ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS

ENDS 231

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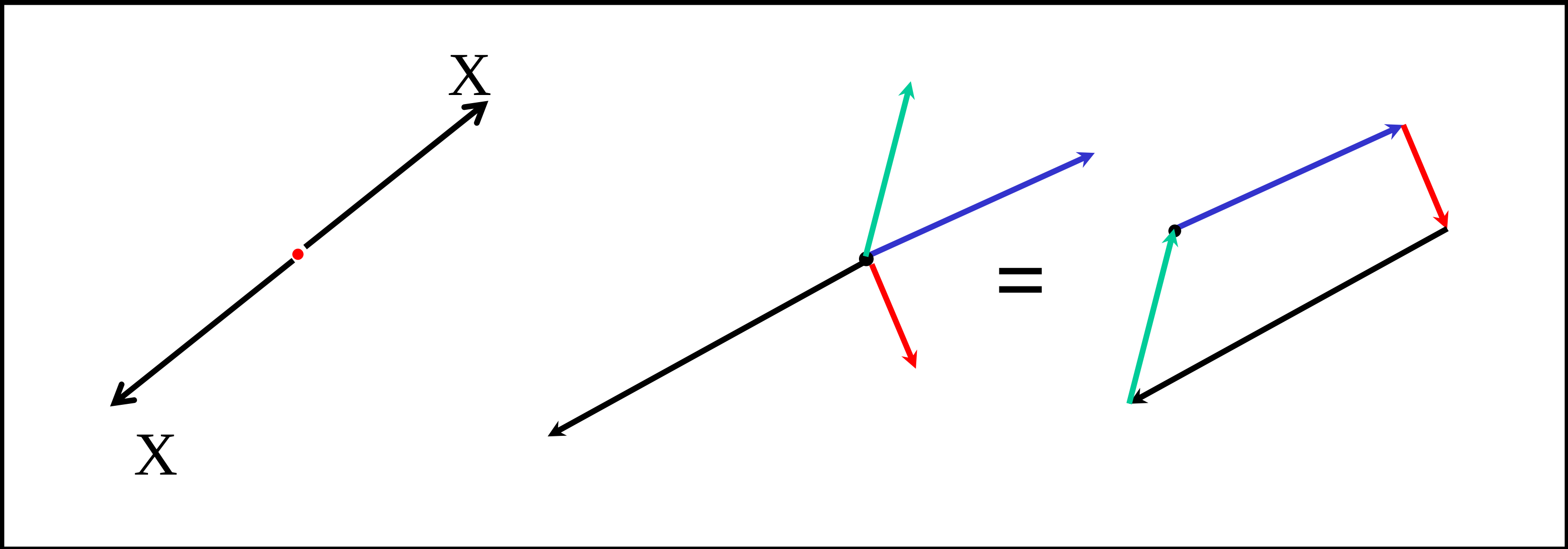
SPRING 2008

