Situational Knowledge Base SKB

FALL 2024  
MEC325: INTRODUCTION TO ENGINEERING DESIGN  
DESIGN PROJECT  
**SITUATIONAL KNOWLEDGE BASE**



Assistive Transport of Children

when Walking

TEAM 1305

# 

# team declaration

We, the undersigned members of Team 1305 in MEC325, agree that:

* All team members have abided by all Ryerson Policies and course rules, and
* One of our members has shared a properly completed Workload Distribution Form with our Teaching Assistant and our instructor.

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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# goals

The goal is to design a human-powered vehicle for newborn to toddler-aged children that enhances the usability, safety, and comfort of traditional strollers while accommodating a broad range of caregivers. This vehicle must be easy to operate by a single untrained user, addressing real-world challenges like public transit, hikes, and public spaces. It should be durable, affordable, and adaptable to the diverse needs of families, including multiple users such as siblings or grandparents. Prioritizing low environmental impact, safety, and ethical considerations throughout its life cycle, the design must also improve the comfort and dignity of both users and co-users.

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# environment

Environmental conditions for the intervention encompass diverse scenarios caregivers and children may encounter. In urban and suburban environments, the vehicle must withstand temperatures ranging from -10°C to 40°C, occasionally reaching extreme conditions. The temperature range of -10°C to 40°C, commonly mentioned for urban and suburban environments, is drawn from general climate data, reflecting typical urban climates where temperatures can vary from sub-zero in winter to extreme heat during summer months. This data is frequently cited in environmental engineering reports, climate studies, and public transport design specifications, such as ASTM and ISO standards [1]. Research in urban ecosystems highlights the variability within cities, where urban heat islands contribute to higher temperatures, particularly during the summer months [2].

The vehicle will frequently encounter precipitation such as rain or snow, with humidity levels typically ranging from 30% to 90%. These levels are based on common meteorological data, where relative humidity during precipitation can vary. Humidity during rain or snow events generally remains high, often peaking near 90%, while in drier conditions, such as during summer months, it can dip lower to around 30% in urban environments [3]. Rainfall levels include light rain (2.5 mm to 10 mm per hour), moderate rain (10 mm to 50 mm per hour), and heavy rain (greater than 50 mm per hour) [4]. Snowfall accumulations are classified as light snow (up to 2.5 cm per hour), moderate snow (2.5 cm to 5 cm per hour), and heavy snow (greater than 5 cm per hour) [5]. These levels are typical for urban and suburban climates, where precipitation events are common, and seasonal variations in rain and snow can be expected. According to the World Meteorological Organization (WMO) and the National Weather Service (NOAA), urban regions generally experience varying precipitation amounts with high humidity during rain and snow events, contributing to these standard ranges [3][4].

Lighting conditions include low-light scenarios, such as dusk, dawn, or shaded areas, where illuminance can drop to 5-50 lux, similar to dim street lighting [6]. For public transport and travel, the design must adapt to compact storage spaces as small as 25 cm × 40 cm × 50 cm, typical of overhead compartments or under-seat areas. It must also handle temperature fluctuations of 10°C to 20°C when transitioning between indoor and outdoor environments and maneuver through crowded spaces with clearances as narrow as 60-80 cm, corresponding to standard aisle widths on buses and trains [7].

# competition

We reviewed a range of existing interventions that can help us understand how they work and the needs of their users in various settings. In most designs, safety and comfort have been enhanced by features such as waterproof material, adjustable harnesses, and strong frame structures. Waterproofing offers protection from rain or moisture, while adjustable harnesses accommodate children's growth and provide secure positioning [8]. Strong structure frames, usually made from lightweight yet robust materials such as aluminum, are important for durability and stability, especially on varied terrains [9]. These features collectively contribute to handling diverse conditions while ensuring the child's safety and comfort. All designs were made with either 3 or 4 wheels for stability, with 4 wheels being more common.   
 Consider the UPPAbaby Vista V2 for example. It is one of those very versatile and flexible strollers in which you can set up anything to suit the needs of your growing children for a single child or more than one. Because of this, it will be perfect for those parents whose families are expanding. It's also built tough, with a solid frame and big wheels that let it roll easily over rough sidewalks or grassy parks. This stroller is designed for regular use in urban and suburban settings where the expectation is a mix of surfaces. While the more complicated structure of the stroller, such as the various attachments, lifts the price and makes it a bit more difficult to maintain, the additional features make it a reliable choice for those who need something versatile.

Of course, not all strollers have to be this complex. For instance, Jogger City Mini GT2 is more about simplicity and ease of use. It is lightweight and can be folded with one hand, ideal for city parents who need to fold up and store the stroller quickly in tight spaces online buses, or cafes. Compared to the Vista V2, this stroller's simplicity is a plus: its ease of making, cheaper production, and simple maintenance; yet readily durable and easy to use.

Contrarily, the BOB Gear Revolution Flex 3.0 is more specialized for rougher hiking trails or rural areas features like all-terrain wheels and an advanced suspension system. The structure of this stroller would therefore suggest that its target is an environment that is far more rugged and outdoorsy, one in which comfort and safety on uneven or unpredictable terrain are of primary concern. The complexity emanates from the fact that high-quality materials and complicated suspension systems are required, which further add to manufacturing costs and maintenance efforts. However, enhanced durability and specialized design are a necessity for the target users.

Another great product is the Doona Car Seat & Stroller because of its functionality that easily and seamlessly changes between a car seat but also into a stroller. It would be the perfect fit for families always on the go moving from one car to another or other public areas, like an airport or shopping center. Because it is smaller and compact, it would be easy to maneuver around such fast-paced environments. While putting car seat and stroller features into one integrates complexities, the engineering should be precise in satisfying both functions when it comes to safety standards. While this might mean more challenges on the manufacturing and maintenance side, it surely provides ultimate convenience to those traveling quite frequently.

On the other hand, with its high-quality materials, ventilated fabrics, and UV protection, the Silver Cross Wave can offer premium products. This stroller would be suitable for places where luxury and comfort were a priority, such as outdoor parks or beaches. Accordingly, it would imply that it is designed for minimal use in rough environments and boasts a stronger focus on comfort between the toddler and the user. From the materials it is made of to the progressive safety features, it makes the stroller more complex and maintenance-intensive, while it provides a premium service for its users.

Last but not least, the ultra-compact fold mechanism of the GB Pockit+ All-City stroller makes it very suitable for traveling and fast-paced urban life. Its lightweight construction is ideal for indoor usage in tight spaces, such as in subways or shopping centers where maneuverability and portability overnight are needed. Because it only has a sheer construction, it reduces manufacturing complexity to the minimum, making it highly reasonable and easy to service. It can still function effectively in its purpose for the highly valued compact and portable environment.

In conclusion, while many features are shared between these strollers, including weather protection and stout construction, each has features that make them more or less adapted for certain environments. Designs range in complexity from highly specialized functions, like those in the BOB Gear Revolution Flex 3.0, to high-end features found in the Silver Cross Wave. These complexities directly affect manufacturing costs and maintenance requirements, key considerations for our project. Our design will inherit the positive features of these strollers in safety, durability, and adjustability and overcome the shortcomings concerning sustainability and usability by the widest range of caregivers possible. We would like to provide a solution that would still be versatile on various terrains and practical for everyday city use.

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# users

**Demographics**

The primary users of Assistive Transport of Children when Walking are typically parents or caregivers aged 20 to 45, while the secondary users are children ranging from newborns to toddlers (0–4 years) [10]. Although users can be of any gender, traditional roles often place mothers as primary users, with fathers and other caregivers also participating [11]. Income levels among users vary, influencing stroller choices, with budget-friendly models starting at around $50 and luxury designs exceeding $1,000 [12]. Caregivers come from diverse cultural and socio-economic backgrounds, shaping preferences for features such as design, functionality, and aesthetics [13].

