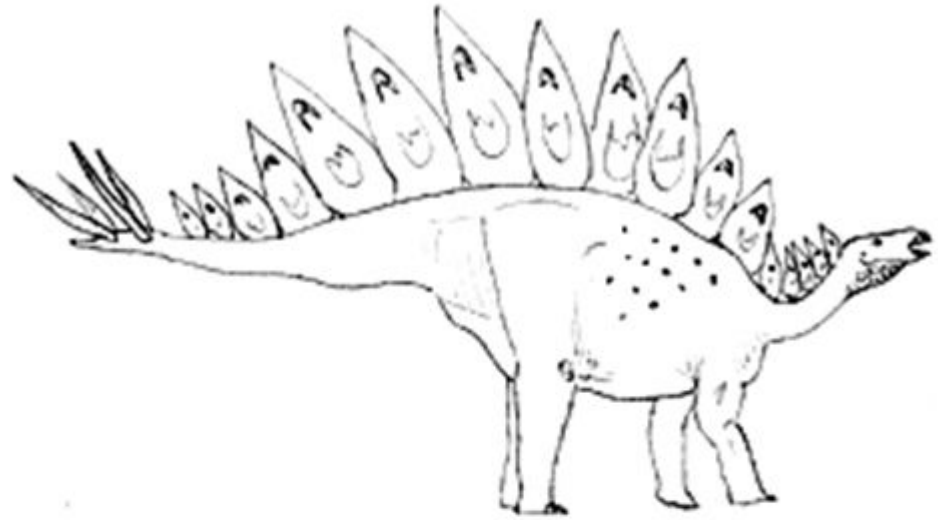
An introduction to Biomechanics and Sports Physiology

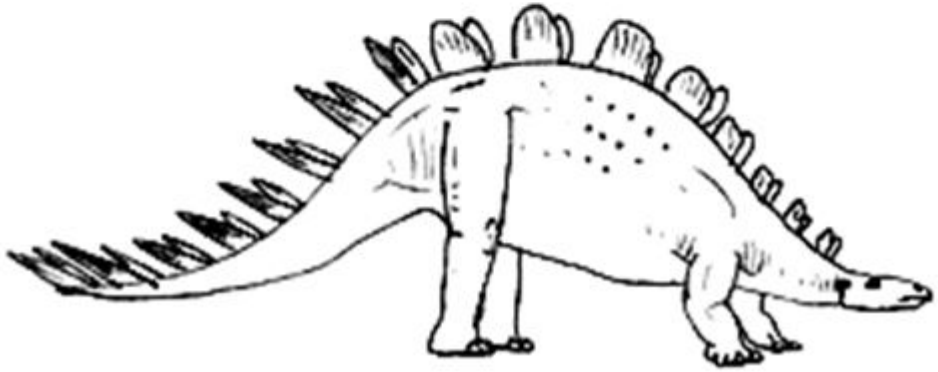
Lecture 1 – The Mechanics in Biomechanics

Outline

- Mechanics and its application to biological systems
- Forms of motion
- Levers
- Balance and center of gravity

How Did It Walk?





Mallison, H. (2010). CAD assessment of the posture and range of motion of Kentrosaurus aethiopicus Henning 1915 *Swiss Journal of Geosciences, 103*, 211-233
http://scienceblogs.com/tetrapodzoology/2011/01/05/heinrichs-digital-kentrosaurus/

How Did It Walk?

Mechanics and Biomechanics

- Mechanics: science that deals with physical energy and forces and their effect on objects
- ***Biomechanics*** - study of the mechanics as it relates to the functional and anatomical analysis of biological systems and especially humans

Performance

Medicine

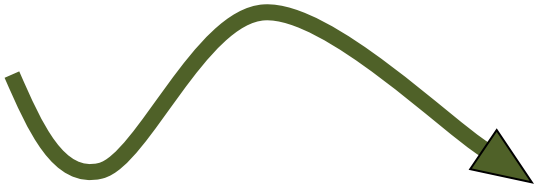
Recovery

Forms of Motion

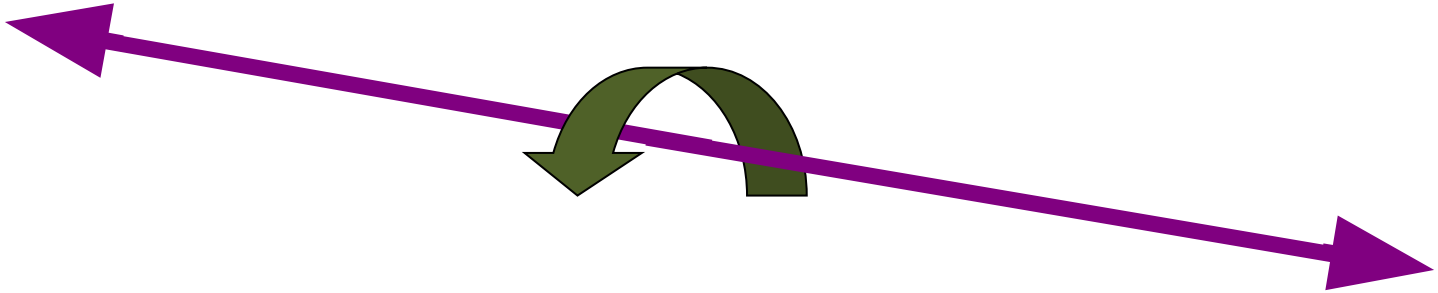
Linear motion: motion along a line

- **Rectilinear** motion: (along a straight line)

- **Curvilinear** motion: (along a curved line)



