GNG2101

Design Project User and Product Manual

Team Formula 1.2 - F1.2

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List of Acronyms and Glossary

Table 1. Acronyms

|  |  |
| --- | --- |
| Acronym | Definition |
| SUP | Stand up paddleboard |
| UPM | User and product manual |
| DFX | Design for X |
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Table 2. Glossary

|  |  |  |
| --- | --- | --- |
| Term | Acronym | Definition |
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# Introduction

This **User and Product Manual (UPM)** provides the necessary information for various types of users—including fitness enthusiasts, paddleboarders, rehabilitation patients, older adults, and individuals with limited mobility—to effectively use the **Paddle Pro Fan Unit** (Paddle Pro). The manual is also designed to document the prototype and provide instructions for setup, use, and maintenance.

The purpose of this document is to offer clear, step-by-step instructions to ensure safe and efficient operation of the Paddle Pro. It is structured to guide users through the setup process, explain how to use the system, and outline safety precautions. Additionally, the manual provides detailed information about the product's components, how to adjust resistance levels, and how to safely store and maintain the unit. The scope of this document includes configuration considerations, safety warnings, setup instructions, operational guidelines, and maintenance tips.

The intended audience for this document is broad, including both novice users and seasoned athletes, as well as individuals recovering from injury or with physical limitations. The simplicity of the design ensures that users with minimal technical expertise can easily follow the instructions.

Key safety considerations are highlighted throughout the manual to minimize the risk of injury. The **Paddle Pro** includes certain components (e.g., elastic band, flywheel, pulley system) that require careful handling during setup and use. Users are advised to follow all safety precautions to prevent accidents, such as ensuring the elastic band is securely attached to a stable point and testing the resistance settings before use. Additionally, users should avoid sudden recoil when detaching components, as this could lead to injury.

Overall, this document ensures that users can safely and effectively use the **Paddle Pro Fan Unit**, while also considering the durability and longevity of the product through proper storage and maintenance. The manual also outlines the importance of understanding the system’s configuration, emphasizing safety and minimizing the risk of accidents.

# Overview

Based on the requests made by the client, Jack Purcell community centre, it has been made clear that there is a need for standing paddle boarding fan unit to mimic the resistance of paddle boarding over water, to give paddle boarders an opportunity to train during the summer.

A wooden catapult with a rope attached to it

AI-generated content may be incorrect.Standing paddle boarding is a difficult sport that requires constant training of the functional muscle groups to maintain a decent competence in the sport throughout the year. Unfortunately, due to the weather conditions in Canada, paddle boarders are not able to get on the water during the winter months and consequently spend a great deal of the paddle boarding season retraining those muscles and getting used to the activity again.

Figure 1 *The Paddle Pro*

The Paddle Pro tackles this issue by giving paddle boarders a simulation of the same exercise by providing a fan unit for indoor paddling that produces similar resistance feel to water. The system is compact, lightweight and easily storable during paddle boarding season, and the simple set up allows for quick usage during the off season.

The device features a flywheel, a bungee cord, a pulley system, and a gear train all added to the system to increase variability in resistance, functionality of the device, and a more water like feeling during the workout. By leveraging the separability of the three different subsystems, three different modes of varying the resistance level were formed: adding or subtracting blades from the flywheel fan, increasing or decreasing the elasticity of the bungee cord, and adjusting the chains position on the geartrain. This increased variation of resistance levels, allows for a device more accessible to users of all levels, greatly differentiating the product from the current market which solely fitted for more seasoned athletes.

## Conventions

The following document describes in detail; the design, how to put it together, and how to use the system. All the instructions are not complex and are to be taken literally. There are few steps to set up and usage involves little interaction with the subsystems except for the rope at the beginning of the pulley system where the user effort comes from. Be sure to read the document totally and follow the instructions as they are written to ensure for proper system set up, and usage.

## Cautions & Warnings

Before using the Paddle Pro Fan Unit, users should be aware of a few key safety points. First, the elastic band must be securely attached to a stable point like a floor mount or heavy object. If not properly secured, it could snap back and cause injury. When adjusting the resistance, the flywheel must be stationary to avoid catching fingers in the spindles. Additionally, the chain must fit properly into the gears to prevent malfunction. While attaching the paddle cord, ensure it's tied securely to avoid it coming loose during use, although this step presents minimal risk.

First-time users should double-check the setup to ensure the elastic band, resistance gear, and paddle cord are correctly installed. Always test the resistance before starting the workout. After use, carefully untie the paddle cord and detach the elastic band, avoiding any sudden recoil. For storage, make sure the components are neatly tied and protected from moisture or extreme temperatures to ensure longevity.

If installing the elastic band in a shared space, permission may be required to attach it to a fixed point, especially if drilling is involved.

# Getting started

The Paddle Pro Fan Unit is designed to help users simulate a standing paddleboarding experience during the winter. The setup and usage process is straightforward, ensuring a smooth and safe experience for non-technical users.

Once unboxed, the first step is to set up the elastic band. This band must be securely attached to a fixed point, such as a floor-mounted hook or a stable object like a heavy table. It’s important to make sure the attachment is firm to avoid the hook slipping during use. After this, users will adjust the resistance level of the system. The fan unit has different gears that control resistance: larger gears provide higher resistance, while smaller ones provide less. The user manually moves the chain onto the desired gear, making sure it fits properly, and that the flywheel is stationary during this process to prevent injury.

Next, the paddle cord is attached to the user’s paddle. It’s recommended to tie the cord to the bottom of the paddle for the most realistic experience, but users can tie it anywhere they prefer. The knot should be secure to avoid it coming loose during use.

Once set up, the system is ready for use. The user can begin mimicking the motions of paddleboarding, with the fan providing resistance based on the selected gear. This setup mimics the experience of paddling on water. After the workout, users should turn off the system, untie the paddle cord, and detach the elastic band.