**Human Factors (HF) Capabilities of Users**

**Primary User Capabilities**

Caregivers must manage loads of 10–15 kg, including the stroller and its accessories, accommodating those with below-average physical strength. Height variations between 150 cm and 190 cm require ergonomic designs suitable for both shorter and taller individuals. The product must also cater to users with limited mobility, such as individuals with arthritis or reduced grip strength, where hand forces as low as 20–30 Newtons might be necessary [14]. Cognitive demands should be minimal, enabling users to perform tasks like folding, adjusting, or securing components within 5–10 seconds [15].

**Secondary User Needs**

Children, as secondary users, range in weight from approximately 3 kg (newborn) to 20–25 kg (toddlers), with heights between 50 cm and 100 cm. Infants and toddlers are sensitive to temperature fluctuations exceeding ±5°C in short periods, necessitating careful thermal regulation. Safety is critical, especially for children aged 6 months to 3 years, who are developing motor skills and balance, increasing their risk of mobility-related accidents [16].

**Co-Users (Extended Caregivers)**

Older caregivers, such as grandparents, often have reduced physical strength, with hand grip forces as low as 10–15 Newtons, and slower reaction times. Features must allow quick, adaptable adjustments within 10–15 seconds to accommodate different user needs [17].

**Additional User Considerations**

**Abilities and Disabilities**

Stroller usability must extend to caregivers with physical disabilities, incorporating features like adjustable handles and lightweight materials. Accessibility for those with mobility impairments is crucial to ensure inclusivity [18].

**Emotional and Psychological States**

Caregivers often navigate various emotional states, such as stress or excitement, while attending to their child. Intuitive designs that emphasize comfort and ease of use can help reduce stress during multitasking scenarios [19].

**Co-Users and Other Agents**

**Children and Other Caregivers**

The child’s comfort, safety, and entertainment are pivotal to the stroller’s functionality. Additional caregivers, such as siblings or grandparents, may also require adaptable features to suit varying physical capabilities [20].

**Maintenance and Retail**

Maintenance personnel benefit from strollers designed for easy disassembly and cleaning, while retailers prioritize user-friendly designs to enhance customer satisfaction and sales [21].

**Adverse Effects and Design Challenges**

Strollers can pose challenges to other pedestrians, particularly those with disabilities like visual impairments. Minimizing noise, enhancing visibility, and ensuring compact dimensions to prevent collisions in crowded areas are essential design considerations [20]. Thoughtful attention to width and turning radius is necessary to prevent disruptions in public spaces [9].

# 

# strategy

**Market segment**

The product targets a broad demographic mentioned in **Users**, which includes parents, and other members from ages 20-45. The emphasis is to accommodate multiple users of varying physical abilities and income who are searching for a safe, durable, and environmentally friendly solution to assist in the caretaking of newborns and toddlers. Furthermore, the product is marketed to be versatile to different types of **Environments** and can provide a comfortable use in them. Furthermore, settings such as urban, rural, and suburban areas are where the majority of the target users are located, providing ease of use in areas of public transportation, for strolls around the neighborhood, or at the beach where specific tires are needed to maneuver through the sand with ease. The product must accommodate these settings to provide a versatile option for a wide range of users.

**Degree of innovation**

This design aims to reconceptualize the stroller to offer a significant improvement in versatility and the ability to adapt to different **Environments**. Through the integration of many components that seamlessly allow for improved usability for the **Users.** Furthermore, the product will expand the market by integrating features found on different types of strollers to create a universal product, while also promoting environmentally sustainable practices in the production and life-cycle of the product. The product focuses on not only the approval of the **secondary users** but also the **primary users** to provide a comfortable experience for everyone.

Furthermore, the design will integrate advanced ergonomics such as flat seating surfaces which are essential for the child's comfort and to develop posture stability, with various reclining angles to accommodate the child depending on the age. Moreover, features such as footrests and adjustable seating allow for a more safe and universal experience that can accommodate a growing child without the need to purchase a new product (SKB 2.1, 4.6, **Users**). Ergonomics for the **primary users** are to be integrated as well, considering aspects such as adjustable handlebars that allow for various **users** of different heights to comfortably push the strollers in an ergonomic fashion (SKB 2.3, 4.6, **Users**). As well as ease of storage accessibility to be able to adapt to various **Environments** where storage space will be necessary for both essential items of the **secondary users** as well as the **primary users** (SKB 2.3, **Environment).**

The product will expand the market by introducing features such as enhanced maneuverability, through the combined integration of swivel and fixed wheels that allow for benefits in both tight spaces and stability in straight-line movement (SKB 5.4), as well as an advanced suspension system that provides a comfortable ride in different **Environments** where rough terrain can be easily traversed, and can minimize any shocks or vibrations through the implementation of an advanced suspension system (SKB 2.2, 4.1, **Environment**). Moreover, integrating an expendable design enables caregivers the ability to reduce the space required to store and use the stroller, whereas, in certain **environments**, compact folding is a huge benefit (SKB 4.2, 4.3, **Environment**). Furthermore, implementing a design that allows for the ability to switch between different seating settings, such as a cradle, to a modular seat allows for a more universal user experience that can negate the purchase of another stroller as the child matures (SKB 2.1, 4.3, **Users**).

Lastly, the implementation of environmentally sustainable materials to produce a design that promotes a healthy product lifestyle is essential. Materials such as lightweight aluminum for the frame and UV-resistant polyester for the canopy reduce the environmental impact while also providing a more comfortable experience through a lightweight frame that promotes durability and longevity (SKB 6.1. 6.2, **Environment**).

**Time to market**

Given the complex task of implementing many features to produce a universal product, the design is required to have thorough testing in the various **Environments** such that it proves to be universally adaptable throughout them. Furthermore, to be able to successfully market the stroller, it will take approximately 3-4 years to fully develop the most suitable product that fully integrates all the features seamlessly and effectively.

Year 1-2 will focus on research and development, focusing on key aspects such as ergonomics and prototypes of key features such as the switching between seat settings and the advanced suspension system. Furthermore, research surveys can be distributed to gain insight into what types of products **users** are looking for. By the end of the 2nd year, initial product versions can be sent to select users for feedback, to gain insight into the usage of the product's features. This early testing can help determine what features are to be tweaked and updated and what needs to be completely redesigned.

Year 3-4 will focus on using all the user data collected to initiate a product launch while also testing the safety conditions as per ASTM International Stroller Safety Standards. Furthermore, additional testing on different terrain **Environments is** used to determine the validity of suspension, wheels, and the final features. Throughout the development process innovations in features will be documented to add to the current design so that any advancements in technology can be accounted for and implemented properly in the design.

**Production**

Though it can be a challenge to find the exact number of baby strollers to make a good year relative to competitors, a rough estimate can be found by looking at successful companies in the field. An example successful competitor is the Canadian-based company Dorel Industries, which reported US$699.1 million in revenue for the first six months of 2024 (22). The most common price range for their strollers is between $150 and $500, with an overall average cost of around $300. Assuming 15% of the revenue is generated from strollers alone since Dorel also produces car seats and other baby products, it is estimated that 350,000 strollers were produced in six months, and 700,000 for the year. This figure would be a solid indicator of a highly successful year.

**Customization**

Customization is a selling point for the product, with its vast variety of **users**, it can be accommodated for different **Environments,** catering to different preferences. Furthermore, the modular components allow a vast customizable experience that can allow for different seat types to be implemented without adding on or purchasing any additional accessories (**Degree of innovation).** Moreover, the wheels allow for the ease of maneuverability in many **Environments**, through rough terrain and long walks/jogs. The stroller containing adjustable handlebars and height adjustment allows for further customization and comfortability for both the child and the parent. Customization ensures that the product caters to the diverse demographic of **Users'** needs across different activities, allowing for flexibility in seating, comfortability, and maneuverability, allowing for a long-term versatile product.

