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COSBURN MIDDLE SCHOOL FLUID POWER PORTFOLIO, 2019

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Our Teamwork and Success Criteria

Success Criteria

- Having good time management
- Making a timetable to plan, design and build that fits everyone's schedules, so the team can meet up in sub-groups and as a whole.
- Making sure everyone has a role in the design and building
- To have good teamwork
- Ensuring we do everything safely
- Making sure everything is well organized
- Having a well laid out design
- Being very efficient with materials
- Designing a good grabbing mechanism
- Having a strong extending arm
- Working together with the syringes to complete our goal of moving the cylinders into the white area

Teamwork played a huge role. During the making of our prototype, without teamwork we wouldn't have gone anywhere. All of us contributed different ideas on how we could improve our prototype. We also made sure everyone had a role in the construction of our final prototype. We did this by taking our device apart after we built it, and then assigning the one part to each of us to study and rebuild for the competition. We divided our mechanism into four parts, so each of us had our own part to build. If one of us was waiting for glue to dry or finished early then they would help someone else instead of just sitting there and wasting time. We also divided the portfolio up so that everyone had their own part to write. Something that helped with our teamwork was working many weeks together and getting to know each other better. We became more comfortable with each other which improved our teamwork a lot. When someone had an idea, we did not push the idea aside, and instead we tried to elaborate and improve the idea which we could use for our final prototype. Time was another thing that put us back. Not everyone on our team could meet everyday, but we made a timetable where everyone can meet and create designs together so we all know what we are doing. We also did not have a lot of time in school considering we have our normal subjects and homework to do. So we decided to do some of the work at home through google docs which can be accessed by everyone. This allowed us to be much more organized and manage our time effectively because everything is online so when you make an edit to it, everybody will be able to see it. This gave us much more time to test our device and practice.

Materials Used:

- Wood Block: *19 cm x 13.5 cm x 4 cm* : 1
- Wooden Pieces: *1 cm cross section* : 4 x 10 cm, 4 x 8 cm, 3 x 14 cm, 5 x 12 cm, 4 x 5 cm, 5 x 4 cm, 2 x 29 cm, 3 x 3 cm, 2 x 20 cm, 2 x 38 cm, 2 x 39 cm, 2 x 8.5 cm, 6x 9 cm, 6 x 7 cm, 1 x 2.5 cm, 2 x 5.3 cm, 8 x 4.3 cm
- Tongue Depressors: *2 cm width x 0.3 thickness* : 1 x 7.3 cm, 1 x 5.3 cm, 2 x 8.5 cm
- Dowel: *3/16" in diameter* : 2 x 20 cm, 1 x 4.5 cm, 1 x 2.2 cm
- Dowel: *7/8 " in diameter* : 1 x 10 cm
- Large Wheel: *with circular 7/8 " hole* : 1
- Square platform: *10.2cm x 10.2cm with circular 7/8 " hole and 3/16 " hole* : 1
- Medium wheel: *5.2cm in diameter with 3/16 " hole* : 1
- Syringe holders: 4
- Gusset Corners Sheet: 2
- 20cc syringes: 8
- Plastic Tubing: 20 cm for each device (rotational, extension, vertical, gripper)
- Axle Holders: 8
- Sticks to spread glue
- Hot Glue Gun
- Hot Glue Sticks
- Wood Glue
- Sheet of sandpaper: 1

Alternative Materials

- Rubber bands would be useful because they could help us support pieces better and they could potentially be a substitute for glue, or they can be used as clamps or vices to help hold pieces in place while being glued together and drying.

- Gears would be another useful item because they would allow us to create a stable and simple rotational movement and could save us one syringe that could be used for something else

- Foam board or corrugated plastic would be extremely helpful because we could use as a base for our devices, (such as our ladder and rotator). It would also help us with little adjustments that cannot be done as easily with wood. For example, if one of our parts break, we could repair it with the corrugated plastic or foam board because it is lightweight and easy to bond with hot glue.

-CDs could be used to replace the wheels and would repurpose plastic instead of sending it to landfill

-A brick could be used as a very stable base with a low center of gravity and ready made holes that could hold the dowel (for the rotational movement) and provide three places to insert the dowel.

Rotator Materials :

- Wood Block: *19 cm x 13.5 cm x 4 cm* : 1
- Wooden Pieces: *1 cm cross section* : 4 x 10 cm, 4 x 8 cm, 1 x 8.5 cm (45 degrees), 1 x 7 cm (45 degrees)
- Dowel: *3/16" in diameter* : 1 x 4.5 cm, 1 x 2.2 cm
- Dowel: *7/8 " in diameter* : 1 x 12 cm
- Large Wheel: *with circular 7/8 " hole* : 1
- Square platform: *10.2cm x 10.2cm with circular 7/8 " hole and 3/16 " hole* : 1
- Medium wheel: *5.2cm in diameter with 3/16 " hole* : 1
- Syringe holders: 1
- Gusset Corners Sheet: 1
- 20cc syringes: 2
- Plastic Tubing: 20 cm
- Sticks to spread glue
- Wood Glue
- Sheet of sandpaper
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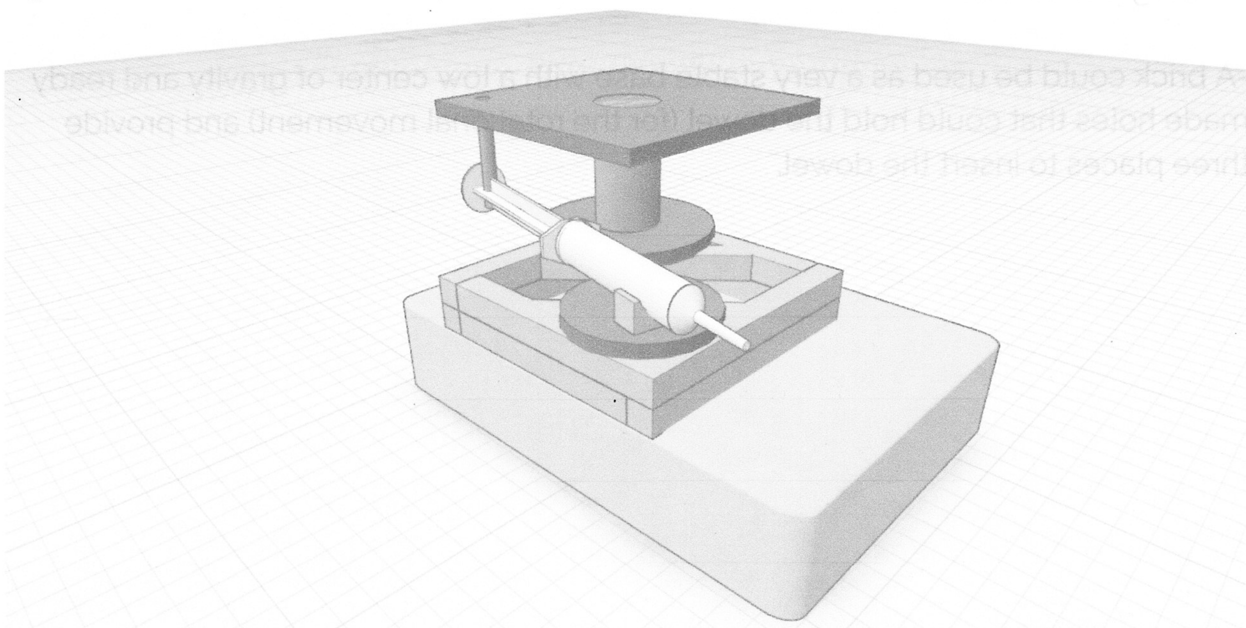
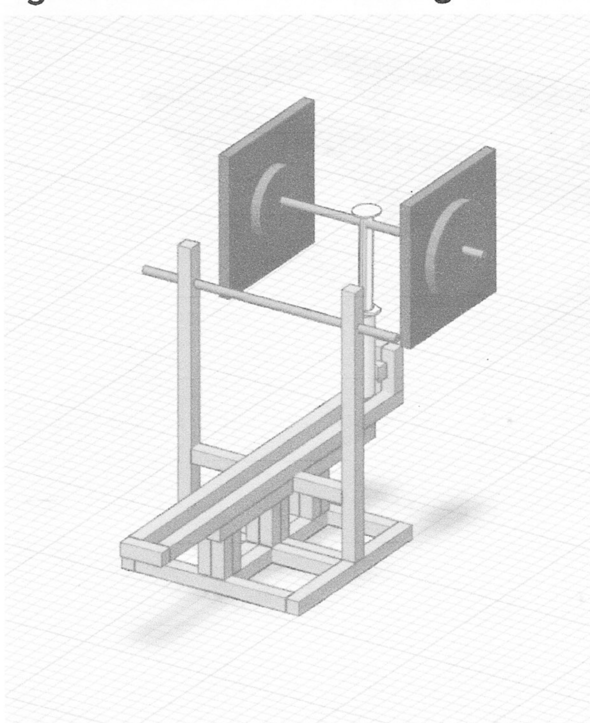
Figure 1: TinkerCad rendering of rotational mechanism



Ladder / Up and Down materials :

- Wooden Pieces: *1 cm cross section* : 2 x 14 cm, 5 x 12 cm, 4 x 5cm, 5 x 4 cm, 2 x 29 cm, 3 x 3 cm, 2 x 20 cm, 4 x 9 cm,
- Dowel: *3/16" in diameter* : 2 x 20 cm
- Syringe holders: 1
- Gusset Corners Sheet: 1
- 20cc syringes: 2
- Plastic Tubing: 20 cm
- Sticks to spread glue
- Wood Glue
- Sheet of sandpaper