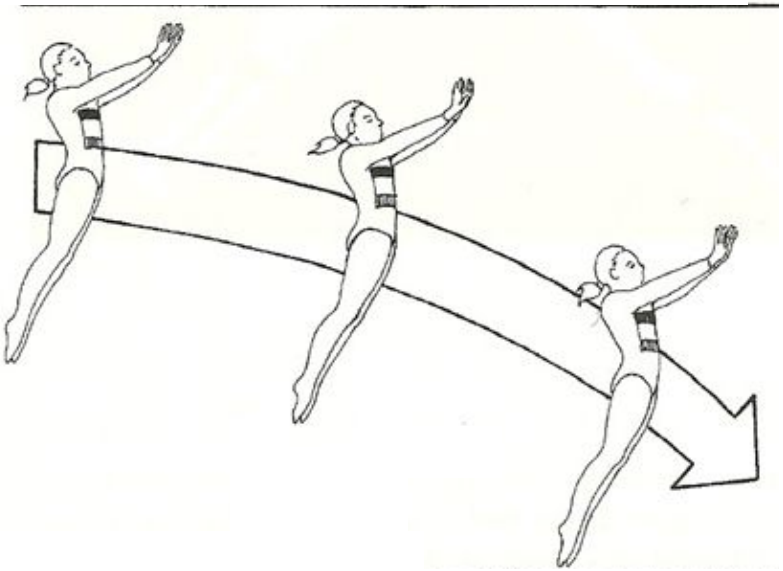
Angular motion: rotation around an axis



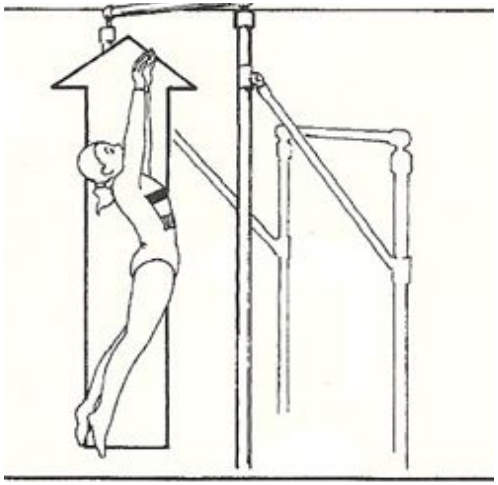
Forms of Motion

Angular motion

Curvilinear motion

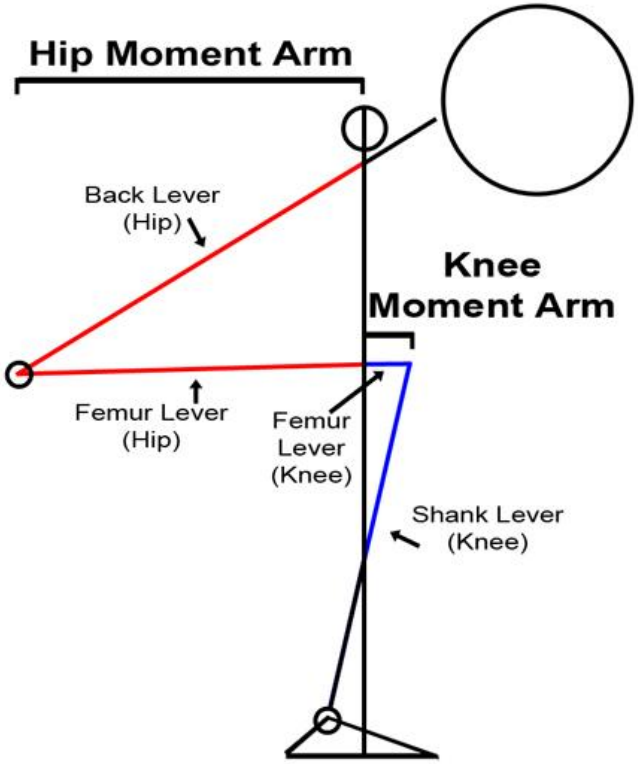


Rectilinear motion



Levers

- Humans move using a system of levers
  - lever is a rigid bar that turns about an *axis* of rotation or a fulcrum
  - axis is the point of rotation about which lever moves
  - levers can be utilized more or less efficiently



Levers

- Levers rotate when a *force* (effort, *E)* is being applied against a *resistance* or weight
- In the body
  - bones are the bars
  - joints are the axes
  - muscles contract to apply force
  - weights or external loads are the resistance

Why Use Levers?

Levers perform two main functions:

To ***increase the resistance*** (or load) that can be moved with a given effort e.g. a crowbar.

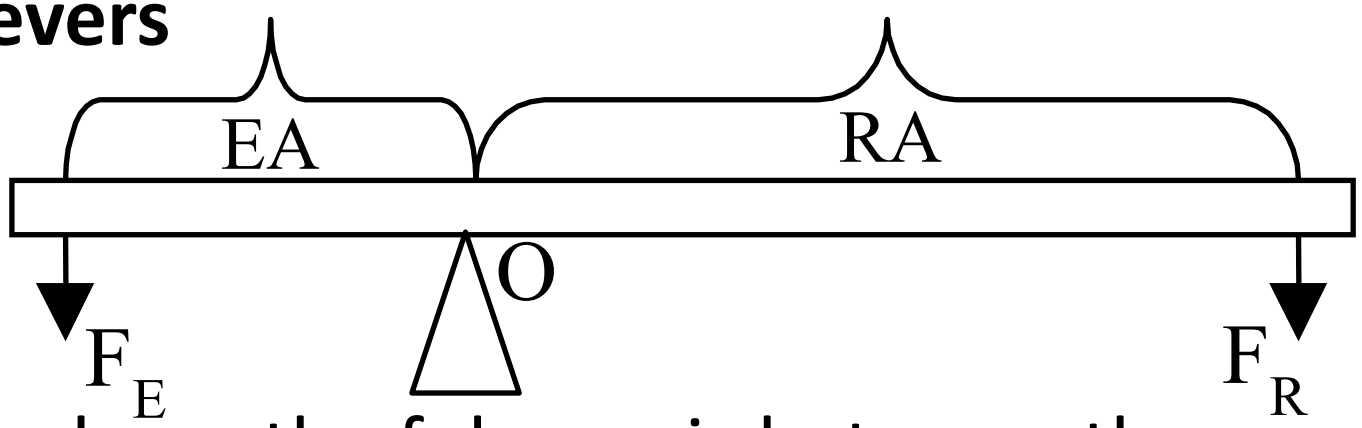
To ***increase the velocity*** at which an object will move with a given force. e.g. a golf club.

Levers

- Three possible orientations of the fulcrum, force and resistance determine the types of lever
- Axis *(O)*- fulcrum - the point of rotation
  - Applied force F_E (usually muscle contraction)
  - Resistance force F_R (can be weight or/and external loads)

