COMMUTER SCOOTER

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Abstract
In a city environment, most commuters take mass transit. Unfortunately, there is usually additional distance that people have to cover from where mass transit ends to their destination. These people have several options such as walking, taking a cab or personal transport. Some may even choose to bring folding bicycles. However, the weight and size of existing folding bicycles dissuades most individuals from using them to cover short distances. An ultra-compact folding personal transport that will comfortably carry people over distances under 1 mile would be ideal. This device will need to be able to fold quickly, fit inside a standard backpack, and be light enough for anyone to carry. Specific design requirements and considerations were developed by examining existing products on the market. Prioritizing the requirements led to several design concepts. These concepts were further developed and analyzed culminating into the current design solution henceforth known as the Commuter Scooter.

Figure 1: Final Design
For more information, please contact J.Papadopoulos@neu.edu.
The Need for Project

This project fulfills a crucial need for urban commuters who have travel gaps between their destinations and where public transportation ends. Urban commuters often face the problem of public transportation not dropping them off exactly at their destination. This means that most commuters must either find another means of transportation, or walk the rest of the way. This project addresses that need with a small, portable, lightweight, and easy to use device for personal transportation. This device will be able to be fit into a partially filled backpack, allowing for easy transport on public transit, and unobtrusive storage in the workplace. It will allow the user to travel at a brisk jogging pace, while using only the amount of energy that it would take to walk. This shortens commute time and saves money on additional transportation.

The Design Project Objectives and Requirements

This device is designed for use in urban environments to travel distances of less than 1 mile. It should be easy to carry and use by the average person.

Design Objectives

The Commuter Scooter needs to be extremely compact and lightweight, but also strong. It needs to convey the user faster than walking speed.

Design Requirements

The device has to be small enough and light enough to be carried by the average person in addition to whatever items they may normally carry. A target folded volume of 14”x4”x4” would be ideal because it would fit in a partially-filled backpack. A total weight of no more than 15 lb. would make the device light enough to carry. The frame should be able to carry a person weighing no more than 220 lb. with a safety factor of 4 to protect the rider against bumps and collisions. The speed of the Commuter Scooter should be at least 8-10 mph because it is ideal for timely travel in urban environments. The actual weight of the device ended up at just over 8 lb., and the projected speed of the device meets the target requirement. The actual folded volume, however, is 18”x5”x7”, which does not meet the original target size. Due to time constraints, several folding concepts had to be abandoned before they could be completely developed. However, the group also opted for a more robust and safer device during the design phase to ensure that the Commuter Scooter would hold up to the stress of use. The increased safety factor also increased the weight of the device, but it is still very much under target. Further details on the device can be found in the technical report.
Design Concepts Considered

Several different folding techniques as well as a skid plate design were developed. One of the first design concepts explored involved the use of multiple hinged members to reduce the folded package size. The concept included an unfolded deck size of 28”, with three bars that would fold into a stackable package. The preliminary design can be seen in Figure 2. While this enabled a small package size, there was no place to house a gearbox in the deck. A telescoping deck was also considered. While the folded volume would be minimal, smaller telescoping members at the middle of the design would not be strong enough. The custom shape of the tubing meant that prototyping these components would be difficult, especially with the limited manufacturing capabilities available. This concept can be seen in Figure 3.

A skid plate is a device that allows a small wheel to surmount larger obstacles. Upon collision, the curve lifts the front wheel off of the ground rather than bringing the scooter to an abrupt stop. This is a necessary feature because the wheels used for this scooter are only four inches in diameter. The skid-plate design, featured in Figure 4, worked in testing, but needed to be revised as the overall design of the scooter evolved to include a cantilevered front wheel and a modified steering column. Additional details about the skid plate and other concepts can be found in the preliminary designs section of the technical report.
**Recommended Design Concept**

The Commuter Scooter device is designed to achieve a minimum folded size and weight while propelling the user at 8-10 mph.

**Design Description**

The design illustrated in Figure 5 is the solution to the design challenge. The Commuter Scooter has a folding deck that is hinged halfway along the folded length. The hinge is offset by 2°, meaning that the cantilevered wheels will be side by side when the deck is folded. In addition, the skid plate was modified to be hinged along the cantilevered arm, and is locked by a spring. In the folded position, the skid plate rests along the deck. The handlebar assembly telescopes into a compact package and folds at the base, parallel to the deck. The gearbox utilizes a multi-pulley wire-cable drive and is housed in the rear section of deck. A pedal is connected to the left side of the deck and drives the rear wheel.

**Analytical Investigations**

The design was analyzed using both SolidWorks and ANSYS modeling and analysis software. Each part was created in digital space, assigned material properties and tested based on expected loading and end conditions. The parts were tested with loads of up to 4 times the maximum calculated load which would give the design a high safety factor. The gear ratios used in the transmission and the top speed of the device were determined based on mathematical modeling.

**Experimental Investigations**

Experiments were conducted to determine the optimum wheel size, the functionality of the skid plate, and the pedal location and functionality. These findings helped shape the final design and can be found in section 6 of the technical report.

**Key Advantages of Recommended Concept**

The key advantage of this design is its unparalleled portability. The Commuter Scooter’s small folded size and light weight construction allows it to be easily carried. The use of both front and rear skid plates allows the device to surmount large obstacles. The device meets most of the original goals (except for folded size) that were set in the project, and fulfills the need of the urban commuter.

![Figure 5: Final Design](image)
Financial Issues

The cost of designing this product was around $500 in materials. Labor costs were non-existent, but a considerable amount of time went into design and manufacturing. Given that only one device was made, the cost per unit was high. Through economics of scale, the cost per unit would be far cheaper. The material costs were high because of the limited pool of suppliers for parts. Most of the parts were bought from McMaster-Carr resulting in the cost being higher than buying in bulk from another wholesaler. Additionally, if more time was available after the final design had been selected, cost reductions could have been implemented.

Recommended Improvements

To lower the weight, the material used in certain parts of the scooter could have been reduced. However, the group was more concerned with the safety of the device. The weight could have been decreased while maintaining a high level of safety if given more time. Additionally, the folded volume ended up being slightly larger than desired. Some of the increased size was due to late changes in the front portion of the deck. In certain places, the modifications meant that the deck could not fold completely inward as intended. Given more time, these interferences could be resolved to further decrease the folded volume.