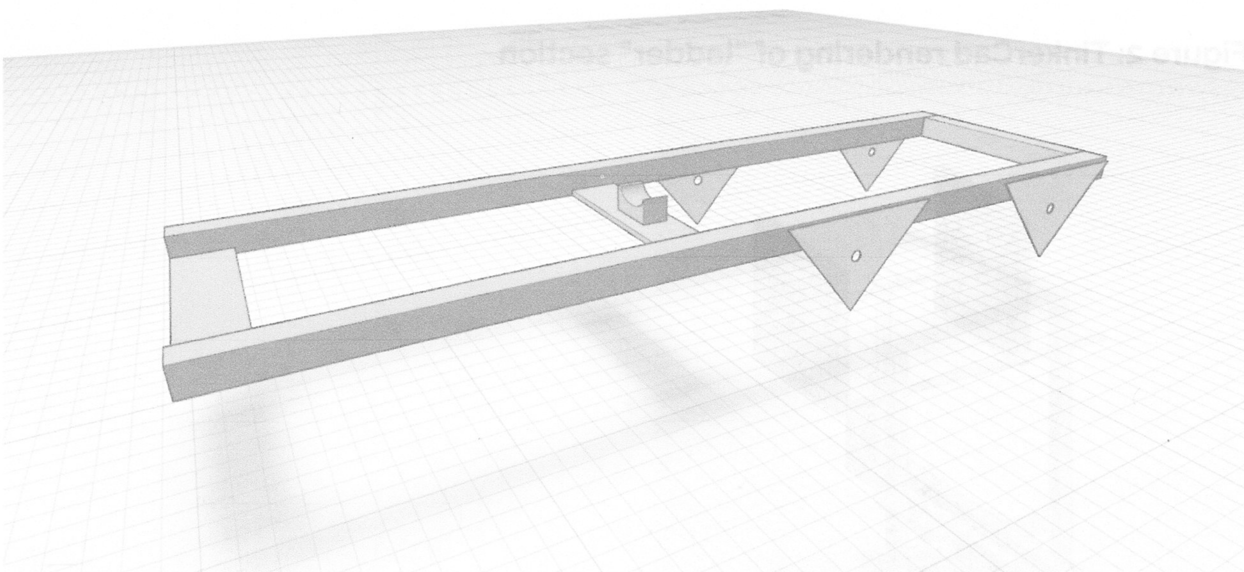
Figure 2: TinkerCad rendering of "ladder" section



Main arm materials:

- Wooden Pieces: *1 cm cross section* : 2 x 38, 1 x 8.5 cm, 1 x 10.5cm
- Tongue Depressors: *2 cm width x 0.3 thickness* : 2 x 8.5 cm
- Syringe holders: 1
- Gusset Corners Sheet: 1
- Axle Holders: 8
- Sticks to spread glue
- Wood Glue
- Sheet of sandpaper

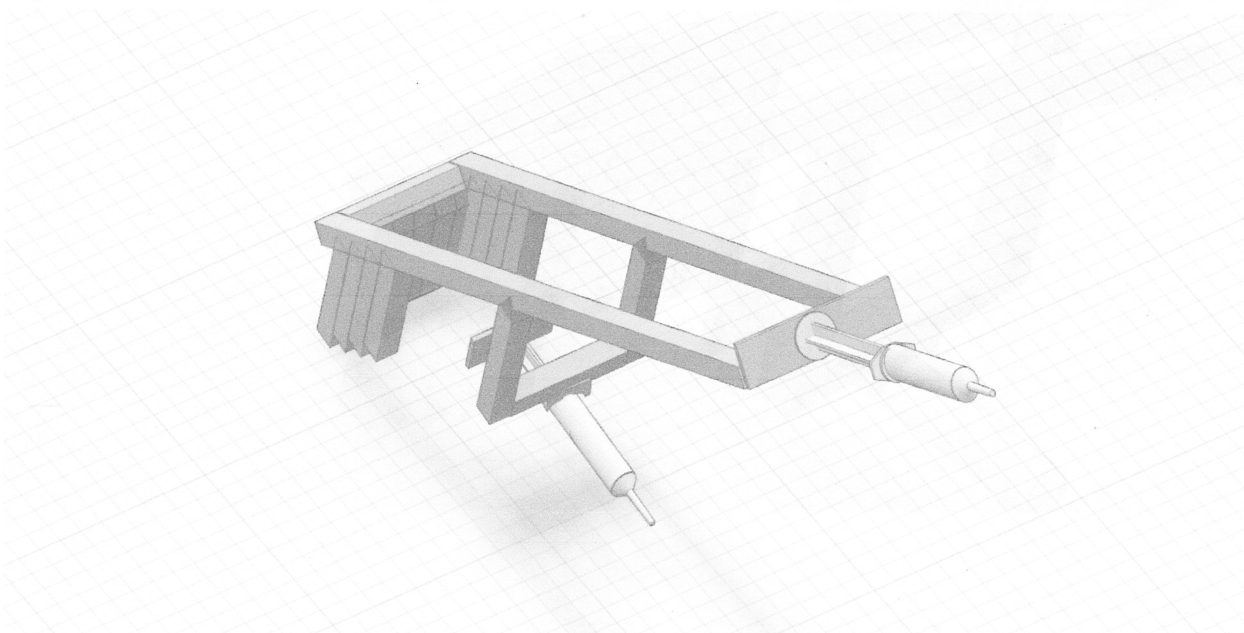
Figure 3: TinkerCad rendering of main arm



Extension Arms materials

- Wooden Pieces: *1 cm cross section* : 2 x 39 cm, 2 x 5.3 cm
- Tongue Depressors: *2 cm width x 0.3 thickness* : 1 x 7.3 cm, 1 x 5.3 cm
- Gusset Corners Sheet: 1
- 20cc syringes: 2
- Plastic Tubing: 20 cm
- Sticks to spread glue
- Wood Glue
- Sheet of sandpaper

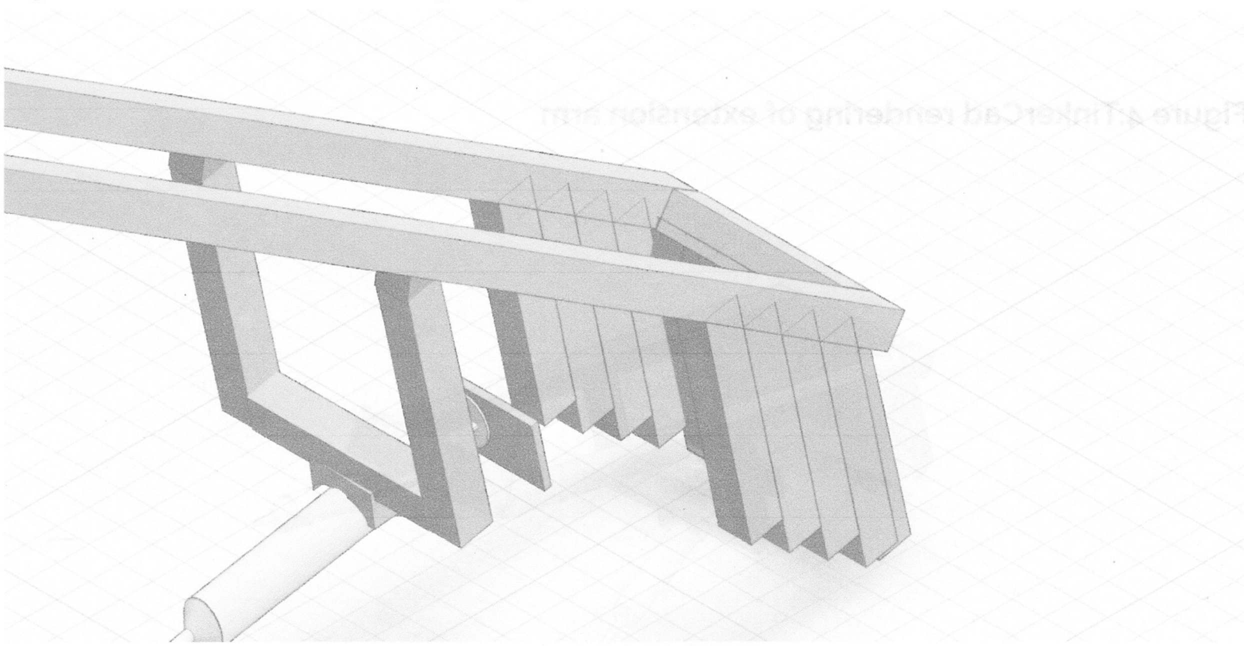
Figure 4:TinkerCad rendering of extension arm



Grabber Materials

- Wooden Pieces: *1 cm cross section* : 2 x 9 cm (45 degrees), 1 x 2.5 cm, 5 x 8 cm (45 degrees),
- Gusset Corners Sheet: 1
- 20cc syringes: 2
- Plastic Tubing: 20 cm
- Sticks to spread glue
- Wood Glue
- Sheet of sandpaper

Figure 5: TinkerCad rendering of "grabber"



Prototype evaluation and our ideas

The thing that helped us the most was testing the model over and over again to see what we could improve and fix.

The First Prototype - With all our combined ideas we created a model that we thought worked best. We created most of our model and while testing the prototype, we noticed an issue with the extender. The extender arm was only 20 cm and didn't reach far enough to place the cylinder in the blue zone As well, the rotation was unsatisfactory and only rotated 70°.

The Second Prototype - With the second prototype we made the extender longer (39 cm) and improved the rotator (now it turns 90°). During one of our tests, we noticed that the grabber did not work well. The jinx wood pieces that were intended to act as a wall against which the cylinder would be pinned and held, were at too great an angle and so we could not grip the cylinder securely. We also observed that the parts holding the syringe were not joined securely were also preventing a good grip on the cylinder. Despite this we felt our concept was good and worth the effort to improve..

The Third Prototype - The third prototype is the one that we're using for the competition. We improved the grabber by placing the syringe below the "U-shaped" part that is located on the underside of the extending arm and attached the syringe with supports around it. We also decided to add "walls" at the far end of the extending arm so the cylinder would be enclosed with no room to move sideways. We added a piece of tongue depressor to increase the contact surface area between the cylinder and the syringe plunger. We covered the tongue depressor with a layer of hot glue to prevent the cylinder from slipping down while we are lifting and moving it. These changes improved the gripper a lot.

