Design Proposal

Process Summary:

When starting the design process, the team first went through the current challenge documentation incredibly thoroughly, making sure everyone had a clear conceptual understanding of the material and putting together a large list of conceptual and design specification questions. After receiving answers, a clear and thorough design specification was developed. To further visualize and conceptualize the prompt, a block diagram was developed. Throughout the design specification stage, the team realized that there are two main parts to the design: the lever and the internal mechanism. The team separated and did research, looking at pre-existing lever designs, in particular those that exist in escape rooms and at places such as Disney parks. The team also looked into pre-existing mechanical systems. Systems of rotational and linear motion and systems that transferred forces between the two were also examined. The team developed several concepts for levers and the internal mechanism. Using the design specification, the team was able to choose some key criteria to evaluate each part of the overall mechanism. Each member created a weighted decision matrix using their own personal weights based on their individual evaluations of the importance of each category. Next the decision matrices were combined and averaged, determining a pivot point based lever was the best lever option and an internal mechanism that used a combination of gears and pulleys would be the best way to transfer force. The team then determined next steps and how to continue progressing on its design.

Design Specification:

<u>Specification Summary</u>

The museum hired a team to design a machine for a family game night event, specifically the control mechanism for a large scale *Guess Who.* This mechanism will allow children five years or older to apply five pounds of force to a lever, which will translate through the machine and cause a three foot by five foot panel, weighing approximately 28 pounds, to rotate up to 100 degrees.

<u>Operation/Movement Specifications</u>

- Transfers a maximum applied constant force of 22 N /5 lb from a lever to pivoting panel
- Must be a solely mechanical design, no electronics used for the movement
- The panel should rotate at a speed proportional to that which the operator uses to push the lever
- Pivoting panel has a range of motion of 0-100 degrees, pivoting no more than 100 degrees exactly
- Lever can travel no more than 90 degrees rotationally and 8” horizontally
- Pushing handle will cause the panel to pivot up, pulling will cause the panel to pivot down
- Panel will stay in place without additional force applied at travel limits
- The panel must undergo a controlled descent when returning to the lowered position
- The system is ideally quiet
- The system must be robust and requires simple maintenance (a manual will be provided for maintenance)
- The device is approachable and easily understood by users without instructions
- The device should be accessible to a wide variety of users

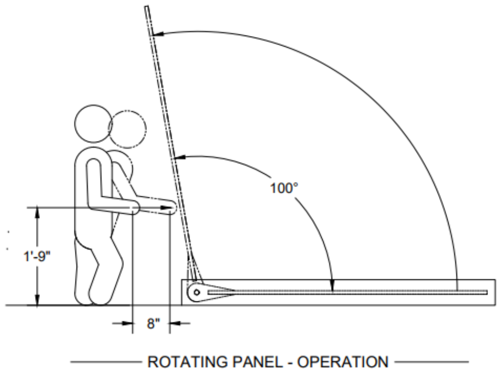


Figure: 2.1

<u>Physical Specifications</u>

- Pivoting panel will be constructed using ¾" plywood. Given size (3' x 5') will weigh approximately 28lb
- Connection interface will be a 1" diameter keyed shaft. Key will be provided
- Lever operating height should be approximately 21" from floor with variation allotted depending on the movement of the lever
- The machine should not be large enough to intimidate a child
- The device is ideally easily replicable
- The image contained on the panel will be located on the side facing the ground when in the "down" position

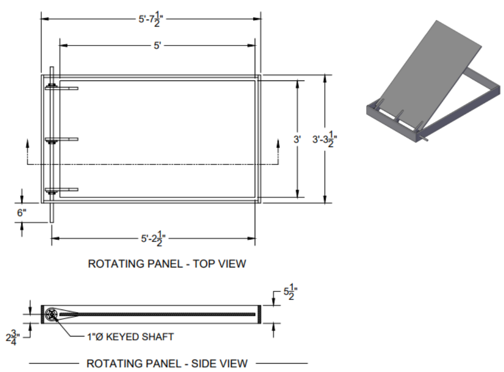


Figure: 2.2

<u>Competition Requirements</u>

- Proposal including:
  - Design specification documents
  - Concept designs
    - Sketches/ Drawings
    - Lo-fidelity prototypes
    - etc.
  - Justification as to why the team choose to follow through on a specific concept
- Working prototype and additional support equipment

- Bound copy of final design document including:
    - Proposal
    - Detailed design materials
        - Estimates
        - Parts lists
        - Technical drawings
        - Math/Engineering analyses
        - etc.
    - As built drawings
    - Documentation of actual costs
    - Safety and/or operation manuals
    - Assessment of successes/failures of the design
    - Assessment of successes/failures of the team

