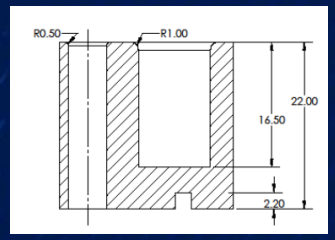
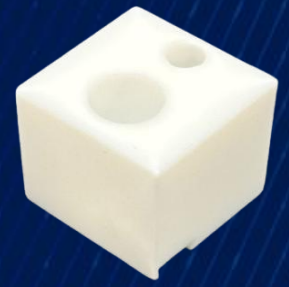
Penn Engineering
University of Pennsylvania

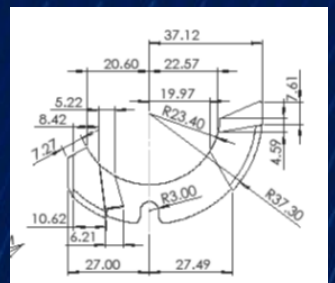
Mechanically Enabling Grease Characterization in Ball-on Disk Tribometers

Nathan Hryniewicz

Summer 2025







Motivation: Energy Efficiency

- 80 to 90% of rolling element bearings are grease lubricated[1]
- Despite this, fundamental lubricating mechanisms are not as well understood as oil-based lubrication.
- **Grease tribology lacks standard test methods—ball-on-disk results are prominent but often inconsistent.**

[1]Lugt (2012)

Why are results unreliable?

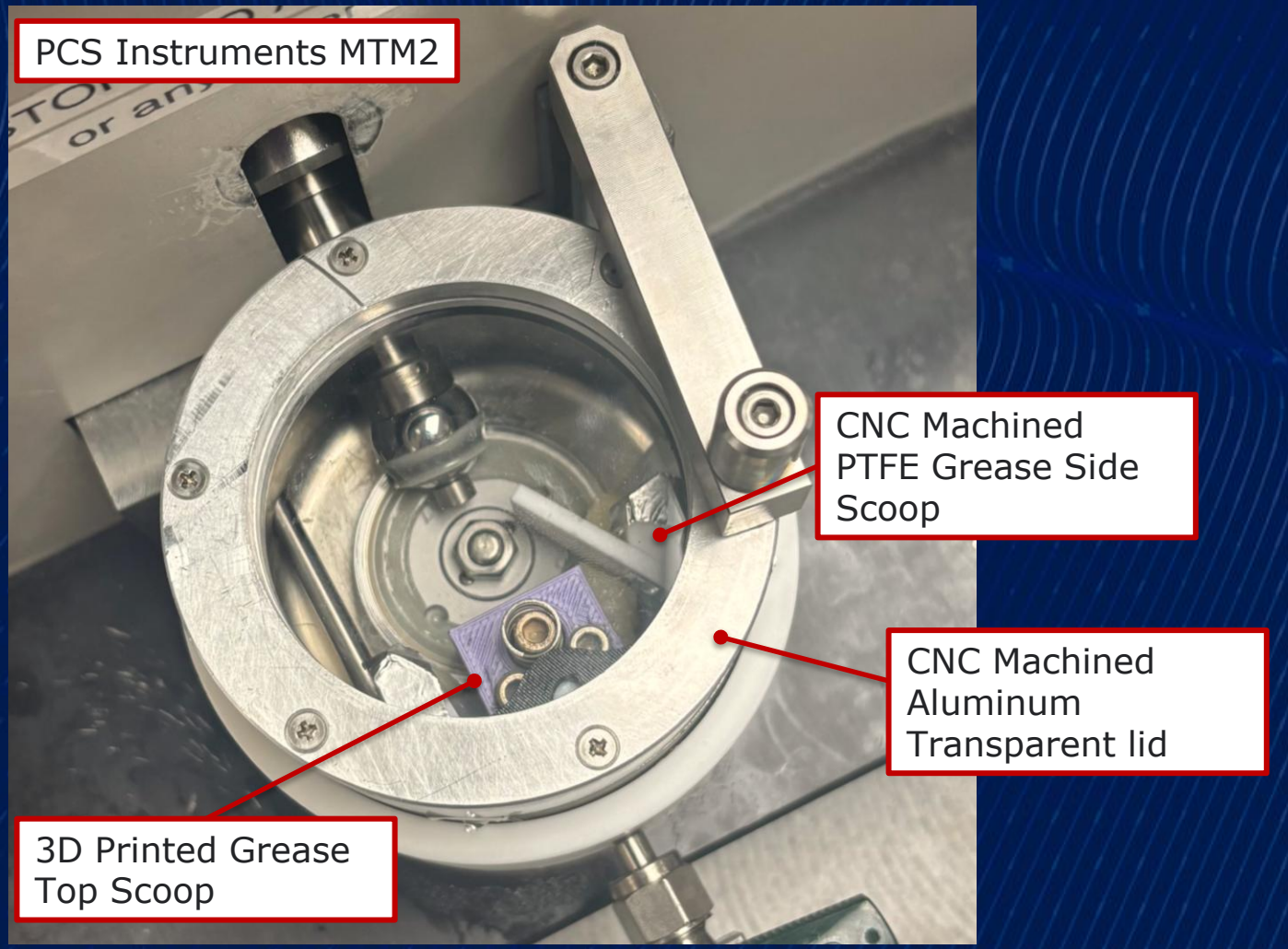
Issues:

- Lid must be removed to ensure no starvation
- Limited speed range due to no lid
- Majority of grease accumulates outside of track–possible starvation
- Grease climbs up shaft and into instrument

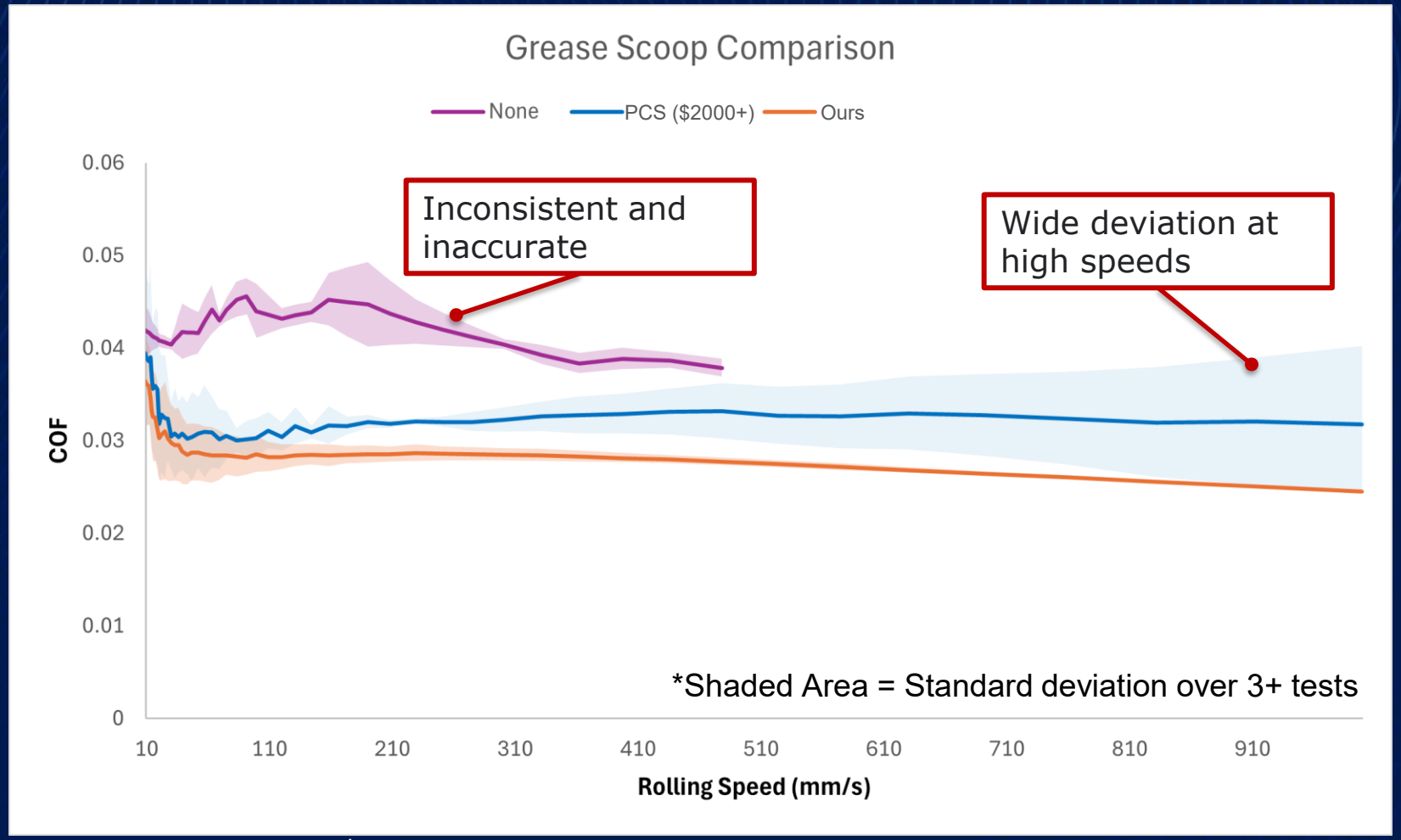
Solution: Final Setup

Modifications/Fixtures:

- Custom machined lid with window
  - Enables high speeds
  - Enables high temps
  - Enables solvent cleaning
- Custom manufactured grease scoops
