BME 301

DEPARTMENT OF

Biomedical Engineering

UNIVERSITY OF WISCONSIN–MADISON

Adaptive Rowing Machine

Preliminary Presentation February 25th, 2022

Client: Ms. Staci Quam

Advisor: Dr. John Puccinelli, Lab Section 305

Team Members

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Overview of Presentation

- Client Introduction
- Problem Statement
- Background Knowledge
- Competing Designs
- PDS
- Design Ideas and Design Matrix
- Preliminary Design
- Future Work

Client Introduction

- Ms. Staci Quam
- Mechanical Engineer and Biomech Lab Lead at Johnson Health Tech

[1][2]

Problem Statement

- Individuals in wheelchairs have trouble utilizing exercise equipment
- Improvement needed for accessibility to adapted machines
- A standard Matrix rowing machine [3] will be adapted
- User safety must be ensured during interactions

[3]

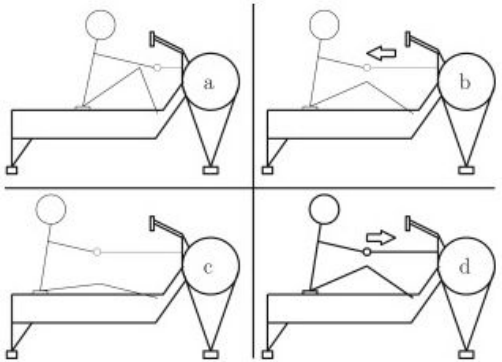
Motivation

- Exercise machines at fitness centers lack adaptive equipment [4]
- Some adaptive machines force users to leave wheelchairs [4]
- Reversible ergometers not found readily in the market. Concept 2 has ability to permanently switch to adapted form [5]

[5]

Physiological Research

- Wheelchair users engage upper body and shoulder complex through daily activities [6]
- Pain in shoulder region is a common complaint [6]
- Consistent exercise is essential to prevent pain [6]
- A rowing exercise activates numerous muscle groups [7]
- 4 phases of the exercise [8]:
  - Catch (a)
  - Drive (b)
  - Finish (c)
  - Recovery (d)



[9]

Competing Designs: Adaptive Rowing Machine (AROW)

- Designed by researchers at BCIT
- Specifically for Concept 2
- Design and fabrication instructions are free

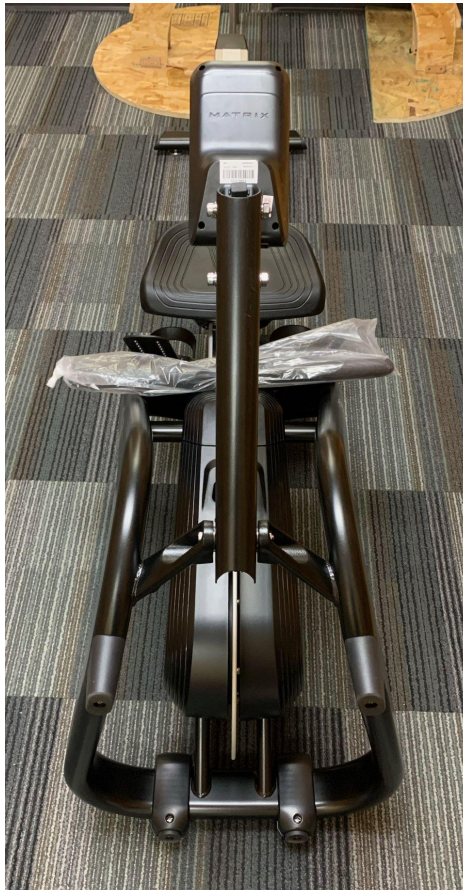
[5]

