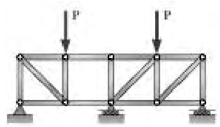
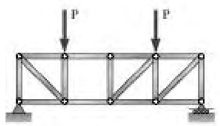
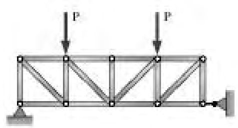
PROBLEM 6.71



(a)



(b)



(c)

Classify each of the structures shown as completely, partially, or improperly constrained; if completely constrained, further classify it as determinate or indeterminate. (All members can act both in tension and in compression.)

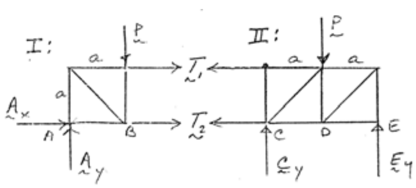
SOLUTION

Structure (a):

Non-simple truss with $r = 4, \; m = 16, \; n = 10$

so $m + r = 20 = 2n$, but must examine further.

FBD Sections:



FBD I: $\Sigma M_A = 0 \;\Rightarrow\; T_1$

II: $\Sigma F_x = 0 \;\Rightarrow\; T_2$

I: $\Sigma F_x = 0 \;\Rightarrow\; A_x$

I: $\Sigma F_y = 0 \;\Rightarrow\; A_y$

II: $\Sigma M_E = 0 \;\Rightarrow\; C_y$

II: $\Sigma F_y = 0 \;\Rightarrow\; E_y$

Since each section is a simple truss with reactions determined,

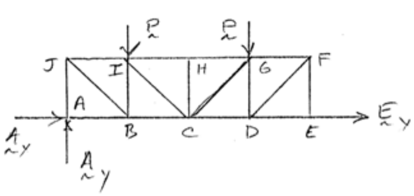
structure is completely constrained and determinate. ◀

Structure (b):

Non-simple truss with $r = 3, \; m = 16, \; n = 10$

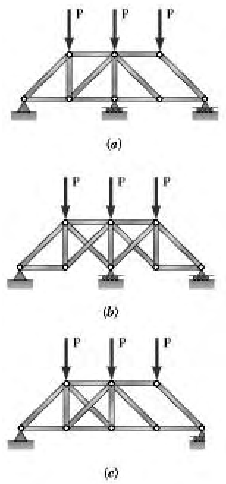
so $m + r = 19 < 2n = 20 \quad \therefore$ structure is partially constrained ◀

Structure (c):



Simple truss with $r = 3, \; m = 17, \; n = 10$

$m + r = 20 = 2n$, but the horizontal reaction forces A_x and E_x are collinear and no equilibrium equation will resolve them, so the structure is improperly constrained and indeterminate ◀

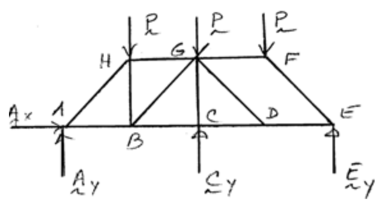


PROBLEM 6.72

Classify each of the structures shown as completely, partially, or improperly constrained; if completely constrained, further classify it as determinate or indeterminate. (All members can act both in tension and in compression.)

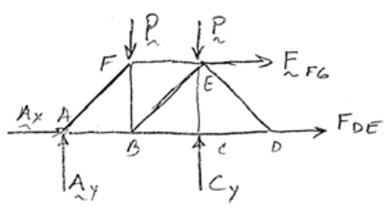
SOLUTION

Structure (a):



Non-simple truss with $r = 4,\ m = 12,\ n = 8$ so $r + m = 16 = 2n,$ check for determinacy:

One can solve joint F for forces in EF, FG and then solve joint E for $\mathbf{E}_y$ and force in DE.

