SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Mechanical Design & Fabrication

WEEK 4

Timeline

- 16 September 2021, 7-9pm
- SOAR Projects Showcase

WEEK 1

- 27 September 2021, 7-9pm
- Intro To Mechanical Design
- Fusion360 Part 1, Basics

- 30 September 2021, 7-9pm
- Introduction to Arduino

WEEK 3

- 4 October 2021, 7-9pm
- Fusion360 Part 2, Assemblies

- 7 October 2021, 7-9pm
- Programming & PWM

WEEK 4

SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Timeline

WEEK 5

- 11 October 2021, 7-9pm
- Fusion360 Part 3, Simulation
- CAD Speed Challenge

- 14 October 2021, 7-9pm
- Ultrasound & Motor Drivers

WEEK 6

- Study Break

WEEK 7

- 27 (1030-1800)-28 October (1000-1800) 2021
- SOAR Challenge!

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Fabrication Techniques

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- Top-Down
  - Machining
    - Milling
    - Lathing
  - Waterjet Cutting
  - Laser Cutting
  - Drilling, Cutting, Bending
- Bottom-Up
  - FDM
  - SLA/DLP
  - SLM/SLS
- PolyJet
- CFF
- Composite Layup
- Casting
- Molding

Overview of FABRICATION Techniques

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Milling

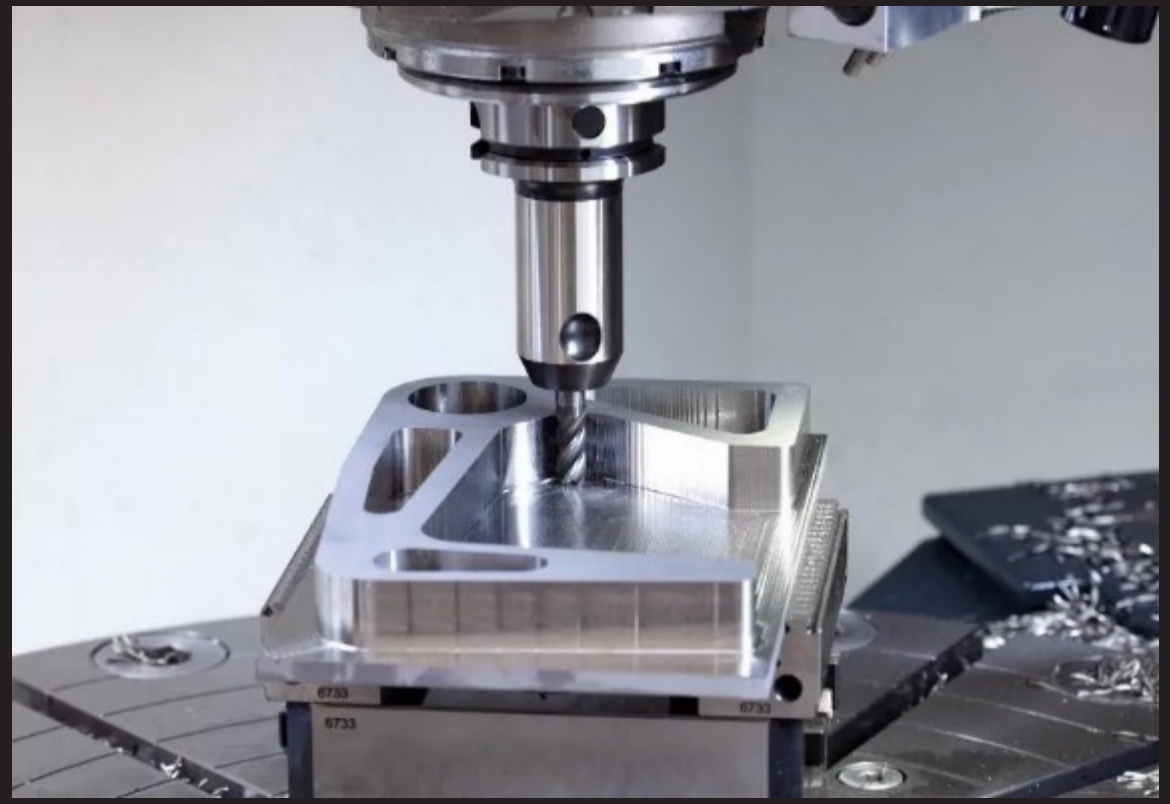
Subtractive Manufacturing

Materials: Aluminum, Steel, Stainless Steel, Titanium, Brass, Copper, PVC, Nylon, Solid Wood/Plywood, Foams

Manual/Computer Numerical Control (CNC)

Typical Use: Milling out parts with good surface finish and high tolerances

Limitations: Cannot mill out "overhangs" (except for high end machines)



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The Lathe

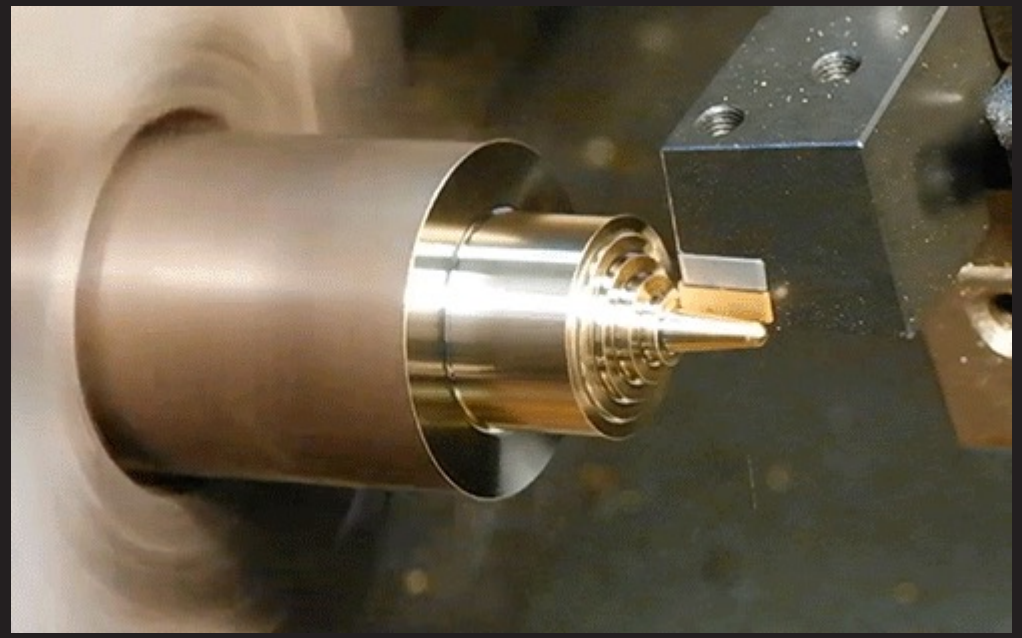
Subtractive Manufacturing

Materials: Aluminum, Steel, Stainless Steel, Titanium, Brass, Copper, PVC, Nylon, Solid Wood/Plywood, Foams

Manual/Computer Numerical Control (CNC)

Typical use: Milling out rotationally symmetrical parts with good surface finish and high tolerance

Limitations: Material must be rigid enough to handle centrifugal/centripetal forces without warping



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Waterjet

Subtractive Manufacturing

Materials: Rubber, foam, plastics, leather, composites, stone, tile, glass, metals, food, etc

Not purely a "water" jet, usually includes abrasive like sand/quartz/diamond in the water

Cutting jet usually thicker than laser cutters and less precise and lower resolution

Laser Cutting

Subtractive Manufacturing

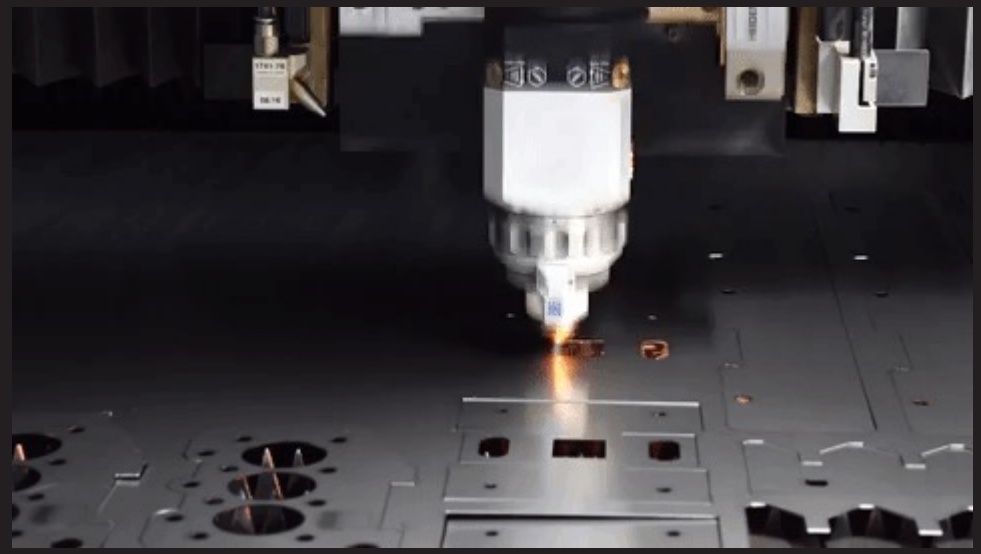
Materials: Acrylic, Metals, Wood, Foams, Cardboard, NOT POLYCARBONATE

Typically more accurate and higher resolution than waterjet

Cutting beam typically thinner than waterjet

thickness of material to cut usually thinner than waterjet

Can also do engraving



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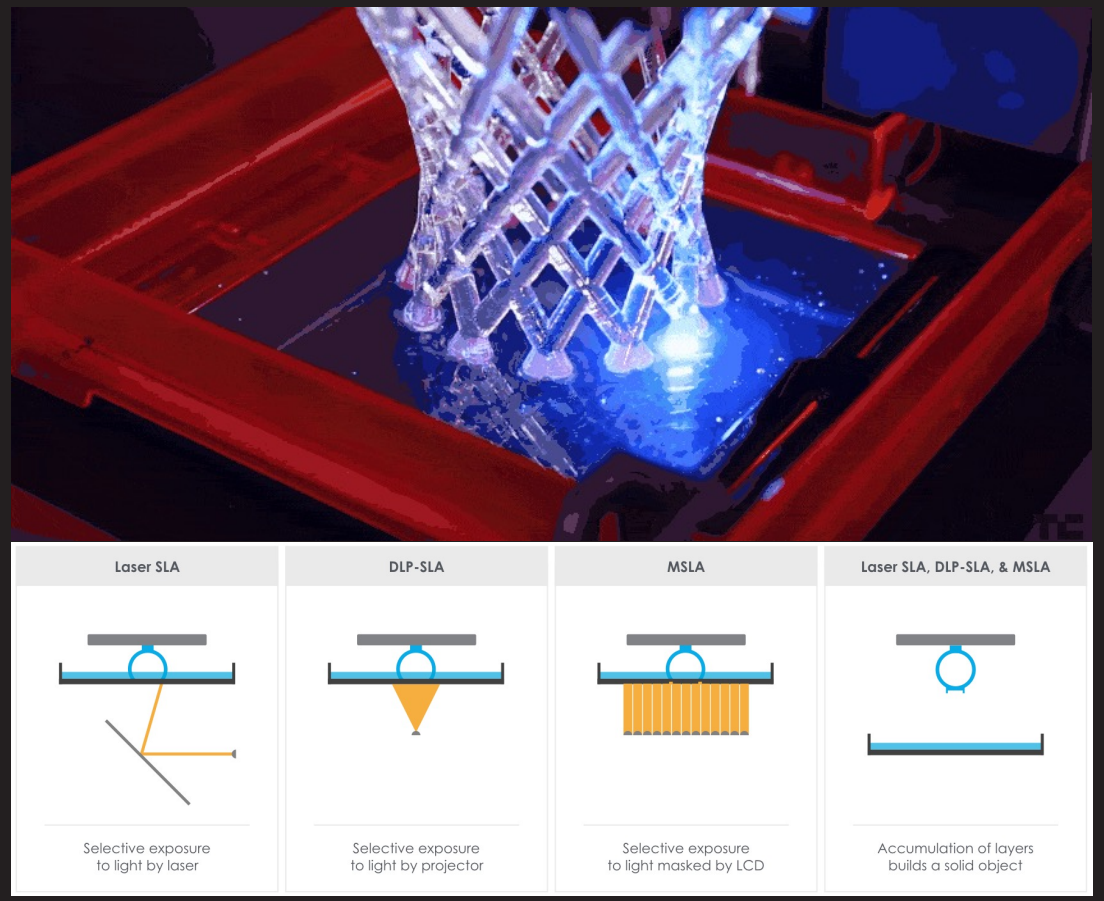
SLA/DLP Printing

Additive Manufacturing

Materials: Assorted UV cured resins with different additives to give different characteristics, eg. engineering resins, dental/medical resins, castable resins

Higher resolution and potentially faster than FDM, though typically smaller maximum print size

Environmental impact: Depending on material, but usually less waste than subtractive manufacturing



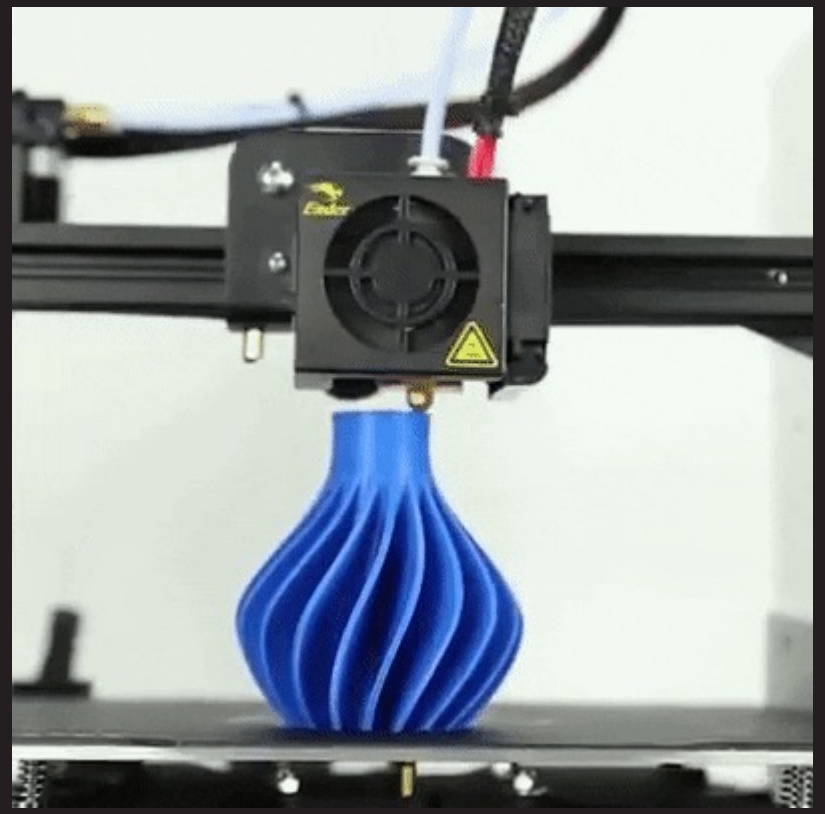
FDM/FFF Printing

Materials: Various thermoplastics, PLA, ABS, PETG, Nylon, TPU, exotic filaments, some with additives

Precision: is dependent on machine but usually 0.1mm layers vertically [z](stepper motor resolution) and 0.3mm [x,y](nozzle diameter)

Cost: ~$20/kg of PLA

Environmental impact: Depending on material, but usually less waste than subtractive manufacturing



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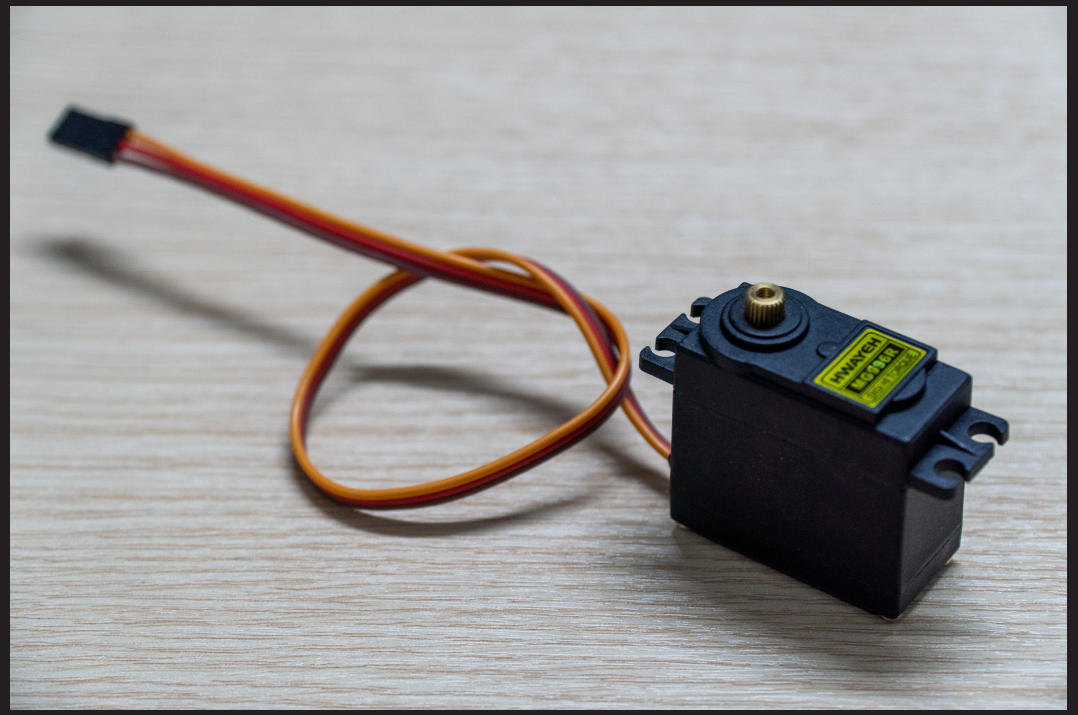
Today's Goal

CAD & Assemble the MG996R



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MG996R
Live Demo

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What You Get:

- Gears
- Axles
- Motor
- Potentiometer
- Bushings
- Screws
- Middle Shell

- To Do:
- Top Shell
- Bottom Shell

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DOWNLOAD Files

https://github.com/sutd-robotics/soar_challenge_2021

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WORKFLOW

1. Sketch/imagine the part
2. Use CAD software to build a model
3. Combine with other parts
4. Fabricate
5. Test
6. Repeat (if required)

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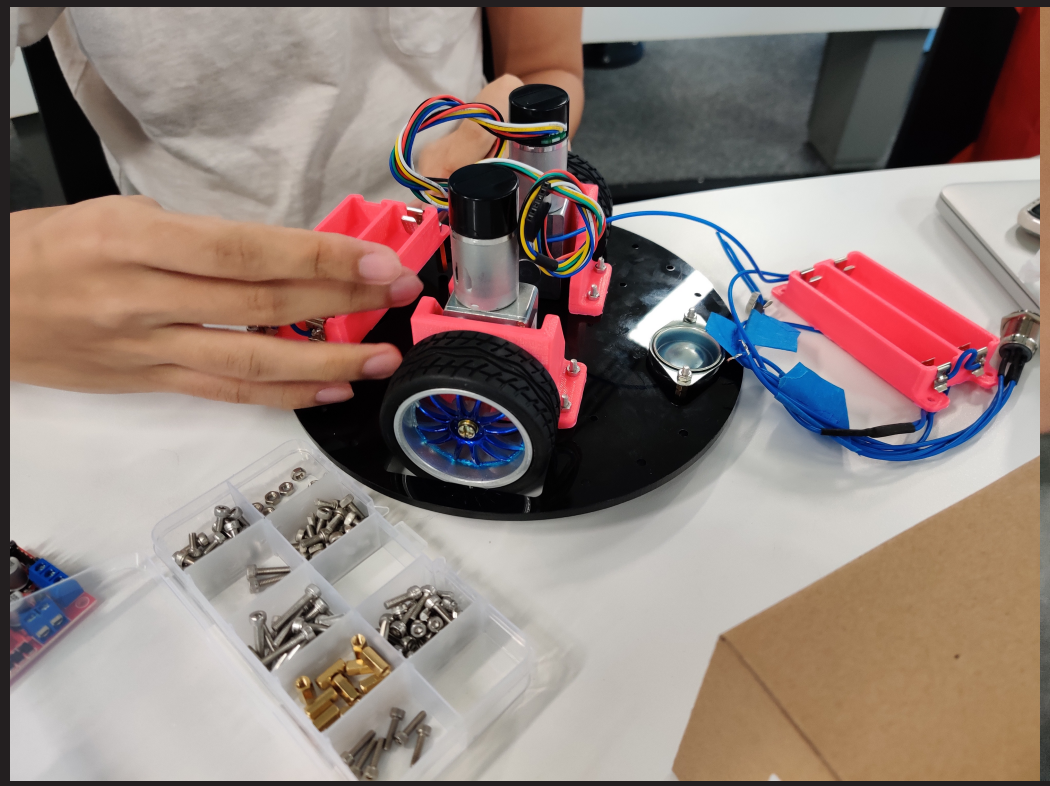
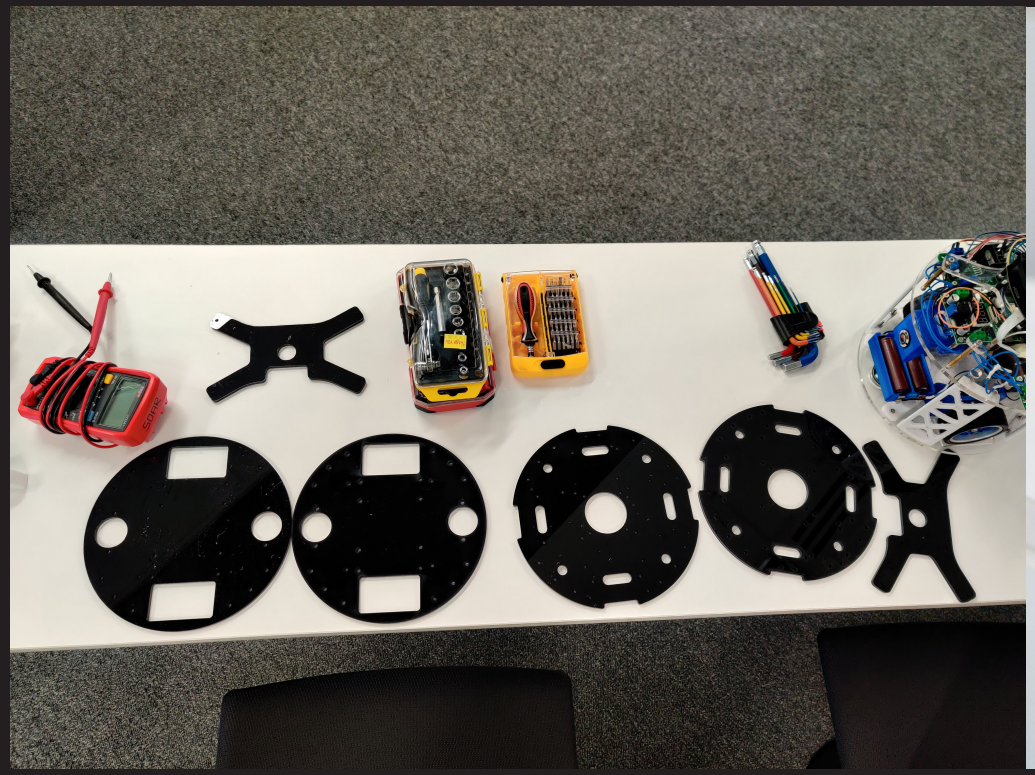
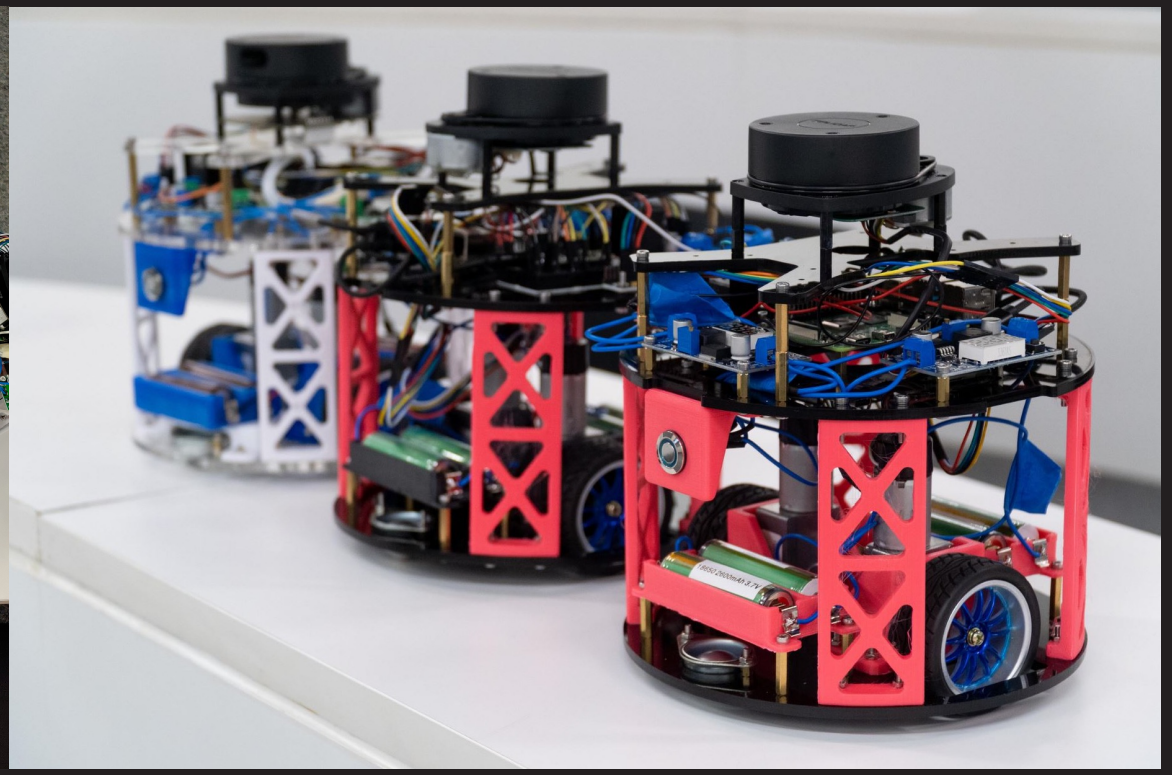


SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS





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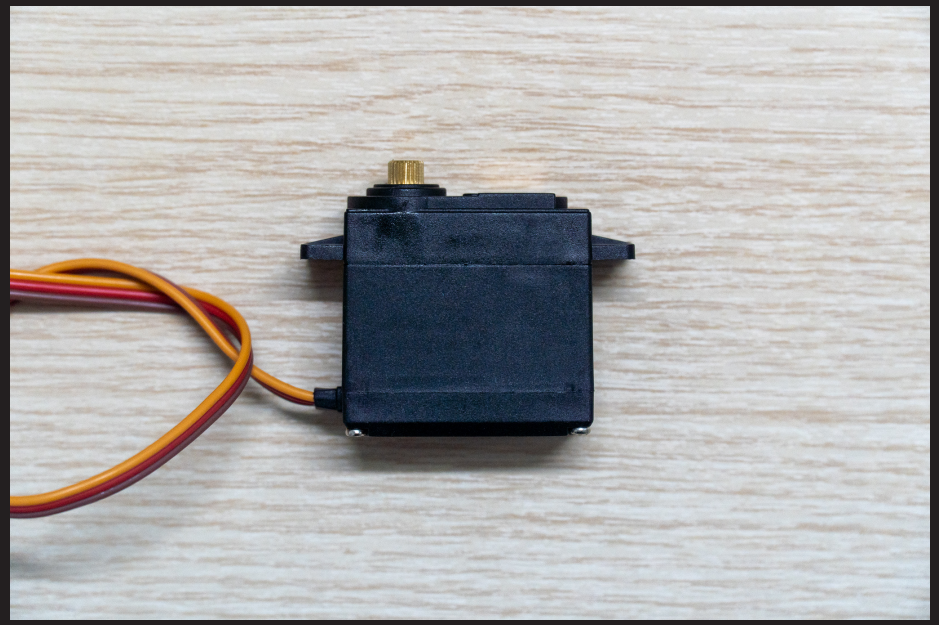
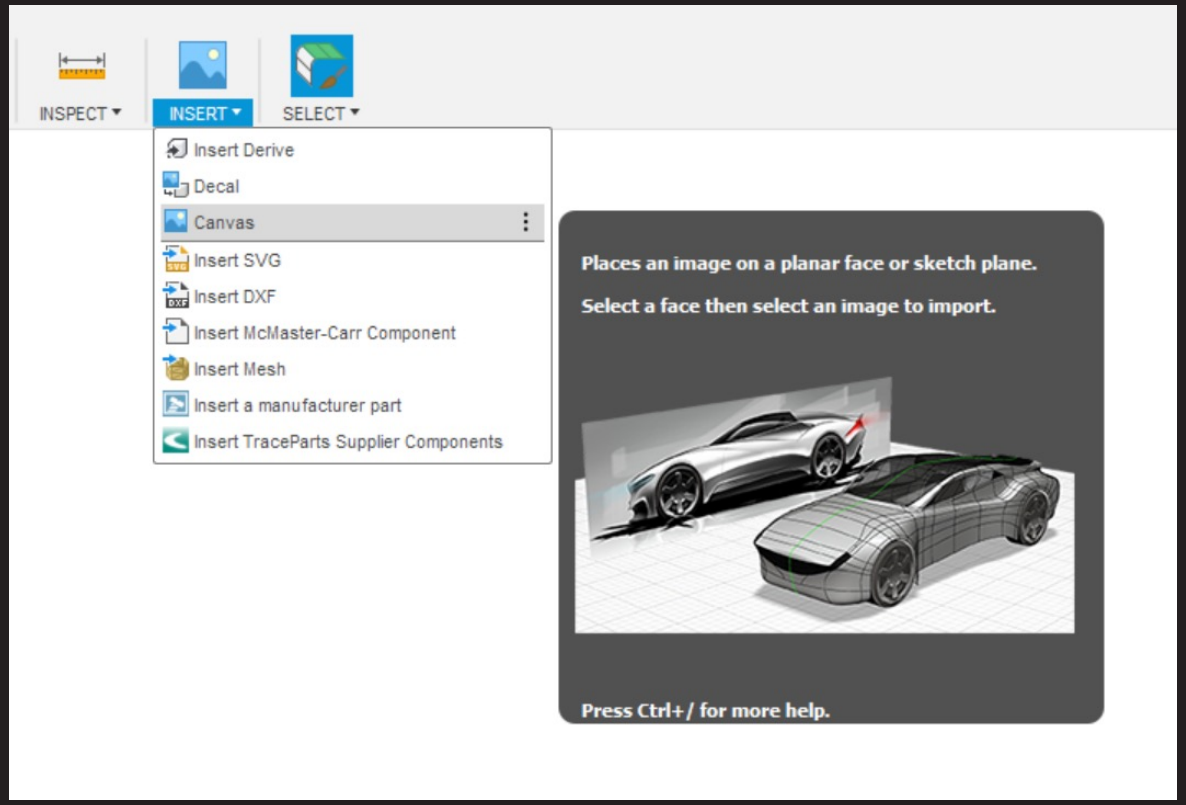
Take Photos of the Top Shell



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

INSERT Canvas

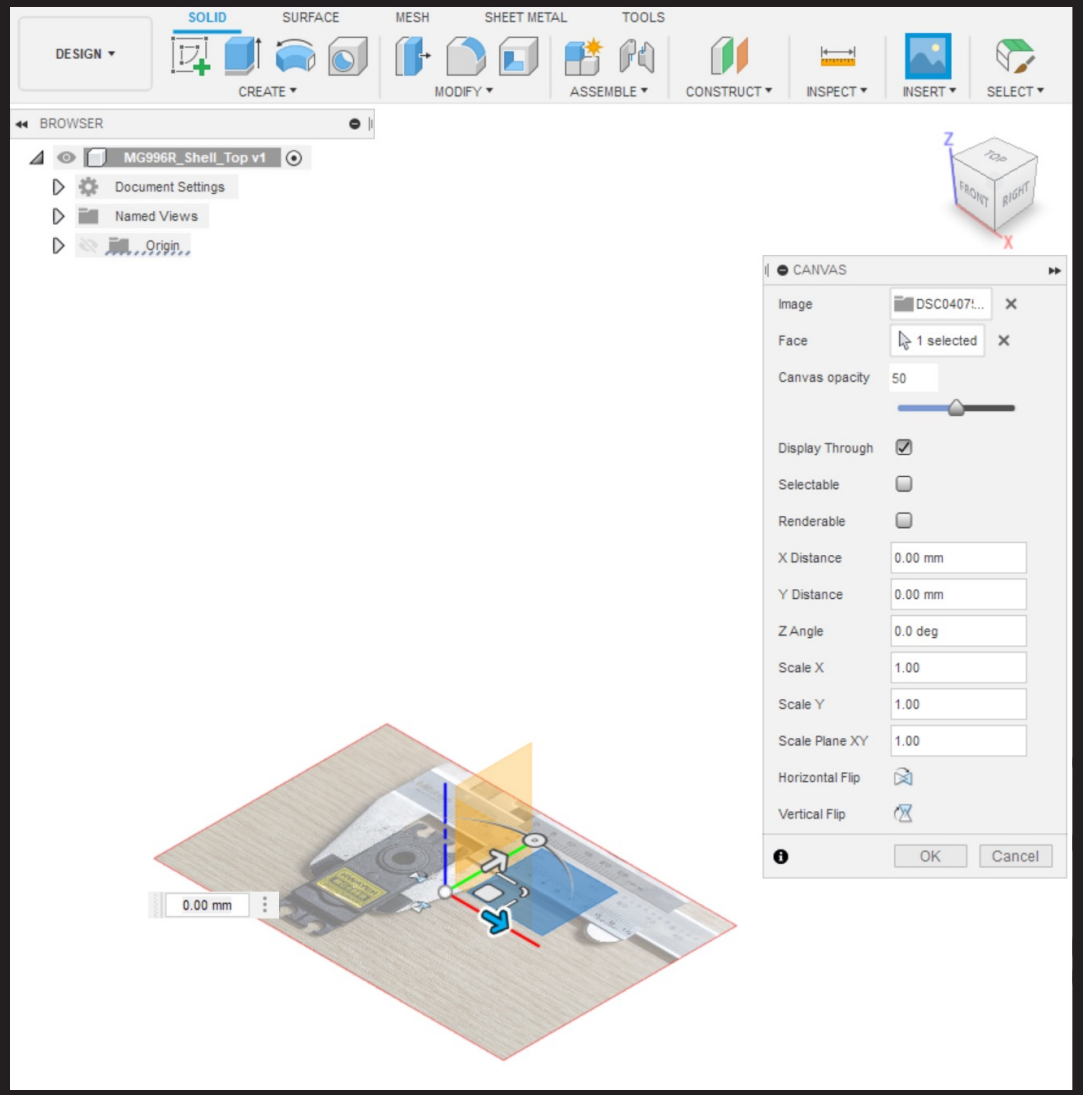
Using images to guide sketching



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

INSERT Canvas

Insert Top View Image onto Top Plane (XY)



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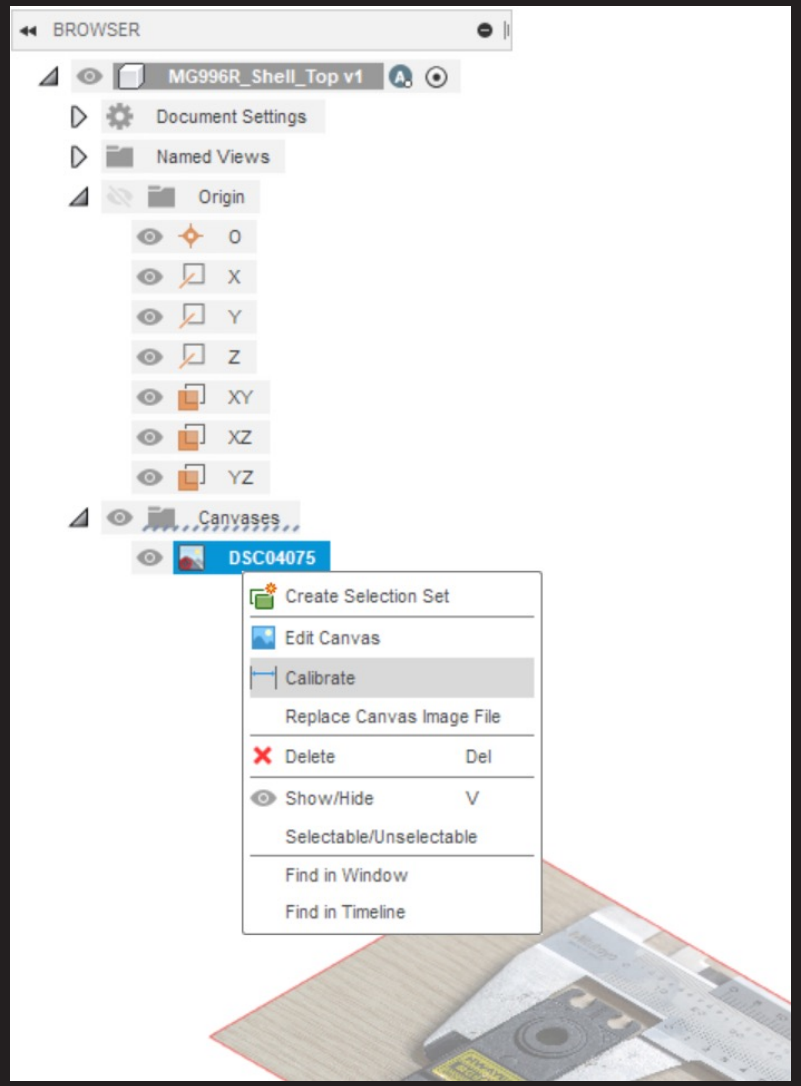
CALIBRATE Canvas

Measure the MG996R using a ruler/vernier caliper



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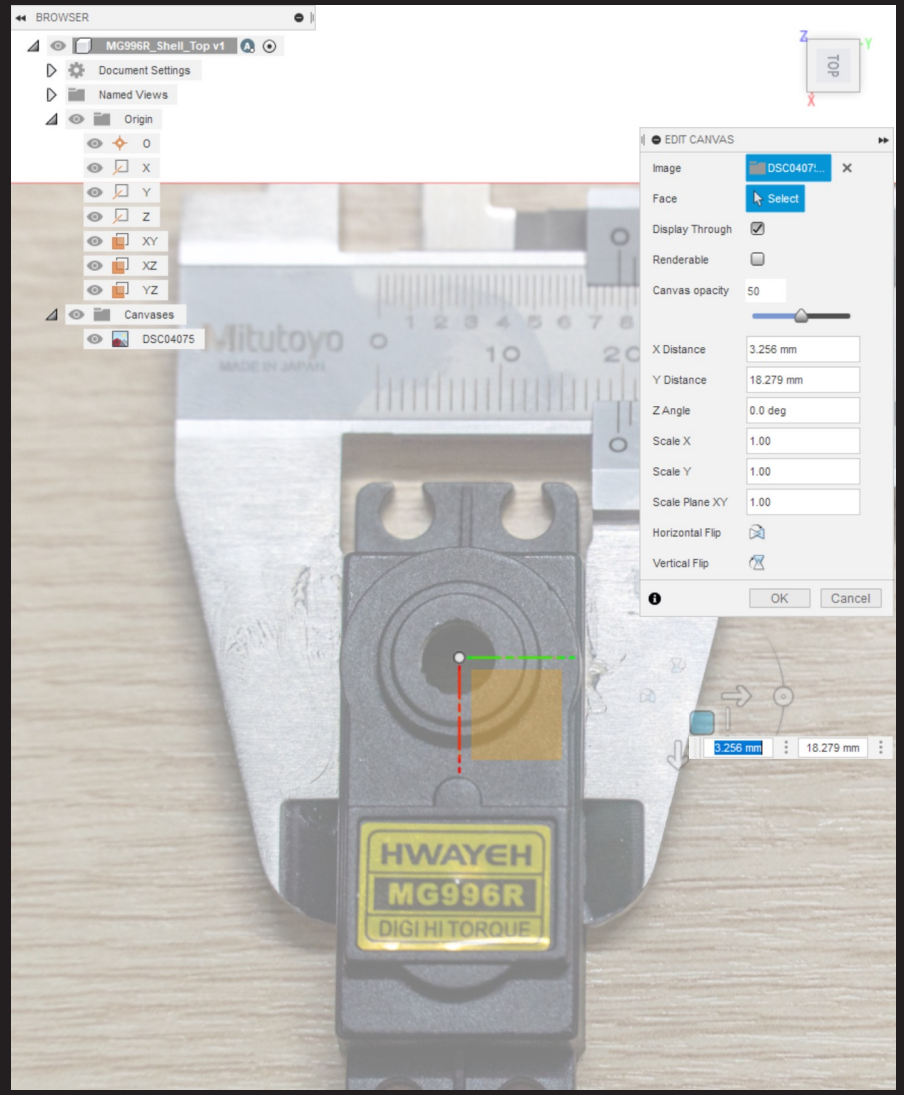
EDIT Canvas

Drag/rotate canvas.
TIP: Position key feature at origin.



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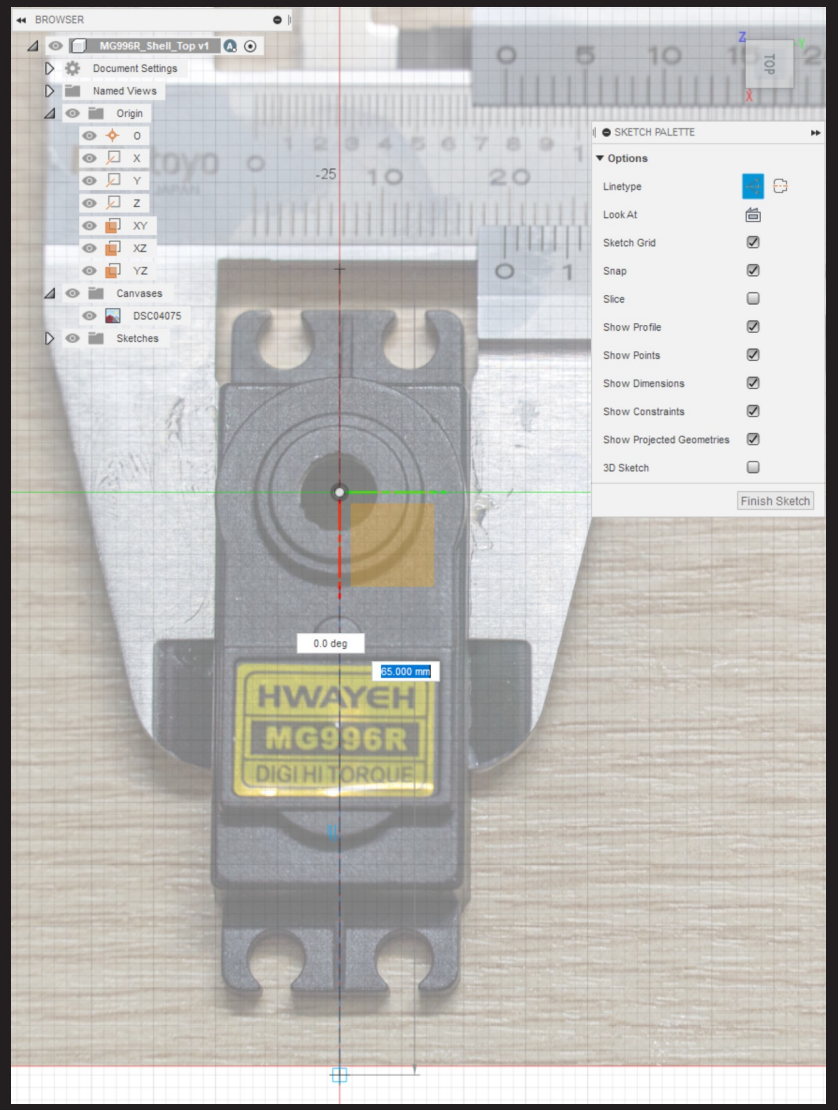
SKETCH & Extrude

Create construction line through origin.



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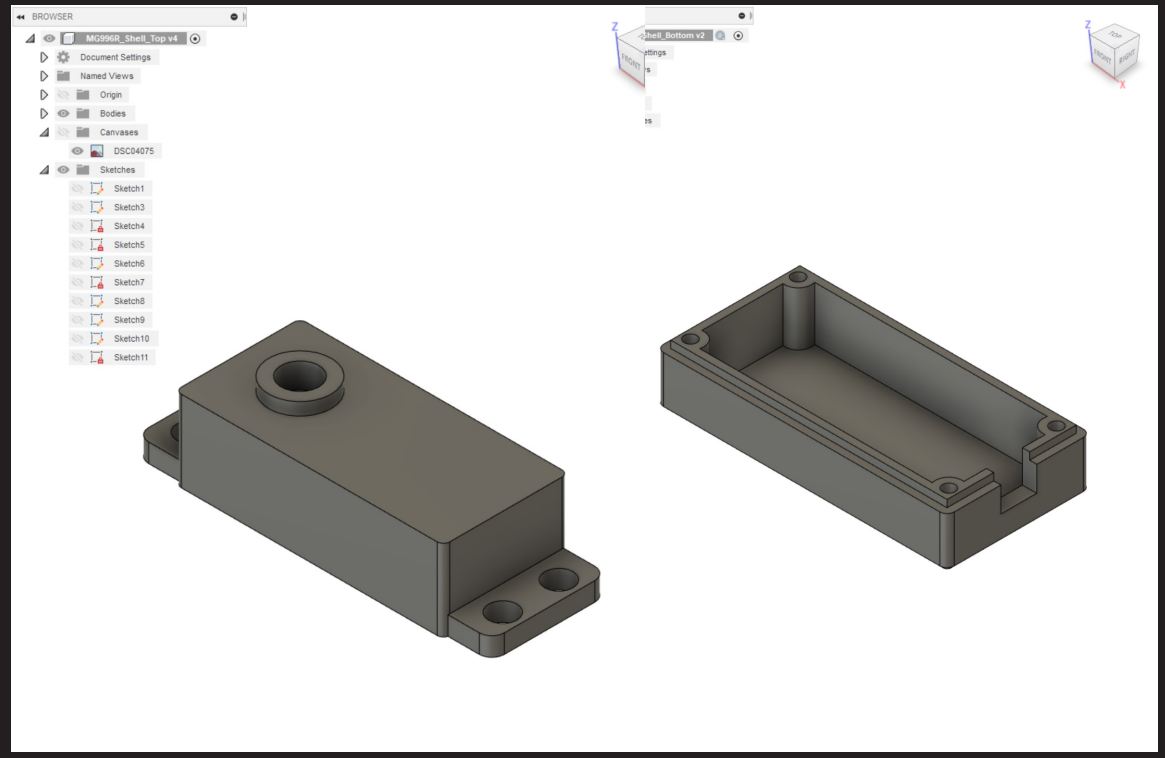
SKETCH & Extrude

Sketch using lines, circles.



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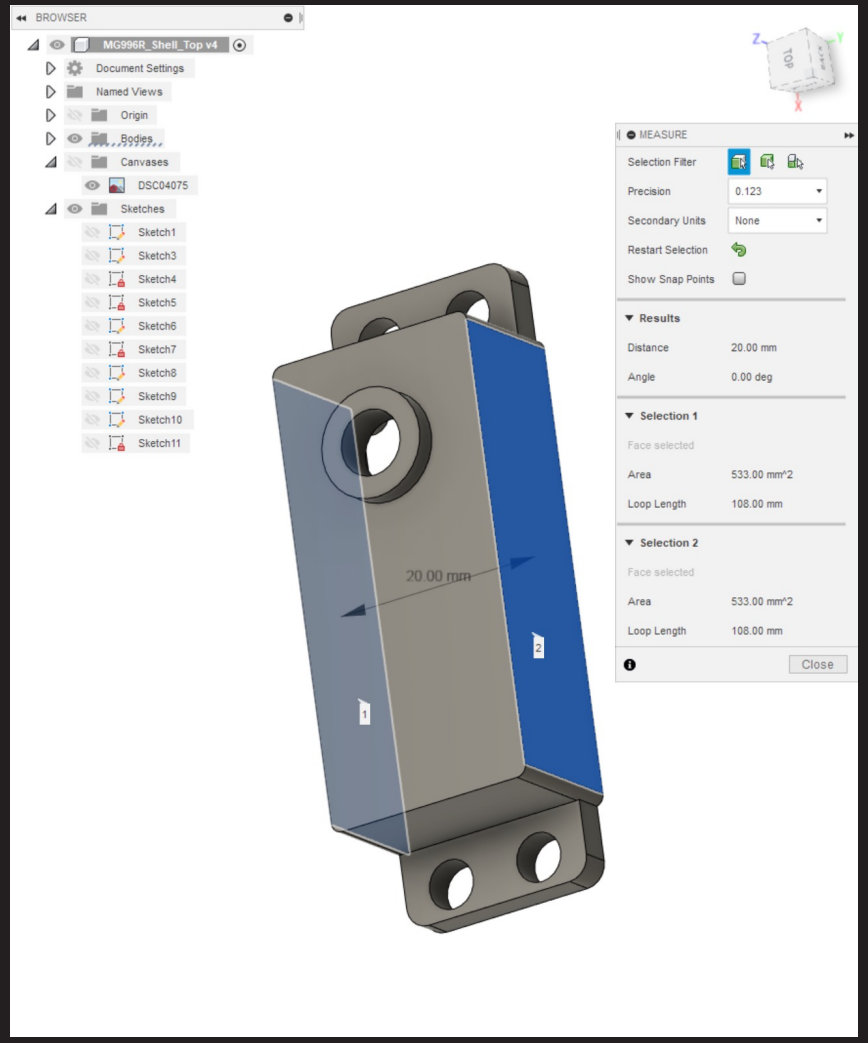
INSPECT - Measure

Good practice: Checking dimensions.
Keyboard Shortcut: 'I' (not L)



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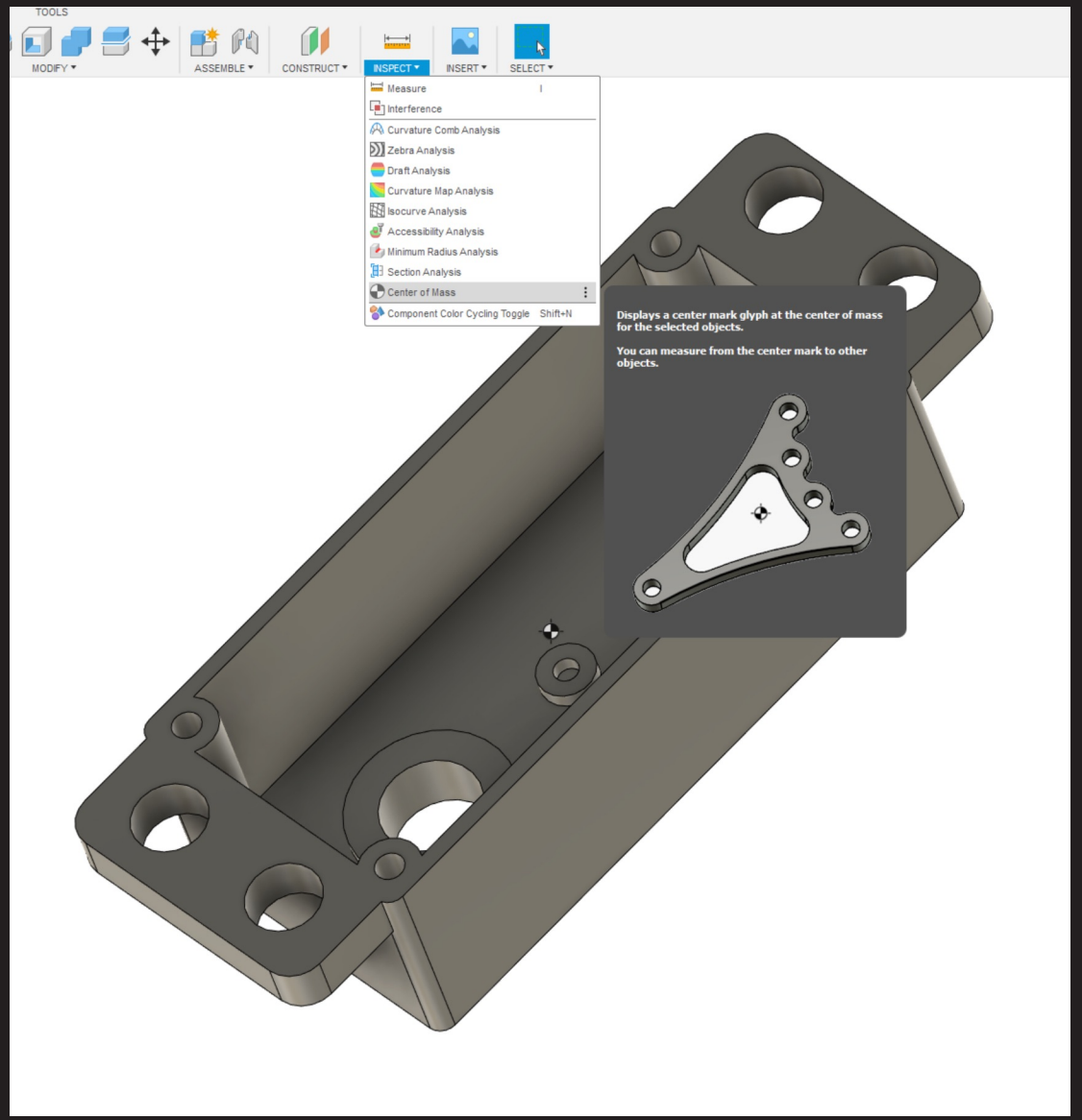
INSPECT – Center of Mass

Checking the Center of Mass.



