



Developing a Countermeasure Device for the Negative Effects of Microgravity on the Body - Part I

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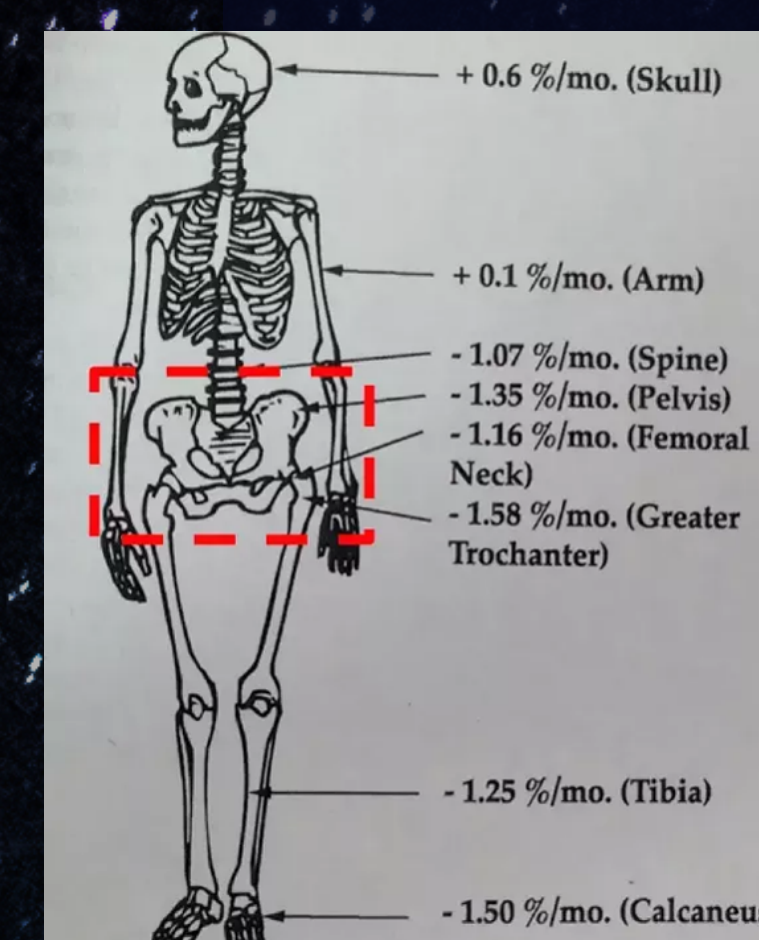
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Objective

The purpose of this project is to optimize a design that combines the benefits of flywheel and band resistance to maximize the amount of muscle fatigue acquired while performing plyometric, resistive exercise. In weight training fatigue is an indication of hypertrophy which leads to an increase in muscle mass and strength. Consistent exercise can combat the inevitable muscular atrophy and loss of bone mineral density that occurs during long term exposure to microgravity environments.

Outer Orbit

All life on Earth has adapted to the constant force that is exerted by our planet's gravitational pull. Microgravity is the sensation of weightlessness that occurs when exposed to an environment with gravity that is much weaker than that of Earth[1]. During long term exposure to microgravity environments, the body is prone to muscle atrophy and a decrease in bone mineral density.



Depiction of non-uniform loss of bone density throughout the body [2].



NASA flight engineer Rick Mastracchio carried to medical tent upon returning to Earth[4]

Prolonged rehabilitation is an unavoidable consequence of returning to earth after long term exposure to microgravity environments[3]. Consistent exercise can help minimize bone loss and muscle atrophy, decreasing rehabilitation time upon returning to Earth.

