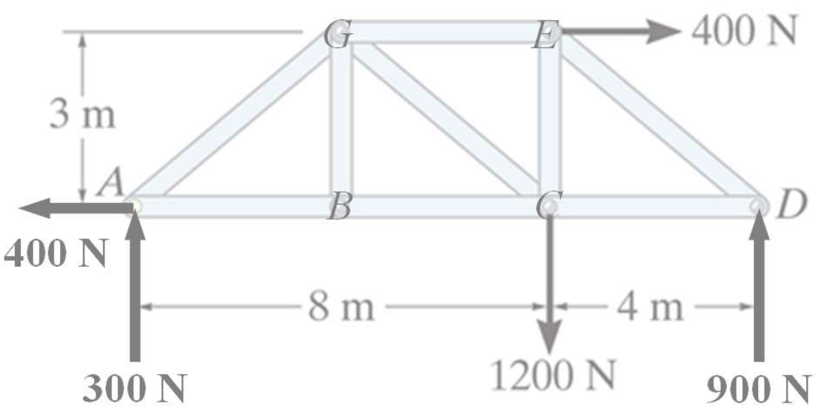
$+ccw \sum M_A = 0;\ \ -1200N(8m) - 400N(3m) + D_y(12m) = 0$ $\qquad D_y = 900N \uparrow$

Sum forces in the y direction and plug in $D_y$ to solve for $A_y$

$+\uparrow \sum F_y = 0;\ \ A_y - 1200N + (D_y{:}\,900N) = 0$ $\qquad A_y = 300N \uparrow$

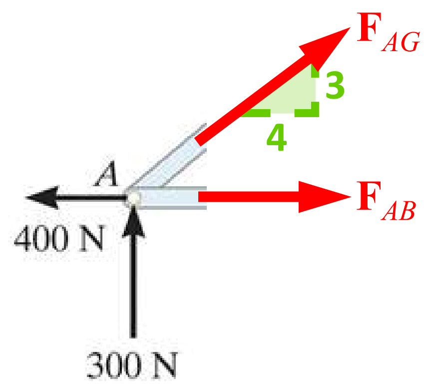
## EXAMPLE: METHOD OF JOINTS

Concurrent: $\sum F_x = 0\,,\ \sum F_y = 0$




**FBD of isolated joint**

model as particle at equilibrium




Sum forces in the y direction to solve directly for $F_{AG}$

$$+\!\uparrow \sum F_y = 0;\quad 300N + \frac{3}{5} F_{AG} = 0 \qquad\qquad F_{AG} = -500 = 500N\ (C)$$

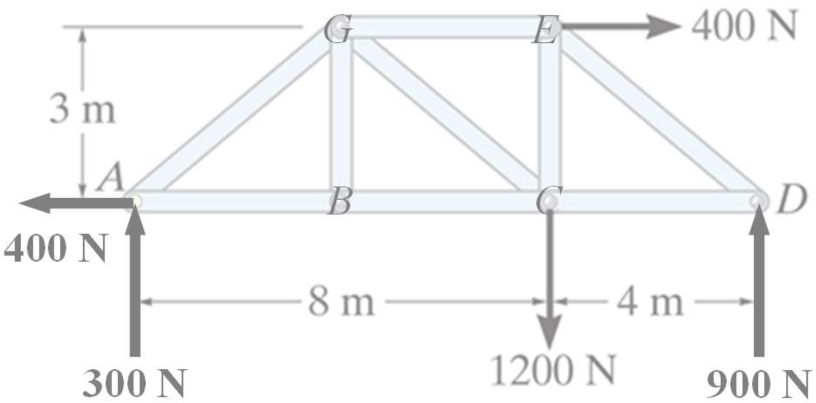
Sum forces in the x direction and plug in $F_{AG}$ to solve for $F_{AB}$

$$+\!\rightarrow \sum F_x = 0;\quad -400\text{N} + F_{AB} + \frac{4}{5}(F_{AG}) = 0$$

$$+\!\rightarrow \sum F_x = 0;\quad -400\text{N} + F_{AB} + \frac{4}{5}(-500N) = 0 \qquad\qquad F_{AB} = 800N\ (T)$$