lecture
four

equilibrium of a particle

Equilibrium

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



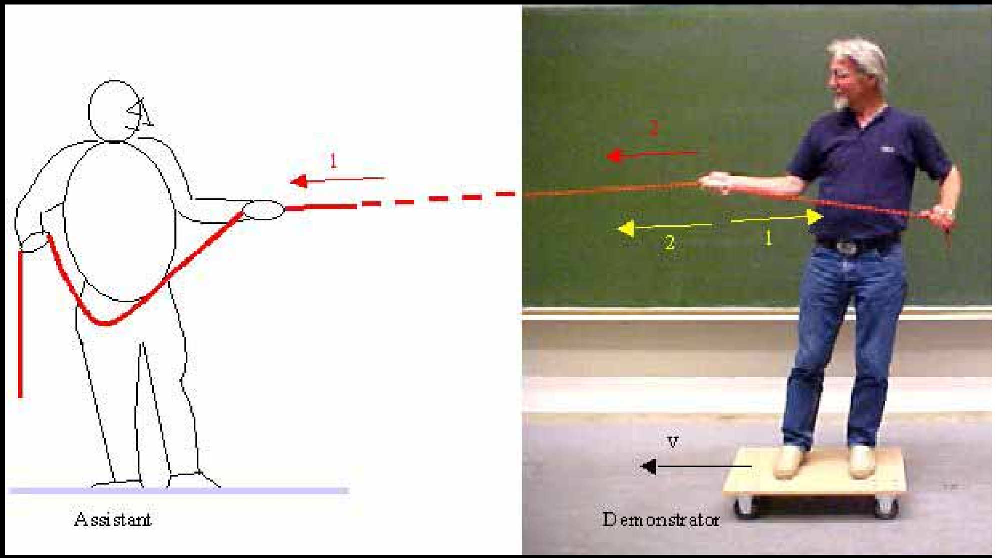
Equilibrium

- *analytically*

$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$

$$\left(M = \sum M = 0\right)$$

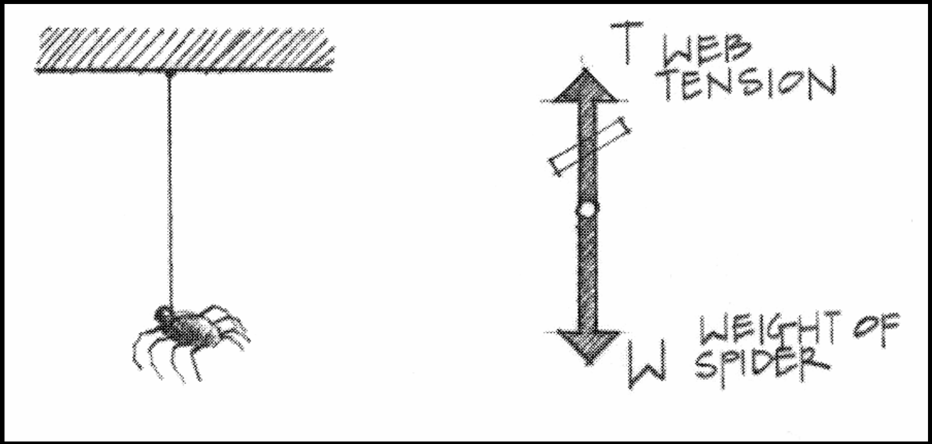


- *Newton convinces us it will stay at rest and won't rotate*

Equilibrium

- *collinear force system*

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



$$\left(R_x = \sum F_x = 0 \qquad R_y = \sum F_y = 0 \right)$$

$$\left(M = \sum M = 0 \right)$$

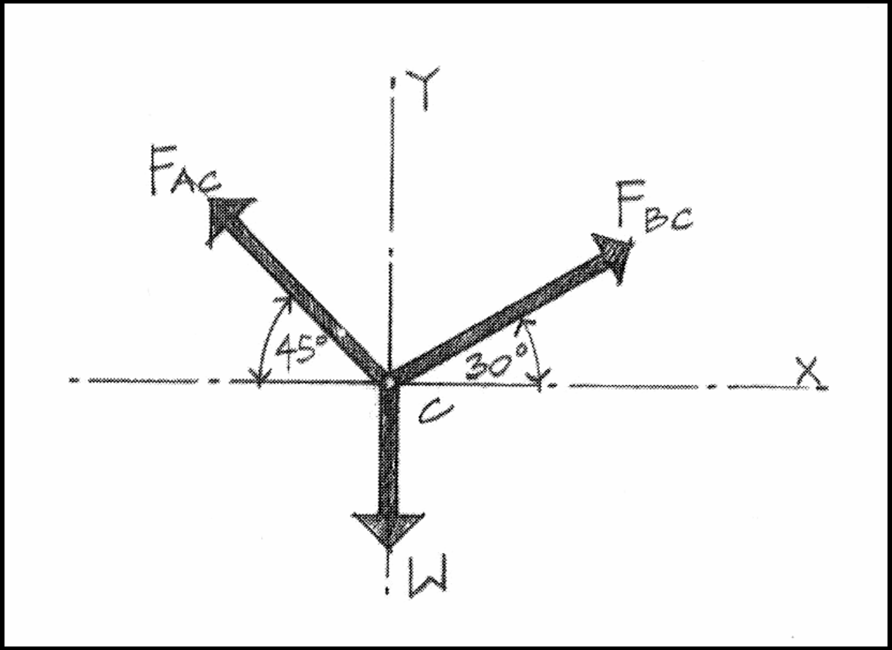
Equilibrium

- *concurrent force system*

$$R_x = \sum F_x = 0$$

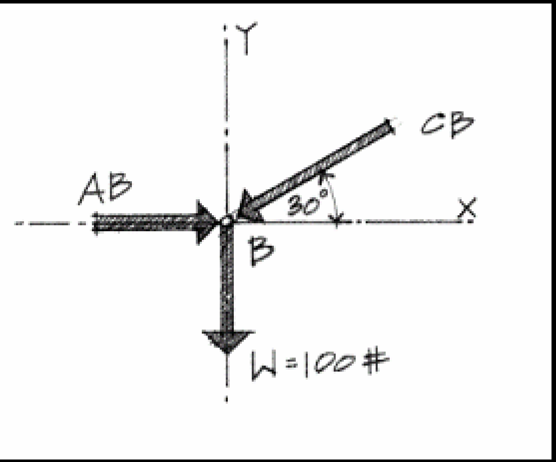
$$R_y = \sum F_y = 0$$

$$\left(M = \sum M = 0\right)$$



Free Body Diagram

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



Free Body Diagram

- *sketch FBD*
- *resolve each force into components*
  - *known & unknown <u>angles</u>*
  - *known & unknown <u>forces</u>*
- *are any forces related to other forces?*
- *write only as many equilibrium equations as needed*

