

equilibrium of a particle



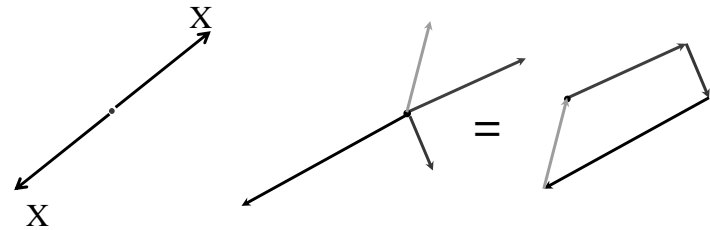
Equilibrium 1
 Lecture 4

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Equilibrium

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



Equilibrium 4

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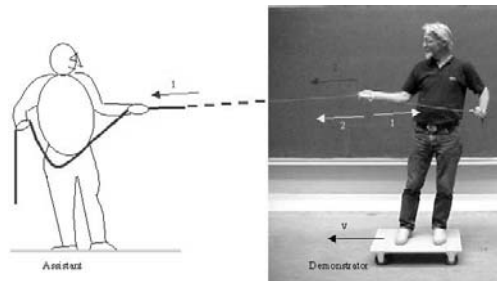
Equilibrium

- *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

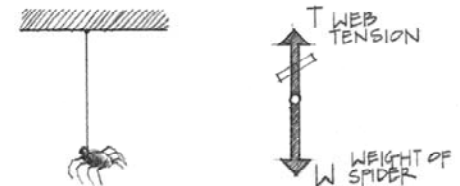
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Equilibrium

- *collinear force system*

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



$$\left[\begin{matrix} R_x = \sum F_x = 0 & R_y = \sum F_y = 0 \end{matrix} \right]$$

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

Equilibrium 6

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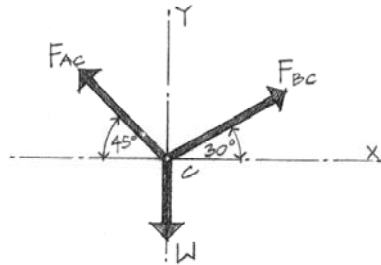
Equilibrium

- concurrent force system

$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$

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



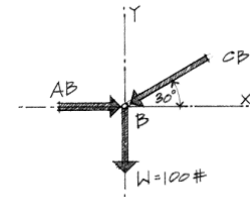
Equilibrium 7

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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*

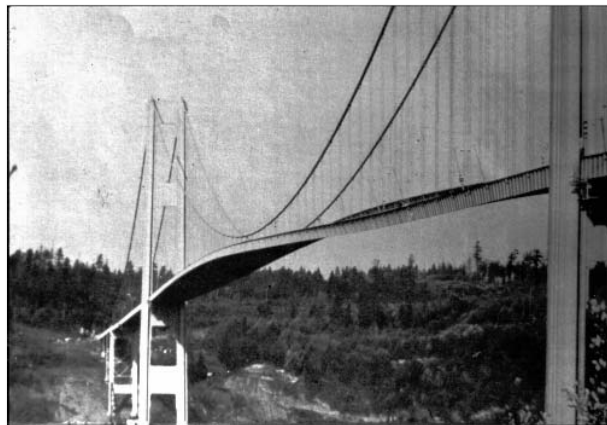


Equilibrium 12

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Cable Structures



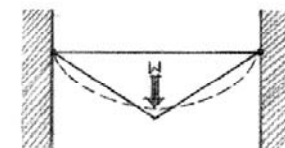
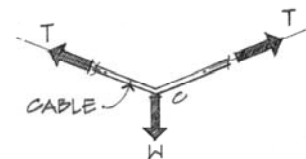
Equilibrium 13

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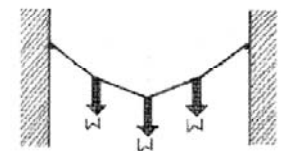
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Cable Loads

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



(a) Simple concentrated load—triangle.



(b) Several concentrated loads—polygon.

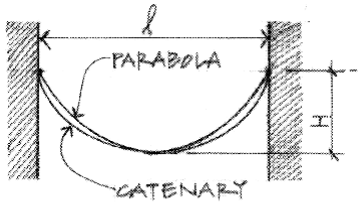
Equilibrium 14

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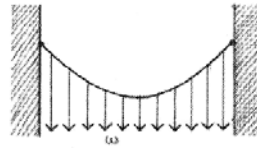
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Cable Loads

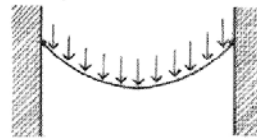
- shape directly related to the distributed load



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



(c) Uniform loads (horizontally)—parabola.



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

Equilibrium 15

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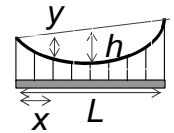
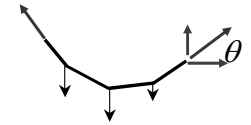
Cable Loads

- 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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