# Jump Measurement Platform

This project is designed to measure an athlete's jump parameters, including:

- **Flight Time**: The duration the athlete spends in the air.
- **Jump Height**: The calculated height based on flight time.
- **Impact Force**: The force exerted upon landing.
- **Body Mass**: The athlete's mass is calculated from load cell readings.

## Hardware Components

The system is built using the following components:

- **ESP32-WROOM-32**: A powerful microcontroller with Wi-Fi and Bluetooth capabilities.
- **ADS1256**: A high-resolution ADC (Analog-to-Digital Converter) for precise load cell readings.
- **YZC-516C Load Cells (x4)**: Force sensors to measure the applied load.

### Component Links

- ESP32-WROOM-32
- ADS1256
- YZC-516C Load Cell

## Wiring Connections

### ESP32 to ADS1256 (SPI)

| ADS1256 Pin | ESP32 Pin |
|---|---|
| VCC (5V) | 5V |
| GND | GND |
| DIN (MOSI) | GPIO23 |
| DOUT (MISO) | GPIO19 |
| SCLK | GPIO18 |
| CS | GPIO5 |
| DRDY | GPIO16 |
| POWN | 5V |

### Load Cells to ADS1256

The system now uses **four** YZC-516C load cells, each connected in **differential mode**:

- **Cell 1**: White to AIN0, Green to AIN1
- **Cell 2**: White to AIN2, Green to AIN3
- **Cell 3**: White to AIN4, Green to AIN5

- **Cell 4**: White to AIN6, Green to AIN7

**Wiring per cell: - Red** → +5V Power **- Black** → GND **- White** → Signal + **- Green** → Signal -

## Driver Installation

To use the ESP32 with your PC, install the CH340 driver from the following link: CH340 Driver Installation

## Software Installation

To install the required libraries, run the following command:

```
pip install -r requirements.txt
```

## Usage

Once the hardware is set up and software dependencies are installed, you can run the program using:

```
python main.py
```

### Requirements

- **Python 3.12 or higher** ## Description of the mathematical calculations in jump tests

Description of the steps and mathematical formulas used in the internal functions of the tests:

- **Test Depth Jump**
- **Test Normal Jump**
- **Test Calculate Force**
- **Test Calculate Mass**

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### 1. testDepthJump

**Threshold calculations:**

1. **Weight**
   The athlete's weight is calculated as the product of mass and gravity:

$$\text{weight} = m \cdot g$$

2. **Net force**
   The net force applied is the difference between the measured force and the weight:

$$F_{\text{net}}(t) = F(t) - \text{weight}$$

3. **Acceleration**
   The instantaneous acceleration is given by:

$$a(t) = \frac{F_{\text{net}}(t)}{m}$$

4. **Amortization start threshold** $(t_0)$
   The first index $t_0$ where the force exceeds a certain percentage of the weight:

$$t_0 = \min\{\, t \geq 0 : F(t) \geq \alpha_{\text{start}}\, \text{weight}\}, \quad \alpha_{\text{start}} = \frac{\text{start\_threshold\%}}{100}$$

5. **Impact velocity**
   Before contact, the subject falls from a known height $h$; the impact velocity is

$$v_{\text{impact}} = -\sqrt{2\, g\, h}$$

6. **Velocity during amortization**
   Integrating the acceleration (cumulative trapezoidal method) starting from $v_{\text{impact}}$:

$$v(t) = v_{\text{impact}} + \int_{t_0}^{t} a(\tau)\, \mathrm{d}\tau$$

7. **Push-off start** $(t_1)$
   The first instant after $t_0$ when velocity reaches zero (within a threshold):

$$t_1 = \min\{\, t \geq t_0 : |v(t)| \leq \varepsilon_v\}$$

8. **Peak amortization force** $(t_2)$

$$t_2 = \arg \min_{t_0 \leq t < t_1} F(t)$$

9. **Take-off** $(t_3)$

$$t_3 = \min\big\{\, t \geq t_1 : F(t) \leq \alpha_{\text{takeoff}}\, \text{weight}\big\}, \quad \alpha_{\text{takeoff}} = \frac{\text{takeoff\_threshold\%}}{100}$$

10. **Landing** $(t_4)$

$$t_4 = \min\big\{\, t \geq t_3 : F(t) > \alpha_{\text{takeoff}}\, \text{weight}\big\}$$