  - Maintains **repeatable** fully flooded conditions
  - Limits amount of grease needed

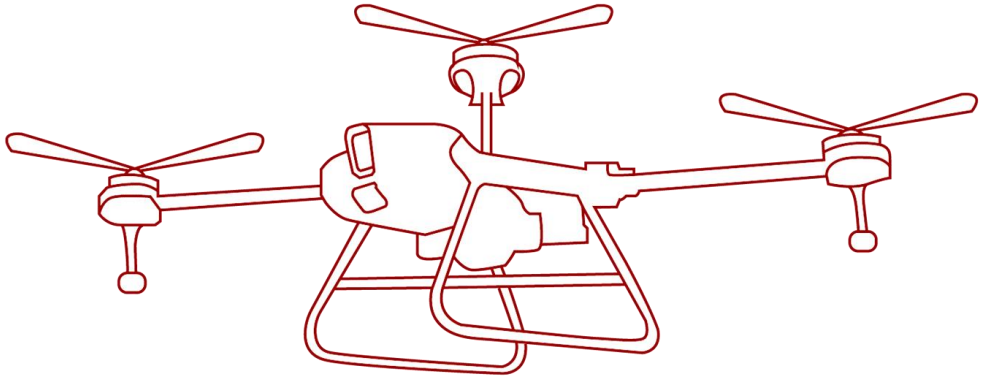


Setup Validation

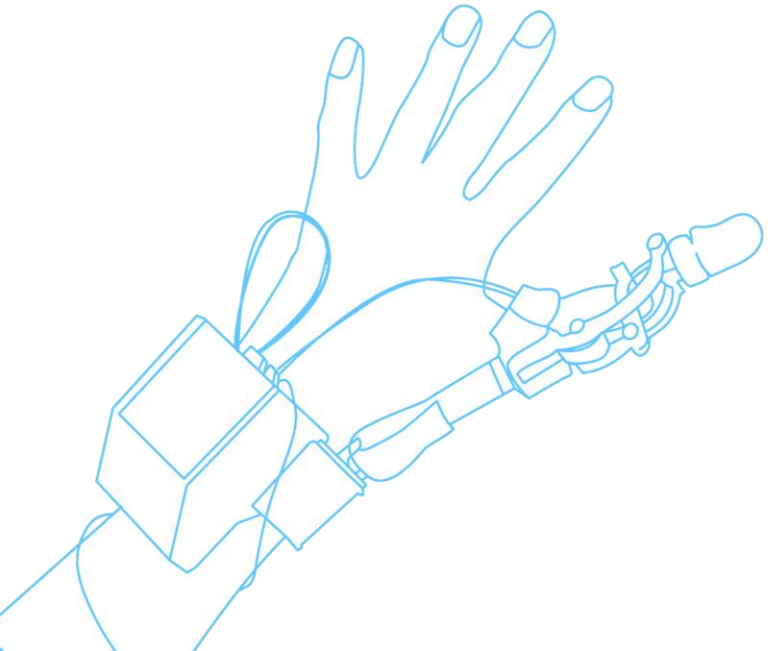


- Results match experimental stribeck curve shape
- Achieved near perfect repeatability
- **Outperformed** expensive commercial solution
- **Enabled reliable grease testing in a ball-on-disk tribometer**

