PROJECT FOUR: MILESTONE 3 – COVER PAGE

Team Number: Thurs-07

Please list full names and MacID's of all *present* Team Members.

Full Name:	MacID:
Blake Freer	freerb
Kartik Chaudhari	chaudk4
Dehe Meng	mengd9
Samuel Parent	parens4

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team Number: Thurs-07

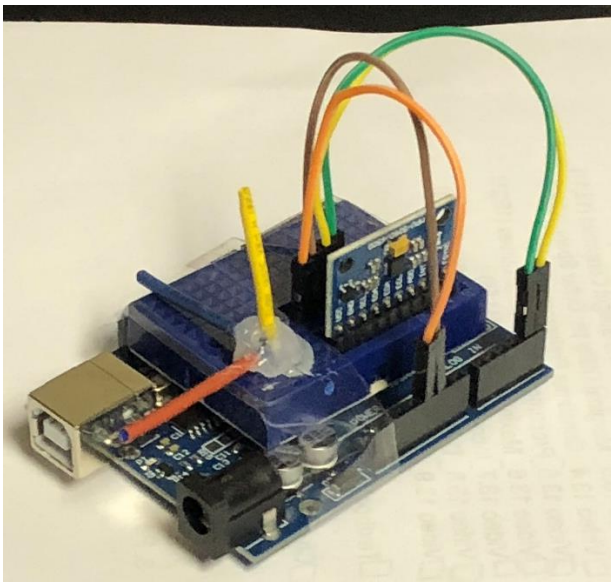
1. Copy-and-paste picture(s) of each team member's refined concept (initial prototype) on the following pages (1 team member per page)
   → Be sure to clearly indicate who each refined concept belongs to
2. Include details on how concept was refined (what feedback was incorporated, what features are different than previous concept exploration, etc.)

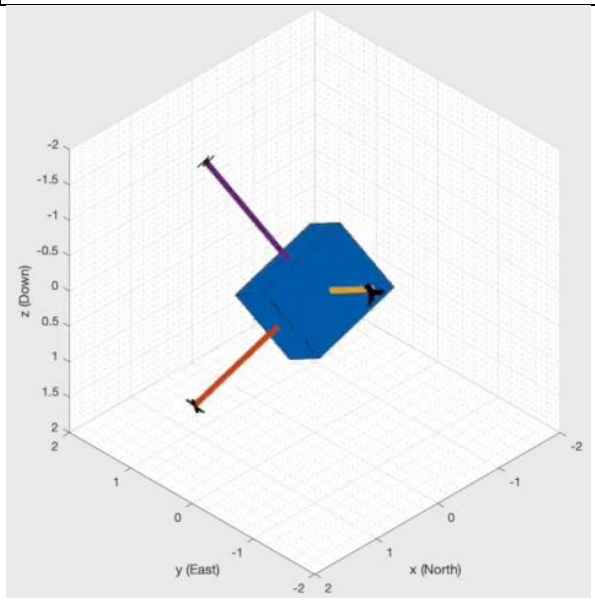
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit picture(s) of their refined concept with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing the rest of the milestone

