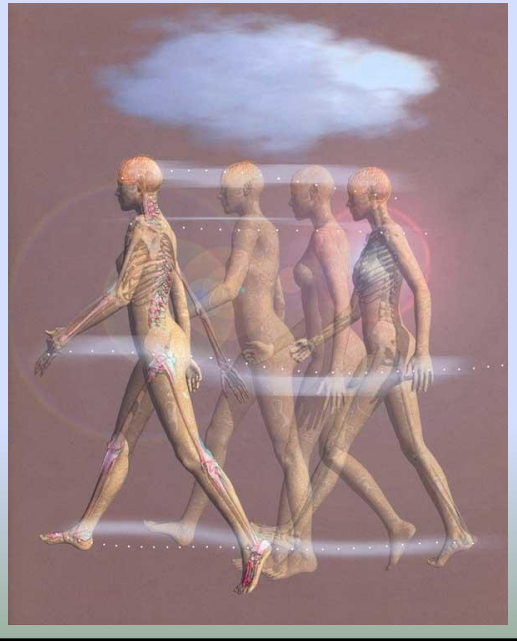
Basic Biomechanics

…the body as a living machine for locomotion…



Mechanics

- The study of forces and motions produced by their actions

Biomechanics

- Mechanical principles applied to
  - Human body
    - Structure
    - Function

Mechanics

- Static
  - Forces associated with non-moving or nearly moving systems

Mechanics

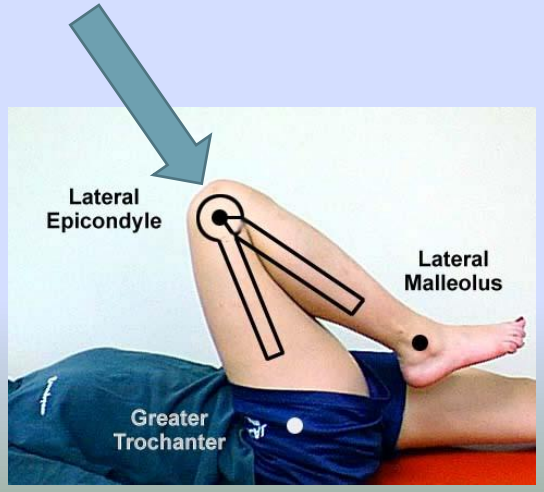
- Dynamics-moving systems
  - **Kinetics-**
  - examines the forces acting on the body during movement and the motion with respect to time and forces
  - **Kinematics-**
  - A branch of biomechanics that describes the motion of a body without regard to the forces that produce the motion

Mechanics

- Kinetics
  - Forces causing movement in a system
    - Gravity

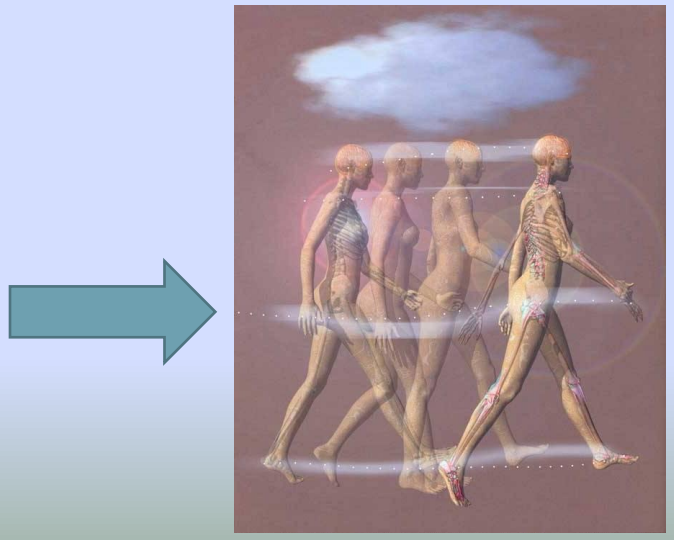
Mechanics

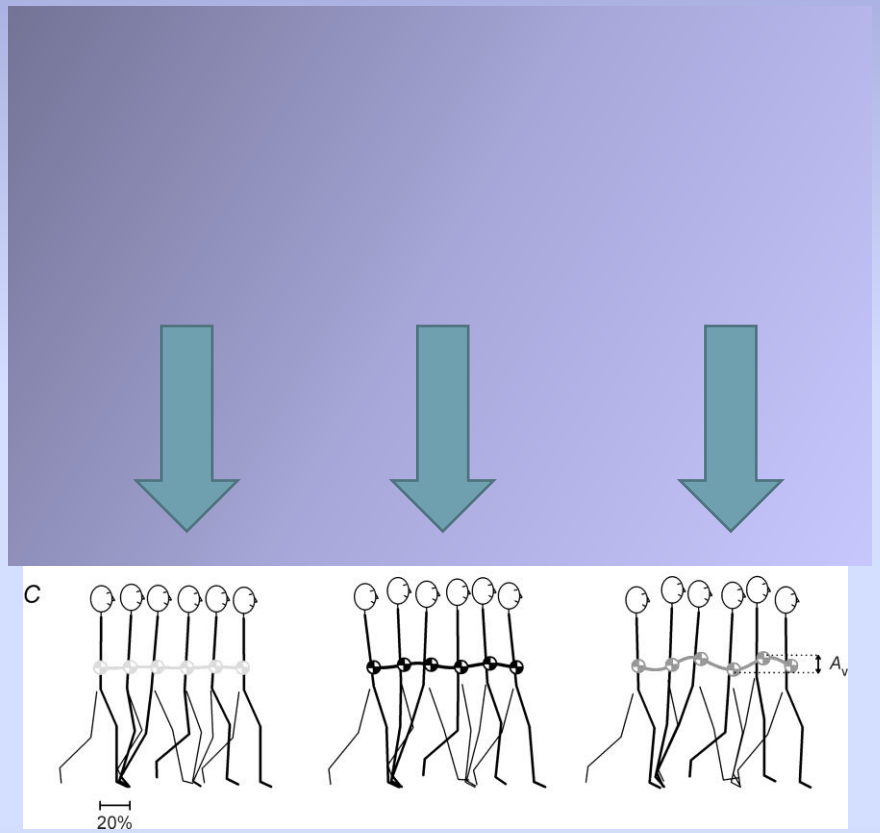
- Kinematics-
  - Translation-When all parts of a "body" move in the same direction as every other part
    - Rectilinear motion = straight line motions (sliding surfaces)
    - Curvilinear motion = curved line of motion (the motion of a ball when tossed)
  - Rotation-the arc of motion around a fixed axis of rotation or a "pivot point"
    - Joints have "pivot points" which are used as reference points from which to measure the range of motion (ROM) of that joint
    -



Kinematics of Walking

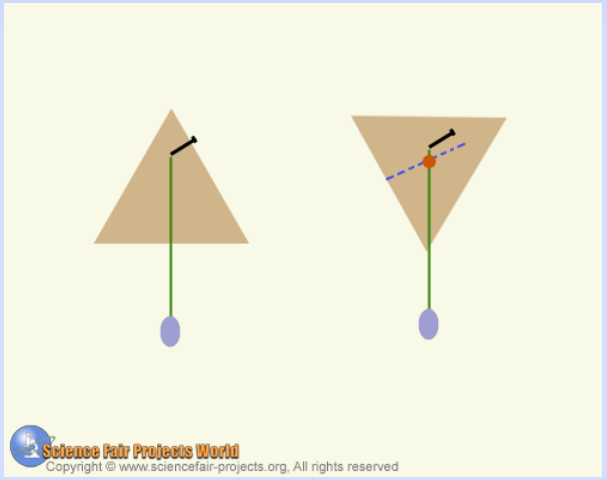
- The hips are moving forward and marked to indicate the curvilinear path that they take in the translatory motion of walking.

