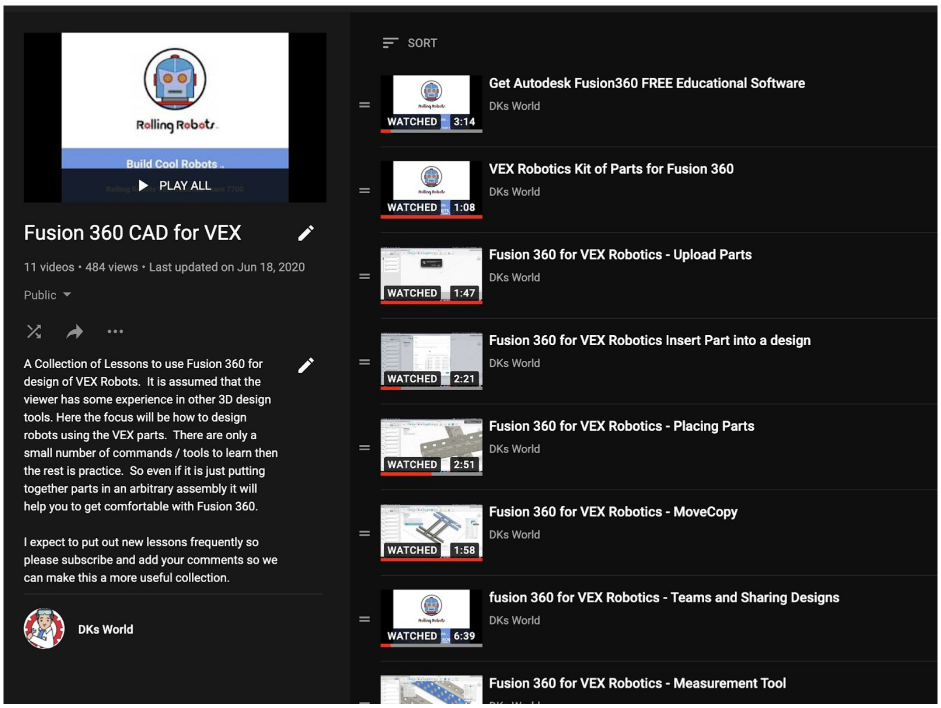
CAD Design using Autodesk Fusion 360

At Rolling Robots we all learn Fusion 360 CAD. As mentor I have created a playlist of YouTube instructional videos that are shared with our team as well as others. Fusion CAD Playlist. Reproduced here is a lesson on 2D and 3D CAD for the Teacher/Coach Fusion 360 Online Challenge Sponsored by Autodesk®



We also have a collection of Online Lessons here.

2D through 3D CAD with Autodesk Fusion 360

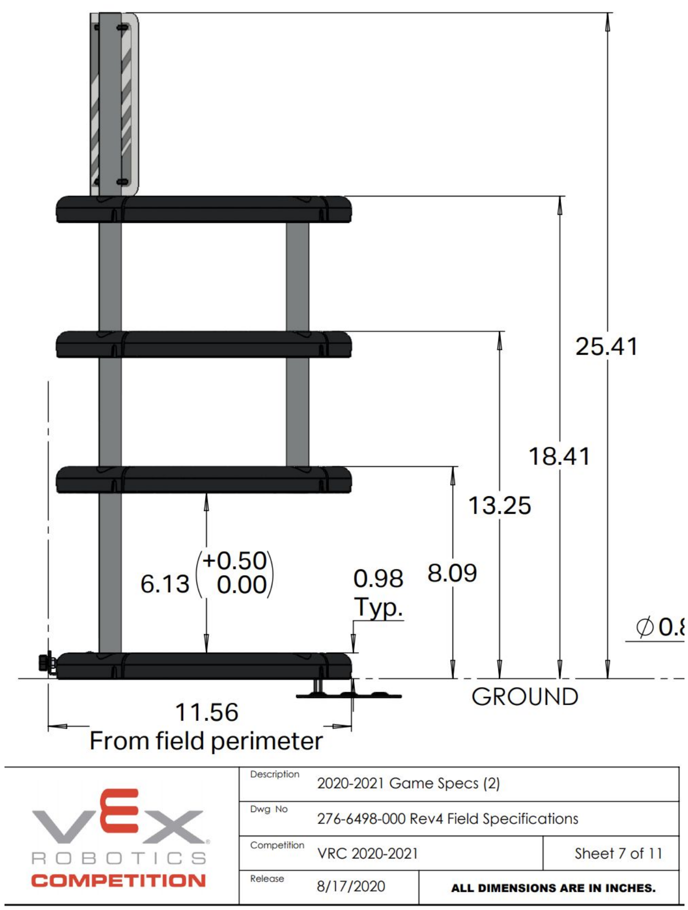
Our design process includes sketching in 2D and assembly of vex parts in 3D. A summary of this lesson is in our online collection 2D-3D CAD

2D Sketch - Crayola

We start our design process using a 2D sketch. We like to call this by the fun name Crayola-CAD since it is reminiscent of our start playing with crayons as a child. In Crayola CAD we are working to develop the design of moving mechanisms to assure fit in size constraints and to be compatible with other structures on the robot. The completed Crayola-CAD can be used to determine abilities of the robot in the game, such as scoring height, game object capacity etc.

Requirements Set Up

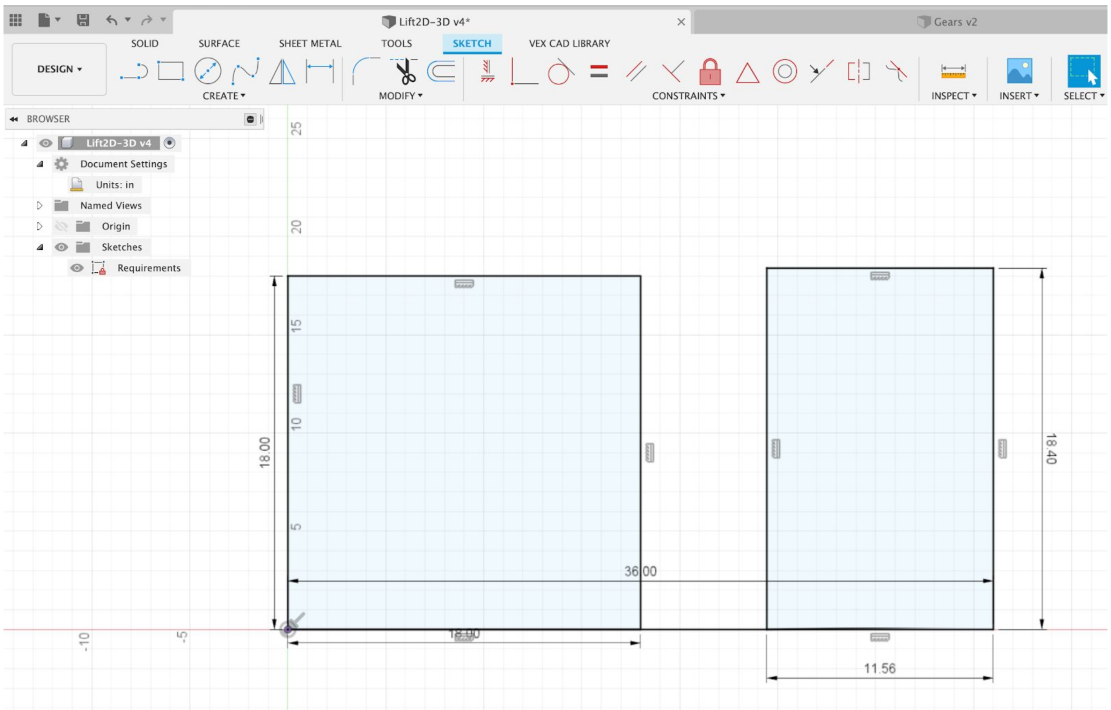
We start with Robot and Game Requirements. The sizing rule for robots is to fit in a cube that is 18 inches on a side. This year the game Change Up allows the robot to expand after the match begins. To develop a requirement for the game we go to the [Game Manual Appendix A]() and find the dimensions of the goal on page14 or drawing sheet 7 of 11 . The goal is 18.41 inches high and 11.56 inches from the field perimeter.



