Ryerson University

Department of Mechanical and Industrial Engineering
Faculty of Engineering and Architectural Science

FALL 2023
MEC325: INTRODUCTION TO ENGINEERING DESIGN
DESIGN PROJECT
FINAL REPORT

EzPUSH STROLLER

TEAM 0602

Table of Contents

Team Declaration

We, the undersigned members of Team 0602 in MEC325, agree that all team members have abided by all Ryerson Policies and course rules.

We furthermore accept that any violation of Ryerson Policy or course rules will lead to a grade penalty or charges of academic misconduct.

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[1] Only the last 5 digits of the student number are required.

Executive summary

This report presents a comprehensive design brief for a new stroller, emphasizing the crucial need for a secure, adaptable, and user-friendly solution for transporting children. The summary of the design brief sums up key considerations such as safety, environmental impact, and human factors. The Requirements section carefully outlines the criteria in several distinct categories such as comfort, nighttime usage, size restrictions, and many other sections.

Subsequently, an integrated design concept was crafted, incorporating key elements from each individual team member's designs and considering the six SUCs and personas. The visualization of the integrated concept was realized through a CAD drawing using Solidworks. Furthermore, a systems analysis was conducted to clarify the multifaceted functions of the stroller which is seen in the PDS.

The report wraps up by pointing out areas where the stroller design could be improved in the future. The main aim of the project is to make a stroller that works well, is eco-friendly, and meets the different needs of kids and caregivers. This final report is the result of a careful 3-step process MS1, MS2, and final report. After each loop had been completed several design issues stood out; these issues were specified in the DCR and by refining the issues we improved our design.

Design Brief Summary

From our team's perspective, several key aspects of the Design Brief stand out as crucial. Firstly, the emphasis on extending the range of users and co-users without causing issues with other aspects is of enormous importance for our group. Transporting infants and small children can be challenging due to their size, vulnerability, and limited mobility. Strollers are the solution to these problems as they provide a safe space for infants and young children.

The Design Brief highlights essential elements for our stroller design project. It emphasizes the need for an accessible and user-friendly stroller, which also increases usability for a diverse range of caregivers. Safety and ethical considerations are arguably the most crucial aspects, enforcing strict adherence to child safety regulations and ethical practices (from PRS pg 16, 31 & 34). Since the design revolves around giving the user the easiest experience possible, it is extremely important to make sure that safety for the infant is ensured and at the same time, reducing stress or worry of any injury and issues for the user. The Brief encourages innovation and environmental consciousness, pushing for more creative solutions that surpass existing designs while minimizing environmental impact. Since this is the case, the stroller's design prioritizes user comfort, ensuring protection from sun and rain, and accommodating children of varying sizes(from SKB pg 7, 10). For users living in Canada, it is also important to take winter conditions into account. The main aid in strolling through snow or ice from our design would be the large rear wheel tires which are made from polyurethane and have extra grip to add friction to certain terrains(from PRS pg 10, 24). Additionally, the entire lifecycle of the stroller, from deployment to storage, is designed with consideration for human factors, recognizing the diversity among parents, caregivers, and children. Our principles steer us towards crafting a stroller that is not only safe and user-friendly but also environmentally conscious and adaptable to a wide range of users.

By considering ecological, ergonomic, economic, and safety factors, our stroller design is very effective and gives the user the easiest experience possible when transporting infants and children since targeting these factors is what appeals most to the users of the stroller. The affordability of the design is also balanced since it is a good investment when considering its lifespan, along with the appealing features and easy usability even in bad weather

conditions(from PRS pg 27, 28).

Background

Within the design and creation of the EzPush, each unique component of the stroller was carefully thought out, researched, and designed. As such, the creation of the EzPush is based on research from numerous different sources and viewpoints. And so, the following is the culmination of research that led to the EzPush's creation.

Materials:

- Main goal of the stroller is to be lightweight and mobile.
    - Must also be structurally sound and reliable.
- The stroller will be made of aluminum and carbon fibre.
- Aluminum is naturally abundant making it a good choice [1].
    - It's low density, cheap, and easy to collect, as well as non-toxic.
    - It's also corrosion-resistant, malleable, and easy to manufacture.
    - Aluminum buildup in the body can have health risks.
        - However precautions can be taken.
    - Also, it's impermeable and 100% recyclable [2].
- Carbon fibre is light while also very strong, being resistant to strain [3].
    - It is highly corrosion-resistant and relatively fatigue-resistant, with a high tensile strength [4].
    - It is hard to obtain and not natural while being 20x more expensive than aluminum and not recyclable.

Wheels:

- The tires on the wheel will be made of polyurethane [5].
    - Polyurethane is flexible, resistant to water, and good at performing under harsh conditions [6].
    - Also low maintenance when changing tires.
- The wheels must have brakes attached to the frame of the stroller [7].
- Axles must be as wide as the base of the stroller for stability purposes [8].
- Front wheels must be 17.5 - 20 cm in diameter and back wheels 22.5 - 25 cm.
    - Front wheels must be able to swivel off a toggle switch for better maneuverability.
    - The stroller must have 4 wheels for proper weight distribution [9].
- Tires will have all-year treads, so users don't have to change them per season.
    - Also caters to a wider range of users.

Carriage:

- The height of the carriage will be equal to the height of the user's arms, matching the lowest handlebar height [10][11].
    - Caters to a healthy user posture.
- The cradle can be placed forward or backward facing [12].

    - This will make use of the sun visor.
- ➢ Carriage must support 30-40 lbs of weight without lowering stability [13].
- ➢ Carriage must meet proper regulations (ASTMF833 and ISO 31110) [14].
    - Prohibits exposure to toxic substances, and regulates baby safety.
- ➢ Carriage will be a plastic shell with a cushioned inner area [15].
    - Protects the user (baby) and increases satisfaction during the ride.

Handlebar:

- ➢ The handlebar should be adjustable in height.
- ➢ Adding padding/cushioning will provide comfort for the user, and reduce any vibrations.
    - Shock absorption will lower the impact of a bumpy ride [16].
- ➢ An ergonomic and slip-resistant grip is necessary for natural hand positioning [17].
- ➢ 40cm in adjustable height for the handlebar is adequate for a wide variety of users.
    - Ideal posture while holding the handlebar is hands around waist height and arms close to ribs [18].
- ➢ To make the handlebar adjustable, a locking adjustable angle hinge will be used [19].
- ➢ The material of choice for the handlebar will be plastic and the grip will be made of rubber [20].

Brakes:

- ➢ Hand-activated brakes are a better alternative to foot-activated ones.
    - Putting the brake on the handlebar allows the most natural use of the brake.
        - Faster to activate, can be done subconsciously, and does not require additional body movement.
- ➢ The brake will be a lever on the handlebar, connected to a cable, connected to the rear wheels.
    - Squeezing the lever triggers the brakes, by creating friction with the wheels.
- ➢ The brake pads will be made of an organic material like rubber [21].
- ➢ The point of hand-activated brakes is their ease of use without affecting hand positioning.
- ➢ The lever should be made of a lightweight material such as aluminum, and be able to be placed on both sides of the handlebar.
- ➢ A locking mechanism will be added so the stroller can be properly parked on all terrain.

Vibration:

- ➢ Excessive vibration amongst infants can lead to discomfort, stress, overstimulation, and shaken baby syndrome/developmental delays.
- ➢ To reduce vibration on the user, a comforter material (inside the carriage), and a linear chassis suspension will be added for accommodating the user [22].
- ➢ Reducing vibrations leads to higher user satisfaction.

Personas

Persona #1

Written by: Abdulrehman

Grealish is a 25-year-old father who recently embarked on a new chapter in Canada after leaving his small hometown in Russia. Deeply rooted in the traditions and cultural values of his upbringing, he is navigating the shift to Western societal norms with dedication and some challenges. Grealish is currently pursuing a business education in Canada while juggling work and commitments to secure a stable future for his wife and 2-year-old daughter. Given his non-native status, Grealish has difficulties with the intricacies of the English language, which can sometimes hinder his interactions with locals. Additionally, his slight physical stature, standing at 5'10" and weighing 120 lbs, and wearing thick glasses, is a result of his financial constraints as a student who is working hard to establish a life in a new country with such different weather conditions. All these struggles make it hard for him to spend time with his daughter. Grealish is actively looking for a stroller that accommodates his physical limitations and remains relatively inexpensive. He seeks a lightweight, easily maneuverable stroller that doesn't require extreme lifting and awkward postures.

Persona #2

Written by: Lucas

Abril is a 33-year-old Venezuelan woman who’s been living in New York in the Manhattan area for just shy of 13 years. She moved to the U.S. to study law abroad and has been saving up so that she and her husband, as well as their newborn daughter Lola, can move into their place comfortably. Tragically, however, 4 years ago Abril was struck by a car that ran a red light and is still in the process of learning how to walk again. She plans on going back to her morning runs when she's in better shape, as well as taking her daughter Lola with her in a stroller since they live within a 10-minute walk of Central Park. Abril loves to go for morning runs because she feels the best way to start a day is with exercise and a clear mind, and hopes to pass that trait down to Lola. Aside from her leg strength, Abril also suffers from weak upper body strength and poor mobility due to the accident. With all that in mind, the best kind of stroller for Abril is a

lightweight multi-use stroller that is not only comfortable for her to use but also able to meet her limited mobility needs. In addition, Abril wishes for the stroller to be adjustable in height since her husband has taken on the role of going on strolls with Lola and he is a few inches taller than Abril.