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# 2. Ergonomic

## 2.1 Child Comfort

1. Summary of sources:

Child comfort is a necessity for any stroller, without the child feeling comfort, the design of the stroller is insufficient and essentially useless. A child must have the necessary lumbar support as well as the proper pelvic position to promote and develop posture & balance and negate back pain [23]. A flat seating surface accommodates these factors, allowing for an upright position with good posture, and a relaxed position when the child is tired. Furthermore, for newborns, the recommended recline angle is a full 180 degrees, while for older babies it should at least recline to 120-135 degrees. [24] The seating orientation is essential for comfort and health, moreover, a common style of seating, the hammock is an example of poor pelvic position and raises concerns about posture, support, and positioning [23].

Moreover, the child's feet should also require necessary support, a footrest allows for feet to be planted, and comforted rather than dangling, which promotes good posture and reduces any safety concerns [23]. An adjustable footrest allows for various heights and positions of the footrest that can suit the child’s comfort and needs. [23]

Furthermore, adjustable seating heights allow for varying sizes of children which makes the stroller more universal and adaptive to the child's growth. [24] The adjustable heights provide versatility and comfortability for the parent and child, the parent can use the adjustable heights to allow for comfortable seating as the child grows rather than purchasing a completely new stroller to accommodate the child. Some examples of height-adjustable strollers include, Graco Modes Nest Travel System, and Joie Hazel 3-in-1 Stroller which are marketed to have different heights to suit different children.

Shade and weather protection help create a more comfortable and enjoyable environment for the child, and especially during the hot summers where UV resistant cloth is used, or during the cold winters, it could act as an insulator and keep the child warm. Aspects such as proper ventilation are considered as well in order to not cause any suffocation and maintain proper air circulation through the stroller. [24]

1. Conclusion:

In summary, strollers should implement the correct seating arrangement for children, a flat seating surface that is essential for posture development and a related, reclined position when the child is tired and needs rest. The angle of reclination is important with a full 180 degrees necessary for newborns and at least 120-135 degrees for older children. The design should implement a means to lock the seat at a given angle. Furthermore, footrests should be implemented in strollers to help with balance and comfortability for the child, moreover, adjustability as a whole should be considered as it allows for a more universal stroller that can still allow for a comfortable ride for the child as it grows, allowing for adjustable height settings. Furthermore, adjustable seats that can change positions should be considered in the design that can fit completely switch from a cradle to other seat positions as the child matures. Shade and weather protection is also a consideration as it can protect the child from harmful UV rays and create a more comfortable and insulated environment when it is cold outside. Implementing a design that integrates shade and weather protection seamlessly with the different seat positions can provide an excellent adaptive stroller.

## 2.2 Stability & Suspension

1. Summary of sources:

A stroller with a suspension system provides a much higher level of comfort when going out or on walks compared to a stroller without it, allowing for smooth rides on rough terrain as well. [24] There are various types of suspension systems that can be built into the wheels or the frame of the stroller. There is a front-wheel suspension system that absorbs shock at the front wheels, where it is felt the most, a full suspension system that includes on both the front and rear wheels. Moreover, there are air filled tires that combine the suspension system as well as these tires, similar to bike tires. These tires are generally more durable outside of the occasional air pumping and allow for the smoothest ride out of the 3 systems. Furthermore, an alternative to air filled tires is foam-filled tires that have similar results of shock absorption and comfort without the need to worry about punctures or filling with air. A suspension system reduces strain on the child's body as well, especially newborns who cannot balance themselves properly. [24]

Vibration reduction in vehicle suspension systems plays a crucial role in enhancing passenger comfort. Typically, a reduction in vibration of approximately 4-6% is considered effective for improving comfort without compromising system dynamics [25]. Advanced suspension technologies, such as electromagnetic inerters, can offer superior performance in comparison to traditional passive systems, with reductions in vibration that lead to noticeable improvements in passenger experience. For instance, newer systems have demonstrated up to a 6% reduction in vibration under certain conditions, which is considered optimal in balancing comfort and suspension dynamics [26].

Excessive or intense vibrations can pose potential risks to newborns. Due to the delicate nature of their skulls and brain development, they are particularly vulnerable to strong or violent movements, which could negatively impact their developing systems. Therefore, it is crucial to ensure that any vibrating devices used are gentle and do not cause excessive shaking, as this may lead to discomfort or developmental issues. Additionally, vibrations that are too strong or prolonged should be avoided, and it is important to follow safety guidelines and monitor the use of vibrating devices to prevent any adverse effects [83, 84].

1. Conclusion:

In conclusion, strollers that implement suspension systems provide a significantly more comfortable ride for both the child and the parent pushing the stroller on rough terrain where it tends to be a challenge to go through. Furthermore, shock absorption improves the child's safety and comfort throughout the ride and makes the ride suitable for long walks or jogs as well. Implementing a suspension system in the stroller is a consideration for the design as it proves to show many benefits. Moreover, the different types of suspension systems show many benefits, however the two clear winners evidently are the air filled tires with suspension system or the foam filled counterpart, which both have the maximum amount of shock absorption and comfort.

## 2.3 Parent Comfort

1. Summary of sources:

The parent's comfort is a necessity, being the individual taking care of the child and pushing the stroller, the comfort of the parent is taken into consideration when designing a stroller. Furthermore, many aspects of the stroller must be comfortable for a parent to use in many situations, long strolls, through tough terrain, at night, for elderly people, or for mothers. A stroller must be able to accommodate various heights in order to comfortably push the stroller to reduce back & shoulder strain, furthermore, the handlebars should promote a neutral wrist position and allow for a firm grip. An adjustable handlebar allows for varying heights to be able to comfortably use the stroller and allow for easy maneuvering, moreover, a wider range of adjustment can help not only with height but also the length the bars extend out allowing for more customization. [23]

A stroller should be easy to maneuver and pick up if needed, especially for the elderly, or individuals with any disabilities, a lightweight stroller allows for a more easy ride for the person pushing the stroller. Moreover, stroller weight depends on a multitude of factors, a stroller that incorporates stroller baskets, and umbrellas or shades is generally heavier. Furthermore, materials play the most important role, choosing a lightweight, sustainable material is essential to provide a sufficient stroller, materials such as aluminum or steel are some examples of good materials to use for the frame. Moreover, a lightweight stroller is much more advantageous for users who take the subway or bus. [27]

Storage is essential for strollers allowing the user to store essential items for their children or for themselves and it allows for a stroller to be more resourceful to help store items on the go for when it is needed. Furthermore, the under stroller storage helps lower the center of gravity which allows for a more stable ride for the child and for the parent and helps reduce the risk of tipping over. [23].

1. Conclusion:

In summary, parent comfort must be an essential factor when designing a stroller, a parent is the individual who pushes the stroller and thus, it must be a comfortable design. Furthermore, adjustable handlebars in both height and extension must be considered, as it allows for a more universal stroller experience for parents who have different heights and thus can suit the needs of multiple individuals of varying heights who need to push the stroller. The adjustable bars reduce back strain and promote a neutral wrist position which allows for a more enjoyable ride with their children. Moreover, a lightweight design promotes the easy maneuverability of the stroller, especially for individuals with disabilities or seniors who do not necessarily have the strength to push a heavy stroller. A sustainable and lightweight material such as magnesium, or aluminum is the most suitable choice for the frame of a stroller. Moreover, storage is also an essential factor for a stroller as it allows for convenient storage that can be used for the child's items or the parents. The under-stroller storage also doubles as a means of more stability as it lowers the center of gravity. The integration of a lightweight stroller that implements storage as well is essential for a successful stroller design.