Open fusion 360, Since vex parts are dimensioned in inches change Document Settings/Units to inches. Select create new sketch, select a plane to sketch on, I usually will choose x-y plane the one with green and red axis. This will be the plane for a side view of the robot, later we can add sketches on the other planes as desired.Then start by drawing a rectangle to represent the size requirement of 18 x 18 inches. We will draw this starting with one corner at the origin.

Then draw a horizontal line to represent the playing field, also start at origin and extend beyond the 18 inch box, maybe 36 inch is good.

From the right endpoint of the line let's draw a rectangle to represent the goal. Select the rectangle tool by pressing R on the keyboard. Click the first corner to be the endpoint of the line and enter height and width of the goal.



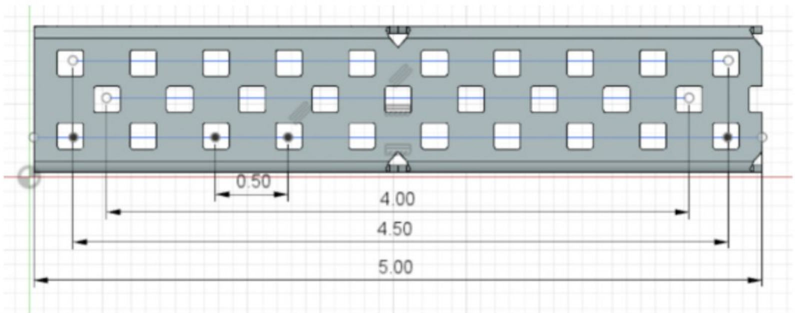
We now have our basic requirements shown on the sketch. You can now click finish sketch , the green check mark. Then click twice on the sketch name in the browser and change it to something meaningful like “Requirements” this is optional but it will help keep organized.

Lift Design

Lines to Represent VEX Parts

All parts are represented by 2 dimensional basic shapes such as lines and circles. so our most used tools will be Line and Circle, press L to get Line tool and C to get Circle, esc releases each tool.

For a structural part usually the length of the line is the length between holes in the part. This way the end of the line is 1/2 inch shorter than the real part if using the center line or 1/4 inch shorter if using a side row. Alternatively and more accurately you could make the line the full length of the part and add points to represent holes that you will use.



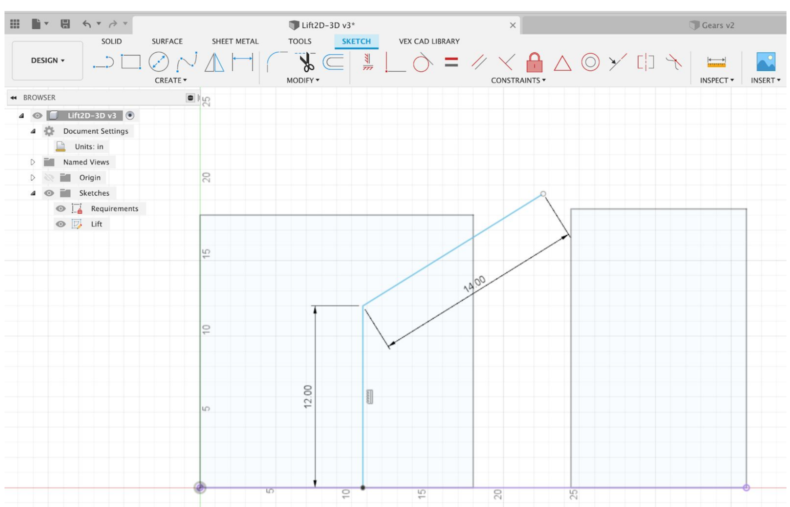
Shown here is a line 4 inches long representing the distance between the holes on the center row. The 4.5 inch line represents the distance between holes on the side rows. The C channel is a 10 hole length that is 5 inches total. the distance between each hole is 1/2 inch. Depending on your design objective you could use lines of any of these lengths to represent this part.

Create a new sketch , select the same plane. This will be where we design our actual lift. Start with a 2 Bar lift design. Choose line tool and draw a vertical line, this will be our tower, select a typical length, maybe 16 inches is good. Remember vex parts have a maximum single length of 35 holes which is 17.5 inches. Draw a second line starting at the top point of the first line. This line should be at some arbitrary angle, not vertical, not horizontal. Pick a length, 16 inch would be a good start.

Constraints

Constraints are used to hold parts together in specific ways. Lets start with the Coincident constraint. Choose constraints/coincident, then select the lower point of the tower bar , it will become highlighted, then select the line that represents the playing field. Be sure to select the line and not the endpoint of the line. After making the constrain hit esc to leave the constraint tool.This will constrain the point to the line, but we will be able to move horizontally along the line. Try it.

Click finish sketch and name the sketch lift.



You can see now that you can move the lift like a real assembly. From this we can easily see that we fit in size, can reach the ground, and can reach the goal.

Changing the Length of parts

Double Click the sketch name in the browser to open it for editing. Double click any dimension to open it, enter a new value for length and hit return. Try different lengths of arms to see what options you have in designing the lift.

