

## Advanced CAD Week 3: GrabCAD and Tenets of 3D Printing

Rohawks 3419 -- Celina, Nathan, Lili -- 2019-2020



### Lesson Goals

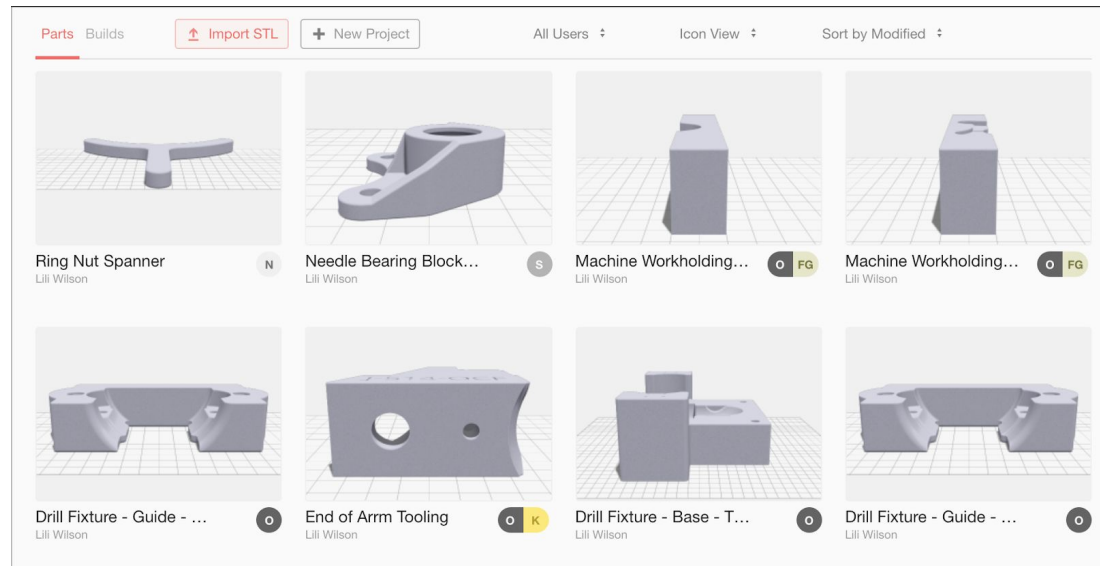
- Explain what GrabCAD is for and show students how to upload and download files.
- Teach students the basics of 3D printing: applications, supporting/embedding techniques, use of eiger.io.

### Lesson Plan

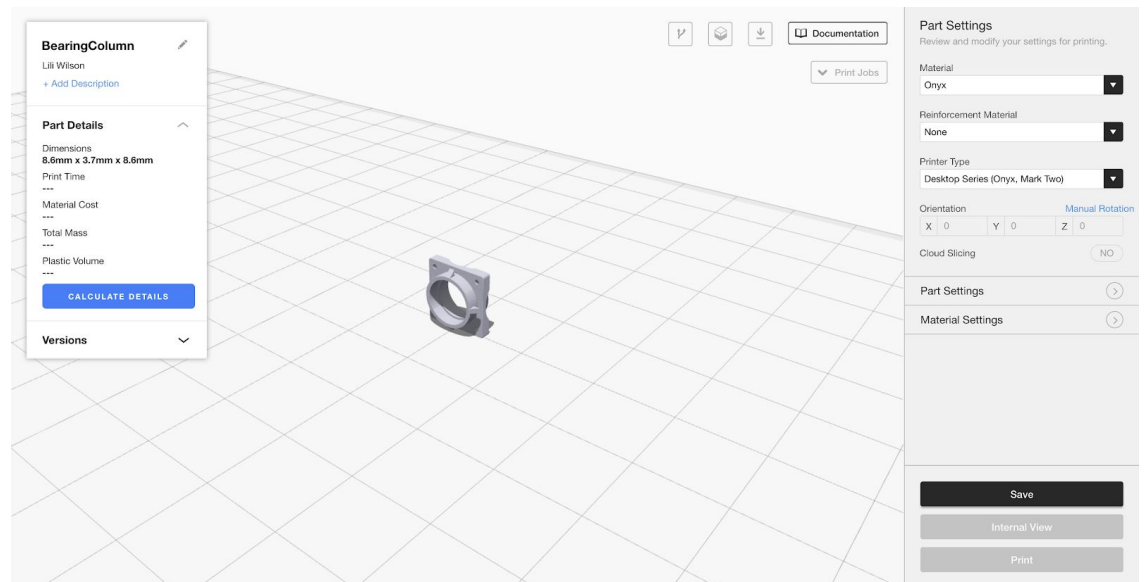
- Pre-lesson setup
  - Send out an e-mail a few days beforehand with instructions on making GrabCAD accounts, for those who have not already, and joining the 3419 collaboration.
- GrabCAD
  - GrabCAD is an online platform that allows engineers to upload, share, and modify 3D models.
  - During build season, the team uses GrabCAD Workbench to update part files as the prototyping and building process progresses.
  - By the time build season begins, everyone will have been added to the 2020 folder, and will be able to track the progress of the robot.
  - Throughout the season, we will ask you to make parts (at home or at AB) and upload them to the GrabCAD project.
  - Team 3419 isn't the only GrabCAD user - to check out the creations of 6 million users, check out their [library!](#)
- GrabCAD Exercise
  - Upload mounts to the Advanced CAD project folder.
  - Download uploaded mounts from other students.
  - Open a mount from a neighboring student.
- 3D Printing Applications
  - 3D printing is useful because it is fast and cheap, allowing us to prototype and iterate quickly.
  - Plastic 3D printers used to produce weak, fragile parts; recently (~last 5 years), advanced materials like carbon fiber have become usable, and can make light and strong ones.
  - 3D printed parts are still brittle, so they are unsuitable for load-bearing struts, belly pans, or swerve bearings.
  - They are excellent for mounts, grabbers, and non-load bearing pieces - all of which might be hard to cut out of metal.

