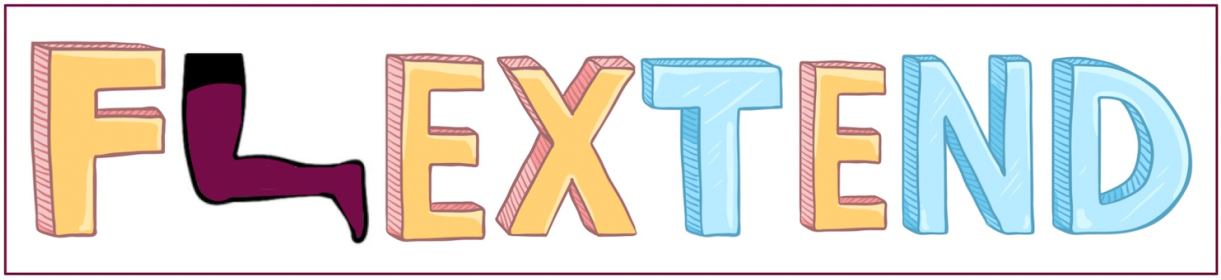
BU Department of Electrical & Computer Engineering

Boston University

EC 463 Senior Design Project I

First Prototype Test Plan



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1.0 Required Materials

1.1 Hardware

1. ADXL345 Digital Accelerometer
2. Arduino Nano 33 IoT
3. 9V Battery
4. 10K Ohm Potentiometer
5. 200 Ohm Resistor
6. 1602 LCD Display Module

1.2 Software

1. Flextend Application
    a. iOS operation (iPhone simulator/iPhone)
    b. Android operation (Android emulator/Android)
2. Google Firebase

2.0 Set Up

2.1 The setup for the testing is in two parts: Arduino board with Gyroscope sensor for hardware and React Native mobile application, both Android and iOS, for software. The HW and SW components are not connected together yet. Hence, we will be showing their functions separately. The mobile device is connected to a computer via usb cable and the application will be run through there. We will be testing login authentication with *Google Firebase*. In the login screen we will be testing that as a phone number is entered the login is successful (navigates to home screen) and that the phone number gets stored in Google Firebase. After navigation to the home screen, we will navigate to the metrics screen where any values for the login user that is stored in the database will be displayed on screen (flexion and extension). Next step will be to test the BLE functionality that it's implemented using *react-native-ble-plx* module. We will test that nearby devices are scanned and

displayed on the screen, and that when one of the devices is clicked, the device shows that it is connected. On the Arduino side, we have the Gyroscope connected to measure position in the x, y, and z-axis. Through a programmed formula, the degrees due to tilt is calculated with respect to a flat surface. This data is sent to the Nano and then to the LCD screen. The LCD is programmed to display the Gyroscope readings.

Circuit Pinout Connection	
1602 LCD Display Module	**Arduino Nano 33 IoT**
RS	D12
E (Enable)	D11
DB4	D5
DB5	D4
DB6	D3
DB7	D2
R/W	GND
VSS	GND
VCC	+3V
LED+	+3V (Through 200 Ohm R)
LED-	GND
V0	+3V and GND (Through 10K Ohm Potentiometer)

Circuit Pinout Connection	
ADXL345 Digital Accelerometer	**Arduino Nano 33 IoT**
GND	GND
Vin	+3V
SDA	SDA (A4)
SCL	SCL (A5)

3.0 Pre-testing Procedure

3.1 Hardware

1. Ensure 9V battery is connected to power in breadboard
2. Make sure Nano 33 IoT lights on
3. Setup the potentiometer for LCD screen contrast and begin measuring

3.2 Software

1. Plug in the iOS or Android device to the host computer (if testing iOS this must be a Mac, otherwise we will use a Windows PC)
2. Start the app on the host computer and begin testing on the mobile device.
3. Login to the Firebase project on computer and open the database.

