NGEE ANN POLYTECHNIC

MECHANICAL ENGINEERING DIVISION
SCHOOL OF ENGINEERING

BMA FINAL YEAR PROJECT 2015
FINAL REPORT

Innovative Foot Stabiliser Device:

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Acknowledgements

Firstly, we would like to sincerely thank all staffs in the Biomedical Center for helping us when we were in trouble with the project while guiding us the right path.

TSO Mr Oh Chwee Kian

He helped us get started for the project by providing us ideas and improvements for our design. Since he has over 20 years of machining experience, he guided and helped us by providing instructions on machining and how to use them with ease to fabricate the parts for our project. We followed all safety precautions mentioned by him and also learned new cutting styles during our fabrication process. He gave us the proper ideas we needed and improvised on it. Nevertheless, He introduced several companies that could provide us the parts we need for our project and we bought our parts from them with no hesitation.

Mr Lim Chye Seng, Supervisor

Mr Lim supervised and guided our group to the right path, making sure we did not deviate from the given requirements and enlighten our minds with useful and practical idea suggestions along the way. We are really thankful for his guidance and all that he has done for us to make this journey meaningful and worthwhile.

Dr Tan Lam Wing, Co Supervisor

We would like to use this opportunity to express our gratitude to Dr Tan who supported us throughout the course of our final year project. We are thankful for his aspiring guidance throughout the course.

Mr Batharutheen Hassan Kutty

Mr Batha helped us to perform precision welding and guided us with tips and suggestion to apply welding where necessary. We are really thankful for his help and guidance.

Last but not least,

The best batch of BMC - 15BMA classmates whom helped us out when we were in need of help despite being busy with their own projects. We were thankful and this success will be shared as a whole class, among them too.

Visit to Singapore General Hospital (SGH)

1st visit

The first visit to SGH was for us to be briefed on what's going on and also to choose a project which we want to work on and among 6-8 projects which were presented by the clinicians, we had a few ideas in mind to accommodate the various projects despite having stronger feels for the projects with the names of " The foot stabiliser for podiatry treatment" and " Hospital Assistive - Sit to stand Rehabilitation Butler"

2nd visit

The second visit to SGH was to meet our clinician, Ms Jennifer, to discuss about the project and know more about what is going on in the podiatry world. We interviewed the clinicians about the daily problems they face while performing the treatment. This gave us a few ideas on what we should work on and resolve with our project.

3rd visit

We met the clinician as per appointment and were shown how the podiatrists perform the treatment, live and direct. By this, we managed to see the treatment process and get an in-depth knowledge on how the treatment is being done and the challenges faced by the clinicians with every treatment.

4th visit

The project prototype design review seminar was our fourth visit to SGH. The entire class have to present the prototype to the clinicians and engineers of the hospital. At the end of the presentation, the clinicians and engineers gave positive feedbacks on how to improve our prototype. We realised that we needed necessary improvements for our project and thus preparing ourselves to make improvements for the project.

Project Background

Podiatry treatments are usually carried out to patients with Structural deformities, painful flat foot and high arch deformity or Heel pain.

Foot pain is a common problem for people aged 50 and over and occurs more often in women than in men. About 60% of the foot problems are forefoot problems and slightly more than half of these patients seek medical help, mainly in the form of podiatry care. Podiatry treatment of forefoot problems is known to be heterogeneous. The aims of the present study are to describe the podiatry treatment of patients with forefoot pain and to evaluate the podiatry examination and treatment using an expert panel.

In Singapore, during a podiatry treatment, Podiatrist usually holds foot up in position with non-working hand while working hand executes treatment. This hence exposes podiatrists to overuse injury and sharp accidents.
Overuse injuries such as strain, wrist pain, arm ache, wrist strains caused when holding the feet in position for very long and lastly injuries or strains on the hands as the doctors will have to apply pressure on the spot where the surgery needs to take place and most of the time patients tend to move about when pain is felt.

Podiatrist's hands are also very close to the surgical blade when the surgery takes place. Therefore, exposing the podiatrists to accidental cuts during surgery.
So, What does a podiatrist do? Podiatrists can be thought of as a type of foot doctor. They can give you and your family advice on how to look after your feet and what type of shoes to wear. They can also treat and alleviate day-to-day foot problems including:

- toenail problems such as thickened, fungal or ingrown toenails
- corns and calluses
- verrucas
- athlete's foot, flat feet
- smelly feet
- dry and cracked heel

Synopsis

In the current world, podiatrists will be holding the patients foot with a non-working hand in an awkward position. It also becomes a hazard to the podiatrists as they are exposed to overuse injury and sharp accidents when using the operational blades. As the Podiatrist's hands are very close to the surgical blade when the surgery takes place. Therefore, exposing the podiatrists to accidental cuts during surgery.

Existing products in the market fail to provide a decent dorsiflexion to the feet by itself as a machine. The doctors or podiatry practitioners have to provide dorsiflexion to the feet in order to do the treatment with ease and also providing minimal human error. Thus causing Overuse injuries such as strain, wrist pain, arm ache, wrist strains caused when holding the feet in position for very long and lastly injuries or strains on the hands as the doctors will have to apply pressure on the spot where the surgery needs to take place and most of the time patients tend to move about when pain is felt.

Current Podiatry equipments has complicated instructions making it difficult for the nurses and caregivers to use it with nominal knowledge.

This project involves a design and development of a device that helps aid nurses or doctors to be able to create a strain free environment while carrying out the Podiatry Treatment and also creating solutions for the patients accurately; preventing and possibly making human error minimal.

Analysis

Marketing Research

MID-MARK 417 Power Programmable Podiatry Treatment Chair

The first things you'll notice about the 417 Power Podiatry Chair are its good looks, contemporary styling and clean lines. And it's easy to keep your 417 looking good. Dirt and stain-resistant vinyl back, seat and foot sections are fastened with Velcro, so they're easy to remove. Makes care, cleaning and changing colours a breeze! And you can choose from thirteen upholstery colours to coordinate with Mid-mark Modular Casework. Price of the chair can go up to US$ 3,500 which can be costly for a chair just performing the function of lifting the leg up and down.

Podiatry Treatment Chair

Nova Eden Podiatry Chair

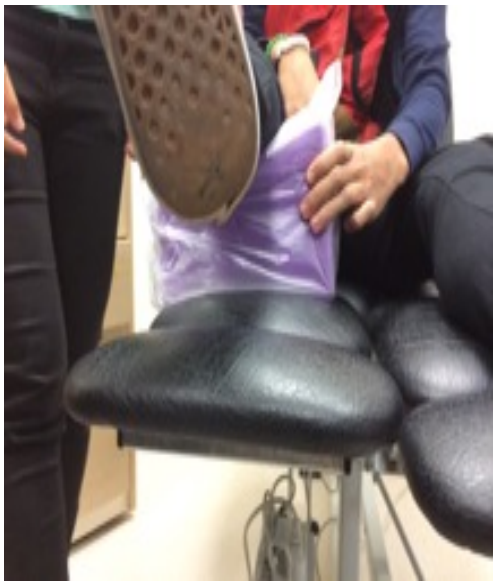
This is a Multi-functional, versatile chair which has the
Combined affordability and with features found in modern high-end chairs.

It's main features are that it has 3 motors allowing you to adjust the seat height, back rest and tilt. Split-leg sections are manually adjustable and are inclinable to 90 °.Heavy duty castors for easy manoeuvrability within the clinic setting. Seat height range from 550 - 1130mm. Manually adjustable headrest for additional patient comfort. An inclusive breathing hole enables patients to be treated whilst lying face down. This chair is equipped with high-quality, modern upholstery, Easy to clean and maintain.

All these functions may seem incredibly good but there comes an issue with the cost. The cost of this product alone is **$2,390.00**, which can be really costly when budget is an issue for some podiatrist or foot practitioners.

Nevertheless, we also tried the Podiatry Chair used at SGH Podiatry Department and gained our own experience on its functions from it.

Product Review



Several problems encountered by the Podiatrists are such of as the Podiatrists being exposed to overuse injuries by holding feet in place. (Arm aching, back pain, wrist pain etc.) Podiatrist's hands are close to the feet when performing surgery with sharp equipment's. Injuries or strains on the hands as the doctors will have to apply pressure on the spot where the surgery needs to take place.

When the corn or pust is squeezed, it tends to splash off the area.
All the existing machines only help the doctor to lift up the patient's leg so that the doctor can access the leg and treat it properly. It does not hold the leg nor feet in place. The patient is still sitting down and the leg is free to move and its not really stabilised.

As seen in all the existing products, they fail to provide a decent dorsiflexion to the feet by itself as a machine. The doctors or podiatry practitioners have to provide dorsiflexion to the feet in order to do the treatment with ease and also providing minimal human error.

As seen in these pictures, the patient's leg is relaxed and the doctors will have to use their hands to provide the dorsiflexion and also hold the feet in place. Which brings us back to one of our objectives which is to produce A comfortable locking mechanism that locks the feet in place. Thus, allowing the doctor to perform treatment with minimal human error. Also, to invent an applicator to stabilise the foot during surgery while providing dorsiflexion to the feet when its on the stabiliser.

By holding the feet in place, the doctors don't have to use the other working hand to hold the feet and at the same time perform the treatment.
This thus reduces the stress and muscle strain on the podiatrists and therefore, allowing them to have 2 working hands to operate or clean the leg during the operation.

Main Problems faced reported was that the leg can still be moved by an inch even if its numb therefore creating a lot of problem if the doctors cut off the wrong part of the skin on the leg.
Thus, our product will minimise all these human errors and make the podiatrist's surgery process easier and less strainful.

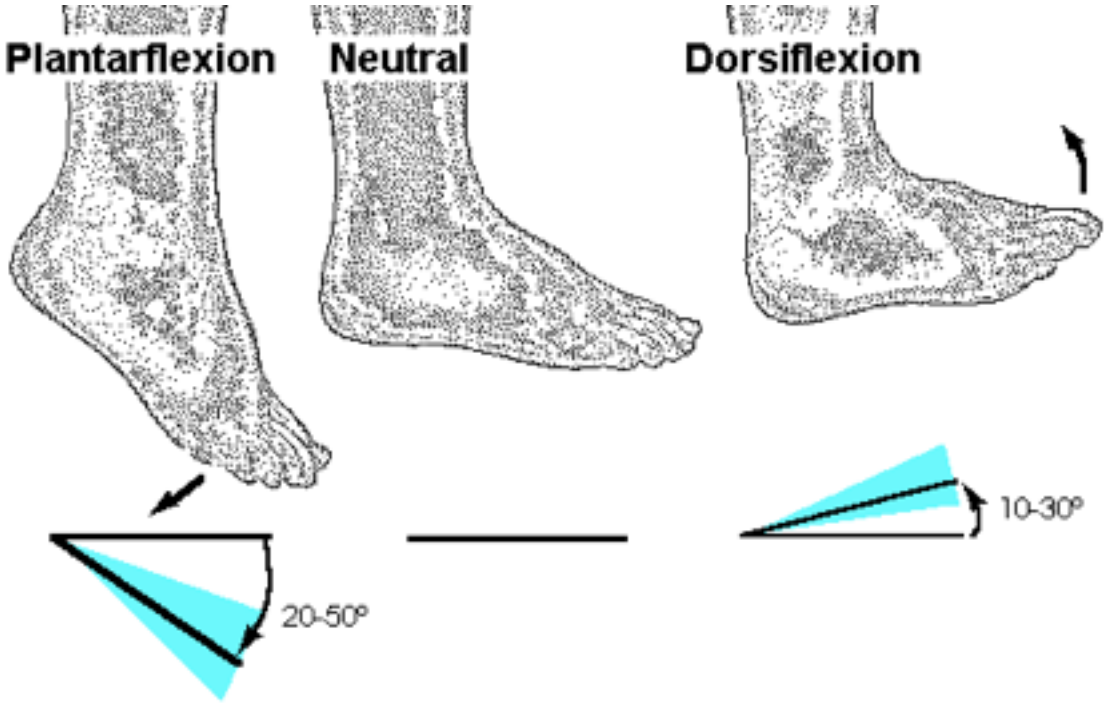
Foot Positioning

We also realised the main reason for the podiatrist to hold the feet in place was to provide a dorsiflexion so that the base of the feet can be facing the podiatrists, thus allowing them to perform the treatment.

Feet is in Plantar Flexion

Foot is in plantar flexion

A Brief introduction to the Movements of the ankle.



The ankle joint is a synovial hinge joint permitting two movements:

- Plantar flexion (=flexion), in which the foot is pointed downwards
- Dorsiflexion (=extension), in which the foot is raised

  Dorsiflexion is a more limited movement (normal range: 10-30°) than plantar flexion (normal range 20-50°).
- Dorsiflexion is brought about by all muscles whose tendons pass into the foot anterior to the ankle joint. These include:
  - Tibialis anterior
  - Extensor hallucis longus
  - Extensor digitorum longus

Therefore, we need to build a stabiliser that create a decent dorsiflexion and thus, this brings us down to the Objectives of the project.

Objectives

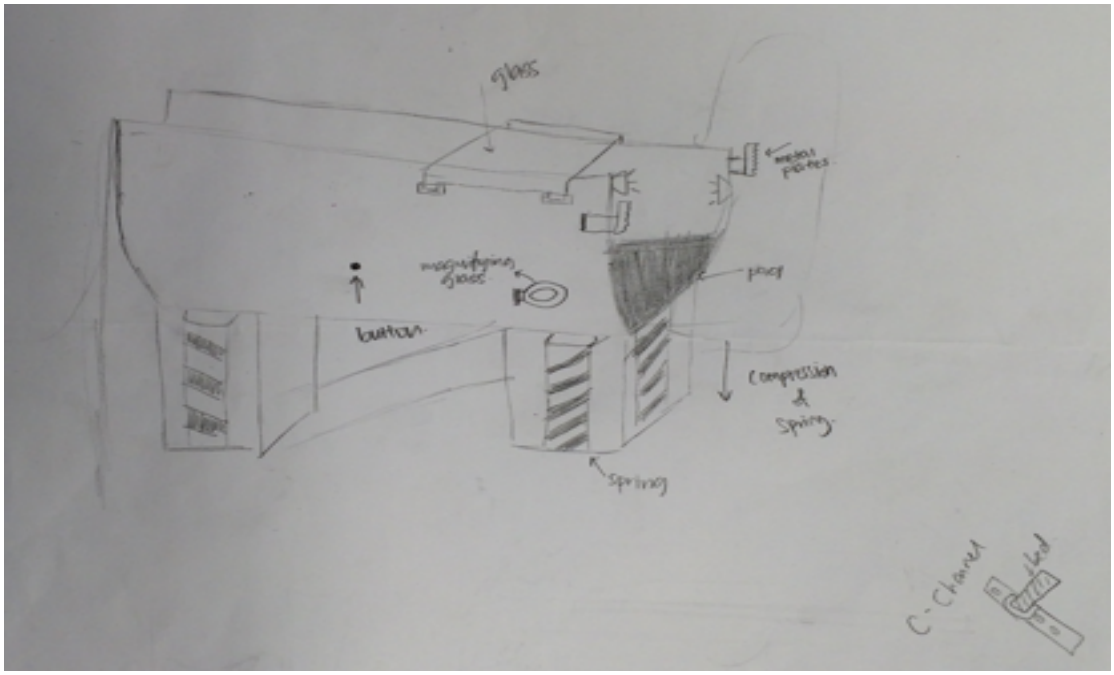
Our design will be based on the following OBJECTIVES

- Stable (Safety Measurements)
- User-friendly and able to meet all Ergonomics and Anthropometry requirements.
- Able to cushion the feet and not cause stress on the feet throughout the treatment.
- Able to be sanitised easily
- A Tension Provider to constantly apply tension and to provide a little pressure on both sides of the foot so that the doctors don't have to use their fingers or an extra hand for help to apply tension on the foot.

- Invent A Locking Mechanism to keep the feet in place comfortably.
- Invent an adjustable applicator to stabilise the foot during surgery.
- Provide dorsiflexion to the feet when its on the stabiliser.

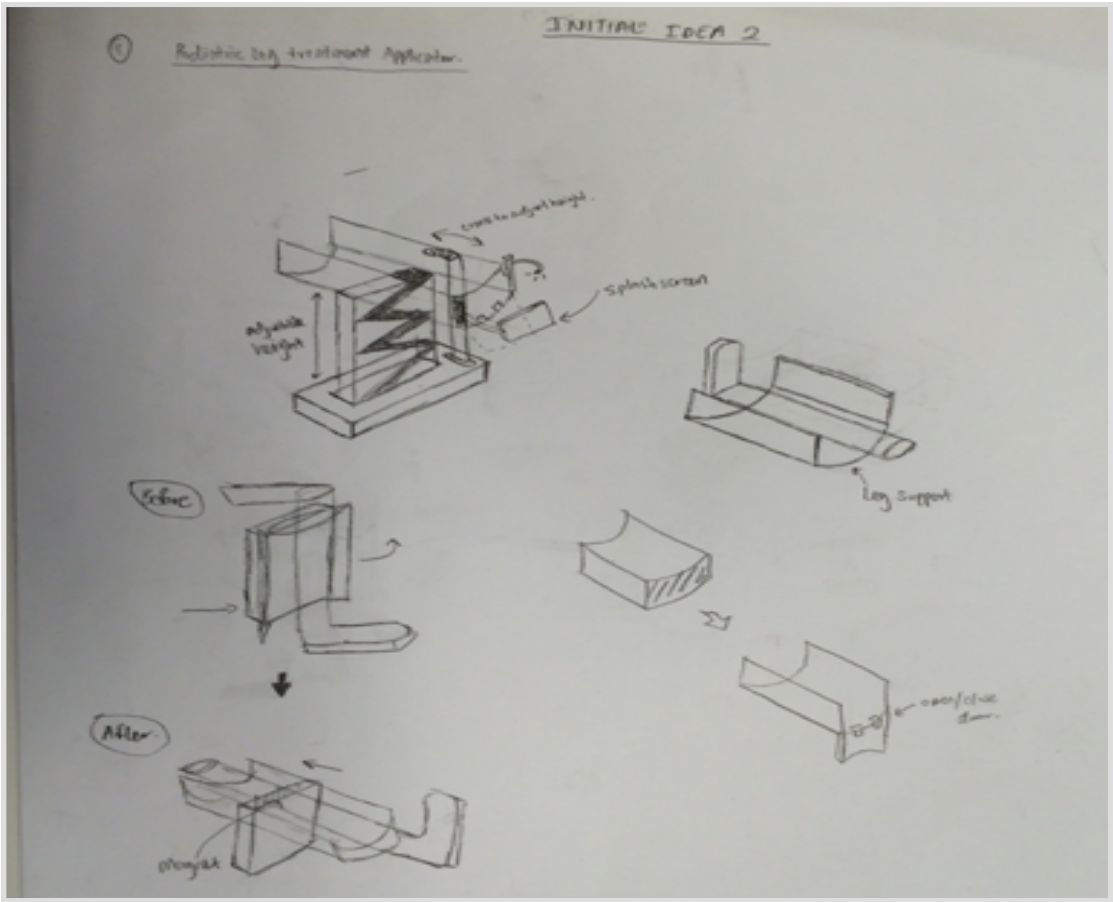
Ideas

Idea 1



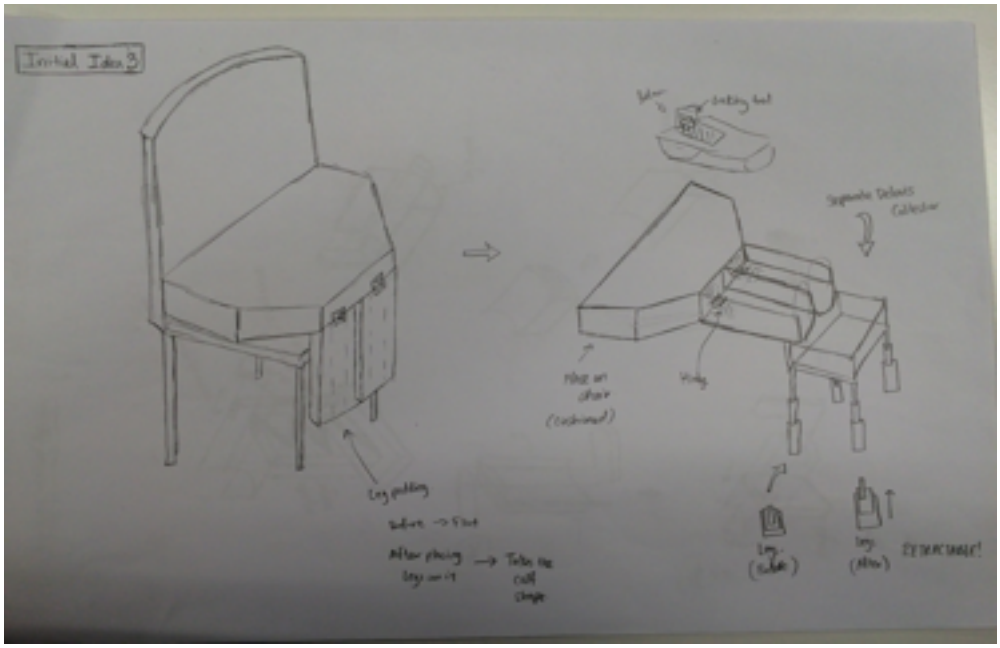
This idea was generated to hold the patient's calf so that during treatment their leg is supported and stabilised by it. There is a splash glass to protect the doctor and surrounding of the doctor. The spring beneath the calf holder will help to suspend the load of the leg and also provide cushioning when the calf is place above it. This idea was a rough sketch of our first impression of a foot stabiliser and personally we didn't choose this idea as the calf support is not supporting the feet instead and we also found that the overall height will decrease as when the load of the leg is on the calf support. Thus with the height decreased, the doctor will have to bend their back more than usual to perform the treatment.

Idea 2

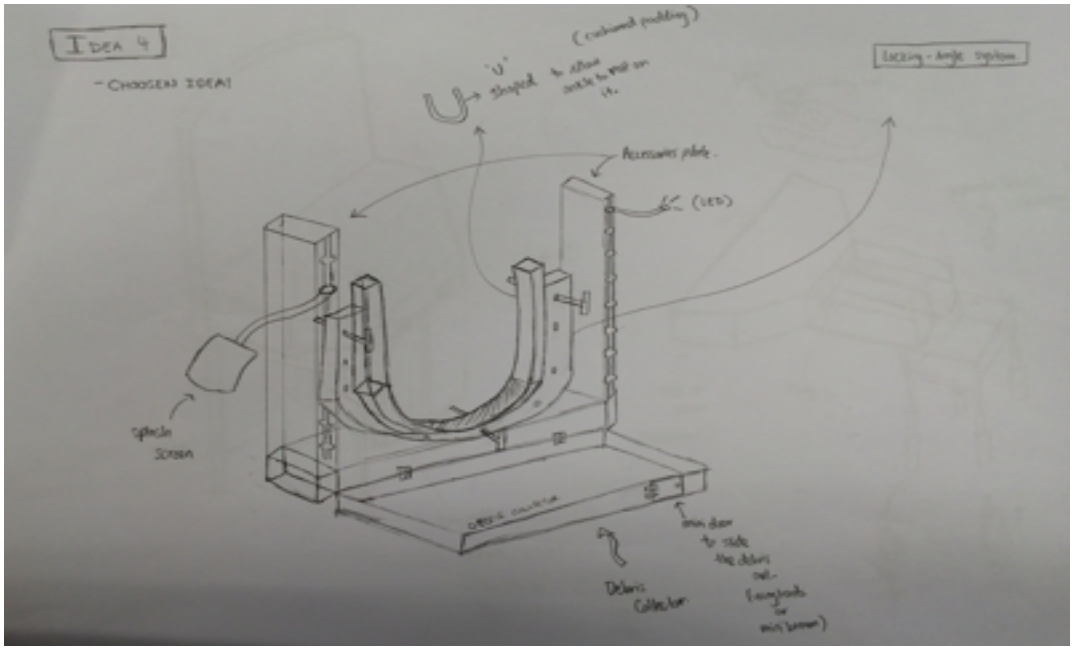


Idea 2 was generated based on a basic concept of being able to lift the leg up from a -90degree to a flat 180degree (As seen in the before and after drawing). The mechanism in the above drawing is similar to the one used in car jacks. It will be able to adjust the height of the feet support. While pulling the shaft multiple times, the leg will be lifted from rest position to the required position needed for the doctor to perform surgery.

Idea 3



Idea 4



Idea 4 has a basic concept of allowing the feet to be locked in different angles as to accommodate to the patients resting posture. So lets say, the patient's foot is resting in a 180degree manner, the locking mechanism will be installed with bearings and it could rotate the feet to a 90degree angle making it easier for the doctor to perform the treatment.

Decision Matrix

Idea	Ergonomic /10	Aesthetics /10	Mobility /10	Mounting /10	Ease of Fabrication /10	Total Score /50
1	4	6	8	6	8	32
2	3	4	5	4	8	24
3	6	7	7	7	7	34
4	6	7	8	9	8	38

Analysis:
In order to ensure that our final design idea is the most suitable and appropriate one, in terms of satisfying the ergonomic, aesthetic,mobility,mounting,ease of fabrication sectors, we came up with a table of factors to aid us in our decision.

These factors are particularly considered for each and every design idea so that our final design will be best suited for the patients to rehabilitate.

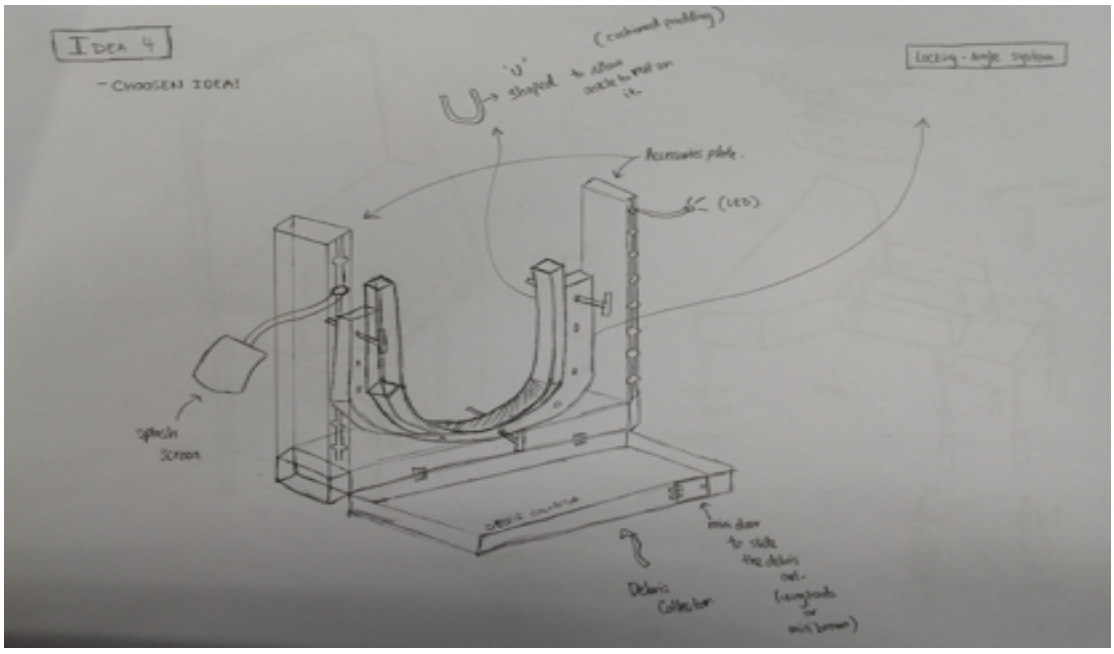
For design idea 1, we design it in the way that it will hold the patient's calf so that during treatment their leg is supported and stabilised by it. Firstly, the design isn't really safe for the user as their calf would be under great pressure if the fitting isn't spacious enough. Thus, this idea didn't fit the Ergonomic sector and is not chosen.