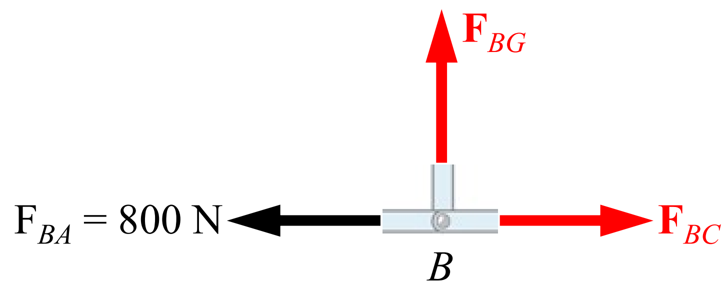
## EXAMPLE: METHOD OF JOINTS

Concurrent: $\sum F_x = 0\,,\ \sum F_y = 0$




### FBD of isolated joint

model as particle at equilibrium




Sum forces in the x direction to solve directly for $F_{BC}$

$+\rightarrow \sum F_x = 0;\quad -800N + F_{BC} = 0$ $\qquad F_{BC} = 800N\ (T)$

Sum forces in the y direction to solve directly for $F_{BG}$

$+\uparrow \sum F_y = 0;\quad F_{BG} = 0$ $\qquad F_{BG} = 0N$

BG supports no load!

