WHEEL CHAIR ICE SKATE

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Executive Summary

The Wheel Chair Ice Skate is based on how skates work when used by persons without disabilities. The skate is made out of aluminum to support the weight of the wheelchair and the person sitting in it. A dual blade system is used, which adds additional stability as well as durability to the whole system.

Introduction

Our team was tasked with designing an ice skate system to be used by people in wheelchairs. The system had to be affordable, lightweight, and easy to use. Multiple designs were created before deciding on the front boot style system. Choosing the best design was affected by the high costs for raw materials. Cost is our main limiting factor in design. Staying within our budget was found to be difficult without sacrificing some of our other concerns.
Problem definition.

An individual confined to a wheelchair needs a way to enjoy the activity of ice-skating and its associated sports. The wheelchair should be able to lock into a device that allows the disabled person to remain in their wheelchair at all times. The device must be able to “lock” onto the wheelchair, and allow for someone to push the wheelchair or allow the person in the wheelchair to propel themselves with a device such as ski type poles. In addition the device should be lightweight, easily transportable, cost effective, and require only up to one other person to install.

Background

In order to understand how our ice skate system works, it is important to understand how skates work in general. Skates for the ice or for the road work in a similar fashion. For use on the ice a blade system is constructed from a metallic alloy, which is it mounted to the bottom of a shoe or similar device. These skates provide directional stability to the user. Prevention of lateral drift is the main focus of our system. Allowing for only forward movement helps keep the user going in his intended direction.
Objectives

Our objectives for the problems defined above are as follows:

1. Design a device that will lock onto the wheelchair
   - Design a way using a type of strap system, or a way for the force of gravity to hold the design on the wheel.

2. Allow the wheelchair to maintain directional stability.
   - The design must prevent the wheelchair from having any lateral movement of “drifting” while on the ice.
   - The design must not inhibit forward motion of the wheelchair on the ice.

3. The design should take into account the necessary space someone would need in order to assist with the forward movement of the wheelchair while skating.
   - The area behind the wheelchair when a person would normally push or assist in propelling must not be reduced in any way.

4. One additional person should be all that is needed in order to set up the sign with the wheelchair.
   - One person other than the person in the wheelchair should be able to employ the design.
   - the design should be simple enough that only simple directions are needed in order to use

5. The device should be lightweight
• The overall weight should not exceed 10 Pounds to allow for easy lifting and carry

6. The design should be easy to transport
• The overall size should allow it to fit into a standard size school backpack

7. The design must be cost effective
• The final cost to a customer should not exceed 125 dollars
• The cost should be comparable to standard skates used by non-disabled persons to ensure a financial factor is not preventing someone from skating in their wheelchair.

Technical Approach

1. Design a device that will lock onto the wheelchair

   1. Design ideas
      1. A strap system to hold some sort of skate to the wheels
      2. A type of groove or area that allows gravity to hold the skate to the wheels

   2. Testing
      1. Use an existing strap type system to hold a straight object on the wheel and test for structural rigidity before moving forward with locking mechanism.
      2. Find an existing device that would use gravity to stay on the wheel and test for structural rigidity before moving forward with final design

   2. Allow the wheelchair to maintain directional stability
1. Design ideas
   1. A device that acts as a skate to “carve” into the ice
   2. A design that will allow the wheel to maintain traction while spinning freely similar to snow chains on a car

2. Testing
   1. Test whether a blade or a tire chain type wheel will provide better stability

3. The design should take into account the necessary space someone would need in order to assist with the forward movement of the wheelchair while skating

1. Design Ideas
   1. The design should not take up any of the space needed for someone to push the wheelchair

2. Testing
   1. Measure the area needed for pushing and ensure the design ideas do not interfere

4. One additional person should be all that is needed in order to set up the sign with the wheelchair.

1. Design ideas
   1. Make the device small enough for one person to be able to operate it effectively

2. Testing
   1. Have someone attach and remove the design without assistance to measure its ease of use

5. The device should be lightweight
1. Design ideas
   1. Construct the design out of lightweight materials

2. Testing
   1. Construct the design out of polymers and metal to save on weight
   2. Ensure the materials fulfill the requirements of goal 1

6. The device should be easy to transport
   1. Design ideas
      1. Design an individual device for each wheel
      2. Design a device that locks onto all the wheels a once that can be folded into a small area
   2. Testing
      1. Take the device and ensure it fits into an average backpack sized bag

7. The design should be cost effective
   1. Design
      1. Use readily available materials to save on cost
      2. Keep the use of metallic alloys to the lowest possible amount to save on cost
   2. Testing
      1. Calculate the materials cost of the design before proceeding with production
Design 1

(Figure 2)

Figure 2 shows our first design, which was a boot made out of a high density polyethylene. The boot works by locking to the wheel and providing a solid mounting point for the skate to the wheel. The problem was in strength versus cost of the design. The cost of the design was roughly $500 above our budget. This made it not affordable to the general public. In order to make this design structurally stable, high cost materials would need to be used. Due to these factors the design was not discarded.
Design 2

(Figure 3, Skate concept 2)