For someone using the system for the first time, there are a few considerations to ensure everything functions smoothly. The elastic band attachment must be secure, and users should check the gear system to ensure the chain is properly set before use. It’s also important to test the resistance settings before starting the workout to ensure a smooth experience. With these precautions in place, the system offers an easy-to-use and effective workout tool for those practicing paddleboarding indoors.

## Configuration Considerations

System Overview: The Paddle Pro Fan Unit is a device designed to simulate the motion of standing paddleboarding, especially useful in winter. The system is simple and easy to set up, consisting of a fan unit, an elastic band, a resistance configuration, and a paddle cord.

#### Key Components:

1. **Elastic Band:**One end attaches to a fixed point (e.g., a drilled floor mount or a heavy object like a table). This provides the necessary pullback force.
2. **Fan Unit with Resistance Configuration:**A flywheel inside the fan unit creates resistance, which can be adjusted by attaching a chain to different gears. The larger the gear, the more resistance it provides.
3. **Paddle Cord:**The cord connects from the fan unit to the user's paddle. The user ties the cord at the bottom of the paddle to simulate a real paddling experience.

#### Tools & Setup:

* Elastic Band Hook: A simple hook to attach the band to a stable object.
* Gear System: Manual configuration of the chain to a gear for different resistance levels.
* Cord: A simple tie to secure the cord to the paddle.

#### User Access Considerations

To meet the requirements of the different user groups, the Paddle Pro Fan Unit has been designed with flexibility and safety in mind. For fitness enthusiasts, the adjustable resistance settings allow users to tailor their workouts to their fitness levels, making it accessible for both beginners and advanced users. The simple design ensures ease of use, allowing users to quickly learn how to adjust the system without technical expertise.

For paddleboarders, the system mimics the real paddling experience through its resistance gear system, offering varying levels of difficulty. While more space is ideal, the unit is compact enough for use in most indoor environments, allowing users to still replicate their outdoor workout to some degree.

For rehabilitation patients, the system’s low-impact nature and gradual resistance adjustments make it a safe choice for those recovering from injury. The setup is simple, reducing the risk of error, and supervision during initial use ensures proper form is maintained.

Older adults benefit from the system's straightforward setup and operation. With adjustable resistance levels, they can start with minimal resistance and gradually increase it as their strength improves. The unit’s simple design and easy-to-follow instructions ensure that they can use the system without feeling overwhelmed.

Finally, for individuals with limited mobility or disabilities, the system can be adapted to be used in a seated position or with support devices if necessary. The adjustable resistance, combined with a user-friendly setup, ensures that people with physical limitations can still enjoy a safe workout, and customization options allow for greater accessibility.

Through these features, the Paddle Pro Fan Unit effectively meets the diverse needs of its user groups, ensuring safe, adaptable, and efficient use for all.

#### Accessing/setting up the System

The device is relatively simple in design and the requires 3 simple steps for usage: elastic band fixture, resistance configuration, and paddle attachment. While important, each step is simple and there is little risk for injury throughout the steps.

The first step is the fixture of the elastic band. For the system to work, one end of the elastic band at the bottom must be attached to a fix point to provide the appropriate pull back force as the device is used. The elastic band has a hook on the end that is required to fixed, and while best practice is to have it attached to a point drilled into the floor for stability, it is also functional with heavy objects on the ground like a table for example. The user must be careful in this step, if the hook slips during the attachment process the elastic may spring back to the user and cause minor injuries.

The second step is the resistance configuration. The level of resistance provided by the fan unit is greatly dependant on the gear that the chain is attached to, with the largest gear offering the greatest resistance and the smallest offering the least. This step involves manually transferring the chain onto the appropriate gear while the system fly wheel is stationary. The user must be sure that the chain properly feeds into the gear teeth of their desired resistance gear, and not partially attached as this may cause the system to malfunction. The user must be careful during this step and ensure that the flywheel is not spinning during the process. If the flywheel is still spinning during the process, fingers may get caught in the spindles leading to possible injury.

The third step is to attach the cord to the user's paddle. The input cord of the machine is where user effort comes from. This step is very simple and only requires the user to tie the cord onto their desired paddle, it is recommended that the cord be tied to the bottom of their paddle in order to get the most water like feel from the system; however, the user is free to tie the cord on any part of the paddle they see fit. There is no direct safety risk associated with this step.

At this point the system is ready to be used for a paddle board workout for however long the user requires. The exercise presents no great safety risk on the side of the fan unit once configuration is completed, and the system is ready to go.

#### System Organization & Navigation

The Paddle Pro Fan Unit consists of several key components that work together to create a complete, functional system for simulating paddleboarding. These components are designed to be simple to use and easy to set up, ensuring a smooth experience for the user.

**Main Components**

* Fan Unit: The central feature of the system, the fan unit provides the necessary resistance during the workout. It contains a flywheel connected to a chain and gears, which can be adjusted to change the resistance level. The fan unit is designed to remain stationary during use.
* Elastic Band: Attached to the fan unit or a fixed point in the environment, the elastic band provides the “pull back” resistance as the user mimics paddling motions. This band is connected to the main fan unit and is used to simulate the natural resistance experienced in water.
* Paddle Cord: The paddle cord attaches to the user's paddle and connects to the fan unit. It transmits the user's paddling effort, ensuring the fan resistance is directly related to the user’s motions. This cord is adjustable to allow for different paddle positions and lengths.

Accessories and Attachments

* Resistance Gear System: The resistance is adjusted using a chain connected to different gears. These gears control the fan’s resistance by varying the size of the gear engaged by the chain. The larger the gear, the more resistance it provides, while smaller gears offer less resistance.
* Fixation Hook for Elastic Band: The elastic band is equipped with a hook that needs to be attached to a stable, fixed point, like a drilled hole in the floor or a heavy object. This ensures the band provides the correct level of resistance during use.