For design idea 2 and 3, both will be using the same technique of lifting the leg up. However, idea 4 is smaller than the other designs and it is easier to fabricate it. The idea allows the feet to move in various angles accommodating to the patients resting posture.Thus, scoring well in the Mobility, mounting and fabrication sectors.

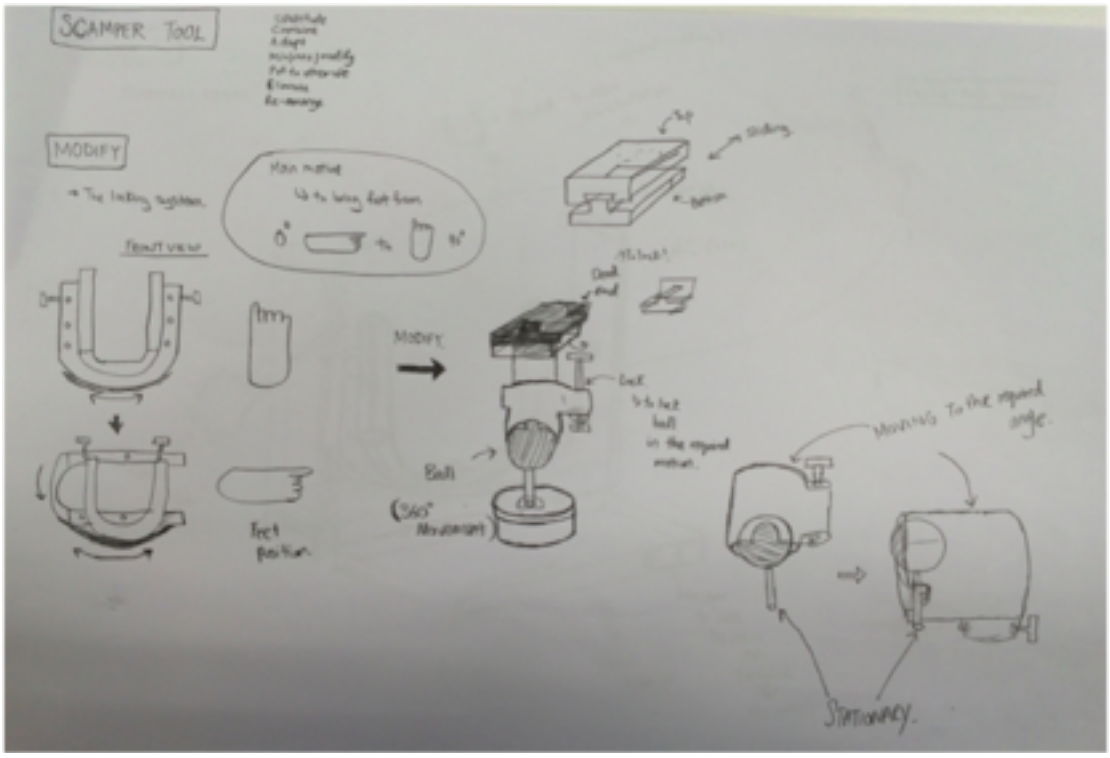
Hence, with satisfying the ergonomic, aesthetic,mobility,mounting,ease of fabrication sectors, **IDEA 4** is the most suitable idea.

Improvements to the Design Idea

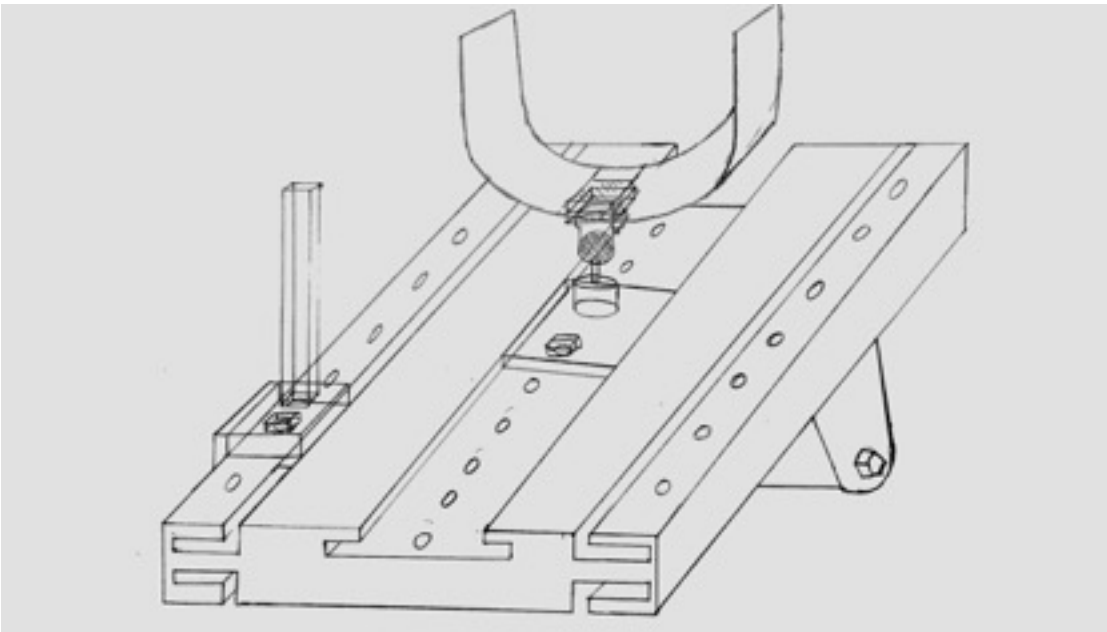
Chosen Idea – 4 -



So we did detailed development using the SCAMPER TOOL.

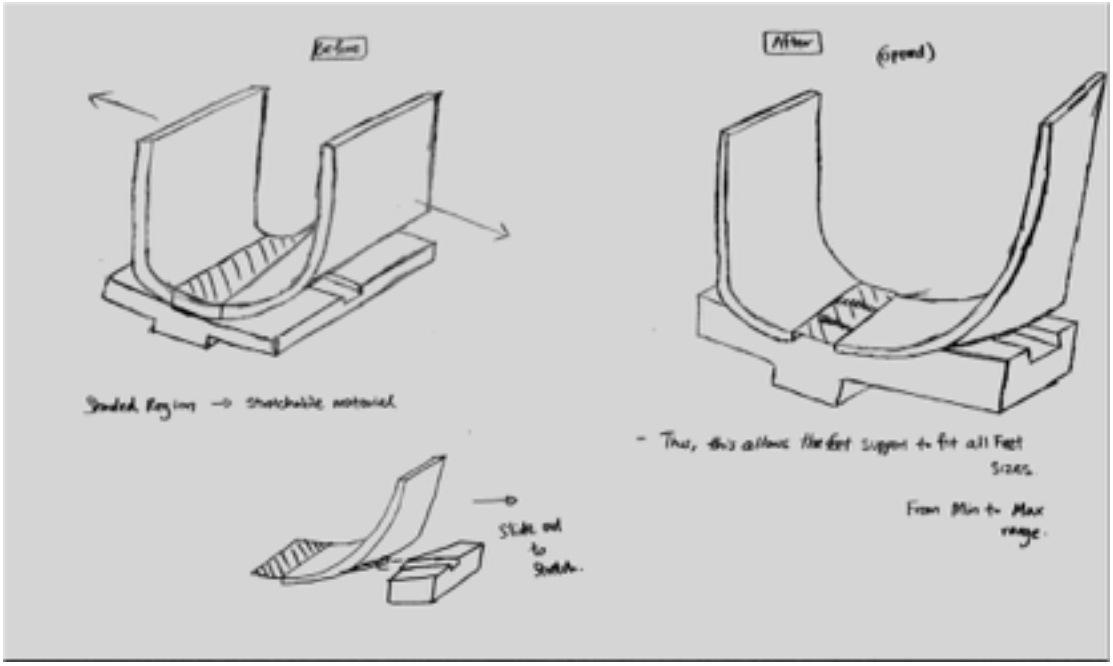


After modifications, New improved Design 5



This design will be attached onto a chair with a gas spring mounting at the back to lift the leg plate up.

As for the Feet Support,



As for the feet support, our main objective was to make the feet holder accommodate to various feet sizes as during treatment, most patients arrive with a swollen feet. Thus, by producing a simple reciprocating motion with the help of springs to provide compressive forces, we managed to achieve the objective.

Anthropometry Data

Anthropometry, the science that deals with the measurement of the size, weight, and proportions of the human body. Tests of anthropometry include measurements of body size, structure, and composition. It is important to be aware of the effects of changes to these factors, and to be able to measure them.

Some common anthropometric measurements include:

Height or length
Weight
Mid-upper arm circumference (MUAC)
Demi-span or arm span
Knee height
Sitting height
Skin fold thickness
Head circumference

As for this project, we need to concentrate mainly on the sitting height and the knee height of the patients.

Figure 1 Anthropometric dimensions of the study (standing) (see online version for colours)

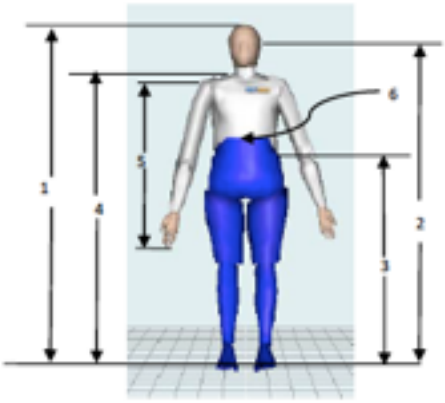
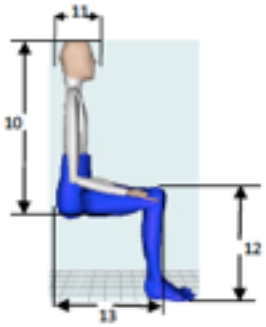


Figure 2 Anthropometric dimensions of the study (sitting) (see online version for colours)

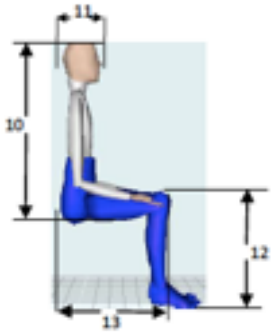


According to Table 2, Anthropometric data of Male and Female population of age group 26 to 35 year. The differences in dimensions were not significant among the age groups.

Table 2 Statistics of anthropometric measurements

	Dimensions	*Min*	*Max*	*Mean*	*SD*	*SEM*	*CV*	*Percentiles*		
								5th	*50th*	*95th*
1	Stature	150	185	167.65	8.95	0.57	5.34	152.00	168.00	183.00
2	Eye height	134	177	155.57	8.95	0.57	5.76	140.90	155.50	170.00
3	Elbow height	67	117	87.77	9.55	0.60	10.88	73.00	87.00	105.28
4	Shoulder height	121	156	138.31	8.10	0.51	5.85	125.00	138.00	152.55
5	Forearm length to middle finger tip	59	89	71.34	5.50	0.35	7.72	63.23	71.00	80.00
6	Waist size	49	94	72.05	7.52	0.48	10.44	58.45	73.00	83.00
7	Back to knuckle depth – fist closed	64	122	87.65	8.80	0.56	10.04	73.00	88.00	100.00
8	Index finger to elbow	27	54.5	37.79	5.28	0.33	13.97	30.00	37.00	46.55
9	Underarm to elbow length	21	35	28.64	3.82	0.24	13.33	22.00	29.00	35.00
10	Sitting/body height	68	105	84.83	6.86	0.43	8.09	74.45	84.00	96.55
11	Chest depth	14	31	24.16	3.87	0.24	16.00	17.45	24.00	30.00
12	Knee height	41	63	52.64	4.64	0.29	8.82	45.45	53.00	60.55
13	Buttock knee length	41.5	70	55.06	5.37	0.34	9.74	47.00	55.00	64.55
14	Head height – crown to chin	22	57	37.35	4.88	0.31	13.07	31.23	37.00	44.00
15	Head width at widest point	12.5	25	18.53	2.60	0.16	14.04	15.00	18.00	23.00
16	Head depth	15	28	20.92	3.07	0.19	14.68	17.00	20.75	26.00
17	Forehead circumference	47	71	58.45	4.68	0.30	8.01	51.00	58.00	66.00
18	Neck size	29	44	36.61	3.35	0.21	9.15	31.00	36.00	42.00
19	Foot length	20	32	26.25	2.24	0.14	8.54	23.00	26.00	30.00
20	Foot width	3	12	8.26	1.94	0.12	23.54	5.00	8.00	11.00
21	Hand length	16	27.5	20.20	2.27	0.14	11.26	17.00	20.00	24.00
22	Hand width	4	11	7.76	1.78	0.11	22.89	5.00	8.00	10.00
23	Middle finger length	4	11	8.09	1.77	0.11	21.94	5.00	8.00	11.00
24	Hand circumference	11	21	15.70	1.92	0.12	12.25	12.73	16.00	18.50

Notes: SD = standard deviation, SEM = standard error of mean,
CV = coefficient of variation.



Thus from the given data, we take the 50th and 95th percentiles.

13. 50th percentile is 55 and 95th percentile 64.55

12. 50th percentile is 53 and 95th percentile 60.55

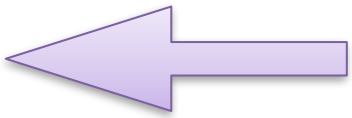
Gas spring Calculations

Calculations made for the selection of gas spring pump.

Percentages of Total Body Weight

Segment	Males	Females	Average
Head	8.26	8.2	8.23
Whole Trunk	55.1	53.2	54.15
Thorax	20.1	17.02	18.56
Abdomen	13.06	12.24	12.65
Pelvis	13.66	15.96	14.81
Total Arm	5.7	4.97	5.335
Upper Arm	3.25	2.9	3.075
Forearm	1.87	1.57	1.72
Hand	0.65	0.5	0.575
Forearm & Hand	2.52	2.07	2.295
Total Leg	16.68	18.43	17.555
Thigh	10.5	11.75	11.125
Leg	4.75	5.35	5.05
Foot	1.43	1.33	1.38
Leg & Foot	6.18	6.68	6.43

Plagenhoef et al., 1983



We needed this data to conclude the mean mass of a person's leg as the gas spring pump will be lifting the leg and feet.

According to Plagenhoef's Weight data, the leg and foot calculates to a 6.43% of the total body weight of a person. Therefore, our max targetted weight of a patient is 120KG.

$$100\% \text{ is } 120kg$$

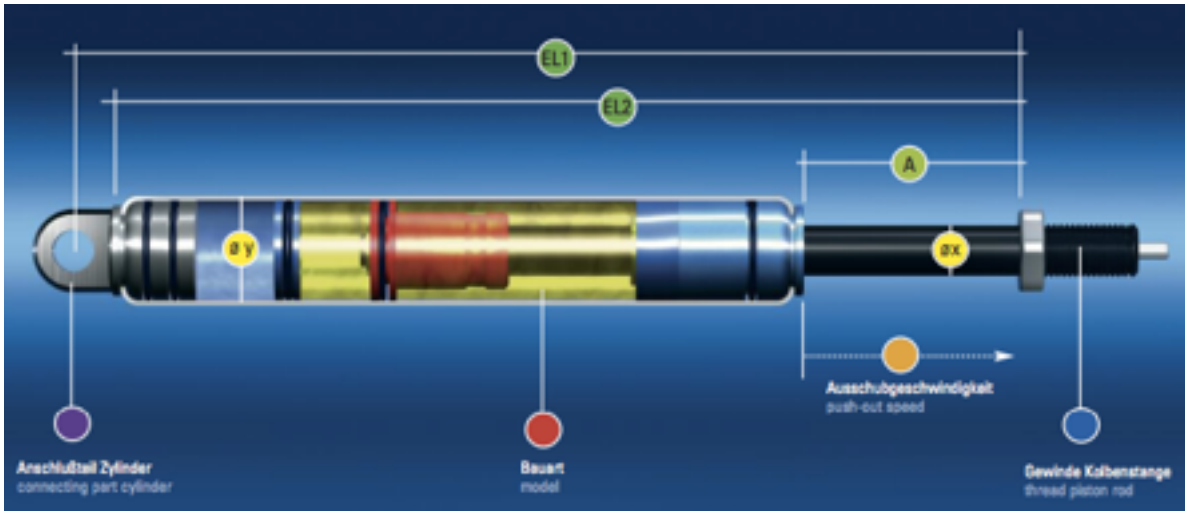
$$6.68\% \text{ is } ?kg$$

$$\frac{120}{100} \times 6.68\% = 8.016kg$$

Max Force required to be lifted by the pump

$$= mass \text{ of } leg \text{ and } feet \times 10N$$

$$8.016kg \times 10N = 80N$$



Hauptbauart main type **K**

starre Blockierung in Auszugrichtung, einschiebend bedingt starr

Rigid locking in pull direction, push-in direction relatively rigid

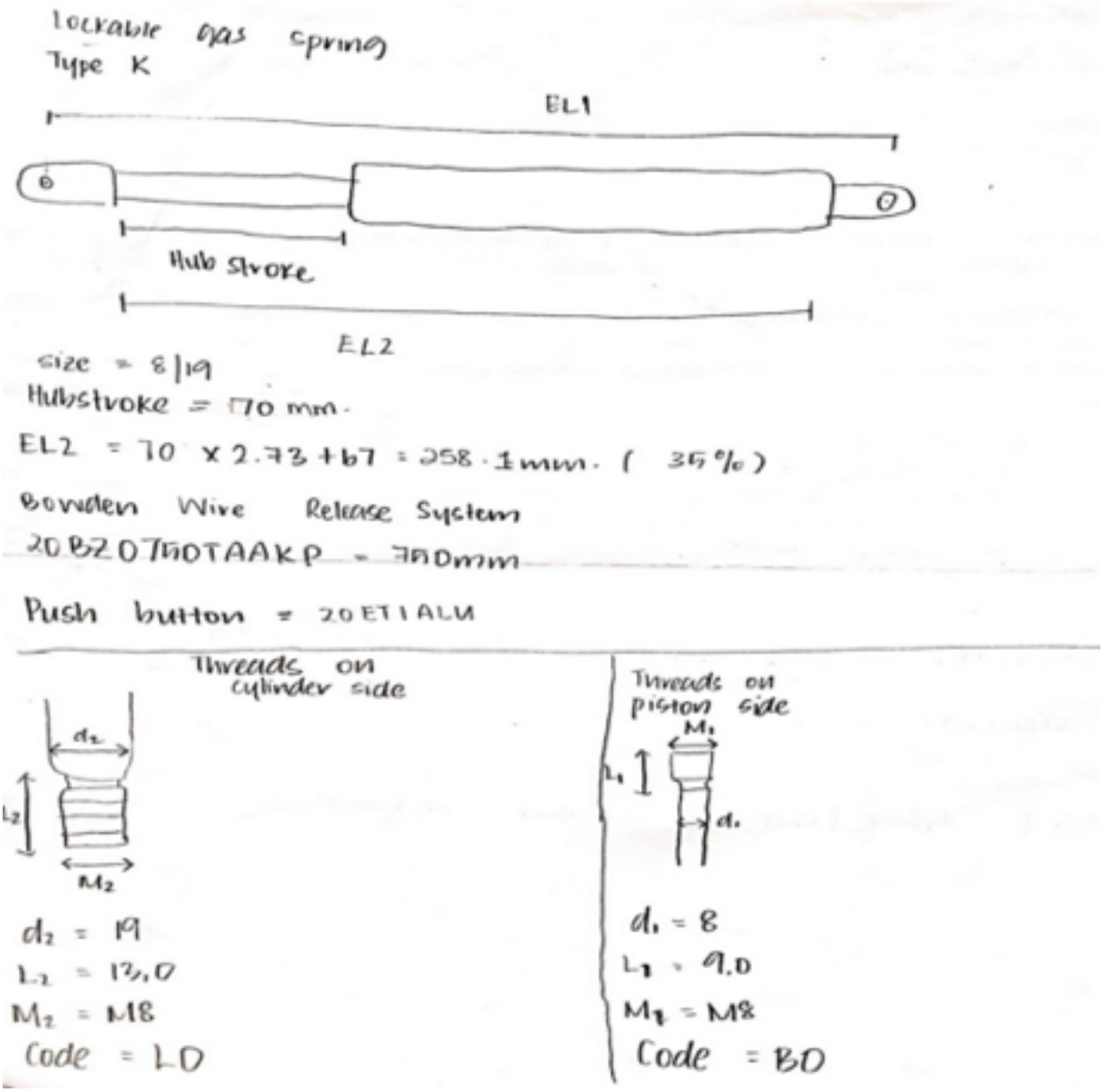
Bestell-Beispiel / *Order-Example*

K0	B1	K	–	3	200	594		001*	550N		
Gewinde Kolben-stange thread piston rod	Anschluß-teile Zylinder connecting parts cylinder	Bauart model	Ausfahr-geschwindigkeit push-out speed	Baureihe size	Hub stroke	Einbaulänge** (siehe Seite 11) extended length** (see page 11)	Progression progressivity	Index Nr.* Index Nr.*	Kraft force	Blocker-Kraft Zug locking force in pull direction	Blockierkraft Druck locking force in push direction
				Bx/By mm	mm	mind. min. EL 2 (mm)	ca. %		(N)	Ausfahr-weg release travel < 1mm	Ausfahr-weg release travel > 2,5mm
K0 = MF 10x1x18 O0 = MF 14x1,5x20 W0 = MF 8 x1x16	siehe Seite 48 "Anschluß-teile" *see page 48 "connecting parts"*	K	– = normal *normal* 0 = schnell *fast* 7 = langsam *slow* K = Kurzauslösung Ausfahrweg < 1 mm anstatt < 3,5 mm *short release Rel. travel < 1 mm instead of < 3,5 mm* B = Besonderheit *special* N = Niro *stainless steel* F = mit Ventil im Zylinder-Endstück *with valve inside the cylinder*	0 = 8/19	10-300	Hub stroke x 3,70 = 67 Hub stroke x 2,52 = 67 Hub stroke x 2,27 = 67	35 50 100	*Durch die Indexnummer – nur für Ihre Nachbestellung erforderlich – können wir einmal gefertigte Produkte exakt reproduzieren. Sie erhalten den Indexcode mit der Auftragsbestätigung/ Rechnung. *With the index no. – only necessary for repeating orders – we can reproduce exactly the same gas spring which has already been produced. You will receive the index no. with the order confirmation / invoice.	40-700	***	***	4 x F1
				1 = 8/22	10-300	Hub stroke x 2,52 = 68 Hub stroke x 2,27 = 68 Hub stroke x 2,19 = 68	35 50 100		40-700	***	***	5,6 x F1
				E = 8/28	10-300	Hub stroke x 3,33 = 72 Hub stroke x 2,24 = 72 Hub stroke x 2,13 = 72	35 50 100		40-700	***	***	9 x F1
				2 = 10/22	10-500	Hub stroke x 3,81 = 73 Hub stroke x 2,58 = 73 Hub stroke x 2,30 = 73	35 50 100		50-1300	***	7000	3,6 x F1
				3 = 10/28	10-500	Hub stroke x 2,52 = 77 Hub stroke x 2,36 = 77 Hub stroke x 2,19 = 77	35 50 100		50-1300	***	10.000	5,8 x F1
				A = 10/40	10-500	Hub stroke x 2,21 = 93 Hub stroke x 2,15 = 93 Hub stroke x 2,06 = 93	35 50 100		50-1300	***	10.000	13 x F1
				5 = 14/28	30-700	Hub stroke x 2,97 = 93 Hub stroke x 2,69 = 93 Hub stroke x 2,32 = 93	35 50 100		150-2600	***	10.000	2,9 x F1
				B = 14/40	30-700	Hub stroke x 2,43 = 99 Hub stroke x 2,21 = 99 Hub stroke x 2,15 = 99	35 50 100		150-2600	***	10.000	6,6 x F1

***Achtung: verringerte Blockierkraft / *Attention: Reduced locking force*

Max Force required to be lifted by the pump ,80N is the exact value required to be exerted by the pump but as we add the load of the materials used, 80N is suitable.

For EL1 and EL2 under the green column - we selected based on these calculations.



Specifications of Product.

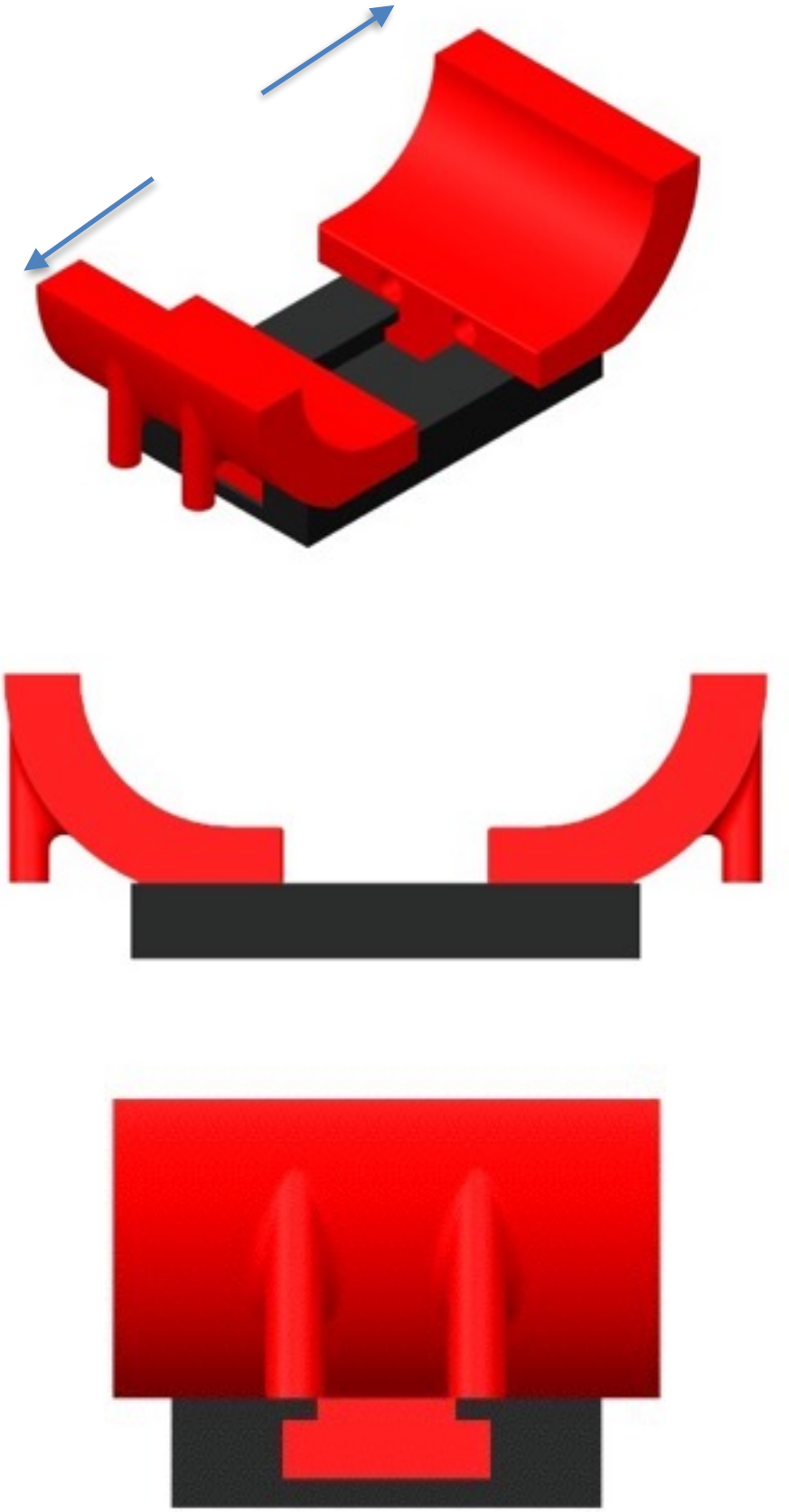
- The Leg plate should be able to withstand a leg weight of 20Kg.
- Adjustable angle of view for operator when using the feet locking mechanism.
- Ankle support must be able to hold various adult feet sizes according to Asian population
- Safety precautions like cushioning should be done at the respective places.
- Ankle support should be able to move 90^{o} horizontally.
- Product should not affect the field of work of the operator.
- Product must be able to detach from the patient's chair if necessary (If patient's treatment is not on the ankle but an amputated leg, our product must be able to detach to carry out the treatment) {Thinking of detaching the lower leg part only}
- Product able to accommodate to different operator/treatment tools requirement.
- Materials use must be able to be easily sanitised.
- No sharp edges.
- User-friendly and able to meet all Ergonomics and Anthropometry requirements.
- Invent A Locking Mechanism to keep the feet in place comfortably.
- Invent an adjustable applicator to stabilise the foot during surgery.
- A Tension Provider to constantly apply tension and to provide a little pressure on both sides of the foot

Feet Support Mechanisms

Feet Size Accommodator

When closed.

