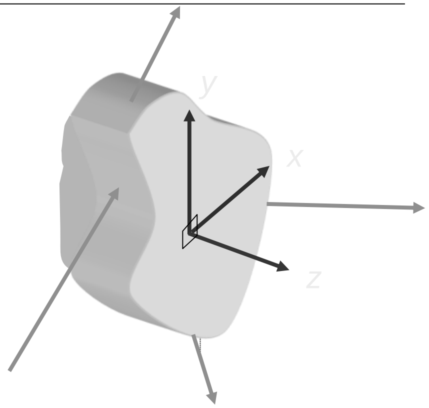
ELEMENTS OF ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN
ARCH 614
DR. ANNE NICHOLS
SPRING 2014

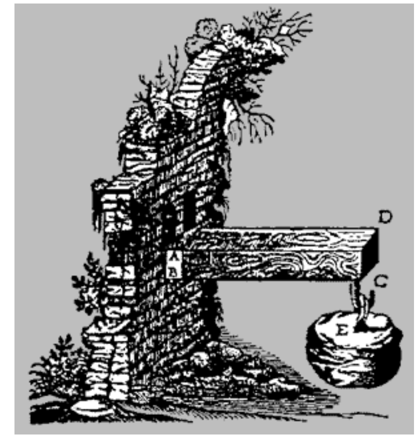
lecture
two



loads, forces and vectors

Structural Design

- planning
- preliminary structural configuration
- <u>determination of loads</u>
- preliminary member selection
- analysis
- evaluation
- design revision
- final design



Structural Loads

- STATIC and DYNAMIC
- dead load
  - static, fixed, includes building weight, fixed equipment
- live load
  - transient and moving loads (including occupants), snowfall

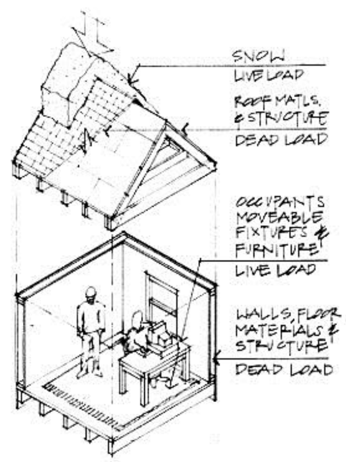


Figure 1.12 Typical building loads.

Structural Loads

- wind loads
  - dynamic, wind pressures treated as lateral static loads on walls, up or down loads on roofs

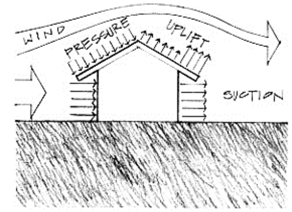
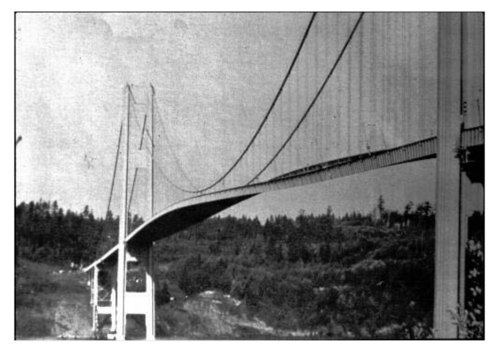


Figure 1.13 Wind loads on a structure.



Structural Loads

- earthquake loads
  - seismic, movement of ground ↕ ↔

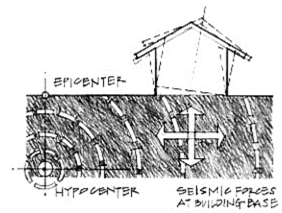
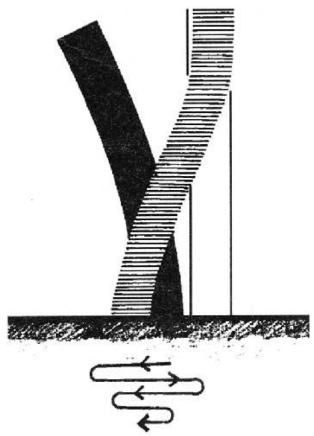
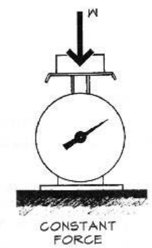


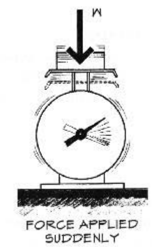
Figure 1.14 Earthquake loads on a structure.

