HANDS-FREE STROLLER

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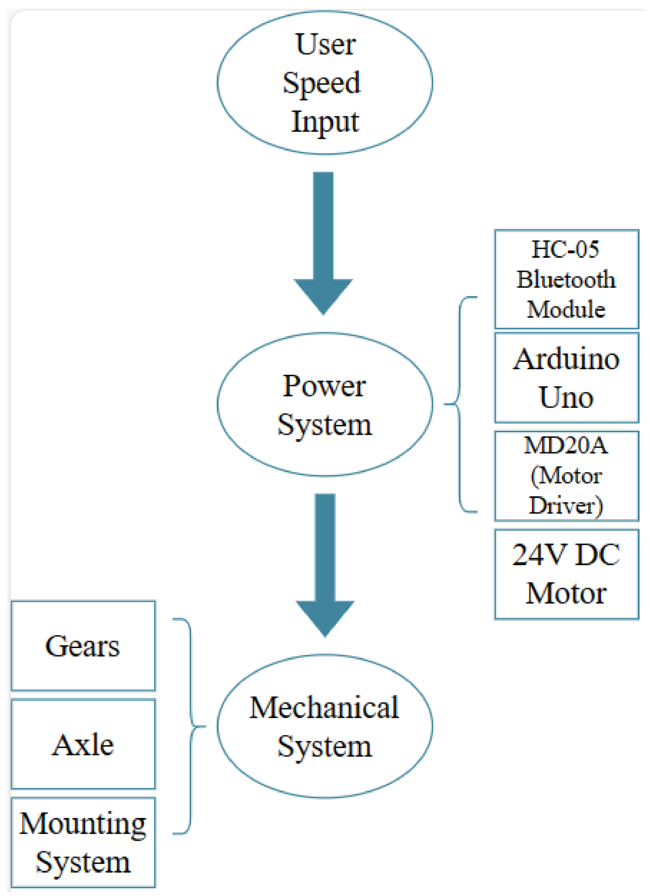
Problem Definition and Background



Design a stroller that allows the caregiver to walk without pushing the stroller with two hands.

- Motorize the system to allow for autonomous motion separate from human mechanical intervention.
- Design a mechanically safe and secure system to interface with electrical components.
- Develop a user-friendly way to engage with the system.

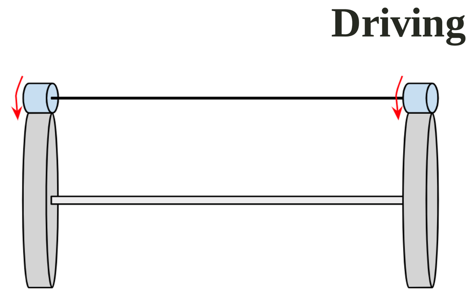
Modern stroller designs are the result of continuous iterations to meet a growing consumer market and meet the changing needs of the consumer from the need for portability met with the foldable stroller to the desire for swift adaptability, as in the three-wheeled “Baby Jogger” [1] [2].

Design Requirements

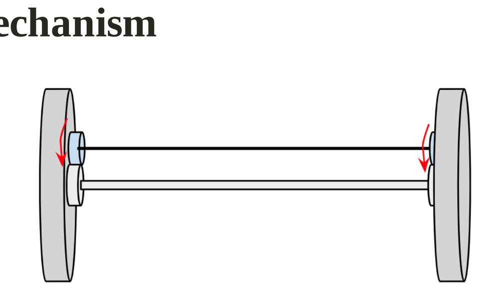
- The stroller must comply with safety standards for strollers outlined in ASTM-F833-21 [3].
- Maximum speed of 15 km/hr (ISO 7176-6:2018) [4]
- Maximum total stroller mass = 32 kg
- Limited undercarriage space of approximately 0.031 m^3 which limits the size of the mechanical and electrical components to be implemented.
- Each interlocking gear must have the same module and pressure angle (ISO 54:1996) [6]
- Coiling of any wiring in the system must avoid 90° pinches according to SAE J1128 [5] for low voltage wiring
- Budget: $400.00