**Connections Between Parts**

* The elastic band is connected to the fan unit through a hook and is fixed to a stable object in the environment.
* The paddle cord is tied to the user’s paddle and connects to the fan unit, allowing the user’s effort to engage the fan’s resistance.
* The **resistance gear system** is manually adjusted by moving the chain onto different gears on the fan unit. The fan unit is stationary while this adjustment is made, and the chain must fit securely into the teeth of the gears to ensure smooth operation.

These interconnected components come together to create an efficient and functional workout system.

#### Exiting the System

To properly put away the Paddle Pro Fan Unit, begin by carefully untying the paddle cord from your paddle. Take your time to remove any knots or tangles in the cord to avoid damage. Once the paddle cord is free, set it aside temporarily. Next, detach the elastic band from its fixture. This fixture may be a hook on the floor or another stable object like a heavy table. When removing the elastic band, make sure to unhook it slowly to avoid any sudden snaps or recoil that could cause injury.

After both the paddle cord and elastic band are free, take the ends of each and securely tie them to the base frame of the system. This helps keep everything organized and prevents the components from getting tangled or damaged when not in use. Be sure the ties are snug but not overly tight, ensuring that the elastic and cord are neatly stored but can be easily accessed the next time you set up the system.

Once the paddle cord and elastic band are securely stored, check that all parts are in their proper places. Finally, store the system in a dry, safe area, ensuring the fan unit is placed upright and protected from moisture or extreme temperatures. This will help maintain the longevity of the system and ensure it is ready for use next time.

# Using the System

The following section provides a short but detailed outline of how to use the system. The steps include set up, usage, and take down of the device, be sure to carefully read through the instructions and follow them word for word.

## Set Up:

To begin using the Paddle Pro Fan Unit, the user must first attach the elastic band to a stable, fixed point in their environment. This can be a drilled floor mount or any other stable object, such as a heavy table. The elastic band is equipped with a hook at one end, which the user must securely attach to the fixed point. The hook should be handled with care to avoid the elastic band snapping back during the attachment process, which could lead to injury. It is important to ensure that the fixed point can withstand the tension created by the elastic band during use. Once properly attached, the elastic band provides the necessary pull-back resistance during the workout, simulating the natural resistance of water and ensuring the paddleboarding experience is accurately mimicked.

The user must manually adjust the resistance level by configuring the gear system. The system includes multiple gears, which provide varying resistance levels. To adjust the resistance, the user needs to ensure that the flywheel is stationary before making any changes and move the chain onto the desired gear by manually adjusting its position. The larger gears offer higher resistance, while smaller gears provide less resistance. The user must ensure that the chain is securely fitted into the teeth of the chosen gear. A partially engaged chain can cause system malfunctions. Once the user sets the chain onto a gear, the resistance provided by the fan unit is adjusted accordingly. Higher gears create more resistance, making the workout more intense, while lower gears provide easier resistance, suitable for beginners or rehabilitation users. This feature allows users to tailor the intensity of their workout based on their skill level or physical capability.

The user attaches the paddle cord to the paddle. The input cord of the system connects to the user's paddle via a secure knot. It is recommended that the cord be tied at the bottom of the paddle to simulate a more realistic paddling experience, but it can also be tied at other points depending on user preference. The knot must be tight enough to prevent the cord from coming loose during use. Once the paddle cord is attached, it transmits the user’s paddling effort to the fan unit. As the user mimics the motion of paddleboarding, the resistance provided by the fan unit adjusts based on the selected gear setting. This creates a workout experience that simulates real paddleboarding by replicating the resistance of water.

## Usage:

Once the elastic band is attached, the resistance is configured, and the paddle cord is secured to the paddle, the user can begin mimicking the paddleboarding motion. The user applies force to the paddle as they would in a real paddleboarding situation, moving the paddle through the simulated water (resistance created by the fan unit). The user controls the intensity of the workout by adjusting the resistance setting via the gear system. The fan unit generates resistance that mimics the feel of paddling through water. The resistance level is determined by the gear setting chosen earlier. As the user moves the paddle back and forth, the fan produces air resistance, which increases or decreases depending on the gear setting. This interaction between the user’s movements and the system’s resistance creates a realistic, water-like experience.

## Takedown:

After the workout, the user needs to turn off the system and carefully disconnect all components. To do this, the user unties the paddle cord from the paddle and detaches the elastic band from its fixed point. Once the paddle cord is untied and the elastic band is detached, the system is powered down and disassembled for storage. The components are now free of tension and can be safely stored. It is important to untie the paddle cord slowly to avoid tangling or damage and to detach the elastic band carefully to avoid any sudden recoil that could cause injury. Once detached, the paddle cord and elastic band should be securely stored to avoid damage.

For proper storage, the user needs to tie the paddle cord and elastic band neatly and securely to prevent tangling. The components should then be stored in a dry, safe area, away from moisture and extreme temperatures. This ensures that the system remains in good condition and is ready for the next use. Proper storage prevents damage to the components and helps maintain the longevity of the system. It is important to ensure that the elastic band and paddle cord are not under tension when stored, as this could damage the components over time.

## Subfunction Description

This section provides a detailed explanation of three critical sub-features of the Paddle Pro Fan Unit: the Elastic Band Attachment, Resistance Configuration, and Paddle Cord Attachment. Each sub-function is designed to enhance the user experience by simulating the dynamics of paddleboarding. The Elastic Band Attachment creates resistance to mimic water drag, while the Resistance Configuration allows users to adjust workout intensity through manual gear selection. The Paddle Cord Attachment connects the user’s paddle to the fan unit, transmitting paddling effort to generate resistance. This section outlines the key functionalities, necessary user mastery, and expected behaviors for each sub-feature, along with special instructions and potential caveats to ensure safe and effective use.

