ES 3323-A24 Final Project:

Modeling and Analysis of a Stirling Engine

Team: PM01

Members: Seth Beyea

Submitted to: Reza Ebadi

Date: 10/04/2024

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Introduction to Project:

Throughout the ES 3323 course, team PM01 was tasked with modeling and analyzing a sterling engine. The team originally consisted of 2 members; however, Seth Beyea is the only member remaining in the group. Therefore, he was tasked with the complete workload of this project. This process began by taking measurements of a physical model, which has been documented in the following appendices. These measurements were then used to design each part in the CPT Creo software. Each part was used to put into a subassembly which would then make up the larger full assembly. Once the assembly was made using pre-defined mates, Static, kinematic and dynamic tests were performed, resulting in the following graphs. The findings from the project have been compiled and organized into the following report.

Engineer’s Drawings

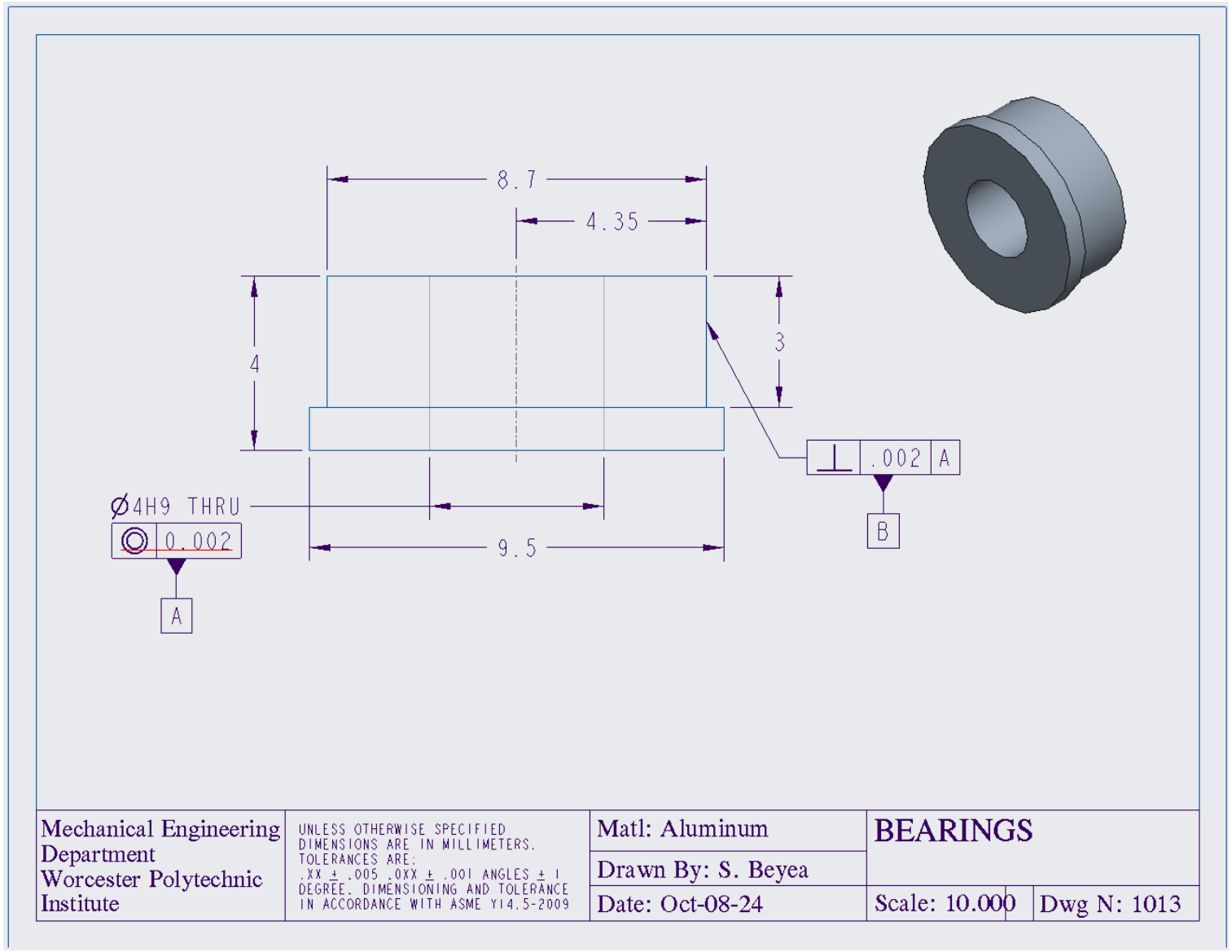


Figure 1) bearings which house the flywheel shaft.

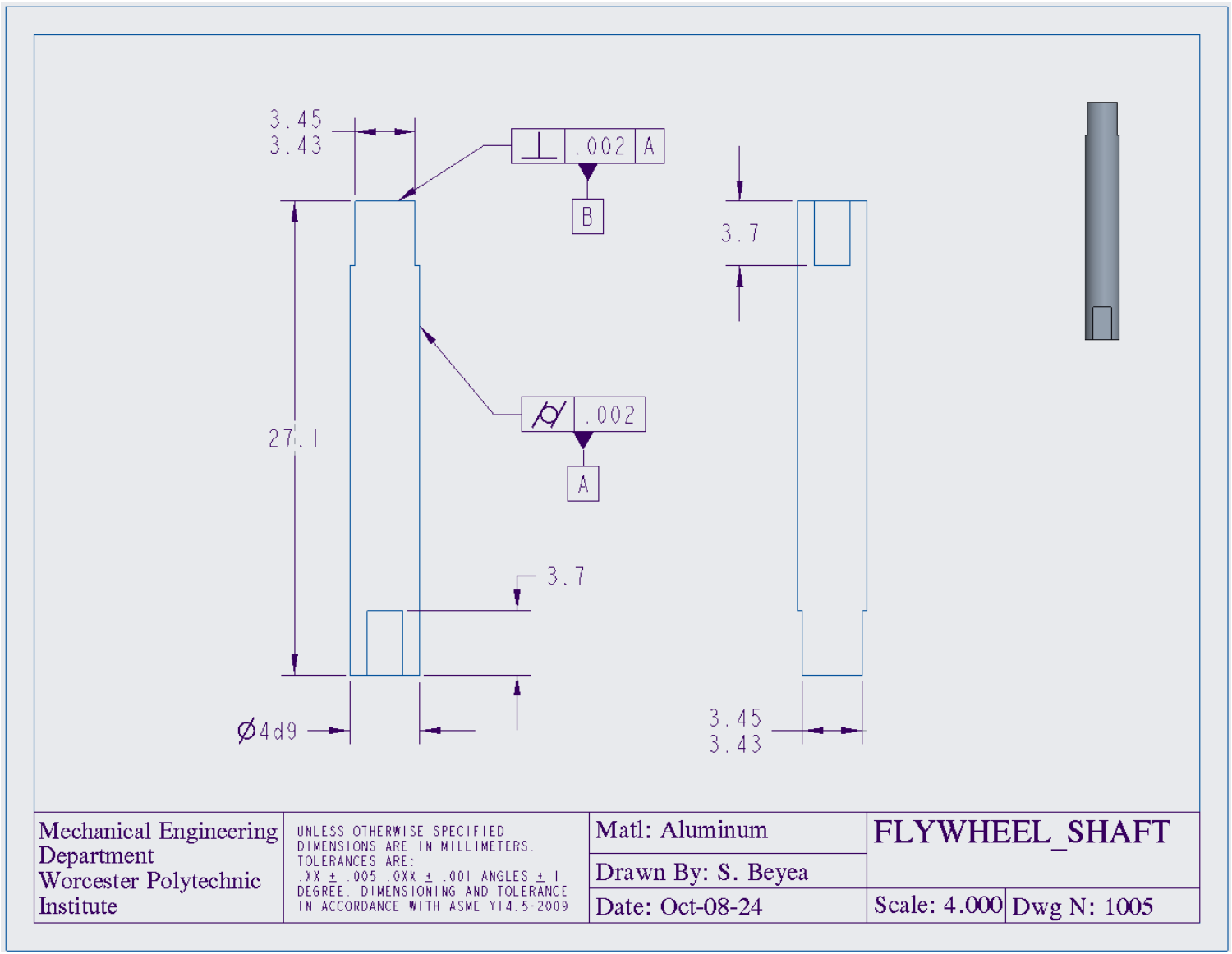


Figure 2) flywheel shaft which the bis and small flywheels mount to.

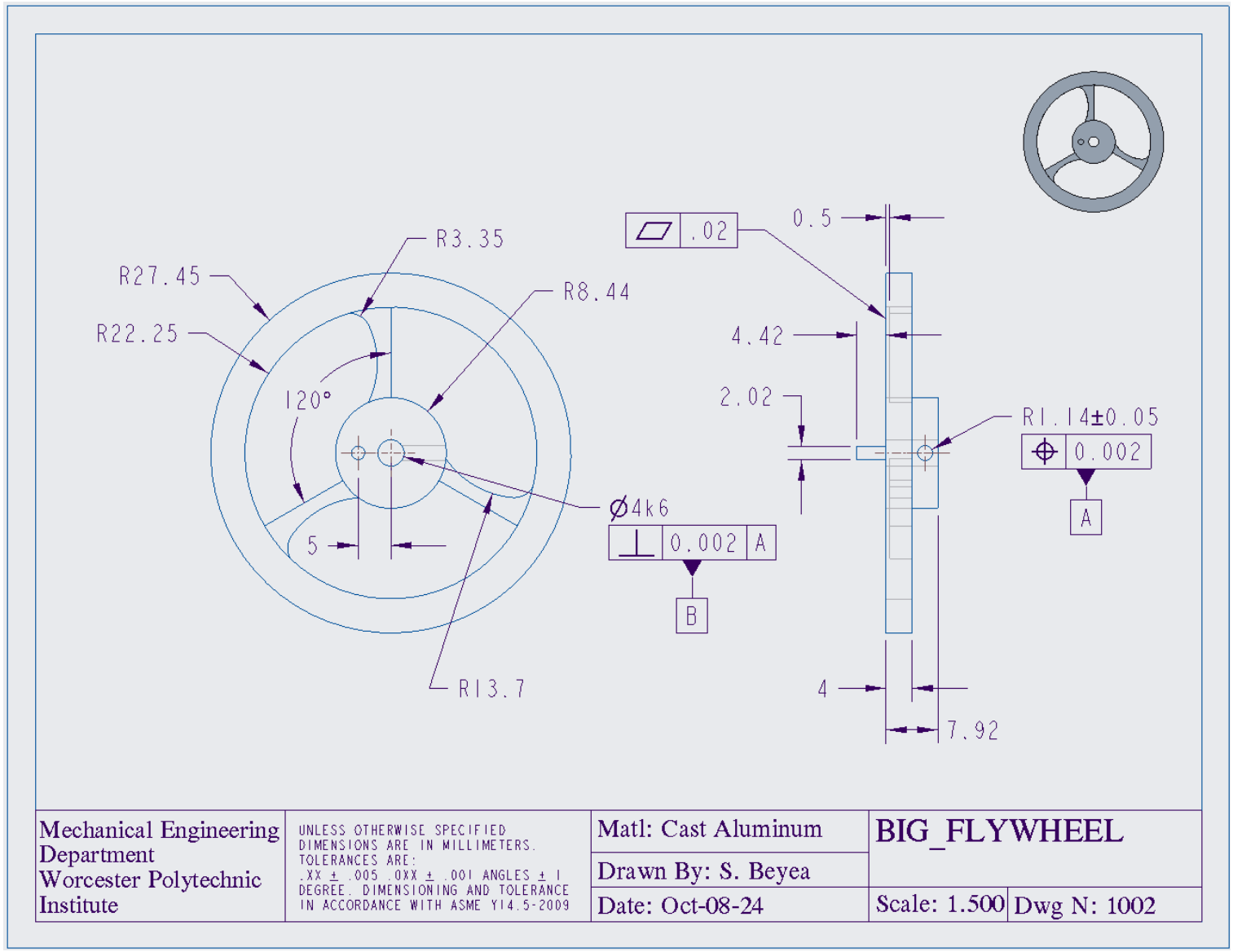


Figure 3) big flywheel which drives the power piston (cold piston).

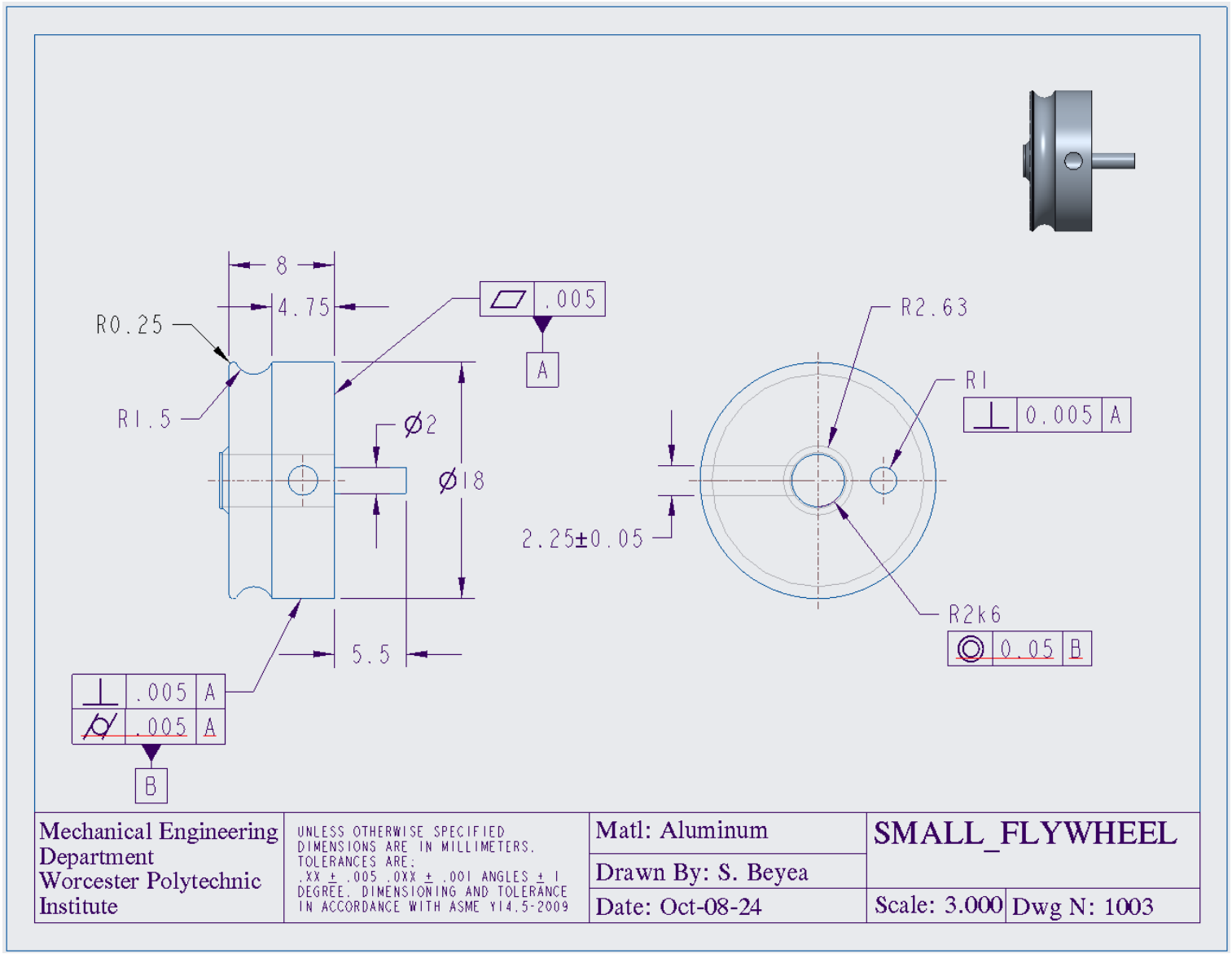


Figure 4) small flywheel which is driven by the displacer piston (hot piston).