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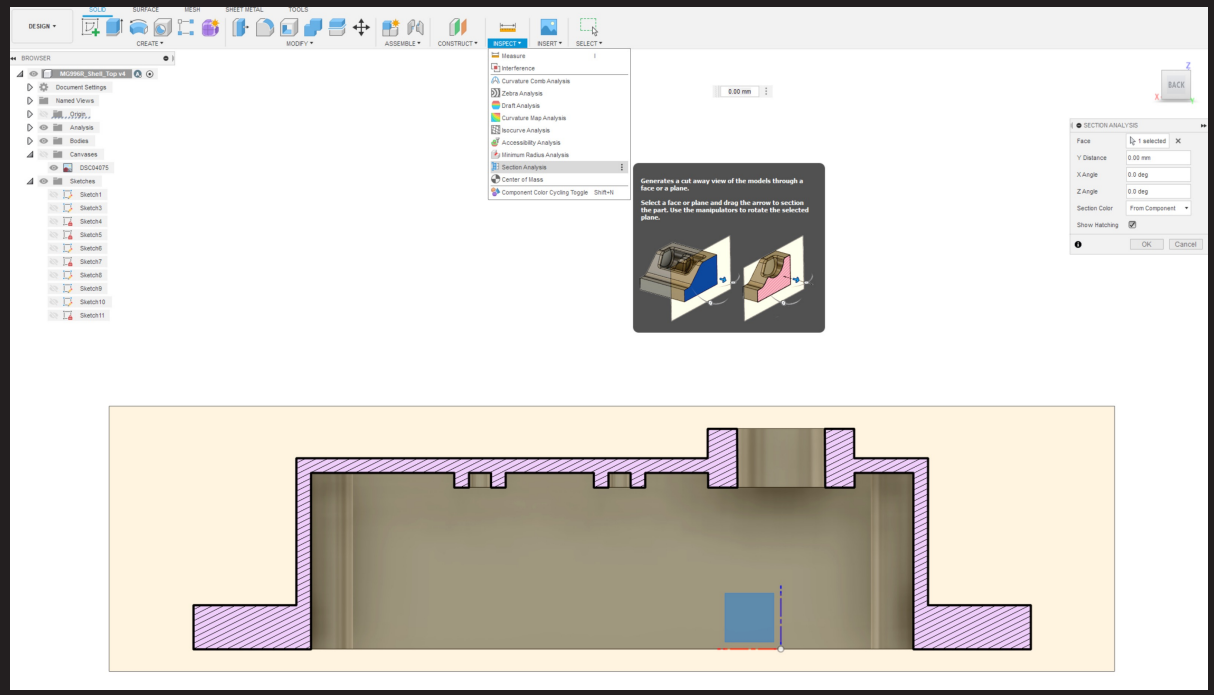
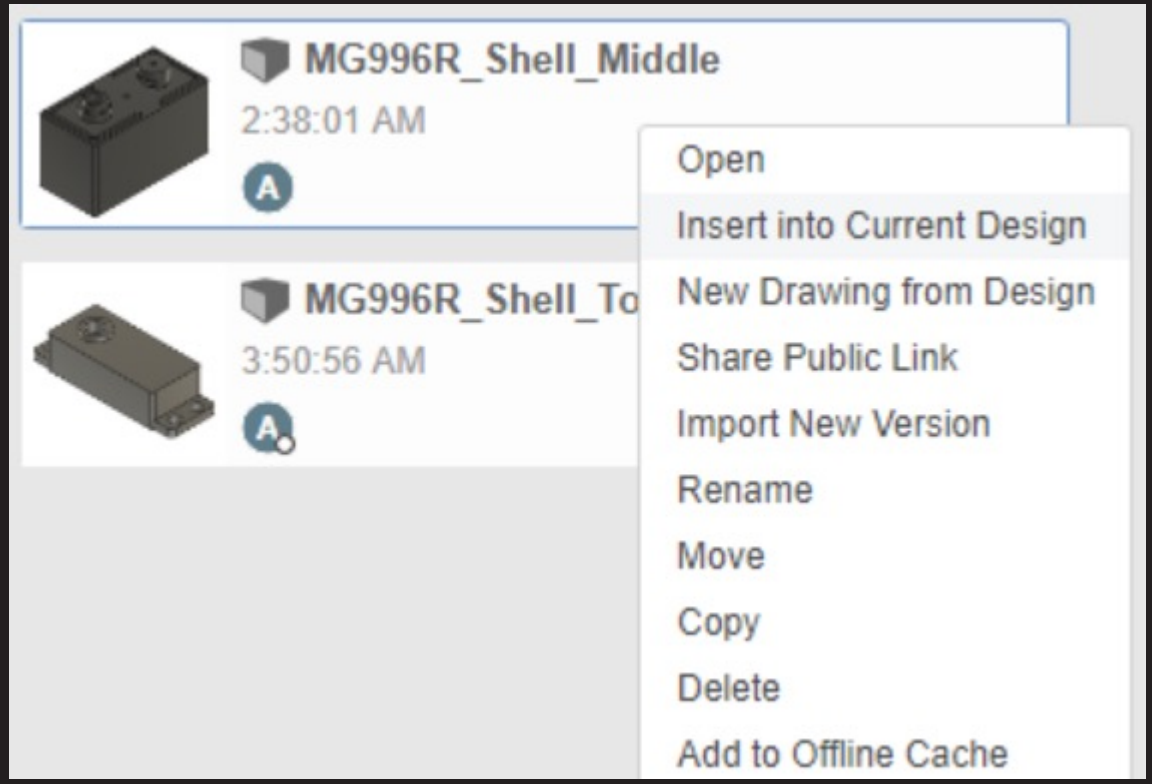
INSPECT – Section Analysis

Check unseen areas.



ASSEMBLE – Import Given Components

Insert into Current Drawing.



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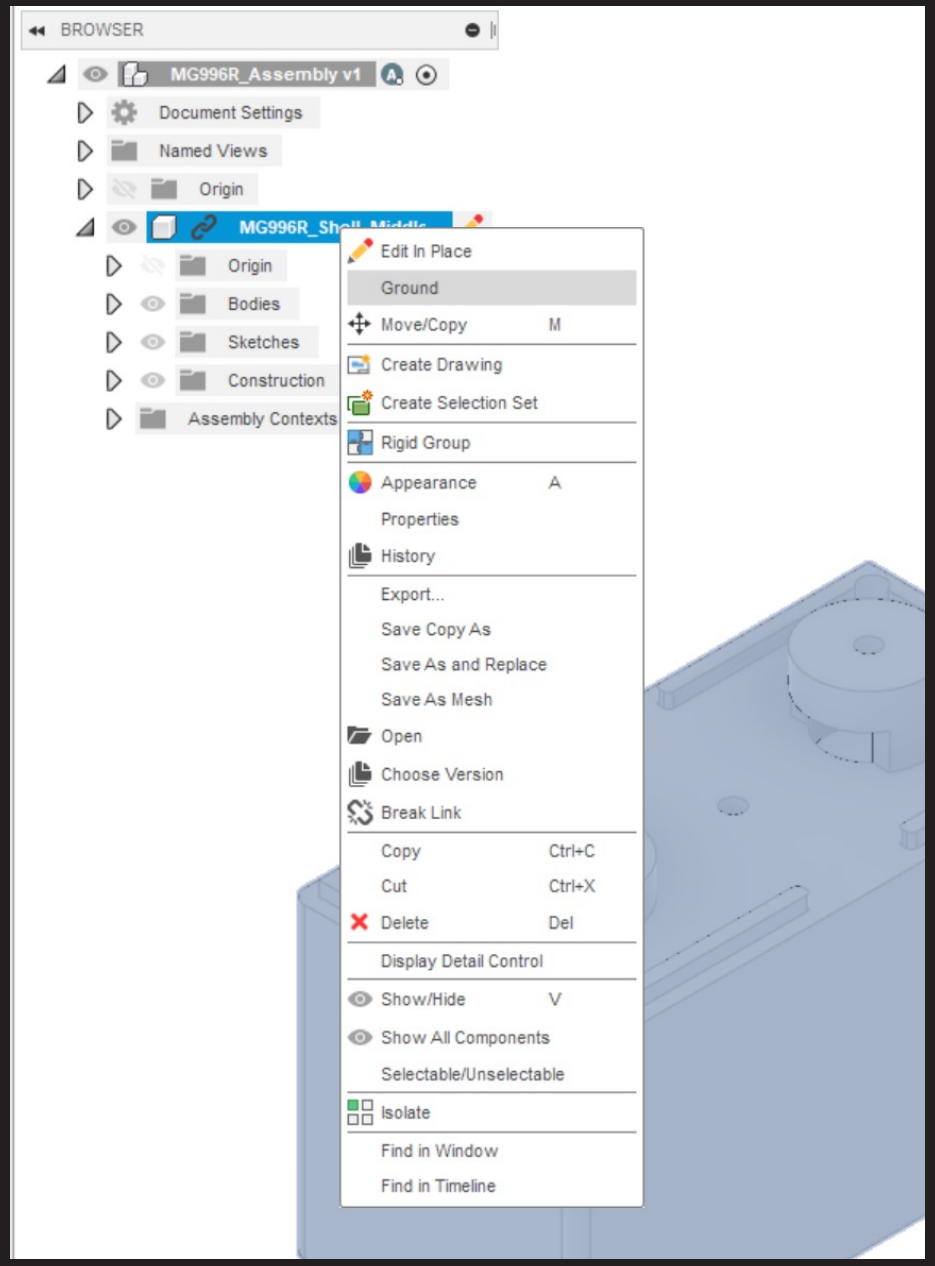
Ground Middle Shell

Fix the component from moving.



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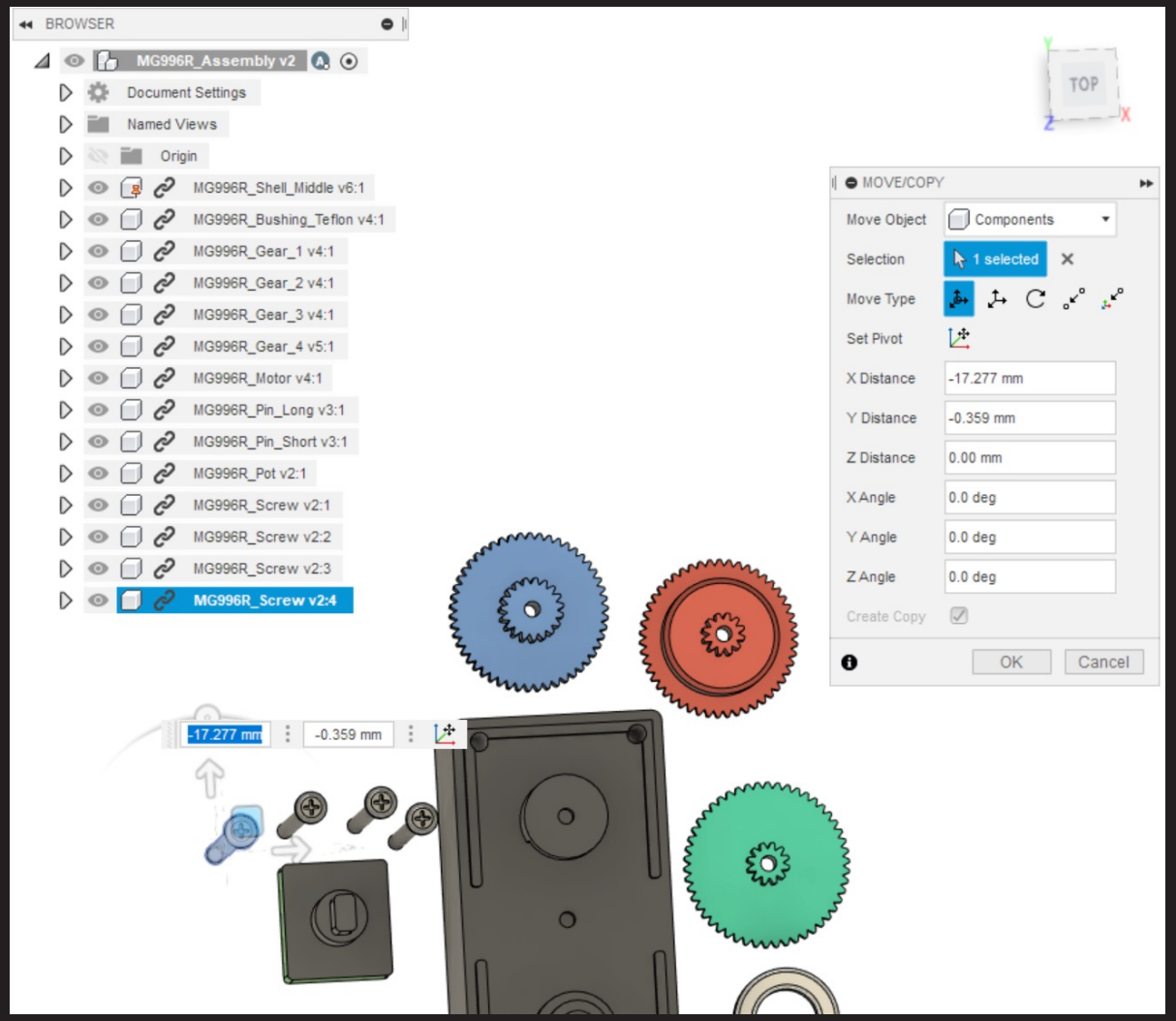
Duplicate Screws

4x Screws using Move/Copy.
Keyboard shortcut: 'M'
Move object: 'Components'
Create copy: 'Check'



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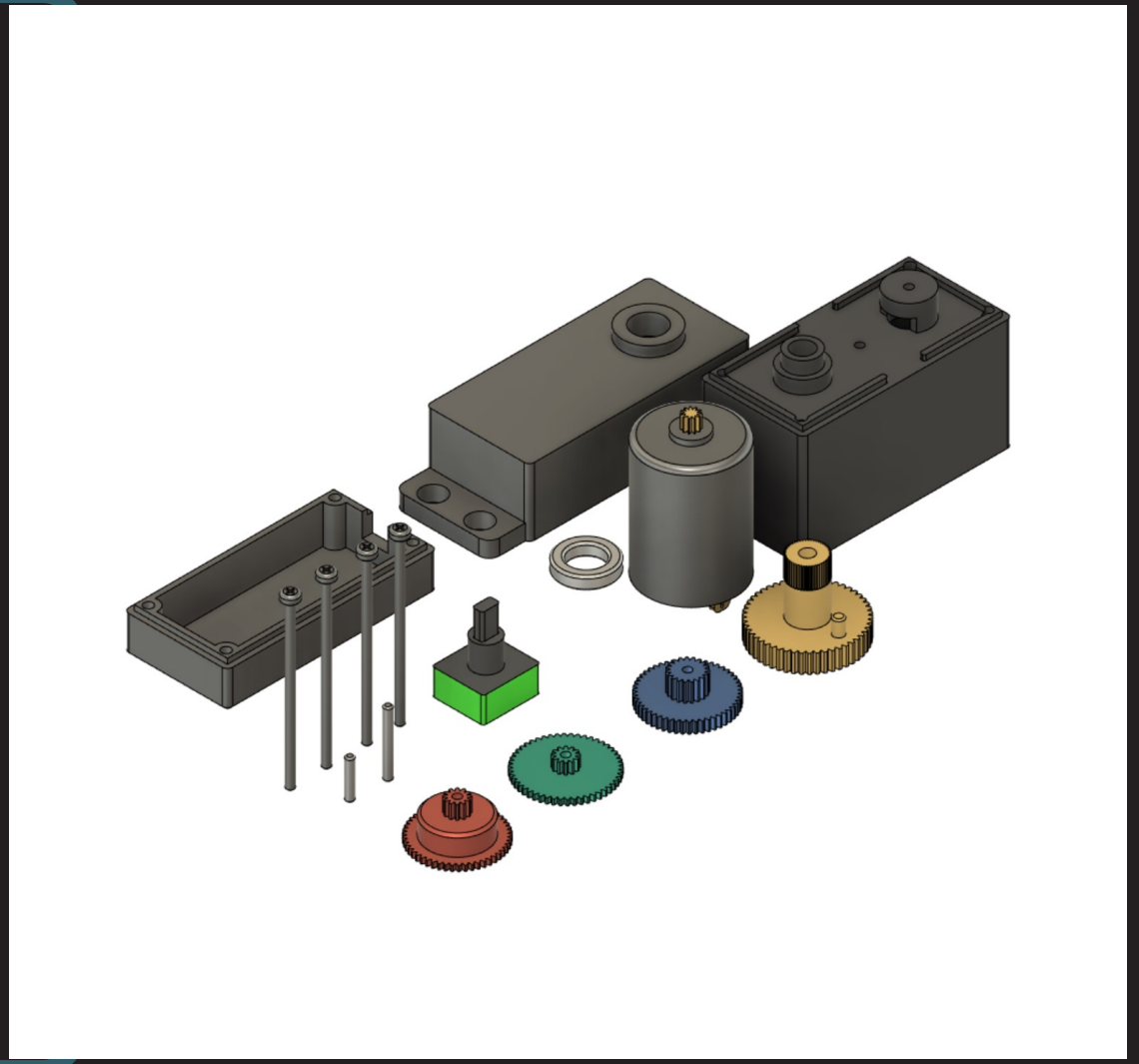
All Components Inserted

- 4x Screws
- Top Shell
- Bottom Shell
- Middle Shell
- Gears 1-4
- Long & Short Pin
- Potentiometer
- Motor
- Bushing



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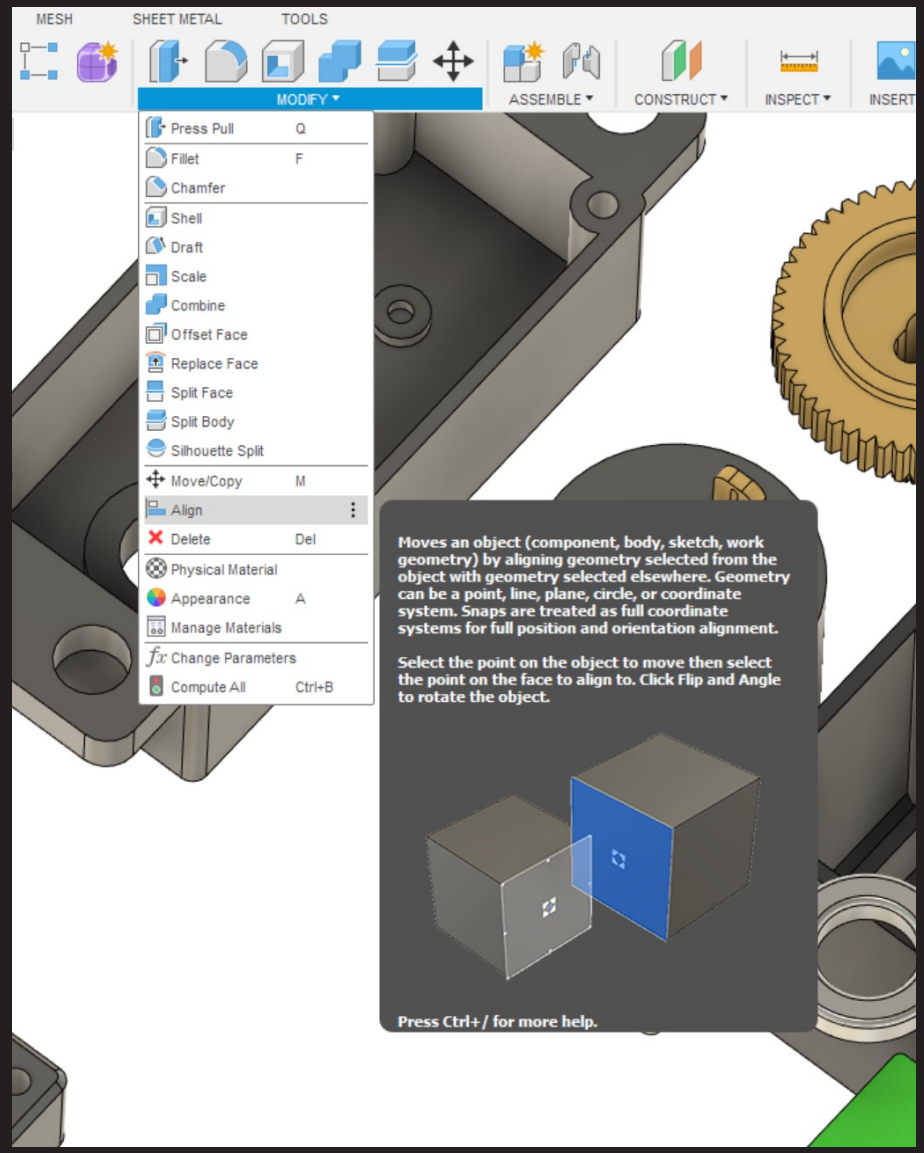
Align

Align components that do not move relative to each other.

Rule 1: Always click on the object that moves first, then the object that stays.



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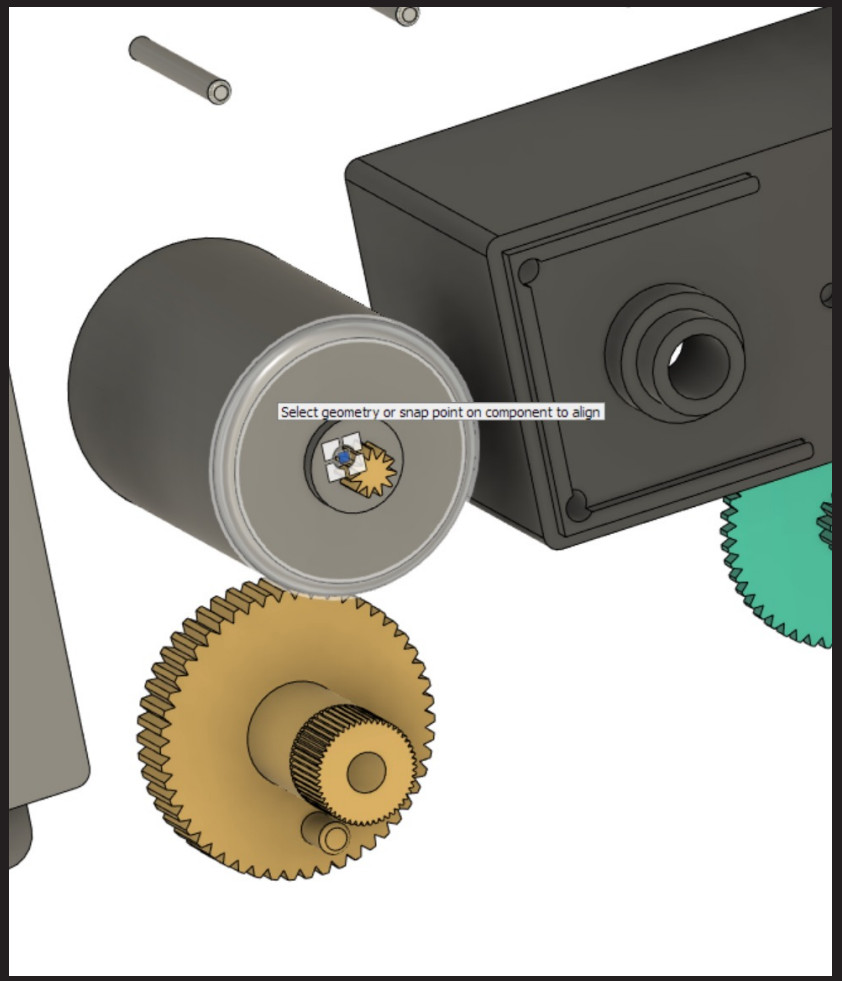
Align Motor

Hold ‘Control’ to lock on to ‘half moons’.



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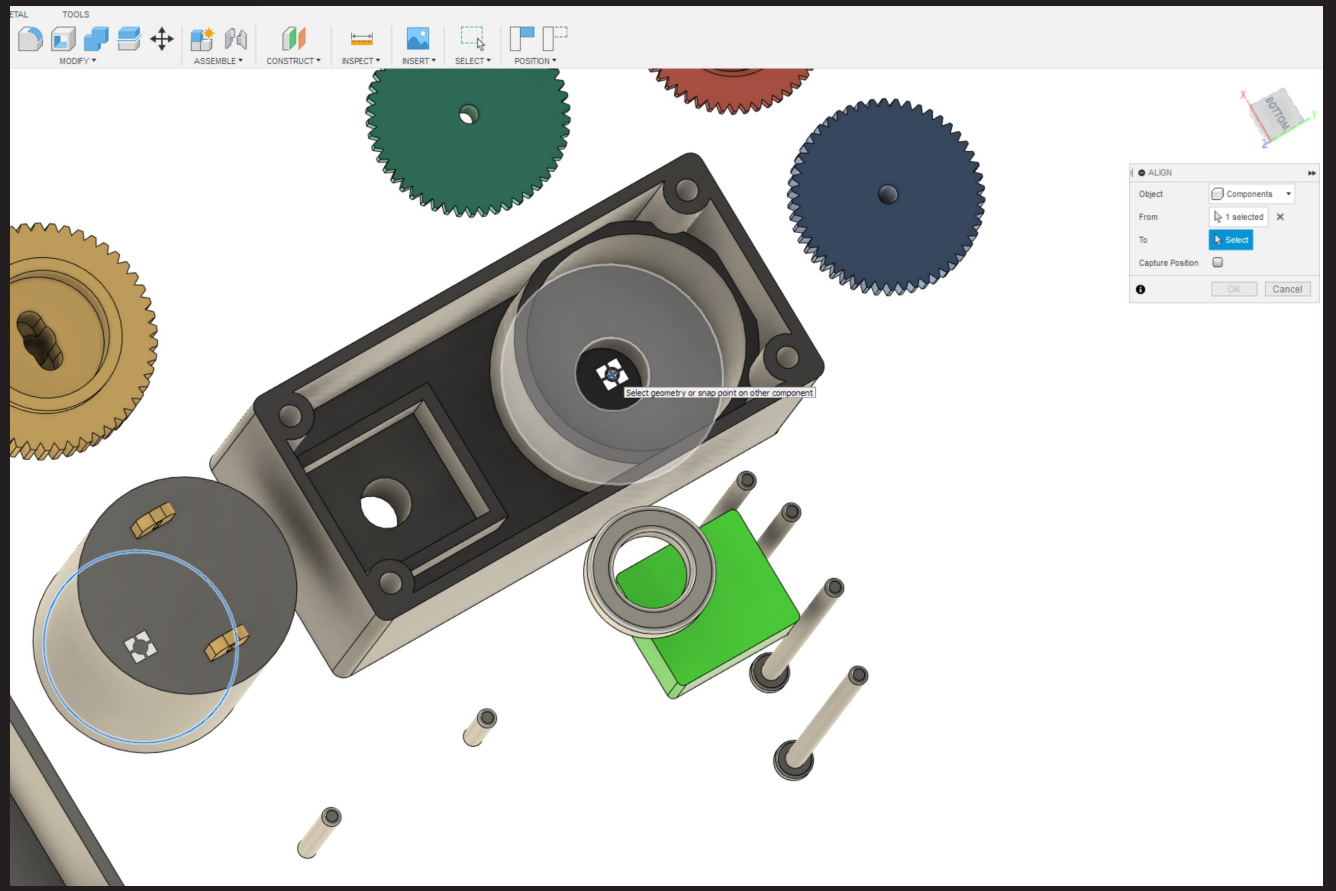
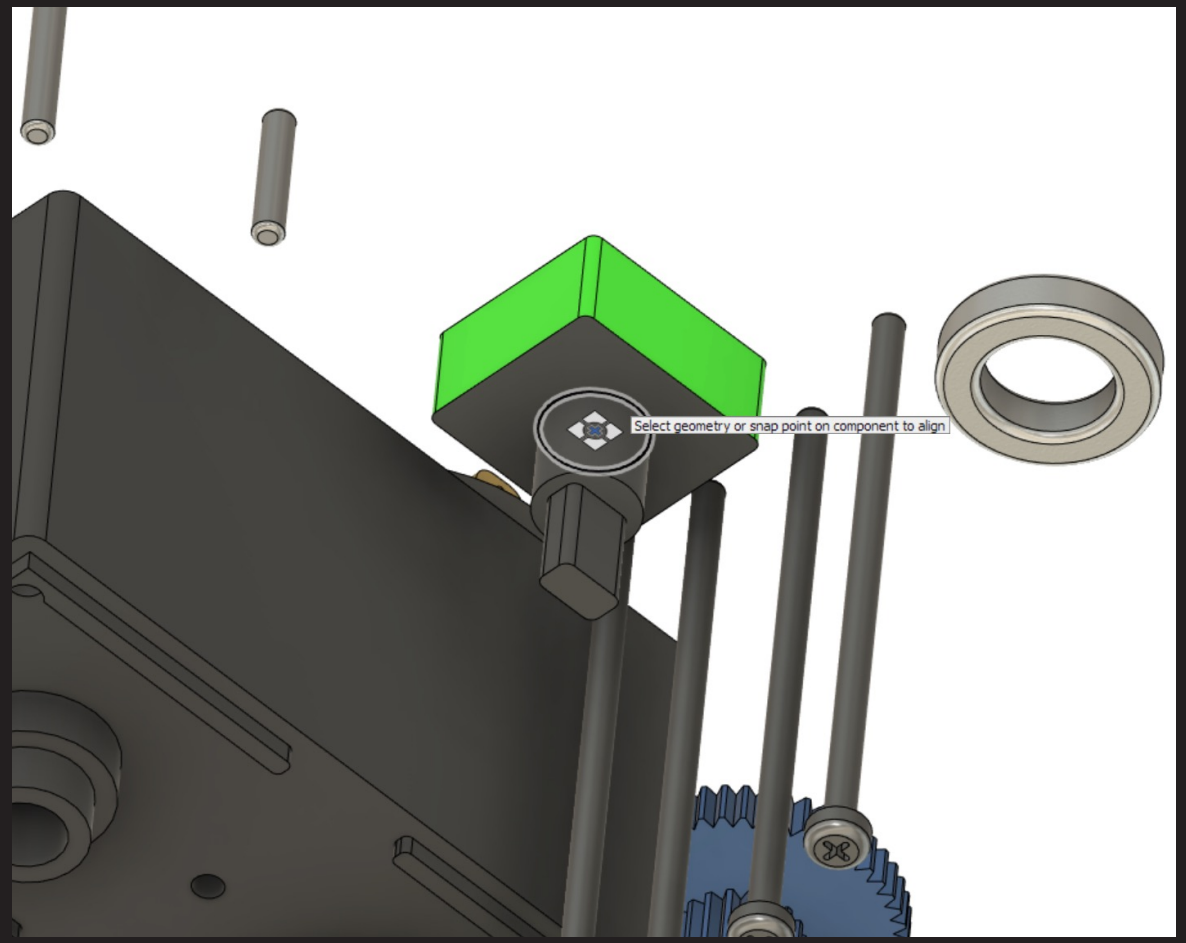


SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Pot

Hold ‘Control’ to lock on to ‘half moons’.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Pot

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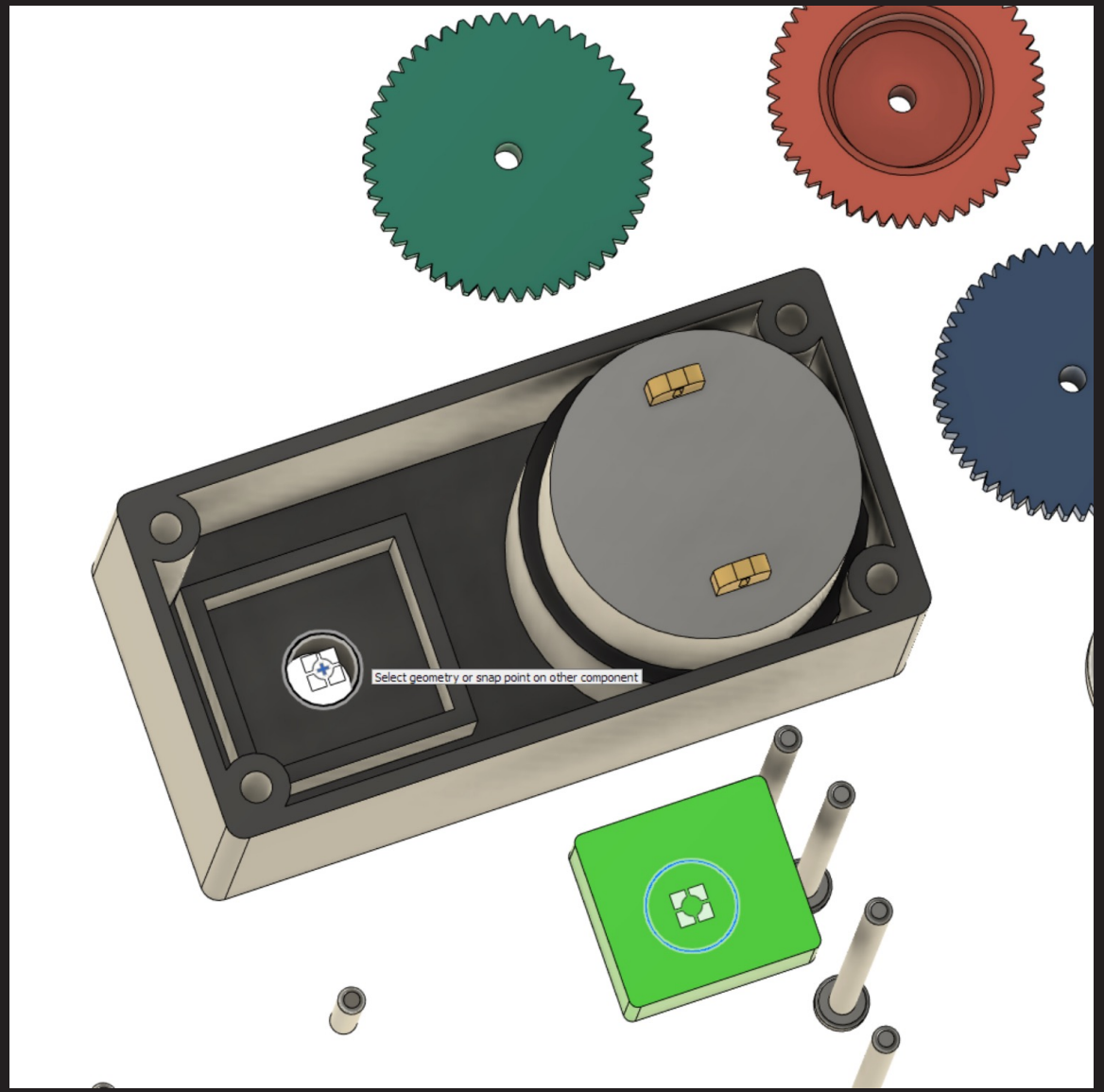

SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Pins

Hold ‘Control’ to lock on to ‘half moons’.

Longer pin in the middle, shorter pin at the side.

SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

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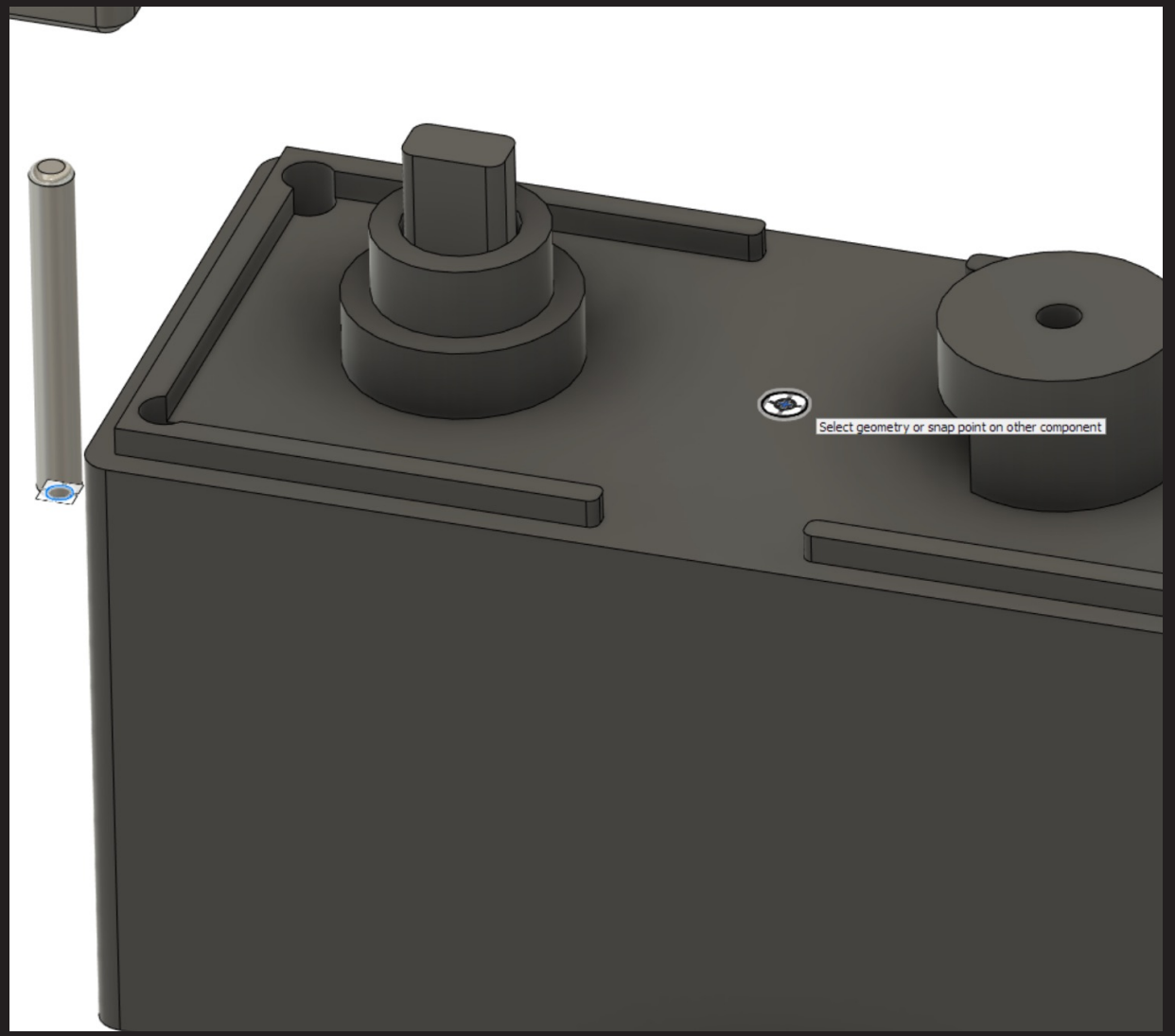

SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

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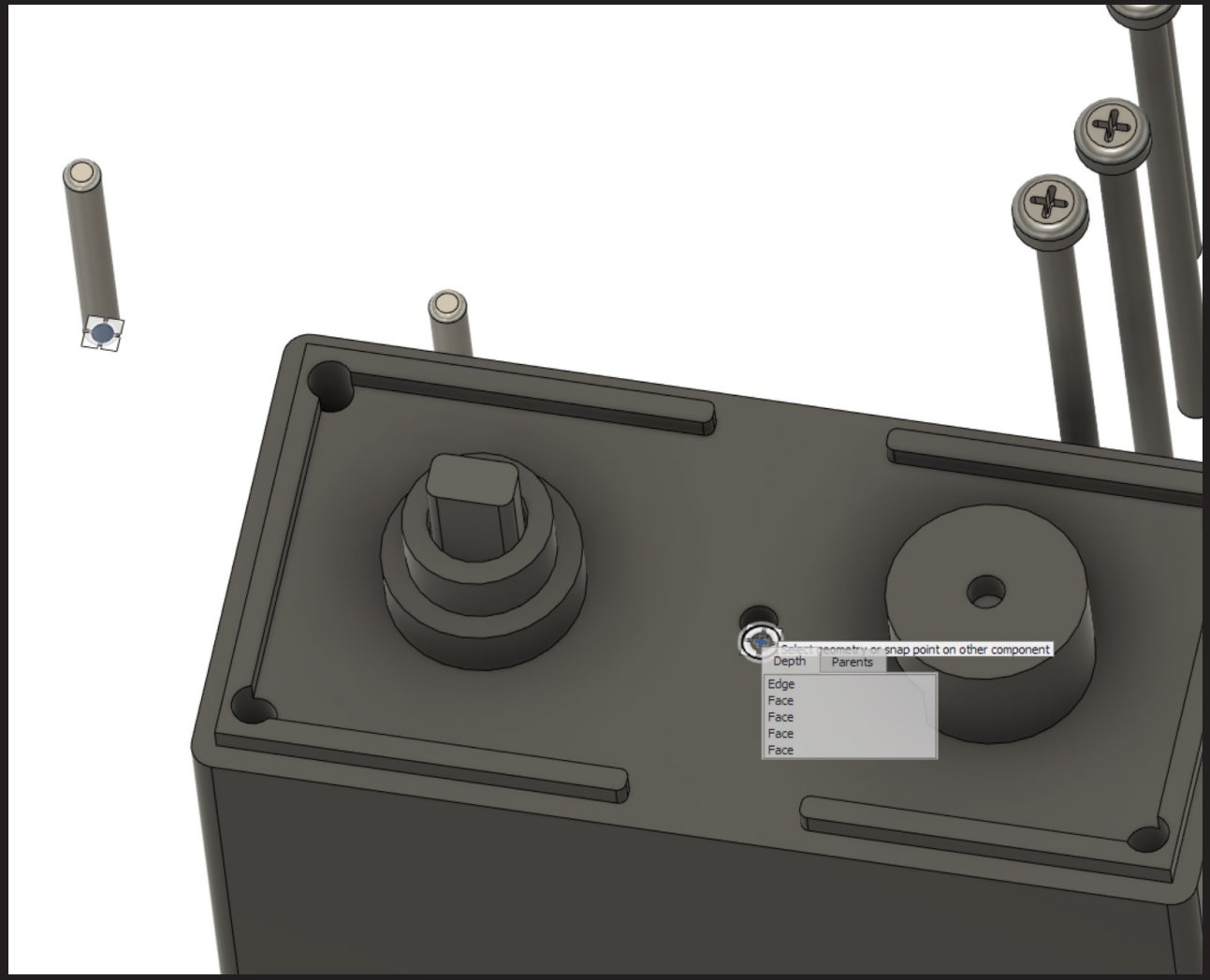

SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

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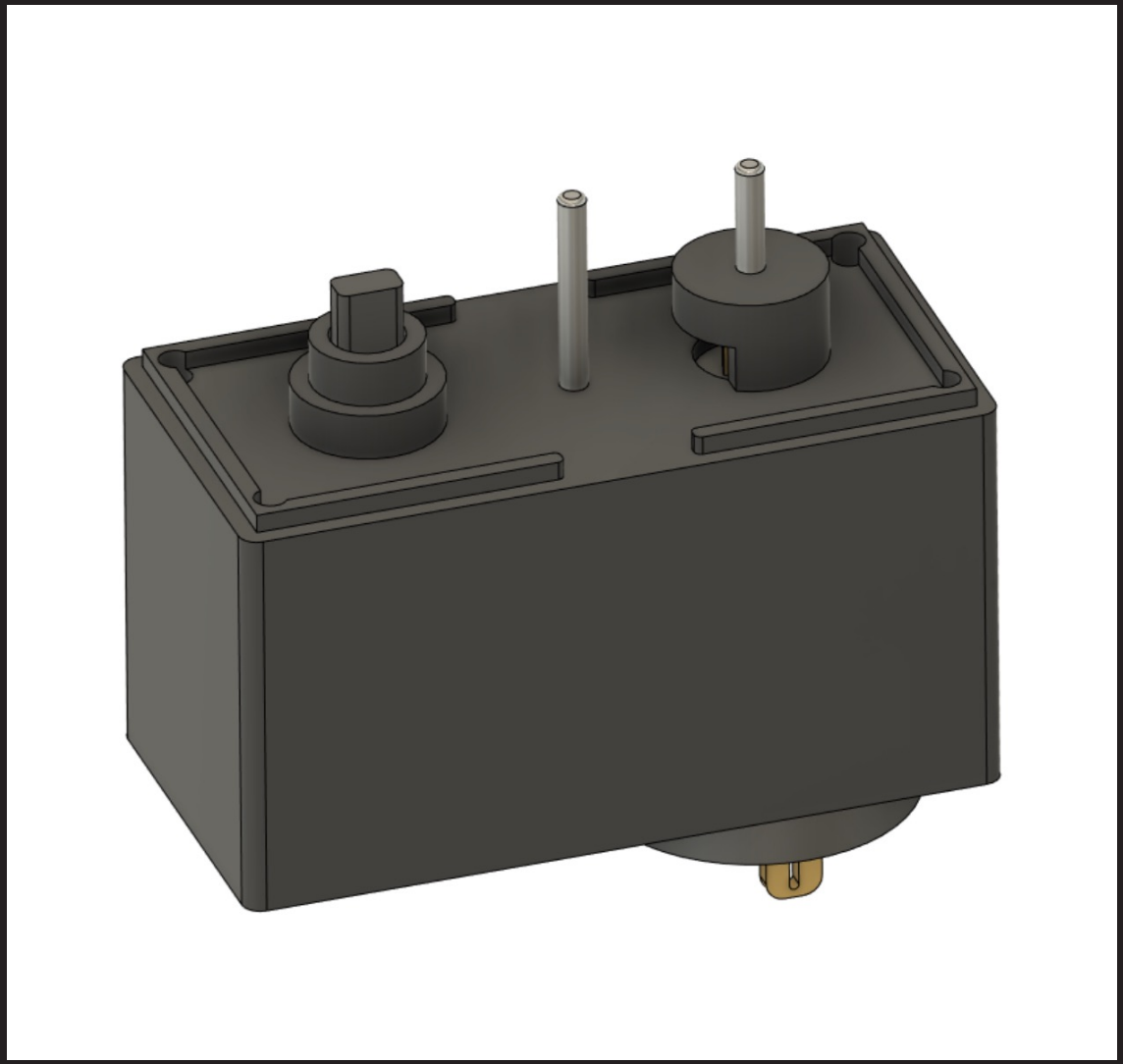
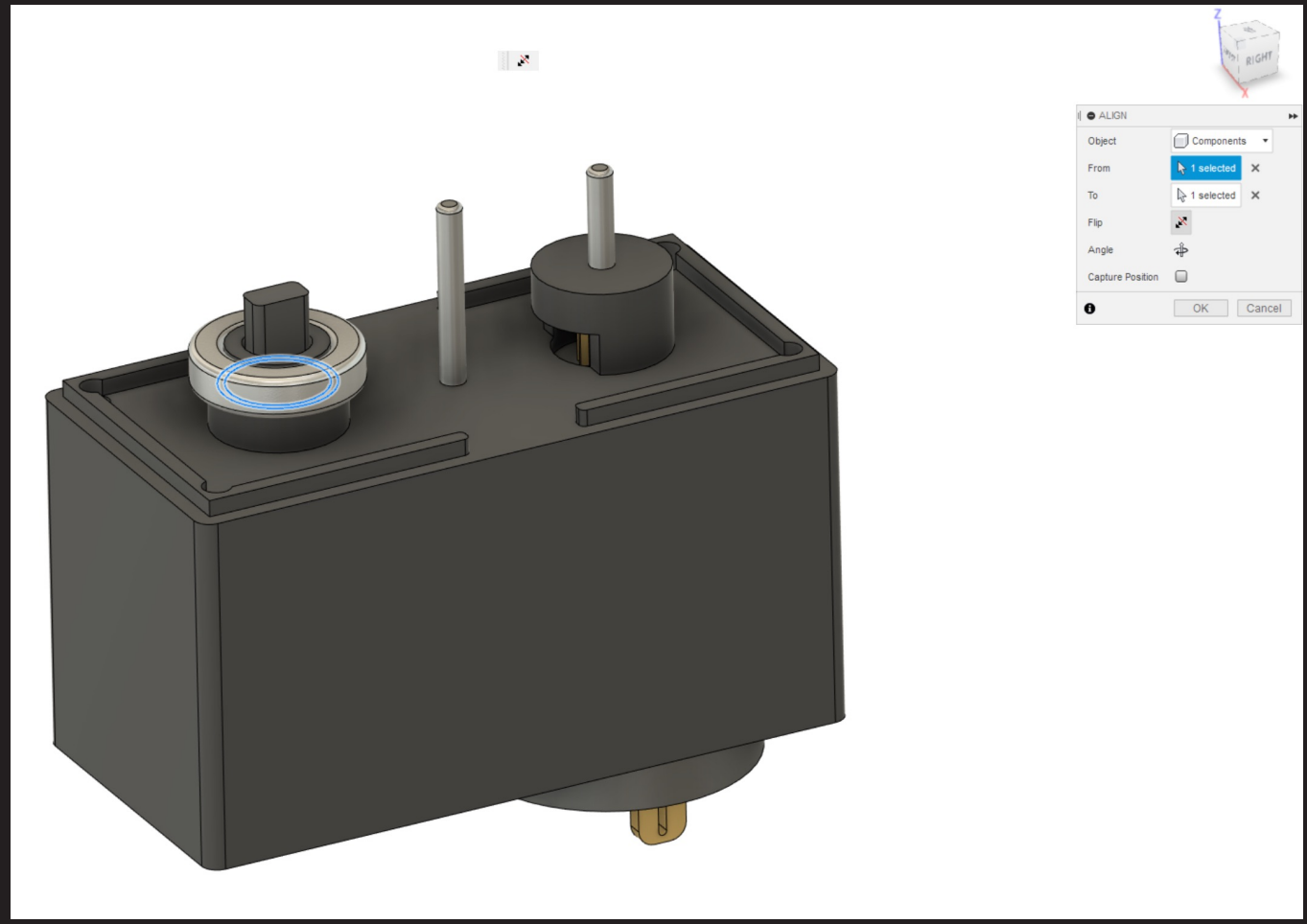


SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Bushing

Hold ‘Control’ to lock on to ‘half moons’.

Longer pin in the middle, shorter pin at the side.



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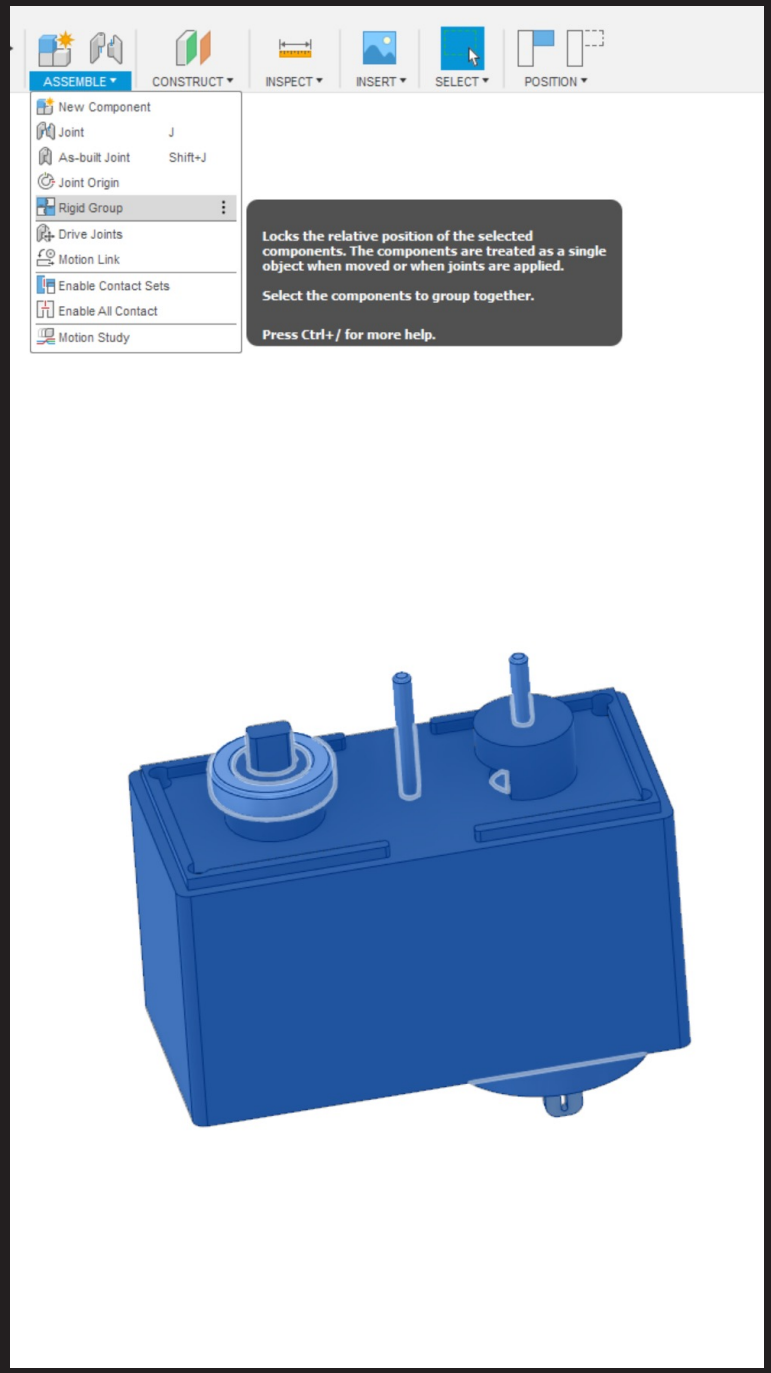
Rigid Groups

Select Middle Shell, Bushing, Pins, Motor, Pot



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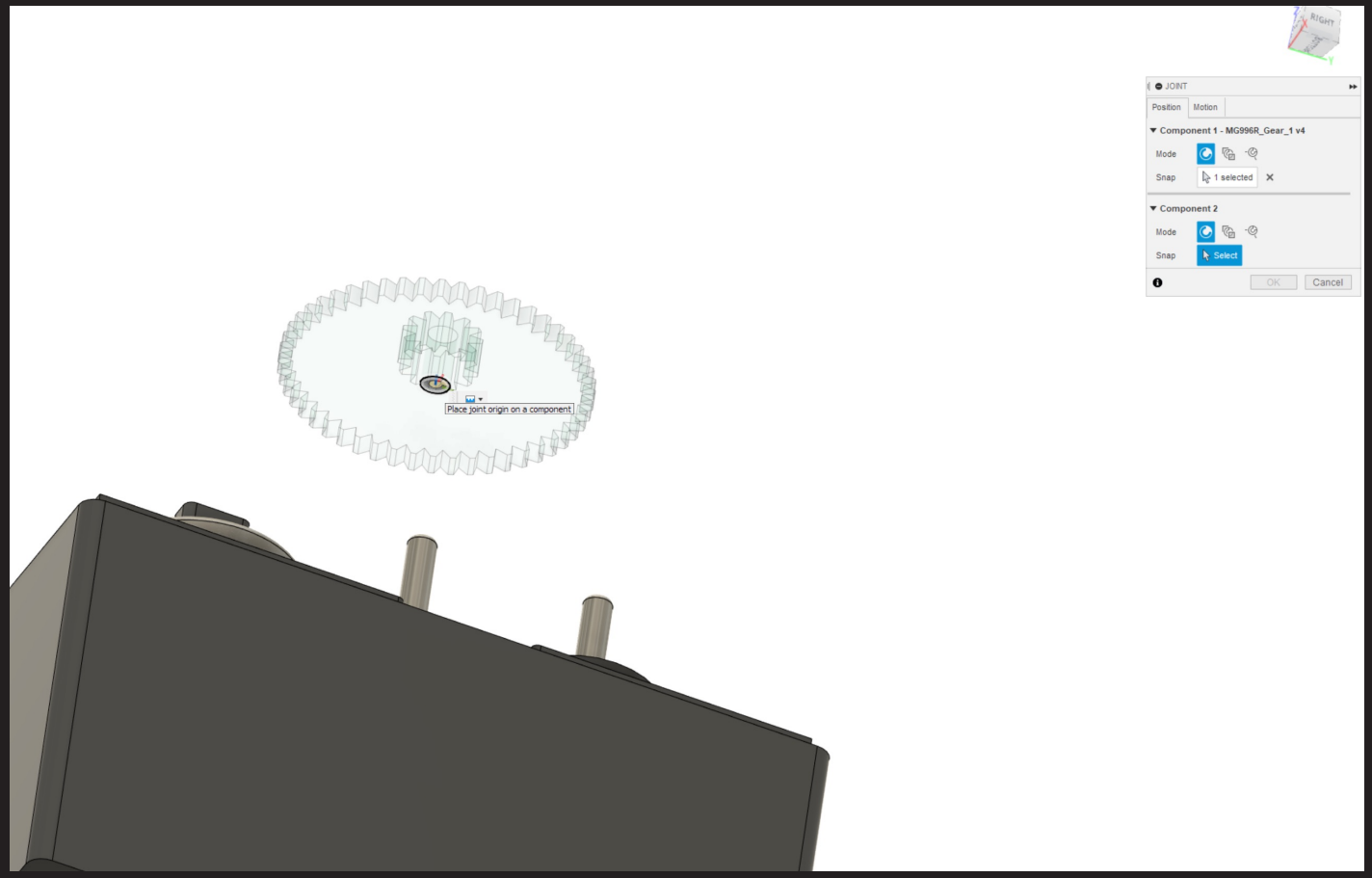
Joints-Gear 1

Join gear 1 to the base of the longer pin.



