Struktur Rangka Batang

Analysis of Truss Structures

- Akan dibahas determinacy, stability, dan analysis dari tiga macam bentuk rangka batang: **simple, compound, and complex.**

Analysis of Truss Structures

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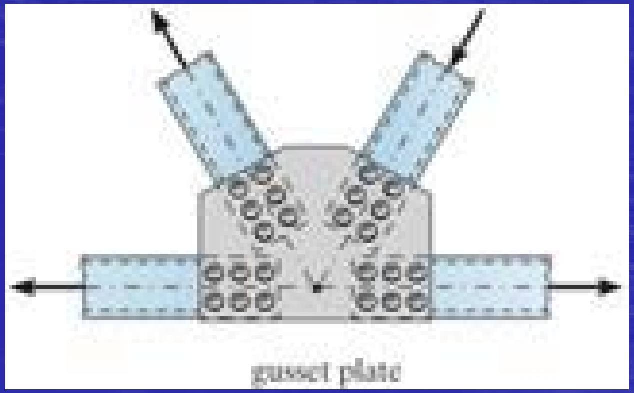
Analysis of Truss Structures

- Difinisi:Struktur Rangka Batang adalah struktur yang terdiri dari elemen-elemen batang dimana ujung-ujungnya dihubungkan pada satu titik dengan hubungan sendi, dan direncanakan untuk menerima beban yang cukup besar (dibandingkan berat sendirinya) yang bekerja pada titik-titik hubungnya.
- Plane truss adalah struktur rangka batang yang terletak pada satu bidang.
- Hubungan antar elemen, biasanya menggunakan baut dan gusset plate.

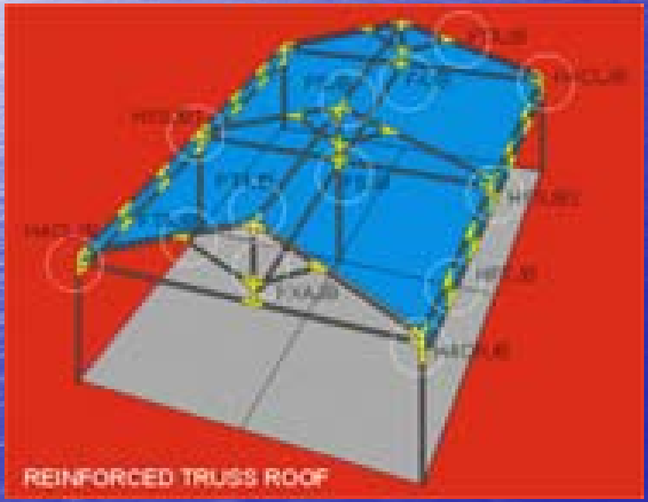
Analysis of Truss Structures

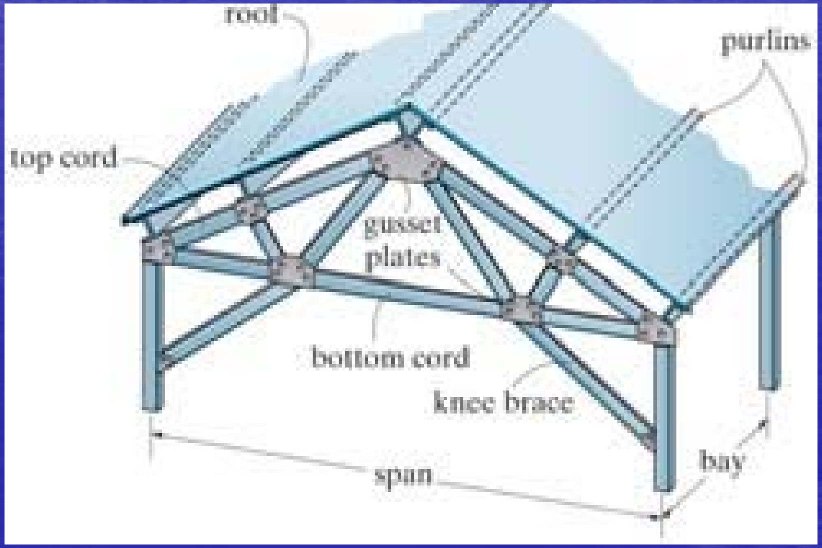


Analysis of A Truss Structure

Common Type of Trusses:

- Roof Trusses: Pada umumnya, beban atap yang bekerja pada truss di teruskan melalui purlin (gording). Rangka atap ditumpu oleh kolom.





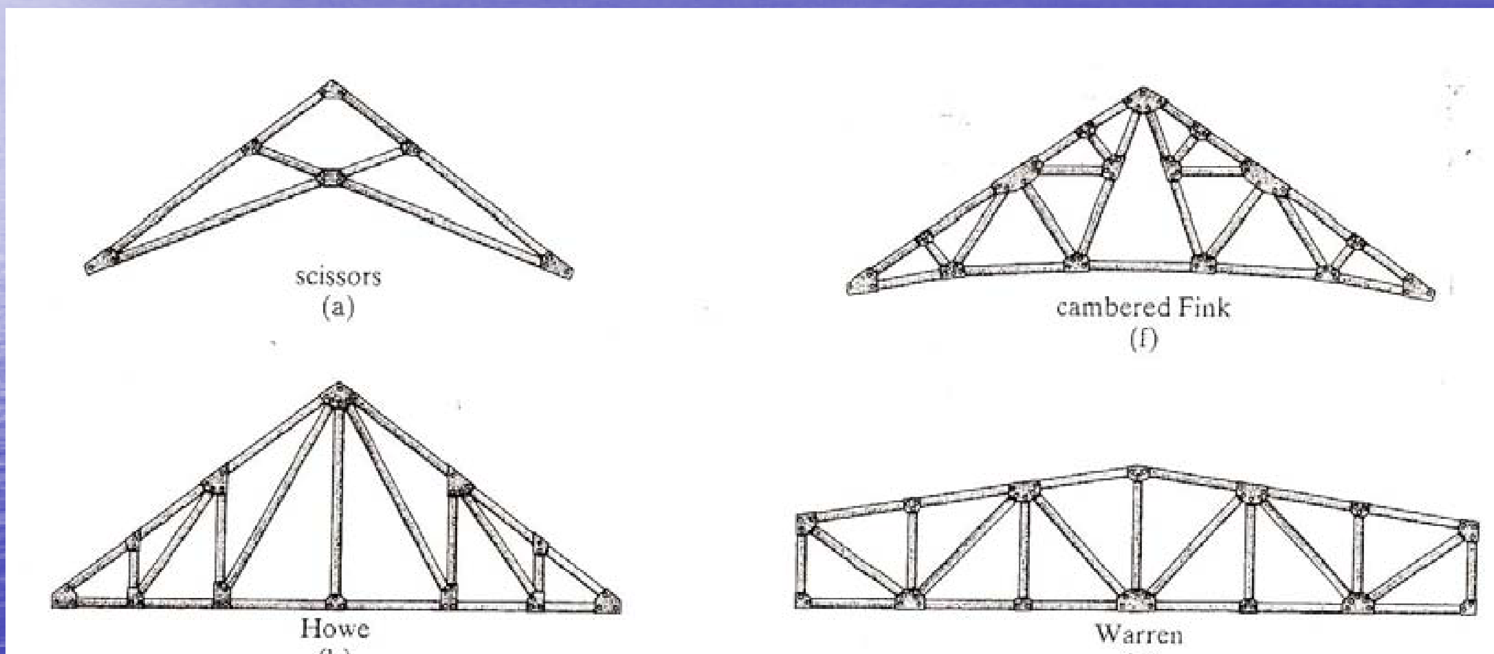
Analysis of A Truss Structure

Bentuk Truss pada umumnya:

- Scissors
- Howe
- Pratt
- Fan
- Fink
- Cambered Fink
- Warren
- Sawtooth
- Bowstring
- Three-hinged arch

