Trusses الجيزان الشبكية

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Definition: A truss is a structure composed of straight slender members that are connected at their ends by pin joints. The truss is one of the oldest and most important structures in engineering applications.

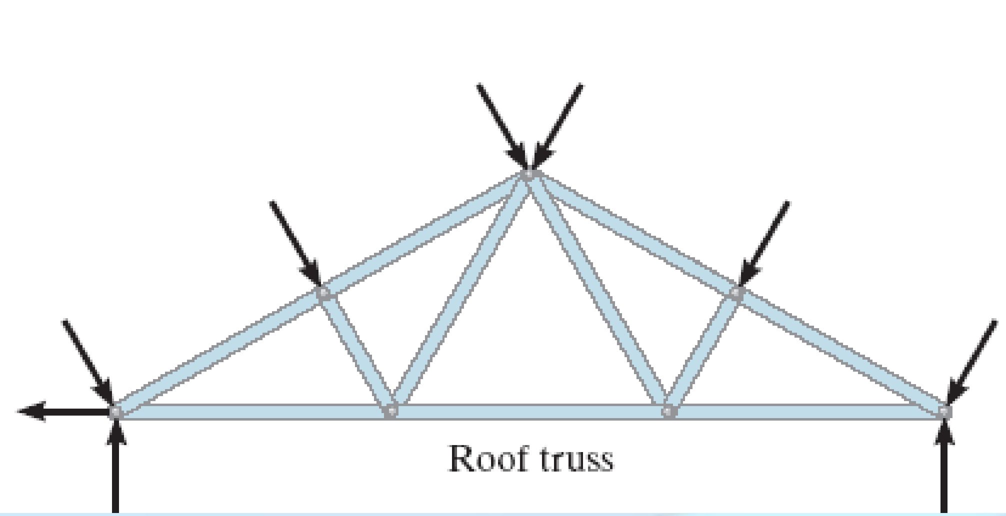
تعريف: يتكون الجائز الشبكي من عناصر مستقيمة نحيلة تتصل ببعضها عند نهاياتها بواسطة عقد مفصلية. يعد الجائز الشبكي واحدا من أقدم الجمل الإنشائية وأكثرها أهمية وفعالية.

1. Statically Determinate Trusses

To be able to determine the internal forces in the individual members of an ideal truss, the following assumptions are made:

1. The members are connected through smooth pins (frictionless joints).

2. External forces are applied at the pins only.



In a plane truss m members connected through j joints, & supported by r reactions.

In order to be able to determine the $m + r$ unknown forces from the $2\,j$ equilibrium conditions, the number of unknowns has to be equal to the number of equations: $2j = m + r$.

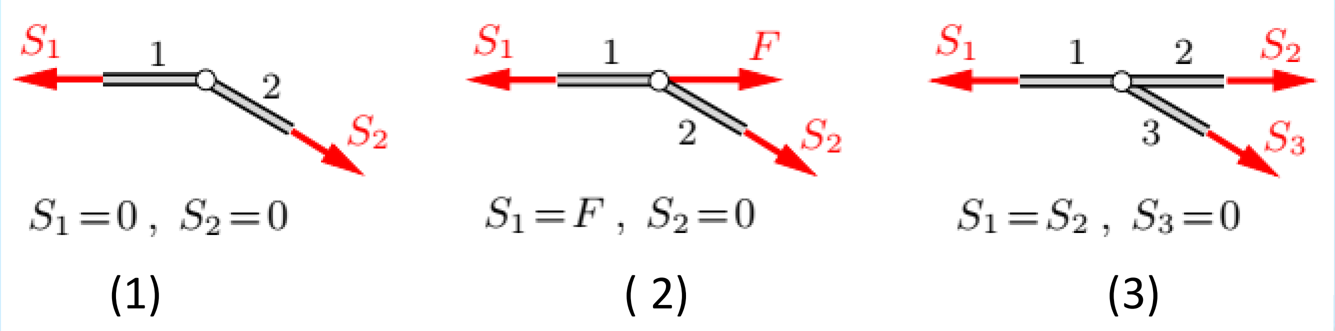
For space truss, the condition becomes: $3j = m + r$.