# 3. Government

3.1 International Safety Standards

3.1.1 General Requirements

1. Summary of Sources

The design and manufacturing of the stroller must abide by the American National Standards Institute (ASTM) Standard Consumer Safety Performance Specification for Carriages and Strollers (Note: Canada also uses these standards for evaluation). The general requirements are as follows:

* The product must not have any sharp points or edges
  + This is to prevent any laceration hazards to the child/occupant or any of the users
* No small parts can be used
  + Preventing choking hazards to the occupant/user. These parts must not have the ability to be removed
  + Small parts must comply with Standard [16 CFR 1501](https://www.ecfr.gov/current/title-16/chapter-II/subchapter-C/part-1501) or image 3.1.1.a
* No lead-based paint can be used
  + This includes all restrictions observed by Standard [16 CFR 1303](https://www.ecfr.gov/current/title-16/chapter-II/subchapter-B/part-1303)
* All exposed wood must be smooth and splinterless
* Hinges
  + Hinges must prevent operation when in normal use
  + Considered as part of the frame, must meet the same stress requirements
  + Hinged links must have at least 2 separate and distinct actions to fold
* Holes/Openings
  + If material is less than 9.53mm thick, if it is able to admit a 5.33mm object, it must then also be able to admit a 9.53mm object.
  + If hole does not go all the way through, then this does not apply
* Scissoring/Shearing/Pinching
  + When in intended use position, it should be design so it prevents any injury from any movements
    - It can cause injury if a 5.33mm probe can fit in the gap, but a 9,53mm one cannot
  + Same requirements for saddle hinges
  + Same requirements for canopy hinges
    - However, Canopy stretching/locking devices are exempt
    - Canopy rods and stops are exempt if the rod does not pass over or through the rod
  + Actual frame folding strollers must also comply with the above
    - Carriages (babies lying down) are exempt
    - If the seat is removable to allow for folding, it is also exempt
* Exposed Coil Springs
  + If the spring can create a space of minimum 5.33mm, it must be covered
* Labeling
  + Warnings must be permanent
  + Non-paper labels must not break apart into small parts
* Cord/Strap Length
  + Straps cannot exceed an internal perimeter of 376mm
  + Cannot stretch more than 188mm
  + If they are used to restrain an occupant, carry straps, attachment straps to infant carriers are all exempt
* Strap/Trap/Grab bar
  + The actual bar does not contain foam
  + Can be padded with foam, but must be covered
  + The overeating cannot come off and the foam cannot disintegrate

b ) Conclusion

All designs and fabrication must follow these requirements. If not, this product would not be available for sale or distribution in Canada and most of the world. These general requirements are also safety standards. If they are not followed, users are at risk of damage, injury, or even death.

# 4. Desired Traits

## 4.1 Smooth Ride & Maneuverability

1. Summary of Sources:

Parents consistently seek strollers capable of traversing diverse terrains, aiming to provide a comfortable and pleasant experience for both themselves and their children. Important features include **all-wheel suspension**, **shock absorbers**, and **oversized wheels**, which are essential for navigating uneven sidewalks, gravel paths, and light off-road trails. For example, the **UPPAbaby Vista V2** is well-known for its ability to glide smoothly over curbs and rough city streets due to its advanced suspension system (Stroller Insider [34]; Little Baby Gear [35]). Similarly, the **Baby Jogger City Mini GT2** features durable "forever-air" rubber tires, offering a stable and comfortable ride on both urban and suburban terrains (Baby Advisor [36]). For more rugged terrains, jogging strollers like the **Bob Revolution Flex 3.0**, with its air-filled tires and sophisticated suspension, provide excellent maneuverability, although they tend to be heavier (Little Baby Gear [35]).

1. Conclusion:

In summary, strollers should focus on enhancing ride quality with features like dual-suspension and large, air-filled tires, making them ideal for caregivers in cities with uneven sidewalks or for active families who enjoy jogging or hiking with their strollers.

## 4.2 Ease of Use & Portability

1. Summary of Sources:

Modern parents, especially those in bustling urban environments or who travel frequently, prioritize strollers that are lightweight, easy to fold, and highly portable. The **Babyzen YOYO2** is favored for its ultra-compact fold, one-hand folding feature, and weight of less than 14 pounds, making it ideal for travel and city use. Its **all-wheel suspension** enhances its performance on uneven urban terrains [37, 38]. Another highly recommended option is the **Zoe Tour+**, weighing just 12 pounds with a quick-fold mechanism, making it convenient for frequent public transport users [39]. The **UPPAbaby Vista V2** offers greater versatility, folding with both seats attached. Though heavier, it remains practical due to its **all-wheel suspension** and one-step fold mechanism, accommodating various family needs [40, 41].

1. Conclusion:

Strollers should integrate one-handed folding systems and utilize lightweight materials such as aluminum to achieve a balance between durability and portability. Compact design is particularly important for city residents or families who frequently use public transportation, making ease of storage a vital aspect of stroller design.

## 4.3 Modular or Expandable Design

1. Summary of Sources:

Parents are increasingly seeking strollers that can adapt as their families grow, particularly those with modular designs that allow for transitions between single and double configurations or combinations with various car seats and bassinets. This modularity helps reduce the need for purchasing multiple strollers over time.

For instance, the **Mockingbird Single-to-Double Stroller** offers exceptional adaptability, featuring over 22 seating configurations and easily converting from a single to a double stroller by adding a second seat. It supports a wide range of car seats, offering flexibility for growing families [42,43]. Similarly, the **UPPAbaby Vista V2** is highly versatile, capable of accommodating a second seat, bassinet, or PiggyBack Ride-Along Board for older siblings. This stroller provides excellent maneuverability and comfort due to its all-wheel suspension and flexible configurations, making it a top choice for long-term family planning [43,45]. Additionally, the **Chicco Bravo** presents an affordable option by allowing the toddler seat to be removed and replaced with a compatible car seat, converting it into a travel system suitable for families with evolving needs [44,45].

1. Conclusion:

Strollers need to be versatile enough to handle various setups, catering to a growing family. They should support everything from single to double configurations and be compatible with car seats and bassinets. This adaptability is attractive to families considering more children, positioning the stroller as a worthwhile long-term investment.

## 4.4 Lightweight and Compact Design

1. Summary of Sources:

Parents typically look for strollers that are easy to handle, transport, and store. However, models built for durability or off-road use, like the Bob Revolution Flex 3.0, are often criticized for being too heavy and cumbersome. Strollers that are challenging to lift or fold can pose a major inconvenience, especially for parents who rely on public transportation or live in urban areas with limited space. Even versatile options, such as the UPPAbaby Vista V2, can feel unwieldy when folded due to their size.

Key Issues: Many parents express frustration over the bulkiness and weight of strollers. A stroller that is difficult to carry, particularly when folded, can be a hassle when getting in and out of vehicles, navigating tight spaces, or using public transit.

The Zoe Tour+ addresses this issue by being an ultra-lightweight stroller that weighs approximately 12 lbs and folds up compactly. Nevertheless, strollers like the Bob Revolution continue to be favored for their durability, indicating that a balance between sturdiness and ease of transport is essential.

1. Conclusion:

Stroller designs should utilize lighter materials, such as advanced aluminum or carbon fiber, to decrease weight while maintaining durability. Additionally, compact folding mechanisms should be improved to minimize the space strollers occupy when folded, making them easier to store in car trunks or small areas. Parents also prefer strollers that can be collapsed with one hand for added convenience while managing their child.

## 4.5 Storage

1. Summary of Sources:

When designing a human-powered vehicle for transporting newborns to toddlers, ensuring sufficient storage space is essential. Research indicates that incorporating at least 2 to 3 cubic feet of storage is recommended to accommodate essentials like diapers, toys, and groceries. For example, a standard diaper bag occupies approximately 0.5–0.75 cubic feet, grocery loads typically require 1.5–2.0 cubic feet, and toys or blankets contribute an additional 0.3–0.5 cubic feet. Many stroller wagons, such as the Larktale Caravan and Delta Jeep Wrangler models, feature this capacity along with additional compartments for convenience [46-48].