Persona #3

Written by: Anthony

Reginald (or “Reggie” as he says) is a 21-year-old Belgian living in Toronto and working part-time at a mechanics shop just down the street from his apartment. Reggie is living with his mother and 2-year-old brother Hampton. Shortly after Hampton's birth, Reggie’s dad died due to an alcohol overdose from the stress of paying rent. Because of this, Reggie’s mother has had to take on a second job and Reggie is now in charge of taking care of Hampton when his mom isn’t home. Hampton loves to be taken on walks around the block however the current stroller he uses has deteriorated in quality due to wear and tear and requires a replacement. Reggie unfortunately doesn’t have an excess of cash to spend due to his low working hours, but he swears to do the most for Hampton so he can have a memorable childhood. Alongside working as a mechanic Reggie dabbles in playing baseball from time to time and wishes to make it to the big leagues and play for the BlueJays.

Persona #4

Written by: Yasaman

Arun is a 35-year-old writer who lives in Vancouver. His wife, Mana, and he had a baby last year. Arun is visually impaired because of his diabetes at a very young age. He is not able to see clearly and he only can recognize light. His wife's maternity leave recently ended. Arun works at home. He is currently working on his new book as well as taking care of his daughter, Julia. Julia, as a one-year-old baby, enjoys playing games and going outside. Arun and Mana used to take her for a walk on a stroller every day but now, Mana stays at her job more often than she used to. This makes her extremely tired and she needs rest during the time she is at home. To combat this issue, Arun's attempt to take Julia for outings reflects not only his commitment to his daughter's well-being but also his pursuit of a semblance of normalcy. He struggles to

overcome the barriers imposed by his visual impairment.

Persona #5

Written by: Nicholas

Lindsay is a 65-year-old grandmother from a small rural town in east Texas. She spends her days looking after her daughter Cassandra's infant daughter while she is at work during the mornings and afternoons. Her day-to-day tasks with her granddaughter include feeding her breakfast and lunch, keeping the house clean and tidy, taking her for walks around the community, or other miscellaneous activities to keep her entertained. Lindsay had been forced into retirement due to an injury in her shoulder in her youth that is somewhat reaggravated and causing her physical strain. Prior to this, she was a cook at a local pub for over 40 years with much passion for cooking. Her recent pain has been taking a toll on her relationship with her granddaughter, as she is no longer able to take her for the long walks through the rural community and parks she was once able to. The stroller that Cassandra owns is far too heavy and bulky for her to use, and she is unable to unfold it or push it without discomfort or pain. Cassandra is heading out of state for business, placing the care of her daughter in Lindsay's hands, but Lindsay fears that she will not be able to perform to her full potential due to her physical limitations. She began looking for a stroller that was lightweight and could be very easily unfolded so somebody with her physical limitations could easily access and push it without stress or pain. The stroller must also offer a smooth ride, as they live in a rural community with lots of nature and very little smooth or paved ground. The ride must not allow for bumps to stir the child but allow for a soft and comfortable experience for Lindsay as well as her granddaughter.

Persona #6

Written by: Clayton

Jacob is a 47-year-old uncle to 2-year-old Beatrice. Beatrice was placed in her uncle's care for 5 months while her parents went to deal with family matters abroad. Jacob is a plumber by trade and makes an honest living to provide for himself and his new guest. Because of the demands of the industry, he often experiences fatigue, which can make it difficult to keep up with the

child's energy. He is also shorter than the average person, standing at about 5 feet even. Jacob lives in the San Francisco area, which is a rough landscape full of hills and elevation changes. This sparked an issue with the stroller Beatrice's parents provided him with. Their stroller is too heavy and does not include a reliable braking system that would be necessary for traveling on such steep hills for long durations. It also proved difficult to push uphill and restrain going downhill. It is because of this that Jacob needs a stroller that is both lightweight and includes a reliable braking system to allow for quick stops going downhill in the valley. He also needs the handlebar height to be suitable for his shorter stature, with clear visibility of the road ahead.

Situated Use Cases

SUC 1	Using a stroller in a crowded park
Owner	Abdulrehman
Description	On a rainy weekend afternoon, a parent is trying to navigate a busy city park with their baby in a stroller.

SUC 2	Using a stroller while handicapped
Owner	Lucas
Description	On an early weekday morning, a parent is trying to take their child for a walk while suffering from low mobility due to physical health.

SUC 3	Using a stroller
Owner	Lucas
Description	On a quiet Saturday afternoon, a man takes his younger brother on a walk in the wind.

SUC 4	Using a stroller with limited eyesight

Owner	Yasaman
Description	A father wants to take his 1-year-old baby girl for fresh air around the house.

SUC 5	Using a stroller
Owner	Nicholas
Description	A grandmother wishes to take her granddaughter on a walk through the forest with a mulch pathway.

SUC 6	Pushing and restraining the stroller
Owner	Nicholas
Description	An uncle wishes to take his niece on an evening walk through the San Francisco Valley, a region with very steep and tall hills.

Requirements

Requirements of a stroller according to Ontario Law:

- Ensure that the stroller has a secure harness or restraint system to keep the child safely in place [22].
- Adhere to the weight limit specified by the manufacturer. Overloading the stroller can affect its stability and safety [23].
- Assemble and use the stroller according to the manufacturer's instructions to ensure it is safe and stable.
- Always engage the brakes when the stroller is parked to prevent it from rolling away.
- Avoid hanging heavy bags or items on the handlebar, as it can affect the stroller's balance and stability [22].
- Select high-quality, durable materials for the frame, fabric, and components [23].
- Design the stroller with ergonomic features to ensure comfort for both the child and the person pushing the stroller [24]

Size Restrictions:

- Stroller height must be a minimum of 92 cm and a maximum of 129.
    - Stroller height depends on people's waist height.
    - The ratio of head size to the whole body is the total height divided by 1.618 [25].

- The stroller handlebar must be adjustable for 40 cm to be suitable for the majority of people.
    - Majority of people are between 150 cm to 193 cm [26].
- An adjustable handler is a must for having good posture while pushing the stroller [27]. The requirement part for an adjustable handlebar is a Locking adjustable angle [4].

Suspensions & Vibrations:

- Reduced vibrations to a lower than 5Hz [28]
- Magnitude of vibrations must not exceed 0.3 G of force[28]
- Cost must be below $15 per vibration reducer[28]
- Must not be too soft to have a significant displacement after loaded by a baby[28]

Types of conditions the EzPUSH must function in:

- The Stroller must be able to function on the following terrains:
    - Sidewalk/pavement
    - Concrete/flooring
    - Grass
    - Gravel
    - Sand
    - Hardwood floor/Tile
    - Light snow
    - Thin ice
- The Stroller must also be able to function in the following weather conditions:
    - Heat
    - Rain
    - Wind
- The stroller must not be susceptible to:
    - Weather and/or terrain damages (Rust, Corrosion, Embrittlement etc.)

- Since Canada can have bad weather conditions[29], our stroller includes the following to give the best user experience possible:

    - Big tires and rotatable front wheels to swivel and push through snow easier which are also made from polyurethane which works well in more severe conditions

    - Suspension and vibration mechanisms to make it easier to stroll through snow

    - Big storage for any extra winter clothes or items

    - Materials like aluminum and plastic are durable in colder conditions

    - the wheels should be able to turn fast as this will allow for more maneuverability

    - front wheel should be swivel wheels

    - good quality bearings should be used

Storage Requirements:

The storage in the stroller will be a sliding component and since this is the case, it should be easily accessible and will have the following parameters to maximize its functions:

- Slightly smaller than the width and length of wheel spacing since longer or wider could impact the center of mass and overall stability of the stroller.
- Ability to carry up to 10 to 15 pounds without affecting the center of mass since the carriage is approximately 30 to 40 pounds max.
- Enough volume to store essential infant items such as diapers, bottles, etc.
- Strap or lock to prevent from accidentally sliding open or spilling/dropping items.

Brakes and Safety:

- The braking system should provide reliable and consistent stopping power, allowing the stroller to come to a complete stop smoothly [30].
- Brakes shouldn't have small parts that would cause issues for small children [30].

- The brake mechanism should be easy for the user to engage and disengage, ensuring convenient control over the stroller's movement.
- The brake lever or mechanism should be positioned in a way that is easily reachable for the person pushing the stroller.
- The design should be intuitive, allowing users to understand how to operate the brake without having to think about it [31].
- It should not require excessive bending or stretching [32].
- The design should be made from environmentally friendly materials.
- The brake system should include a safety feature such as a lock to prevent accidental engagement.
- Brakes should be designed to function effectively in various weather conditions, including rain and snow.

Snow Requirements:

Canopy can protect babies from wind, rain, and snow during the time they are using a stroller. The canopy must be water-resistant, wind-resistant, and heat-resistant.

Materials to be resistant:

1. Water: Polyester
2. Wind: For instance, in designing umbrellas, the most important factor in making them windproof is a steady supportive base structure that can hold them in place. This feature is also used in the stroller's overall base structure. Another key factor is that the canopy must fully cover the baby's entire body for this attribute to be affected. The canopy must be attached tightly to the base structure of the stroller [33] .
3. Heat: the use of Darker colors must be limited since they are extremely heat absorbent. This feature primarily focuses on the canopy of the stroller, not the body [34].

Tire with more tread:

A Tire with deeper tread is suitable for winter. It can increase the acceleration and help to have better handling during winter when the condition is snowy, icy, slushy, wet, and dry with a cold surface [34].

Cost Limitations:

● General benefit of our stroller cost

- Although there are cheaper strollers, our design is made to last a very long time and can support children from birth to 4 or 5 years old and will be sold for around $300 to $600[35].