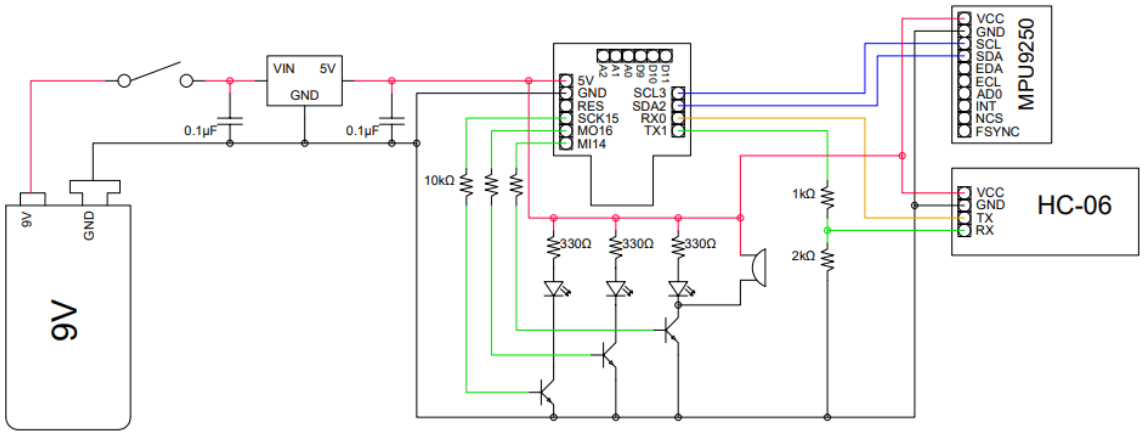
Team Number: Thurs-07

Name: Blake Freer	MacID: freerb





Name: Blake Freer	MacID: freerb



*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

Name: Blake Freer	MacID: freerb

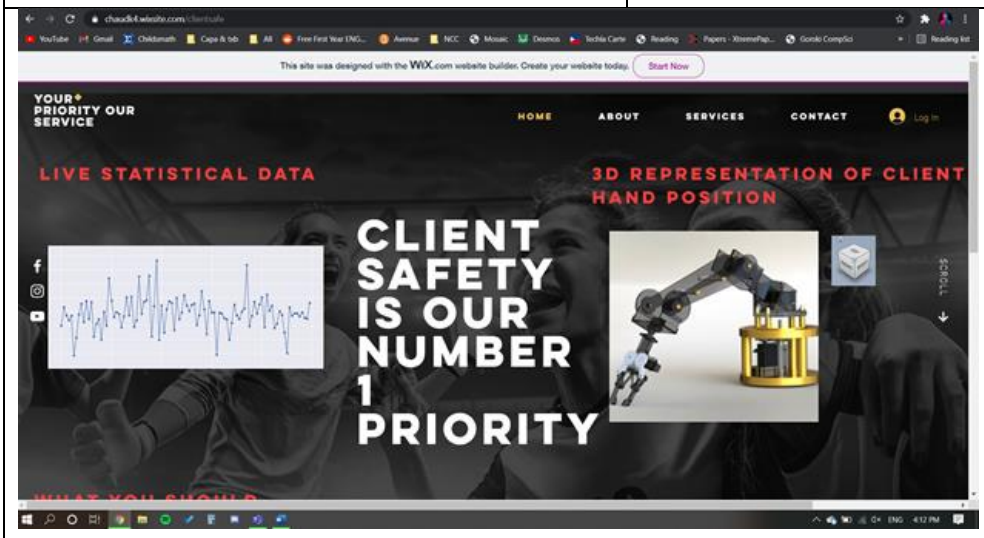
To make the prototyping stage simpler, the circuit was divided into smaller modules that can be designed, assembled, and tested individually. In this circuit, the 3 modules are the power circuit (left), the output feedback circuit (bottom center), and the Arduino sensors (right). As this was my first time making a voltage regulator circuit, research was necessary to determine the correct configuration of the voltage regulator and capacitors. I have prior experience working with transistors and sensors, so the other 2 modules were relatively simple to design.