1. Conclusion:

When designing a human-powered vehicle for transporting newborns to toddlers, it's essential to include 2–3 cubic feet of storage space to accommodate essentials like diapers, toys, and groceries. Many stroller wagons, such as the Larktale Caravan and Delta Jeep Wrangler, are designed with this storage capacity, featuring additional compartments for convenience.

## 4.6 Adjustable Features and Comfort

1. Summary of Sources:

One common challenge associated with strollers is their restricted adjustability, which affects the comfort levels of both the child and the caregiver. For example, certain models, such as the Joovy Zoom 360 Ultralight, come with fixed handlebars that can be uncomfortable for caregivers of different heights. Furthermore, strollers that lack adequate seat recline options or footrest adjustments may not be suitable for a growing child, leading to discomfort during longer outings.

A considerable number of strollers do not provide the necessary adaptability for caregivers of various heights, resulting in discomfort and dissatisfaction. Additionally, as children experience rapid growth, the lack of adjustable seats, footrests, and handlebars can make a stroller impractical long before its anticipated lifespan is reached.

Some strollers, like the Baby Jogger City Mini GT2, offer adjustable handlebars, allowing caregivers to customize the stroller's height for more comfortable pushing. However, many other models still lack this essential feature, which restricts their usability for families with caregivers of differing heights.

1. Conclusion:

Adjustable handlebars should be considered a fundamental feature in modern strollers, allowing caregivers of different heights to maneuver them effortlessly. Furthermore, strollers ought to offer multiple reclining positions and adjustable footrests to ensure children's comfort as they grow. This level of adaptability not only enhances comfort but also extends the stroller's lifespan, making it a more valuable investment for parents.

## 4.7 Adaptive Responsiveness

1. Summary of Sources:

To ensure that an intervention moves at the same speed as the user walks, it must be designed to dynamically adjust to the user's gait and exertion. Studies on gait and speed adaptation show that devices capable of responding to the user's walking velocity provide a smoother experience, preventing fatigue and resistance. For instance, treadmills equipped with speed control systems adjust to the user's walking speed, making the device move in sync with the user’s natural movements, which helps maintain comfort and encourages a more natural walking pattern. This principle is crucial for strollers, carts, or other human-powered devices to ensure that the force required to move them is aligned with the user's effort, facilitating ease of use and reducing strain [51, 52].

1. Conclusion:

In conclusion, dynamic adjustment to the user's walking speed is essential for improving comfort and reducing strain. Devices that sync with the user’s natural movements, such as treadmills, strollers, or carts, provide a smoother experience by aligning the force required to move them with the user's effort. This adaptability enhances usability and ensures a more natural, effortless user experience.

## 4.8 Carrying capacity

1. Summary of Sources:

When designing a human-powered vehicle for newborns to toddlers, it is essential to ensure adequate weight capacity for both the child and additional cargo. Toddlers, who may weigh up to 50 lbs (22.7 kg), represent the upper limit of the user spectrum, necessitating each seat in a multi-child design to support at least this weight [70], [72]. Furthermore, storage compartments typically add another 10–20 lbs (4.5–9 kg) of capacity to accommodate essential items such as diaper bags, toys, and groceries [71]. To ensure safety, durability, and ease of handling, the total load capacity for each seat—including the child and storage—should range between 70 and 100 lbs. High-quality child transport systems, such as specialized strollers and carriers, adhere to these weight ranges to maintain stability and usability for caregivers while meeting the demands of growing families [71], [72].

1. Conclusion:

In conclusion, designing a human-powered assistive transport vehicle for newborns to toddlers requires careful consideration of weight capacity to ensure safety and functionality. The vehicle should support a minimum of 70–100 lbs per seat, which includes the weight of a toddler (up to 50 lbs) and an additional load for storage (10–20 lbs) [70-72]. This range accommodates varying needs while ensuring the vehicle's durability and stability. Prioritizing this weight capacity ensures the design meets the practical demands of caregivers and remains versatile for different environments and purposes.

# 5. Wheels

## 5.1 Types of Wheels

1. Summary of Sources:

The most common types of stroller wheels are EVA, pneumatic, and air chamber wheels, each with distinct characteristics. EVA wheels consist of an outer plastic layer, making them lightweight. Since the tire portion is entirely composed of EVA, these wheels are resistant to flats; however, they wear down quickly on rough terrain, making them best suited for urban and city environments. Pneumatic wheels feature an outer tire and an inner tube, similar to bike tires. Pneumatic wheels provide extra suspension and more durability but require regular maintenance to maintain air pressure and are prone to flat wheels. Pneumatic wheels are ideal for off-road use due to their superior suspension and durability. Air camber wheels consist of a thick rubber wheel with a large air chamber that offers additional suspension and makes them puncture-proof and maintenance-free. Air chamber wheels are versatile, being suitable for both city and off-road use. [53]

1. Conclusion:

In conclusion, air chamber wheels stand out as the best option for stroller design due to their combination of durability, versatility, and low maintenance. Unlike EVA and pneumatic wheels, air chamber wheels offer superior suspension without the risk of punctures or the need for regular maintenance. Their ability to perform well on both city streets and off-road terrain makes them ideal for families seeking a stroller that can handle diverse environments. The puncture-proof design ensures reliability, while the maintenance-free feature provides long-term convenience, making air chamber wheels the most practical and dependable choice for modern strollers.

## 5.2 wheel configuration

1. Summary of Sources:

3-wheel strollers offer excellent maneuverability, particularly on uneven terrain or in tight spaces, thanks to its single front wheel. The all-terrain capability makes it ideal for jogging and outdoor activities, and it performs well on grass, gravel, or rough surfaces. However, it may feel less stable on flat surfaces, especially during sharp turns or sudden stops, and it tends to be bulkier and harder to fold and transport. A 3-wheel design can be less ideal for boarding public transportation because users typically lift the stroller by tipping in onto the rear wheels, followed by the front wheel. With a 3-wheel stroller, this process requires extra effort to maintain lateral balance when tipping on the front wheel, increasing the risk of instability during boarding. In contrast, a 4-wheel stroller provides greater stability due to the even distribution of weight across four wheels, making it ideal for smooth flat surfaces. It is typically more compact and lightweight, making it easier to fold and transport, particularly for city use. [54]

1. Conclusion:

Ultimately, a 4-wheel configuration is a superior choice for stroller design due to its enhanced stability, compactness, and ease of use in everyday situations. The even distribution of weight across four wheels provides greater balance and security, especially on flat surfaces, making it ideal for city environments. Additionally, 4-wheel strollers are typically lighter and more compact, making them easier to fold, transport, and store. The extra wheel also improves maneuverability and stability when navigating public transportation, offering a more reliable and practical solution for parents seeking a versatile, easy-to-use stroller.

## 5.3 Wheels size

1. Summary of Sources:

When selecting stroller wheel sizes, it is important to match the size to specific needs. Larger wheels (10 to 12 inches) are ideal for rough terrain and jogging strollers, offering better stability and smoother rides, whereas smaller wheels (5 to 8 inches) are more suited for lightweight strollers and urban environments, providing greater maneuverability in tight spaces. Safety standards from the U.S. Consumer Product Safety Commission (CPSC) emphasizes the importance of well-assembled wheels to prevent tip-overs and accidents [55]. Ergonomic design principles also consider wheel size to ensure smooth mobility and safety [57]. The best wheel size depends on its intended use: larger wheels for uneven terrain, and smaller wheels for city portability. [55]

1. Conclusions:

Ultimately, selecting the right stroller wheel size depends on the intended use and environment. Larger wheels provide superior stability and smoother rides on rough terrain, making them ideal for jogging strollers and all-terrain models, while smaller wheels offer better maneuverability for urban settings and lightweight strollers. Adhering to safety standards from the U.S. Consumer Product Safety Commission (CPSC) ensures that the wheels are robust and well-assembled to prevent accidents.