EXTEND

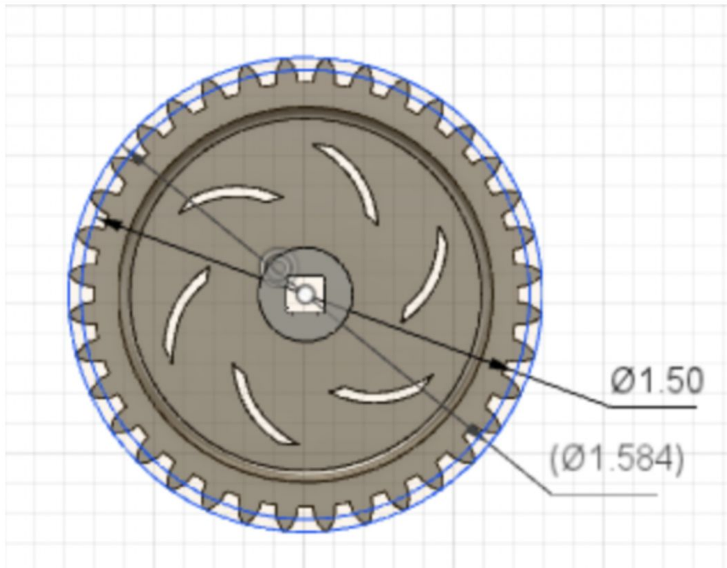
Create other lift types, 4 bar etc, example shown.

Learn about Gears

Gears are drawn in 2D as circles.

Gear sizes

The vex gears are 24 diametrical pitch, meaning that a gear with 24 teeth would be 1 inch in diameter. The 36 tooth gear is 36 / 24 = 1.5 inches in diameter. The outer diameter is slightly larger by the size of the teeth. All the gears have the same tooth dimensions so we just add a constant to diametrical pitch. For the vex gears the outer diameter is 0.084 inch more than the pitch diameter.



Dimensioned 36 tooth gear showing pitch diameter and outer diameter.

Gears are represented by a circle that is on the pitch diameter where the teeth mesh. This is somewhat smaller than the physical outer diameter of the gear. When two gears are meshed together and two circles are tangent the distance between axles will be correct.

Gear Spacing

Draw a Horizontal line starting at origin, any length 16 inch is a good start. Draw the gear as circles with their centers on the lines. Space them so that they are not touching each other. Gear diameters in inches are the number of teeth / 24 . To make the gear mesh choose constraints / tangent. Select the gear you want to move by clicking on the circle, then click the circle that you want it to mesh to and it will move. When you are done hit escape to leave the constraint tool.

Add Gears to the Lift

Use a typical gear ratio for the lift. The driving gear should be 12 tooth and the driven gear can be 60 or 84 tooth.

Place the larger gear circle so that the center is at the top of the tower arm, the joint of the tower and the lifting arm.

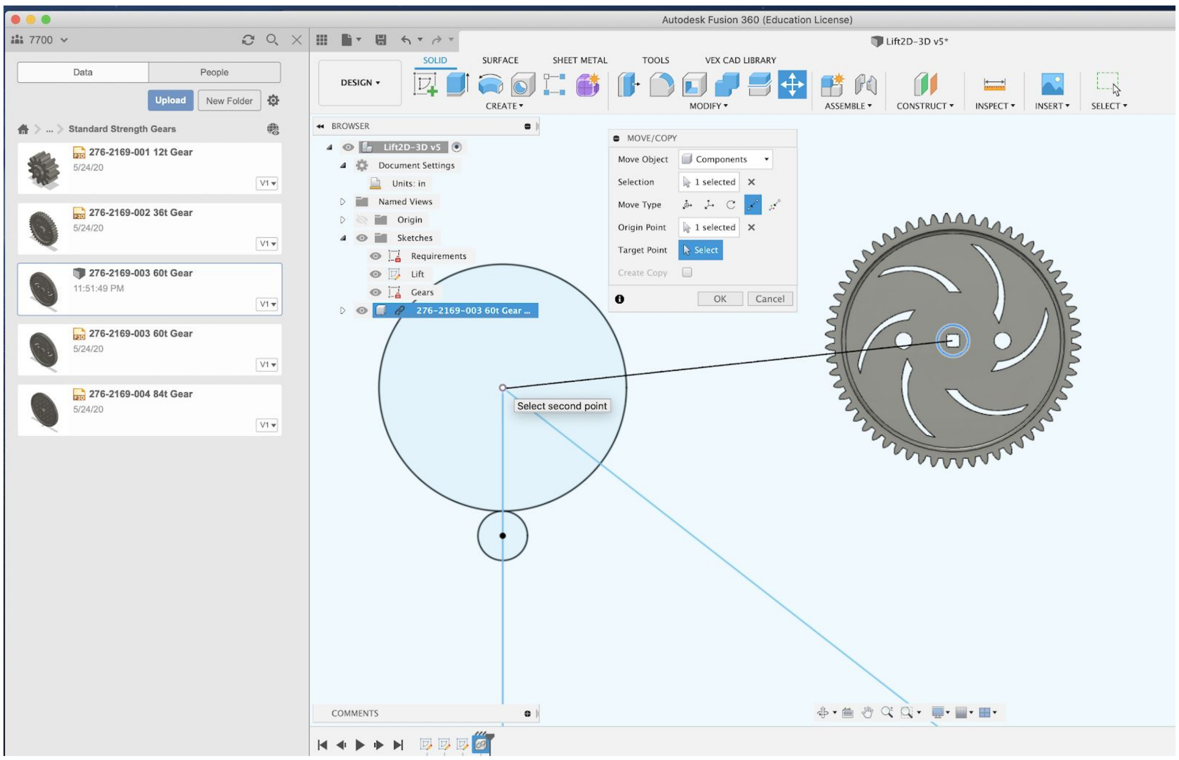
Draw the smaller gear 0.5 inch diameter circle anywhere on the tower line.

To make the gears mesh choose constraints / tangent. Select the smaller gear by clicking on the circle, then click the circle of the larger gear and it will move. When you are done hit escape to leave the constraint tool.

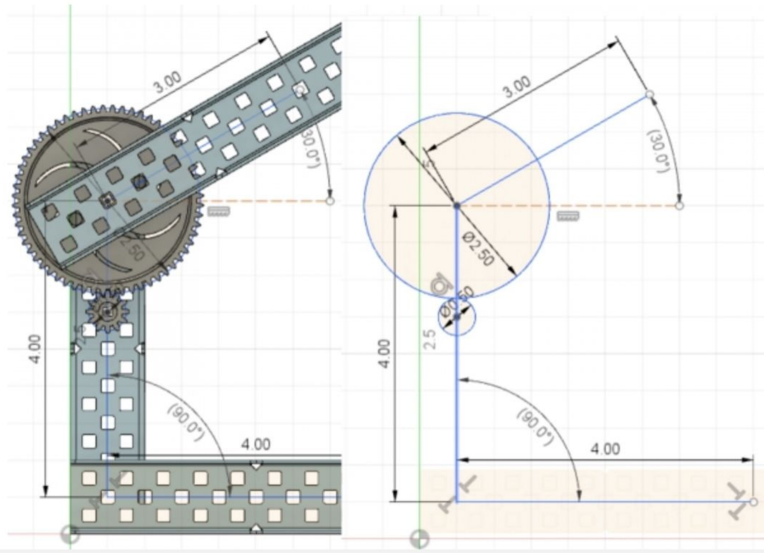
Assembly of 3D Parts

All of the vex parts are available as step files from vexrobotics.com. Each can be uploaded to fusion 360 individually as needed. We usually start by uploading the entire parts library from this link [VEX-KOP.](VEX-KOP.) See this instructional [VEX-KOP video]() if you need to load the parts library.

