UES 009 Mechanics
Truss _ Method of Sections

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

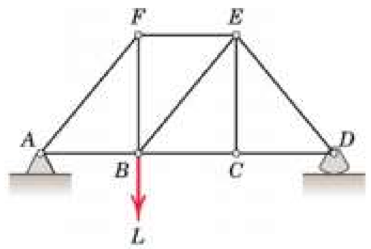
Dr. Kishore Khanna
Mechanical Engineering Department
Thapar Institute of Engineering and Technology, Patiala

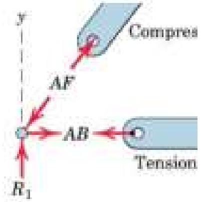
Trusses

Trusses

Gliwice Transmission Tower, Poland

Trusses: Method of Analysis



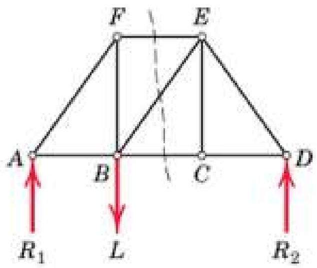


Method of Joints: only two of three equilibrium equations were applied at each joint because the procedures involve concurrent forces at each joint

→Calculations from joint to joint

→More time and effort required

$\Sigma F_x = 0$
$\Sigma F_y = 0$



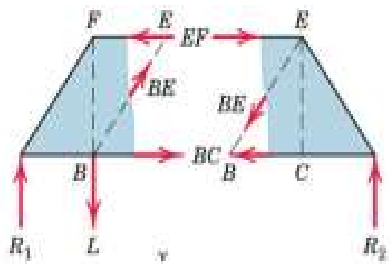
Method of Sections

Take advantage of the 3[rd] or moment equation of equilibrium by selecting an entire section of truss

$\Sigma F_x = 0$
$\Sigma F_y = 0$
$\Sigma M = 0$

→Equilibrium under non-concurrent force system

→Not more than 3 members whose forces are unknown should be cut in a single section since we have only 3 independent equilibrium equations



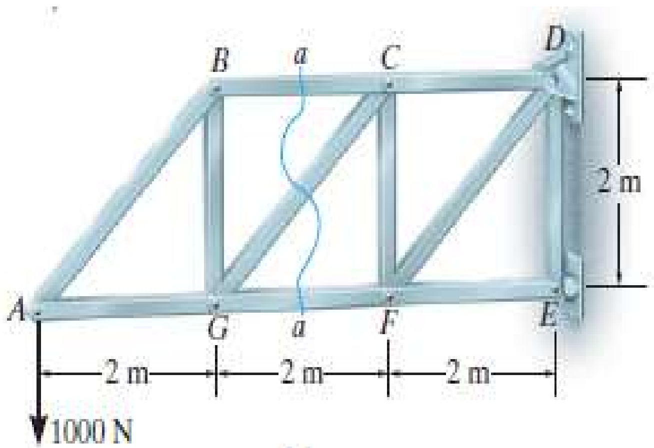
Trusses

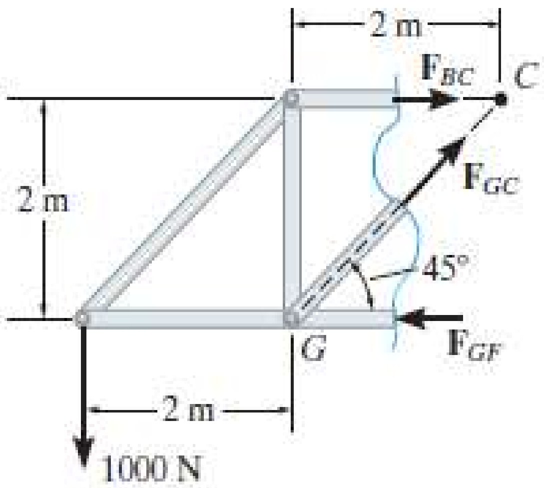
The forces in selected members of this truss can readily be determined using the method of sections.

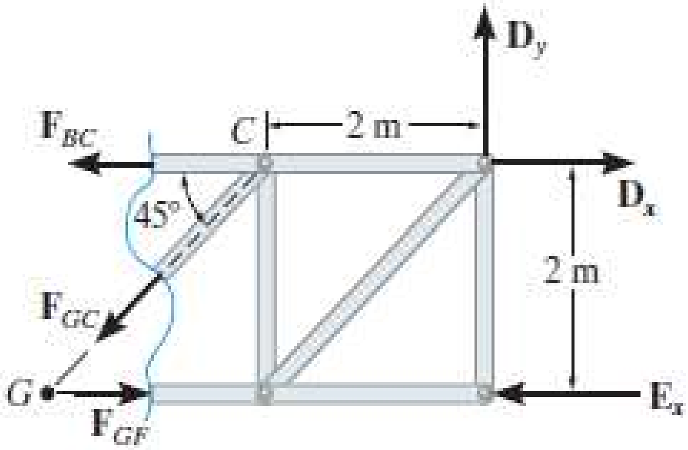
METHOD OF SECTION

When we need to find the force in only a few members of a truss, we can analyze the truss using the ***method of sections***. It is based on the principle that if the truss is in equilibrium then any segment of the truss is also in equilibrium. In this method an imaginary section, is used to cut each member into two parts and thereby "expose" each internal force as "external" to the free-body diagrams shown.