- This is a valuable investment since it can last for any future children and is very easy to use, while cheaper strollers are harder to use, will have way less functionality, and also not last as long which is less convenient overall.

● income and affordability of our stroller

- Real median household income in America was $74,580 in 2022, a 2.3 percent decline from 2021 [36].

- The typical average standard stroller can cost between 50 and 150 dollars [37].

- we will be able to construct the stroller with quality materials and minimize the cost as we will be avoiding “unnecessary” features such as complex folding mechanisms, advanced tech features, and necessary small parts.

- Manufacturing Processes: should be simple to minimize cost [38].

- Material will be low cost which also helps for costs if maintenance must be applied.

Human Factor Requirements (Parents/Guardian):

- **Adjustable Handlebars**: Angles should be able to be adjustable to allow parents and guardians to adjust the handlebars to suit their needs [39].
    - This will account for users that may be too tall and also too short.
- **Easy Maneuverability:** Incorporate features that can be operated with one hand, such as a simple folding mechanism or a one-handed brake system. (This is particularly helpful for parents who may be holding the child with *one hand*)
- **Comfort:** Padding and Cushioning
    - People with sensitive bones and arthritis can use it with minimal discomfort.
- **Vision:** The canopy shouldn't be too big otherwise it'll obstruct the view of the parent [40].
- **Weight:** Stroller should be relatively lightweight to allow the parents to move it around with minimal effort.
- **Rear Wheel brake:** You can lock the rear wheels with your feet and there is no need to bend down for people who have limited mobility [41].

Human Factor Requirements (baby/infant/child):

- Adjustable: Footrest and backseat must be adjustable depending on the baby's size. This includes the popliteal height (it may vary for each child).
- Vision: Transparent polyester parts in front of the canopy help the baby to be able to see outside of the stroller.
- Comfort: Blanket
- Safety: A simple harness design will allow parents to easily keep their children safe during any minor impact while in the stroller.
- Airflow: Having an airflow system helps the baby breathe comfortably and keep the temperature balanced.

People with impaired vision:

To use a stroller with limited or no vision, users need to use their other senses to navigate through their environment. Having distance sensors surrounding the stroller helps the guardians to be aware of their environment.

- Sense of touch: One of their other accessible senses is the sense of touch. The guardian can be notified of the upcoming obstacle through a specific vibration of the handlebar.
- Sense of hearing: The other senses to consider is the sense of hearing. By this method, the user can be notified of their surroundings using sound.

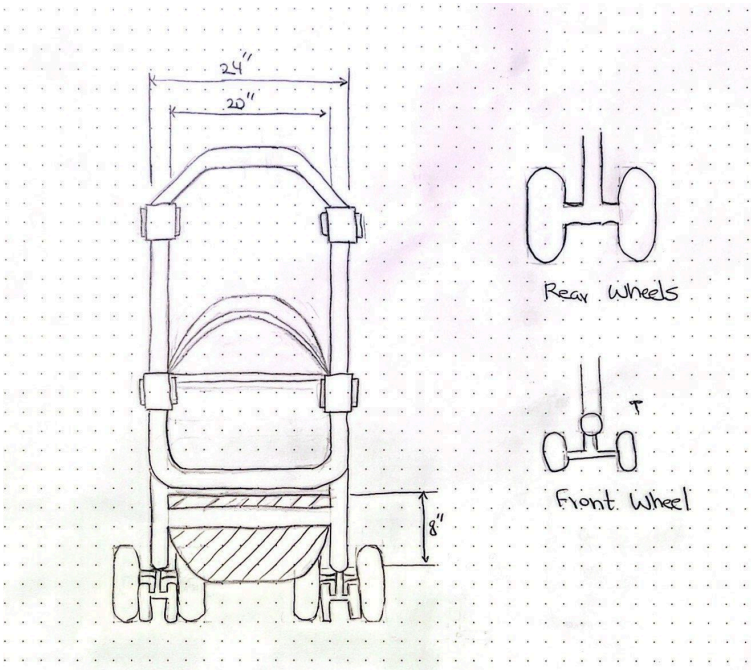
Night-time usage requirements:

To allow the users to have the best experience with their stroller, we want to add some features that make the stroller more user-friendly especially for people using the product in the dark. Having the stroller operate well in the dark can create a greater sense of safety and security for the user and child.

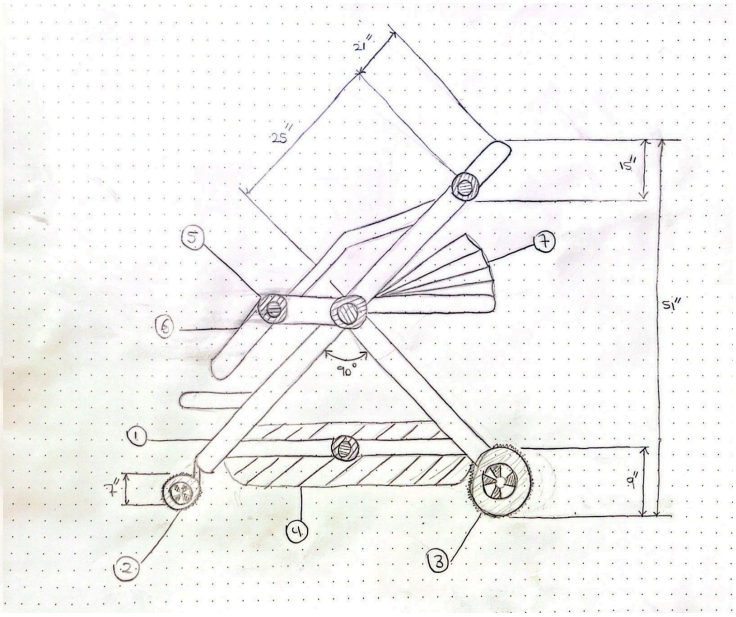
- Firstly, we will incorporate reflective materials and strips. These strips will be placed on the sides of the EzPush.
- Some of the fabric on the EzPush will be made out of reflective material such as a canopy with reflective lining to increase visibility from above.
- Design wheels with reflective elements. This can improve visibility from the side and make the stroller more noticeable in low-light conditions.
- Some materials that are good for this job are PVC Prismatic Reflective Tape
- Heat Transfer Vinyl this material works well in all types of weather conditions whether wind cold or rain [41].

By incorporating these features, a stroller can provide enhanced safety and visibility in night or dark areas, giving caregivers confidence when taking their child out during low-light conditions.

Integrated Design Concept



Graph 1. Front view of EZ push.



Graph 2. Side view of EX push.

The integrated stroller design concept emerges as a comprehensive solution catering to the diverse needs of parents or guardians caring for infants and young children, particularly addressing many of the human factor considerations. Drawing inspiration from six individual design concepts, the final iteration capitalizes on the strengths while mitigating weaknesses. Taking a look at the strengths and weaknesses of each design concept this included aspects such as functionality, aesthetics, cost, sustainability, and feasibility. Next, we established clear evaluation criteria based on the project's objectives. For example, we looked into design concept 1 page 20 of MS2. For this particular design, we liked how the stroller was able to fold and be stored in any given area. And all the folding took place through the main central pivot. Design 3 on page 34 in the PDS also had a design that we considered. We were happy with the way it looked aesthetically and the handlebars were also looking appropriate. The main issue with this design was that it had two handlebars. We realized if a user were to push with one hand it would require a lot of stability to balance the stroller and keep it from going side to side. So we decided to switch back to a regular handlebar with an ergonomic grip. Overall some features that made us come up with the integrated design concept included adaptability to diverse user needs,

catering to infants and young children with varying heights. The adjustable hinges for the handlebar, footrest, and back seat ensure a great experience for both infants and young children.

Creativity Methods

Design by Attributes

1. Cost-Effective Design, Cost Issue: Grealish is struggling to afford a high-end stroller:

Utilize a design-by-attribute approach to reduce costs. Explore materials and manufacturing processes that maintain quality while being more budget-friendly. Consider simplifying components and minimizing unnecessary features.

2. Fewer Number of Parts Issue: Grealish's budget constraints may be eased by a simpler design. Resolution:

Redesign the stroller with fewer parts to reduce production and assembly costs. A simple structure can contribute to affordability without compromising functionality.

3. Design by attribute:

Having 360° rotation on the front wheel and different widths for front and rear wheels which change the shape of the stroller. The trapezoid shape of the stroller helps users to change direction easily. A bigger canopy is used to cover the whole body. Canopy is used to protect a baby from any weather conditions such as snow, rain, and sun. The canopy that is big enough to cover the whole body increases the protection.

4. Analogical Design

Distance sensors are normally used for other technologies to avoid accidents and alarm the users from foreign however, this design sensor is used to help guardians with a lack of clear vision.