2. Determination of the Internal Forces — 2. تحديد القوى الداخلية

2.1. Method of Joints — 2 .1. طريقة توازن العقد

The method of joints consists of applying the equilibrium conditions to the free-body diagram of each joint of the truss. It is a systematic method and can be used for every statically determinate truss.

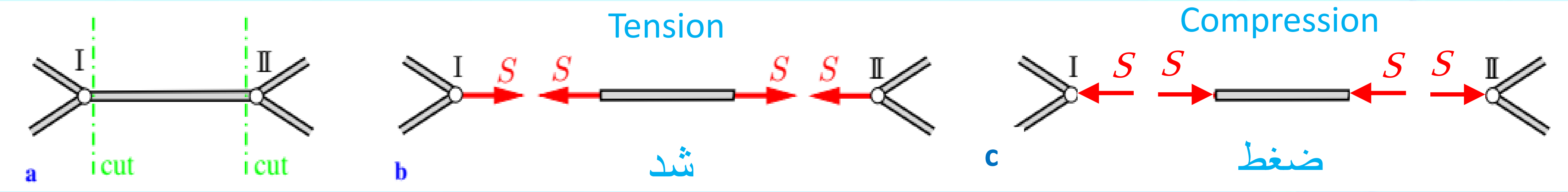
Identification of zero-force members



تنعدم القوة الداخلية في عناصر الجائز الشبكي في أي من الحالات التالية:

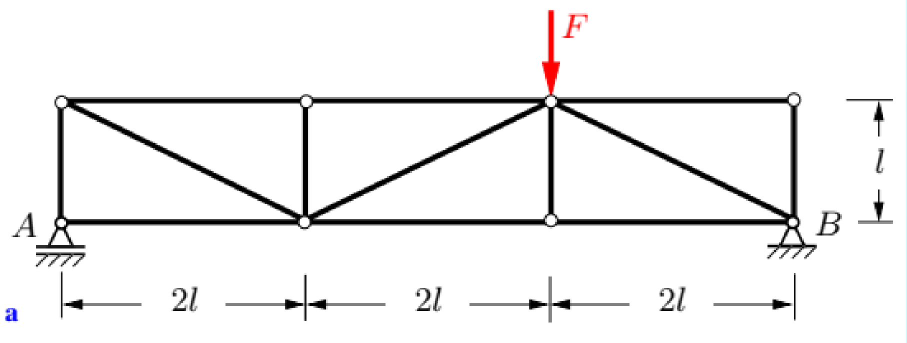
1. عنصران متلاقيان في عقدة غير محملة لا تحوي غيرهما.
2. عنصر مائل على حمولة في عقدة تحوي عنصرين فقط ومحملة باتجاه أحدهما.
3. عنصر مائل في عقدة غير محملة تحوي ثلاثة عناصر اثنان منهما على استقامة وتحدة.

Tension member or Compression member



It is not always possible to determine by inspection whether a member is subject to tension or compression. Therefore, we shall always assume that all the members of a truss are under tension. If the analysis gives a negative value for the force in a member, this member is in reality subject to compression.

In practice, it may be more convenient to determine first the support reactions from the free-body diagram of the complete truss. Then three other equilibrium equations within the method of joints will serve as checks.



Example 1. The truss shown in Fig. a is loaded by an external force F. Determine the forces at the supports and in the members of the truss.

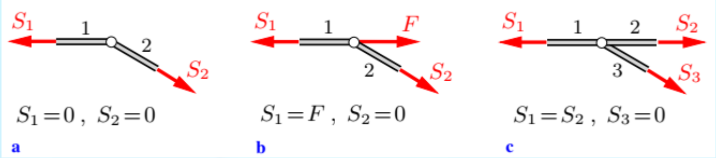
Solution: numbering joints & members: $2j = m + r$.

