CENTER OF MASS
(CENTER OF GRAVITY)

• When gravity acts on a body, every particle of which it is composed is attracted toward the earth. The resultant force is the body's weight.
• Through what point does the resultant force act?
• Center of gravity (CG)
  [also called Center of mass (CM)]
  – CG: Theoretical point at which all of a body's weight is considered to be concentrated; point about which a body will balance.

• NOTE: It is not necessarily the point about which there are equal amounts of mass or weight. Rather, it is the location about which there are equal and opposing moments or torques.
• Consider: pencil balancing on your finger; where's the CG?
• Seesaw?
• CG location is dependent on weight distribution of body.
• Consider: Human Body
  – Is the CG of the human body always in the same location in the body?

• In the *anatomical position* - CG near the waist...expressed as % body height:
  – Males: 54-57% - Females: 53-56%
• Does CG have to be within the physical limits of a body (i.e., where mass is located)?
  • No –
    – Tire
    – Basketball
    – Helmet
    – Boomerang
    – Human body CG may also fall outside body’s physical limits (e.g., pole vaulter)

• Can you guess where CM (of CG) is located in figures?
POSTURAL STABILITY

• Many times we adjust a variety of factors to manipulate our stability to either make it easier or more difficult for us to move.

• Stability dependent on 4 factors:
  1. Size of our base of support
  2. Position of line of gravity relative to boundaries of the base.
  3. Weight of the body
  4. Height of the CG above the base

• 1. Size of base--larger the base, the more stable the object tends to be. I.e. CG can be shifted to a greater extent without line of gravity moving beyond boundaries of base.
  – Wrestler--wide base or Ballet--small base
• 2. Position of line of gravity relative to boundaries of base—body will be balanced as long as line of gravity is kept within base. If line of gravity falls beyond base, body is unstable and movement occurs until new base is established.
• Nearer the line of gravity falls to center of base, more stable the body tends to be.

• When manipulating base, consider:
  A. Direction from which displacing force is expected.
  B. Line of gravity shifted towards displacing force.
    – Want to maximize the distance that the CG can travel without passing beyond boundaries of base.
• What happens when set to be pushed from the front but instead you get it from the rear?

• Thus far (with 1 and 2) we've thought only of enhancing stability. In some situations it may be desirable to assume a position in which stability is easily lost.
• Example?
• Track sprinter's starting position
  – Want line of gravity as far forward as possible—ideally, over hands. Not beyond edge of base but just within.
• 3. Weight of body (includes any external load)
  • Simply: increase weight, increase stability.
  • Pick up a suitcase--increase weight, so more stable from this standpoint but must also consider influence on cg and line of gravity positions relative to base.
    • Remember, CG is shifted toward added weight. If shift is large enough, could move line of gravity beyond edge of base.
  • Solution to this problem?
    • Move some opposing segment away from load--usually lean or throw other arm out away from the body. Helps keep CG closer to center of base.

• 4. Height of CG above base.
  • Simply: lower the CG, the greater the stability.
    – High speed race car--low CG
    – Wrestler--low CG