GNG2101

Design Project User and Product Manual

Project Foothold

Submitted by:

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
PF	Project Foothold
PLA	Polylactic Acid (Common 3D Printing material)
TPU	Thermoplastic Polyurethane (Compressible 3D Printing Material)

Table 0.1 - Acronyms

Table 2. Glossary

Term	Acronym	Definition
Project Foothold	PF	The given name for the system

Table 0.2 - Glossary

1 Introduction

This User and Product Manual (UPM) provides the information necessary for *users with lower-body mobility issues* to effectively use the Project Foothold (PF) system and for prototype documentation.

This document is broken down into the following sections:

1. **Overview**: Highlights the conventions and safety precautions of using this system.
2. **Getting Started**: Breakdown of the different use configurations on the system, along with proper setup and dismount procedures.
3. **Using the System**: Demonstrating the proper use and breakdown of each component of the system.
4. **Troubleshooting & Support**: Different troubleshooting and maintenance steps regarding prolonged use of the system.
5. **Product Documentation**: Technical breakdown of every component of the system.

The purpose of this document is to provide a clear understanding of the PF system and its internal processes, such that any user may safely use this product and ensure its longevity. This document is intended for the use of the PF system by any user with mobility issues seeking help getting proper exercise on a Leg Press machine. It is also intended for any individual seeking to recreate this product in its entirety, with all of the document outlines and specifications provided.

2 Overview

Our objective is to adapt an existing leg press machine to hold a user's feet in place. This is to accommodate any lower-body limitations that may prevent users from independently holding their legs on the machine platform.

Our client is at the Jack Purcell Community Center, a unique gym in Ottawa where people may come to exercise and improve their strength regardless of their physical abilities.

This product is the first of its kind (as of when this document was created) – before this product was introduced, the client utilized resistance bands to hold a user's feet on the leg press platform. Our product has many capabilities: it allows a user's feet to be placed at any location on the leg press platform and be pivoted to accommodate any additional needs.

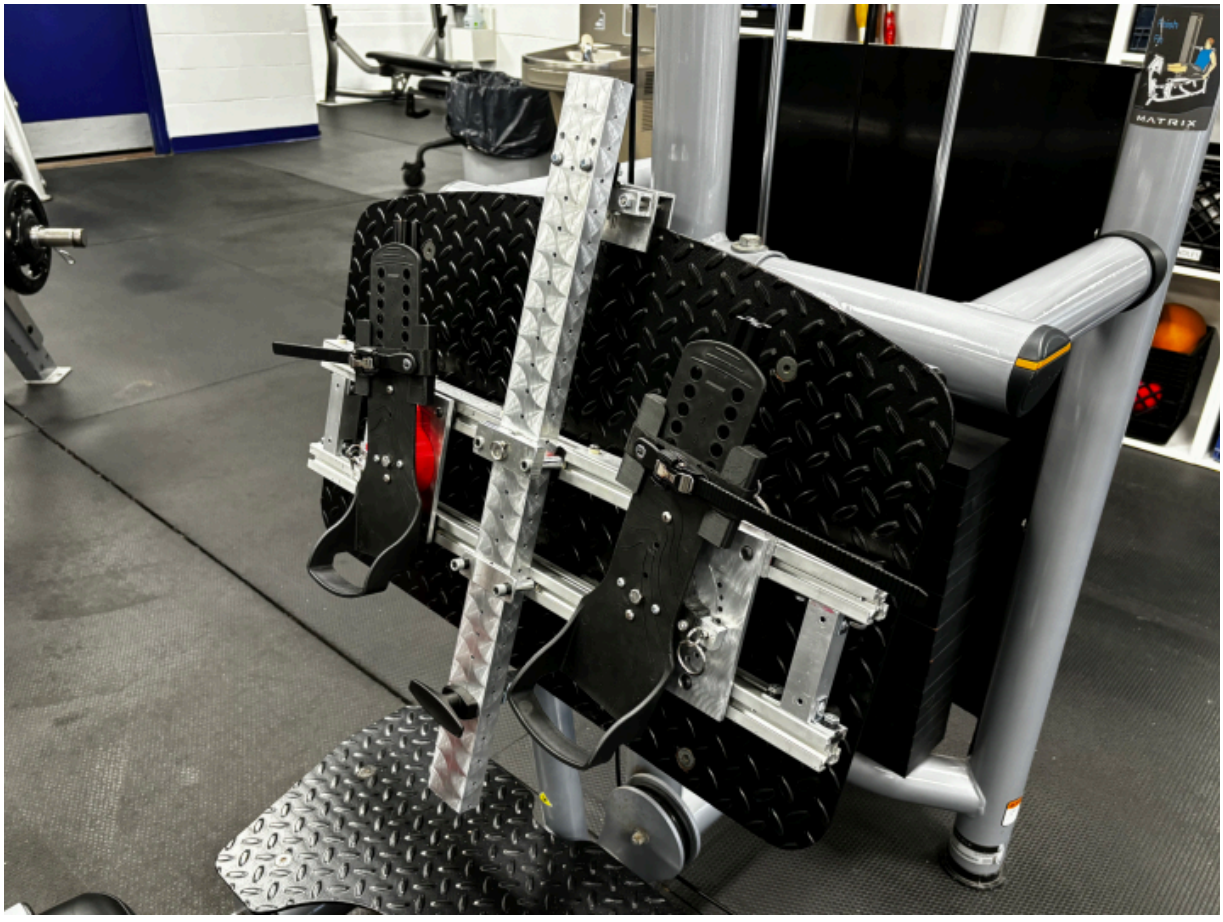


Figure 2.0.1

Final physical prototype

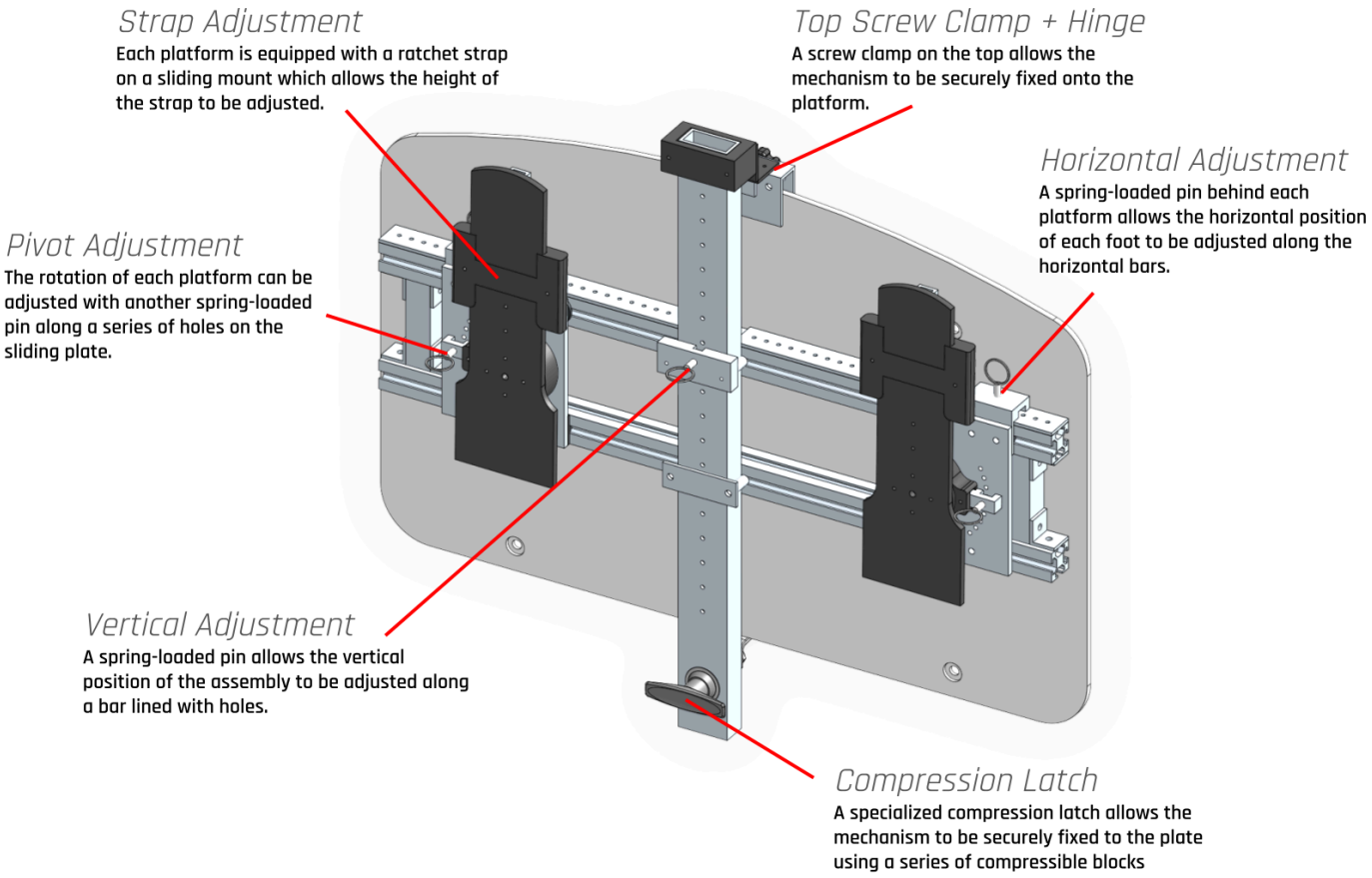


Figure 2.0.2

Final prototype CAD model.

2.1 Cautions & Warnings

- Avoid exceeding 400 lbs of weight on the leg press configuration. Our team has tested extensively at 400 lbs, and no signs of the product failing were seen. Although the product can likely withstand much more, our team would recommend against trying.
- Before the user is to use the machine, ensure all pins are securely set in a hole, ensure the user's foot is securely strapped in place, and ensure the attachment shows no visible signs of damage
- Consult with professionals if you have any injuries, disabilities, or medical conditions that may prohibit you from using a standard leg press to prevent harm.
- Do not use any excessive, sudden, or strange force during use. This attachment will not prevent your leg from being strained if you do not perform the workout properly.
- Avoid using this attachment on any type of machine that is not a leg press (refer to 3.1)

- Keep away from children, this attachment is comprised of mostly aluminum metal and leads to children accidentally hurting themselves

3 Getting started

3.1 Configuration Considerations

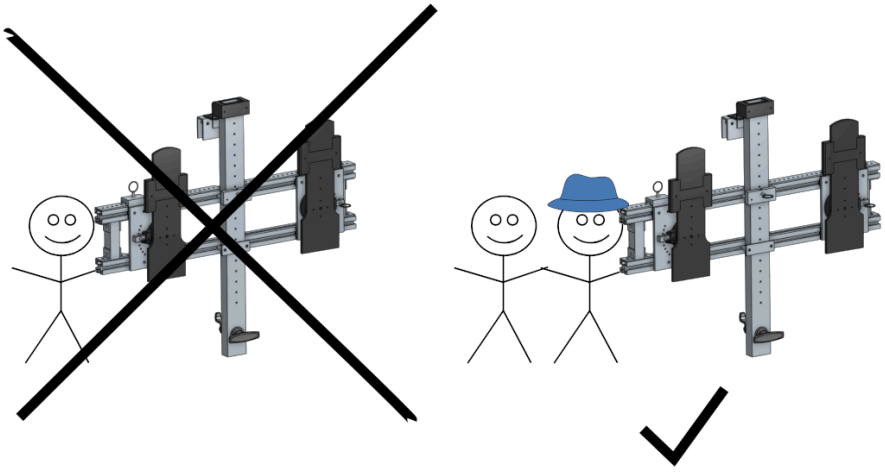


Figure 3.1.1

Any adjustments or setup should be done with supervision or by a fitness trainer.