Before making our final model, we tried to improve it as much as we could. Our main goal was to make it as stable and to operate reliably and consistently. We tried many designs and all of us had many great ideas, but by the end we created a model that is simpler and requires less time to build and functions better. We worked a lot on the grabber and the extender. Originally our grabber was flat on the extending arm and did not work properly. After much consideration we decided to move our extender below the extending arm and attach it to the extensor arm on an angle, so when the up/down syringe is fully compressed and the extensor arm is lowered to the table, the walls at the far end of the grabber would be perpendicular to the table and parallel to the cylinder.

Structural Strength and Stability

While building our model there were a few things we wanted to focus on, one of which was making sure our model was strong and stable, and we did this by using gussets to hold everything in place. We decided to start planning from the bottom up, the base, then the rotator, then the arm with the rising movement, then the extender, then the grabber. But in the end, we decided to start at the top. An advantage of starting our design at the top was that we would know how much support was needed at the bottom. We began by making a design for the arm, extension part, and grabber. When building the arm, we decided to measure the distance between where our machine sits and where we the cylinder is initially placed, which is approximately 32cm, and also the distance between where our machine sits and one area of the white zone (where we wish to deposit the cylinder) which is approximately 52cm so we knew that our extender had to be able to contract to 32cm and extend to 52cm. So after doing some math, we knew how long our extender had to be. Knowing how long we had to make our extendor, we also had to think about the weight that would be put on that end and how we could counterbalance it. Another reason for providing a counterbalance is that our grabber, though strong- places a large load at one end of the arm and shifts the center of gravity towards that end. Without adding counterweights, more force would be needed to lift the arm (using hydraulics) and the load of the grabber itself might place excessive tension on the syringe at the rear of the extender arm. Counterweights would also bring the center of gravity from the grabber end back towards the middle of the extender arm. We considered aesthetics too by symmetrically adding shapes to both sides of the extender arm. We also wanted to place the weight symmetrically because the weights were threaded onto each side a dowel that was connected to the vertical movement: We wanted to avoid the possibility that one side would be under compression and the other side would be under tension due to too much weight being placed on one side of the dowel.

We added a horizontal support beam to hold up the syringe and to add some counter balance. Originally with the grabber, we had a very unstable design where our syringe was supported by just one, low-hanging piece of jinx wood. We later decided to modify our design and use two pieces of jinx wood connected with a horizontal support beam. This really helps us to support our load. One thing that seems surprising but that actually provides a lot of support are the pivot points. Lastly, adding gussets as a joining method helps add a lot of support and stability.

EXPLANATION OF PLACEMENT OF HYDRAULICS /FLUID SYSTEMS

We used hydraulics, which use liquids, instead of pneumatics, which use gases, because liquids, unlike gases, are NOT compressible. This means that when the syringe plunger is operated the movement is immediate instead of delayed as it would be in a pneumatic system. According to the Particle Theory, gas particles are dispersed with large spaces between them whereas particles in a liquid are closely packed together with no space between them. When placed under pressure, gas particles first move closer together, and this is what causes a delay before any parts move in a pneumatic system. In a hydraulic system parts begin to move immediately because the particles are already close together. This is important in our machine because we need to maximize the movements that each hydraulic component achieves in order to complete the challenge, in particular being able to place the cylinder in the blue zone. As well, we used 20cc syringes which have longer barrels and so we are able to achieve greater linear movement than 10cc syringes would allow. Hydraulics work by transmitting pressure using the principles of Pascal's law. Pascal's law states that in a fluid at rest in a closed container (such as ours with closed syringes and tubing between) a pressure change in one part is transmitted without loss to every portion of the fluid and to the walls of the container. In our system only the plunger is able to move and so the hydraulic pressure forces the plunger to move out of the syringe (opposite to the syringe that is being operated). When we pull back on the plunger, negative pressure causes the plunger of the opposite syringe to withdraw into the plunger.

<u>BASE</u>

For our base, we decided to use the wooden block that was provided to us. On top of that we made a rotator that was glued down to it. The rotator used a square platform that attached to the hydraulic, and it works when syringe A is pushed in and syringe B is pushed out, causing the platform to rotate. Syringe A is the input and B is the output. It happens with the opposite way too, We use water instead of air because water is denser than air which creates better movement. We understood Pascal's law because we used the same size syringe so they would produce equal pressure and movement to each other. Adjusting the pivot of the syringe clip also affected the rotation range.

VERTICAL UP AND DOWN

For the vertical movement, Syringe B is placed on the support bar of the ladder. By placing pressure on syringe A, the up and down movement is controlled. When syringe A is pushed in, the output of syringe B causes the arm go up and when you pull syringe A out, the output of syringe A would make the arm go down. The up and down movement on our device uses a class 1 lever. We used the class 1 lever by placing the fulcrum in the middle, the effort at the very back which is the syringe and the load at the front, which is the grabber.

EXTENDERS

For our extender, the hydraulic is attached to the main arm with a clip. When it is secured in place, an arm that we built separately will be attached to the end of the syringe, and then it allows the arm to move horizontally(forward and backward). Syringe A is the input and syringe B is the output. We decided to attach the grabber onto the arm because it creates a counterbalance for the back part.

GRABBER

For our grabber we used hydraulics to operate the system and grab the cylinder. When we push (the input) the plunger of syringe A, the output extends the plunger of syringe B to clamp and hold the cylinder. To clasp the cylinder, we originally oriented the syringe straight (parallel to the extender arm) but then realized that it wouldn't grab because the top of the syringe plunger was at an angle relative to the cylinder. Our solution was to put the syringe on a 55 degrees angle. We also realized that our grabber wasn't sturdy enough so we added wood on the sides of the grabber to make it more sturdy and to make sure the cylinder wouldn't be able to move to the side. Finally, we added a tongue depressor at the end of the syringe plunger to increase the surface area in contact with the cylinder.

REFLECTION

As we went through iterations of our prototype, we had lots of problems. First, we made a mistake calculating the length of the extending arm. It could only reach the cylinder and the red area of the platform. Note that the red platform gives the least points and we are aiming for the higher point areas such as the white and blue. We had to make many adjustments until we got our desired extension. Some other problems were the grabber, because at first it wouldn't work on an angle so we adjusted its location and the angle of the syringe to 55 degrees. Subsequently, we realized that the grabber wasn't sturdy and was being dislocated while we did our testing so we added more support on the sides which helped stabilize and strengthen that part of the device.

As a process we learned a lot about the importance of testing and retesting, of planning and making a realistic schedule that we followed and about what good teamwork feels like when it's working. We were able to eat lunch, talk and have fun but more importantly, we could count on each other to finish the parts we were each responsible for. At the beginning we realised we didn't have that much time so we set goals and targets to have parts completed. Being on schedule gave us the time to do testing and to make changes in an organized and thoughtful way. Testing is really important and that's the time you learn if what you've made works. We worked hard and we are hoping that we will build a great device for the challenge.

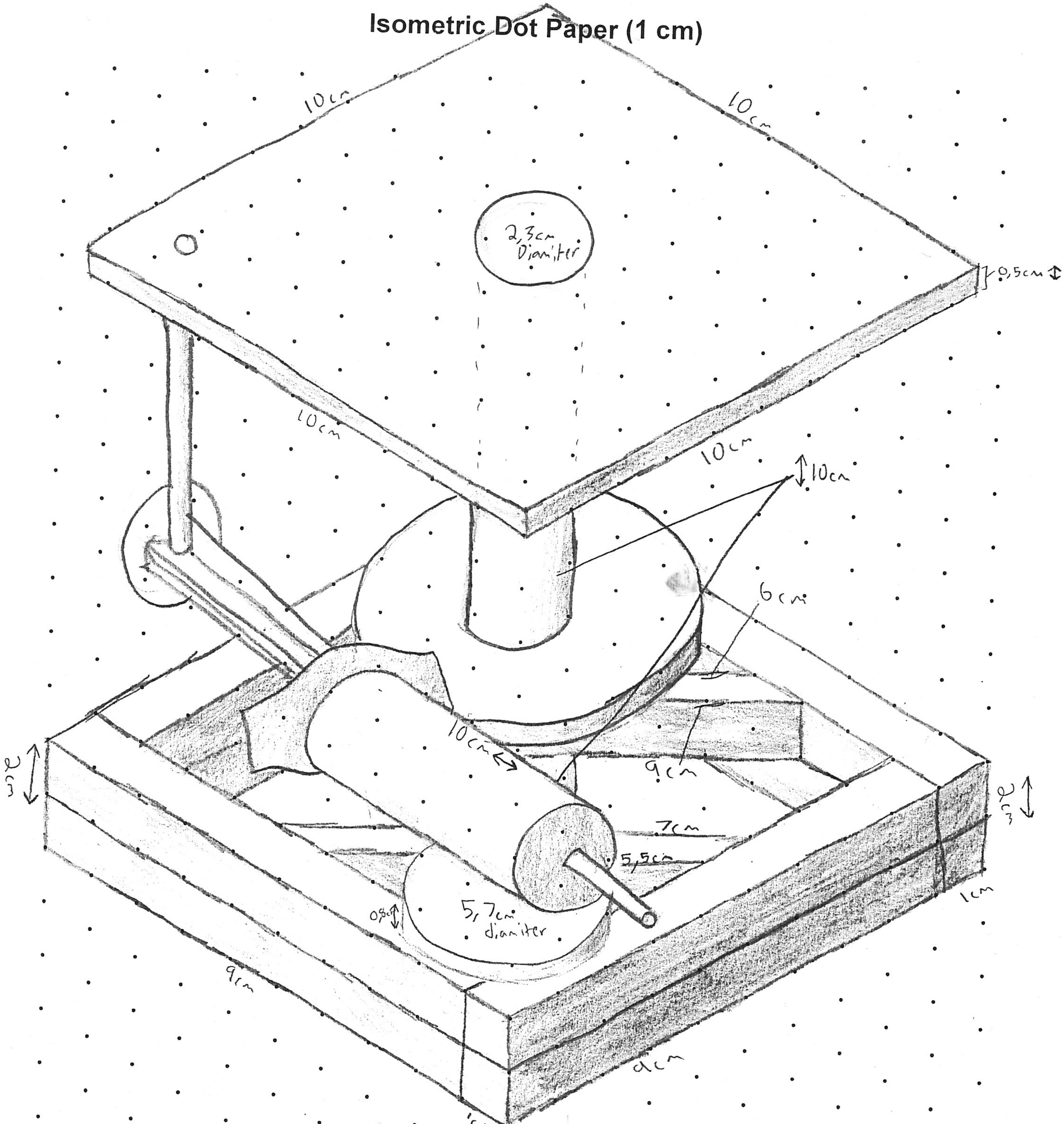
CONCLUSION

Our design has definitely changed throughout the whole process. We went from one idea to another and by the end we created a device that we're really proud of. Through lots of trial and error we noticed and fixed all the errors of our construction, and now we can make the best version of our model at the competition. Teamwork has made a huge impact on the preparing process. With all our ideas combined together the process went by way quicker and more efficiently. This challenge has not only provided us with better knowledge of hydraulic systems, but has also made us all very close. Because of all the time we spent together working on the challenge, we got to know each other better and became very good friends which improved our teamwork a lot. The challenge has taught us so much and we're all so excited to be a part, it has given us many skills, that we can use in the future. We've learned to be good team members ,to share the work equally and to listen to different ideas about how to build something. We know more about how to build and design a strong and stable structure and how to tackle problems as they arise.