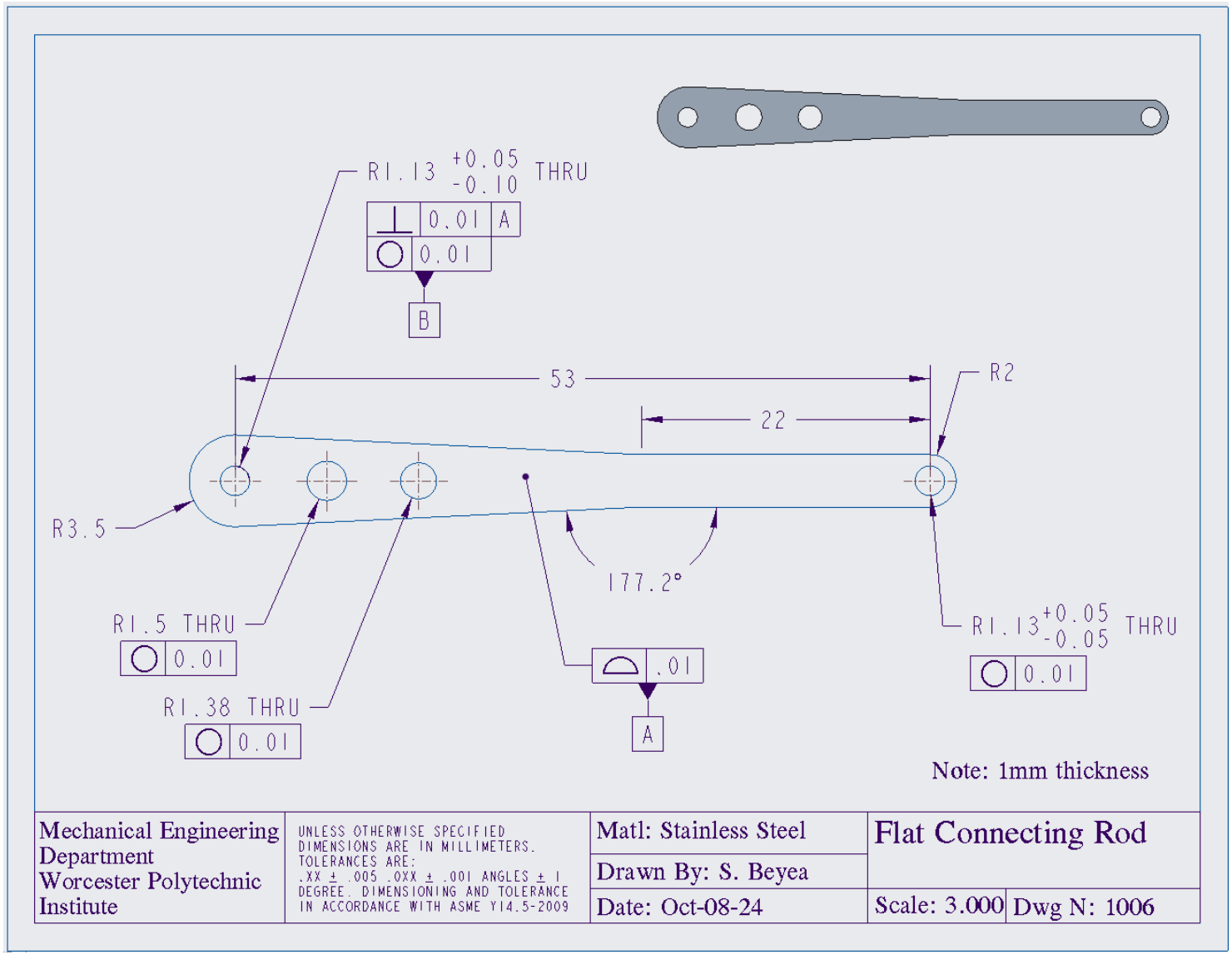


Figure 5) connecting rods which connect the flywheels to the pistons.

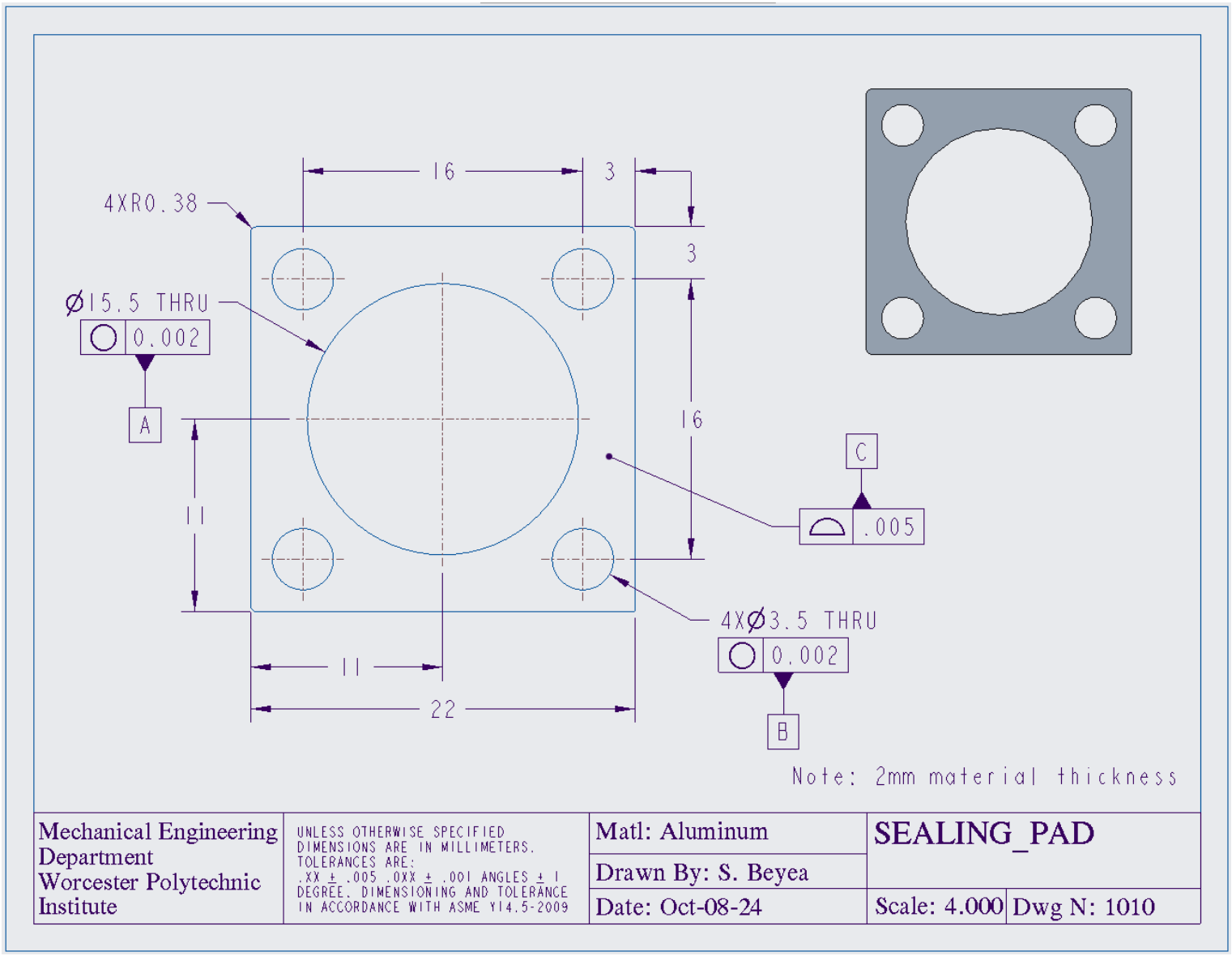
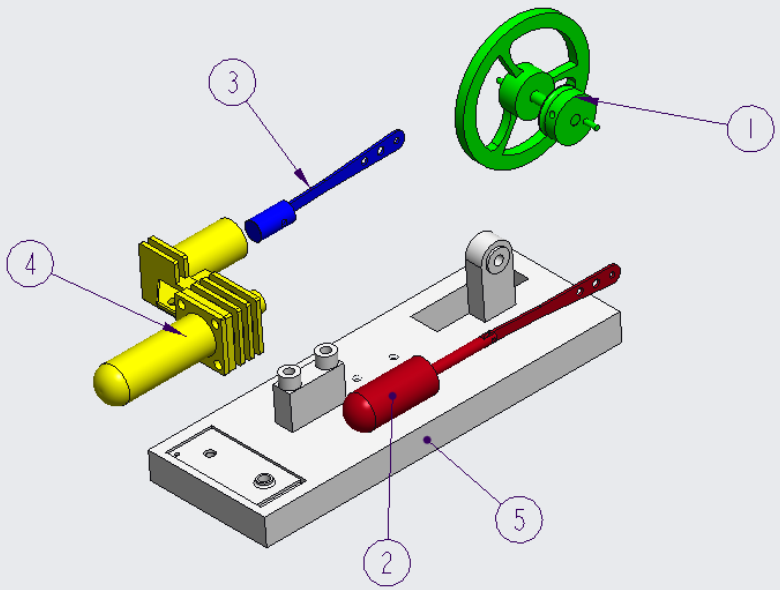


Figure 6) the sealing pad which seals the gas chamber of the heat cylinder.

Sub-Assemblies and Full Assembly

-Drawings-

Index	Name	Type	Qty.
1	Flywheels	Sub-Assem.	1
2	Hot Piston	Sub-Assem.	1
3	Cold Piston	Sub-Assem.	1
4	Radiator	Sub-Assem.	1
5	Base	Sub-Assem.	1



Mechanical Engineering Department Worcester Polytechnic Institute	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS. TOLERANCES ARE: .XX ± .005 .0XX ± .001 ANGLES ± 1 DEGREE. DIMENSIONING AND TOLERANCE IN ACCORDANCE WITH ASME Y14.5-2009	Sheet 1:1	FULL_ASSEMBLY	
		Drawn By: S. Beyea		
		Date: Oct-10-24	Scale: 0.200	Dwg N: 1111

Figure 7) exploded view of full assembly sterling engine(with balloons and BOM)

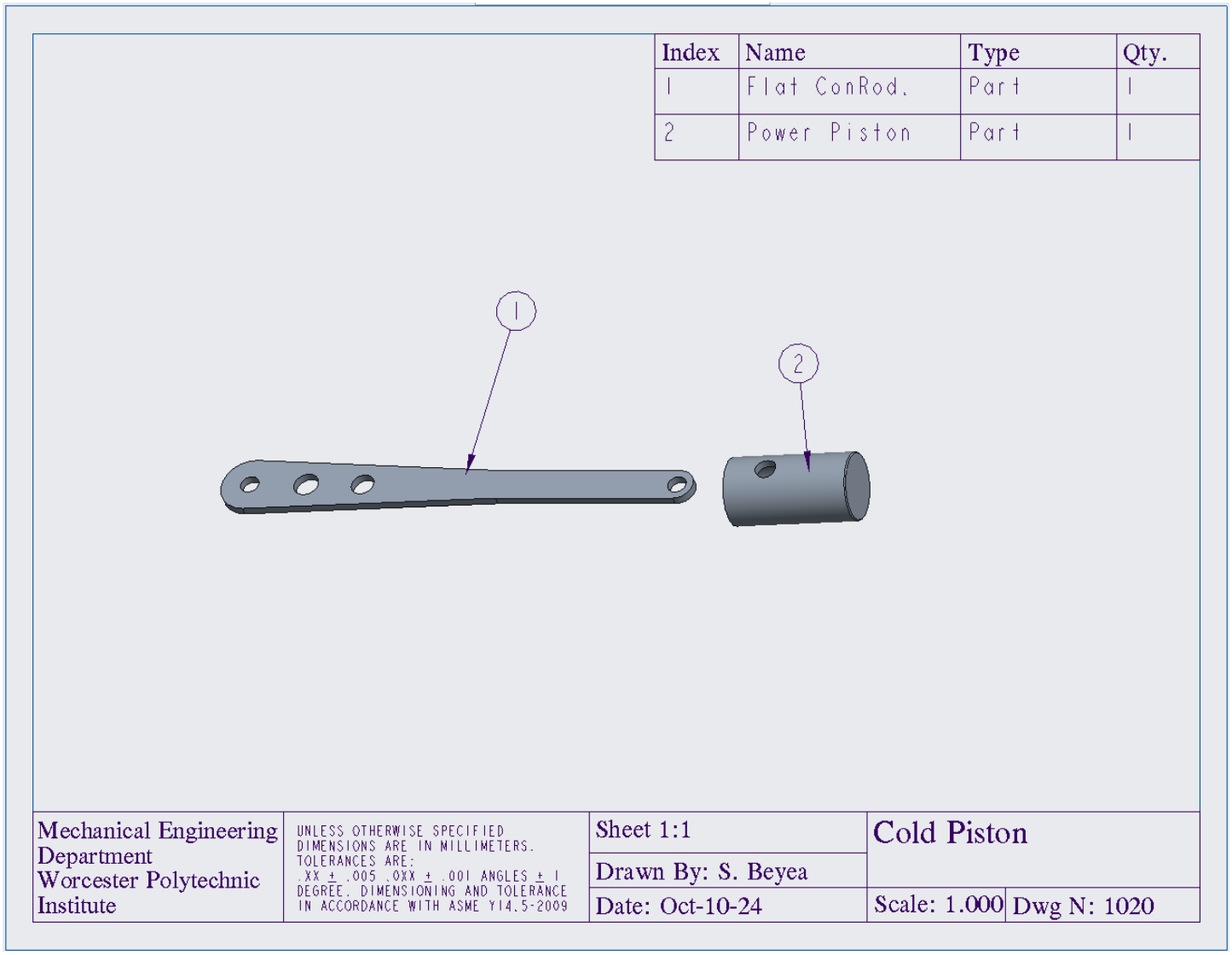


Figure 8) exploded view of the cold piston assembly (with balloons and BOM).