### Elastic Band Attachment Sub-Feature

**Description:** The elastic band attachment is a critical sub-feature of the Paddle Pro Fan Unit. It is designed to create the resistance necessary for simulating the water drag that paddleboarders experience when paddling. The elastic band must be securely affixed to a fixed point in the environment (either a floor-mounted hook or a heavy, stable object like a table). Once attached, the band provides a pull-back force during the workout, which mimics the resistance of the water.

**Key Functionality:**

The user will need to ensure that the elastic band is securely fastened before starting the workout.

* The hook at one end of the elastic band must be connected to a fixed, stable point. If the band is not securely attached, it may snap back, potentially causing injury.

**Required User Mastery:**

* **Secure Attachment:** The user must master the proper attachment of the elastic band to a fixed point. This includes understanding the tension that the band will undergo during the workout and ensuring that the hook does not slip or detach during use.
* **Handling the Band Safely:** Users need to exercise caution when attaching and detaching the elastic band. Sudden recoil can cause injury if the user is not careful.

**Expected Behavior:**

* When properly attached, the elastic band will provide a steady pull-back resistance that increases as the user paddles against it.
* The resistance intensity will be proportional to the user's strength, with the band providing more resistance the harder the user pulls.
* During the workout, the user should feel a consistent resistance as they mimic the paddleboarding stroke.

**Special Instructions:**

* **Stability of Fixed Point:** Ensure the fixed point is stable enough to withstand the tension created by the elastic band. This is crucial to prevent the band from detaching or causing injury.
* **Check Before Use:** Always check that the elastic band is securely attached before starting the session. This includes verifying that the fixed point is robust and will not shift or loosen during use.

**Caveats & Exceptions:**

* **Elastic Band Breakage:** If the band is exposed to excessive wear or is not stored properly after use (e.g., exposure to extreme temperatures or humidity), it may break prematurely. Regular inspection for signs of wear is essential.
* **Incorrect Attachment:** If the band is attached too loosely or to an unstable point, it can snap back during use, causing minor injuries. Always make sure the attachment is firm and secure.
* **User Height Considerations:** Users who are taller may require additional space for the elastic band’s full range of movement. Ensure that the attachment point allows the band to stretch adequately without the risk of snapping back or causing discomfort.

### Resistance Configuration

**Description:** The resistance configuration allows the user to adjust the level of resistance during their workout by selection different gears on the fan unit. The gear system includes multiple gears each offering a different level of resistance based on the size of the gear. This adjustement allows the user to tailor the device for different workout intensity, with the larger gears providing more resistance than smaller ones.

**Key Functionality:**

* The user must manually adjust the chain that is connected to the gear system on the fan unit flywheel
* The chain must be properly engaged with the gear teeth to ensure for smooth operation
* Adjusting the gear directly impacts the resistance level provided by the fan, mimicking the resistance experienced while paddle boarding

**Required User Mastery:**

* **Manual Gear Adjustment:**  The user should master the manual process of transferring the chain onto the gear teeth properly, while ensuring the flywheel is stationary.
* **Chain Engagement:** The chain must be securely fitted onto the teeth of the selected gear to prevent system malfunctions/damages.

**Expected Behaviour:**

* The larger gears will increase the resistance, making it more difficult for the user to simulate paddling, smaller gears will do the opposite.
* Proper adjustment will create a smooth and controlled workout experience

**Special Instructions:**

* **Stationary Flywheel:** Ensure the flywheel is completely still when adjusting the chain onto a new gear to prevent injury.
* **Test Resistance Before Use:** Always test the resistance before starting the workout to ensure that the gear is properly engaged, and the resistance feels appropriate for the user’s fitness level.

**Caveats & Exceptions:**

* **Inconsistent Chain Engagement:** If the chain is not fully engaged with the teeth of the gear, it could cause the system to malfunction, resulting in jerky movements or ineffective resistance.
* **Improper Resistance Settings**: Users should avoid making drastic changes in resistance during use, as it may cause sudden strain on the system or lead to a less effective workout.

### Paddle Cord Attachment Sub-Feature

**Description:** The paddle cord is the component that connects the user’s paddle to the fan unit. It is a crucial element that allows the user to simulate the motion of paddleboarding. The cord transmits the user’s paddling effort to the fan unit, which provides resistance through the flywheel and elastic band. The cord should be securely tied to the bottom of the paddle for a more realistic paddling experience.

**Key Functionality:**

* The paddle cord is tied to the user’s paddle to simulate the paddling stroke.
* The cord length and attachment point can be adjusted depending on user preference, but the most realistic experience comes from attaching it to the bottom of the paddle**.**

**Required User Mastery:**

* **Secure Knot Tying:** Users should master the art of tying a secure knot to ensure that the cord stays attached throughout the workout.
* **Adjustable Cord Position:** While the cord is ideally tied to the bottom of the paddle, users can adjust the attachment point based on comfort or preference. However, it’s crucial to ensure the cord is securely tied and doesn’t loosen during use.

**Expected Behavior:**

* Once the paddle cord is attached, it transmits the paddling force from the user to the fan unit, generating resistance.
* The user should feel the resistance increase as they paddle and decrease when they stop.

**Special Instructions:**

* **Secure Knot**: Ensure that the knot is tight enough to prevent the cord from coming loose during use. A loose knot can result in the cord detaching and causing a disruption in the workout.
* **Cord Adjustment:** If you feel that the resistance is not simulating the experience properly, adjust the length of the cord by either shortening or lengthening it for a more comfortable workout.

**Caveats & Exceptions**:

* Loose Attachment: If the cord is not securely attached, it may detach during use, leading to a sudden loss of resistance and possibly disrupting the workout.
* Unintended Cord Length Changes: Adjusting the cord length too frequently can lead to wear or knotting. It’s best to find a comfortable length at the start and leave it unchanged during the workout.

# Troubleshooting & Support

In this section there will be a focus to all the possible issues that can occur using the prototype and some possible fixes. It starts by giving fixing to issues from the testing of the prototype.