Cosburn MS

Isometric drawing of rotational movement

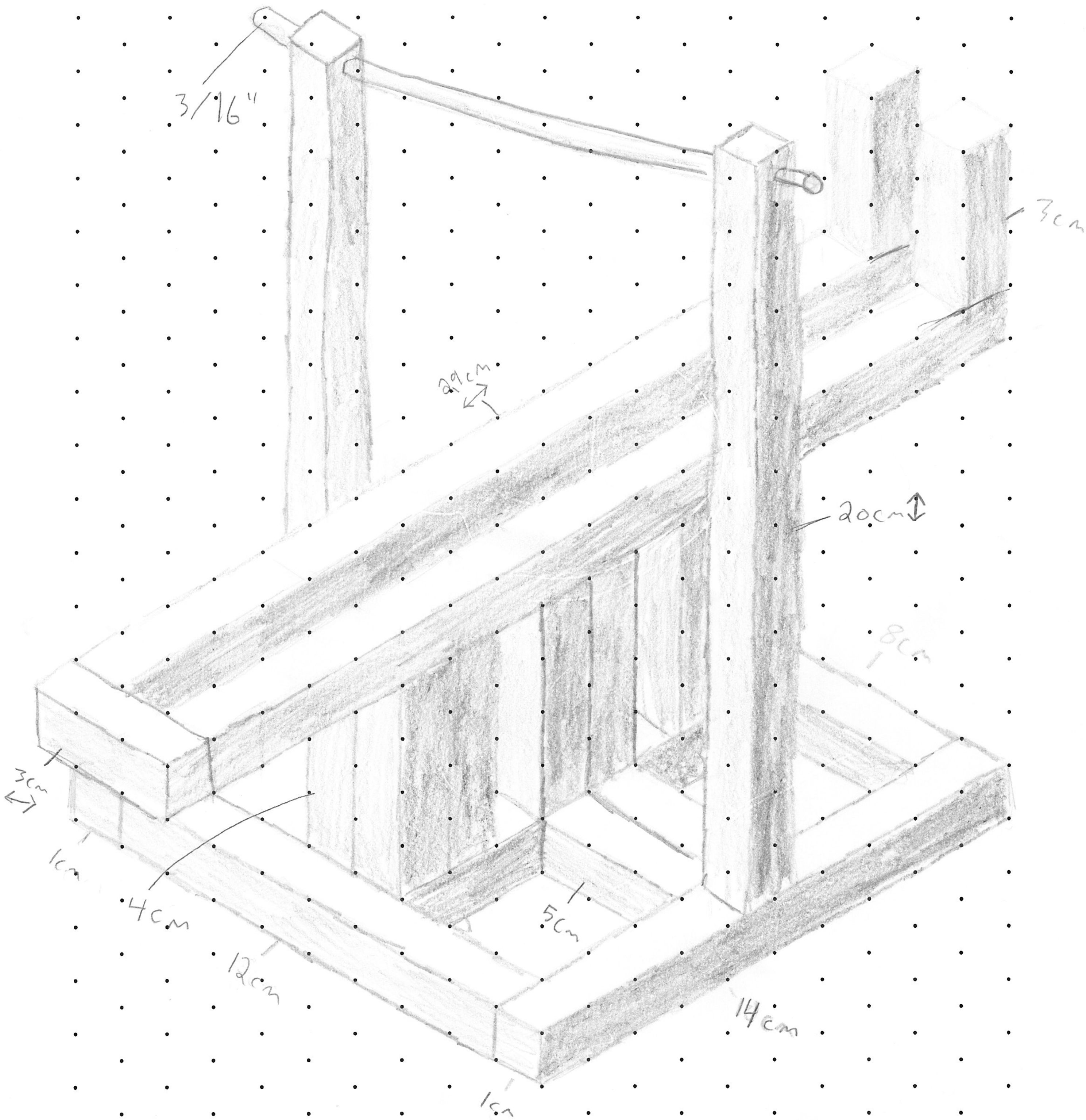
Isometric Dot Paper (1 cm)

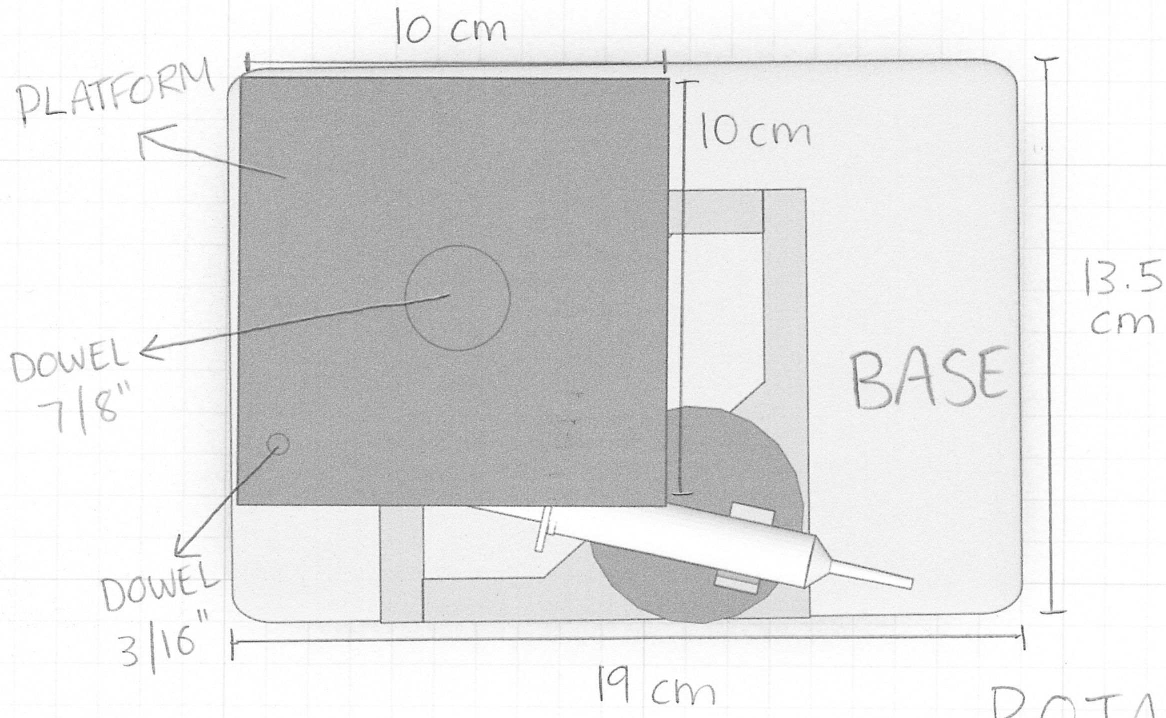


Cosburn MS

Isometric drawing of up/down movement

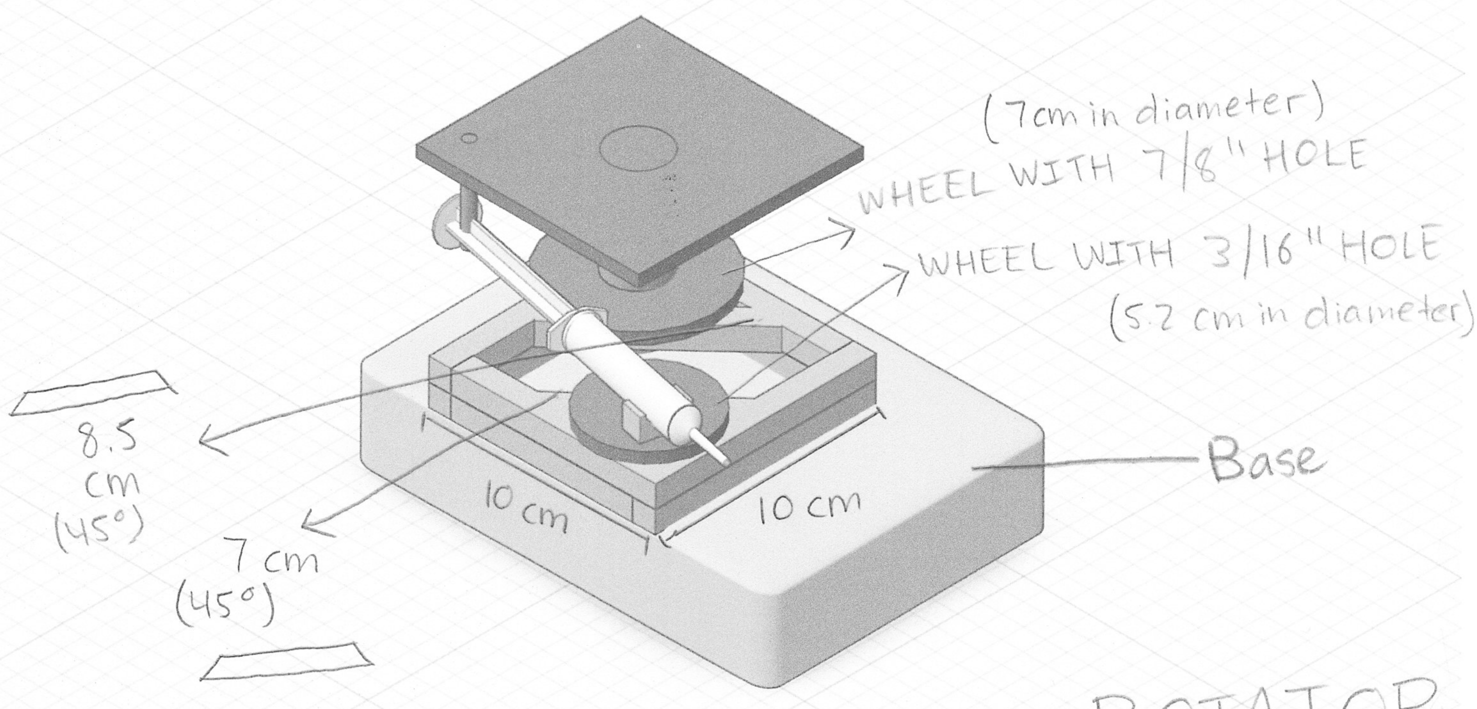
Isometric Dot Paper (1 cm)





