Rope Climbing Machine

Smokin' Joe

PROBLEM STATEMENT

Joe Anderson, an entrepreneur in Niagara Falls, NY, is involved in various industries and has connections with the Department of Defense, athletic trainers, and professional athletes. He values exercise for healthy development and disabled veterans. The team must design, build, and optimize a velocity limiting device and load adjustment mechanism for a rope-based exercise machine. They must work with the sponsor to patent modifications and reduce safety issues

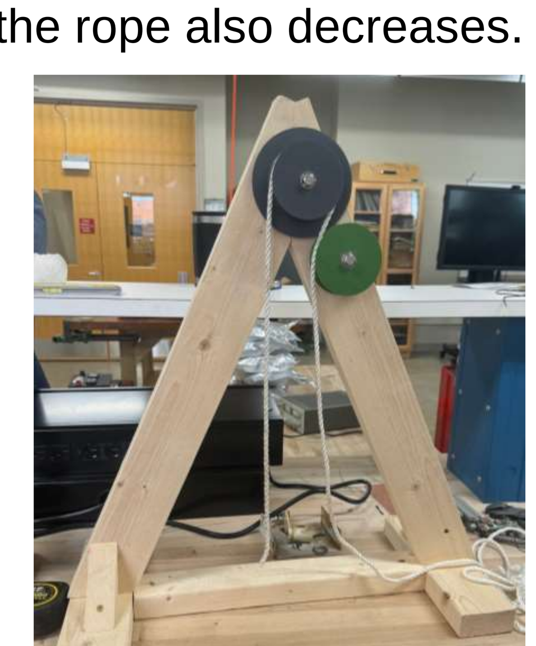
The machine will be mass-produced for gyms, military, and other customers, so a manufacturing plan must be developed for any vendor.

REQUIREMENTS

#	Description
1	The seat must lower when the rope is released in a controlled manner with user weights from 50 to 350 pounds.
2	The resistance on the rope is adjustable from no extra resistance to added resistance of 1.5 times the user's bodyweight.
3	The machine cannot be altered to utilize a continuous rope.
4	The seat is limited to a total displacement of 5 feet.
5	The shuttle and caps must be designed for injection molding.
6	The team must develop a manufacturing plan.
7	The team must develop an instructional video or decal that is easily accessed by users.

CONCEPTS

The team initially proposed adding a disk brake to the pulley above the user to add resistance. A prototype was created using models of two pulleys, including one with a disk, to simulate the braking mechanism. However, the team discovered that the disk brake idea would not satisfy project requirements as the rope would slip before achieving satisfactory resistance. This is because resistance depends on the tension in the rope, and as the user's weight decreases, the tension in the rope also decreases.



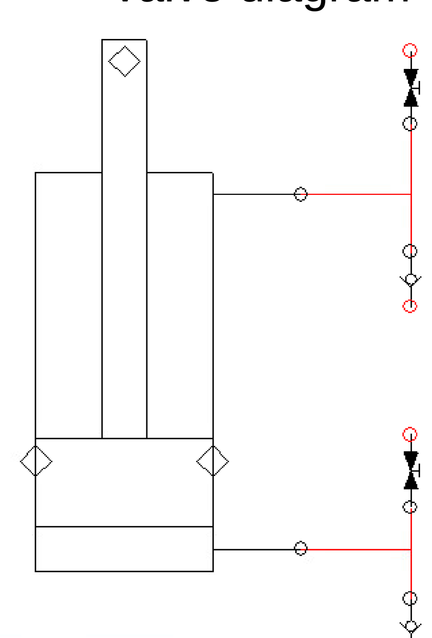
The team also developed a prototype for a two-chamber shuttle system, incorporating resistance and dampening in one mechanism. They found that the final system will require a larger diameter pipe and valves for varying resistance.

