# Impulse Calculation

Lab 3

# Introduction

- Newtons' laws of mechanics define the relationship between force and the linear motion of a particle or rigid body to which it is applied. Three such relationships are described below:
  - Law of Inertia:  describes how a body moves in *the absence* of external force, stating a body will remain in its current state of motion unless acted upon by an external force.
  - Law of Acceleration:  describes how a rigid body moves when an external force is applied to a body.  F=ma.
  - Law of Reaction:  describes how two masses interact with each other.

# Objectives

- The objectives of this lab is to perform calculations of Impulse from data acquired by a force plate.
  - Impulse will be calculated from $\boldsymbol{F} = \frac{\boldsymbol{m\Delta v}}{\boldsymbol{\Delta t}}$.
  - Impulse will be calculated from $\boldsymbol{F\Delta t} = \boldsymbol{mv_f} - \boldsymbol{mv_i}$.
- Create a Dartfish Mediabook that will display the key positions used for the calculations.
- The data used for the calculations will be gathered with subjects performing a Squat Jump.

# Theoretical Background

- Newton's Second Law generates an equation that relates to this: **Force = Mass * Acceleration** or **F=ma**.
- Acceleration is defined by $\Delta \boldsymbol{v}/\Delta \boldsymbol{t}$, or change in velocity divided by change in time. Thus, $\boldsymbol{F} = \frac{\boldsymbol{m}\Delta \boldsymbol{v}}{\Delta \boldsymbol{t}}$**.** The product of mass and velocity **($\boldsymbol{m} * \boldsymbol{v}$)** in the numerator of the right hand side of the equation is known as **MOMENTUM**, or the quantity of motion of an object.
- Acceleration is defined as $\Delta \boldsymbol{v}/\Delta \boldsymbol{t}$, or change in velocity divided by change in time. $\boldsymbol{F} = \boldsymbol{m} * \frac{\Delta \boldsymbol{v}}{\Delta \boldsymbol{t}}$. If each side is multiplied by Δt to remove the fraction on the right side, the result is $\boldsymbol{F} * \Delta \boldsymbol{t} = \boldsymbol{m} * \Delta \boldsymbol{v}$**, or** $\boldsymbol{F}\Delta \boldsymbol{t} = \boldsymbol{m}\boldsymbol{v}_{\boldsymbol{f}} - \boldsymbol{m}\boldsymbol{v}_{\boldsymbol{i}}$**.**
- The left hand side of the equation, $F\Delta t$ is a quantity known as an **IMPULSE**, and has the units newton-seconds (Ns). Impulse is the measure of what is required to change the motion of an object

# Data Acquisition

- In today's lab exercise, we will use data acquired from a Single Squat Jump trial, using a single force plate, to calculate impulse. The accompanying lab sheet provides the table needed to report data found in the appropriate AccuPower Software graph panel. We utilize the Squat Jump Test since the athlete is expected to begin the motion with a vertical velocity of ZERO, and then see that velocity rise to a maximal value at takeoff.
- Each subject will perform three Squat Jump Test trials using procedures described below. Data are saved and will be opened later for analysis

# Data Analysis

- For the initial calculation of IMPULSE, all data will be acquired from the Velocity Graph Panel. This analysis will calculate IMPULSE using the right side of the impulse-momentum equation.
- From each trial, you will need to record the following data to the lab sheet:
- **Body mass**
- **Final Velocity**, which will be the peak velocity value for each trial.
- **Final Velocity Time**: this will be the time stamp of the final velocity value.
- **Initial Velocity**, which will be the first positive velocity value for each trial.
- **Initial Velocity Time**: this will be the time stamp of the final velocity value.
- **Change in Velocity**: Subtract initial velocity from final velocity.
- **Change in Time**: Subtract initial velocity time stamp from final velocity time stamp.
- **IMPULSE** = $F\Delta t = \boldsymbol{m}(\boldsymbol{v_f} - \boldsymbol{v_i})$

# Data Analysis

- The second calculation of IMPULSE looks to the left side of the above equation.  To do so, switch to the GRF (Ground Reaction Force) Graph Panel.
  - Fz at Final Velocity:  Follow the Fz time series data to the same instant of time as Final Velocity.
  - Fz at Initial Velocity:  Follow the Fz time series data to the same instant of time as Initial Velocity.
  - Average Force:  Add the two forces values and divide by two.
  - IMPULSE:  Multiply Average force by change in Time.
  - **IMPULSE** = $F\Delta t = \boldsymbol{m}(\boldsymbol{v_f} - \boldsymbol{v_i})$