Product Design Specifications

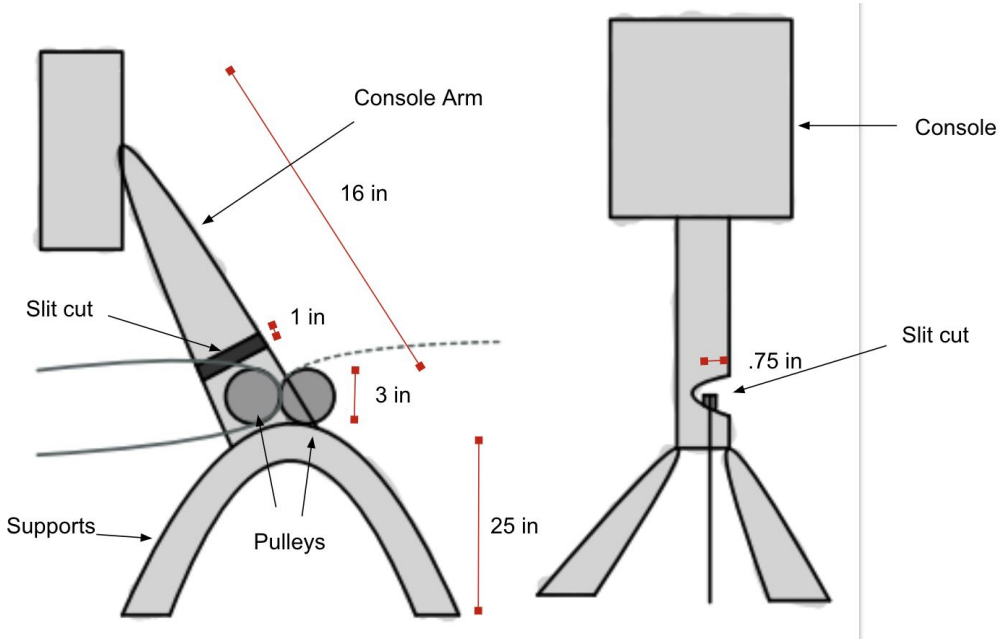
- Minimal outside assistance
- Withstands at least 10 years of usage - 8 million meters [10]
- Adaptations allow users to stay in wheelchair
- Normal rowing motion is preserved - 4 rowing phases
- Safety mechanisms to prevent tipping
- Ideally, the ergometer can be adjusted for usage by non-wheelchair individuals
- $200 R&D budget

Matrix Rower

[3]



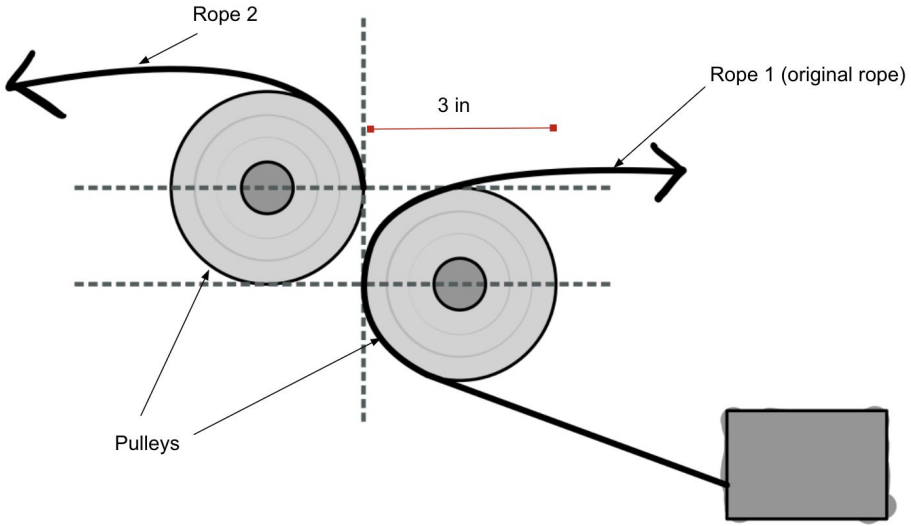
Pulley Design 1: 2 Pulleys with Slit



Note: Drawings not to scale

- Use 2 pulleys at same height
- Slit cut into console arm allows for transition of rope
- Only uses 1 rope, so requires moving the rope from one side to the other

Pulley Design 2: 2 Pulleys With 2 Ropes



Note: Drawings not to scale

- Uses 2 pulleys
- Includes 2 ropes and 2 handlebars, one on regular side and one on adaptive side
- Would require adding another coiling mechanism for the second rope

Pulley Design Criteria

Higher Weighting

Lower Weighting

User Stability / Safety (25%)

Ease of Fabrication (25%)