TOP VIEW ORTHOGRAPIC DRAWING

ROTATOR

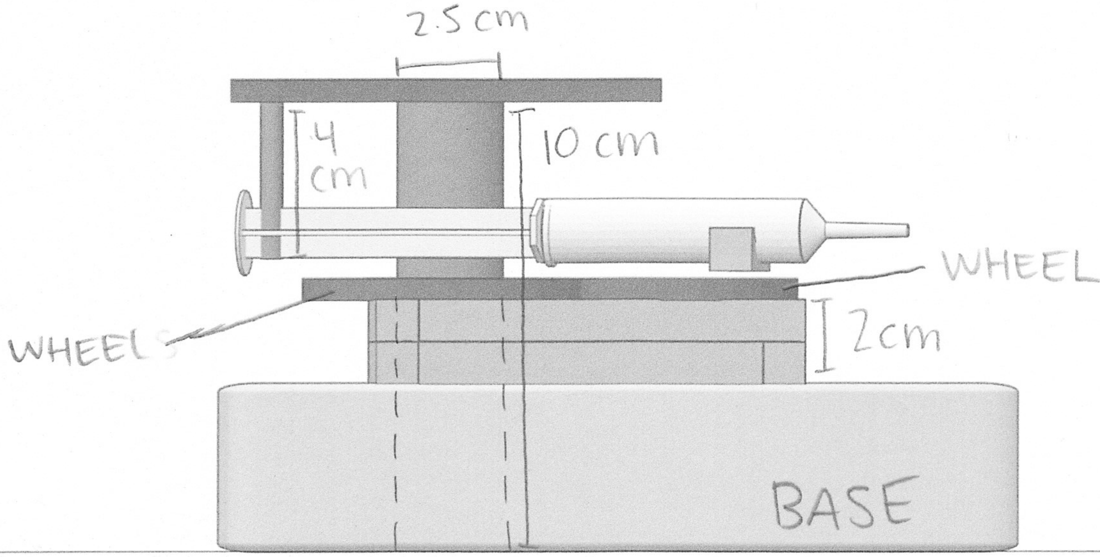


BIRD'S EYE ISOMETRIC DRAWING

ROTATOR

CMS

Tinkercad Rendering

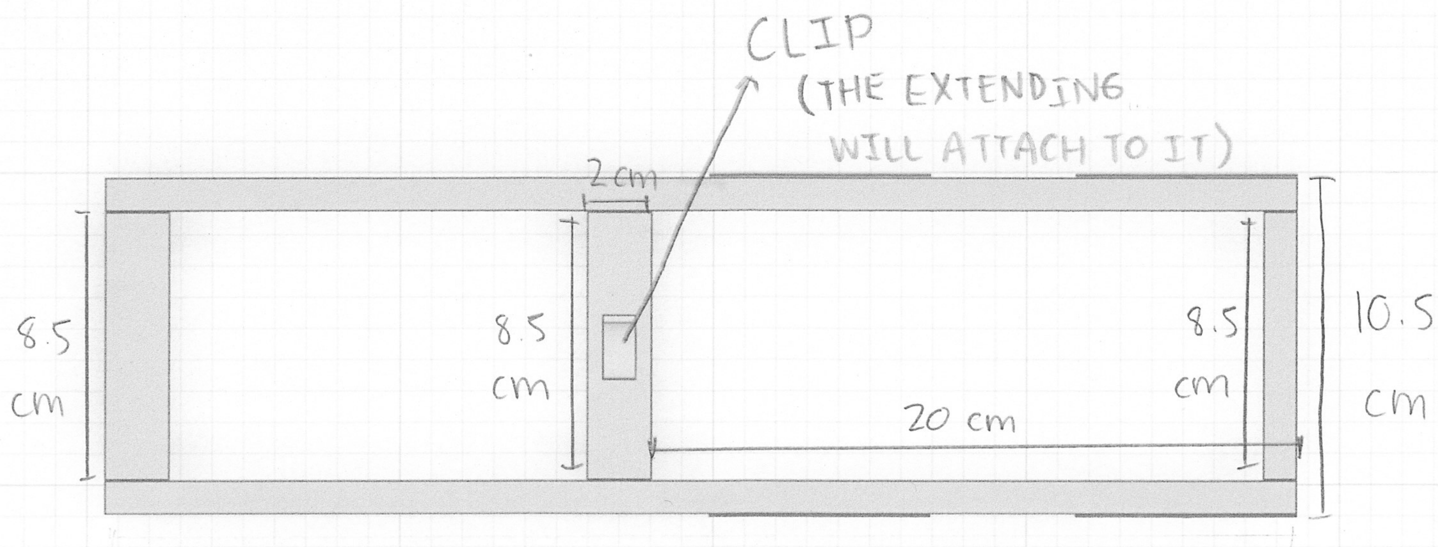


SIDE VIEW ORTHAGRAPHIC DRAWING

ROTATOR

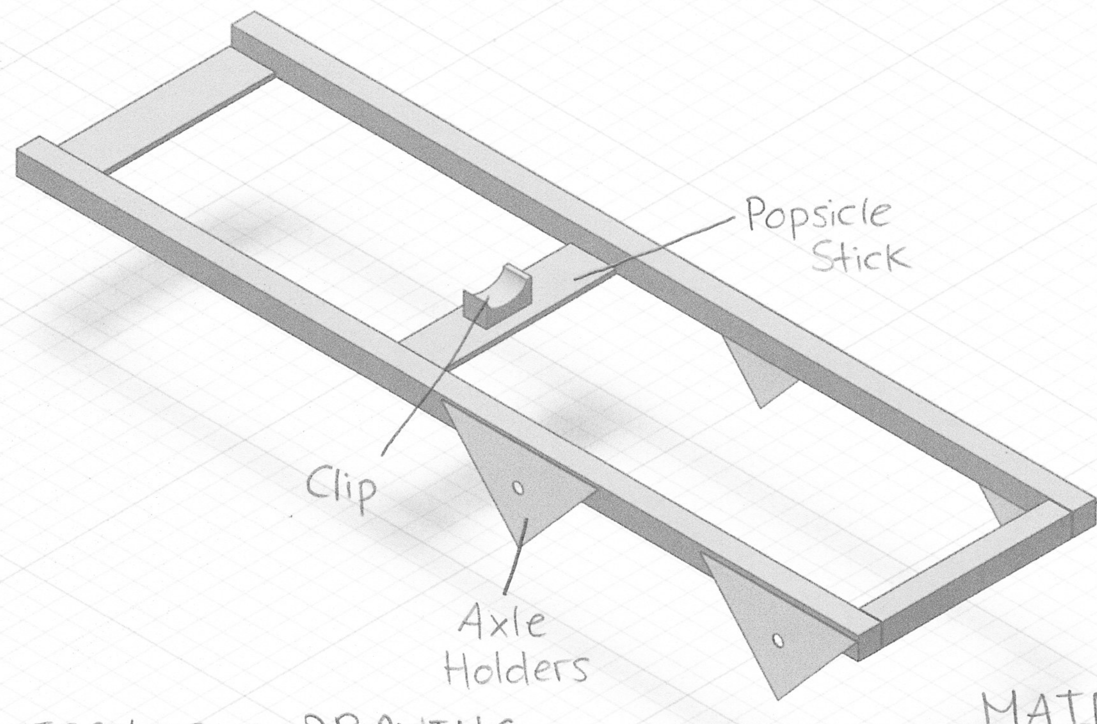
CMS

Tinkercad Render



TOP VIEW ORTHAGRAPHIC DRAWING

MAIN ARM

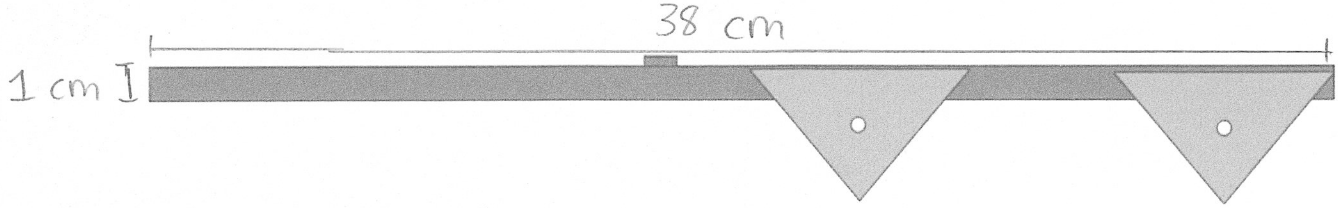