Design Objectives

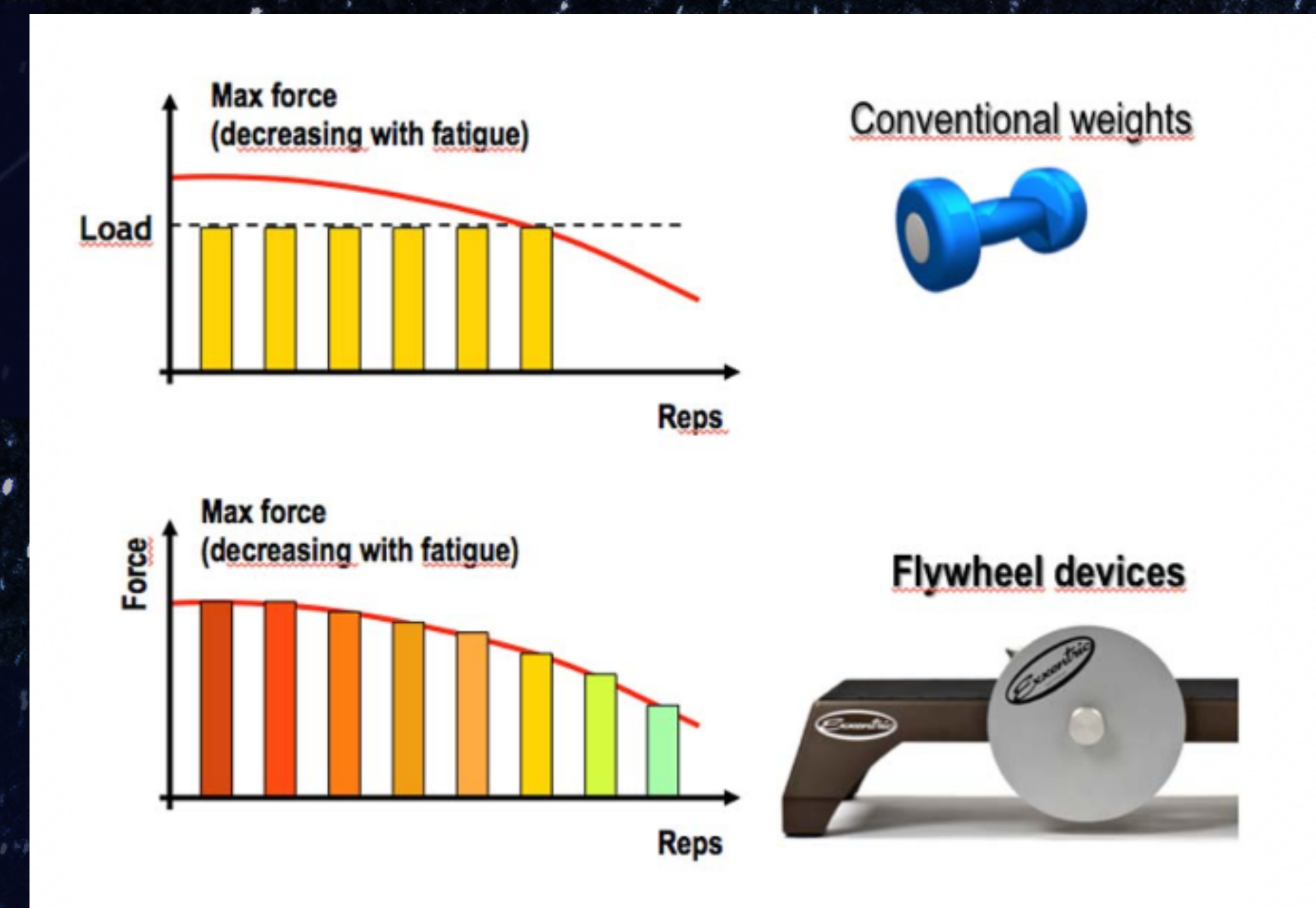
- Compact-able
- Versatility
- Cost Efficient
- Ease of use
- Safety
- No external power source



Advanced Resistive Exercise Device (ARED)[5]

