Arterial Line Simulator

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ABSTRACT

Arterial lines communicate information about cardiovascular health. The team designed a device that simulates multiple arterial waveforms for the purpose of education. This was done using a cam design that created waveforms with some error.

MOTIVATION

- Important for healthcare providers to receive proper training on how to monitor blood pressure using an arterial line
- Manikins can be expensive for labs that might not be able to afford it
- Manual manipulation of syringe does not produce waveforms of the same accuracy as manikins

PROBLEM STATEMENT

- Want to simulate arterial line waveforms without use of a manikin for teaching purposes in simulation lab
- Current practice is to move the syringe by hand

BACKGROUND RESEARCH

- Arterial line monitoring is an invasive way to measure blood pressure and heart rate
- Used for real time feedback
- Not a lot of available products to practice reading arterial waveforms without the use of expensive manikins
- Three waveforms for blood pressure are normal, overdamped, and underdamped

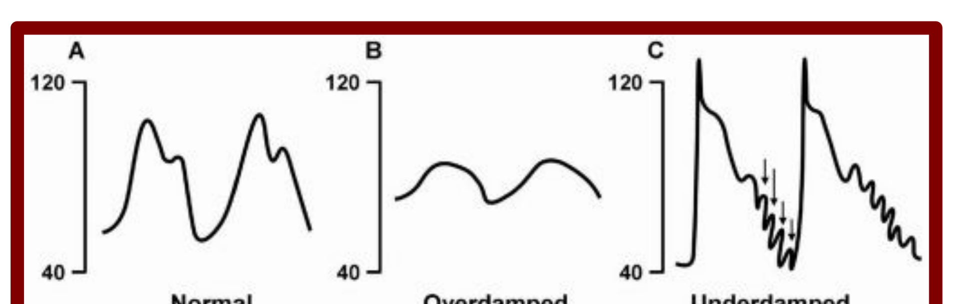

Figure 1: Various arterial waveforms [1]

DESIGN SPECIFICATIONS

- Connect to the arterial line and 10 mL syringe plunger
- Produce an accurate normal arterial pulse waveform
- Minimal user setup
- Size no larger a VHS tape
- Operate for a full instructional period
- Electronics should be covered, use durable materials
- Low cost with a maximum expense of $1000

