Architectural Structures I:
Statics and Strength of Materials

ENDS 231

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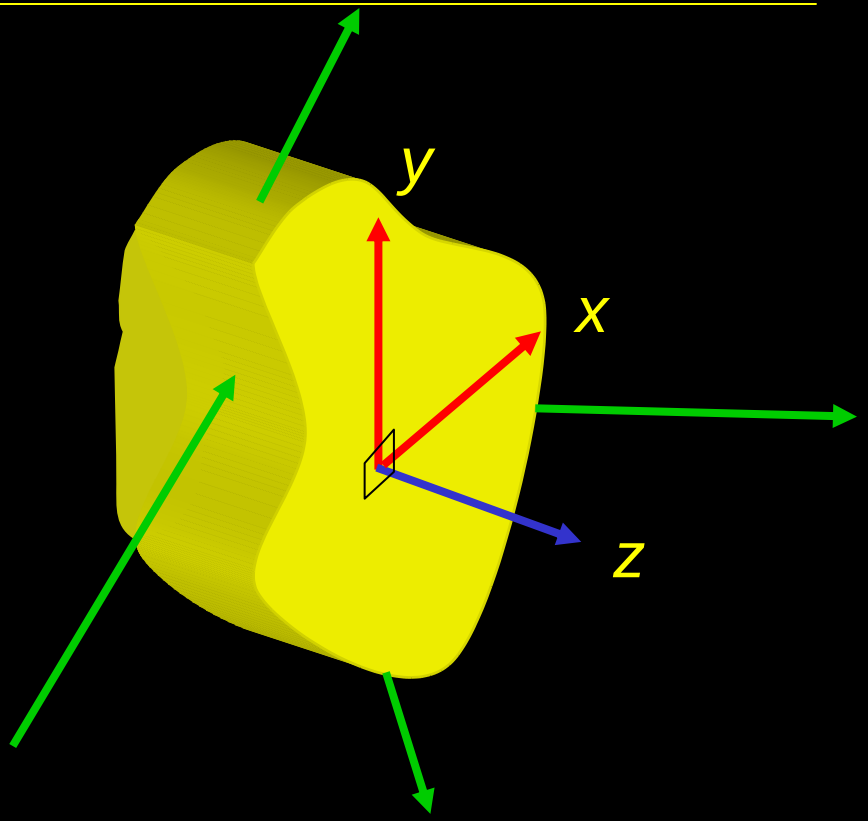
Summer 2006