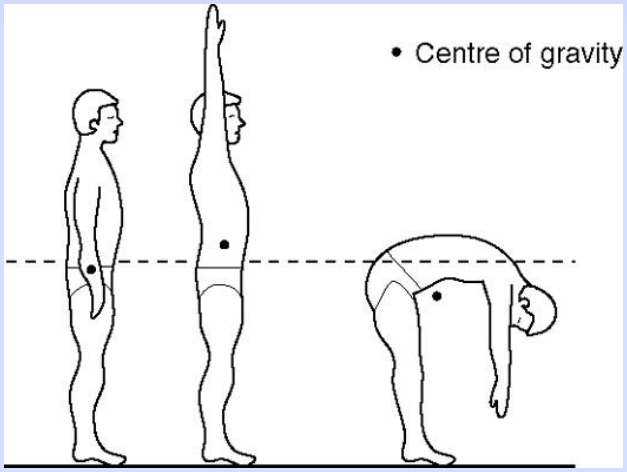




Kinematics of Motion

- Movement of the body = translation of the translation of the body's center of mass
  - Center of Mass/Center of Gravity



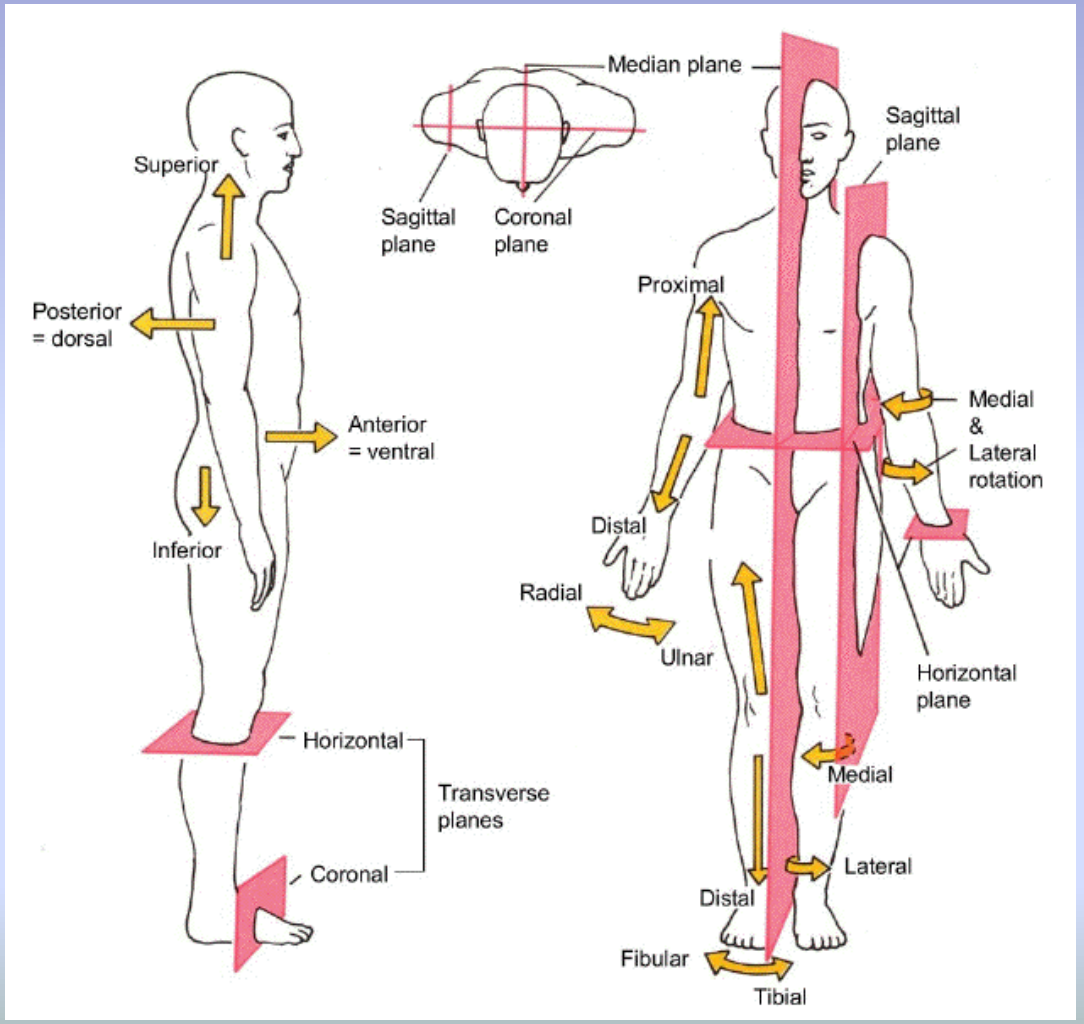


Kinematics of Motion: Active versus Passive

- Active-
  - Generated by muscle contraction
- Passive-
  - Occur due to stresses placed on the tissue other than muscle contraction
    - Gravity
    - Resistance
    - An applied stretch from someone or something else

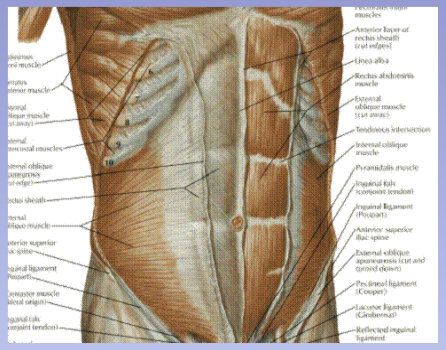
Terminology

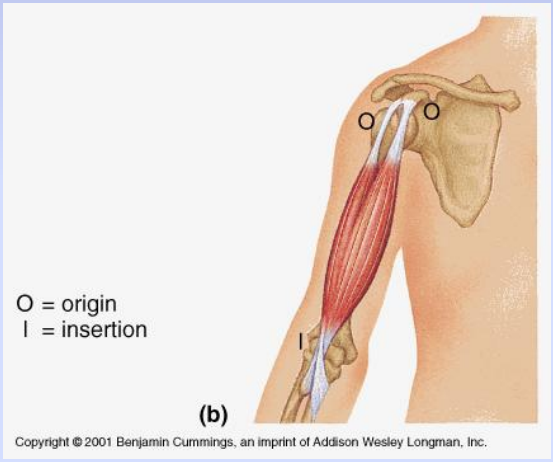
- Required to describe:
  - Movement
  - Position
  - Location of anatomic features

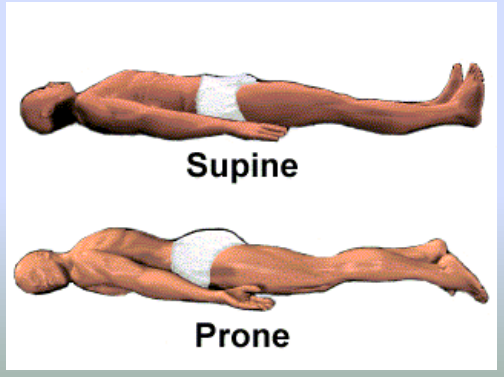


Terminology

- Deep-
  - toward the inside of the body
- Origin-
  - the proximal attachment of a muscle or ligament
- Insertion-
  - the distal attachment of a muscle or ligament
- Prone-
  - lying face down
- Supine-
  - lying face up