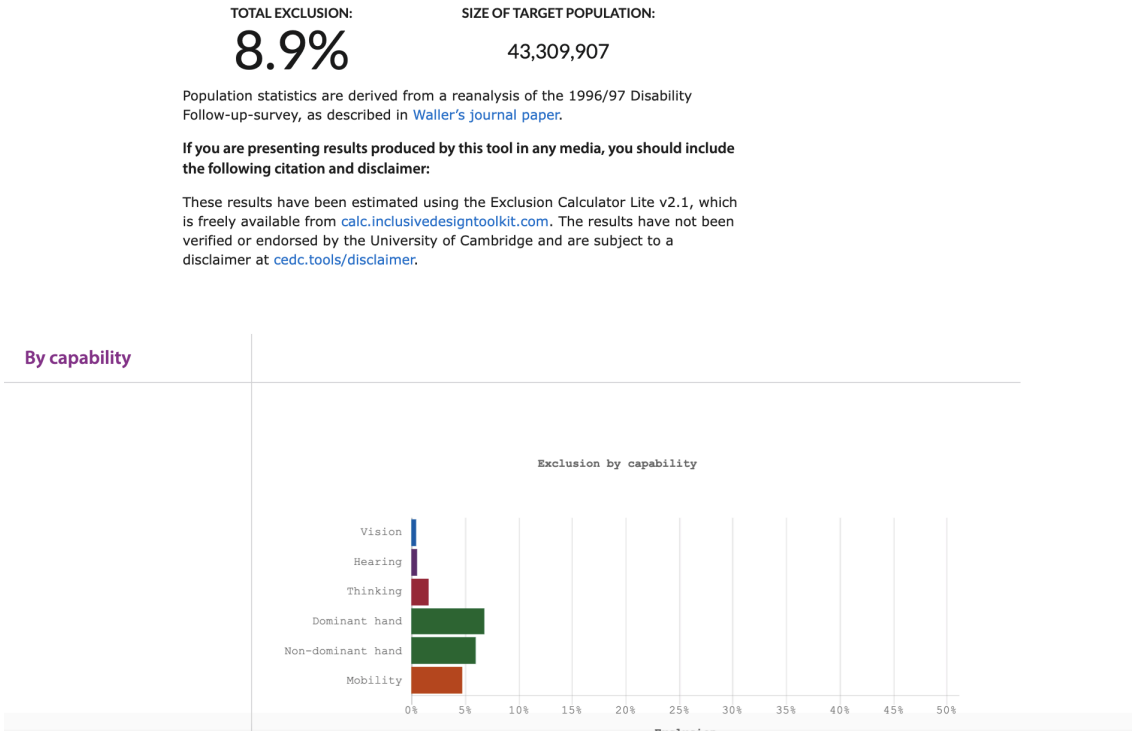
5. Challenge Assumptions:

By no longer assuming that every user wants their child to always face forward, more users are satisfied by the design. Allowing the carriage to be rotated forwards and backward caters to more users and increases user satisfaction.

6. Design by Attribute:

By changing the brake on the stroller from a foot brake to a more optimal hand brake, the action of braking becomes more natural as the user doesn't need to be in an uncomfortable position to set off the brakes. In addition, due to them being closer to the user, the delay between reaction and action becomes a lot smaller, decreasing the chances of failure.

CEC and USAGE SCENARIO



Graph 3. CEC for the mentioned size of the target population and exclusion percentages.

1. Setup

    A. Place the stroller on level ground.

    B. Unfold the stroller.

    C. Make sure the carriage and the frame of the stroller are properly fastened.

    D. Adjust the handlebar and height of the stroller to the desired position.

    E. Place the child in the carriage.

2. Use

    F. Place hands on the handlebar.

    G. Begin pushing the stroller at a safe speed.

H. Be aware of your surroundings and avoid obstacles as needed.

I. Continue until the destination is reached.

3. Put away

J. Remove the child from the stroller.

K. Fold the stroller back into the storage position.

L. Store stroller in designated storage area.

Table 1:

HF DEMAND	US STEP WITH HIGHEST DEMAND (#, description)	% Excluded	Comment
Vision	2H	0.4%	Must be able to scan the area for any danger.
Hearing	2H	0.5%	Must be able to hear around them for any danger.
Concentration memory	1C	1.6%	Must remember to lock and appropriately fasten the child.
Strength & dexterity (dominant)	1E/3J	6.8%	Must be able to lift a child into and out of the stroller.
Strength & dexterity (non-dominant)	1E/3J	6.0%	Same as the previous comment.
Walking and Mobility	2I	4.7%	Must be able to walk for extended periods, depending on location.

Systems Analysis

Subsystem Identification Matrix

Table 3:

FUNCTION	ADJUSTABLE HINGE	CUSHIONED PART	WATER RESISTANT MATERIAL	TRANSPARENT MATERIAL	CANOPY	STORAGE BIN	BIG REAR WHEEL	BRAKES	ROTATABLE FRONT WHEEL	TIRE WITH TREAD	HOLLOW COMPONENTS	REFLECTIVE STRIPS
COMFORTABLE FOR DIFFERENT SIZE BABY	X	X										
COMFORTABEL FOR DIFFERENT SIZE USER	X	X										
FRONT VISION				X								
USE IN DIFFERENT TERRAINS							X		X	X		
STORE IN SMALL PLACES	X										X	
DIFFERENT WEATHER CONDITION USE			X		X	X	X		X	X		
EASY TO PUSH		X									X	
STORE ESSENTIALS						X						
BALANCE							X				X	
STABILITY								X				
NIGHT TIME USE												X

System Diagram

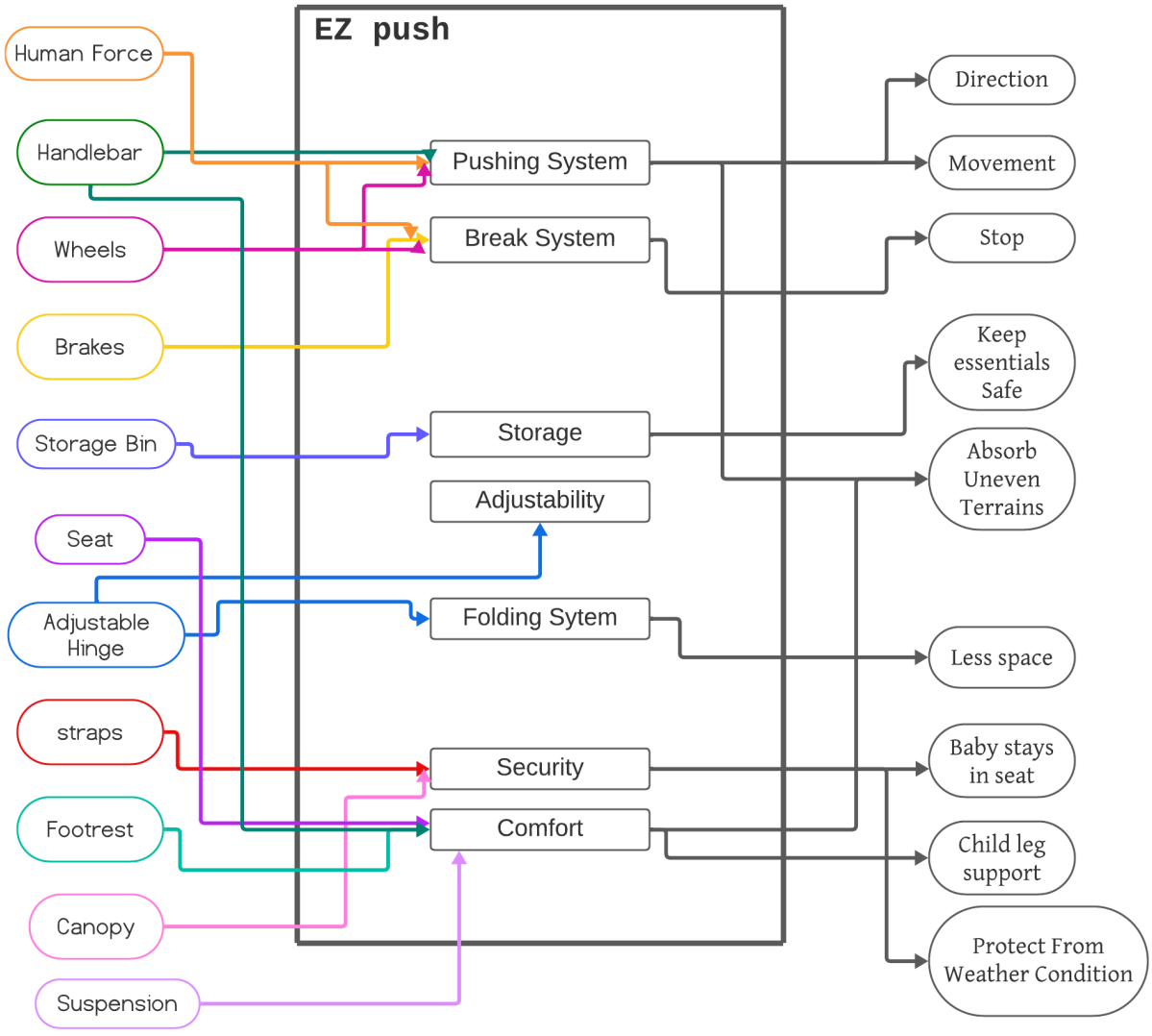


Diagram 1. System analysis.

System Interface list

- Ergonomics handlebar: Adjustable for 40cm for people from 92 cm to 192 cm in weight height. Effortless steering and control [25] [26].
- Responsive Brake control: Quick and precise stopping - enhancing safety - easily reachable
- Secure Harness System: child safety during the ride - 3-point harness - straps are two fingers apart from baby's chest for young children.
- Effortless Folding Mechanism: user-friendly folding mechanism- Minimal effort - easy storage
- Adaptable Canopy: adjustable for optimal shade for different weather conditions - the size is smaller than the handle part of the vehicle to open completely.
- Convenient Storage: Enough space for essentials - easily accessible basket - smaller than width and length of wheel spacing - carries up to 10 to 15 pounds.
- Smooth Wheel System: effective suspension system - vibrations to a lower than 5Hz - Magnitude of vibrations must not exceed 0.3 G of force [28].
- Customizable footrest: Adjustable footrest supports the proper position for the child’s leg

The design of a stroller is a complex but well-organized system that prioritizes user comfort, safety, and ease of use. The design process begins by understanding the external elements that influence the system, considering it an opaque entity whose internal workings are yet to be defined. This interface includes various components contributing to the overall functionality and user experience. The handlebar facilitates steering with an emphasis on ergonomic design. Safety is prioritized with a responsive braking system. Adjustable features allow customization for user preferences. The harness and straps subsystem ensures child safety and comfort. Foldability improves convenience for storage and transportation. A canopy protects the baby from weather conditions, and a spacious storage basket ensures easy access to essentials. A smooth-ride wheel system addresses various terrains, and customizable leg support enhances the child's comfort during the journey. Together, these components create a user-friendly and adaptable stroller system. The smooth integration of these subsystems results in a comprehensive

stroller system that addresses the diverse needs of both the parents/guardians and the child. The system design follows a flow, starting from user inputs and steering controls, progressing through safety features and adjustments, and culminating in a comfortable and secure ride for the child.