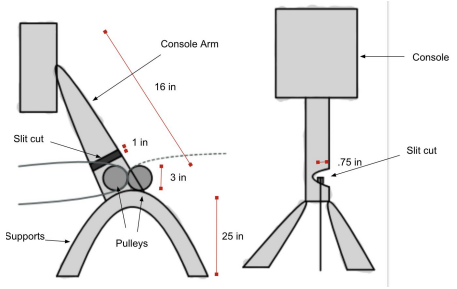
Ease of Use / Ergonomics (20%)

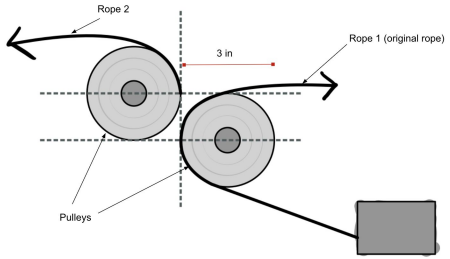
Versatility (10%)

Durability (10%)

Cost (10%)

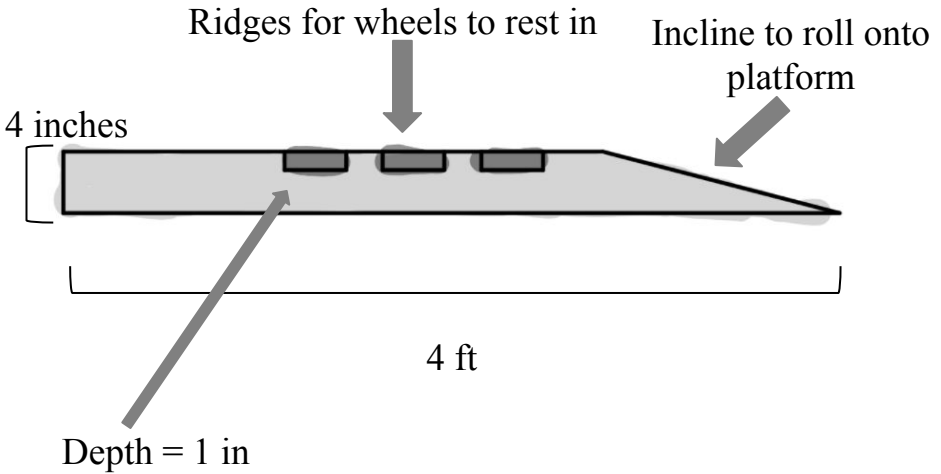
Design Matrix For Pulleys





Criteria	2 Pulleys With Slit		2 Pulleys With 2 Ropes	
User Stability / Safety (25%)	4/5	20	5/5	25
Ease of Fabrication (25%)	4/5	20	2/5	10
Ease of Use / Ergonomics (20%)	4/5	16	5/5	20
Versatility (10%)	5/5	10	5/5	10
Durability (10%)	5/5	10	5/5	10
Cost (10%)	5/5	10	3/5	6
Total	**86**		**81**	