When adding parts you can follow this video - [Placing Parts]() In the simple case we will add a 60 tooth vex gear. We insert into design and then use Point to Point move and put the center of the gear at the joining point of the 2 lines that make up our 2 D lift.



Continue with the remaining parts until you have a completed 3D assembly.



Putting it all together, we have a small 2 bar lift using 10 hole long c-channels and a 12 tooth gear driving a 60 tooth lift arm gear.

Tools

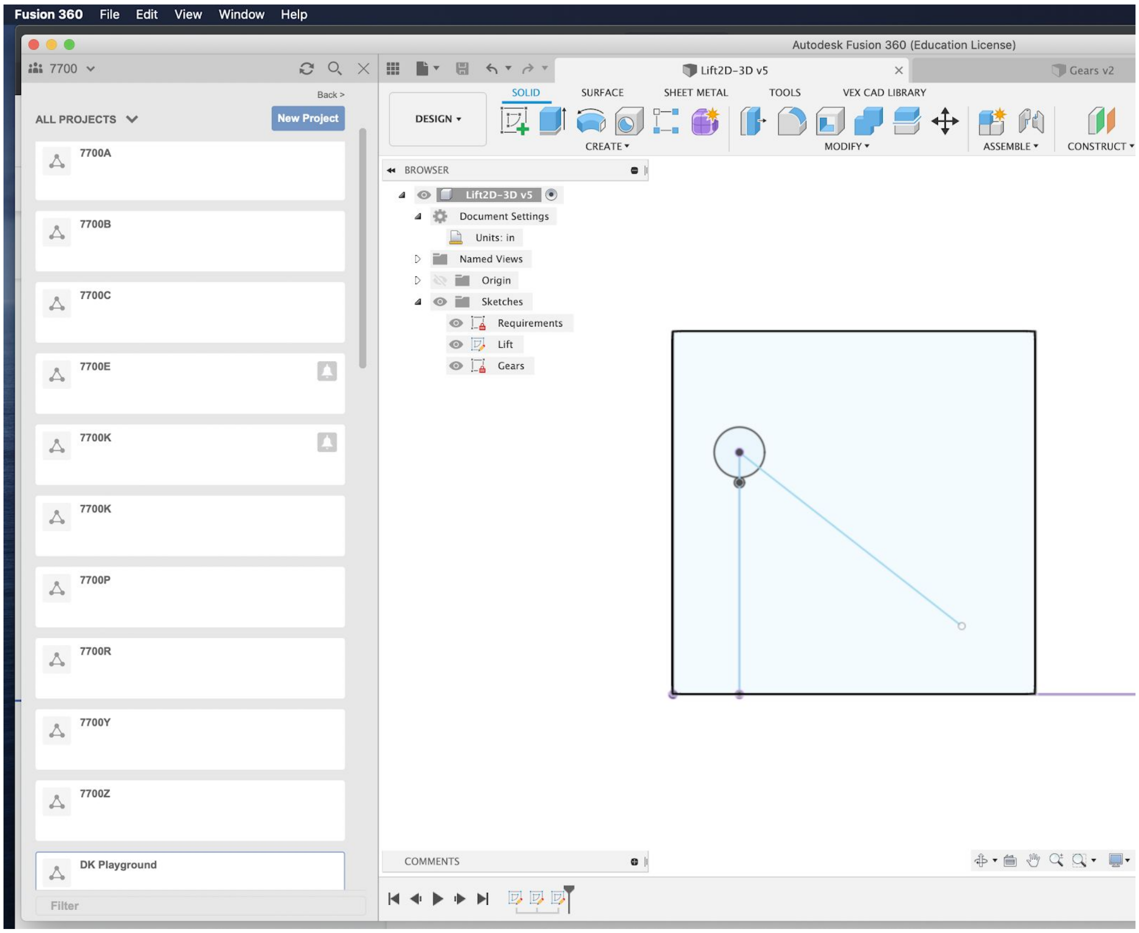
Line L click at the first point and drag then enter length and hit return.
Rectangle R click at the first corner then enter height, tab, width and hit return.
Circle C click at center, drag then enter diameter and hit return.

Constraints

Coincident makes two points coincident, like putting a screw through a hole.
Tangent constrains a line to meet a circle at only one point, or two circles to meet at only one point.
Horizontal constrains a line to be horizontal
Vertical constrains a line to be vertical

Student Reflections

We share a team on Autodesk Fusion 360. Each team has their own project folder and as the Mentor I have access to each teams project to review and guide work. Mentor keeps a shared project called DK Play Ground here are examples used in the lessons and other inspirational CAD works. We have an online lesson of how to use teams- [Autodesk Teams]



Reflection by Colin A. 8th Grade

“As captain of team 7700C I have used the lessons on CAD to help me learn. I like the youtube videos and slow them or step through to follow. We started with crayola to brainstorm and evaluate ideas.

Each time we start work on a new part of the robot I do CAD and show it to the rest of the team to use in building. In our remote work we spend more time on CAD and only have short times to work in person so I have a big responsibility to lead design with CAD.”

Reflections by Sean Magers, Harrison Kim both 8th Grade

Rolling Robots

12/30/2020

CAD Challenge

This season I learned a lot about CAD I did not know, I have done cad for the last 2 years but there are always new features to learn and updates. I learned how to make blueprints better, learned how to optimize how I place stuff and learned more about Crayola CAD.

