Review the assignment due date

final-project-skeleton

- Team Number: 8
- Team Name: Stayin Alive

- Team Members: Shruthi A, Howard X, Zora M
- GitHub Repository URL: https://github.com/upenn-embedded/final-project-s25-stayin-alive
- This project is a baby CPR machine that uses a crank-slider mechanism powered by a motor to perform real chest compressions, while a speaker relays real-time voice instructions and audio cues. The system also includes a heart rate sensor to determine the effectiveness of CPR and a user-controlled knob to adjust compression speed through an analog input. This device is designed to be a fully functional CPR machine for emergency infant care scenarios.
- GitHub Pages Website URL: [for final submission]

Final Project Proposal

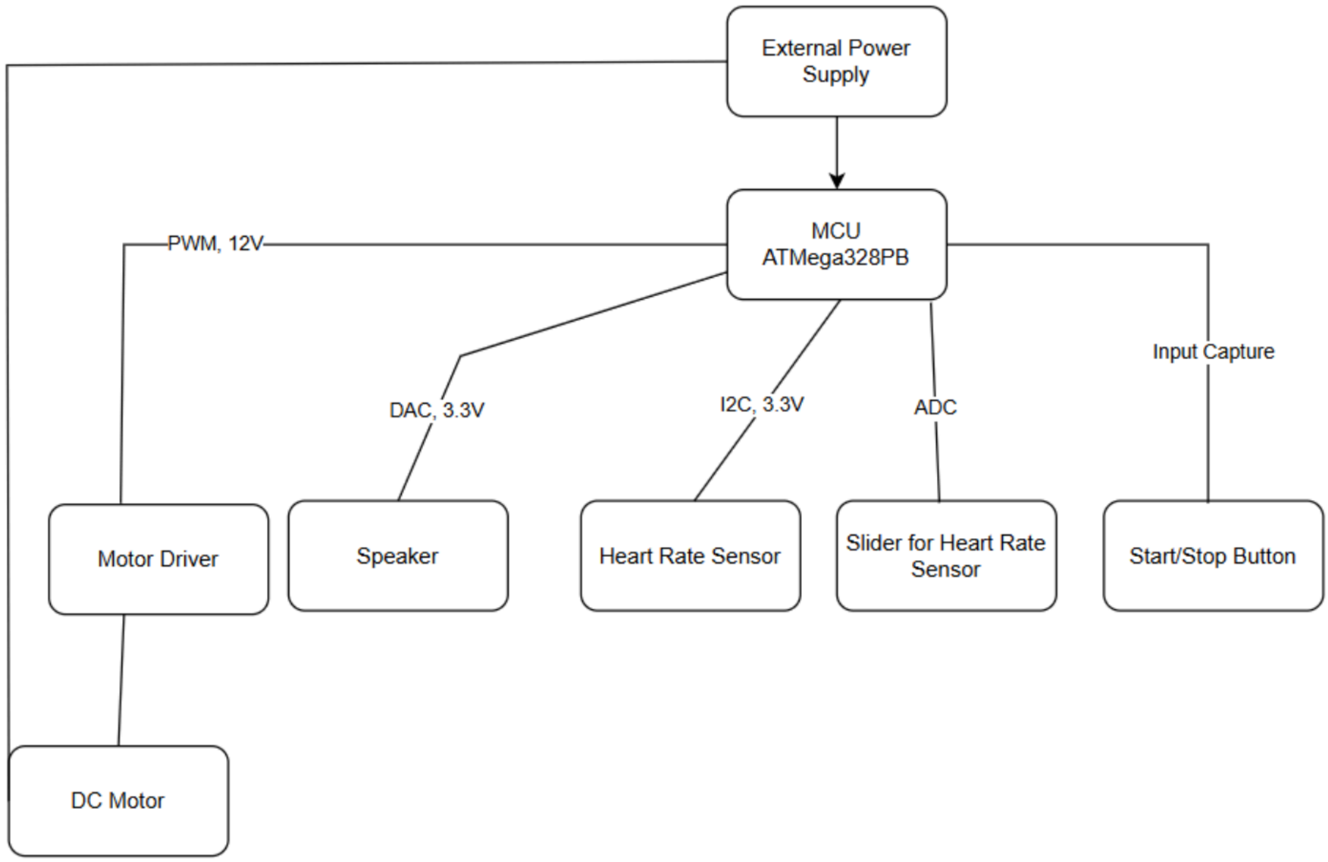
1. Abstract

This project is a baby CPR machine that uses a crank-slider mechanism powered by a motor to perform real chest compressions, while a speaker relays real-time voice instructions and audio cues. The system also includes a heart rate sensor to determine the effectiveness of CPR and a user-controlled knob to adjust compression speed through an analog input. This device is designed to be a fully functional CPR machine for emergency infant care scenarios.