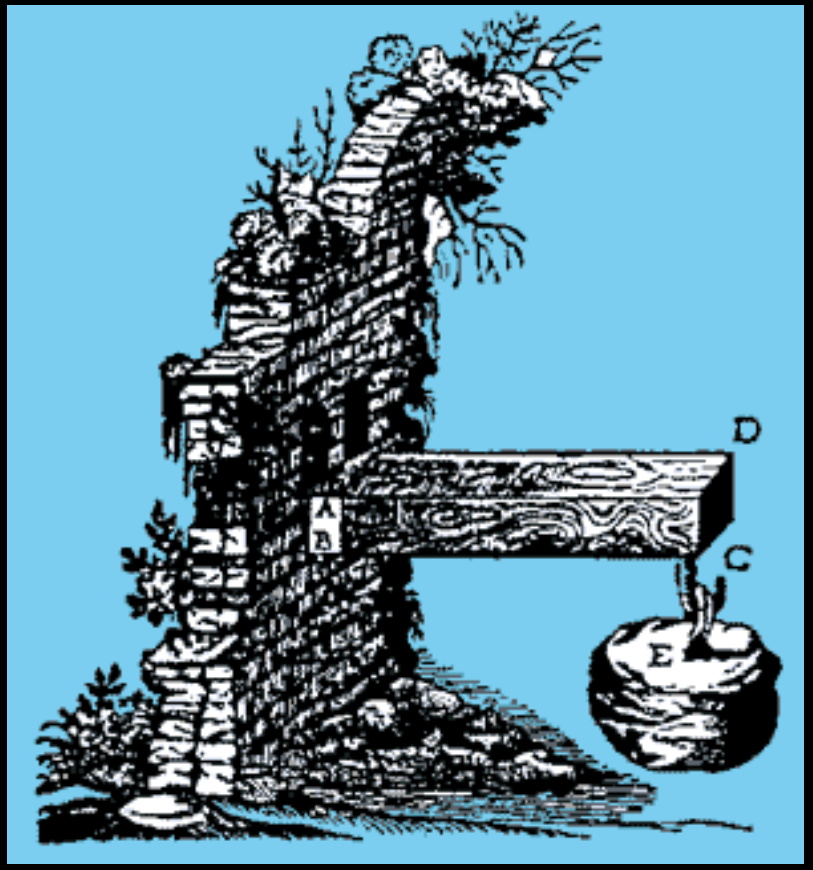
lecture
two



loads, forces and vectors

Structural Design

- *planning*
- *preliminary structural configuration*
- *determination of loads*
- *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*

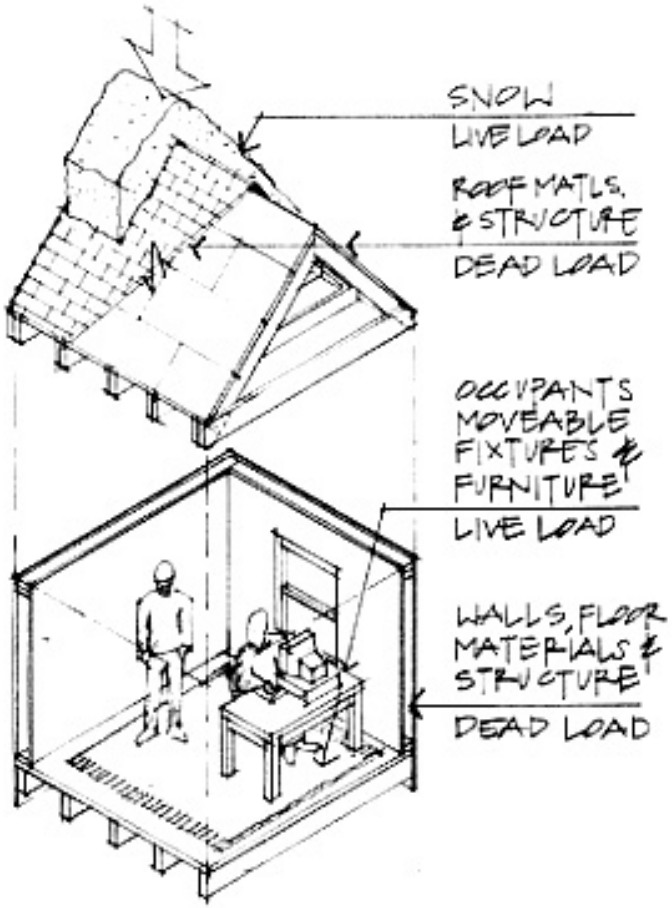


Figure 1.12 Typical building loads.

Structural Loads

- *wind loads*
  - *dynamic, wind pressures treated as lateral static loads on walls, up or down loads on roofs*
- *earthquake loads*
  - *seismic, movement of ground* ↕ ↔
- *impact loads*
  - *rapid, energy loads*

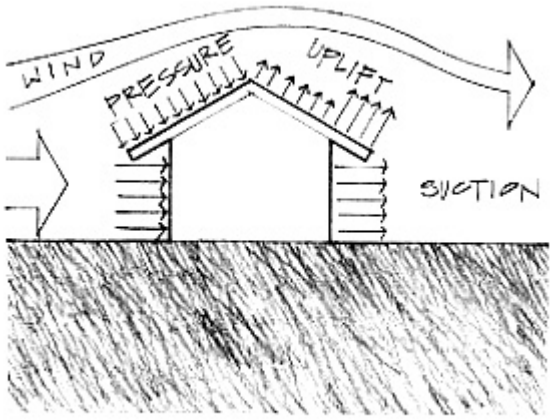


Figure 1.13 Wind loads on a structure.

