ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 331
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SUMMER 2013

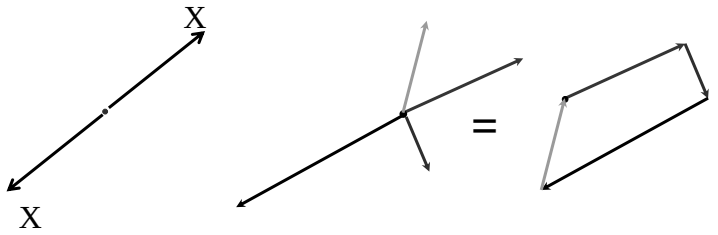
lecture
three

http:// nisee.berkeley.edu/godden

point equilibrium and planar trusses

Equilibrium

- balanced
- steady
- resultant of forces on a particle is 0

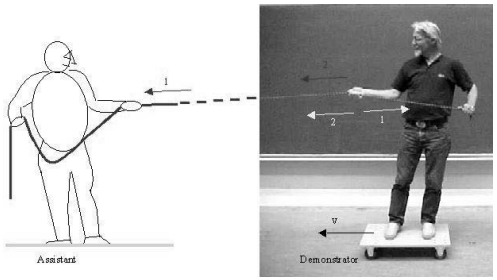


Equilibrium on a Point

- analytically

$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$



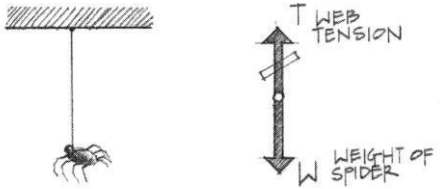
http://www.physics.umd.edu

- Newton convinces us it will stay at rest

Equilibrium on a Point

- collinear force system
  - ex: cables

$$\sum F_{in-line} = 0$$



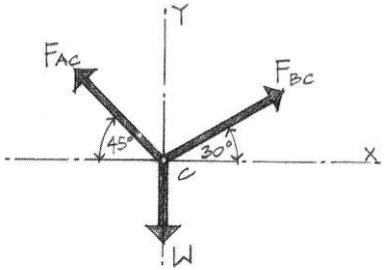
$$\left\{ R_x = \sum F_x = 0 \qquad R_y = \sum F_y = 0 \right\}$$

Equilibrium on a Point

- *concurrent force system*
  - *ex: cables*

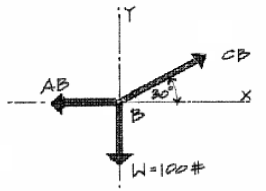
$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$



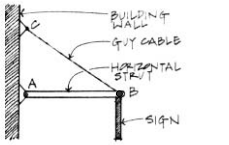
Free Body Diagram

- *FBD (sketch)*
- *tool to see all forces on a body or a point including*
  - *external forces*
  - *weights*
  - *force reactions*
  - *internal forces*

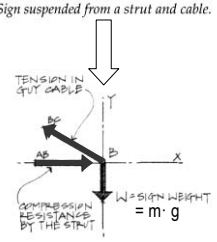


Free Body Diagram

- *determine point*
- *FREE it from:*
  - *ground*
  - *supports & connections*
- *draw all external forces acting ON the body*
  - *reactions (supporting forces)*
  - *applied forces*
  - *gravity*



Sign suspended from a strut and cable.



FBD of concurrent point B.