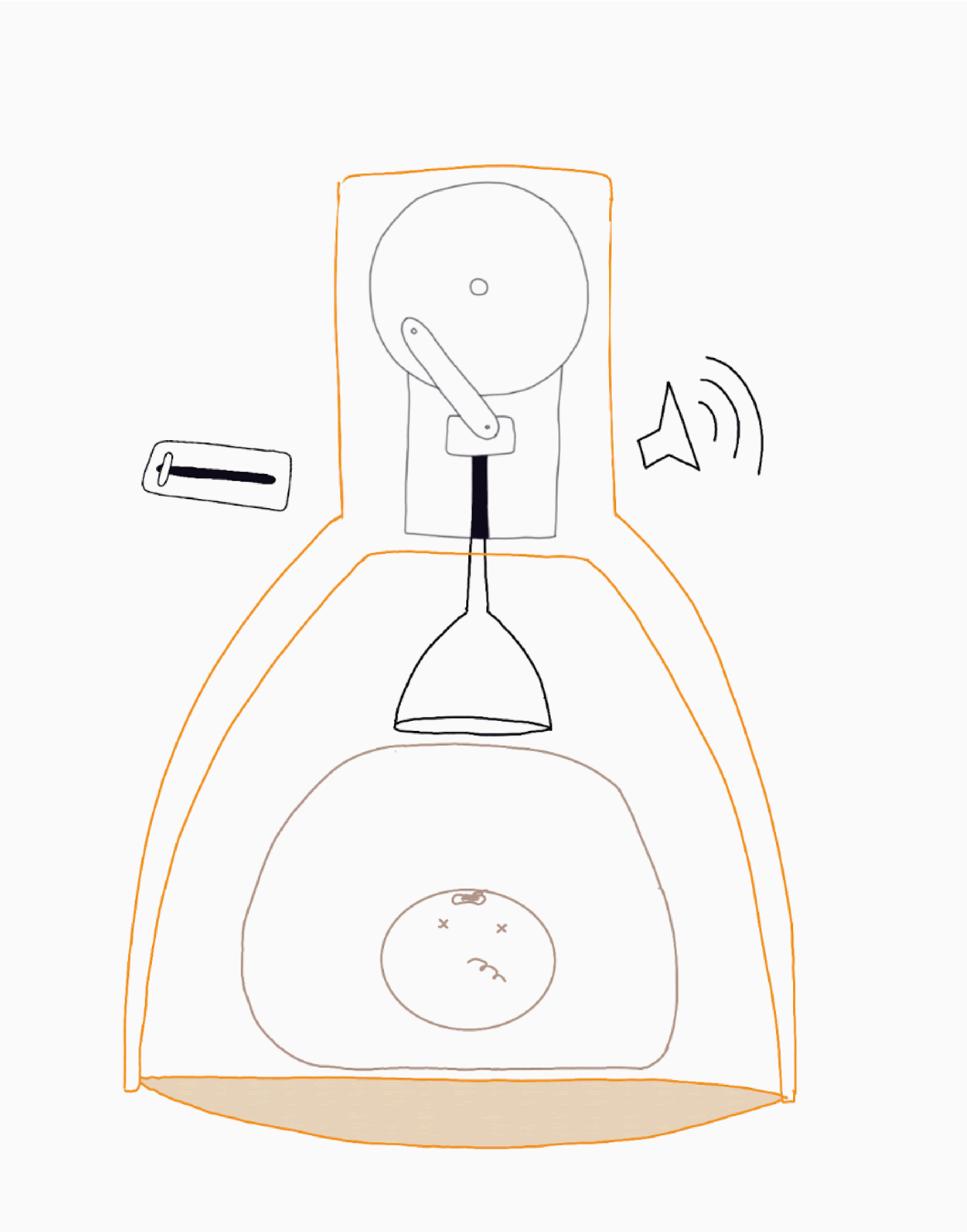
2. Motivation

Sudden cardiac arrest in infants requires immediate and precise CPR. Manual CPR can be inconsistent and tiring, especially for untrained or stressed individuals. This device aims to provide an automated CPR solution for infants that ensures precise compression timing and force, giving caregivers and responders a reliable way to administer emergency resuscitation. It also provides audio feedback and celebrates success by playing a tune when a viable heartbeat is detected. There is significant unmet need in this product space, as existing devices only work on adults and have an exorbitant price range.

3. System Block Diagram



4. Design Sketches



Component Parts:

- Base will house motor and crank-slider mechanism
- Soft padded “suction cup” compressor on infant’s chest
- Embedded speaker for instructional audio and success signal
- External slider to control compression speed (via ADC)

- Heart rate sensor placed on dummy or user to detect pulse

Manufacturing Techniques: 3D printing (housing, crank slider mechanism part)

5. Software Requirements Specification (SRS)

5.2 Functionality

ID	Description
SRS-1	Timing 100-120 compressions per minute via PWM.
SRS-2	Input capture to time when to stop compressions (and begin simulator “breaths”?). Should be around 15 seconds in the compression sequence.
SRS-3	ADC from input slider pin to modulate compression frequency.
SRS-4	Voice instructions synchronization with motor operations.
SRS-5	Start/stop button pin change interruptions to initiate and emergency stop compressions.
SRS-6	Polling/interrupting heart rate sensor for stable heart rate.