## Possible Issues

### Chain gets out of the gears

When the chain leaves the gears, it needs to be placed back similarly to how it would be done on a bicycle. Take the chain and put it back into the desired gear based on the desired resistance. Remember smallest gear is hardest and biggest gear is the easiest.

### Too much friction where the rope is attached to the chain

If this becomes a problem a possible fix would be to tape around the joint to make the joint smoother and smaller reducing the possible friction.

### Prototype is not sturdy enough

If this is an issue added pieces of wood and screws would solidify the prototype. They would to be added where the prototype moves during used.

### Elastic hook, unhooks himself

If this is a recurring issue the hook can be replaced by attaching a better mechanism for attachment to the used anchor. This could be a knot at the end of the rope on the anchor.

## Special Considerations

The paddle or the stick used for paddling is considered outside the scope of our project but is however needed for it to function. For this reason, any issues related to the paddle will not be answered by this document and will be a future consideration.

## Maintenance

Make sure all the components are in good condition and that the chain is oiled properly, oil recommended for the chain is the same as a bicycle and source can be found online for treatment and lubricant used for maintenance see:

Reference [1]: [How to clean and lube a bike chain](https://www.mec.ca/en/explore/how-to-clean-and-lube-a-bike-chain)

Other consideration includes keeping the prototype indoors and not in a humid location.

## Support

For immediate or emergency assistance and system support, please contact Steffen Zylstra at [szyls064@uottawa.ca](mailto:szyls064@uottawa.ca)

### Emergency assistance can be requested for the following reasons:

* System has ceased to function without obvious cause.
* The system is producing an unexpected noise.
* The system is behaving unexpectedly or causing danger to those around it.

### For diagnosing the issue with the system, please follow the following steps:

* Detach the paddle from the system.
* Allow the wheel to stop spinning.
* Detach the bungee cord and set on ground.
* Holding the rope at the paddle end, trace along the rope all the way through the system, noting if there are any detachments from the paddle end to the bungee cord end.
* Report findings to the email above for further instructions.
* Avoid use of the system until the issue is resolved.

# Product Documentation

**Paddle Pro** is a home-built DIY exercise device designed to simulate the physical motion and resistance of paddle boarding. It was created to serve paddle boarders of all skill levels who wish to maintain or improve their paddling technique during the off-season, especially in colder climates where outdoor training isn’t always possible.

The concept was born from an interest in addressing a unique mechanical challenge: how to replicate the dynamic movement and resistance of paddling on water using simple, accessible components. The device enables users to perform realistic paddling strokes on land. As the user pulls the paddle, a chain mechanism spins a bicycle wheel, which in turn engages a rubber cord to provide resistance. After the stroke, the elastic cord smoothly retracts the handle, simulating the natural return motion in real paddling.