Detailed Design

Body:

The frame of the stroller is entirely made of aluminum alloy. The team opted for aluminum rather than aluminum or carbon fibre because the properties of aluminum alloy better aligned with the priorities of the team and the desired outcome. Aluminum was selected for its lightweight nature, as well as its strength properties [1-2]. This was selected because ease of use was a team priority. Selecting the lightest possible material without sacrificing strength and affordability was crucial for designing the final iteration of the stroller. This means that the stroller will be easier to push as its overall weight will be reduced compared to stainless steel alternatives, but strength and resistance to corrosion will not be sacrificed [2]. It was decided to use an alloy of aluminum, to increase strength capabilities. 6063 aluminum alloy demonstrates fair strength properties, more than sufficient strength for the needs of a stroller. It also showed promising corrosion resistance. It is also easy to weld and machine, making it an ideal product as manufacturing the stroller may be cheaper than it would be using other materials [42]. Another promising trait of aluminum for the frame is that it is 100% recyclable [2]. This is desirable because it is easy to obtain, but can also be disposed of easily and without harm to the environment, appeasing the ethical side of manufacturing. In terms of the usability of the product, the frame is composed of three major pieces, which connect at the central hinges. These hinges act as fold points, causing the stroller to collapse into itself and take up as little space as possible when folded. This was done to consider the families that do not have space as an asset and need to be able to fit the stroller into compact places, such as closets or attics. The hinges should be operational for years, but if they are damaged and must be replaced they can easily detach from the rod that connects to the cradle, and be replaced with new ones. They can also be oiled or greased if they become too stiff.

Wheels:

The wheels will be specially manufactured in-house. This will slightly increase the overall

cost when compared to buying them from a manufacturer, but it aligns more with the scope of the project. The wheels will be of synthetic rubber, and polyurethane with tread all around them. This was decided for a few specific reasons. The tires will be made from polyurethane. This material was chosen as opposed to regular rubber because it is very durable, flexible, and capable of harsh weather conditions [6]. It is a very versatile material and requires very little maintenance over time. Because of its durability, the tires will not need to be replaced very often and the tread should last multiple winters [43]. This was a very desirable quality because it ensured that there would be minimal wear, meaning less overall maintenance cost for the product. Polyurethane wheels will also not require any air pumping or filling. The material itself is strong and sturdy, meaning the tire can be thick but also tough without any air [43]. This means the wheel cannot puncture, also promoting the longevity of the tire. Overall, very little to no maintenance will be required for the wheel to function. The brakes, on the other hand, will be hand operated, rather than foot operated. They will allow the user to grip the brake lever which will use friction to stop the wheels at the axle. They will not undergo heavy loads but will need maintenance. The pads may become stripped as they wear, which will cause them to need replacing. The lever will need to be lubricated to prevent grinding or stripping.

Miscellaneous Parts/Pieces:

Shock-absorbing springs in the frame connecting to the wheels. These will require little maintenance as they will be enclosed and protected from the elements. They serve the purpose of reducing vibration experienced by the frame and the baby in the stroller [44].

All parts such as screws and nuts will be steel. Steel was selected because of its resistance to corrosion and its strength. Steel has been proven to be a very strong material, while not being too heavy, and it also does not rust [45]. Because of these properties, these parts should last the entire lifetime of the stroller, however, if they do become damaged they can easily be replaced as these parts can be found at nearly all hardware stores very inexpensively.

Within the canopy, there are “hinges” made out of fabric which allow it to collapse and expand from its fully closed position to its fully open position. These parts can be sewn if damaged, or they would have to be replaced. They will attach to the outer frame of the canopy which will be carbon fibre. Carbon fibre is the material of choice for this position because it is extremely lightweight and demonstrates promising strength capabilities [3-4]. This will put

minimal stress on the fabric hinges, decreasing the chances of it snapping, while also maintaining strength allowing the baby to be protected from the elements.

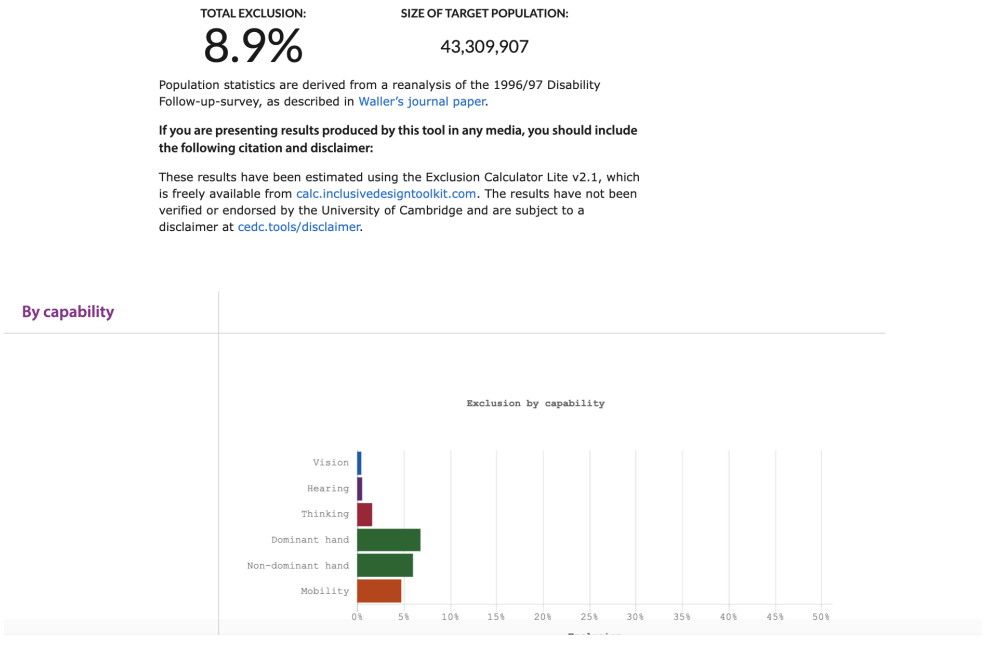
Reflective tape will be placed on the frame to allow for vehicles to see the stroller at night time. Reflective tape can dramatically increase the level of visibility that an outside observer will have on the object [46]. These can last for several years and can easily be replaced [46].

Design Issues

Throughout the refinement of the EzPush design, the second iteration unveils significant considerations and challenges. These enhancements stem from a comprehensive analysis that encompasses issues identified in both Milestone 1 and Milestone 2 of the design process.

Human factor considerations

- ➢ Ergonomic Design of the handlebars.
    - The ergonomic handle, inspired by snow shovel designs, may not provide universal comfort. Shorter users and those with smaller hands may struggle to secure a comfortable grip (PDS page #24).



Most of the human factor issues were due to the high level of usage of the dominant hand, to reduce the effect we designed the handlebars with a special focus on ergonomics.

- ➢ Storage Area Location.
    - The storage compartment is located at the bottom of the stroller, and this will make it a little harder for users who have any major knee and joint problems (PDS page #29).
- ➢ Thicker and Heavier Tires.
    - The tires on the stroller are designed for users to have an easy time traveling through snow and harsh Canadian winters. This in turn makes the turning a little challenging and adds some extra weight which will require slightly more effort pushing (PDS page #34).
- ➢ The Folding Mechanism.
    - The folding mechanism works through a main central pin which allows the stroller to fold completely. However, this system may take some time getting used to and may require a higher level of comprehension on the user's part (PDS
    - page #24).

Procedural Challenges/issues

- ➢ Some issues in the setup procedure in the Usage scenario include (PDS Page 55)
    - The instructions for picking up the stroller do not specify a particular part, potentially leading to confusion.
    - Releasing the stroller's folding mechanism may lack clarity if the mechanism is not well-defined.

- Adjusting the stroller handles to a comfortable height might not be specified clearly, leading to uncertainty.

➢ Some issues in the use procedure in the Usage scenario include (PDS Page 55)

- The instruction to securely grip the stroller for control lacks specific details on the recommended grip or hand placement.
- The guidance on positioning the stroller for pushing could benefit from more specific details on the ideal posture.
- Troubleshooting instructions are mentioned but not detailed, potentially confusing if users encounter issues.

➢ Some issues in the put-away procedure in the Usage scenario include (PDS Page 55)

- Folding and collapsing the stroller using the designated mechanism may be unclear without specific instructions.
- Storing the stroller in a designated area lacks details on where the designated area should be and how to ensure proper storage.

Some Technical Issues may Include:

➢ Provide easily adjustable features

- In the first design concept the seat wasn't adjustable, however at the end of Loop 3. The seat was able to rotate so users could see their children's faces. This can accommodate different child sizes and preferences.
- Ensure that adjustment mechanisms are smooth, requiring minimal force from users.

