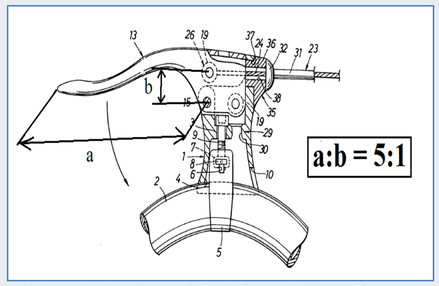
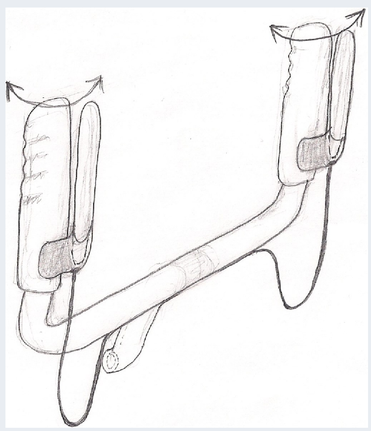
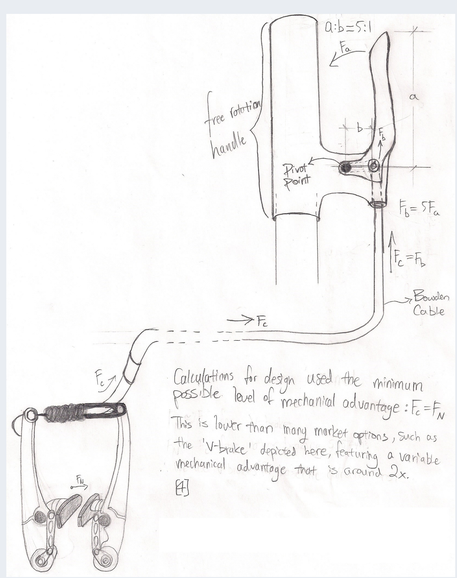
Designing A Bicycling Handlebar System for Persons with Arthritis T30125
University of Toronto

Current Design Iteration



Brake Lever Dimensions. Picture taken from US Patent No. 4,679,460 [7]





Engineering Design Process [Pro]

1) Problem Definition and Reframing

RFP Problem Statement: *Design an improved bicycle handling system that permits individuals who suffer from arthritis in their wrists and hands to control their bicycles safely and comfortably.*

Revised Problem Statement: *Design a system on bicycles that permits individuals who suffer from arthritis in their wrists and hands to brake and steer comfortably.*

Reframing:

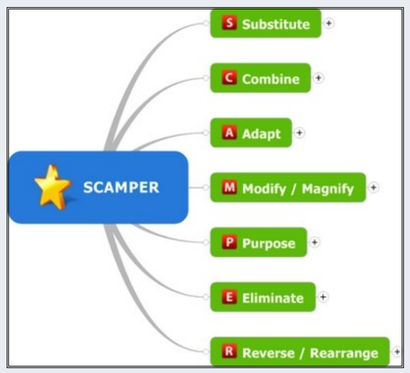
1. **Prioritising Requirement**
   a. Steering:
      The solution space for steering is more limited than that of braking.
      As a result, prioritizing a design for steering will help frame the solution space for braking.
   b. Braking:
      Braking is critical to the safety of cyclists and those around them.
      Rheumatoid arthritics and osteoarthritics have difficulty applying the force required to engage current braking solutions, according to the RFP.
   c. Braking Distance:
      Braking distance is solely dependent on the deceleration of the bike. This is caused by the force of friction between the tire and the ground.
2. **Relevance of Gear Shifting**
   Gear shifting is modular and can be removed and reattached to a new handle system easily
   In order to change the ways gears are shifted, a large amount of the bike's intricate mechanisms will need to be adjusted
   Different bicycles have different amounts and increments of gear shifting, making an universal design hard
   The goal is to widen the array of compactible bikes and minimize the impact on any single bike
3. **Viability on Recumbent Bikes**
   Recumbent bikes are less compatible with our design than other conventional bike frames
   A 2011 bicycle sales industry survey shows that only 0.2% of overall units sold were recumbent bikes

2) Generate Possible Solutions

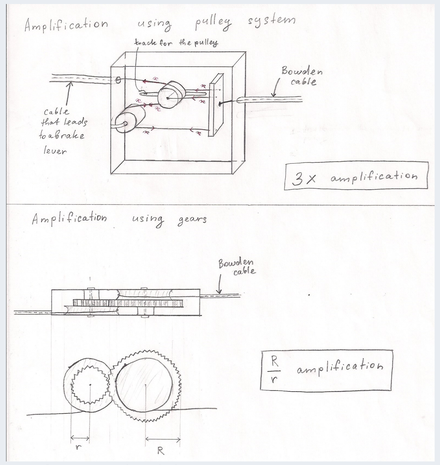
Function Decomposition:

1. Steering:
   Cyclist turns a bar relative to an axis-> directly attached to front wheel which moves in direction of "bar turn"
2. Braking:
   The squeezing of the lever -> Tension of the Bowden cable -> Force squeezes a spring and activates brake pads to squeeze the bicycle rim

SCAMPER:



The Different Sections of SCAMPER [Scamp]



Ways of Increasing Mechanical Advantage

Calculations showing the needed mechanical advantage

$a = 0.43 * g$ [9]

$m_{bike} = 11.2\ kg$ [9]

$m_{women} = 66.8\ kg$ [10]

$\mu = 0.678$ [11]

$F_{Grip\ Average} = 41.6\ N$ [12]

$F_{Grip\ Peak} = 58.3\ N$ [12]

The force of friction is divided between two wheels:

$$F_{wheel} = 0.215 * 9.8 * (11.2 + 66.8) = 164\ N$$

$$F_{brake} = \frac{F_{wheel}}{\mu} = \frac{164}{0.678} = 242\ N$$

$$Mechanical\ Advantage\ Average = \frac{242\ N}{41.6\ N} = 5.81$$

$$Mechanical\ Advantage\ Peak = \frac{242\ N}{58.3\ N} = 4.15$$

Decision Making Matrix Deciding on the Best Braking Mechanism

Criteria	Weight	Gear Braking System	Pulley Braking System	Lever Arm Braking System
Cost (lower is better)	6	5	6	10
Potential for Failure (lower is better)	10	8	5	10
Potential Mechanical Advantage (higher is better)	8	8	9	6
Level of compatibility with various frames (more is better)	4	8	8	9
Level of RFP Infractions (lower is better)	4	7	7	9
Ease of Installation (easier is better)	5	8	8	10
Ease of Use (easier is better)	6	8	8	9
Total		**48**	**48**	**54**

General Material Selection for Bar Handle					
Criteria	**Weight**	**Aluminum Grades**	**Steel**	**Titanium**	**Carbon Fibre**
Cost (lower is better)	5	9	7	2	5
Strength-to-weight	4	8	5	9	8
Durability	3	9	10	8	6
Current Market	3	10	7	4	5
Light	3	8	5	10	10
Weighted Total		**80.2**	78.2	67.4	58
Aluminum grade chosen: 6061-T6, Anodized					

3) Evaluate Possible Solutions

a. Clustering Stage
All our designs fell into the following general categories:
Steering Ideas
Braking Ideas
Leg-based solutions
Hand-based solutions

b. Convergent Stage
Using the requirements of the RFP and our pushback criteria, we cut out several ideas
Narrowed it down to gear design, pulley design, and extended lever arm handle

c. Detailed Design
A 5x mechanical advantage was chosen
Material Selection

Dimensions			
Span(from levers to bars)	400 mm		
Clamp Size	25.4 mm	26 mm	31.8 mm
Width - Bar	36 - 46 cm	* w/ 2 cm increments	
Diameter - Handles	22.2 mm		23.8 mm

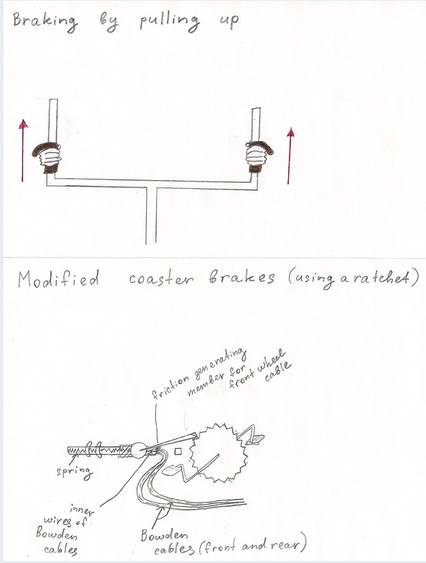
Current and Future Plans:

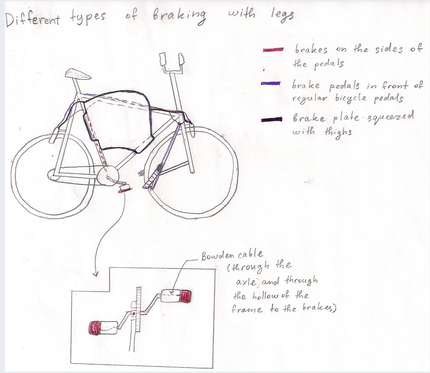
4. Make and Test a Model
A low-fidelity prototype has been made and shows the functions of the final design solution

5. Modify and Improve the Design
a. Flaws in Current Prototype
- Materials are unrepresented in the current prototype
- The measurement of the low-fidelity prototype are not to scale
- Arthritis-friendly grip design is not shown in the prototype
- Lever brake system is not properly built

b. Improvements to be Implemented
- Make a prototype that is representative of the chosen materials
- The high-fidelity will feature the exact dimensions
- Final revolving grip will take into account the correct coefficient of friction
- Lever Brake
- Make overall design aesthetically pleasing

6. Communicate the Final Design
Occurs at Showcase.





Ways of Braking the Bike