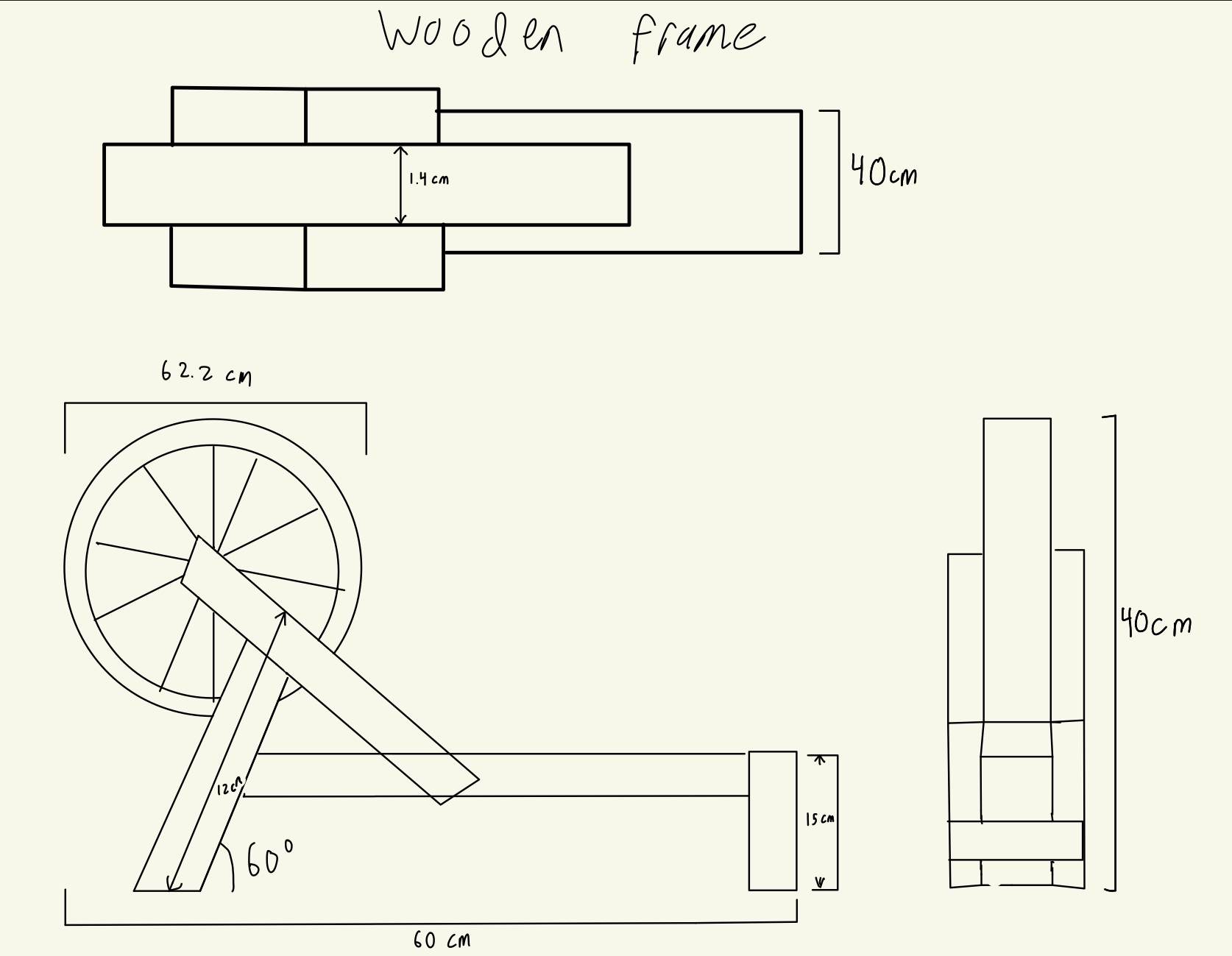
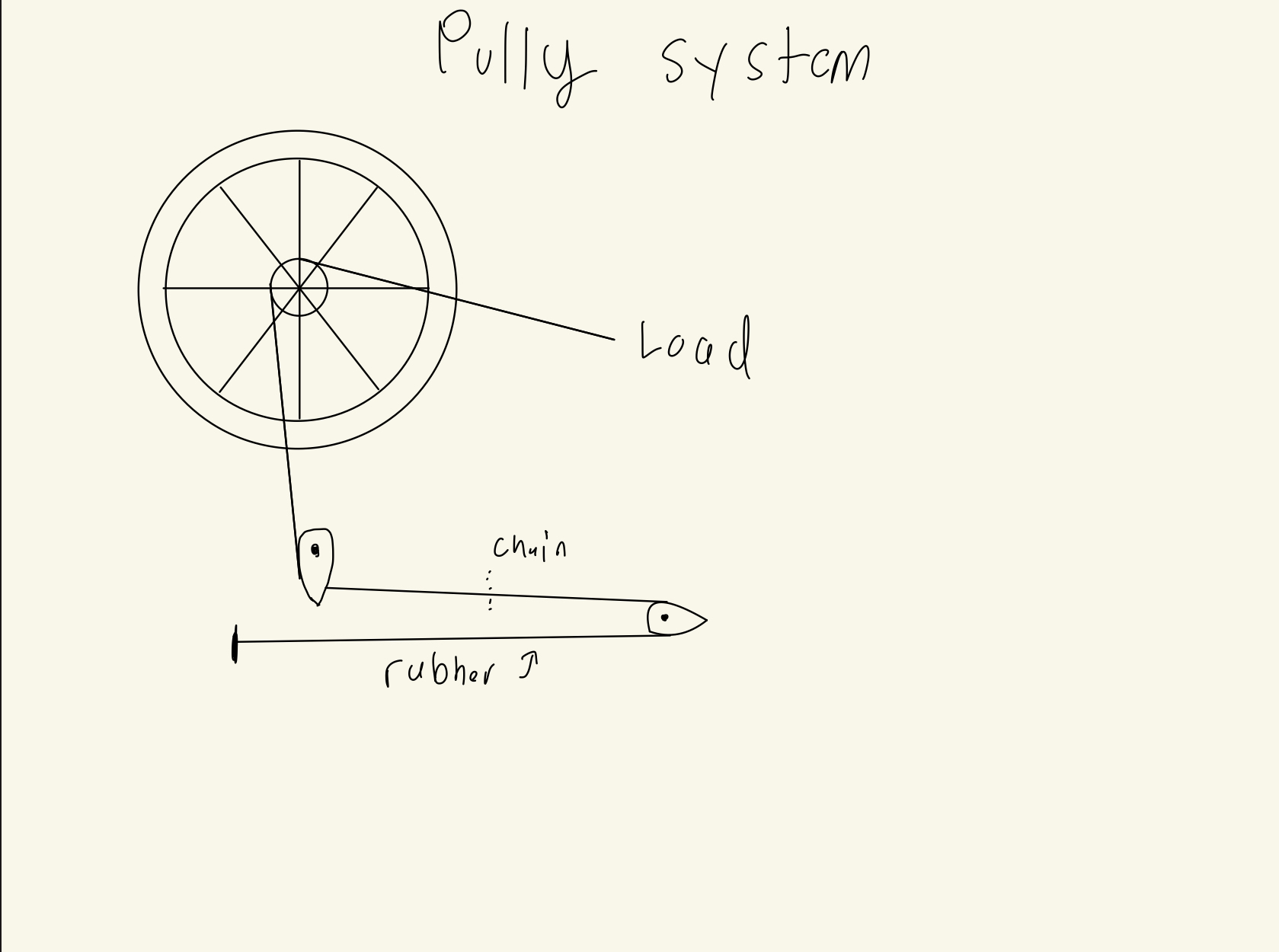


Figure 2 Frame Design

  
Figure 3 Resistance subsystem design

What sets Paddle Pro apart from other paddle training solutions is its **DIY-friendly approach**. It is designed to be built at home using a combination of recycled bike components and affordable off-the-shelf materials. This not only reduces costs but also promotes sustainability and accessibility.

A number of design constraints and performance goals were identified early in the development process to guide the final prototype:

* Stable resistance with a variable curve, ranging from 1 to 40 N
* **Limited pull-back resistance** (<1 N or 30% of max force) for a natural feel
* Maximum total weight of 5 kg, ensuring portability
* **Compact footprint** of 100 cm x 60 cm x 60 cm for space efficiency
* **Durable construction** targeting a lifespan of at least 5 years

These requirements informed every major design decision and material choice, from the selection of the chain drive to the use of elastic cord for resistance. The result is a cost-effective and functional prototype that can be replicated or improved upon by other DIY builders and paddle sports enthusiasts.