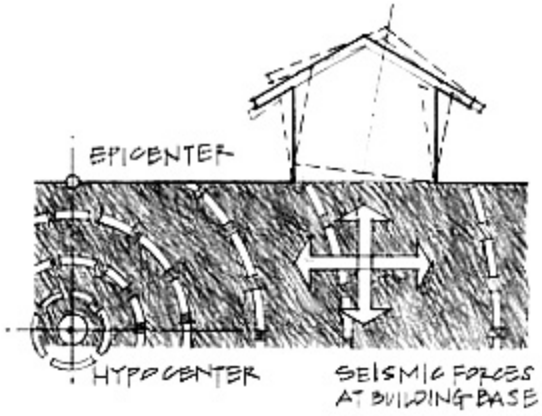
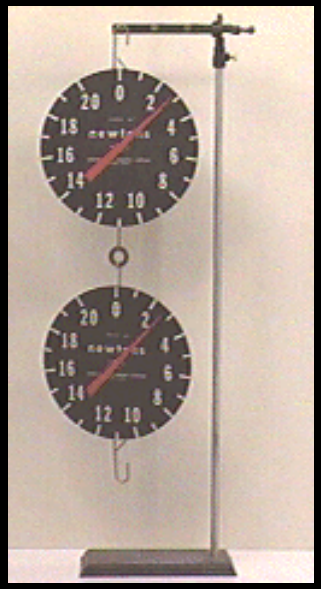
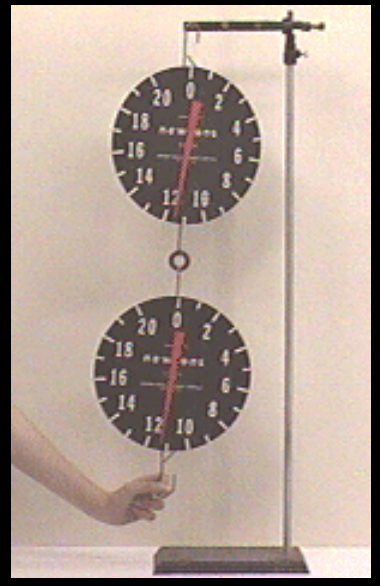


Figure 1.14 Earthquake loads on a structure.