## 5.4 Fixed vs Swivel Wheel

1. Summary of Sources:

Fixed wheels offer superior stability and strength, making them ideal for straight-line movement and heavy loads. They are often simpler in design with fewer moving parts, which reduces the risk of mechanical failure. However, the downside is their limited maneuverability, as they cannot swivel, making it difficult to navigate corners or tight spaces. Turning with fixed wheels requires lifting or pivoting the object, which can be challenging in dynamic environments. [58-59]

In contrast, swivel wheels provide excellent maneuverability with their 360-degree rotation, allowing for easy movement in any direction. They are more flexible and convenient for environments requiring frequent turns or navigation around obstacles, such as warehouses or medical settings. Despite their ease of use, swivel wheels are less stable than fixed wheels, especially at higher speeds, and their more complex mechanics may lead to faster wear and the need for more maintenance. A combination of both wheel types is often used to achieve a balance of stability and maneuverability, with fixed wheels providing straight-line control and swivel wheels enabling easier turns. [58-59]

1. Conclusion:

A combination of both swivel and fixed wheels is ideal for stroller design, as it offers the best of both stability and maneuverability. Fixed wheels provide straight-line control and stability, especially on rough or uneven terrain, making the stroller easier to push on longer walks or when carrying heavier loads. Swivel wheels, on the other hand, enhance maneuverability, allowing the stroller to navigate tight spaces, corners, or crowded areas with ease. This balanced configuration ensures that the stroller is versatile enough for a variety of environments, offering parents a smooth, controlled ride without sacrificing convenience or ease of movement.

## 5.5 Wheel Caster Angle

1. Summary of Sources:

Caster is the inclination angle measure between the vertical axis and the pivot axis or line of action. It can also be described as “the forward or backward tilt of a line drawn through the top and bottom pivot points during steering” (Shivansh Sabhadiya). As described, the caster can be either forward or backward, which is known as a positive or negative caster. Positive caster is when the point at which the steering axis

intersects the ground is ahead of the contact point of the wheel, whereas negative caster is when it falls behind the contact point. In strollers, a positive caster is typically preferred as it enhances stability, making it easier to maintain a straight line during forward motion. This helps prevent unwanted swaying or veering off course, especially when the stroller is being pushed at higher speeds. A slight positive caster also aids in smoother maneuverability by allowing the wheels to return to a neutral, forward-facing position after making turns, improving the overall handling experience for the user.

However, an excessive positive caster can make the stroller harder to steer, requiring more effort to turn. Therefore, designers need to balance the caster angle to achieve a balance between stability and ease of handling. Negative caster would not be ideal to use in a stroller as it would result in less stable and predictable steering behavior, reducing the usability for a large number of users especially on uneven terrain.

1. Conclusion:

In the context of baby strollers, the optimal caster angle is carefully chosen based on the specific needs of the user and the terrain the stroller is expected to navigate. For example, strollers designed for urban environments may have a different caster setting compared to those meant for jogging or all-terrain use, where higher stability at varying speeds is essential.

## 5.6 Turning Radius

1. Summary of Sources:

A minimum turning radius of 4 feet is a critical design consideration for human-powered devices like strollers and carts, as it allows for greater maneuverability in confined spaces. Devices with a smaller turning radius, such as electric wheelchairs, make it easier to navigate through tight doorways, narrow hallways, and crowded areas. A 4-foot turning radius ensures that users can make quick directional changes without exerting excessive force, improving overall usability. This design feature enhances both the safety and convenience of devices, particularly in environments with limited space​ [60-62].

1. Conclusion:

In conclusion, a 4-foot minimum turning radius is crucial for enhancing maneuverability in human-powered devices, such as strollers and carts. It allows users to navigate tight spaces like doorways and crowded areas more easily, improving overall convenience, comfort, and safety. Devices with this turning radius are better suited for daily use in diverse environments, providing smoother navigation with minimal effort.

# 6. Build materials

## 6.1 Stroller Frame

1. Summary of sources:

When deciding what material the main frame of the stroller should be made out of, many things should be considered, such as weight, strength/durability, and cost. Both steel and aluminum are often used for many similar applications as both are quite common materials and offer relatively high tensile strength. Steel tends to be cheaper than many aluminum alloys allowing for decreased production costs, however, many steel alloys tend to weigh 2-3 times the weight of aluminum. Steel also is prone to oxidation when exposed to the elements decreasing its strength and durability, though stainless steel can be used, cost may increase. Aluminum tends to cost more than steel, however, is much lighter whilst maintaining a relatively high tensile strength. Aluminum alloys tend to be resistant to oxidation therefore increasing its longevity. A combination of the two materials would, in theory, allow for the best of both worlds, however, if the two materials are in contact with each other, galling can occur fusing the two parts, and an electron transfer between the two metals can occur such that the aluminum would weakening, therefore when looking for fasteners, the material that they are made up of has to be considered. [63]

1. Conclusion:

Ultimately, a full aluminum frame would offer the best cost-performance for the product without having a great compromise on durability. Aluminum would offer a lightweight design allowing for a better user experience, and the inherent oxidation resistance would provide a long-lasting product for the consumer.

## 6.2 Stroller carriage

a. Summary of sources:

The material of the stroller carriage is quite important for the comfort of the passenger and the protection of the user from the elements. Natural materials such as cotton or wool would offer decent durability and comfort as the softer fibers would be better for sensitive skin. Cotton and wool do not do well in the elements as they are quite water absorbent, this will also lead to the absorption of any fluids produced by the user causing increased maintenance and increased chance for bacterial growth within the material. Cotton and wool are quite susceptible to mildew resulting in the material deteriorating over time if mildew were to occur. Synthetic materials such as polyester also offer decent durability and tend to be water resistant allowing for better protection against the elements. The inherent water resistance of the material allows for an easier clean-up if any accidents were to occur, also decreasing the chance of bacterial growth. However, due to the stiff fibers and chemicals used to treat the fibers, polyester fabrics may irritate users with more sensitive skin resulting in rashes. [64]

b. Conclusion:

A combination of the two fabrics would provide the best of both worlds allowing for good protection against the elements. By having the outer layer be multiple thick layers of polyester fabric, it allows for a more protective outer layer utilizing the water resistance of the fabric to help protect the passenger from the elements. Having a thicker layer of fabric as an outer layer, would allow for the fabric to protect against UV rays, as the inherent UPF 30+ rating of the fabric would block the UV rays. Also having an interior layer of cotton or wool would help increase the comfort of the passenger and decrease the chance of skin irritation.

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## 6.3 Packaging

1. Summary of sources:

With the advent of online shopping and deliveries, there has been an influx of disposable packaging filling landfills, as a result when designing a product the packaging material must be taken into consideration. A promising substitute to the current plastic packaging that is most commonly used, is mycelium composite materials. Mycelium packaging shows promising results, as it displays relatively high compressive strength allowing it to replace styrofoam packaging materials. As mycelium packaging is also biodegradable, it can be used as a more environmentally friendly option for packaging. A cardboard box will still be required, however having biodegradable packaging material will help decrease the environmental impact of the packaging. Due to mycelium packaging being relatively new and not widely adapted, an increased production cost will occur as a result of the technology for production being quite limited and development quite small for the product. [65, 66]

1. Conclusion:

Using both cardboard and mycelium packaging would allow for biodegradable packaging. With the combination of minimal packaging by grouping loose parts together and by using folded packaging to minimize the use of adhesives, the packaging can then be potentially upcycled, more easily recycled, or composted allowing for a more environmentally friendly product.