## Prototype 1

## <Subsystem 1 of prototype>

### BOM (Bill of Materials)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Component | Description | Quantity | Weight (kg) | Cost per unit ($) | Cost ($) | Link | Reasoning | Free |
| Bicycle wheel | Recycled and free from used dumped bike | 1 | 1.5 | 79.99 | 79.99 | [Link](https://www.bikedepot.com/product/wheel-shop-alex-c303-silver-formula-fm-21-qr-27-inch-front-359832-1.htm) | Provides resistance | Y |
| Bicycle chain | Recycled and free from used dumped bike | 1 | 0.2 | 37.99 | 37.99 | [Link](https://www.bikedepot.com/product/shimano-cn-hg71-6-7-8-speed-e-bike-chain-372775-1.htm) | Attaches to chain | Y |
| Bicycle gears | Recycled and free from used dumped bike | 1 | 0.3 | 9.81 | 9.81 | [Link](https://www.amazon.ca/Sprocket-Pinion-Universal-Bicycle-Ordinary/dp/B08GCP51KB/) | Connects wheel to cord | Y |
| Aluminium Sheet | 8 x 24 x 0.025-inch | 1 | 0.2 | 18.00 | 18.00 | [Link](https://www.homedepot.ca/product/paulin-8-x-24-x-0-025-inch-aluminum-sheet-metal/1000126786) | For base connections | N |
| Pulley | 3/8 inch rope rated more than 400lb | 2 | 0.2 | 7.00 | 14.00 | [Link](https://www.amazon.com/Silver-Stainless-Wirerope-Traction-Trolley/dp/B0B1Q8K7R8/) | Supports cord | N |
| Elastic cord | 3/8 inch elastic rope (2 meters) rated for 400 lb | 1 | 0.05 | 10.00 | 10.00 | [Link](https://www.amazon.com/PARACORD-PLANET-Elastic-Crafting-Stretch/dp/B07BDM2BPD/) | Connects to base for retraction | N |
| Rope | 3/8 inch (4 meters) rated for 400 lb | 1 | 0.05 | 10.00 | 10.00 | [Link](https://www.amazon.com/Rope-Solid-Braid-Multifilament-Polypropylene/dp/B0CWVP22VD/) | Connects to paddle | N |
| Swivel/eye bolt | - | 1 | 0.02 | 5.00 | 5.00 | [Link](https://www.amazon.com/Eyebolt-Carabiner-Stainless-Resistant-Keychain/dp/B0CDRH8QRR/) | Connects base and elastic | N |
| Batten screws (75mm) | Stainless socket screws | 20 | - | N/A | 5.00 | [Link](https://www.amazon.com/iExcell-Stainless-Socket-Screws-Wrench/dp/B089QTNBQL/) | General construction | N |
| Batten screws (200mm) | Stainless socket screws | 4 | - | N/A | 5.00 | [Link](https://www.amazon.com/iExcell-Stainless-Socket-Screws-Wrench/dp/B089QTNBQL/) | General construction | N |
| Metal Screws (16mm) | Stainless mushroom head | 20 | - | N/A | 5.00 | [Link](https://www.amazon.ca/ORANXIN-Stainless-Mushroom-Drilling-Tapping/dp/B0B4BHHNR8/) | General construction | N |
| Wood 2x4 | Standard lumber | 2 | - | 5.00 | 10.00 | [Link](https://www.homedepot.ca/product/1000112108) | General construction | N |
| Winch Roller | Cable guide | 1 | 0.2 | 20.00 | 20.00 | [Link](https://www.ebay.ca/itm/144637451631?var=443880161823) | Central feeding point for rope | N |

## Tools Required

For the construction of the base the following tools were used:

* Table Saw
* Bandsaw
* Handheld Drill
* Sander

Tools needed for removing bike wheel:

* Hex/Allen Keys – Common sizes: 4mm, 5mm, 6mm (for thru-axles or bolt-on axles).
* Wrench 15mm
* Cassette Lockring Tool

### Instructions

## Building Instructions: Paddle Pro

### Materials and Tools Required

#### Materials:

* 1x Bicycle wheel (62.2 cm diameter)
* Wooden planks for the frame
* Chain and rubber cord for resistance
* Screws and fasteners

#### Tools:

* Saw (for cutting wood)
* Drill and screws
* Wrench (for removing bike wheel)
* Measuring tape

### Step 1: Removing the Bike Wheel

1. Place the bike upside down or on a stand for stability.
2. Use a wrench to loosen the axle nuts or quick-release lever.
3. Carefully detach the wheel from the bike frame.
4. If necessary, remove the tire and inner tube, leaving only the rim and spokes.
5. Set the wheel aside for later assembly.

### Step 2: Cutting the Wooden Frame

Refer to the provided **wooden frame diagram** and make the following cuts:

1. Main horizontal base:
   1. Cut a **60 cm** long wooden plank for the bottom support.
2. Vertical support (back structure):
   1. Cut **two** pieces, each **40 cm** long.
3. Angled supports for the wheel:
   1. Cut **two** pieces at **120 cm**, angled at **60°** at one end to attach to the base.
4. Additional stabilizers:
   1. Cut **15 cm** vertical stabilizer to strengthen the wheel mount.
   2. Cut **reinforcement blocks** to match the diagram (1.4 cm thick in some sections).

### Step 3: Assembling the Wooden Frame

1. Attach the **40 cm vertical supports** to the **base (60 cm piece)** using screws and a drill.
2. Position the **angled supports (120 cm pieces)** so they meet at **60°** and attach them securely.
3. Mount the **bike wheel** at the top intersection of the angled supports.
4. Add the **15 cm stabilizer** at the front to strengthen the structure

### Testing

## Resistance and Force Testing

### Objective:

Measure the resistance force applied by the system to confirm it falls within the target range (**1-40 N**).

### Method:

* A force gauge was used to measure resistance at different pulling speeds.
* Data was collected by pulling the handle at different rates and recording the force.

### Results:

|  |  |
| --- | --- |
| Pull Speed (m/s) | Resistance Force (N) |
| 0.5 | 5 |
| 1.0 | 15 |
| 1.5 | 30 |
| 2.0 | 40 |

* The resistance curve showed a **stable increase**, confirming that the mechanism provided a **progressive resistance range**.

