*ARCHITECTURAL STRUCTURES I:*
*STATICS AND STRENGTH OF MATERIALS*

*ENDS 231*

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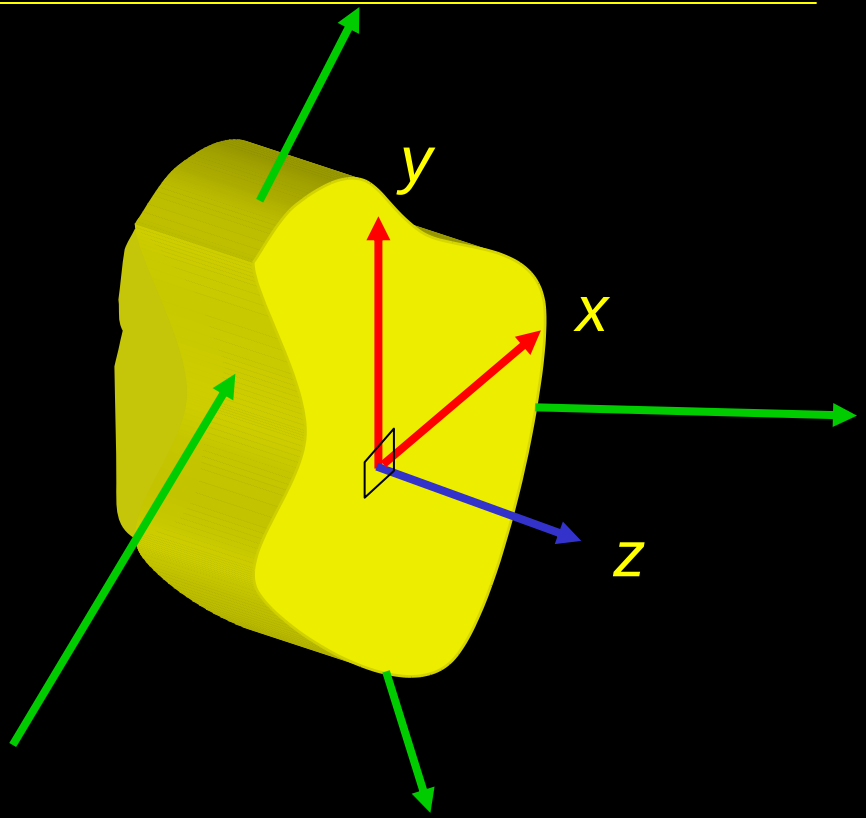
*SPRING 2007*

