PA Governor's STEM Competition
State Project Plan

2016

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Real World Problem

When a ramp or elevator is unavailable to complete a floor interchange, many handicapped people face the ever-treacherous task of traversing the stairs…

Current methods include learning inconvenient means: hopping, climbing, and hazardously blocking the stairwell, presenting a danger of falling. Some nursing homes and various public institutions offer only a single crowded handicap-accessible method. For businesses, accessible transport brings costs of insurance, inspection, and maintenance leading to a lack of availability. Some handicapped are limited to only one floor of their houses because they have no viable means of ascending or descending the stairs without having the installation of an expensive chairlift. The ability of converting a walker into a device that allows these people to traverse through their home and publicly without the need of an elevator or lift could open the door to a new level of enjoyment and mobility.

Community Needs and Improvements

Those handicapped from injuries or the elderly, simply having developed frail and weak legs, are in need of cheap, efficient means of climbing stairs. If their medical devices were capable of expanding and contracting at their bases, one could perform these activities without much difficulty or danger (as 70% of accidental deaths in the US are from falls).

With commercial building codes permitting a maximum rise of near seven inches, a contraction of the frontal legs of a walker could compensate to allow upward motion. Eventually, extension could be implemented for retrograde motion as well as safety locking mechanisms for increased stability. This type of modification to the walker would also pose a great increase in confidence and comfort when traversing up and down sloped grades whether it be a ramp, driveway, or earthen slope.

Engineering Process

1. Identify Problem
    a. We determined that a major issue encountered daily by a significant portion of the population has a simple possible solution.
2. Research
    a. We discovered the real scope of the problem and the feasibility of constructing a device under the given budget and time constraints. We found current designs which are flimsy or impractical by their mechanism of choice.
3. Plan
    a. We set aside time to work through this process.
        i. Brainstorming
        ii. Identifying community partners
        iii. Purchasing and measuring walker
        iv. Constructing CAD models for experimentation
        v. Purchasing adequate parts (gas springs, assembly devices, etc.)
        vi. Interviewing community partners
        vii. Initially constructing simulation plastic and working metal prototypes
        viii. Adjusting offset debacles
        ix. Allowing others to test on a pristine stairwell
4. Prototype
    a. We began by printing a scale 3D model.
    b. We moved to working on the actual walker by aligning and installing the gas springs.
    c. Between all phases, we ensured the walker would be level at an average height.
    d. Minor fabrications were required to develop prototype
        i. cutting of front legs
        ii. custom sitting of gas spring release head
        iii. 3D prototyping of specialized parts
5. Improve
    a. We thought of multiple solutions with springs and handles positioned in varying directions, but decided the simplest approach would leave the most space for the user.
    b. We fixed the alignment of the legs so walker is level on flat surfaces and stairs.
    c. Taking input from the regional competition, we reconsidered the necessity of the lower cross brace and developed a mechanism inspired by a pipe clamp to reattach it securely.
    d. Realizing the confusing and tensile danger of allowing the handles to rotate freely, we developed a slot mechanism which, together with downward tension, allows only linear motion.

Budget

Item Description	Unit Cost	Quantity	Total Cost	Use
Stair Mechanism				
Lever Releases	$25.65	**2**	$51.30	Angular motion
Release Heads	$14.62	**2**	$29.30	Activating springs
Gas Springs	$149.15	**2**	$298.30	Ascending
Walker	$36.77	**1**	$36.77	Support
3D Printed Parts ($4.62/$in^3$)				
Foot Brace	$3.42	**0.74 in^3 x 2**	$6.84	Attaching feet
Pull Handle	$4.25	**1.08in^3 x 2**	$8.50	Activation
Spacers	$1.06	**0.23in^3 x 4**	$4.24	Holding spring head
Top Clamps	$3.24	**0.81in^3 x 2**	$7.48	Holding handle
Base Clamps	$2.40	**0.52in^3 x 2**	$4.80	Supporting top clamp
Rod Clamp Apparatus	$8.73	**1.89in^3 x 4**	$34.93	Reattaching bar
Hardware/Miscellaneous				
¼”x1.5”Carriage Bolt	$0.16	**2**	$0.32	Holding spring head
¼” Lock Nut	$0.11	**2**	$0.22	
1/16” Braided Cable	$0.20	**4**	$0.80	Activation
Terminal Clamp	$0.24	**4**	$0.96	
VEX Hardware (Nut+Bolt)	$0.10	**12**	$1.20	Holding Clamps
Total			**$485.96**	

Plan and Identification of Costs/Improvements

Stair Ascent Mechanism ($400)

- Add custom gas and/or tension springs at a marginal cost.
- The base should actuate with reasonable force over a standard 7 inches, a minimum stroke length.
- A small mechanism should be used to halt it. (Important to realize is that the spring is self-damping.)
- To insert it, a number of mounting devices will need to be removed and relocated.
- A hole will need to be cut to fit a release lever and a more accessible one will need to be affixed to it.
- A support rod must be removed to fit the spring.