Free Body Diagram

- *sketch FBD with relevant geometry*
- *resolve each force into components*
  - *known & unknown angles – name them*
  - *known & unknown forces – name them*
- *are any forces related to other forces?*
- *for the unknowns*
- *write only as many equilibrium equations as needed*
- *solve up to 2 equations*

Free Body Diagram

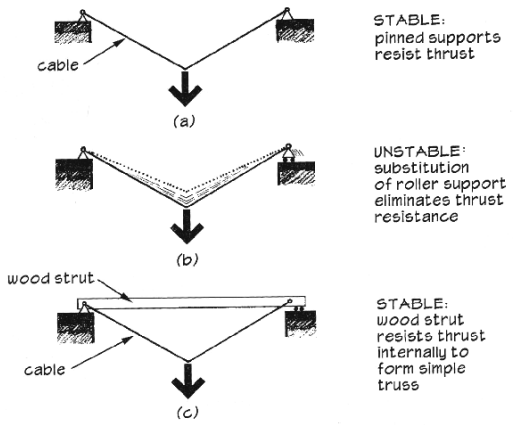
- *solve equations*
  - *– most times 1 unknown easily solved*
  - *– plug into other equation(s)*
- *common to have unknowns of*
  - *– force magnitudes*
  - *– force angles*

Truss Structures

- *ancient (?) wood*
  - *– Romans 500 B.C.*
- *Renaissance revival*
- *1800's analysis*
- *efficient*

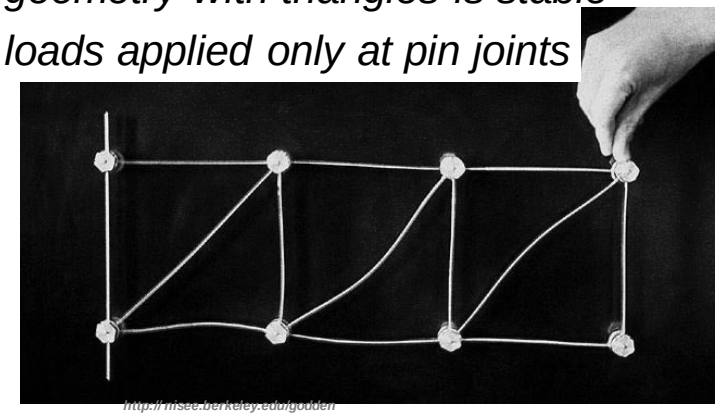
Truss Structures

- *– analogous to cables and struts*



Truss Structures

- *comprised of straight members*
- *geometry with triangles is stable*
- *loads applied only at pin joints*



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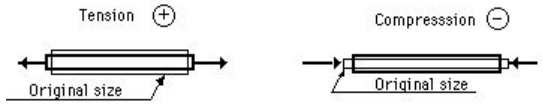
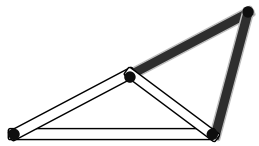
Truss Structures

- *2 force members*
  - *forces in line, equal and opposite*
  - *compression*
  - *tension*

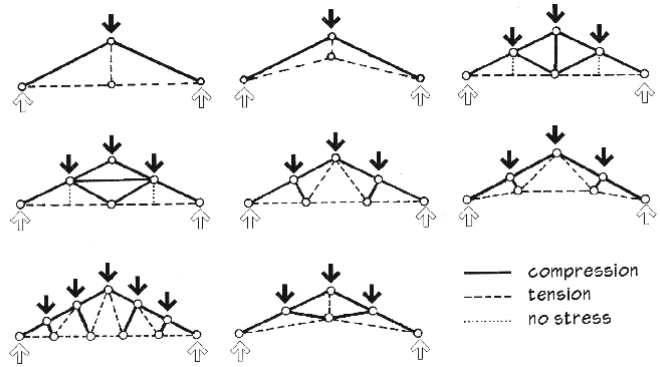


- *3 members connected by 3 joints*
- *2 more members need 1 more joint* $b = 2n - 3$



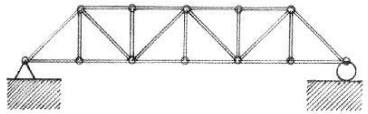
Truss Structures

- *compression and tension*

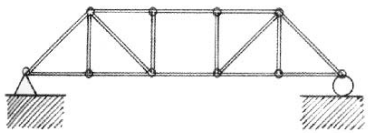


Truss Structures

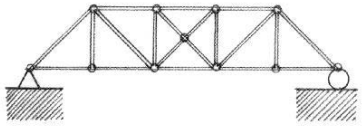
- *statically determinate*
- *indeterminate*
- *unstable*



b = 21 *n = 12* $2(n) - 3 = 2(12) - 3 = 21$
(a) Determinate.