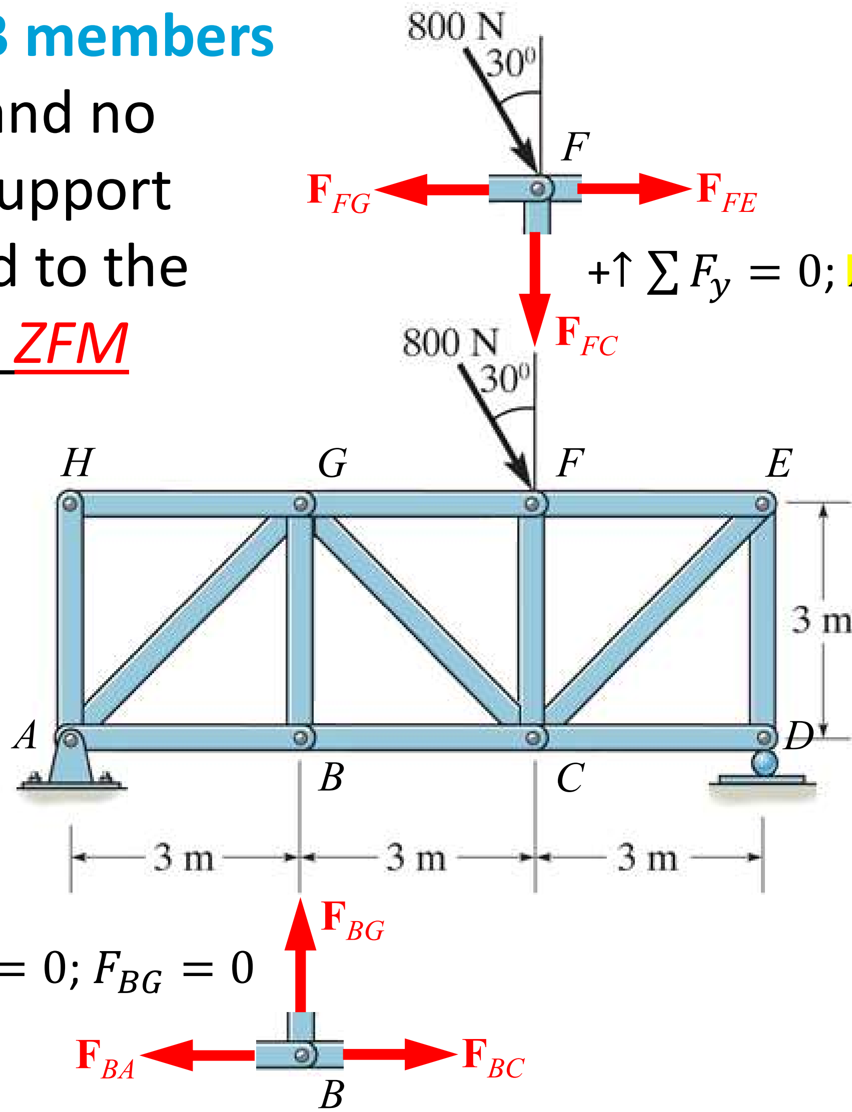
**Zero-Force Member (ZFM)**

Necessary for stability and to provide support if loading changes

# ZERO-FORCE MEMBERS (ZFM)

## Inspect joint w/ 3 members

If 2 are collinear and no external load or support reaction is applied to the joint then *3rd is a ZFM*




$+\uparrow \sum F_y = 0;\ F_{FC} \neq 0$

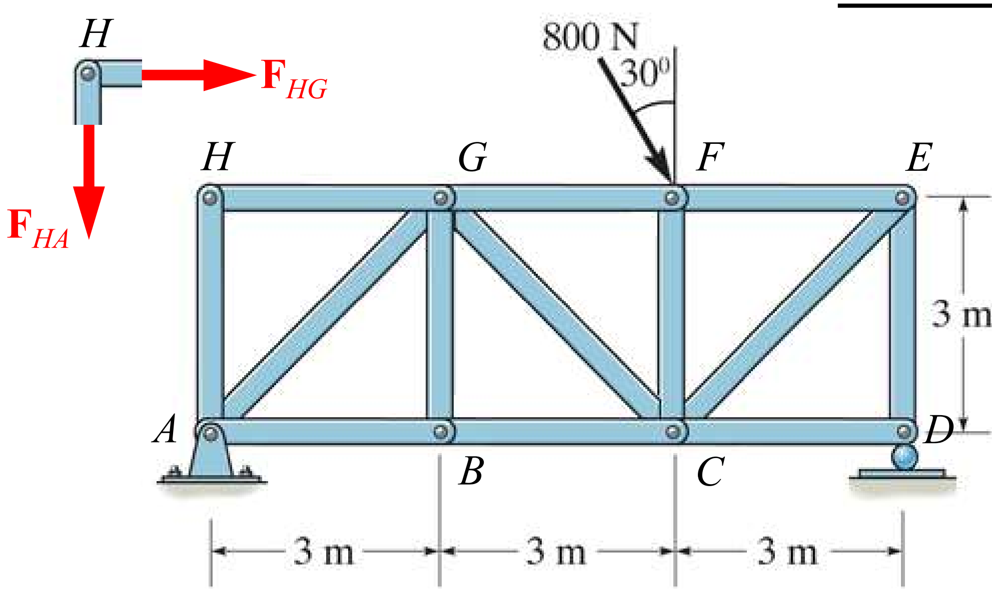
$+\uparrow \sum F_y = 0;\ F_{BG} = 0$

# ZERO-FORCE MEMBERS (ZFM)

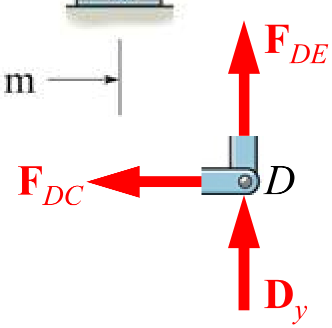
## Inspect joint w/ 2 members

If no external load or support reaction is applied to the joint then *both are ZFMs*

$$+\rightarrow \sum F_x = 0\,;\, F_{HG} = 0$$
$$+\uparrow \sum F_y = 0;\, F_{HA} = 0$$