Force

- *"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*





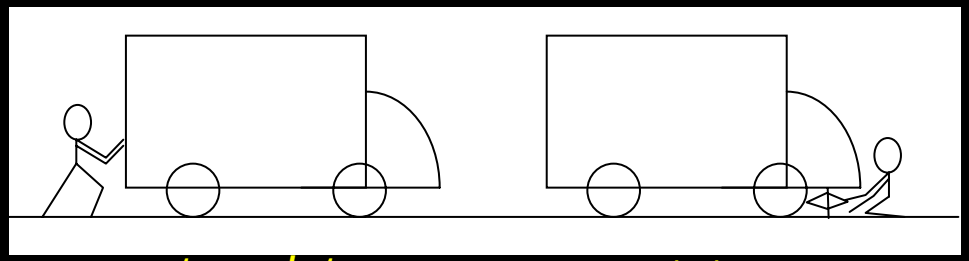
Force Characteristics

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

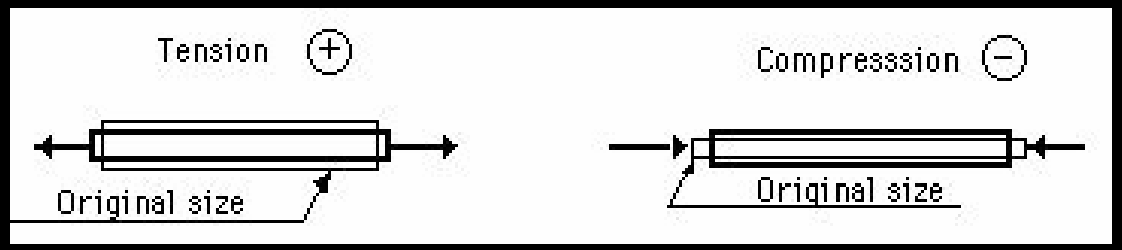
(tail) *(tip)*

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*

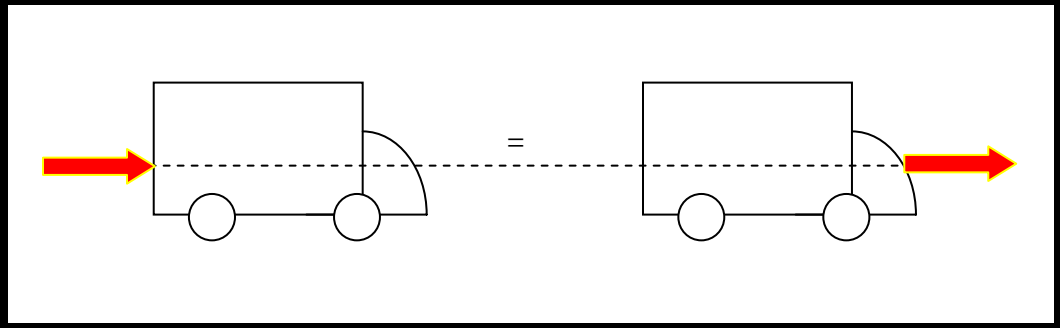


translate *rotate*



Transmissibility

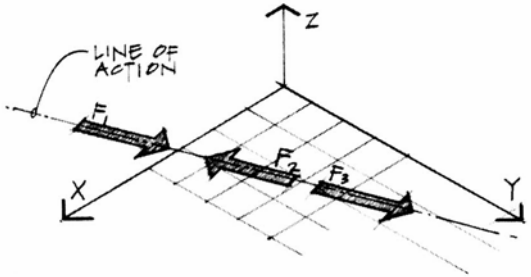
- *the force stays on the same line of action*
- *truck can't tell the difference*



- *only valid for EXTERNAL forces*

Force System Types

- *collinear*

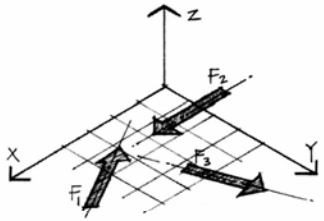


Collinear—*All forces acting along the same straight line.*

Figure 2.17(a) Particle or rigid body.

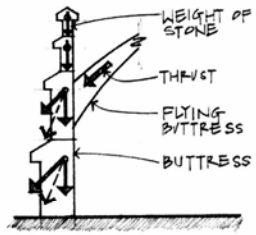
Force System Types

- *coplanar*

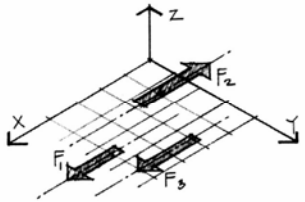


Coplanar—*All forces acting in the same plane.*

Figure 2.17(b) Rigid bodies.

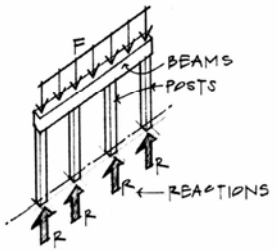


Forces in a buttress system.

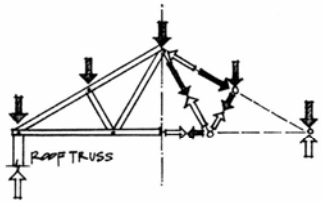


Coplanar, parallel—*All forces are parallel and act in the same plane.*

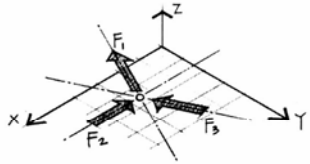
Figure 2.17(c) Rigid bodies.



A beam supported by a series of columns.



Loads applied to a roof truss.

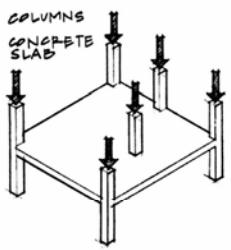


Coplanar, concurrent—*All forces intersect at a common point and lie in the same plane.*

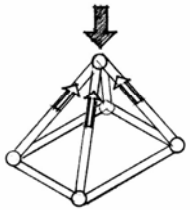
Figure 2.17(d) Particle or rigid body.

Force System Types

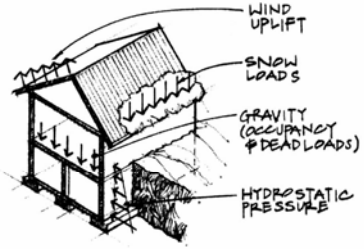
- *space*



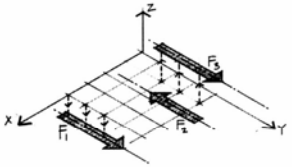
Column loads in a concrete building.



One component of a three-dimensional space frame.