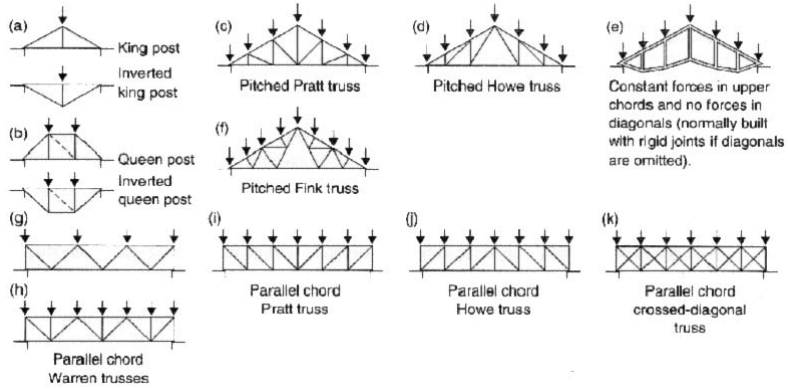
b = 16 *n = 10* *b = 16 < 2(10) − 3 = 17*
(Too few members—square panel is unstable)
(c) Unstable.



b = 18 *n = 10* *b = 18 > 2(10) − 3 = 17*
(Too many members)
(b) Indeterminate.

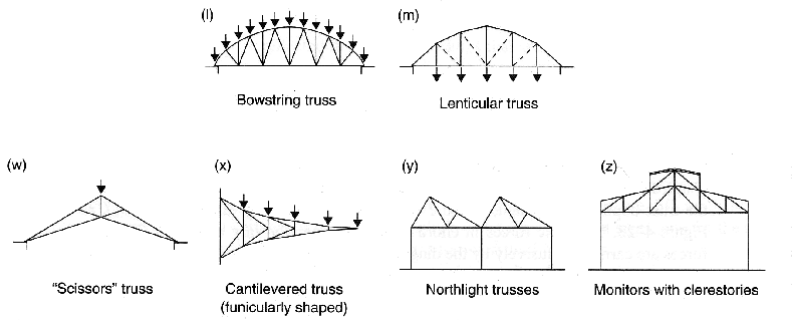
Trusses

- *common designs*



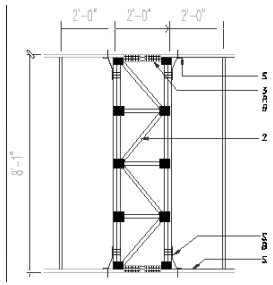
Trusses

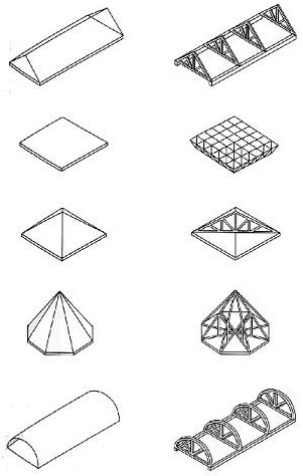
- *common designs*



Trusses

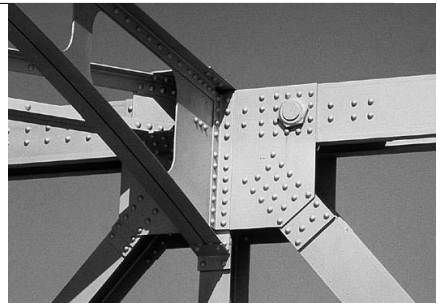
- *uses*
  - *roofs & canopies*
  - *long spans*
  - *lateral bracing*