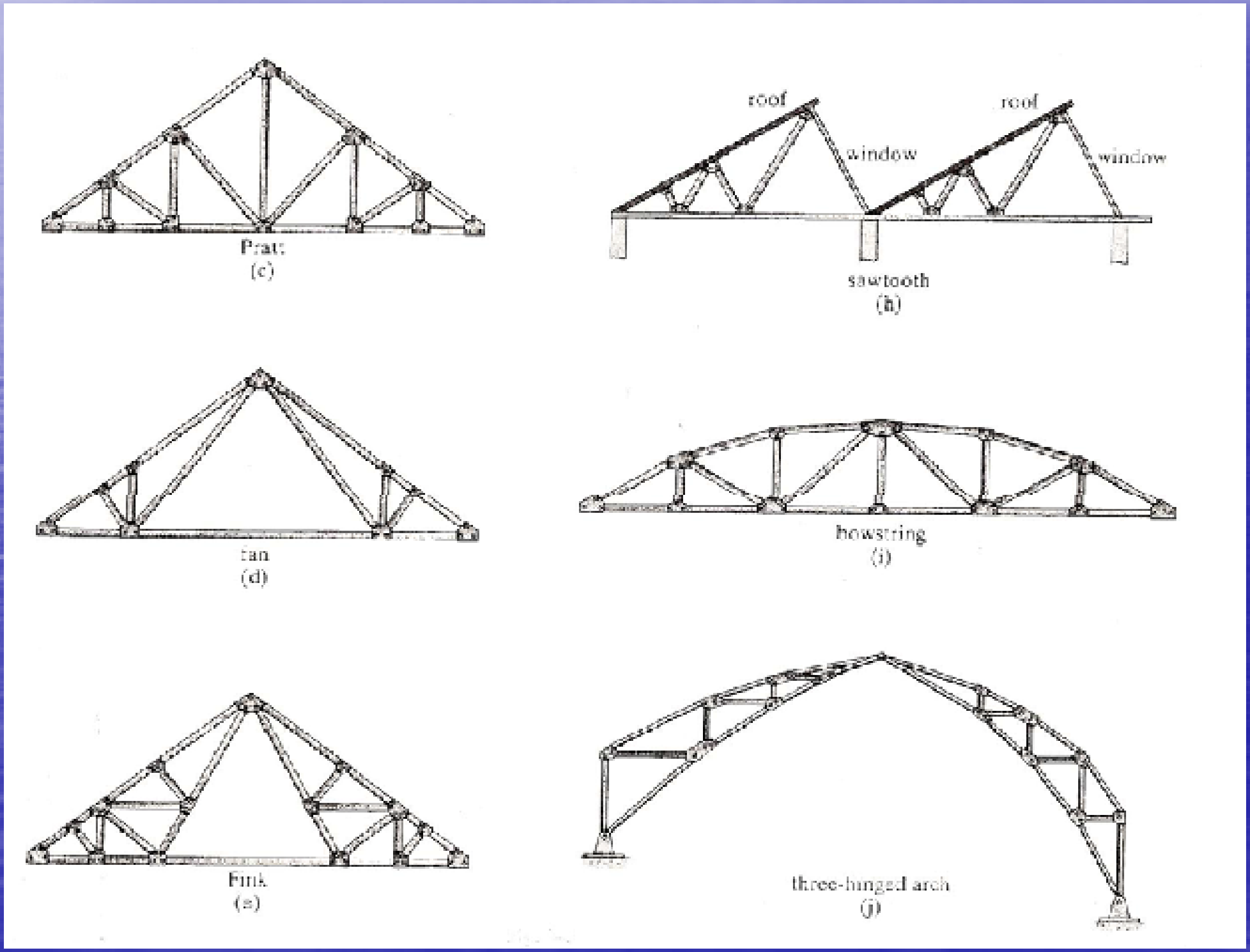
Analysis of A Truss Structure

Bentuk Truss pada umumnya:



Analysis of A Truss Structure

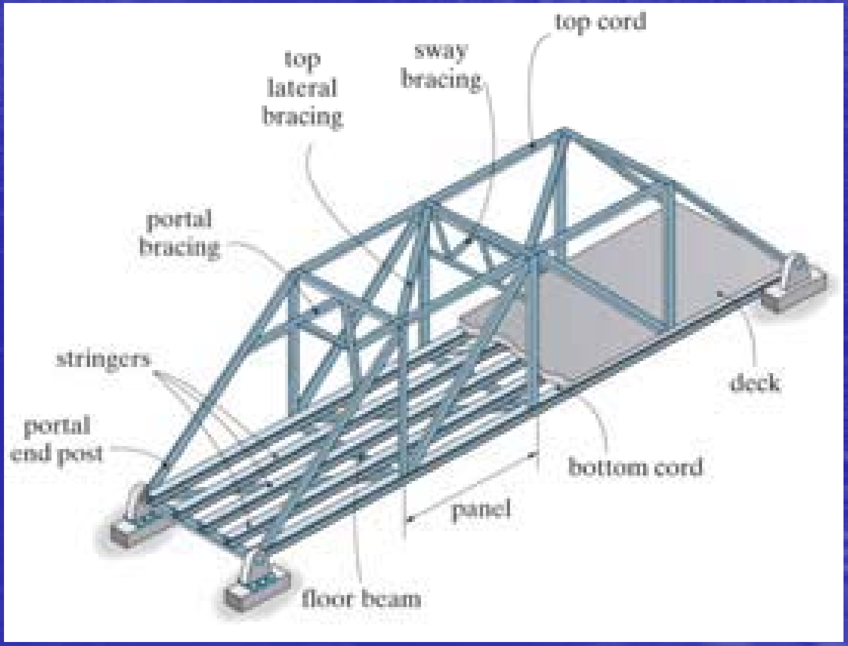
Bentuk Truss pada umumnya:



Analysis of Truss Structures

Common Types of Trusses:

- Bridge Trusses: Beban diteruskan dari lantai kendaraan ke struktur rangka melalui sistem lantai yang terdiri dari balok memanjang dan balok melintang yang ditumpu pada dua buar struktur rangka batang yang paralel.
- Bagian atas rangka batang dihubungkan dengan lateral bracing.