Flywheel vs Band Resistance

Flywheel Resistance



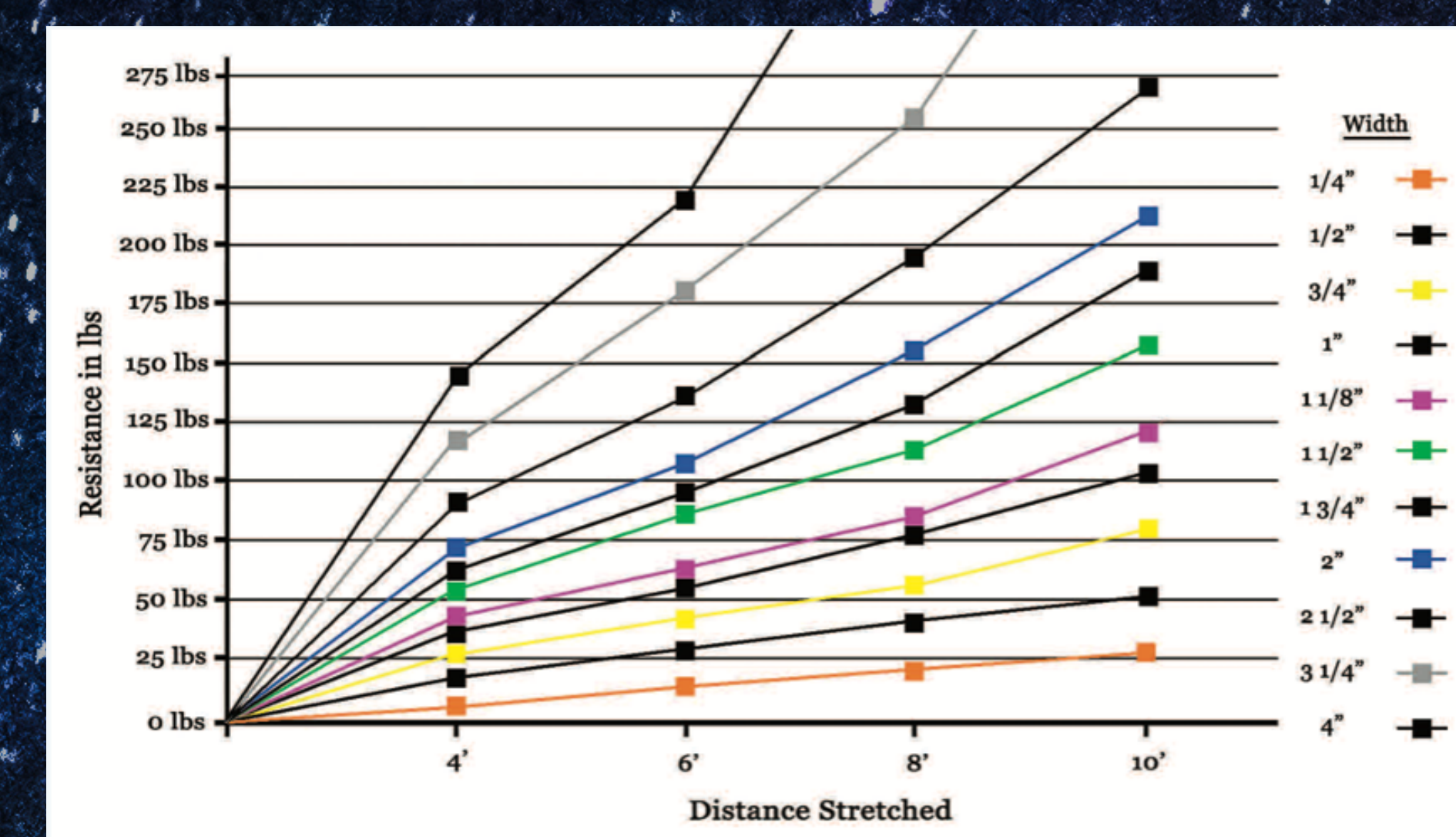
Flywheel Resistance vs Conventional weight training as fatigue occurs [6]

- Flywheels provide resistance based on the principle of rotary inertia
- Resistance is generated as the flywheel is accelerated during the concentric muscle contraction.
- Resistance is also generated when decelerating the flywheel during the eccentric motion of the exercise.
- 100% compliant dynamic resistance throughout exercise
- Unlike conventional weight training, flywheels provide resistance that is independent of gravity.