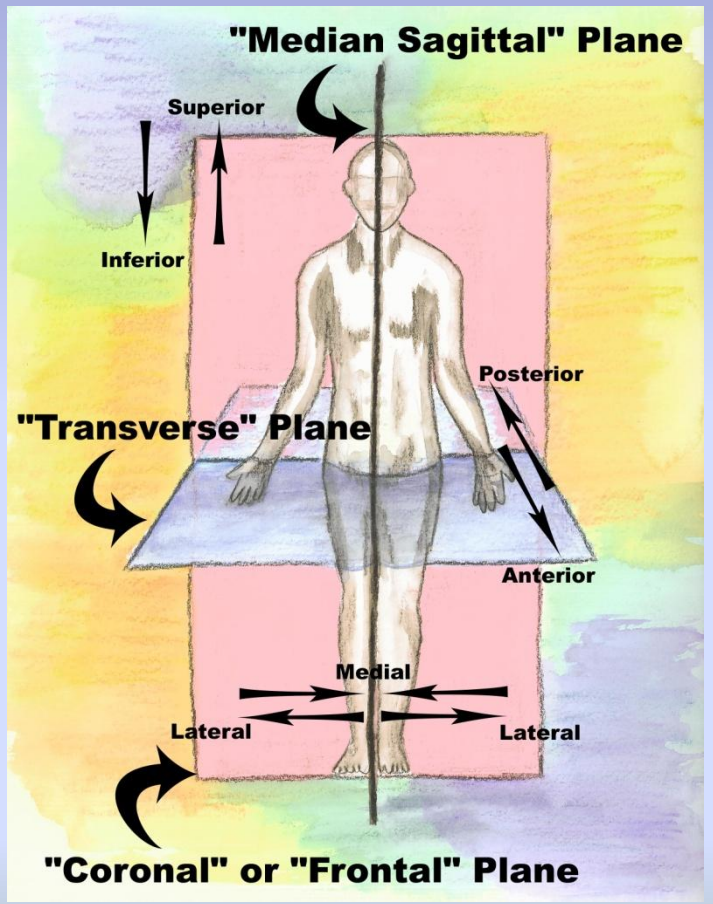






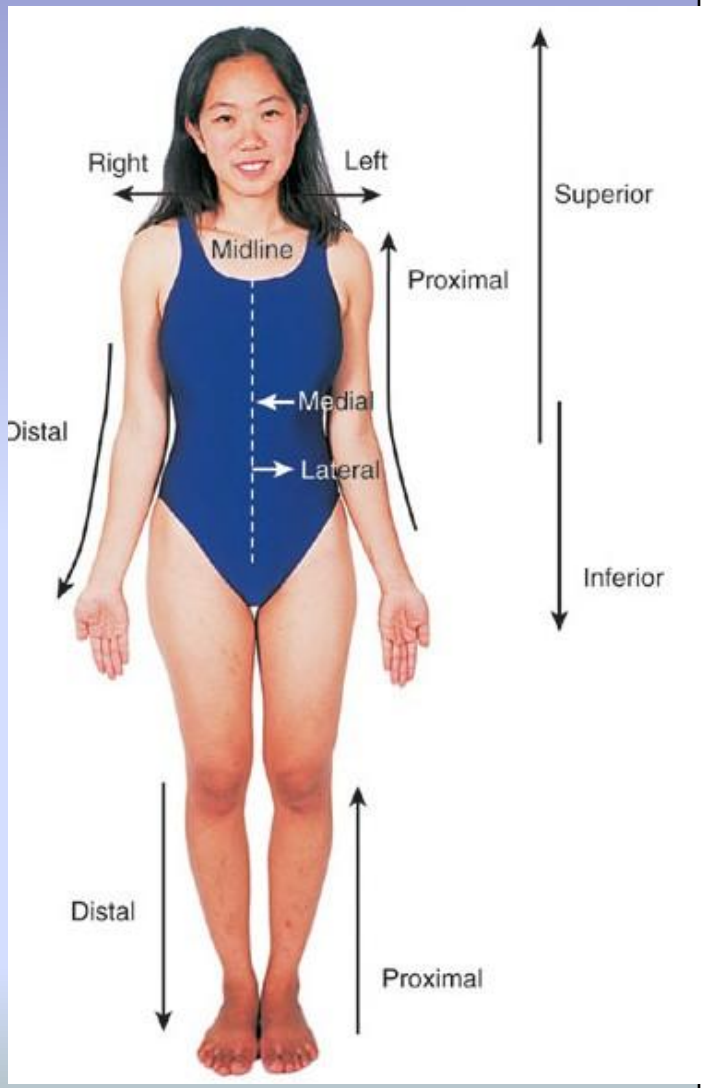
Osteokinematics-

- Motion of bones through a range of motion relative to the 3 cardinal planes of the body and around the axis in that joint
- Planes:
  - Saggital or Median
    - Flexion & extension
  - Frontal or Coronal
    - ABD & ADD
  - Horizontal or Transverse
    - Rotational motions

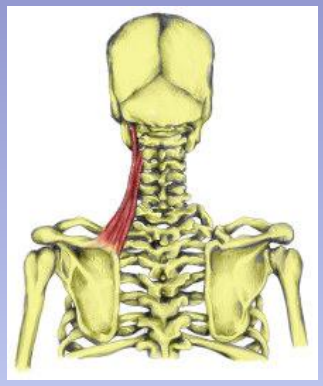


Anatomic Position

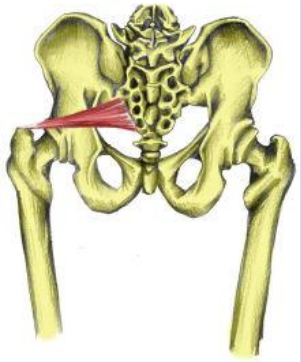
- Standard Reference Point
  - Axis of rotation
  - Planes of motion
  - Actions of muscles are referenced from anatomic position

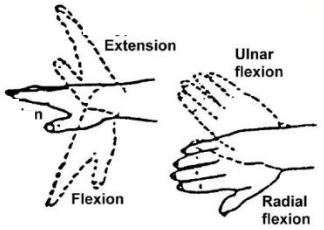


Osteokinematics



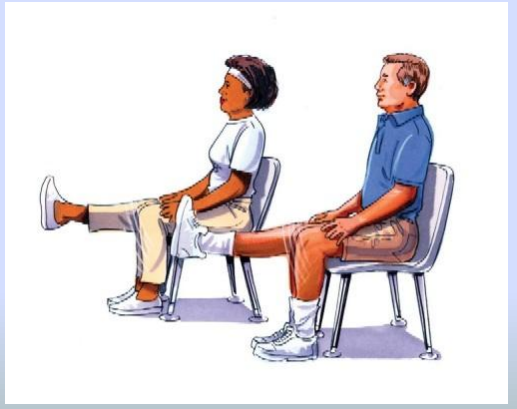
- Axis of Rotation = "pivot point"
  - It's ALWAYS perpendicular to the plane of motion!
- Degrees of Freedom
  - The number of planes of motion allowed to a joint
    - The shoulder and hip have 3
    - The elbow and knee have just 1
    - The wrist has 2





Osteokinematics: Fundamental Motions

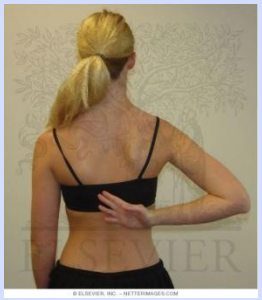
- Flexion and Extension:
  - Occur in the saggital plane around a medial/lateral axis
  - Flexion = motion of one bone approaching the anterior aspect of another bone
  - Extension = opposite of flexion



