Executive Summary

The Spaceflight Wearable Circulation Pump project was sponsored by Dr. Lonnie G Petersen's lab. The main objective of the project was to develop a vacuum pump that would power a Lower Body Negative Pressure (LBNP) suit that acts as a countermeasure device against the harmful effects of prolonged exposure to microgravity - a condition astronauts are constantly in. Currently, the main method used to combat these health effects is scheduled exercise for about two hours a day. While this helps mitigate some effects, like muscular atrophy, during short term explorations, it is not nearly as effective for longer explorations as there are usually long-term negative effects on the astronauts. This was the motivation of the project as it aimed to combat the effects in totality with the LBNP suit that could be worn for extended periods of time. The main requirements for the hardware of the design were:

- Compactness: The pump design could not take up too much space in the shuttle.
- Mobility: Users must be able to perform regular daily activities while wearing the suit. These activities include performing science experiments and exercising.
- Comfort: Ensure astronauts are comfortable wearing it for 6-8 hours daily.
- Battery longevity/replaceability: Batteries should be easily swapped out and recharged.
- The wearer should be able to switch between two modes, Normal Mode where it would be depressurized by -20 mmHg and Exercise Mode where it would be depressurized by -30 mmHg.

Project Achievements:

- Successfully depressurized the suit by -20mmHg for normal conditions and -30mmHg while the wearer was exercising.
- Measured the wearer's heart rate and shut off the vacuum when it exceeded the specified thresholds of 60-100 BPM in Normal Mode and 60-175 BPM in Exercise Mode.

The requirements for this project were met using a design that consisted of a portable vacuum as shown attached to a lower body suit via a harness (Figures 1 and 2). The vacuum was controlled by an Arduino through the implementation of a PID controller such that the pressure difference between the internal suit and ambient conditions is -20 mmHg in Normal Mode and -30 mmHg while in Exercise Mode.

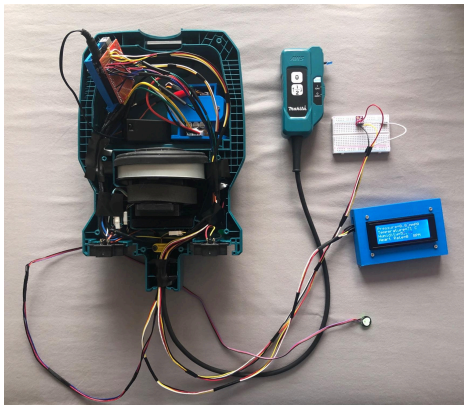

Figure 1: Makita Portable Vacuum used to depressurize the suit.

Figure 2: Suit with vacuum hose entry.