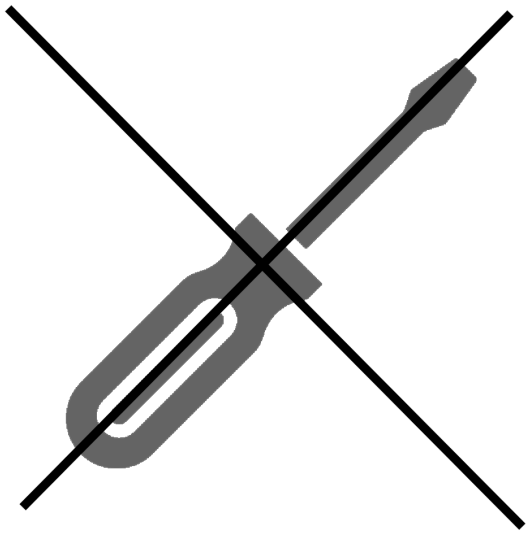


Figure 3.1.2

Tools are not required in the regular use of the attachment

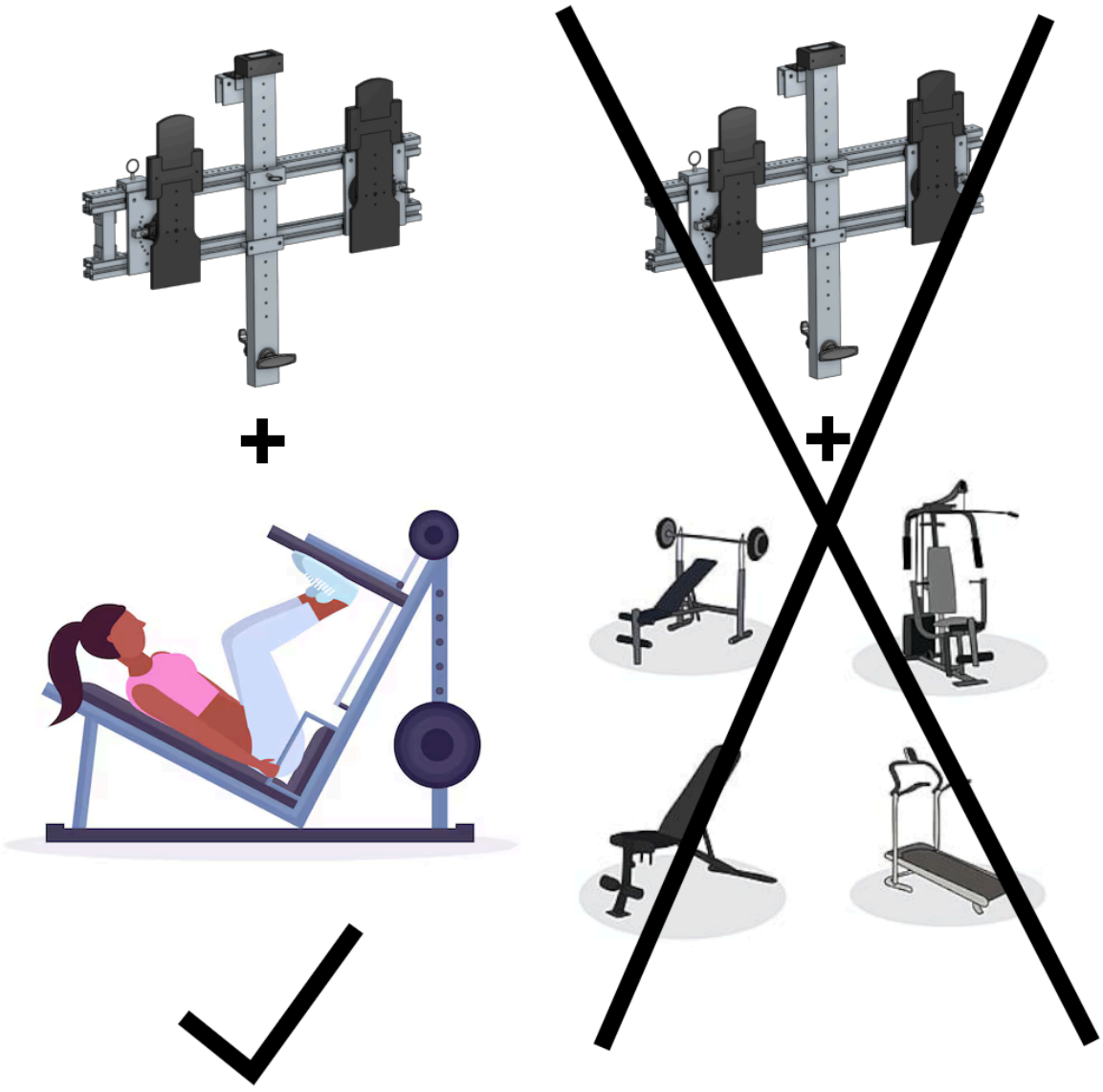


Figure 3.1.3

Only use this product on the leg press machine

3.2 User Access Considerations

3.2.1 Asymmetric rest position of feet

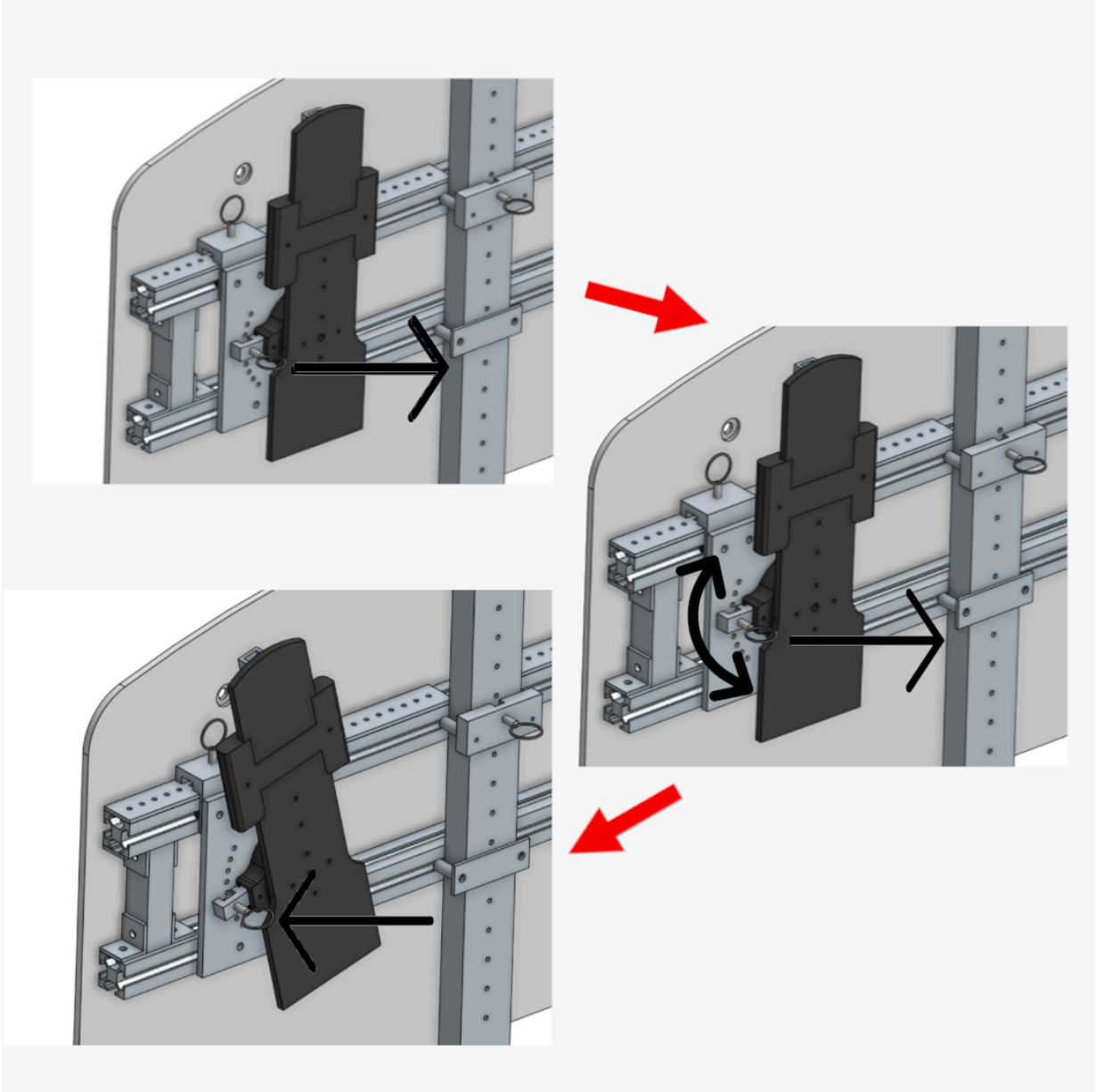


Figure 3.2.1.1

3.2.1 Adjust Rotation of Feet

Simply adjust the foot rotation on each side to match the user's comfortable foot position.

3.3 Setup Process

3.3.1 Top Clamp

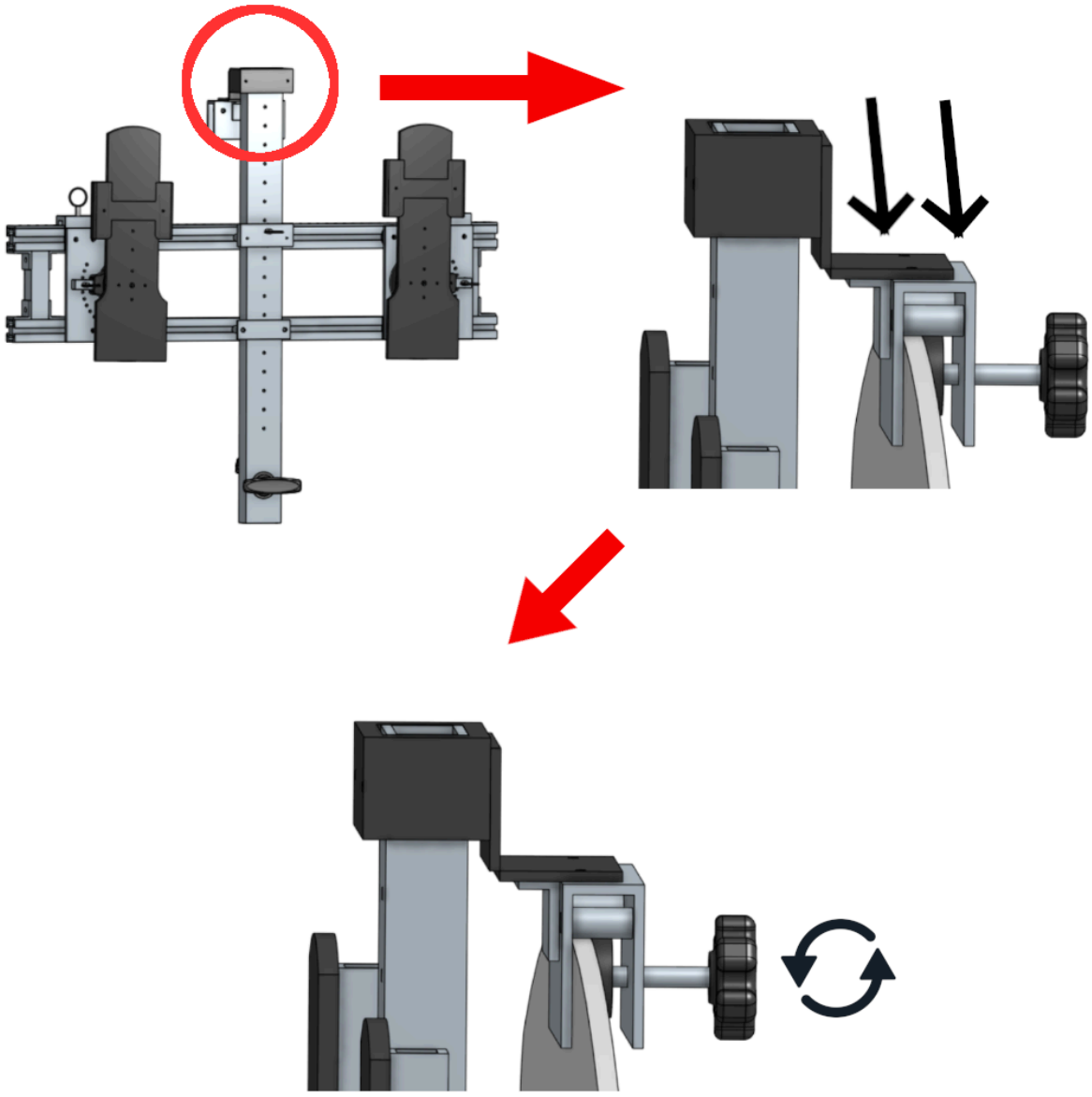


Figure 3.3.1.1

Attach the top clamp onto the leg press platform, then tighten the clamp

3.3.2 Engage Compression Latch

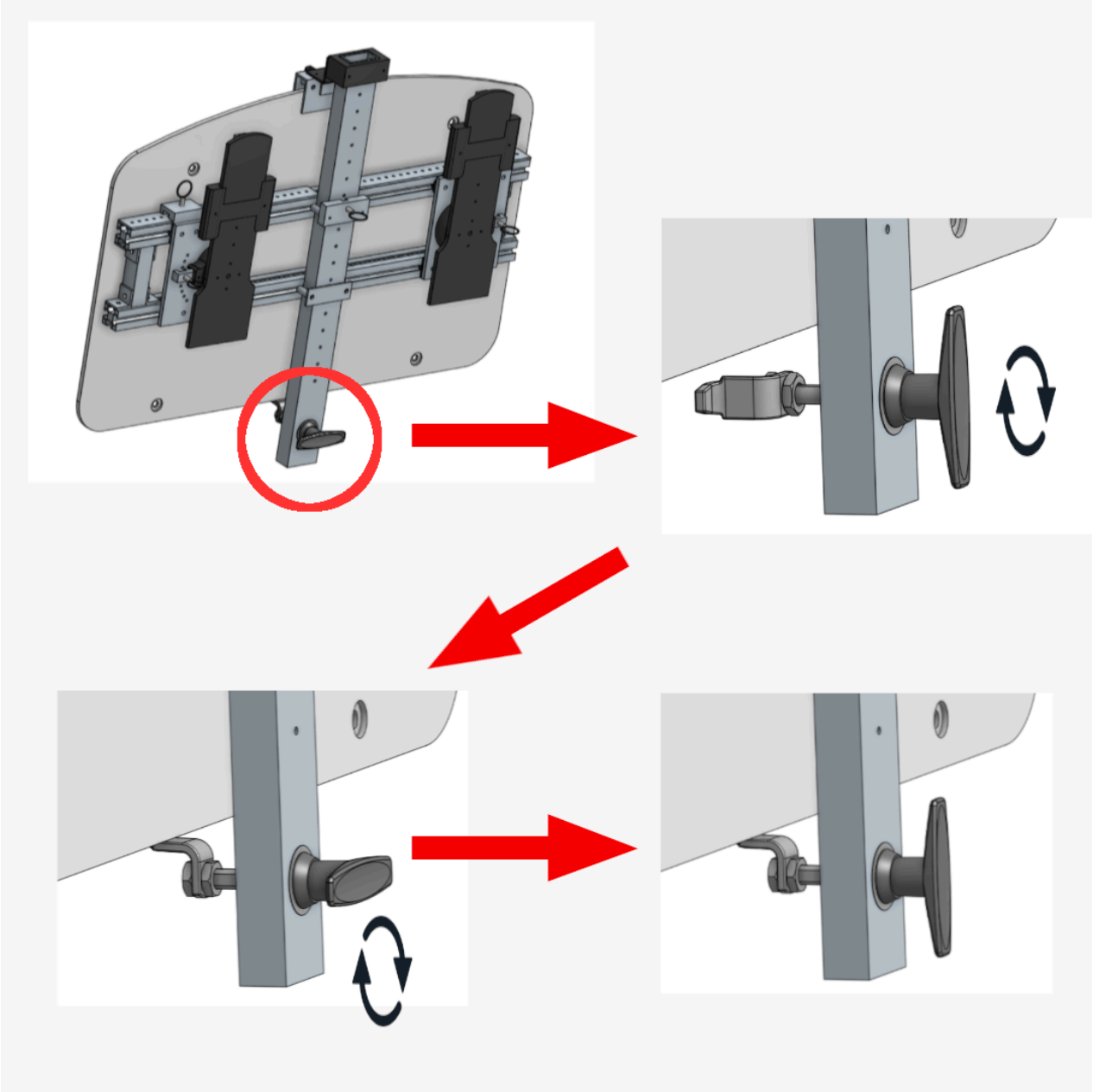


Figure 3.3.2.1

Rotate the compression latch 180 degrees clockwise to secure the frame onto the leg press platform