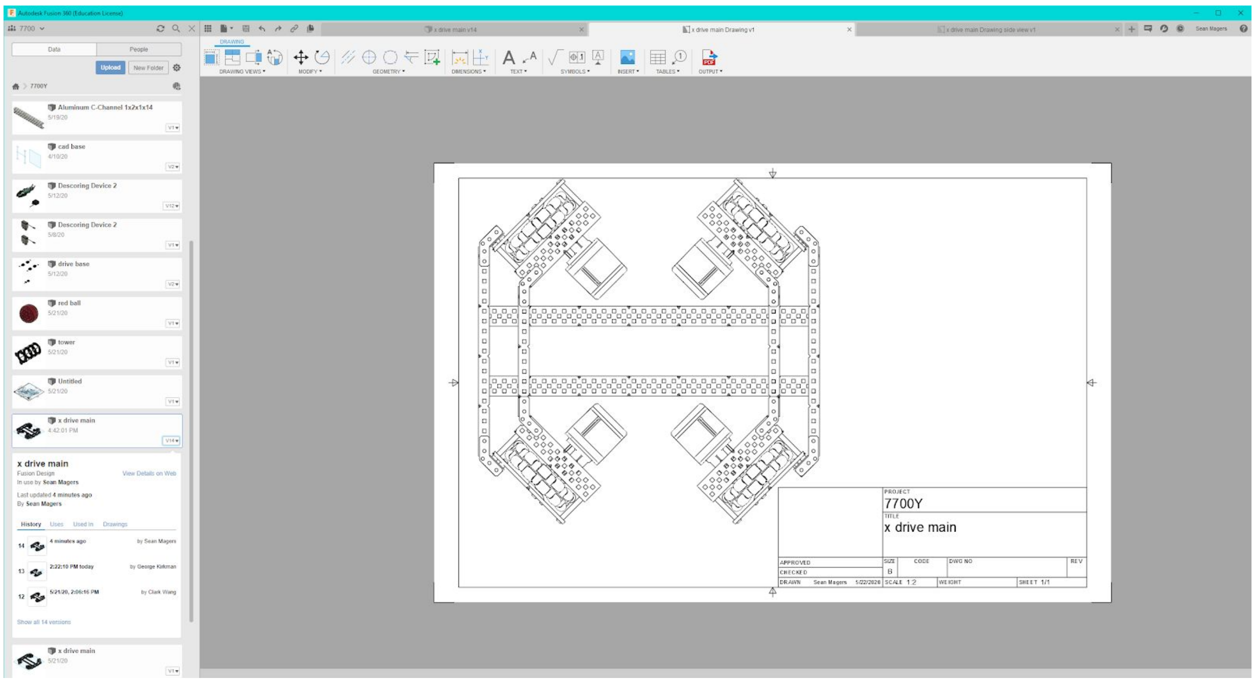
The CAD for our robot was not perfect, and it made me improvise on some parts, but as the main builder, I would say that the CAD was a very good basis for the basic design on our robot. It helped me find what size C-Channels I would need as well as what spacing I should have. In the end, our robot could not have been this good without the CAD and planning ahead.

Reflection

CAD has helped my team and me a lot this year, if we just build something out of scratch it might not work, it might not move the way we want or be out of size. With a Crayola cAD, we can see if the design is in size and if it will move the way we want. Later when we find the Crayola CAD is good and everything is how we want we build the robot in CAD with to size parts. Now we can see if we missed something or if something from Crayola CAD does not work in real life. -Sean Magers

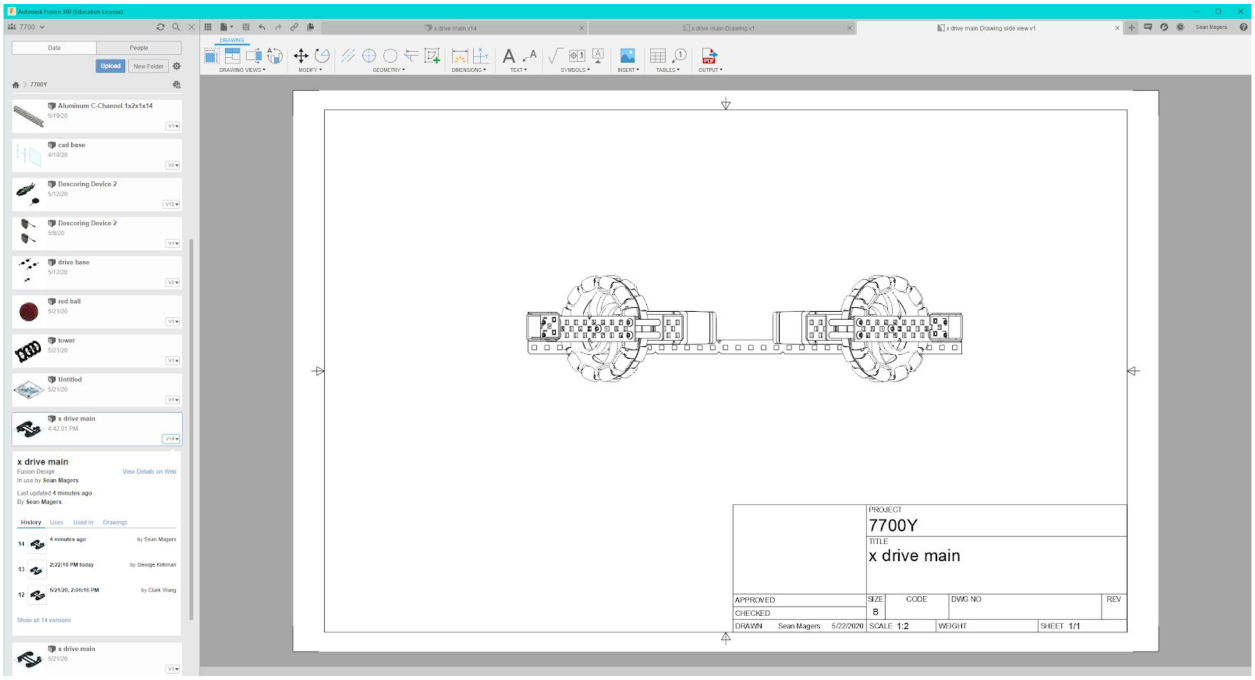
Personally, I would use CAD on all of my robot designs going forward. The CAD designs in both crayola and fusion have helped my team build and vision what we want our robot to do. CAD has helped us envision our ideas on a screen, and save time building and taking apart our robot. -Harrison Kim

Drive base top



5/17/2020

Drive base side



5/22/2020

x drive base

You can see how the CAD blueprint and the final design look very similar.

Student reflections of our team are also represented by their entries on the engineering notebook. The team utilizes an electronic notebook to document the design process. Here are just a few pages that show the team utilizing CAD in their design process and online discussions.

Team 7700C Notebook

Team Members

Colin A:

He is the team captain. He is also the design lead for the robot and has done all of the CAD. He is 13 years old.

Peter S:
He codes the driver code for the robot. He is also one driver of the team. He is 11 years old.
Ella N:
She builds using CAD and drives the robot. She is 12 years old. She is also one of the drivers.

Phoebe M:

She codes the auton and teams up with Claire. She is 10 years old.

Claire C:

She does code with Phoebe and develops the auton for our robot. She is 10 years old.