METHOD OF SECTION





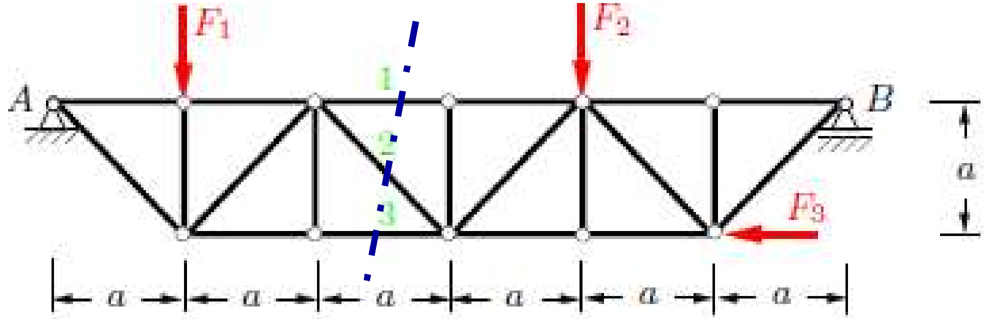


Trusses: Method of Sections

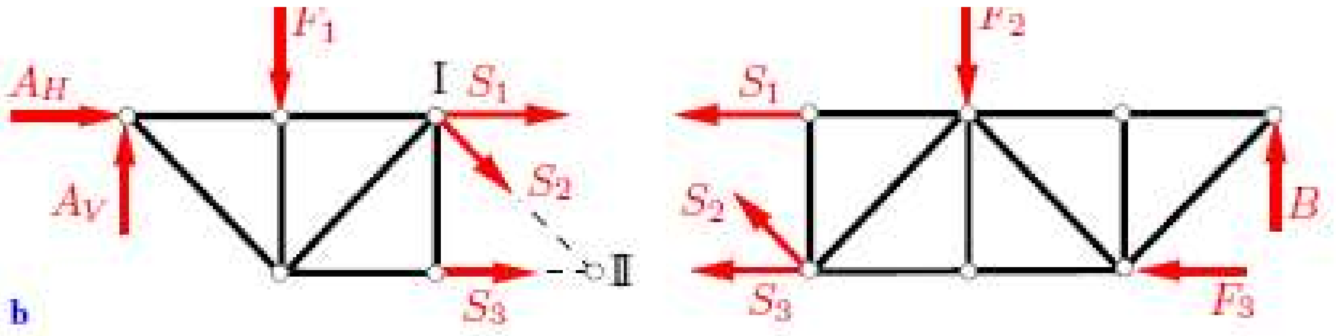
- It is not always necessary to determine the forces in all of the members of a truss.
- If several forces only are of interest, it may be advantageous to use the method of sections instead of the method of joints.
- In this case, the truss is divided by a cut into two parts.
- The cut has to be made in such a way that it either goes through three members that do not all belong to the same joint, or passes through one joint and one member.
- If the support reactions are computed in advance, the free-body diagram for each part of the truss contains only three unknown forces that can be determined by the three conditions of equilibrium.

Trusses: Method of Sections

- Forces are required in member 1,2, and 3.



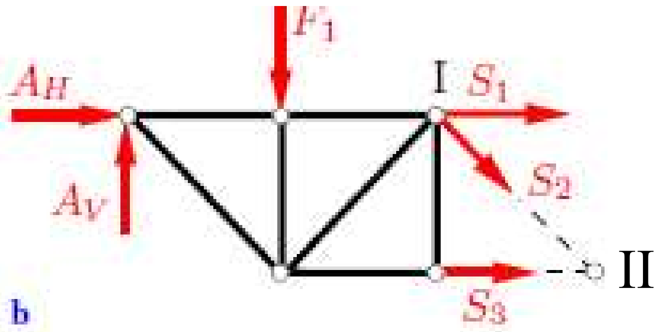
A cutting plane is passed through these members to cut the truss into two parts



Apply the equilibrium conditions to the free-body diagram of either part

Trusses: Method of Sections

Apply the equilibrium conditions to the free-body diagram of left part



$$\overset{\curvearrowleft}{\mathrm{I}}: \quad -2\,a\,A_V + a\,F_1 + a\,S_3 = 0 \quad \rightarrow \quad S_3 = 2\,A_V - F_1\,,$$

$$\overset{\curvearrowleft}{\mathrm{II}}: \quad -3\,a\,A_V - a\,A_H + 2\,a\,F_1 - a\,S_1 = 0$$

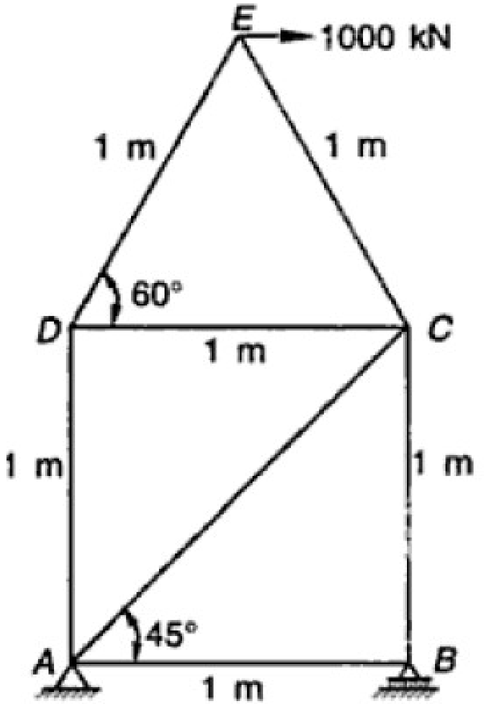
$$\rightarrow \quad S_1 = 2\,F_1 - 3\,A_V - A_H\,,$$

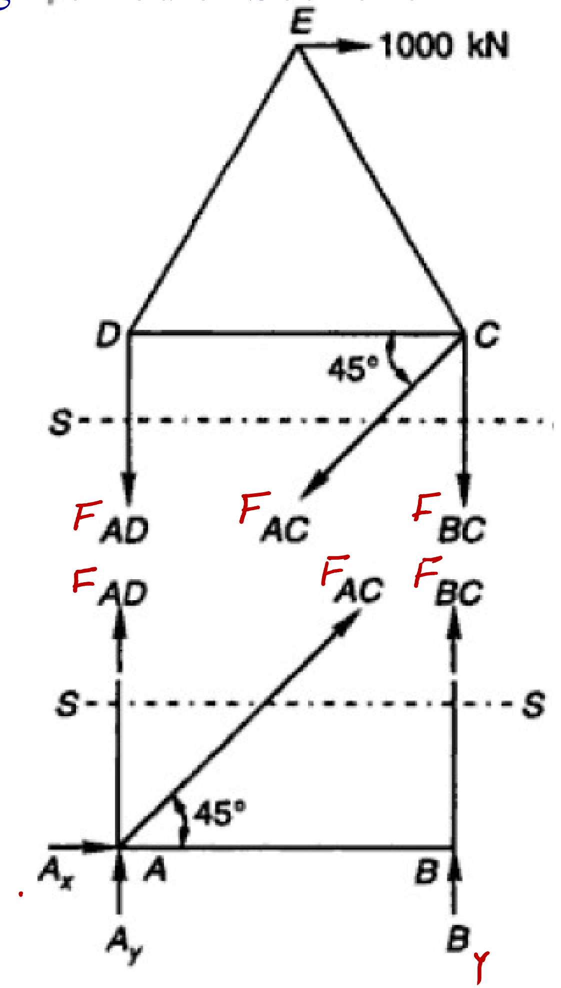
$$\uparrow: \quad A_V - F_1 - \frac{1}{2}\sqrt{2}\,S_2 = 0 \quad \rightarrow \quad S_2 = \sqrt{2}\,(A_V - F_1)\,.$$