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*

Cables

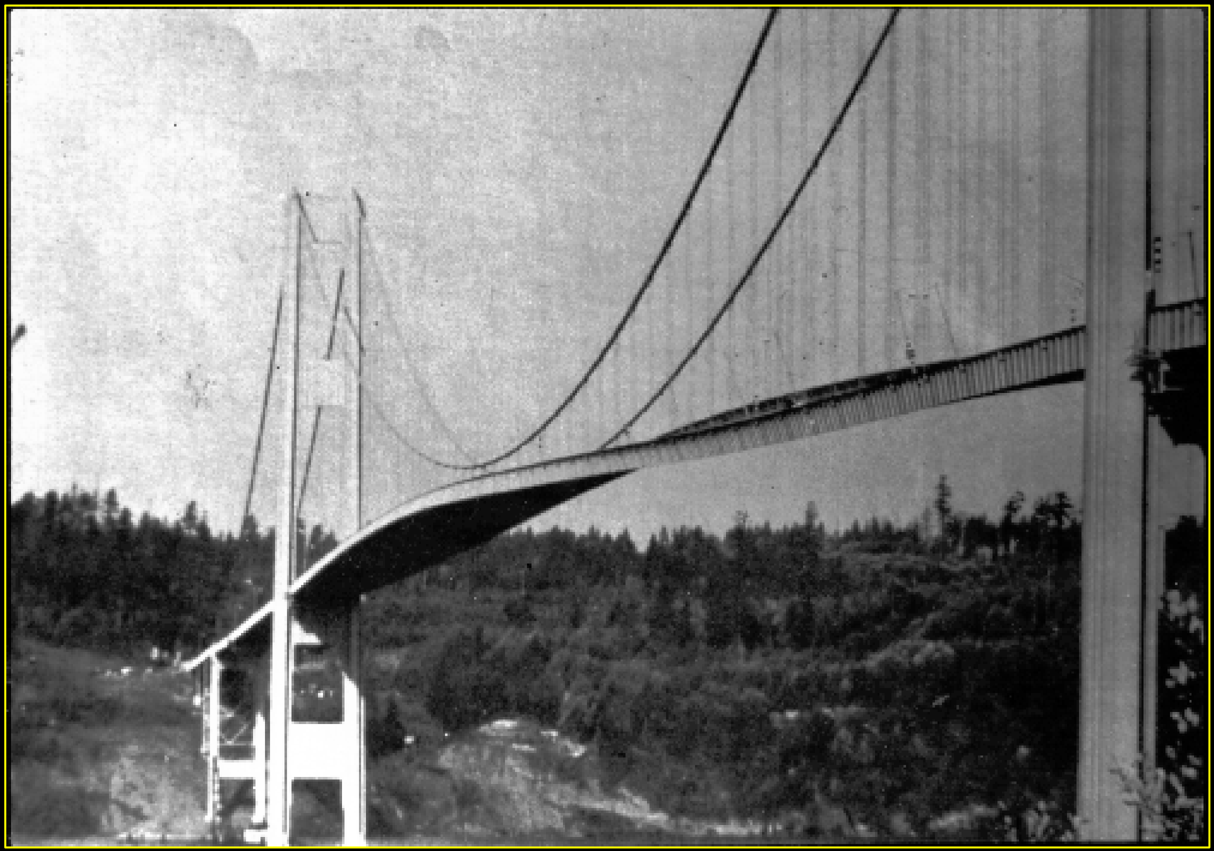
- simple
- uses
  - suspension bridges
  - roof structures
  - transmission lines
  - guy wires, etc.

- have same tension all along
- can't stand compression

Cables Structures

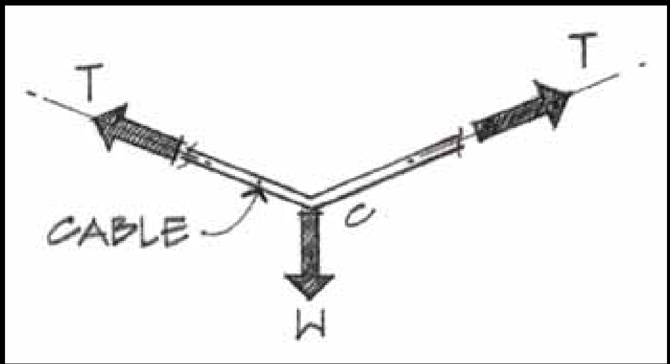
- use high-strength steel
- need
  - towers
  - anchors
- don't want movement