When Opened.



Ball-Joint Locking Mechanism

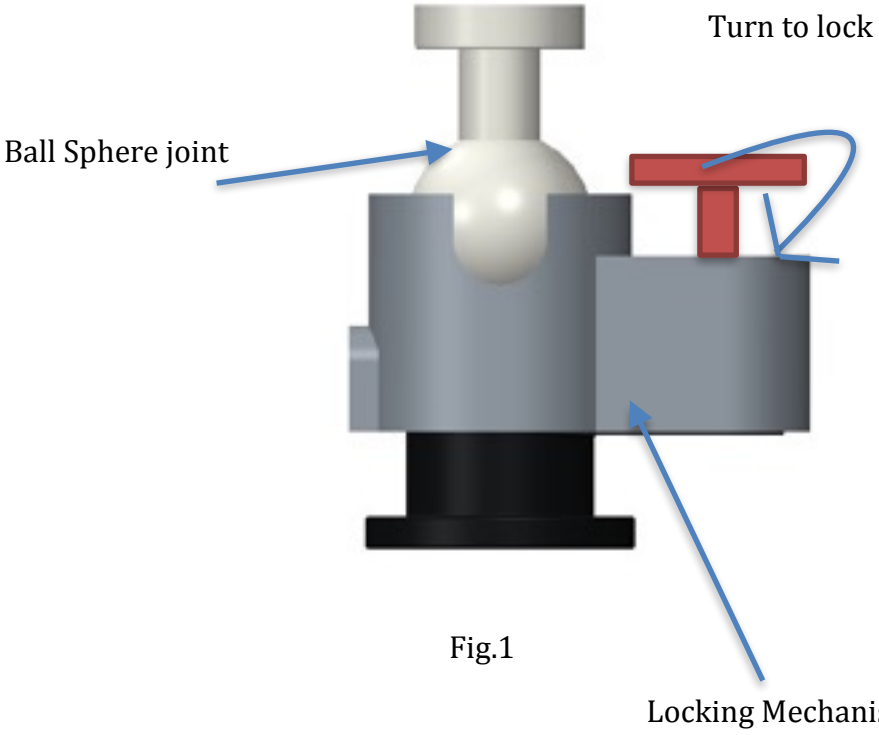


Fig.1

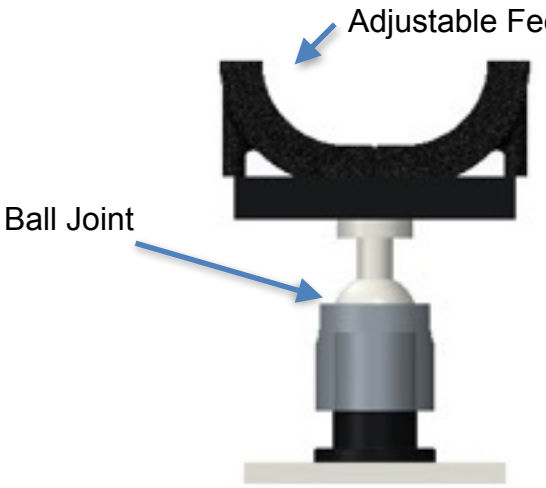
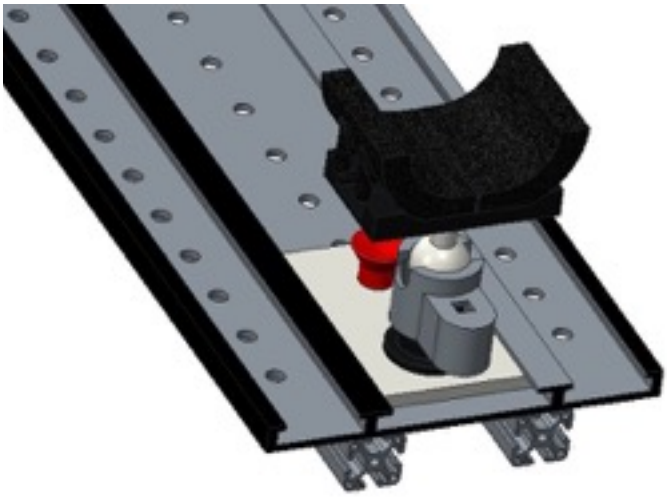
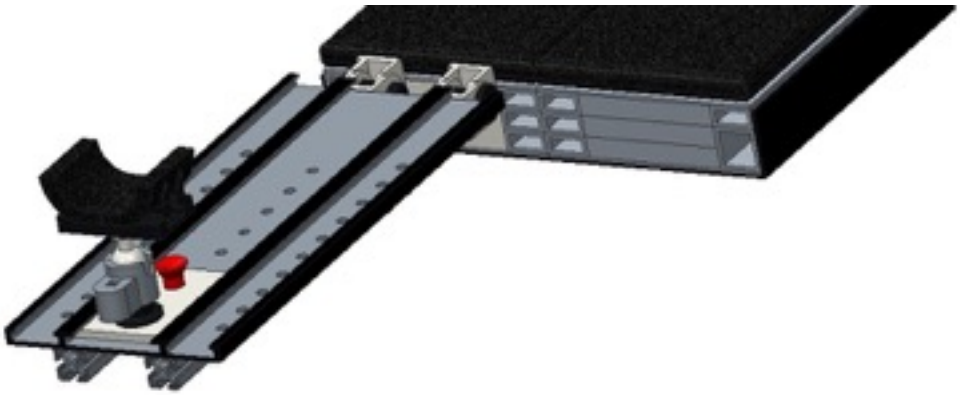


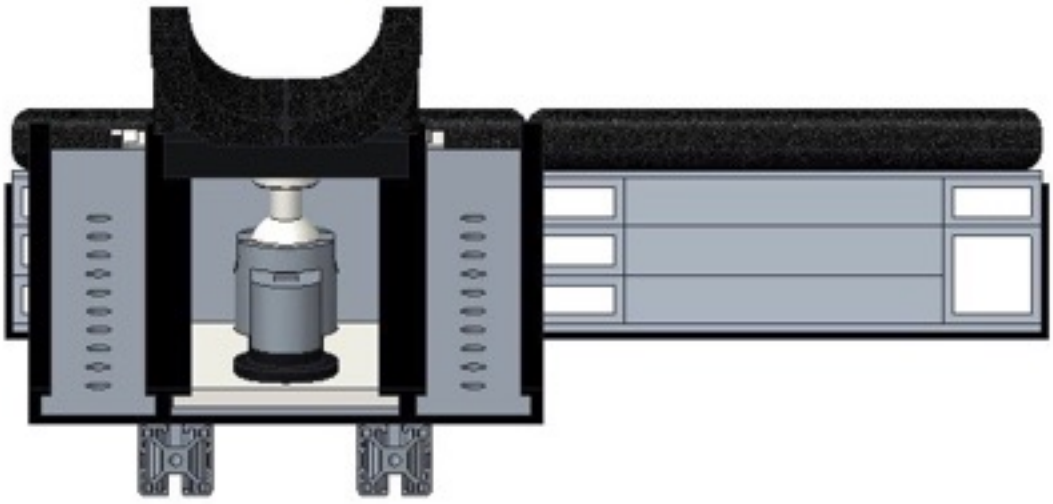
Fig.2

In Fig,2, a ball joint is used to provide 180 degree movement for the feet as to accommodate the patient's resting posture and it will be adjusted to satisfy the podiatrist's view of comfortability. In Fig.1, A locking device to lock the feet in place when the patient and podiatrist are satisfied with the position. The Feet support was created to hold the patient's feet comfortably and it is designed in a way to cater to all feet sizes thus being suitable for most patients to place their feet on it.

The Combined Mechanisms

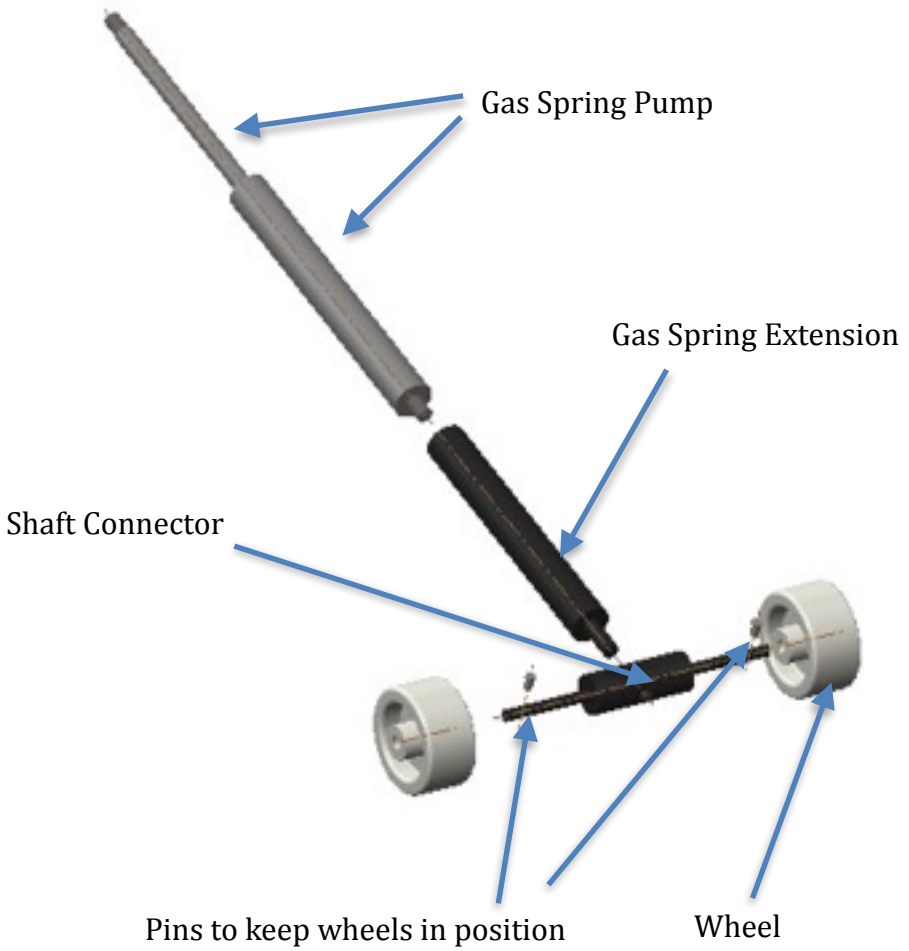




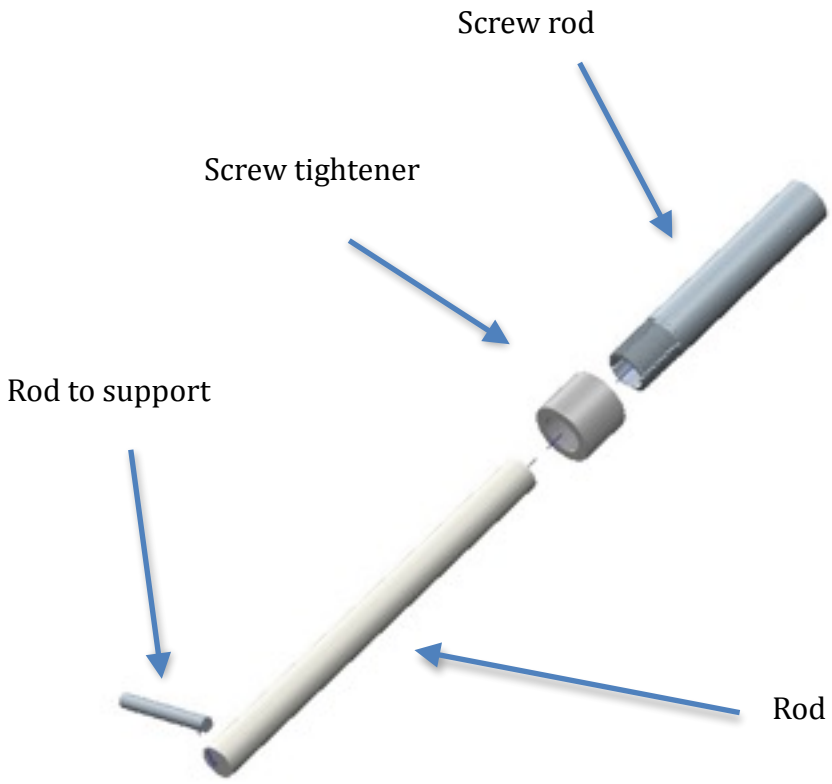


Wheel-Shaft Mechanism for Gas Spring Pump

This idea was designed to allow the gas spring pump to have a greater length so that it doesn't result to heavy bending overtime. Thus, wheels were used to absorb the vertical force produced into a horizontal force towards retracting the gas spring pump.



Extendable Screw - Shaft Mechanism



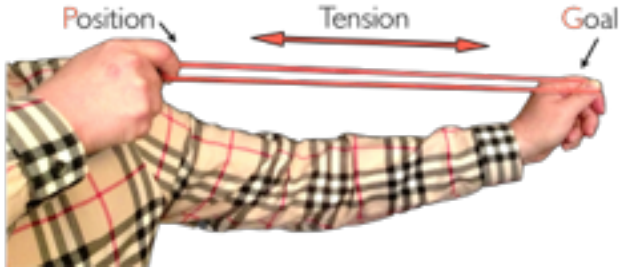
Tension Providing Mechanism

Introduction to our Idea of providing Tension

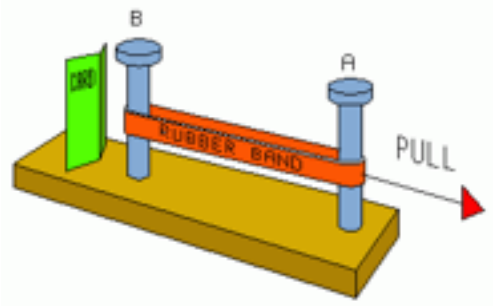
Profile bars would be used in the process of providing tension.
We had an idea of creating tension in the form of elasticity.

Ftens = Tension Force

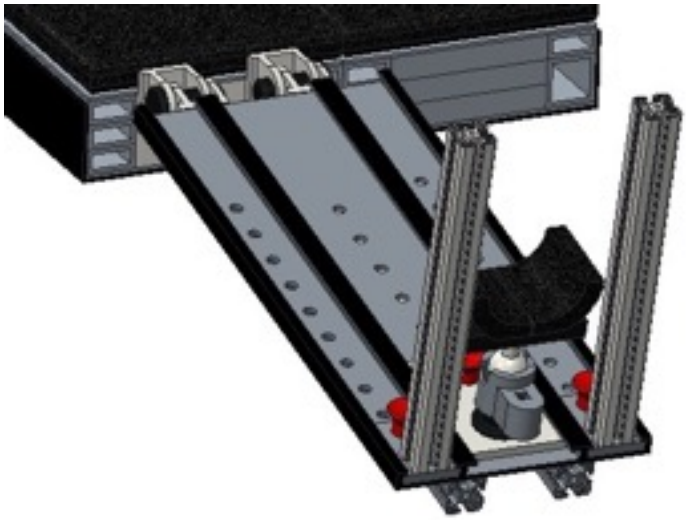
The tension force is the force that is transmitted through a string, rope, cable or wire when it is pulled tight by forces acting from opposite ends. The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.



When an elastic object gets pulled apart in tension, it becomes thinner and it somewhat stretches the soft object behind it.



Designing with CAD



The tension provider mechanism is there to provide a decent dorsiflexion using the disposable elastic plastic films (Fig A) attached to the profile bar.

Disposable Plastic Films

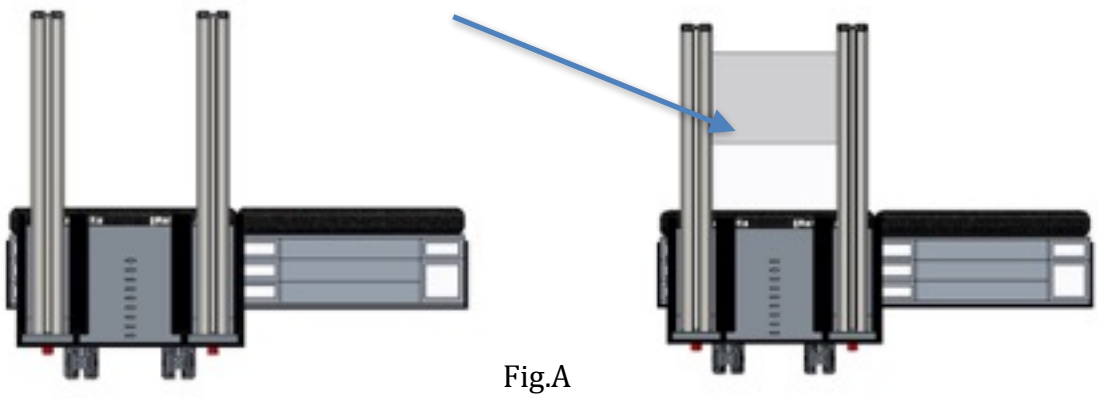
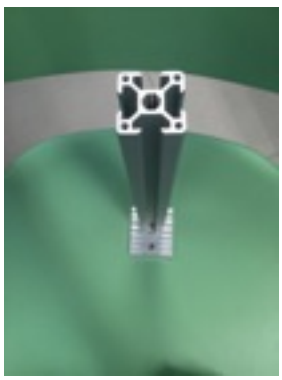


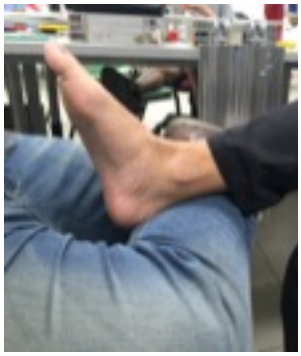
Fig.A

Our Idea - with demonstration

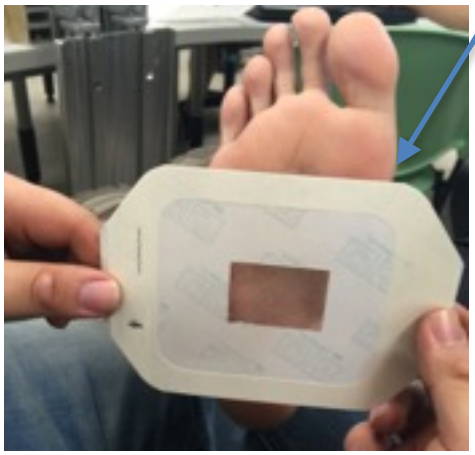
Thus having similar concept to the above, the 2 profile bars would be creating the force to stretch the rubber/plastic strip and hold it in place till the surgery is over.



Here is a simple demonstration on how the tension is going to be provided with the design with a step by step explanation.

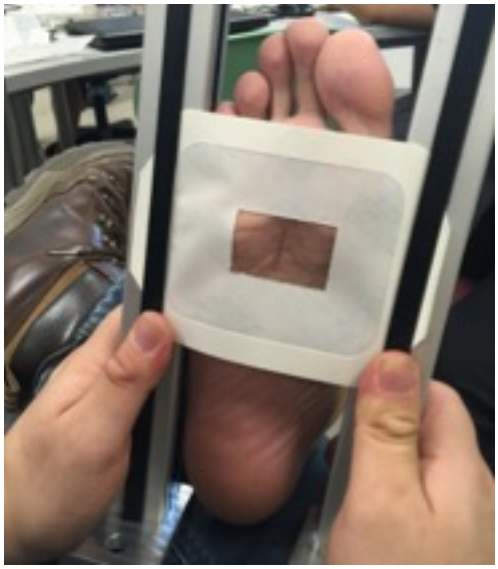


Firstly, as seen the feet is in its natural plantar flexion state where the feet is facing forward.



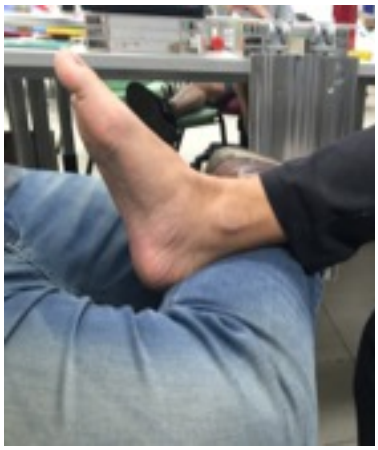
Next, the podiatrist has to see which area he/she wants to operate and work on. Followed by cutting a random shaped hole on the plastic sheet once the place is confirmed.

Thirdly, slide in the plastic sheet of paper into the profile bar and lock it in place with the black plastic strips.



As the slot fits perfectly, the podiatrist can remove the white plastic and proceed to paste it on the feet. After its on the feet, the podiatrist has to just drag the profile bar behind to provide a decent dorsiflexion for the surgery.

Before



After

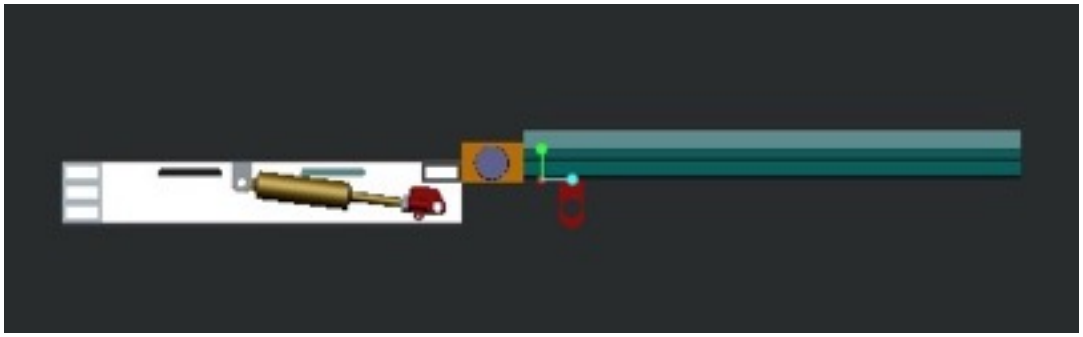
Design Refinements

Along the way, we had several design refinements to the project. It can be shortly described into 2 Sections such as

1. Placing of the Gas spring pump / Extendable shaft Mechanism
2. Having the leg holder to accommodate to both left and right leg users.

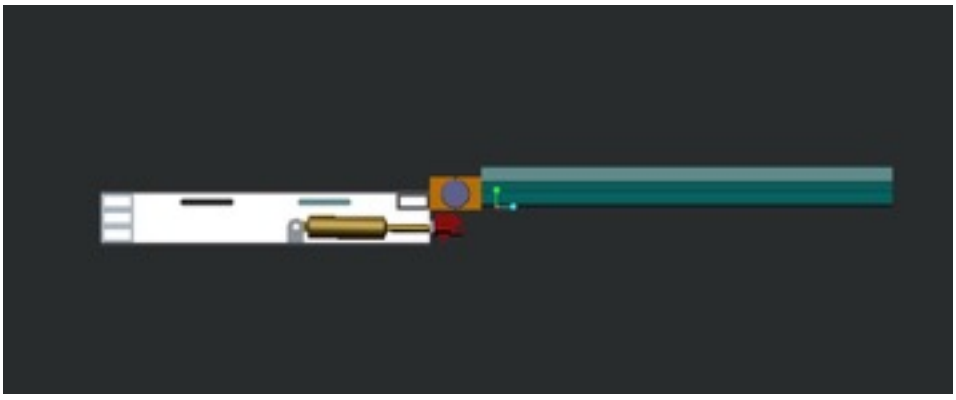
Placing of the Gas Spring pump

Idea 1



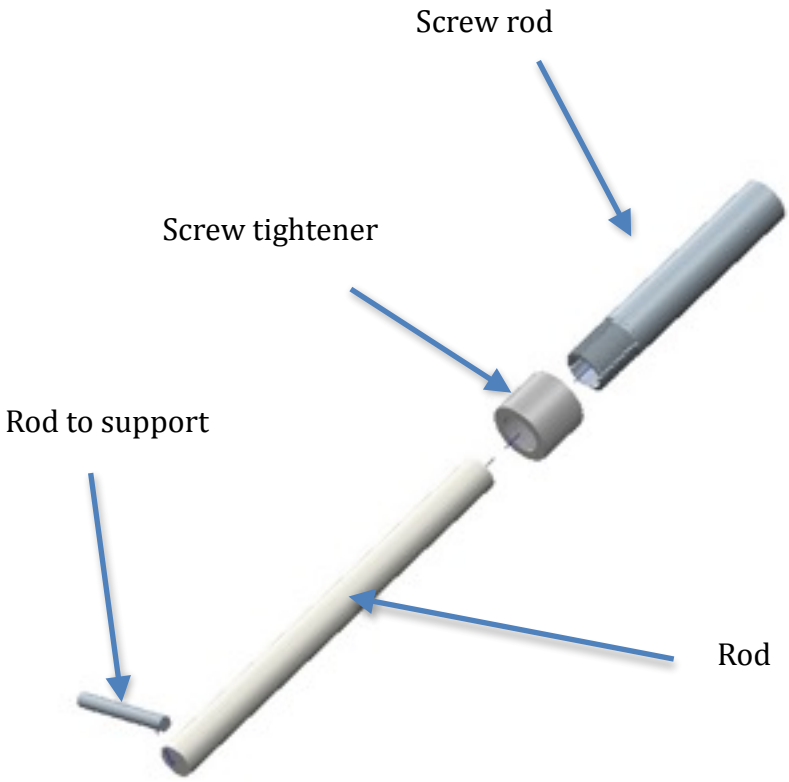
Idea 3

Idea 2



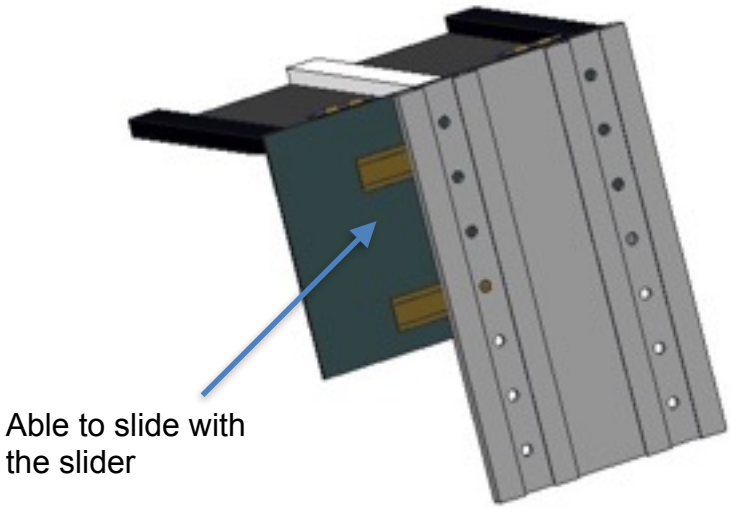
Idea 2 was selected as it is more stable compared to the other designs as it is installed to the base for stability. Idea 3 requires another medium to support the gas spring pump if it is installed in that manner. Thus, it isn't appropriate.