Computing the support reactions, the forces in members 1-3 are now known

Method of Sections: Illustrative Example

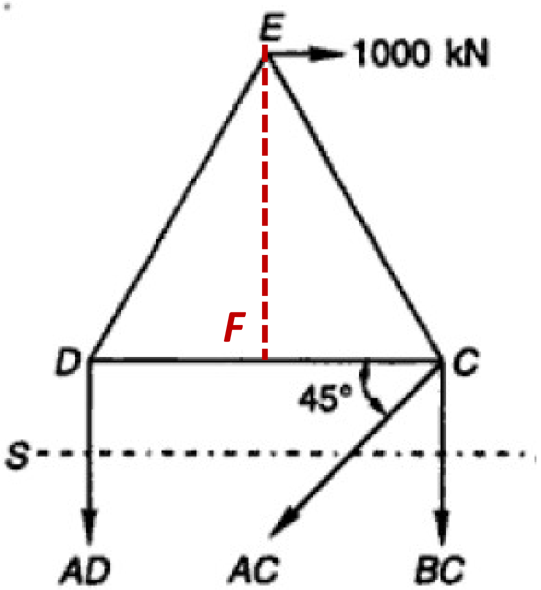
Ex: Determine the forces in the members AC, AD and BC using method of Sections





A Section is cut through AD, AC, and BC to cut the Truss in two parts

Method of Sections: Illustrative Example



Considering the Upper Part for Equilibrium

$\Sigma F_x = 0;$
$1000 - AC\cos 45 = 0;$ $\boldsymbol{AC = 1414\ kN(T)}$

In $\Delta\, EFC, EF = (1m)\sin 60 = 0.866m$
$\Sigma M_C = 0,$
$(1000 \times 0.866) - AD \times 1 = 0;$
$\boldsymbol{AD = 866kN(T)}$

$\Sigma F_y = 0; -AD\ - BC\ - AC\sin 45 = 0;$
$BC = -1866\ kN;$ $\boldsymbol{BC = 1866kN(Comp.)}$

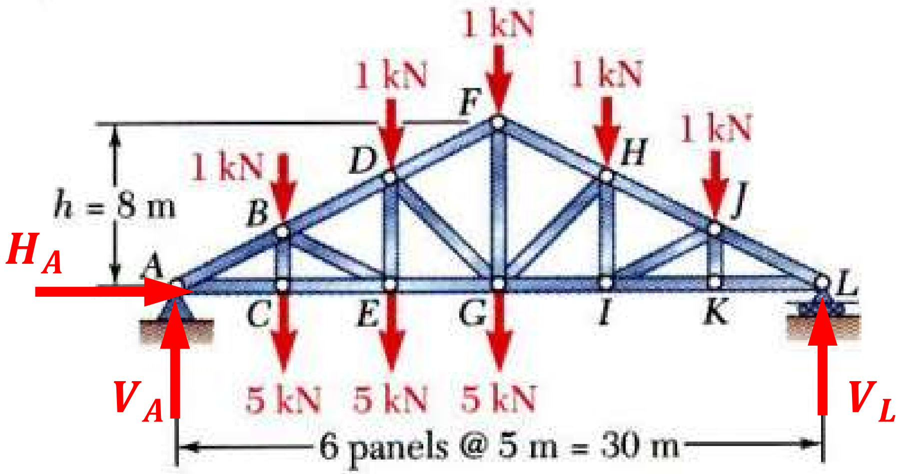
Method of Sections: Helpful Hint

- There is no harm in assigning one or more of the forces in the wrong direction as long as the calculations are consistent with the assumption.
- A negative answer will show the need for reversing the direction of the force.

Method of Sections: Illustrative Example

Find out internal forces in members FH, GH and GI.

Solution: Find out reactions at the supports

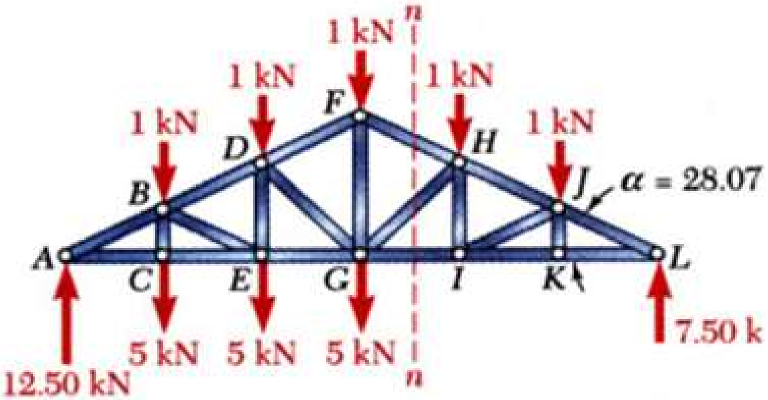


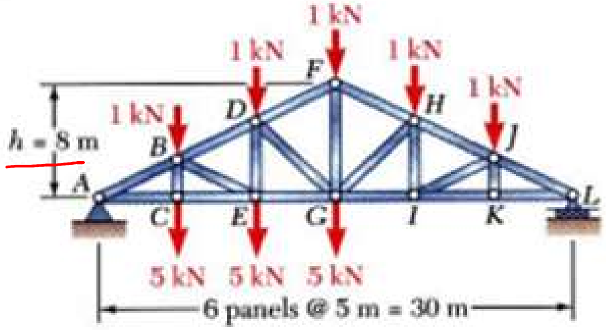
$$\sum M_A = 0 = -(5\text{ m})(6\text{ kN}) - (10\text{ m})(6\text{ kN}) - (15\text{ m})(6\text{ kN}) - (20\text{ m})(1\text{ kN}) - (25\text{ m})(1\text{ kN}) + (30\text{ m})V_L$$

$$V_L = 7.5\ kN$$

$$\Sigma F_Y = 0;\ V_A + V_L = 20kN;$$
$$V_A = 12.5\ kN$$
$$\Sigma F_H = 0;\ H_A = 0$$

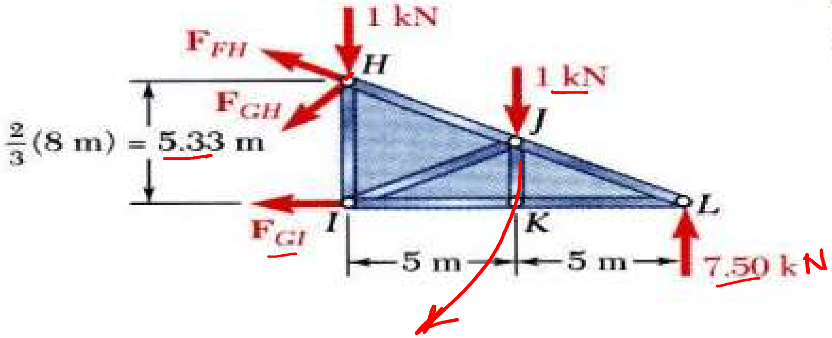
Pass a section through members FH, GH, and GI and take the right-hand section as a free body.





$$\tan\alpha = \frac{FG}{GL} = \frac{8\text{ m}}{15\text{ m}} = 0.5333 \qquad \alpha = 28.07°$$

$\Sigma M_H = 0$



Apply the conditions for static equilibrium to determine the desired member forces.