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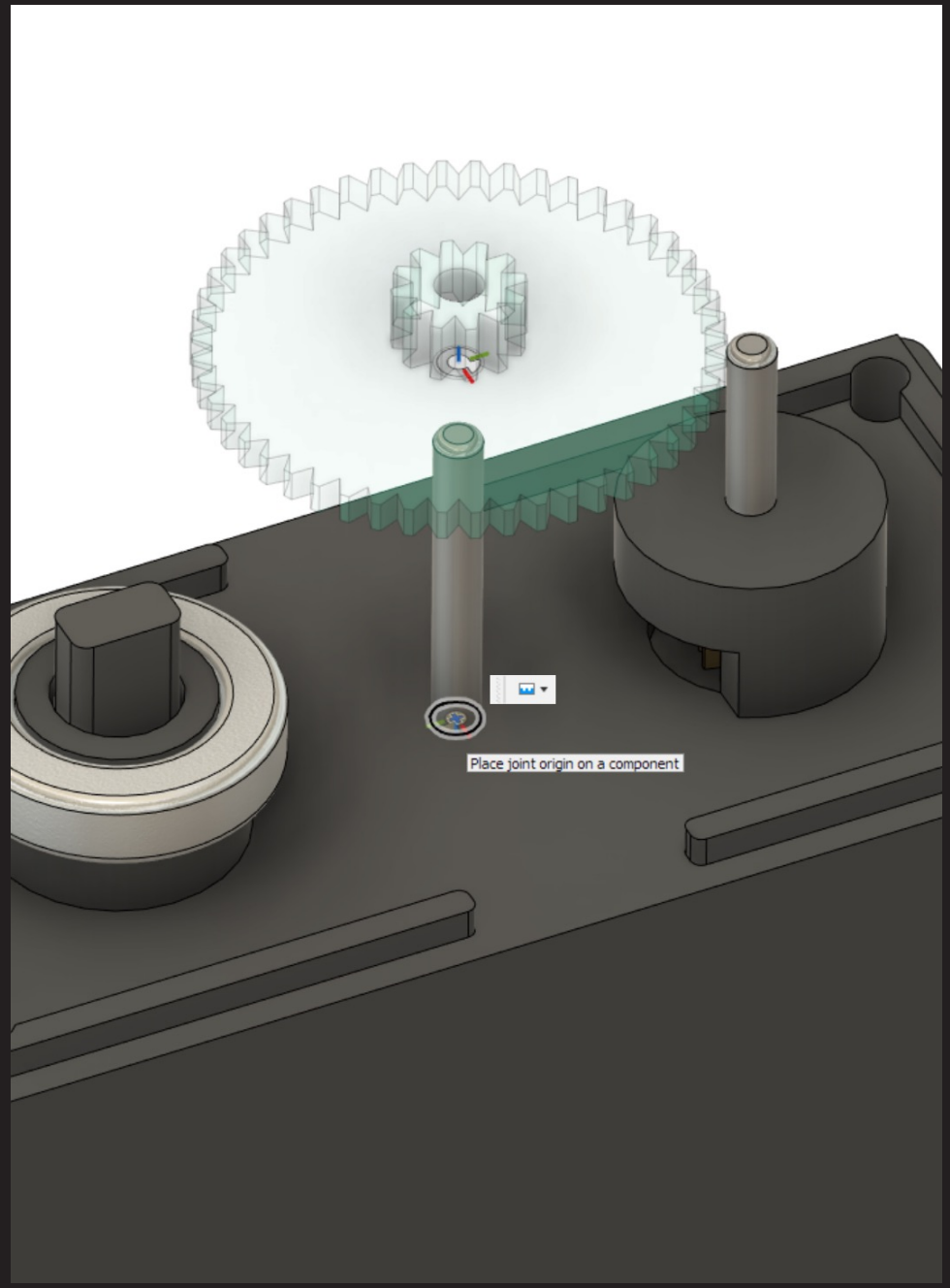

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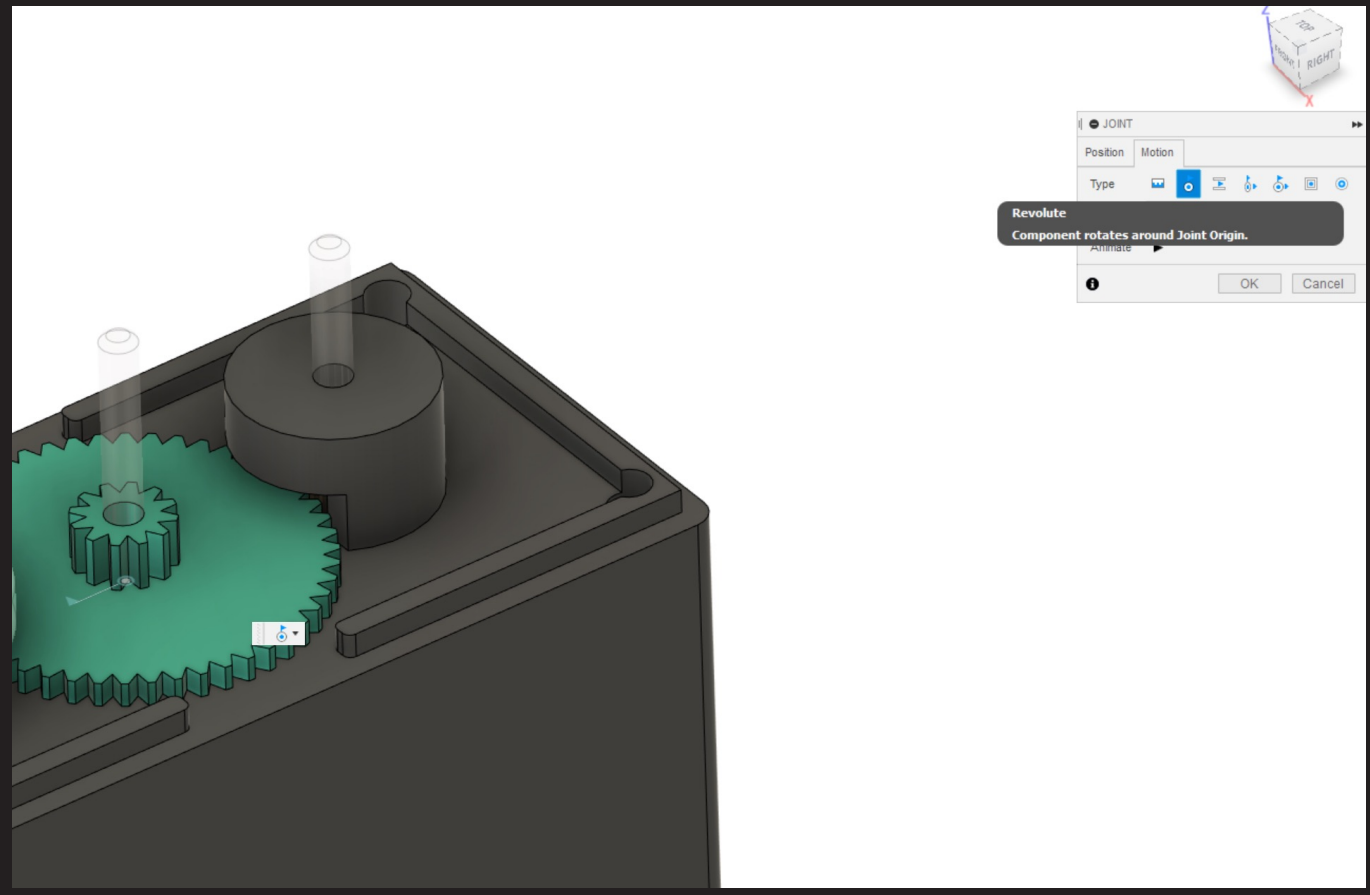
Joints-Gear 1

Under the ‘Motion’ tab, select ‘Revolute’.



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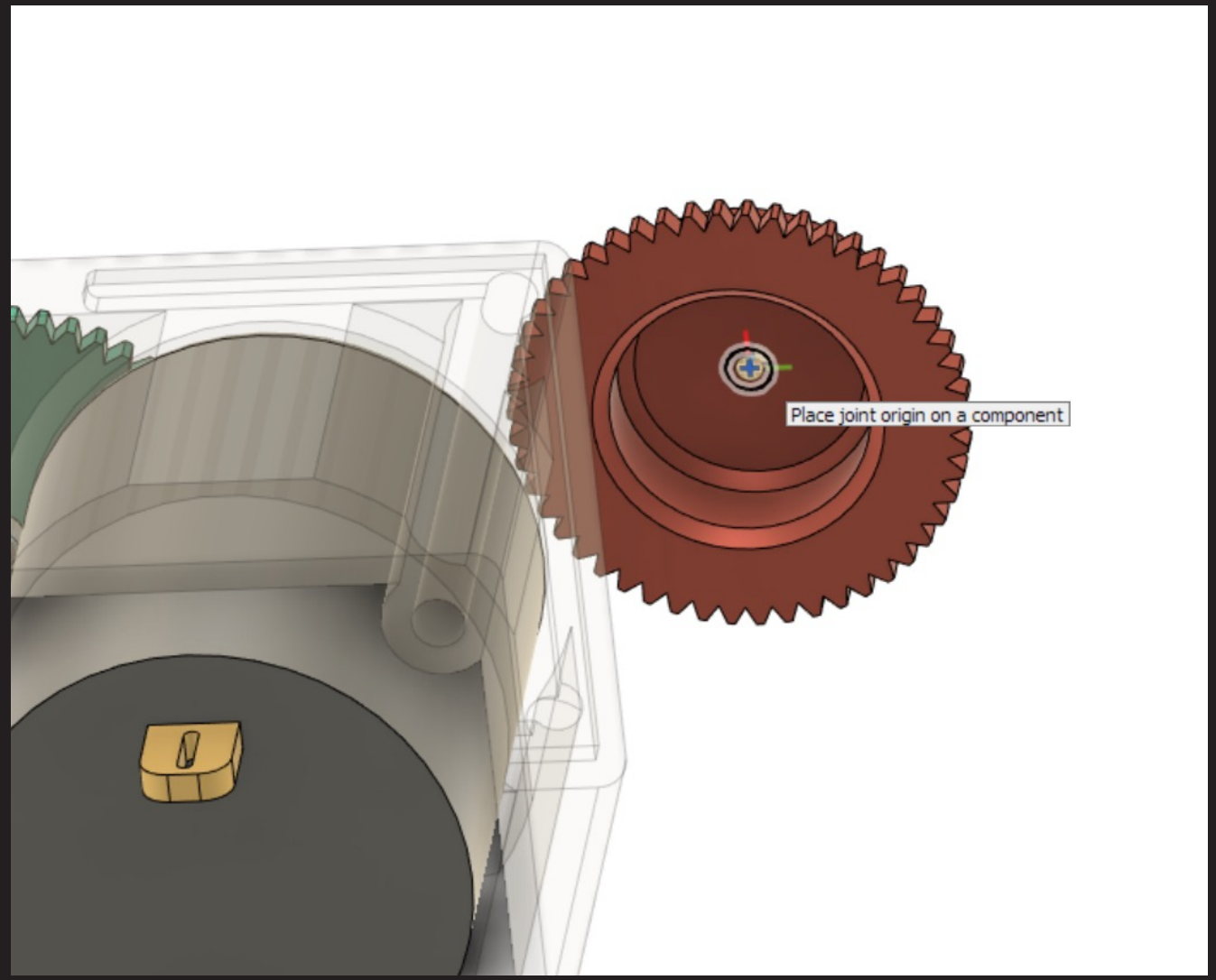
Joints-Gear 2

Similarly, add a joint to gear 2 using ‘revolute’.



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Joints-Gear 2

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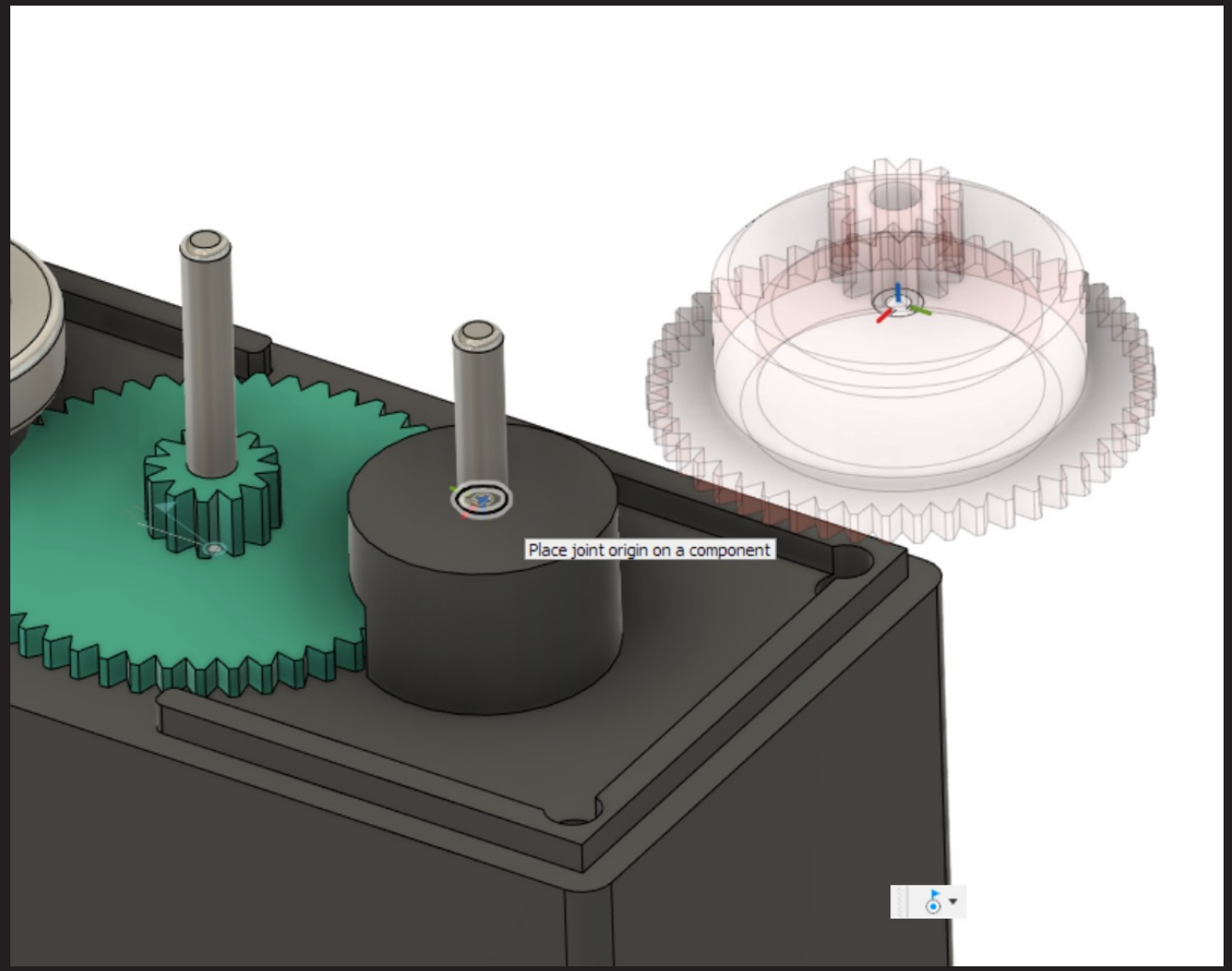

SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Joints-Gear 2

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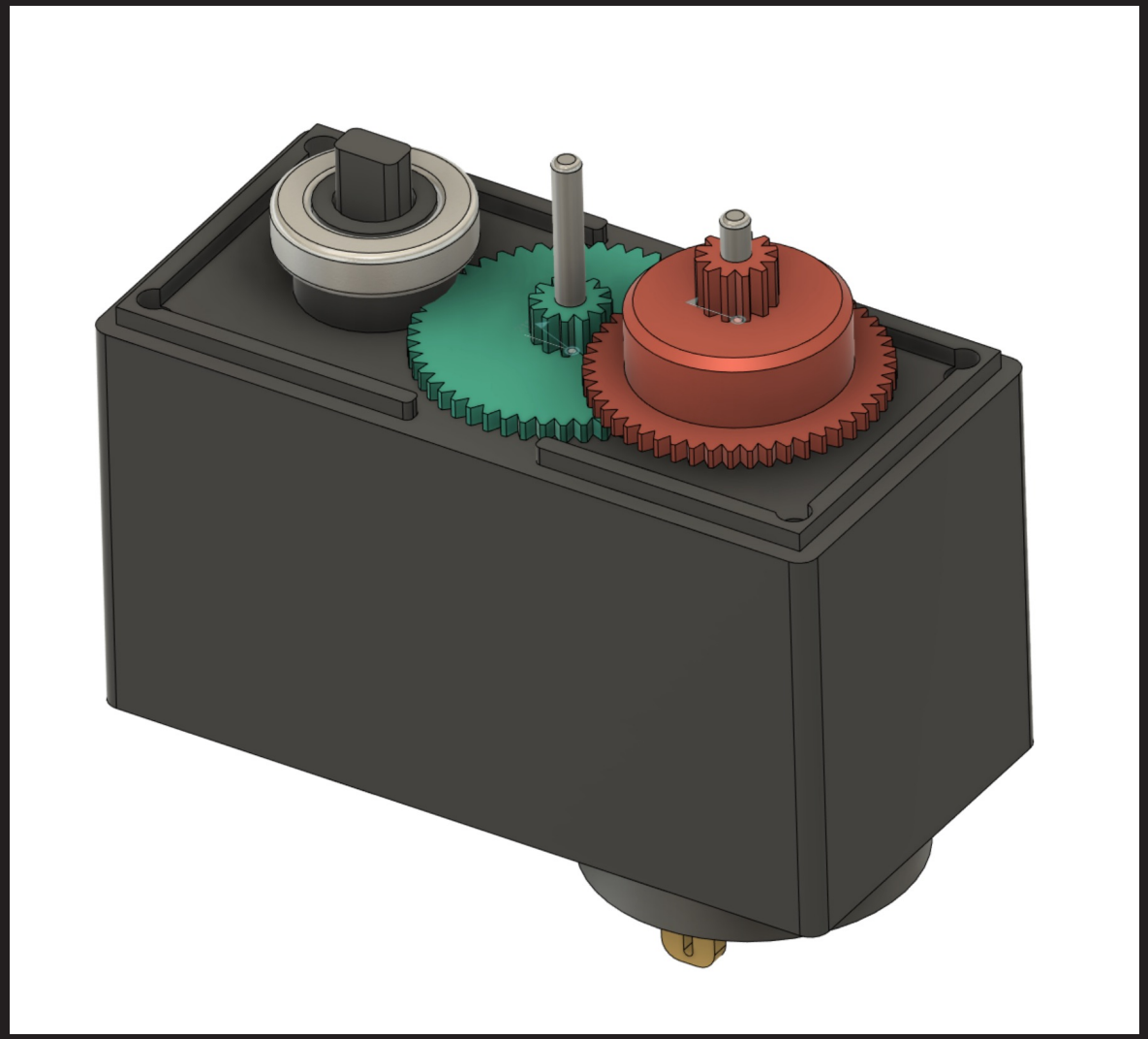
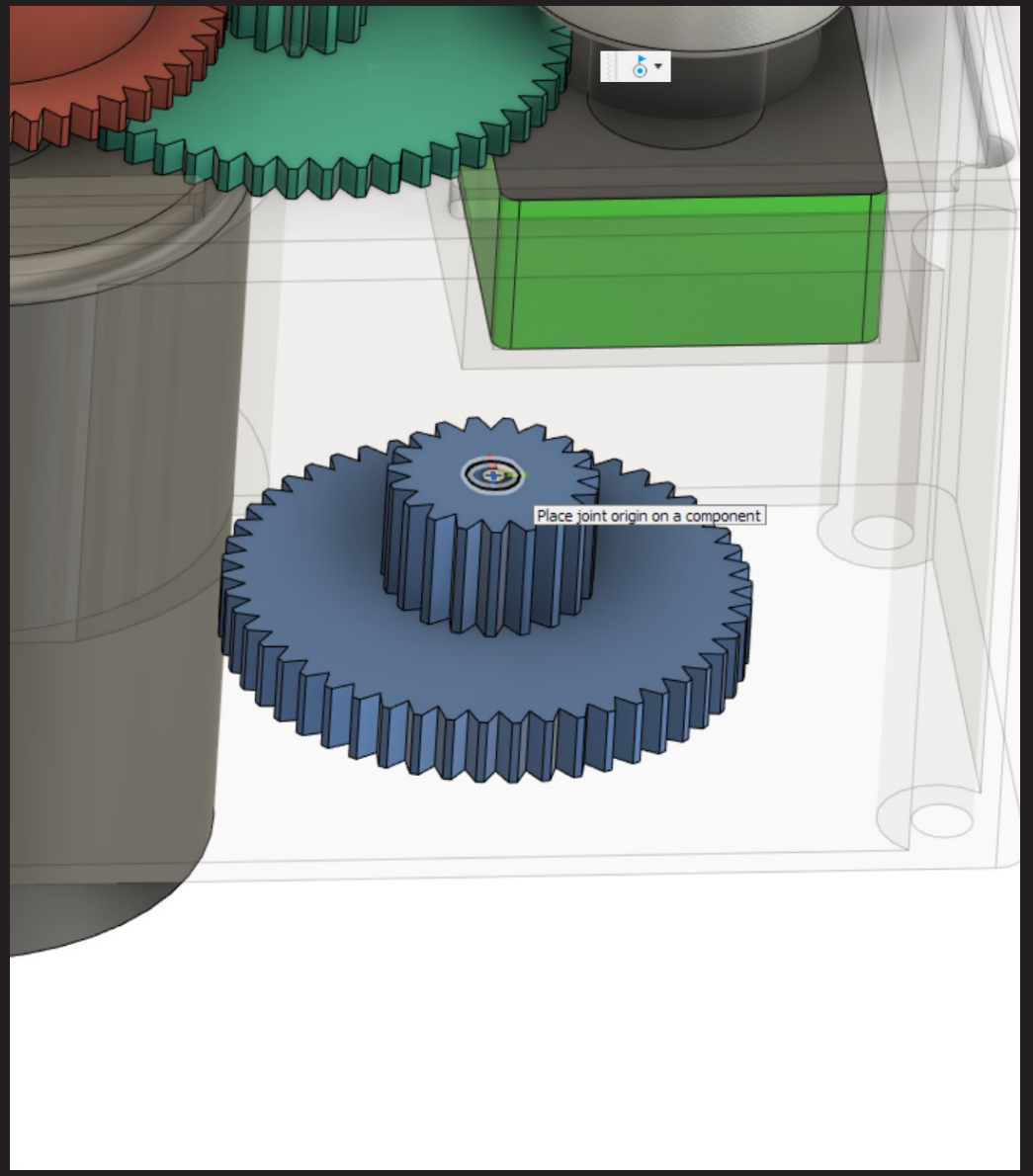


Joints-Gear 3

Similarly, add a joint to gear 3 using ‘revolute’.



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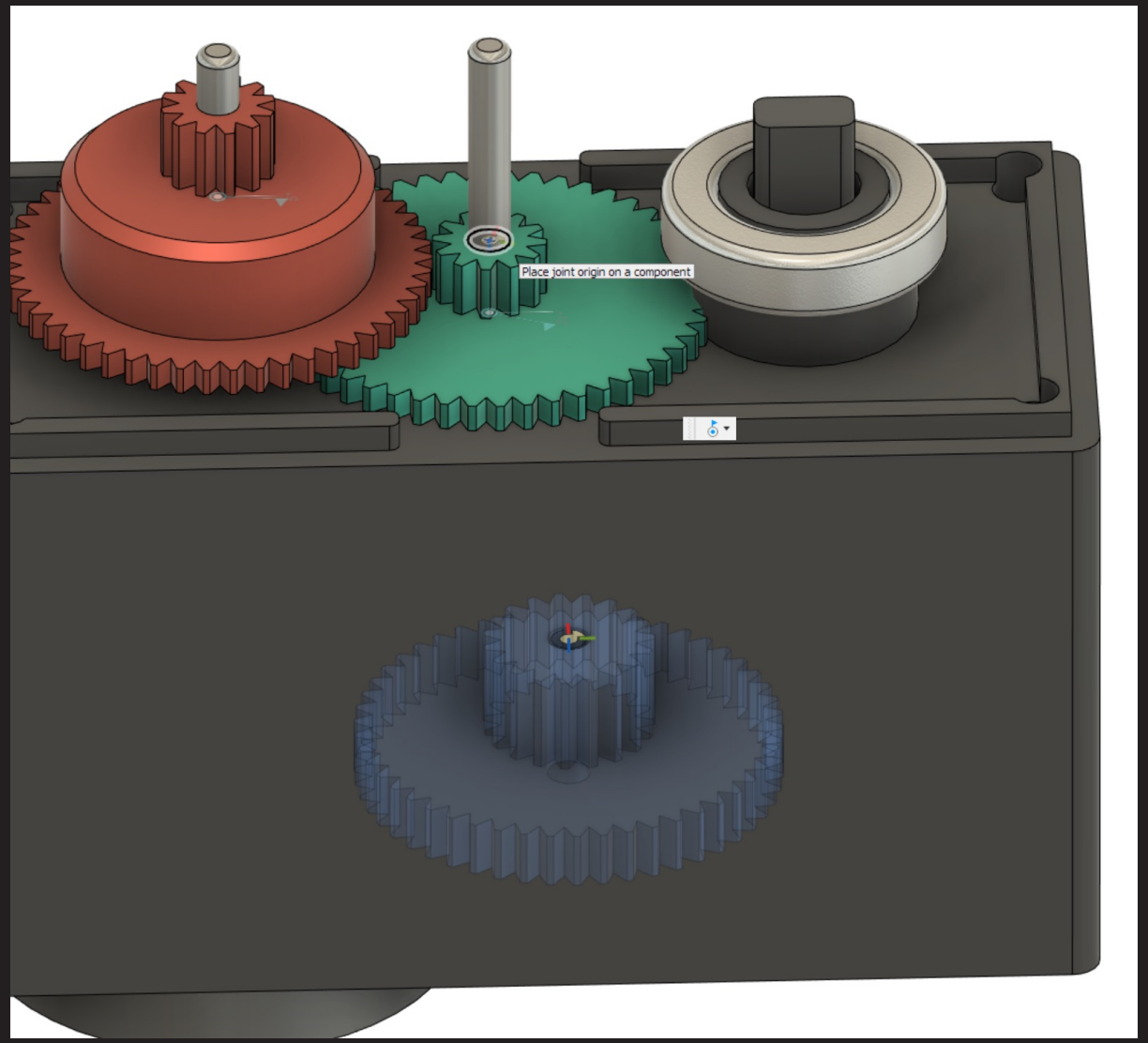
Joints-Gear 3

Similarly, add a joint to gear 3 using ‘revolute’.