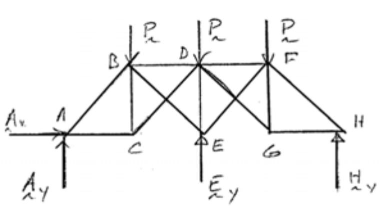


This leaves a simple truss $ABCDGH$ with

$$r = 3,\ m = 9,\ n = 6 \qquad \text{so} \qquad r + m = 12 = 2n$$

Structure is completely constrained and determinate ◀

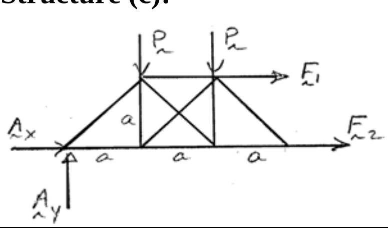
Structure (b):



Simple truss (start with ABC and add joints alphabetically to complete truss) with $r = 4,\ m = 13,\ n = 8$

so $\qquad r + m = 17 > 2n = 16 \qquad$ Constrained but indeterminate ◀

Structure (c):



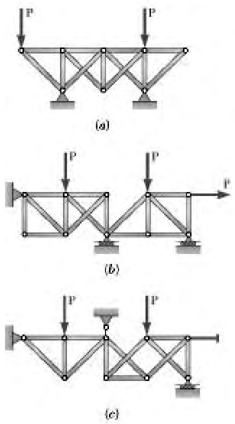
Non-simple truss with $r = 3,\ m = 13,\ n = 8$ so $r + m = 16 = 2n$. To further examine, follow procedure in part (a) above to get truss at left.

Since $\mathbf{F}_1 \neq 0$ (from solution of joint F),

$\Sigma M_A = aF_1 \neq 0$ and there is no equilibrium.

Structure is improperly constrained ◀

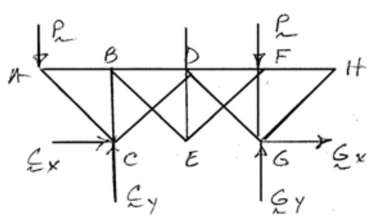
PROBLEM 6.73



Classify each of the structures shown as completely, partially, or improperly constrained; if completely constrained, further classify it as determinate or indeterminate. (All members can act both in tension and in compression.)

SOLUTION

Structure (a):

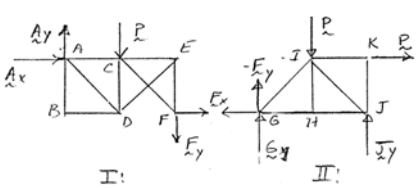


Simple truss (start with *ABC* and add joints alphabetical to complete truss), with

$$r = 4, \quad m = 13, \quad n = 8 \qquad \text{so} \qquad r + m = 17 > 2n = 16$$

Structure is completely constrained but indeterminate. ◀

Structure (b):



From FBD II: $\Sigma M_G = 0 \Rightarrow J_y$

$\Sigma F_x = 0 \Rightarrow F_x$

FBD I: $\Sigma M_A = 0 \Rightarrow F_y$

$\Sigma F_y = 0 \Rightarrow A_y$

$\Sigma F_x = 0 \Rightarrow A_x$

FBD II: $\Sigma F_y = 0 \Rightarrow G_y$

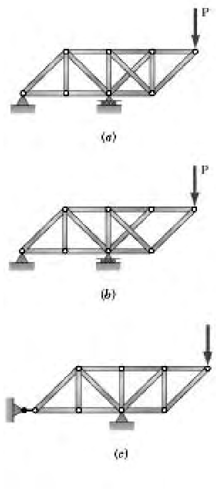
Thus have two simple trusses with all reactions known,

so structure is completely constrained and determinate. ◀

Structure (c):

Structure has $r = 4, \quad m = 13, \quad n = 9$

so $\quad r + m = 17 < 2n = 18$, structure is partially constrained ◀



PROBLEM 6.74

Classify each of the structures shown as completely, partially, or improperly constrained; if completely constrained, further classify it as determinate or indeterminate. (All members can act both in tension and in compression.)