3.4 System Organization & Navigation

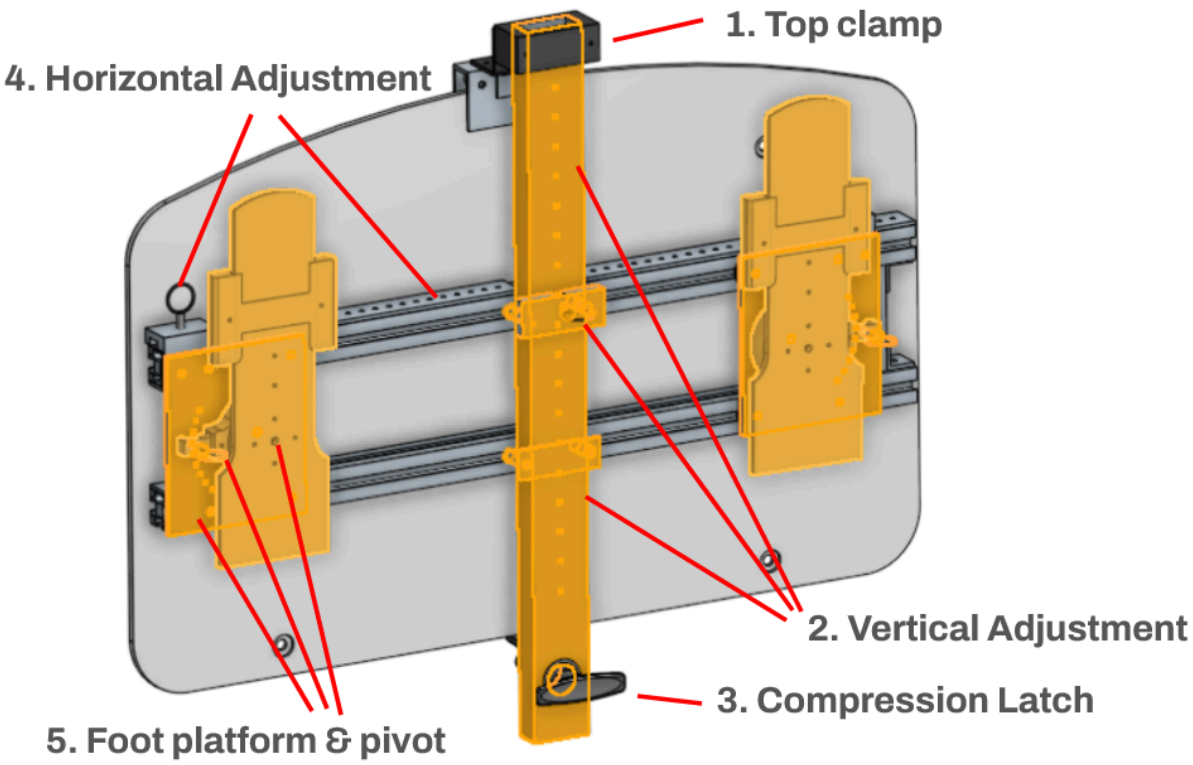


Figure 3.4.0.1

3.4.1 Top clamp

A clamp to attach the attachment onto the leg press platform. Screw to lock the clamp in place.

3.4.2 Vertical Adjustment

Vertical bar attached to the entire horizontal component. Spring pin and consistent holes to adjust vertical foot position.

3.4.3 Compression Latch

Compression latch to securely lock mechanism in place with friction.

3.4.4 Horizontal Bar

Horizontal t-slot extrusion bar to secure foot platform. Spring pins and periodic holes to adjust horizontal foot position.

3.4.5 Foot Platform

Rowing machine foot pad, snowboard strap, and support to securely lock feet in place. Spring pins and circular, uniformly distributed holes for individual rotational adjustability. Adjustable strap heights to accommodate different-sized shoes.

3.5 Dismount Procedure

3.5.1 Disengage Compression Latch

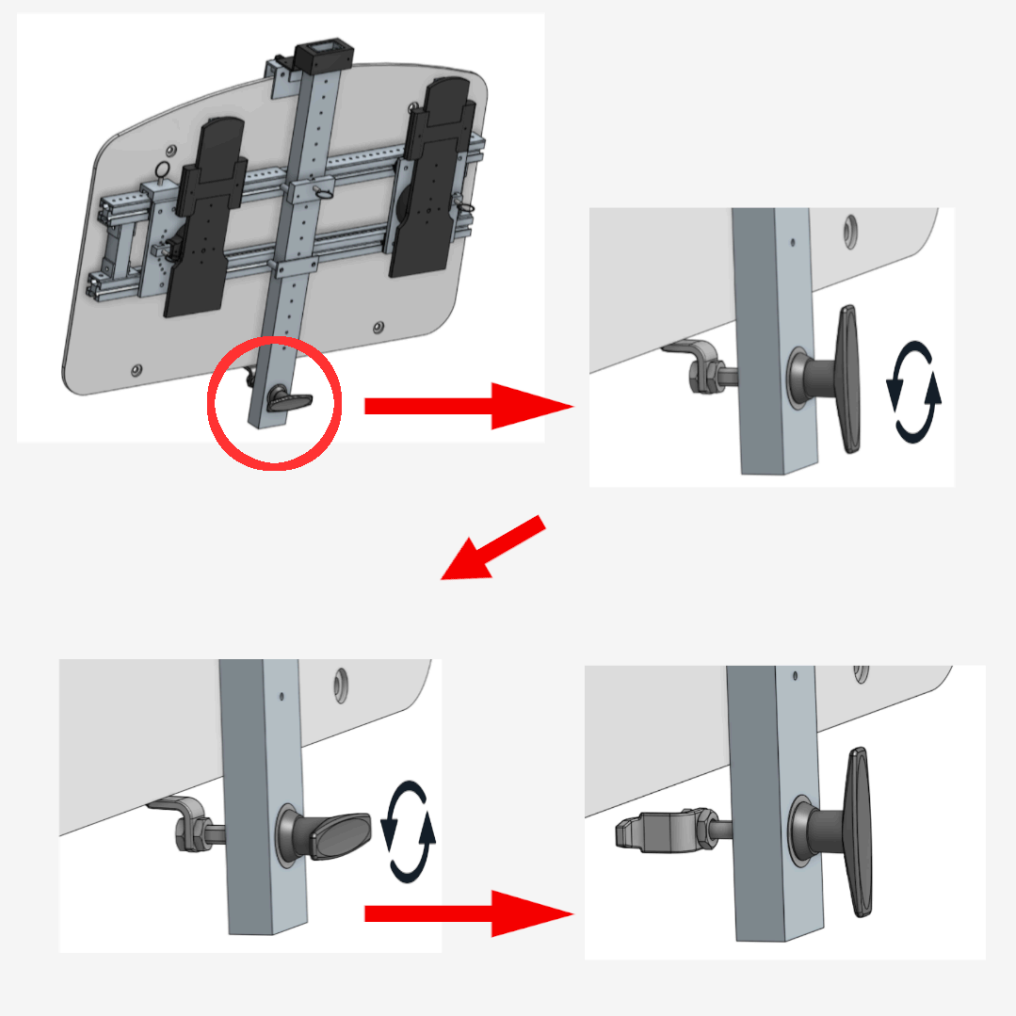


Figure 3.5.1.1

Disengage Compression Latch by rotating 180 degrees counter-clockwise

3.5.2 Unscrew Top Clamp

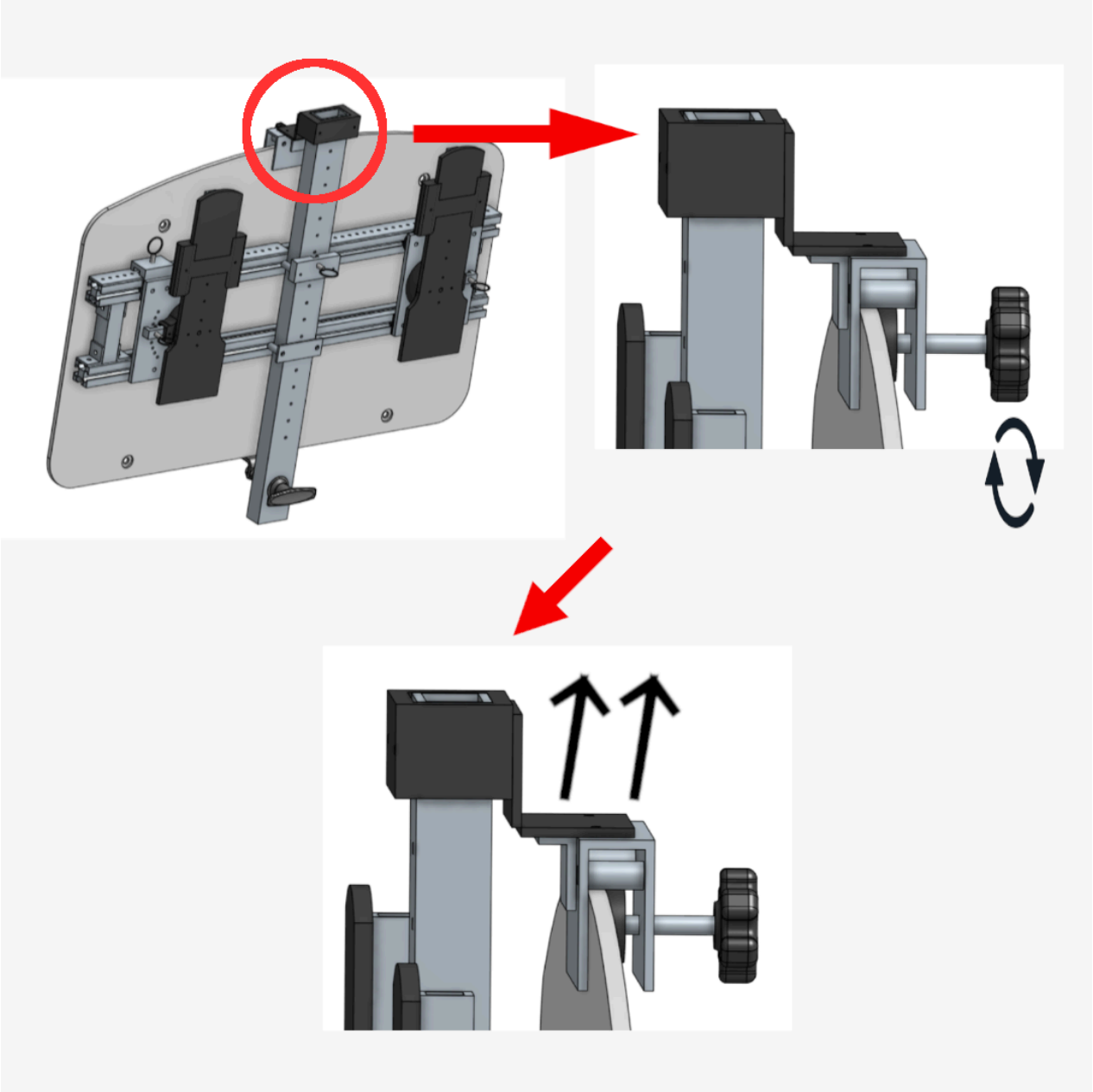


Figure 3.5.2.1

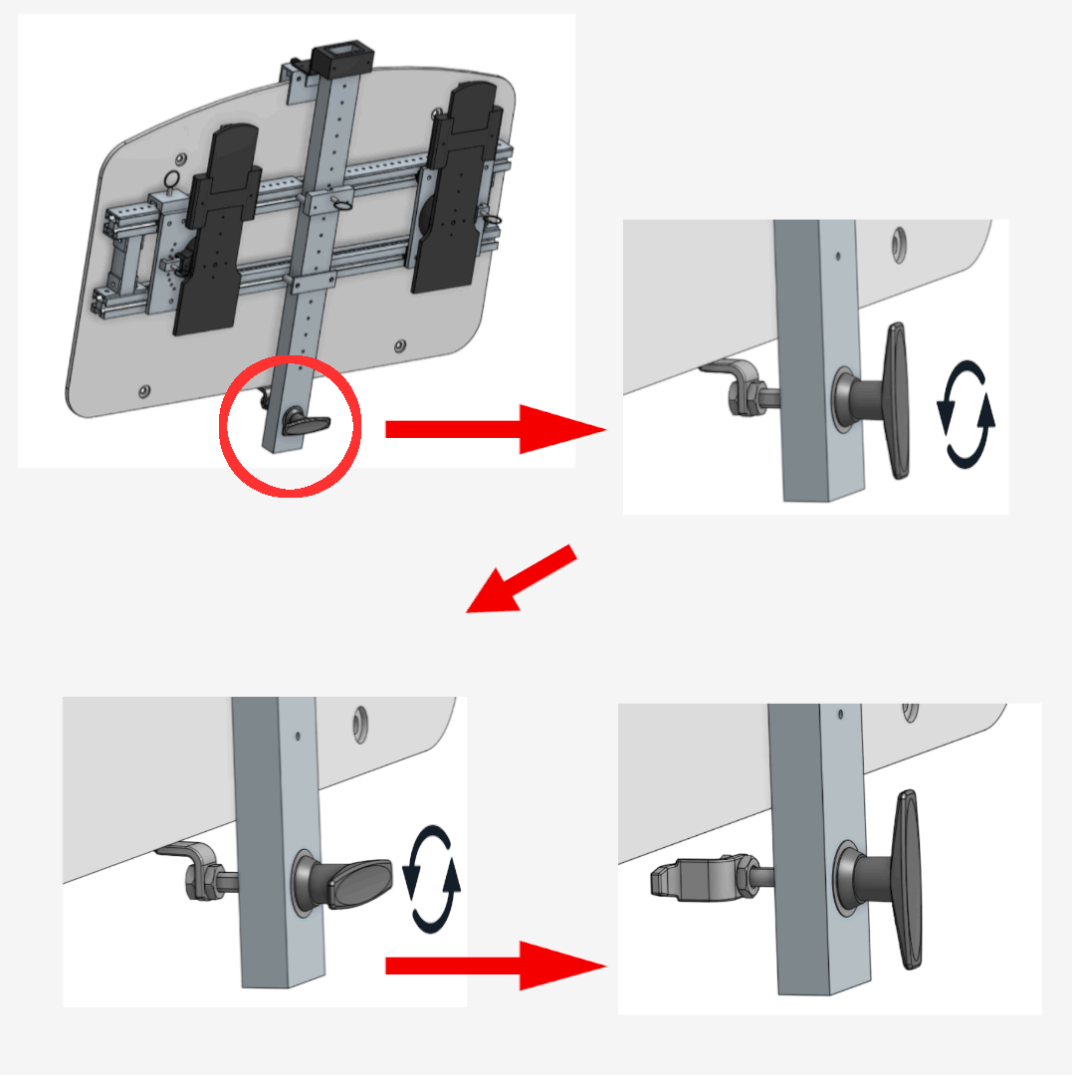
Unscrew the Top Clamp and pull up the frame

4 Using the System

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the PF System.