## 6.4 Recycled material

1. Summary of Sources:

Including a minimum of 50% recycled material in products is becoming an increasingly important requirement for both environmental and economic reasons. This approach reduces the need for virgin resources, helping to conserve natural materials, reduce waste, and lower carbon footprints. Several regions, including the European Union and California, have already set recycled content mandates to help drive these goals forward. For example, the EU's Plastic Packaging Directive mandates that packaging producers use at least 50% recycled content by 2025 ​[80, 81]. In the U.S., California has set ambitious targets for plastic beverage bottles, pushing for up to 50% post-consumer recycled content by 2030 ​[82].

1. Conclusion:

These initiatives promote sustainability by ensuring that materials are reused, rather than discarded, which can help reduce pollution and enhance recycling infrastructure. However, achieving these goals requires cooperation across industries, better waste sorting, and consumer education to increase the availability and quality of recycled materials [81, 82].

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# 7. Manufacturing

## 7.1 Injection Molding

1. Summary of Sources:

Injection molding is a highly efficient and versatile manufacturing process ideal for producing plastic parts in large volumes. It offers remarkable production efficiency, with cycle times ranging from 15 to 30 seconds, allowing for the rapid production of numerous identical components. Modern injection molding machines are equipped with advanced automation technologies, which not only speed up the process but also reduce downtime and minimize labor requirements. This automation ensures precision, consistency, and quality across all parts, which is especially crucial in industries requiring tight tolerances, such as automotive or medical sectors [73, 74].

Another advantage of injection molding is its exceptional design flexibility. The process supports the creation of complex geometries and intricate features that would be challenging or expensive to achieve using other methods. Multi-cavity molds can produce several parts simultaneously, increasing productivity further. Additionally, injection molding offers material versatility, allowing manufacturers to choose from various thermoplastics tailored to meet specific mechanical, chemical, or aesthetic needs. This capability extends to using multiple materials in a single cycle for enhanced functionality [73, 74].

The cost-effectiveness of injection molding becomes apparent in large-scale production. While initial tooling costs are significant, the cost per unit decreases substantially as production scales. This scalability, coupled with minimal material waste and the ability to recycle leftover plastics, makes the process sustainable and economically viable. The automated nature of the process also reduces labor costs, as machines handle most of the production, leaving personnel to focus on quality assurance and design refinement [73, 74].

1. Conclusion:

Injection molding is an exceptionally efficient and versatile manufacturing process, offering rapid production cycles, high precision, and consistent quality, making it indispensable for large-scale production across various industries. Its ability to create complex geometries and accommodate diverse materials ensures unmatched design flexibility, while multi-cavity molds and automation enhance productivity and reduce labor costs. Despite high initial tooling expenses, the scalability of injection molding significantly lowers per-unit costs in mass production. Additionally, its sustainability is bolstered by minimal material waste and the capacity for recycling. These advantages firmly establish injection molding as a cost-effective and reliable solution for producing high-quality plastic components [73, 74].

## 7.2 Repair and Maintenance

1. Summary of Sources:

To ensure ease of repair and maintenance for both intervention owners and refurbish program workers, products should incorporate several key design principles. One of the most effective strategies is **modular design**, where products are created with easily replaceable components, reducing the need for specialized tools or expertise. Companies like SHIFT, which produce modular smartphones and headphones, exemplify this approach, allowing users to perform repairs without voiding warranties [75]. Another important consideration is **access to spare parts** and **repair manuals**. Ensuring that parts are readily available, either through official channels or third-party services, is essential for both consumers and workers in refurbish programs, allowing repairs to be performed quickly and efficiently [75]. Furthermore, focusing on **sustainability** and a **circular economy** helps reduce waste. By enabling easy repairs and parts replacement, products can be refurbished and reused, rather than disposed of, as seen with companies like Thermoplan, which offer modular coffee machines to allow businesses to replace parts quickly, reducing downtime and waste [75]. Additionally, **legislation** such as a repairability index, as implemented in Europe, can further support repairability by providing consumers and workers with clear guidelines and documentation, promoting long-term sustainability [75]. Lastly, for complex systems, adopting **service models**, such as the "Product-as-a-Service" model, can ensure continuous maintenance. For instance, Philips offers healthcare institutions ongoing access to equipment, along with repair, maintenance, and upgrades, reducing downtime and extending the product’s lifecycle [75]. Incorporating these design elements not only facilitates easier repairs and maintenance but also contributes to a more sustainable life cycle, benefiting both end-users and workers involved in refurbish programs.

1. Conclusion:

In conclusion, designing products with ease of repair and maintenance in mind is crucial for both end-users and workers involved in refurbish programs. By focusing on modularity, access to spare parts, and repair manuals, manufacturers can ensure quick, cost-effective repairs without requiring specialized tools or expertise. Additionally, prioritizing sustainability through circular economy principles, such as refurbishing and reusing parts, reduces waste and contributes to a longer product lifecycle. Implementing clear repairability standards, like the repairability index, and offering continuous service models for complex systems further enhance the long-term usability of products. Overall, these design strategies not only improve the user experience but also foster a more sustainable and efficient lifecycle for products, benefiting both consumers and the environment.

## 7.3 Off The Shelf Fasteners

1. Summary of Sources:

Off the shelf fasteners are widely available and cost-effective due to their mass production, which helps reduce overall manufacturing costs while ensuring reliable performance. Their standardized nature allows technicians to quickly and easily source replacements without facing supply delays, ensuring minimal downtime during repairs [76]. Additionally, the familiarity of these components among service technicians streamlines maintenance tasks, reducing the need for extensive training and enabling faster, more efficient service [76]. Off-the-shelf fasteners also promote modularity in design, making it possible to replace individual components without disrupting the entire system, which further facilitates quick repairs and reduces complexity [77]. Moreover, these fasteners are designed for ease of installation and removal without requiring specialized tools, contributing to more efficient maintenance cycles [77]. By using standardized fasteners, products become easier to repair, maintain, and refurbish, which is essential for supporting sustainability and reducing product waste.

1. Conclusion:

In conclusion, incorporating off-the-shelf fasteners into product design significantly enhances the ease of repair and maintenance for both intervention owners and refurbish program workers. These fasteners offer cost-effective, reliable, and readily available solutions that streamline the repair process. Their standardized nature ensures quick and efficient sourcing, while their simplicity and modular design reduce the need for specialized tools and complicated procedures. This contributes to faster repairs, reduced downtime, and greater overall product sustainability. By making maintenance more accessible, manufacturers can improve the user experience, reduce waste, and promote the long-term viability of their products. Therefore, integrating standardized fasteners into design not only improves serviceability but also supports broader environmental and economic goals in product lifecycle management.

## 7.4 Refurbish Program

1. Summary of Sources:

Incorporating a refurbishment program for Assistive Transport of Children when Walking intervention can offer significant benefits, both environmentally and economically. Refurbishment helps reduce waste by extending the lifespan of the product, which is essential in mitigating the impact of single-use consumer goods. It also aligns with the growing trend toward sustainability, as reusing and refurbishing materials cuts down on the energy and resources needed for manufacturing new products. By offering a program where customers can return, repair, or upgrade their strollers, manufacturers can foster customer loyalty while reducing the environmental footprint. Furthermore, refurbishing strollers can help make products more affordable, as people have the option to buy refurbished versions instead of brand-new ones [78][79].

1. Conclusion:

A refurbishment program for strollers supports sustainability by reducing waste, extending product lifespan, and promoting a circular economy. It helps lower the environmental impact of manufacturing, conserves resources, and offers more affordable alternatives to consumers​.

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# 8. Safety

## 8.1 Stopping mechanism

1. Summary of Sources:

The ability of an intervention to effectively stop or slow motion is a critical safety requirement, particularly in dynamic and high-risk environments such as public transportation. In settings like buses or trains, sudden stops, starts, and turns can destabilize an intervention, leading to risks of movement, tipping, or accidents. Ensuring effective control mechanisms allows users to secure the intervention, minimizing risks to themselves, children, or others nearby [67-69].