Truss Connections

- *"pins"*



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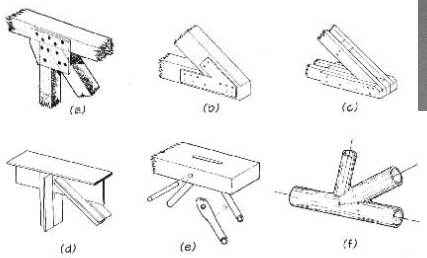
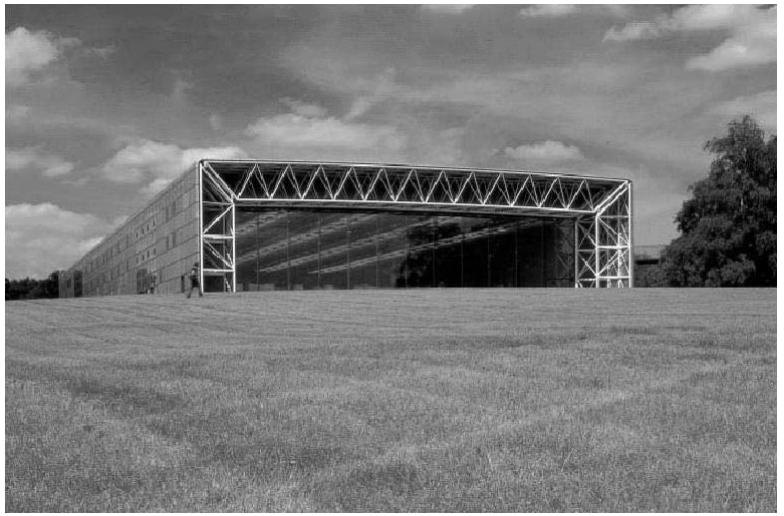
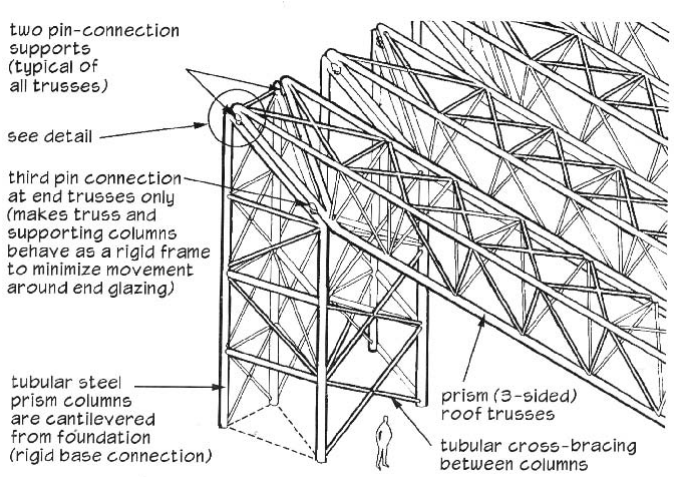


Figure 4.8: Truss joints.