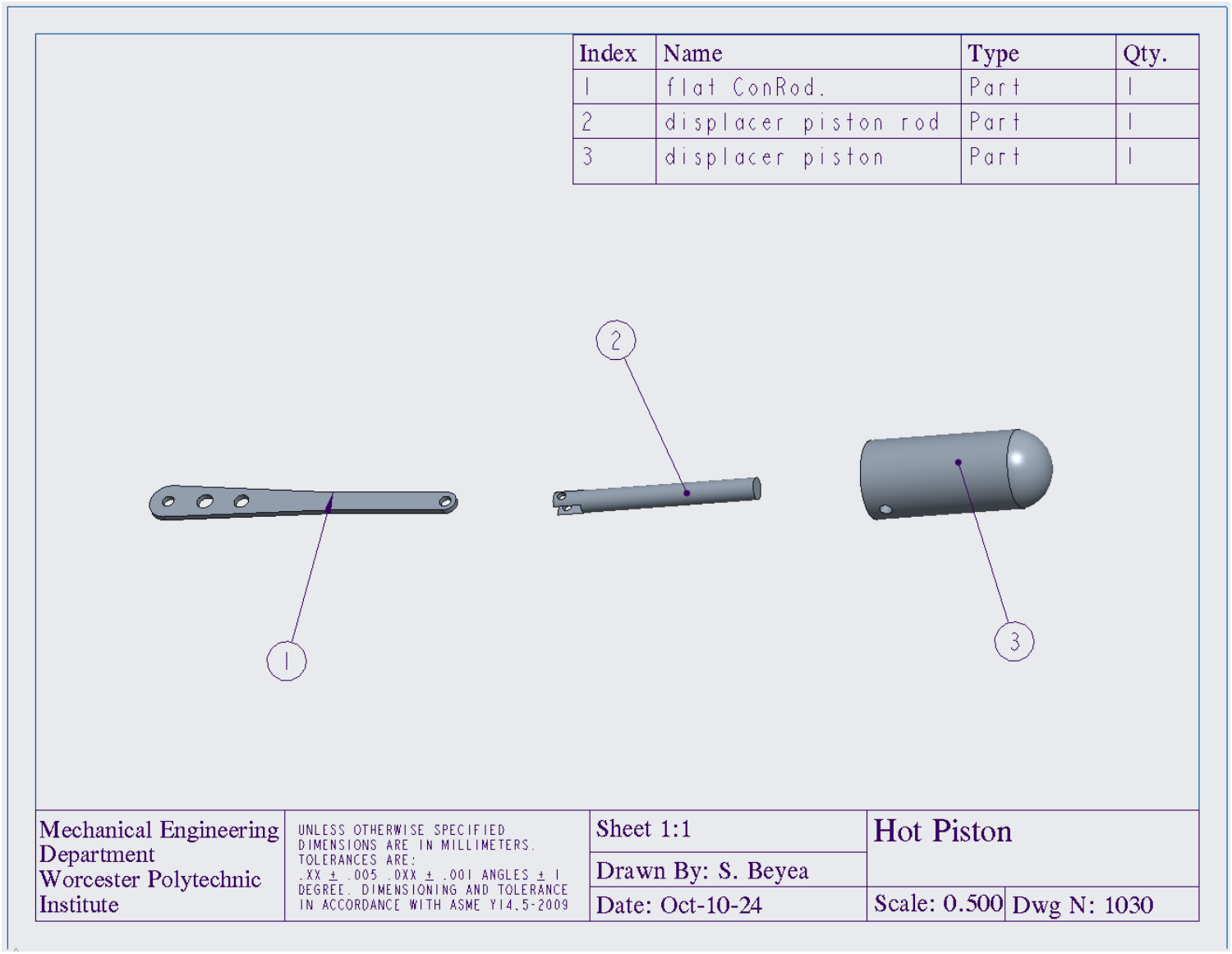


Figure 9) exploded view of the hot piston assembly (with balloons and BOM).

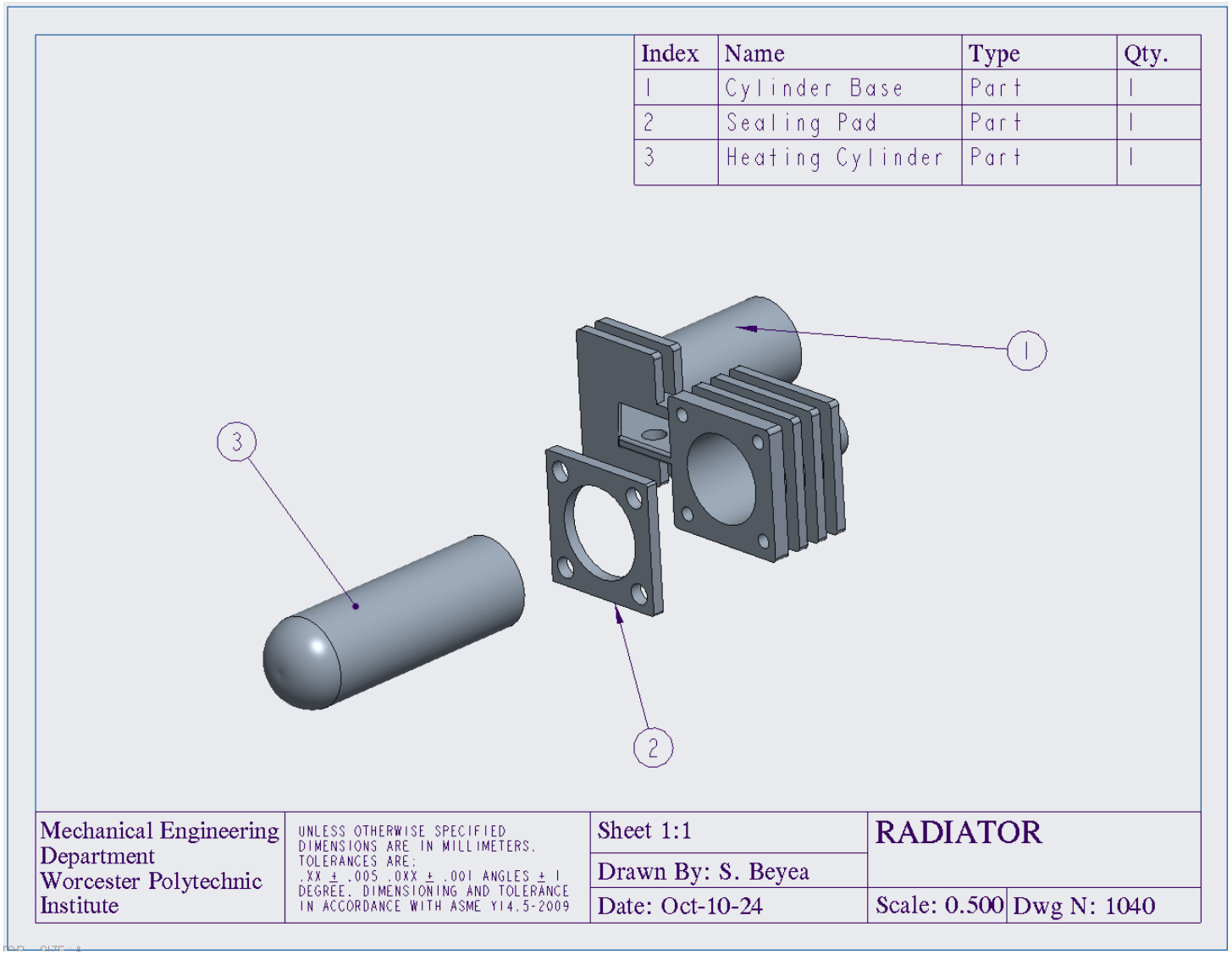


Figure 10) exploded view of the radiator assembly (with balloons and BOM).

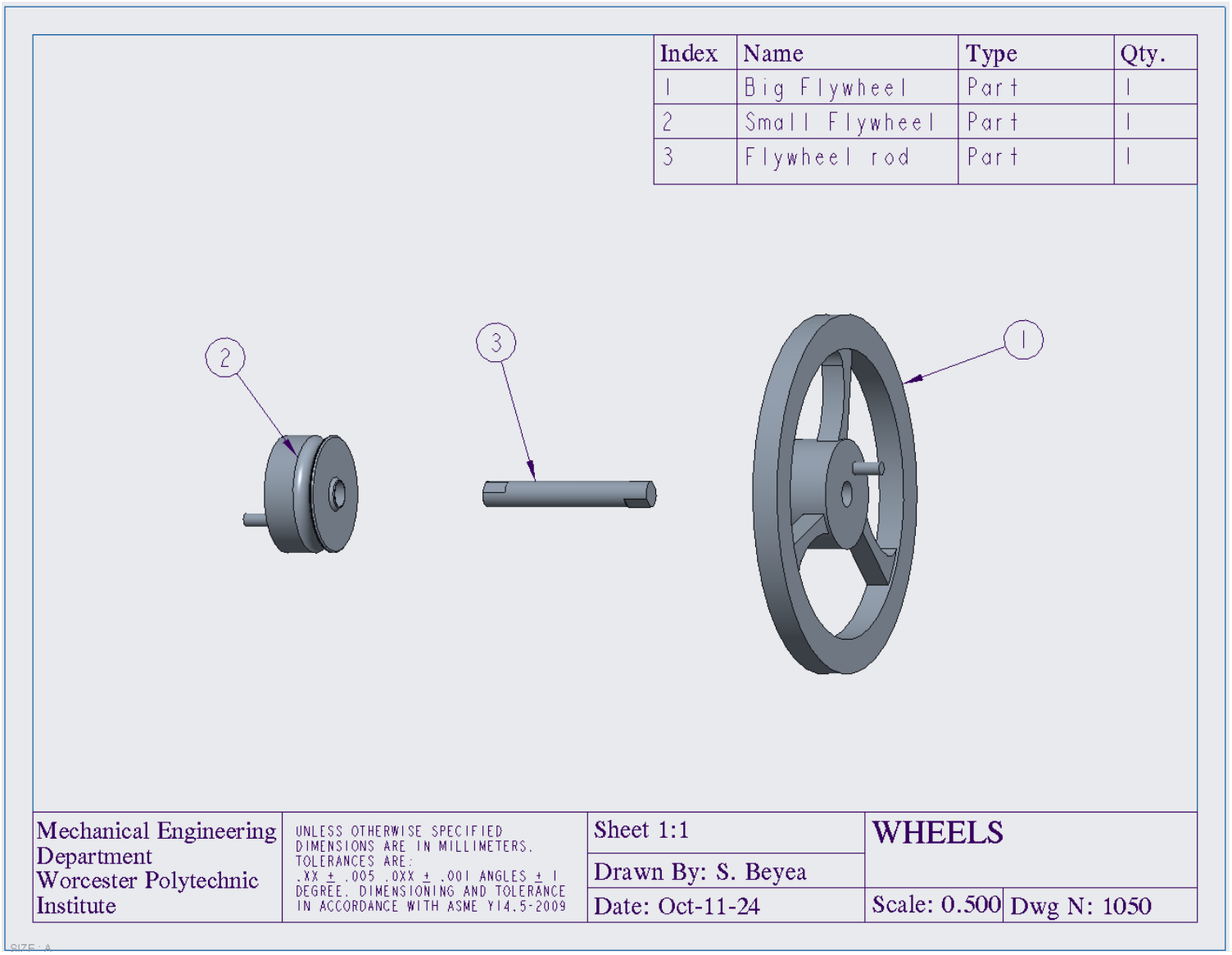


Figure 11) exploded view of the flywheel assembly (with balloons and BOM).