Venue Information

- Up to 15 A 110-120 VAC power per team available
- 100 PSI air pressure available by ¼" tube or quick connect available upon request in advance
- Pyrotechnics and explosives are forbidden

Timeline

- Written proposal due February 28th
- Competition on May 8th

Concept Designs:

Functional Block Diagram

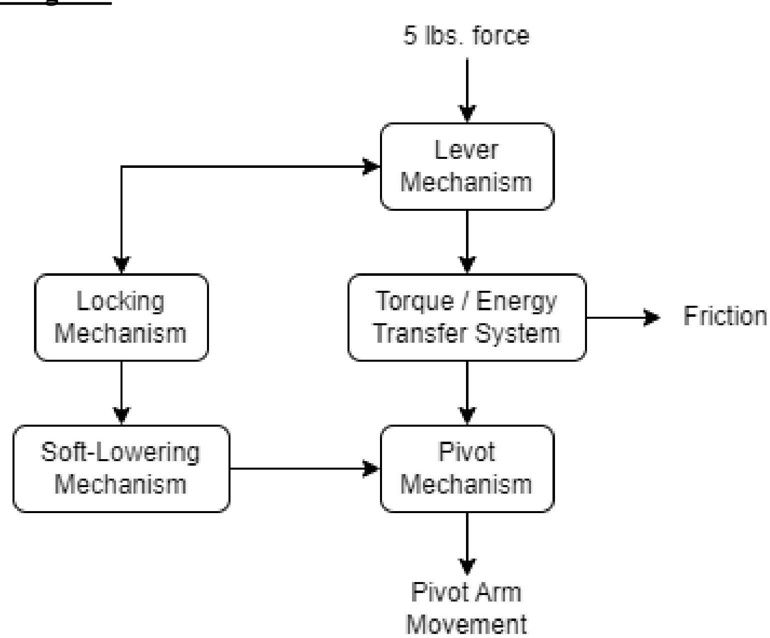


Figure: 3.1

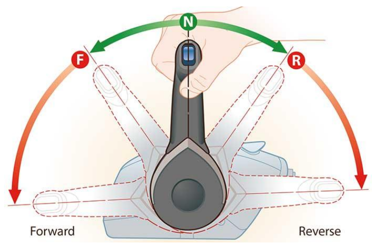
Research

Since the team is designing for a children's museum, we wanted to keep in mind a general sense of whimsy and fun. We immediately thought of ToonTown at Disneyland. It is an example of practicality and physics being combined with creativity to create something that looks straight out of a cartoon. We knew that we would be knee deep in math and engineering analysis for most of this project, but that ultimately this was an installation for children and we wanted to make sure our final product resembled that no matter how technically complex the mechanism was.

Photo by John Fiedler, www.charactercentral.net

In our research for lever designs, we looked at a video from Gratuitous Sets about escape room levers (https://www.youtube.com/watch?v=xKIhH_0VX9I). A couple of other implementations of lever handles that left an impact on us were TNT plungers, arcade machines, the speed control on a boat, and the levers on the spaceship control panel from Smuggler's Run at Disneyland.

Bay Tek Games Inc.
(https://files.winwithp1ag.com/products/redemption-games/ticket-redemption/Bay-Tek-Big-Bass-Wheel-Manual.pdf)



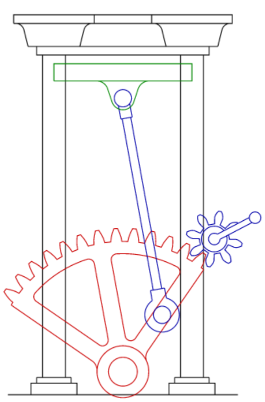
Soucre: BoatUS
(https://www.boatus.com/expert-advice/expert-advice-archive/2014/december/getting-your-boat-in-gear)

https://screencrush.com/millennium-falcon-smugglers-run-tips/

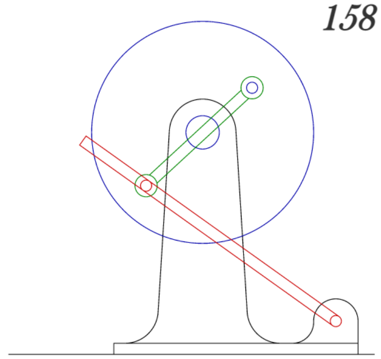
Another common lever we had all interacted with was a seat rest. We found this video from thang010146 on YouTube (https://www.youtube.com/watch?v=MNbIinTK25M) that shows how it moves along with its locking mechanism. Overall, we felt like we had many examples of levers that were successful both cosmetically and mechanically to inspire our own lever design.