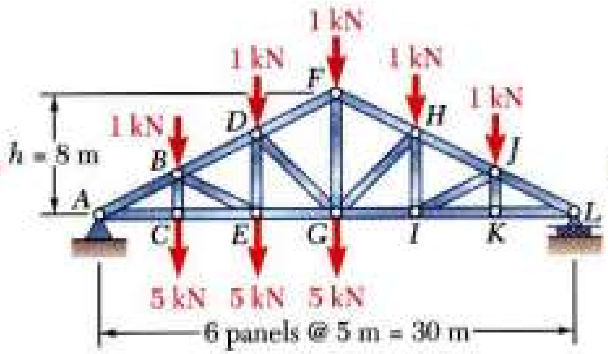
$$\sum M_H = 0$$

$$(7.50\text{ kN})(10\text{ m}) - (1\text{ kN})(5\text{ m}) - F_{GI}(5.33\text{ m}) = 0$$

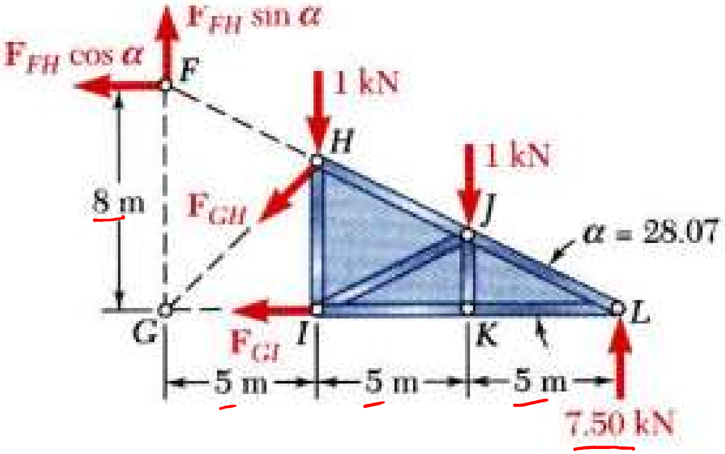
$$F_{GI} = +13.13\text{ kN}$$

$$\boxed{F_{GI} = 13.13\text{ kN } (T)}$$

Method of Sections: Example Solution



$\Sigma F_y = 0$
$\Sigma F_x = 0$



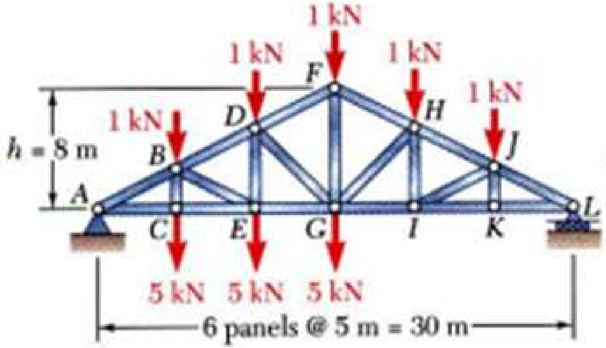
$$\sum M_G = 0$$

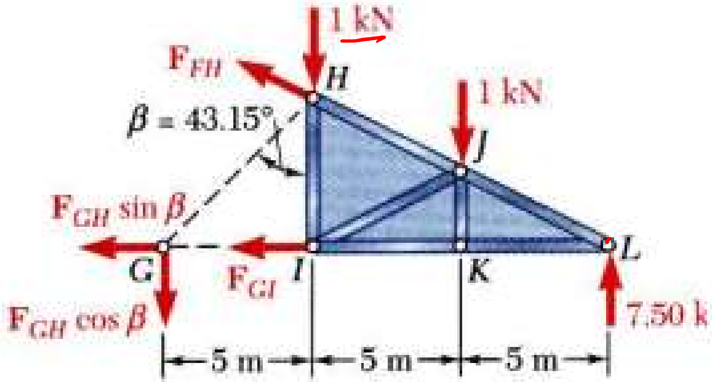
$$(7.5\,\text{kN})(15\,\text{m}) - (1\,\text{kN})(10\,\text{m}) - (1\,\text{kN})(5\,\text{m}) + (F_{FH}\cos\alpha)(8\,\text{m}) = 0$$

$$F_{FH} = -13.82\,\text{kN}$$

$$\boxed{F_{FH} = 13.82\,\text{kN}\,(C)}$$

Method of Sections: Example Solution





$$\tan\beta = \frac{GI}{HI} = \frac{5\text{ m}}{\frac{2}{3}(8\text{ m})} = 0.9375 \qquad \beta = 43.15°$$

$$\sum M_L = 0$$

$$(1\text{ kN})(10\text{ m}) + (1\text{ kN})(5\text{ m}) + (F_{GH}\cos\beta)(15\text{ m}) = 0$$

$$F_{GH} = -1.371\text{ kN}$$

$$\boxed{F_{GH} = 1.371\text{ kN}\ (C)}$$

Method of Sections: Illustrative Example

Calculate the force in member *DJ* of the Howe roof truss as shown. Neglect any horizontal components of force at the supports.

Solution:

- ❑ Calculate reactions at supports:

$V_A + V_G = 30kN;$

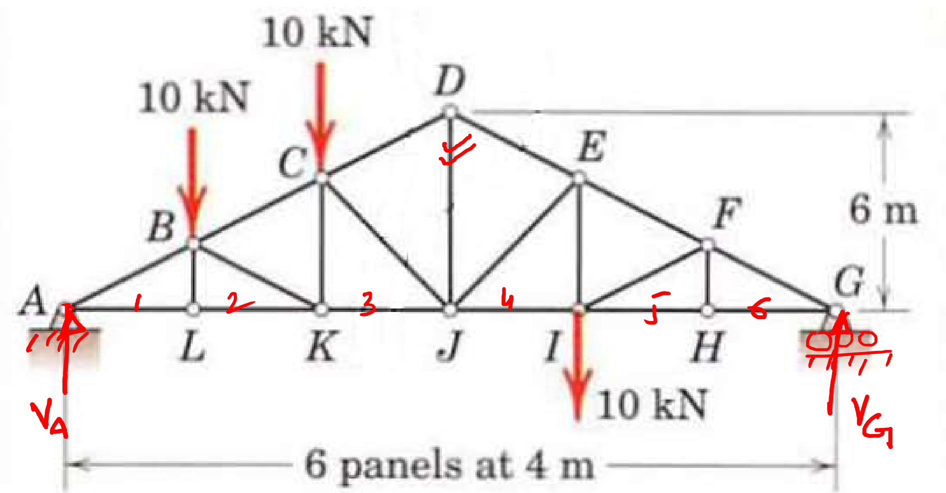
$\Sigma M_A = 0;$

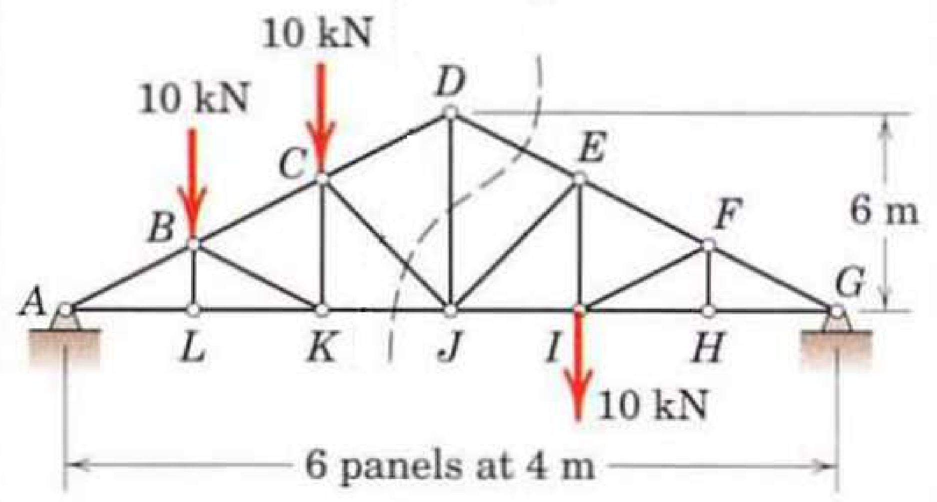
$10 \times 4 + 10 \times 8 + 10 \times 16 - V_G \times 24 = 0;$

$V_G = 11.67\ kN$ and $V_A = 18.33\ kN$

- ❑ Take a section that cuts the member DJ

- ❑ It is not possible to pass a section through *DJ* without cutting four members whose forces are un known.

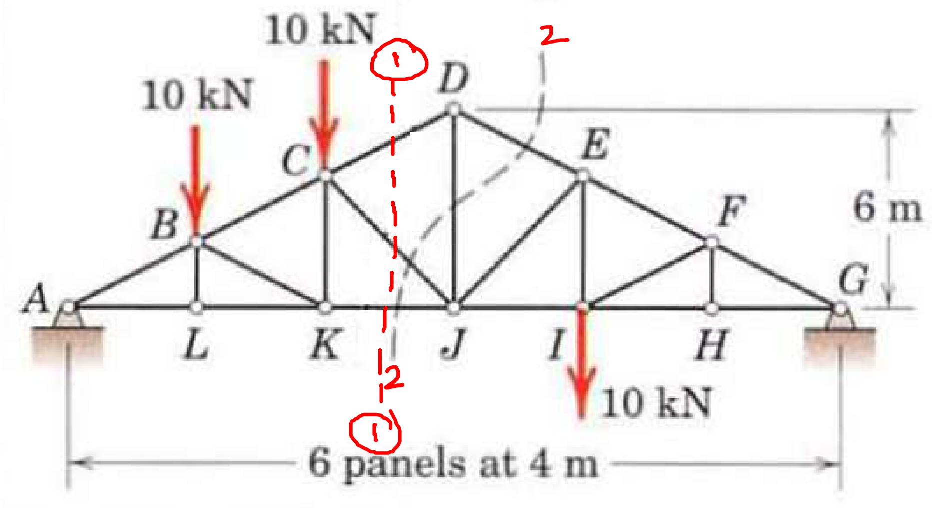


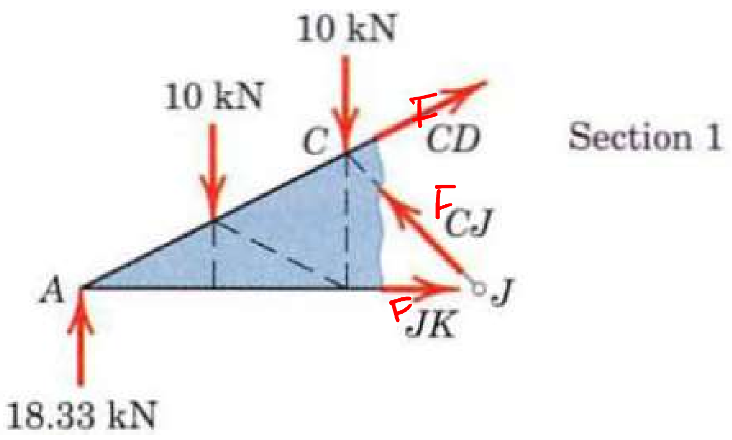


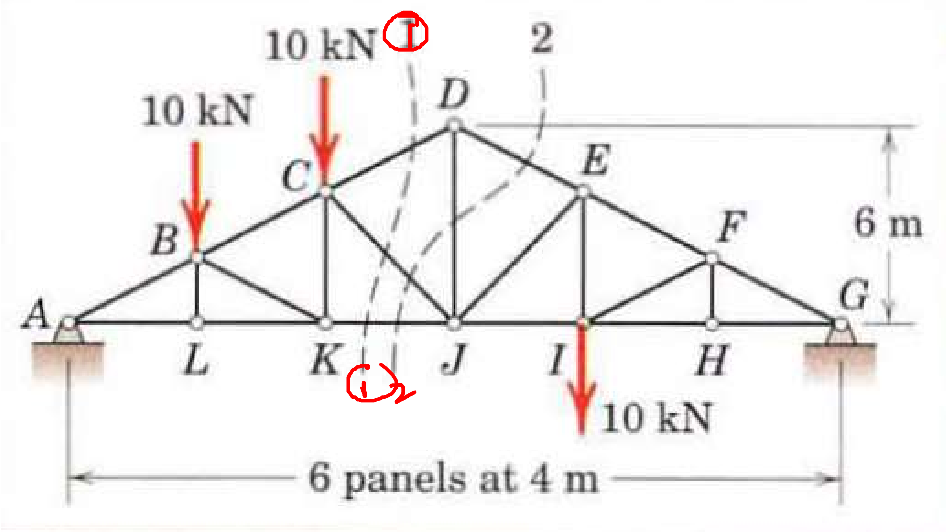
Method of Sections: Illustrative Example

- ❑ It is not possible to pass a section through *DJ* without cutting four members whose forces are un known.