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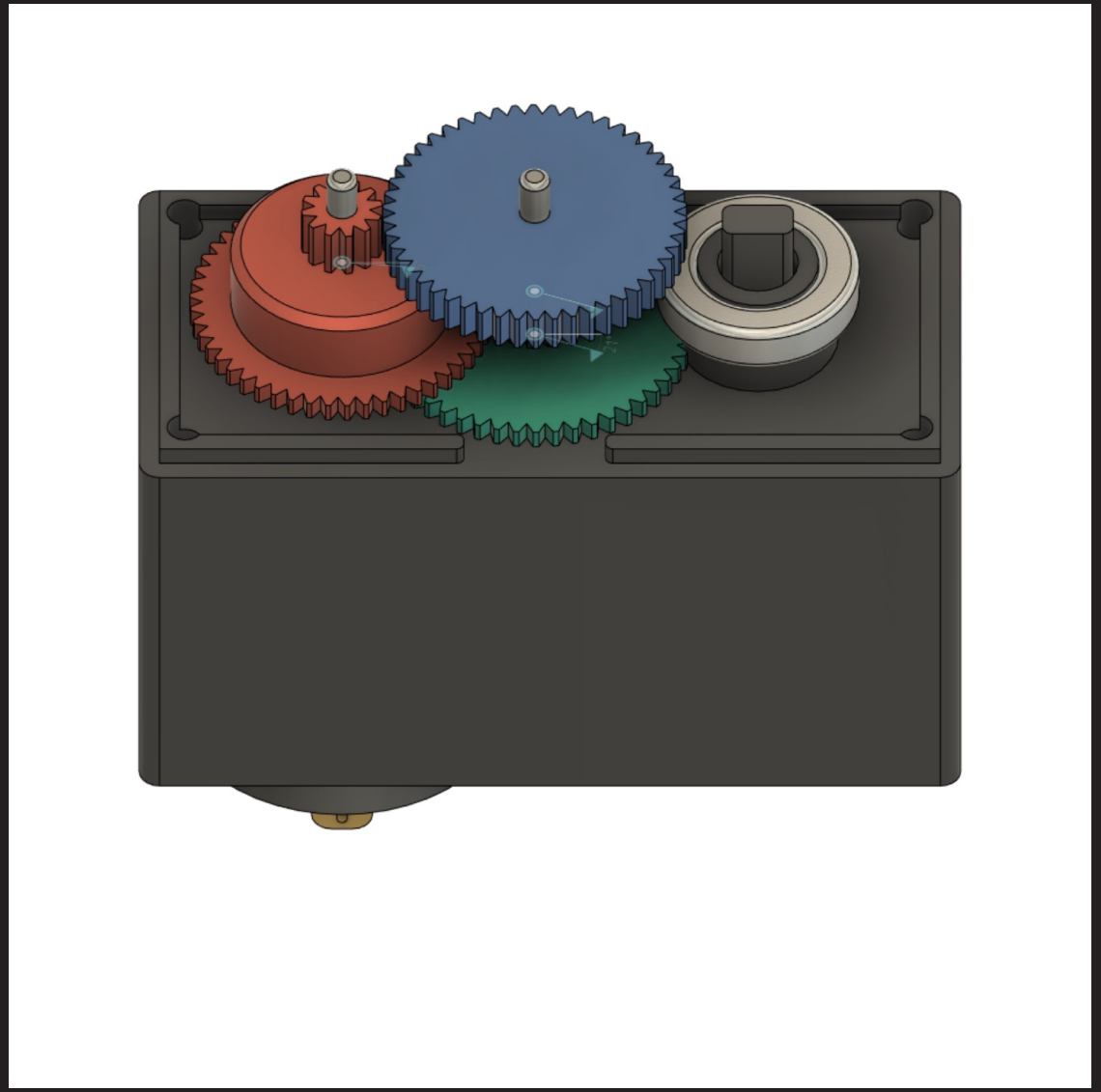
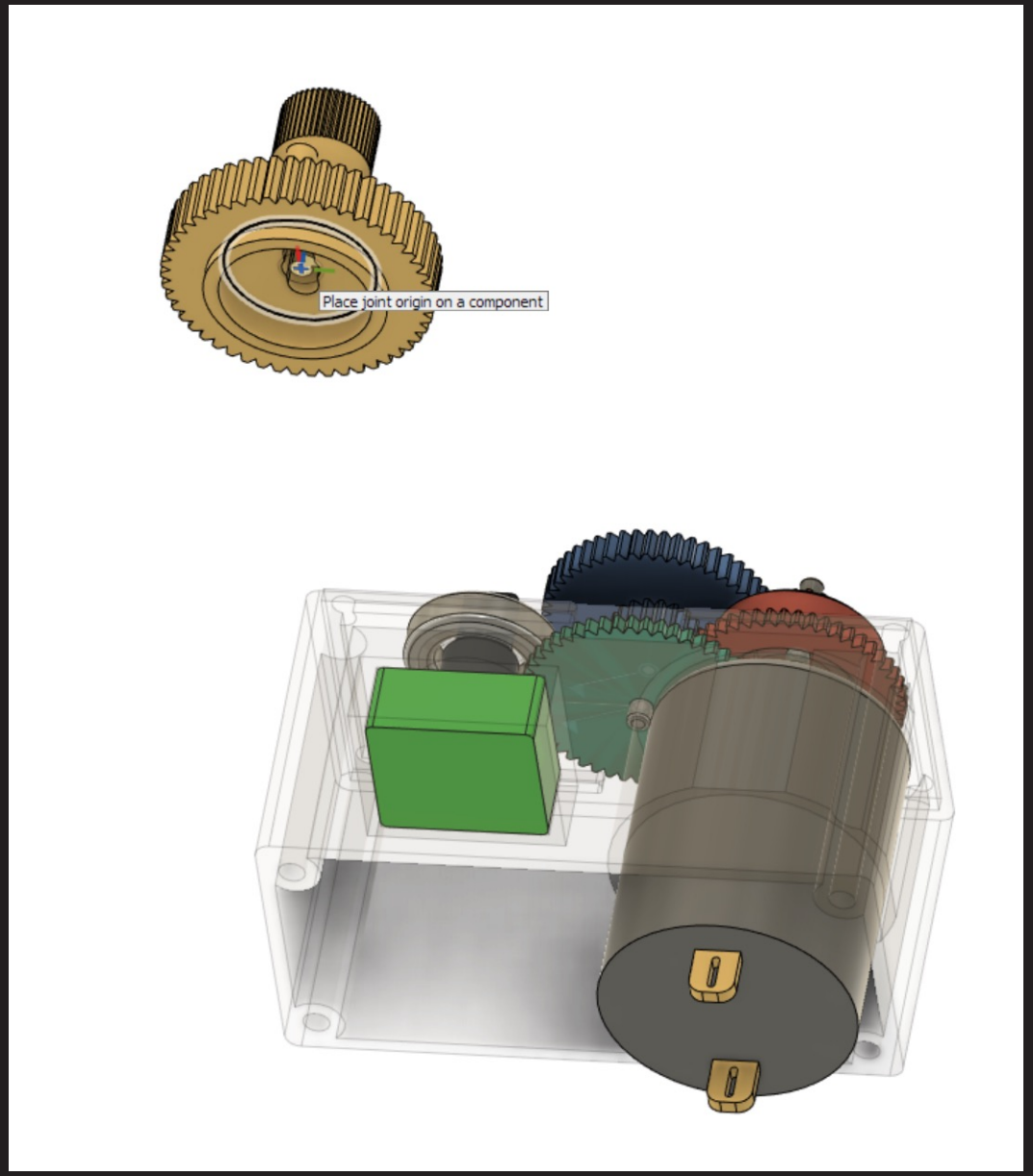
Joints-Gear 3

Similarly, add a joint to gear 3 using ‘revolute’.



Joints-Gear 4

Similarly, add a joint to gear 4 using ‘revolute’.



Joints-Gear 4

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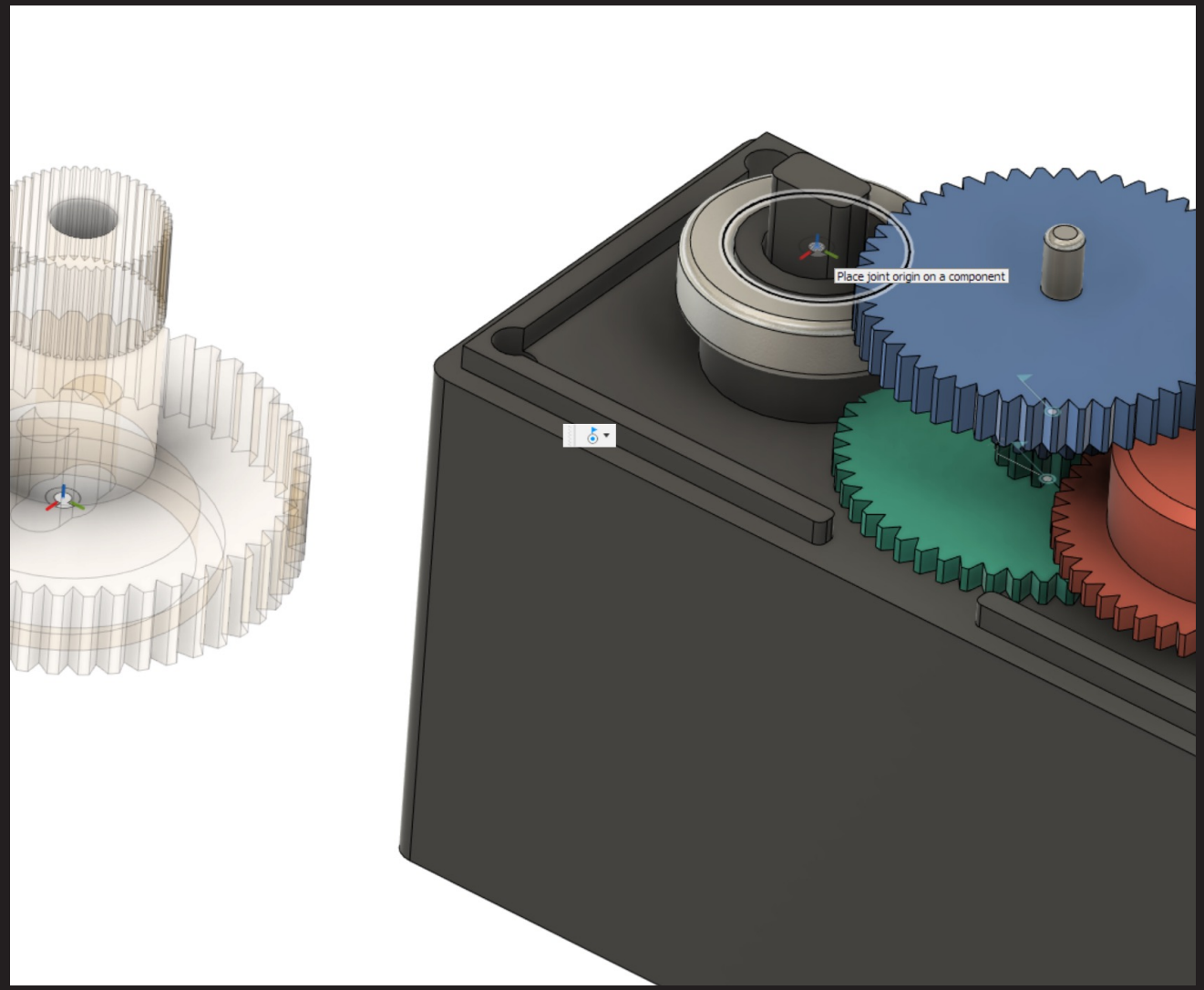

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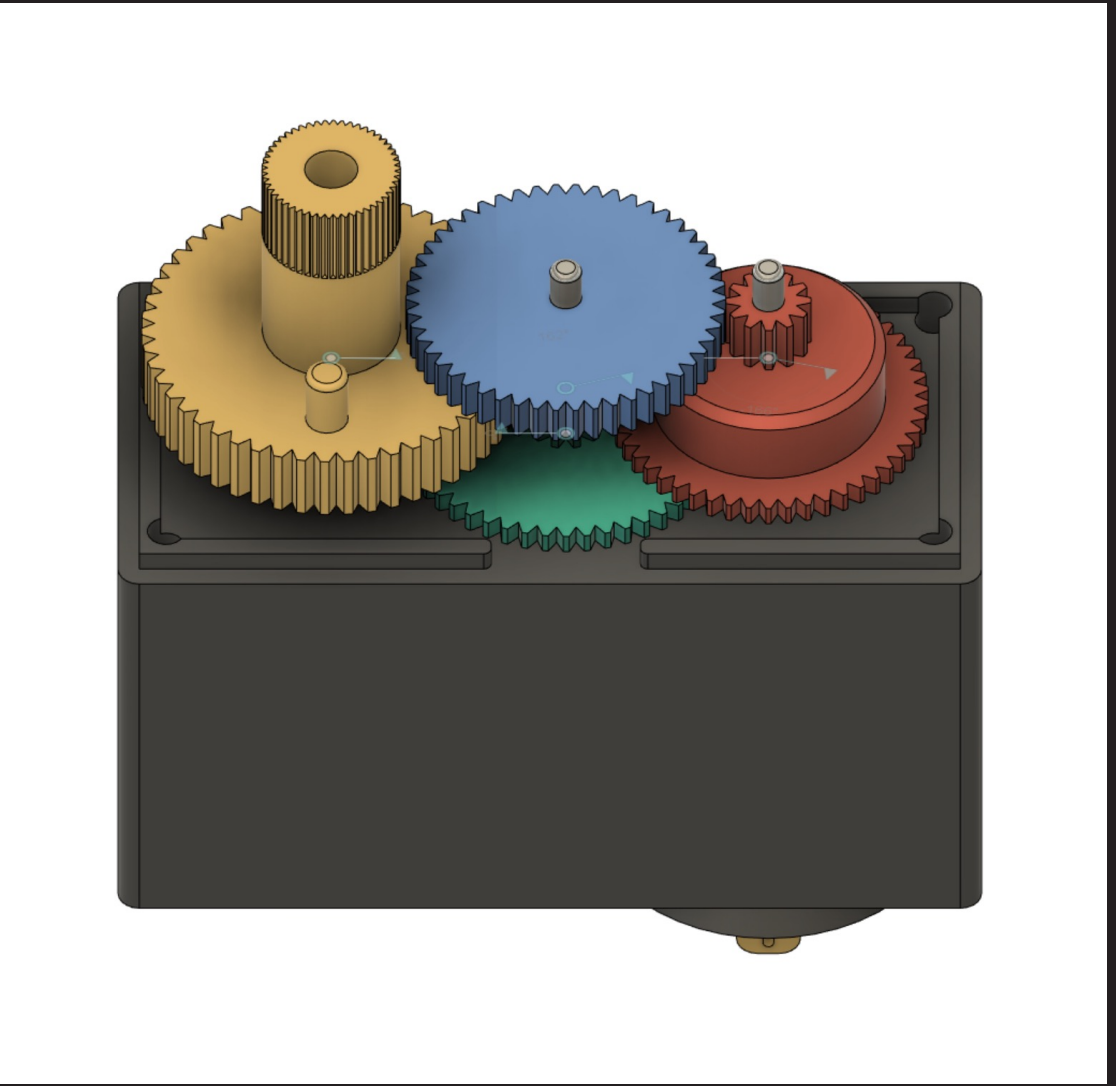
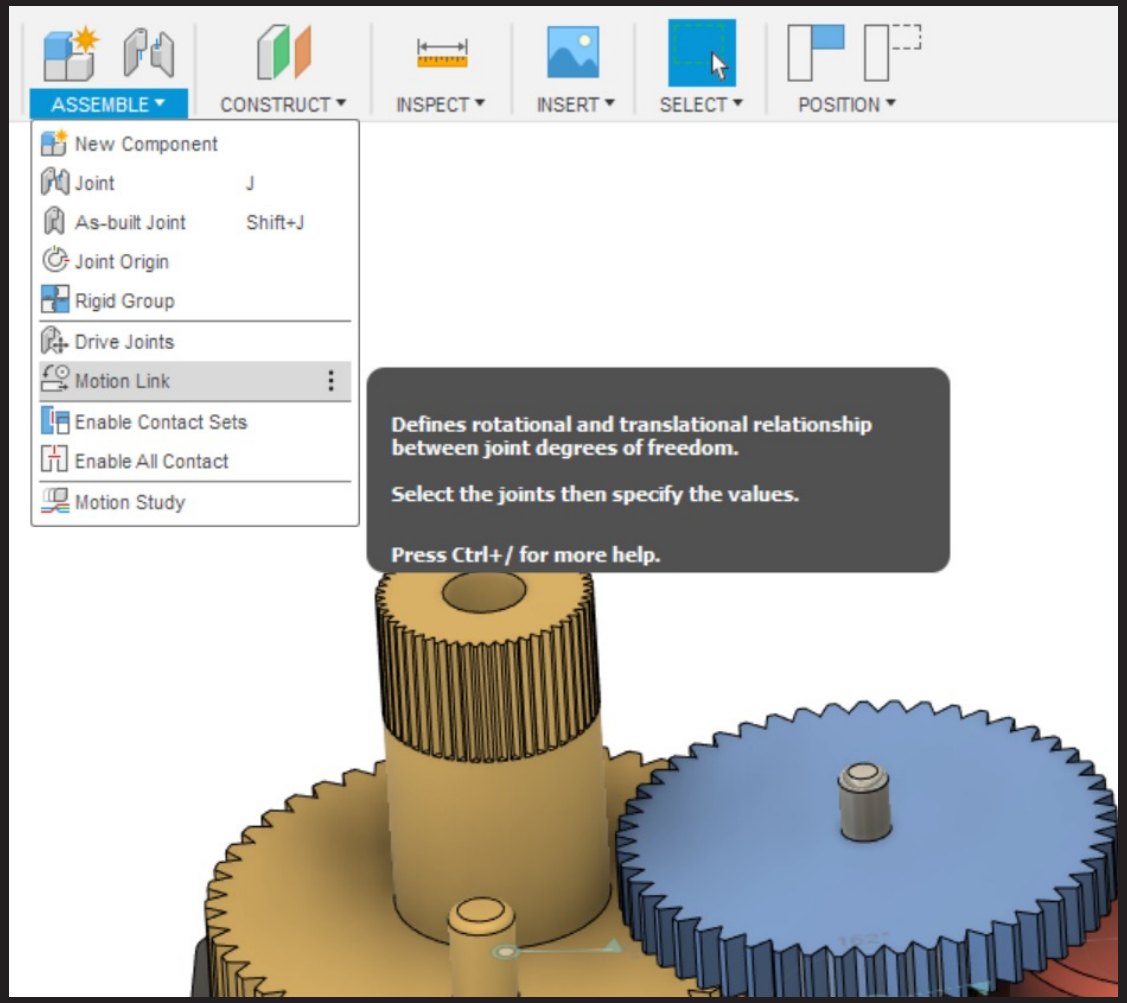


Motion Links

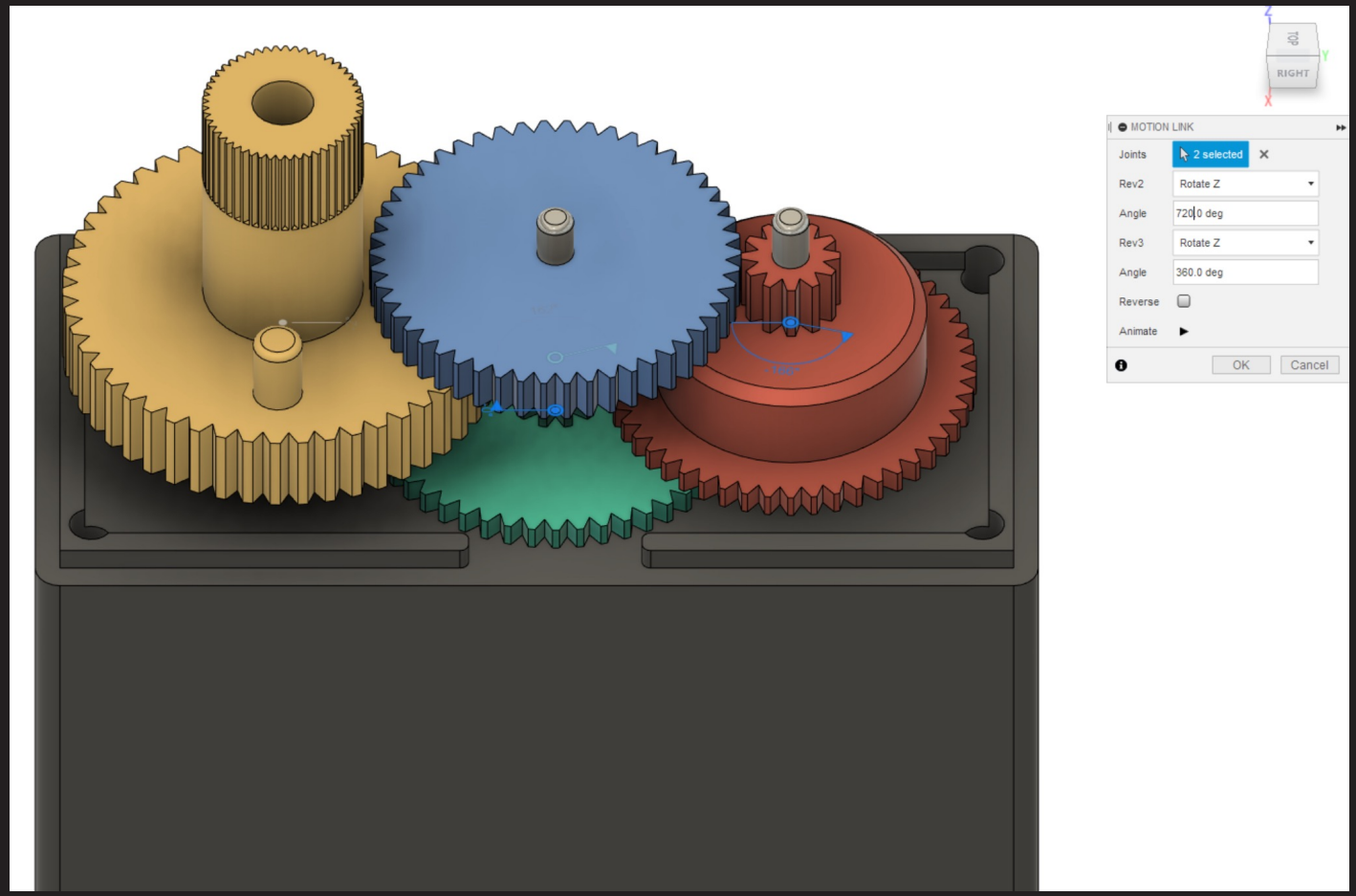
Relating individual joint together.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Motion Link Gears 1 & 2

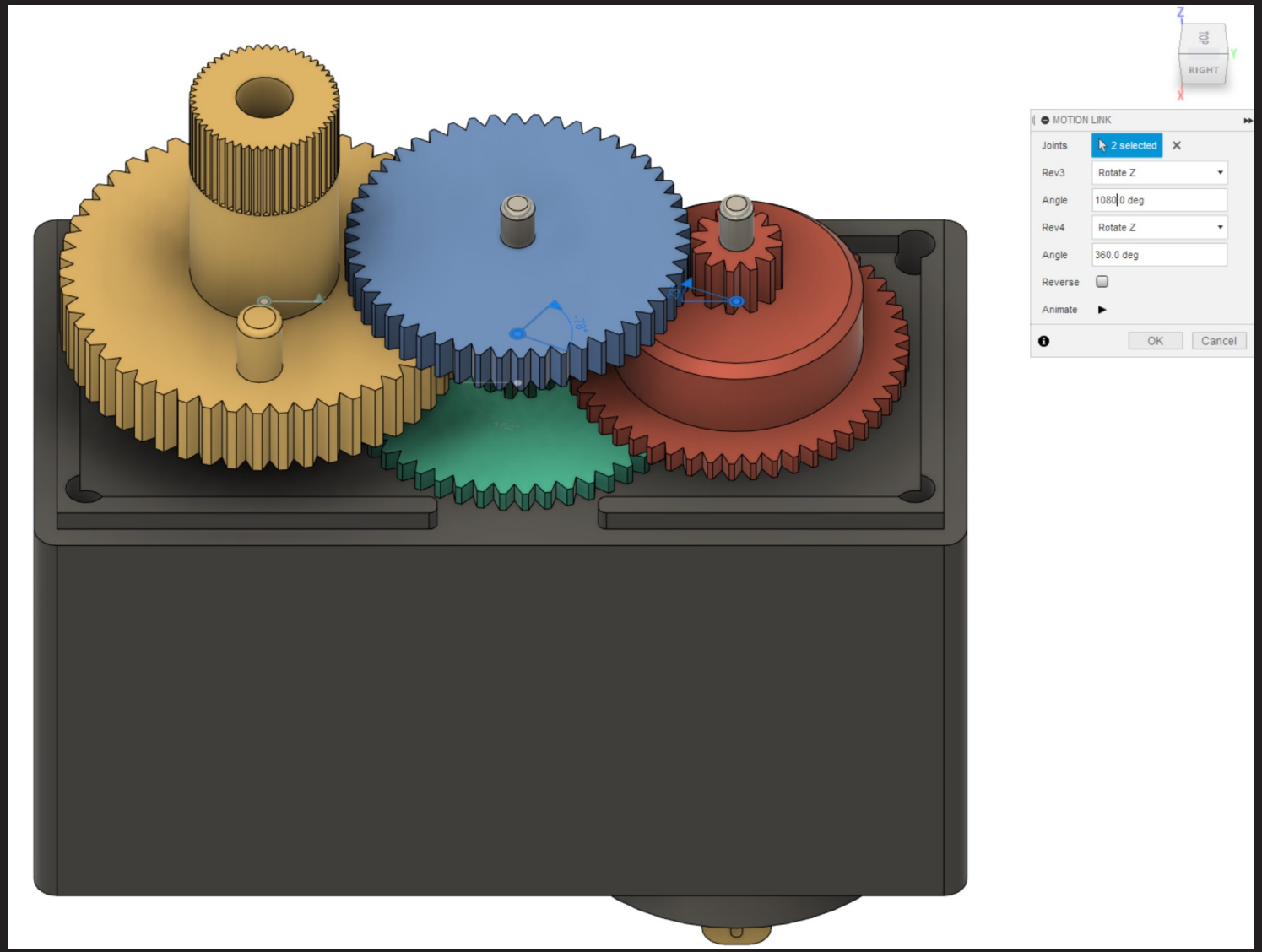
Change the ‘gear ratio’ by altering the angles option.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Motion Link Gears 2 & 3

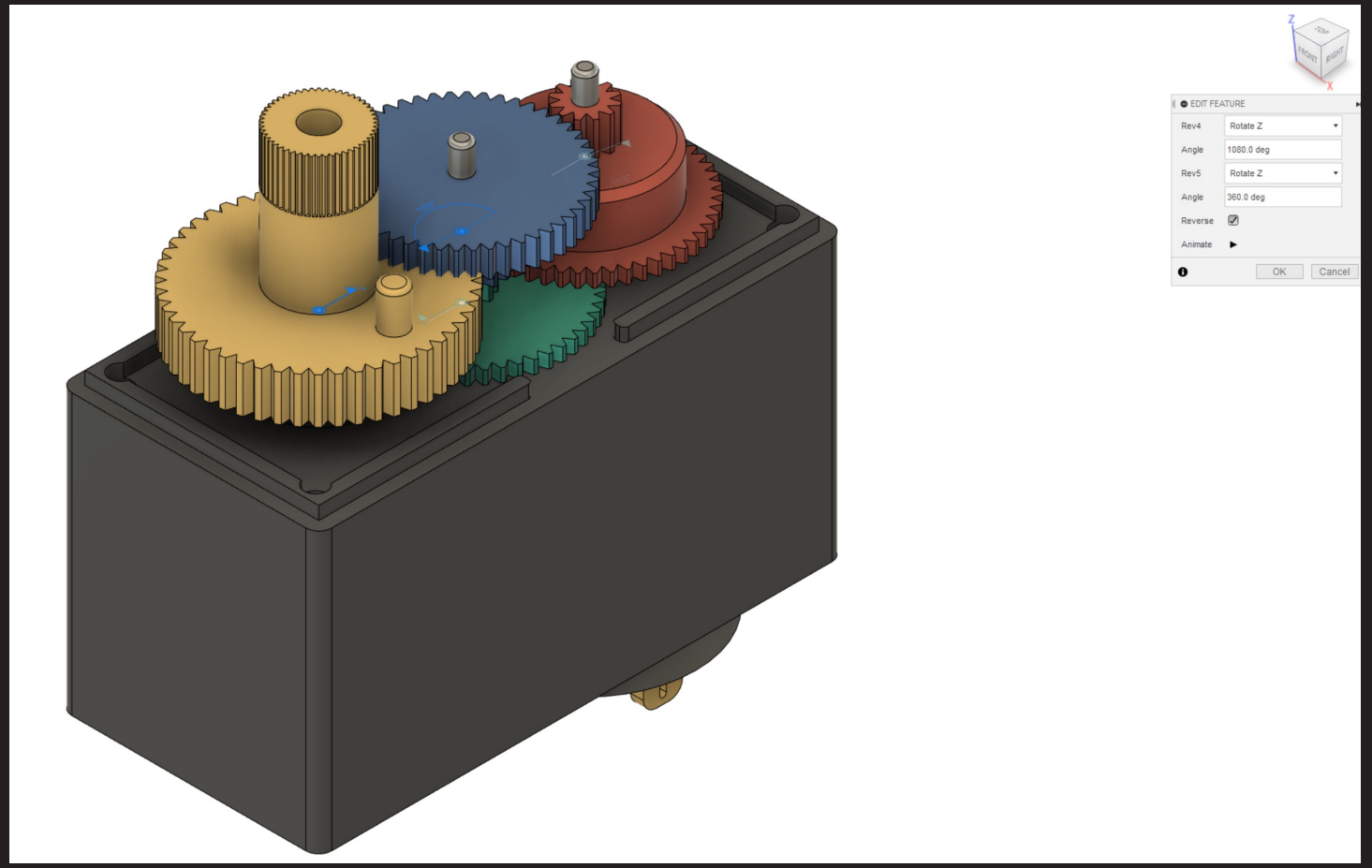
Change the ‘gear ratio’ by altering the angles option.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Motion Link Gears 3 & 4