Safety Reinforcements ($50)

- Cross-brace clamp added after regional competition to address safety concerns
- Clamp for handle added to prevent twisting which results in loss of motion

Future Improvements and Mass Production

Future Improvements:

- Stair Descent Mechanism ($200)
    - Add additional mechanism to adjust this as spring would be taller than walker
- Handrail Anti-slip Clamping System ($100)
    - Add clamp affixed to walker and handrail to hold and prevent walker from tipping backwards and forwards.

Further Improvements:

- Simplified manufacturing procedure
    - Custom non-imported springs molded in assembly of walker as opposed to a modification
    - Materials cost reduction: $\mathbf{\Delta P_{net}}$ **~ $230 (47%)**
        - $150/stainless spring x $9 galvanized/$14 stainless = $96/galvanized spring -> $\mathbf{\Delta P_{springs}}$ **= -$108** (aluminum negligible)
        - $66.79 Plastic * ($0.30/in^{3}ABS)/($4.62/in^{3}Plastic) = $4.30 Plastic -> $\mathbf{\Delta P_{plastic}}$ **= -$62**
        - Lever releases likely functional shorter with cheaper materials, likely ¼ price, along with release -> $\mathbf{\Delta P_{lever}}$ **= -$60.50**
- Larger line of products, perhaps crutches and canes
- Stricter tolerances for greater control and safety

STEM professions required for manufacture:

Mechanical Engineers / Fabricators

Machinists / Maintenance

Quality Inspectors

Communication with Local STEM Business: EberHVAC - Johnstown, PA

1. How prevalent is your work in the community?

A great deal of work is done for the businesses in the community, including industrial, institutional, retail, and even high maintenance buildings such as hospitals.

2. How much of your clientele is local?

All clientele is within 65 miles of the office, as traveling adds to the cost and increases the difficulty of completing the project.

3. What tactics do you employ to maintain a stable stream of business for your employees?

Constant sales. Across all industries, any given business can lose 10% of its customers each year, so things like advertising, planning, and scheduling can make or break a company.

4. How much of your work is contractual bidding as opposed to direct work?

Most of our work comes in the form of bidding.

5. How many workers are necessary for each project?

A typical job requires 4-6 people to complete in a timely manner.

6. What education is necessary for your job?

A high school education is absolutely necessary. Furthering your education through a specific trade is a step in the right direction, as well as a 5 year apprenticeship that handles both work and school, while ensuring that you won't have to pay for your education.

7. What trade skills are looked for in this occupation?

Of course mechanical trade skills, but in this day and age it is important to have a solid understanding of algebra and reading comprehension.

8. What is your prior work experience (i.e. tech jobs, school projects)?

I graduated from Johnstown, and attended the Naval Academy where I earned my degree in engineering. From there I was deployed to a submarine, where I worked as the Nuclear Engineer for 5 years.

9. Do you give incentives for your workers who excel?

In short, no, as it would be unlawful for me to do so. However hard work leads to a full time position, so there is incentive to always work hard on any project.

10. Are you unionized and how effective is it?

Yes, hospitalization pension is of course a priority. The union also helps because it allows us to work together with our employees. Because of the union we are able to bring on more people to a project and lay them off as needed.

11. What are your positions' median incomes?

Employees are paid $33.50 an hour while working in shop, and $10.00 an hour otherwise.

12. What is your general process for completing a job?

Bidding (Setting price and organizing a contract), Building (Completing the actual project), and Collecting (Receiving payment for work done)

13. How standardized is your work (codes, metric/imperial)?

There is not a lot of standardization. We are however required to follow the guidelines in the SMACNA manuals.

14. How many methods are reused between jobs?

Our methods are constantly evolving, so we always work to improve on what we can do for each job we take on.

15. Overall, how important is STEM in your work? How would you feel about students being more involved in these?

STEM absolutely makes the industry. Students who are involved in STEM are offered jobs at a very high rate, particularly over the past few years.