11. **Peak landing force** ($t_5$)

$$t_5 = \arg\max_{t \geq t_4} F(t)$$

**Value calculations:**

1. **Push-off impulse**
   Calculated by integrating the net force between push-off start and take-off:

   $$I = \int_{t_1}^{t_3} \left[F(\tau) - m\,g\right] \mathrm{d}\tau$$

2. **Take-off velocity**
   From the impulse $I$:

   $$v_0 = \frac{I}{m}$$

3. **Jump height (from force)**
   From energy conservation:

   $$h_{\text{force}} = \frac{v_0^2}{2\,g}$$

4. **Contact time and flight time**

   - **Contact time**:

     $$\Delta t_c = t_3 - t_0$$

   - **Flight time**:

     $$\Delta t_f = t_4 - t_3$$

5. **Jump height (from flight time)**
   Assuming uniformly accelerated motion up and down:

   $$h_{\text{flight}} = \frac{1}{2}\,g\left(\frac{\Delta t_f}{2}\right)^2$$

6. **Estimated average height**

   $$h_{\text{avg}} = \frac{h_{\text{force}} + h_{\text{flight}}}{2}$$

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**2. testNormalJump**

**Threshold calculations:**

1. **Weight**

$$\text{weight} = m \cdot g$$

2. **Start Movement** ($t_0$)

$$t_0 = \min\{\, t \geq 0 : F(t) \leq \alpha_{\text{start}}\, \text{weight} \}, \quad \alpha_{\text{start}} = \frac{\text{start\_threshold\%}}{100}$$

3. **Start Deceleration** ($t_2$)

$$t_2 = \min\{\, t \geq t_0 : F(t) \geq \text{weight} \}$$

4. **Start Braking** ($t_1$)

$$t_1 = \arg \min_{t_0 \leq t < t_2} F(t)$$

5. **Take-off** ($t_4$)

$$t_4 = \min\{\, t \geq t_2 : F(t) \leq \alpha_{\text{takeoff}}\, \text{weight} \}, \quad \alpha_{\text{takeoff}} = \frac{\text{takeoff\_threshold\%}}{100}$$

6. **Peak Take-off Force** ($t_3$)

$$t_3 = \arg \max_{t_2 \leq t < t_4} F(t)$$

7. **Landing** ($t_5$)

$$t_5 = \min\{\, t \geq t_4 : F(t) > \alpha_{\text{takeoff}}\, \text{weight} \}$$

8. **Peak Landing Force** ($t_6$)

$$t_6 = \arg \max_{t \geq t_5} F(t)$$

9. **Negative impulse and balancing**

   - **Negative (eccentric) impulse**:

$$I_- = \int_{t_0}^{t_2} \big[F(\tau) - m\, g\big]\, \mathrm{d}\tau$$

- **Cumulative deceleration**:

$$A(t) = \int_{t_2}^{t} \big[F(\tau) - m\,g\big]\,\mathrm{d}\tau$$

- **Balancing** ($t_b$):

$$t_b = \min\big\{\, t \geq t_2 : A(t) \geq |I_-| \big\}$$

10. **End of push-off** ($t_7$)

$$t_7 = \min\big\{\, t \geq t_b : F(t) \leq \text{weight} \big\}$$

**Value calculations:** Same as **Test Depth Jump**, but the impulse integral is taken from **balancing** to **take-off**:

$$I = \int_{t_b}^{t_4} \big[F(\tau) - m\,g\big]\,\mathrm{d}\tau$$

followed by: - $v_0 = I/m$
- $h_{\text{force}} = v_0^2/(2\,g)$
- $h_{\text{flight}} = \frac{1}{2}\,g(\Delta t_f/2)^2$
- $h_{\text{avg}} = (h_{\text{force}} + h_{\text{flight}})/2$

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## 3. Test Calculate Force

1. **Mean force**

$$\bar{F} = \frac{1}{N} \sum_{i=1}^{N} F_i$$

2. **Index of maximum force**

$$k = \arg\max_i F_i$$

3. **Resulting mass** (from mean force):

$$m_{\text{avg}} = \frac{\bar{F}}{g}$$

4. **Maximum mass** (from peak force):

$$m_{\text{max}} = \frac{F_k}{g}$$

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## 4. Test Calculate Mass

1. **Mean force**

$$\bar{F} = \frac{1}{N} \sum_{i=1}^{N} F_i$$

2. **Resulting mass**:

$$m = \frac{\bar{F}}{g}$$

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This project enables precise measurement of an athlete's jump performance, providing valuable data for training, performance evaluation, and biomechanical analysis.