Hardware Requirements Specification (SRS)

6.2 Functionality

ID	Description
HRS-1	Timing 100-120 compressions per minute via PWM
HRS-2	Input capture to time when to stop compressions (and begin simulator “breaths”?). Should be around 15 seconds in the compression sequence
HRS-3	Slider shall vary compression speed with ADC values

ID	Description
HRS-4	Heart rate sensor shall detect a stable BPM range for success feedback, and the BPM shall be within +-5 BPM of the true value
HRS-5	Compression precision shall be within ±10% of the reported compression cadence
HRS-6	The system shall be durable enough for 100+ compressions

7. Bill of Materials (BOM)

Bill of Materials (BOM):

For our power management system, we either need a transformer to plug into the wall or a power bank large enough to power the compression system for a reasonable period of time, potentially in addition to a buck converter. This system will drive a powerful motor to perform the compressions. A slider will serve as input to adjust the rate of compressions, and a heart rate monitor will monitor the patient's heart rate to stop compressions if the heart begins beating on its own. The system will also require a speaker to broadcast setup instructions to the user.

Google Sheet Link: Stayin Alive BOM

8. Final Demo Goals

Final Demo

- Device will be placed on baby mannequin
- Demonstrates automatic compressions with adjustable speed using the knob
- Plays CPR instructions through speaker
- Detects existence of pulse using heart sensor (test via human finger) and plays celebratory tune upon success

Constraints:

- No damaging doll
- Can attach doll to machine within 30 seconds

9. Sprint Planning

You've got limited time to get this project done! How will you plan your sprint milestones? How will you distribute the work within your team? Review the schedule in the final project manual for exact dates.

Milestone	Functionality Achieved
Sprint #1	Finalize mechanical + source components, begin microcontroller setup
Sprint #2	Assemble crank-slider, basic motor test, integrate ADC knob for speed control
MVP Demo	Integrate heart sensor, write logic for pulse detection and feedback audio
Final Demo	Final testing, polish demo and final presentation

Team Roles:

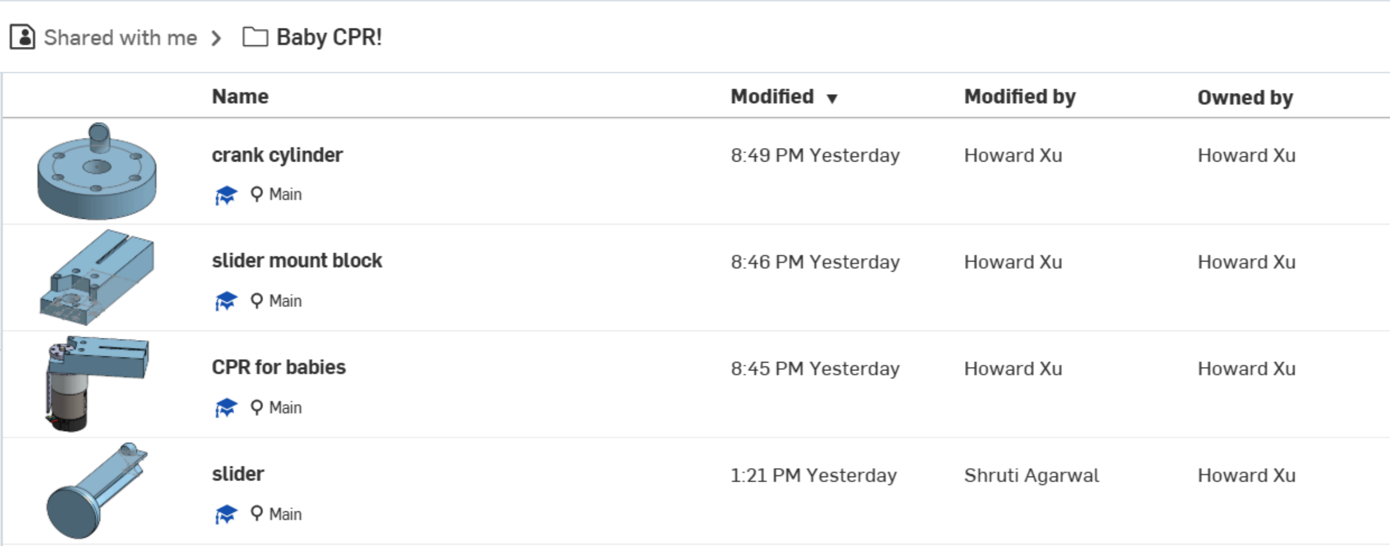
- Shruti: Embedded code (PWM/audio/button/ADC/heart logic)
- Zora: CAD and physical assembly of crank slider mechanism
- Howard: Electrical + power system + audio integration

This is the end of the Project Proposal section. The remaining sections will be filled out based on the milestone schedule.