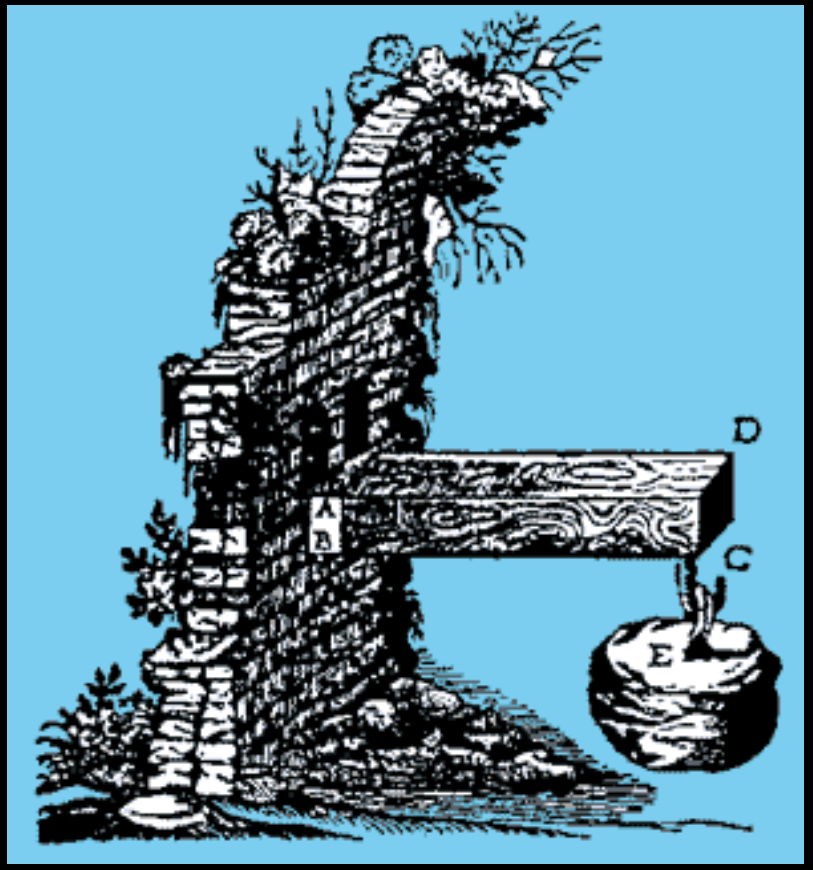
*lecture*
*two*




# *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*

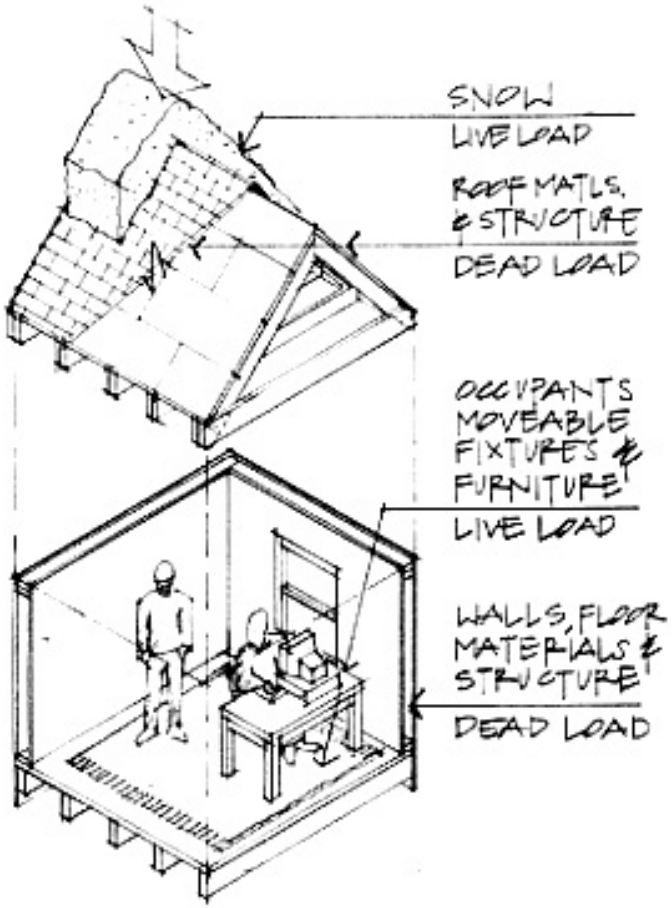



*Figure 1.12 Typical building loads.*