From our lgeneral internal mechanics research, we loved the website http://507movements.com/. Two designs that stuck out and were relevant to us were designs 133 and 158.

133



158



We also referenced the book *Mechanical Design for the Stage* by Alan Hendrickson which describes many common machines used in theater and the mathematical calculations associated with them. We specifically reviewed the chapters on bearings and wheels, shafting, and speed reduction.

Lever Concepts

Wheel:

Figure: 3.2

Circular rotation applied to system in the form of a wheel

Pros

- Easily understandable to a child
- Easily to source

Cons

- Harder to understand within design specification
- Only 90 degrees of motion to accomplish task allowed
- Can accomplish same rotational motion in a simpler way
- Not as accessible, requires grip strength

Pivot Point Lever:

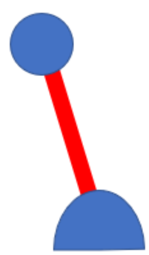


Figure: 3.3

Lever uses a pivot point in the stand to rotate

Pros

- Easy transfer to rotational motion
- Straightforward

Cons

- Orientation is important
- Accessibility may be an issue
- Contains pinch points to be managed

Push Lever:

Figure: 3.4
Uses single push/pull lever to travel horizontally

Pros
- Clearly defined within specifications

Cons
- Harder to transfer to rotational motion

Internal Mechanism Concepts

Gears:

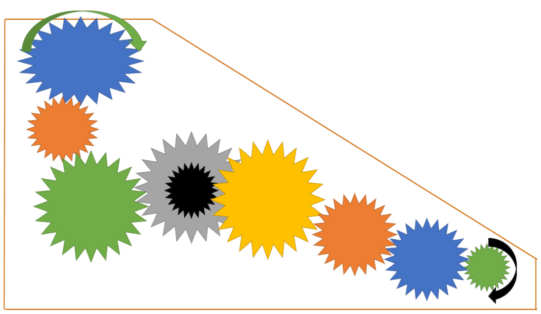


Figure: 3.5
Uses a system of gears to pass force, angular displacement, and torque through system

Pros
- Predictable mechanical motion
- Easily manufacturable
- Calculations are feasible

Cons
- Requires precise assembly
- Requires lubricant and routine maintenance
- Gear tooth precision, as well as number of teeth, affect precision of rotation
- More teeth = more friction

Belts/Pulleys/Chains:

Uses a system of belts and pulleys to pass force, angular displacement, and torque through system

Pros

- Calculations are feasible
- More precision in movement
- Ready made chain sizes (especially bike chains) create unified gears and chain sizes
- Can transfer energy over longer distances

Cons

- Can be expensive
- Potential to snap, causing total failure
- Trickier to fabricate belts

Combination of belts/gears:

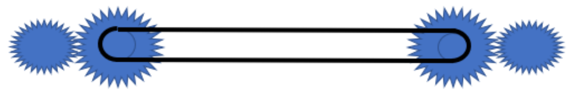


Figure 3.6

Uses a system of gears to pass force, angular displacement, and torque through system

Pros

- Can transfer energy longer distances
- Fewer pinch points
- Fewer places for friction loss

Cons

- More parts
- Meshing more parts that might not necessarily be designed to work together
- Belt could snap causing total failure

Piston Linear to Rotational Motion:

Figure 3.7

Converts linear motion to rotational motion in a similar manner to slider crank mechanisms in pistons. Can be connected to belts or gears

Pros

- Simple
- Easy to gauge force and motion translation

Cons

- Trickier build
- Additional supplies needed

Pneumatics / Hydraulics:

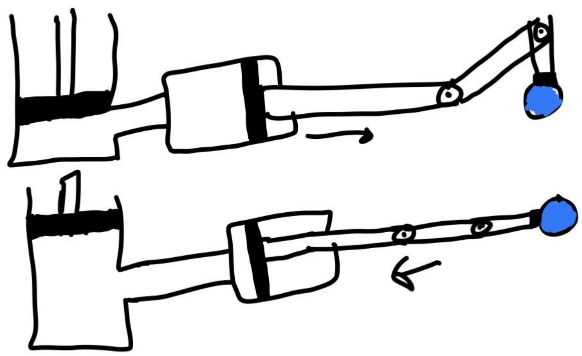


Figure 3.8

Uses the vertical motion of the lever to push pistons and connected connected links with pressure, to generate torque

Pros

- Exact distance moved every time

Cons

- Hard to fix it a short amount of time if it breaks
- Can be very loud
- Need an air source or a oil/water tank

The systems which will lock the mechanism in the upright position and slowly lower the panel into the downward position

<u>Evaluation</u>

Using the design specification and documentation provided, the team determined these are the important areas to evaluate for each mechanism.

