Department of MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

Portable Step Trainer

Yara Ahmed, Carson Martines, Julia Metivier, Melissa Srey, Ellie Vail, Natalie Vu
Advisor: Dr. Erika Pliner

Introduction

Aging populations and others with mobility issues face a high risk of trips and falls due to unexpected hazards in their environments. There aren't many resources available to them to be able to prepare themselves for these hazards and know how to respond quickly.

Project Objective

Design a portable step trainer to be utilized as a tool that can improve reaction times and improve lower limb mobility to better handle hazards.

To create a safe product, we needed to meet the metrics below.

- Must be able to withstand 225 lbs (1000 N) of force.
- Low profile to not be a tripping hazard.
- Light and portable so it can be easily transported in a rehabilitation facility or to the user's home.
- Non-slip on the bottom and top.

Figure 1: Image of a user stepping on the step trainer (left) and a closeup of the step trainer (right).

Methods

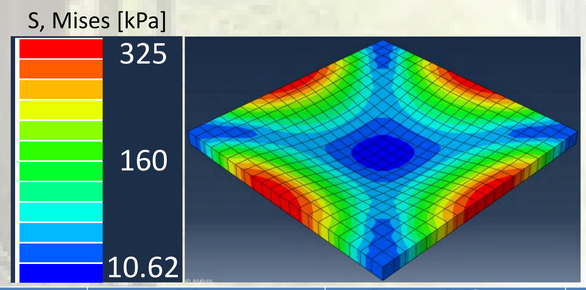
Once manufacturing began, we 3D printed various components to allow iterating for optimal design. Once the design was finalized, we moved forward in manufacturing a second step trainer and printing finalized pieces with higher strength.

Design Requirement	Target Value	Achieved Value
Bear most people's weights	> 1000N	1190N
Low profile to avoid injury	< 3 cm	2.7 cm
Simple user interface	< 10 buttons	5 buttons
Lightweight	< 2 kg	0.895 kg
Low energy usage	< 10 V	9.6 V

Table 1: Step trainer design meets all measurable target metrics.

Testing Results

We conducted various tests to ensure that the top plate of the step trainer wouldn't fail under normal use and misuse cases, which verified the step trainer could take at least 1100 N of force. We utilized finite element analysis to approximate the amount of stress the top plate would experience. Our results show a maximum stress of 325 kPa.



# of Elements	Max. Displacement	Max. Mises Stress	Scale Factor
196	1.17 cm	309.85 kPa	1.515
324	1.41 cm	322.33 kPa	1.262
441	1.47 cm	324.88 kPa	1.202

Table 2: Finite element analysis (FEA) which validates our design.

The following has also been verified by user testing:

- Overall user friendliness,
- accommodation for colorblindness,
- accommodating most shoe sizes,
- is portable,

and other accessibility considerations.

Final Design

The final design is as follows:

- 19 x 19 x 2.2 cm aluminum base
- 0.318 cm thick acrylic top plate for stepping, suspended by a pair of springs at each corner
- Eight buttons are under the acrylic plate to sense stepping
- LED matrix to turn blue (step on), red ("trick" light), or rainbow (end of session)
- Separate 3D-printed box to house most electric components: an LCD display, three buttons for different difficulties (green for easy, yellow for medium, red for hard), and one black button to reset the session

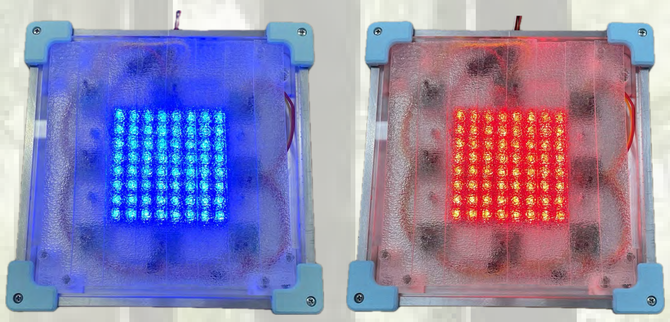


Figure 2: Step trainer lights up blue (left) indicating to step and red (right) indicating to not step.

Conclusion

We are happy with the success of our project and met one of our stretch goals of making two step trainers that work together. We also stayed underbudget and were able to use our remaining funds to buy a case for the step trainer to make transportation easier.

Acknowledgements

We would like to thank Dr. Erika Pliner for her support throughout the project. In addition, we'd like to thank the following people who helped us during our research phase: Ben and Will Lange, Luke Schumm, David Silski, Dr. Kota Takahashi, and Kyle Weinberg. Lastly, thank you to Dr. Steven Naleway and Dr. Roseanne Warren for their guidance through the ME 4000/4010 classes.