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ME 399: Gibbot Frame
Professor Lynch

## Requirements/Specs

We were given the following requirements and specifications:

- Link length between 12" and 18"
- 5lbs maximum link weight
- Magnet tangential holding force >= 40lbs (from Nelson's simulations)
- Motor/gearing requirements: 133 rpm, 10 N-m
- A≈.55, where A*L is the location of the center of mass of each link
- B≈.28, where B=I/(m*L^2)

## Winter Quarter Tasks

- Select a motor and design/choose appropriate gearing
- Select electromagnets
- Design magnet assembly, including how to pass power through rotation, and how to incorporate an encoder
- Design link geometry, with consideration for magnets, motor, batteries, and circuitry

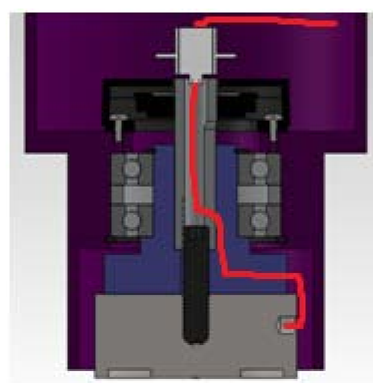
## What I Did Winter Quarter

### Magnet Selection

To start off with, I took the magnet from the first version of the Gibbot (APW EM-150-24-122) and tested it to determine its holding force. APW's magnets are rated only for normal holding force, so testing was required to determine shear holding force. This testing was accomplished by supplying power to the magnet while in contact with the steel sheet that will be used for the Gibbot. After engagement, weights were hung from the magnet until sliding occurred. While this original magnet was rated to hold 66lbs normal force, it only held 15lbs in shear. Based on this relationship, a new magnet was chosen (APW EM-237-24-212), which is rated for 190lbs normal. One magnet was ordered/tested and found to hold 39.75 lbs in shear. After consulting Nelson, this was determined to be strong enough.

### Magnet Assembly

I designed and prototyped the assembly for the electromagnets. In order to allow the magnets to rotate freely, power needs to be passed through the rotation, so there is a hollow shaft through in the magnet holder, which is mounted on bearings. At the top of the shaft is an encoder, to track the magnet position, and then a slipring, to transmit power through the rotation. In the image to the right, the red lines indicate the path of the magnet's power supply wires. The bottom section rotates with the magnets, while the top section is fixed relative to the frame.



### Motor Selection

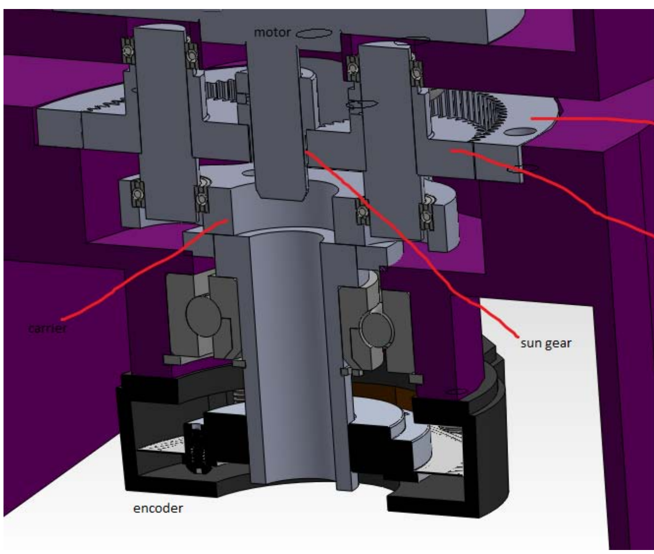
With Nelson's help, we selected an EC-60 pancake motor from Maxon Motor. This allows us to place the motor at the pivot point, freeing up space within the links for batteries and electronics. Based on the motor specs and our required specs, a 6:1 gear ratio is required for the EC-60 motor.

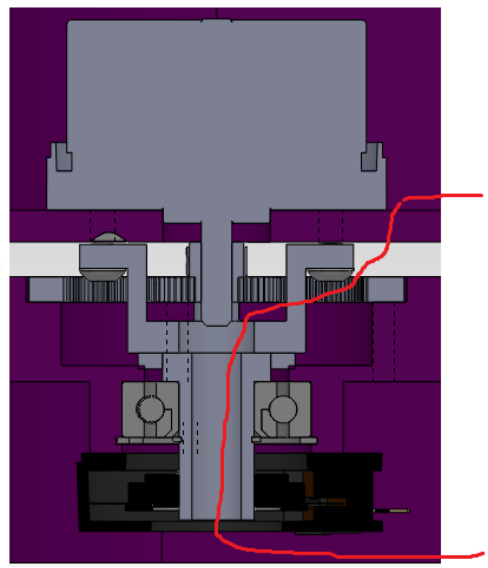
## Gearing

Since the motor axis is in line with the pivot axis, we chose to use a planetary gear train, with the sun gear as the input, the ring gear as the output, and the planet carrier fixed. To accomplish this, I selected the following gears from SDP/SI, whose combination yields a 6:1 gear ratio.

Sun: S10T05M020A0508, 20 teeth
Planet: S10T05M050A0508, 50 teeth
Ring: S1E05ZM05S120, 120 teeth

All gears have a module of .5mm and a face width of 5mm. The picture on the left shows the assembly with parts labeled. On the right, the red line shows how power will be passed through the joint. The carrier and the shaft attached to it are both fixed relative to the link with the motor in it, so the wire can be fixed throughout that whole length. I also made a mockup of the gear assembly as a proof of concept. We discovered a few issues with passing the wire as planned, which we are now aware of and developing solutions for.



## Gibbot Assembly/CAD

After designing the magnet assembly and the motor packaging, gearing assembly, I incorporated it all into a CAD model of the whole Gibbot assembly. I also developed a spreadsheet to keep track of all the component weights and inertia values. This spreadsheet calculates the total mass, center of mass and inertia of each link. We are using this spreadsheet to mess around with the placement of all the components in order to meet the A and B parameters specified above.

## What's Left

- Finalize link length/width and placement of all internal components
- Incorporate components for smart wall charging
- Finalize CAD geometry for links (including ribbing, supports, component attachments, and covers)
- Program CAM, order material, and machine both links
- Machine parts for magnet assembly and gear/motor assembly
- Assemble and test first iteration of frame