4.1 Vertical Adjustment

4.1.1 Disengage Compression Latch



4.1.2 Adjust Vertical Position

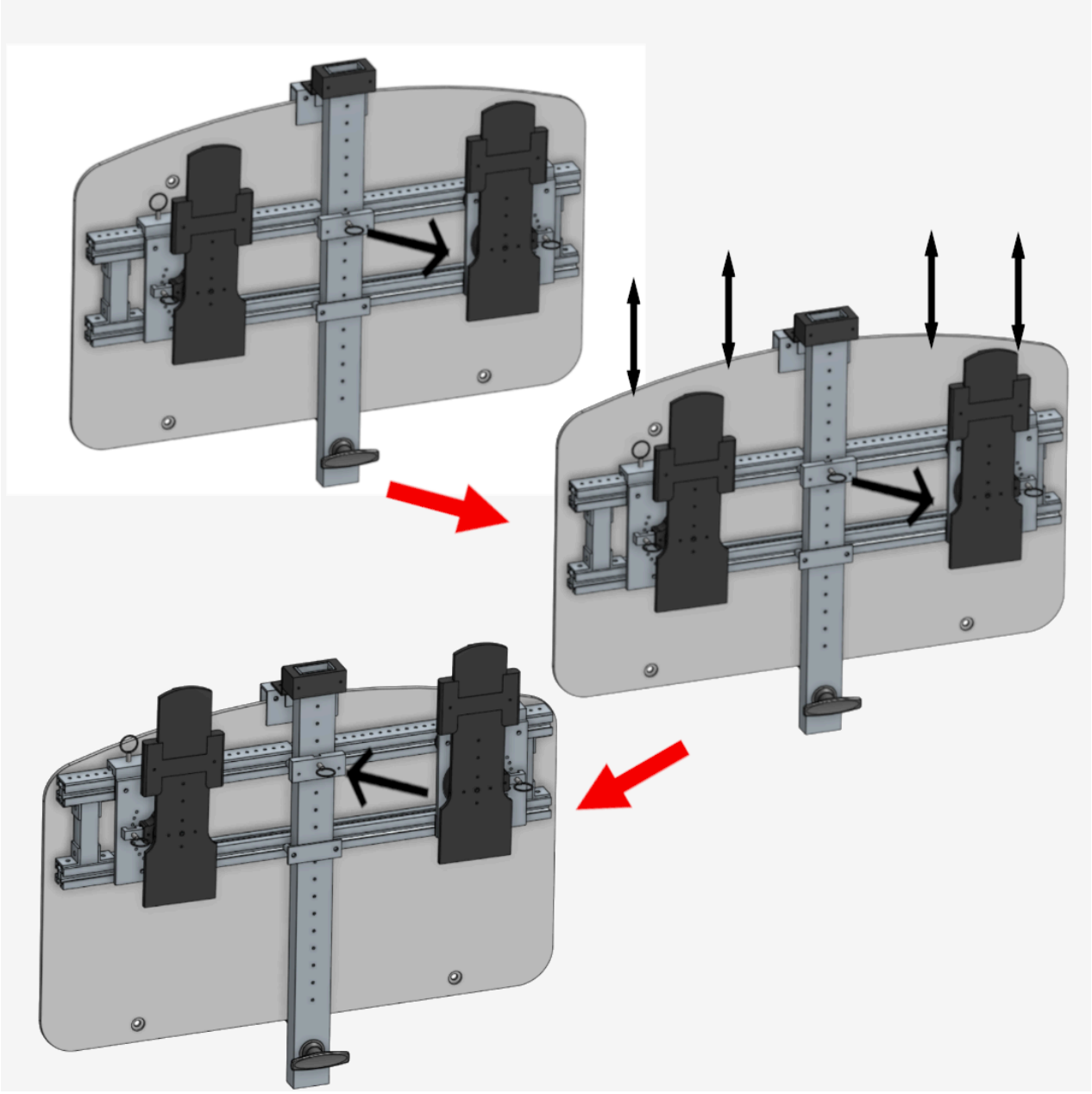


Figure 4.1.2.1

Adjust the vertical position by pulling the key ring on the pin and sliding the assembly up or down. Release the pin into the desired hole on the bar to lock.

4.1.3 Re-engage Compression Latch:

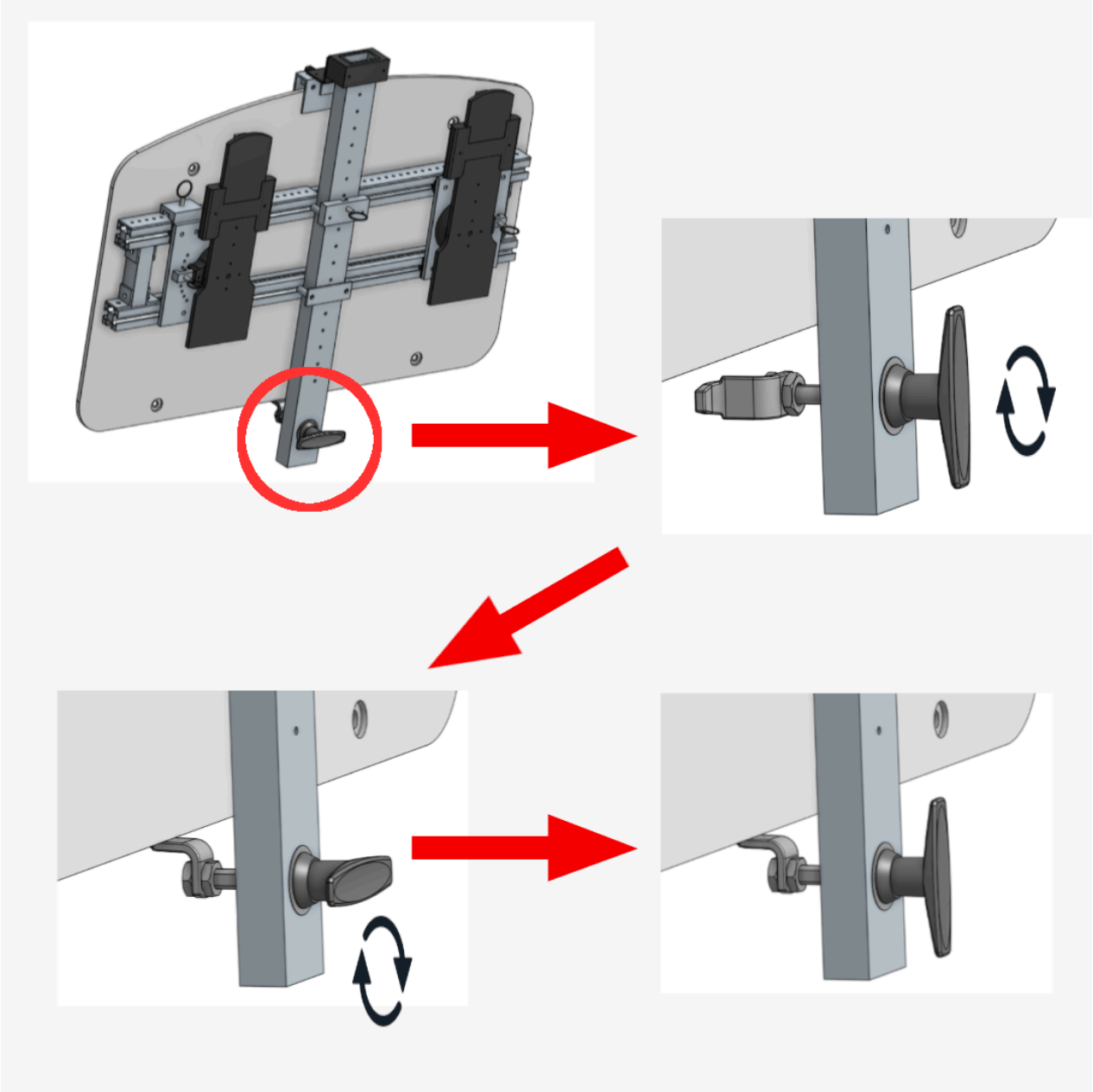


Figure 4.1.3.1

Reengage Compression Latch

4.2 Horizontal Adjustment

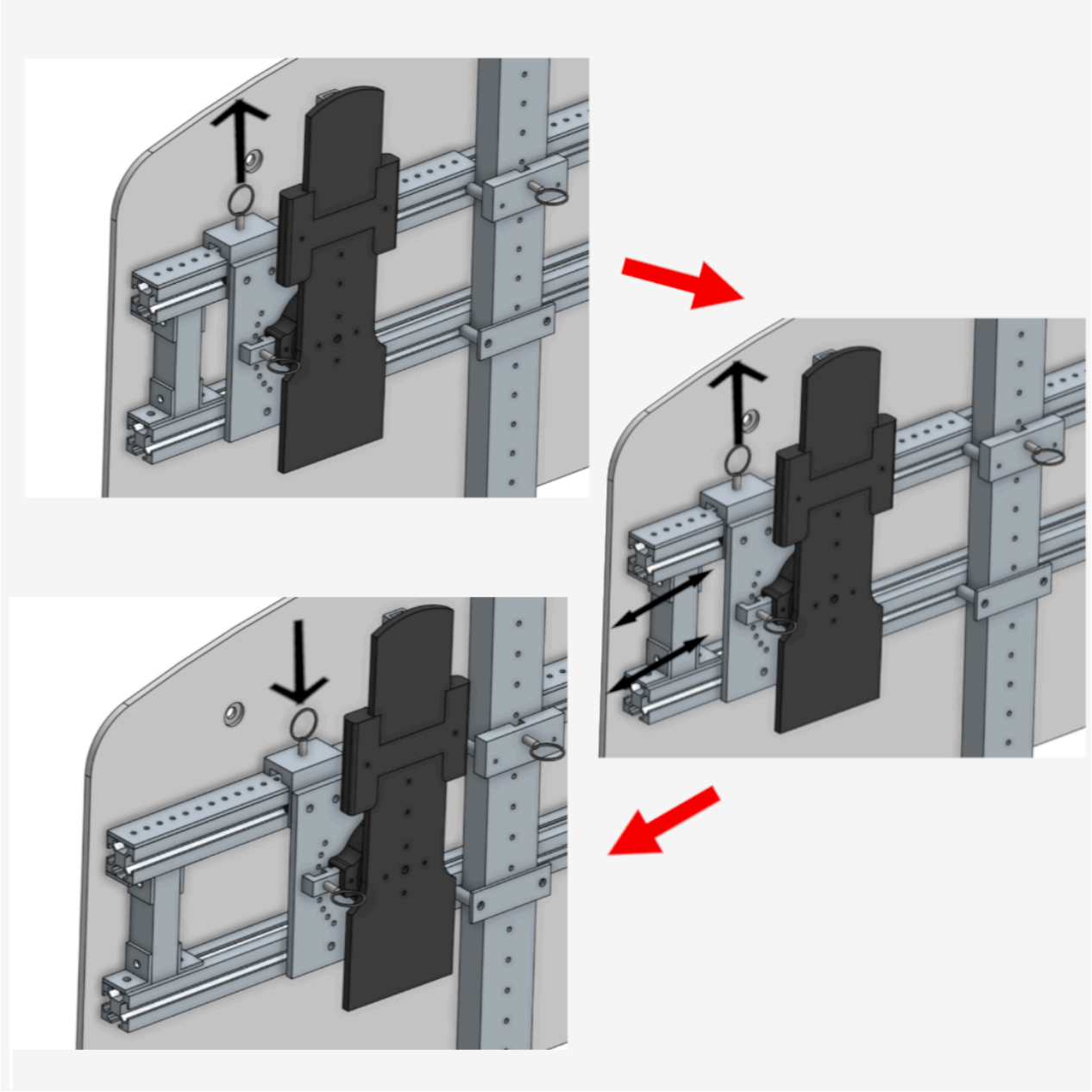


Figure 4.2.1

Adjust the horizontal position by pulling the key ring on the pin and sliding the assembly left or right. Release the pin into the desired hole on the bar to lock.

