CORNELL DEBUT
BIOMEDICAL ENGINEERING PROJECT TEAM

Elbow Torque Tracker: Internal Athletic Immersion Program Protocols

Version 1.0, Rev A
October 19th, 2025

Project Manager: Andrew D'Onofrio
Contributor(s): Emma Weiss, Holbrook Langley

Team Lead Signature	Project Manager Signature

Table of Contents

A. Abstract

Evaluate the impact mock sensors and potential brace designs have on the ability to play tennis in terms of comfort, ergonomics, usability, and practicality. By participating in various sports, the mechanical design engineers further outline the major requirements for an athletic device of this variety for arm-oriented sports (tennis, baseball, etc.). The process involves members immersing in the experience of particular athletes testing various form factor designs and providing feedback on the specific experience.

B. Materials

The following are materials to simulate various variables identified as necessary to characterize during the team immersion program:

A. Measuring Equipment
   1. Tailor Tape Measurer
   2. Driveline Pulse Device
   3. Camera Equipment (Gymbal, Tripod, iPhone Camera)
   4. Marking Tools (i.e. Marker)

B. Equipment for Testing Additional Variables
   1. Charging cables (various lengths)
   2. Electrical wire (rigid and flexible)
   3. Extra 3D Printed Component (small and large)
   4. Weights (Various forces on the arm)

C. Fixturing Equipment
   1. Compression Sleeve
   2. Pre-Wrap
   3. Athletic Flexible Tape
   4. Tapes (Masking, Electrical, etc.)

D. Sports Equipment
   1. Tennis Racket
   2. Tennis Balls
   3. Lacrosse Sticks
   4. Lacrosse Balls
   5. Baseballs and Gloves

C. General Procedural

1. Warm Up Athletes (*Est. Time 30 minutes*)
   a. General Stretching for 5-10 minutes
   b. General Introduction to Basics of Tennis
2. Complete Preliminary Survey for Tennis Background/ Experience
   a. See the following link
3. Record Preliminary Arm Dimensions per Individual
4. Assign specific sport and parameters per individual

5. Administer the Variable and the Range of Questions Needed to Be Answered
    - Give Time for Player to Experience the Sport
    - Ask Questions to Gauge Experience based off of the Major Design Constraint Questions Provided in the Table Below
    - Record with Preferred Method (Videos, Individual Forms, etc.)
6. Conduct Final Interview Gauging Personal Preferences and Final Remarks

Major Design Constraint Questions		
Number	***Constraint Type***	***General Concerns***
1	Weight of Moving Object	1. What is the maximum/ minimum weight of the device on the arm? 2. Are there ideal distributions of the weight on the arm? 3. Where are areas of concern for weight specifically?
2	Weight of Stationary Object	1. What is the heaviest device you are willing to carry alone? Is this dependent on volume?
3	Length of Moving Object	1. What is the longest device (circumferentially and longitudinally) individuals are comfortable wearing while exercising? 2. What are the realistic end-points of the product? 3. What do we need to avoid across the length of the arm? 4. How long do wires need to be between components above and below the elbow to maintain full range of motion during pitching? a. Do stretchy wires decrease the required wire length compared to rigid wires?
4	Length of Stationary Object	1. What is the comfortable size for transporting the device
5	Area of Moving Object	1. Is it uncomfortable to house electrical components on the chest? 2. Is it uncomfortable to have any sensors below the elbow?
6	Area of Stationary Object	

7	Volume of Moving Object	1. What is the maximum bulkiness of the sensors and electronics 2. How are ergonomics/ interfacing of the sensors optimized for the players?
8	Volume of Stationary Object	
9	Speed	1. What is the efficiency of assembly and data reading? Will a mobile app be ideal for reading this information?
10	Force	1. What is the anticipated force exerted externally on the device? (Dynamic, Shear, Torsion, Normal, etc.)
11	Stress or Pressure	1. What are the minimum and maximum compressive limits for the device? 2. What is the maximum stress experienced by such a device? 3. Does a compression sleeve increase or decrease ergonomic appeal? Does athletic tape improve flexibility of placement compared to the compression sleeve?
12	Stability	1. How much motion is permitted in the device? 2. Is comfortability or stability more important?
13	Strength	1. What is the durability required for the device? 2. What types of external forces are these types of devices experiencing? 3. What are the tradeoffs
14	Duration of Action By Moving Object	1. How long does this device need to be worn? 2. How long does the battery life need to be functional? 3. How long does the data need to be stored for? 4. How long does the process of taking data from the device and putting in the software need to take?
15	Duration of Action by Stationary Object	1. How long does the shelf life need to be of all components? 2. What components particularly need