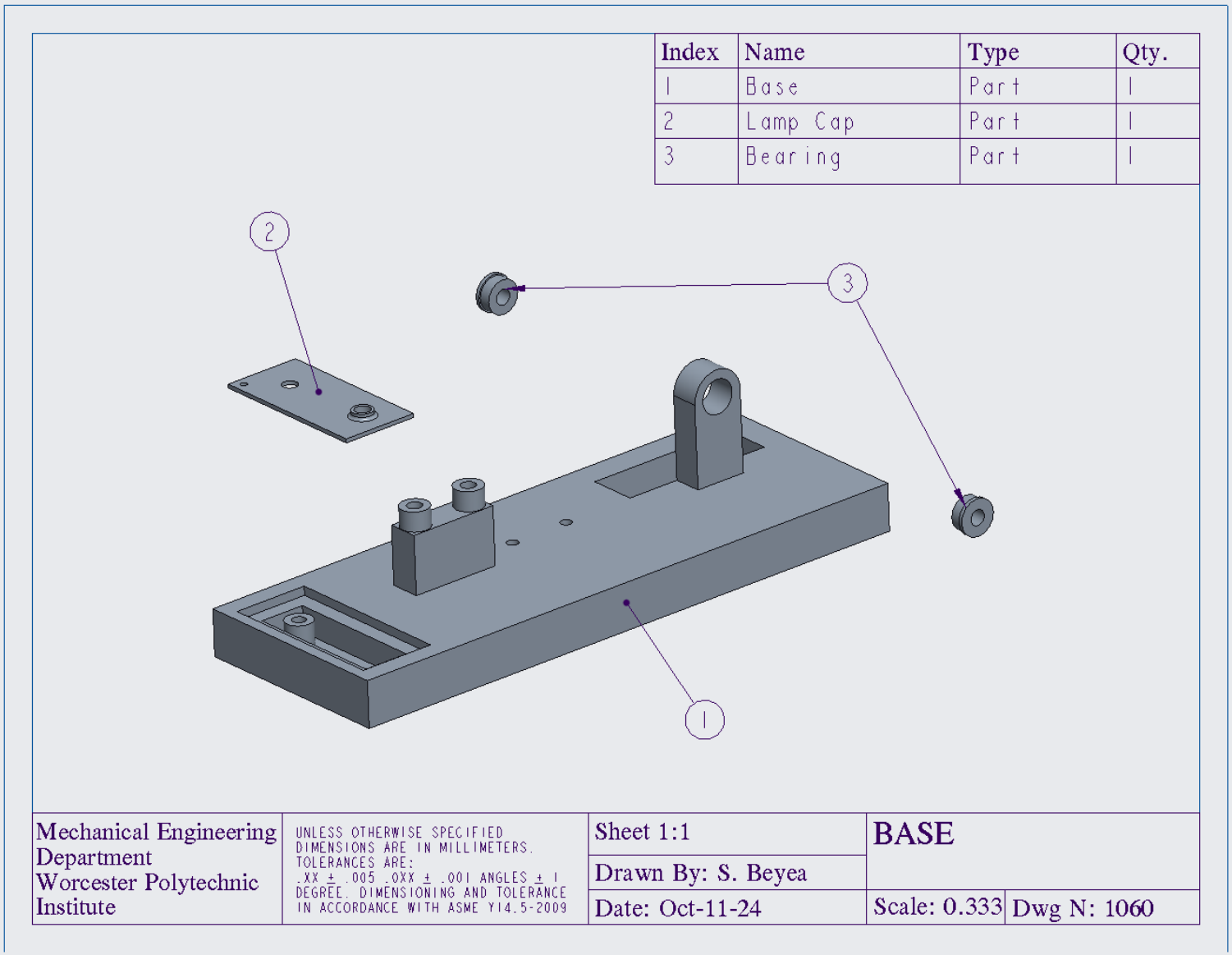
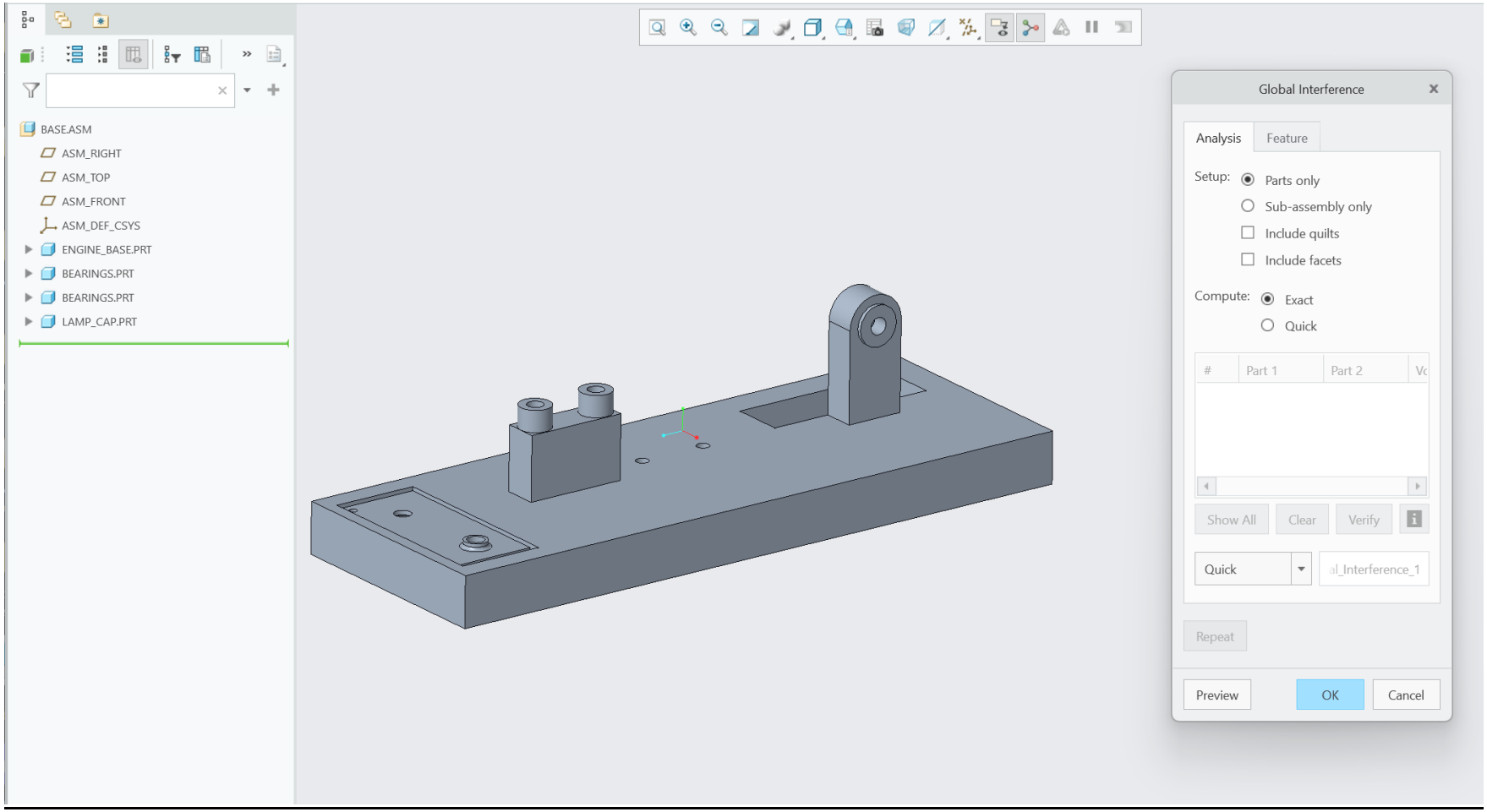


Figure 12) exploded view of the base assembly (with balloons and BOM).