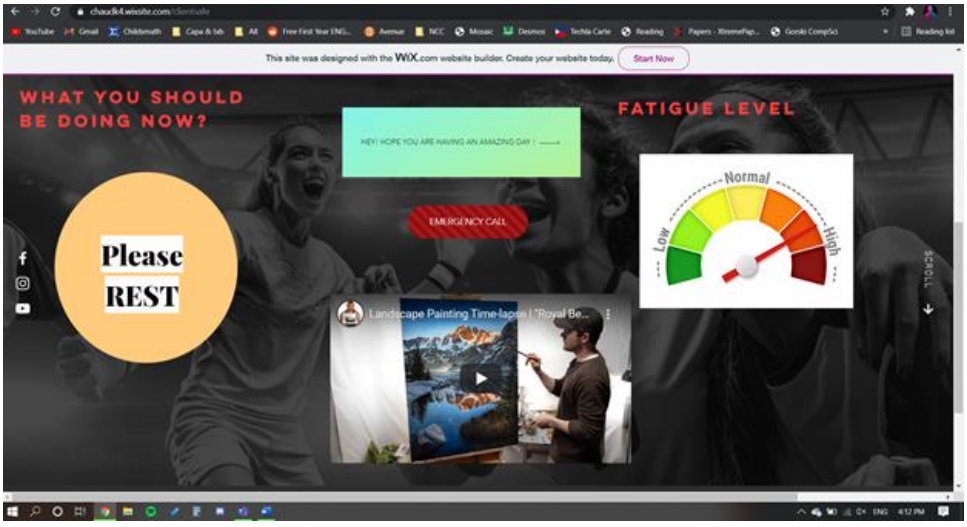
The sensor module was tested using some prototyped code. I used MATLAB to verify that the MPU9250 sensor was functioning properly (2nd image) and created some basic serial interaction code to test the HC-06 Bluetooth module.

With only 3 control pins available, there may only be 3 different state to interact with the user. I discussed this with my team to get feedback, and we decided to have the 3 output states as follows: 1) Green Light → User is in good condition 2) Orange Light → User may be becoming fatigued 3) Red light + buzzer → User should immediately rest.

Team Number: Thurs-07

Name: Kartik Chaudhari	MacID chaudk4





Name: Kartik Chaudhari	MacID chaudk4

We had initially decided that we would move ahead with 4 main sections on our website and the first section we decided was ***1) Live statistical data:-*** *This is the live data which would keep updating periodically where the x axis represents time and y axis represents the sum of all the sensor values that could be stored in a csv file.*

The second section would consist of the ***2) Live Position of the clients hand:-*** *We thought of getting the 3D representation of the hand's position but found out that it could be quite difficult*

hence we might just stick to 2D representation. Our third Section consists of ***3) What exactly the client must be doing now?*** *And just to make it look more attractive we would try including pictures of rest, work or slow down.*

Lastly, the Section ***4) Consists of a meter which basically presents the current fatigue level*** *of the client. The meter consists of 3 main components (Low, Normal and High) which indicate the clients condition at that moment.*

One change I thought to include in this prototype was having an option of emergency call (using twilio). So, in case of an emergency of the client is on the website and she isn't feeling well she can just tap the option. Integrating all these 4 sections to a site is difficult but whatever is possible we will try our best to incorporate it.

Team Number: Thurs-07

Name: Samuel Parent	MacID parens4

Insert picture(s) of your refined concept (initial prototype) below.

Name of Prototype: Fatigue Analysis Computer Program

File: Receive and Store Data

Lead: Blake Freer and Samuel Parent

Functions:

- Receive data from serial
- Format data in 2d array
- Store last x entries in a .csv file

*Note: preferably done using multiprocessing with concurrency model i.e. threading

File: Transmit Fatigue Data

Lead: Blake Freer

Functions:

- get data from csv
- send to arduino through serial

File: Analyze Data

Lead: Samuel Parent

Functions:

- Possible: Find norm of the accelerometer data
- Possible: find the average jerk for a set of points
- Possible: Find the frequency of periodic acceleration using positive and negative as change values
- Determine the fatigue level:
  - using one of the above methods, determine if significant trembling has occurred in a time interval
  - if it has added 1 to fatigue level, if fatigue level is below 3, do nothing, if fatigue level is above 3 subtract 1
  - returns the new fatigue level
- Read from CSV file