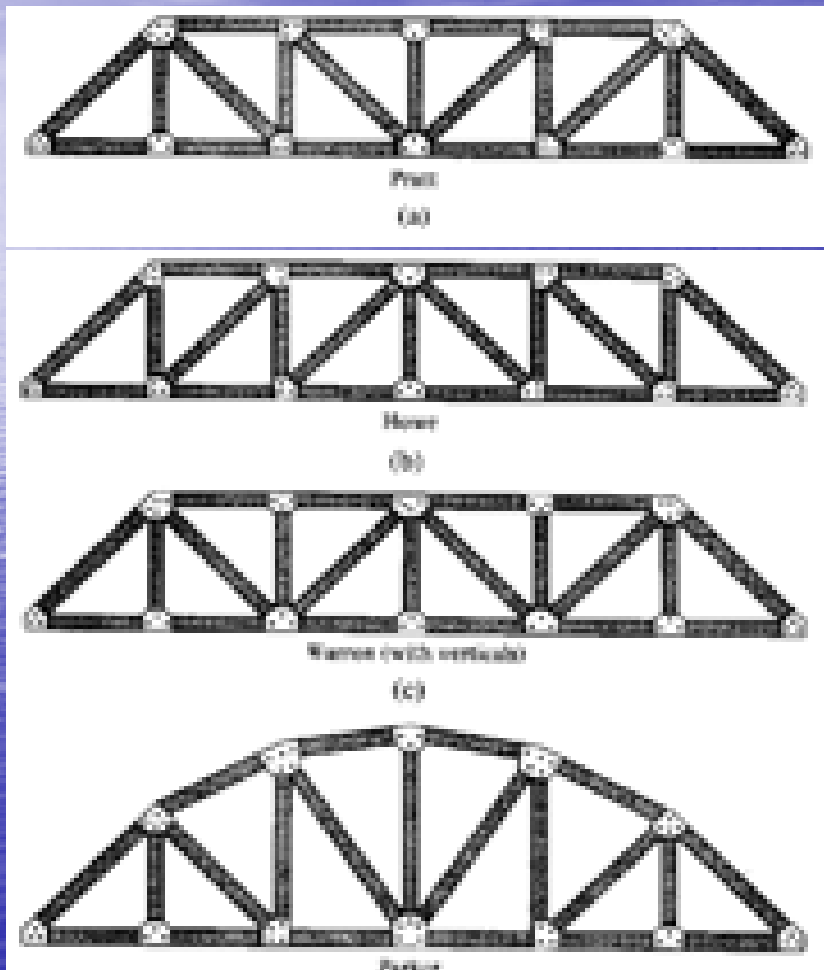
Analysis of Truss Structures

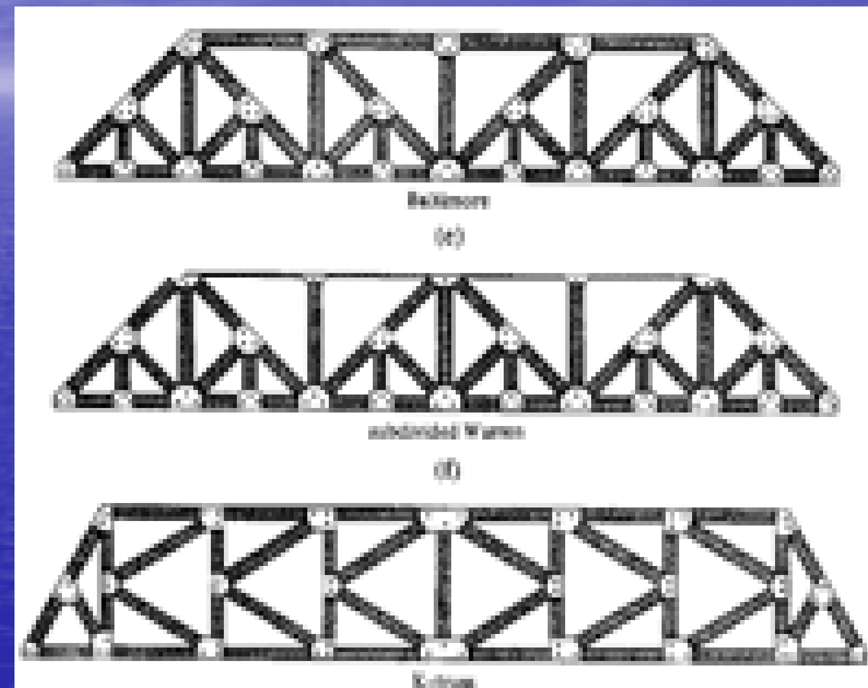
Analysis of Truss Structures

Common Typesof Trusses:

- Bridge Trusses:
  - Pratt
  - Howe
  - Warren (with verticals)
  - Parker
  - Baltimore or Subdivided Pratt
  - Subdivided Warren
  - K-Truss

Analysis of Truss Structures





Analysis of Truss Structures

Asumsi dalam perencanaan rangka batang:

- Sumbu batang setiap elemen bertemu di titik hubung rangka batang dan masing-masing elemen hanya menerima beban aksial. Hubungan antar elemen berupa sendi

  - ❖Tegangan yang timbul pada setiap elemen disebut tegangan primer.

  - ❖Asumsi hubungan sendi valid untuk semua tipe sambungan, baik sambungan baut ataupun sambungan las.

  - ❖Karena setiap sambungan sesungguhnya mempunyai kekakuan, maka pada setiap elemen akan muncul momen yang dikategorikan tegangan sekunder.

  - ❖Tegangan sekunder biasanya tidak diperhitungkan dalam alanisa rangka batang yang dilakukan secara manual.

Analysis of Truss Structures

Asumsi dalam perencanaan rangka batang:

- Semua beban dan reaksi perletakan hanya ada di titik hubung

  - ❖ Karena berat elemen relativ kecil dibanding beban yang bekerja, seringkali berat sendiri diabaikan.
  - ❖ Bila berat sendiri elemen diperhitungkan, maka dianggap berat sendiri diperhitungkan bekerja pada tititk hubung.
  - ❖ Berdasarkan asumsi tersebut, maka elemen struktur hanya akan menerima beban aksial tekan atau beban aksial tekan.
  - ❖ Pada umumnya, batang tekan sangat dipengaruhi oleh stabilitas terhadap tekuk.

Analysis of Truss Structures

Alasan sehubungan dengan asumsi yang dibuat: untuk mendapatkan rangka batang yang ideal dimana elemen hanya menerima gaya aksial.

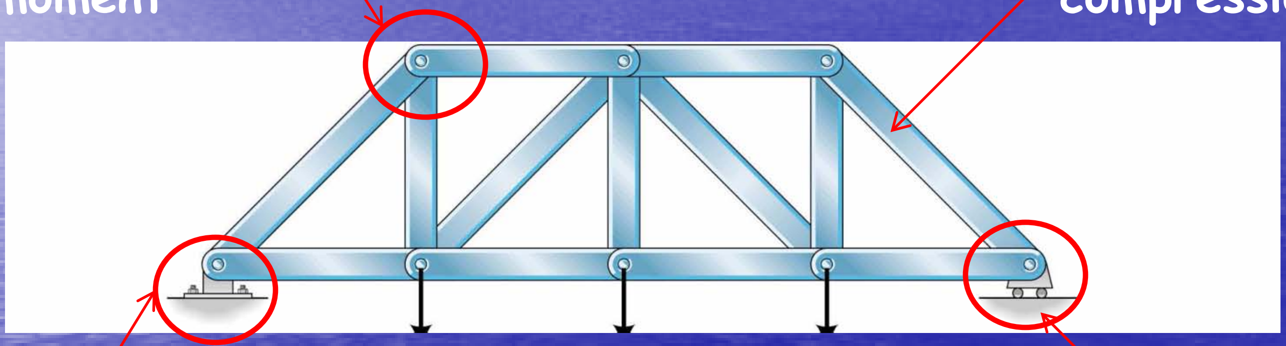
Primary Forces ≡ gaya aksial yang didapat pada analisa rangka batang yang ideal

Secondary Forces ≡ penyimpangan dari gaya-gaya yang diidealisasikan seperti: momen dan gaya geser pada elemen rangka.

Analysis of Truss Structures

truss members are connected by frictionless pins – no moment

members are weightless and can carry axial force (tension or compression)



provides vertical & horizontal support but no moment

loads only applied to ends of members at the joints

provides vertical support but no moment or horizontal force

Analysis of Truss Structures

Types of Trusses:
Basic Truss Element

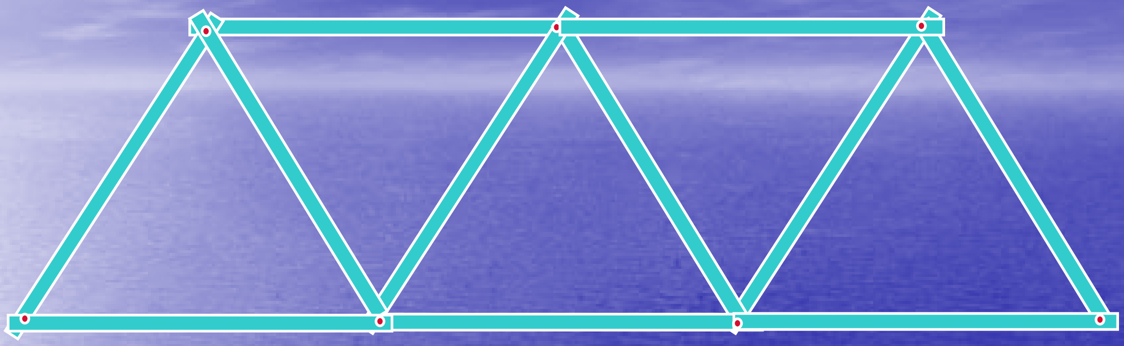
≡ tiga elemen membentuk rangka segitiga

Simple Trusses – terdiri dari basic truss elements

$$m = 3 + 2(j - 3) = 2j - 3$$

for a simple truss
m ≡ total number of members
j ≡ total number of joints

Analysis of Truss Structures



Jika ditambahkan titik simpul sebanyak = s

Dibutuhkan tambahan batang (n) = 2 x s

Jika jumlah titik simpul = j, maka tambahan titik yang baru = j - 3

Banyaknya batang tambahan = 2 x (j – 3)

Jumlah batang total (m) = 3 + 2 x (j – 3) = 2j - 3

Pada contoh di atas, m = 2 x 7 – 3 = 11

Analysis of Truss Structures

- Since all the elements of a truss are two-force members, the moment equilibrium is automatically Satisfied.