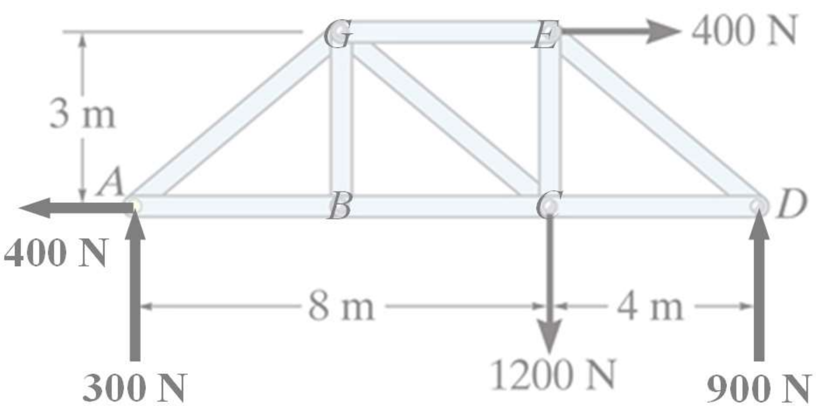



$$+\rightarrow \sum F_x = 0\,;\, F_{DC} = 0$$
$$+\uparrow \sum F_y = 0;\, F_{DE} \neq 0$$



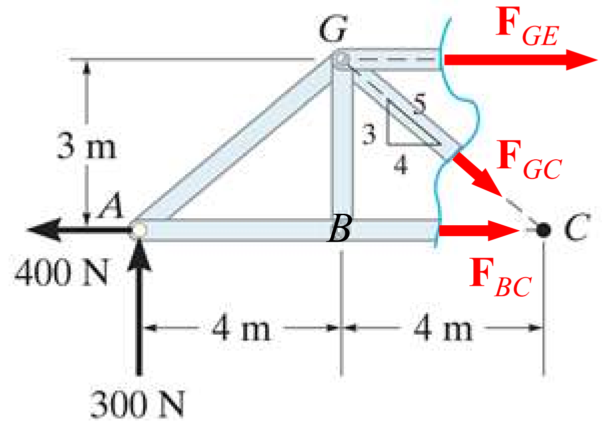
## EXAMPLE: METHOD OF SECTIONS

Non-concurrent: $\sum F_x = 0 , \sum F_y = 0 , \sum M_z = 0$




### FBD of cut section

expose internal forces as external




Sum forces in the y direction to solve directly for $F_{GC}$

$+\uparrow \sum F_y = 0; \;\; 300N - \frac{3}{5} F_{GC} = 0 \qquad F_{GC} = 500N\ (T)$

Sum moments about G to solve directly for $F_{BC}$

$+ccw \sum M_G = 0; \;\; -300N(4m) - 400N(3m) + F_{BC}(3m) = 0 \qquad F_{BC} = 800N\ (T)$

Sum moments about C to solve directly for $F_{GE}$

$+ccw \sum M_C = 0; \;\; -300N(8m) \; - F_{GE}(3m) = 0 \qquad F_{GE} = -800 = 800N\ (C)$

## **PROCEDURE FOR ANALYSIS** --- PLANAR TRUSS, 2D EQUILIBRIUM

- *Only if needed*, whole truss FBD to solve for support reactions
- **Isolate joint or section and draw FBD**
  - Internal forces are exposed only for members that are "cut"
  - Draw the "assumed" sense for unknown forces (tension?)
- **Apply equations of equilibrium** to solve for unknowns (directly!)
- Repeat until done!

## **HINTS, TIPS, SIMPLIFICATIONS**

- Inspect for any ZFMs and mark (may help in deciding how to cut)
- "Cut" members of interest to expose internal forces
  - **Joint cut: expose max of 2 unknowns**
    Concurrent: $\sum F_x = 0 \, , \; \sum F_y = 0$
  - **Section cut: expose max of 3 unknowns**
    Non-concurrent: $\sum F_x = 0 \, , \sum F_y = 0 \, , \sum M_z = 0$
- $\sum M$ about point where LOA of multiple unknown forces *intersect;* may be a point that has been "cut" off in the section FBD