Example of a flywheel resistance exercise device[8].

Band Resistance



Band resistance vs distance stretched for different thickness bands [7]

- Resistance bands provide a force in response to being stretched
- The more the band is stretched, the greater the resistance it provides
- The resistance increases more drastically the further the band is stretched
- This force can be approximated with Hooke's Law when looking at a small change in distance stretched.
- Like flywheel resistance, band resistance provides resistance that is independent of gravity.



Vertimax band resistance platform [9]

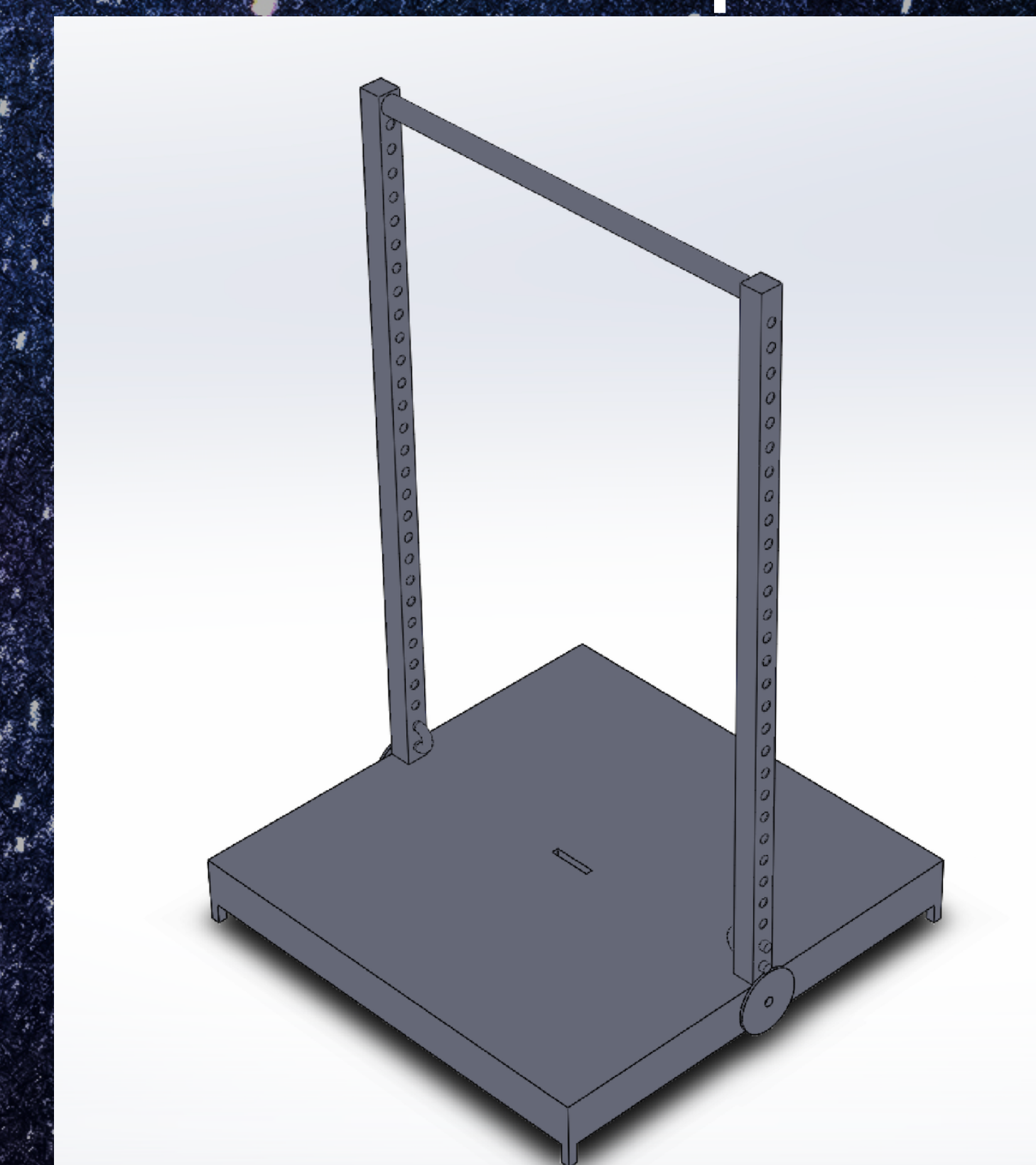
Future work - Part II Testing

- A Range of Resistance bands will be tested in order to find an approximation for Hooke's constant K that meets the design needs when an expected elongation of the band is executed.
- The bands will need to provide a force that meets the exercise requirement when combined with the resistance provided by the flywheel.
- A prototype flywheel mechanism will be constructed to test the resistance experienced when different sized disks are used.
- Once the optimal ratio between flywheel and band resistance is determined materials for final prototype can be ordered.

Design

- The final goal of this project is to design a testable prototype that allows the user to perform a variety of exercises.

Concept



Prototype Testing

- Once prototyped, the machine will be taken to the kinesiology lab in New Hampshire Hall for testing.
- Test subject strength will be measured before and after exercise.