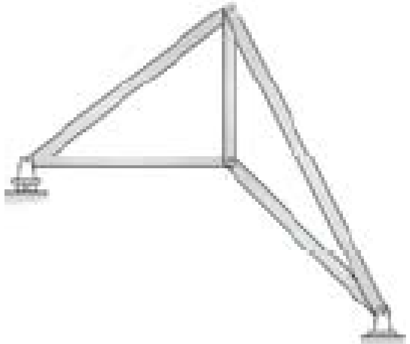
- Therefore there are two equations of equilibrium for each joint, j, **in a truss. If r is the number of reactions** and m **is the number of bar members in the truss,** determinacy is obtained by

m + r = 2j   Determinate

m + r > 2j   Indeterminate

Analysis of Truss Structures

Determinacy of Coplanar Trusses

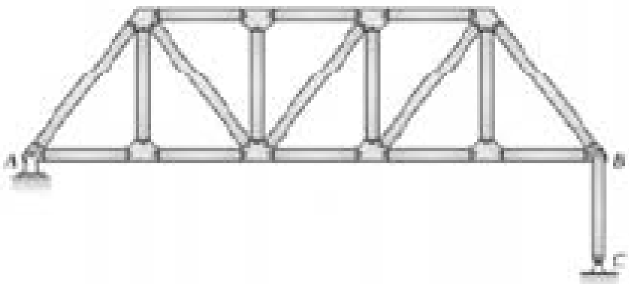


r = 3

m= 5, r+m = 2j

j = 4

determinate



r = 4

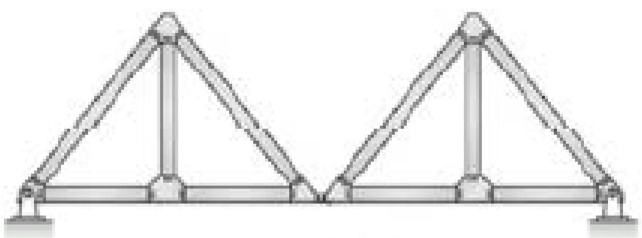
m= 18, r+m =2j

j = 11

determinate

Analysis of Truss Structures

Determinacy of Coplanar Trusses

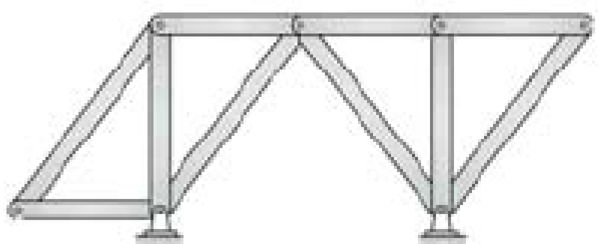


r = 4

m= 10, r+m =2j

j = 7

determinate



r = 4

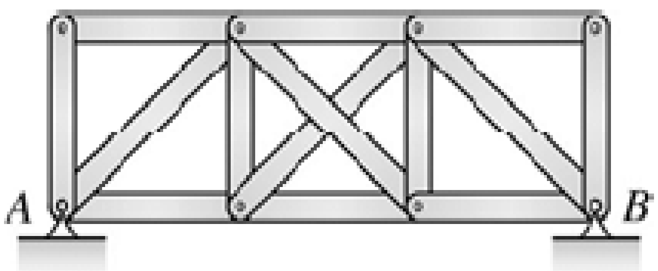
m= 10, r+m =2j

j = 7

determinate

Analysis of Truss Structures

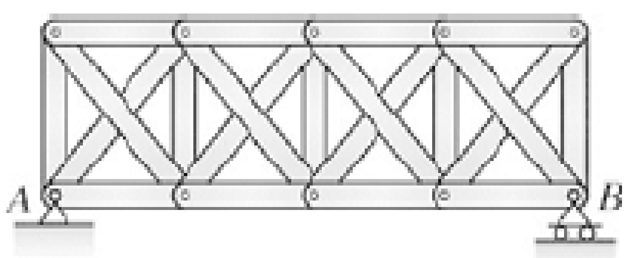
Determinacy of Coplanar Trusses



$r = 4$

$m = 14$, $r + m > 2j$ **indeterminate**

$j = 8$



$r = 3$

$m = 21$, $r + m > 2j$ **indeterminate**

$j = 10$

Analysis of Truss Structures

Stability of Coplanar Trusses

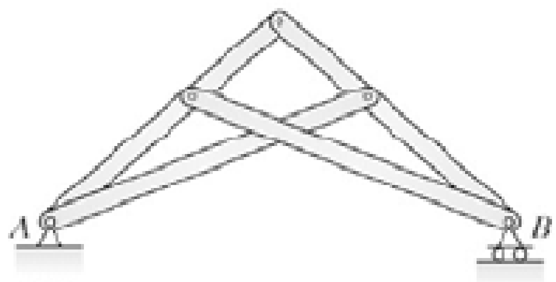
- If **$b + r < 2j$, a truss will be unstable, which means the** structure will collapse since there are not enough reactions to constrain all the joints.

- A truss may also be unstable if $b + r > 2j$. In this case, stability will be determined by inspection

$b + r < 2j$ Unstable
$b + r > 2j$ Unstable if reactions are concurrent, parallel, or collapsible mechanics