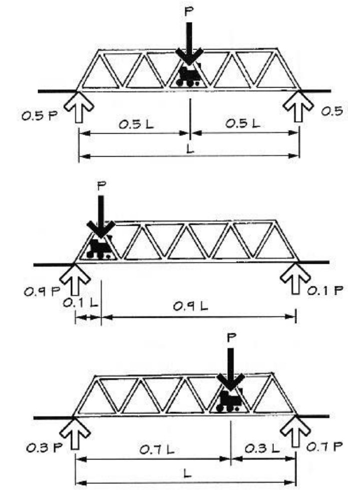


Structural Loads

- impact loads
  - rapid, energy loads

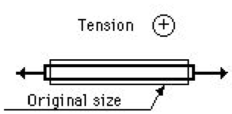






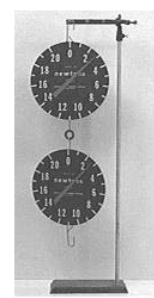
Forces

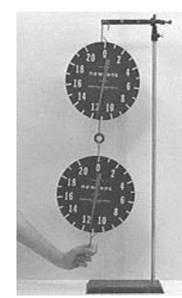
- statics
  - physics of <u>forces</u> and reactions on bodies and systems
  - equilibrium (bodies at rest)
- forces
  - something that exerts on an object:
    - motion
    - tension
    - compression



Forces

- "action of one body on another that affects the state of motion or rest of the body"
- Newton's 3rd law:
  - for every force of action there is an equal and opposite reaction along the same line





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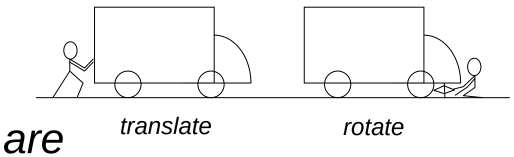
Force Vectors

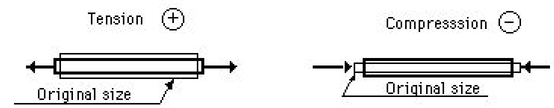
- applied at a point
- magnitude
  - Imperial units: lb, k (kips)
  - SI units: N (newtons), kN
- direction
- sense

Forces on Rigid Bodies

- for statics, the bodies are ideally rigid
- can translate and rotate

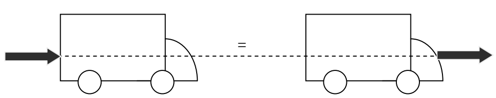


- internal forces are
  - in bodies
  - between bodies (connections)
- external forces act on bodies



Transmissibility

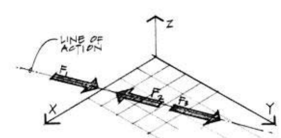
- the force stays on the same line of action
- truck can't tell the difference



- only valid for EXTERNAL forces

Force System Types

- collinear

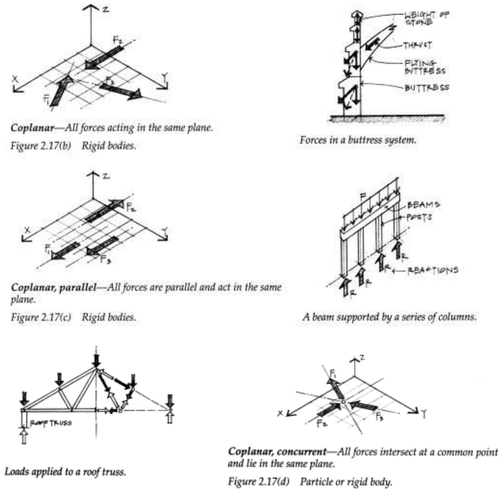


Collinear—All forces acting along the same straight line.

Figure 2.17(a) Particle or rigid body.

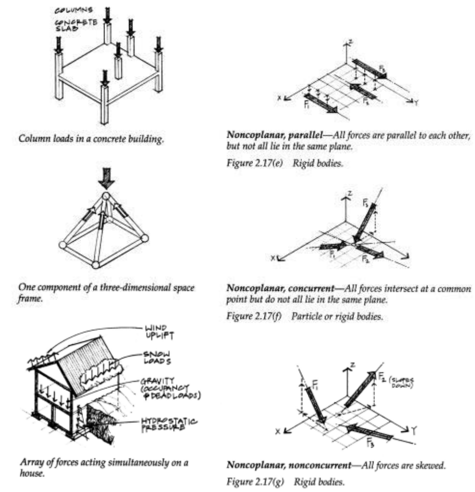
Force System Types

- *coplanar*



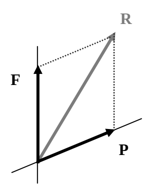
Force System Types

- *space*

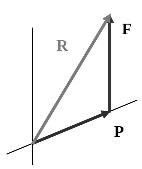


Adding Vectors

- *graphically*
  - *parallelogram law*
    - *diagonal*
    - *long for 3 or more vectors*

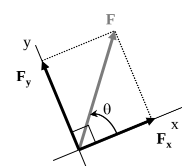


  - *tip-to-tail*
    - *more convenient with lots of vectors*



Force Components

- *convenient to resolve into 2 vectors*
- *at right angles*
- *in a "nice" coordinate system*
- *θ is between F_x and F <u>from F_x</u>*