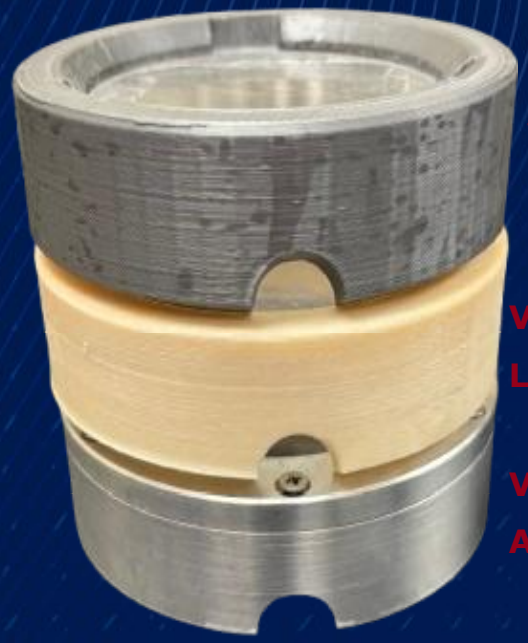
Penn Engineering
University of Pennsylvania



How It Was Designed



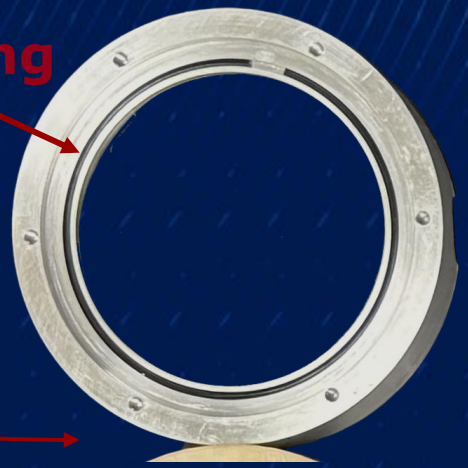
Clear Lid

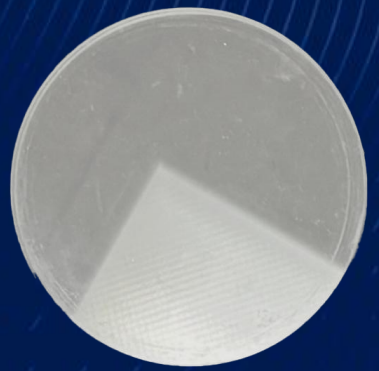


V1 (3D-Printed PLA, Laser cut acrylic)

V2 (3D-Printed ABS, Laser cut acrylic)