		to be swapped out? 3. How often does the device need to be charged? 4. How often will an individual interact with the device (daily, weekly, monthly, etc.)?
16	Temperature	1. Is there realistically a maximum operating temperature for the device? 2. Will the device run at an unsafe temperature? 3. Are there any major components on the device that are temperature-sensitive?
17	Illumination Intensity	1. Are there any major components on the device that are sun-sensitive?
18	Use of Energy by Moving Object	1. Does the device need to be tied to the specific data?
19	Use of Energy by Stationary Object	
20	Power	1. What are the general power requirements of the anticipated sensors? 2. How much power storage is minimally required for the following device? What is preferred? What is ideal?
21	Loss of Energy	1. Are any mitigations required for loss of power for the device? What is the failure condition?
22	Loss of Substance	1. Are any mitigations required for losing the overall device? What is the failure condition? 2. How do we protect user sensitive data if the device is stolen/ lost?
23	Loss of Information	1. Are any mitigations required for loss of information for the device? What is the failure condition?
24	Loss of Time	1. What is the general time breakdown for utilizing the device
25	Quantity of Substance	1. How much equipment is required for assembly and what specifically is

		utilized the most? 2. What is single-use and what is multi-use in the device?
26	Reliability	1. What is a realistic lifespan for the device? 2. How is this device accessible across patients?
27	Measurement Accuracy	
28	Manufacturing Precision	
29	External Harms or Effects	1. What is the worst case scenario to occur to someone while using the device (not caused by the product specifically)? How do we prevent the product from interfering with first-responders?
30	Object-Generated Harmful Factors	1. What is the greatest harm generated from the following product?
31	Ease of Manufacture	
32	Ease of Operation	
33	Ease of Repair	
34	Adaptability or Versatility	
35	Device Complexity	1. How articulated can the device realistically be? 2. Do sensors need to be fully integrated?
36	Extent of Automation	1. What level of protocol assistance is required for assembly (GUI specific)? 2. What degree does placement of sensors need to be assisted? 3. What degree does calibration need to be assisted? 4. How should data be communicated
37	Productivity	

D. Specific Procedurals

General Users:

General Arm Dimensions	
Wrist Diameter	
Elbow Diameter	
Bicep Diameter	
Shoulder-Finger Length	
Shoulder-Elbow Length	
Elbow-Finger Length	

Answer the following questions regarding your athletic experience:

1. Do you have any experience with playing any sport? (*User Characterization)*
2. What sports/athletic activities are you involved in? (*User Characterization)*
3. Do you wear/use any special equipment when partaking in high-intensity physical activities? (*Define Spatial Component, 1-8)*
4. How often are you bringing special equipment to exercise? (*Quantity of Substance*, *25)*
5. Do you carry a bag to exercise? If so, what are the general dimensions of this bag and how often do you bring this (*Define Spatial Component, 1-8)*
6. What tools do you use to monitor your conditions while you exercise? (ex. Apple Watch)? (*Duration of Action, 18/19)*
7. What do you usually bring when you go to exercise? (*Volume limitations, 7/8*)
8. What's the most durable piece of athletic equipment you own? (*Reliability*, *26*)

Software Engineer:

Observe the usage of the Driveline Pulse Device and Answer the following questions

1. What is the general flow of using the following device?
2. What are the major components of the primary GUI?
    a. What values are relayed by the GUI?
    b. What types of charts are provided
3. How is data recorded and stored (files, cloud, etc.)
4. What is the range of bluetooth connection?
5. How clear is the data communication?
6. How quickly does it take data to be updated?
7. What are the current pros and cons of the following GUI?

E. Results Template

User Name: _____

Scribe Name: _____

Date: _____

Start Time: _____

End Time: _____

A. Contextual Questions

Which Sport is Administered?

- ☐ Baseball
- ☐ Tennis
- ☐ Lacrosse
- ☐ Other: _____

Pulse Driveline Administered?

- ☐ Yes
- ☐ No

B. Specific Tasks

Complete the Following Tasks Prior to Beginning Conducting Immersion

- ☐ Athletics Background Pre-Immersion Survey
- ☐ Stretching and Hydrating

General Arm Dimensions	
Wrist Diameter	
Elbow Diameter	
Bicep Diameter	
Shoulder-Finger Length	
Shoulder-Elbow Length	
Elbow-Finger Length	

Main Design Constraint Number and Type: _____

List the Type of Variable Provided: _____

Elaborate with Detail: _____

_____

_____

_____

_____

_____

_____

C. Design Constraint Learnings

1. Design Constraint Number and Type: _____

   Learnings

   _____

   _____

   _____

2. Design Constraint Number and Type: _____

   Learnings

   _____

   _____

   _____

3. Design Constraint Number and Type: _____

   Learnings

   _____

   _____

   _____

4. Design Constraint Number and Type: _____

   Learnings

   _____

   _____

   _____

D. Final Remarks and Conclusions

Notes: _____

_____

_____

_____

_____

_____