# 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*

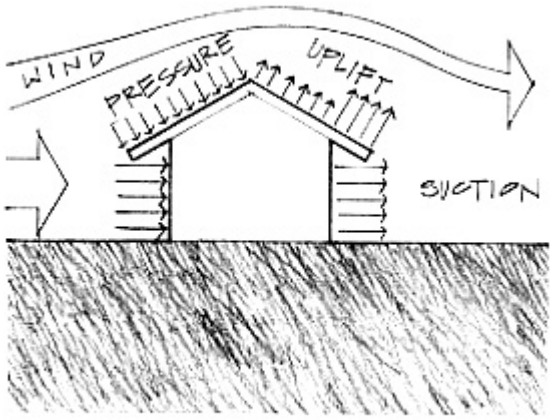



*Figure 1.13 Wind loads on a structure.*

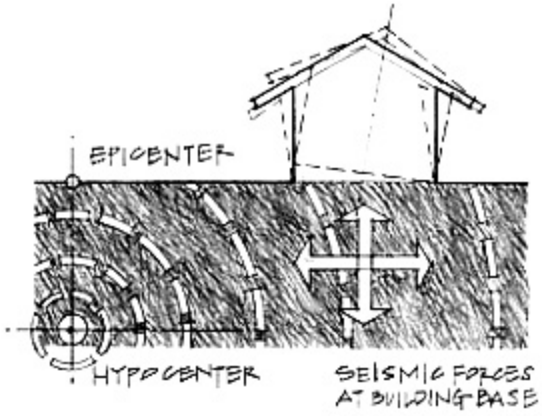
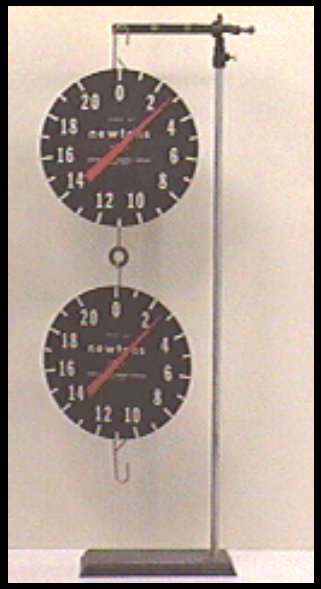
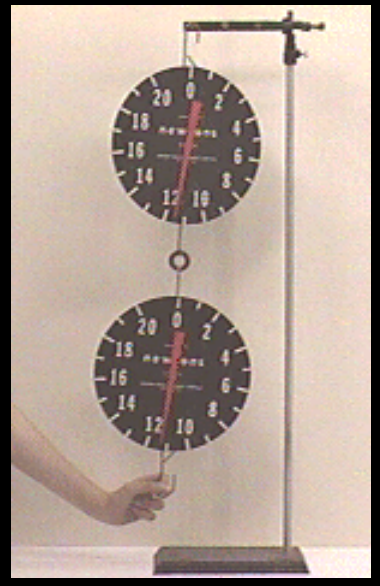