➢ Storage area was rather small

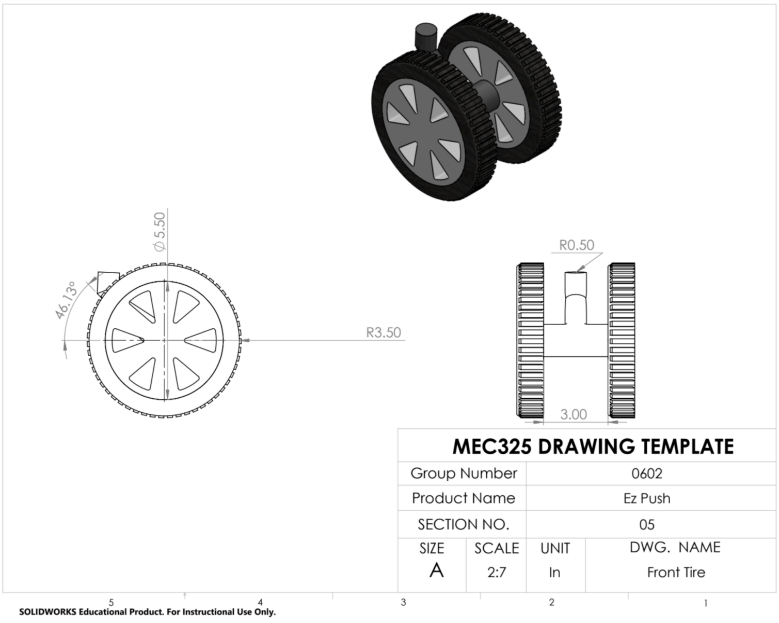
- From MS1 design issue 1, the stroller had a small unremovable storage compartment.

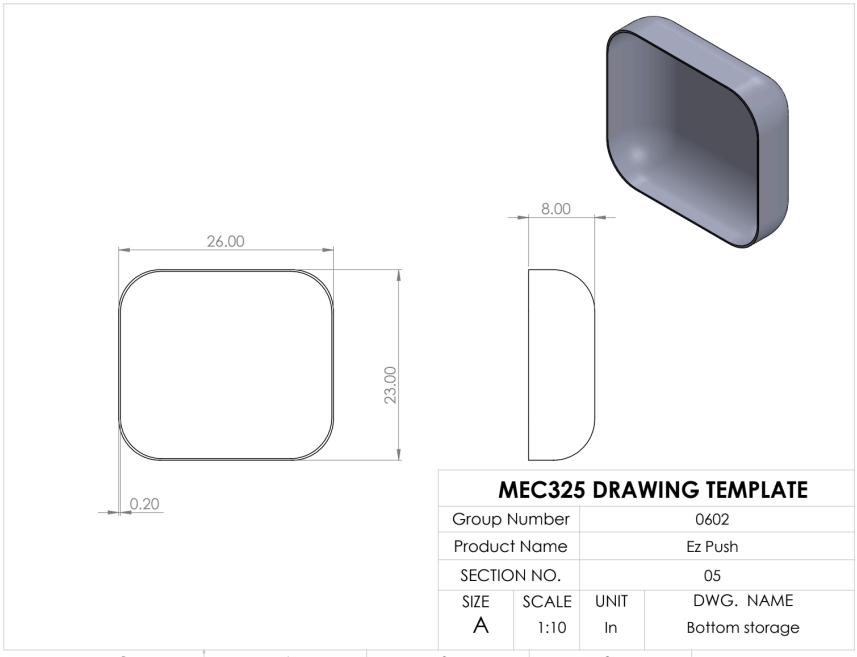
- However, by the end of loop three this issue has been resolved and the compartment is removable and allows for more space.

➢ Another issue was the design of the handlebars

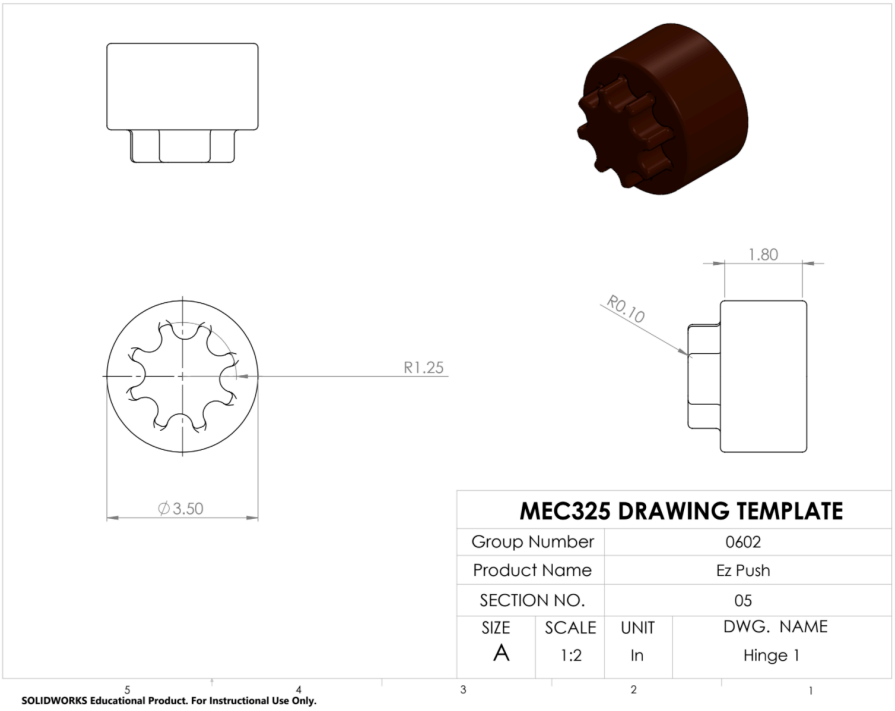
- Instead of having two individual handlebars, we decided to stick with one which is connected.

CAD Drawings

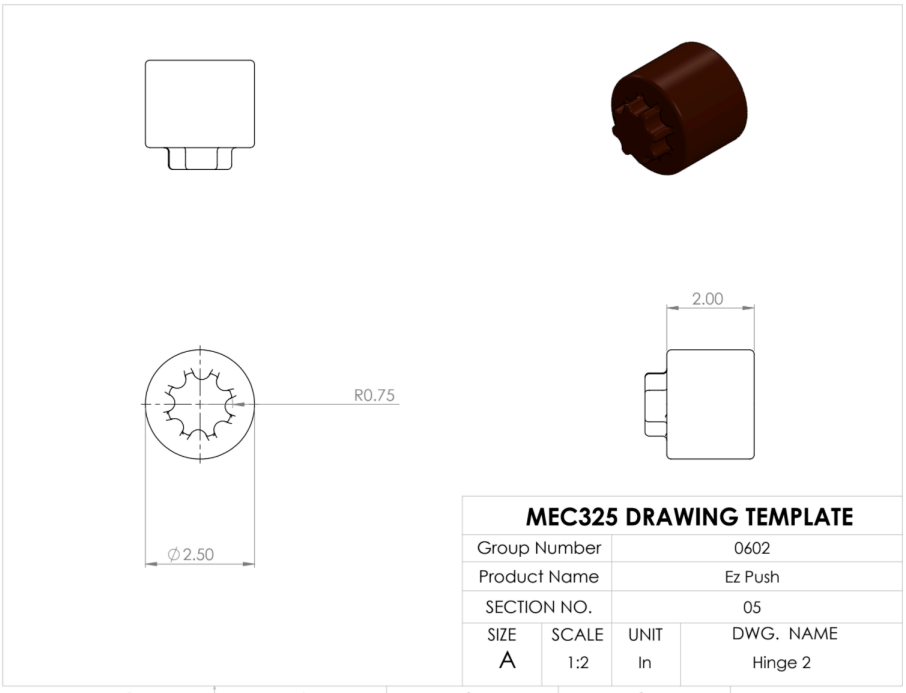




MEC325 DRAWING TEMPLATE			
Group Number	0602		
Product Name	Ez Push		
SECTION NO.	05		
SIZE	SCALE	UNIT	DWG. NAME
A	1:10	In	Bottom storage

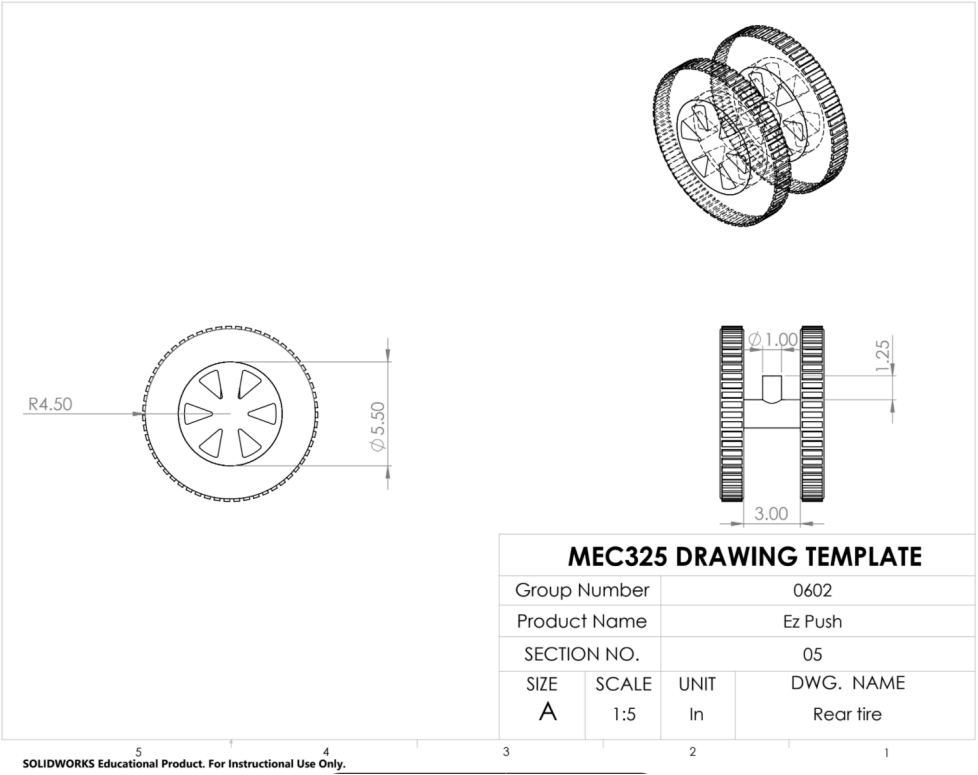


MEC325 DRAWING TEMPLATE			
Group Number	0602		
Product Name	Ez Push		
SECTION NO.	05		
SIZE	SCALE	UNIT	DWG. NAME
A	1:2	In	Hinge 1



MEC325 DRAWING TEMPLATE			
Group Number	0602		
Product Name	Ez Push		
SECTION NO.	05		
SIZE	SCALE	UNIT	DWG. NAME
A	1:2	In	Hinge 2

SOLIDWORKS Educational Product. For Instructional Use Only.