Osteokinematics: Fundamental Motions

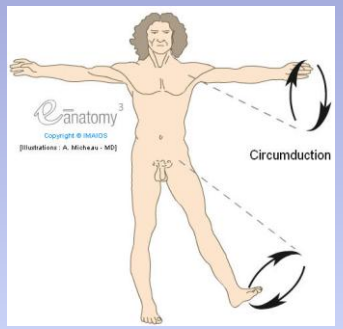
- ABDuction & ADDuction
  - ABD = movement away from midline
  - ADD = movement toward midline

- Rotation
  - Internal Rotation = anterior surface moving toward midline
  - External Rotation = anterior surface moving away from midline



Osteokinematics: Fundamental Motions

- Circumduction
  - Circular motion through 2 planes
    - If a joint can draw a circle in the air, it can circumduct
- Protraction & Retraction
  - Protraction
    - Translation of bone away from midline in a plane parallel to the ground
  - Retraction
    - Translation of bone toward midline in a plane parallel to the ground

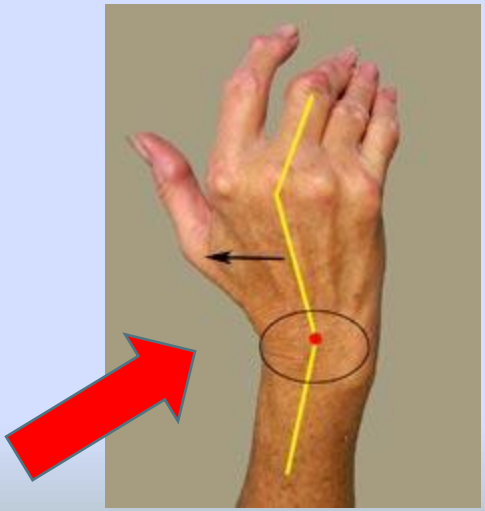


Osteokinematics: Fundamental Motions

- Horizontal ABD & ADD
  - Shoulder flexed to 90º
- Pronation & Supination
  - Takes place in the forearm with pronation turning the palm down and supination turning the palm up

Osteokinematics: Fundamental Motions

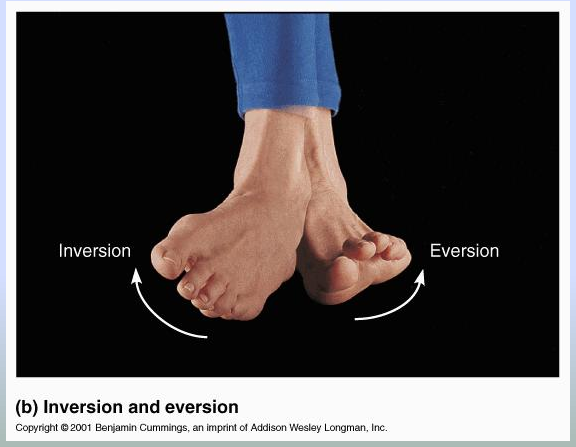
- Radial & Ulnar Deviation
  - Takes place at the wrist with movement toward either the radius or ulna



Osteokinematics: Fundamental Motions

- Dorsiflexion & Plantar Flexion
  - Takes place at the ankle with dorsiflexion bringing the foot upward and plantar flexion pushing the foot down

- Inversion & Eversion
  - The sole of the foot faces medially in inversion and laterally in eversion



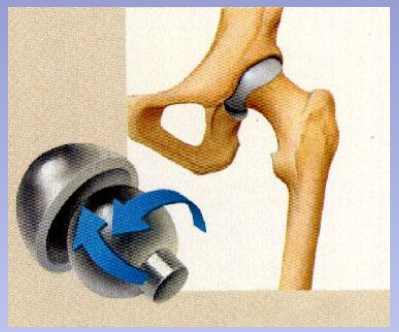
(b) Inversion and eversion

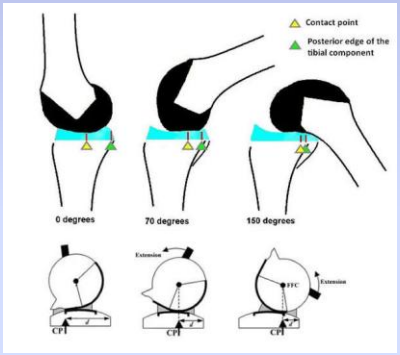
Mechanics

- Arthrokinematics
  - Manner in which adjoining joint surfaces move in relation to each other or how they fit together
    - helps to improve the movement of the joint
      - Parts may move in
        - the same direction
        - the opposite direction

Fundamental Movements: Joint Surfaces

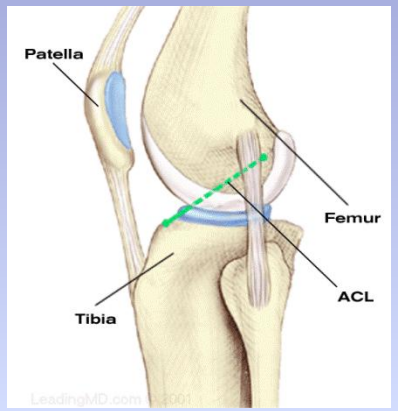
- Roll
  - Multiple points maintain contact throughout the motion
- Slide
  - A single point on one surface contacts multiple points throughout the motion
- Spin
  - A single point on one surface rotates on a single point on the other surface





Roll & Slide Mechanics

- Convex on Concave
  - When a convex joint surface moves on a concave joint surface
    - The roll and slide occur in opposite directions



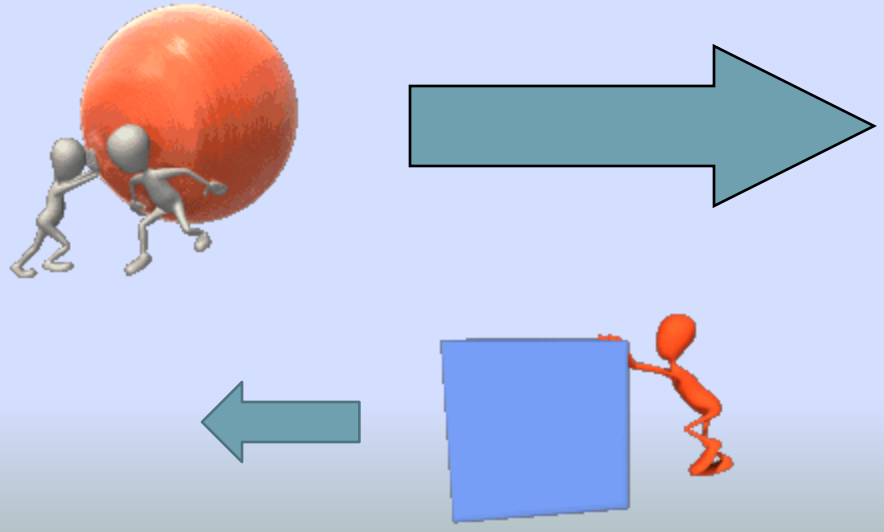
- Concave on Convex
  - When a concave joint surface moves about a stationary convex joint surface
    - the roll and slide occur in the same direction

Kinetics

- The effect of forces on the body
  - Force
    - Any action or influence that moves a body or influences the movement of a body
    - Forces "control" movement of the body
      - Internal
        - Muscle contraction
        - Tension from ligaments
        - Muscle lengthening
      - External
        - Gravity
        - An external load
        - A therapist applying resistance or a
        - free-weight for resistance training