Luke F:

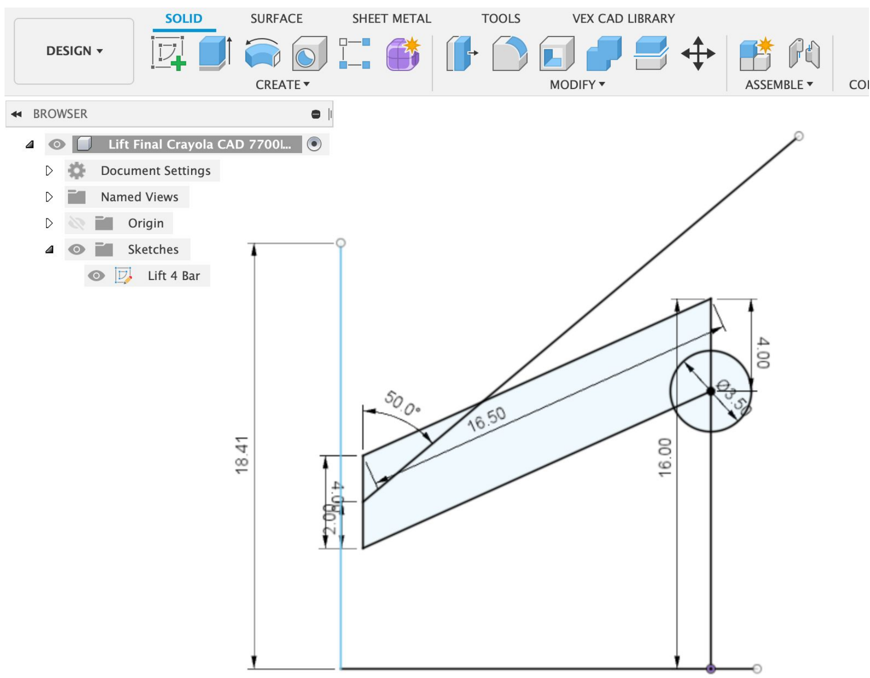
He builds. He is 11 years old. He likes to cut stuff.

Kit M:

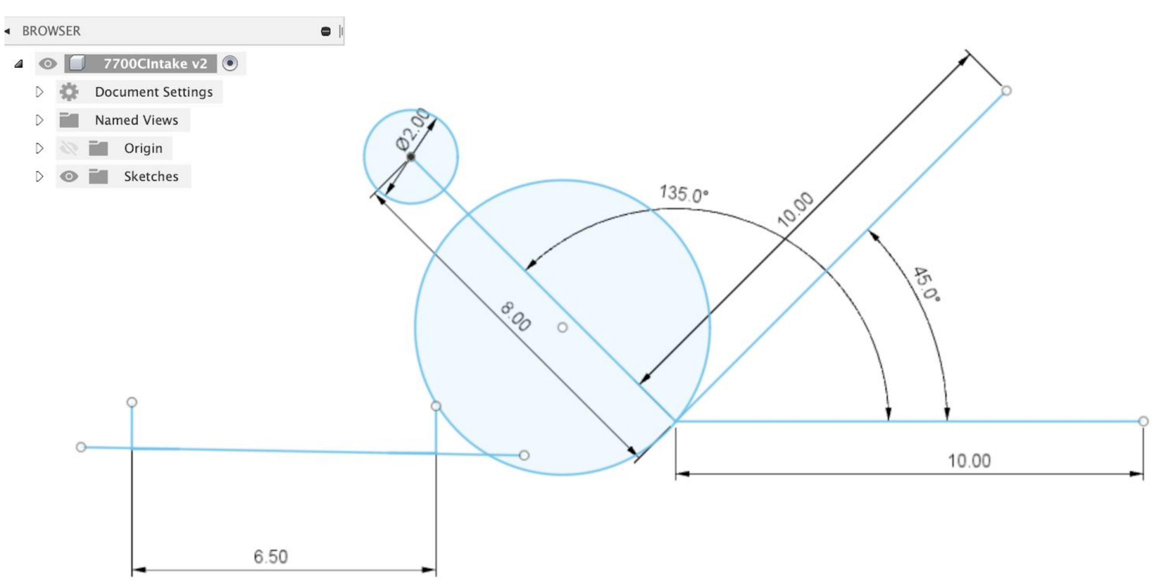
She is 12 years old and she likes to build and create anything.

Robot Crayola CAD

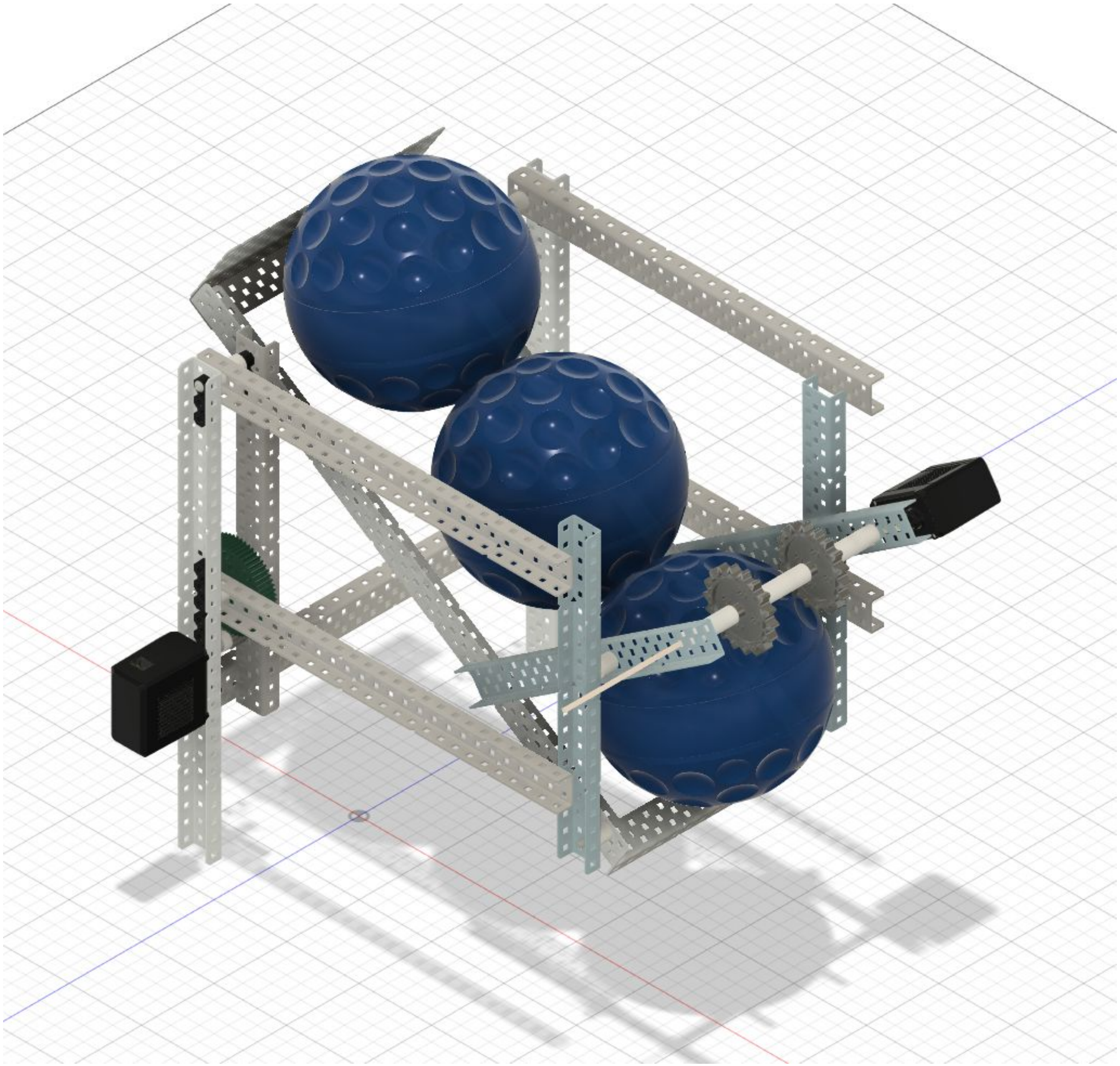
Lift:

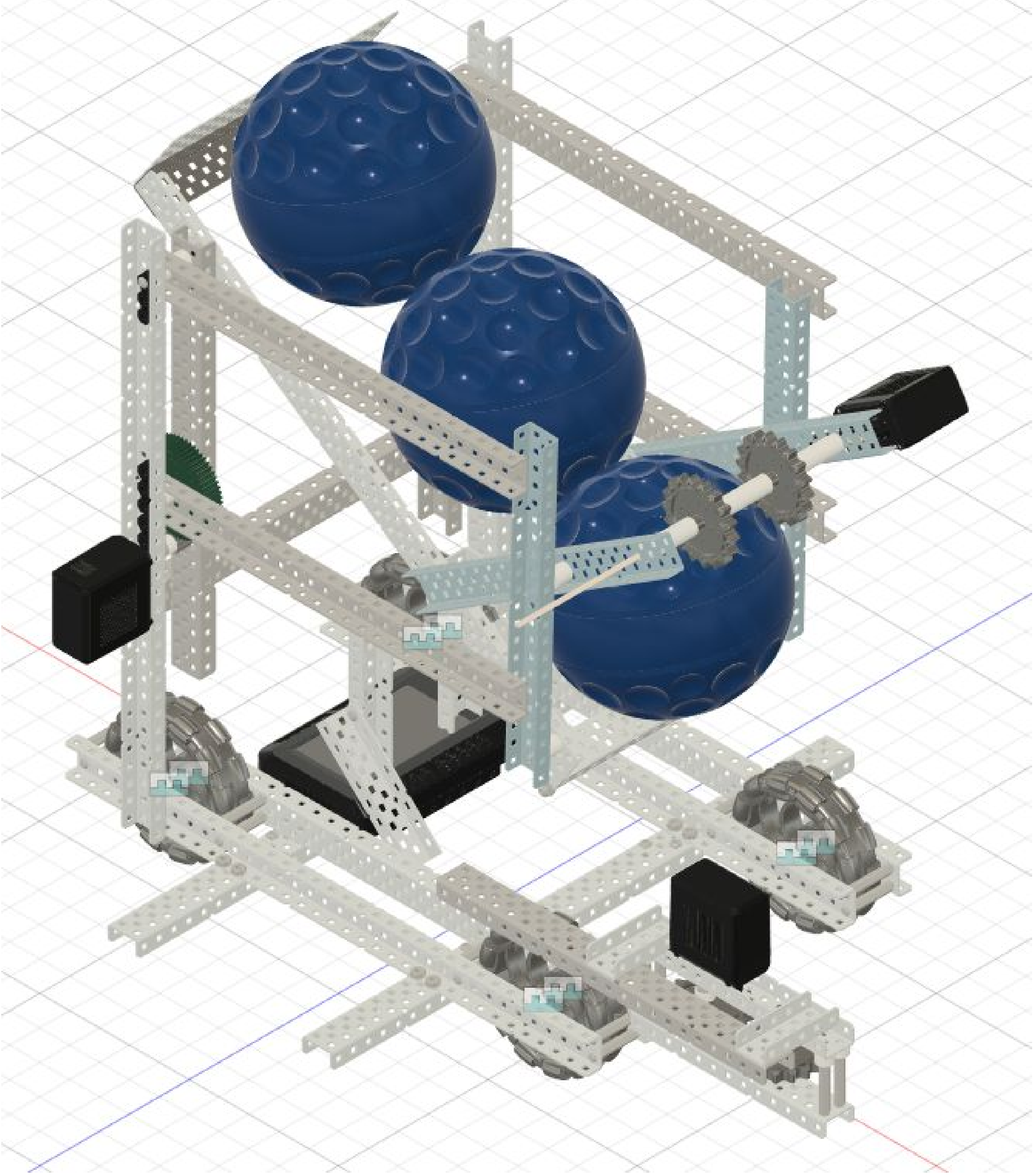


Intake:



Robot 3D CAD



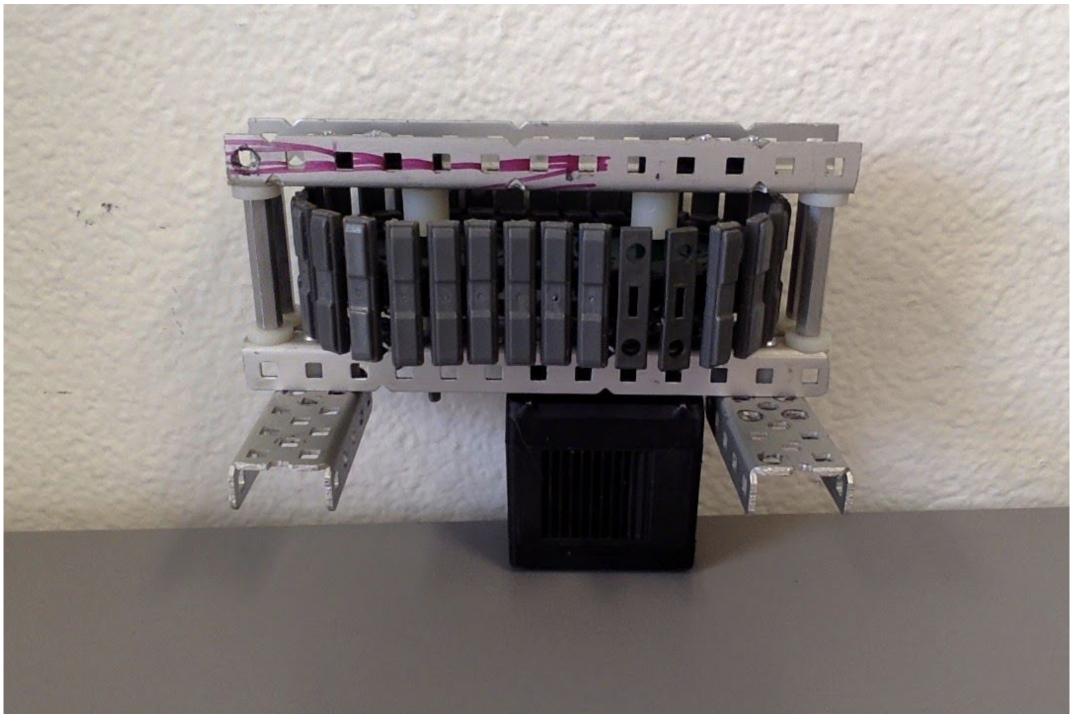


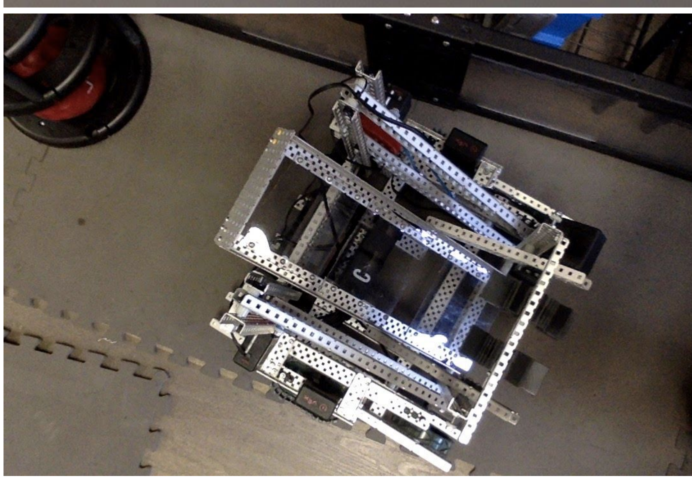
Zoom meeting 11/6/2020

Today we did more notebook work. We only had three of us attend the zoom today and the mentors checked in on us. We made sure we had all of the things we needed to make a good strategy. We talked about what we will do tomorrow when we meet in person and what to do. If we get the robot functional and good enough to score a decent amount of points then we can go to a tournament.

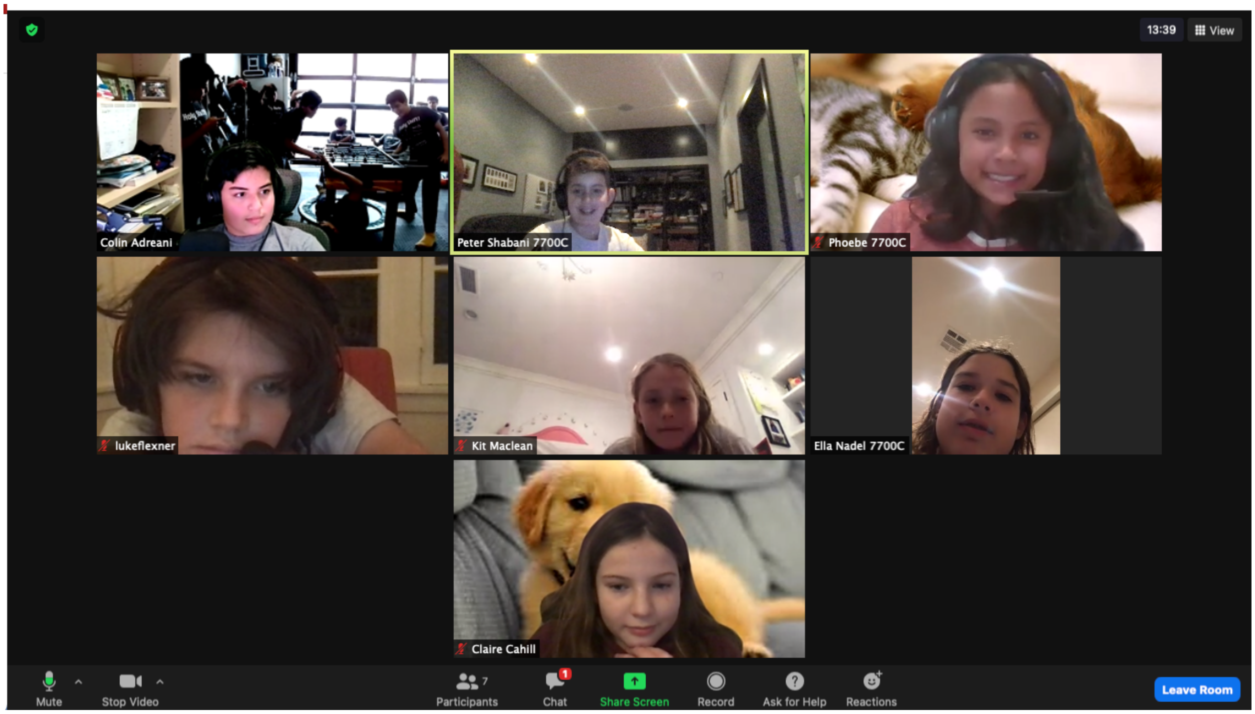
In Person Meeting 11/6/2020

Colin and Peter came today. We are working on the intake roller today. We are doing CAD so we can place the intake roller. We are also a little out of size. Another thing we have to do is to get the robot insize today. The new intake will help us get the balls inside the robot, without slamming it against the wall. We also had to make it swing out to meet the balls so we were insize. It is a janky solution that I hope we will find a better way to deploy them. Without them the robot would not be able to go to competitions.



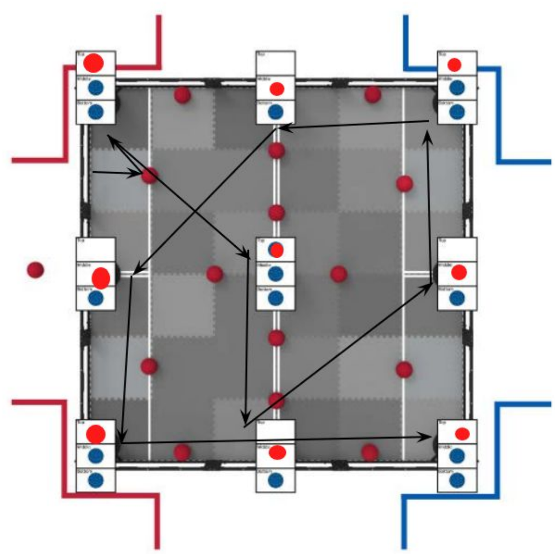


Zoom Meeting 11/20/2020



In this session, we worked on the CAD for the intake. We rethought the design of our intake to allow us to reliably pick up balls from the field. We discussed our skills strategy in which we put one ball in every goal giving us 103 points for the skills. Skills are very important this year, as we stated before and having a good skills score could get our team to worlds.

This is the cad of the new intake \/ with everyone there



While this is the Auton strategy ->