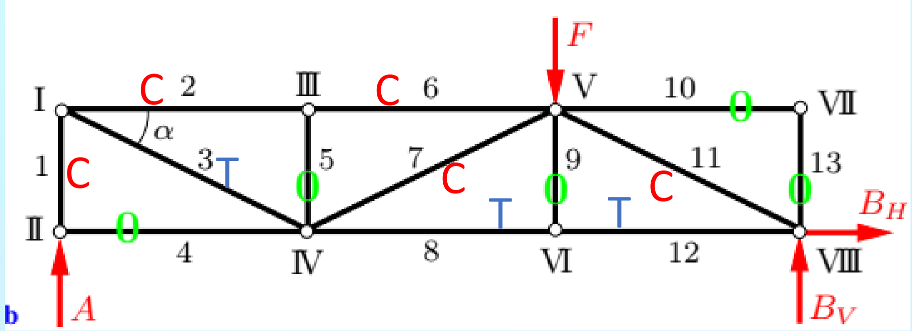
1) Fig. b, F. B. D. of the truss. Eq. Eqs.:

→: $B_H = 0$

↶^{A}=0: $-4lF+6lB_V=0 \Rightarrow B_V=(2/3)F$

↶^{B}=0: $2\,lF-6lA=0 \Rightarrow A=(1/3)F$





2) Identification of zero-force members.:

3) Joint Equilibrium: F. B. Ds. for joints

II) ↑: $S_1 + A = 0 \Rightarrow S_1 = -A = -(1/3)F$

I) ↑: $-S_1 - S_3\sin\alpha = 0 \Rightarrow S_3 = -S_1/\sin\alpha = (1/3)F/\sin\alpha$

→: $S_3\cos\alpha + S_2 = 0 \Rightarrow S_2 = -S_3\cos\alpha = -(1/3)F/\tan\alpha$

III) →: $-S_2 + S_6 = 0 \Rightarrow S_6 = S_2 = -(1/3)F/\tan\alpha$

IV) ↑: $S_3\sin\alpha + S_7\sin\alpha = 0 \Rightarrow S_7 = -S_3 = -(1/3)F/\sin\alpha$

→: $-S_3\cos\alpha + S_7\cos\alpha + S_8 = 0 \Rightarrow S_8 = S_3\cos\alpha - S_7\cos\alpha = (2/3)F/\tan\alpha$

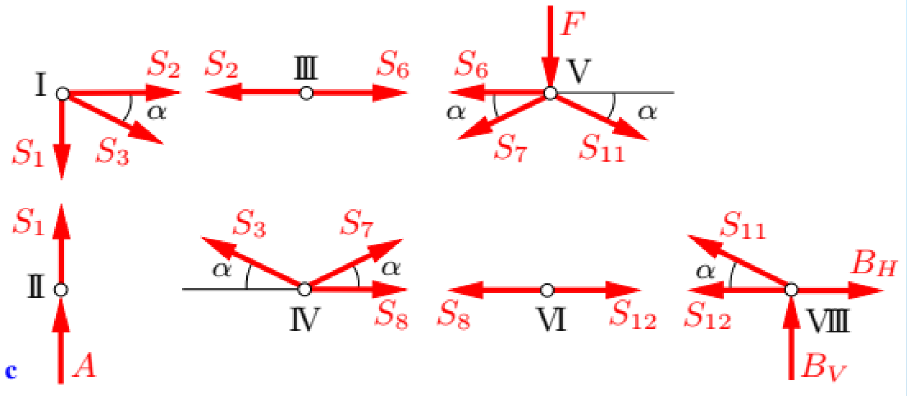
V) ↑: $-S_7\sin\alpha - S_{11}\sin\alpha - F = 0 \Rightarrow S_{11} = -S_7 - F/\sin\alpha = -(2/3)F/\sin\alpha$

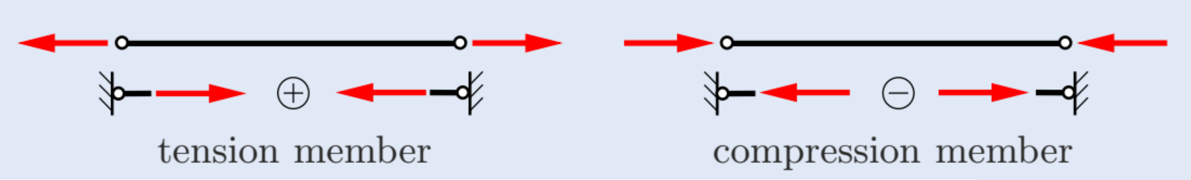
→: $-S_6 - S_7\cos\alpha + S_{11}\cos\alpha = 0 \Rightarrow [(1/3)+(1/3)-(2/3)]F/\tan\alpha \equiv 0$