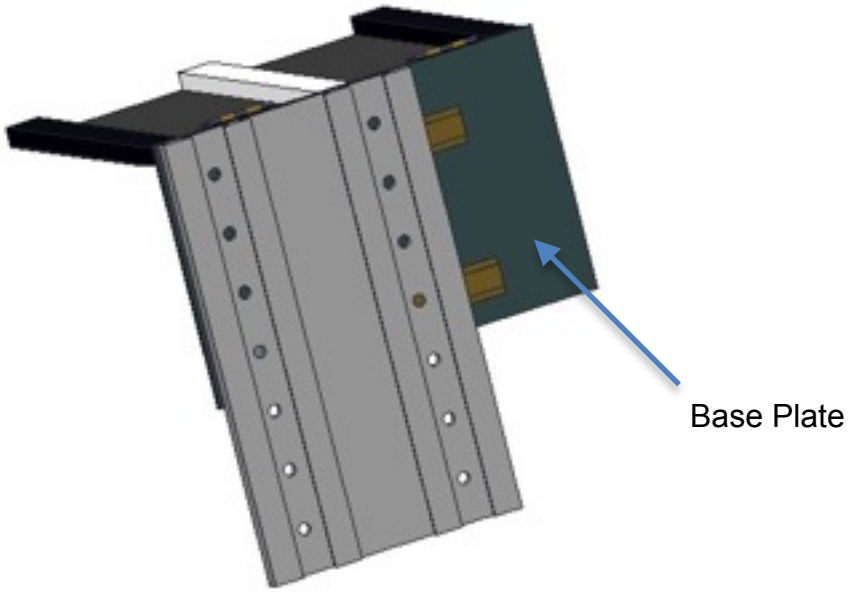
Extendable Screw shaft Mechanism with Idea 2 - concept (Chosen idea)



Modular Seat Design to accommodate both legs.

Idea 1

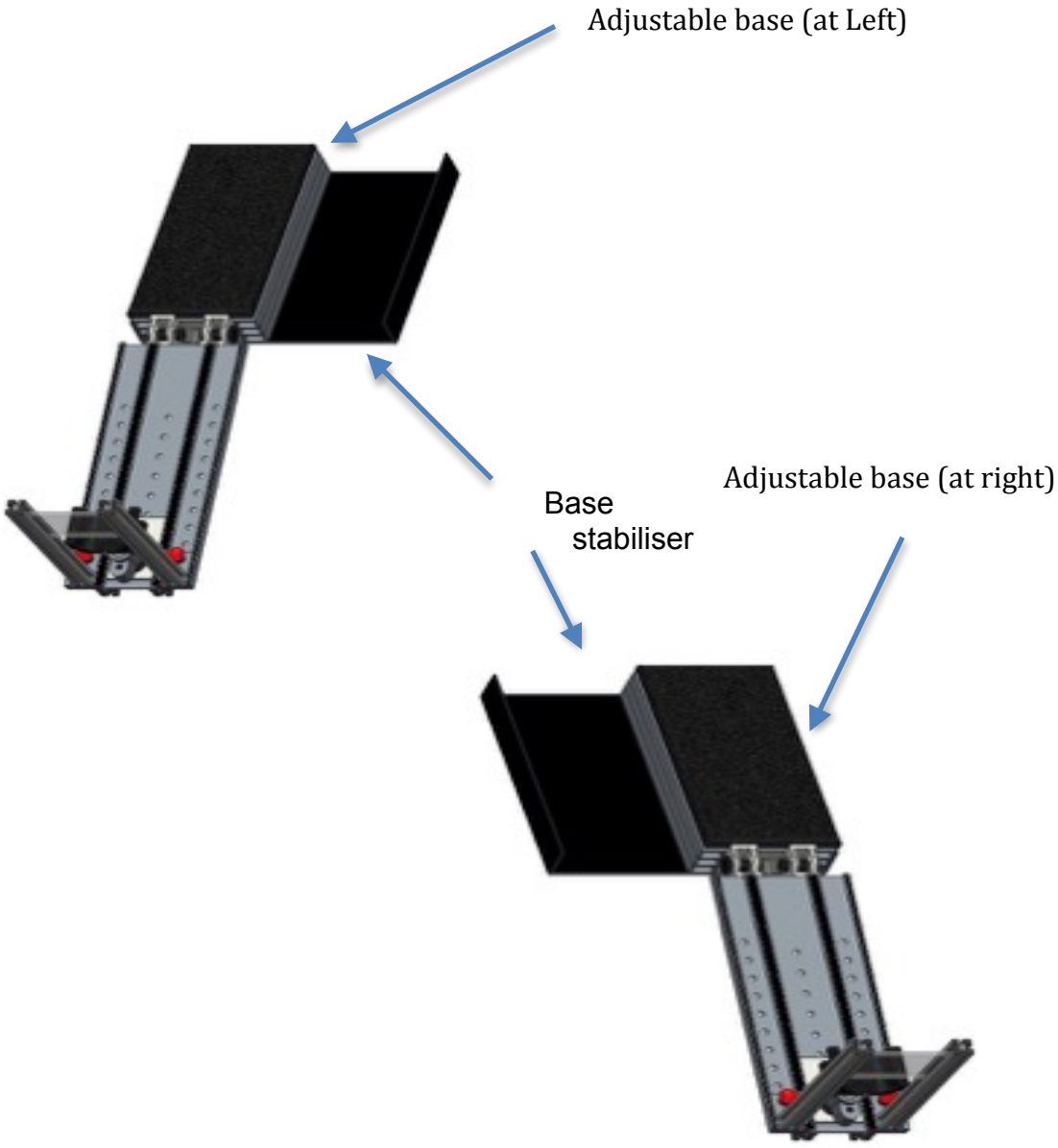




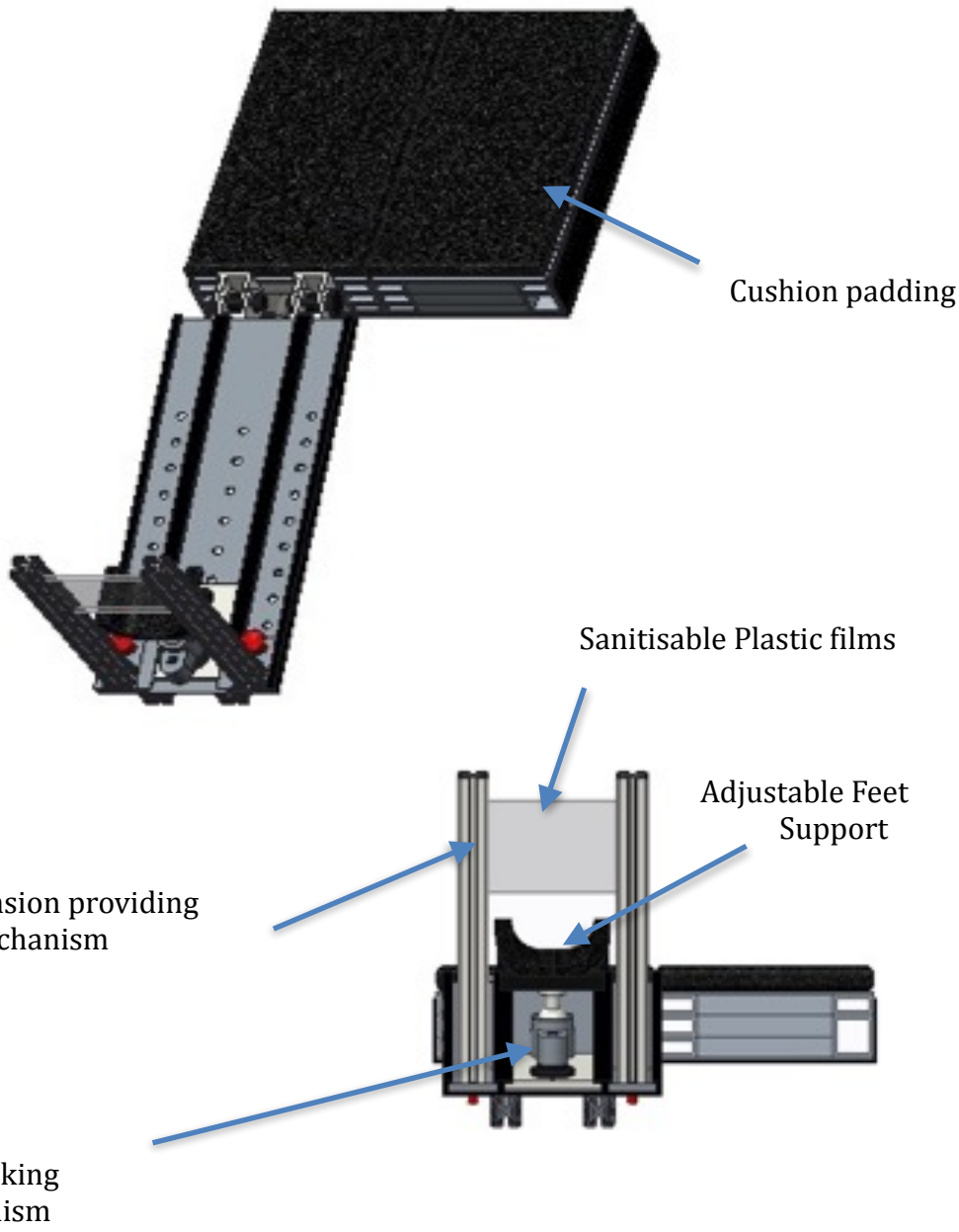
Able to slide left and right to accommodate both legs but it requires another base plate for it to slide on. This thus adds on to the total weight of the project making it heavy and bulky.

Idea 2 - Chosen Idea

Adjustable seat mechanism provide a feature to adjust to the position of the seat, for their surgical need on both feet. (Figure 4). The base stabiliser is used to stabilise the adjustable base to make sure its levelled and balanced when placed on a chair. Thus, the invention is designed for operation on both feet.



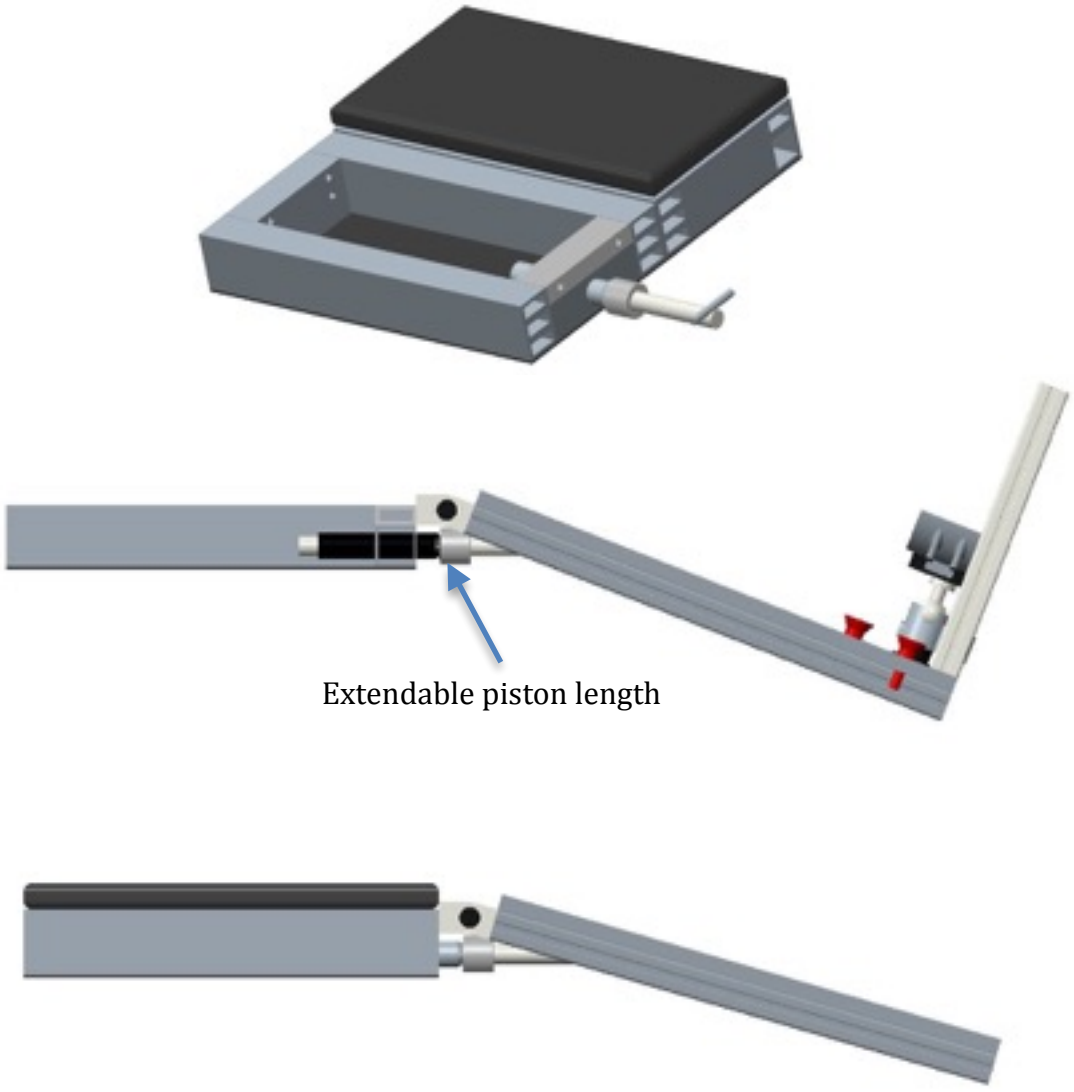
Final Design



Internal Structure of the Invention

Internal structure of the prototype when the **Extendable Screw shaft Mechanism** is in

F**ully Extended** Position. (Figure 3)

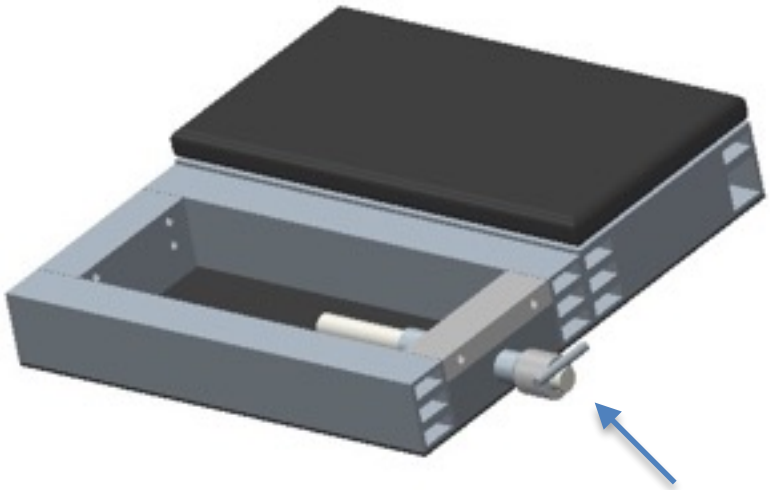


(Figure 3)

When the **Extendable Screw shaft Mechanism** is in

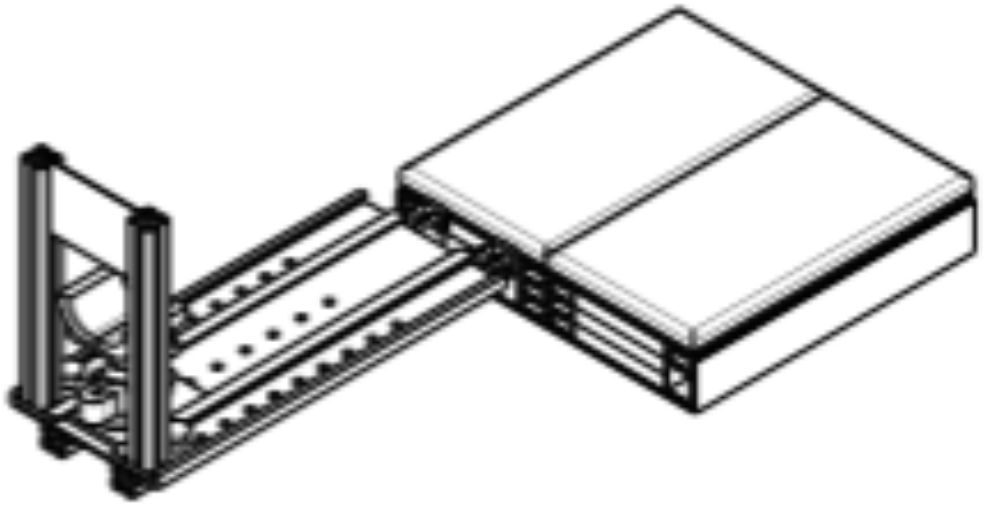
Fully Retracted Position. -

(For safety purposes, no mechanisms will be installed onto it when its being retracted.) (Figure 4)



(Figure 4)

Isometric View



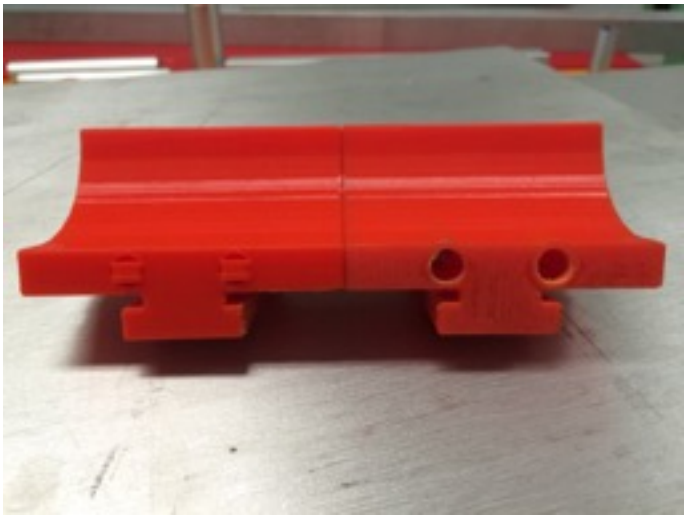
Isometric View

Safety Precautions

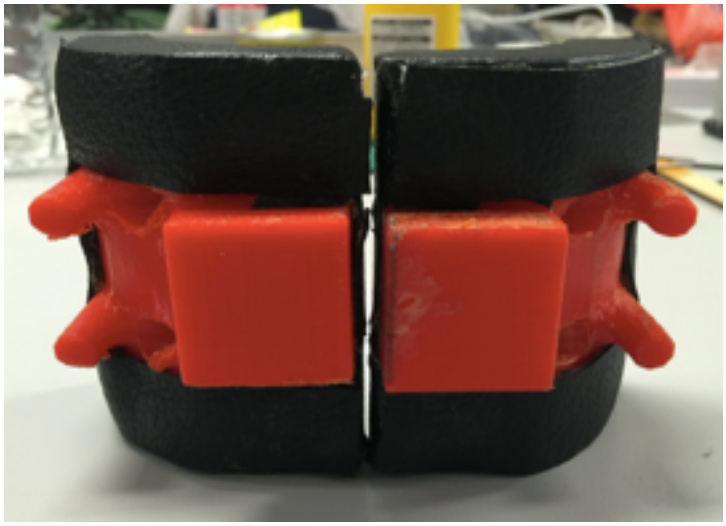
There were many precautions taken to make the stabiliser turn our safe and comfortable for the user. One of it was the application of cushion paddings at areas where the product will have direct contact with the patient.

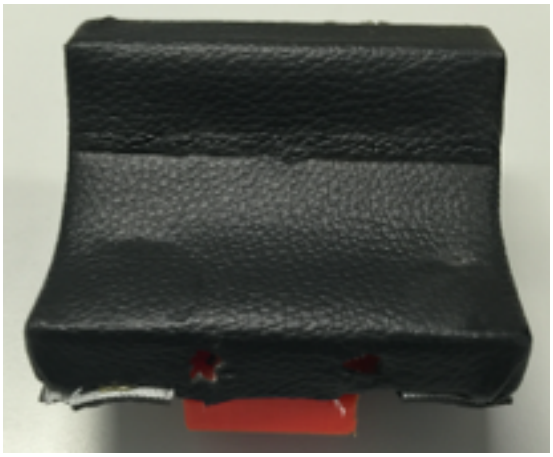
The Leg holder and seating have direct contact with the patients thus cushioning will be applied onto the items.

Before



After



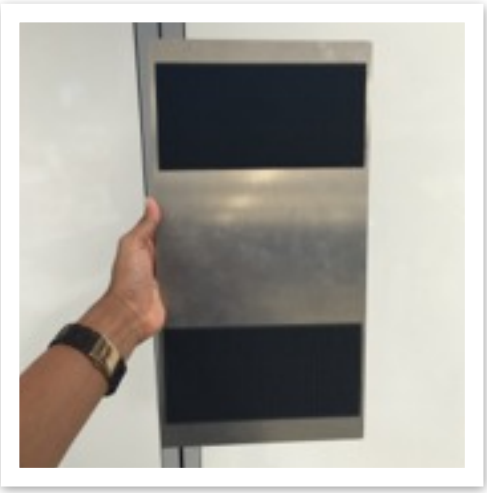


Cushioning is added so that patients don't feel the raw materials protruding out, which may eventually be unsafe for the patients.

Cushioning at the top plate where the patient sits on.

Before **After**

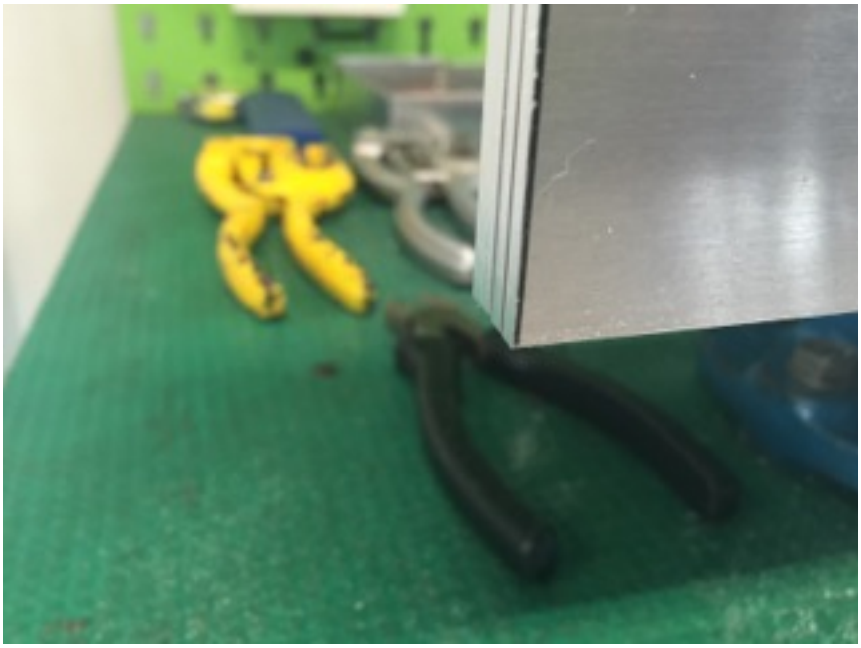
Cushioning at the top plate where the patient sits on.



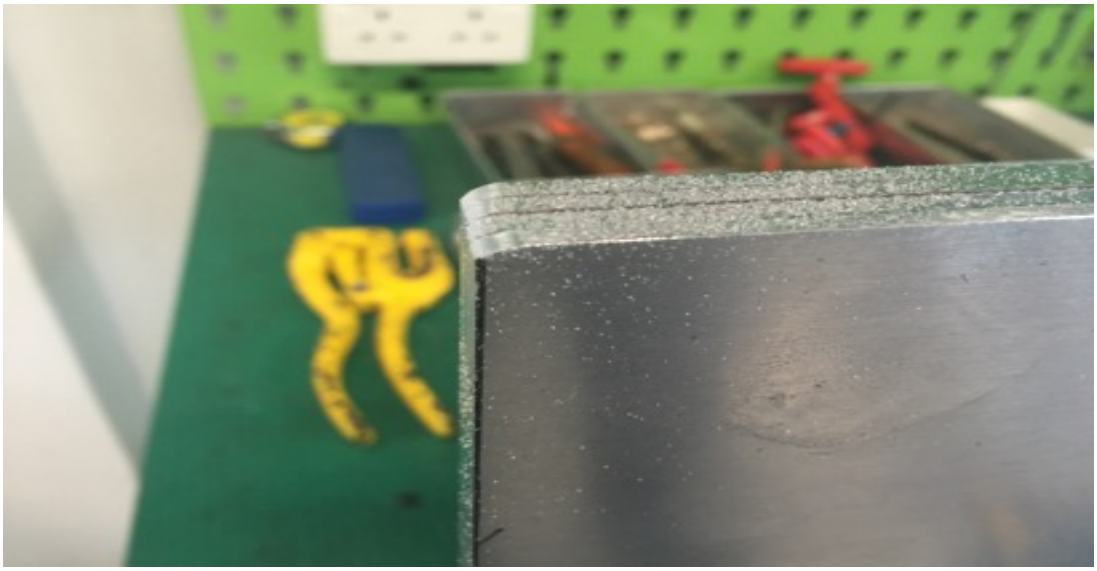
Thick leathered padding is used as its easy to sanitise it when it gets dirty and the thickness of the padding is relatively thick as we didn't want any users to feel the aluminium metal beneath the cushion when they're sitting on it.

Rounding-off the edge of the Metal sheets.