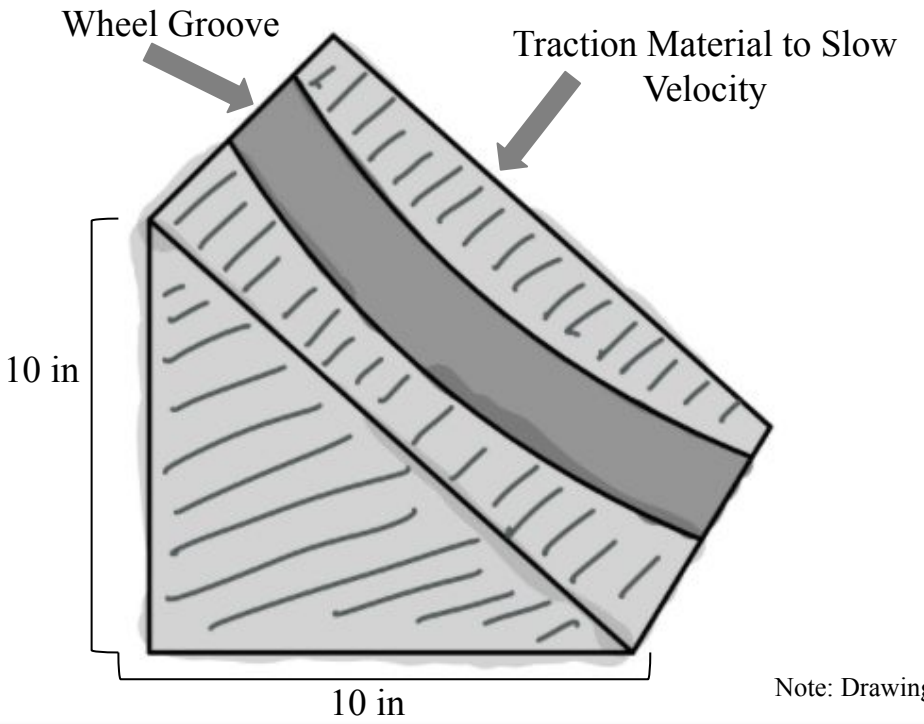
Stability Design 1: Highway Ridges



Note: Drawings not to scale

- Similar to current designs at Johnson Health Tech
- Least complex to fabricate
- Easy for user to roll up into platform ridges
- Possibly less effective at preventing forward/backward tipping

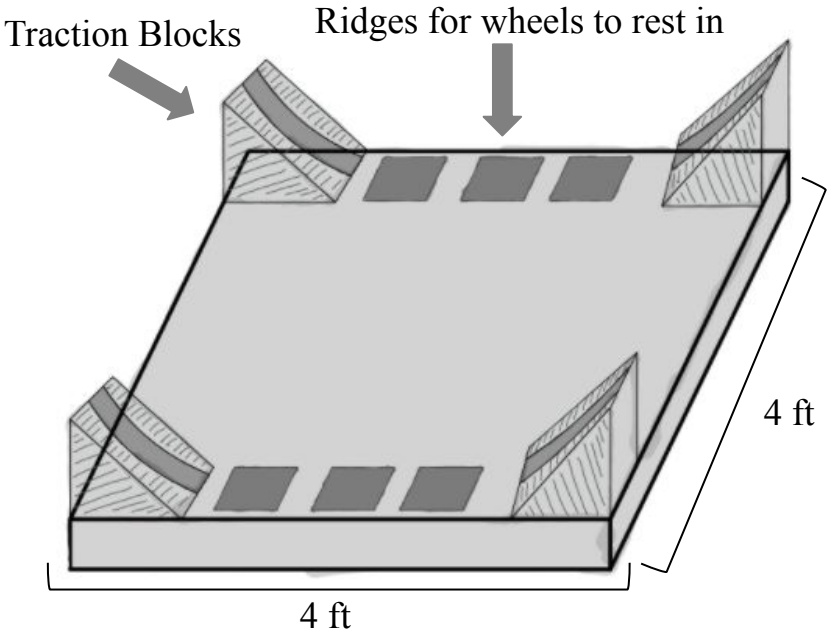
Stability Design 2: Traction Blocks



- Allows for "recoil" motion to prevent forward/backward tipping
- More complex fabrication due addition of traction material
- Requires outside assistance to insert blocks once user in place

Note: Drawings not to scale

Stability Design 3: Combined Design



Note: Drawings not to scale

- Prevents forward/backward rotation
- Most costly and complex to fabricate
- Possible redundancy in preventing translation
- Requires outside assistance to insert traction blocks

Stability Design Criteria

Higher Weighting

Lower Weighting

User Stability / Safety (25%)

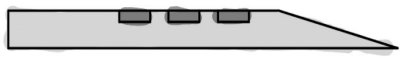
Ease of Fabrication (25%)

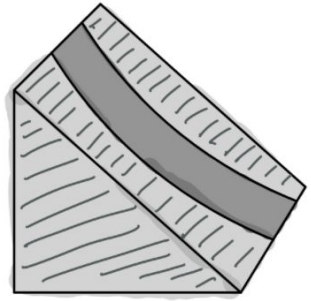
Ease of Use / Ergonomics (20%)

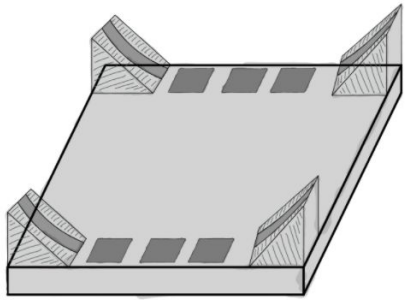
Durability (15%)

Cost (15%)