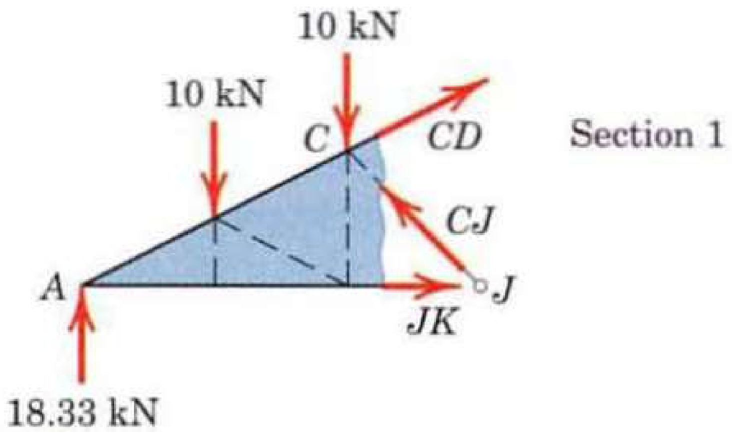
- ❑ It is necessary to consider first the adjacent section 1 before analysing section 2.

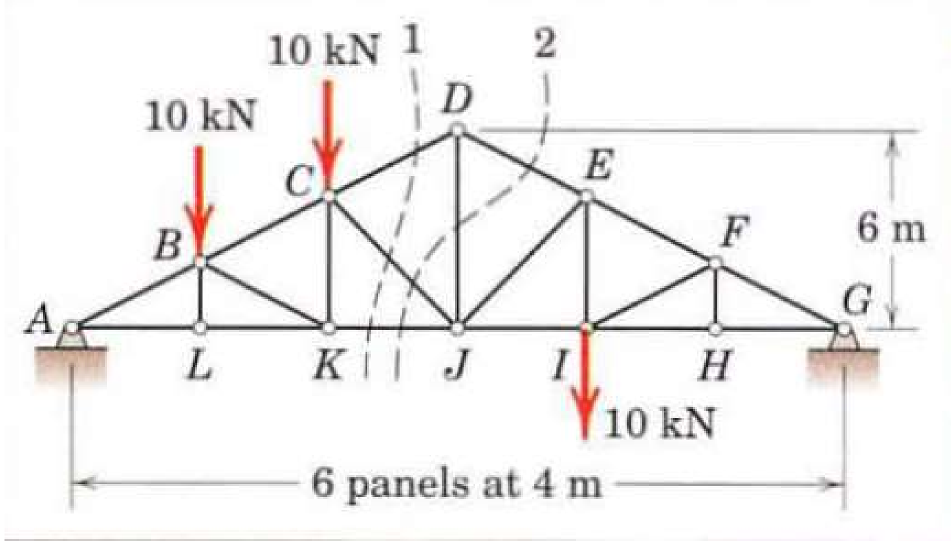




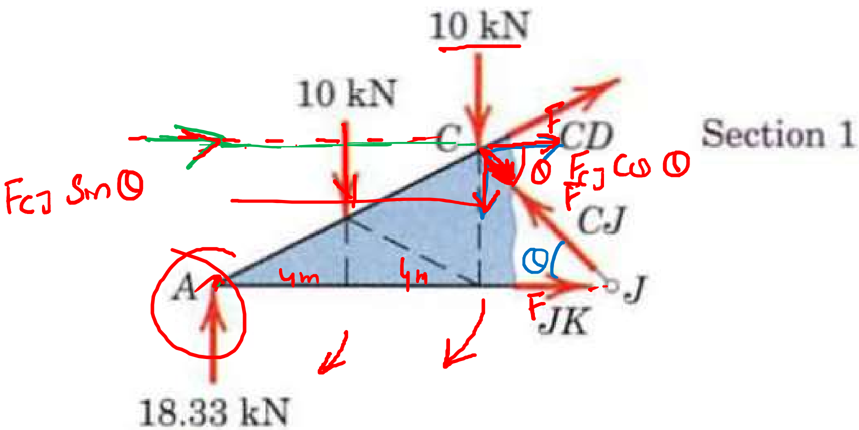


Method of Sections: Illustrative Example





Method of Sections: Illustrative Example



$$\Sigma M_A = 0$$

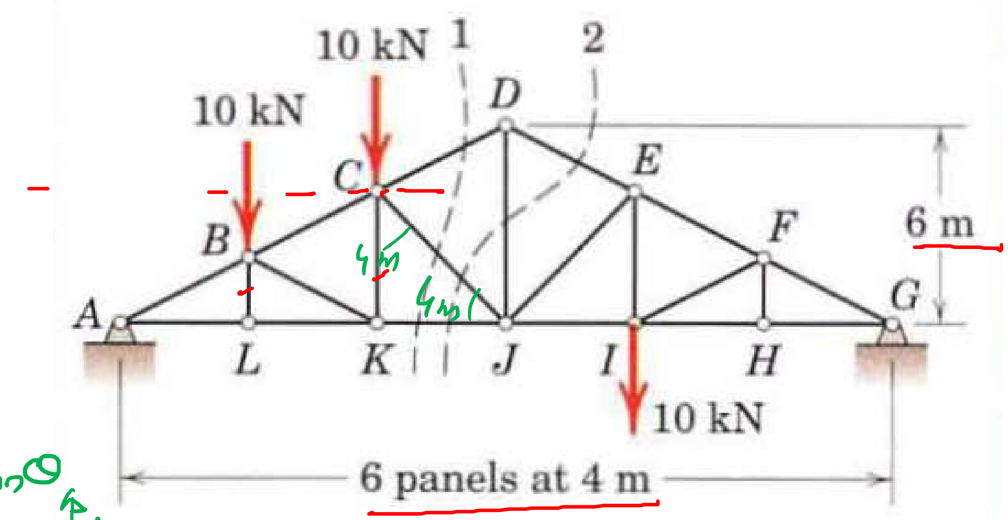
$$10\times4 + 10\times8 + F_{CJ}\sin45\times8 + F_{CJ}\cos45\times4 = 0$$