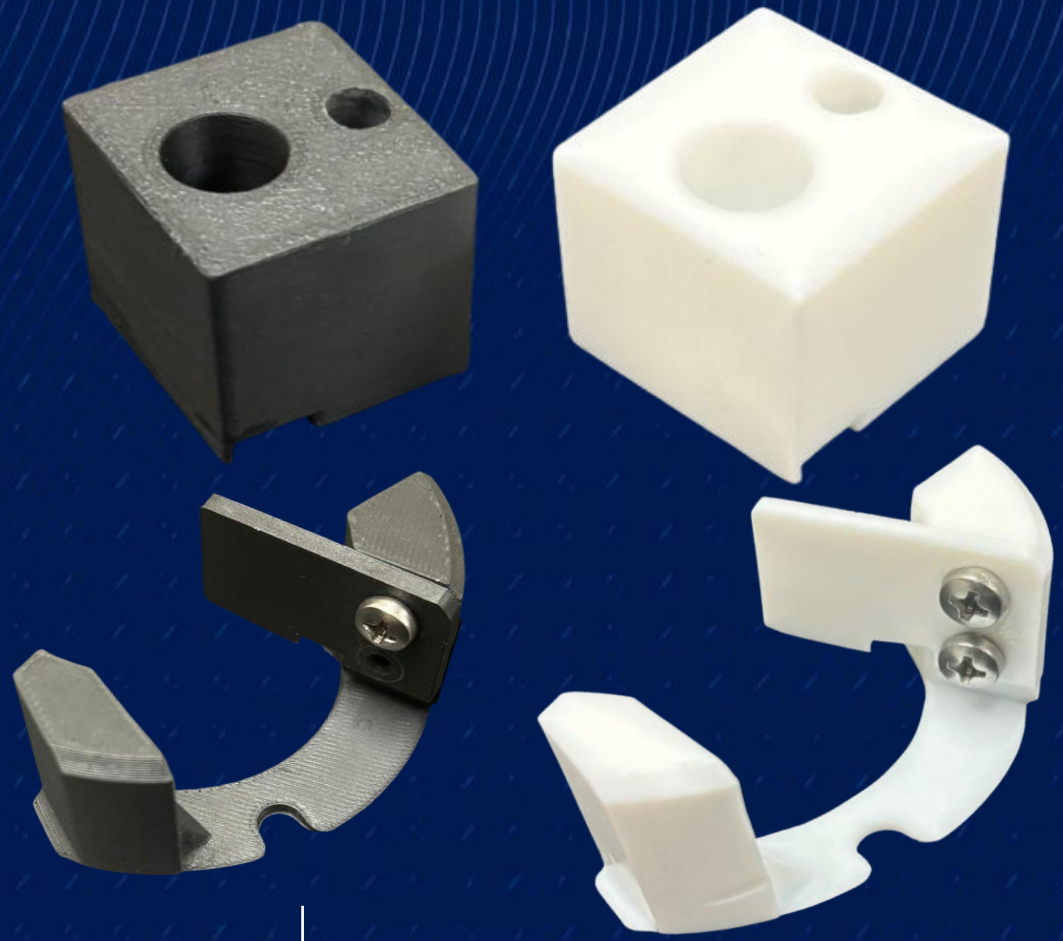
V3 (Machined Aluminum, Glass)