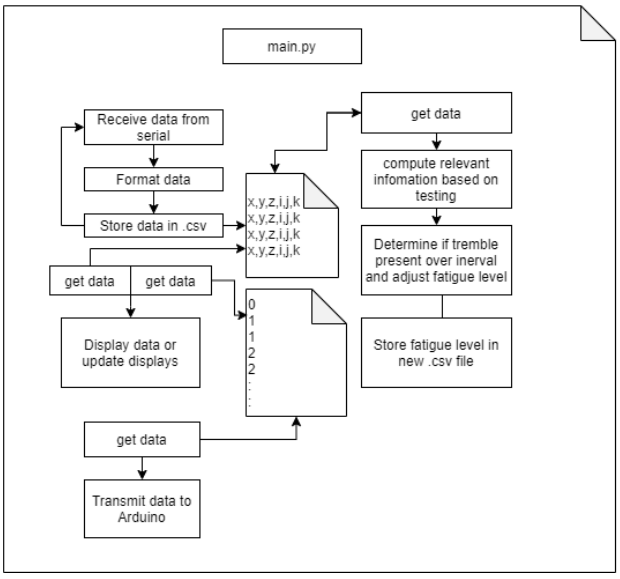
*Note: test data required to know how data analysis will be done.

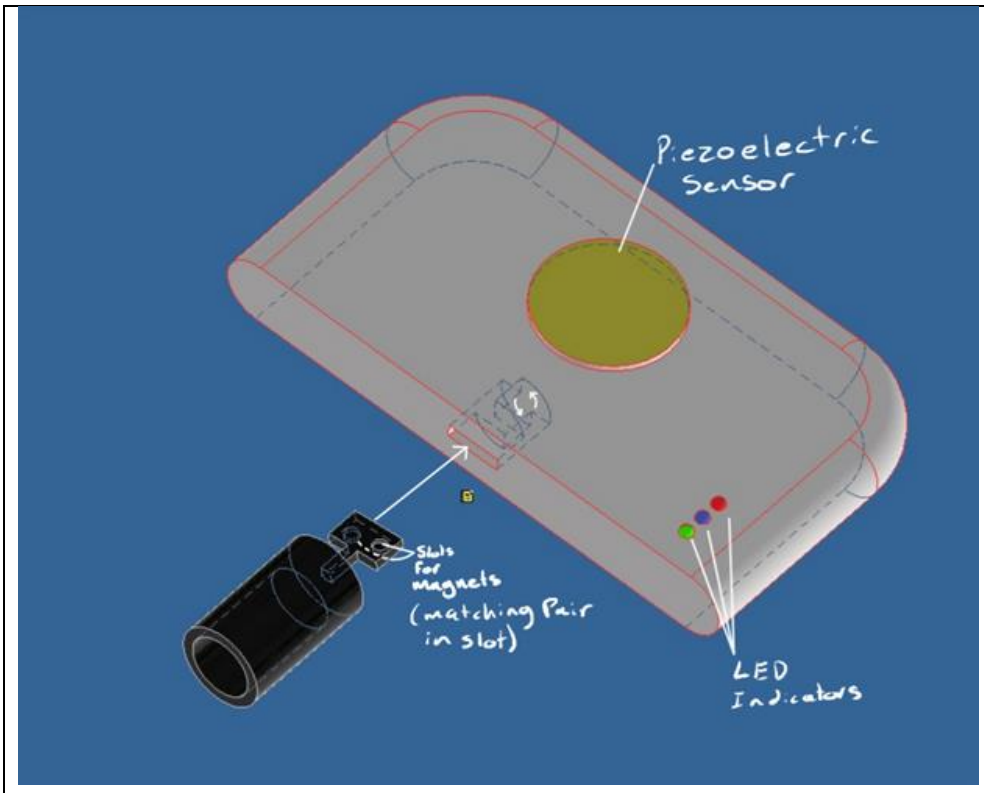
File: Receive and Store Data

Lead: Kartik

Functions:

- Display level of fatigue
- Display graph
- Possible: update displays
- use: read from csv file from analyze data





(second concept referenced in decision matrix)

Name:Samuel Parent	MacID parens4

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

The concept that this relates to is a multi purpose handle with an integrated inertial measurement unit (IMU) sensor and Arduino that would provide data to be analyzed and used to predict fatigue.