Analysis of Truss Structures

Stability of Coplanar Trusses

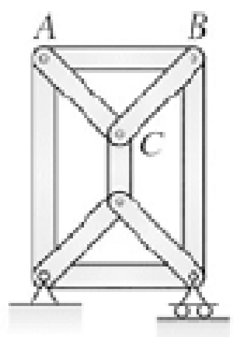


r = 3

m=6, r+m <2j

j = 5

unstable



r = 3

m=9, r+m =2j

j = 6

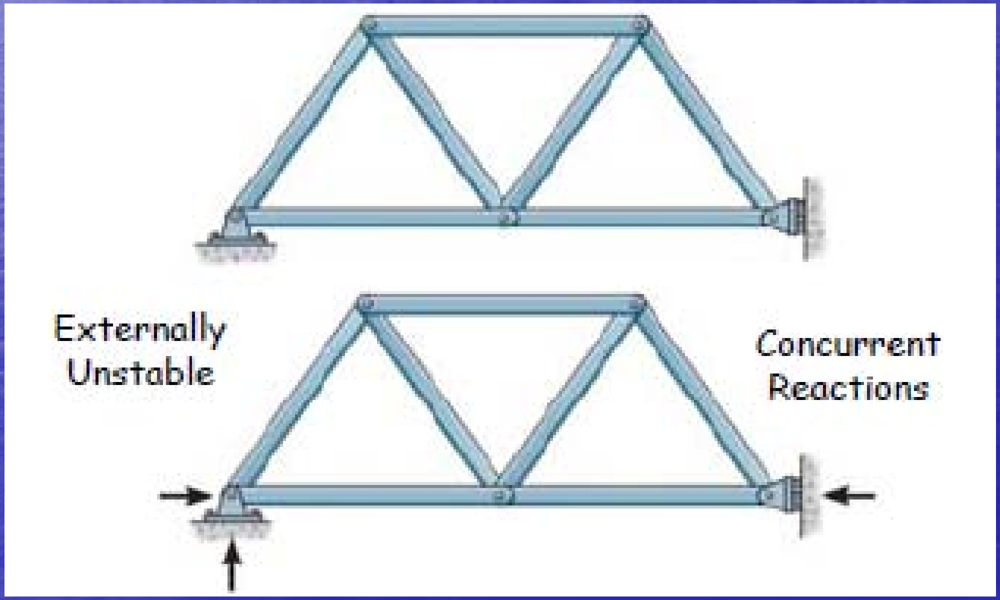
unstable

Section ABC is supported by three parallel links

Analysis of Truss Structures

Stability of Coplanar Trusses

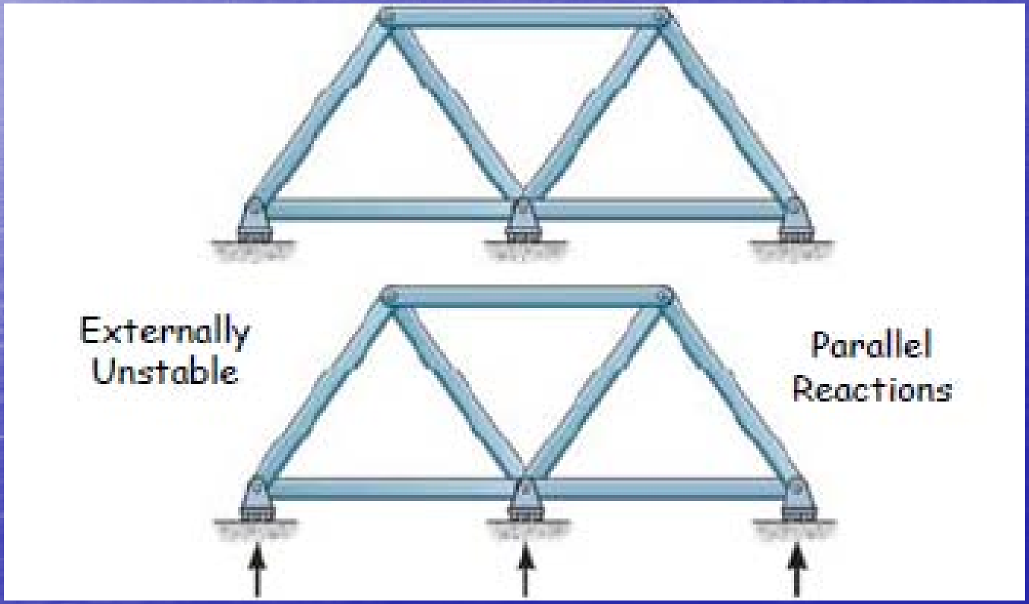
- **External stability - a structure (truss) is externally** unstable if its reactions are concurrent or parallel.



Analysis of Truss Structures

Stability of Coplanar Trusses

- **External stability - a structure (truss) is externally unstable if its reactions are concurrent or parallel.**



Analysis of Truss Structures

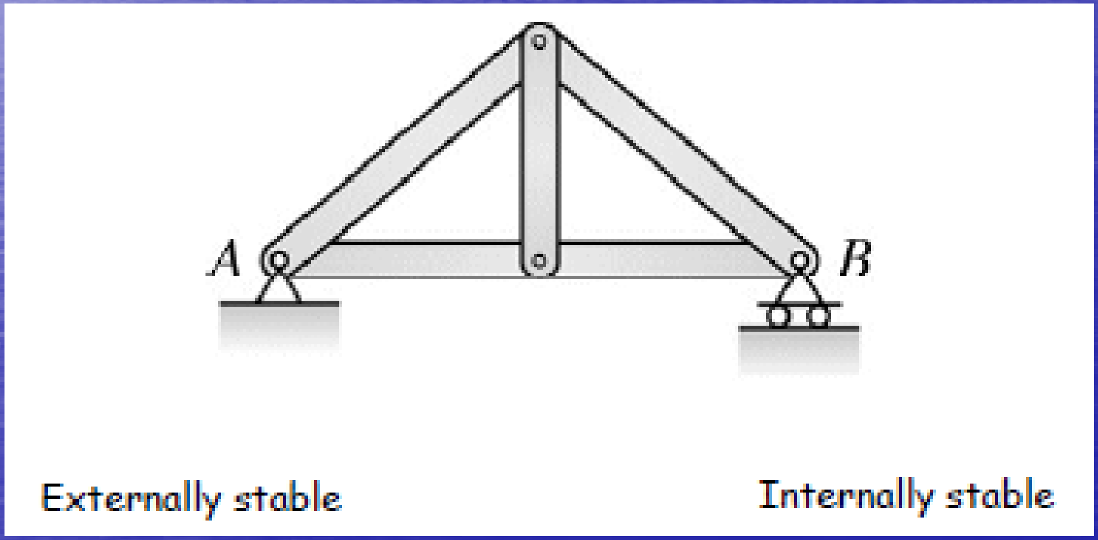
Stability of Coplanar Trusses

- **Internal stability - may be determined by inspection of** the arrangement of the truss members.
  - A simple truss will always be internally stable
  - The stability of a compound truss is determined by examining how the simple trusses are connected
  - The stability of a complex truss can often be difficult to determine by inspection.
  - In general, the stability of any truss may be checked by performing a complete analysis of the structure. If a unique solution can be found for the set of equilibrium equations, then the truss is stable