4.0 Testing Procedure

4.1 Arduino and Electronics

1. Place Nano breadboard onto measuring paper
2. Tilt breadboard to angle on paper and observe accuracy
3. Confirm that the LCD Screen is efficiently outputting data of gyroscope in degrees

4. Repeat steps for each angle

4.2 Mobile Application

1. On the login screen enter a valid phone number with the correct format (+1 234 567 8910).
2. Firebase authentication will give a confirmation code sent to the phone number entered.
3. Enter this code in the verification text input field.
4. Verify that the phone number is stored in Firebase database (Through computer screen inside Firebase project)
5. Repeat the procedure for a few numbers for additional confirmation.
6. Navigate to the metrics screen and verify that it shows information for the logged user.
7. Confirm that it is the same information stored in the Firebase database.
8. Repeat a couple of times for additional confirmation.
9. Navigate to the BLE set up screen.
10. Press the “scan devices” button and verify that a list of nearby available BLE devices are displayed on the screen.
11. Click on one of the devices (We will use one of our laptops) and verify that the *connected* property is set to *true.*

5.0 Measurable Criteria

5.1 Hardware

1. The Gyroscope successfully captures movement of the circuit board in degrees.
2. The LCD screen receives data from the Gyroscope. The results are displayed on the LCD in degrees.

5.2 Software

1. The user is able to log into the application by providing their phone number as well as the country code.
2. Google Firebase records any phone number used to sign into the application.
3. The user navigates the application successfully from any given screen.
4. The user can search for devices using bluetooth. Once a device is found, the user can pair the application and device.
5. The user can see their individual metrics on the Metric Screen. Google Firebase Firestore database contains all specific user metrics for knee flexion and extension. The application successfully gets data from Firestore.

6.0 Score Sheet

6.1 Hardware Score Sheet (Gyroscope + LCD)

Tests	**Theoretical Value (Degrees)**	**Experimental Value Displayed on LCD (Degrees)**	**Within $\pm$ 3°? (Y/N)**
Test #1	0°	0.7°	Y
Test #2	30°	32.2°	Y
Test #3	45°	48.5°	Y
Test #4	60°	64.0°	N
Test #5	90°	87.6°	Y

6.2 Software Score Sheet (Login Process)

Phone Number	Successful Login? (Y/N)	Stored in Google Firebase? (Y/N)
+1 1111111111 (Valid)	Y	Y
+1 2012801587 (Valid)	Y	Y
7862738812 (Not Valid)	N	N
+1 2345 (Not Valid)	N	N

6.3 Software Score Sheet (Metric Display)

Phone Number	Data Displayed on Metric Screen (Degrees)	Data Displayed on Google Firebase (Degrees)	Correct? (Y/N)
+1 1111111111	Flexion: 50° Extension: 26°	Flexion: 50° Extension: 26°	Y
+1 2012801587	Flexion: 42° Extension: 20°	Flexion: 42° Extension: 20°	Y

6.4 Software Score Sheet (Bluetooth)

Devices Listed? (Y/N)	Connection Established? (Y/N)
Y	Y

7.0 Testing Results

7.1 Hardware

Almost all the testing results were below the ± 3° degrees uncertainty level we have decided for measurements. Only measurement that was not in the uncertainty level was 60° degrees. However, when we look at the results, there is a pattern between theoretical and experimental values. Experimental values are about 2° degrees more than theoretical values on average. This implies that we need a better calibration for our zero offset. This calibration should fix the pattern and decrease the uncertainty level.

Another issue we observed was the contrast of the LCD screen was too low. The screen was too bright and it was only possible to read the results when looking at the LCD screen from certain angles. We decided that the potentiometer we installed has a maximum of 10k ohm resistor which is insufficient to increase the contrast for easier reading of results. We will be increasing the resistance to set up the contrast of the LCD screen for faster reading.

7.2 Software

Most components of the software testing ran as planned with the exception of the Android emulator which encountered some issues loading the authentication page. This error, however, was probably due to an internet connection to the computer and not an internal code error because previous testing did not have this issue.

We received some feedback from the graders about the data transmission between device and app. The device will be using two gyroscopes for angle measurement and calibration. The data transmission over BLE should take into account the data that is being read from both sensors and only take into consideration the correct values for extension and flexion. They suggested we could either process these values in the Arduino or in the application. We decided to ultimately drop any values that were used solely for calibration and process the remaining data.