Sprint Review #1

Last week's progress

We worked on the crank slider mechanism which will be performing the compression motion. CAD pictures below:



Shared with me > Baby CPR!

	Name	Modified ▾	Modified by	Owned by
	crank cylinder Main	8:49 PM Yesterday	Howard Xu	Howard Xu
	slider mount block Main	8:46 PM Yesterday	Howard Xu	Howard Xu
	CPR for babies Main	8:45 PM Yesterday	Howard Xu	Howard Xu
	slider Main	1:21 PM Yesterday	Shruti Agarwal	Howard Xu

Each team member was responsible for a different part of the mechanism.

Zora: crank cylinder

Howard: slider mount block

Shruti: slider

Current state of project

We are finishing up the CAD and getting ready to 3d print, making sure the measurements align with the pololu motor we are using. We hope to finish 3D printing by the end of the week. This is only the first part of the necessary functionality we hope to implement, though. In terms of hardware, we have ordered everything we need, we just need to coordinate with Detkin/the other groups to ensure we receive all of the parts (team number mix up).

Next week's plan

We want to finish 3D printing.

- Estimated Time: 1 hour
- Assigned Team Member: Zora

We would like to connect and test the motor with the crank slider mechanism.

- Estimated Time: 2-3 hours
- Assigned team members: all

Additionally, we would like to implement the code needed to finish the compression mechanism part.

- Estimated Time: 2 hours
- Assigned team member: all

Sprint Review #2

Last week's progress

We finished CAD-ing all the files and were able to put together the crank slider mechanism. We also starting coding instructions to drive the PWM-driven compressions. This file is attached in our Github repository.

Current state of project

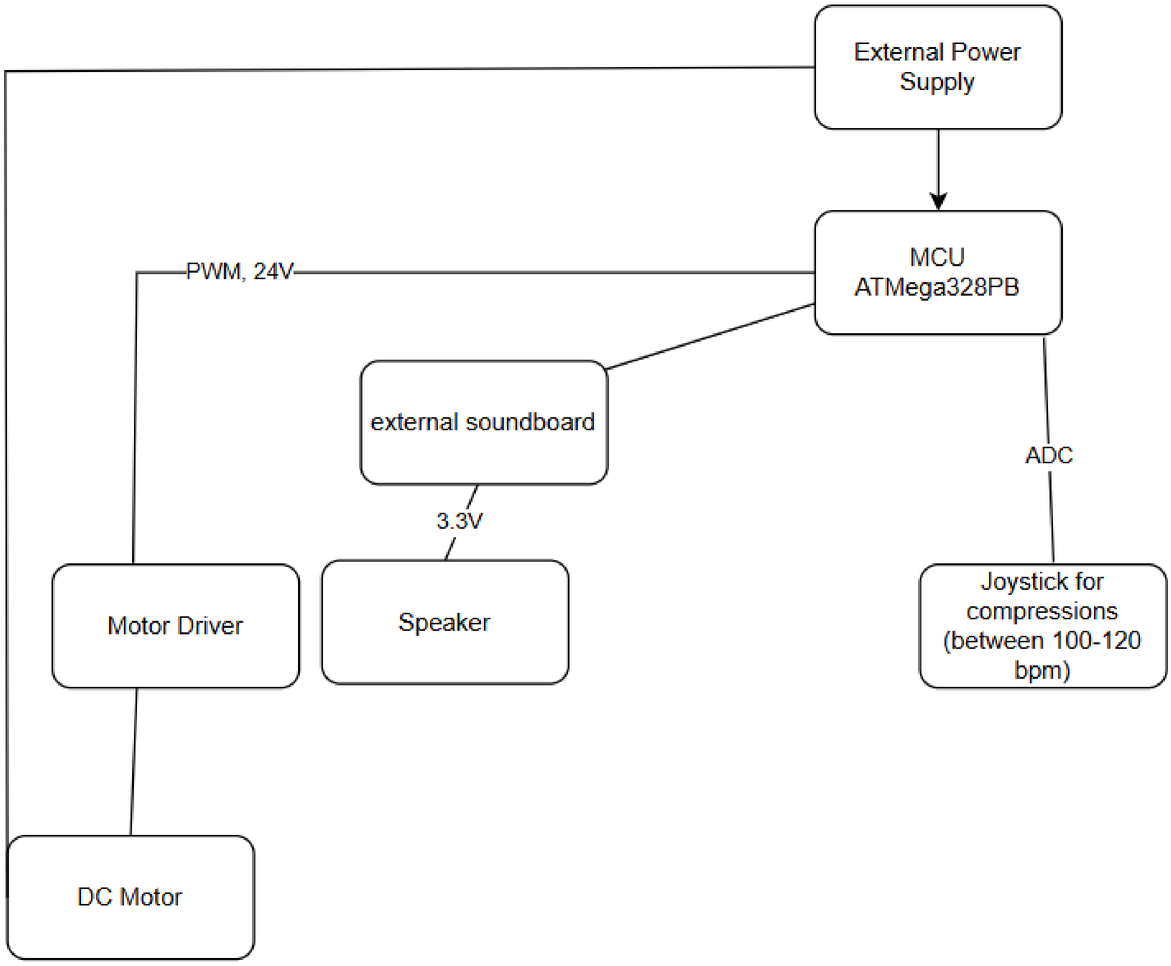
Here is a video with our finished CAD files, showing how the mechanism would ideally work: https://drive.google.com/file/d/1BcY2H6HLj2-3rJgRCMZpnzcnL9ISp_Vk/view?usp=sharing

