# PRIMATE PORTAL: A MODULAR TOUCHSCREEN-BASED DEVICE FOR IN-CAGE MACAQUE BEHAVIORAL TRAINING


**Team: Logan Olivera, Sameer Bhatt, Kalob Kimmel, Charlie Fischesser, Jackson Stewart, Andrew Dirkse**

Client: Prof. David Herzfeld, Department of Neuroscience, UW–Madison

Advisor: Prof. Dhananjay Bhaskar, Department of Biomedical Engineering, UW–Madison


December 5, 2025

## Abstract


The goal for primate portal is to create a modular in-cage positive reinforcement device to train Rhesus Macaque. Training is currently overseen by researchers and takes many hours of in person time for the researchers to collect data and ensure the trials are done correctly. The Primate Portal allows for this training to be automated in the primate's home environment, and it lets the researchers reallocate their time to other areas of research. This is done through an in-cage mounted touchscreen that provides trials and supplies the primate with juice when a trial is completed correctly. If a trial has an incorrect input there is no reinforcement, and a new trial is run. The casing was stress tested in SolidWorks, the software was tested for completion accuracy, and the pump was tested for volume output. Results were satisfactory with all values within tolerance, and no malfunctions occurred with device when tested with humans.


## Background and Motivation

**Project Statement:**

There is a desire for a safe, modular, and automated NHP training system that uses positive reinforcement to deliver rewards for completing cognitive tasks to research further about the complex cognitive systems of NHPs. The system must be easy to use, inexpensive, easily detachable for use with different cage units, compatible with the NHPs' home environment, and flexible for modifications and improvements in the future.

**Background/Motivation:**

- Client: David Herzfeld, neuroscience professor [1]
  - Studies how neural circuits control complex behaviors
- Non-human primates (NHPs) commonly trained by neuroscientists to complete behavioral tasks
  - In-cage training decreases NHP stress and need for researcher supervision
- Competing design: Primate In-Cage Training System by THOMAS Recording [2]
  - Expensive (~$100,000)
  - Limited extensibility

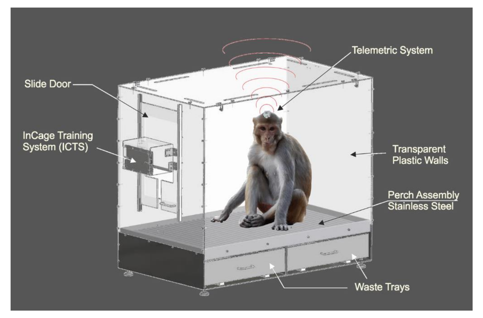

Figure 1: Model of Primate Training

## Design Specifications

**Client Requirements:**

Dispense juice after successful task, Protect electronics, Waterproof, Sturdy

**Performance Requirements:**

- Used daily, lasts 3-5 years in use or 10 years in storage, very accurate.
- Needs to follow IEC 61010-1 safety guidelines and have an IP 64 rating.
- Must be waterproof, light, and easy to remove.
- Must comply with IEC 60601 and Animal Welfare Act Regulations.

**Competition:**

- The Thomas RECORDING's InCage Training System (ICTS), $100,000

**Cost:**

- All materials cost roughly $1300.