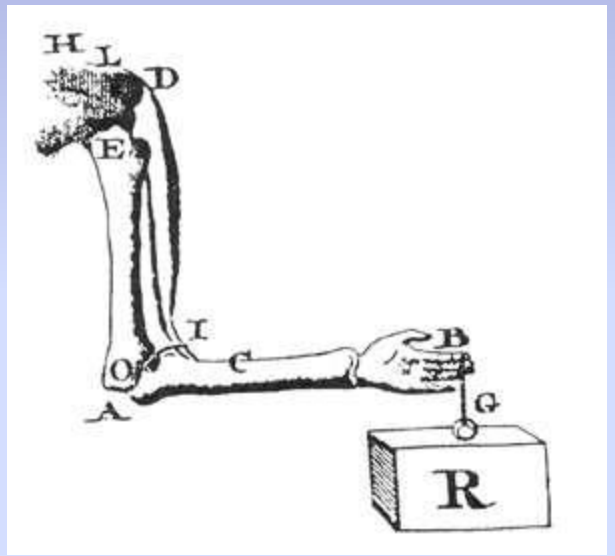
Mechanics

- Force
  - Any action or influence that moves an object
- Vector
  - A quantity having both force and direction



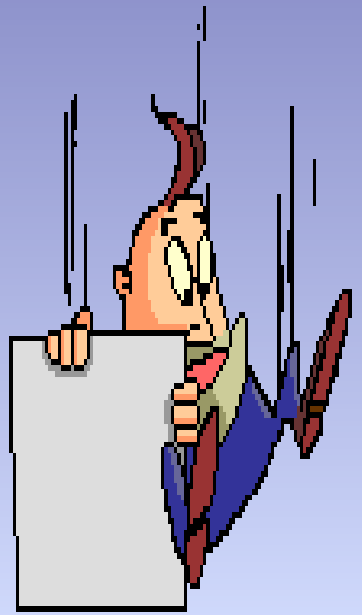
Kinetics

- Torque
  - The rotational equivalent of force
    - Force = Distance between the force exerted and the axis of rotation (moment arm)
    - Torque = moment arm x force (resistance)



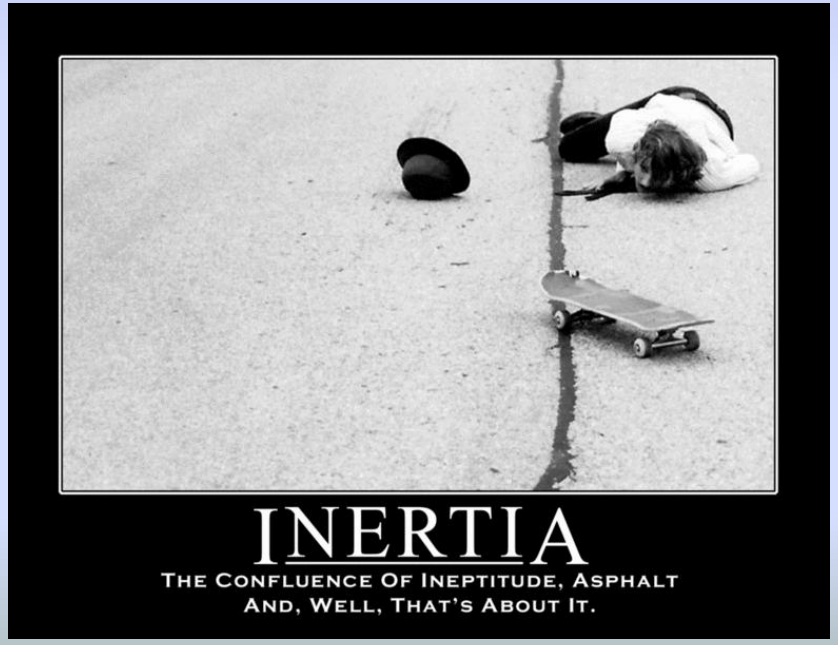
Mechanics

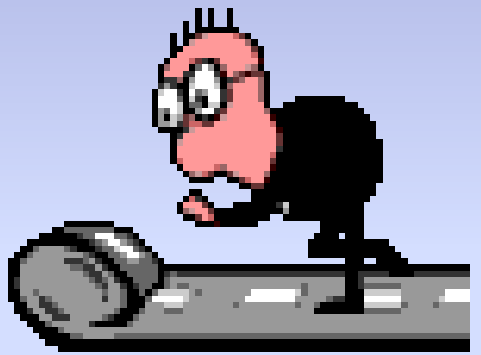
- Mass
  - Amount of matter that a body contains
- Inertia
  - Property of matter that causes it to resist any change of its motion in either speed or direction



Mechanics

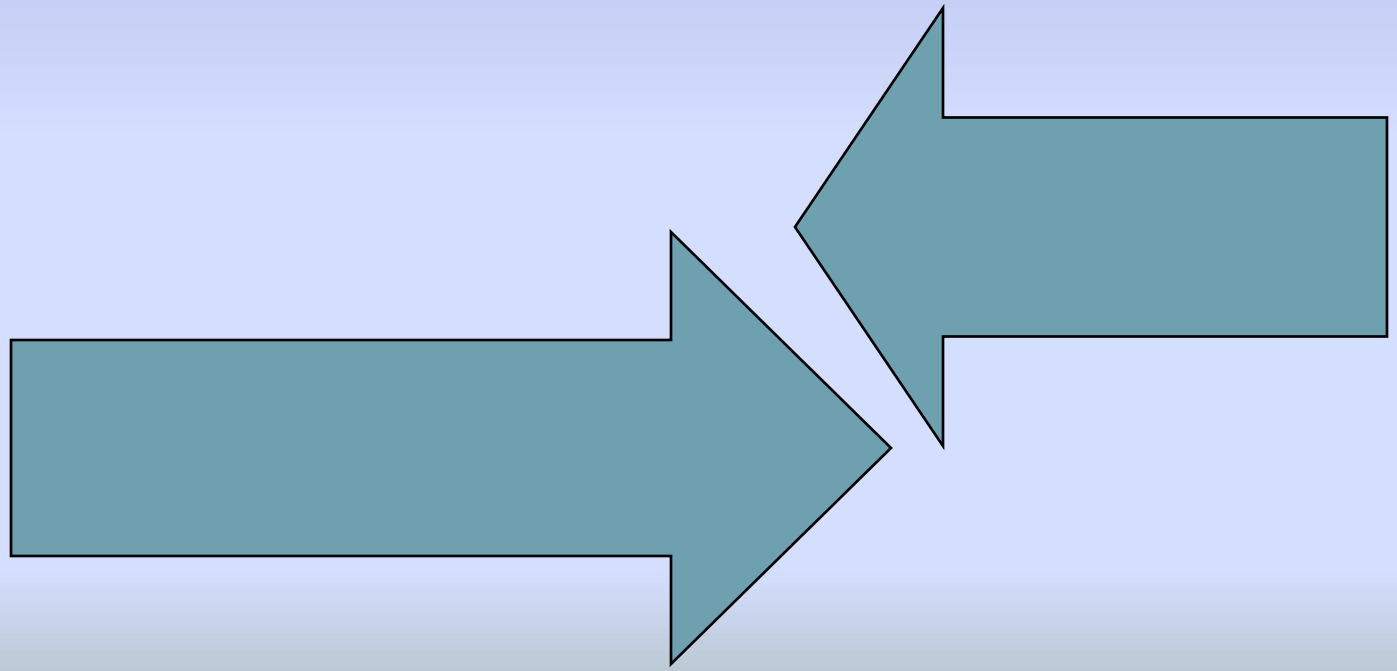
- Mass is a measure of inertia
  - Resistance to a change in motion