The computer program, separate from the Arduino program, would require multiple layers. Special attention needs to be given to the way this program will run as data will be written, read, analyzed, displayed, and transmitted back to the Arduino in real time. Using a .csv file allows us to share the data across multiple .py files with relative ease.

The way in which data would be analyzed remains undetermined as test data will be necessary to find an appropriate algorithm. Some methods that could possibly be used have been mentioned in the flow chart.

The "Fatigue level" will be a value from 1-10. Data analysis will be performed on a window of data and will either contribute +1, -1, or 0 to the fatigue level based on its results and the current state of the fatigue level.

The entire program is subject to change if the prototype were to be fully developed as we do more research and find more effective methods to run the system.

Team Number: Thurs-07

Name: Dehe Meng	MacID mengd9

Insert picture(s) of your refined concept (initial prototype) below.

Name: Dehe Meng	MacID mengd9

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

The paintbrush holding glove is designed to help the client to hold the pen more easily and comfortably. For the figure part, the brush is made of soft material like memory foam, which can fit the shape and position of the hand so the client will feel comfortable to wear. The size of the glove will be customized for the client precisely. The other parts are covered with metal that has low density such as aluminum and titanium alloy to minimize mass and provide high strength. The glove is also equipped with sensors that can detect painting time and identify whether the client

needs to take a rest. All the sensors and power source are placed in a small box at the back of the hand. On the index finger of the glove, there is a ring-shaped device that can hold the paintbrush and its size can be adjusted for different sizes of brushes, in this way the client can hold pen or paintbrushes easily without exerting much force on the pen.

*If you are in a team of 5, please copy and paste the above on a new page.

MILESTONE 3.2 – DECISION MATRIX

Team Number: Thurs-07

1. As a team, use a decision matrix to aid you in choosing two concepts to proceed with.
   → Your concept titles should be descriptive (i.e., "Pencil with Hook" instead of "Design A")

Include your team's Decision Matrix below.

*Our team has come up with a system that would allow Alanna to use tools with more comfort. We also came up with a system to detect fatigue levels. We will use two decision matrices to answer two sets of questions: "**Which physical design should we use to hold the tool?"** and **"Should we make use of sensors/electronics to detect fatigue levels? Which sensors should we use?"***

Physical Design

Objective	Durable	Multi-purpose	Non-aggravating	Lightweight	Feels natural to use	Total
Durable	1	1	0	0	0	2
Multipurpose	0	1	0	0	0	1
Non-aggravating	1	1	1	1	1	5
Lightweight	1	1	0	1	1	4
Feels natural to use	1	1	0	0	1	3

		Generic multipurpose handle		*Paint brush holding glove*		*Brace style wrist mount*	
Objective	Weight	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
Durable	**2**	3	6	4	8	1	2
Multipurpose	**1**	4	4	2	2	5	5
Non-aggravating	**5**	5	25	2	10	1	5
Lightweight	**4**	3	12	4	16	1	4
Feels natural to use	**3**	5	15	3	9	2	6
SCORE			**62**		**45**		**22**

Sensor Selection

Objective	Precision	Ease of integration	Speed	Data Relevance	Score
Precision	1	1	1	0	3
Ease of integration	0	1	1	0	2
Speed	0	0	1	0	1
Data Relevance	1	1	1	1	4

		Inertial Measurement Unit (MPU)		*Piezoelectric Force Sensor and EMG*		*Internal Timer*	
Objective	Weight	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
Precision	**3**	4	12	5	15	4	12
Ease of integration	**2**	2	4	1	2	5	10
Speed	**1**	3	3	3	3	4	4
Data Relevance	**4**	5	20	4	16	1	4
SCORE			**39**		**36**		**30**