*Figure 1.14 Earthquake loads on a structure.*

# *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*





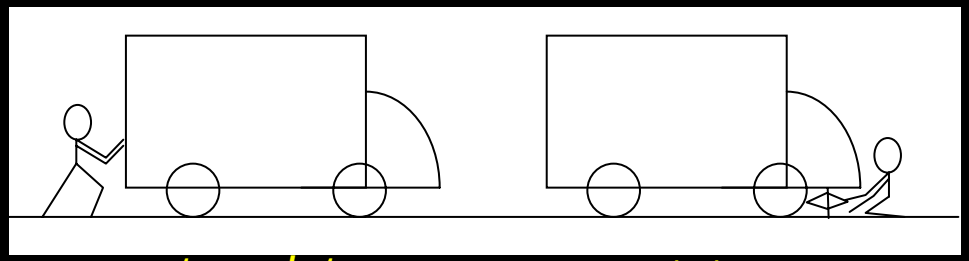
# *Force Characteristics*

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

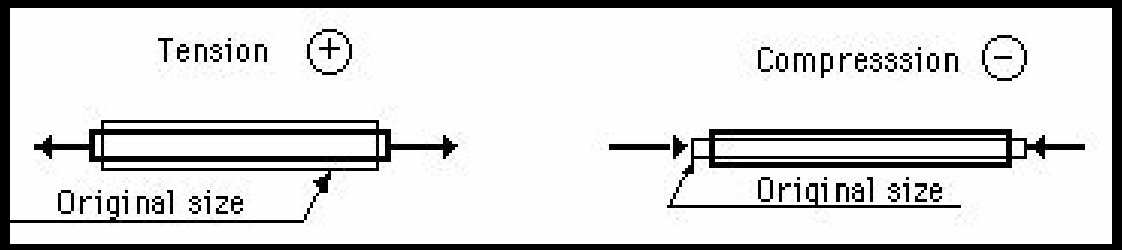
*(tail)*  *(tip)*

# 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*

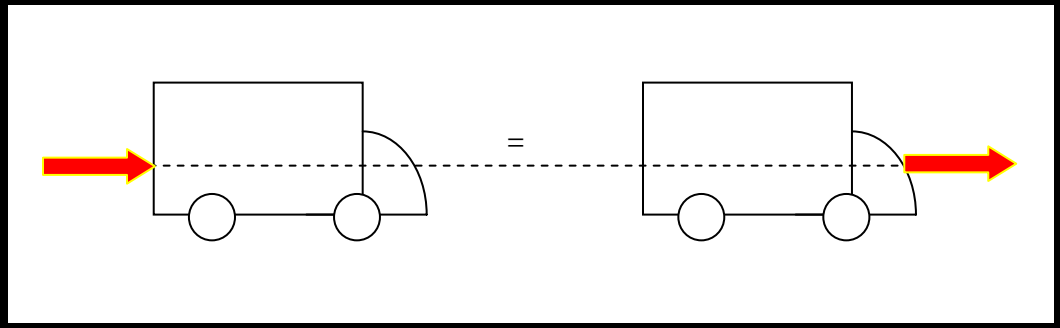


*translate* *rotate*



# *Transmissibility*

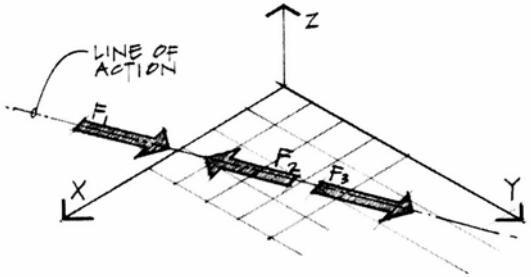
- *the force stays on the same line of action*
- *truck can't tell the difference*




- *only valid for EXTERNAL forces*

# Force System Types

- *collinear*

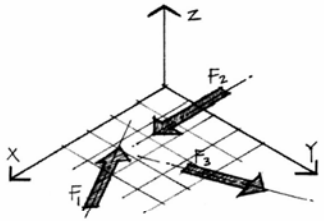



***Collinear***—*All forces acting along the same straight line.*

*Figure 2.17(a) Particle or rigid body.*

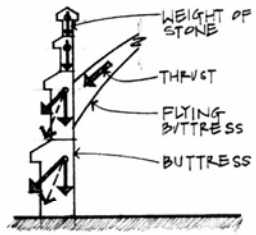
# Force System Types

- *coplanar*

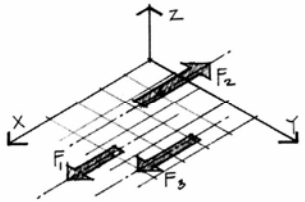



***Coplanar***—*All forces acting in the same plane.*

*Figure 2.17(b) Rigid bodies.*

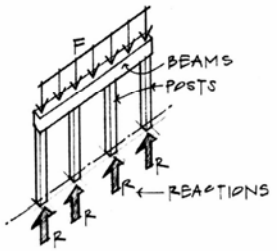



*Forces in a buttress system.*

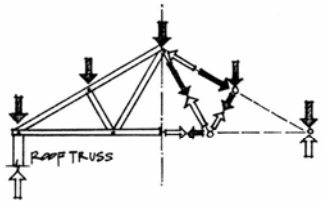



***Coplanar, parallel***—*All forces are parallel and act in the same plane.*

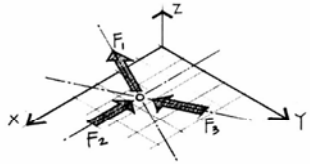
*Figure 2.17(c) Rigid bodies.*




*A beam supported by a series of columns.*




*Loads applied to a roof truss.*

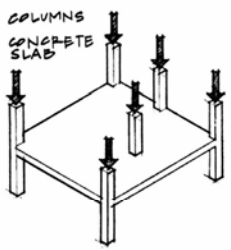



***Coplanar, concurrent***—*All forces intersect at a common point and lie in the same plane.*

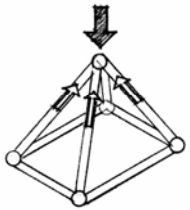
*Figure 2.17(d) Particle or rigid body.*