4.3 Rotational Adjustment

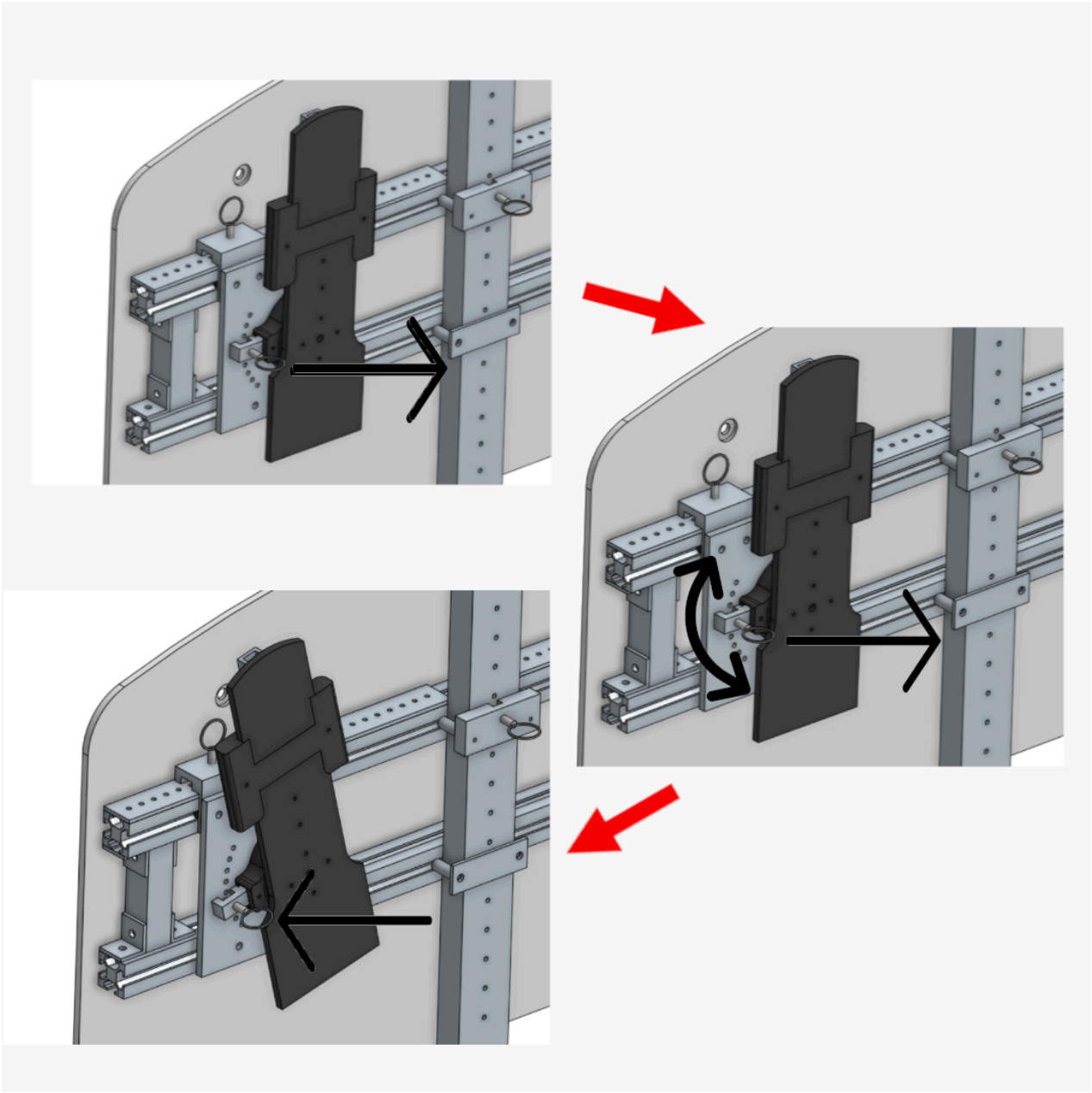


Figure 4.3.1

Adjust the rotational position by pulling the key ring on the pin and rotating the platform. Release the pin into the desired hole on a plate to lock.

4.4 Strap Adjustment

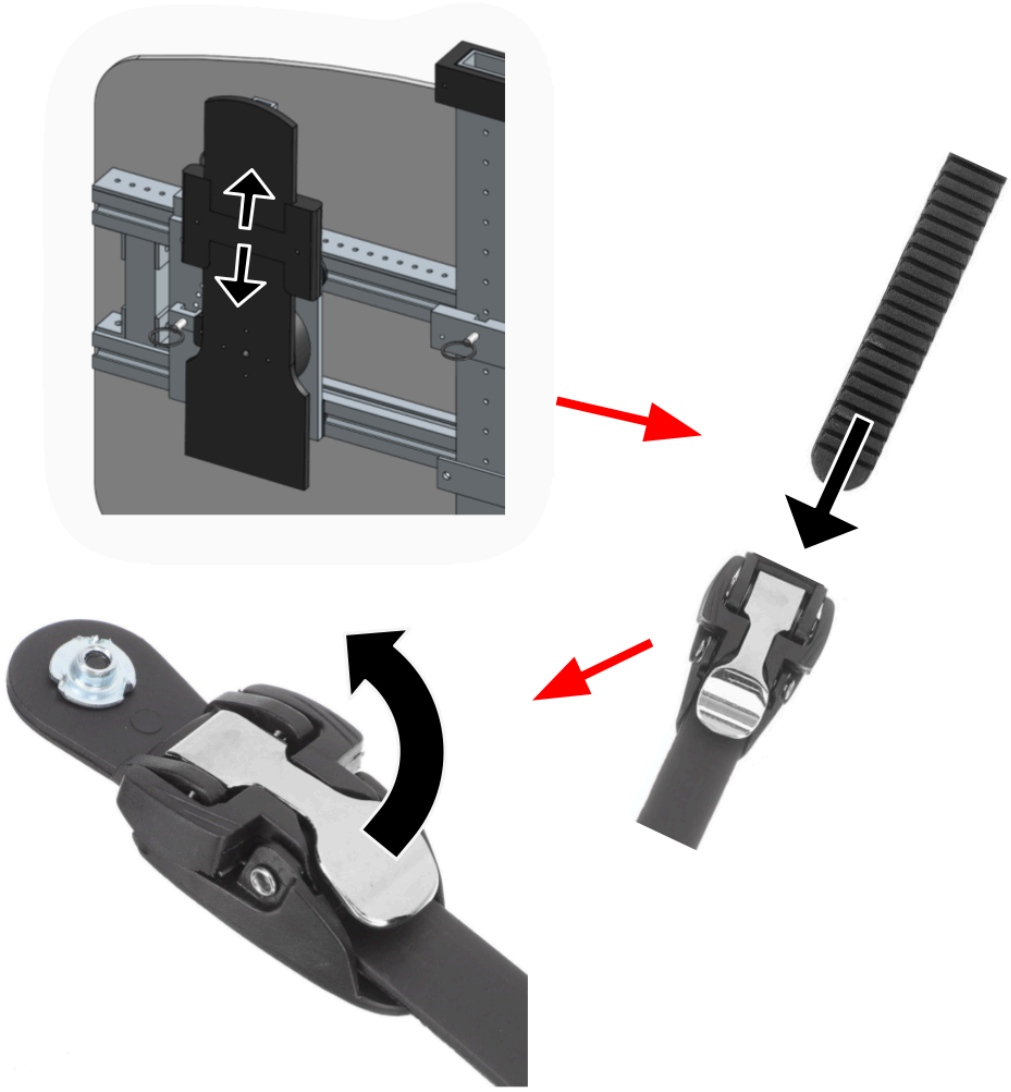


Figure 4.4.1

Slide strap mounts up or down until strap is approx 4 in from the top of the shoe. Slide the strap inside the ratchet mechanism, and pull the lever up and down until tight.

4.5 Release of Straps

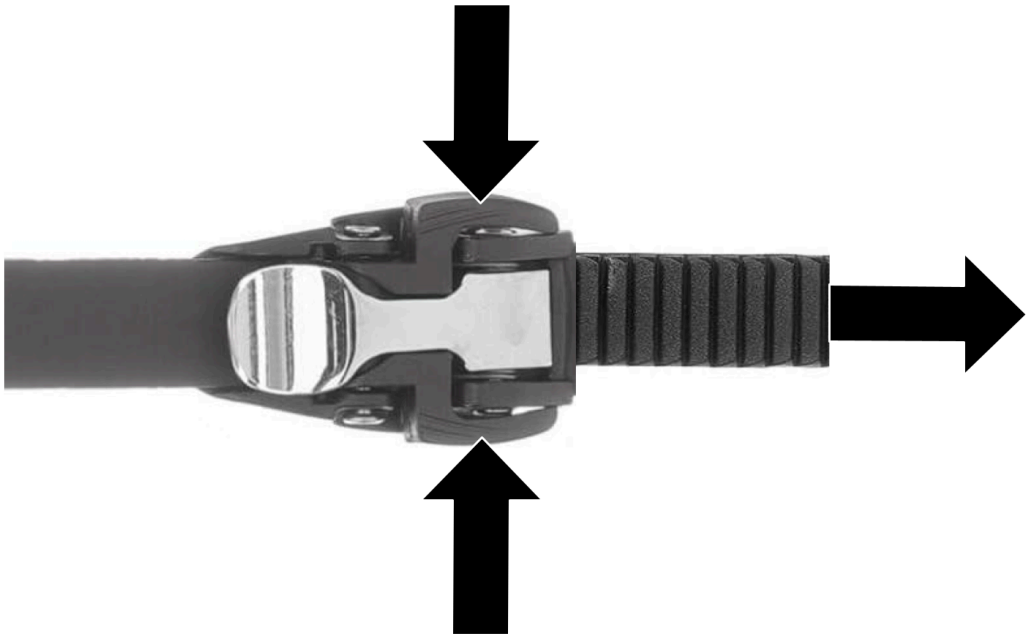


Figure 4.5.1

Compress buttons on either side of the ratchet mechanism and pull on the strap until loose.

5 Troubleshooting & Support

5.1 Behaviours

5.1.1 Compression Latch is not engaging/not securely clamping mechanism

The compression latch features an adjustable cam to allow for different thicknesses of the mounting plate. If locking nuts were not properly secured during the first installation, the cam may have moved and will need to be tightened again.

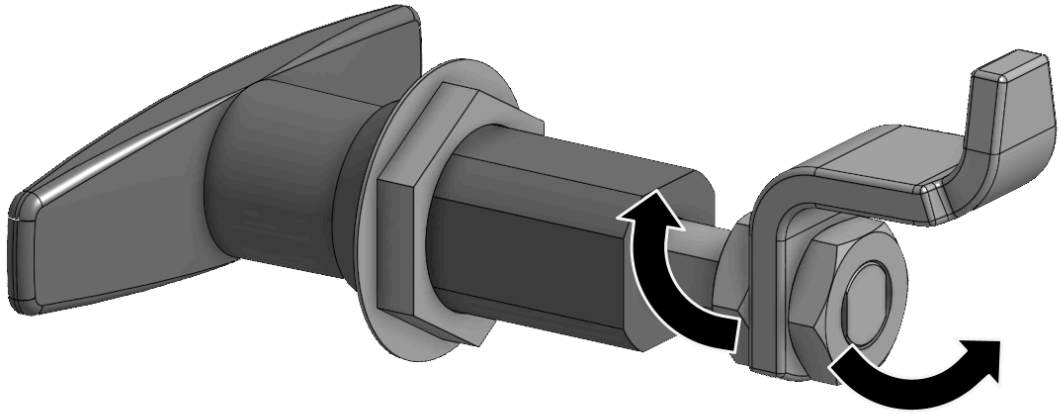


Figure 5.1.1.1

Unscrew nuts in opposite directions as shown in the diagram to loosen. Move the cam to the desired position and tighten the nuts to lock. Tool use is recommended.

5.1.2 The Horizontal Adjustment mechanism is not moving smoothly

The horizontal adjustment mechanism requires very little friction to move smoothly on the adjustment bar. If all 5 screws on the horizontal plate are secured, you may add a drop of suitable lubricant on the surface shown in Figure 5.1.2.1, and distribute it by sliding the mechanism back and forth.

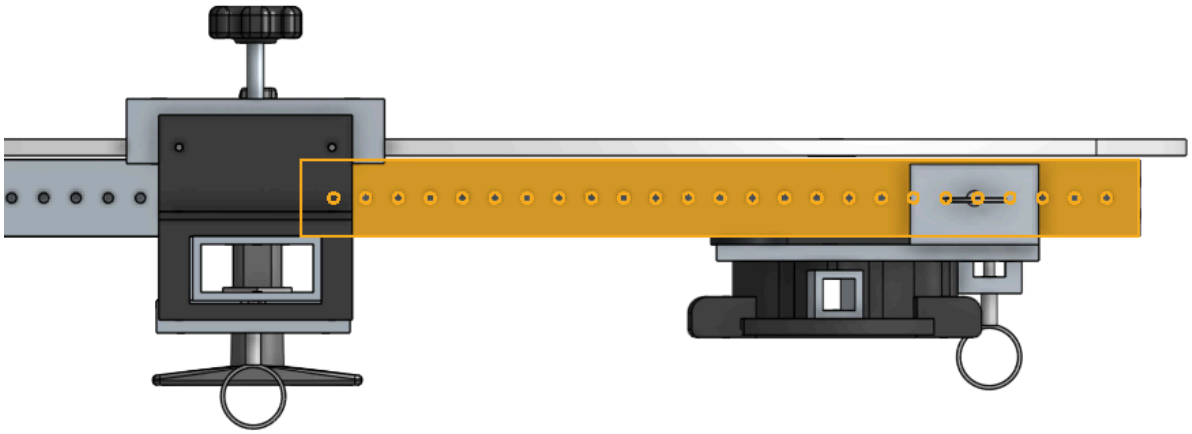


Figure 5.1.2.1

5.1.3 Horizontal Pins Not Engaging

If the horizontal pin is only engaging on one side of the range, or not at all, verify the screws found in the positions in Figure 5.1.3.1 below are both centered and tight. If the problem persists, you may loosen these screws and push the bar forwards or backwards as shown in Figure 5.1.3.2 until the pin begins to engage again. Tighten screws and ensure the full range of holes can be used.