FINAL DESIGN, APPROACH, PLAN

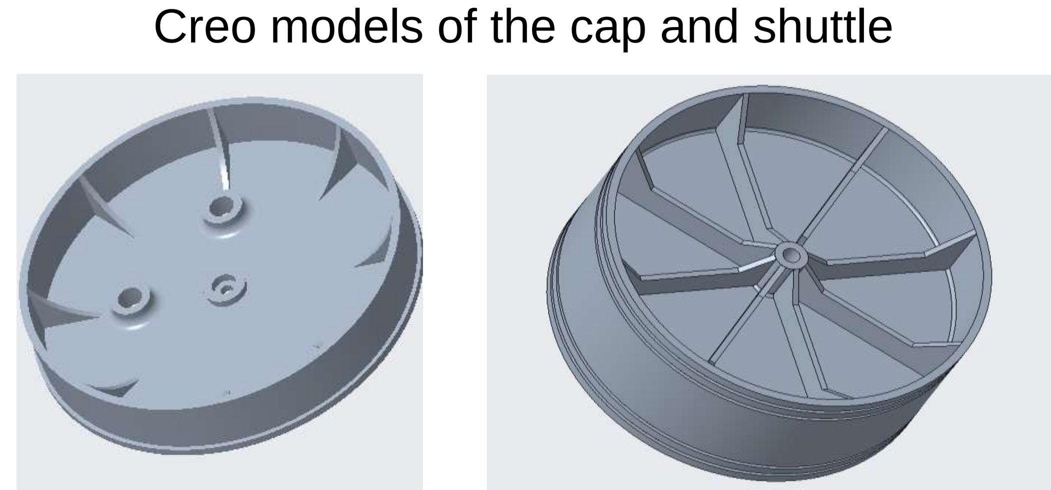
The team developed a pneumatic shuttle system to replace the existing piston and valve assembly and improve the machine's capabilities. The shuttle system connects to the chair via cables and pullies. Using a 2:1 pulley ratio, the shuttle moves at twice the rate of the chair. This compresses the air inside of the cylinder at half of the chair's displacement allowing the system to build pressure faster.

The system allows the user to control resistance by varying the flow of air in and out of the cylinder with adjustable needle valves. When the chair is lowered, the shuttle moves up and compresses the air in the upper chamber, while when raised, it moves down and compresses the air in the lower chamber. One-way valves allow air to flow back into the low-pressure chamber.

Valve diagram



Creo models of the cap and shuttle



RESULTS

Upon complete assembly, the team tested the variable resistance on the climb, the controlled descent, and the ability of the seat to lower on its own. During testing, the team found that the adjustable needle valves did not contribute enough variability to produce a noticeable difference in resistance. In addition, despite all efforts to reduce friction, the seat was unable to consistently lower without an external force being applied due to the amount of friction remaining in the system.

SUMMARY AND CONCLUSIONS

The team has developed a modified machine that improves the performance and functionally by reducing friction and adding valves and redesigning the pneumatic piston in order to give the machine adjustable resistance.

They installed ball bearings into the pulleys by machining a pocket into the original pulleys and pressing in new bearing so new pullies did not have to be purchased.

The team designed and implemented a pneumatic shuttle assembly to replace the existing piston. The shuttle is a short cylinder with an outer diameter slightly smaller than the inside diameter of the cylinder. It has O-rings on the top and bottom to prevent air passing by. It uses a threaded rod with eye-nuts for reinforcement and as connection points for the cable. The shuttle was 3D printed but was designed to be injection molded for future mass production.

The team has designed end caps that are a press fit to seal the end of the cylinder. They were also 3D printed but designed to be injection molded. The caps have a recess in the center to allow for a press in seal to prevent air from escaping through the hole for the cable. They also have two bungs to allow for ½" NPT pneumatic fittings to connect the valve that control resistance

Valves were added to allow the user to control the resistance by varying the flow of air in and out of the cylinder using a series of adjustable needle valves and low-pressure check valves connected to the caps.

The machine's frame was modified to keep the caps in place, reposition the pulleys, and to hold and elevate the cylinder. The team accomplished this by fabricating a square platform and an upper subframe.

FUTURE WORK

The team believes that in order for the chair to return without an external forcing being applied, the rails that the chair slide in and the pneumatic cylinder will need to be redesigned and remanufactured.

The poor surface finish inside of the cylinder is leading to high amounts of friction between the cylinder and the O-rings on the shuttle. It is also not allowing the O-rings to seal properly and air is leaking past the shuttle causing the valves to have little to no effect on resistance.

The rails that guide the chair up and down are prone to binding. The rails can contract the front and back of the rollers at the same time causing the rollers to lock up and slide instead of roll.

TEAM & ACKNOWLEDGEMENTS

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