

# equilibrium of a particle



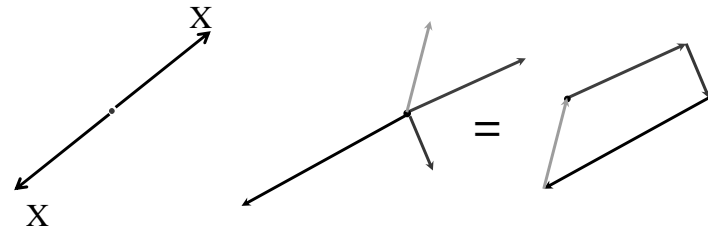
Equilibrium 1  
 Lecture 4

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# Equilibrium

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



Equilibrium 4

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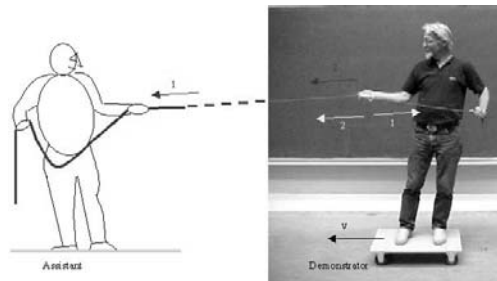
# Equilibrium

- *analytically*

$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$

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



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

Equilibrium 5

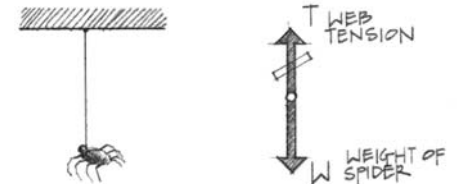
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# Equilibrium

- *collinear force system*

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



$$\left[ R_x = \sum F_x = 0 \quad R_y = \sum F_y = 0 \right]$$

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

Equilibrium 6

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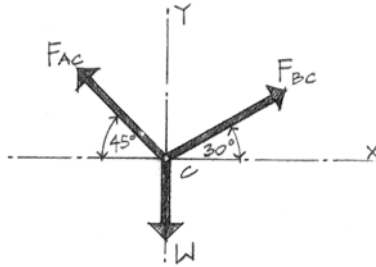
## Equilibrium

- concurrent force system

$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$

$$\left( \underline{M = \sum M = 0} \right)$$



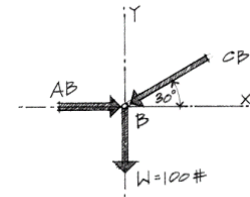
Equilibrium 7

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## 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



Equilibrium 8

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## Free Body Diagram

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

Equilibrium 9

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## 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

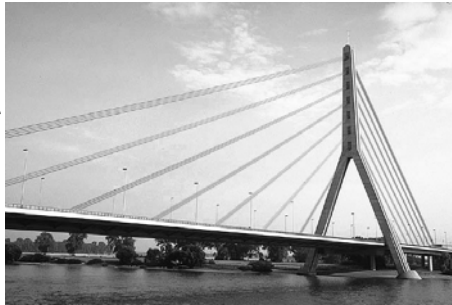
Equilibrium 10

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## Cables

- *simple*
- *uses*
  - *suspension bridges*
  - *roof structures*
  - *transmission lines*
  - *guy wires, etc.*
- *have same tension all along (straight)*
- *can't stand compression*



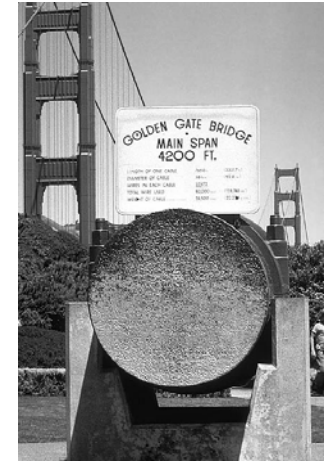
Equilibrium 11

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## Cables Structures

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



Equilibrium 12

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## Cable Structures



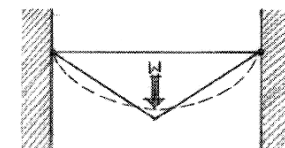
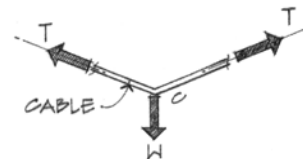
Equilibrium 13

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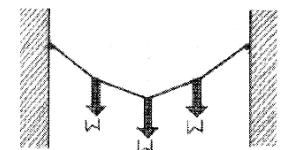
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## Cable Loads

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



(a) Simple concentrated load—triangle.



(b) Several concentrated loads—polygon.

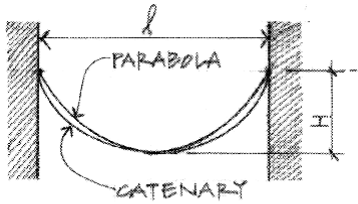
Equilibrium 14

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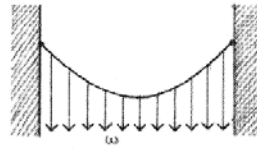
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## Cable Loads

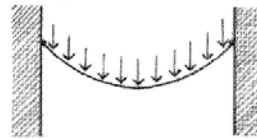
- shape directly related to the distributed load



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



(c) Uniform loads (horizontally)—parabola.



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

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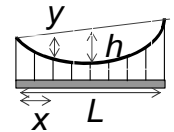
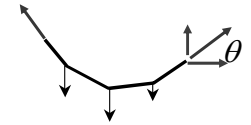
## Cable Loads

- trig:  $T_x = T \cos \theta$   
 $T_y = T \sin \theta$

- parabolic (catenary)  
– distributed uniform load

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

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



Equilibrium 16

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