SOLUTION

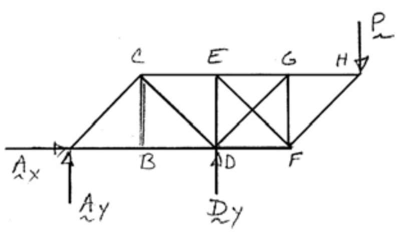
Structure (a):

Rigid truss with $r = 3, \;\; m = 14, \;\; n = 8$

so $\qquad r + m = 17 > 2n = 16$

so completely constrained but indeterminate ◀

Structure (b):

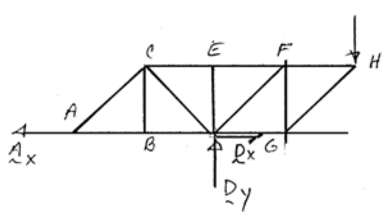


Simple truss (start with *ABC* and add joints alphabetically), with

$$r = 3, \;\; m = 13, \;\; n = 8 \qquad \text{so} \qquad r + m = 16 = 2n$$

so completely constrained and determinate ◀

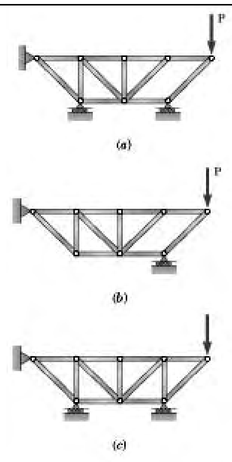
Structure (c):



Simple truss with $r = 3, \;\; m = 13, \;\; n = 8$ so $r + m = 16 = 2n,$ but horizontal reactions $(A_x$ and $D_x)$ are collinear so cannot be resolved by any equilibrium equation.

$\therefore$ structure is improperly constrained ◀

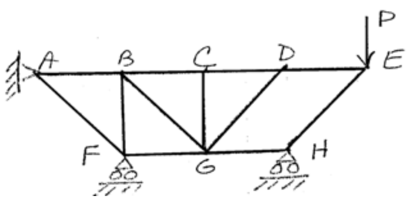
PROBLEM 6.75



Classify each of the structures shown as completely, partially, or improperly constrained; if completely constrained, further classify it as determinate or indeterminate. (All members can act both in tension and in compression.)

SOLUTION

Structure (a):

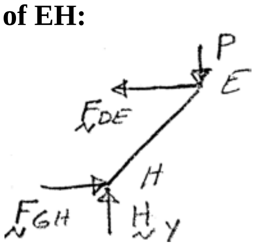


No. of members $m = 12$

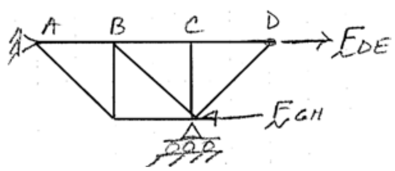
No. of joints $n = 8$ $\qquad m + r = 16 = 2n$

No. of react. comps. $r = 4$ $\qquad$ unks = eqns

FBD of EH:



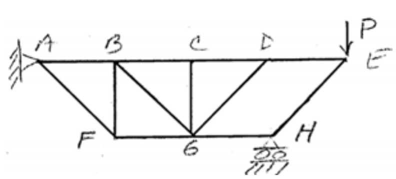
$$\Sigma M_H = 0 \;\rightarrow\; F_{DE}; \;\; \Sigma F_x = 0 \;\rightarrow\; F_{GH}; \;\; \Sigma F_y = 0 \;\rightarrow\; H_y$$



Then *ABCDGF* is a simple truss and all forces can be determined.

This example is completely constrained and determinate. ◀

Structure (b):



No. of members $m = 12$

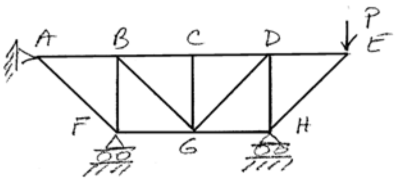
No. of joints $n = 8$ $\qquad m + r = 15 < 2n = 16$

No. of react. comps. $r = 3$ $\qquad$ unks < eqns

partially constrained ◀

Note: Quadrilateral *DEHG* can collapse with joint *D* moving downward: in (a) the roller at *F* prevents this action.