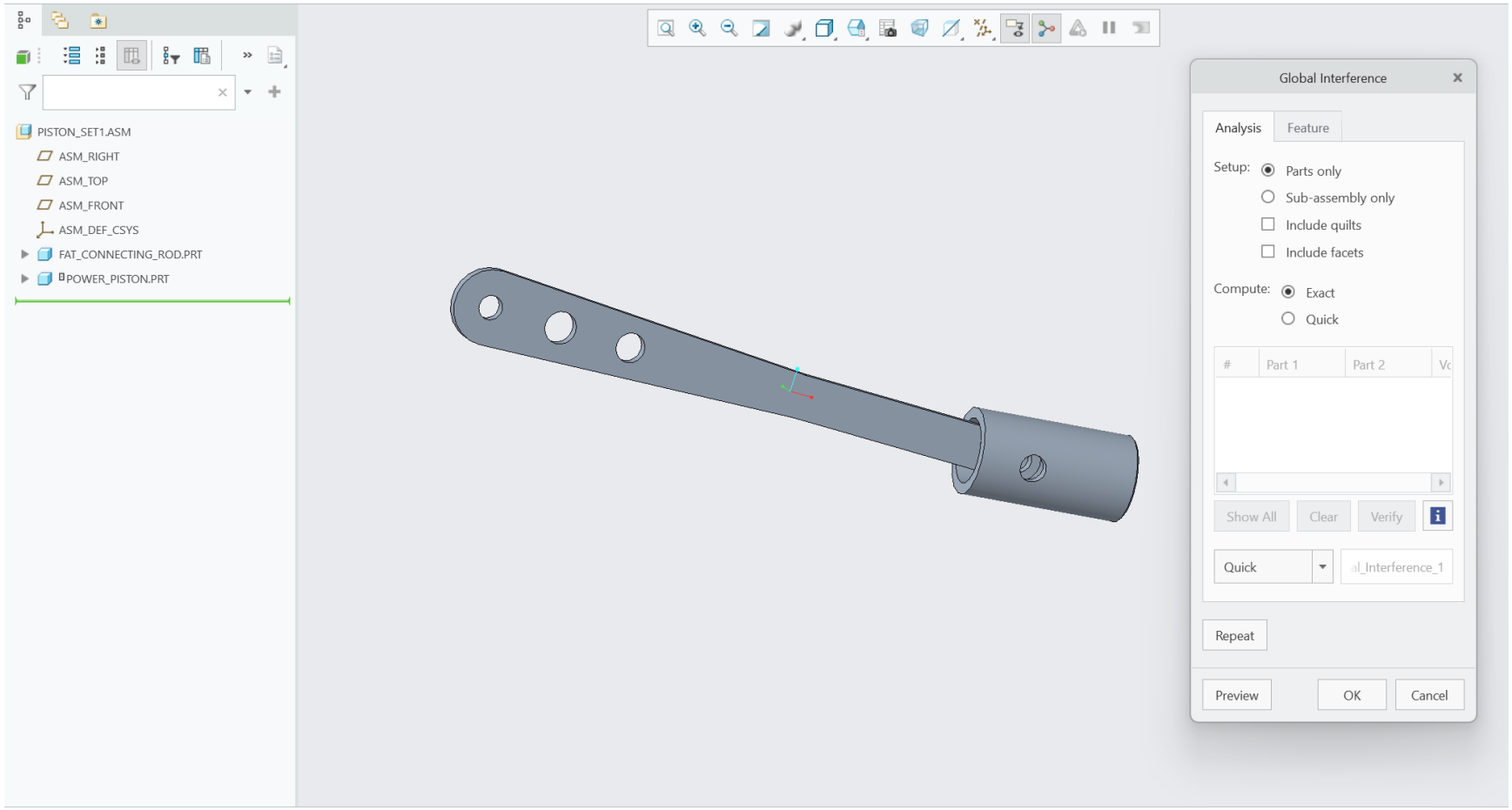
Sub-Assemblies and Final Assembly

-With Interference Checks-

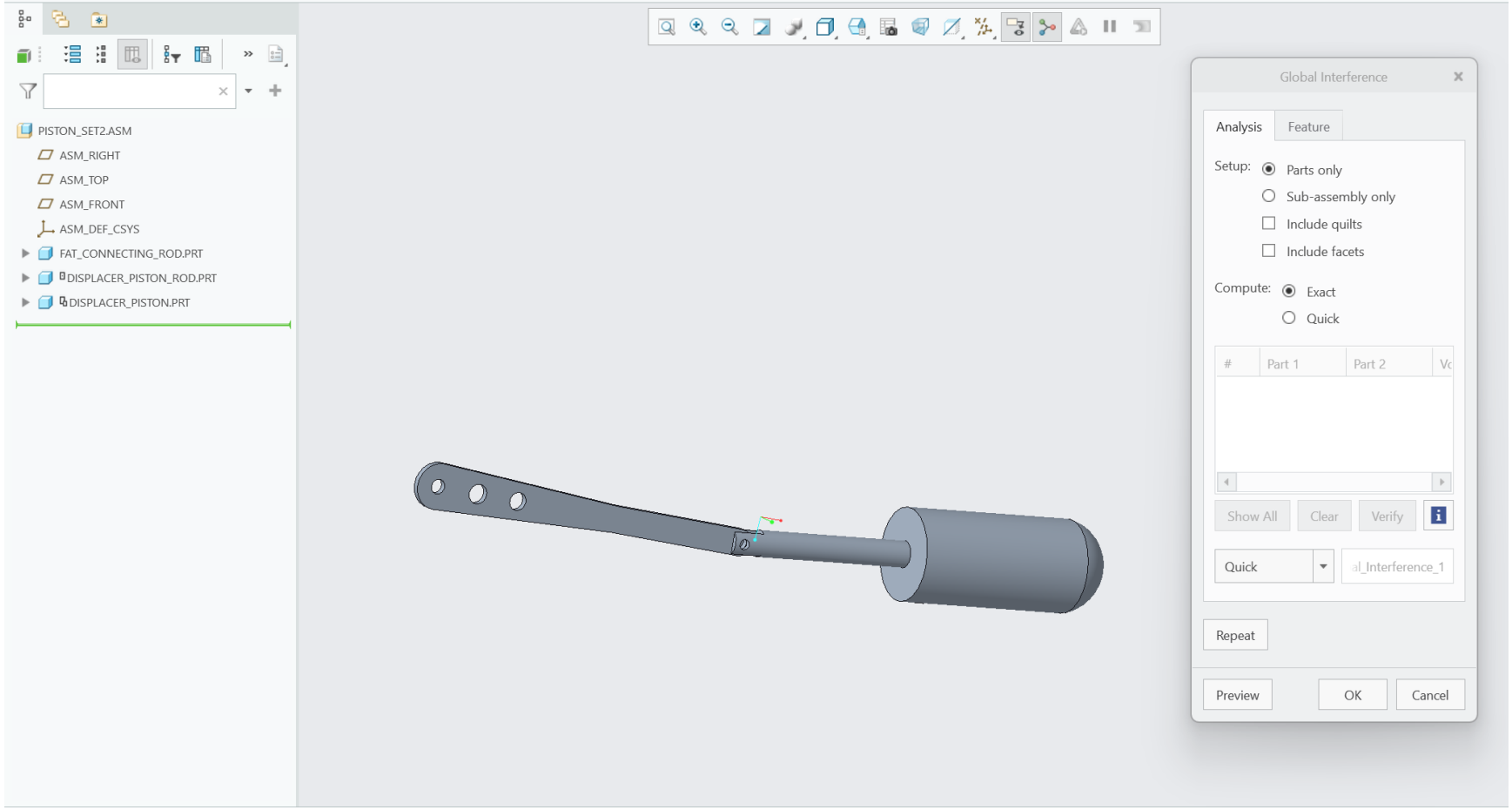
Base Assembly



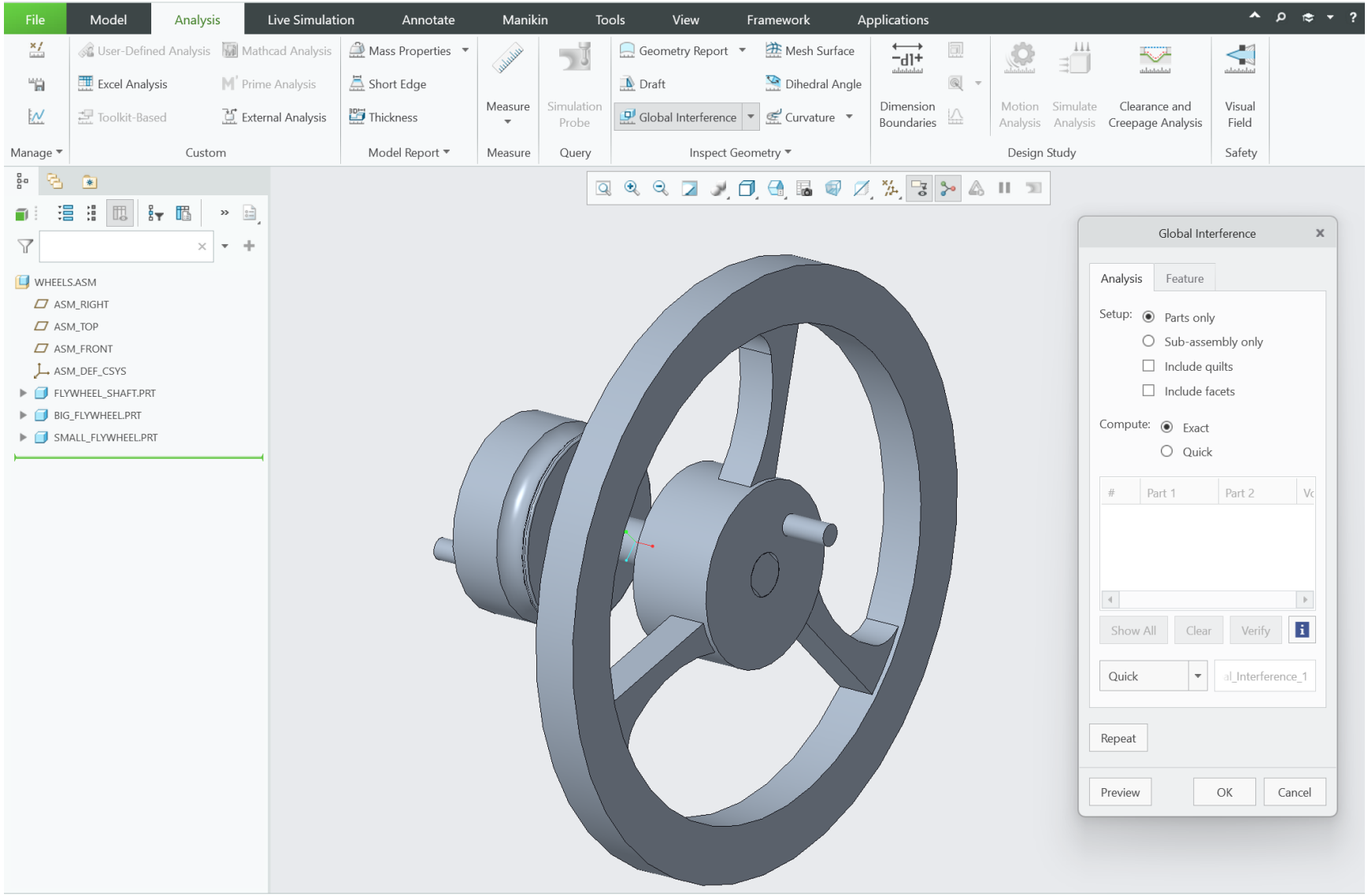
Cold Piston Assembly



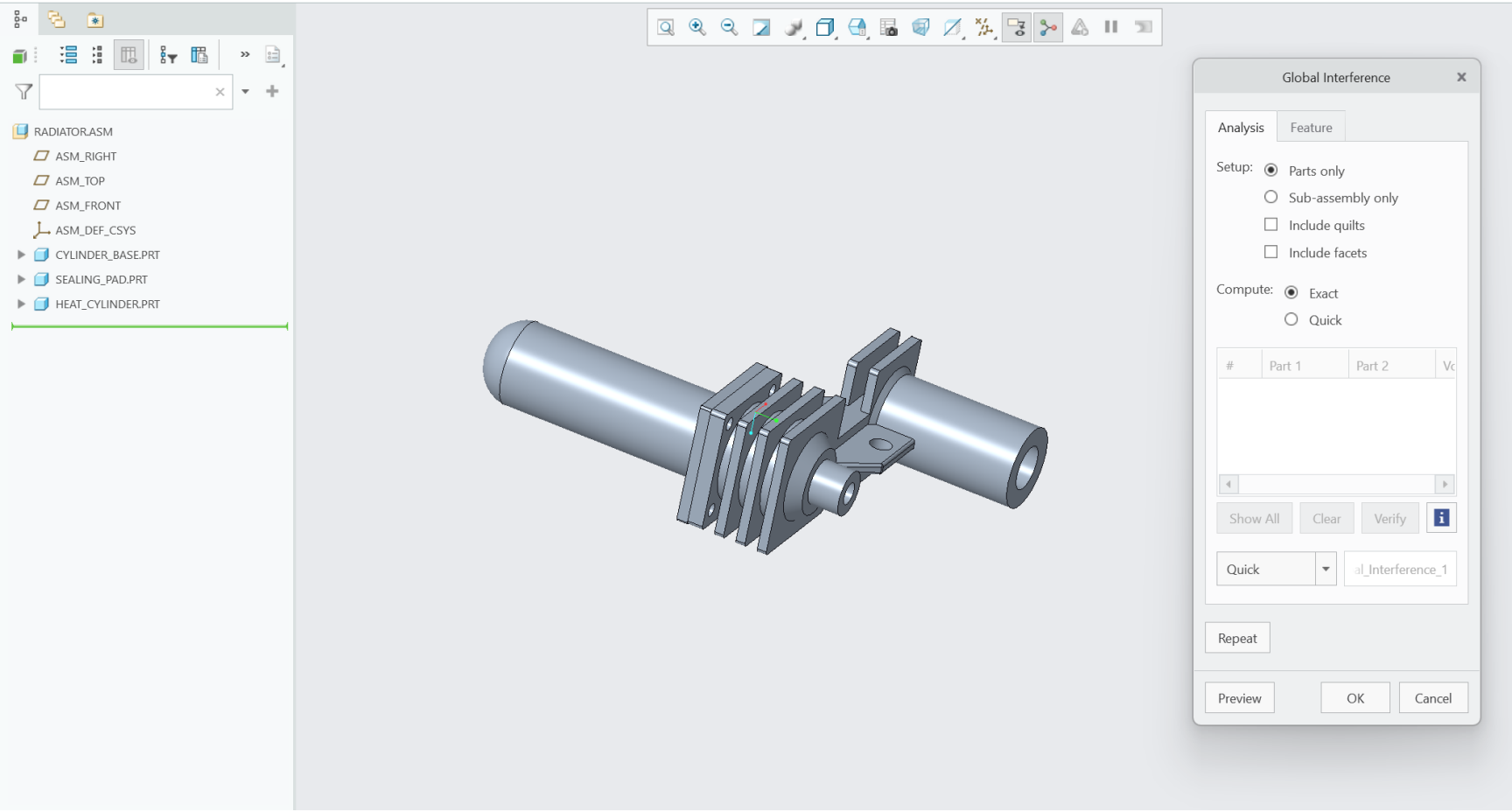
Hot Piston Assembly



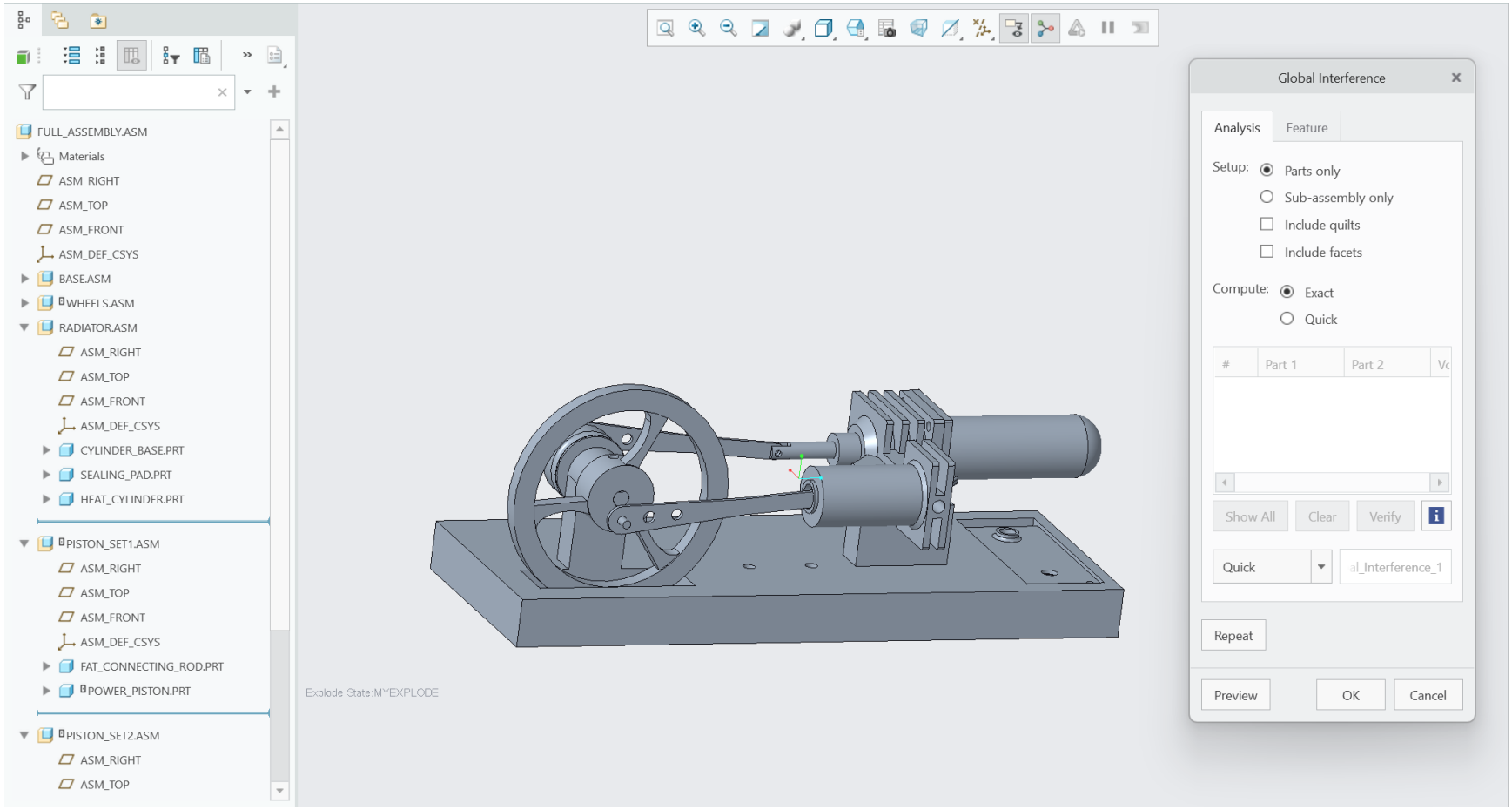
Flywheel Assembly



Radiator Assembly



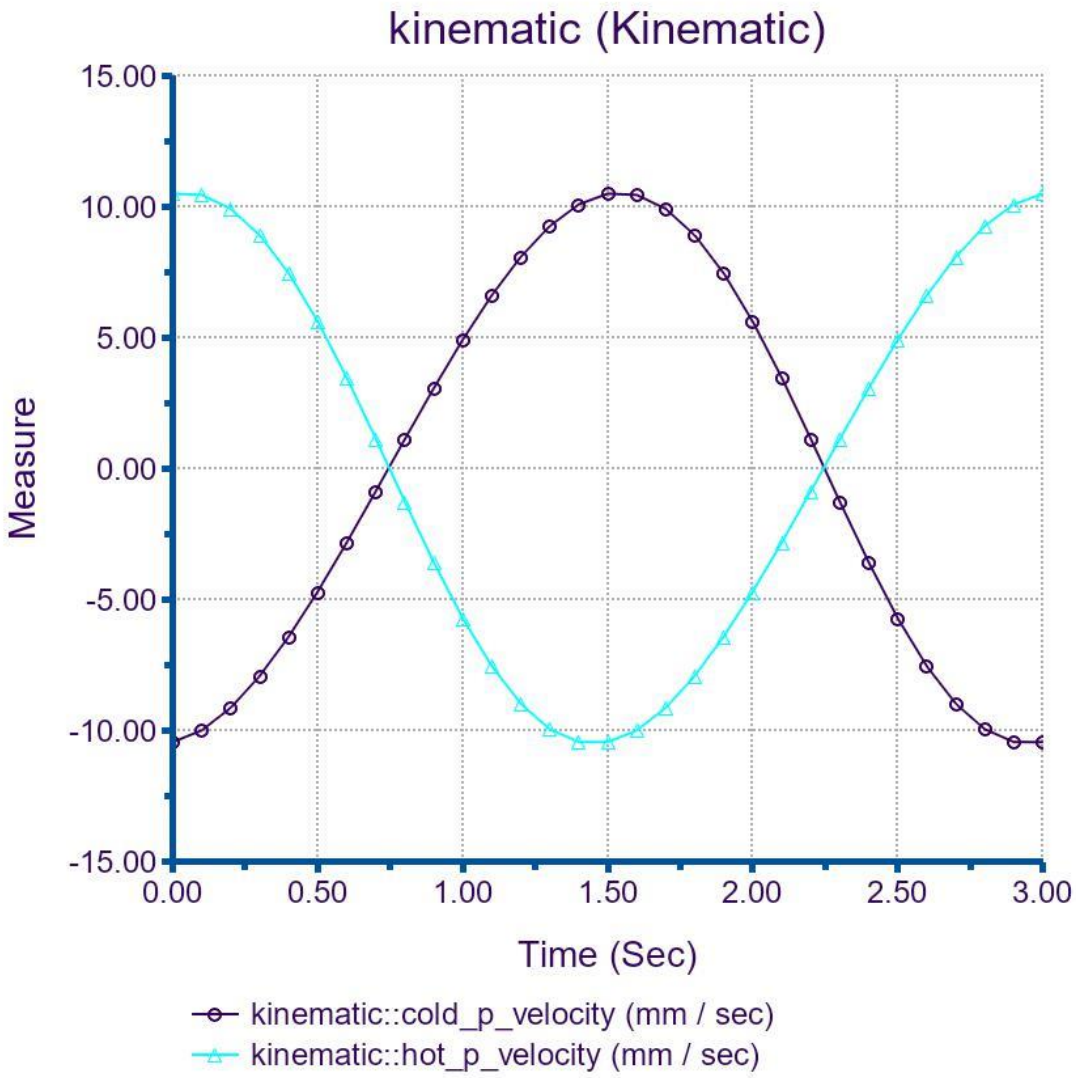
Full Assembly