Design 2 (figure 3) was based around a 2-3 bladed system often used by those just learning to skate. The multi blade system allows for directional stability and a very stable platform. The design was to be machined from a solid block of aluminum, which would prevent corrosion as well as increase durability. Attaching it to the wheels would be achieved by using Velcro style straps through the spokes of the wheel. This design however provided challenges in the cost department. With current prices of raw materials we decided to not develop this idea.
Design 3

(Figure 4, Ski style system)

Concept 3 (figure 4) was based on a snow ski style attachment adapted to the ice. A long blade would run along the bottom of the ski allowing directional stability and ease of movement. Problems were run into during design, including overall size and cost. The cost of one ski was going to exceed $200 and the idea was set to the side and other designs were generated.
Final Design

Our design calls for a way to mount our skate to the front wheels of a wheelchair. The system is strapped to the wheelchair using Velcro straps and held in place mainly by the weight of the wheelchair and user. Star hooks are bolted to the main skate body. The mounting points allow the straps to be hooked to the skate through the spokes of the wheel. When assembled the only movable part of the entire assembly is the straps, due to the need for them to be able to be removed and placed on the wheel. The center slot of our skate is where the wheel will rest. Rounding on the front of the actual blade will reduce hang ups on un-even areas of ice. Figure 1-1 shows the main skate body assembly individual parts. All parts in this drawing are fixed once assembled. Figure 4 shows the blade attachment points not shown in figure 1-1.
Figure 1-2 shows the placement of the strapping system when the wheel is inserted into the assembly.

When properly installed the skate will provide directional stability to the front wheel allowing the user to easily move in their chosen direction. It should be noted that the front wheels will still be able to turn allowing the wheelchair to turn in a controlled manner.
Prototype

The prototype (figure 5) was modeled in Solid works in order to have a reference for machining the parts. Below are the drawing used for machining and assembly. The slot in the main skate assembly was machined out on a mill. The Strap hooks are mounted to the main assembly with 1/4x20 0.5 inch long bolts. The skate blade is attached to the main body with rivets to allow for a flush mounting without anything getting in the way of the wheels. Paint is applied as a last step to help make the skates aesthetically pleasing.

(Figure 4. Used for construction)
# Materials Order

The Bill of materials (Table 1) shown below is the list of items used to manufacture the prototype. The quantities shown in the order do not reflect the quantity used to make the prototype.

(Table 1. Bill of materials)

<table>
<thead>
<tr>
<th>Item #</th>
<th>Item ID</th>
<th>Item Description</th>
<th>Vendor</th>
<th>Quantity</th>
<th>Price/Unit</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>172795</td>
<td>1/4&quot;-20 X7/16 grade 18-8 hex cap screws</td>
<td>fastenal.com</td>
<td>8</td>
<td>0.3502</td>
<td>2.8016</td>
</tr>
<tr>
<td>2</td>
<td>6AL20</td>
<td>U-Channel, 6063AL, 1/2 in Leg, 1 1/2 in x4RT</td>
<td>grainger.com</td>
<td>1</td>
<td>14.42</td>
<td>14.42</td>
</tr>
<tr>
<td>3</td>
<td>33211</td>
<td>1/4&quot; x 2.000&quot; OD Low Carbon Zinc Finish Steel Fender Washer</td>
<td>fastenal.com</td>
<td>10</td>
<td>0.3846</td>
<td>3.846</td>
</tr>
<tr>
<td>4</td>
<td>B013WGW9PC</td>
<td>4 Pack (18&quot; x 1.5&quot;) AIRNEX Velcro Reusable Buckle Cable Tie Down Cinch Strap Hook Loop</td>
<td>amazon.com</td>
<td>2</td>
<td>10.95</td>
<td>21.9</td>
</tr>
<tr>
<td>5</td>
<td>6ALP2</td>
<td>Square Tube, AL, 1 3/4 in Inside Sq, 3 ft</td>
<td>grainger.com</td>
<td>1</td>
<td>24.98</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>32KT7</td>
<td>Blind Rivet, 1/4 Dia, 0.560 L, PK50</td>
<td>grainger.com</td>
<td>1</td>
<td>11.00</td>
<td>11.00</td>
</tr>
<tr>
<td>7</td>
<td>3HDX2</td>
<td>Serrated Flange, 1/4-20, Gr 2, ZP, PK100</td>
<td>grainger.com</td>
<td>1</td>
<td>11.37</td>
<td>11.37</td>
</tr>
</tbody>
</table>

|         | TOTAL    | 90       |
(Figure 6. Strap hook)

The Strap hook (figure 6) is made from a standard steel washer. Sections were cut out in order to create a tab to be bend in a curve in order to make an area for the straps to mount to.
Three rivets (Figure 7-1 and 7-2) were used to secure the blade to the main skate body. Rivets were used due to their high strength and their ability to be ground down out of the way. This leaves a clean finish and no protruding segments like there would be using conventional bolts and nuts.
Materials for the prototype were chosen based on cost and weight. Aluminum was chosen due to its good structural stability and overall light weight. Aluminum is strong enough to support the weight of the wheelchair and rider. The illustration (figure 8) shows a load applied to the blade assembly and where its failing point is. The yield strength of the blade itself is just under 4000 PSI. This should be enough to support any weight loaded on the blade assembly.
(Figure 8, Skate blade under load)