MEC325 DRAWING TEMPLATE			
Group Number	0602		
Product Name	Ez Push		
SECTION NO.	05		
SIZE	SCALE	UNIT	DWG. NAME
A	1:5	In	Rear tire

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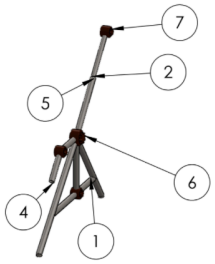
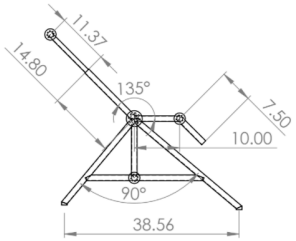


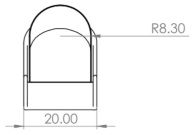


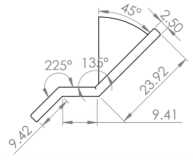
ITEM NO.	PART NUMBER	QTY.
1	Support truss	1
2	Top side support pt.1	1
3	Bottom support pt.1	1
4	Bottom support pt.2	1
5	Top side support pt.2	1
6	hinge 1	1
7	hinge 2	3

MEC325 DRAWING TEMPLATE

Group Number		0602	
Product Name		Ez Push	
SECTION NO.		05	
SIZE	SCALE	UNIT	DWG. NAME
A	1:2	In	Right side

5 4 3 2 1

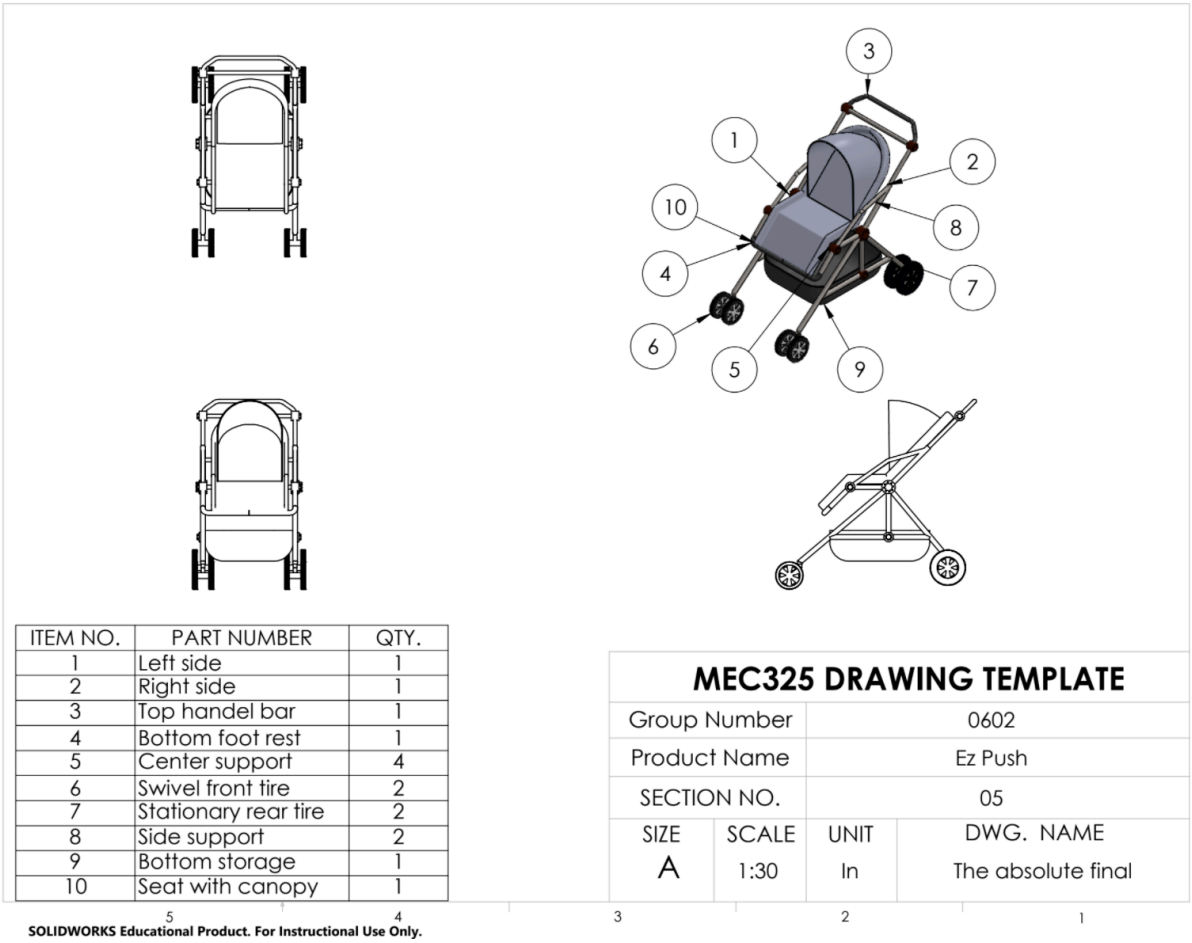




MEC325 DRAWING TEMPLATE

Group Number		0602	
Product Name		Ez Push	
SECTION NO.		05	
SIZE	SCALE	UNIT	DWG. NAME
A	1:20	In	Seat with canopy

5 4 3 2 1



References

Background:

[1] thyssenkrupp Materials, “6 best advantages of aluminum - thyssenkrupp materials (UK),” Materials UK, https://www.thyssenkrupp-materials.co.uk/advantages-of-aluminium.html (accessed Oct. 10, 2023).

[2] “Aluminium - element information, properties and uses: Periodic Table,” Aluminium - Element information, properties and uses | Periodic Table, https://www.rsc.org/periodic-table/element/13/aluminium (accessed Oct. 10, 2023).

[3] P. Gupta, S. Sharan, P. Roy, and D. Lahiri, “Aligned carbon nanotube reinforced polymeric scaffolds with electrical cues for neural tissue regeneration,” Carbon,

https://www.sciencedirect.com/science/article/abs/pii/S0008622315302098 (accessed Oct. 10, 2023).

[4] P. Bhatt and A. Goe, “Carbon2,” Material Science Research India, https://www.materialsciencejournal.org/vol14no1/carbon-fibres-production-properties-and-potential-use/ (accessed Oct. 10, 2023).

[5] B. n G. B. Blog, “What kind of Pram Wheels are best?,” Bubs n Grubs Baby Shop, https://www.bubsngrubs.com.au/baby-blog/what-kind-of-pram-wheels-are-best (accessed Oct. 2, 2023).

[6] P. Urethane, “Polyurethane & urethane properties,” Polyurethane Advantages - Urethane Properties & Benefits | Precision Urethane, https://www.precisionurethane.com/urethane-advantage.html (accessed Oct. 13, 2023).

[7] H. Canada, “Government of Canada,” Canada.ca, https://www.canada.ca/en/health-canada/services/infant-care/strollers-carriages.html (accessed Oct. 2, 2023).

[8] K. M. Cronan, Ed., “Choosing safe baby products: Strollers (for parents) - nemours kidshealth,” KidsHealth, https://kidshealth.org/en/parents/products-strollers.html (accessed Oct. 2, 2023).

[9] C. Désy, “How to choose a baby stroller?,” Naitre et grandir.com, https://naitreetgrandir.com/en/pregnancy/third-trimester/how-to-choose-a-baby-stroller/ (accessed Oct. 2, 2023).

[10] *Baby Strollers 3 in 1 car seats newborn infant cradle baskets baby carriage prams multi functional high landscape folding portable using at Mall Supermarket Halloween Thanksgiving Christmas outdoor baby strollers - baby & maternity* (no date) *Temu*. Available at: https://www.temu.com/baby-strollers-3-in-1-newborn-infant-cradle-baskets-baby-carriage-prams-multi-functional-high-landscape-folding-portable-using-at-mall-supermarket-outdoor-baby-strollers-g-601099513309727.html (Accessed: 15 October 2023).

[11]*Buy b.childhood Baby Stroller set portable anti-shock luxury for newborn infant cradle convert to bassinet car SEAT basket 0-4 year in black online at low prices in India* (no date) *Buy B.Childhood Baby Stroller Set Portable Anti-Shock Luxury for Newborn Infant Cradle Convert to Bassinet Car Seat Basket 0-4 Year in Black Online at Low Prices in India - Amazon.in*. Available at: https://www.amazon.in/B-Childhood-Stroller-Portable-Anti-Shock-Bassinet/dp/B08J98LNY9 (Accessed: 15 October 2023).