Next week's plan

Our plan for next week includes finishing the PWM-driven compressions, as well as adding ADC for our knob controll of the actual speed of compressions. If we receive out speaker, we will investigate how to communicate instructions via the audio module we purchased.

MVP Demo

1. Show a system block diagram & explain the hardware implementation.



We have a motor that is powered with 24V, which we are using PWM to control the beats per minute. We also currently use a joystick to change the compressions per minute from 100 bpm to 120 bpm, and also to stop the compressions. Additionally, we use an external soundboard to play audio through our speaker, relaying instructions for the user.

2. Explain your firmware implementation, including application logic and critical drivers you've written.

   In our firmware implementation thus far, we've written code for the motor driver (with the encoder capturing the frequency of the compressions), alongside relaying voice instructions. The motor driver involves sending a PWM signal to the motor with a dynamic duty cycle, depending directly on the ADC value received from our input device.

3. Demo your device.

4. Have you achieved some or all of your Software Requirements Specification (SRS)?

SRS-1: Timing 100-120 compressions per minute via PWM. We've achieved this by testing different duty cycles, determining that a duty cycle within the 40-50% range achieves this BPM. We've attached an image of the oscilloscope, showing the rate of compressions captured of the motor per second (scaled up by a factor of 1120). According to the specifications of the encoder, one rotation of the motor is equivalent to 1120 ticks. We've used the serial terminal to display the final BPM (see video under SRS-3).

SRS-2: Input capture to time when to stop compressions (and begin simulator "breaths"?). Should be around 15 seconds in the compression sequence. We have not achieved this, because we decided we are going to stick to a compression sequence, rather than a compression/breathing sequence. Therefore, we are letting go of this requirement.

SRS-3: ADC from input slider pin to modulate compression frequency. We achieved this using PC0 to measure the ADC value received from our joystick input device; this week, we intend to switch this joystick for a slider. Attached is a video displaying the changing compression speed with a changing ADC value.

https://drive.google.com/file/d/18KjJh7z2JQtU2WsWvnEp5noG2TvVmWYm/view?usp=drivesdk

Math (BPM corresponding to encoder PWM frequency): 2250 x 60 / 1120 = 120.5357142857, 1900 x 60 / 1120 = 101.7857142857

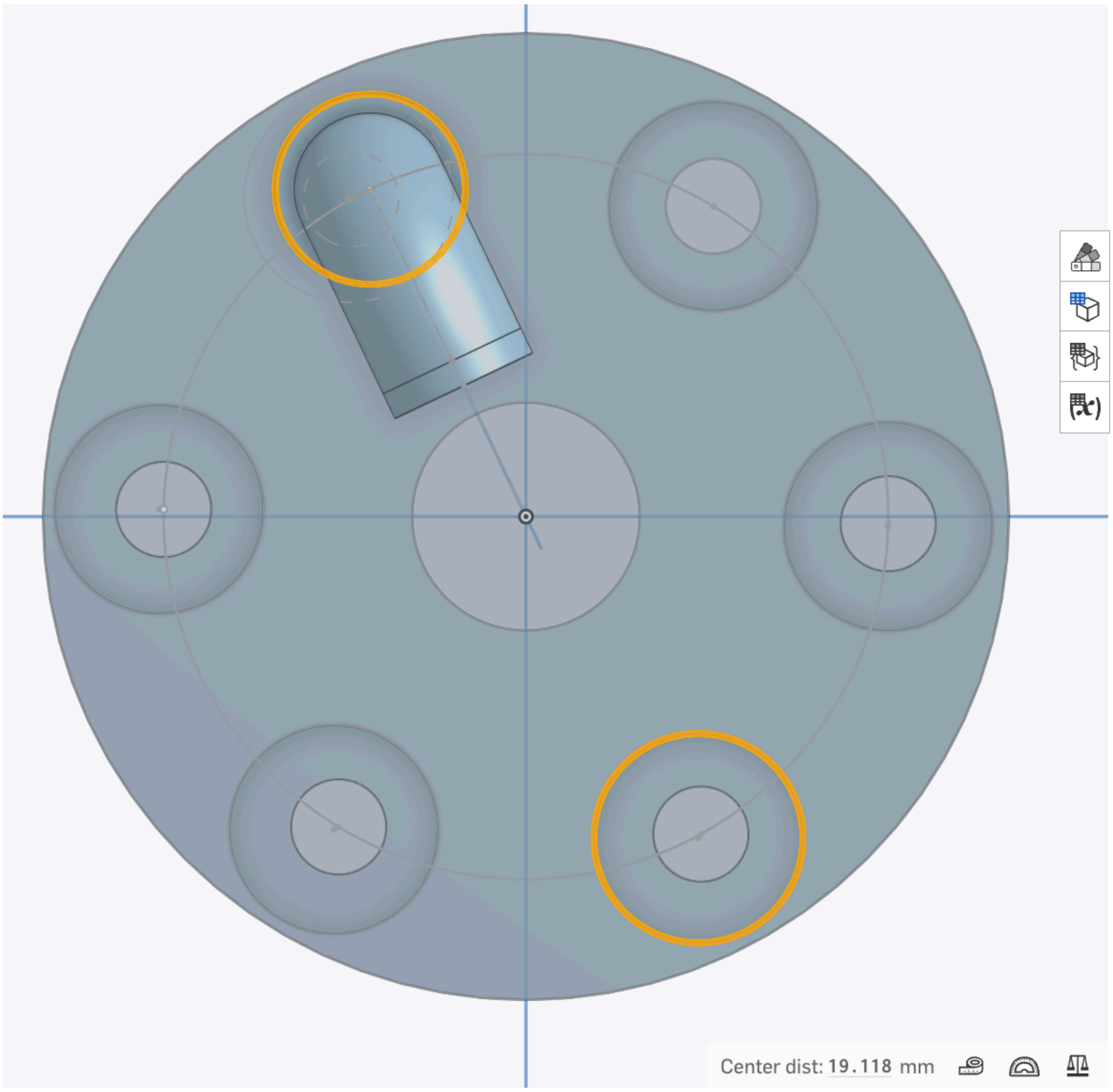
SRS-4: Voice instructions synchronization with motor operations. We've achieved this. Attached is a video displaying how the audio controls synchronize with motor operations.
https://drive.google.com/file/d/1d2OzKgbDKBN98MRBmpH-0eDDmVQTMjfH/view?usp=drivesdk
https://drive.google.com/file/d/1HsucxccEQHHMFxV_PzVdPIGKXBBRkYkZ/view?usp=drivesdk