Design Alternatives

Driving Mechanism

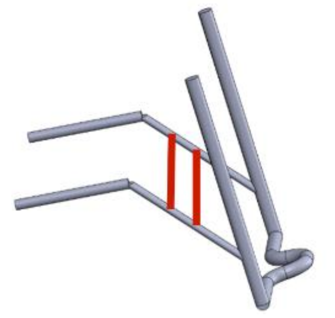


A. Friction rollers on new axle interfacing with tires

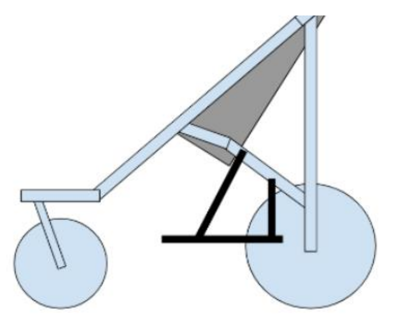


B. Gears on new axle interfacing with gears on stroller

Mounting System



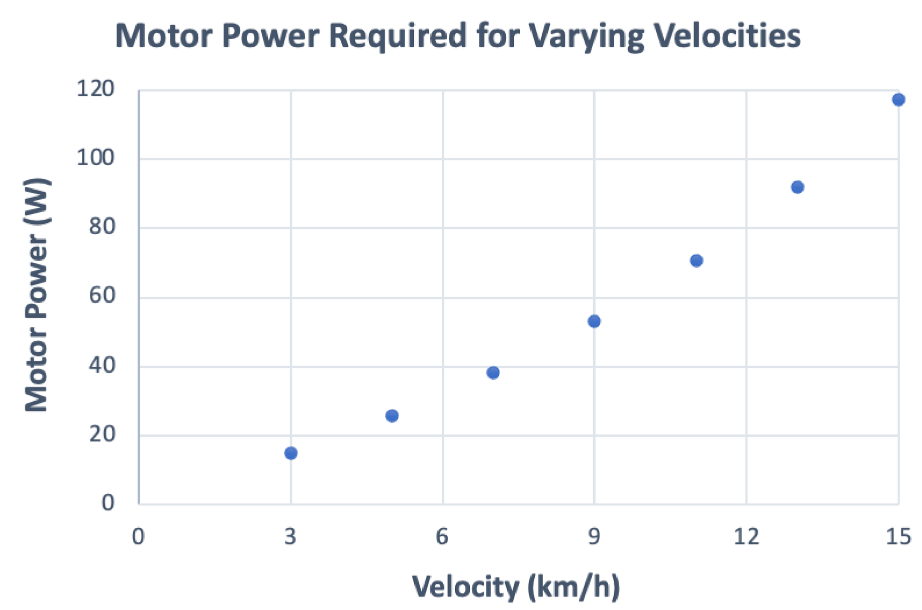
A. 3D view of dual crossbar mount in undercarriage of stroller



B. Side view of the shelf design in undercarriage of stroller

Design Evaluation and Iterative Process

The power required from the motor at different speeds was calculated by relating stroller dynamics to transmission system and rear wheel properties. The plot below shows the range of power required from the motor. The maximum power required from the motor is **117.2 W.**

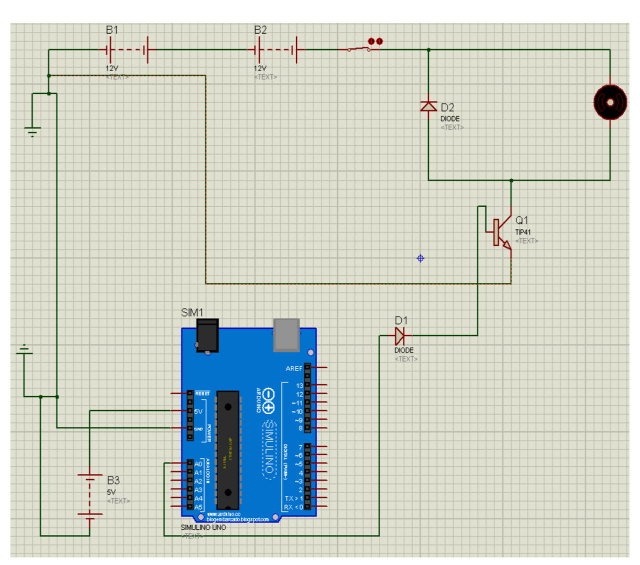


To ensure that an appropriate battery was selected, the battery life was calculated [7].

