



## LOW INTERFACE WHEELCHAIR FOOTREST

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PRELIMINARY PRODUCT DESIGN SPECIFICATIONS

*BME 301*

*Lab Section #: 302*

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**Function :**

Currently, there is a noticeable absence in the market of wheelchair footrests that facilitate individuals who are not fully paralyzed to execute beneficial movements, such as using their feet to open doors or retrieve objects from the floor. Moreover, existing footrest models exhibit drawbacks, as they tend to be cumbersome, weighty, and lack user-friendly features for convenient removal and storage during periods of non-utilization. While footrests play a pivotal role in providing support when the wheelchair tilts or reclines, it is imperative to devise an innovative wheelchair footrest that accommodates enhanced foot mobility for users as needed, while offering seamless storage options. The refined footrest should possess adaptability to suit an individual's necessities, have effortless removal and storage capabilities, reduced weight, and a more streamlined design, all while retaining the essential benefits of a traditional wheelchair footrest.

**Client requirements:**

- Total weight of less than 5 pounds
- Must have the ability to fold and be easily storable
- Must be able to withstand clients full weight
- Has the ability to move with the wheelchair during reclining or uprising position
- Still be able to provide the benefit of a traditional wheelchair footrest

**Design requirements:**

1. Physical and Operational Characteristics

a. *Performance requirements:*

The wheelchair footrest must have a lifespan of at least five years, corresponding to the average time duration that a wheelchair base lasts [1]. To preserve reproducibility, currently, the production cost should remain under \$200. The footrest should be lightweight and durable, weighing under 5 pounds total while being strong enough to hold the user's weight on a continuous basis. The rest should promote user comfort and accessibility, with adjustable features to adapt to

individual needs. Lastly, the footrest needs to be easily storable, preferably on the side of the wheelchair.

b. *Safety:*

The materials used when creating the footrest must not be sharp or be able to cause injury to the user. The storage mechanism should be user-friendly and secure, preventing any accidental deployment or collapse during storage, and minimizing the risk of pinching hazards. While also being durable, the material used for the footrest should be as anti-slip as possible, mitigating the risk for falling. If electronics are used in the footrest design, the wires should not be visible or have the ability to be tangled in the footrest. The footrest design must comply with relevant wheelchair safety standards and regulations to guarantee a high level of safety and reliability for users.

c. *Accuracy and Reliability:*

The footrest should be able to securely connect to the wheelchair for its entire lifespan. All joints and plates should stay unbent and at desired angles under normal conditions.

d. *Life in Service:*

The footrest will mostly be used outdoors, and will be repeatedly packed and unpacked during transport when it isn't needed on the wheel chair. This processes is expected to happen hundreds to thousands of times over the life of the footrest, as it should last at least as long as the wheel chair it is designed for, so 5-10 years [2]

e. *Shelf Life:*

The footrest will fold into itself to allow for easy storage, and transportation. It will need to withstand being transported in suitcases or bags. All parts should hold together when folded so as to not have bending or tearing of joints connected to pieces that hang off the main body.

f. *Operating Environment:*

The footrest will be used inside and outside at all times of the year. This means it must function in any weather, and will encounter water, dust, mud, bumps and should be able to support the clients throughout.

g. *Ergonomics:*

The footrest should be able to support the clients legs and feet, which is estimated to be 12.2% of their body weight [3], while the footrest itself remains lightweight

to allow it to be transported easily. The footrest should also be able to move around while attached to the wheelchair to limit its interference with everyday activities such as leaning forward or opening doors.

h. *Size:*

The design should take a client specific approach when considering the size. The footrest should account for the coverage of the entire feet according to client specific shoe size, excluding margin of error from the shoes. According to Nike's shoe size chart, the corresponding length should be at least 31.3 cm in length [4]. Due to personal habits, the actual feet size is smaller than given on the chart. The aim is to provide a necessary amount of support while resting, while keeping as minimum for portability.

i. *Weight:*

The design should take into account the client's specific condition: muscular dystrophy, and the client's request to disassemble and reassemble for packaging. Common wheelchair footrest, made from various types of a combination of plastic and metals, ranges from 3-10 lbs. The footrest will aim to minimize burden during transportation and the process of disassembling to ensure proper alignment with portability. Thus 3-5 lbs is a reasonable range for the design.

j. *Materials:*

Since, by client request, the footrest is mainly used outdoors, the footrest should be constructed using high quality and corrosion resistant materials. This provides services to various weather conditions. Frame can be designed from aluminum alloy for its exceptional strength-to-weight ratio [5], allowing movability along with durability. Since the footplate is meant to be de-attachable, the footplate should use non-slip, easy to clean material to provide a clean surface to the user, using acrylic to PVC. For better ease of fabrication, tough PLA can be considered using 3D printing to provide dynamic shapes [6].

k. *Aesthetics, Appearance, and Finish:*

The aesthetic and appearance of the stamp will be uncomplicated, it will be a silicone item with no finish to minimize contamination during use. It will be a ductile design that is meant for multiple uses.

## 2. Production Characteristics

### a. *Quantity:*

The client aims to create an initial prototype as an attachment to their current wheelchair. Upon the successful development of this prototype, there is potential for scaling production to serve a larger user population.

### b. *Target Product Cost:*

The final market product cost aims to be less than 10% of the development cost, including materials fees during the design process.

## 3. Miscellaneous

### a. *Standards and Specifications:*

ISO 7176: This is the international standard that outlines the testing protocols for different mechanical elements of a wheelchair. Sections 1[7] and 2[8] pertain to the wheelchair's static and dynamic stability during motion. Additional sections address specifications related to the wheelchair's size, required space for maneuvering, durability, among other characteristics. It is crucial to acknowledge these factors, as the testing equipment could influence the wheelchair's inherent physical attributes.

CFR890.3920: This is the FDA regulations regarding wheelchair components. A wheelchair component is defined as a medical device that's an integral part of a wheelchair, including those sold separately, which applies to our design. These devices are not required to undergo the premarket notification process,[9] subject to limitations.

### b. *Customer:*

The footrest is specifically designed to fit the needs of our client, Dan Dorszynsk, who has expressed dissatisfaction with existing footrest options, which limit his capacity to perform small daily tasks, like opening doors. With that said, the design principles and solutions the teams develop could be applicable to a broader audience, as other wheelchair users with varying degrees of mobility may experience similar challenges and could benefit from the final design.

### c. *Patient-related concerns:*

This footrest is designed for patients like our client, whose legs still have some strength and can perform lighter duty tasks and support the body without the

footrest when sitting. These patients do not need the footrest for the majority of the time, and will only need them when traveling. Hence it should be easily removable, for packing when traveling. The height of the footrest should also be adjustable, as study has shown improper height of the wheelchair footrest may lead to increased average pressure, potentially leading to ulcers and other problems for patients with less mobility of the lower bodies[10].

d. *Competition:*

Most wheelchairs footrests come with the wheelchairs themselves, [9] although there are still a wide variety of footrests available on the market. Prices range from 30 dollars[11] to 120 dollars[12]. Most of the footrests share a similar design. With metal frames for support and connection, and plastic or metal footrest itself attached to the frame that can fold up sideways. Some premier ones come with cushions or paddings for legs.

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