## References


[1] D. Herzfeld. "Welcome to the Herzfeld Lab." Herzfeld Lab. Accessed: December 3, 2025. [Online.] Available: https://herzfeldlab.neuro.wisc.edu
[2] Thomas RECORDING. "Thomas InCage Training System." Thomas RECORDING. Accessed: October 11, 2025. [Online.] Available: https://www.thomasrecording.com/thomas-incage-training-system-icts
[3] Intertek, "IEC 61010 – Safety requirements for electrical equipment for measurement, control, and laboratory use," *Intertek*, 2025. [Online]. Available: https://www.intertek.com/medical/iec-61010/. [Accessed: 18-Sep-2025].
[4] International Electrotechnical Commission, *IEC 61010-1:2010, Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*, 3rd ed., Geneva, Switzerland: IEC, 2010. [Online]. Available: https://webstore.iec.ch/en/publication/4279. [Accessed: 18-Sep-2025].
[5] U.S. Department of Agriculture, "9 CFR Part 3, Subpart D – Specifications for the Humane Handling, Care, Treatment, and Transportation of Nonhuman Primates," *Electronic Code of Federal Regulations*, 1991. [Online]. Available: https://www.ecfr.gov/current/title-9/chapter-I/subchapter-A/part-3/subpart-D. [Accessed: 18-Sep-2025].
[6] Allentown, Inc., "Large animal housing – Primate," *Allentown, Inc.*, 2025. [Online]. Available: https://www.allentowninc.com/large-animal-housing/primate/. [Accessed: 18-Sep-2025].
[7] University Committee on Animal Resources, "Policy on Macaque Food and Water Restriction," *University of Rochester Medical Center*, 2016. [Online]. Available: https://www.urmc.rochester.edu/medialibraries/urmcmedia/ucar/policies/documents/macaquefoodandwaterrestriction.pdf. [Accessed: 18-Sep-2025].
[8] L. J. Capitanio and S. J. Emborg, "Contributions of non-human primates to neuroscience research," *Lancet Neurology*, vol. 17, no. 12, pp. 1129–1140, Dec. 2018. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/29708048/. [Accessed: 18-Sep-2025].
[9] Beetronics, "12-inch touchscreen monitor," *Beetronics*, 2025. [Online]. Available: https://www.beetronics.com/12-inch-touchscreen. [Accessed: 18-Sep-2025].
[10] Legal Information Institute, "9 CFR § 3.89 – Feeding," *Cornell Law School*, 2025. [Online]. Available: https://www.law.cornell.edu/cfr/text/9/3.89. [Accessed: 18-Sep-2025].


## Final Design

**Physical Design:**

- Touchscreen placed inside 3D-printed case and locked in via front panel
- Pegs on the back to attach to the cage

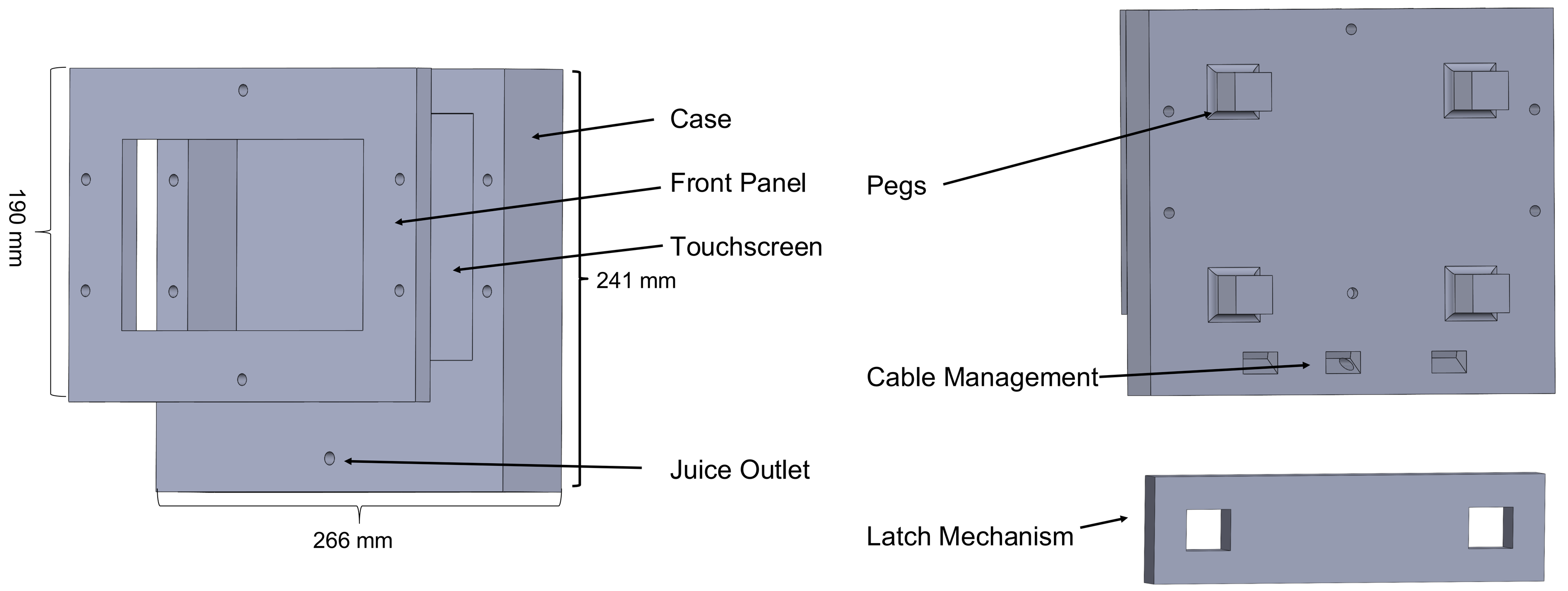

Figure 2: CAD Model of Primate Portal Enclosure

**Electronics:**

- Raspberry Pi controls circuit
- Greentouch Touchscreen is IP65 water resistant, scratch resistant, and impact resistant (figure 3)
- Figure 4 shows the hardware diagram of the primate portal system