SRS-5: Start/stop button pin change interruptions to initiate and emergency stop compressions. We have not achieved this requirement yet, but it is on our todo-list for this week.

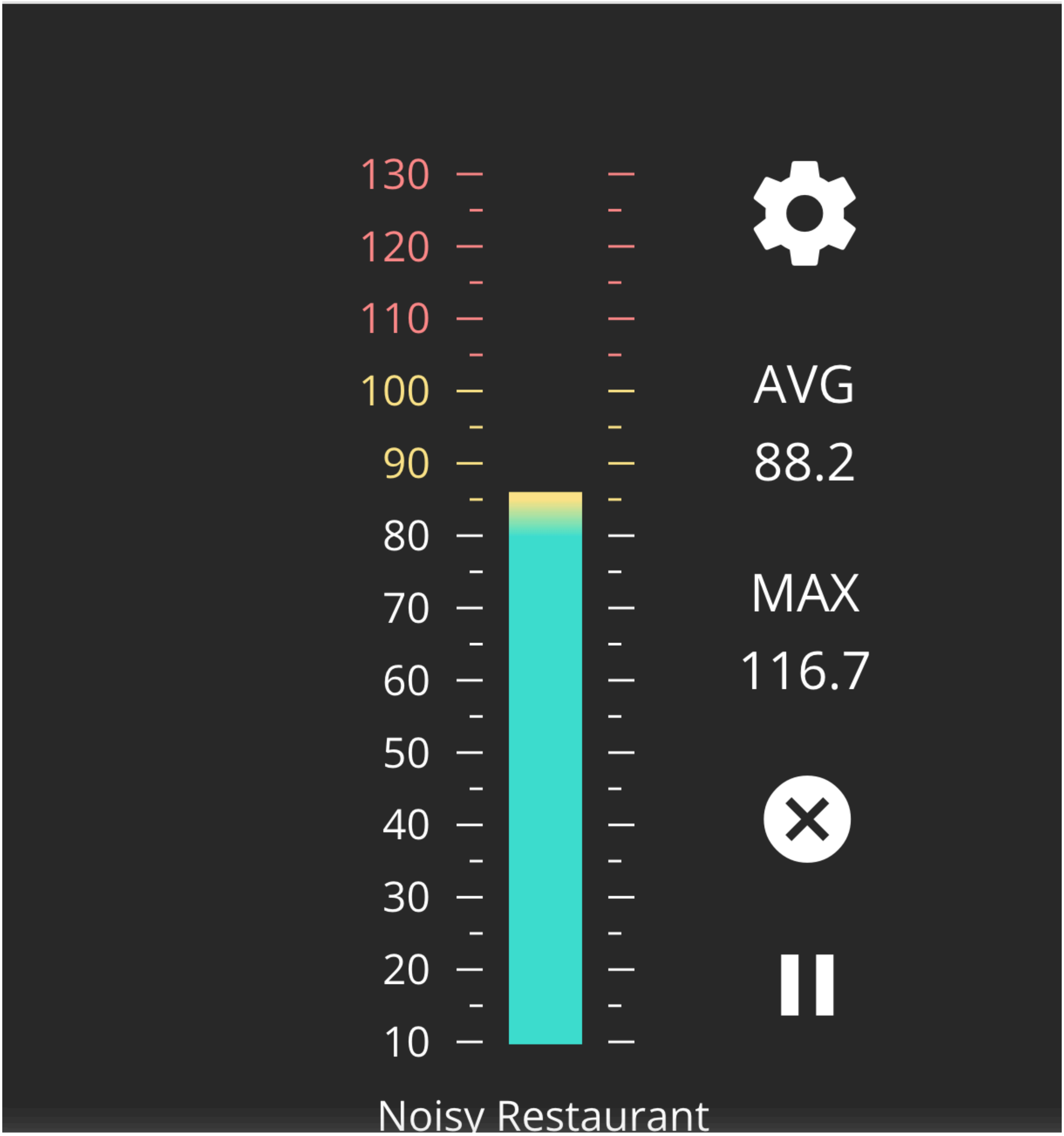
SRS-6: Polling/interrupting heart rate sensor for stable heart rate. We have not achieved this requirement yet. Given our other objectives, we will make a judgement call as to whether we will have enough runway to complete this.