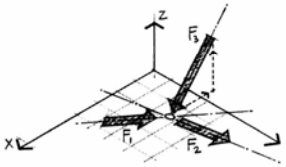


Array of forces acting simultaneously on a house.



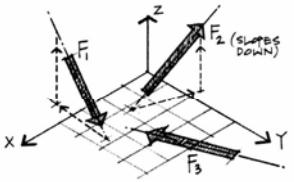
***Noncoplanar, parallel**—All forces are parallel to each other, but not all lie in the same plane.*

Figure 2.17(e) Rigid bodies.



***Noncoplanar, concurrent**—All forces intersect at a common point but do not all lie in the same plane.*

Figure 2.17(f) Particle or rigid bodies.

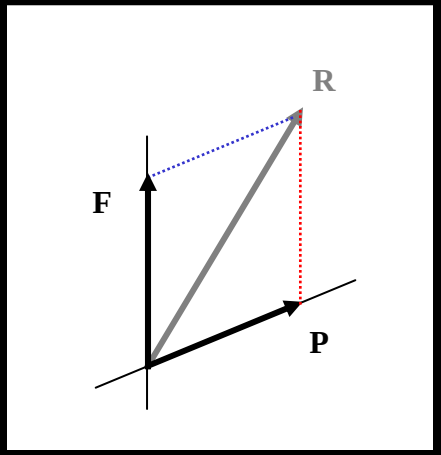


***Noncoplanar, nonconcurrent**—All forces are skewed.*

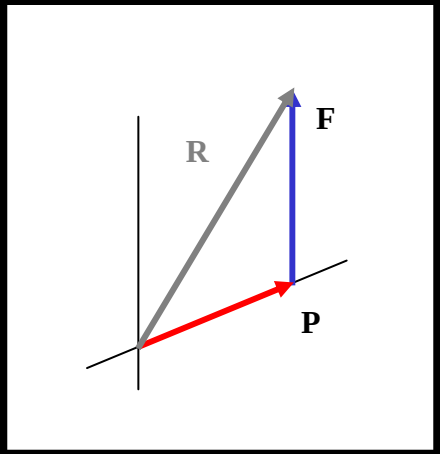
Figure 2.17(g) Rigid bodies.

Adding Vectors

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



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



Force Components

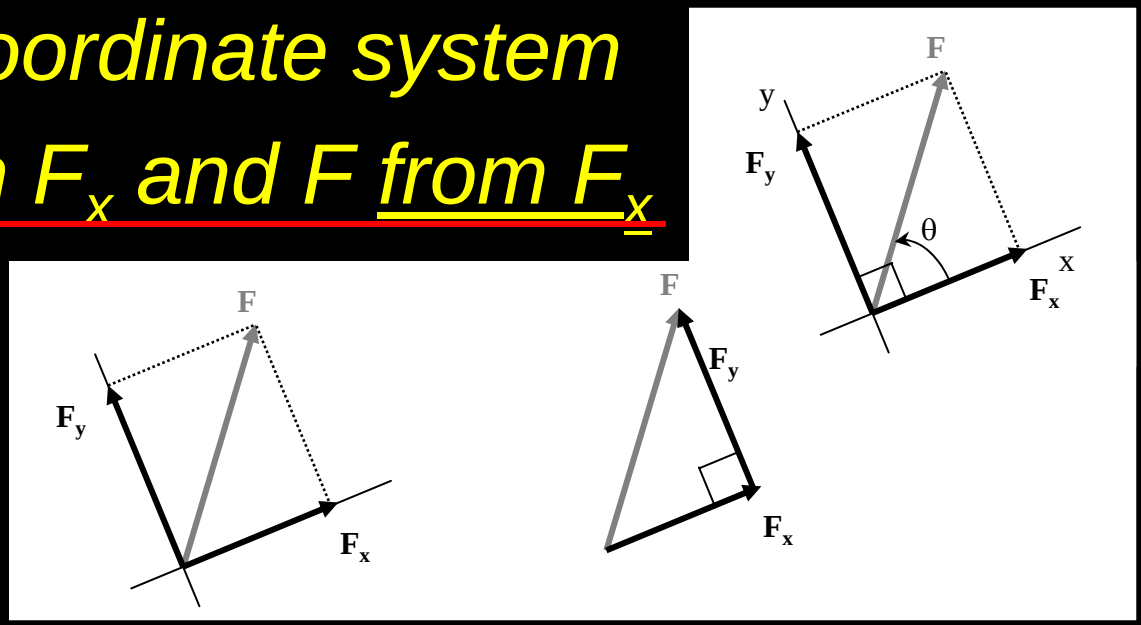
- convenient to resolve into 2 vectors
- at right angles
- in a "nice" coordinate system
- θ is between F_x and F from F_x