Design Matrix

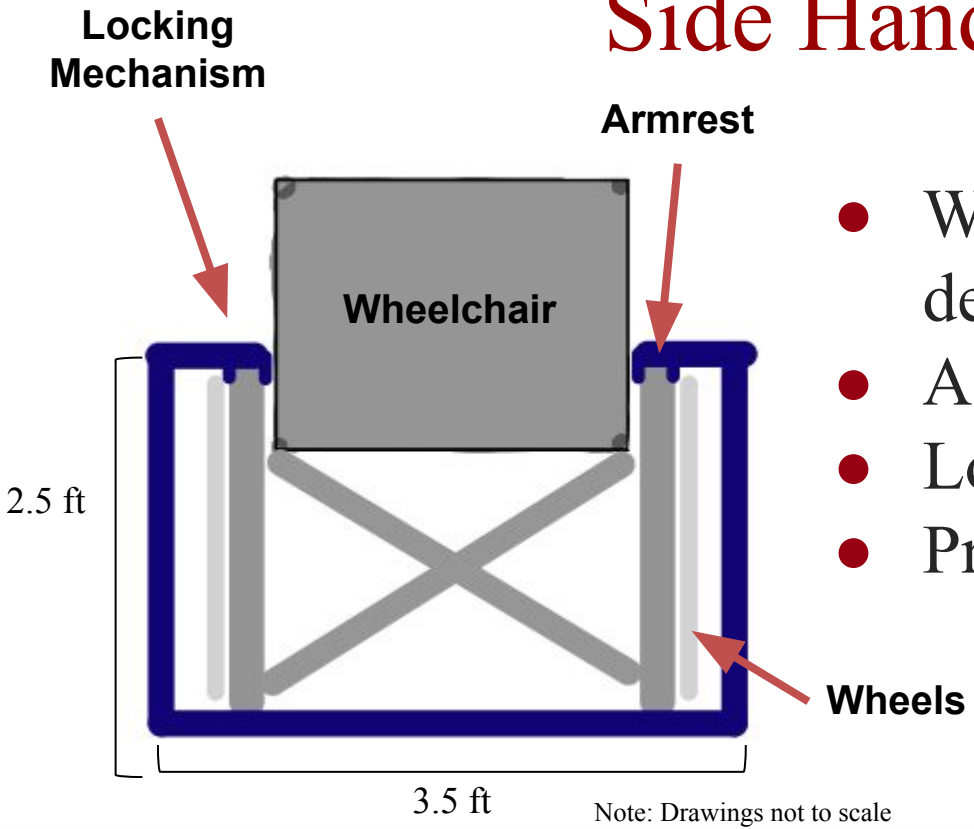






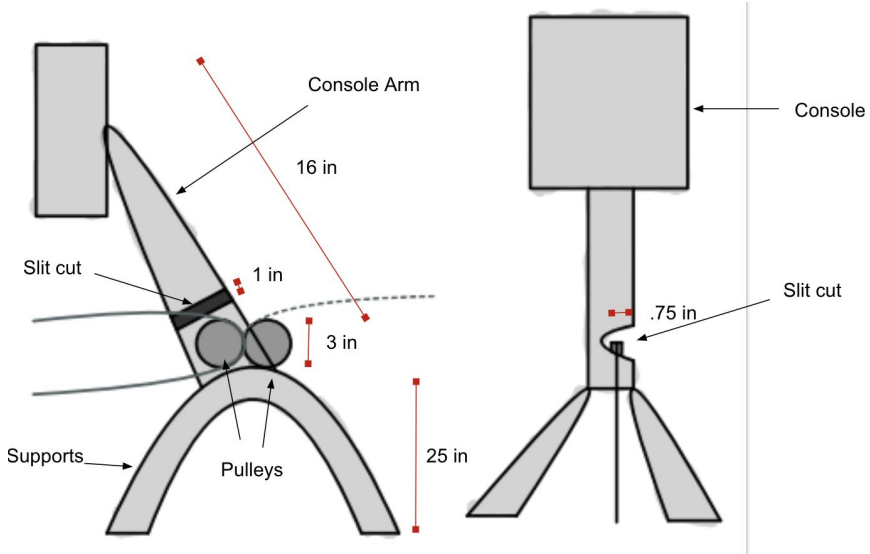
Criteria	Highway Ridges		Traction Blocks		Combined Design	
User Stability / Safety (25%)	4/5	20	4/5	20	5/5	25
Ease of Fabrication (25%)	5/5	25	4/5	20	3/5	15
Ease of Use / Ergonomics (20%)	5/5	20	3/5	12	3/5	12
Durability (15%)	5/5	15	4/5	12	4/5	12
Cost (15%)	5/5	15	4/5	12	3/5	9
Total	**95**		**76**		**73**	