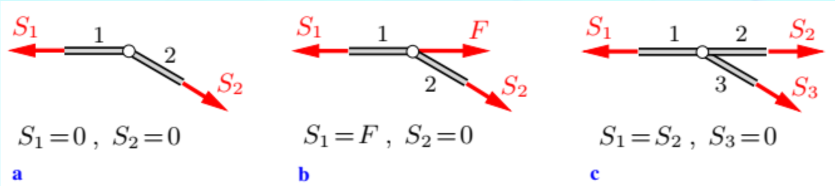
VI) →: $-S_8 + S_{12} = 0 \Rightarrow S_{12} = S_8 = (2/3)F/\tan\alpha$

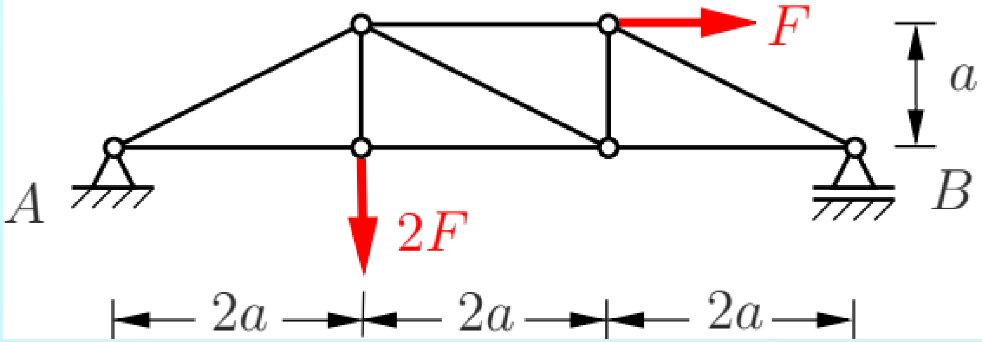
VIII) ↑: $B_V + S_{11}\sin\alpha = 0 \Rightarrow [(2/3)-(2/3)]F \equiv 0$

→: $-S_{12} - S_{11}\cos\alpha + B_H = 0 \Rightarrow [-(2/3)+(2/3)]F/\tan\alpha + 0 \equiv 0$