Before



After

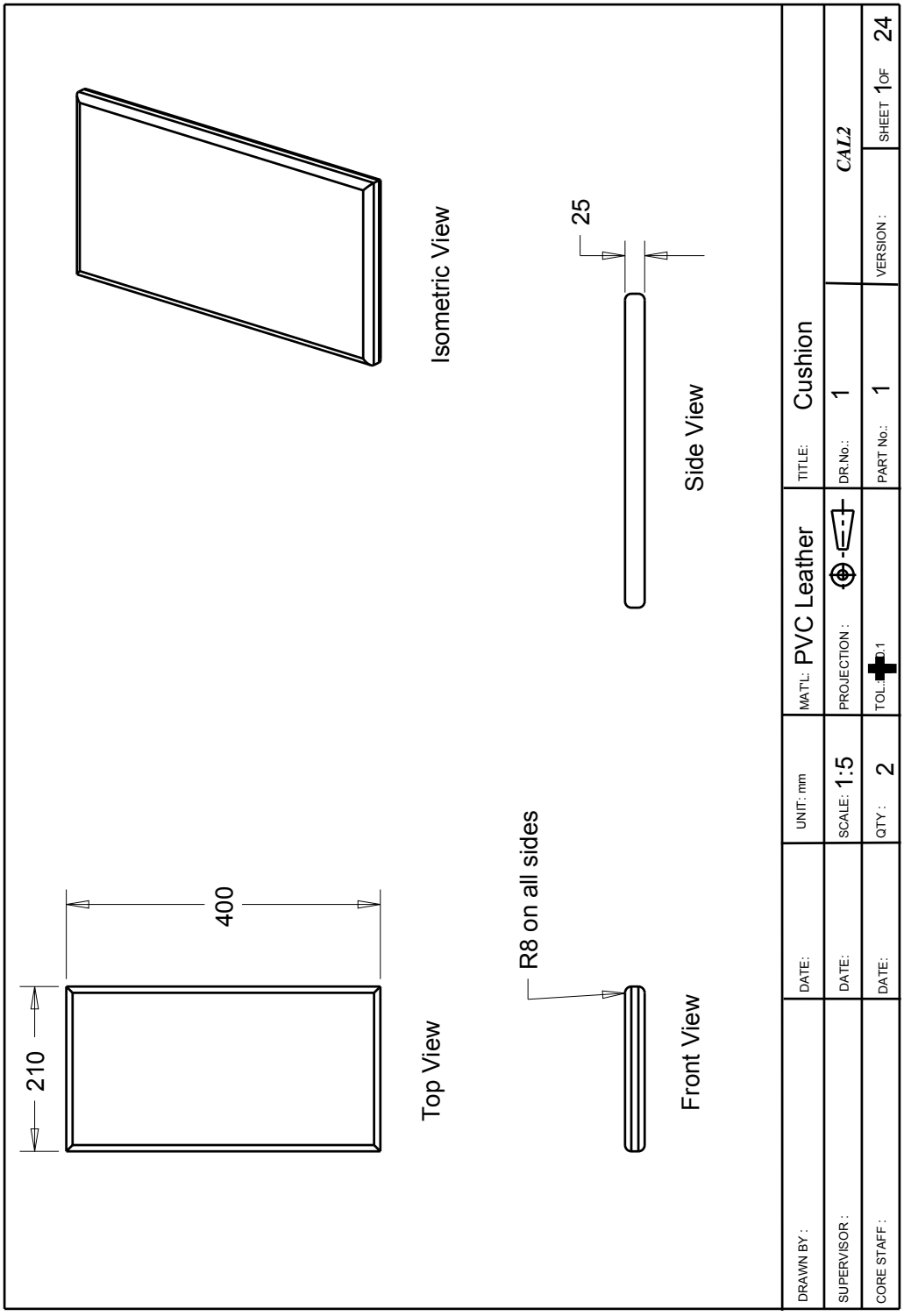


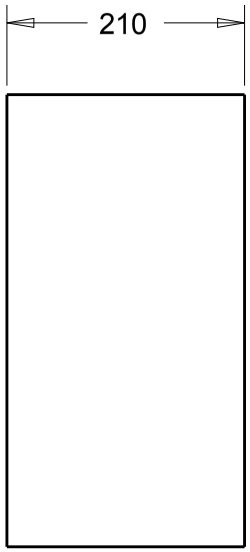
Weight - Counter balancing

The Product is designed in such a way that there must be a person seated on it to counter balance the weight of the Leg plate (Figure 1). Thus, we added a safety feature such as the Safety Belt to hold the product to the seat or whichever platform it is being placed on. This, prevents the material from falling over and it allows the prototype to be independent on the seat till a patient sits on it.

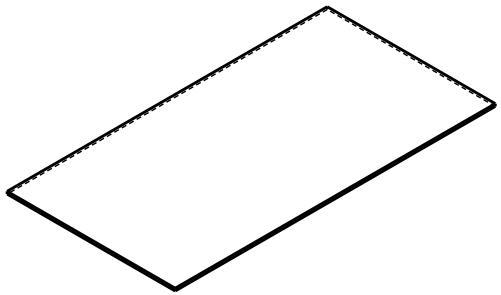
(Figure 1)

Working Drawing - Part Files

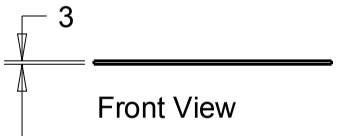




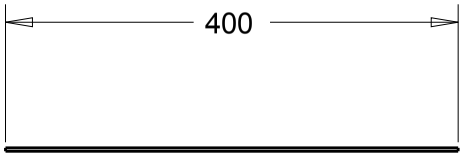
Top View



Isometric View

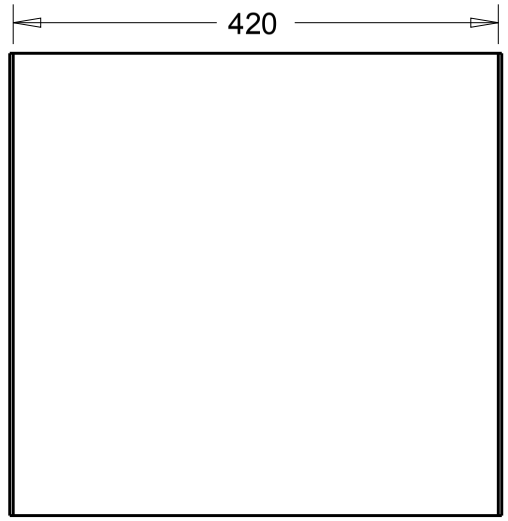


Front View

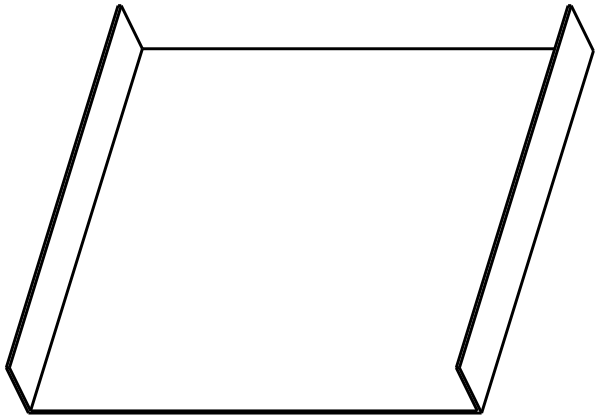


Side View

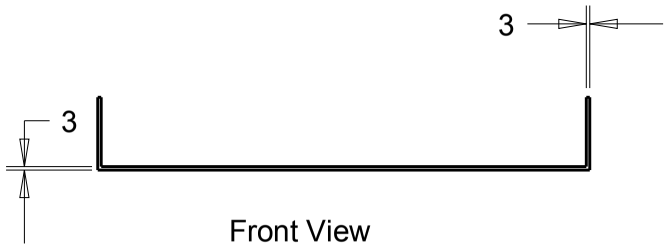
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Top and Base Plate		
SUPERVISOR :	DATE:	SCALE: 1:5	PROJECTION :	DR.No.: 2	*CAL2*	
CORE STAFF :	DATE:	QTY : 4	TOL.: ±0.1	PART No.: 2	VERSION :	SHEET 2 OF 24



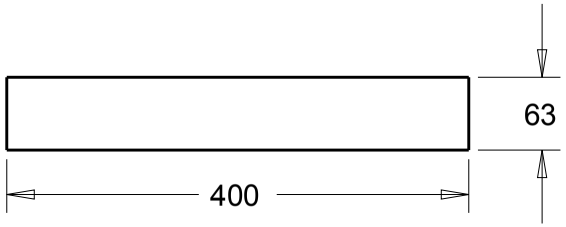
Top View



Isometric View

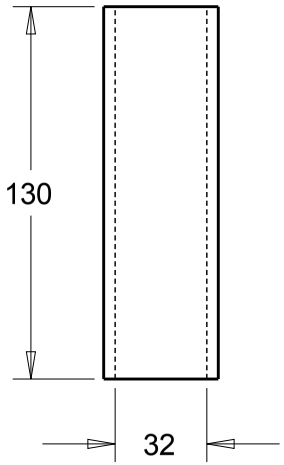


Front View

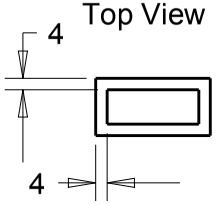


Side View

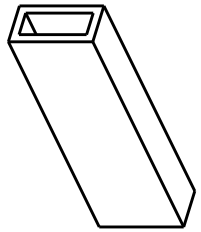
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Structure Holder		
SUPERVISOR :	DATE:	SCALE: 1:5	PROJECTION :	DR.No.: 3	*CAL2*	
CORE STAFF :	DATE:	QTY : 1	TOL. ±0.1	PART No.: 3	VERSION :	SHEET 3 OF 24



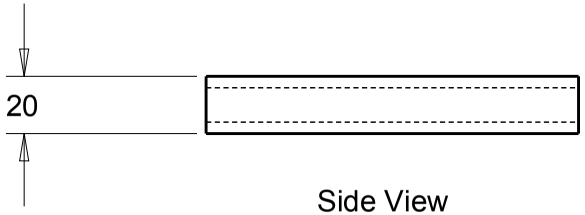
Top View



Front View

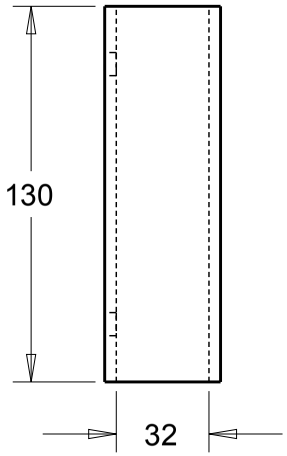


Isometric View

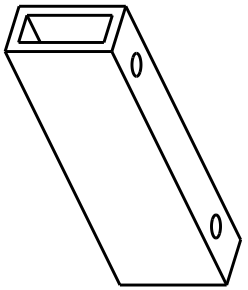


Side View

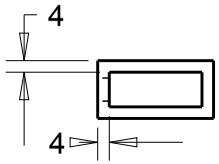
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Short Rectangular Block		
SUPERVISOR :	DATE:	SCALE: 2:5	PROJECTION :	DR.No.: 4	*CAL2*	
CORE STAFF :	DATE:	QTY : 6	TOL.: 0.1	PART No.: 4	VERSION :	SHEET 4 OF 24



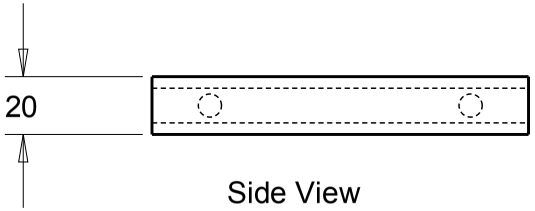
Top View



Isometric View

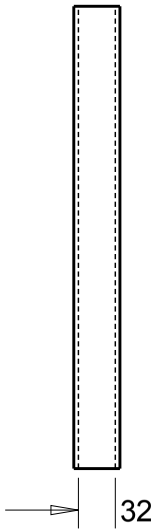


Front View

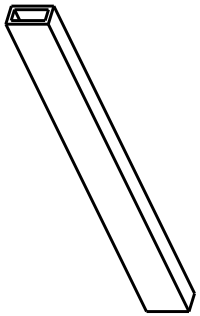


Side View

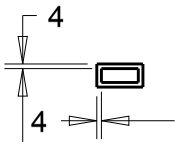
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Shortest Rectangular Block	
SUPERVISOR :	DATE:	SCALE: 1:2	PROJECTION :	DR.No.: 5	*CAL2*
CORE STAFF :	DATE:	QTY : 4	TOL.: ±0.1	PART No.: 5	VERSION : SHEET 5 OF 24



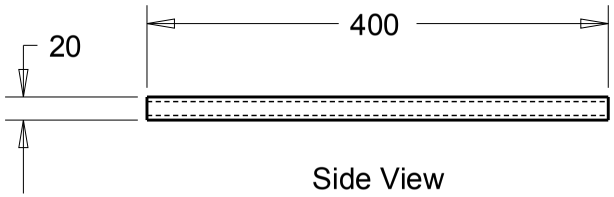
Top View



Isometric View

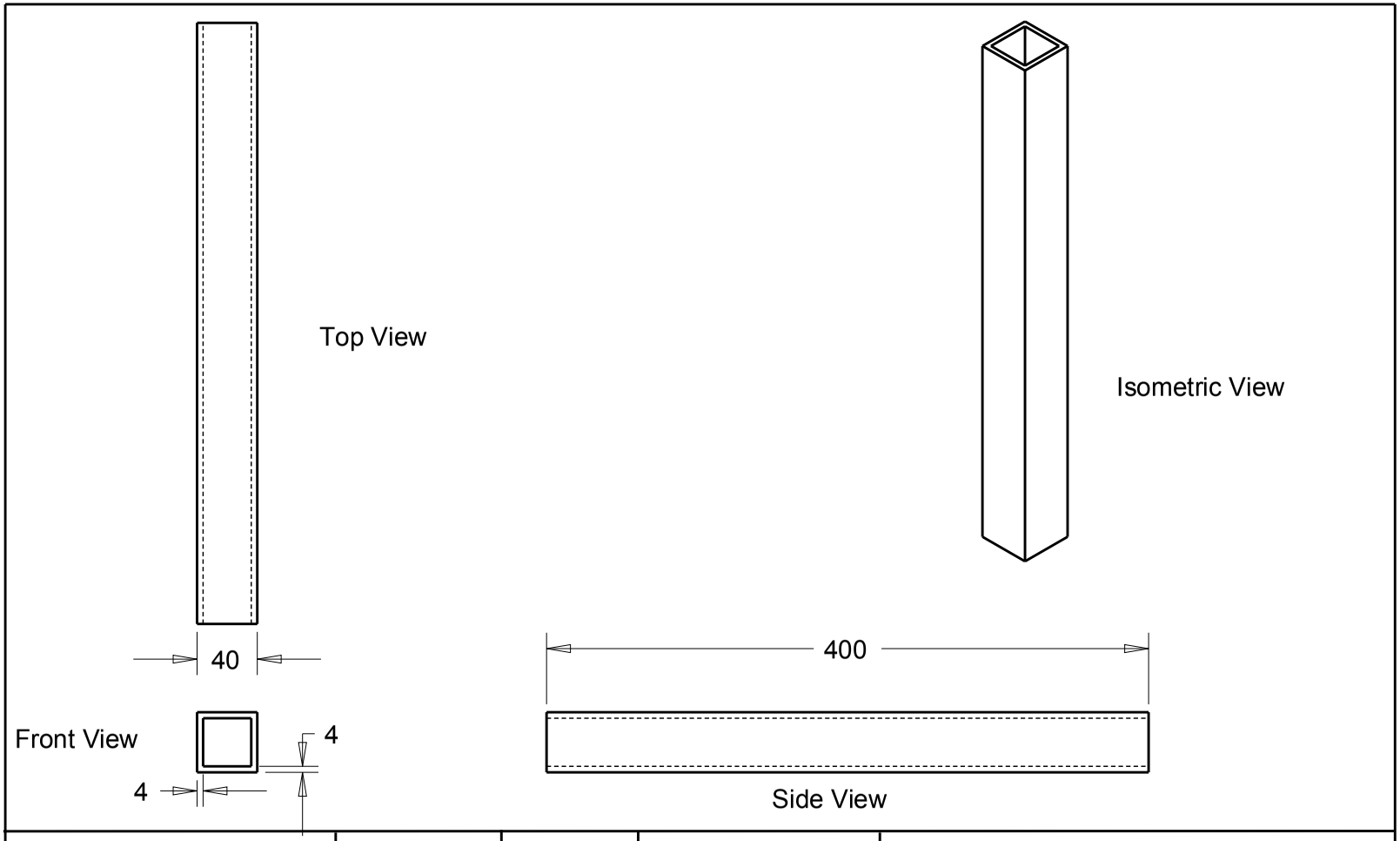


Front View

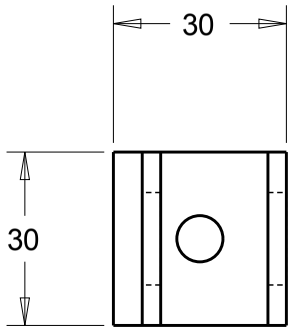


Side View

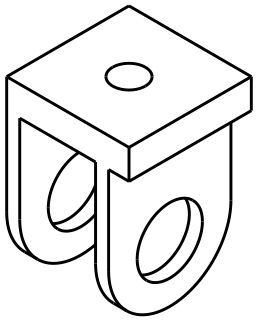
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Long Rectangular Block		
SUPERVISOR :	DATE:	SCALE: 1:5	PROJECTION :	DR.No.: 6	*CAL2*	
CORE STAFF :	DATE:	QTY : 10	TOL.: ±0.1	PART No.: 6	VERSION :	SHEET 6 OF 24



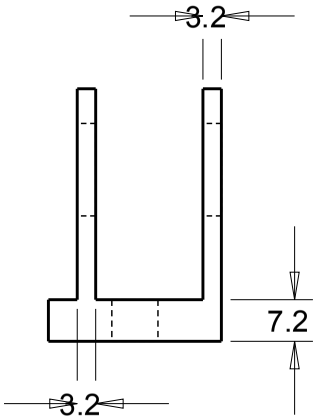
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Thick Rectangular Block		
SUPERVISOR :	DATE:	SCALE: 3:10	PROJECTION :	DR.No.: 7	*CAL2*	
CORE STAFF :	DATE:	QTY : 1	TOL.: ±0.1	PART No.: 7	VERSION :	SHEET 7 OF 24



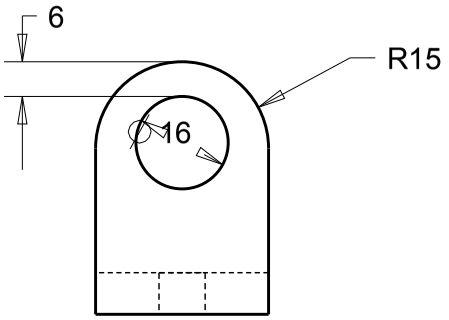
Top View



Isometric View

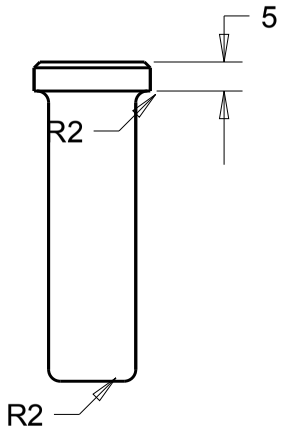


Front View

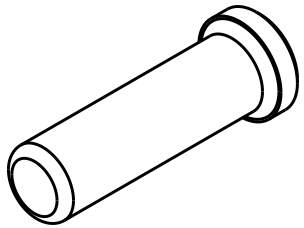


Side View

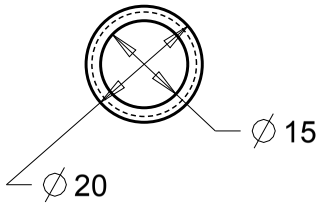
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Hinge		
SUPERVISOR :	DATE:	SCALE: 1:1	PROJECTION :	DR.No.: 8	*CAL2*	
CORE STAFF :	DATE:	QTY : 4	TOL.±0.1	PART No.: 8	VERSION :	SHEET 8 OF 24



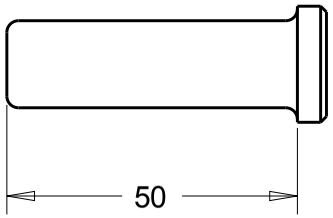
Top View



Isometric View

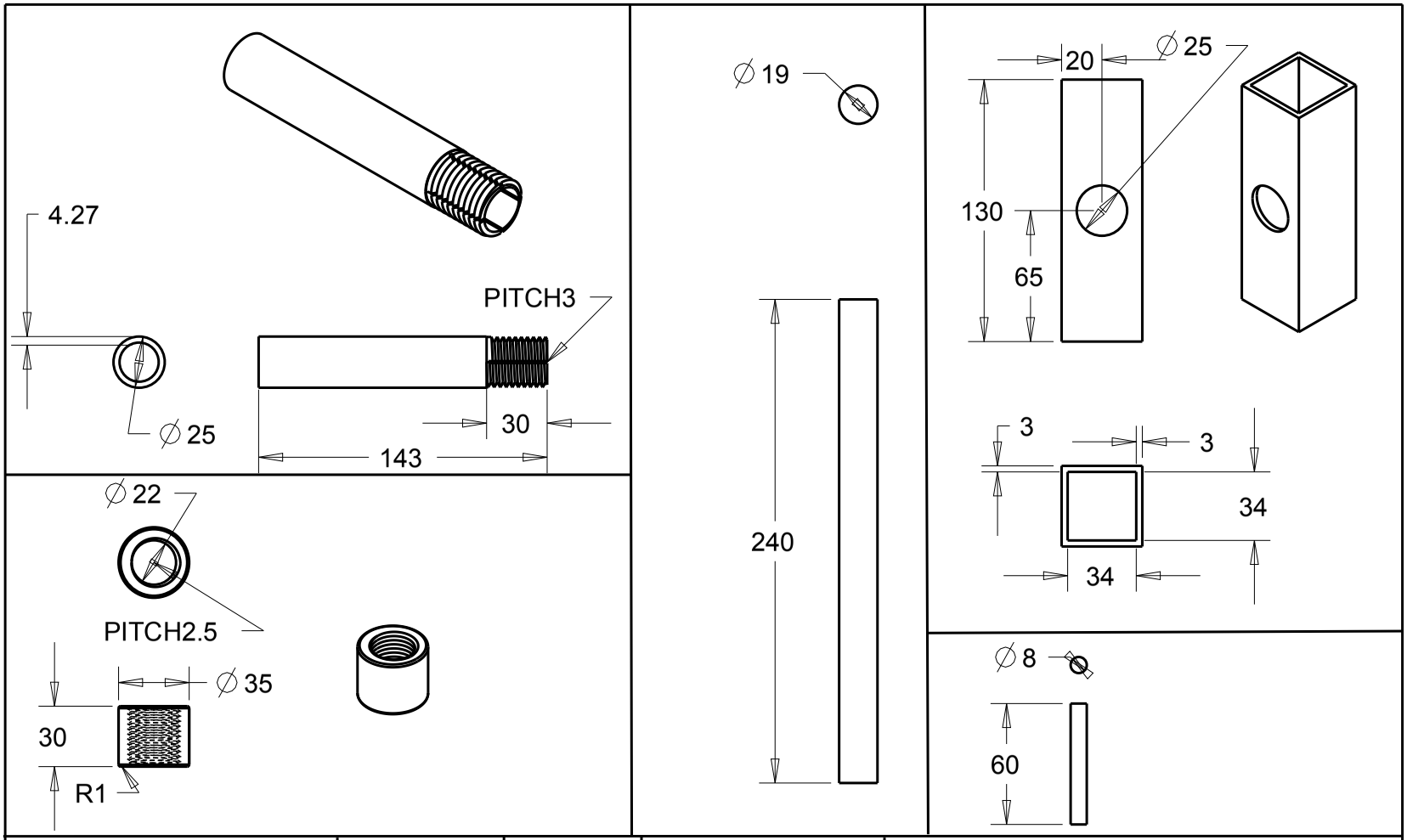


Front View

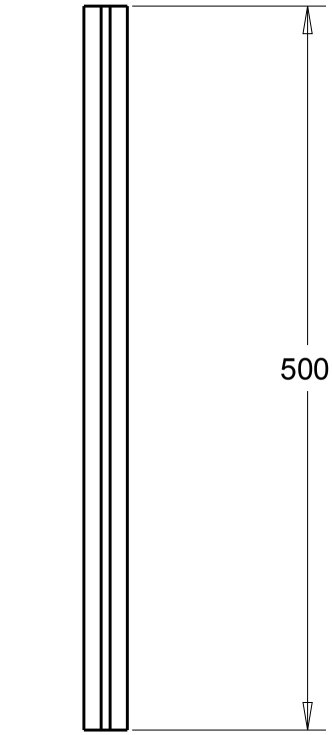


Side View

DRAWN BY :	DATE:	UNIT: mm	MAT'L:	TITLE: Hinge Pin		
SUPERVISOR :	DATE:	SCALE: 1:1	PROJECTION :	DR.No.: 9	*CAL2*	
CORE STAFF :	DATE:	QTY : 2	TOL.: ±0.1	PART No.: 9	VERSION :	SHEET 9 OF 24

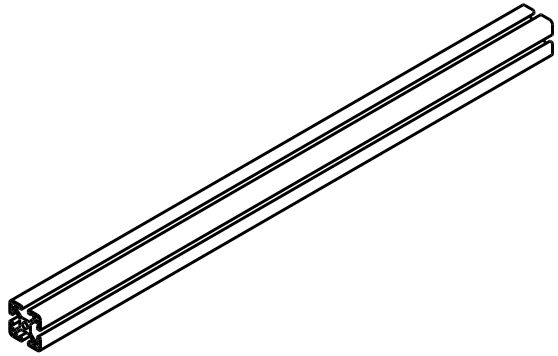


DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Extendable Screw Shaft Mechanism	
SUPERVISOR :	DATE:	SCALE: 2:5	PROJECTION :	DR.No.: 10	*CAL2*
CORE STAFF :	DATE:	QTY :	TOL.±0.1	PART No.: 10	VERSION : SHEET 10 OF 24

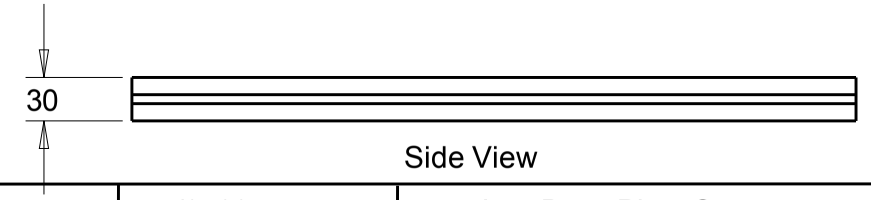


Top View

Front View

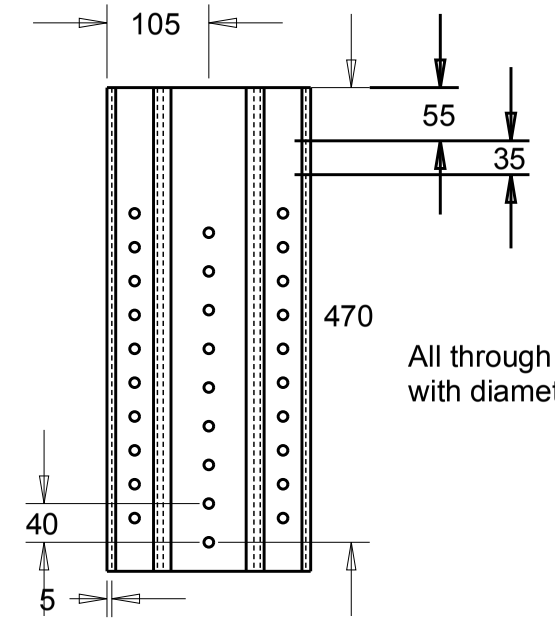


Isometric View



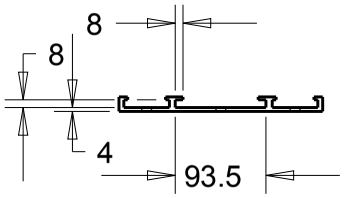
Side View

DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Leg Base Plate Support		
SUPERVISOR :	DATE:	SCALE: 1:4	PROJECTION :	DR.No.: 11	*CAL2*	
CORE STAFF :	DATE:	QTY : 2	TOL.: ±0.1	PART No.: 11	VERSION :	SHEET 11 OF 24