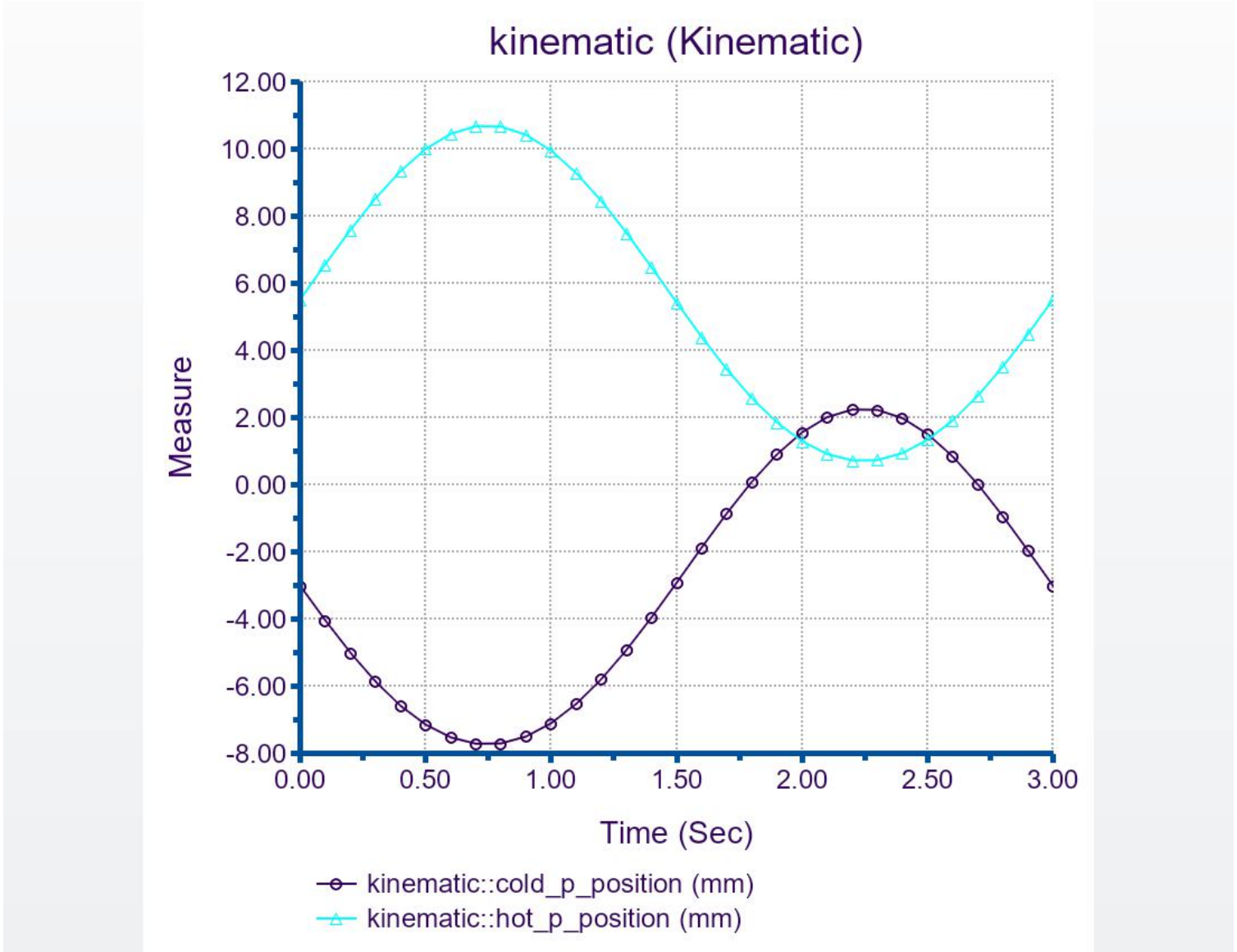
Kinematic/Dynamic Analyses

-With Servo Motor-

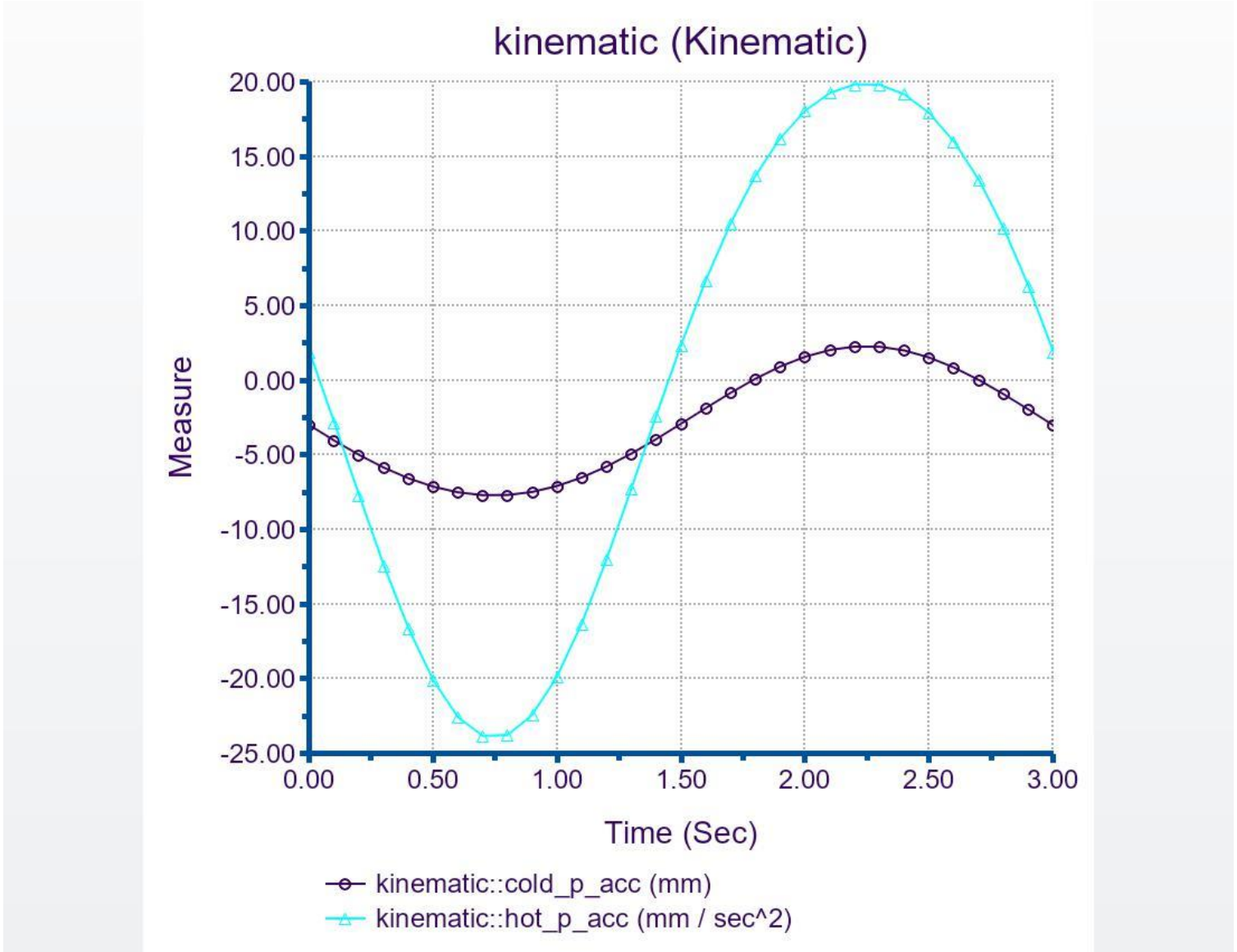
Linear Velocity vs. Time



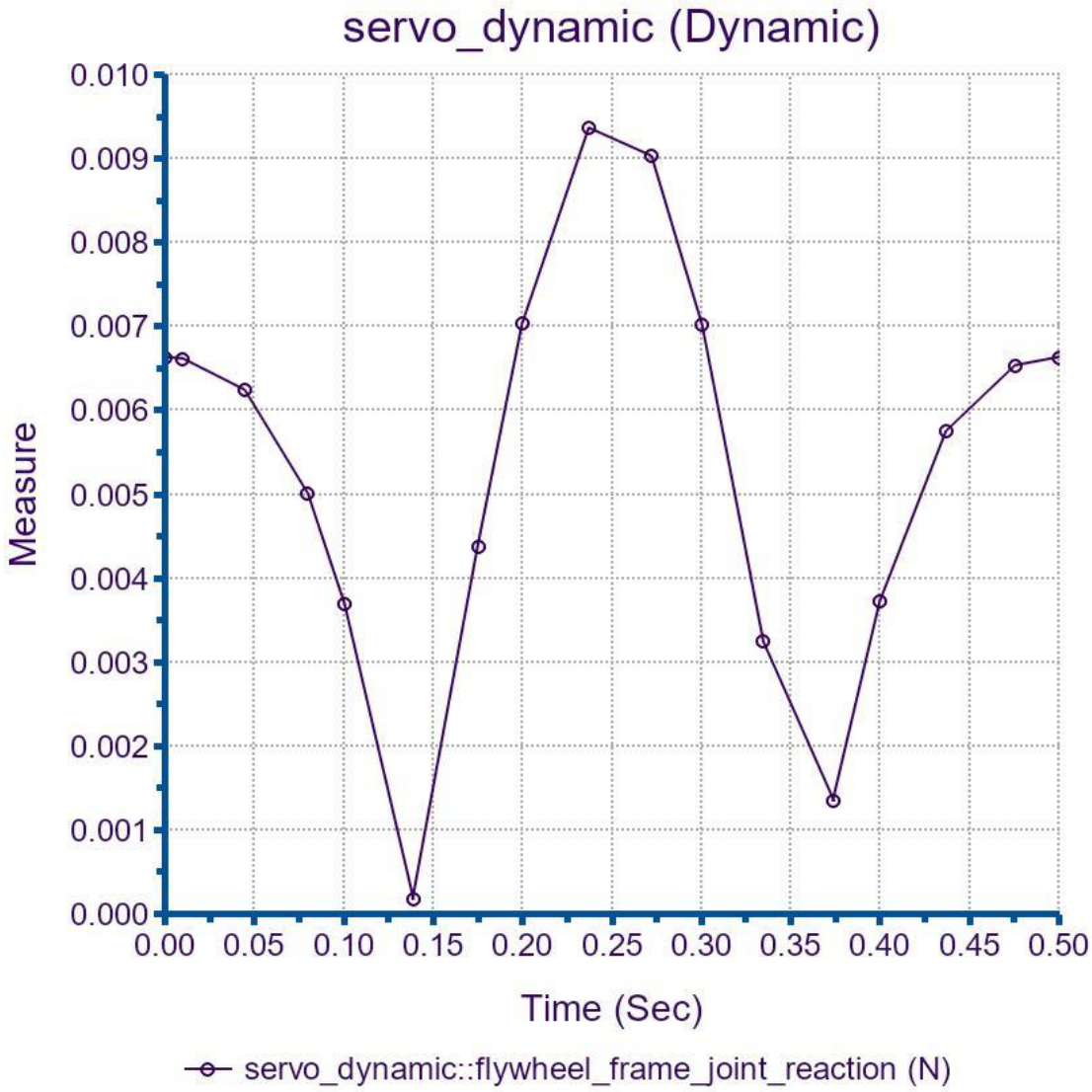
Linear Displacement vs. Time



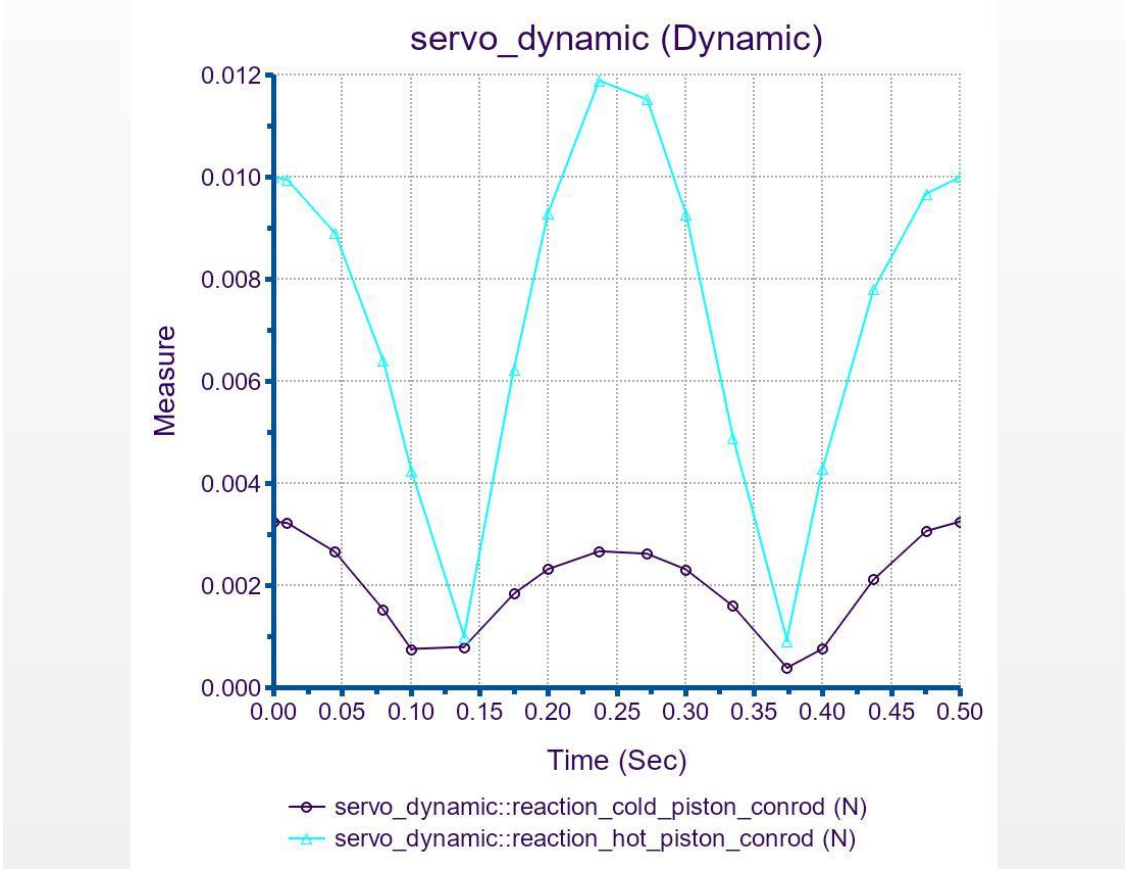
Linear Acceleration vs. Time



Flywheel/Frame Joints Reaction Force vs. Time



Piston Connection Rod Reaction Force



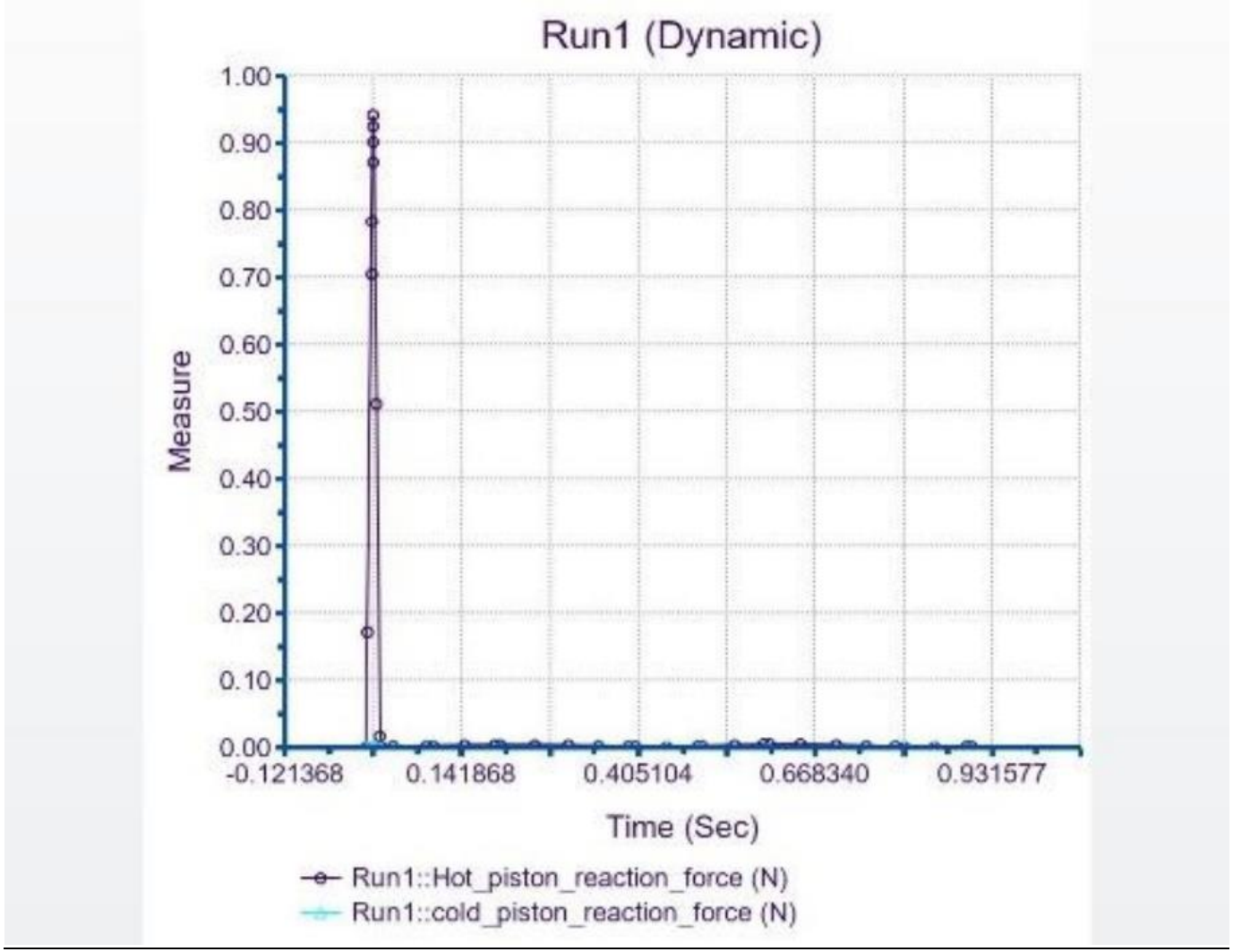