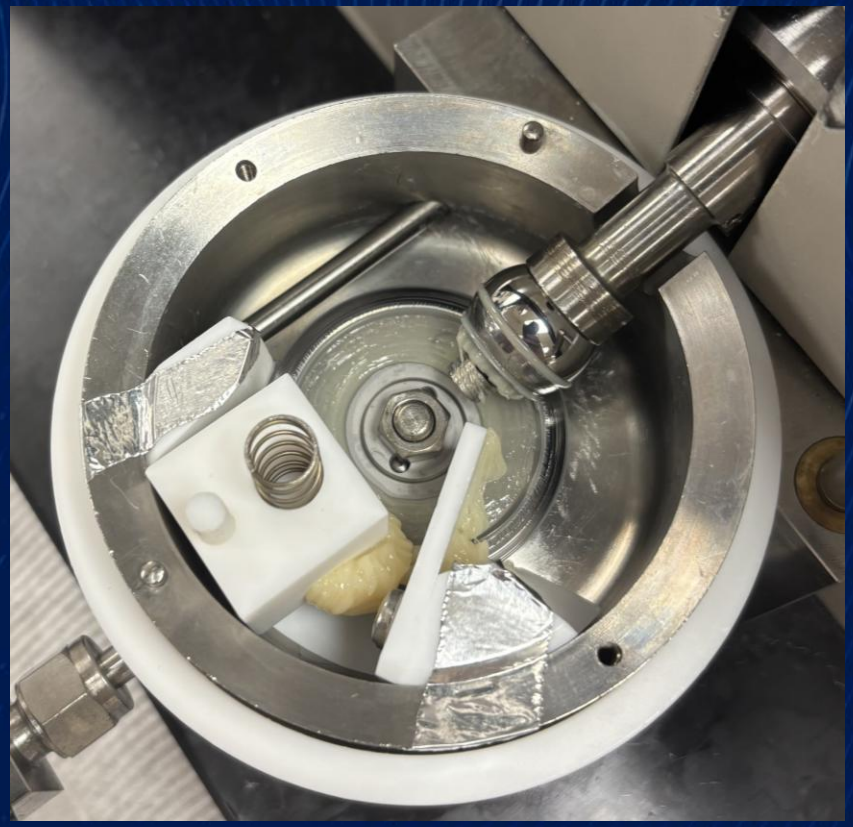




Grease Scoops

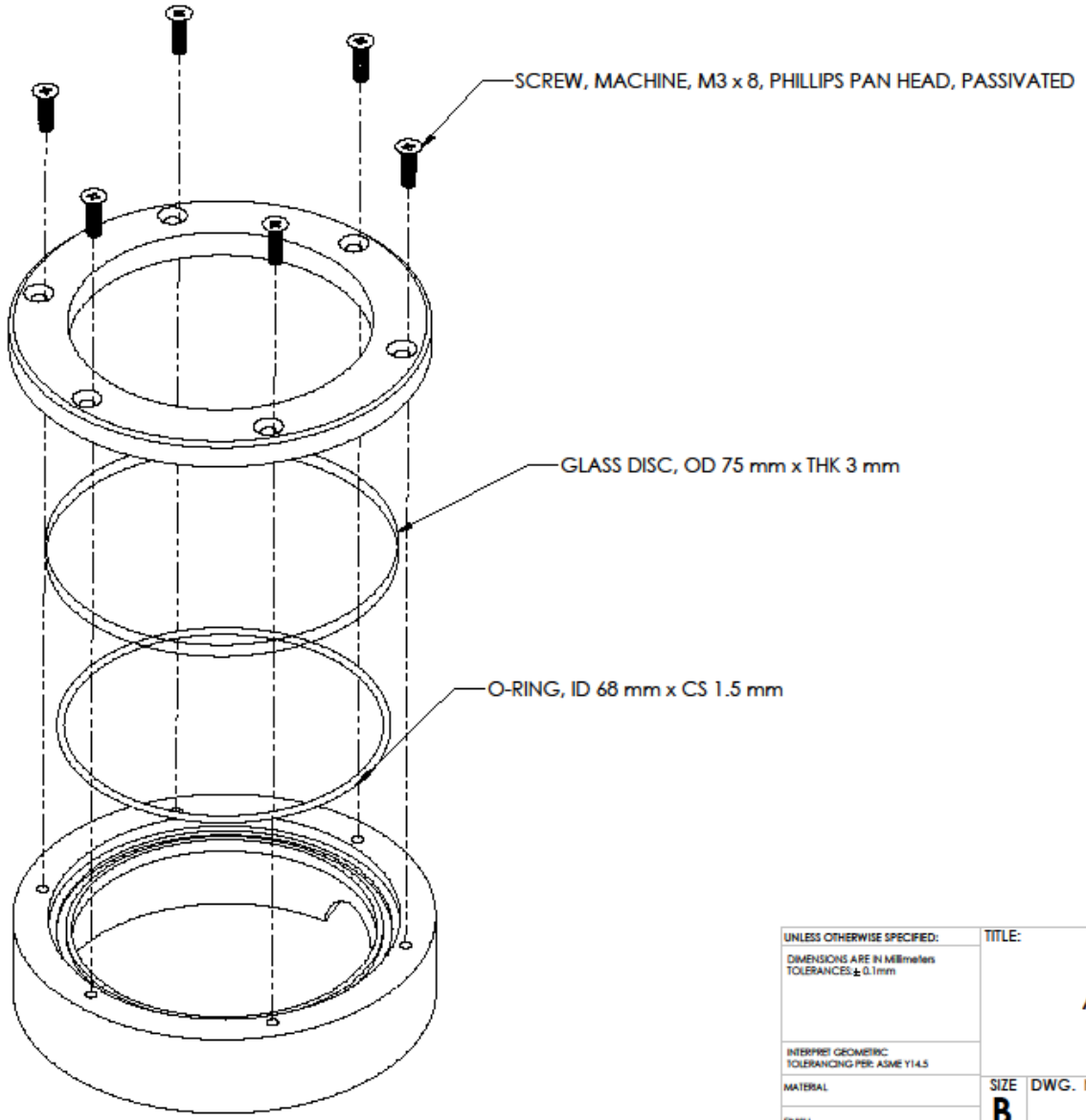
V1 (3D-Printed PLA) **V2 (Machined PTFE)**