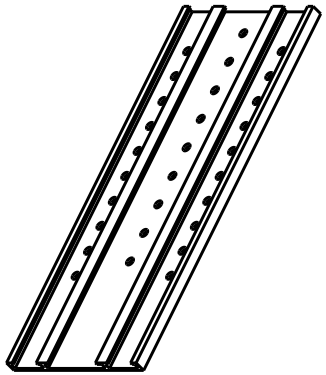


All through holes
with diameter of 10 mm

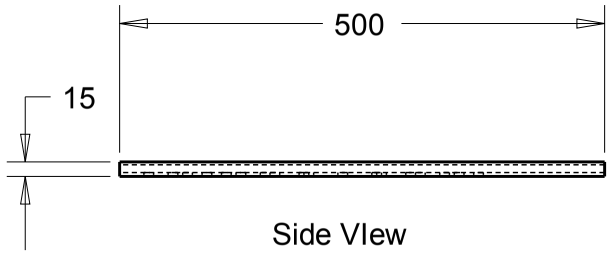
Top View



Front View

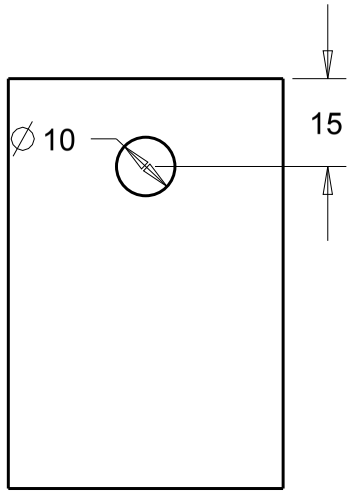


Isometric view

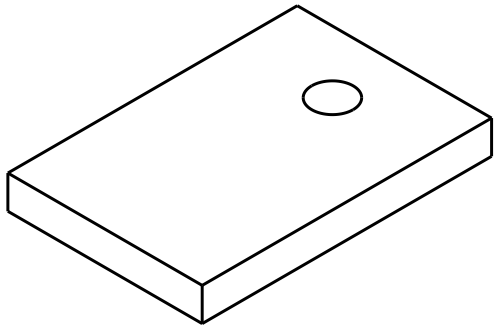


Side VIew

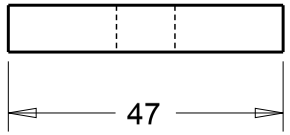
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Leg Base Plate		
SUPERVISOR :	DATE:	SCALE: 3:20	PROJECTION :	DR.No.: 12	*CAL2*	
CORE STAFF :	DATE:	QTY : 1	TOL.: ±0.1	PART No.: 12	VERSION :	SHEET 12 OF 24



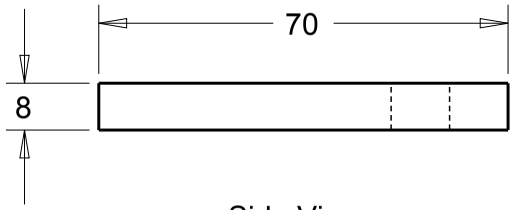
Top View



Isometric View

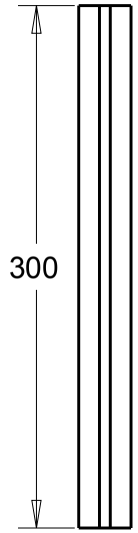


Front View

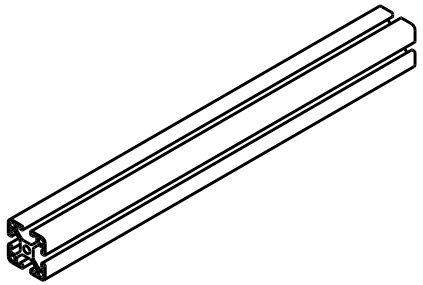


Side View

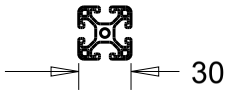
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Accessories Bar Slider		
SUPERVISOR :	DATE:	SCALE: 1:1	PROJECTION :	DR.No.: 13	*CAL2*	
CORE STAFF :	DATE:	QTY : 2	TOL.: ±0.1	PART No.: 13	VERSION :	SHEET 13 OF 23



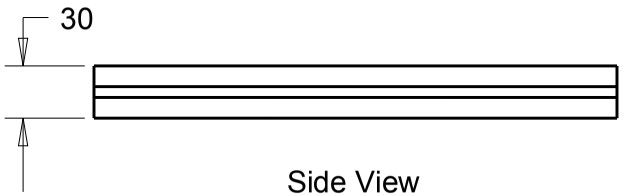
Top View



Isometric View

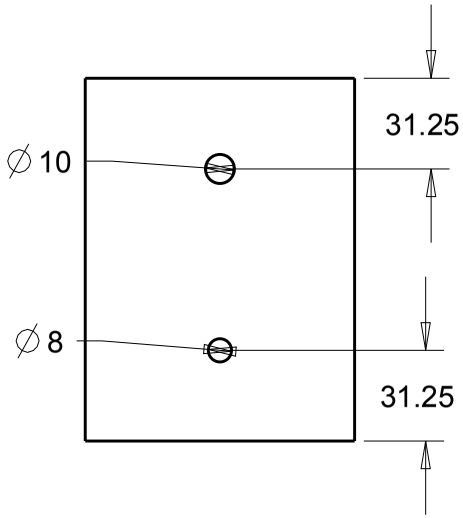


Front View

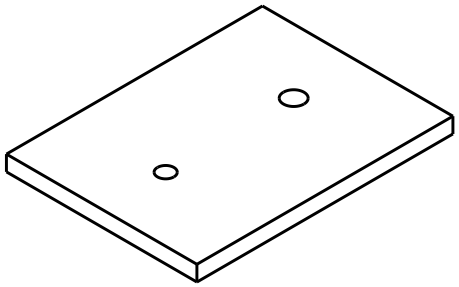


Side View

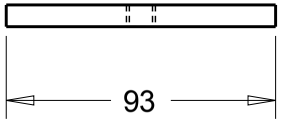
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Accessories Bar		
SUPERVISOR :	DATE:	SCALE: 3:10	PROJECTION :	DR.No.: 14	*CAL2*	
CORE STAFF :	DATE:	QTY : 2	TOL.: ±0.1	PART No.: 14	VERSION :	SHEET 14 OF 24



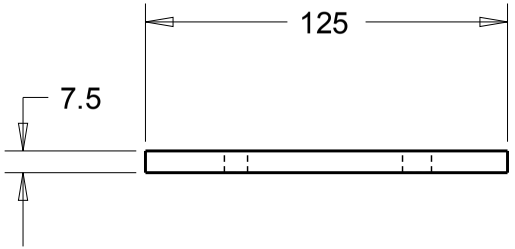
Top View



Isometric View

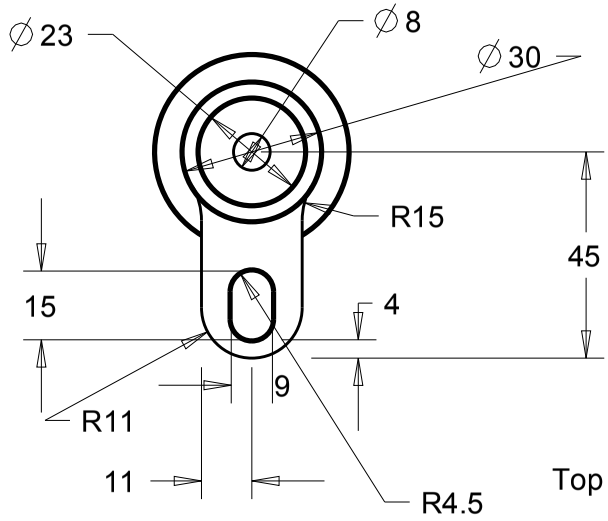


Front View

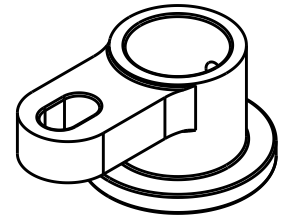


Side View

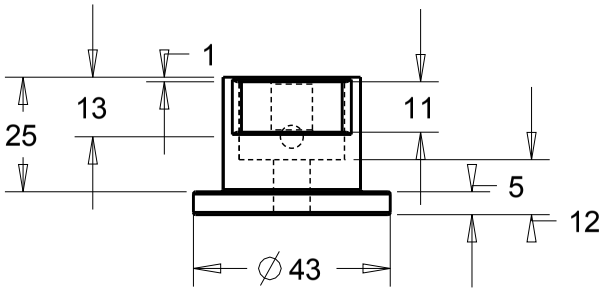
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Center Slider		
SUPERVISOR :	DATE:	SCALE: 1:2	PROJECTION :	DR.No.: 15	*CAL2*	
CORE STAFF :	DATE:	QTY : 1	TOL.: ±0.1	PART No.: 15	VERSION :	SHEET 15 OF 24



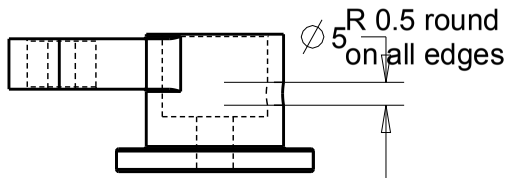
Top View



Isometric View

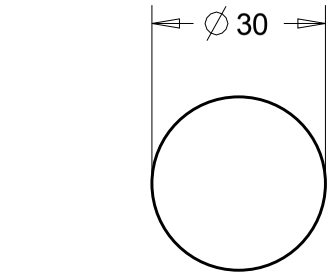


Front View

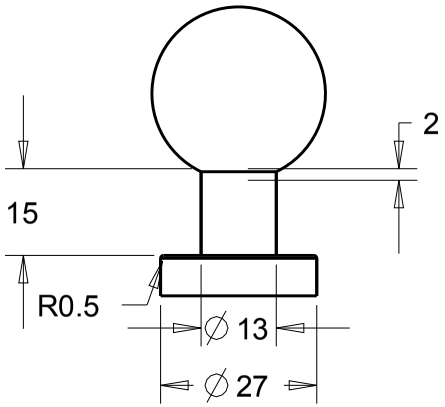


Side View

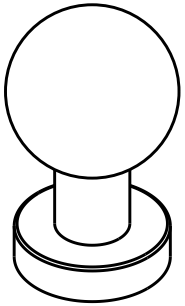
DRAWN BY :	DATE:	UNIT: mm	MAT'L: ABS	TITLE: Ball Joint Lock Base		
SUPERVISOR :	DATE:	SCALE: 4:5	PROJECTION :	DR.No.: 16	*CAL2*	
CORE STAFF :	DATE:	QTY : 1	TOL.: ±0.1	PART No.: 16	VERSION :	SHEET 16 OF 24



Top View

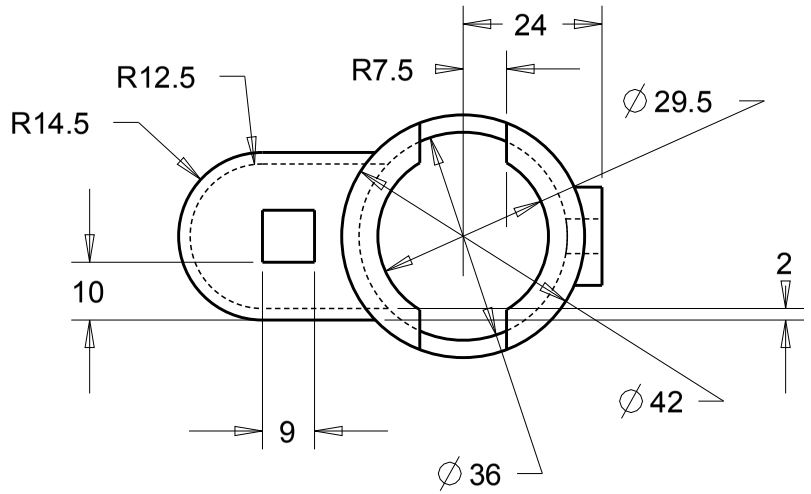


Front View

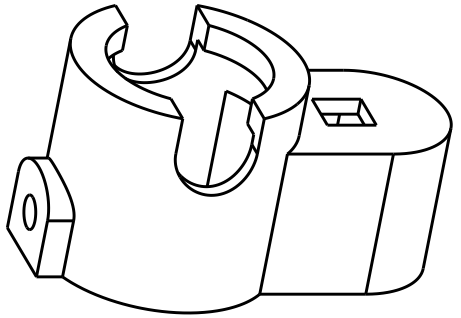


Isometric View

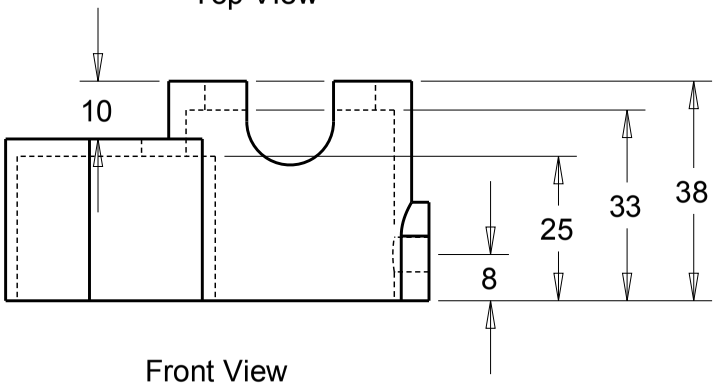
DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Ball Joint		
SUPERVISOR :	DATE:	SCALE: 1:1	PROJECTION :	DR.No.: 17	*CAL2*	
CORE STAFF :	DATE:	QTY : 1	TOL.: ±0.1	PART No.: 17	VERSION :	SHEET 17 OF 24



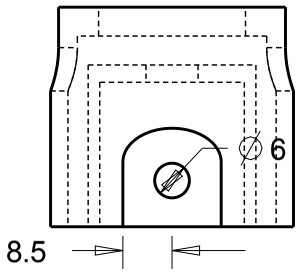
Top VIew



Isometric View

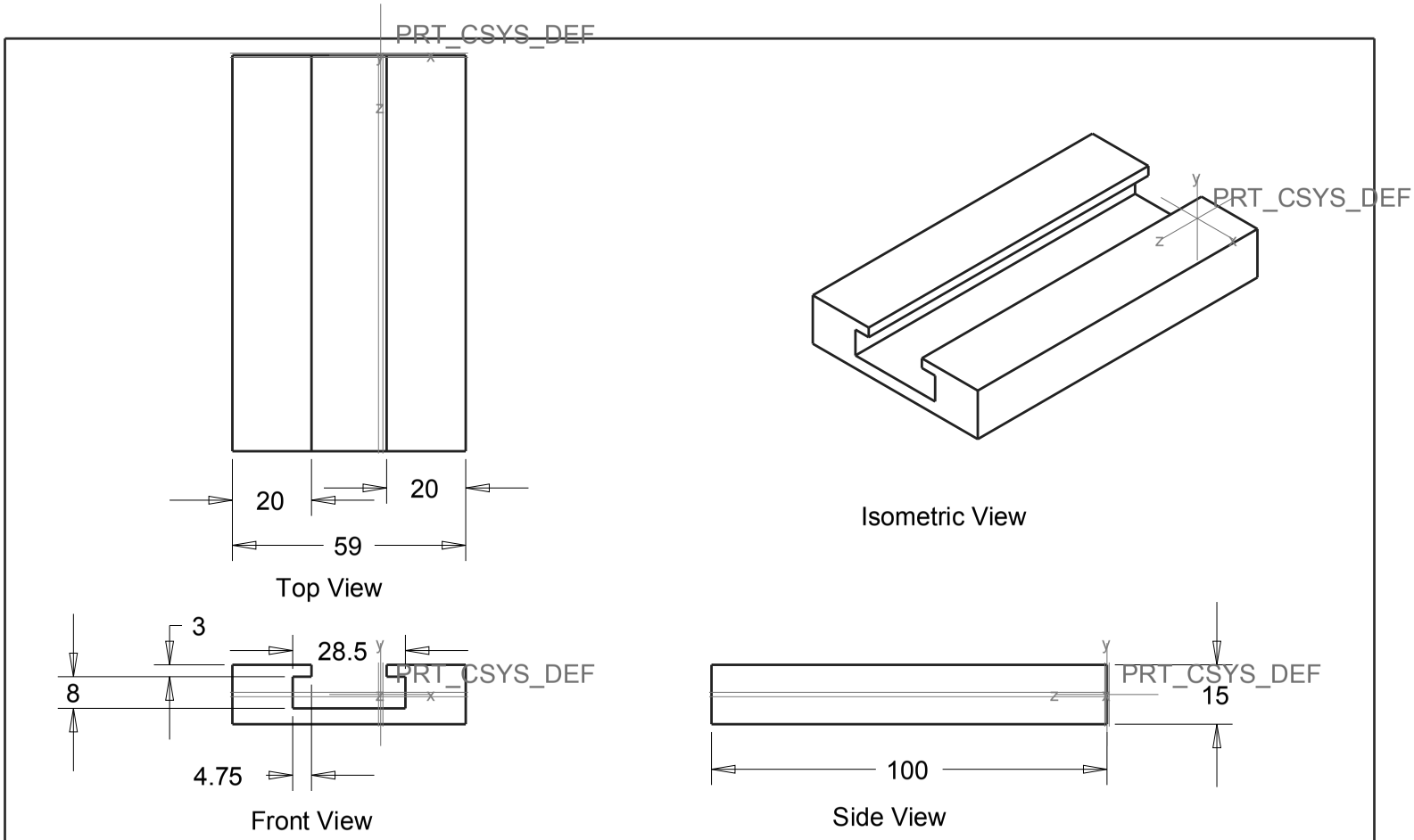


Front View



Side View

DRAWN BY :	DATE:	UNIT: mm	MAT'L: Aluminium	TITLE: Ball Joint Lock Cover	
SUPERVISOR :	DATE:	SCALE: 1:1	PROJECTION :	DR.No.: 18	*CAL2*
CORE STAFF :	DATE:	QTY : 1	TOL.: ±0.1	PART No.: 18	VERSION : SHEET 18 OF 24



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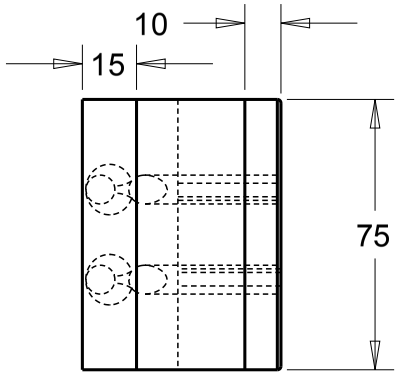
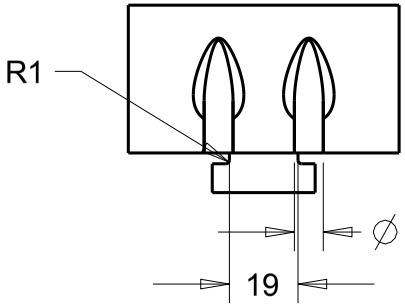
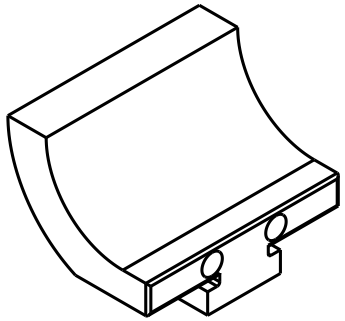
SUPERVISOR :	DATE:	SCALE: 4:5	PROJECTION :	DR.No.: 19	*CAL2*
CORE STAFF :	DATE:	QTY : 1	TOL: ±0.1	PART No.: 19	VERSION : SHEET 19 OF 24

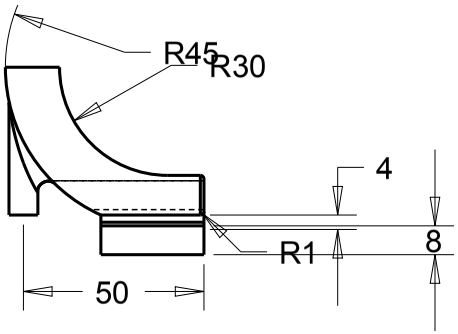


Top View



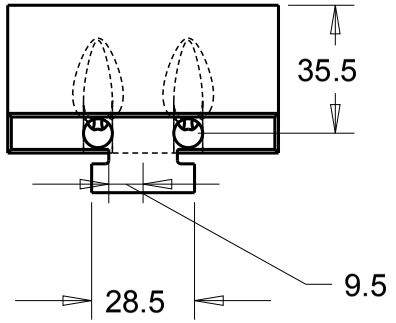


Isometric View

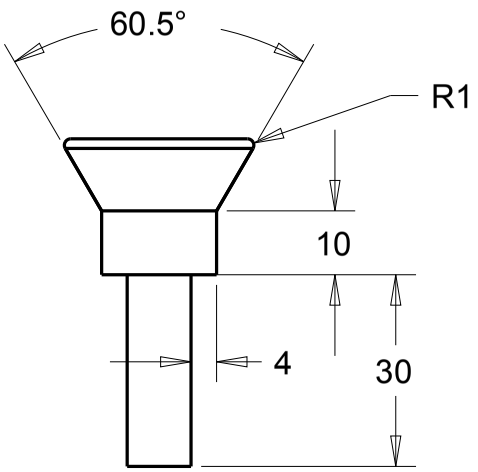


Front View

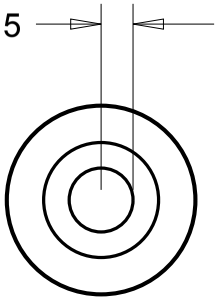
Side Views



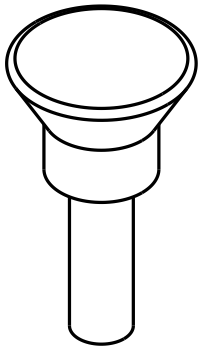
DRAWN BY :	DATE:	UNIT: mm	MAT'L: ABS	TITLE: Leg Holder		
SUPERVISOR :	DATE:	SCALE: 3:5	PROJECTION :	DR.No.: 20	*CAL2*	
CORE STAFF :	DATE:	QTY : 2	TOL.: ±0.1	PART No.: 20	VERSION :	SHEET 20 OF 24



Front View

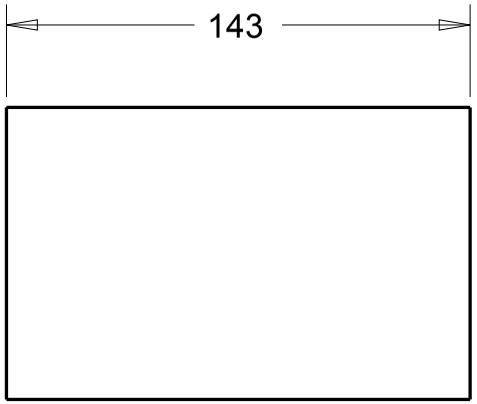


Top View

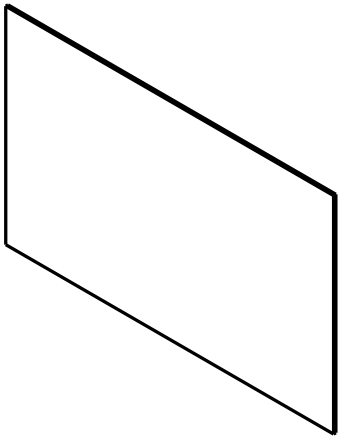


Isometric View

DRAWN BY :	DATE:	UNIT: mm	MAT'L: ABS	TITLE: Pin		
SUPERVISOR :	DATE:	SCALE: 1:1	PROJECTION :	DR.No.: 21	*CAL2*	
CORE STAFF :	DATE:	QTY : 3	TOL.: ±0.1	PART No.: 21	VERSION :	SHEET 21 OF 24

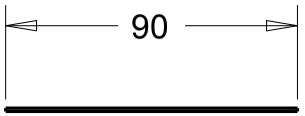


Front View



Isometric View

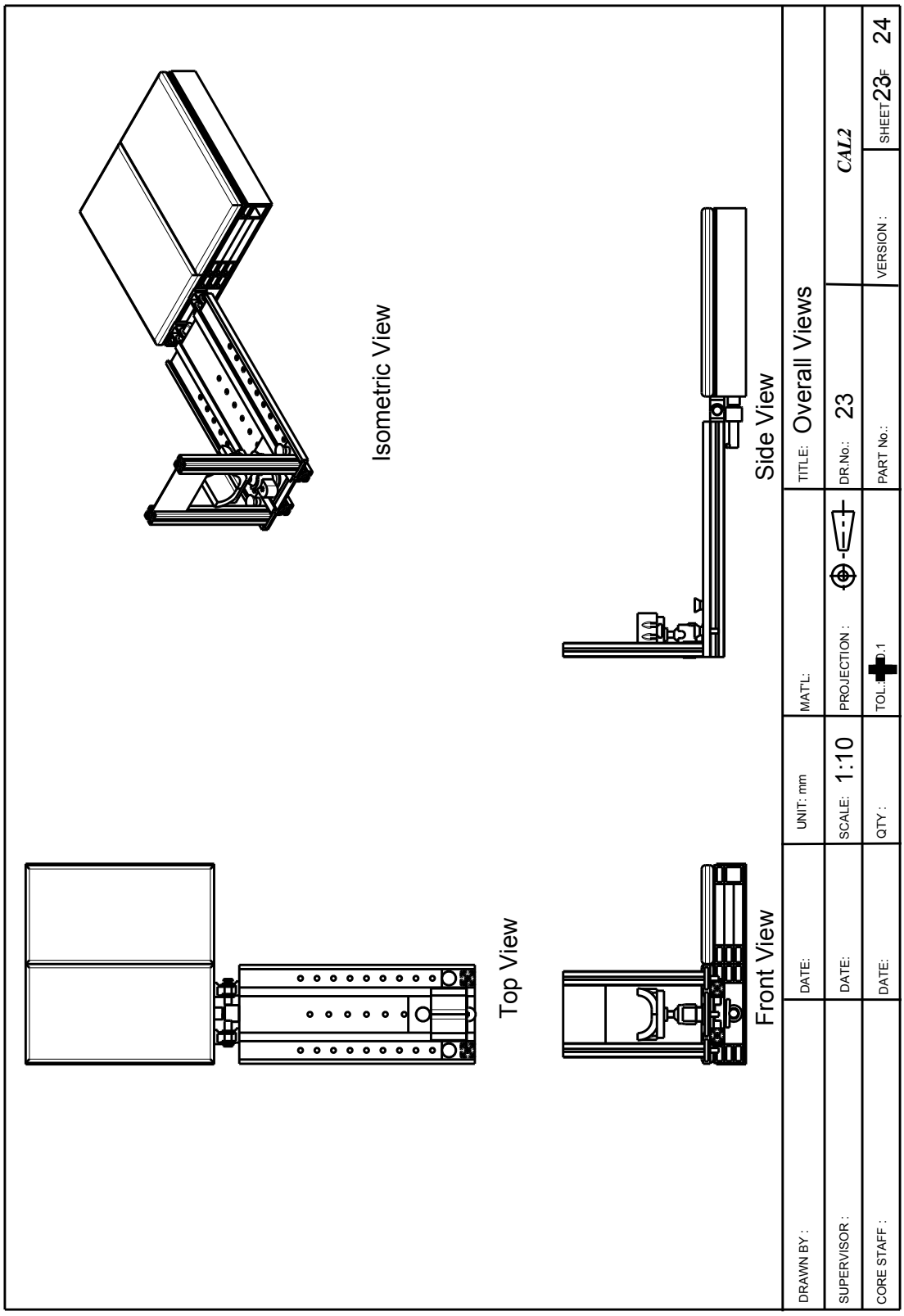
Top VIew



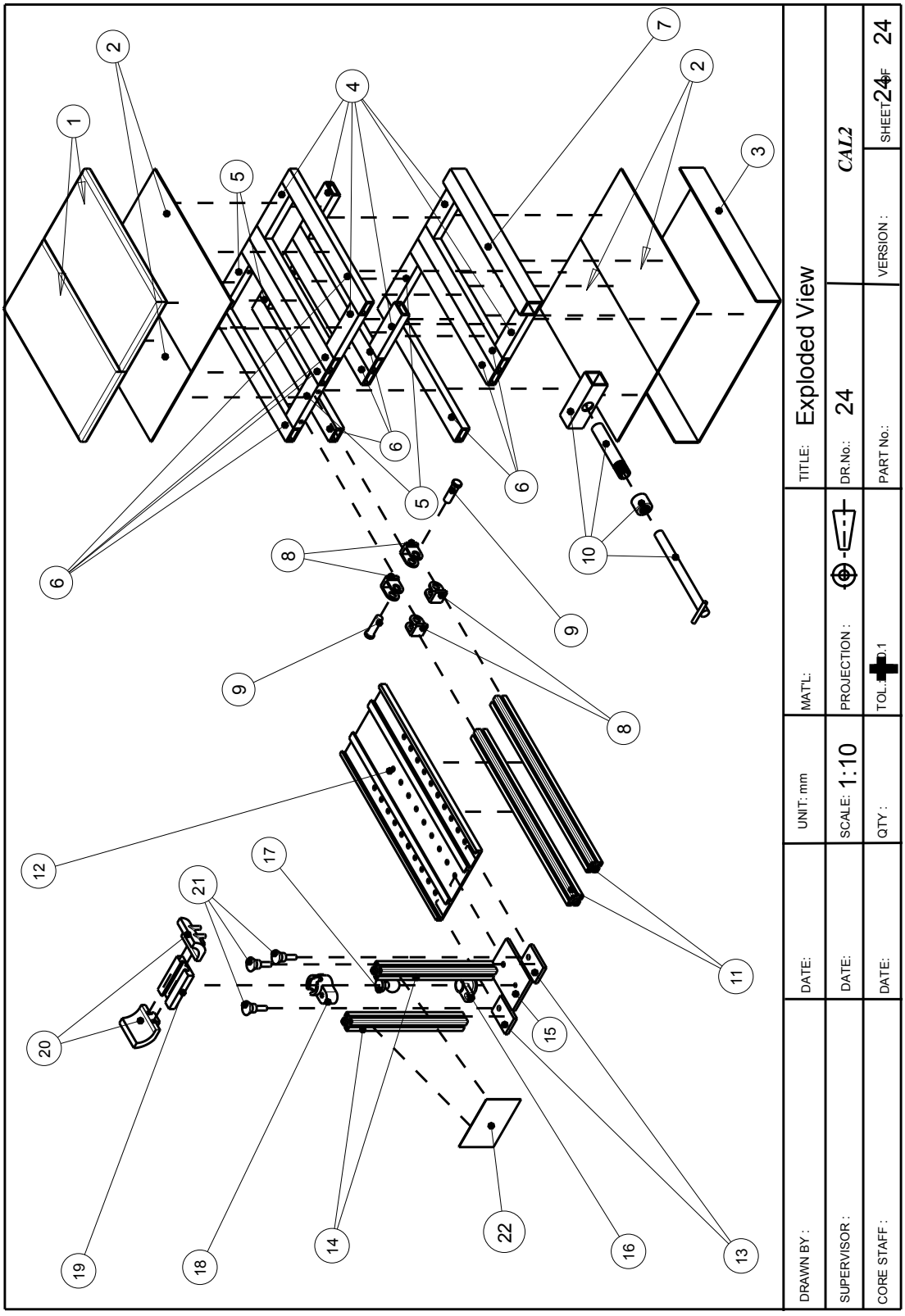
Side View

DRAWN BY :	DATE:	UNIT: mm	MAT'L:	TITLE: Tegaderm		
SUPERVISOR :	DATE:	SCALE:	PROJECTION :	DR.No.: 22	*CAL2*	
CORE STAFF :	DATE:	QTY :	TOL.: ±0.1	PART No.: 22	VERSION :	SHEET 22 OF 24

