Lowest Sum of Joint Forces When Landing After a Jump
The Biomechanical Model

- Sum of Joint Forces
- External Forces
- Friction Force
- Vertical Ground Reaction Force
- Coefficient of Friction
- Linear Speed
- Application Time of the Internal Forces Slowing the Body Down
- Mass

**Action – Reaction Principle**

- **External Forces Principle**
- **Friction Force Principle**

**Linear Impulse-Momentum Principle**
Biomechanical Model
Lowest Sum of Joint Forces When Landing after a Jump

- **Action – Reaction Principle**
Biomechanical Model
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- External Forces Principle

- External Forces
  - Vertical Ground Reaction Force
  - Friction Force
Biomechanical Model
Lowest Sum of Joint Forces When Landing after a Jump

- **Friction Force Principle**

\[ F_{FR} = \mu F_{VGR} \]
Biomechanical Model
Lowest Sum of Joint Forces When Landing after a Jump

- **Linear Impulse – Momentum Principle**

\[ F_{VGR} = \frac{\text{ms}}{t} \]
Interpreting the Biomechanical Model

- Sum of Joint Forces
  - External Forces
    - Friction Force
      - Vertical Ground Reaction Force
        - Linear Speed
        - Application Time of the Internal Forces Slowing the Body Down
        - Mass
      - Coefficient of Friction
Biomechanical Analysis

Lowest Sum of Joint Forces when Landing after a Jump

Fundamental Biomechanical Principles
Action – Reaction Principle

- This principle is derived from Newton’s 3rd Law of Motion (Linear)
  - For every action there is an equal and opposite reaction
- This principle may be interpreted in several different ways.
- For this Biomechanical Model, the principle is interpreted as follows:
  - the sum of joint forces that the body must absorb when slowing down is equal in magnitude and oppositely directed to the external forces applied to slow the body down
External Forces Principle

- This principle may be interpreted in several different ways.
- For this Biomechanical Model, this principle is interpreted as follows:
  - whenever the body is in contact with the ground, there are two ground reaction forces (one vertical and one horizontal) that slow the body down.
- Units of Measurement
  - Newtons (N)
Friction force $F_{FR}$  

Vertical Ground Reaction Force $F_{VGR}$
Friction Force Principle

- Friction Force
  - The horizontal ground reaction force between your foot and the ground

\[ F_{FR} = \mu F_{VGR} \]
Friction Force Principle

- **Real-World Application**
  - A decrease in friction force is caused by
    - a decrease in the coefficient of friction (µ) and/or
    - a decrease in the vertical ground reaction force
  - The coefficient of friction is a number that represents the material properties of a surface that influence friction force:
    - hardness/softness
    - smoothness/roughness
  - Friction force does not decrease if the contact area decreases!
Linear Impulse-Momentum Principle 1

- Newton’s 2\textsuperscript{nd} Law of Motion (Linear)
  - If a net force (\(\Sigma F\)) is exerted on an object, the object will linearly accelerate in the direction of the net force, and its linear acceleration (a) will be proportional to the net force and inversely proportional to its linear inertia (m)
  - The equation for Newton’s 2\textsuperscript{nd} Law of Motion (Linear) is

\[ \Sigma F = ma \]
The Linear Impulse-Momentum Principle is derived from Newton’s 2\textsuperscript{nd} Law of Motion (Linear)

\[ \Sigma F = ma \]

\[ \Sigma F \left( \frac{\Delta s}{t} \right) \]

\[ \Sigma Ft = m(\Delta s) \]
Linear Impulse-Momentum Principle 1

- $\Sigma Ft$ is known as linear impulse
  - Unit of measurement
    - Newton-sec (N-s)

- $m(\Delta s)$ is known as the change in linear momentum
  - Unit of measurement
    - kilogram meter per second (kg-m/s)
Linear Impulse-Momentum Principle 1

- Real-World Application
  - A decrease in the Vertical Ground Reaction Force is caused by a decrease in the mass \( (m) \) of the body and/or a decrease in the linear speed \( (s) \) of landing, and/or an increase in the application time \( (t) \) of the internal forces slowing the body down.

\[
F_{\text{VGR}} = \frac{ms}{t}
\]
Interpreting the Biomechanical Model

- Sum of Joint Forces
- External Forces
  - Friction Force
  - Vertical Ground Reaction Force
  - Coefficient of Friction
  - Linear Speed
  - Application Time of the Internal Forces Slowing the Body Down
  - Mass