2. The numbers you associate with your criteria (objectives and constraints) will probably be an estimation at this point, so **your top two concepts may not always end up being the top two scoring from the decision matrix**. You should provide justification for your team's thought process in choosing the top two concepts. This should include, but is not limited to, explaining:
   - → Your choice of decision matrix tool
   - → Your rationale behind your choice of criteria
   - → Why you prioritized criteria the way that you did (if ranking and/or weighing them)
   - → What metrics you used to decide your scoring of concepts within the criteria

	Insert your team's top two concepts below.
Concept 1:	*Generic multipurpose handle with IMU*
Concept 2:	*Paint brush holding glove*

For both decision stages, a Priority Checkmark table was used to determine the relative importance of each objective, then these ranks were used as the weightings for a Pugh's Matrix where we analyze each proposed concept. This staged approach presented us with sufficient time to think about every element of the concepts and score them appropriately. The weightings help amplify the important qualities of a design to ensure that the winning design performs well in the categories that matter most.

Based on the information that Alanna has provided us during Q&A sessions, we have come up with some objectives that are important to the physical design of our device. She has young children who take interest in the tools she currently uses to help with her conditions and they often break these tools. For this reason, it had to be durable. She has a hard time lifting heavy objects and therefore, the device should be as lightweight as possible. She has mentioned that her lymphedema often causes irritation when certain materials are in contact with her skin. For this reason, we wanted to make sure that the physical device would not aggravate her lymphedema. For Alanna to use our product, it will have to feel natural to use, otherwise the entire design does not have much value.

Alanna must often take rest days which are a result of overexertion in her daily activities. For this reason, we wanted to use sensors to predict when she is experiencing fatigue. For our two chosen concepts we merged the two highest scoring sensors with the two highest scoring sensors. The IMU system will require more protection which is why we decided to pair it with the handle which will act as a protective case. We also paired the flexible piezoelectric sensor with the glove as this will take full advantage of the flexible property of the sensor.

With regards to the physical design, the order of importance that was produced from most important to least important is as follows: Non-aggravating, lightweight, natural to use, durable, and multipurpose. If the device were to aggravate any of Alanna's other conditions, it would immediately render the device completely useless. As is evident by the ranking of the rest of the criteria, user experience was a high priority.

With regards to the sensor choices, the priority was to have data that would allow us to predict when fatigue might occur without using complex analytical methods which would be time consuming. This meant the data had to be relevant and consistent (precise). The easier the sensor would be to integrate, the more time could be spent on optimization of the data analysis algorithm. Though speed is important, none of the methods we will be using will take up very much time to begin with so this would not be the greatest of issues.

To score the performance of the different proposed sensors, personal experience and data about the sensors were used. For example, the IMU and EMG sensor arrangements are more difficult to integrate into a system as they require various communication protocols, whereas the timer is integrated onto any microchip and therefore is trivial to use. However, this criterion is much less important than the relevance of the provided data. The motion data provided by an IMU gives a very good description of the effects of fatigue in the user, whereas the timer provides no information about the condition of the user.

MILESTONE 3.3 – DESIGN REVIEW

Team Number: Thurs-07

Include your feedback from both your peers and the science students below.

Include feedback from peers in this row. *-Make it easier to attach a tool to the handle* *-Make sure that any actions that may be taken do not cause false triggers*
Include feedback from science students in this row. • Try to model the movements as sin/cos graphs from the sensor values • Use of glove (the model for paint brush holding glove) might cause discomfort to the client, so try to change the design of it reduce the weight • Create a real time data dashboard without having to refresh the web app from time to time (for the front end) • Modify the collect data mechanism to better identify the different state of the client, whether she is tired or fatigue from other movements of hand. • The holding position designed for brush in the brush holding glove need to be adjusted.