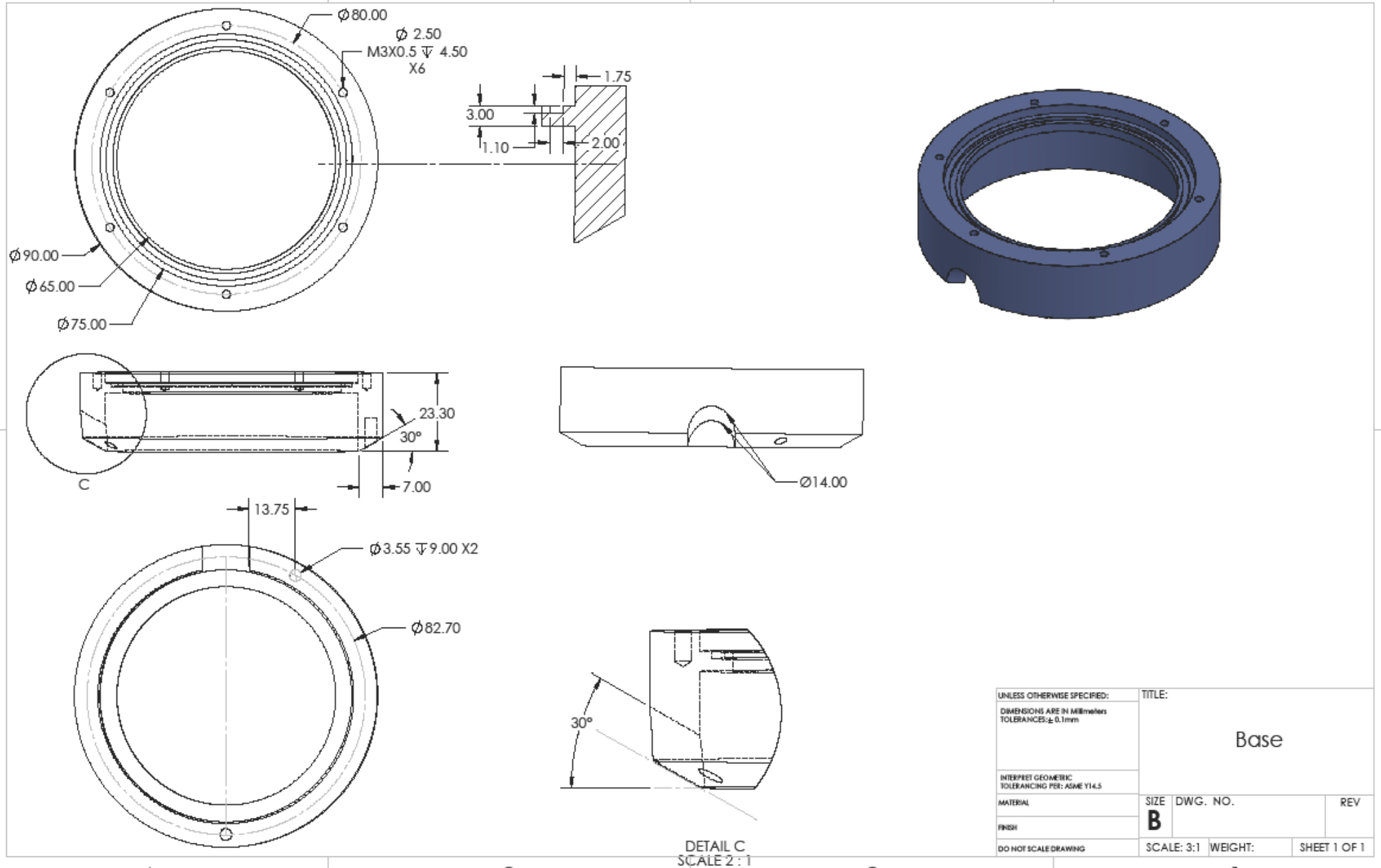


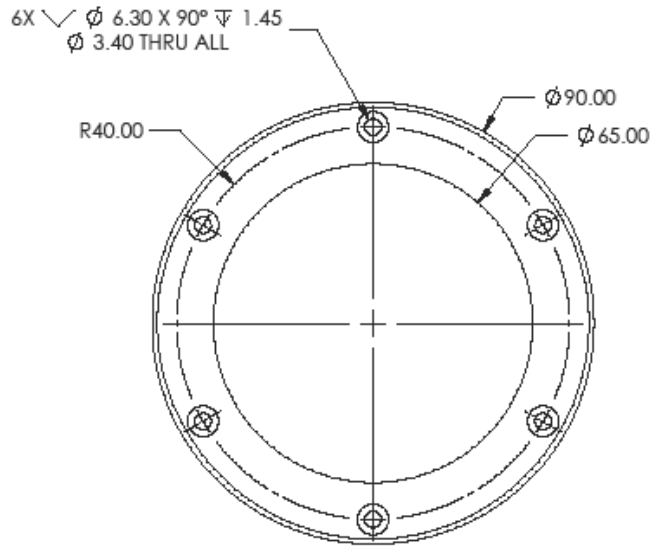
Credit to Rory MacAllister, Imperial College London for inspiration and reference

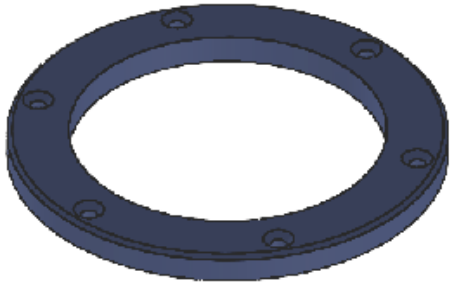
Drawings ↪

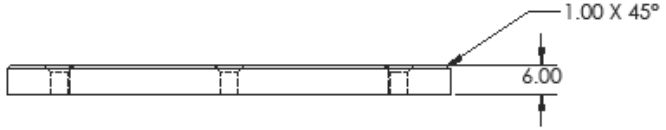


