Impulse-Momentum-Impacts

- Momentum: "quantity of motion"
  - Any object which has both **mass** and a **velocity** is said to have momentum.

$$M = m \cdot v$$

(units of measurement: **kg·m/s** or N·s)

Momentum and Impacts

- Momentum is an especially useful measurement in describing the outcomes of collisions or impacts between two or more objects.
- Remember - momentum depends on two quantities:
  - **Mass**
  - **Velocity**

- During impact/collision situations in sport, we often want to manipulate the momentum of at least one of the colliding objects to produce some desired outcome of the collision.
- Examples:
  - Baseball
    - "swinging away" vs. laying down a bunt
    - catching a ball stiffly vs. "giving" with the ball
  - Volleyball
    - attack vs. dink
  - Soccer
    - Trapping (controlling) the ball vs. shooting on goal

Conservation of Momentum

- "The total momentum of any given *system* will remain constant unless acted upon by an external force."

or

- The momentum before a collision is equal to the momentum after a collision.

Example: Bowling

- Momentum of ball (before): MV
- Momentum of pins (before): m0
- Momentum of ball (after): Mv
- Momentum of pins (after): mV

$$\left(m_{ball}v_{ball}\right)_{before} + \left(m_{pins}v_{pins}\right)_{before} = \left(m_{ball}v_{ball}\right)_{after} + \left(m_{pins}v_{pins}\right)_{after}$$

Link to Kinetics

- Impulse-momentum relationship (a very useful form of Newton's 2nd Law):
  - Impulse = product of net force and the time over which the net force is applied ($\Sigma F \cdot t$)

Impulse = Change of Momentum

$$\Sigma F \cdot t = \Delta m \cdot v$$

$$\Sigma F \cdot t = \Delta m(v_f - v_i)$$

$$\Sigma F = \Delta m(v_f - v_i)/t$$

Example

A 50 kg gymnast dismounts from the vault and sticks her landing. If she impacted the ground at a speed of –3.75 m/s, how would landing technique affect the forces she experienced in coming to a stop?

Hard landing: dissipating a large force over short time ($\Delta t = 0.20$ s)

Soft landing: dissipating a large force over long time ($\Delta t = 0.60$ s)

Other common examples of this relationship:

- Example Problems
  - How does the impulse-momentum relationship influence vertical jumping performance?
  - Do you think landing technique is related to lower extremity injury? Why or why not?
  - From a standing position, rapidly squat down and hold this position.
    - Draw the net force vs. time profile of this motion
    - Compute the impulse generated during this task.
  - How do airbags help reduce the severity of many automobile accidents?