Hot Piston Max Force: 0.011882 N

Cold Piston Max Force: 0.003246N

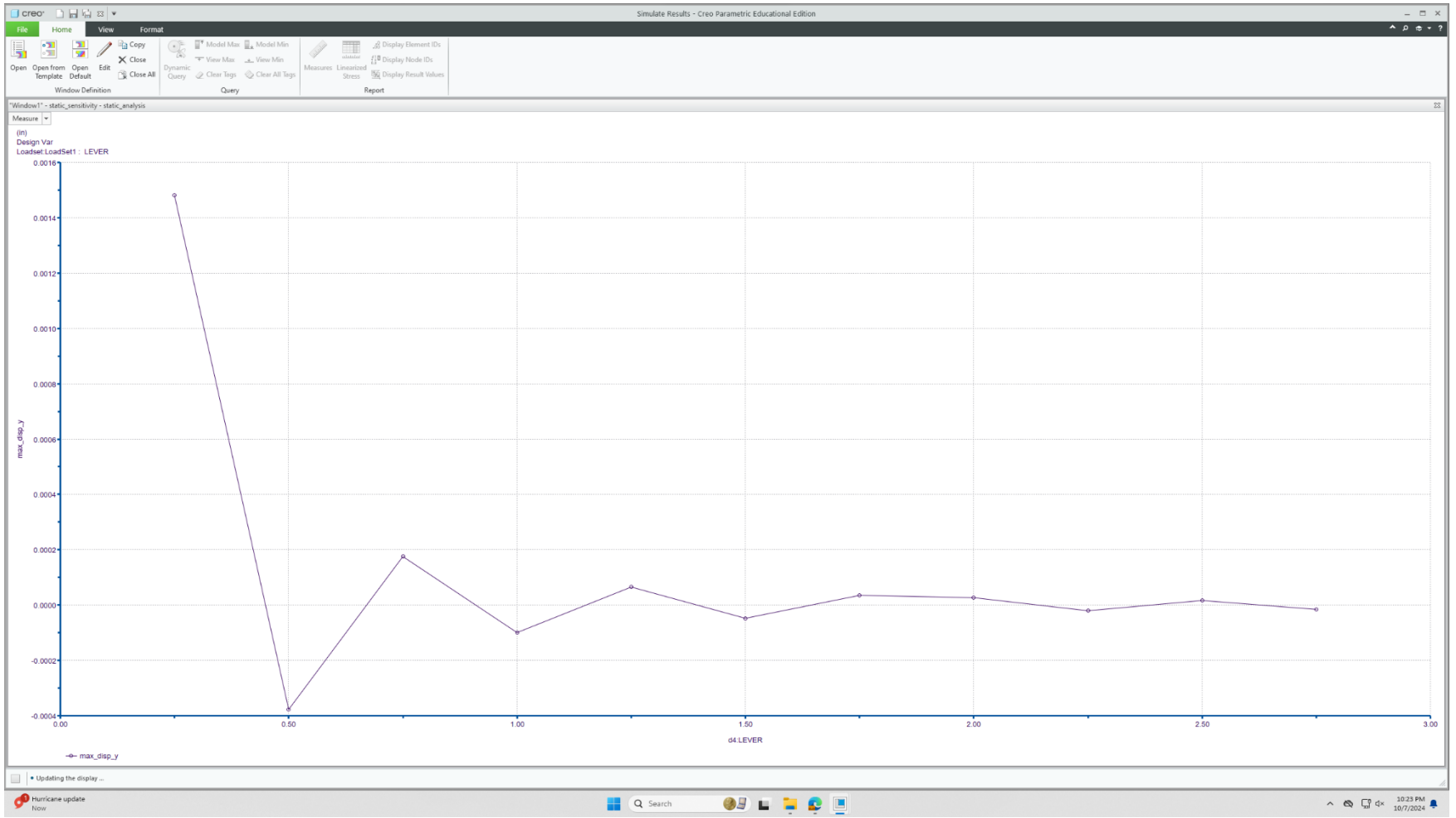
Kinematic/Dynamic Analyses

-With Hot Piston Force-

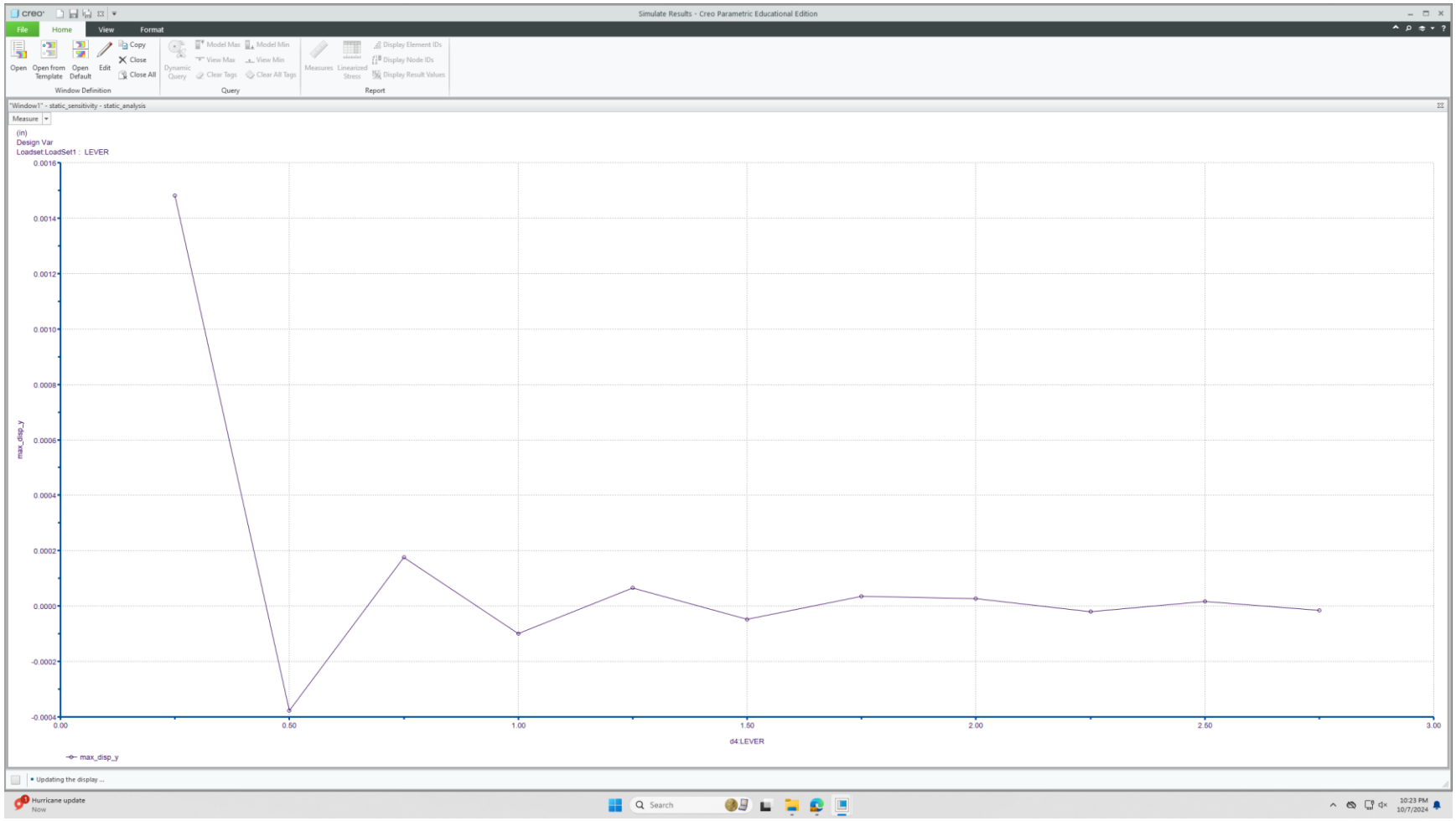
Cold Piston/Connection rod reaction force vs. time



Linear Displacement of Pistons vs. Time



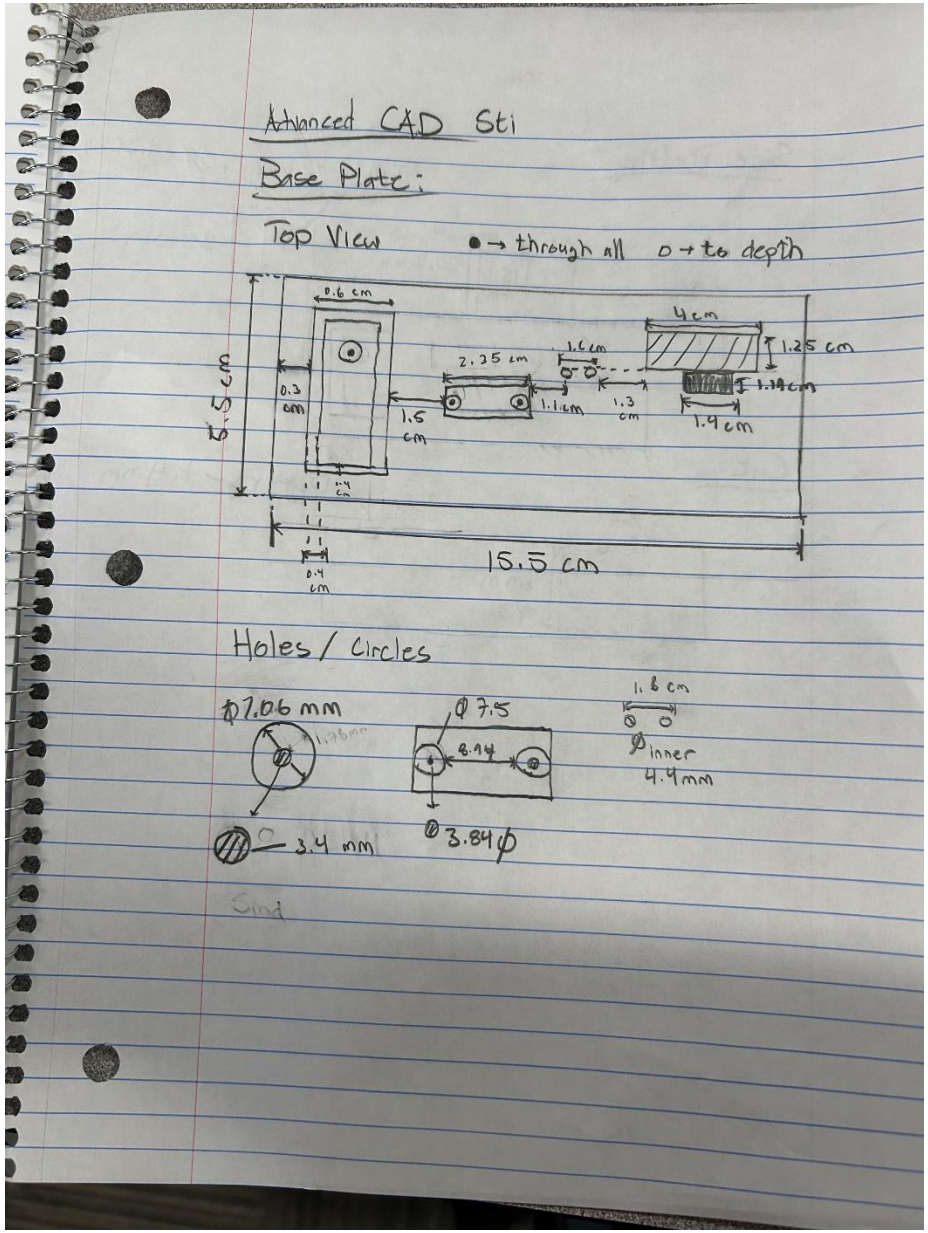
Velocity of Pistons vs. Time



Appendix: A

Measurements taken from model.