Side Handle Bars

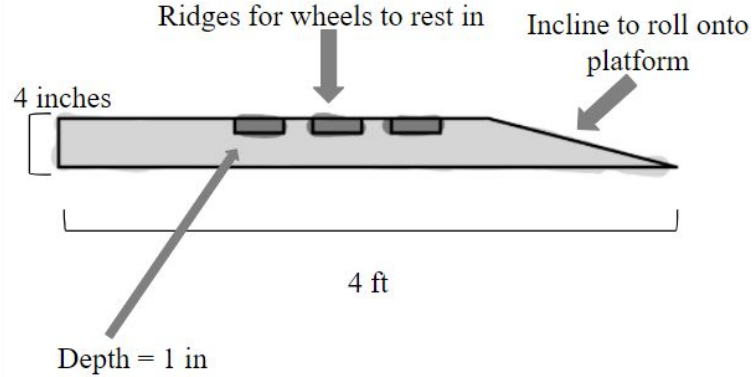


- Will be used in tangent with other designs
- Additional support
- Locks into armrests of wheelchair
- Prevents lateral rotation/tipping

Preliminary Design



- 2 Pulleys With Slit
  - Ergonomics and affordability
- Highway Ridges
  - Ease of fabrication/use



Future Work

- Create CAD files of final designs
- Present designs to client for approval
- Source materials (JHT materials)
- Begin fabrication

Acknowledgements

Thank you to our advisor and teacher - Dr. Puccinelli

Thank you to our client - Ms. Staci Quam

References

[1]“Johnson Health Tech North America,” Facebook. [Online]. Available: https://www.facebook.com/JHTNA/. [Accessed: 23-Feb-2022].
[2] “Matrix fitness,” *Matrix Fitness*. [Online]. Available: https://matrixhomefitness.com/. [Accessed: 23-Feb-2022].
[3]“Rower | Matrix Fitness - United States.” https://matrixfitness.com/us/eng/group-training/cardio/rower (accessed Feb. 07, 2022).
[4] J. H. Rimmer, B. Riley, E. Wang, A. Rauworth, and J. Jurkowski, “Physical activity participation among persons with disabilities: Barriers and facilitators,” American Journal of Preventive Medicine, vol. 26, no. 5, pp. 419–425, Jun. 2004, doi: 10.1016/j.amepre.2004.02.002.
[5] “Rowing Solutions – Adapted Rowing Machine (AROW).” https://adaptederg.commons.bcit.ca/rowing-solutions/ (accessed Feb. 07, 2022).
[6] O. W. Heyward, R. J. K. Vegter, S. de Groot, and L. H. V. van der Woude, “Shoulder complaints in wheelchair athletes: A systematic review,” PLOS ONE, vol. 12, no. 11, p. e0188410, Nov. 2017, doi: 10.1371/journal.pone.0188410.
[7] David, “Muscles used,” Concept2, 26-Jul-2021. [Online]. Available: https://www.concept2.com/indoor-rowers/training/muscles-used. [Accessed: 04-Feb-2022].
[8] N. Caplan, A. Coppel, and T. Gardner, “A review of propulsive mechanisms in rowing,” Proceedings of The Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, vol. 224, pp. 1–8, Mar. 2010, doi: 10.1243/17543371JSET38.
[9]H. De las Casas, K. Kleis, H. Richter, K. Sparks, and A. van den Bogert, “Eccentric training with a powered rowing machine,” Medicine in Novel Technology and Devices, vol. 2, p. 100008, Jun. 2019, doi: 10.1016/j.medntd.2019.100008.
[10]“How Long Will A Concept 2 Rowing Machine Last? - Rowing Machine 101.” http://rowingmachine101.com/concept-2-rowing-machine-lifespan/ (accessed Feb. 09, 2022).