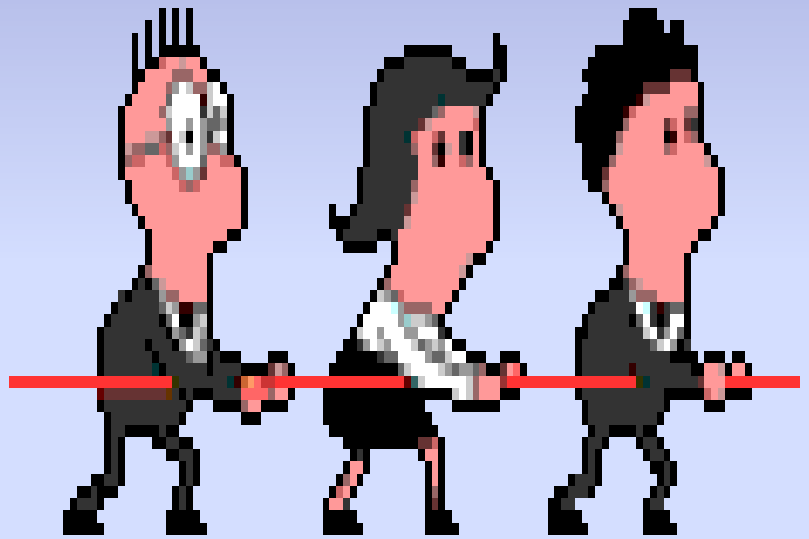
Friction

- A force that is developed by two surfaces



Friction

- Tends to prevent motion of one surface across the other
  - The coefficient of friction must be overcome for movement to occur



Friction

- It is easier to move across something once the coefficient of friction has been met.

Mechanical Advantage

- Ratio between the
  - force arm
    - Distance between the force and the axis
- and the
  - resistance arm
    - Distance between the resistance and the axis

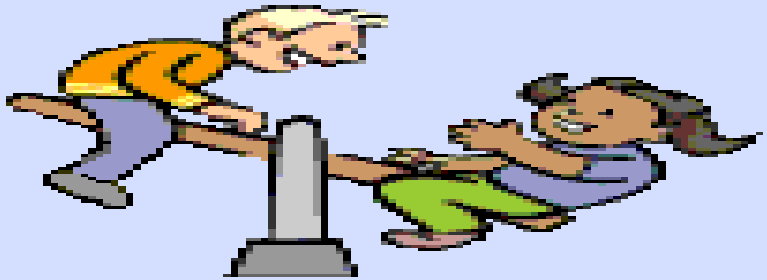
Resistance arm

Force arm

Mechanical Advantage (MA)

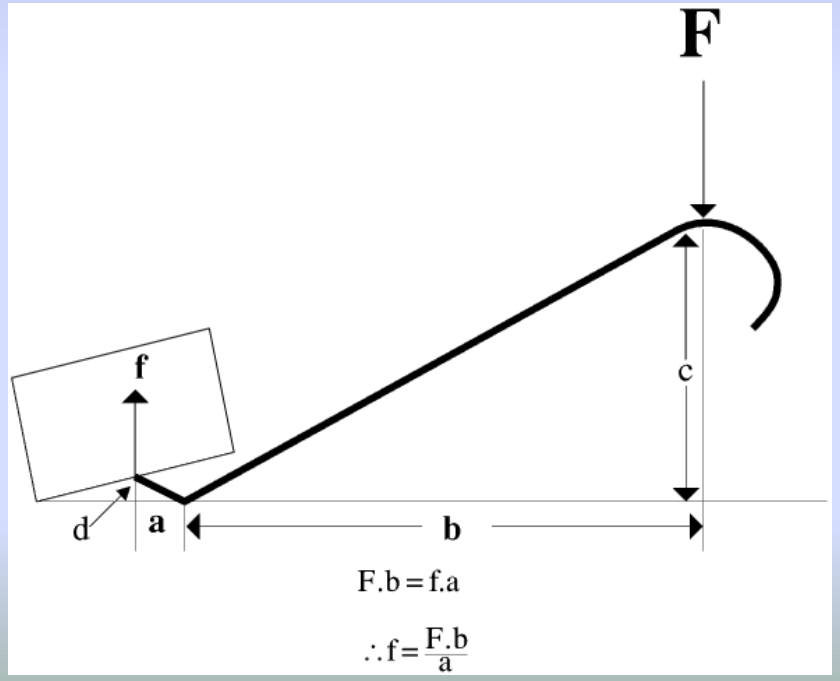
- To determine
  - Length of force arm
  - Length of resistance arm

$$\frac{\text{Length of force arm}}{\text{Length of resistance arm}} = \text{MA}$$



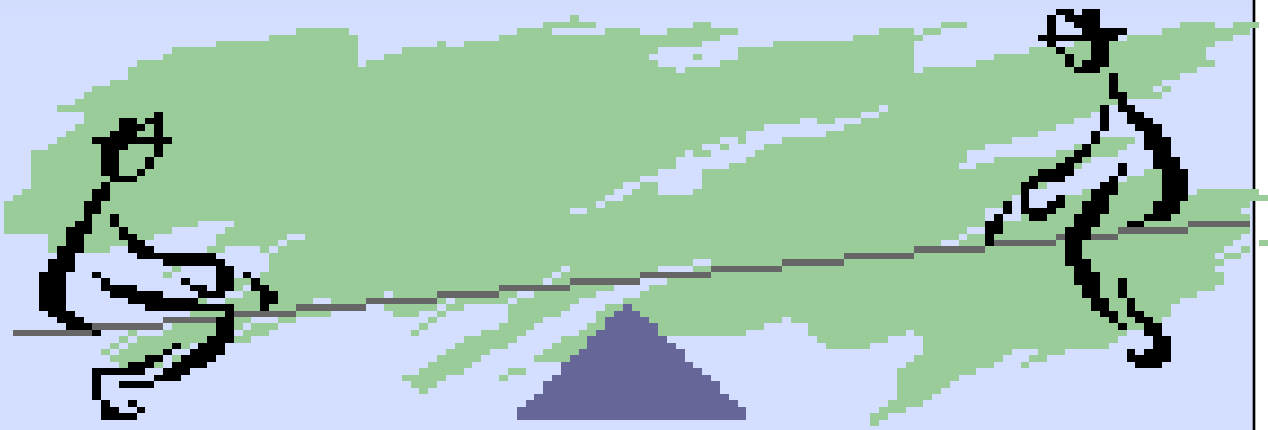
Mechanical Advantage (MA)

- When the FA is greater than the RA
  - The MA is greater than 1
  - The force arm has more force than the RA