# Force System Types

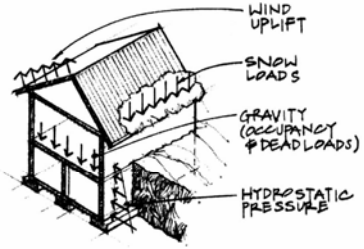
- *space*



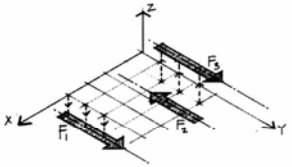

*Column loads in a concrete building.*



*One component of a three-dimensional space frame.*

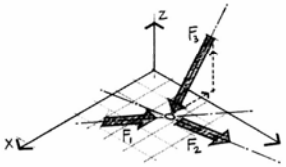



*Array of forces acting simultaneously on a house.*



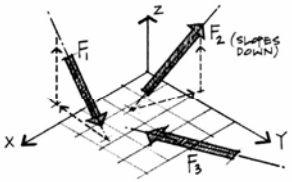

***Noncoplanar, parallel**—All forces are parallel to each other, but not all lie in the same plane.*

*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.*

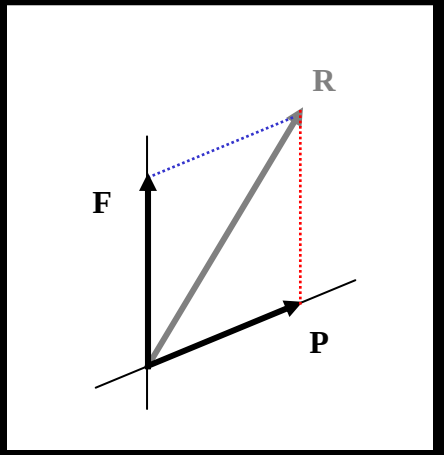



***Noncoplanar, nonconcurrent**—All forces are skewed.*

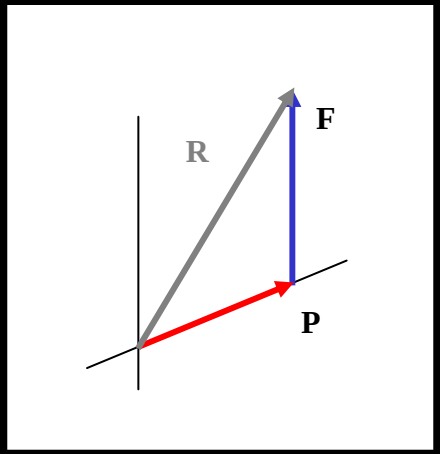
*Figure 2.17(g) Rigid bodies.*

# Adding Vectors

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




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



# Force Components

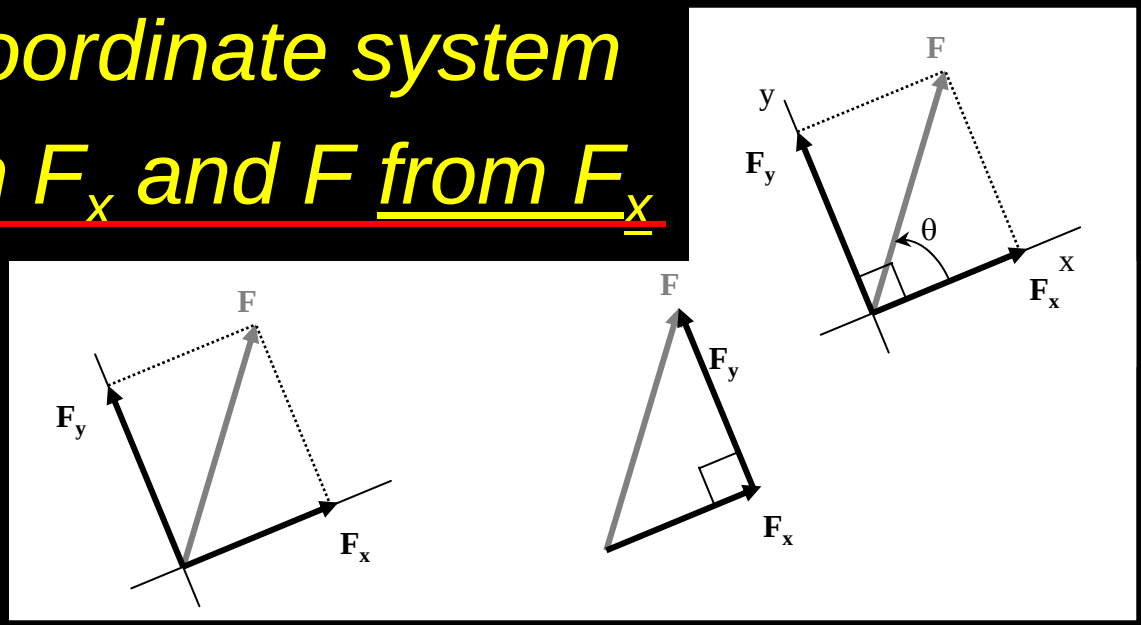
- convenient to resolve into 2 vectors
- at right angles
- in a "nice" coordinate system
- $\theta$ is between $F_x$ and F from $F_x$