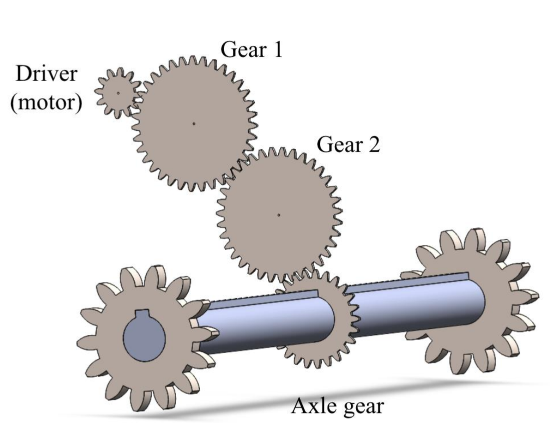
$$Battery\ life = \frac{Battery\ capacity * Voltage}{Power}$$

The battery life of a 7.2Ah battery for the stroller continuously running at 15 km/h was approximately 2 hours before the battery would need to be charged. On the other hand, the battery would have 4.5 hours of continuous usage if running consistently at 7 km/hr.

The initial proposed speed control system, in the scope of the power system, was dependent on transistors acting as digital switches for Arduino driven PWM signals. The final iteration pivoted towards the usage of a motor driver due to its simplification of the circuit and onboard current limiting capabilities to avoid damaging back EMF in the Arduino [8].



Initial transistor motor control circuit schematic



Initial gear design spanning from the motor to the new axle

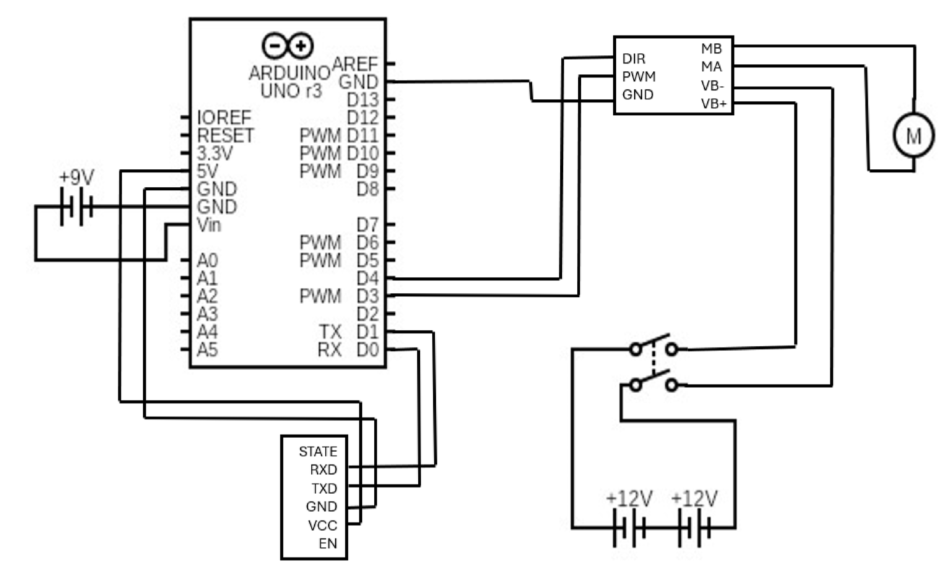
The initial design of the mechanical system (left image) was adapted throughout the project to meet mechanical system requirements. Two intermediate gears (Gear 1 and Gear 2) of 30 mm diameters sufficiently spanned the distance from the motor to the new axle. The gears on the new axle interlock with gears on the stroller through equivalent gear module and pressure angle.