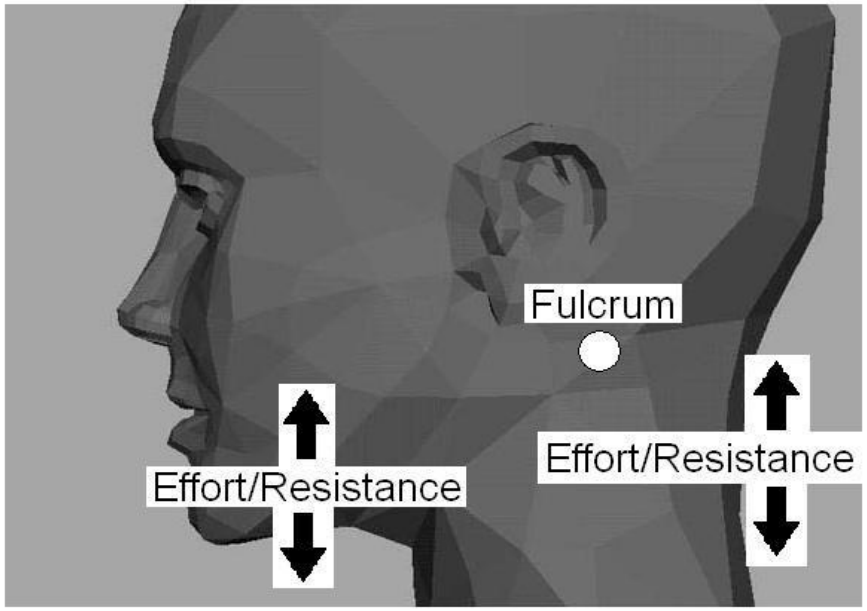
The First Class of Levers

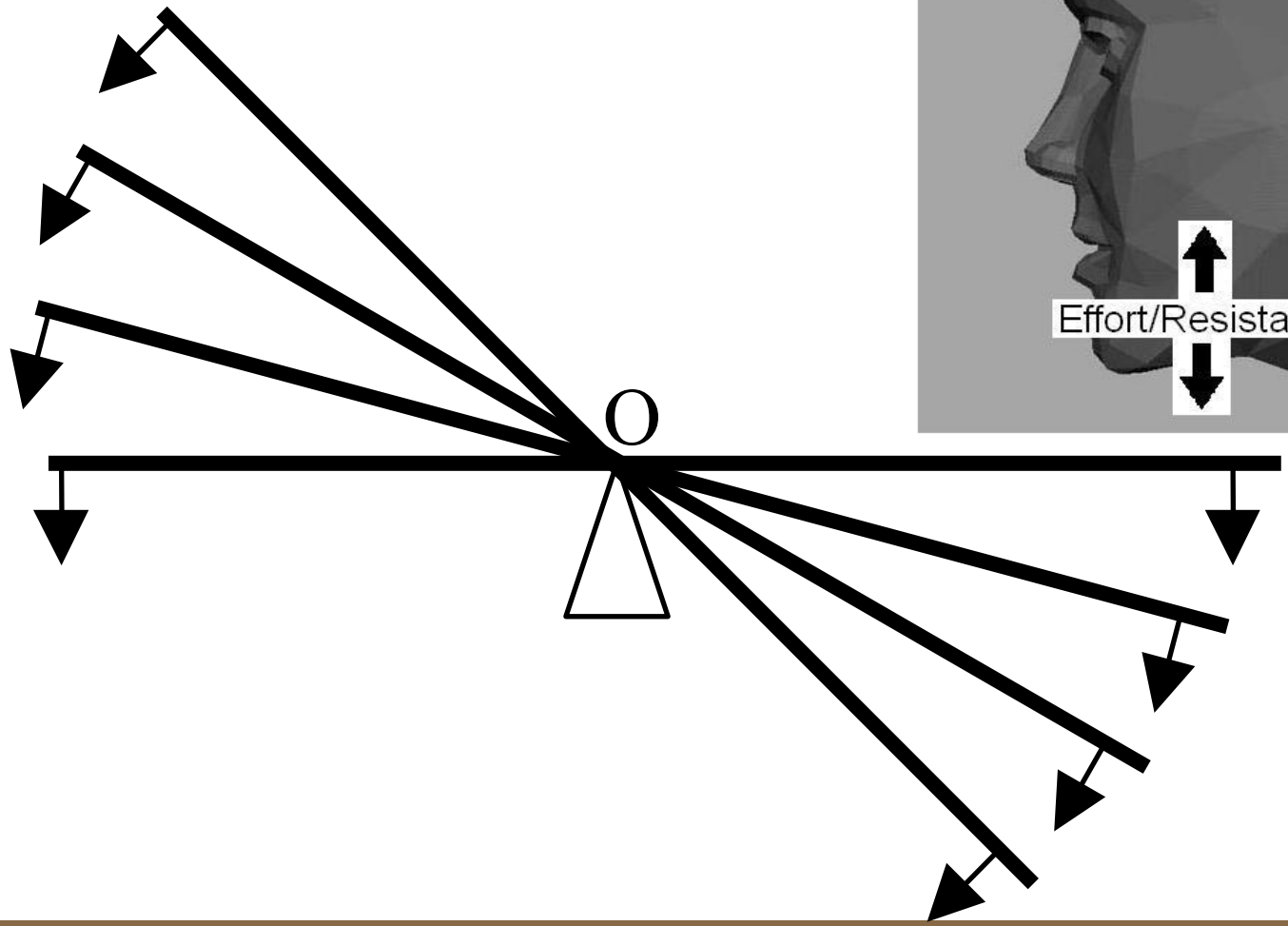
- **First class Levers**



- In a first class lever the fulcrum is between the effort and the resistance.
- This type of lever can increase the effects of the effort and the speed of a body. Also good for keeping balance.