Working Drawing of Final Design



Exploded View with BOM



Exploded View with BOM - Continue

PT. No.	DESCPRTION	Material	QTY	Remarks
1	Cushion	PVC Leather	2	Purchased
2	Top & Base Plate	Aluminium	4	Manufactured
3	Structure Holder	Aluminium	1	Manufactured
4	Short Rectangular Block	Aluminium	6	Manufactured
5	Shortest Rectangular Block	Aluminium	4	Manufactured
6	Long Rectangular Block	Aluminium	10	Manufactured
7	Thick Rectangular Block	Aluminium	1	Manufactured
8	Hinge	Aluminium	4	Purchased
9	Hinge Pin	Aluminium	2	Purchased
10	Extendable Screw Shaft Mechanism	Aluminium	1	Manufactured
11	Leg Base Plate Support	Aluminium	2	Manufactured
12	Leg Base Plate	Aluminium	1	Manufactured
13	Accessories Bar Slider	Aluminium	2	Manufactured
14	Accessories Bar	Aluminium	2	Manufactured
15	Center Slider	Aluminium	1	Manufactured
16	Ball Joint Lock Base	ABS	1	Manufactured
17	Ball Joint	Aluminium	1	Manufactured
18	Ball Joint Lock Cover	Aluminium	1	Manufactured
19	Leg Holder Slider	Aluminium	1	Manufactured
20	U-Holder	ABS	2	Manufactured
21	Pin	ABS	3	Manufactured
22	Tegaderm	Plastic	1	Purchased

Manufacturing Process

To begin the manufacturing process for all the parts required in our design, we started off with something that we have not tried before. Since some parts are hard to manufacture, we decided to use 3D Printing to achieve the desired model.

3D Printing was done for parts such as the feet holder, ball-socket locking mechanism and a simple pin screw was also made with 3D Printing as we decided not to use a metallic pin as it is heavy and might contain sharp edges in the screw thread which could be harmful for the users.

Advantages of using 3D Printing

1. Less Waste and light in weight.
Manufacturing plastic and metal objects in particular is generally a wasteful process with a lot of surplus materials and chunky parts. The finished product of 3D printing can be up to 60 percent lighter than the machined part but still sturdy.

2. Cheap Manufacturing
3D printing helps companies save up to 70 percent of their manufacturing cost. This is attained through lower packaging and shipping costs related to more reliable and cheaper raw materials and lesser workforce needed, as well as overseas parts suppliers.

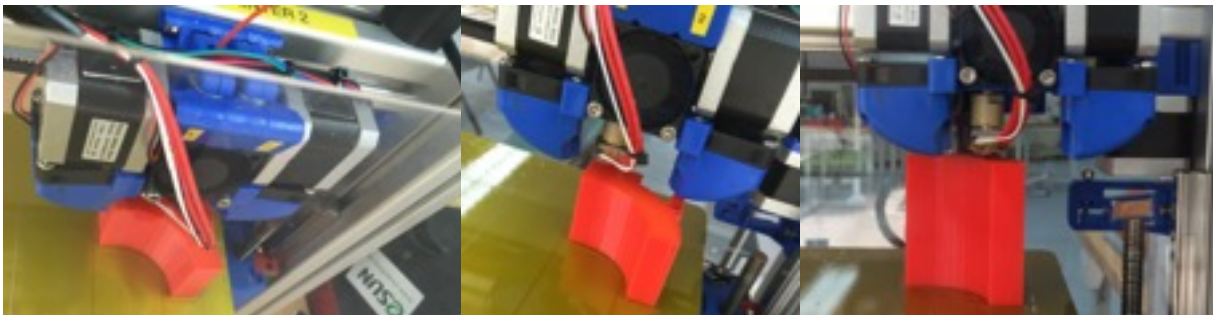
3. Quick Manufacturing
The speed of 3D printing is quicker as compared to the traditional method. It's similar to comparing the top speed of a sports car to a horse cart. They both take you to your destination, but the travel period differs significantly. With industrial 3D printing technologies being able to create an object in a few hours, the traditional manufacturing methods, taking up to two or more days (from prototype to finish product), are gradually becoming obsolete. 3D printing enables quick production of prototypes or small-scale versions of the real object. This helps researchers and engineers plan the actual object and catch any design flaws that may affect quality and functionality.

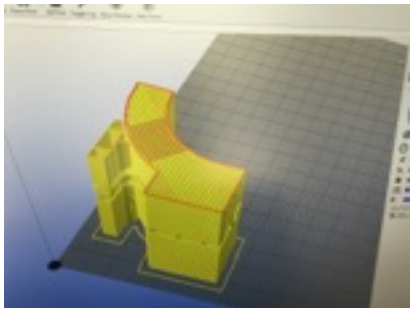
Advantages of ABS Plastic

- Excellent impact resistance. It can have good appearance for cosmetic parts. Strength is moderate. Good resistance to acids and bases.
- Flame Retardant
- Heat Resistance, High
- Impact Resistance, Good
- Impact Resistance, High
- Process-ability, Good

Plastic material used in 3D printing - **Acrylonitrile Butadiene Styrene (ABS)**

Step by Step Manufacturing

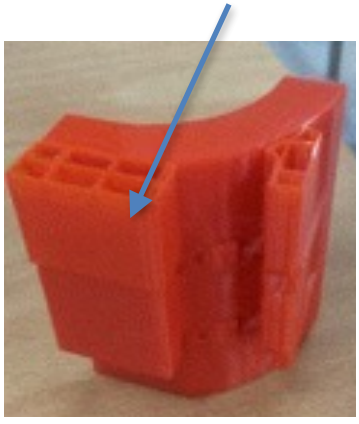


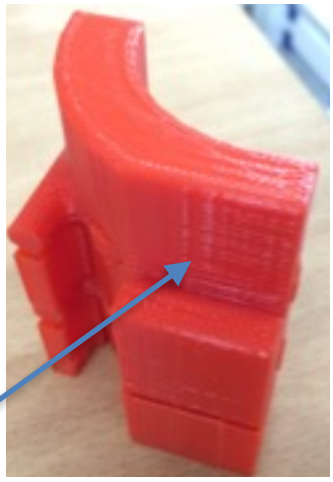


Making of the U-Shape Holder

Step 1: Draw out the Part File using Creo Parametric 2.0 and then proceed to convert it to a .Stl File after completing the model. We then sent the parts for 3D Printing and here are several shots captured in the process of printing the part.
-Material Strength is set to 70% as the material will be holding the feet under great forces.

Step 2: Cut off the extra pieces which was used as a support for the 3D printing and adjust accordingly.



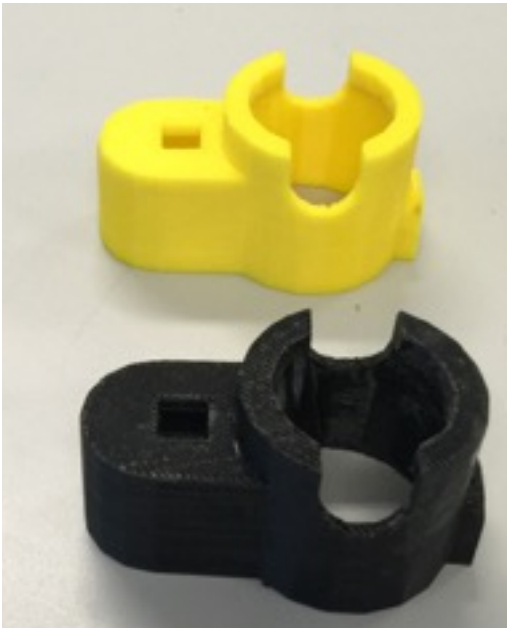


After cutting off

Step 3: File the part till its has a relatively smooth texture and done!

Making of the Housing for the Ball Joint

Measurements were taken and A part file was created through Creo Parametric.



The yellow piece was a prototype to see the outcome of the part. We then proceeded to increase the Strength of the material to 80% and thus, producing the black coloured housing.

Metal Casting was done as to withstand great force produced upon the part.

Making of the Ball Joint

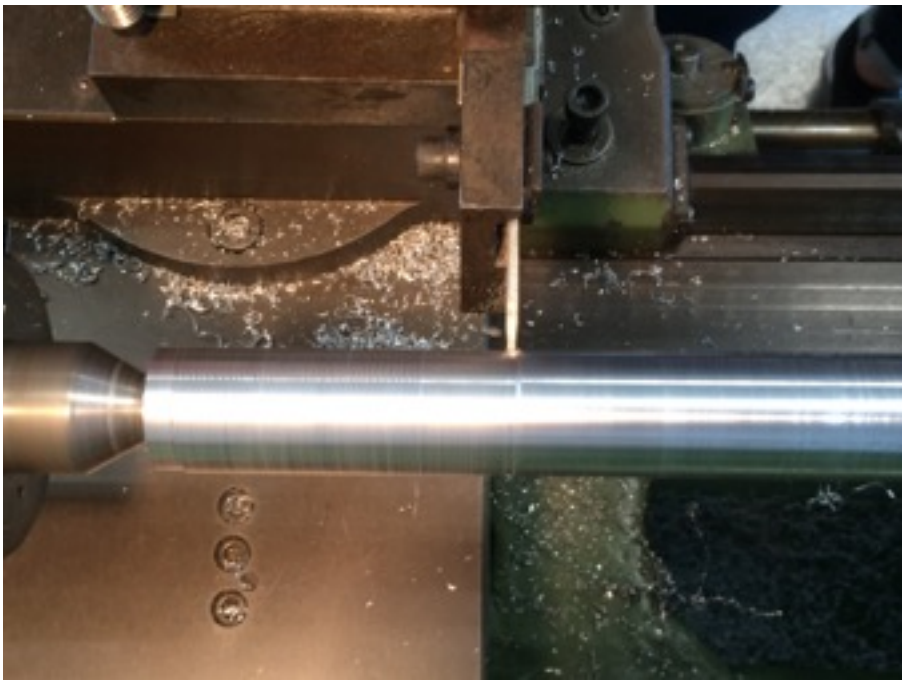
We decided to 3D Print the Cad file and experiment the Strength of the material.

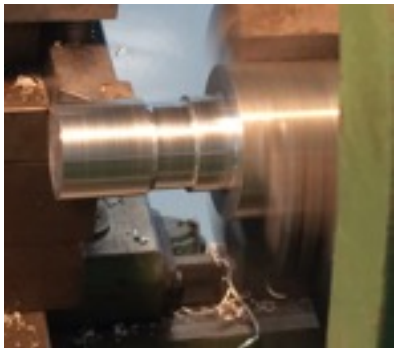
We printed the Blue coloured ball joint and the base resulted to be large to fit the housing joint and thus we re-measured and made amendments to our dimensions and sent in a new piece which is the black coloured ball joint.

To increase the durability and strength of the Locking Mechanism, we decided to turn the Ball Joint with aluminium rod.

After testing that it is able to fit the housing, we then proceeded to do turning.

All Safety precautions must be taken before using the Machines in the machining room.





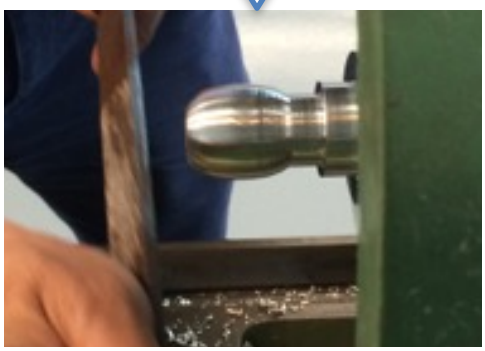
Step 1: Cut the long metal rod to a dimension of 70mm in length.

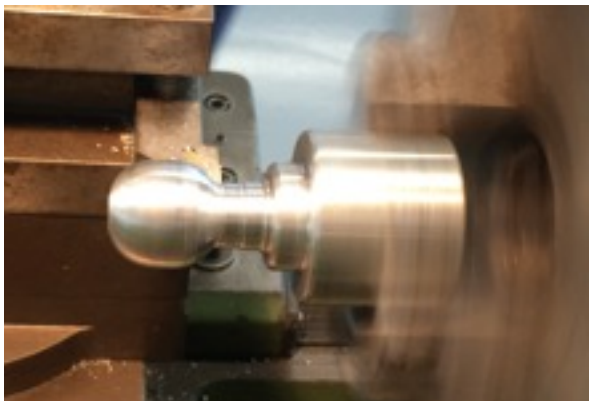
Step 2: Start turning the part with the carbon cutter and achieve the shape of the ball joint according to its measurements.

Step 3: Use the file to manually achieve the sphere shape carefully while in motion.

Step 4: Make a gauge to see if the diameter of the ball sphere is correct. The diameter of the sphere to reach is 30mm. We can know if the diameter is same when it fits the shape of the self-made gauge.

Repeat Step 3, till it fits the diameter of 30mm.

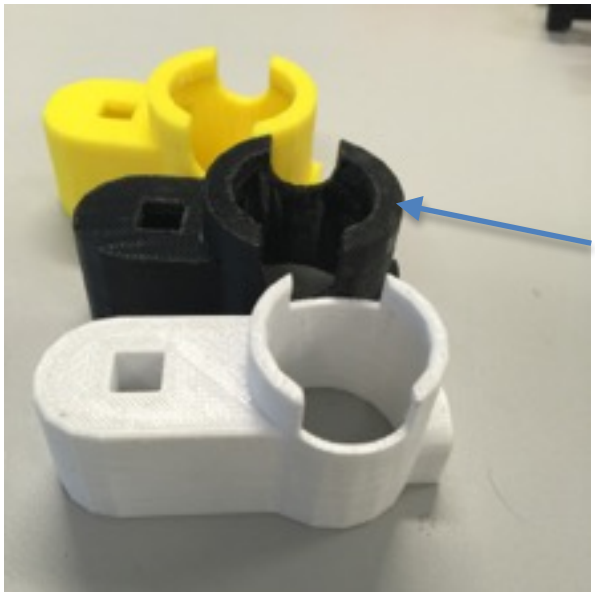




Step 5: The shape is achieved thereafter.

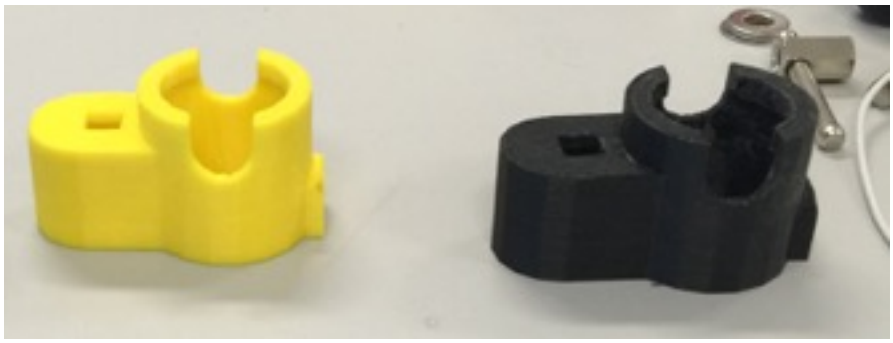
Making of the ball joint locking mechanism.

As seen in the White 3D printed part, the surface catch isn't as secured and wide enough to grip the ball joint.

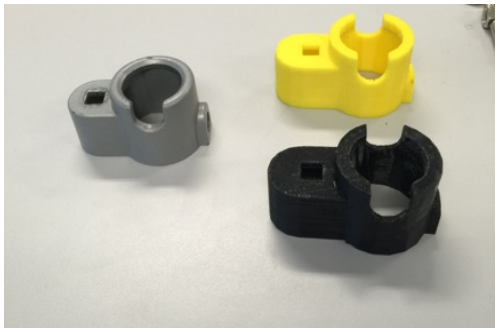


Thus, we decided to re-modify the dimensions and extend the grip so that the ball can easily sit on the slot and not go through it.

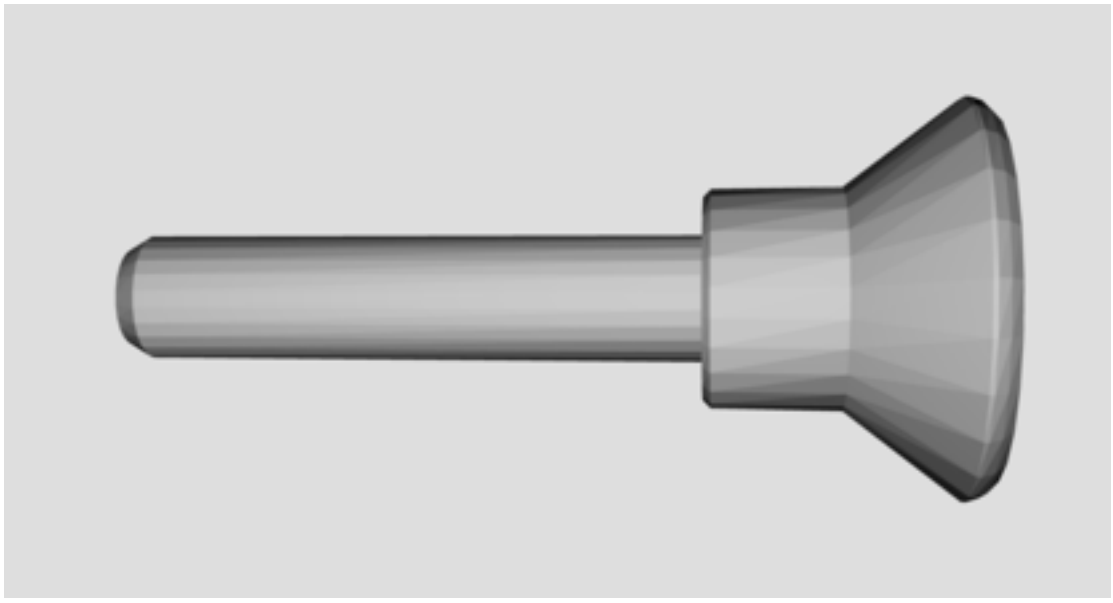
3D Printing was done to produce the prototype version of the locking mechanism. The white version was our initial prototype but we decided to make arrangements and adjust the design so that it is hollow like the black version.

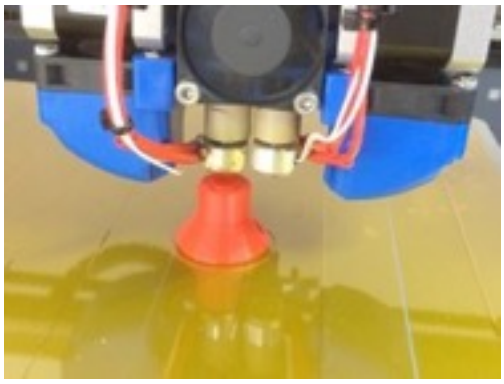


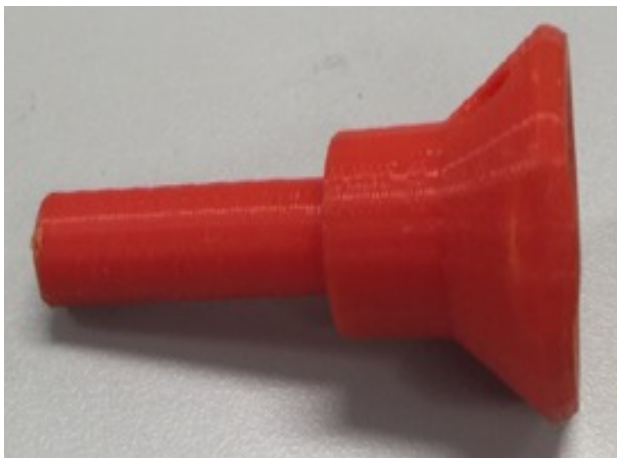
We then proceeded to cast the part as the dimensions were accurate in our 3D printing prototype.



Making of the Slot Holders.







Machining the base for the leg holder.

Next, we will proceed on with manufacturing the base where all the mechanism will be on. Due to the work piece being too big to be clamp on the vice, using the clamping tools will be much safer during manufacturing.

Step 1:

To ensure that the work pieces is clamped parallel with the clamping tools, we will need to use a parallel bar to offset the workpiece in the Y direction with the table to ensure the accuracy during milling.

With that, we will cut the work piece down in depth with a carbide cutter.

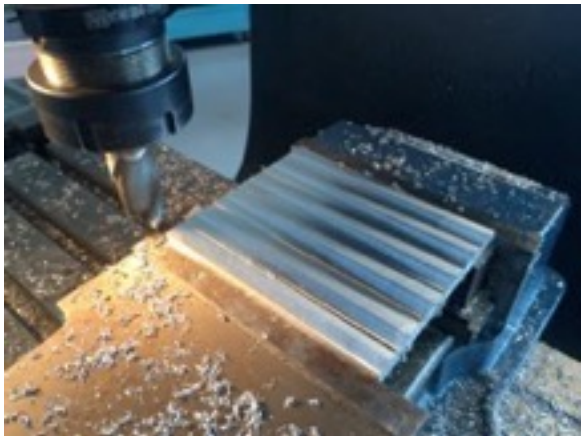
Step 2: we proceeded by using the T-Slot cutter to cut out the slots up to dimensions in the middle of the plate.

Finishing touches was then done when we achieved the dimensions required. Thus, producing a polished and well-finished look.The cutter was cutting at an increment of 10mm

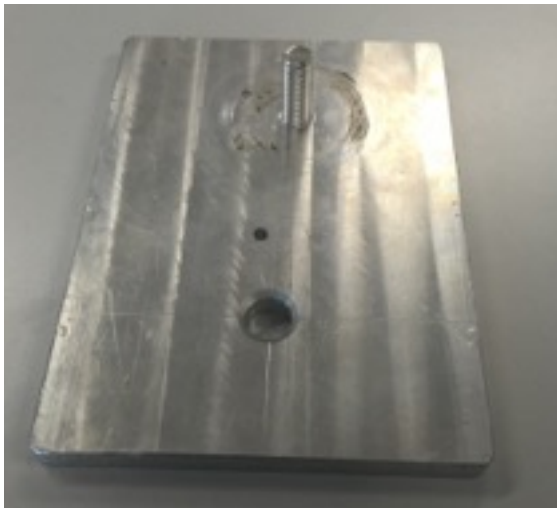
Step 3: We then proceeded to use the T-Slot cutter to cut out the slots at sides for our accessories. The cutter was cutting at an increment of 10mm to 15mm to achieve our desired dimensions with minimal human error possible.

Machining of the Accessory bar and the respective sliders.

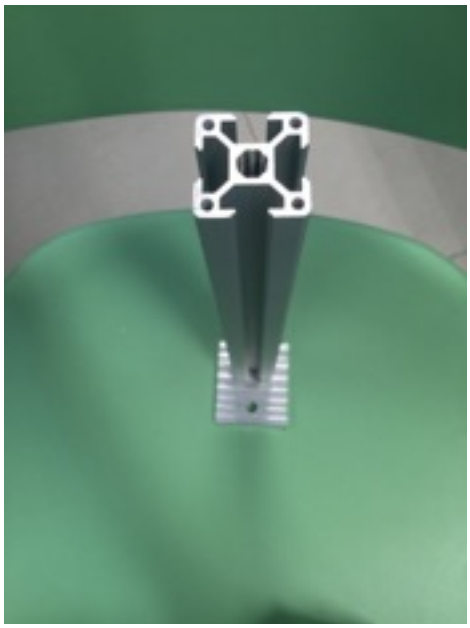
Middle Slider



We will now cut a block of metal piece that will be sliding in between the slots. To ensure a smooth movement when sliding, workpiece must have a smooth finishing.
Next, do a countersunk hole at the bottom of the surface where the locking mechanism is going to be placed.



Machining of the Accessory bars and its slider.



Step 1: Cut a profile bar to length.

Step 2: Next, Cut the slider to dimension

Step 3: Drill 2 holes, one for the countersunk and the other for the pin which will be holding the slider onto the aluminium plate.

Machining of the Base - To sit on.

Machining of parts (Seat)

Step 1. Handsaw the 1m aluminium rectangular block to about 10 pieces with around 10mm of tolerance at the ends.

Step 2. Handsaw 1 of the thick aluminium block out with around 10mm of tolerance at the ends.