Sainsbury Center, Foster 1978

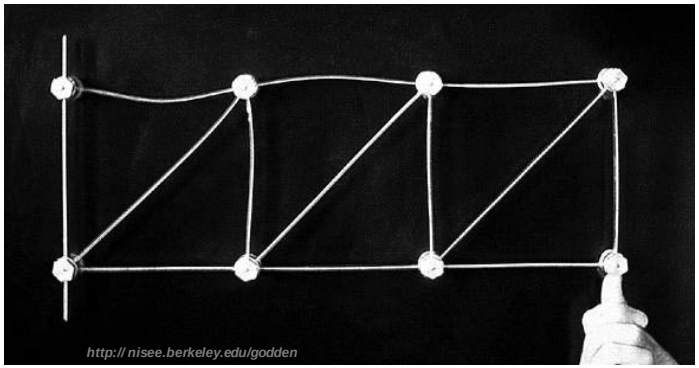


Sainsbury Center, Foster 1978



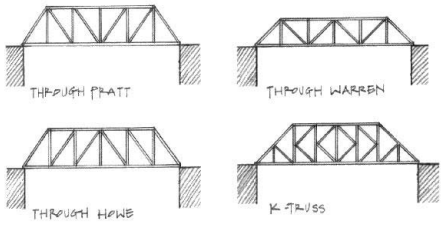
Truss Analysis

- *visualize compression and tension from deformed shape*

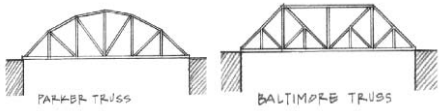


Truss Analysis

- *Method of Joints*
- *Graphical Methods*
- *Method of Sections*

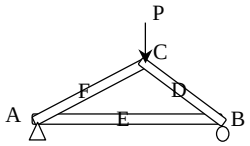


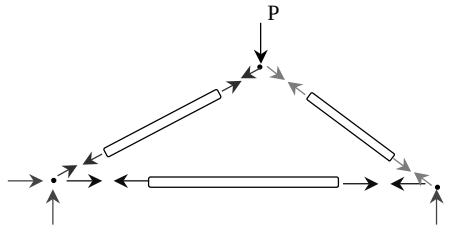
- *all rely on equilibrium*
  - *of bodies*
  - *internal equilibrium*



Method of Joints

- *isolate each joint*
- *enforce equilibrium in F_x and F_y*
- *can find all forces*