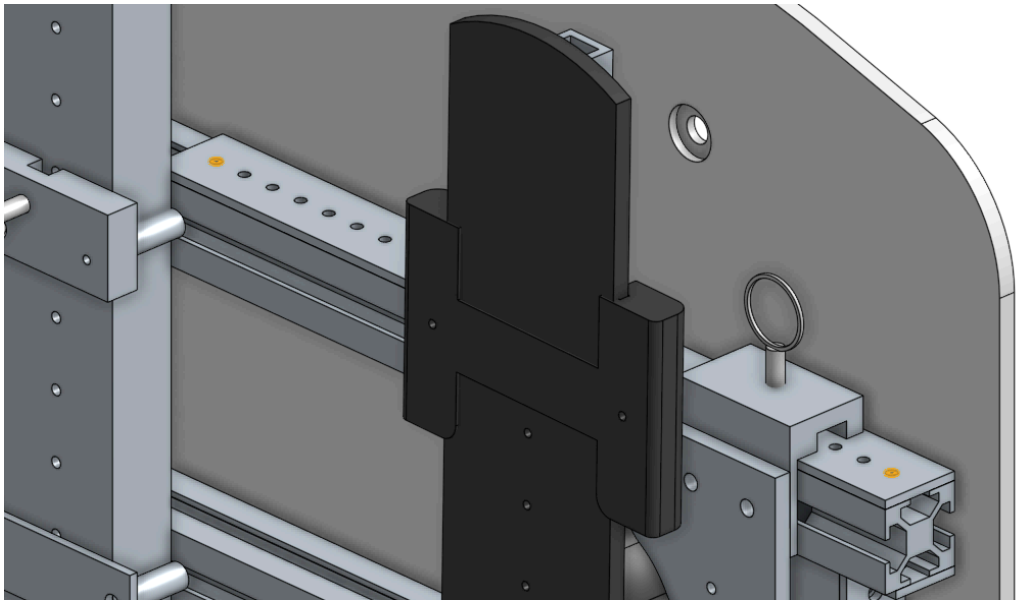


Figure 5.1.3.1

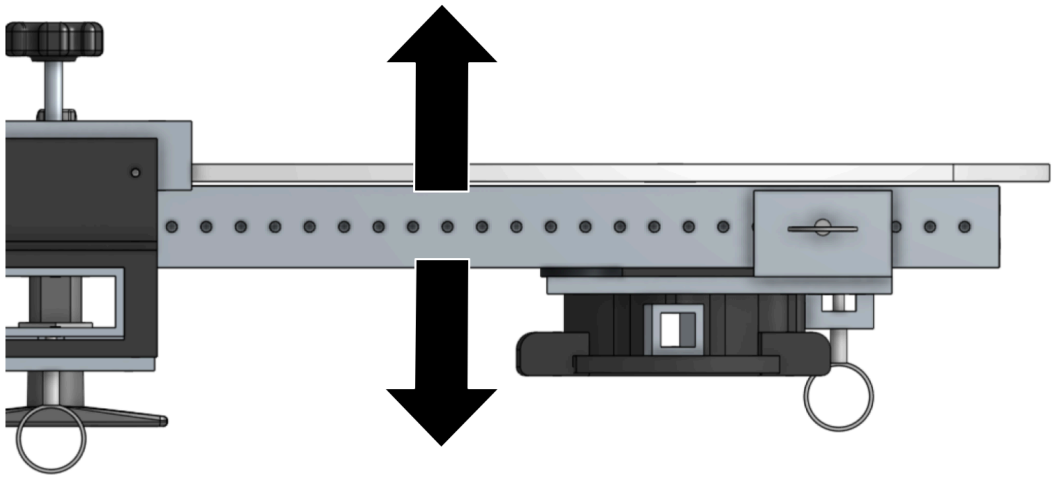


Figure 5.1.3.2

5.2 Special Considerations

5.2.1 Mounting Precision

The mounting system consisting of the top clamp and compression latch has been manufactured with limited resources and may be susceptible to inconsistencies in installation. If distance A and distance B (Figure 5.2.1.1) are not equal, the compression latch may be difficult to engage when the assembly is toward the top (Figure 5.2.1.2) versus near the bottom (Figure 5.2.1.3), where the latch strength may be reduced. This behaviour will most often be easily fixed by referring to section 5.1.1, but if distance A still appears to be too far, replacing the two spacers on the bolts securing the vertical bar and the hinge with thinner ones may be necessary.

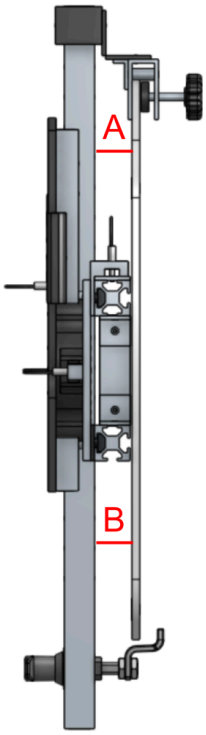


Figure 5.2.1.1

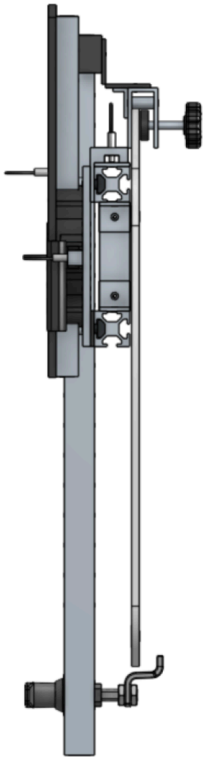


Figure 5.2.1.2

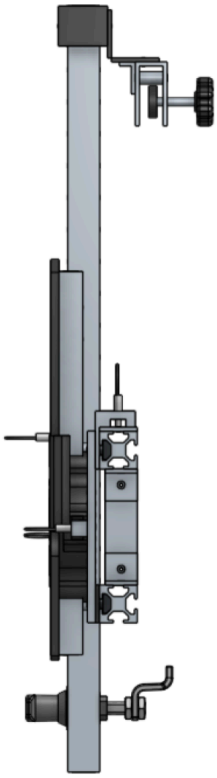


Figure 5.2.1.3

5.3 Maintenance

This device should not require frequent maintenance outside of regularly checking that screws and fasteners are tight and following any procedures listed in section 5.1 if needed. It is recommended that the slots of the horizontal bars are cleaned regularly to prevent the buildup of dust and particles that may interfere with use.

Straps may need to be replaced if the ratchet mechanism breaks or wears out over time.

5.1 Support

For support inquiries, please contact design lead **Alex Karachok** at alexkarachok@gmail.com or (289) 772-9851.

6 Product Documentation

6.1 Vertical Adjustment

6.1.1 BOM (Bill of Materials)

Name	Description	Quantity	Material	Source	Amount Spent	Production Cost
Vertical Bar	1 x 2 x 1/16" Box Extrusion	24"	Aluminum	Offcuts	$0	$11
Spring Pin	4mm pin	1pc	Stainless Steel	Amazon	$2	$2
Retainer Brackets	0.5 x 1 Bar Extrusion	2pc x 2.5"	Aluminum	Offcuts	$0	$4
Bracket Standoffs	3/8" Rod Extrusion	4pc	Aluminum	Offcuts	$0	$3
M6 Bolts	M6 x 30mm	4pc	Steel	Amazon	$2	$2
1/4-20 Bolts	1/4 x 2.5in	2pc	Steel	MakerLab	$0	$1
M6 Lock-nut		1pc	Steel	MakerLab	$0	$0.5
3030 T-Nuts		4pc	Stainless Steel	Amazon	$2	$2

Table 6.1.1.1

6.1.2 Equipment list

- Saw for cutting Aluminum
- Mill for cutting a lock-nut pocket in the retainer bracket
- Drill for making holes in aluminum
- Assorted wrenches for installing bolts

6.1.3 Instructions

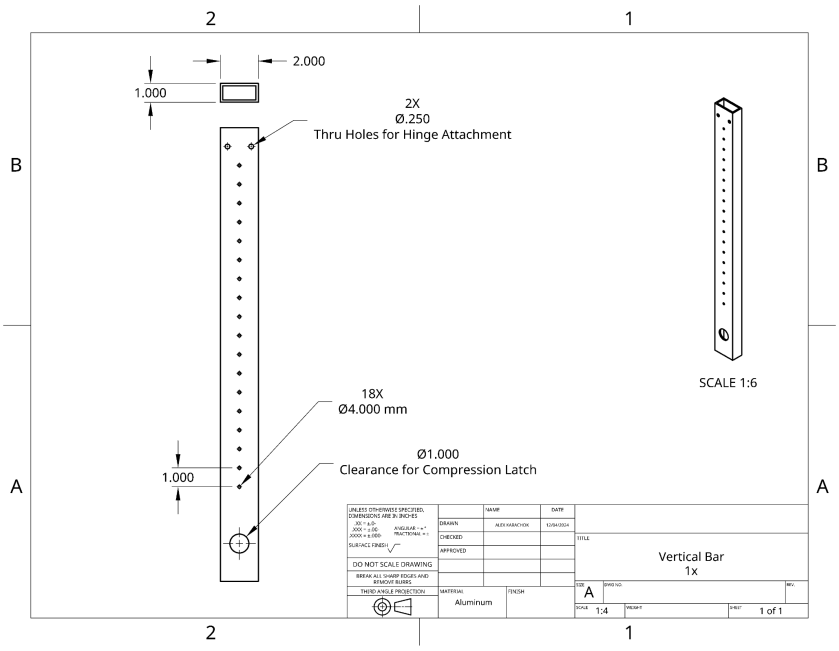


Figure 6.1.3.1

- Box tube or similar extrusion is recommended for the vertical bar to resist deformation during compression.
- Drill a series of holes up the middle of the extrusion for the pin to fit into.
- Holes for hinge may vary depending on hinge dimensions
- Clearance and mounting instructions for compression latch may vary depending on compression latch type and dimensions.

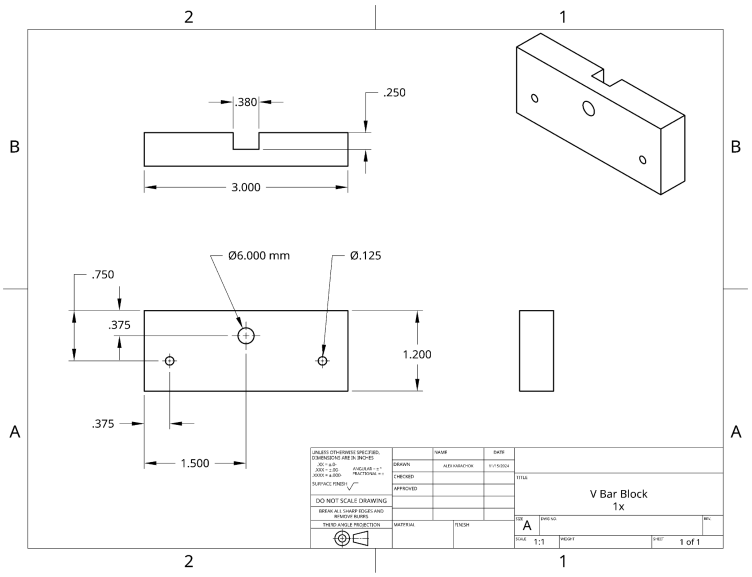


Figure 6.1.3.2

- Insert the nut into the milled slot of the block and thread the pin into the nut through the 6mm hole

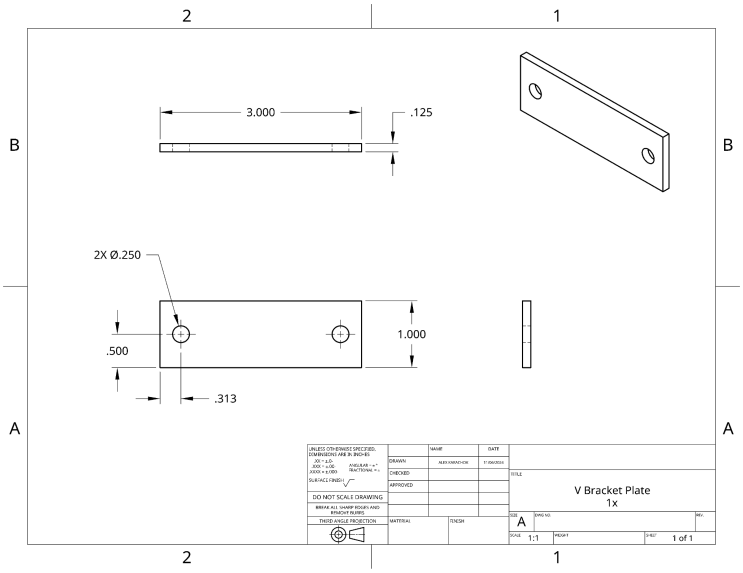


Figure 6.1.3.3

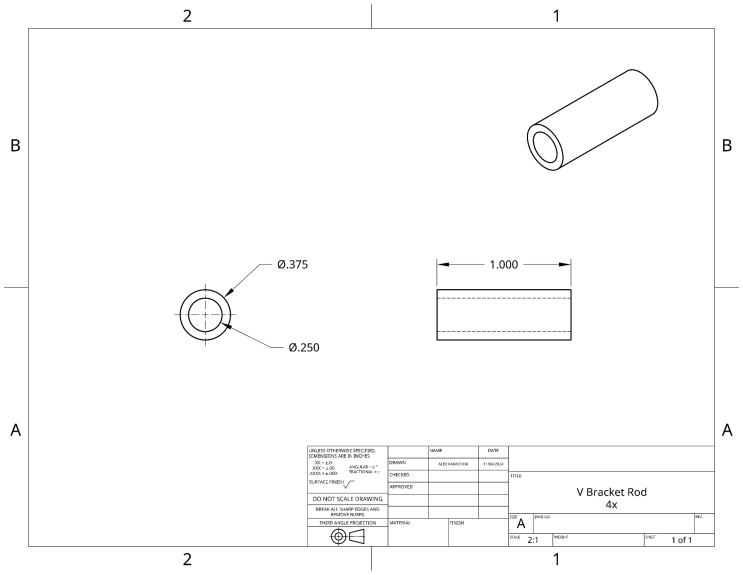


Figure 6.1.3.4

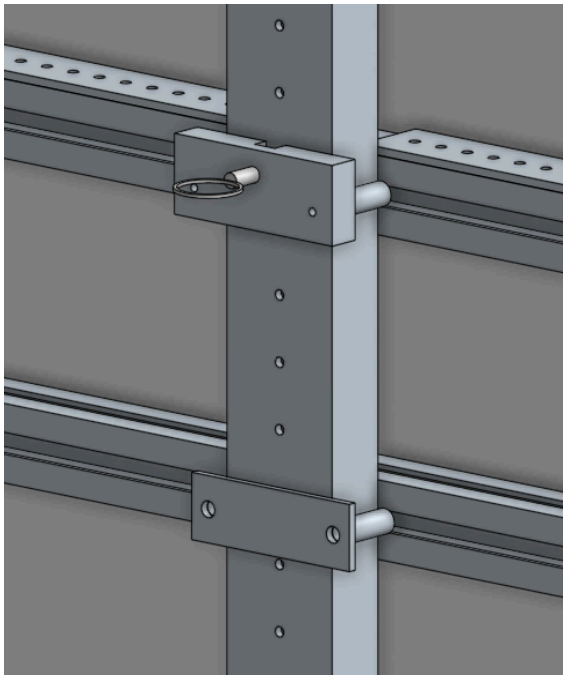


Figure 6.1.3.5

- Insert 6mm bolts into brackets and rods as shown in figure 6.1.3.5, insert vertical bar between brackets, and loosely thread T-nuts onto bolt ends for fixing onto horizontal bars later