Figure 3: Greentouch Touchscreen

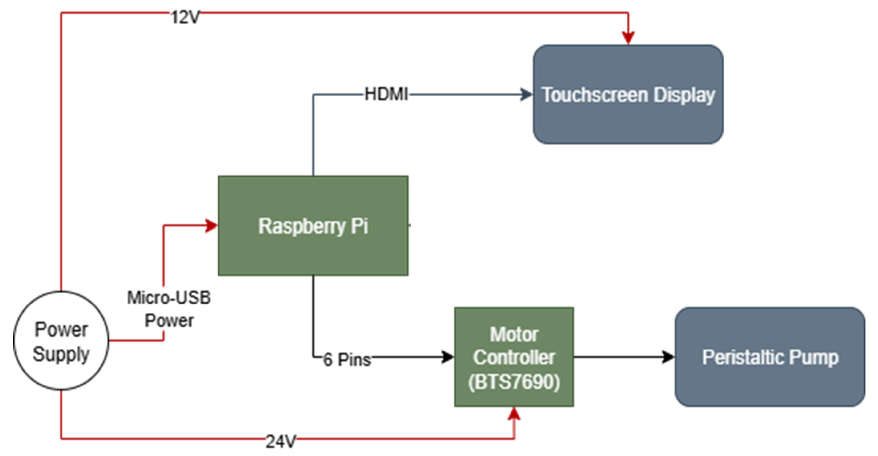

Figure 4: Hardware Diagram

## Testing

**SolidWorks Testing:**

- SolidWorks testing was enacted on the case holding bars where the force will be concentrated. This simulates possible points of failure.
- The final CAD case model was used and simulated as the material PETG.
- A vertical stress load was applied on the surface of the case holding bars to simulate weight, forces from the NHP, and forces from removal.

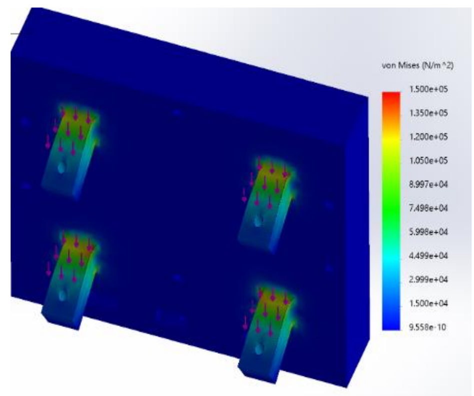
Figure 5: CAD Failure Testing

**Pump Calibration Testing:**

- The system outputted varying amounts of water (1mL = 1g) as a function of time which was then measured.
- Before each trial, scale was zeroed and motor controller code changed to reflect next time period to be measured.
- All data saved in excel for further analysis in results section

**Pump Consistency Testing:**

- Once calibrated to 1mL (0.3 seconds), the testing diagram shown in figure 6 was set up
- 1mL of liquid was pumped with the weight of liquid and current of the pump recorded
- This process was repeated 50 times to understand how consistently the pump will work