FINAL DESIGN

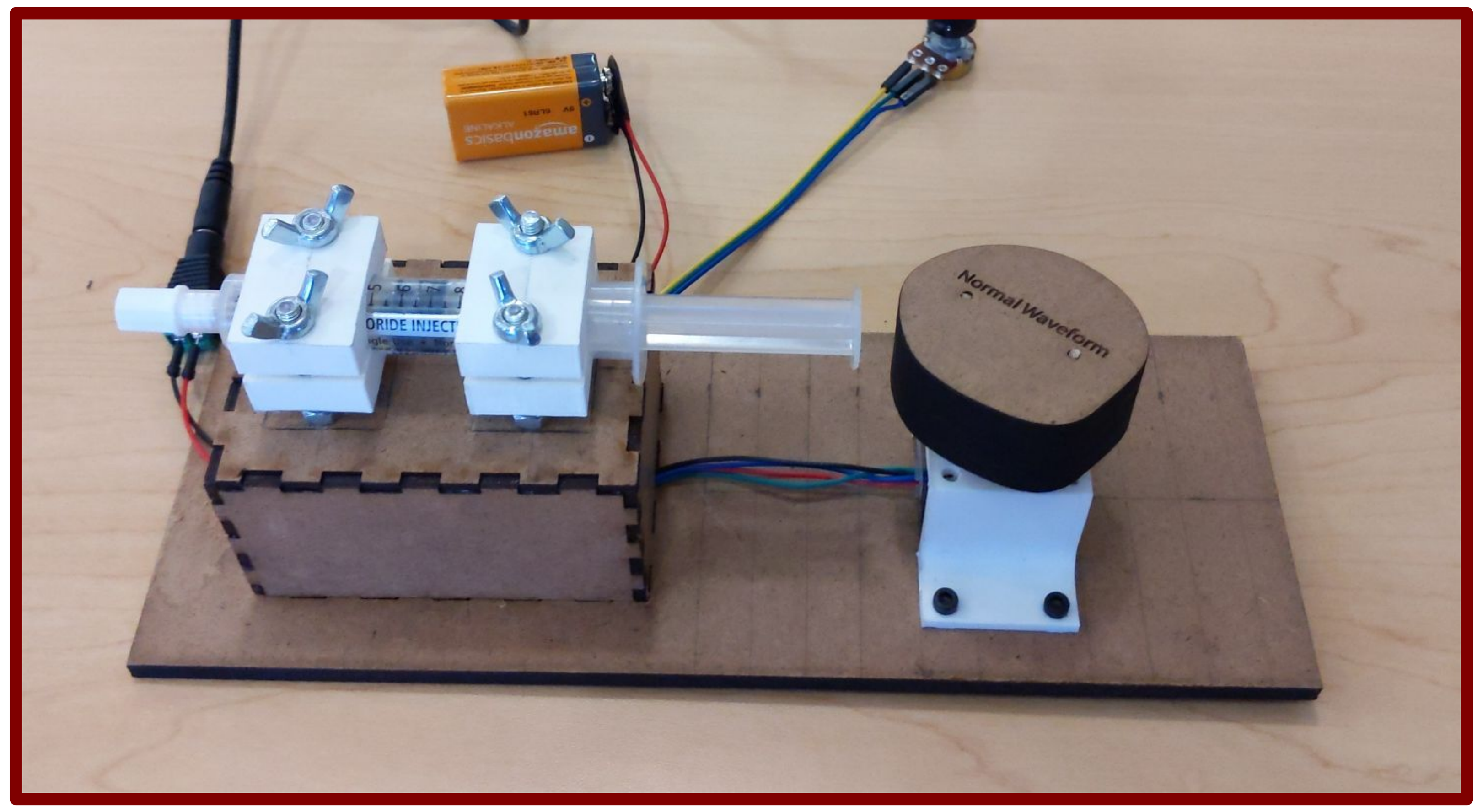

Figure 2. Final Design

- Final design consists of a cam mechanism that presses on the syringe as it rotates.
- Cam designed specifically to produce normal and overdamped waveforms