Structure (c):

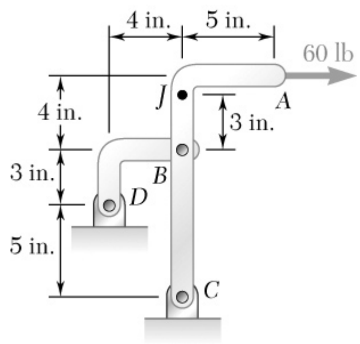


No. of members $m = 13$

No. of joints $n = 8$ $\quad m + r = 17 > 2n = 16$

No. of react. comps. $r = 4$ $\quad$ unks $>$ eqns

completely constrained but indeterminate ◀

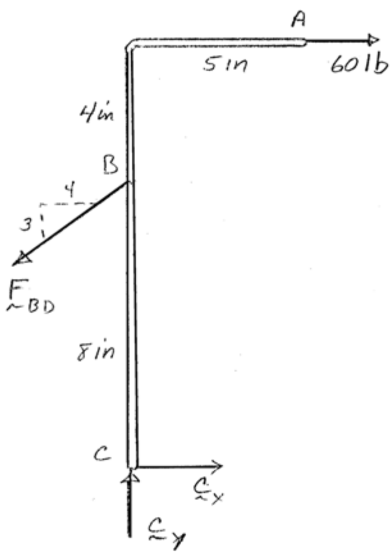


PROBLEM 6.76

For the frame and loading shown, determine the force acting on member ABC (a) at B, (b) at C.

SOLUTION

FBD member ABC:



Note: BD is a two-force member so $\mathbf{F}_{BD}$ is through D.

$$(a)\quad \circlearrowleft \Sigma M_C = 0:\; (8\text{ in.})\left(\frac{4}{5}F_{BD}\right) - (12\text{ in.})(60\text{ lb}) = 0$$

$$\mathbf{F}_{BD} = 112.5\text{ lb} \measuredangle\, 36.9° \blacktriangleleft$$

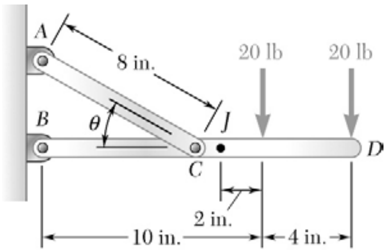
$$(b)\quad \longrightarrow \Sigma F_x = 0:\; 60\text{ lb} + C_x - \frac{4}{5}(112.5\text{ lb}) = 0$$

$$C_x = 30\text{ lb}$$

$$\uparrow \Sigma F_y = 0:\; C_y - \frac{3}{5}(112.5\text{ lb}) = 0$$

$$C_y = 67.5\text{ lb}$$

$$\text{so } \mathbf{C} = 73.9\text{ lb} \measuredangle\, 66.0° \blacktriangleleft$$

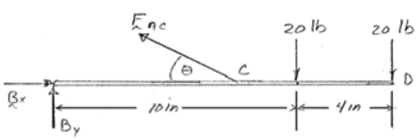


PROBLEM 6.77

Determine the force in member AC and the reaction at B when (*a*) $\theta = 30^{\circ}$, (*b*) $\theta = 60^{\circ}$.

SOLUTION

FBD member BCD:



Note: AC is two-force member so $\mathbf{F}_{AC}$ is through A.

$$\overset{\frown}{BC} = (8\text{ in.})\cos\theta$$

$$\circlearrowleft \Sigma M_B = 0: (8\text{ in.})\cos\theta(F_{AC}\sin\theta) - (10\text{ in.})(20\text{ lb})$$

$$-(14\text{ in.})(20\text{ lb}) = 0$$

$$F_{AC} = \frac{60\text{ lb}}{\sin\theta\ \cos\theta}$$

$$\longrightarrow \Sigma F_x = 0:\ B_x - F_{AC}\cos\theta = 0 \qquad B_x = \frac{60\text{ lb}}{\sin\theta}$$

$$\uparrow \Sigma F_y = 0: B_y + F_{AC}\sin\theta - 20\text{ lb} - 20\text{ lb} = 0$$

$$B_y = 40\,lb - \frac{60\text{ lb}}{\cos\theta}$$

(*a*) $\theta = 30^{\circ}$ $\qquad F_{AC} = 138.56\text{ lb}$

$F_{AC} = 138.6\text{ lb T}$ ◀

$B_x = 120.0\text{ lb} \qquad B_y = -29.28\text{ lb}$

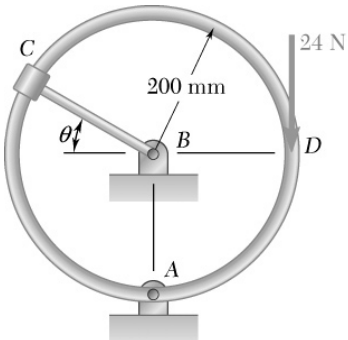
$\mathbf{B} = 123.5\text{ lb} \searrow 13.71^{\circ}$ ◀