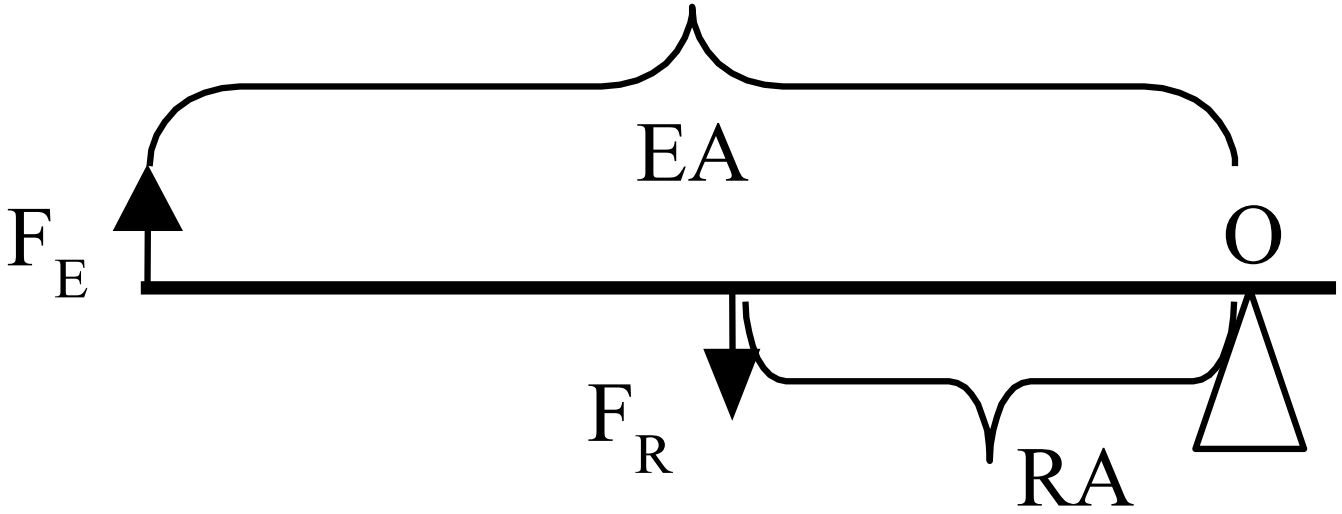
First Class Lever





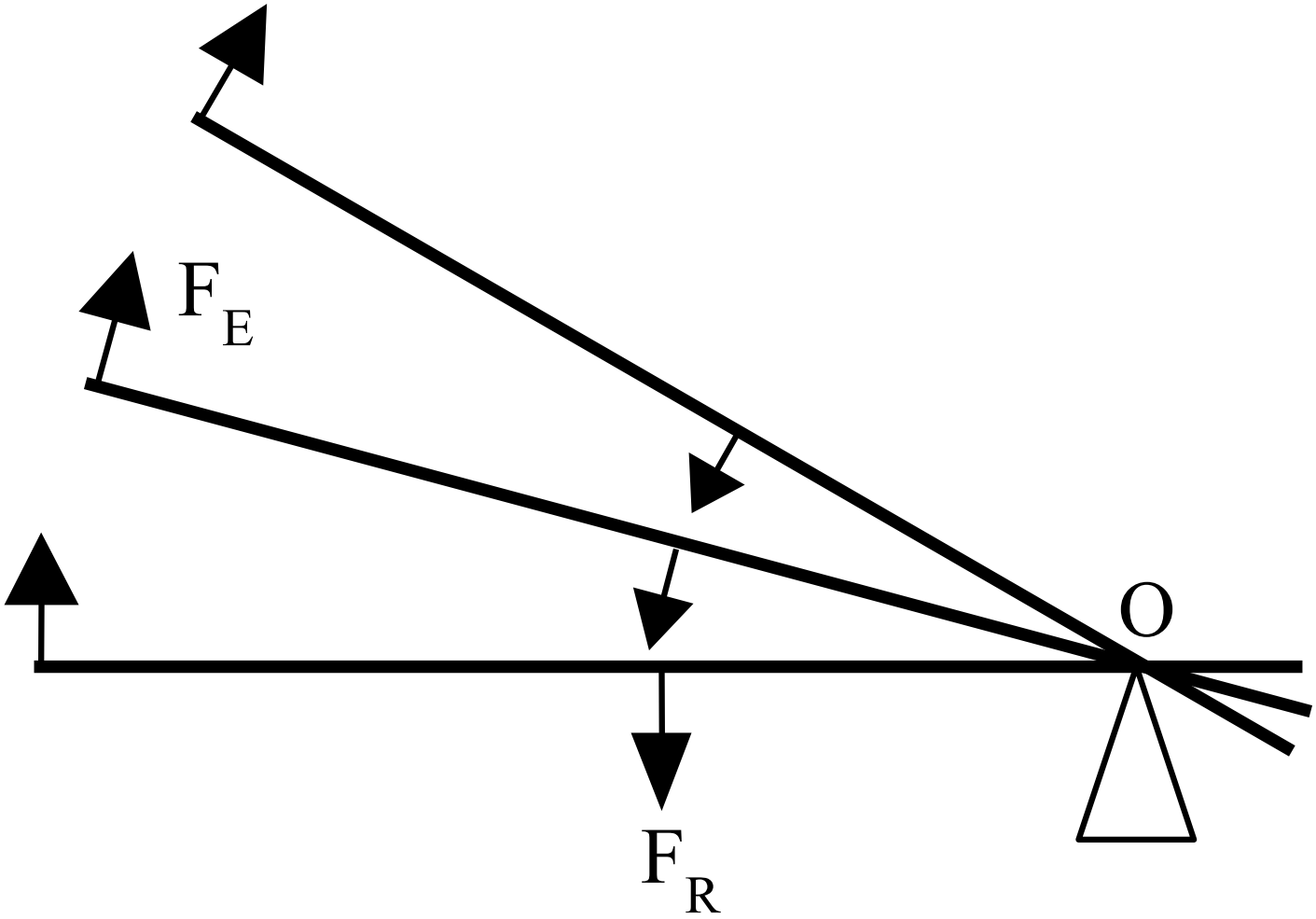
The Second Class of Levers

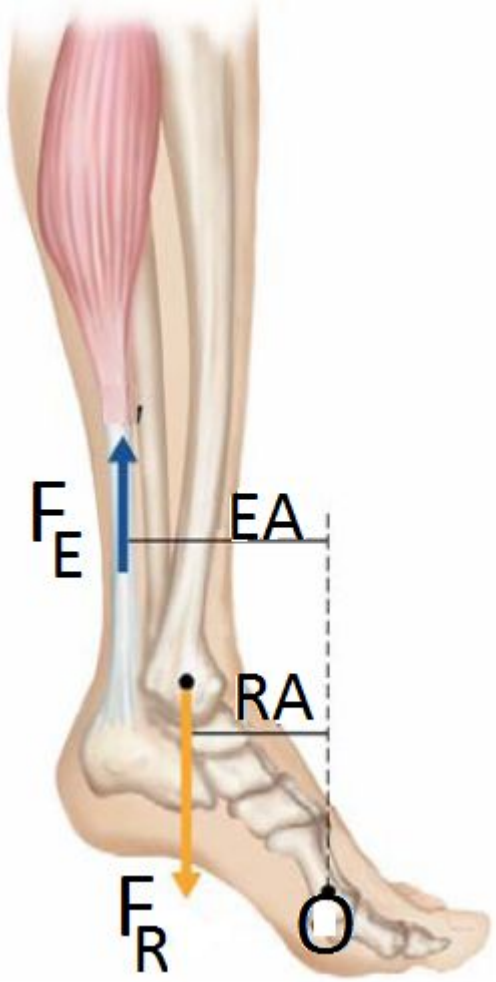
- **Second class levers**



- Here the resistance is between the fulcrum and the effort.
- This type of lever is generally thought to increase only the effect of the effort force.