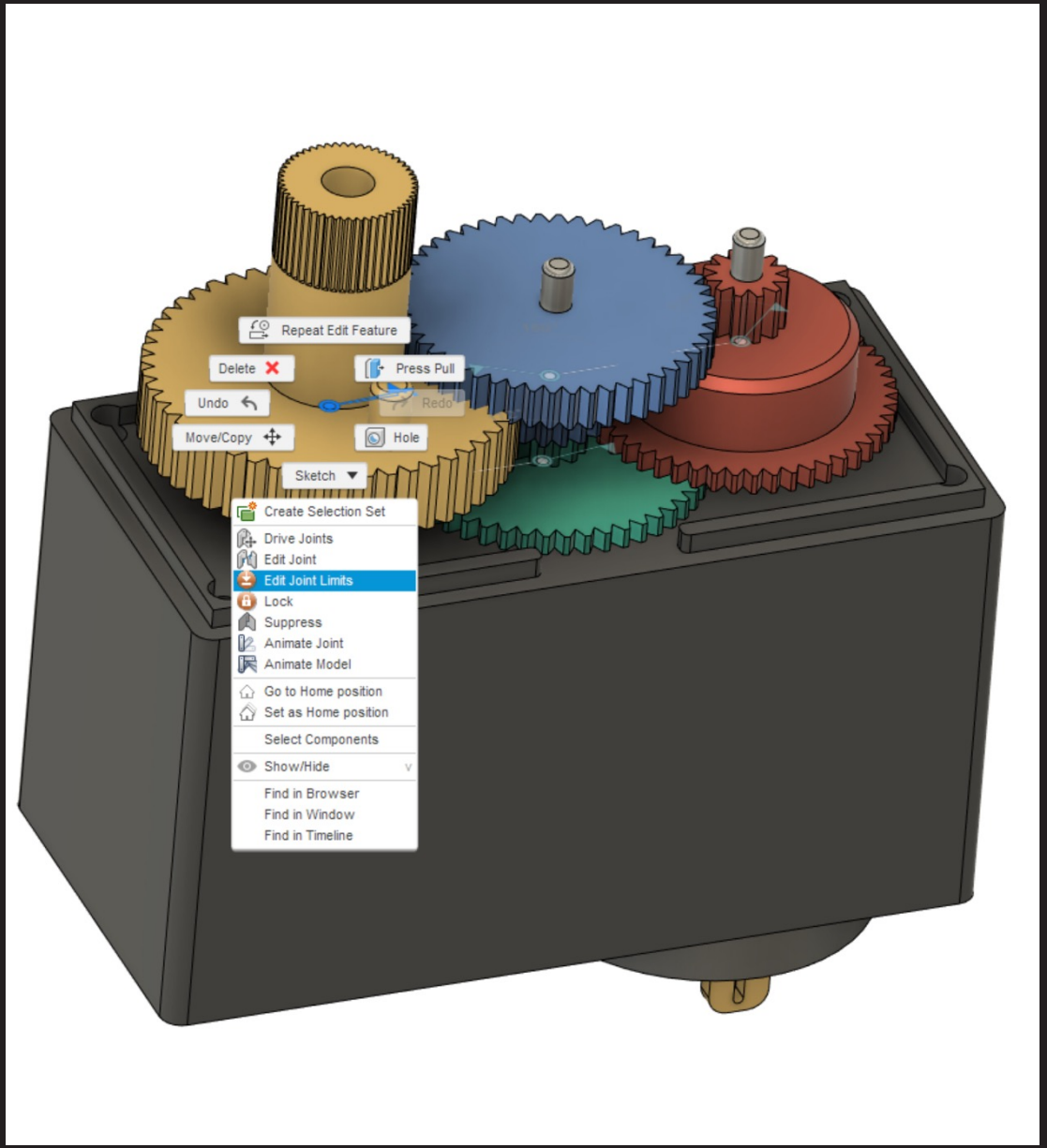
Change the ‘gear ratio’ by altering the angles option.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Edit Joint Limits

Limit the ‘sweep’ of the servo.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

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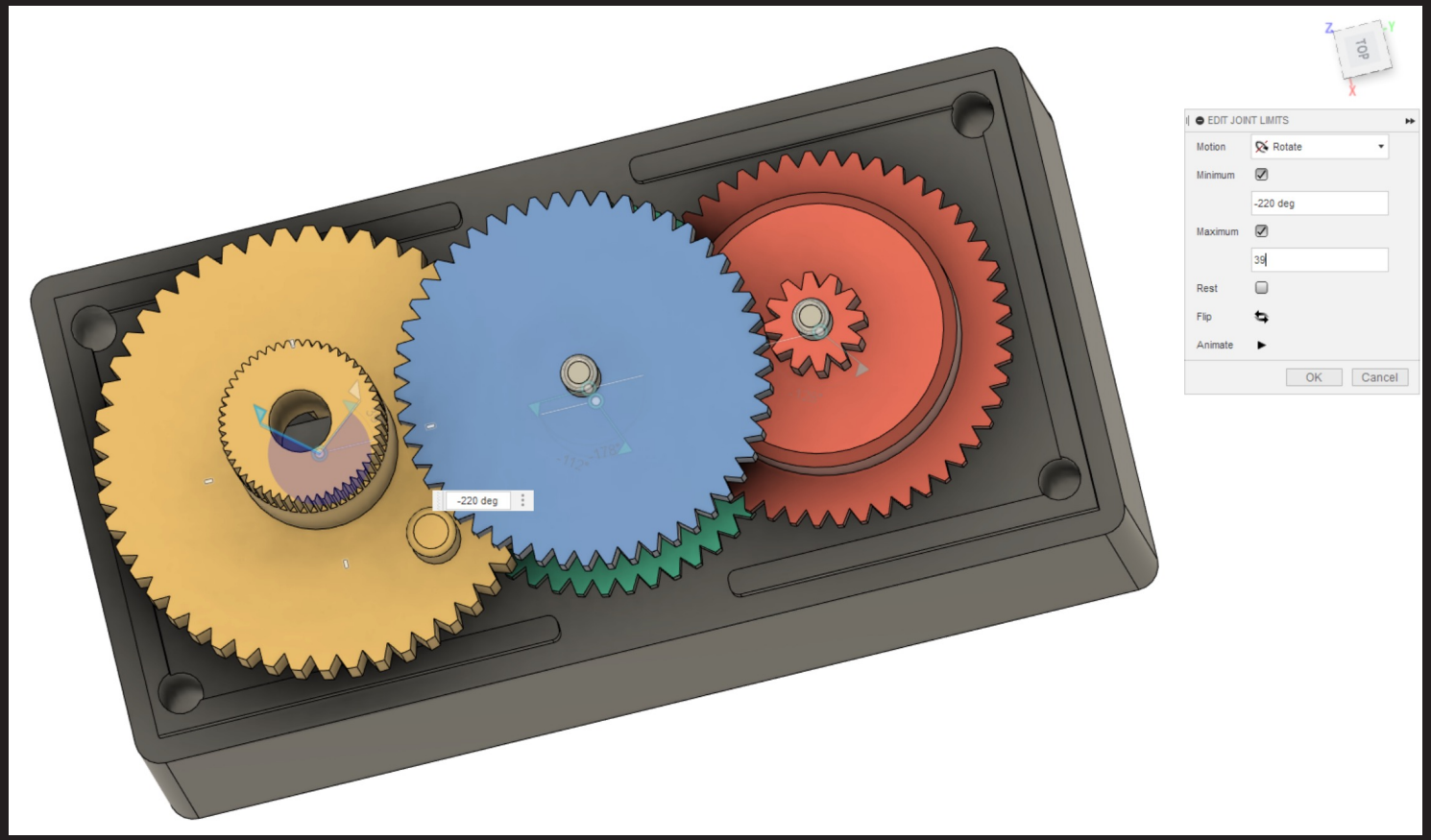
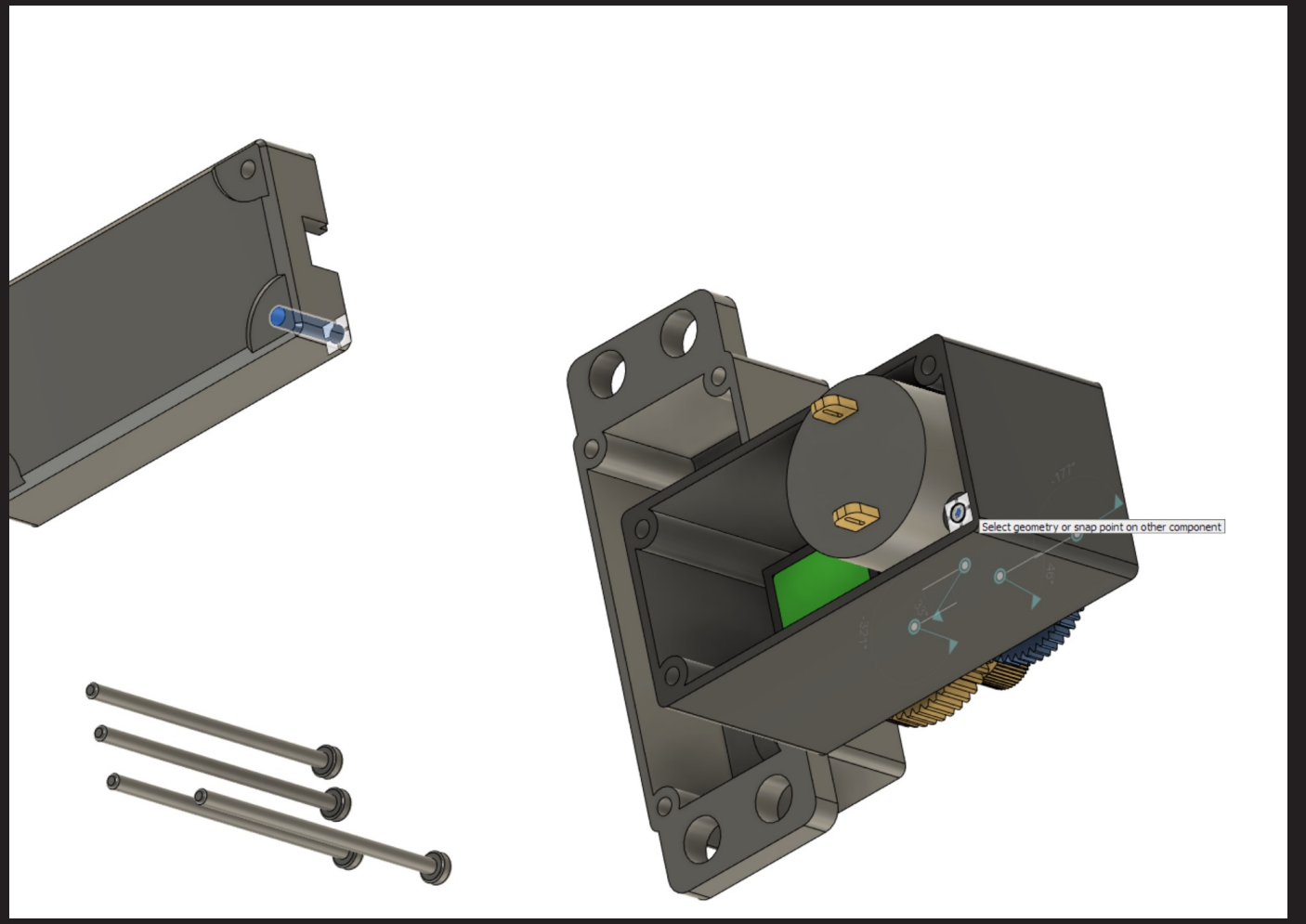


SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Bottom Shell

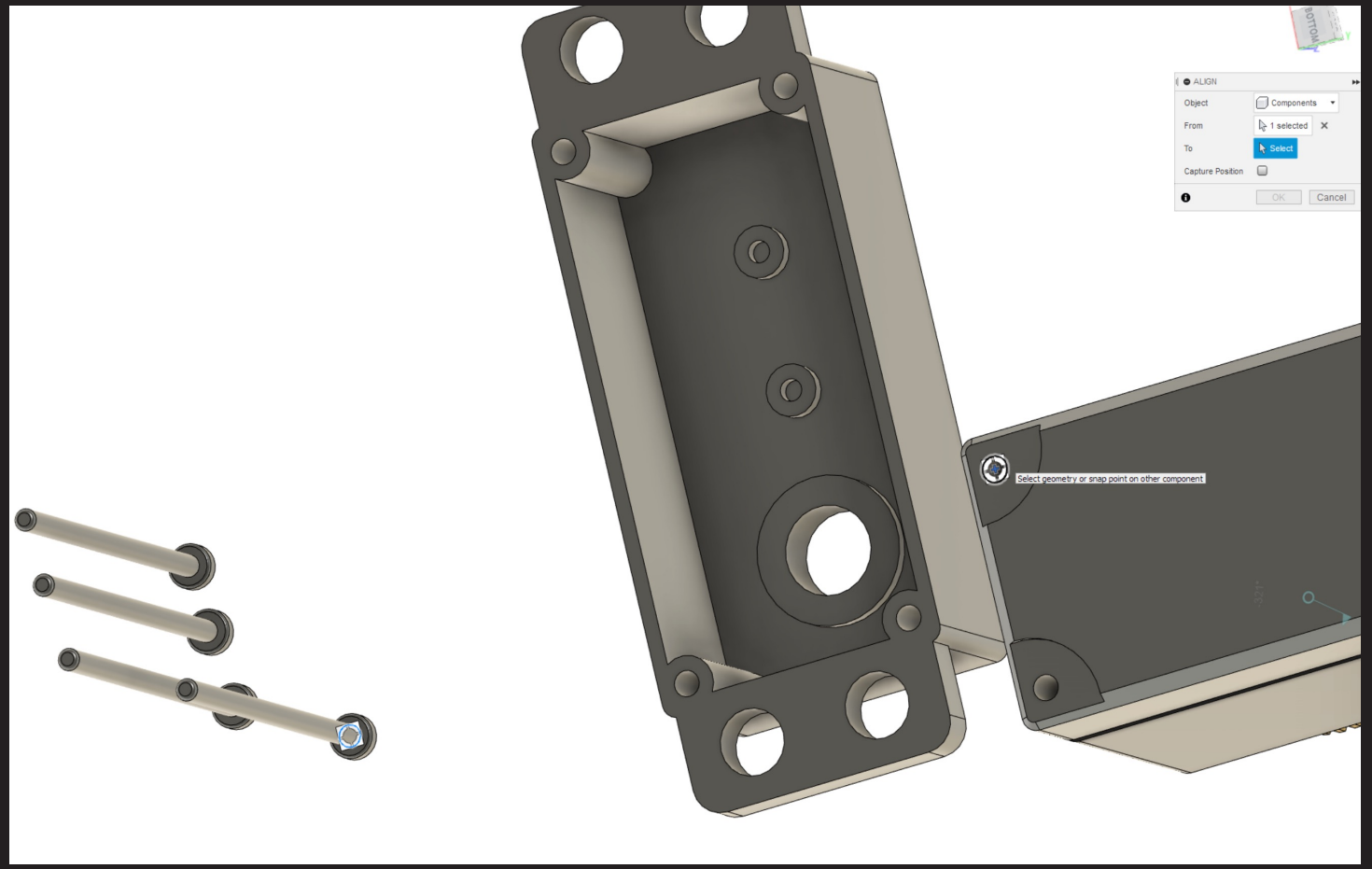
Assemble the remaining components.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Screws

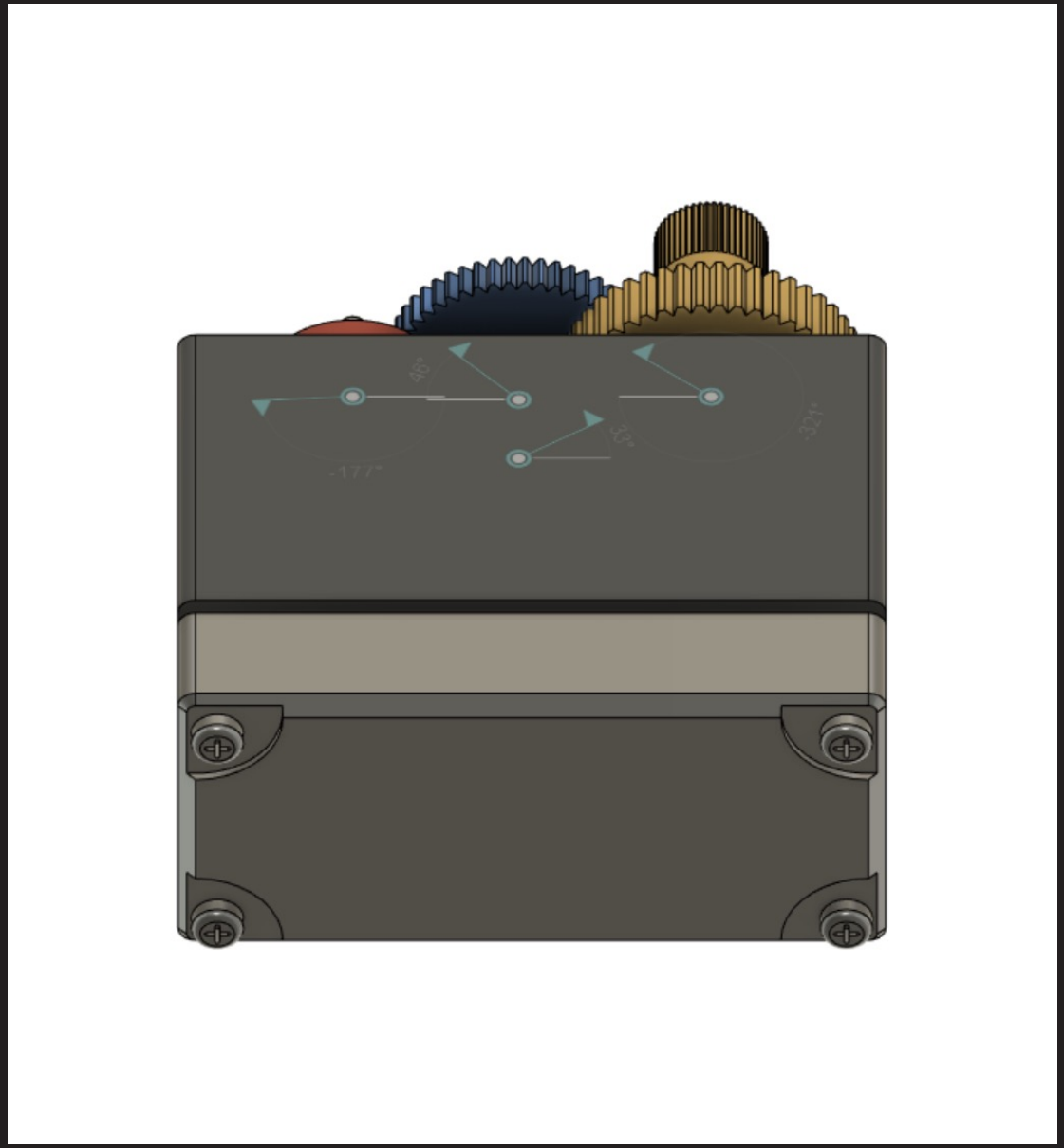
Assemble the remaining components.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Screws

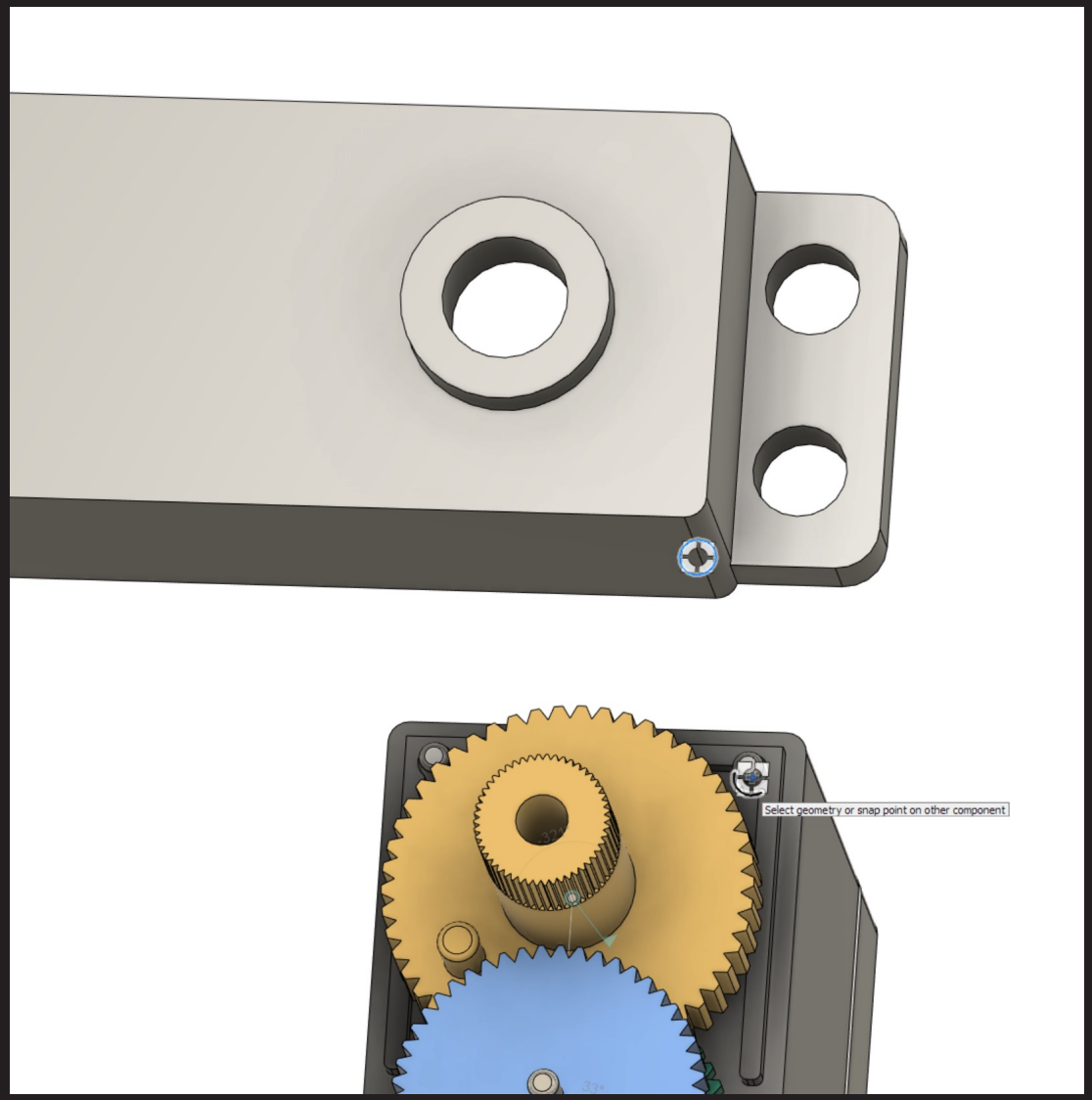
Assemble the remaining components.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Align Top Shell

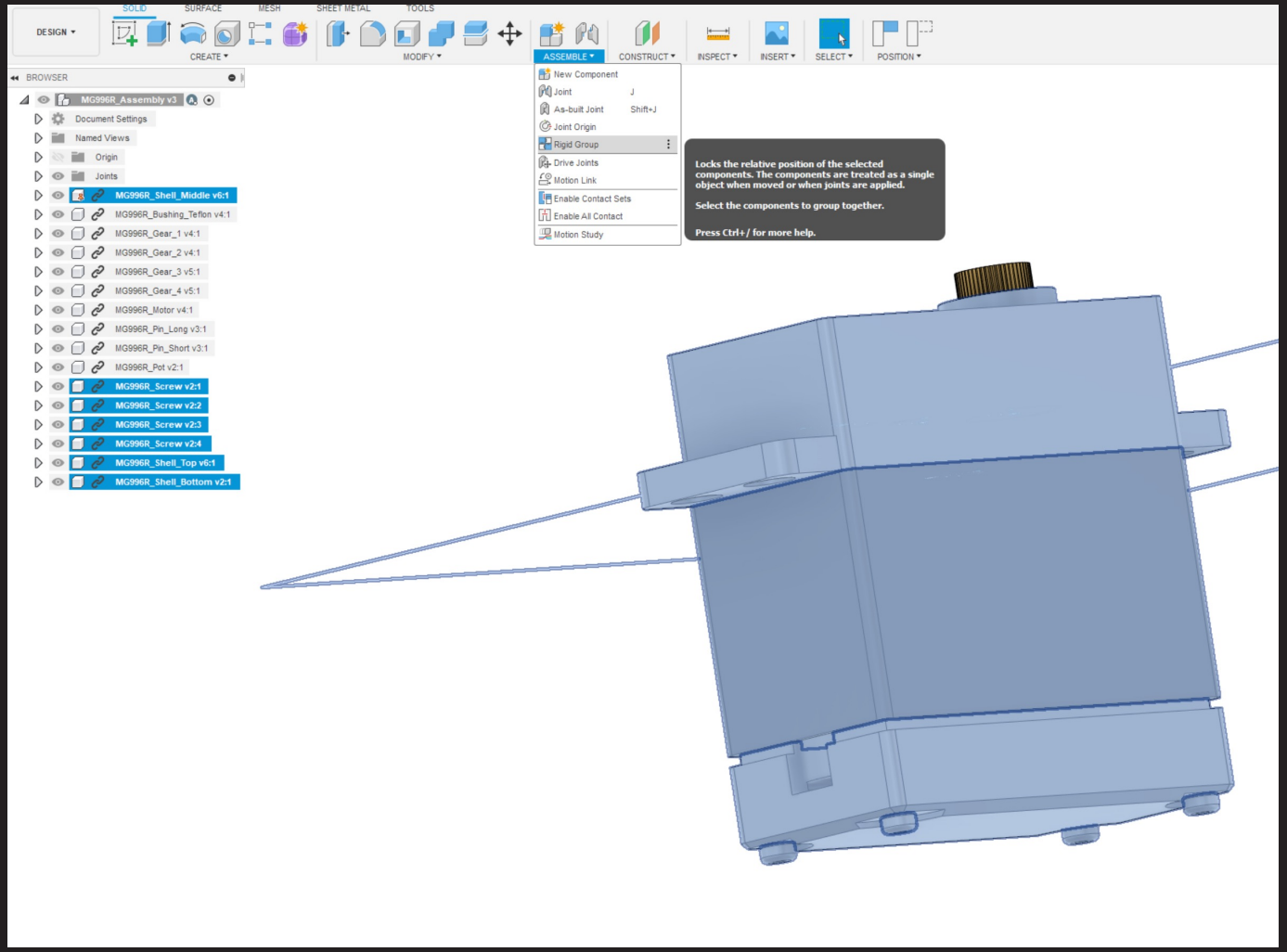
Assemble the remaining components.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Rigid Group