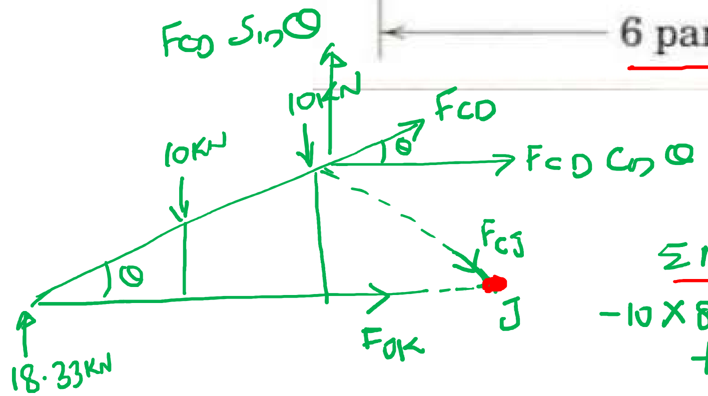
$$40 + 80 + 5.66\,F_{CJ} + 2.83\,F_{CJ} = 0$$

$$F_{CJ} = -14.14\ \text{kN}$$

$$\boxed{F_{CJ} = 14.14\ \text{kN (Comp)}}$$

$$\Sigma M_J = 0$$





$$\tan\theta = \frac{2}{4}$$

$$\theta = 26.56^\circ$$

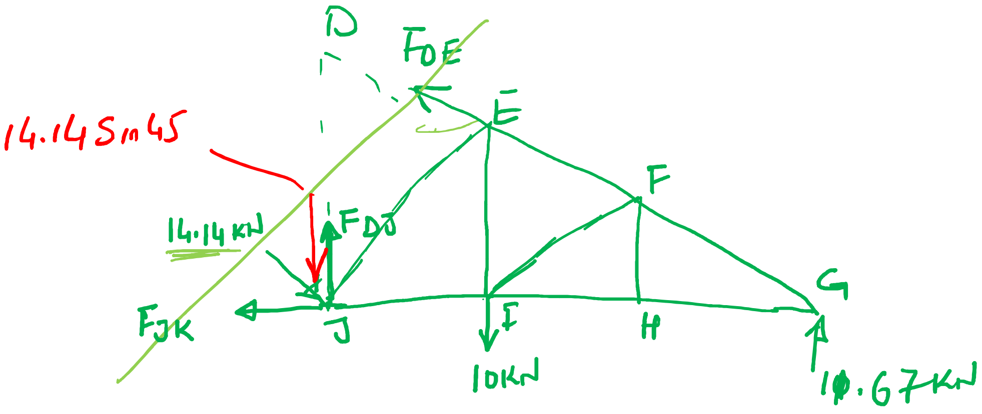
$$\Sigma M_J = 0$$

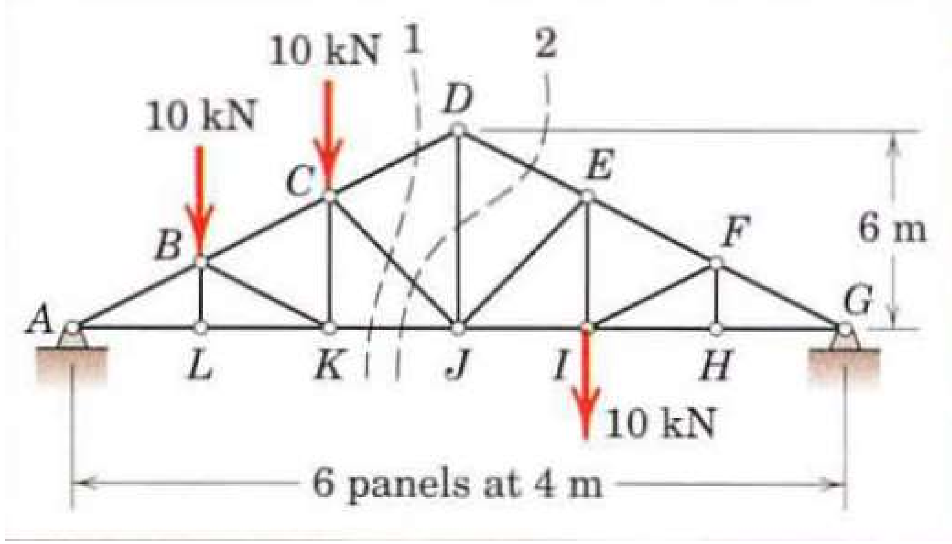
$$-10\times8 - 10\times4 + 18.33\times12 + F_{CD}\cos26.56\times4 + F_{CD}\sin\theta\times4 = 0$$

$$F_{CD} = -18.61\ \text{kN}$$

$$\boxed{F_{CD} = 18.61\ \text{kN (Comp)}}$$

Method of Sections: Illustrative Example





$$\Sigma M_G = 0$$

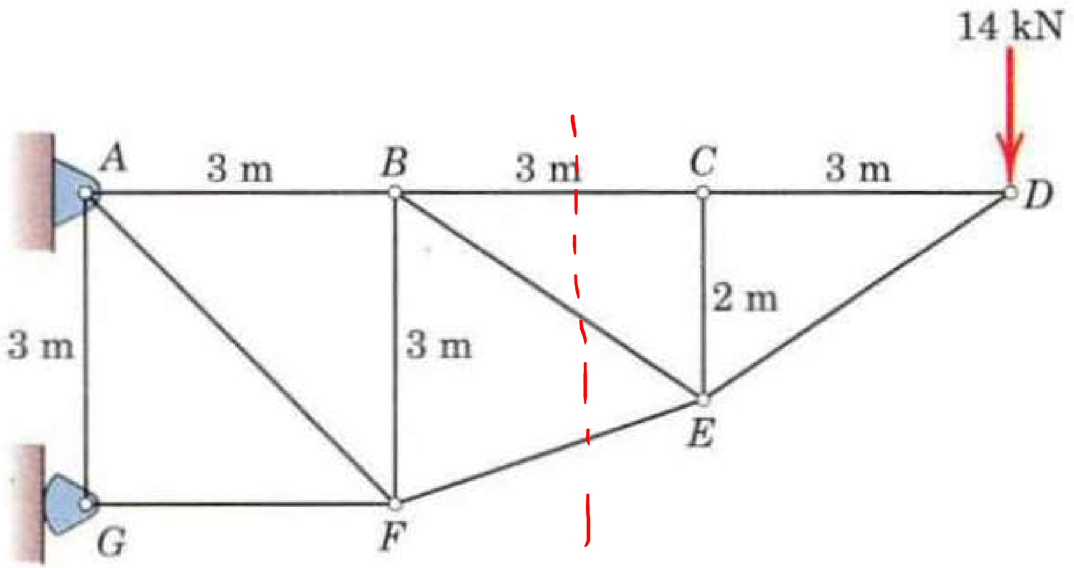
$$-10\times 8 + F_{DJ}\times 12 - 14.14\sin 45\times 12 = 0$$