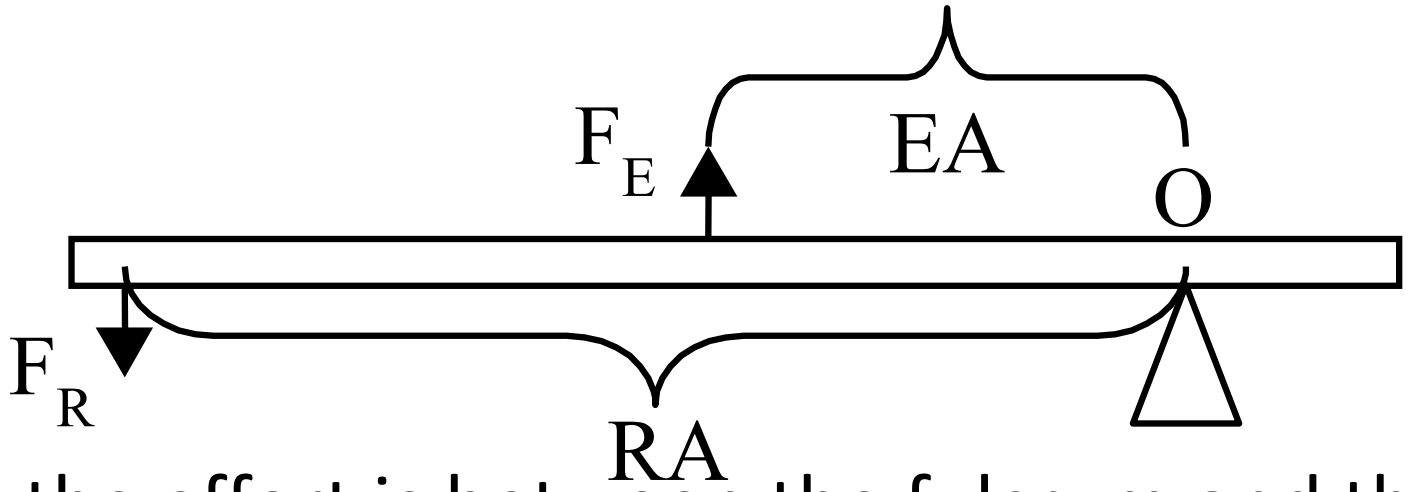
Second Class Lever





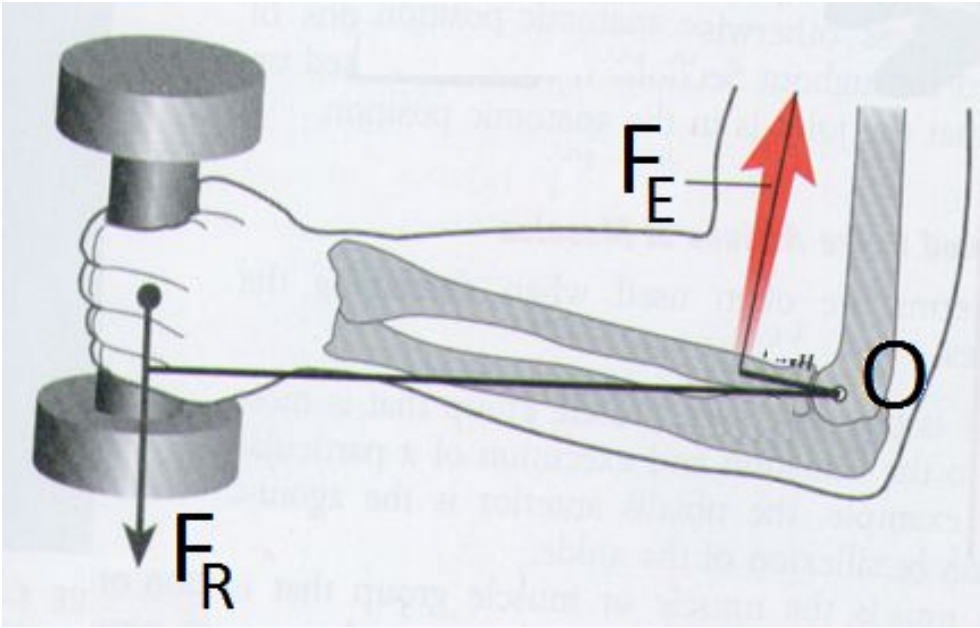
The Third Class of Levers

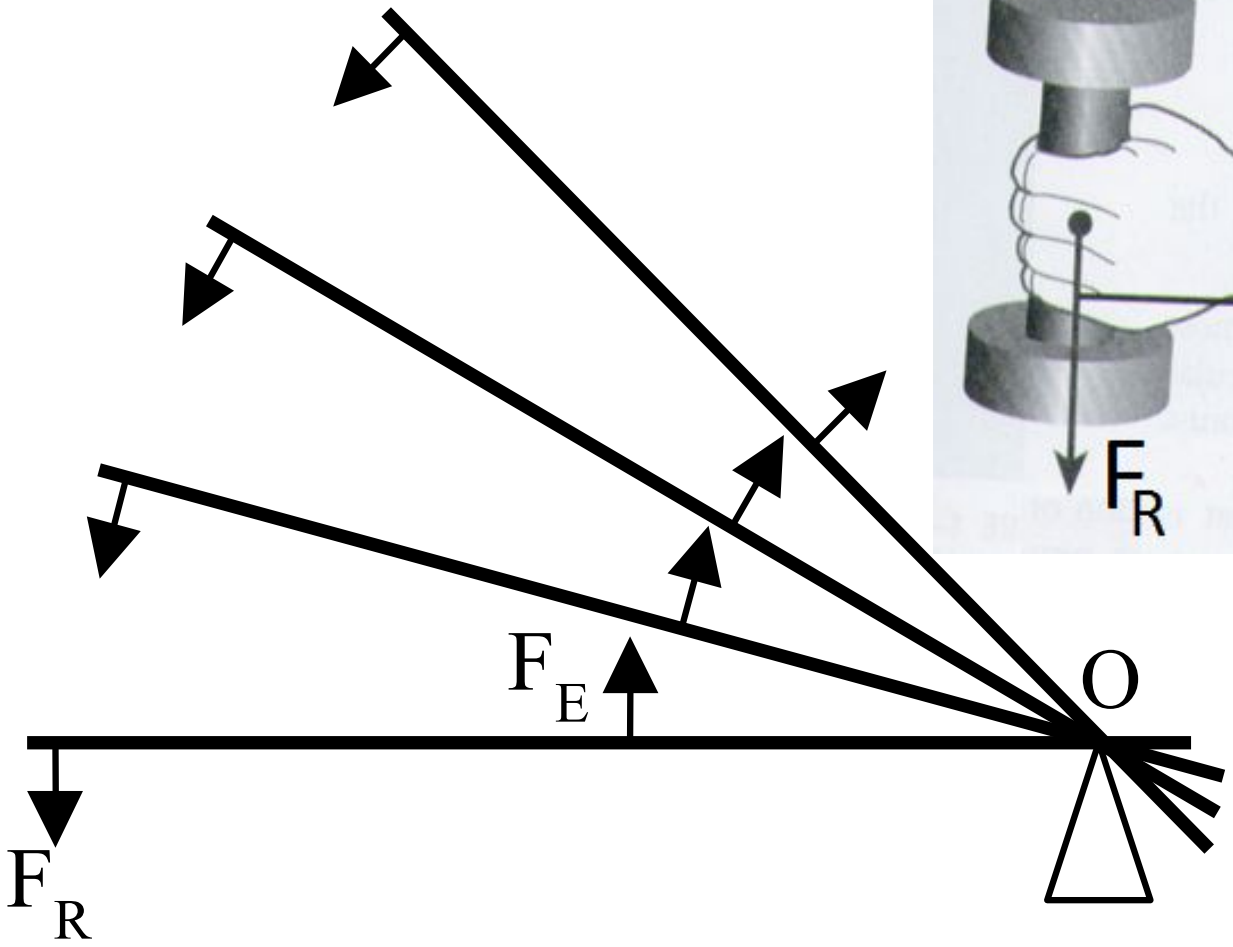
- **Third class Levers**



- Here the effort is between the fulcrum and the resistance and can be seen in the.
- They can increase the body's ability to move quickly but in terms of applying force they are very inefficient.