- The 3D printers we use are supplied by our generous sponsor [Markforged](#).
- 3D Printing Tenets - Overhang and Supports
  - There are a lot of types of 3D printers, but the ones we use are fused deposition modelling (FDM) printers, meaning prints are built from the bottom up layer by layer.
  - This means there is a limit to how much overhang (the amount one layer extends outward without any support below it) our printers can handle when creating a part.
  - Imagine 0 degrees is directly north; our printers can handle 45 degrees of overhang.
  - However, if a part must be printed in a way that has layers more than 45 degrees steep, we can enable supports.
  - Supports are material that is printed below those 45+ degrees layers. They allow those layers to be printed successfully, and are later somewhat easily removed from the final print.
  - However, a part sometimes must be completely without supports, meaning it has to be designed with 45 degrees or less of overhang. Depending on the print, it might be easier to either design the part forgoing supports or simply deal with the support removal afterwards — do what is most efficient!
- 3D Printing Tenets - Teardrop Holes and Diamond Nuts
  - Since our printers can only handle 45 degrees of overhang, normally we'd need supports if we wanted to print vertical, circular holes.
  - To circumvent this, we instead print teardrop holes! The top half of the circle — which normally would require an overhang of greater than 45 degrees — is instead replaced by two perpendicular lines tangent to the original circle. This forms a teardrop shape with a 45 degree overhang, no supports needed.
  - When embedding nuts into our print, we usually use square nuts instead of the usual hexagonal nuts because it is impossible to avoid a 45+ degrees overhang when printing a vertical hexagonal shape.
  - To avoid supports with a square nut, orient the square in a diamond shape.
- Eiger.io!
  - In order to 3D Print the parts that we design using Inventor, we have to transfer those files onto the Markforged software. Eiger.io is the online 3D Printing website that we use to convert our CAD models into files that the 3D printer can read!
  - After making a model, the first step is to upload it to eiger.io. Go to File → Export (hover over export) → “CAD Format”. This will bring up a window where you can save your file. At the bottom of that window, it says “Save as type” with a drop down menu. Click .stl and save the file (eiger.io reads STL files).

- When you open eiger.io, you'll be greeted by this screen with all of your past parts. At the top of the screen, click "Import STL." Your part will then appear on a grid!



- To rotate around the part, just click and drag! (easier than in Inventor)
- After this, you have to choose which face you want the part to be printed on (orientation). We won't get into specifics now, but the time to print may change depending on orientation because of SUPPORTS! Some orientations may require more supports than others, therefore they use more material and take longer. To change the face that's flush with the 3D printing plate, just click the face on the eiger model.



- Now, it's time to choose settings for the printer. Don't worry about the settings at the top of the sidebar on the left for now. Just remember that we use the

ONYX printers (hehe destination deep space robot name). Click “Part Settings” and change layer height to 0.2 mm. That’s basically all you’ll need to change for the time being.

- You can check part details on the left side of the screen. This is pretty useful information when considering the types of parts we’ll be using on the robot. You can also check the time it will take to print your part, good for planning when to print it.
- **\* info abt how to print multiple parts at same time on 1 printer**
- After all the settings are in place, click “Print” and download a .MFP file, which is 3D Printer friendly (mfp stands for markforged print! I think...). Then, just put it on a USB and bring it to the printer! More specific instructions on how to physically set up the printer each time you use it will be explained at the workshop—there really isn’t much.
- 3D Printing Tenets - Embedded Nuts
  - While we can leave empty spaces on the outside of the print to pop nuts in after the print is complete, we can also embed nuts inside the print during the printing process.
  - While we have used hexagonal nuts in the past, USE SQUARE NUTS for this if you can! Hexagonal nuts can chip away at the print while a bolt is being turned into the nut, eventually wearing the print away until a circle remains.
  - To embed a nut, leave a space in your CAD for the nut. Imported your STL into Eiger. Scroll through the layers of your print in Eiger, and find the layer RIGHT BEFORE the printer starts building a layer above the space left for your embedded nut. Check a box to pause your print there.
  - Once your part is printing, pop your nut into your print when it pauses. Remember to make sure your part is still securely glued to the printing bed, then continue the print.