Analysis of Truss Structures

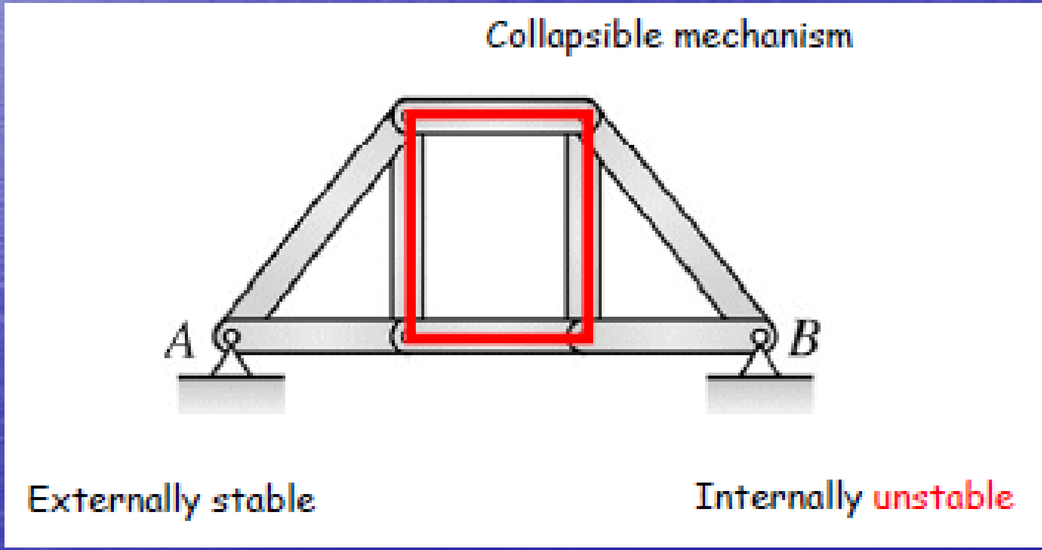
Stability of Coplanar Trusses

- **Internal stability**



Analysis of Truss Structures

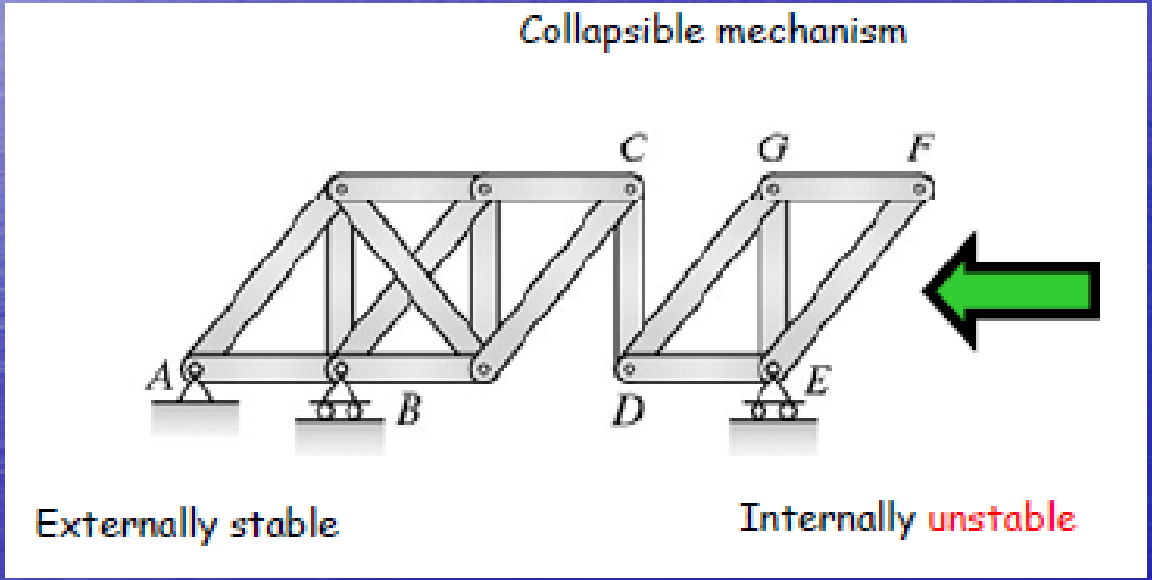
Stability of Coplanar Trusses
- **Internal stability**



Analysis of Truss Structures

Stability of Coplanar Trusses

- **Internal stability**

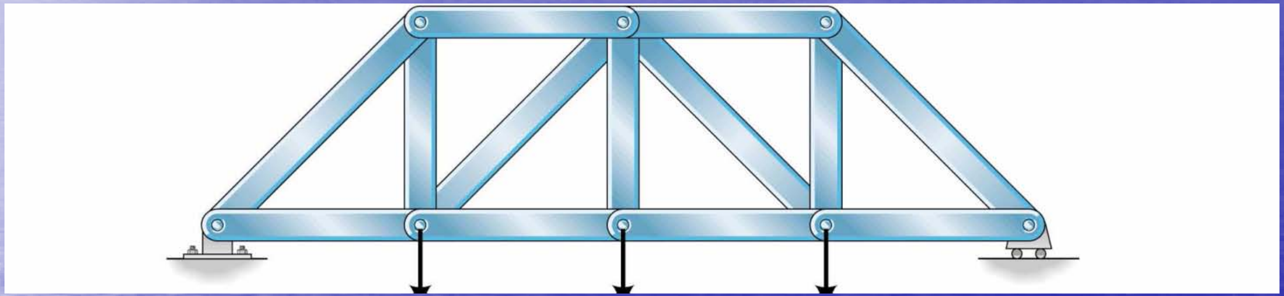


Classification of Co-Planar Trusses

- Simple Truss
- Compound Truss
  - This truss is formed by connecting two or more simple trusses together. This type of truss is often used for large spans.
- Complex truss: is one that cannot be classified as being either simple or compound

Classification of Co-Planar Trusses

- Simple Truss

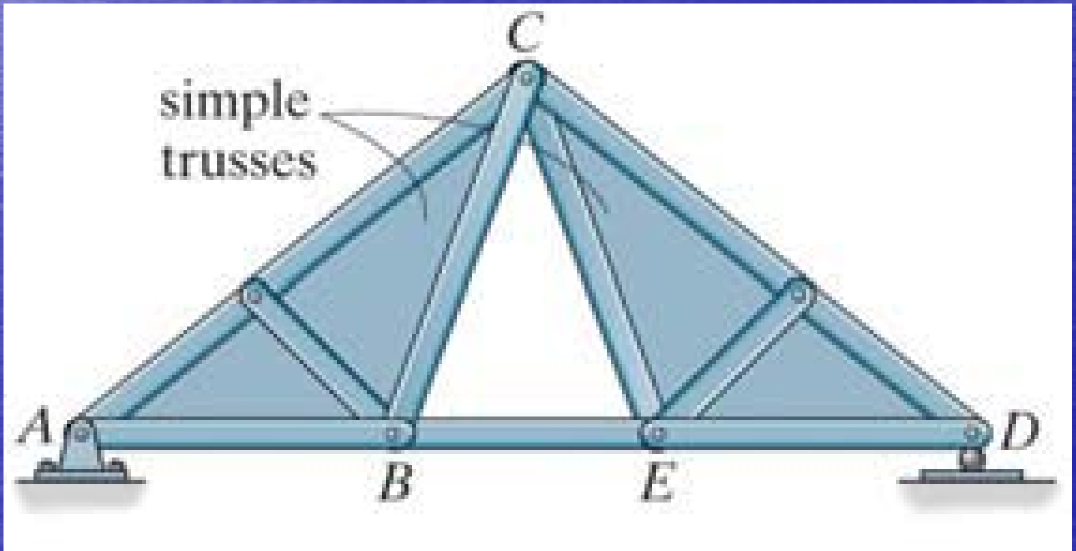


Classification of Co-Planar Trusses

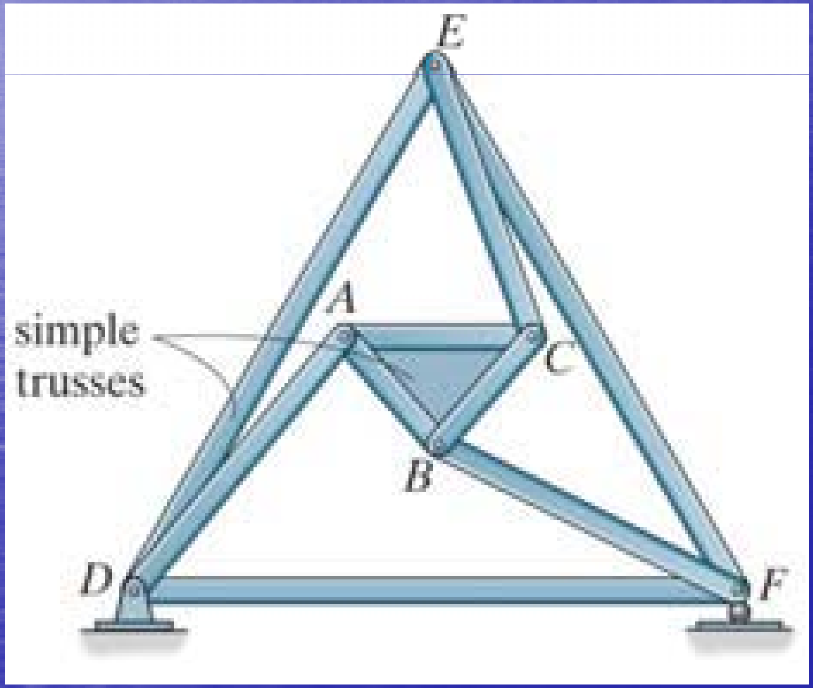
- Compound Truss

  There are three ways in which simple trusses may be connected to form a compound truss:

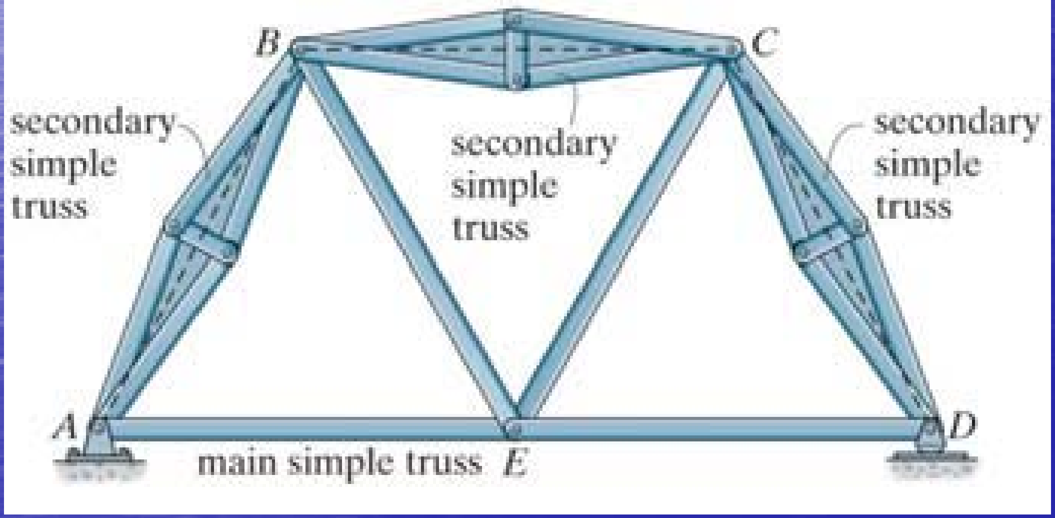
  1. Trusses may be connected by a common joint and bar.



2. Trusses may be joined by three bars.

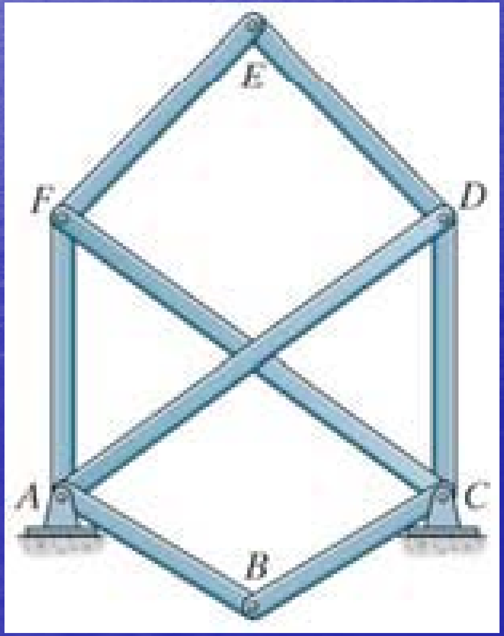


3. Trusses may be joined where bars of a large simple truss, called the main truss, have been substituted by simple trusses, called secondary trusses



Classification of Co-Planar Trusses

- Complex truss:



Analysis of Truss Structures

Common techniques for truss analysis

- Method of joints – usually used to determine forces for all members of truss
- Method of sections – usually used to determine forces for specific members of truss
- Determining Zero-force members – members which do not contribute to the stability of a structure
- Determining conditions for analysis – is the system statically determinate?

Analysis of Truss Structures

Method of Joints
Do FBDs of the joints
Forces are concurrent at each joint à no moments, just

$\Sigma Fx = 0$; $\Sigma Fy = 0$

Procedure

1. Choose joint with
   a. at least one known force
   b. at most two unknown forces

2. Draw FBD of the joint
   a. draw just the point itself
   b. draw all known forces at the point
   c. assume all unknown forces are tension forces and draw
      i. positive results à tension
      ii. negative results à compression

Analysis of Truss Structures

Procedure

3. Solve for unknown forces by applying equilibrium conditions in x and y directions:

$$\Sigma F_x = 0; \qquad \Sigma F_y = 0$$

4. Note: if the force on a member is known at one end, it is also known at the other (since all forces are concurrent and all members are two-force members)

5. Move to new joints and repeat steps 1-3 until all member forces are known

Analysis of Truss Structures

Method of sections
Do FBDs of sections of truss cut through various members
Procedure
1. Determine reaction forces external to truss system
    a. Draw FBD of entire truss
    b. Note can find up to 3 unknown reaction forces
    c. Use $\Sigma F_x = 0$; $\Sigma F_y = 0$; $\Sigma M = 0$ to solve for reaction forces

2. Draw a section through the truss cutting no more than 3 members

3. Draw an FBD of each section – one on each side of the cut
    a. Show external support reaction forces
    b. Assume unknown cut members have tension forces extending from them