BIRD'S EYE ISOMETRIC DRAWING

MAIN ARM

CMS

Tinkercad Rendering

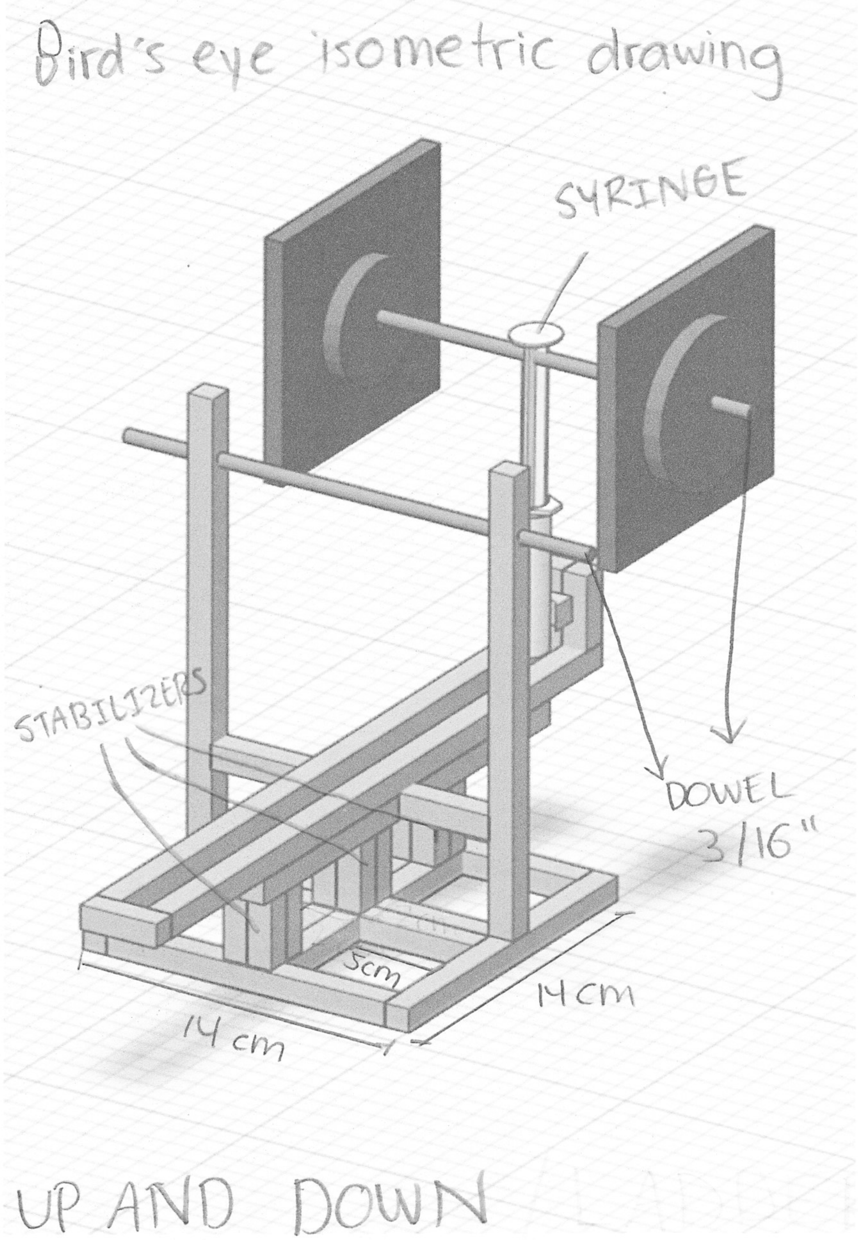


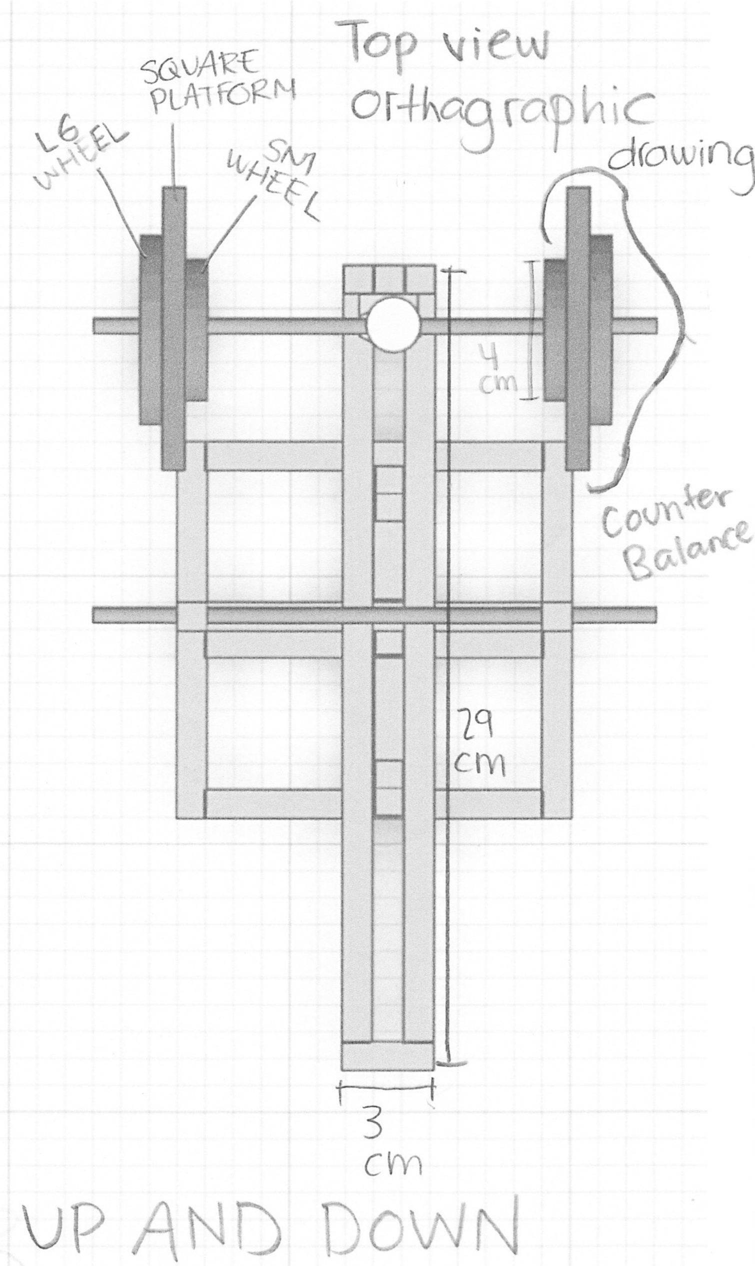
SIDE VIEW ORTHAGRAPHIC DRAWING

CMS

MAIN ARM

Tinkercad Rendering

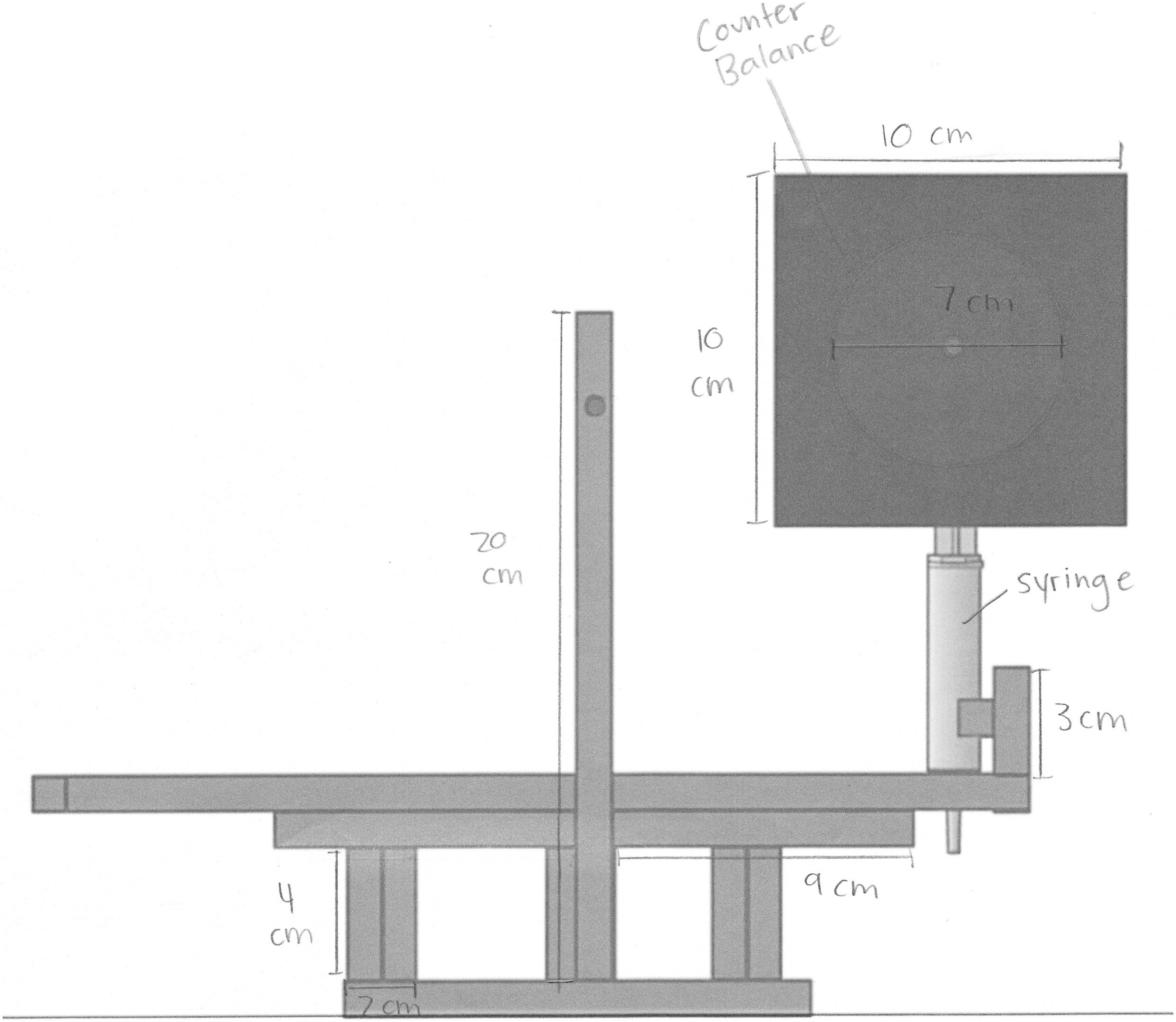




CMS

Tinkercad Rendering

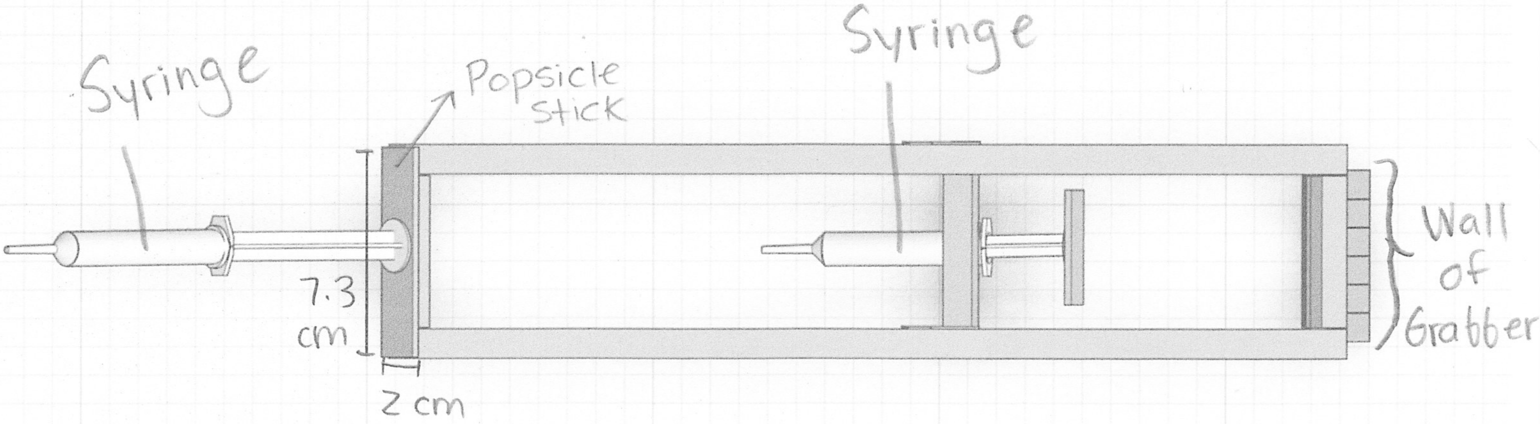
UP AND DOWN



SIDE VIEW ORTHAGRAPHIC DRAWING