$$F_x = F\cos\theta$$

$$F_y = F\sin\theta$$

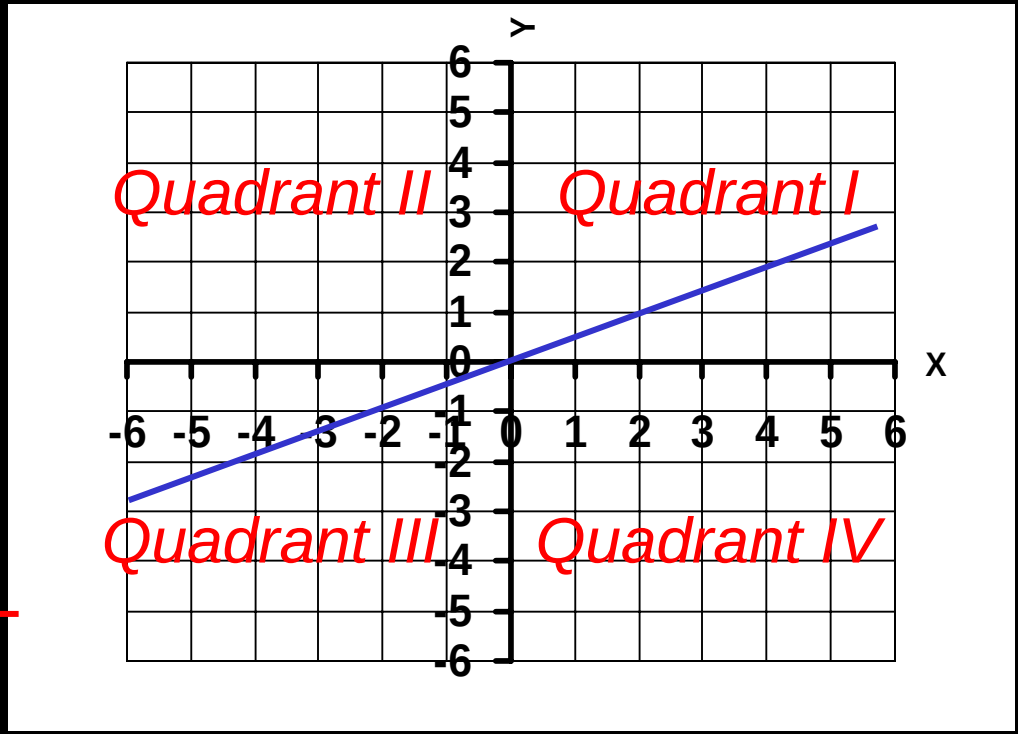
$$F = \sqrt{F_x^2 + F_y^2}$$

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



# 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

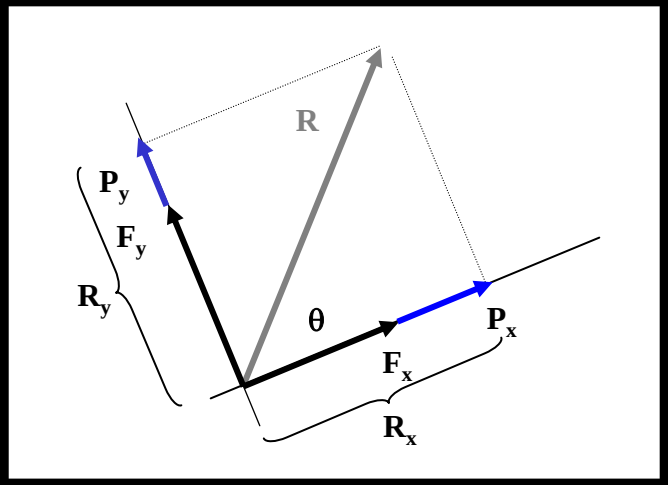


# *Component Addition*

- *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*
- *$\phi$ 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*