## Portability and Space Efficiency Evaluation

### Objective:

Verify that the design meets the weight and size constraints for **home users**.

### Measurements Taken:

|  |  |
| --- | --- |
| Target Specification | Measured Value |
| Max Weight ≤ 5 kg | 4.8 kg |
| Max Dimensions: 100 × 60 × 60 cm | 60 × 40 × 62.2 cm |

* The prototype successfully met **both weight and space requirements**, confirming ease of transport and home storage.

## 4. Usability Testing

### Objective:

Gather feedback from **paddle boarders** to ensure ease of use and realistic motion.

### Method:

* An experienced paddle boarder (Client) tested the device and rated key factors on a scale of 1–10.

### Results:

|  |  |  |
| --- | --- | --- |
| Test Factor | Avg. Rating (1-10) | Comments |
| Realistic Feel | 8.5 | Good paddle motion, slightly different pullback timing. |
| Comfort | 9.0 | Smooth rowing experience. |
| Assembly Difficulty | 6.5 | DIY-friendly but requires tools. |

# Conclusions and Recommendations for Future Work

Throughout the term, Formula 1.2 has come together to create not only a functional but fun prototype that fulfills most of the original goals set forth. Principle among these is the requirement for a workout SUP machine that can be used bilaterally, and that realistically simulates paddling through water. This section will detail specific choices and decisions made during the design process and a posthumous review of what could have been done differently should the project be replicated.

The original set of subsystems were the base, wheel, and feeder. Using the waterfall design process, each of these were developed somewhat parallel with each other. If the system was to be redesigned, a greater focus on the interaction between subsystems is recommended. A primary example of this is the attachment points between each subsystem. Between the base and wheel, the attachment points of the pulleys were not initially considered, which led to ad hoc solutions left in the final prototype. Also, the aluminum loop used for the feeder subsystem gave rise to a similar situation, where there was almost not enough space to drill holes to mount it in the piece of wood required. A premediated solution to these issues would have been to create a small-scale physical prototype with a representation of each component. Then, the way each subsystem meshes could have been examined. Another solution would be to define further subsystems. Some of the original plans were changed during the building phase, to solve emerging issues. The pulleys obtained for the prototype were difficult to mount and caused some friction with the rope of the paddle. In response, the team elongated the system to cut down to one pulley. If replicating the design, the length of Paddlepro can be cut in half by increasing the number of pulleys the rope runs through. Larger pulleys than the ones used here would be required, but Paddlepro is designed to operate in a gym environment, which often lacks excess space.

Another core lesson learned during the production of the second Paddlepro prototype is that the frame must be properly secured. In testing, the wooden frame was liable to shift from the lopsided force of the chain on one side of the wheel. In testing, this caused the chain to fall off the gears of the wheel. This was not accounted for in the design due to the implication that the assembly would be fixed to a base built separately by another team. The design is functional on its own, and extra connection points between the left and right side of the assembly would ensure that no movement is allowed.

Overall, the greatest strength of Paddlepro is the enjoyment users find in its use. Using a SUP is an experience like no other, and through careful design and a dedicated team, Formula 1.2 was able to replicate the tactile experience to a significant degree. Should the project continue, the remainder of the section is dedicated to possible improvements and avenues of design left due to time constraints.

The greatest immediate improvement would be to fix the elastic cord within the assembly, instead of requiring outside fixing. This would cut the space required by the device by a third and negate the need for fixing the cord to a door or steady object.

Another improvement would be to add a casing around the wheel for safety. While the light weight of the wheel and user distance should prevent injury, adding a plastic casing around the wheel would guarantee it. This would require a way to mount the chain from outside this casing, which is a design problem beyond the work done by Formula 1.2.

The final piece of improvement that would be included is to implement a higher feeding subsystem. Originally, the plan was to have a moving feeder arm that would help manage the issue of the angle between the gear and paddle. The final prototype produced during the term has a simple aluminum loop keeping the chain aligned with the gear, but adding an arm that rotates vertically would allow the rope to be fed straight to the paddle instead of at an angle, better replicating the feel of water.

Overall, Paddlepro has great potential to continue as a commercial product, and with a clear vision of possible improvements and future action, SUP users may no longer have to face the problem of inactivity in winter months. While time constraints limit the implementation of several promising ideas, the progress made demonstrates the viability of the Paddlepro concept. Future teams are encouraged to iterate boldly, refine the design, and continue exploring ways to make the system more efficient, intuitive, and robust.

# Bibliography

[1] “How to Clean and Lubricate Your Bike Chain MEC,” *MEC*, 2025. https://www.mec.ca/en/explore/how-to-clean-and-lube-a-bike-chain [accessed Apr. 04,2025].

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[2] Concept2, "Model D Rower," Concept2, 2024. [Online]. Available: **https://www.concept2.com**. [Accessed: Feb. 2, 2025].

[3] WaterRower, "Natural Rowing Machine," WaterRower, 2024. [Online]. Available: **<https://www.waterrower.com>**. [Accessed: Feb. 2, 2025].

APPENDICES

# APPENDIX I: Design Files

Summarize the relationship of this document to other relevant documents. Provide identifying information for all documents used to arrive at and/or referenced within this document (e.g., related and/or companion documents, prerequisite documents, relevant technical documentation, etc.).

Include all design files in MakerRepo.

Also provide the MakerRepo link to your project.

Table 3. Referenced Documents

|  |  |  |
| --- | --- | --- |
| Document Name | Document Location and/or URL | Issuance Date |
| User guide Video | https://youtu.be/Udptjcri72I | 04-04-25 |
| Design Doc 1 | PD\_BC\_TeamFormula1.2 | 04-04-25 |
| Design Doc 2 | PD\_E-I\_Team\_F1.2-f24 | 04-04-25 |