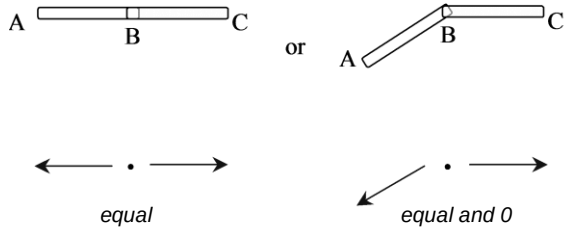




- *long*
- *easy to mess up*

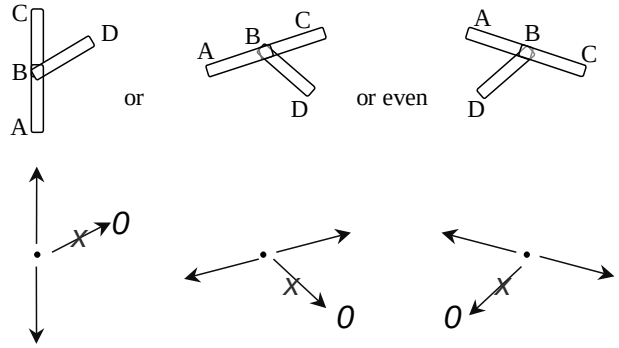
Joint Cases

- *two bodies connected*



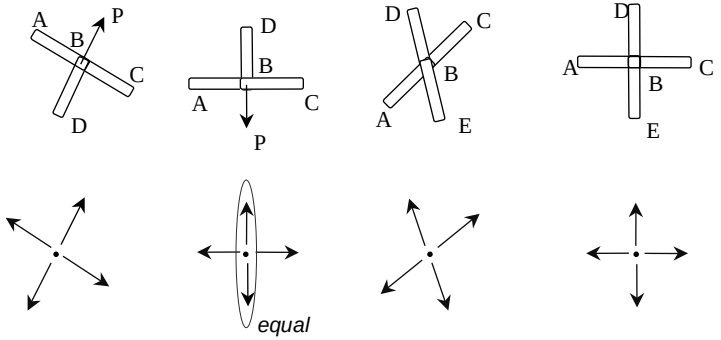
Joint Cases

- *three bodies with two in line*



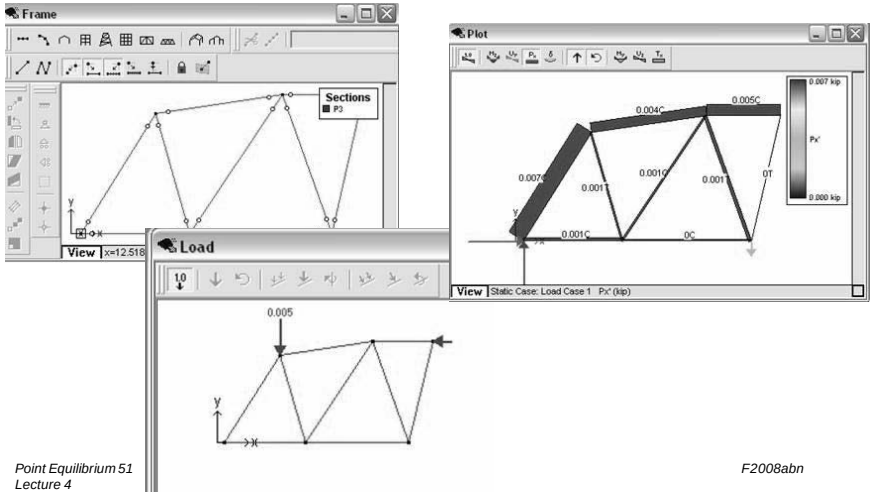
Joint Cases

- *crossed*



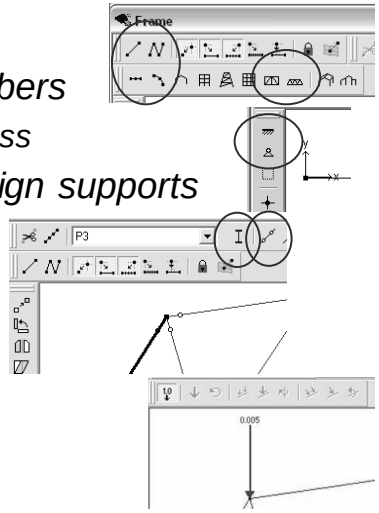
Tools – Multiframe

- *in computer lab*



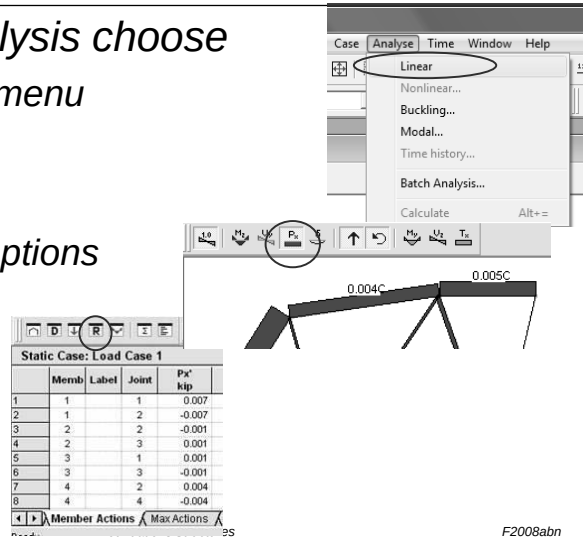
Tools – Multiframe

- *frame window*
  - *define truss members*
    - *or pre-defined truss*
  - *select points, assign supports*
  - *select members, assign section & assign pin ends*
- *load window*
  - *select points, add point load*



Tools – Multiframe

- *to run analysis choose*
  - *Analyze menu*
    - *Linear*
- *plot*
  - *choose options*
- *results*
  - *choose options*



	Memb	Label	Joint	Px' kip
1	1		1	0.007
2	1		2	-0.007
3	2		2	-0.001
4	2		3	0.001
5	3		1	0.001
6	3		3	-0.001
7	4		2	0.004
8	4		4	-0.004