$$F_{DJ} = \frac{200}{12} = 16.67\,kN$$

$$\boxed{F_{DJ} = 16.67\,kN\,(T)}$$

Method of Sections: Exercise Problems

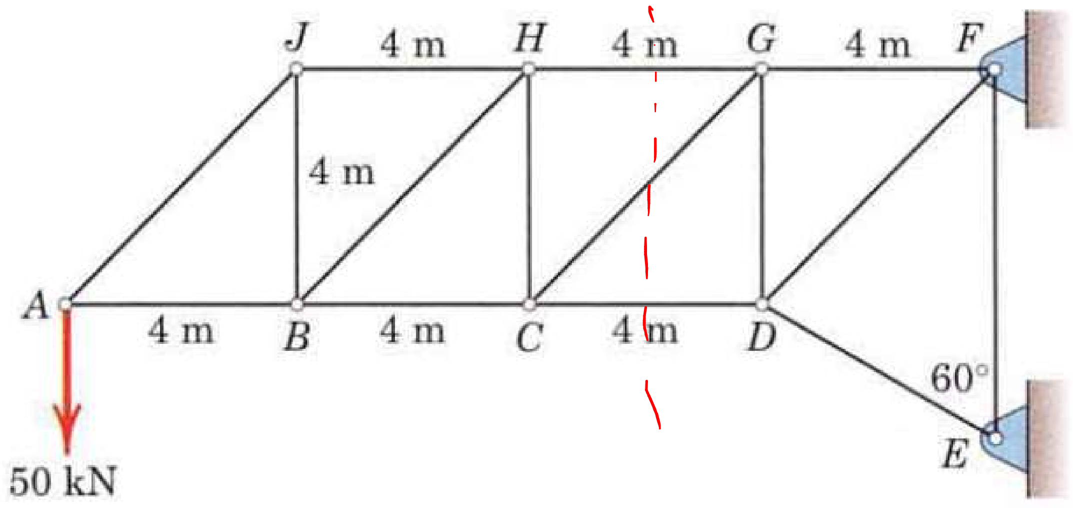
Exercise: Calculate the forces in members *BC*, *BE*, and *EF*.



Ans. $BC = 21$ kN T, $BE = 8.41$ kN T
$EF = 29.5$ kN C

Method of Sections: Exercise Problems

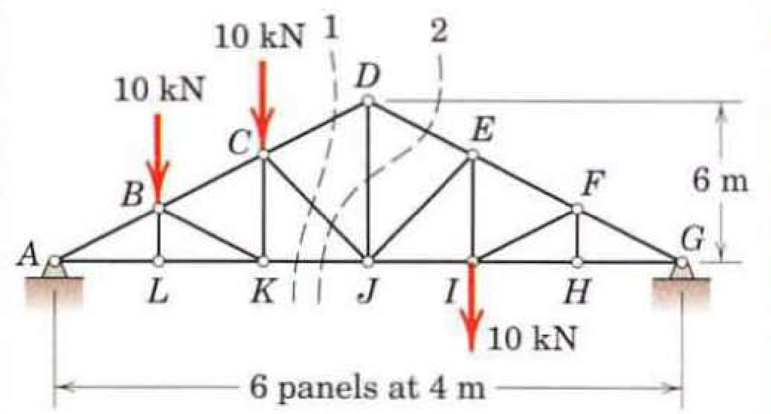
Determine the forces in members *CG* and *GH* for the truss loaded and supported as shown.

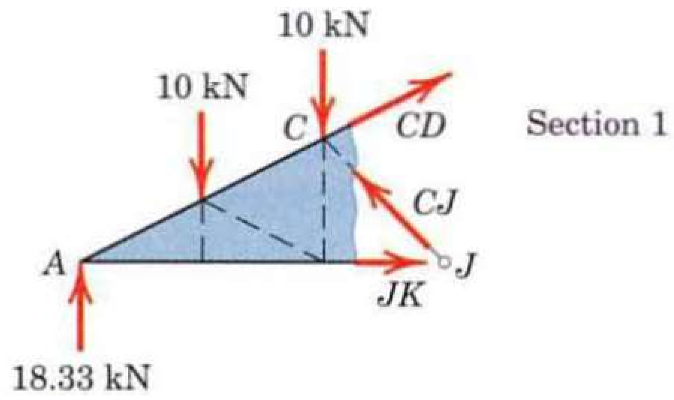


Ans. $CG = 70.7$ kN T, $GH = 100$ kN T

Thank you

Method of Sections: Illustrative Example





By the analysis of section 1, CJ is obtained from

$$[\Sigma M_A = 0] \qquad 0.707CJ(12) - 10(4) - 10(8) = 0$$

$$CJ = 14.14 \text{ kN } C$$

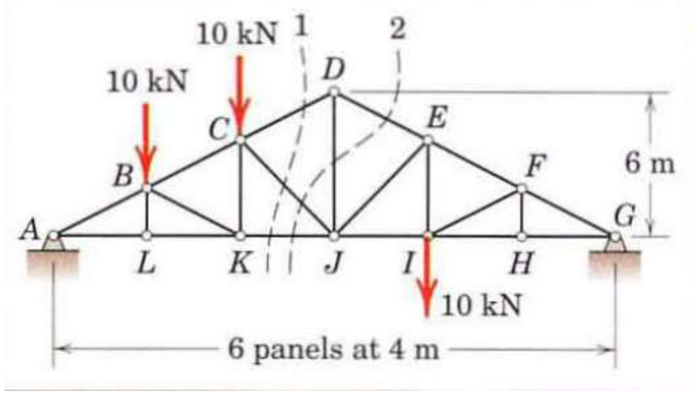
$$[\Sigma M_J = 0] \qquad 0.894CD(6) + 18.33(12) - 10(4) - 10(8) = 0$$

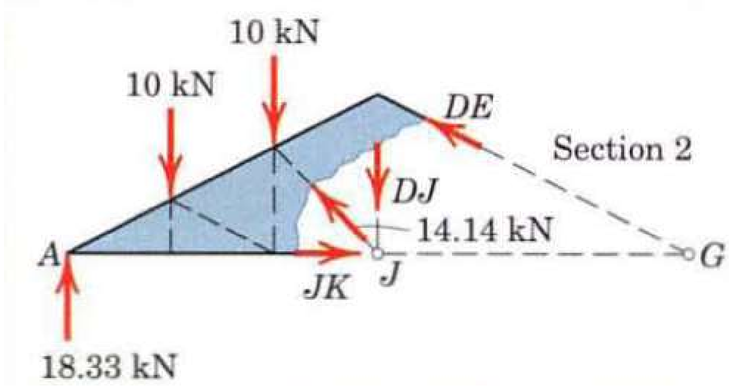
$$CD = -18.63 \text{ kN}$$

The moment of CD about J is calculated here by considering its two components as acting through D. The minus sign indicates that CD was assigned in the wrong direction.

Hence, $\qquad CD = 18.63 \text{ kN } C$

Method of Sections: Illustrative Example





From the free-body diagram of section 2, which now includes the known value of CJ, a balance of moments about G is seen to eliminate DE and JK. Thus,

$$[\Sigma M_G = 0] \qquad 12DJ + 10(16) + 10(20) - 18.33(24) - 14.14(0.707)(12) = 0$$

$$\boxed{DJ = 16.67 \text{ kN } T}$$