Analysis of Truss Structures

Procedure

4. Solve FBD for one section at a time using

$\Sigma Fx = 0$; $\Sigma Fy = 0$; $\Sigma M = 0$

- Note: choose pt for moments that isolates one unknown if possible

5. Repeat with as many sections as necessary to find required information

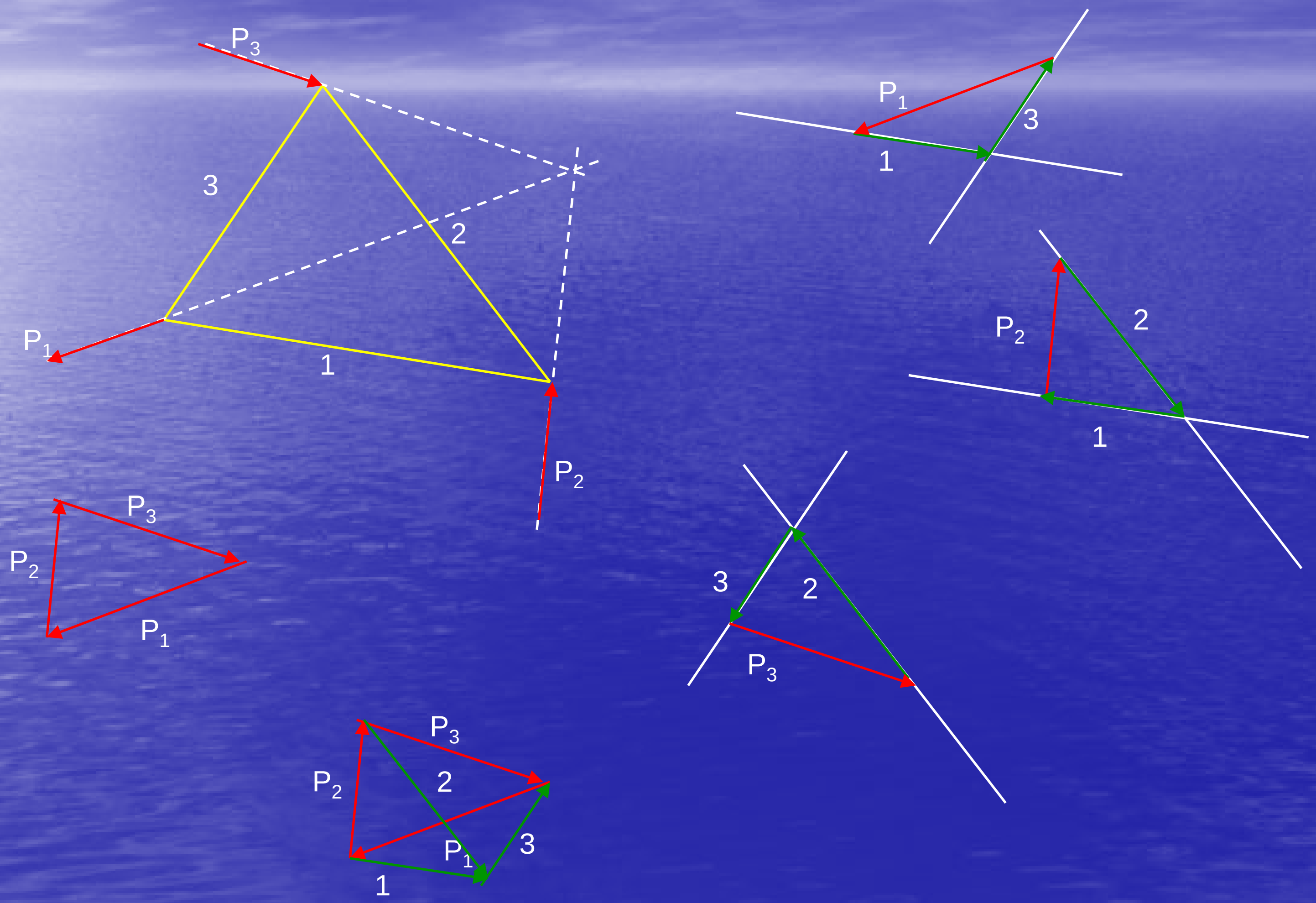
Analysis of Truss Structures

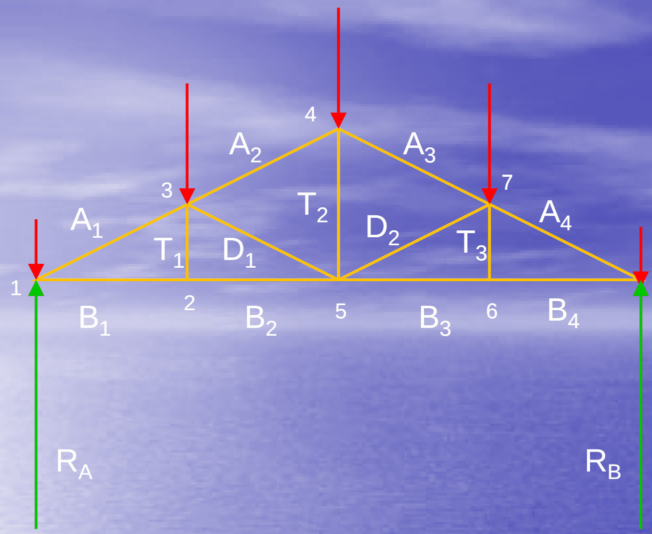
Zero Force Members
Usually determined by inspection

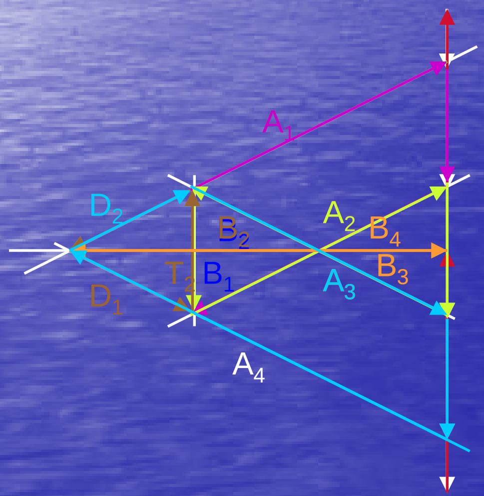
Method of inspection
1. Two-member truss joints:
both are zero-force members if (a) and (b) are true
a. no external load applied at joint
b. no support reaction occurring at joint

2. Three-member truss joints:
non-colinear member is zero-force member if (a), (b), and (c) are true
a. no external load applied at joint
b. no support reaction occurring at joint
c. other two members are colinear

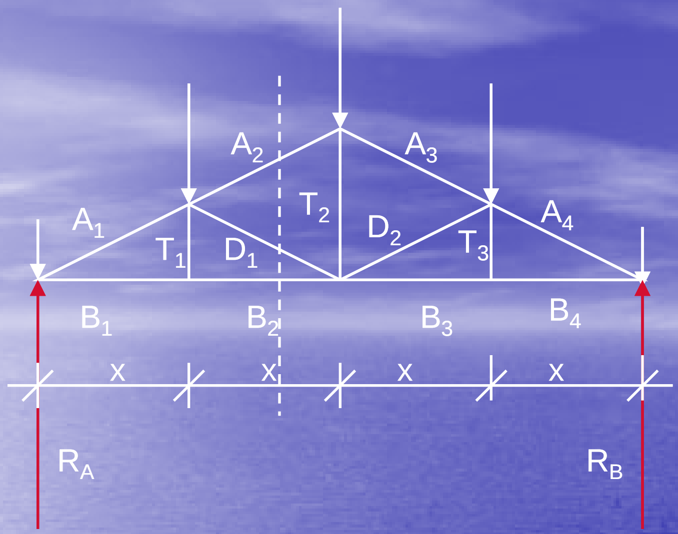
Cremona

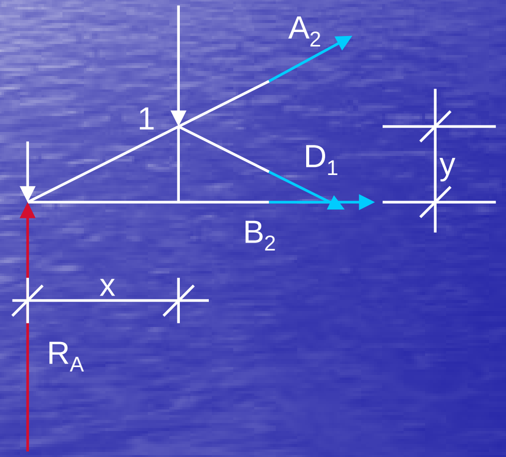






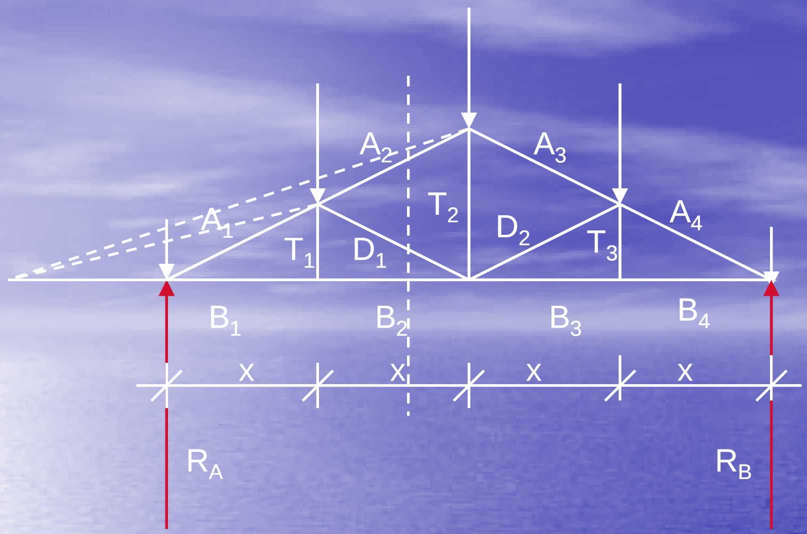
No	No. Batang	Gaya Batang
1	A1	-( )
2	A2	-( )
3	A3	-( )
4	A4	-( )
5	B1	+( )
6	B2	+( )
7	B3	+( )
8	B4	+( )
9	T1	-( )
10	T2	+( )
11	T3	-( )
12	D1	-( )
13	D2	-( )



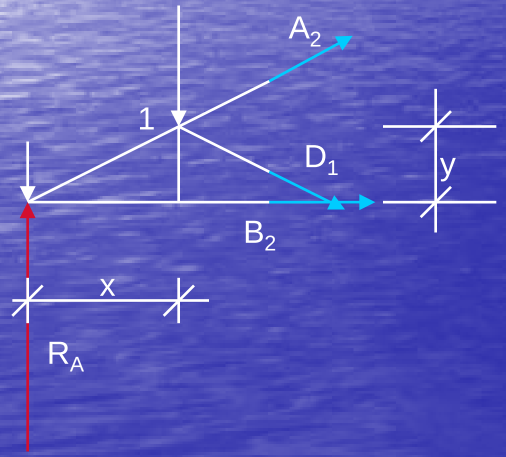


$$\sum M_1 = 0$$

$$(R_A \times x) - (P \times x) - (B_2 \times y) = 0$$



A_1
A_2
A_3
A_4
T_1
T_2
T_3
D_1
D_2
B_1
B_2
B_3
B_4
x
x
x
x
R_A
R_B



A_2
1
D_1
y
B_2
x
R_A