$$F_x = F\cos\theta$$

$$F_y = F\sin\theta$$

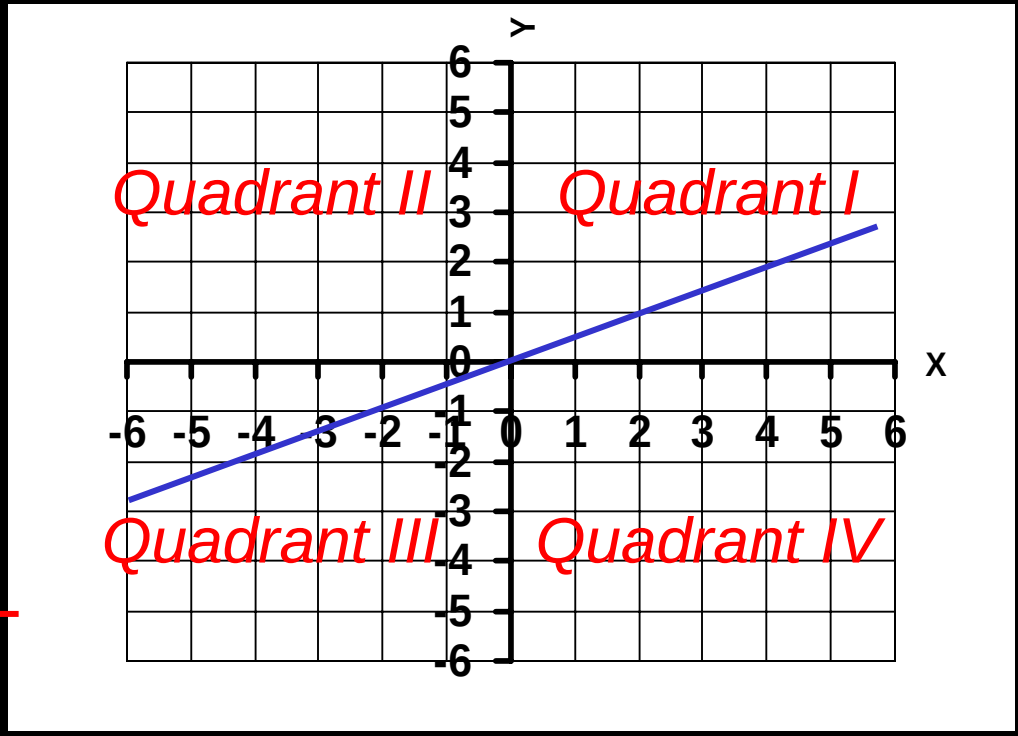
$$F = \sqrt{F_x^2 + F_y^2}$$

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



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

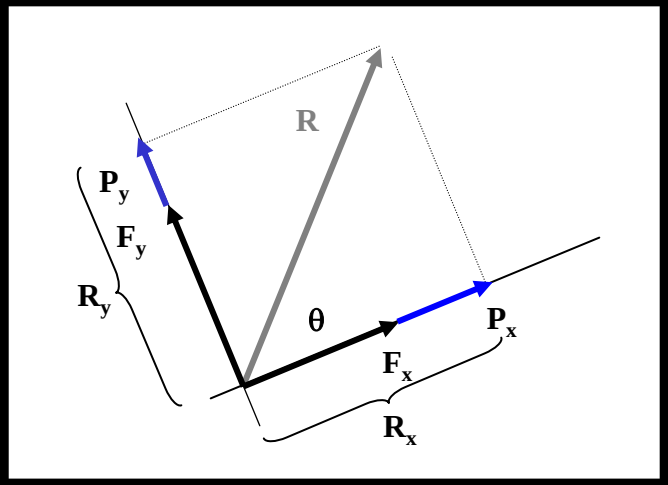


Component Addition

- *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*