5. Have you achieved some or all of your Hardware Requirements Specification (HRS)?

HRS-1: Motor and crank mechanism shall produce 1.5 inches of vertical motion. We've altered this objective to account for our miniature baby doll (which does not compress very far due to its small size), to make the depth 0.75 inches (19mm). Attached is a CAD screenshot showing the depth of the groove of our crank-slider mechanism.



HRS-2: Speaker shall be audible in a noisy environment (>~70 dB output). We've achieved this objective. Attached is a screenshot displaying the detected decibel value of Detkin during our audio testing. You can listen to the speaker in action in the videos under SRS-4.



HRS-3: Slider shall vary compression speed with ADC values. We've achieved this objective. See video under software requirement SRS-3.

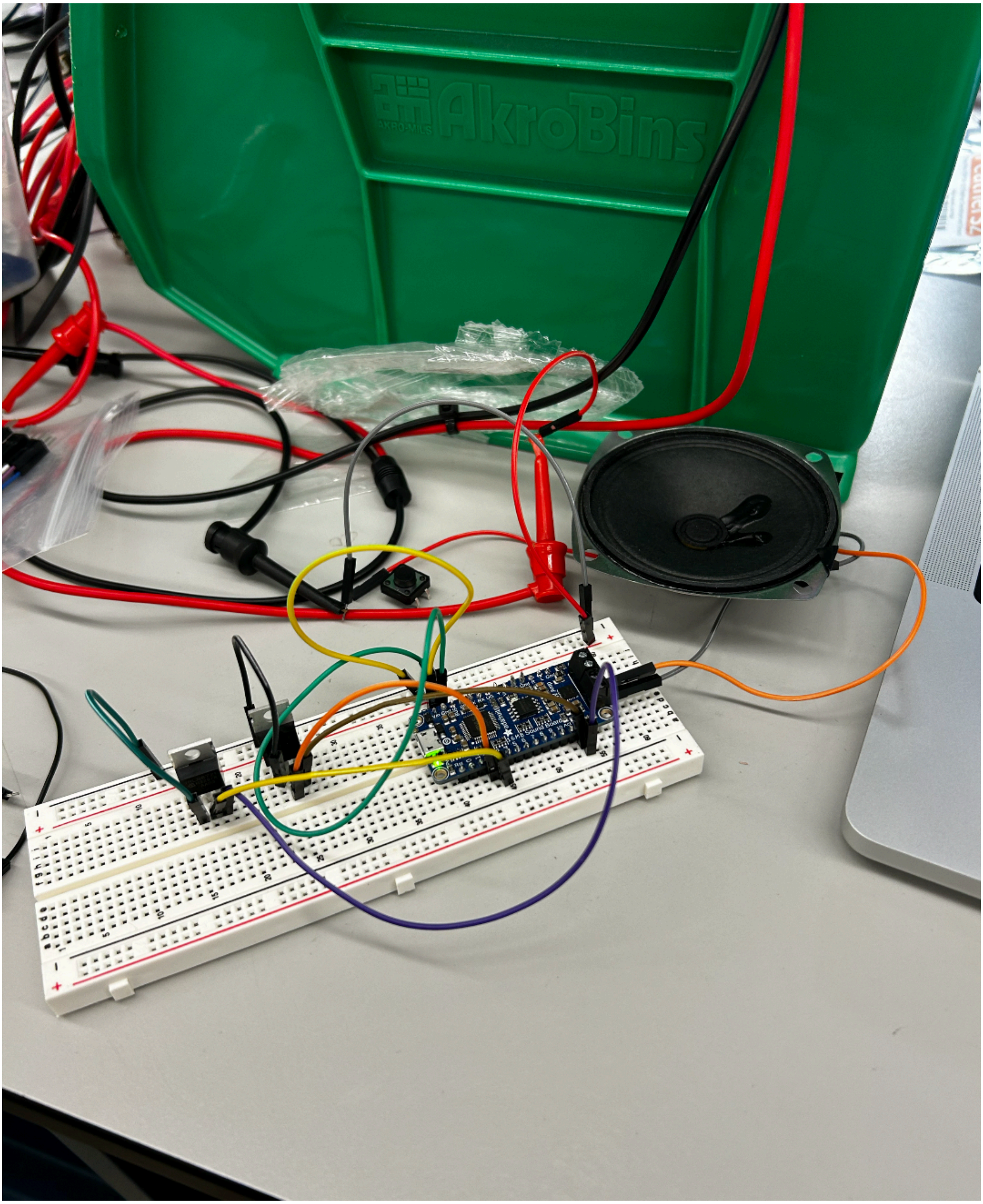
HRS-4: Heart rate sensor shall detect a stable BPM range for success feedback, and the BPM shall be within +-5 BPM of the true value. We have not achieved this objective, as we are still deciding whether the heart rate sensor is a viable addition. It appears to require using Arduino, which is beyond the scope of our final project requirements. If we have the time, we will explore a workaround.