(*b*) $\theta = 60^{\circ}$ $\qquad F_{AC} = 138.56\text{ lb}$

$F_{AC} = 138.6\text{ lb T}$ ◀

$B_x = 69.28\text{ lb} \qquad B_y = -80\text{ lb}$

$\mathbf{B} = 105.8\text{ lb} \searrow 49.1^{\circ}$ ◀

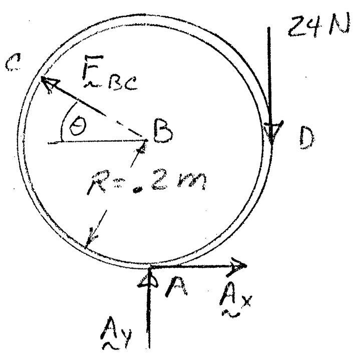


PROBLEM 6.78

A circular ring of radius 200 mm is pinned at *A* and is supported by rod *BC*, which is fitted with a collar at *C* that can be moved along the ring. For the position when $\theta = 35°$, determine (*a*) the force in rod *BC*, (*b*) the reaction at *A*.

SOLUTION

FBD ring:



$(a)\ \theta = 35°$

$$\Sigma M_A = 0: (0.2\text{ m})F_{BC}\cos 35° - (0.2\text{ m})(24\text{ N}) = 0$$

$$F_{BC} = \frac{24\text{ N}}{\cos 35°} = 29.298\text{ N}$$

$$F_{BC} = 29.3\text{ N C} \blacktriangleleft$$

(b)

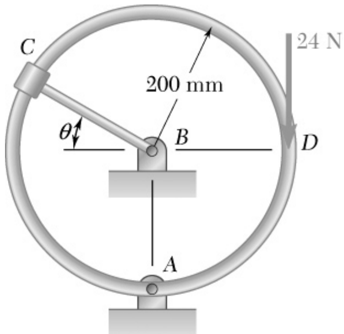
$$\xrightarrow{} \Sigma F_x = 0: A_x - \frac{24\text{ N}}{\cos 35°}\cos 35° = 0$$

$$A_x = 24\text{ N}$$

$$\uparrow \Sigma F_y = 0: A_y + \frac{24\text{ N}}{\cos 35°}\sin 35° - 24\text{ N} = 0$$

$$A_y = 7.195\text{ N}$$

so $\mathbf{A} = 25.1\text{ N} \measuredangle 16.69° \blacktriangleleft$

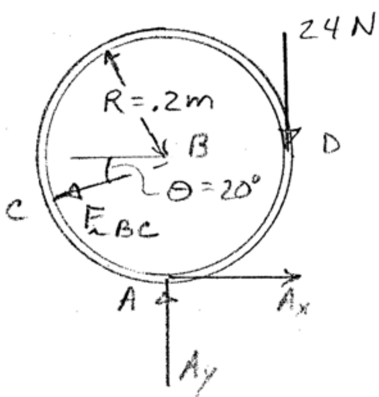


PROBLEM 6.79

Solve Prob. 6.78 when $\theta = -20°$.

SOLUTION

FBD ring:



$(a)\quad \theta = 20° \quad \circlearrowleft \Sigma M_A = 0\colon (0.2\text{ m})(F_{BC}\ \cos 20°) - (0.2\text{ m})(24\text{ N}) = 0$

$$F_{BC} = \frac{24\text{ N}}{\cos 20°} = 25.54\text{ N}$$

$F_{BC} = 25.5\text{ N C}$ ◀

$(b)\quad \uparrow \Sigma F_y = 0\colon A_y - \frac{24\text{ N}}{\cos 20°}\sin 20° - 24\text{ N} = 0$

$$A_y = 32.735\text{ lb}$$

$$\circlearrowleft \Sigma M_B = 0\colon (0.2\text{ m})A_x - (0.2\text{ m})(24\text{ N}) = 0$$

$$A_x = 24\text{ N}$$

so $\mathbf{A} = 40.6\text{ N} \measuredangle 53.8°$ ◀