- If results yield that the subject admits less torque after the workout is completed, it can be deduced that muscle fatigue has taken place.
- Muscle fatigue is an indicator that muscle has been overloaded and stressed during exercise.

References

[1] D. Harland, "Microgravity," Encyclopedia Britannica. [Online]. Available: [2] R. Frost, "Is it true that astronauts in space lose on average 1% of their bone mass a month? If so, then what causes that?," quora.com, 18-Aug-2017. [Online]. [3] "NASA: Exercising in Space," nasa.tumblr.com, 05-Jun-2016. [Online]. [4] <https://res.cloudinary.com/jerrick/image/upload/v16011024/pzm601vtuvj24efq8qy3.jpg> (online) [5] https://www.nasa.gov/images/content/67708main_16s030603005_full.jpg (online) [6] <https://www.freelapusa.com/what-every-athlete-ought-to-know-about-flywheel-training/> (online) [7] <https://www.performbetter.com/First-Place-Superbands?#page=2> (online) [8] [https://www.researchgate.net/profile/Ernest-Baiget/publication/330202985/figure/fig7/AS:712475112652801@154687872117/Flywheel-parallel-equat-lef-A-and-right-B-Fcet-should-be-maintained-flat-over-the-pn\(online\)](https://www.researchgate.net/profile/Ernest-Baiget/publication/330202985/figure/fig7/AS:712475112652801@154687872117/Flywheel-parallel-equat-lef-A-and-right-B-Fcet-should-be-maintained-flat-over-the-pn(online)) [9] [https://lh3.googleusercontent.com/pr0xy/OjkdSIg-Cn105Hx_Fx_3Fsn8xSYhC3F883at58aMLngL8e25FmYUedxT_tzhYcSLWwYwm-3302NA92Gb_RWZU6YBalyQSDqETKH8B2z7uZ6GODBihGwA\(online\)](https://lh3.googleusercontent.com/pr0xy/OjkdSIg-Cn105Hx_Fx_3Fsn8xSYhC3F883at58aMLngL8e25FmYUedxT_tzhYcSLWwYwm-3302NA92Gb_RWZU6YBalyQSDqETKH8B2z7uZ6GODBihGwA(online))