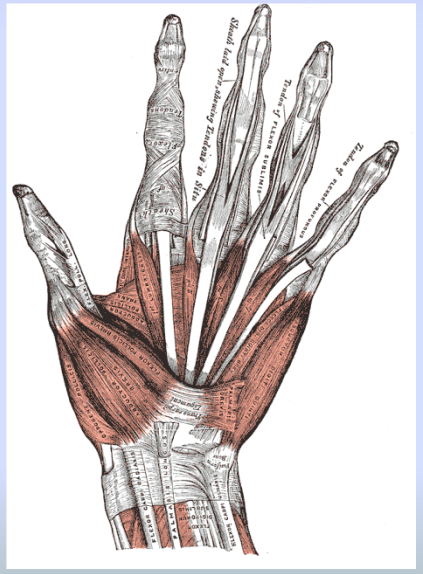
Mechanical Advantage

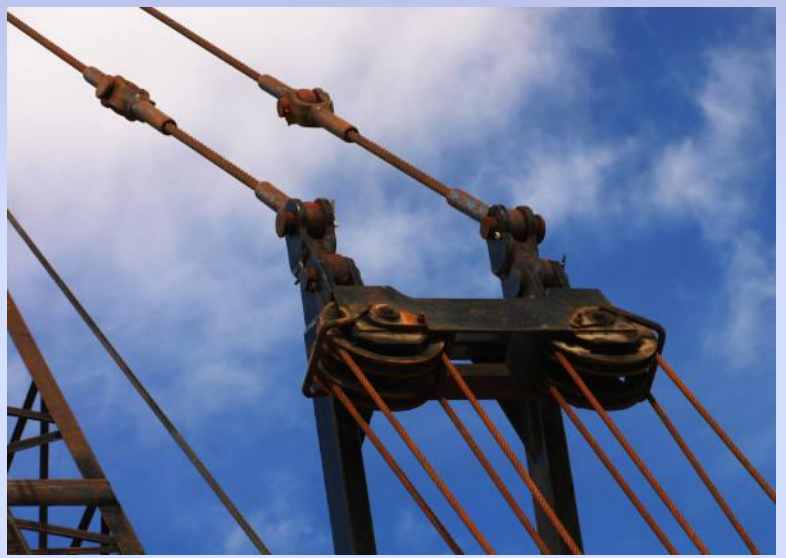
- It takes less force on your part if you apply resistance distally rather than proximally.



Pulleys

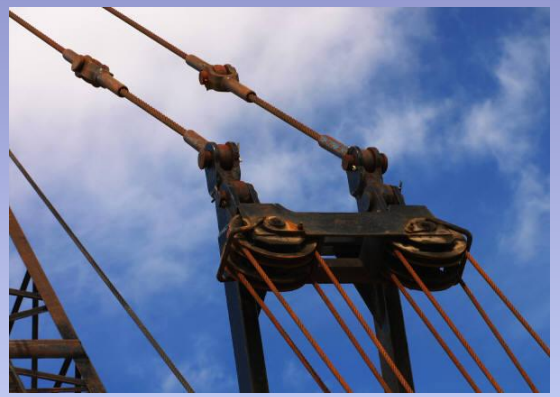
- A Pulley
  - A grooved wheel that turns on an axel with a rope or cable riding in the groove

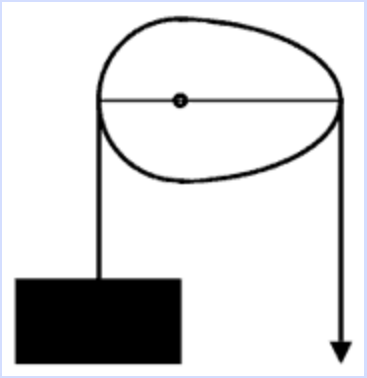




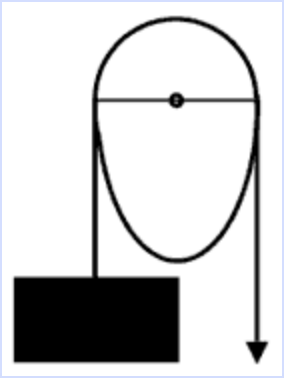
Pulley

- Function
  - To change the direction of a force
  - To increase or decrease the magnitude of a force

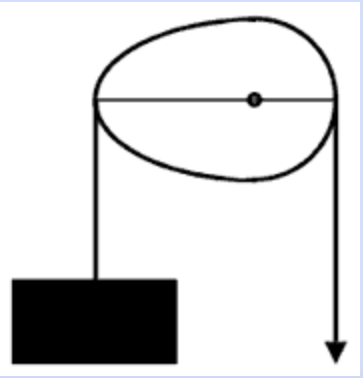




Light Cam



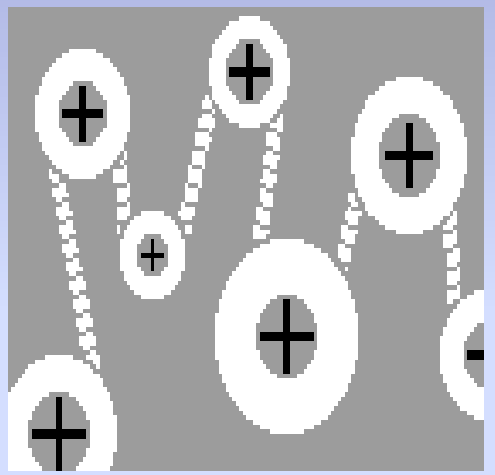
Neutral Cam

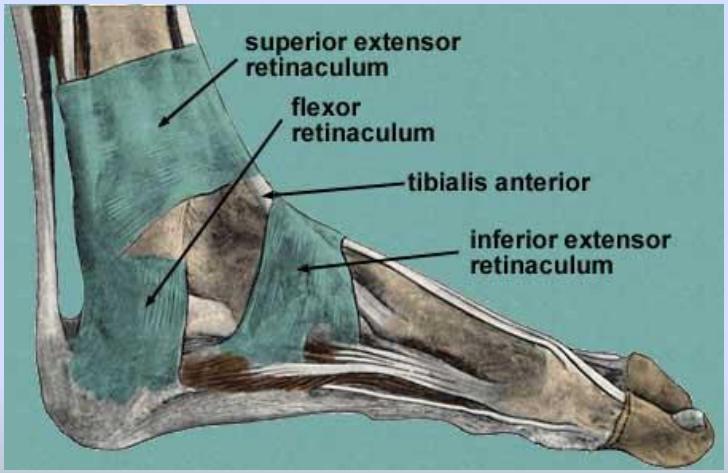


Heavy Cam

Pulley

- Function
  - To increase or decrease the magnitude of a force
    - The load is supported on both segments on either side of the pulley, decreasing effort

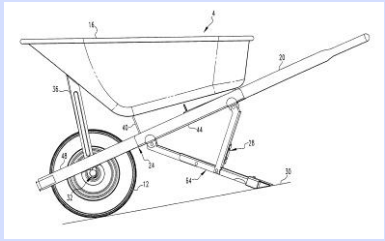




Biomechanical Levers

- Interaction of internal and external forces control movement and posture through a system of levers within the body.
- The body has Three Classes of Levers
  - First
    - Similar to a "see saw"

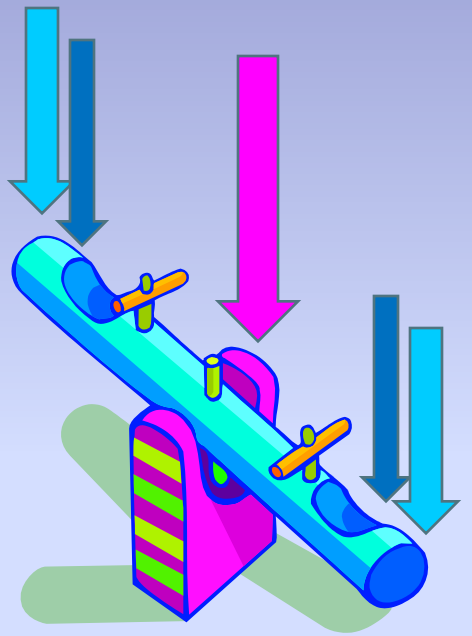
  - Second
    - The axis is located at one end to provide "good leverage"