Third Class Lever





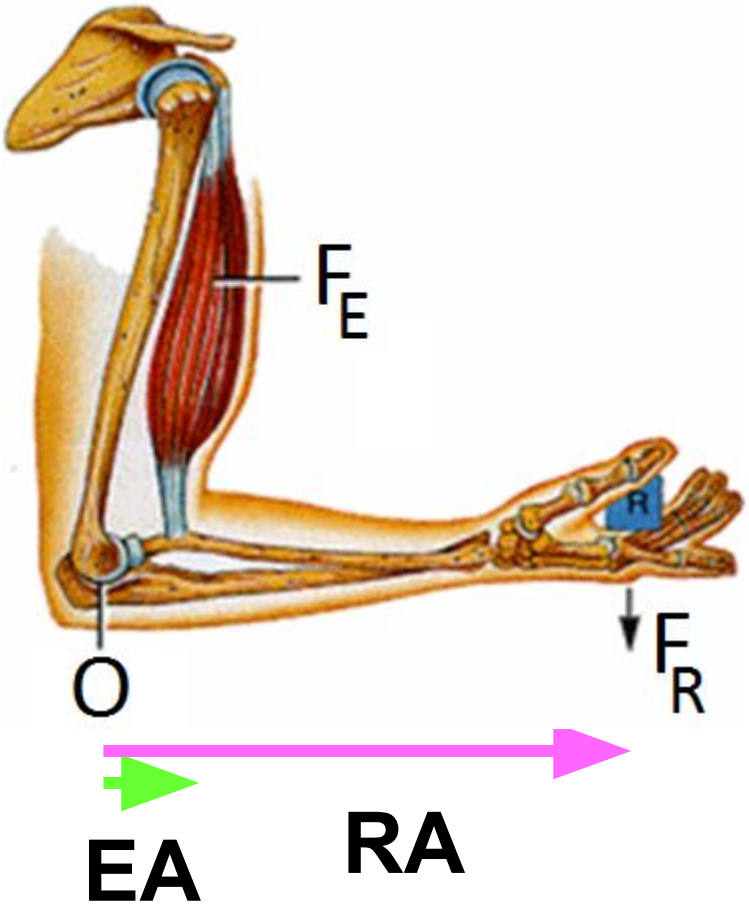
Human Body Levers

- Human's levers are mostly built for speed and range of movement at expense of force
- Thus, short force arms and long resistance arms require great muscular strength for movement
- Examples: biceps and triceps attachments
  - biceps force arm is 1 to 2 inches (1inch=2.54cm)
  - triceps force arm is less than 1 inch

Example

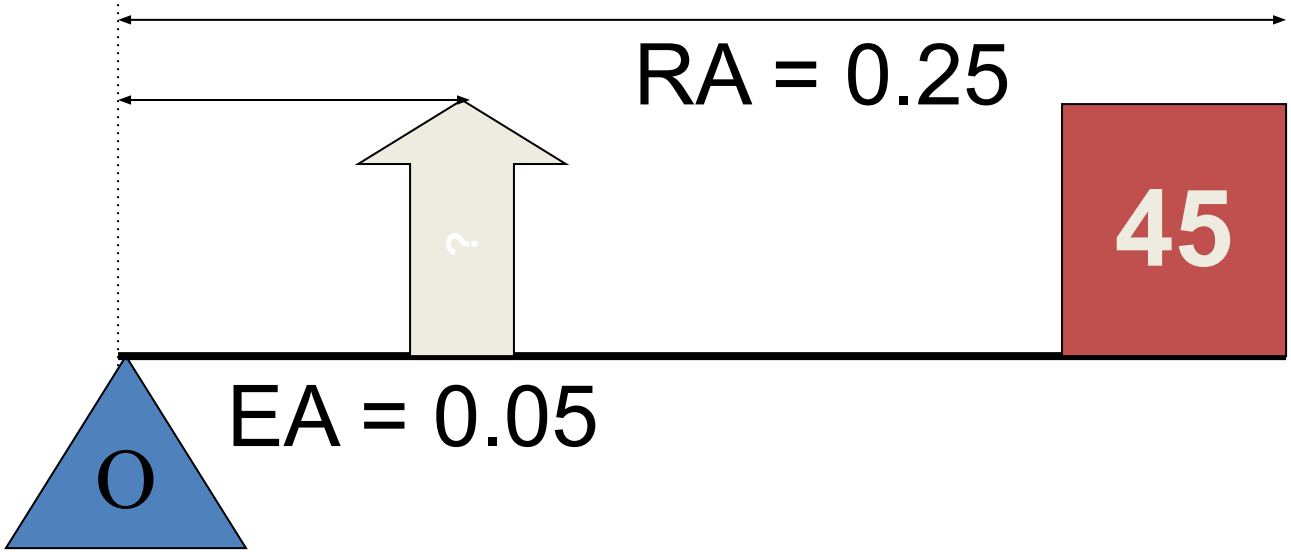
1. How much force (in kg) needs to be applied to move 45 kg when the RA is 0.25 m and the EA is 0.05 meters?

- Use the formula
  - **F_E x EA = F_R x RA**
- Note: kgs are not units of force, but sometimes force is divided by g(9.8m/s^2) and expressed in kilograms.