Iterations of this system varied based on the following considerations:

- Relative gear size and diameter
- Gear thickness determined by allowable stress in the gear teeth
- Required structure to secure gears and axle in specific location
- User disengagement of power drive system

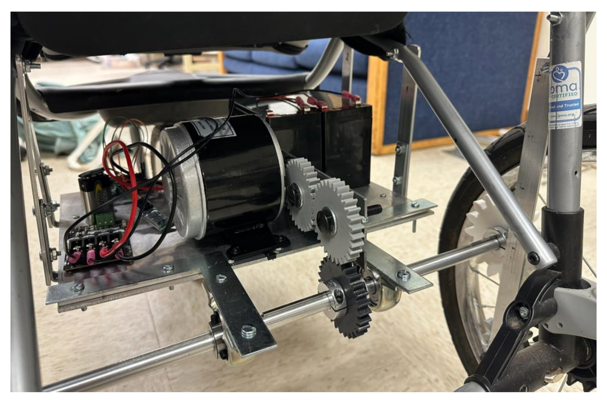
Final Design and Implementation

Power System:
A brushed motor of 350 W, 24 V and 3000 RPM rating was selected such that the motor power is above the maximum power required calculated. Two 12 V, Sealed Lead Acid, 7.2 Ah batteries connected in series provide current to the system. A Cytron 20A Bi-directional 6V-30V DC Motor driver interfaces with an Arduino Uno. The Arduino Uno is powered with a 9V battery and receives a signal from an HC-05 Bluetooth Module.



Final wiring diagram of all electronics incorporated into the design

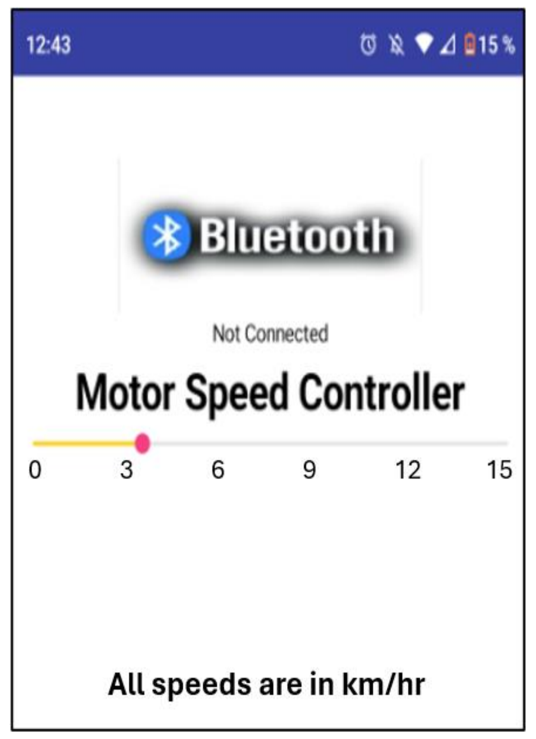
Mechanical System:
The final design implemented a gear train that spanned from the motor to the new axle with gears on either end that interlock with the stroller. The electrical power system is stored during operation on the mounting system in the undercarriage of the stroller.



The final design highlighting the mechanical system and the electrical power system mounted in the undercarriage. Also pictured is a lever and gear that allows the user to disengage the power drive system.

User Interface System:

An app was designed through MIT APP Inventor such that the thumb position of the caregiver on their mobile device screen could be translated into a Post Width Modulation (PWM) signal for the variation of the speed of the motor. In the interface, a Bluetooth signal is transmitted from a mobile device to an HC-05 Bluetooth Module as a byte which is then translated to a PWM signal by an Arduino Uno to culminate in a desired RPM of the gears system within the range of 0 to 15 km/hr.



MIT App Inventor for Bluetooth connection to Android 5+ Devices

Discussion, Conclusions, and Recommendations

The hands-free stroller design was based on suitable standards and design requirements. A mechanical analysis was performed to select a suitable motor and power supply. The mechanical system interfaces with the electrical power system to deliver power from the motor to the wheels, resulting in forward motion of the stroller. The final design allows the user to remotely control the speed and braking of the stroller through an application on their phone.

Future work includes:

- Implementation of proximity sensors that regulate the deceleration of the stroller in a controlled way once a caregiver is detected outside of a 2 ft range.
- Obstacle detection in the stroller’s front path to ensure safe emergency deceleration in case of unpredicted hazards.
- Attach accelerometers to the wheels to ensure adherence to a linear path and alert when the terrain necessitates adjustment to its path of motion.
- Decrease the mass of the power and mechanical systems to allow more flexibility for weight applied by the child and the caregiver’s belongings, namely with a change in material for the mounting system.

Of the available $400 budget, the project totaled $382.73, operating at much lower prices compared to market counterparts [9].

Acknowledgements

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References

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