Notes:

- Block with captive nut is meant to allow secure fastening of pin
- Dimensions of rods and brackets may need to be adjusted to allow the vertical bar to slide freely

6.2 Top Clamp

6.2.1 BOM (Bill of Materials)

Name	Description	Quantity	Material	Source	Amount Spent	Production Cost
Clamp Bracket	0.75 x 2 x 3/16" U Extrusion	1pc x 4"	Aluminum	Offcuts	$0	$3
1/4-20 Bolts	1/4 x 2.5in	5pc	Steel	MakerLab	$0	$2
1/4-20 Nuts		4pc	Steel	MakerLab	$0	$1
Hinge	2 x 3/4"	1pc	Stainless Steel	Canadian Tire	$3	$3

Table 6.2.1.1

6.2.2 Equipment list

- Saw for cutting Aluminum
- Drill for making holes in aluminum
- Assorted wrenches for installing bolts

6.2.3 Instructions

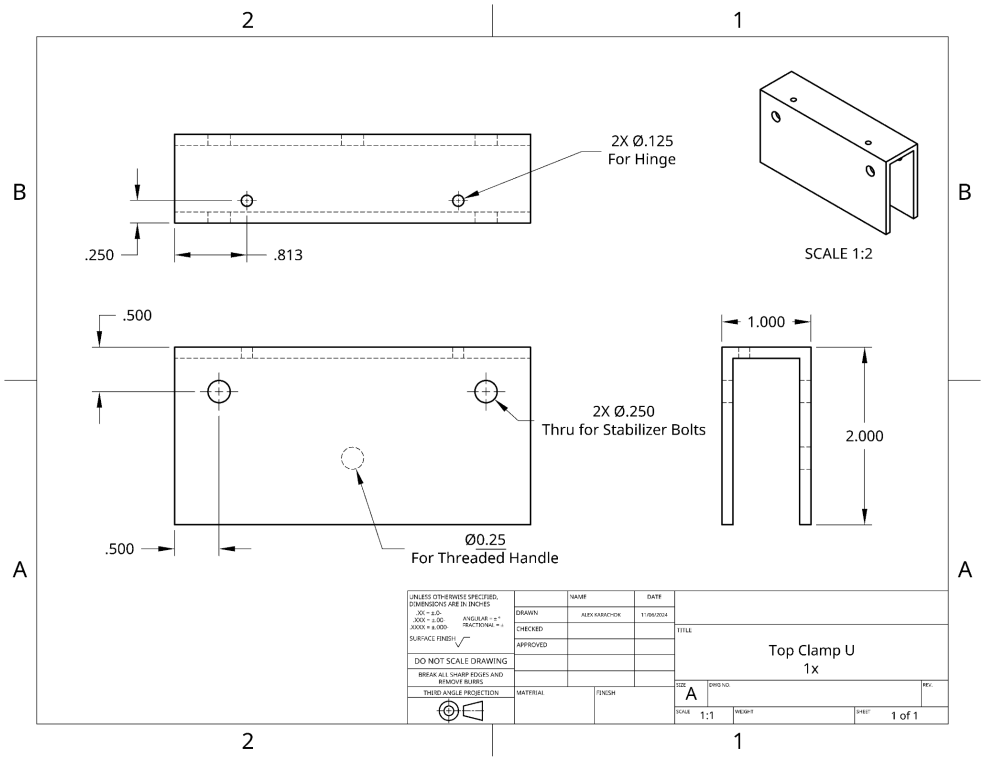


Figure 6.2.3.1

- Cut U-Bracket to around 4 in (length is arbitrary, only hole positions are relevant)
- Securely bolt the hinge onto the top
- Insert stabilizing bolts (these can be ordinary ¼-20 bolts) into holes and fasten with nuts to allow stable resting on a curved surface
- Thread a bolt (¼-20 minimum size recommended) or prefabricated handle into the hole

6.3 Horizontal Adjustment System

6.3.1 BOM (Bill of Materials)

Name	Description	Quantity	Material	Source	Amount Spent	Production Cost
Horizontal Bars	3030 T-Slot Extrusion	2pc x 28"	Aluminum	MakerLab	$0	$50
Pivot Plates	¼ x 5" Bar Extrusion	2pc x 6"	Aluminum	MetalPros	$13	$13
Connector Bars	1 x 1 x 1/16" Box Extrusion	2pc x 4"	Aluminum	Offcuts	$0	$12
Horizontal Pin Mount	2 x 2 x 3/16" L Extrusion	2pc	Aluminum	Offcuts	$0	$3
Horizontal Index	1/8 x 1" Bar Extrusion	2pc x 12"	Aluminum	MetalPros	$7	$7
M6 Bolts	M6 x 14mm	22pc	Steel	Amazon	$10	$10
T-Nuts		22pc	Stainless Steel	Amazon	$12	$12
Horizontal Sliders		4pc x 6g	PLA	3D Printed	$0	$0.50
Spring Pins	4mm pin	2pc	Stainless Steel	Amazon	$10	$10
L Brackets	1 x 1"	8pc	Stainless Steel	Canadian Tire	$4	$4

Table 6.3.1.1

6.3.2 Equipment list

- Saw for cutting Aluminum
- Drill for making holes in aluminum
- Assorted wrenches for installing bolts
- 3D Printer for sliders

6.3.3 Instructions

- Cut 3030 extrusion to size (near the width of the leg press platform, around 28 in)

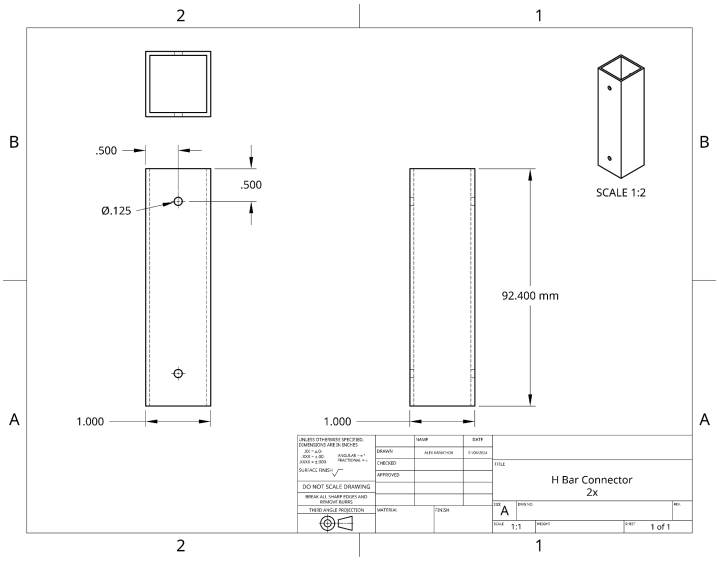


Figure 6.3.3.1

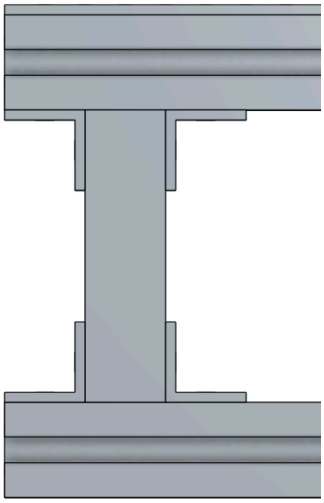


Figure 6.3.3.2

- Connect the two horizontal bars using the horizontal bar connectors and L brackets in a configuration as shown in Figure 6.3.3.2. Use M6 bolts and T-nuts to secure into slots.

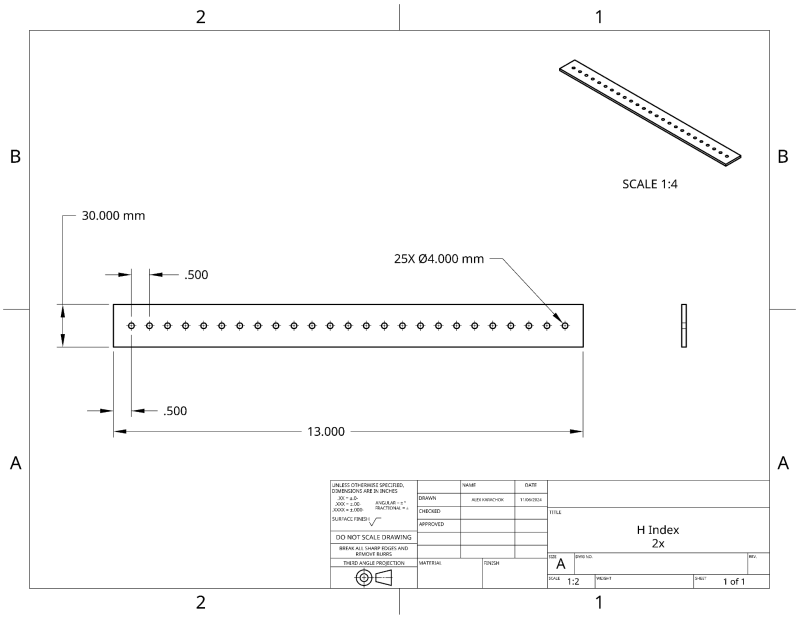


Figure 6.3.3.3

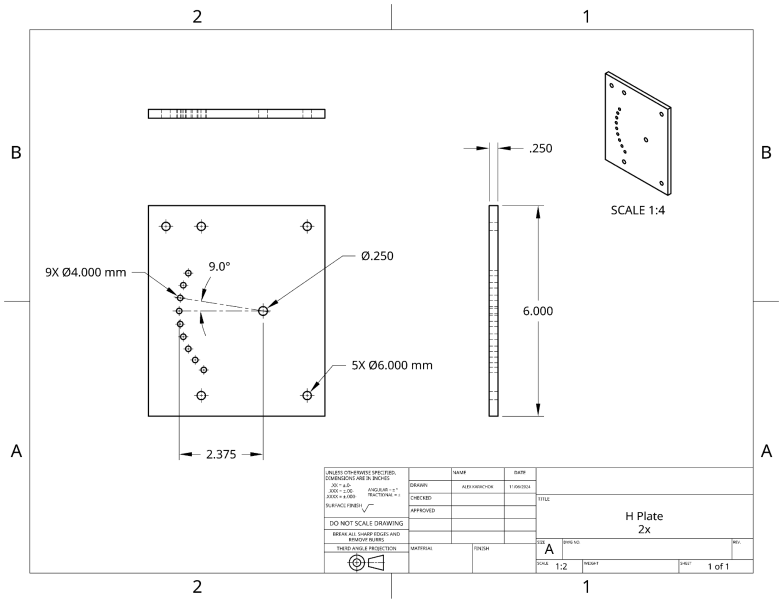


Figure 6.3.3.4

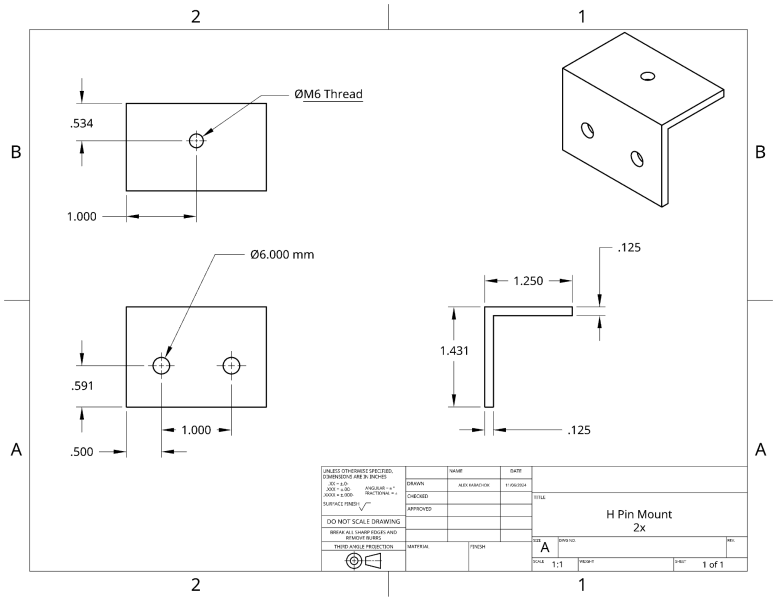


Figure 6.3.3.5

- Bolt plates onto horizontal bar slots using T-nuts. Use sliders and spacers with equal thickness to pin mount brackets (L-brackets) to reduce friction
- Widen the outermost holes of the horizontal index bar to allow it to be fixed into the tops of the horizontal bars using T-nuts
- Insert pin mount brackets between plates and horizontal bar using the two holes at the tops of the plates, ensuring the hole for the pin aligns with the index holes
- A similar captive nut to the one used in the vertical adjustment system is recommended as threading the pin into the thin aluminum will not be durable

Notes:

- Spacers between the T-nuts and sliders (within the slot gap) may be required to allow for full tightening of bolts without binding of sliders

6.4 Pivot Adjustment System

6.4.1 BOM (Bill of Materials)

Name	Description	Quantity	Material	Source	Amount Spent	Production Cost
Pivot Disk		2pc x 55g	PLA	3D Printed	$0	$2
Pivot Support	2020 T-Slot Extrusion	2pc x 12"	Aluminum	Offcuts	$0	$11
Rowing Machine Platforms		2pc	ABS Plastic	Amazon	$20	$20
Pin Blocks	0.5 x 1 Bar Extrusion	2pc x 2.5"	Aluminum	Offcuts	$0	$4
Spring Pins	4mm pin	2pc	Stainless Steel	Amazon	$10	$10
1/4-20 Bolts	1/4 x 2.5in	2pc	Steel	MakerLab	$0	$6
1/4-20 Nuts		2pc	Steel	MakerLab	$0	$3
M4 Bolts	M4 x 10mm	4pc	Steel	MakerLab	$0	$1
M6 Lock-nut		2pc	Steel	MakerLab	$0	$1