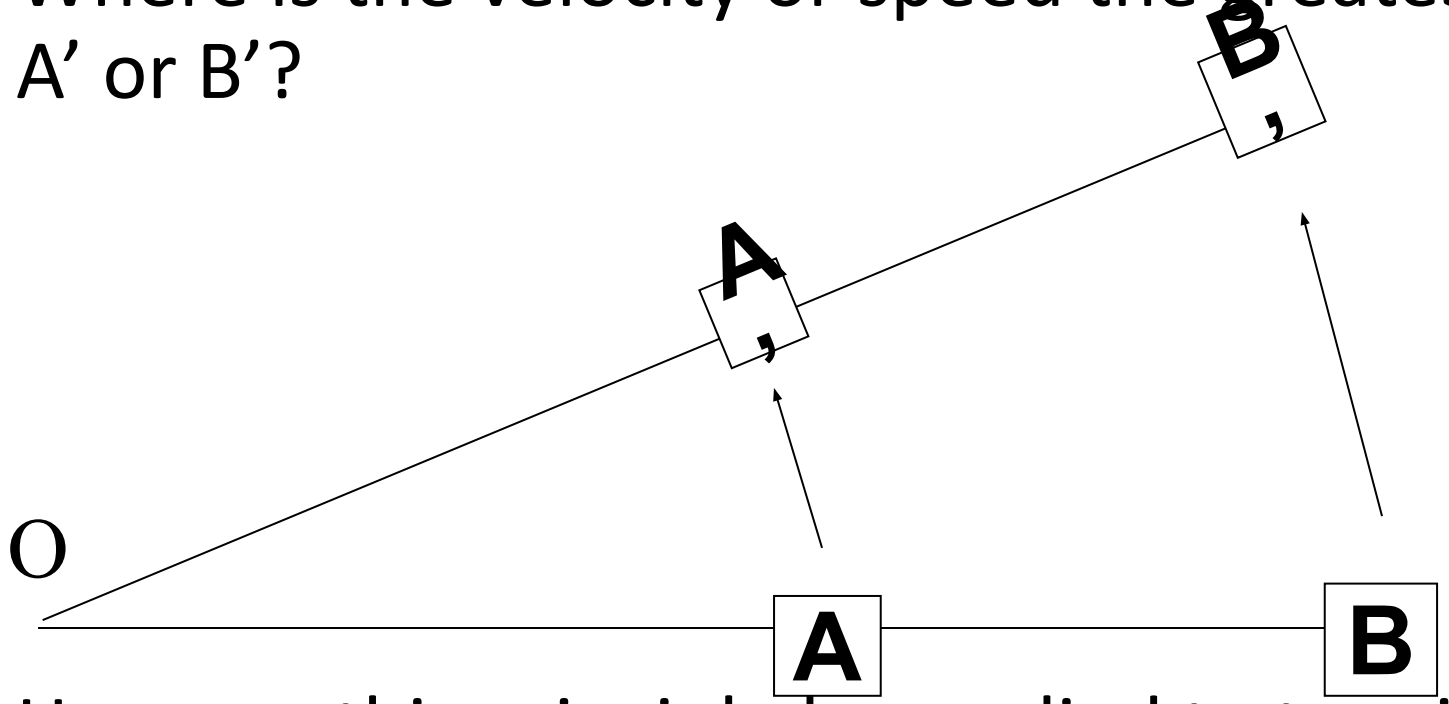
Example

- F_E x 0.05 meters = 45 kg x 0.25 meters
- F_E x 0.05 = 11.25 kg
- F_E = 225 Kg



Lever Length

- Where is the velocity or speed the greatest; at A' or B'?



- How can this principle be applied to tennis?

Lever Length

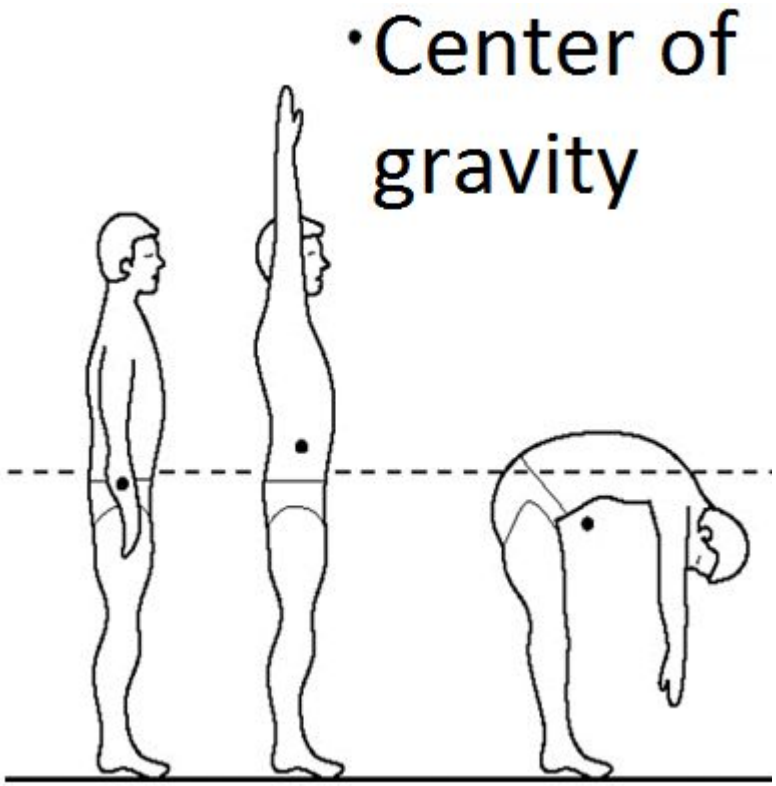
- A longer lever increases the speed at the end of the racquet unless the extra weight is too great. Then the speed may actually be slower.

Stability

- **Center of gravity (CG):** Point at which all parts of a body are equally balanced
- **Base of support (BOS):** Area within an object's point of contact with the ground
- **Line of gravity (LOG):** Direct line from the center of gravity to the ground

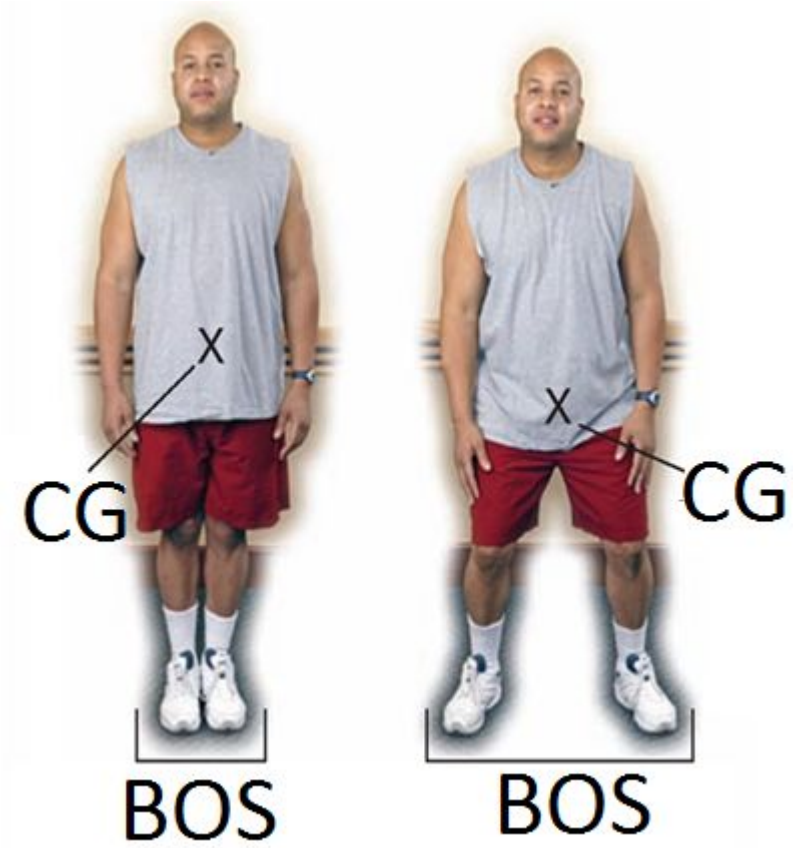
Center of Gravity

- The center of gravity can be shifted by stretching, bending, changing position
- The center of gravity can be outside of the body
- Low center of gravity is typical for more stable positions