HRS-5: The reported compression cadence shall be within ±10% of the desired compression range of 100-120BPM. We've achieved this objective. The video attached in SRS-1 displays the range of reported compression speeds between 102-121BPM, which aligns with our precision requirements.

HRS-6: The system shall be durable enough for 100+ compressions. We've tested this independently, and our system experiences no wear after 100+ compressions.

8. Show off the remaining elements that will make your project whole: mechanical casework, supporting graphical user interface (GUI), web portal, etc.

   Attached are images of each component of the project, including the casework, compressions, and voice module.



9. What is the riskiest part remaining of your project? How do you plan to de-risk this? Although a fairly safe undertaking, the remaining riskiest part of our project lies in integrating the heart rate sensor. Being able to detect an accurate pulse is crucial to be able to know when exactly to stop the compressions. With an incorrect reading, we may prolong or truncate compressions, which, in a real-world scenario, may lead to undesirable outcomes. To de-risk this, we will thoroughly test our heart rate detection procedure.

10. What questions or help do you need from the teaching team?

We may need help setting up our heart rate sensor to perform accurate readings. It appears that it requires an external C library, which we're having trouble integrating.

Final Project Report

Don't forget to make the GitHub pages public website! If you’ve never made a GitHub pages website before, you can follow this webpage (though, substitute your final project repository for the GitHub username one in the quickstart guide): https://docs.github.com/en/pages/quickstart

1. Video

[Insert final project video here]

- The video must demonstrate your key functionality.
- The video must be 5 minutes or less.
- Ensure your video link is accessible to the teaching team. Unlisted YouTube videos or Google Drive uploads with SEAS account access work well.
- Points will be removed if the audio quality is poor - say, if you filmed your video in a noisy electrical engineering lab.

2. Images

[Insert final project images here]

Include photos of your device from a few angles. If you have a casework, show both the exterior and interior (where the good EE bits are!).

3. Results

What were your results? Namely, what was the final solution/design to your problem?

3.1 Software Requirements Specification (SRS) Results

Based on your quantified system performance, comment on how you achieved or fell short of your expected requirements.

Did your requirements change? If so, why? Failing to meet a requirement is acceptable; understanding the reason why is critical!

Validate at least two requirements, showing how you tested and your proof of work (videos, images, logic analyzer/oscilloscope captures, etc.).

ID	Description	Validation Outcome
SRS-01	The IMU 3-axis acceleration will be measured with 16-bit depth every 100 milliseconds +/-10 milliseconds.	Confirmed, logged output from the MCU is saved to "validation" folder in GitHub repository.

3.2 Hardware Requirements Specification (HRS) Results

Based on your quantified system performance, comment on how you achieved or fell short of your expected requirements.

Did your requirements change? If so, why? Failing to meet a requirement is acceptable; understanding the reason why is critical!

Validate at least two requirements, showing how you tested and your proof of work (videos, images, logic analyzer/oscilloscope captures, etc.).

ID	Description	Validation Outcome
HRS-01	A distance sensor shall be used for obstacle detection. The sensor shall detect obstacles at a maximum distance of at least 10 cm.	Confirmed, sensed obstacles up to 15cm. Video in "validation" folder, shows tape measure and logged output to terminal.

4. Conclusion

Reflect on your project. Some questions to address:

- What did you learn from it?
- What went well?
- What accomplishments are you proud of?
- What did you learn/gain from this experience?
- Did you have to change your approach?
- What could have been done differently?

- Did you encounter obstacles that you didn't anticipate?
- What could be a next step for this project?

References

Fill in your references here as you work on your final project. Describe any libraries used here.