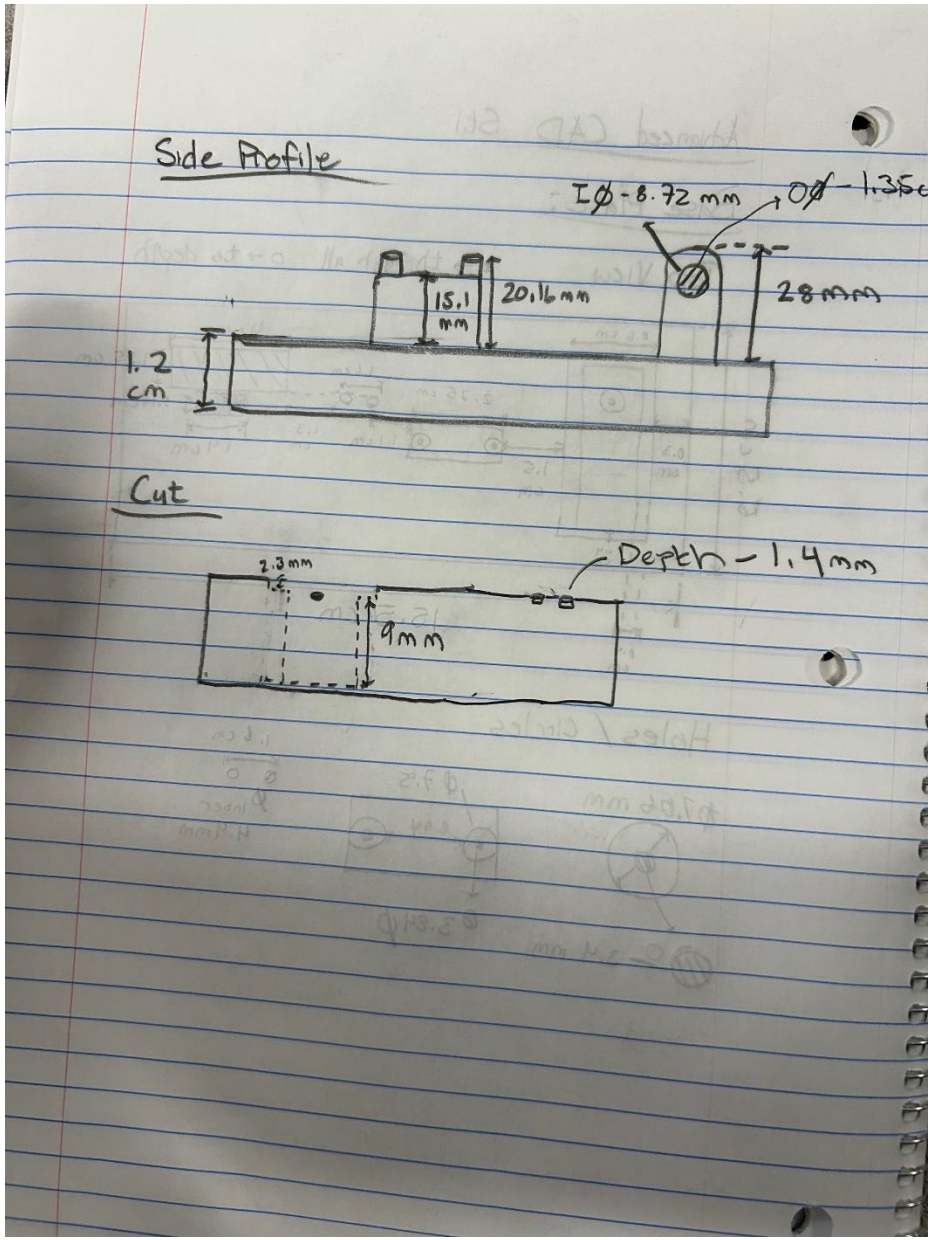
-base (top view)



Appendix: B

Measurements taken from model.

-base (side profile)



Appendix: C

Measurements taken from model.

-heat cylinder

-displacer piston

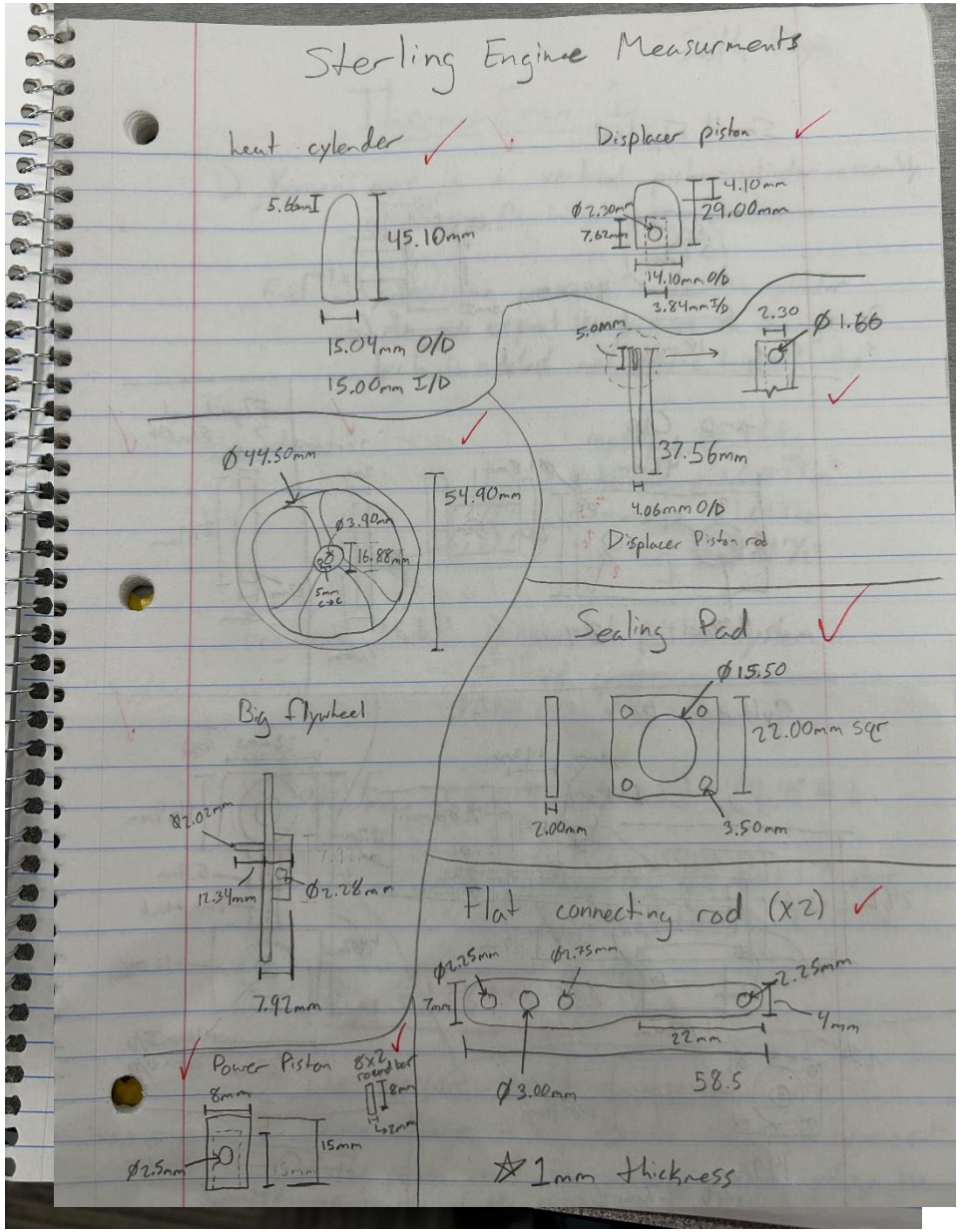
-big flywheel

-displacer piston rod

-sealing pad

-power piston

-flat connecting rod



Appendix: D

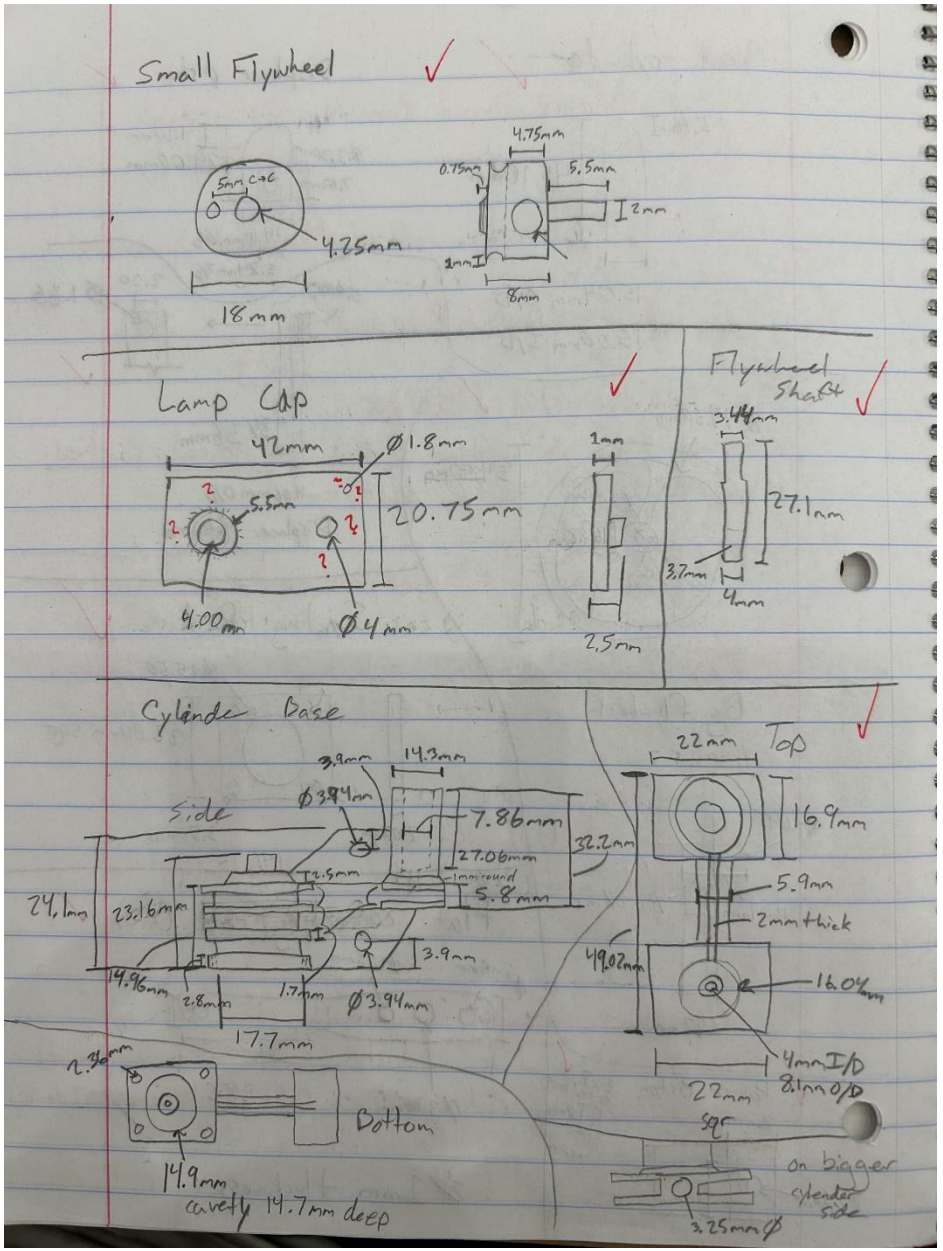
Measurements taken from Model.

-small flywheel

-lamp cap

-flywheel shaft

-cylinder base



Appendix: E

Disassembly instructions.

DIY-605 User Guide

WARNING: CHOKING HAZARD – Small parts. NOT FOR CHILDREN UNDER 3 YEARS. Children should be supervised while playing this engine.

Whole process of assembling will take about 20-30 minutes; alcohol purity >= 95% is highly suggested.

We uploaded some gifs of assembling to https://goo.gl/8DV5Re, you can visit if not sure what to do.

Have fun!

Thanks for Mr. Joe Symon from Illinois helping us to revise this guide.

1. Base Plate
2. Cylinder Base
3. M3x4 Screw
4. M4x6 Screw
5. M3x5 Screw
6. M3x3 Screw
7. 8x2mm Round Bar
8. Retaining Ring
9. Spacer
10. 27x4mm Flywheel Shaft
11. Bearing
12. Flat Connecting Rod
13. Sealing Pad
14. Small Flywheel
15. Heat Cylinder
16. Displacer Piston
17. Displacer Piston rod
18. Sealing Ring
19. Power Piston
20. Big Flywheel
21. Lamp Cap
22. Sealing Gasket
23. Wick
24. 1.5mm Hex
25. 2.5mm Hex
26. 3.5mm Hex

Step 1. Using 2x M4x6 screws(4) to fasten Cylinder Base(2) on Base Plate(1) tightly. Using 3.5mm Hex wrench to tighten. Do not over tighten.

PLEASE UNDERSTAND THIS IS A DIY KIT: ONE STEP WRONG, AT OUR SIDE OR YOURS, THIS ENGINE MIGHT WILL REFUSE TO WORK.

IF SO, PLEASE CONTACT US FOR A REPLACEMENT KIT. IF YOU STILL CAN NOT MAKE THE SENCOND ONE WORKING, WE WILL REFUND YOU.

Step 2. Remove 2x Bearings(11) from 27x4mm Flywheel Shaft(10); insert Bearings into the hole on Base Plate; then insert the Flywheel Shaft into the bearings. Make sure Side A on the Flywheel Shaft is on the right side as shown in 2-6.

Side A of Flywheel Shaft is with longer flat surface

Remove

Side A

Step 3. Connect one Flat Connecting Rod(12) and Power Piston(19) with a 8x2mm Round Bar(7); insert the Power Piston into the chamber.

Step 4. Use a M3x5 Screw(5) to fasten the Big Flywheel(20) on Side A of the 27x4mm Flywheel Shaft(10), make sure the hole on the Flywheel and flat side of the Side A on the Flywheel shaft point to 12 o'clock; using 1.5mm hex to tighten. Do not over tighten. Then put a Spacer(9) on the small pin of the flywheel; connect the Flat Connecting Rod to the small pin; then put a Retaining Ring(8) on the small pin.

Appendix: F

Disassembly instructions.

Step 5. Use a M3x5 Screw(5) to fasten the Small Flywheel(14) on Side B of the Flywheel Shaft, make sure that the hole on the Small Flywheel and flat side on Side B point to 12 o'clock (at this time small pin on the Big Flywheel should point at 3 or 9 o'clock). Using 1.5mm hex to tighten. Do not over tighten.

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Step 6. Use a 8x2mm Round Bar(7) to connect Displacer Piston Rod(17) with one Flat Connecting Rod(12); put 2x Retaining Rings(8) at each side of the Round Bar; insert the Displacer Piston Rod into the chamber; then connect the Flat Connecting Rod to small pin on the Small Flywheel like you do at step 4: put a Spacer(9) on the small pin of the Flywheel; connect the Flat Connecting Rod to the small pin; then put a Retaining Ring(8) on the small pin.

https://goo.gl/TcG6yd

- Solid metal construction
- CNC machined
- Speed up to 2300 RPM
- Light up colorful LED
- Fancy gift for everyone

Step 7. Have a rest.

Step 8. Insert Displacer Piston Rod(17) into the Displacer Piston(16) deeply; use a M3x3 Screw(6) to fasten it; using 1.5mm hex to tighten. Do not over tighten.

Step 9. Put the Sealing Ring(18) on bottom of Heat Cylinder(15); insert the Heat Cylinder into the chamber deeply; then put the Sealing Pad(13) on the Heat Cylinder, use 4x M3x4 Screws(3) to fasten it. Using 2.5mm hex to tighten. Do not over tighten.

Step 10. Place Sealing Gasket(22) onto base; pass the Wick(23) though the hole on the Lamp Cap(21); then place Lamp Cap onto base and fasten with M4x6 screw(4). Using 3.5mm hex to tighten. Do not over tighten.

Step 11. Fill the lamp with alcohol purity >= 95%; light up the lamp; preheat for about 30 seconds, then try to spin the flywheel gently and repeatedly until it rotate by itself.

Two ways of injecting alcohol:
Easy way: though this hole by using a syringe which we do not provide;
Hard way: remove the cap and inject with the pipette we provide.

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IF SO, PLEASE CONTACT US FOR A REPLACEMENT KIT. IF YOU STILL CAN NOT MAKE THE SENCOND ONE WORKING, WE WILL REFUND YOU.

Please contact me if you have any questions or problems. Please give me a chance to serve you, please...

DjuinoStar®