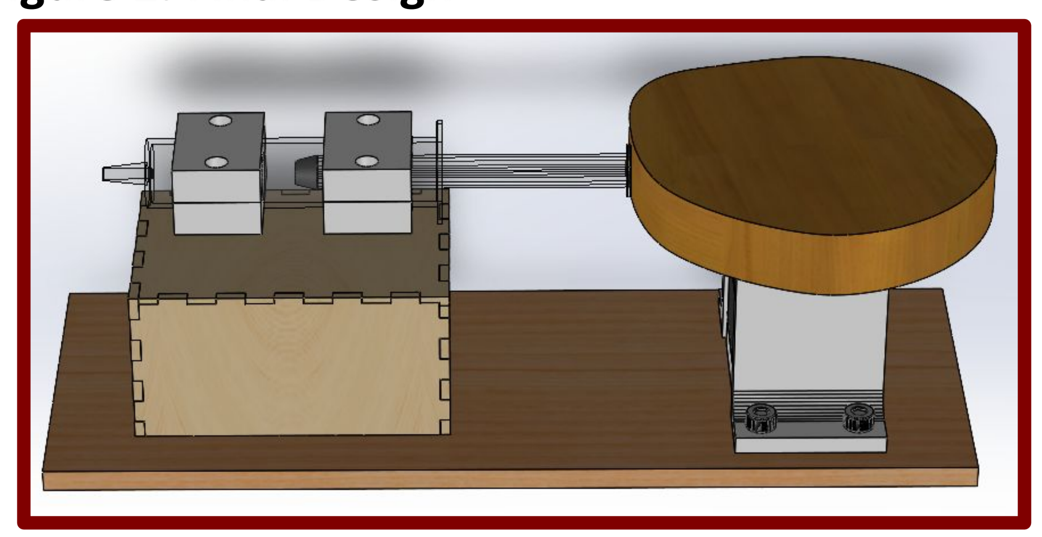

Figure 3. Solidworks Render

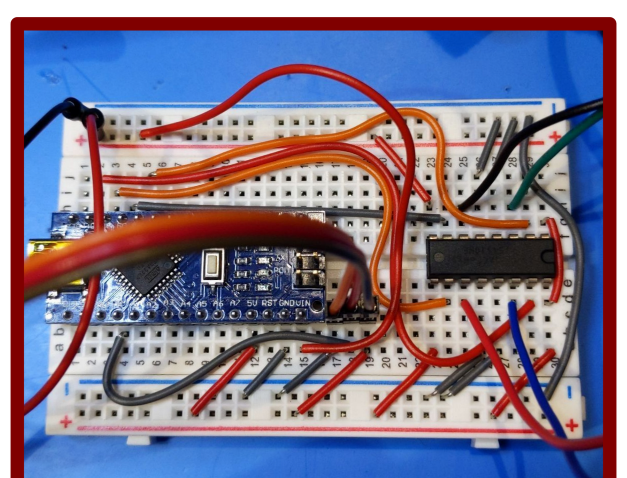

Figure 4. Electronics

- Power provided to the Arduino via a 9 volt battery
- Motor is powered using wall power.
- A potentiometer is used to regulate the speed of the motor. The signal is read in by the Arduino and sent to the motor driver.

MATERIAL COSTS

Material/Part	Cost
Laser Cut and 3D Print Material Costs	$13.55
Stepper Motor	$22.50
Misc. Electrical Components (Stepper Driver, Arduino, 12V Adaptor)	$64.29
Hex Shaft Adaptors, Bolts, Misc. Hardware	$11.32
Total	**$111.66**

TESTING & RESULTS

- Run four cams (two per waveform) at variable speeds and syringe distances
- Compare generated waveform to ideal waveform
- Cam shapes will need to be slightly modified to produce proper waveforms

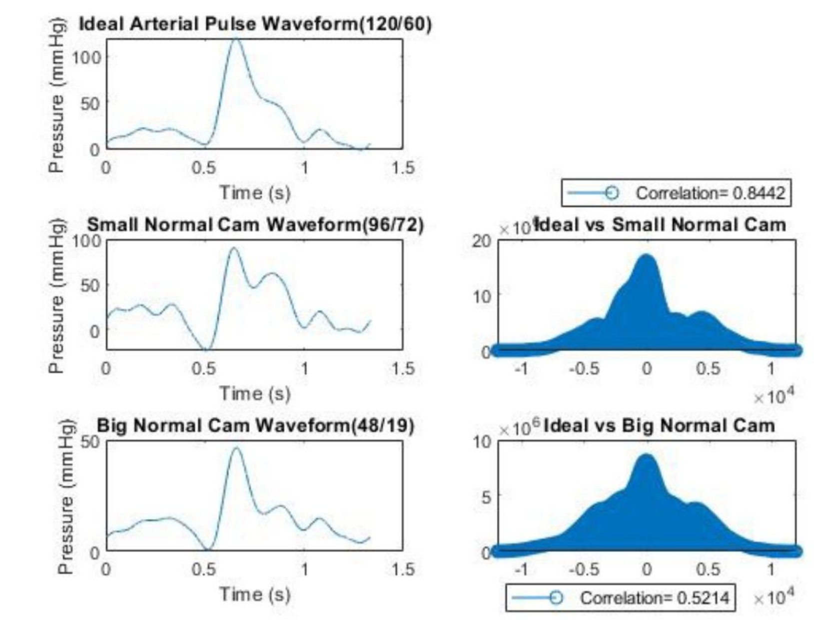

Figure 5. Test Results

DISCUSSION & FUTURE WORK

- Best able to recreate the normal waveform using the smaller normal waveform cam and the box being supported from only the back edge
- Achieved at medium high speed and stabilizing the base platform to reduce vibrations
- Not enough pressure difference generated, need stronger forces to more accurately replicate the waves
- Main issue was a side force rather than straight in and out
- Possible improvements and future work
  - Elongate the base platform to support the actual transducer sensor
  - Add rubber feet in order to reduce vibrations
  - Add a hinge to the back side of the box
  - Produce a better cam shape for the three different waveforms

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REFERENCES

[1] U. F. O. Themes, “Avoid errors in invasive blood pressure measurement,” Anesthesia Key, 01-Jul-2016. [Online]. Available: https://aneskey.com/avoid-errors-in-invasive-blood-pressure-measurement/. [Accessed: 11-Oct-2021].