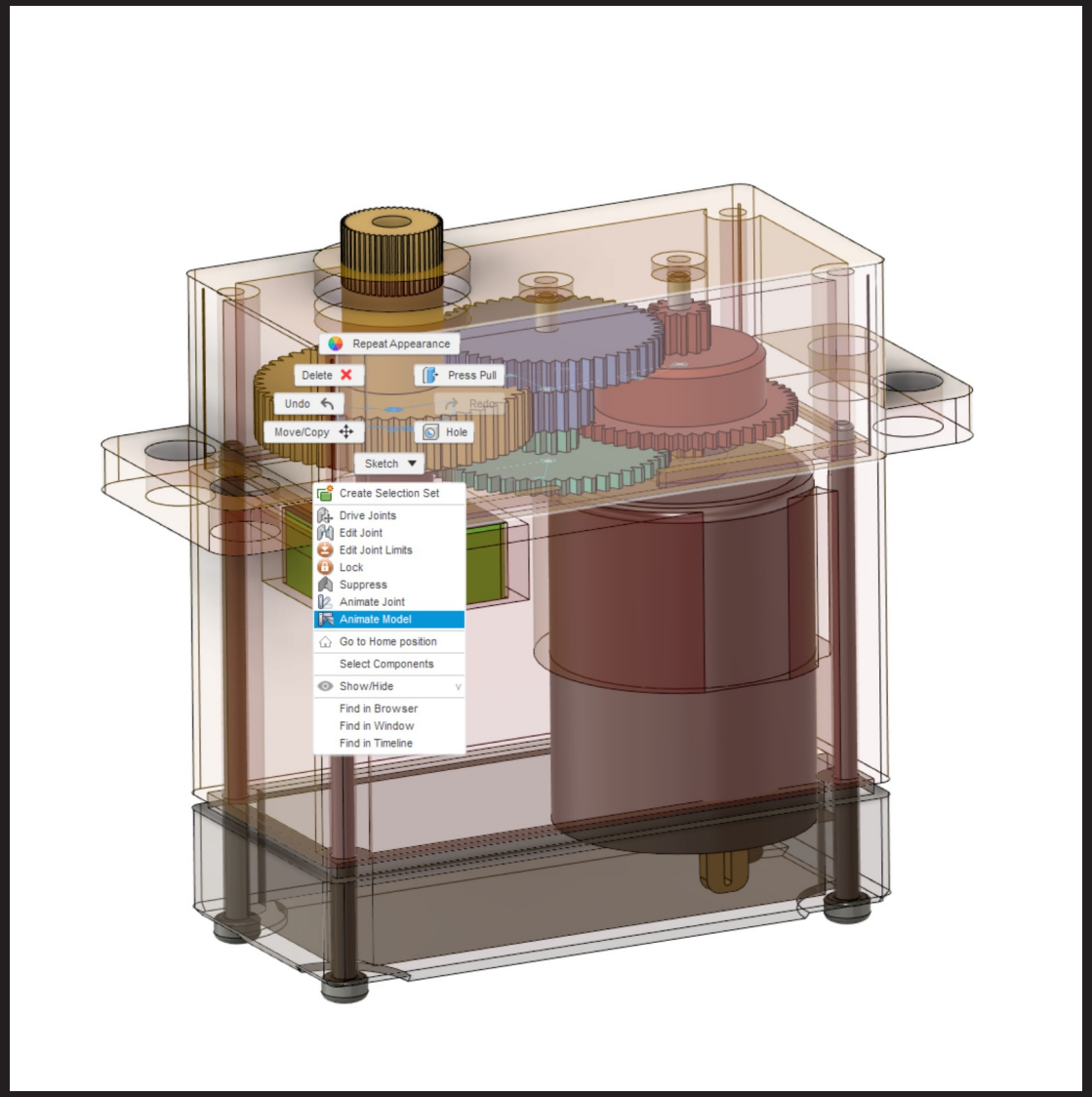
Fix the top, bottom shells and screws.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Animate Group

See the servo in action.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Animate Group

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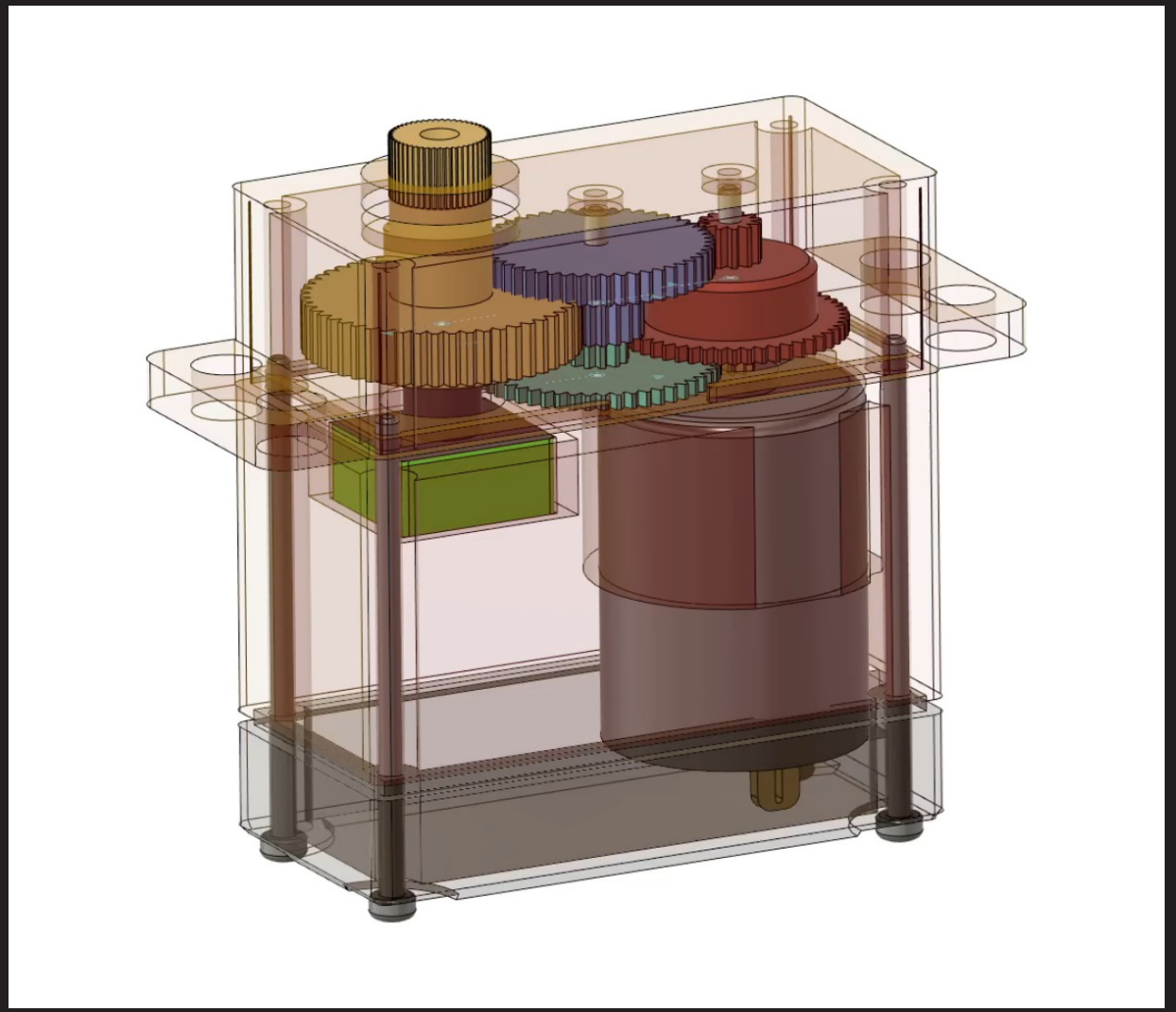
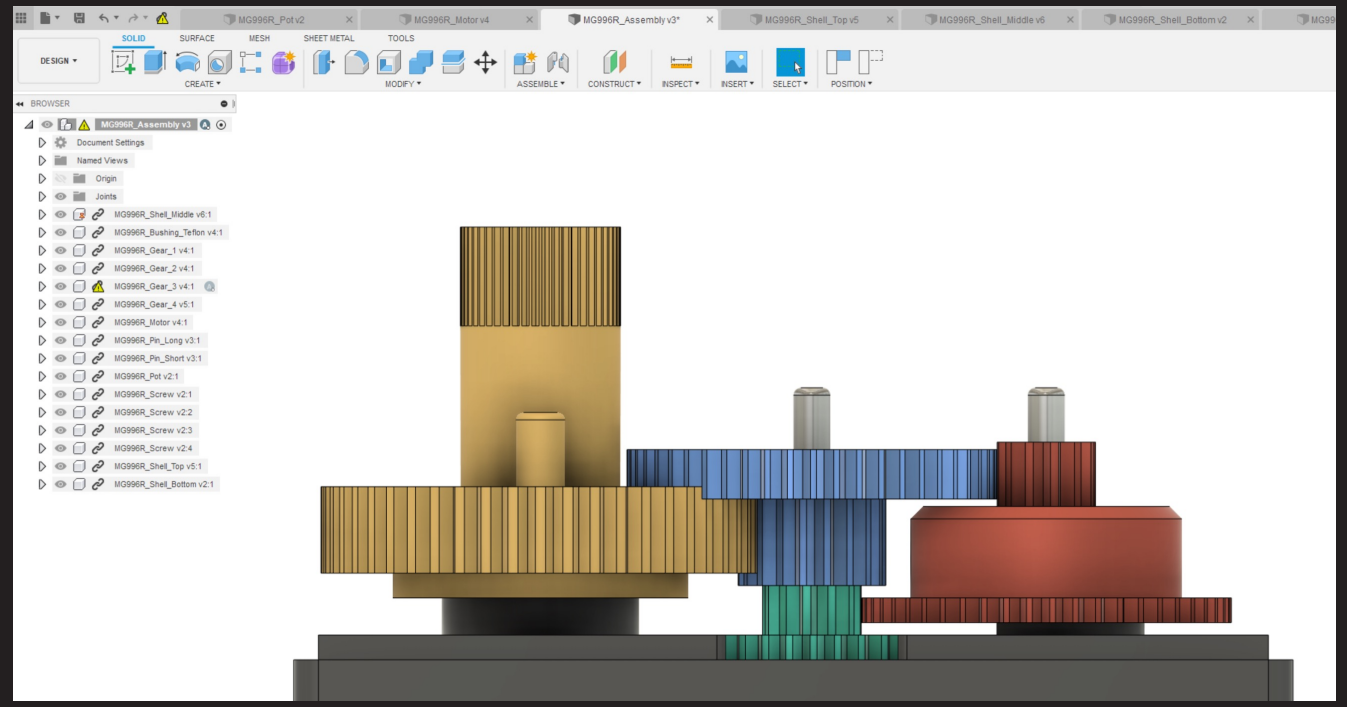


SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

Modify External Component

Click the yellow ‘Update’ icon in the assembly to update changes.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

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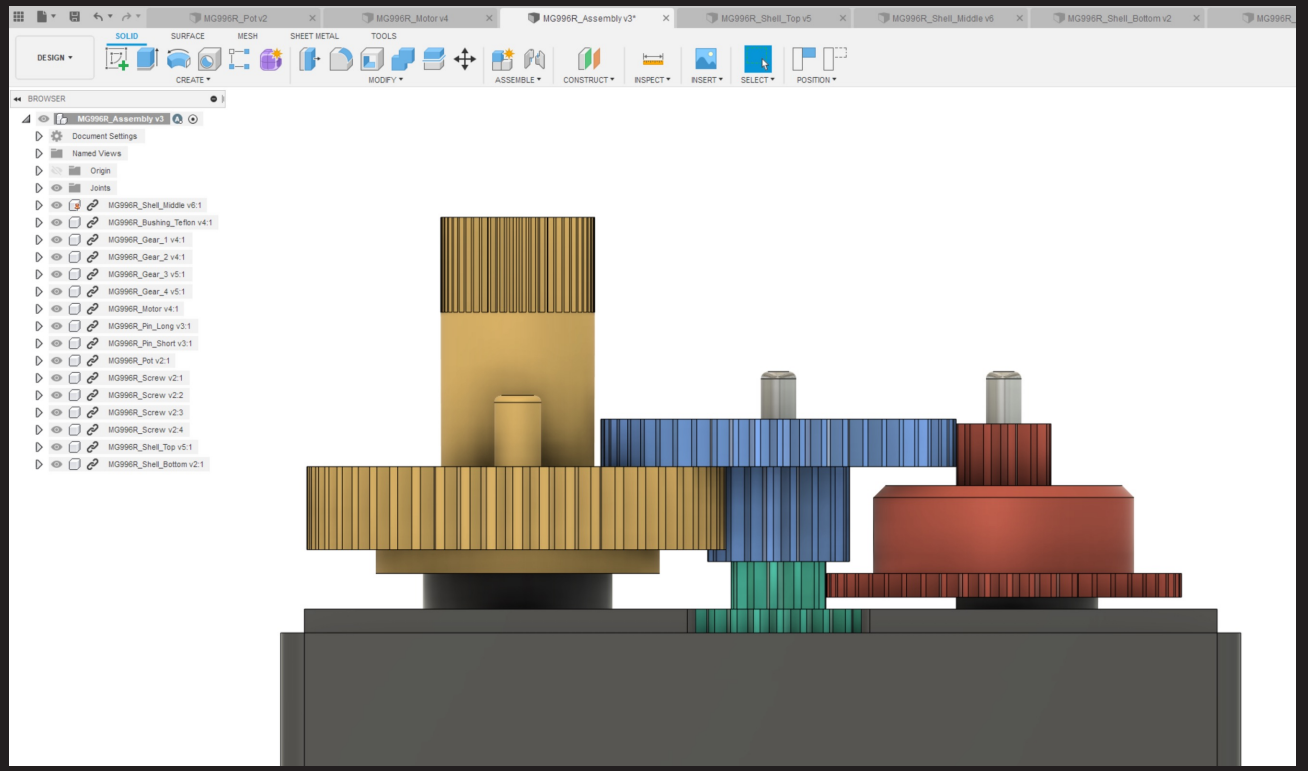

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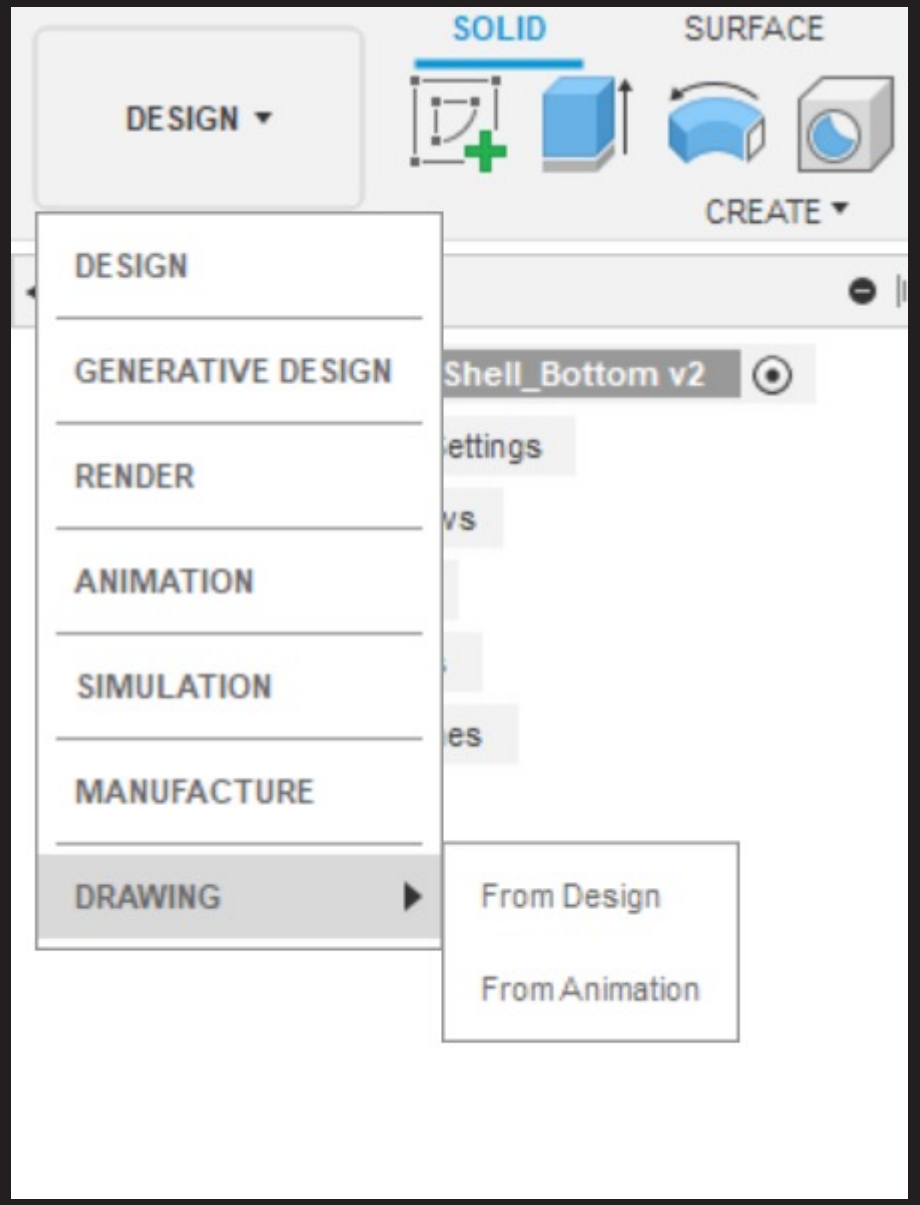
DRAWINGS - Export

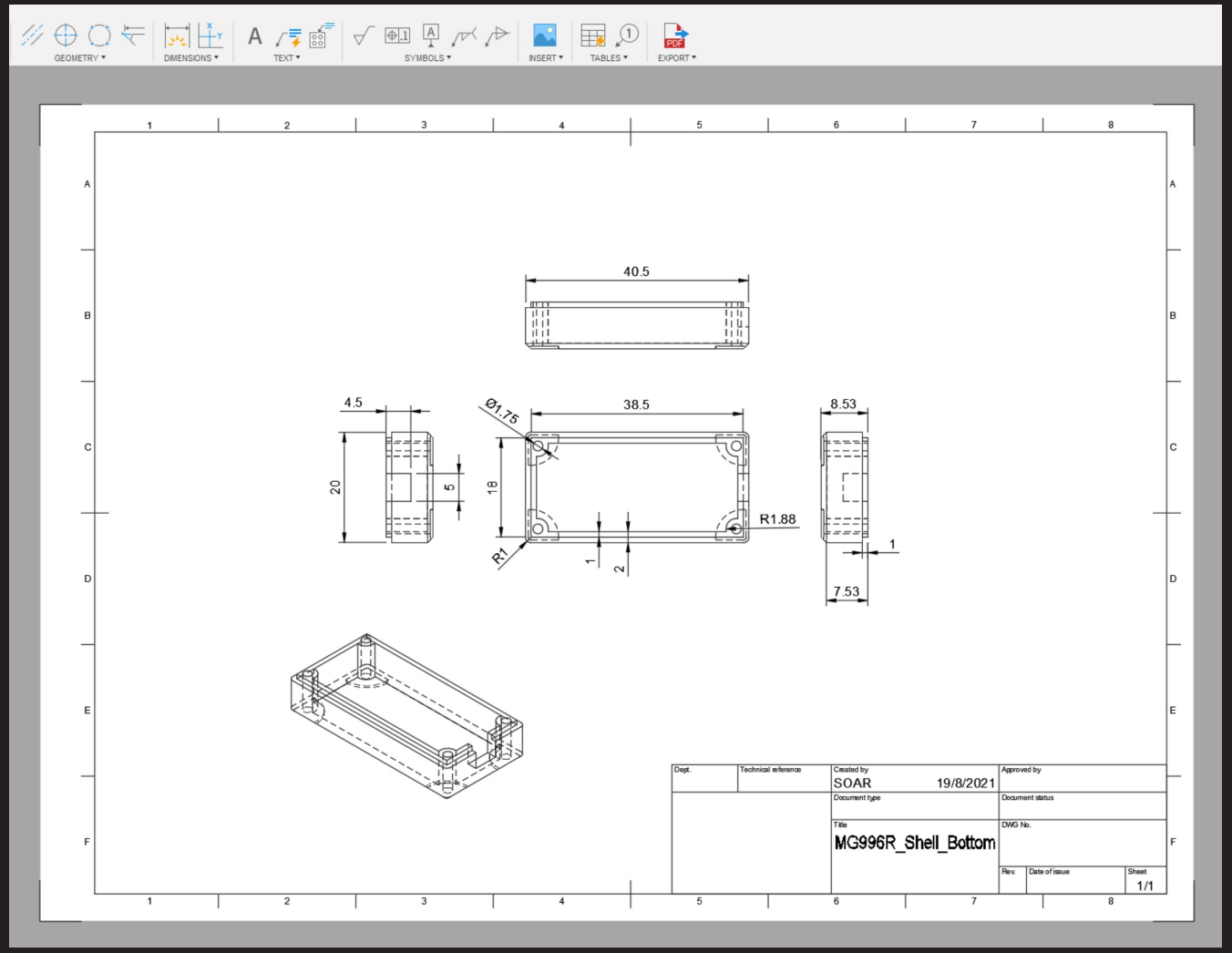
Go to drawings from design in ‘Workspace’ drop down menu.



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

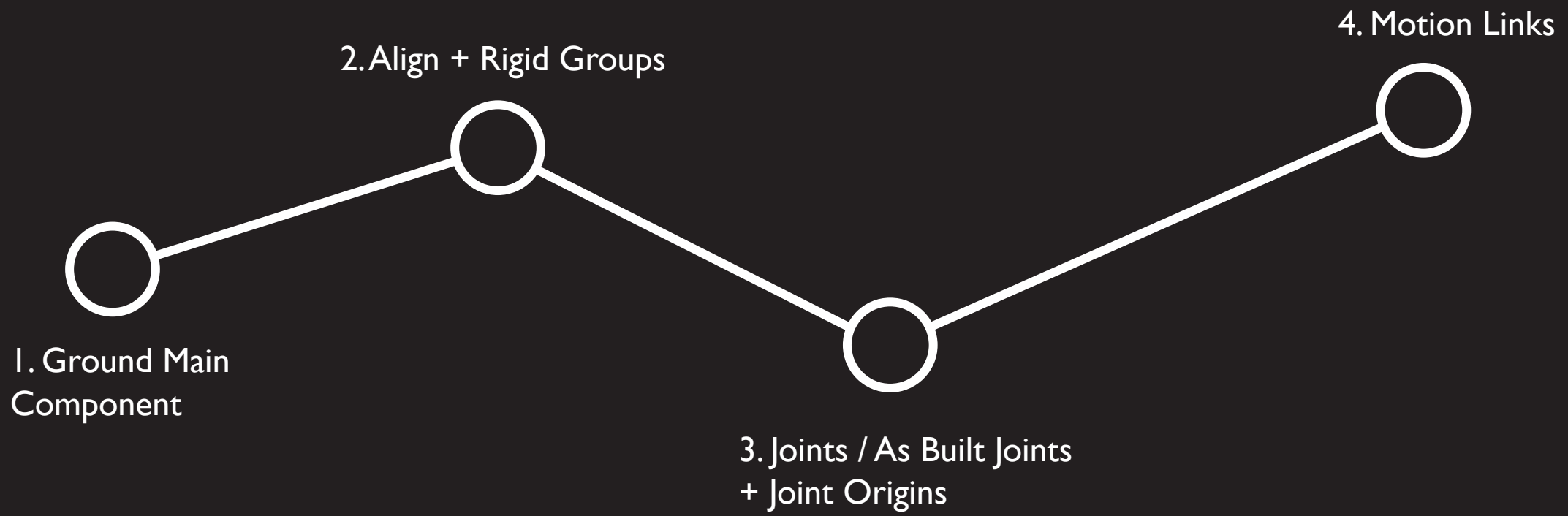
DRAWINGS - Export

Add various views, dimensions.
4 side +1 isometric



SOAR
SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

SUMMARY - Assembly Workflow



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Speed Challenge Trial

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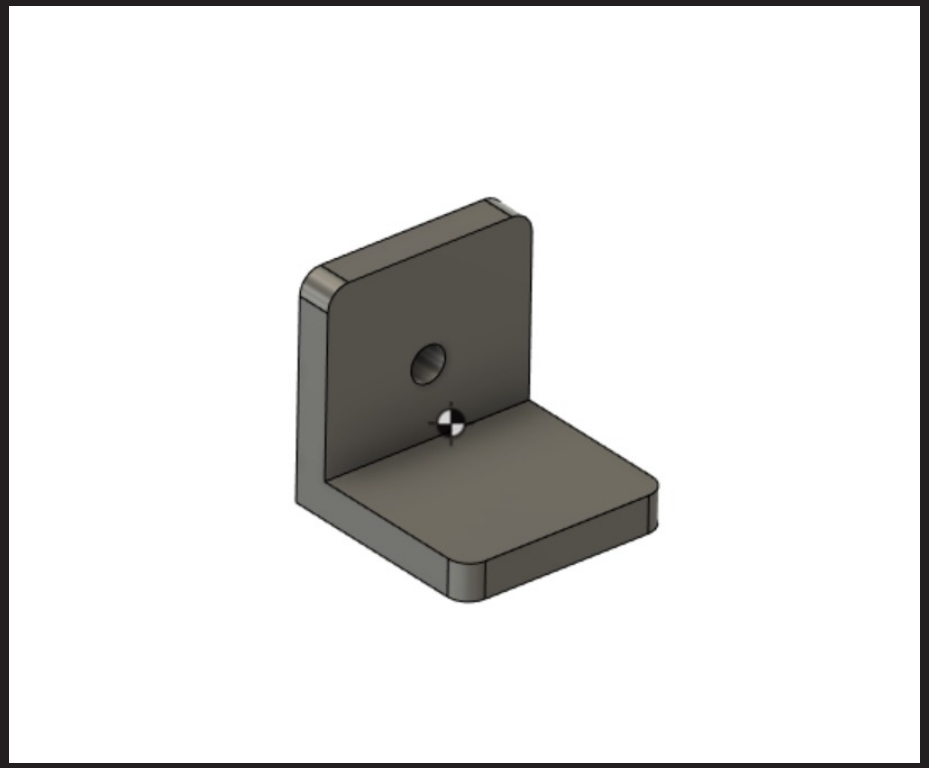
SOAR_Mech_Speed_Challenge_Trial.pdf

1. CAD this from the given drawing as quickly as you can but not compromising on accuracy.

2. Under properties, find the mass of the part (with material set to steel)

3. Send the mass of your part in the Discord chat

4. Fastest fingers win!



SUTD ORGANIZATION OF AUTONOMOUS ROBOTICS

SOAR_Mech_Speed_Challenge_Trial.pdf

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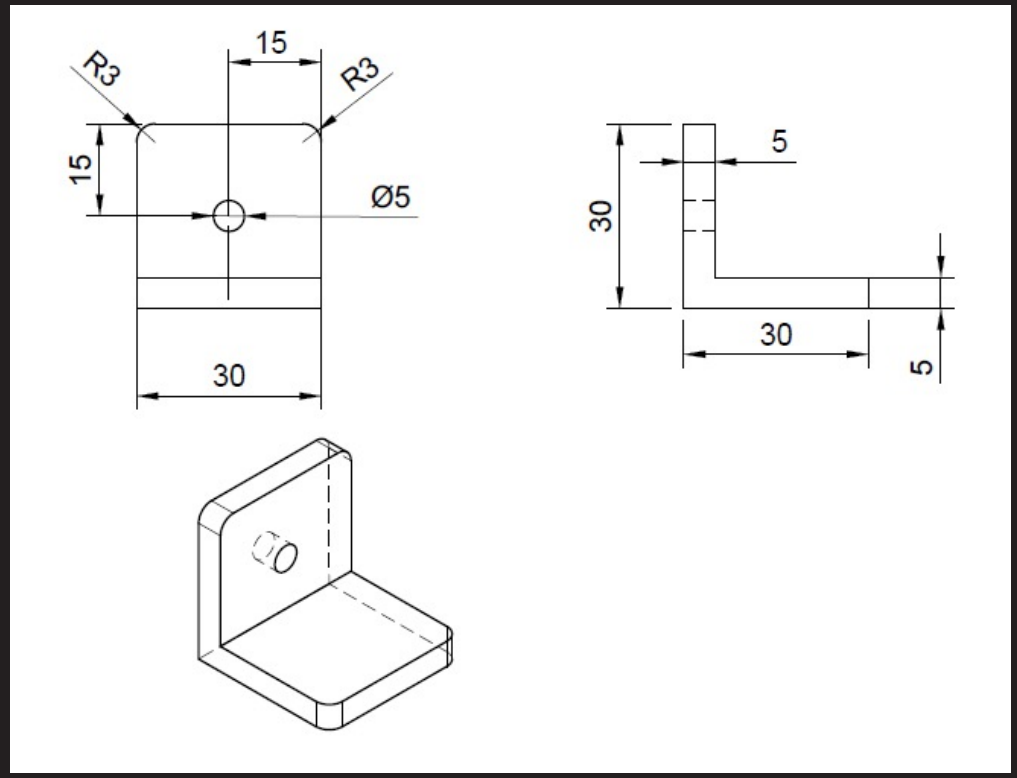

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See you next week!

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