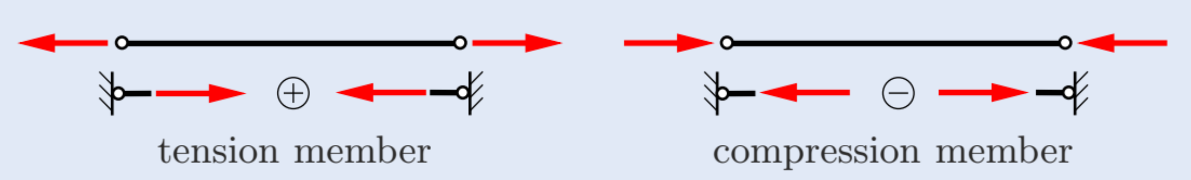


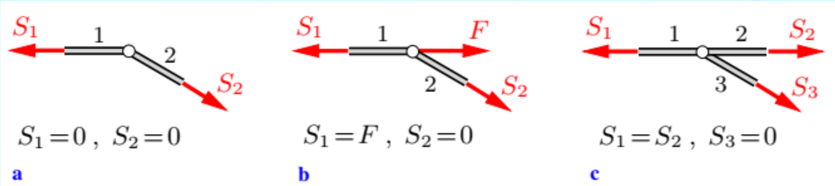


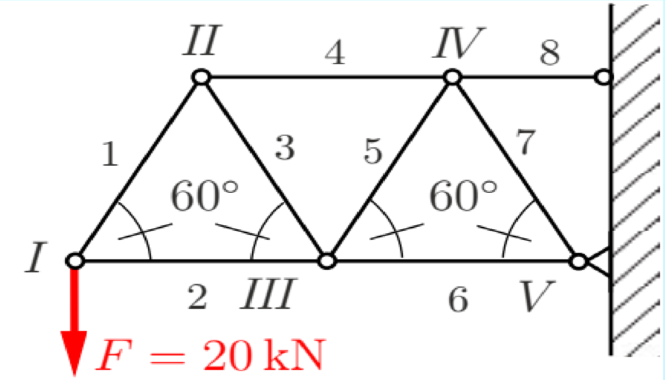




Example 2. For the given truss, the forces in the bars shall be determined.

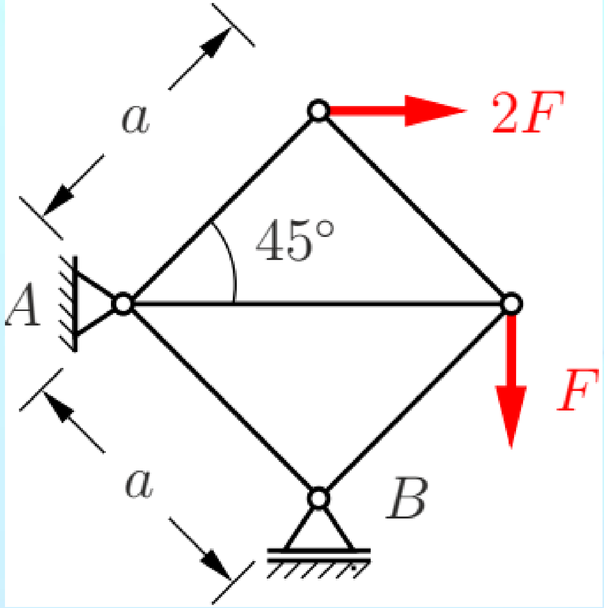




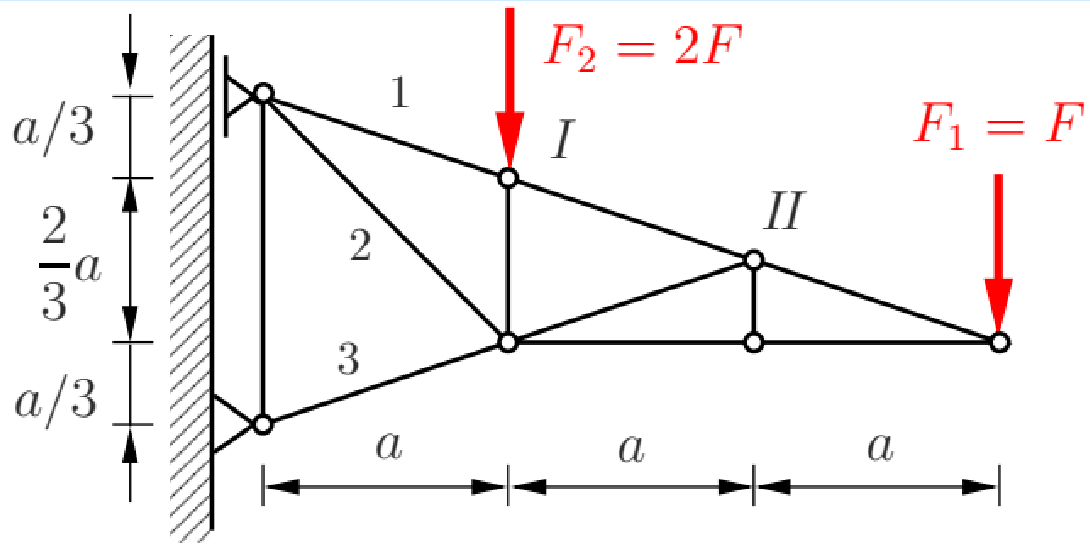


Example 3. For the given truss, all bar forces have to be determined.

Problem 1. For the given truss, the bar forces have to be determined with the Method of Joints.



Problem 2. For the given truss, the bar forces have to be determined with the Method of Joints.



Problem 3. Determine the bar forces for the given truss.