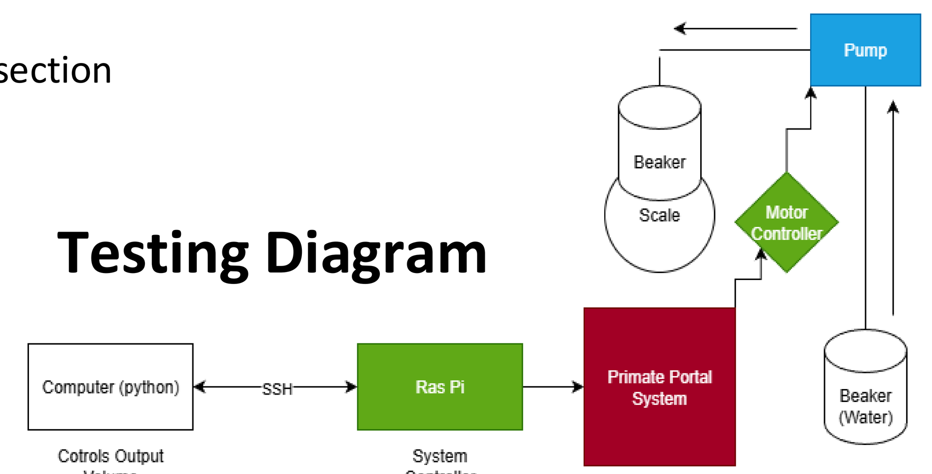

Figure 6: Device Testing Diagram

## Results

**SolidWorks Testing Results:**

- SolidWorks testing ended with exemplary results. As shown in figure[], the case bars receive the most stress at the joint between the case and the bar.
- The failure load is 1.5 x $10^5$ N/$m^2$. At this point, the bar deforms plastically and starts to bend at the joint, slowly working its way up the bar.
- The maximum load the case is expected to carry is 88 newtons. This means that over the 0.00129 meters squared that the force is distributed there is a maximum expected stress of 6.89 x $10^4$ Pa. This gives us a FOS of 2.18.

**Calibration Results:**

- The data collected from the calibration testing was used to create a calibration curve, correlating time the pump was running to volume in mL of water pumped (figure x).
- Linear Least-Squares fit applied to find 1mL ~ 0.3 seconds

**Pump Consistency Results:**

- The 50 trials resulted in the histogram and box plot shown in figure x.
- Mean output volume = 0.982mL, Standard Deviation = 0.0397mL
- Percent Error from 1mL = -1.838%

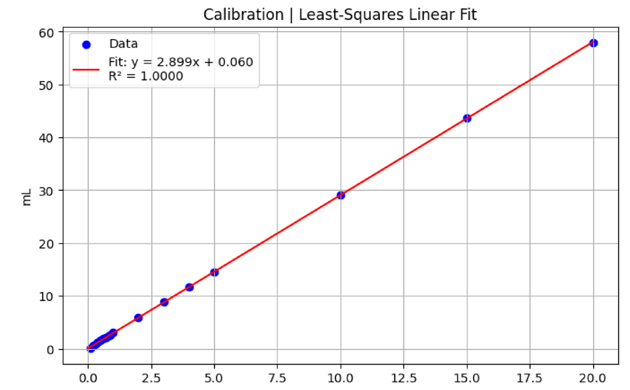

Figure 7: Calibration Curve

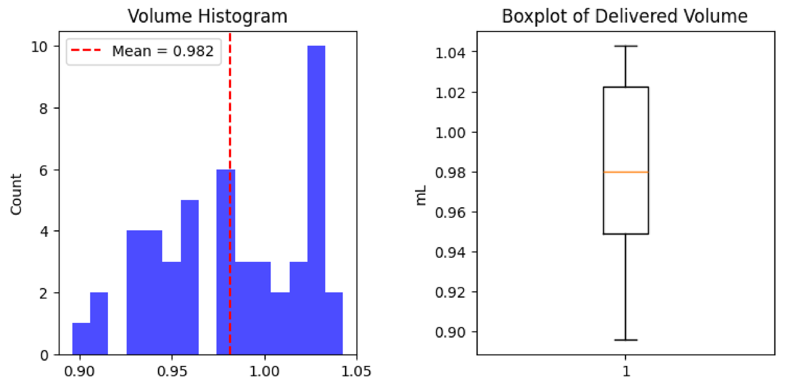

Figure 8: Pump Consistency Plots

## Future Work and Conclusion

**Future Work:**

- Magnetic interlock for easier detachability
- Self calibrating pump output in mL for better results and functionality
- Create the frame out of stainless steel for stronger structural integrity
- Begin animal trials
- Eye tracker for more advanced animal trials and research

**Conclusion:**

- Our team was successful in creating a final product that had positive testing results and functioned properly.
- The device can be easily detached and reused in different training environments.
- The initial pump was swapped as it was not working for a cheaper option for a last minute switch.
- The device is made of a weaker material than steel; however, this material is strong enough for little to none deformation when undergoing testing.

## Acknowledgements


The team would like to thank Dr. Bhaskar for his guidance and support, Dr. Herzfeld for his flexibility and involvement in the project, and Dr. Puccinelli along with BME department for making this project possible.