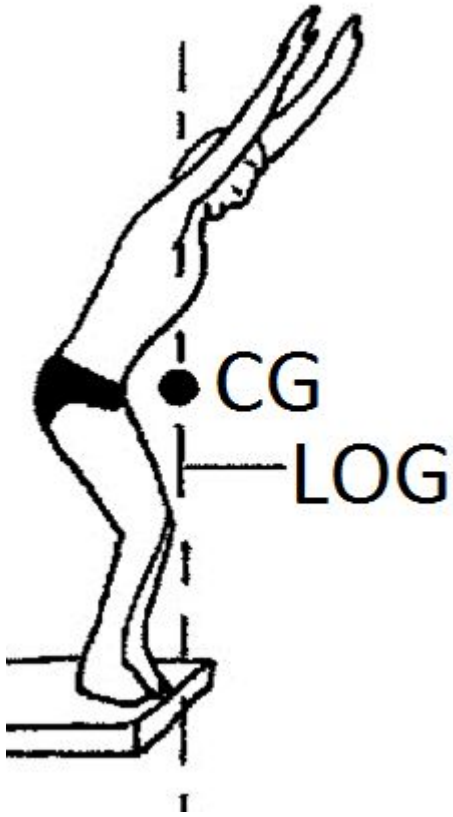
Base of support

- The BOS area can be changed
- Larger BOS area is typical for more stable positions
- In humans, wide BOS is usually accompanied by low CG



Line of Gravity

- The line of gravity is always vertical
- The LOG must outside the base of support to initiate or continue movement
- The further away the LOG from the BOS, the greater the tendency to move in that direction



Stability

low wide within

stable

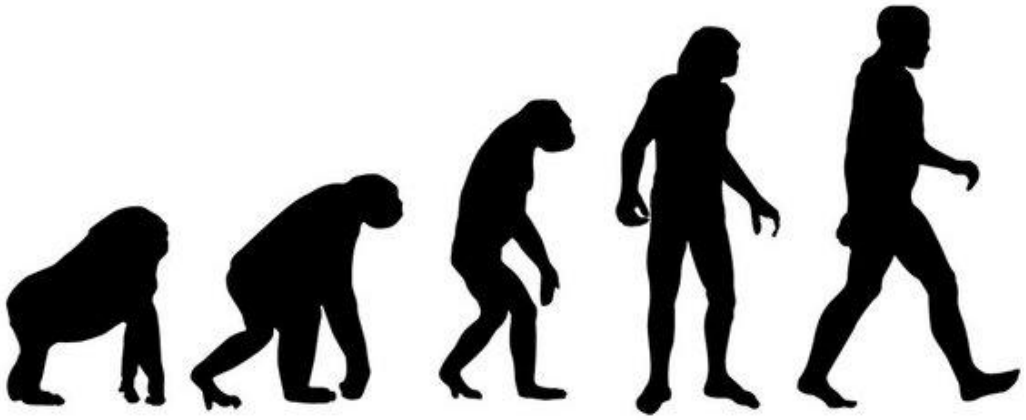
gravity support

Someone is more _____when they have a _____centre of _____, a _____ base of _____ and a line of gravity that falls _____the body.

Advantages/Disadvantages to Bipedal Locomotion

What about strength? Animals vs humans?

- Disadvantages
  - Loss of speed
  - Loss of agility
  - Loss of stability
- Advantages
  - Carry food
  - Carry tools
  - Increased ability to nurture/protect offspring

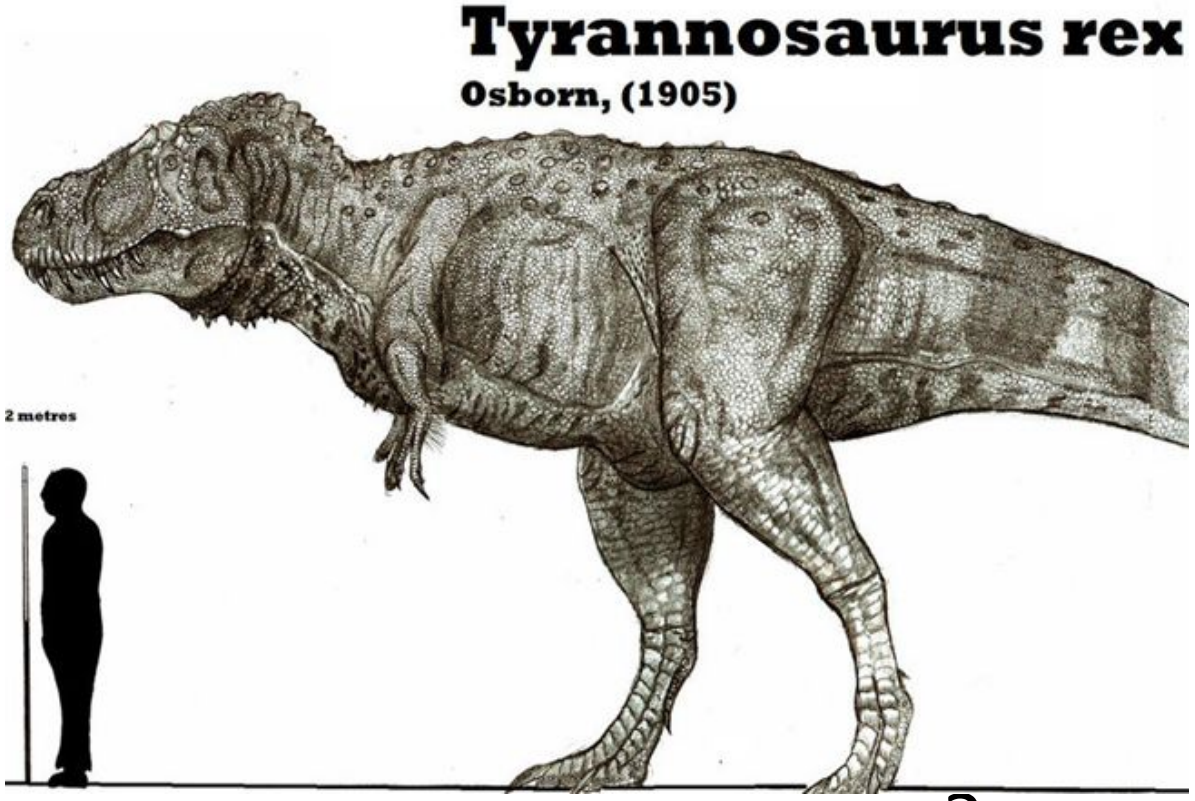


Interesting Fact: T Rex Arms

How much could T Rex lift with its arm?

(50x6=300lbs

≈136kg)



?

(160-200kg)

Open Question

- Do artificial legs provide an unfair advantage?
- If yes, how?
- If no, why?

Summary

- Mechanics and its application to biological systems
- Scope of biomechanics
- Types of motion
- Levers in human body
- Stability and center of gravity

For The Seminar

Please, make sure your understand how levers work

Refresh your problem solving skills in statics

Make sure you are familiar with different muscle types