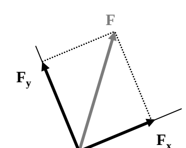


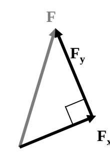
$$F_x = F\cos\theta$$

$$F_y = F\sin\theta$$

$$F = \sqrt{F_x^2 + F_y^2}$$

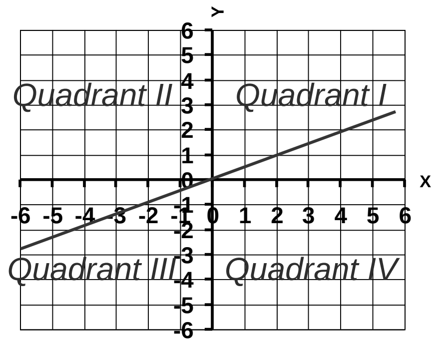
$$\tan\theta = \frac{F_y}{F_x}$$





Trigonometry

- F_x is negative
  - 90° to 270°
- F_y is negative
  - 180° to 360°
- tan is positive
  - quads I & III
- tan is negative
  - quads II & IV

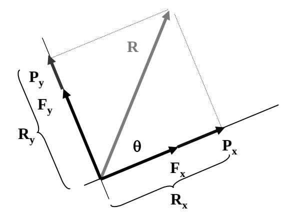


Component Addition

- find all x components
- find all y components
- find sum of x components, R_x (resultant)
- find sum of y components, R_y

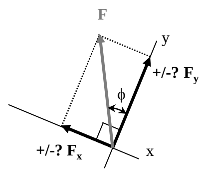
$$R = \sqrt{R_x^2 + R_y^2}$$

$$\tan\theta = \frac{R_y}{R_x}$$



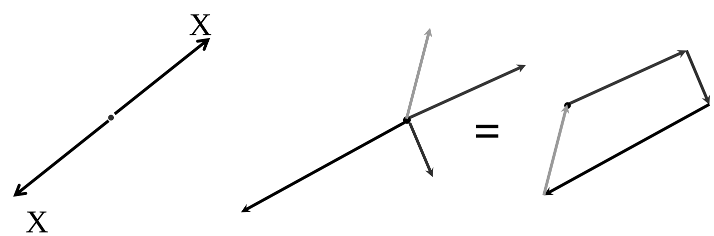
Alternative Trig for Components

- doesn't relate angle to axis direction
- ϕ is "small" angle between F and <u>EITHER F_x or F_y</u>
- no sign out of calculator!
- have to choose RIGHT trig function, resulting direction (sign) and component axis



Static Equilibrium

- balanced & steady
- no motion or translation
- equilibrant is opposite resultant



Cables

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

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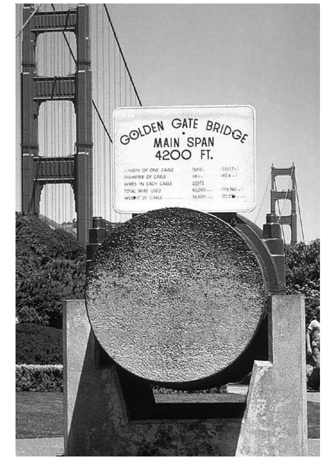
Cables Structures

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



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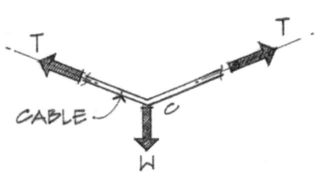
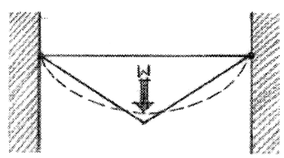
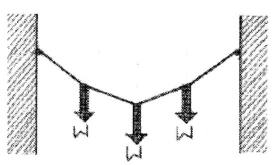
Cable Loads

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





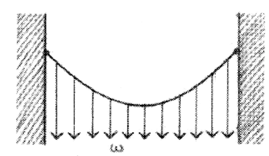
(a) *Simple concentrated load—triangle.*



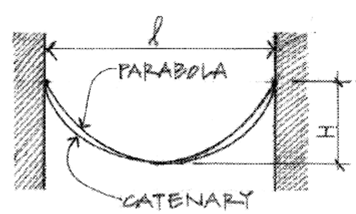
(b) *Several concentrated loads—polygon.*

Cable Loads

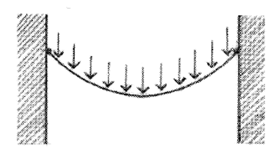
- *shape directly related to the distributed load*



(c) *Uniform loads (horizontally)—parabola.*



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

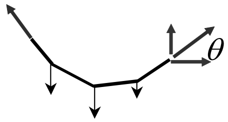


(d) *Uniform loads (along the cable length)—catenary.*

Cable Loads

- *trig:* $T_x = T\cos\theta$

  $T_y = T\sin\theta$



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

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

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