[12](No date) *U.S. – CPSC adopts ASTM F833-19 for carriages and strollers in direct final rule*. Available at: https://www.intertek.com/consumer/insight-bulletins/cpsc-adopts-astm-f833-19-for-carriages-and-strollers/ (Accessed: 15 October 2023).

[13](No date a) *International ISO standard 31110*. Available at: https://cdn.standards.iteh.ai/samples/72243/fa0781c01949464c98350fe79def75ff/ISO-31110-2020.pdf (Accessed: 16 October 2023).

[14]Government of Canada, P.W. and G.S.C. (2022) *Government of Canada*, *Canada Gazette, Part 1, Volume 156, Number 24: Carriages and Strollers Regulations*. Available at: https://www.gazette.gc.ca/rp-pr/p1/2022/2022-06-11/html/reg3-eng.html# (Accessed: 15 October 2023).

[15]Branch, L.S. (2023) *Consolidated federal laws of Canada, carriages and Strollers Regulations*, *Legislative Services Branch*. Available at: https://laws-lois.justice.gc.ca/eng/regulations/sor-85-379/20110620/P1TT3xt3.html (Accessed: 15 October 2023).

[16]strollerboardsStrollerBoards is a family managed website with me (Ben) and my wife doing most of the work. We are proud parents of two wonderful kids and love reviewing baby travel gear. We have a firm but friendly “democratic parenting” style and offer s (2022) *Adjustable stroller handle: Save your back with this useful feature*, *Stroller Boards, Parts, Accessories*. Available at: https://www.strollerboards.com/adjustable-stroller-handle (Accessed: 15 October 2023).

[17]*Height of humans* (no date) *Bioblast*. Available at: https://www.bioblast.at/index.php/Height_of_humans (Accessed: 15 October 2023).

[18]*Make your walks work for you: 5 tips for better stroller posture* (2022) *Phoebe*. Available at: https://hiphoebe.com/make-your-walks-work-for-you-5-tips-for-better-stroller-posture/#:~:text=Keep%20your%20hands%20low%2C%20at,to%20help%20with%20the%20push. (Accessed: 15 October 2023).

[19]Sugatsune (2022) *Multi Angle Locking Hinge*, *MULTI ANGLE LOCKING HINGE – Quincaillerie Architecturale / Industrielle*. Available at: https://sugatsune.ca/product/multi-angle-locking-hinge-2/ (Accessed: 15 October 2023).

[20]*Baby Stroller* (no date) *How Products Are Made*. Available at: http://www.madehow.com/Volume-4/Baby-Stroller.html (Accessed: 15 October 2023).

[21] K. Walker, "It's all about the brake," Pushchair Expert, https://www.pushchairexpert.com/advice-inspiration/advice-and-guides/its-all-about-the-brake/ (accessed Oct. 15, 2023).

[22] C. Reports, "Strollers: 5 important safety features to look for," Product Reviews and Ratings - Consumer Reports, https://www.consumerreports.org/cro/news/2009/08/strollers-5-important-safety-features-to-look-for/index.htm (accessed Oct. 15, 2023).

[23] K. M. Cronan, Ed., "Choosing safe baby products: Strollers (for parents) - Nemours kidshealth," KidsHealth, https://kidshealth.org/en/parents/products-strollers.html (accessed Oct. 15, 2023).

[24]Abu-Taieh, E. and Al-Bdour, H.S. (2018) *A human body mathematical model biometric using golden ratio: A new algorithm*, *IntechOpen*. Available at: https://www.intechopen.com/chapters/60714 (Accessed: 15 October 2023).

[25]*Height of humans* (no date) *Bioblast*. Available at: https://www.bioblast.at/index.php/Height_of_humans (Accessed: 15 October 2023).

[26]*Make your walks work for you: 5 tips for better stroller posture* (2022) *Phoebe*. Available at: https://hiphoebe.com/make-your-walks-work-for-you-5-tips-for-better-stroller-posture/#:~:text=Keep%20your%20hands%20low%2C%20at,to%20help%20with%20the%20push (Accessed: 15 October 2023)

[27]Sugatsune (2022) *Multi Angle Locking Hinge*, *MULTI ANGLE LOCKING HINGE – Quincaillerie Architecturale / Industrielle*. Available at: https://sugatsune.ca/product/multi-angle-locking-hinge-2/ (Accessed: 15 October 2023).

[28]P;, H. Y. (n.d.). *Subjective discomfort caused by vertical whole-body vibration in the frequency range 2-100 Hz*. Ergonomics. https://pubmed.ncbi.nlm.nih.gov/30296383/

[29] H. Gleason, "11 best strollers for snow in 2024: A buying guide ," Gleason Family Travels, https://gleasonfamilytravels.com/best-strollers-for-snow/#:~:text=Make%20sure%20that%20your%20stroller,sidewalks%20or%20crowded%20winter%20festivals (accessed Nov. 13, 2023).

[30] strollerboardsStrollerBoards is a family managed website with me (Ben) and my wife doing most of the work. We are proud parents of two wonderful kids and love reviewing baby travel gear. We have a firm but friendly "democratic parenting" style and offer s, "Brakes: An important stroller feature," Stroller Boards, Parts, Accessories,https://www.strollerboards.com/stroller-brakes (accessed Oct. 15, 2023).

[31] E. Astoul, "7 Brands Selling Sustainable Strollers for safe and Green Adventures with your little ones," Sustainably Chic, https://www.sustainably-chic.com/blog/sustainable-strollers#:~:text=WHAT%20ECO%2DFRIENDLY%20MATERIALS%20SHOULD,can%20find%20on%20the%20market(accessed Oct. 15, 2023).

[32] E. Astoul, "7 Brands Selling Sustainable Strollers for safe and Green Adventures with your little ones," Sustainably Chic, https://www.sustainably-chic.com/blog/sustainable-strollers#:~:text=WHAT%20ECO%2DFRIENDLY%20MATERIALS%20SHOULD,can%20find%20on%20the%20market (accessed Oct. 15, 2023).

[33]Beaufurn and Beaufurn (2023) *Best patio umbrellas for high wind conditions*, *Beaufurn Blog*. Available at: https://beaufurn.com/blog/2022/02/best-patio-umbrellas-for-high-wind-conditions/(Accessed: 13 November 2023).

[34](No date) *The effective implementation of professional learning communities - ed*. Available at: https://files.eric.ed.gov/fulltext/EJ1194725.pdf (Accessed: 13 November 2023).

[35] Straightgoodsmotherhood, “Baby Stroller Pros and Cons - are strollers good for babies?,” Straight Goods Motherhood, https://straightgoodsmotherhood.com/baby-stroller-pros-and-cons/ (accessed Nov. 13, 2023).

[36] G. G. and M. Kollar, “Income in the United States: 2022,” Census.gov, https://www.census.gov/library/publications/2023/demo/p60-279.html#:~:text=Highlights,and%20Table%20A%2D1). (accessed Nov. 13, 2023).

[37] bombi, “How much does a stroller cost? understanding price points,” Bombi Gear, https://bombigear.com/en-ca/blogs/the-hive/how-much-does-a-stroller-cost (accessed Nov. 13, 2023).

[38] B. Schwartz, “Best cost control techniques,” ProjectManager, https://www.projectmanager.com/blog/cost-control-techniques#:~:text=Importance%20of%20Cost%20Control%20In%20Manufacturing&text=It%20allows%20manufacturers%20to%20identify,the%20selling%20and%20distribution%20process. (accessed Nov. 13, 2023).

[39]*Handlebar adjustments and hand position in bike fitting* (no date) *BikeFit*. Available at: https://bikefit.com/blogs/bikefit-blog/handlebar-adjustments-and-hand-position-in-bike-fitting (Accessed: 13 November 2023).

[40]*Coast rider Stroller Canopy* (2023) *Dream On Me*. Available at: https://dreamonme.com/products/baby-gears/strollers/coast-rider-stroller-canopy/ (Accessed: 13 November 2023).

[41]*Bugaboo Dragonfly Seat Stroller midnight Black Sun Canopy, midnight Black Fabrics, black chassis* (no date) *Bugaboo*. Available at: https://www.bugaboo.com/ca-en/strollers/bugaboo-dragonfly/bugaboo-dragonfly-seat-stroller-PM006775.html (Accessed: 13 November 2023).

[42] G. Team, “6063 aluminum: Get to know its properties and uses,” Gabrian, https://www.gabrian.com/6063-aluminum-properties/ (accessed Dec. 4, 2023).

[43] Thombert, “Polyurethane and Rubber Tires: A Comparative Overview” chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.thombert.com/userdocs/PolyurethaneRubberTires.pdf (accessed Dec. 4, 2023).

[44] L. Herbert, “4 concerning effects of vibration on infants to know,” Focus on Your Child - Sound Parenting Help, https://www.focusonyourchild.com/effects-of-vibration-on-infants/ (accessed Nov. 12, 2023).

[45] H. Canada, “Government of Canada,” Canada.ca, https://www.canada.ca/en/health-canada/services/infant-care/strollers-carriages.html (accessed Oct. 15, 2023).

[46] Nadco, “Reflective tapes for visibility: NADCO tapes and labels,” NADCO® Tapes & Labels, Inc, https://www.nadco-inc.com/the-importance-of-reflective-tapes-for-visibility-and-safety-control/ (accessed Dec. 6, 2023).