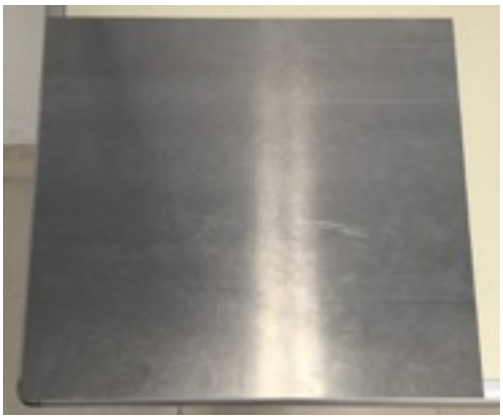
Step 3. Handsaw the rest of the short aluminium rectangular block of 2 different length out with around 10mm of tolerance at the ends.

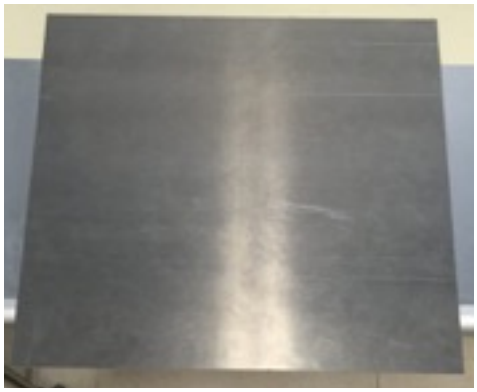
Step 4. With a milling machine, do a finishing cut to all the blocks.

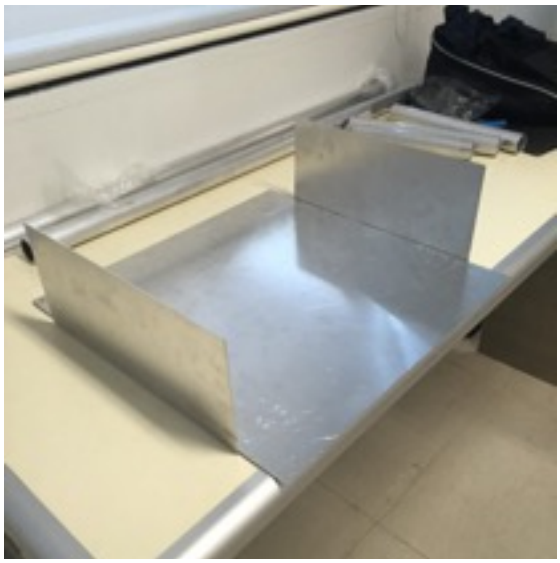
Step 5. With a milling machine, mill 2 slots from 4 of the 10 rectangular blocks.

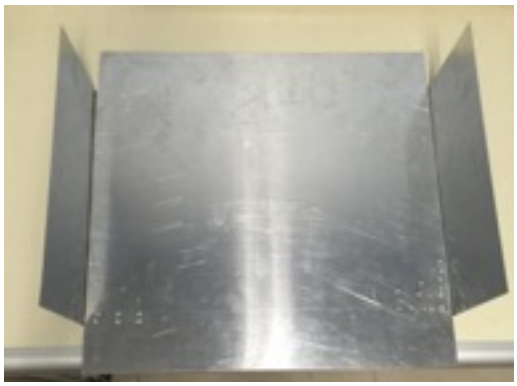
With the top plate being cut in size by the vendor, we may now proceed in mounting all the parts together.

Spot Welding of the Base Plate





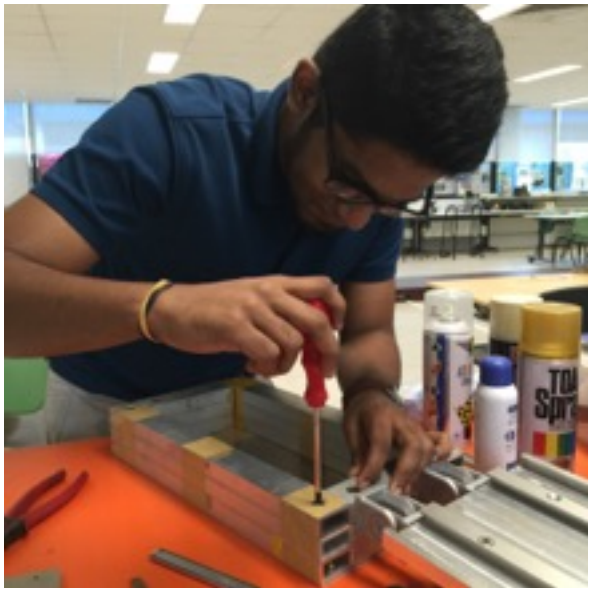




Spraying of the Final Product

We recommend the user to spray the product part by part and not as a whole piece after assembling. This ensures that all the parts are spray painted equally and properly.

Screwing and Assembling of Prototype.



Fasten the parts with M4 Screw followed by a spring washer and a nut. This allows the parts to be firm and strong at its position. By Using the spring washer, it allows the parts to be strongly fastened and not move about its position.

After Manufacturing - Final Outcome

(Can be used on various chairs)

Step-By-Step Process on Application

Figure 1

Figure 2

Figure 3

Figure 4

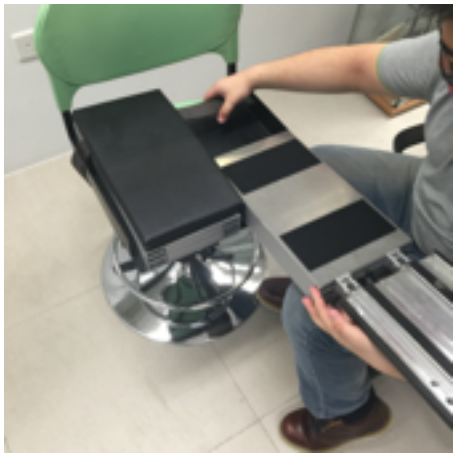


Figure 5

Figure 6

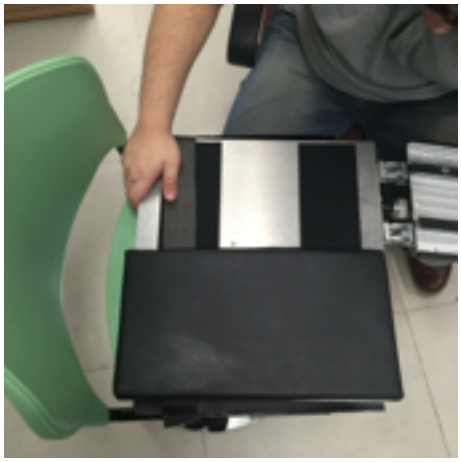


Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

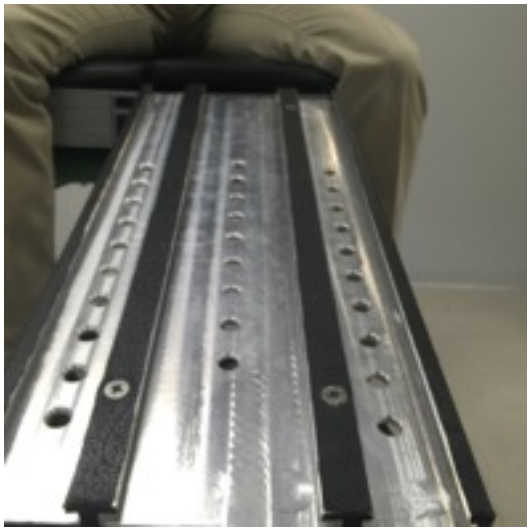
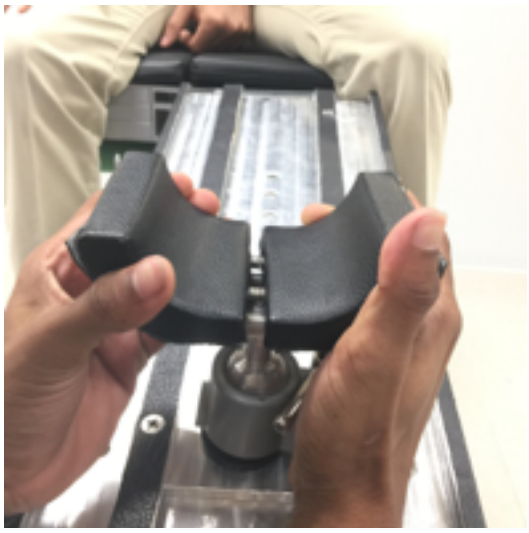


Figure 17

Figure 18

Figure 19



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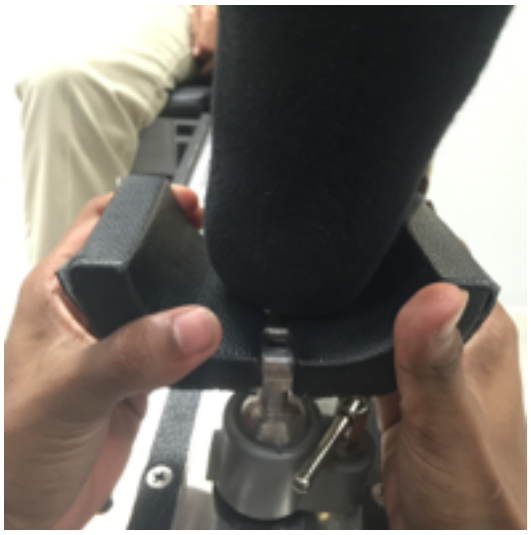

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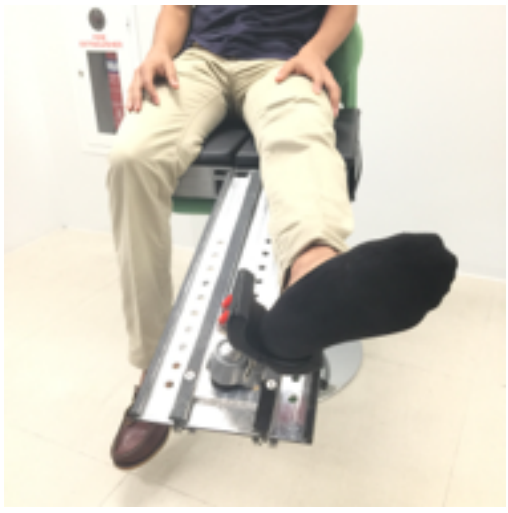


Figure 22

Figure 23

Figure 24

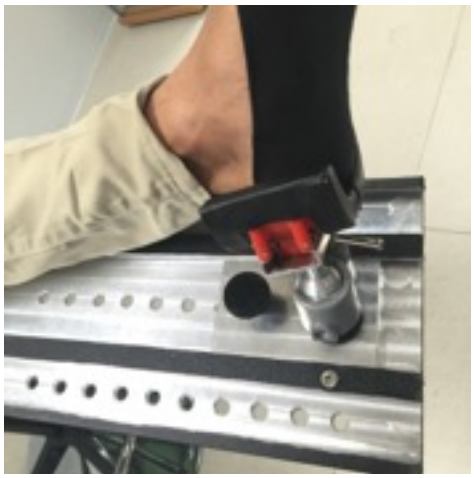


Figure 25

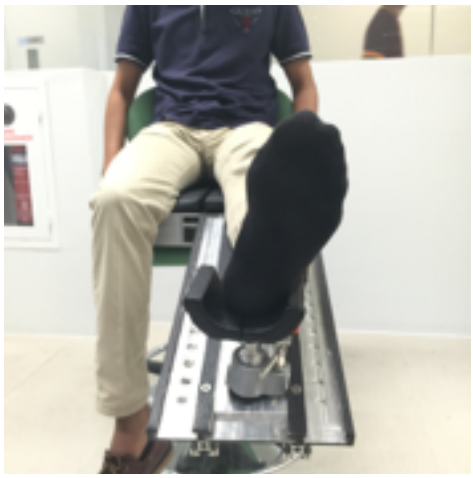


Figure 26

Figure 27

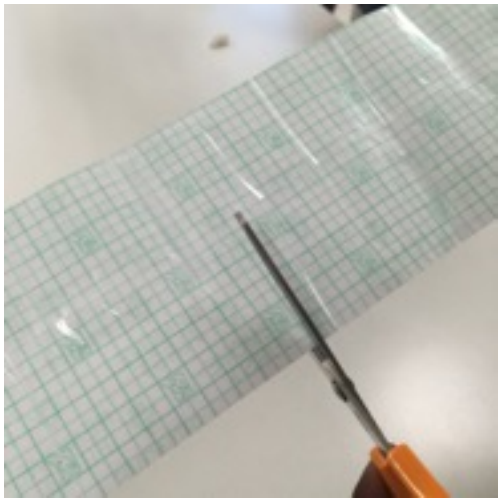


Figure 28

Figure 29

Figure 30

Figure 31

Figure 32

Figure 33

Figure 34

Figure 35

Figure 36

Step-By-Step Process on Changing seat

Figure 37

Figure 38

Figure 39

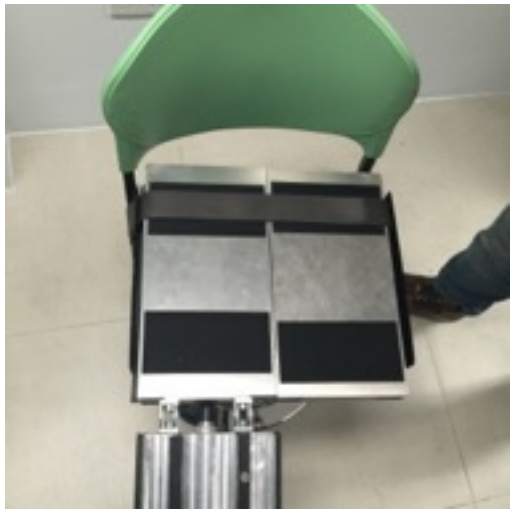


Figure 40

Figure 41

Figure 42

Figure 43

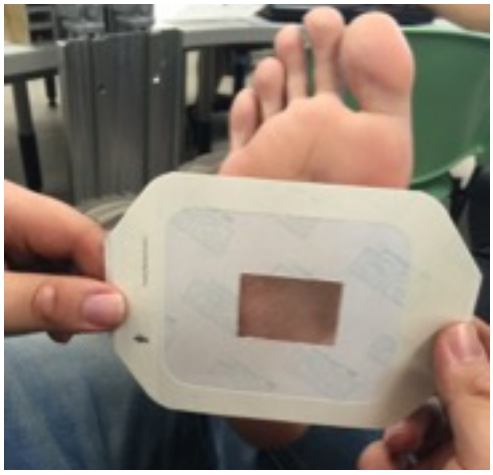


Figure 28i

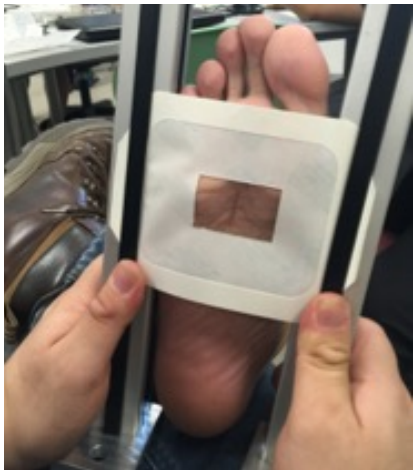


Figure 28ii

Figure 28iii

Figure 28iv

Figure 1 to 2 - Firstly, the seat holder should be set up on the respective chair which will be used- as shown in above picture.

Figure 3 to 4 - Place the cushioned modular seats onto the seat holder. Make sure the seat belt is inserted into the seat belt slot and fastened properly.

Figure 5 to 7 - Place the remaining seat onto the base of the seat holder and adjust accordingly. Make sure to fasten the seat belt once the seats are comfortably placed.

Figure 8 to 11 - These images show how to fasten the seat belt under the seat. In figure 11, the seat belt has to be tight and the strap must be under tension so that it doesn't slip off easily.

Figure 12 to 14 - Adjust the Screw Shaft Mechanism by turning the ring clockwise to lock it. To unlock the shaft, the ring must be turned counterclockwise to loosen the shaft. The user can adjust the length accordingly to fit the height of the leg plate (which will be resting on the shaft).

Figure 15 to 16 - Once the Mechanism is locked in place, the leg plate can be placed onto the shaft and it will be firm.

Figure 17 to 19 - Let the patient sit on the chair and gauge the patient's leg length by making him place the leg on the leg plate. Once the length is gauged you can proceed to prepare the feet locking mechanism.

Figure 20 to 21 - After gauging the position of the feet locking mechanism, use the black pins on the plate to lock the placing of it and Place the feet on the Feet size accommodator and adjust the mechanism to the patient's feet width.

Figure 22 to 26 - Once the feet is on the feet locking mechanism, Adjust it by bringing it upright facing the user's sight of vision. Once thats completed, lock it in place by using the feet locking mechanism and it will hold the feet in place.

Figure 27 to 32- Firstly, the feet is in its natural plantar flexion state where the feet is facing forward. The podiatrist has to then cut out the plastic films. Next, the podiatrist has to see which area he/she wants to operate and work on. Followed by cutting a random shaped hole on the plastic sheet once the place is confirmed. Thirdly, slide in the plastic sheet of paper into the profile bar and lock it in place with the black plastic strips. As the slot fits perfectly, the podiatrist can remove the white plastic and proceed to paste it on the feet. After its on the feet, the podiatrist has to just drag the profile bar behind to provide a decent dorsiflexion for the surgery.

Figure 33 to 35 - Place the plastic films on the feet and prepare to drag the profile bar backwards to provide the decent tension. Lock the profile bar into the slots with the pin provided. Thus allowing it to stay in position.

Figure 36 - The final outcome of the process.

Figure 37 to 40 - Remove the seat with the leg plate and place it on the other side and proceed the step used in F**igure 3 to 7.**

Figure 41 to 43 - The Seats can be used on various chairs.

Bill of Materials - Cost

PT. No.	DESCPRTION	QTY	Cost
1	Cushion	2	$50
2	Top & Base Plate	4	$80
3	Structure Holder	1	$20
4	Short Rectangular Block	6	$80
5	Shortest Rectangular Block	4	
6	Long Rectangular Block	10	
7	Thick Rectangular Block	1	$20
8	Hinge	4	$10
9	Hinge Pin	2	
10	Extendable Screw Shaft Mechanism	1	$20
11	Leg Base Plate Support	2	$20
12	Leg Base Plate	1	$50
13	Accessories Bar Slider	2	$10
14	Accessories Bar	2	$20
15	Center Slider	1	$15
16	Ball Joint Lock Base	1	$30
17	Ball Joint	1	FOC
18	Ball Joint Lock Cover	1	FOC
19	Leg Holder Slider	1	$30
20	U-Holder	2	$20
21	Pin	3	FOC
22	Tegaderm	1	$13

Total cost: $488

Planning and Scheduling

Planned	
complete	

Week 1 to Panel 1

No	Agenda	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1	Research on Foot Rehabitation						
2	Planning on project and synopsis						
3	Existing Product research						
4	Idea generation and finalization of idea						
5	Presentation for panel 1						

Week 7 to panel 2

No	Agenda	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
6	Remodification of ideas						
7	Drawing of 3 ideas and finalised ideas						
8	SCAMPER and detailed drawing						
9	Prototype making and estimated cost						
10	Panel 2						

Week 13 – Panel 3

No	Agenda	Week 13	Week 14	Week 15	Week 16
11	Modifications to the finalised idea				
12	Detailed drawing of the finalised idea				
13	Calculations and specifications				
14	Cost of project				
15	Panel 3				

Week 16 to Panel 4

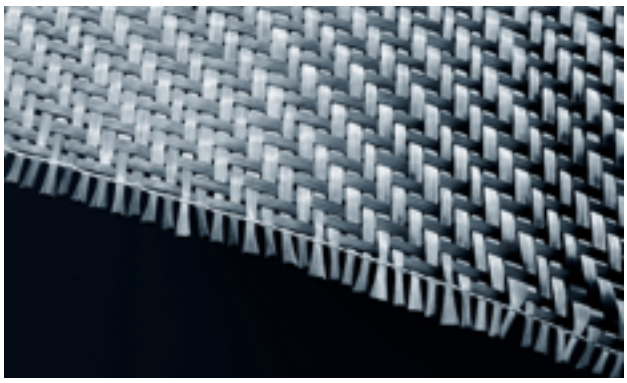
NO	Agenda	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21
16	Preparations of materials						
17	Measurements and precision cutting						
18	Fabrication and design						
19	Safety and assembling and testing						
20	Modifications						
21	Panel 4						

Week 21 – Panel 5

S/N	Agenda	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26
22	Adjustments						
23	Modifications to finalise						
24	Testing						
25	Conclusion						
26	Preparation of panel 5						
	Prepare for project inspection and improvements.						

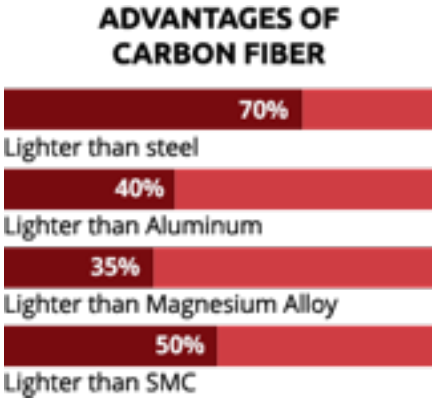
Future Improvements

1.) Carbon Fibre Body - Light Weight



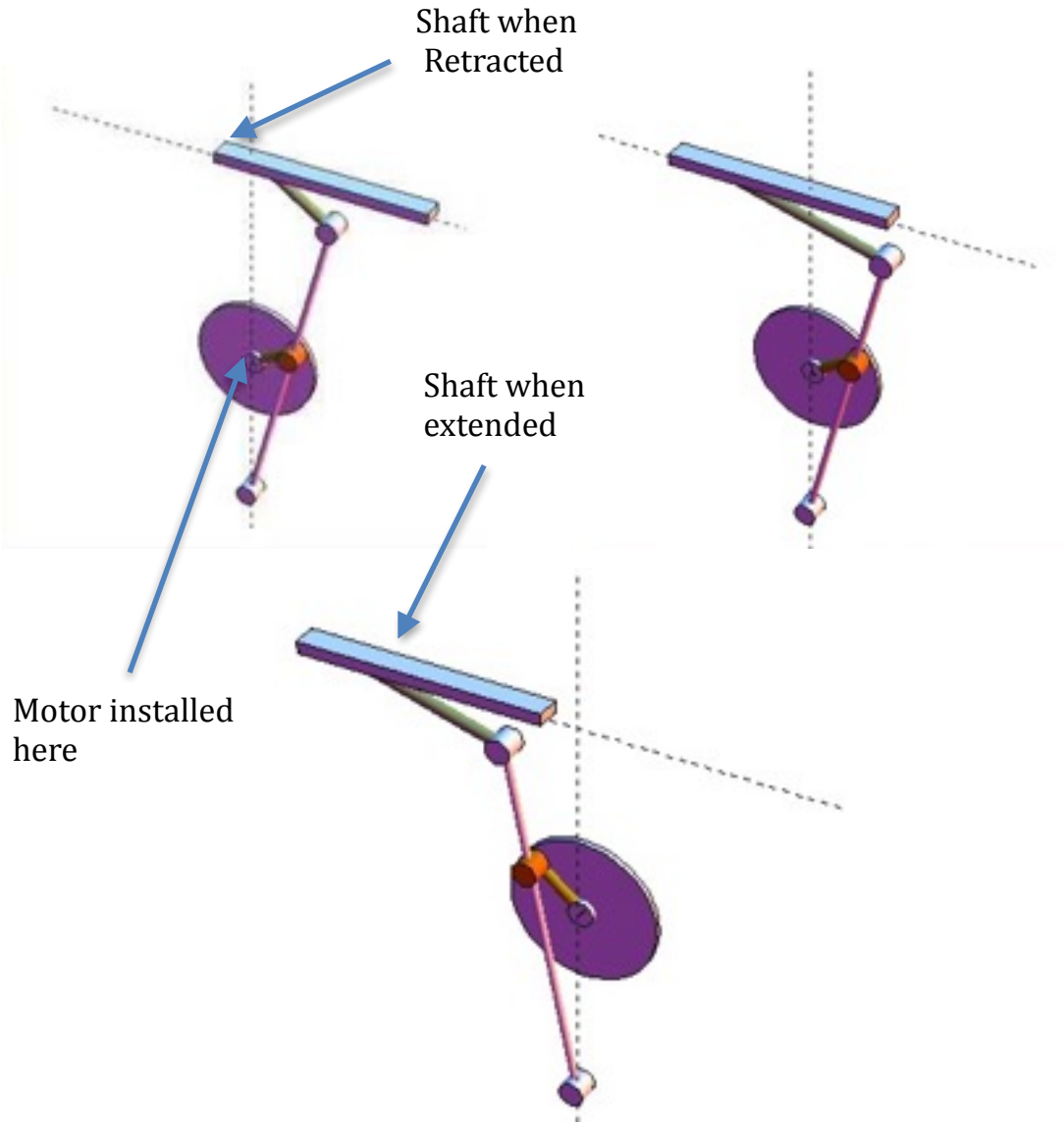
Carbon fiber's distinct lightness and strength make it a viable, versatile, and useful commercial product for a wide variety of markets. Along with strength and lightweight properties, the benefits of carbon fibre and its composites include :

- A unique and distinct appearance that's nearly impossible to replicate.
- Excellent strength to weight ratio, compared to other materials.
- Works well with other materials (fibre, plastics, metals, wood, concrete).
- Suitable for complex contours and designs.
- Superior fatigue properties.
- High Stiffness.
- High heat tolerances and resistance.
- Flexible thermal and electrical properties.
- Corrosion-resistance (with proper resins).
- The strongest carbon fibre is 10x stronger and 5x lighter than steel.
- The strongest carbon fibre is 8x stronger and 1.5x lighter than aluminium.

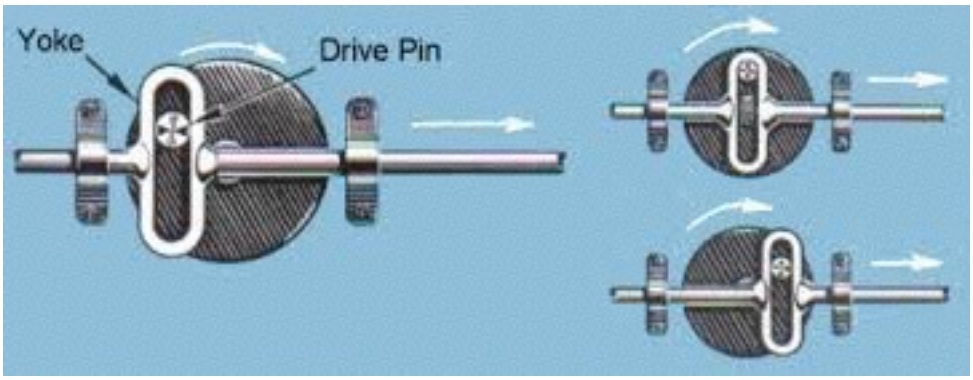


Thus, having to replace the current material with the carbon fibre will be a good idea.

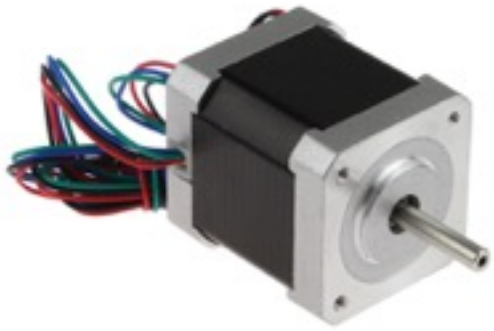
2.) Extendable screw shaft mechanism can be improved with Motor Design.



Idea 2 -



Motor



A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence.

Thus by using the motor, podiatrists are able to control the length of shaft extension and they wont have to manually use their hands to turn the knob to tighten the shaft in place. This allows easy access to lift the leg plate up and down.

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