Lever

- Precision of motion
- Ease of fabrication
- Ease of maintenance
- Accessibility
- Usability
- Safety

Internal Mechanism

- Precision of motion
- Ease of fabrication
- Ease of maintenance
- Mathematically analyzable
- Safety
- Usability
- Mechanical simplicity
- Feasibility

Decision Matrices

Each team member filled out a weighted decision matrice using the same evaluations. Each member decided on the weights of the evaluations.

Clare							
	precision of motion	ease of fabrication	ease of maitenence	accessibility	safety	usability	
Weight	3	1	2	3	3	3	total
lever 1	1	3	3	2	3	2	33
lever 2	3	2	3	2	2	3	42
lever 3	3	2	2	2	3	2	36

	precision of motion	ease of fabrication	ease of maitenence	safety	usability	mechanical simplicity	feasibility	
weight	3	1	2	3	2	2	3	total
mech 1	3	1	1	2	2	1	2	30
mech 2	2	3	2	3	2	2	2	36
mech 3	2	2	2	3	2	1	2	33
mech 4	1	1	3	2	3	2	2	32
mech 5	3	2	1	2	2	2	1	30

Elle							
	precision of motion	ease of fabrication	ease of maitenence	accessibility	safety	usability	
Weight	3	1	2	3	3	3	total
wheel 1	3	3	3	1	3	2	36
lever 2	2	2	2	3	1	3	33
lever 3	1	2	1	2	1	3	25

	precision of motion	ease of fabrication	ease of maitenence	safety	usability	mechanical simplicity	feasibility	
weight	3	1	2	3	2	2	3	total
gears	3	3	3	3	2	3	3	46
belts pullys	2	3	3	2	2	3	2	37
combo	3	3	3	2	2	2	3	41
piston	1	2	2	3	3	1	2	32
pneumatics	1	1	1	2	1	2	1	21

Szczesny								
	Precision of motion	Ease of fabrication	Ease of maitence	Accessibility	Safety	usability	Total	
Weight	3	1	2	3	3	3		
Wheel	3	3	2	2	2	2	34	
Pivot Point	3	1	3	3	1	3	37	
Push Lever	2	1	1	3	2	3	33	
	Precision of motion	Ease of fabrication	Ease of maitence	Safety	Usability	Mechanical simplicity	feasability	total
Weight	3	1	2	3	2	2	3	
Gears	2	3	2	1	2	2	3	24
Belts/pulley	3	2	3	2	2	3	2	33
Combo syste	3	3	3	2	3	3	3	36
Piston	1	1	1	2	3	1	1	20
Pneumatics/	3	1	1	3	3	1	1	29

Ethan								
	precision of motion	ease of fabrication	ease of maitenence	accessibility	safety	usability		
Weight	3	1	3	2	3	3	total	
lever 1	1	1	2	1	3	2	27	
lever 2	3	2	2	3	3	3	41	
lever 3	2	2	2	2	3	2	33	
	precision of motion	ease of fabrication	ease of maitenence	safety	usability	mechanical simplicity	feasibility	
weight	3	1	2	3	2	3	2	total
mech 1	3	2	2	1	2	1	2	29
mech 2	2	2	1	2	2	1	2	27
mech 3	3	3	2	3	2	2	3	41
mech 4	1	2	1	2	2	1	2	24
mech 5	2	1	1	3	2	1	1	27

	Totals	Average
wheek	130	32.5
pivot lever	153	38.25
push lever	127	31.75
gears	129	32.25
belts	133	33.25
gears/belts	151	37.75
piston	108	27
pneumatics	107	26.75

The mechanism will be a pivot point lever attached to a combination belt and gear mechanical system.

<u>Final Conclusion</u>

Research and analysis will be done to create a system of gears and chains that provides enough torque and translational motion. Details to flush out include the housing for the lever and internal mechanism, materials for the lever, and gear and chain sizes.
Ideally, the lever can be operated using one hand, but if necessary works with two hands.

Moving Forward

As the team has made a decision on which lever and mechanism designs to pursue, the next steps will include performing physical and mathematical analysis on the designs, creating a model of the designs, and beginning a plan to manufacture the parts. Additionally, the team will begin to source materials, and in doing so, set a budget for each element of the project. After the materials are acquired, an initial prototype will be constructed for the lever and panel lifting mechanisms. Any adjustments and revisions that are needed will be discussed and then implemented. This process will be repeated until a final prototype is reached. At this moment, the team will focus on revising certain aspects of the design, such as the aesthetics, approachability, and adaptability of the mechanisms. It is important that this step focuses on user-machine interactions and safety. Finally, this iteration will be tested to meet all requirements set forth by the team and the exhibit curators to determine if the design is feasible for showcase.