On public transport, caregivers must often manage the intervention in tight, crowded spaces, where movement needs to be minimized to avoid collisions or rollaways. This is especially important when designated secure spaces are unavailable, requiring caregivers to respond quickly to stabilize the intervention during abrupt vehicle movements. Features that enable incremental slowing or complete stopping provide critical safety and convenience, particularly in preventing strain on the caregiver, who might otherwise have to hold the intervention in place manually for extended periods [68,69].

Moreover, the intervention's ability to stop or slow effectively supports broader usability and accessibility. By ensuring stability and control, caregivers can focus on navigating their environment, holding onto support rails, or managing additional responsibilities with confidence. This highlights the importance of designing interventions with robust, user-friendly stopping systems that are well-suited to the unique challenges of public transportation and other dynamic environments [67-69].

The brake system in strollers must be capable of holding the stroller stationary without slipping, even on inclines, to ensure safety when parked on slopes or when the user is momentarily distracted. According to ASTM F833-19, the brake system must hold the stroller stationary on an incline of 12 degrees without slipping, ensuring it is robust enough to prevent unintended movement on significant slopes. Additionally, the stroller must be able to stop within 1 to 2 meters (3 to 6 feet) when moving at moderate speeds of around 1-2 m/s (3-4.5 mph). These performance requirements are essential to prevent unintended rolling, especially on sloped or uneven surfaces. The system must engage quickly and hold the stroller securely in place to minimize risks of rolling. These specifications ensure strollers are effective, safe, and reliable under typical use conditions, meeting safety standards and enhancing user confidence [85-86].

1. Conclusion:

In conclusion, the ability of an intervention to effectively stop or slow motion is a fundamental requirement for ensuring safety and usability across various settings. In dynamic environments such as public transportation, where sudden movements are frequent, interventions must provide reliable control to prevent accidents, stabilize movement, and protect both users and bystanders. This capability also enhances user confidence, reduces physical strain, and facilitates better maneuverability in complex or crowded spaces. Designing interventions with robust, ergonomic, and user-friendly stopping mechanisms is essential to meet the diverse demands of real-world use, particularly in high-risk scenarios where stability and safety are paramount.

## 8.2 Automatic safety locks

1. Summary of Sources:

Automatic safety locks on an intervention folding mechanism are essential for child safety, as they prevent the intervention from collapsing unexpectedly and protect against serious injuries. By keeping the intervention securely locked in place, these mechanisms mitigate risks of entrapment or pinching of small fingers during use. Safety guidelines emphasize that these locks should be regularly checked to ensure reliable performance and prevent accidental folding, which aligns with standards from safety organizations. The Australian Competition and Consumer Commission (ACCC) and child safety networks highlight the importance of this feature, noting that it enhances both caregiver convenience and intervention stability [49, 50].

1. Conclusion:

In conclusion, automatic safety locks are vital for preventing intervention collapses, protecting children from potential injuries such as finger entrapment. These locks provide stability, ensuring the intervention stays secure during use. Regular maintenance is recommended to ensure proper functioning, aligning with safety standards that give parents peace of mind and enhance intervention usability.

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*Fig. 3.1.1.a: Small Parts cylinder in compliance with 16 CFR 1501*

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# 9. Other Features

## 9.1 Tent Pole Spring Pins

These high-quality stainless steel spring button clips are perfect for locking and adjusting telescoping poles. Designed for durability and corrosion resistance, they are ideal for camping gear, tent poles, extension handles, and more. The spring-loaded design ensures secure locking, and they fit seamlessly into round tubing. Easy to install and use, these clips are a reliable solution for a variety of applications.

# images

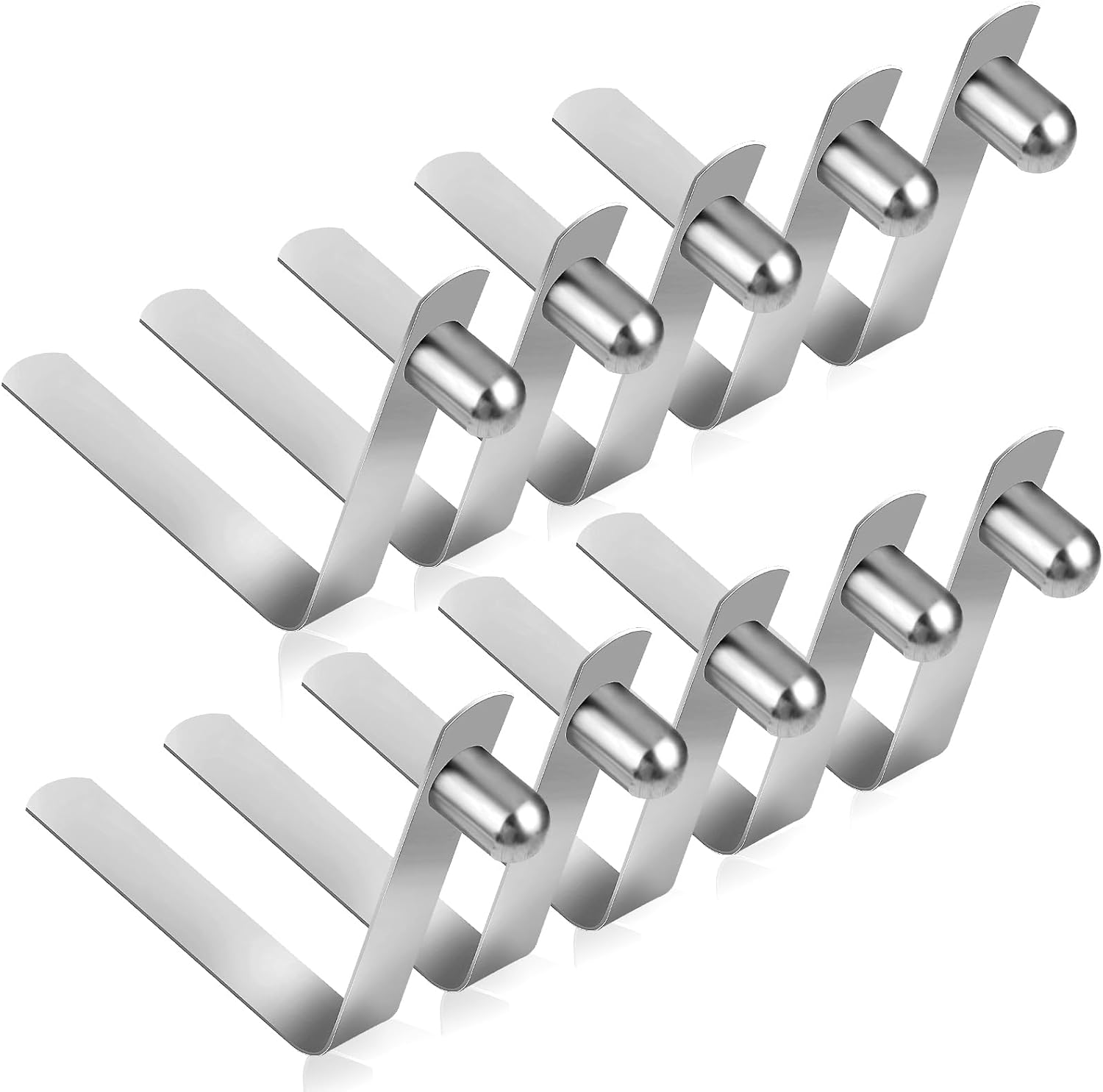


Figure 9.1.1 Tent Pole Clips

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1. Only the last 5 digits of the student number are required. [↑](#footnote-ref-0)