Table 6.4.1.1

6.4.2 Equipment list

- Saw for cutting Aluminum
- Drill for making holes in aluminum
- Assorted wrenches for installing bolts
- 3D Printer for disk

6.4.3 Instructions

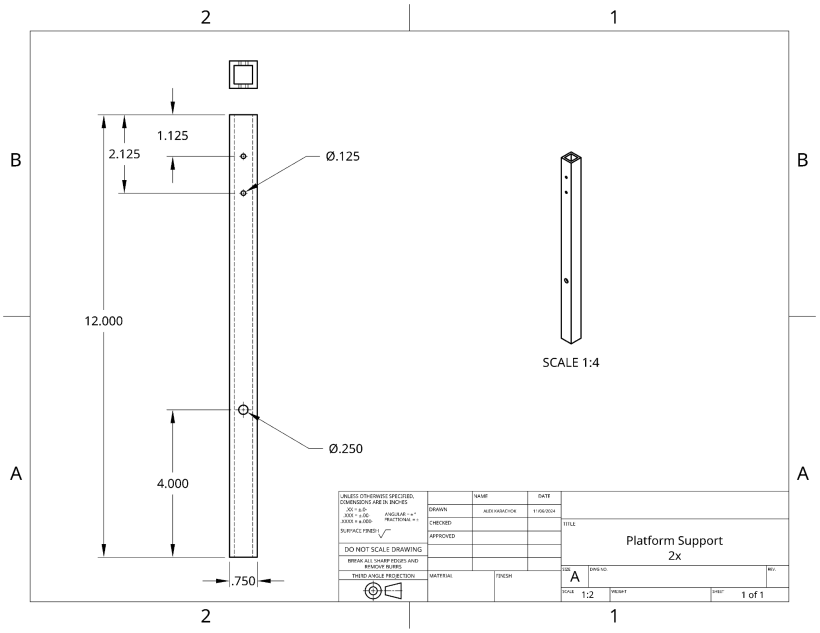


Figure 6.4.3.1

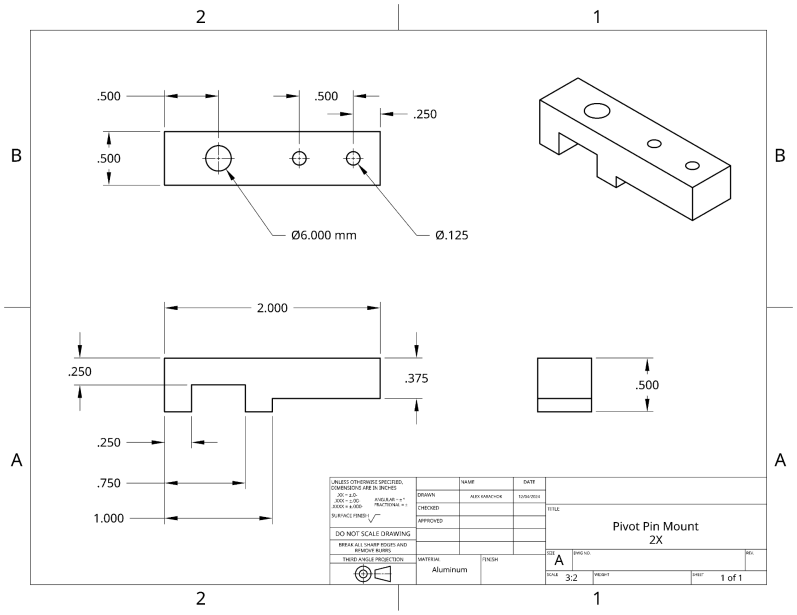


Figure 6.4.3.2

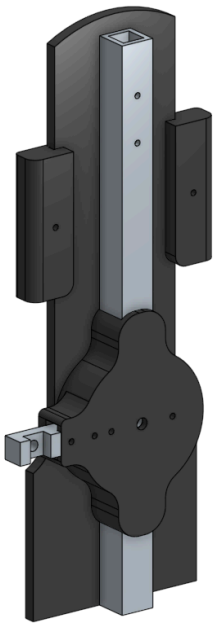


Figure 6.4.3.3

- Inset platform support bar and pivot pin mount into pivot disk as shown above
- Place platforms overtop and drill holes to fix parts together using M4 bolts
- Insert the M6 nut into a slot in pin mounts and thread the spring pin into a 6mm hole
- Insert ¼-20 bolt into the front of the platform and send it through the central hole of the horizontal plates from the previous section. Secure end with ¼-20 nuts and ensure assembly rotates freely but does not wiggle (star/lock washers between nut and plate are recommended)

Notes:

- Positions of holes for the support bar may vary depending on platform geometry, but it is recommended to have one approx 1 in from the top of the bar and one approx 1 in from the bottom of the bar.

6.5 Strap Adjustment System

6.5.1 BOM (Bill of Materials)

Name	Description	Quantity	Material	Source	Amount Spent	Production Cost
Ratchet Straps		2pc	Mixed Plastic	Amazon	$11	$11
Strap Mount		2pc x 38g	PLA	3D Printed	$0	$1.50
Wood Screws	½ in length	4pc	Steel	MakerLab	$0	$0.50
Fabric	1 in wide	4pc x 4 in	Synthetic Fabric	MakerLab	$0	$0.25

Table 6.5.1.1

6.5.2 Equipment list

- 3D Printer
- Drill to drive wood screws into print

6.5.3 Instructions

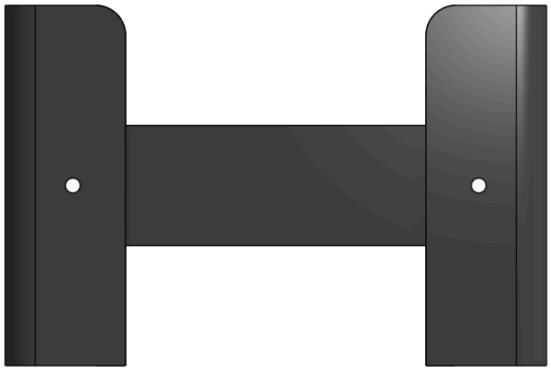


Figure 6.5.3.1

- Use wood screws to fix the ends of fabric strips to the strap mount so they extend outwards
- Make holes on other ends of fabric and use hardware included with ratchet straps to fix ends onto the ends of each ratchet strap component
- Slide strap mount onto foot platform with the connector facing outwards

6.6 Compression System

6.6.1 BOM (Bill of Materials)

Name	Description	Quantity	Material	Source	Amount Spent	Production Cost
Compression Latch	6mm Compression	1pc	Stainless Steel	Donated by SouthCo	$0	$35
TPU Blocks		8pc x 13g	TPU	3D Printed	$0	$2
M6 Bolts	M6 x 6mm	8pc	Steel	Amazon	$4	$4
T-Nuts		8pc	Stainless Steel	Amazon	$4	$4

Table 6.6.1.1

6.6.2 Equipment list

- 3D Printer
- Wrench to drive bolts into T-nuts

6.6.3 Instructions

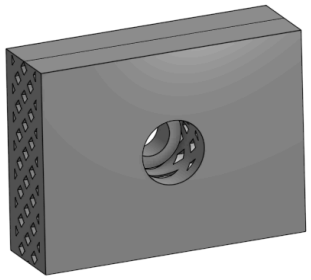


Figure 6.6.3.1

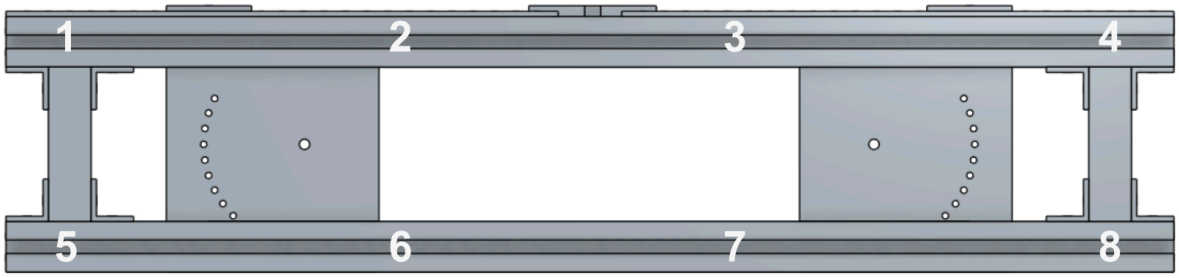


Figure 6.6.3.2

- Compressible spacers should be approximately 30mm x 40mm x 8mm in size with a density of approx. 40% by volume.
- Secure blocks into slots using M6 bolts and T-nuts in positions shown in Figure 6.6.3.3. Ensure the bolt sits inside the hole so it does not prevent compression.

6.7 Testing & Validation

#	Metric	Priority	Ideal	Explanation	Experimental Results
1	Length of **time** it takes to set the system	**2**	**~20s, 10%**	Further research and testing will reveal how long each session will last, and a more accurate estimate will be made in comparison to this time (a small percentage of the use time should consist of setup/ takedown).	**50 secs**
2	Perpendicular deflection during maximum load	**1**	**<0.5x**	Deflection should ideally be less than half of x, or the calculated point at which plastic deformation will begin to occur	**No deflection**
3	The **force** required to overcome static friction in the vertical direction for the entire mechanism	**1**	**>2x**	The force required to disengage any system involving friction should be at least two times the estimated maximum load	**Our system will need to be further tested to confirm these results**

4	The **force** required to overcome static friction in the horizontal direction for the foot platforms	**1**	**>2x**	The force required to disengage any system involving friction should be at least two times the estimated maximum load	**Our system will need to be further tested to confirm these results**
5	Average **cost** of off-the-shelf components	**5**	**<$0.50**	Individual fasteners, etc should not cost more than $0.50, and anything expensive should be designed for durability versus repairability.	**Hardware costs $0.2/pc on average, other parts cost ~$5-20 excluding compression latch**
6	Total horizontal adjustment **range**	**5**	**~10 in**	10 inches in each direction will emulate the size of the original platform	**6 inches**
7	Total vertical adjustment **range**	**5**	**~12 in**	12 inches of vertical adjustment will emulate the size of the original platform	**11 inches**
8	Amount of **Force** the system can withstand, especially with different weights	**5**	**N**	500N = 1102.31lbs This will withstand the entire load of the leg press.	**Further testing will need to be done to confirm these results**
9	Dimensions when stored	**4**	**< 32x24x10 in**	This should be small enough for the product to be very portable	**28inc x 24inc x 6inch**
10	Foot movement **distance** during regular use	**4**	**~10mm**	The foot should be strapped in hard enough so that they can comfortably use the leg press machine, but it shouldn't be tight to the point of discomfort	**No foot movement during exercise**
11	Maximum and minimum foot **length**	**4**	**8.00-11.8in**	The minimum foot size for women is around 8.0 in and the maximum for men is around 11.8 in	**No min - 13inc**
12	Total **weight** of the assembly	**3**	**~20 lbs**	20lbs for an aluminum attachment	**20lbs for an aluminium attachment**

13	**Ease** of construction	**5**	**N/A**	Easy to put together when placing the attachment on the platform	**Very easy to put together and test**

Table 6.7.1

We did multiple different testing scenarios, we tested the setup time to begin with, and we managed to determine it can take anywhere from 20 seconds - to 60 seconds to set up depending on how much experience the user has with the attachment, or how many adjustments are necessary.

Following the next set of tests was seeing how much load the attachment could withstand and we found that the attachment could take a full load of the leg press machine which is 390 lbs at any location on the leg press platform. We tested at different rotations on the vertical, and horizontal plane and it all functioned as intended. These tests also included seeing if there was any deflection which there was none, and the amount of force to overcome static friction in the vertical, and horizontal planes.

We also tested to find the optimal dimensions for the compressible blocks by varying the thickness, surface area, and density by volume. We concluded that for a compression that securely fixes the mechanism onto the plate but does not require excessive force, the blocks should be 30mm x 40mm, 8mm thick, and have 40% density by volume.

Finally, we tested the total weight of the attachment and storability. We determined it to be 15 lbs for the entire attachment and very easy to store.

7 Conclusions and Recommendations for Future Work

This has been a very intense project with many moving parts, both literally and figuratively. If our prototype were to be redesigned, we would do so with an emphasis on planning hardware first. We will also have much more freedom around materials as we will not be held back by any budget, so parts will be able to “work together” more easily and the design process will be much more streamlined.

We also ran into a lot of issues when it came to integrating all the different subsystems. This can be difficult to anticipate, especially if the subsystems work well independently. Simply keeping in mind that the systems you are designing will eventually need to fit together will help anticipate these issues before it’s too late, and allow you to make corrections in advance.

Some changes we would like to make include more secure pin mounts for the horizontal adjustment system. The dimension constraints of the part prevented us from doing something similar to the vertical or pivot pin mounts, so a better alternative would be remaking the L-brackets out of steel and welding a nut directly to the part instead of inserting a captive nut.

The spacers and sliders featured in the horizontal adjustment system should be remade from stronger material (ie aluminum or a prefabricated low-friction plastic) to prevent deformation when tightening, resulting in a much smoother, more rigid system.

It would be ideal for some parts to be replaced or upgraded. The hinge, which is currently a placeholder, should be replaced with a proper machine hinge with much lower tolerances and higher resistance to the forces it will endure during use. While the pins currently work well, the key rings are somewhat difficult to grab onto.

Finally, the client has shown interest in having visual indicators on every index so that different clients can have their exact configuration of each axis recorded. It will be either very difficult, costly, or time-consuming to do this based on the research we have done into finding ways to do this - the most common way would be to use off-the-shelf marking powder/spray and a laser cutter to “draw” a series of numbers or indicators onto the parts requiring them.

APPENDICES

8 APPENDIX I: Design Files

MakeRepo: https://makerepo.com/JadKreit/2340.element-13-project-foothold

The only document to be linked is a simple video demonstrating the use of this product.

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Video Demonstration	https://www.youtube.com/watch?v=NTEgvB2q8MM	November 24th, 2024
Intro User Video	https://youtu.be/xtSUhBY5DVs	December 2nd, 2024

Table 8.1