Test 1

Full Range of motion on each finger - The device should be able to move in the full range of motion for each finger. Determine through flex sensor data in the amount of flexion (degrees).

Scope:

- **System:** Robotic/assistive hand device equipped with flex sensors
- **Goal:** To determine if each finger achieves its full range of motion
- **Test Expectations (Hypothesis):** The device should enable each finger to achieve range of motion within 5% error of an average human's natural finger range.

Administrative Details:

- **Client/Organization:** UCSC BSOE CSE123A&B
- **Test Conductors:** Research Team under Prof. David Harrison.

Design of Experiment:

- **Type of test method:** Controlled experiment using flex sensors to track finger flexion
  - Significance: Ensures the device can replicate the expected movement range of human fingers.

Testing Apparatus & Equipment:

- Glove with integrated flex sensors
- Voltage divider circuit with known resistor (? ohms)
- Arduino
- Computer for data logging and visualization

Independent variable(s): Actuation movement signal sent to device.
Dependent variable(s): Measured flexion angle (degrees) from flex sensors
Number of Factors: Single-factor (flexion range per finger)
Sampling Procedure:

- **Sample Collection:** Each finger tested individually through repeated movement cycles.
- **Sample Size:** Minimum of 30 repetitions per finger to ensure statistical validity.

Procedure:

1. **Setup:** Mount the device securely and ensure proper calibration of flex sensors.
2. **Baseline Measurement:** Record natural rest position of each finger.
3. **Testing:**
   - Actuate each finger from full extension to full flexion.
   - Record flex sensor data at key points of movement (0°, 45°, 90°, etc.).
   - Repeat the process for each finger, ensuring consistency.
4. **Safety Precautions:**
   - Ensure the device does not exceed mechanical limits to prevent damage.
   - Wear protective gear when handling moving parts.
5. **Data Collection:**
   - Data logged digitally via the DAQ system (laptop).
   - Observations recorded manually for potential external influences.
6. **Observation of External Factors:**

- Ambient temperature variations.
- Device vibrations and mechanical inconsistencies.
- Any potential latency in response times.

Expected Outcomes:

- The device should demonstrate flexion within the expected biomechanical range (0°- 90° for DIP, 0°- 100° for PIP, 0°- 90° for MCP, depending on finger).
- Deviation beyond 2.5% of standard human range to be flagged for recalibration.
- If the device does not meet the expected range, adjustments in control algorithms and mechanical design may be necessary.

Test 2

Ability to fit on a common hand - The device should be able to fit securely and comfortably on common hand sizes. Using straps for adjustability.

Scope:

- **System Identified:** Robotic/assistive hand device designed for human use with adjustable straps.
- **Goal/Purpose:** To determine if the device can fit securely and comfortably on common hand sizes.
- **Parameters Defined:** Fit assessment will be conducted based on security, comfort, and adjustability of the straps.
- **Justification for Inclusion:** Ensuring the device can be worn by a range of users with different normal hand sizes is critical for usability.
- **Test Expectations (Hypothesis):** The device should fit securely around the middle of the hand and forearm using adjustable straps, providing a snug but comfortable fit.

Administrative Details:

- **Client/Organization:** UCSC BSOE CSE123A&B
- **Test Conductors:** Research Team under Prof. David C. Harrison.

Design of Experiment:

- **Type of Testing Method:** Physical fit testing using standardized hand models.
  - **Significance:** Ensures that the device can accommodate a range of hand sizes.

Test Apparatus & Equipment:

- Robotic/assistive hand device with straps for adjustability.
- 3D hand model (male/female).

- Measuring tools for assessing gaps and pressure points (ruler, measuring tape, etc.).
- User feedback for qualitative comfortability assessment

Variables Identified:

- **Independent Variable:** Strap tension and hand size.
- **Dependent Variable:** Fit security, pressure distribution, and comfort level

Number of Factors Considered: Two-factor (strap-adjustability and hand size variations)

Sampling Procedure:

- **Sample Collection:** Fit tested on different hand models.
- **Sample Size:** Two hand sizes tested (male and female 3D models), three trials per size

Procedure:

1. **Setup:**
    - Prepare the hand models and device with adjustable straps.
    - Ensure straps are at their default adjustment before each trial.
2. **Baseline Measurement:**
    - Measure the circumference of each hand model at the middle of the hand and forearm.
3. **Testing:**
    - Place the device on each hand model and secure it using the straps.
    - Adjust the straps for a snug but comfortable fit.
    - Record strap tension using measuring tape and pressure sensors.
    - Conduct subjective assessment for comfort and stability.
4. **Safety Precautions:**
    - Ensure straps do not exert excessive pressure that could restrict circulation.
    - Confirm that the device does not cause discomfort or excessive movement restrictions.
5. **Data Collection:**
    - **Quantitative data:** Strap tightness, pressure distribution, and movement stability.
    - **Qualitative data:** User comfort feedback (1-10 scale).
6. **Observation of External Factors:**
    - Impact of movement on strap security.
    - Any noticeable discomfort due to prolonged wear.

Expected Outcomes:

- The device should securely fit common hand sizes without excessive gaps or pressure points.
- The adjustable straps should allow for a customized fit without discomfort.
- If fit issues arise, modifications to strap length, padding, or buckle placement may be necessary.

Test 3

Durability of the device - The device should have enough structural integrity to survive repeated usage and external forces.

Scope:

- **System Identified:** Robotic/assistive hand device.
- **Goal/Purpose:** To determine the durability and structural integrity of the device under repeated usage and external forces.
- **Parameters Defined:** Durability will be assessed based on mechanical wear, structural integrity, and functional performance over time.
- **Justification for Inclusion:** Ensuring the device maintains function and structural integrity over extended use is critical for reliability and user safety.
- **Test Expectations (Hypothesis):** The device should withstand repeated flexion cycles, external forces, and environmental conditions without significant performance degradation.

Administrative Details:

- **Client/Organization:** UCSC BSOE CSE123A&B.
- **Test Conductors:** Research Team under Prof. David C. Harrison.

Design of Experiment:

- **Type of Testing Method:** Accelerated life testing, mechanical stress testing, and environmental exposure testing.
    - **Significance:** Ensures device longevity and reliability in real-world usage scenarios.

Test Apparatus & Equipment:

- Robotic/assistive hand device.
- Mechanical testing rig for repeated flexion cycles.
- Load cell sensors to measure stress and strain.
- Environmental chamber for temperature and humidity variations.
- Impact testing apparatus for drop and shock resistance.

Variables Identified:

- **Independent Variable:** Number of flexion cycles, applied force, environmental conditions.
- **Dependent Variable:** Structural integrity, material wear, loss of functionality.

Number of Factors Considered: Three-factor (mechanical fatigue, impact resistance, environmental durability).

Sampling Procedure:

- **Sample Collection:** Multiple devices subjected to different stress conditions.
- **Sample Size:** Minimum of 5 units per test condition.

Procedure:

1. **Setup:**
   - Mount the device on a mechanical testing rig.
   - Calibrate sensors to measure force, stress, and performance degradation.
2. **Baseline Measurement:**
   - Record initial material integrity and functionality metrics.
3. **Testing:**
   - **Mechanical Fatigue Test:**
     - Subject each finger mechanism to repeated flexion cycles (minimum 100,000 cycles).
     - Monitor for signs of wear, stiffness, or failure.
   - **Impact Resistance Test:**
     - Drop the device from various heights onto different surfaces.
     - Assess structural damage and continued operability.
   - **Environmental Durability Test:**
     - Expose the device to temperature fluctuations (-10°C to 50°C) and high humidity.
     - Evaluate material degradation and operational stability.
4. **Safety Precautions:**
   - Ensure testing rig prevents unintended hazards.
   - Use protective barriers during impact testing.
5. **Data Collection:**
   - Quantitative data: Wear analysis, force measurements, failure rates.
   - Qualitative data: Observations of material degradation and user-reported durability issues.
6. **Observation of External Factors:**
   - Effects of prolonged use on mechanical performance.
   - Environmental factors leading to premature material failure.

Expected Outcomes:

- The device should maintain functional integrity for at least 100,000 flexion cycles without significant degradation.
- The structural components should withstand typical impact forces without catastrophic failure.
- Environmental exposure should not lead to material breakdown or loss of functionality.
- If durability issues arise, material selection, mechanical design, or protective coatings may need revision.

Date & Location for Testing:

	Name(s):	Date:	Location:
Test 1: Full Range of Motion on each finger			
Test 2: Ability to fit on common hand			
Test 3: Device Durability			