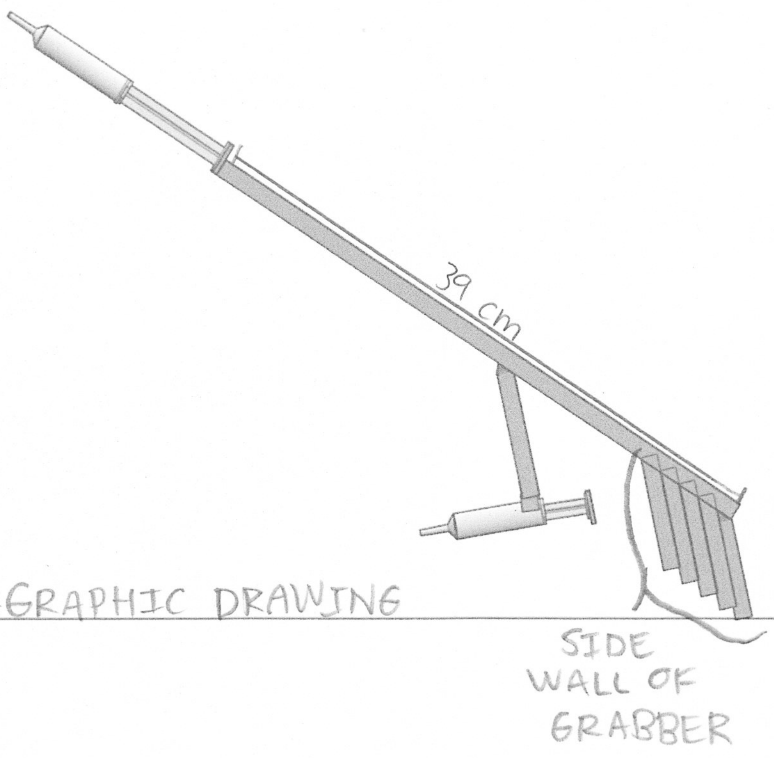
CMS

Tinkercad Rendering



TOP VIEW ORTHAGRAPHIC DRAWING

EXTENDING ARM

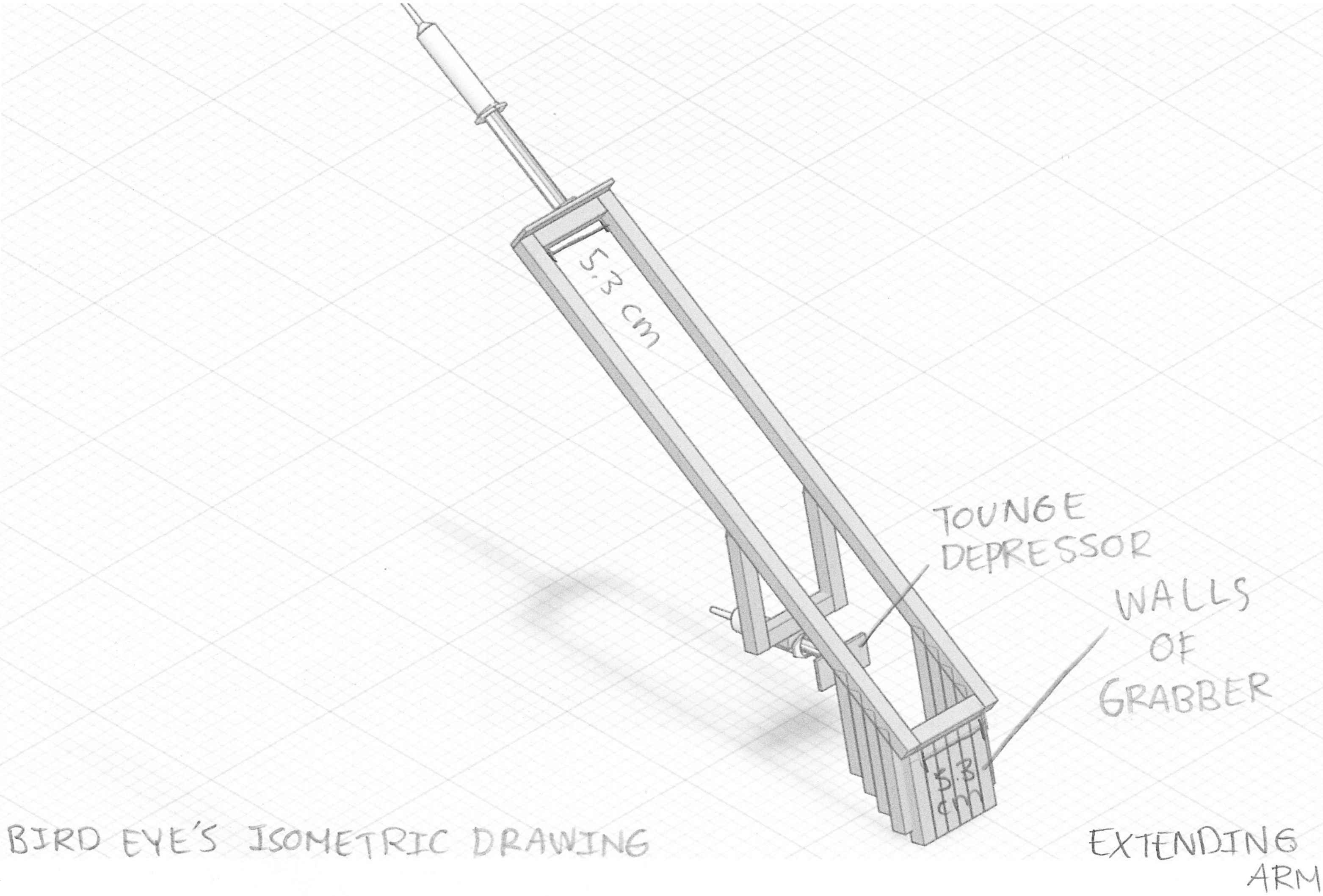


SIDE VIEW ORTHAGRAPHIC DRAWING

EXTENDING ARM

CMS

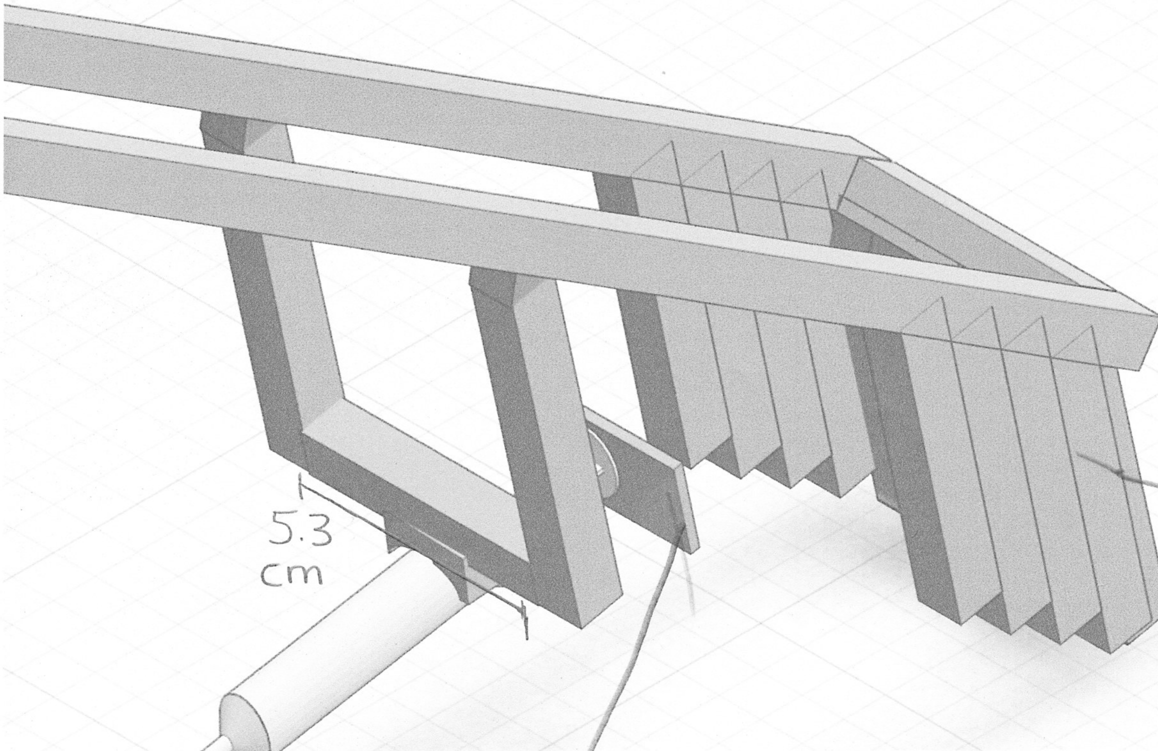
Tinkercad Rendering



CMS

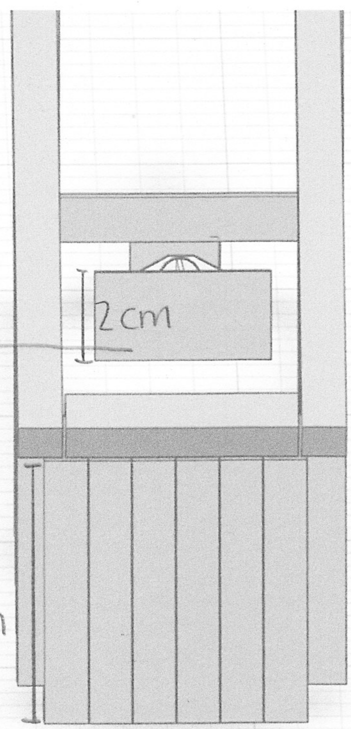
Tinkercad Rendering

BIRD'S EYE ISOMETRIC DRAWING



GRABBER