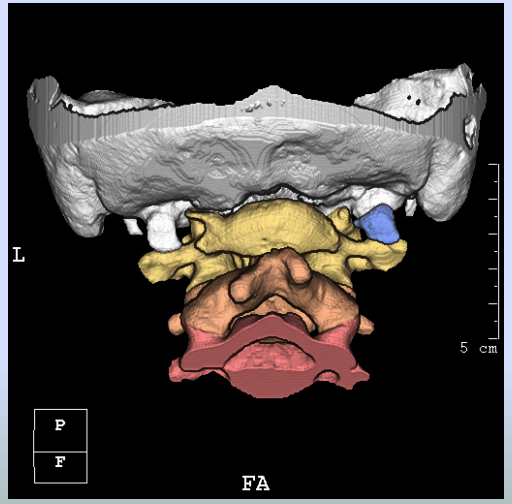


  - Third
    - The axis is also at one end but gravity has more "leverage" than muscle meaning that more muscle force is needed to lift a small load

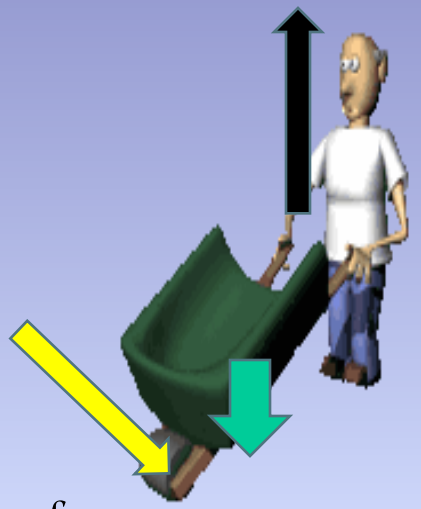
Biomechanical Levers

- First Class Lever
  - F - A – R
    - Force, Axis, Resistance
  - Designed for balance
    - The head sitting on the cervical vertebrae

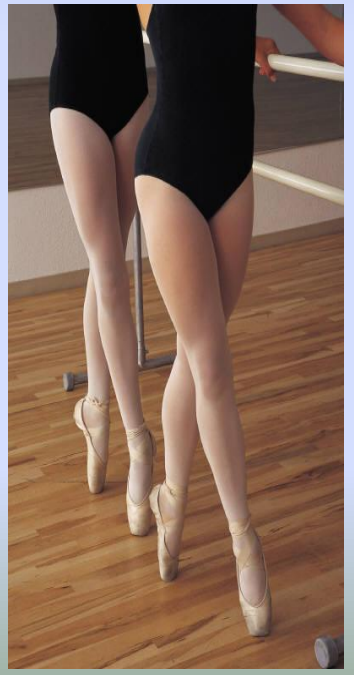




Biomechanical Levers

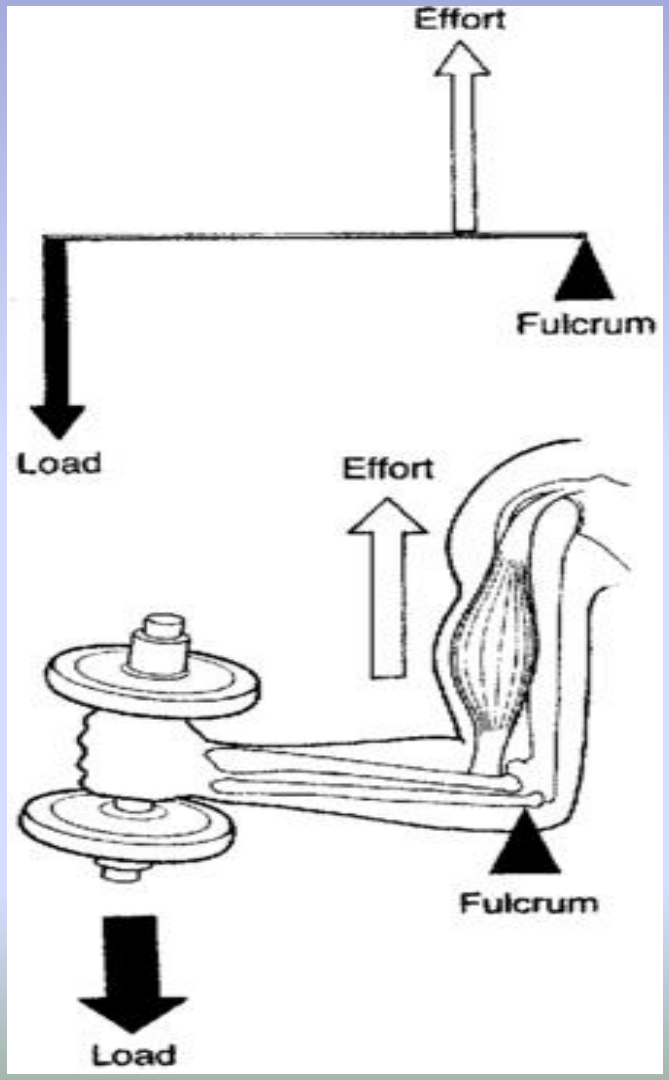


- Second Class Lever
  - A – R – F
    - Designed for power
      - Ankle plantar flexors are the perfect example of a second class lever.
      - There is excellent leverage so that the body is easily elevated with relatively little force generated by the plantar flexors of the calf.



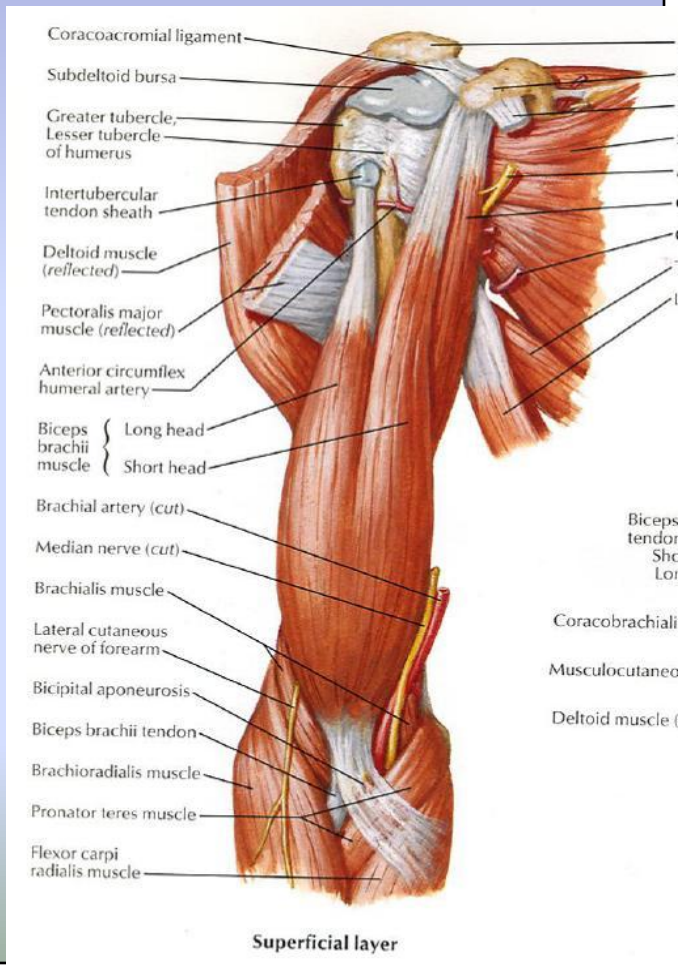
Biomechanical Levers

- Third Class lever
  - **A – F – R**
    - Designed for motion
      - The most common lever in the body because they favor large ranges of motion
      - Favor speed and distance



Line of Pull

- A muscle's line of pull describes the direction of muscular force which can be represented in a vector. (*the motions that are possible)*
- Before a muscle can act upon a joint, it must first cross that joint.
- If a muscle crosses a joint, it acts on that joint.



Kinesiology: Form & Function