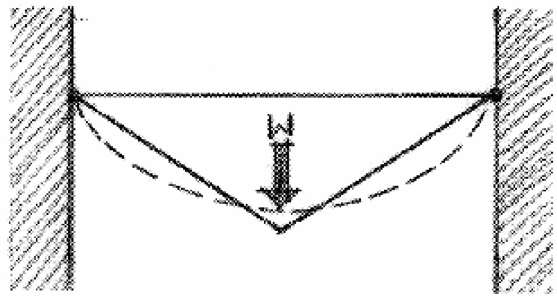
Cable Structures



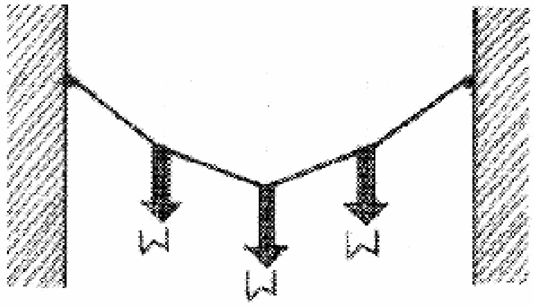
Cable Loads

- straight line between forces
- with one force
  - concurrent
  - symmetric





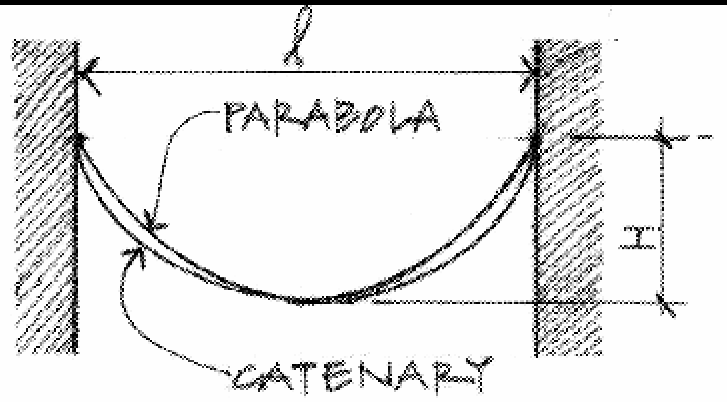
(a) Simple concentrated load—triangle.



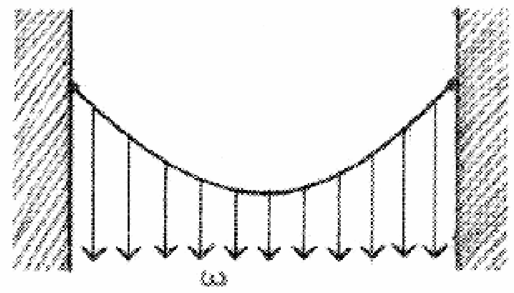
(b) Several concentrated loads—polygon.

Cable Loads

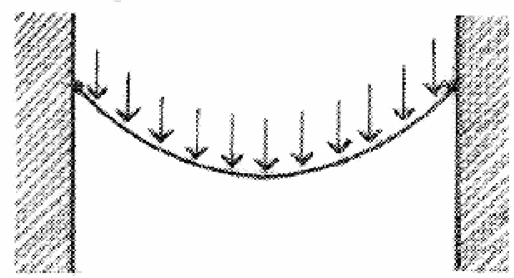
- *shape directly related to the distributed load*



(e) Comparison of a parabolic and a catenary curve.



(c) Uniform loads (horizontally)—parabola.



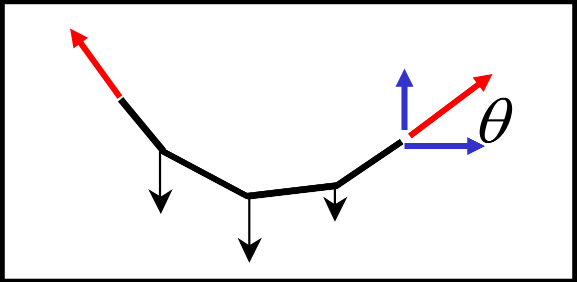
(d) Uniform loads (along the cable length)—catenary.

Cable Loads

- *trig:*

$$T_x = T\cos\theta$$

$$T_y = T\sin\theta$$



- *parabolic (catenary)*
  - *distributed uniform load*

$$y = 4h(Lx - x^2)/L^2$$

$$L_{total} = L(1 + \tfrac{8}{3}\tfrac{h^2}{L^2} - \tfrac{32}{5}\tfrac{h^4}{L^4})$$