FRONT VIEW ORTHAGRAPHIC DRAWING

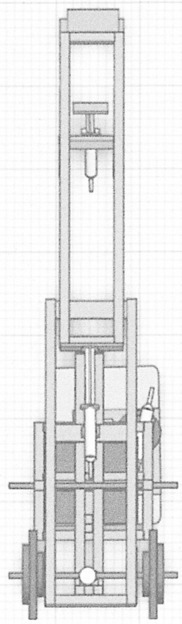


GRABBER

CMS

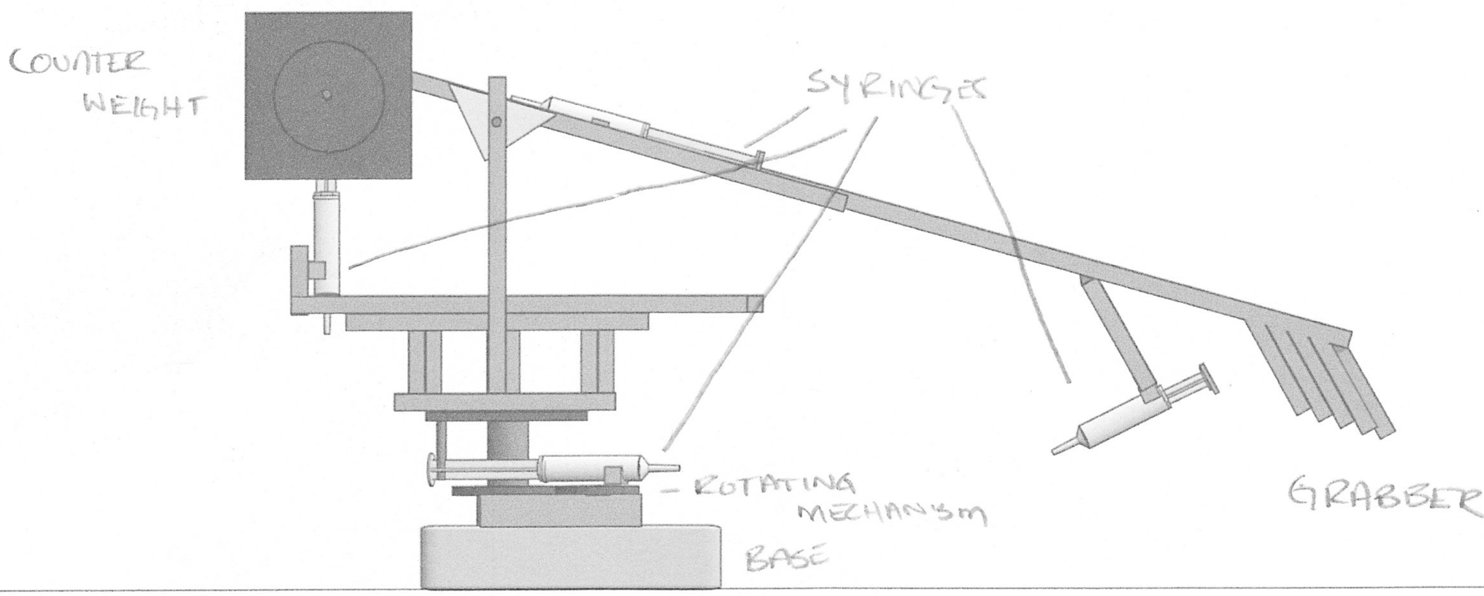
Tinkercad Rendering

FINISHED DESIGN



TOP VIEW ORTHAGRAPIC DRAWING

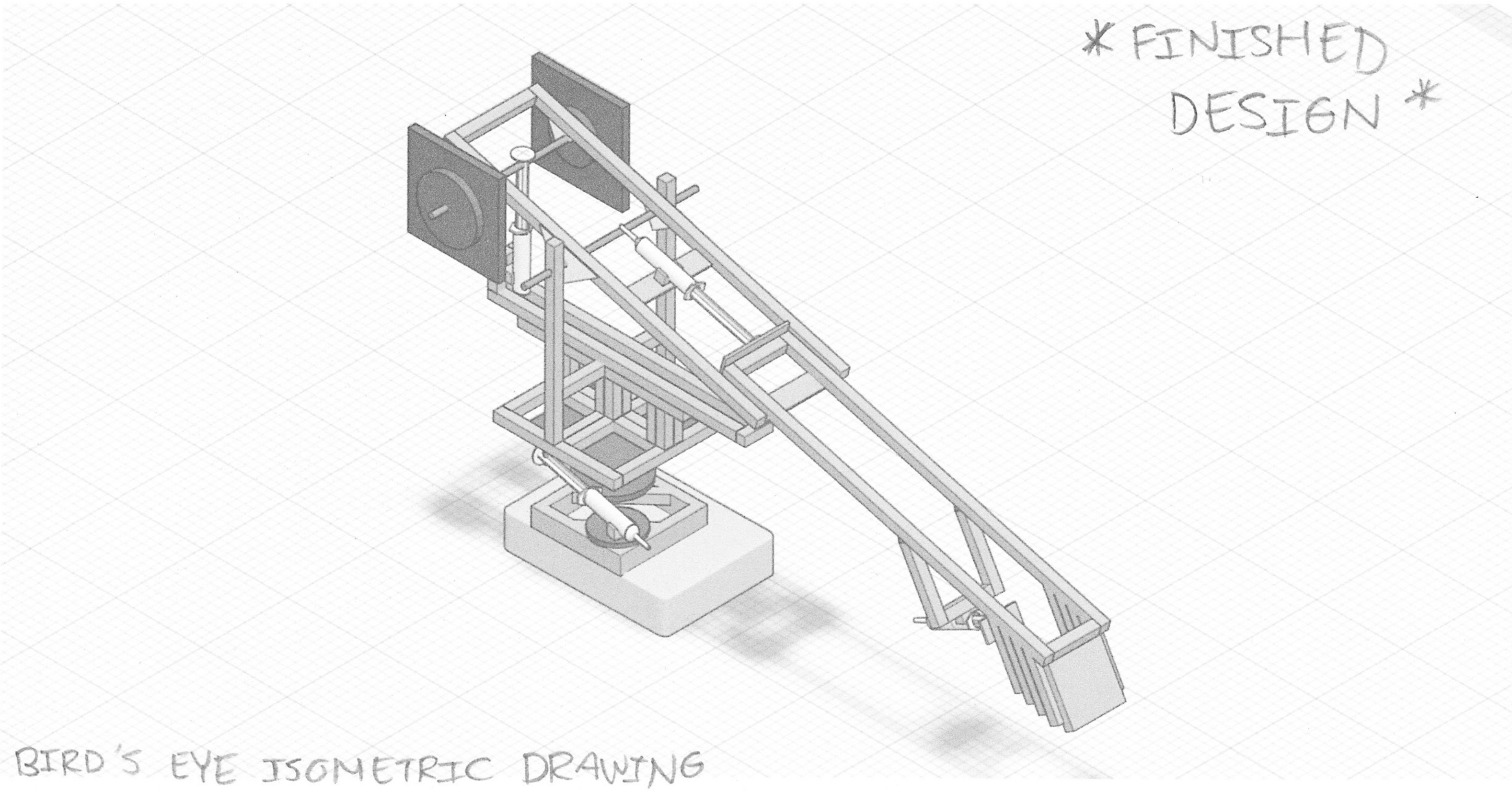
FINISHED DESIGN



SIDE VIEW ORTHAGRAPHIC DRAWING

CMS

Tinkercad Rendering



BIRD'S EYE ISOMETRIC DRAWING

CMS

Tinkercad Rendering