UNLESS OTHERWISE SPECIFIED:	TITLE:
DIMENSIONS ARE IN Millimeters TOLERANCES: ± 0.1mm	Assembly
INTERPRET GEOMETRIC TOLERANCING PER: ASME Y14.5	
MATERIAL	SIZE B / DWG. NO. / REV
FINISH	
DO NOT SCALE DRAWING	SCALE: 1:1 / WEIGHT: / SHEET 1 OF 1

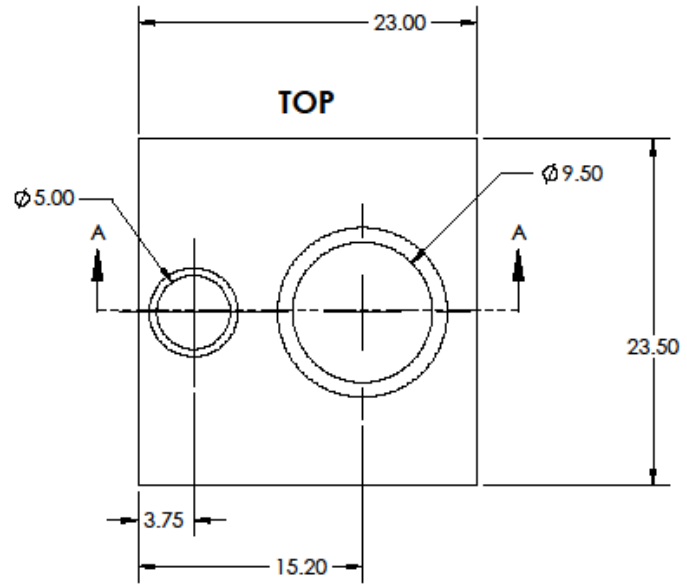


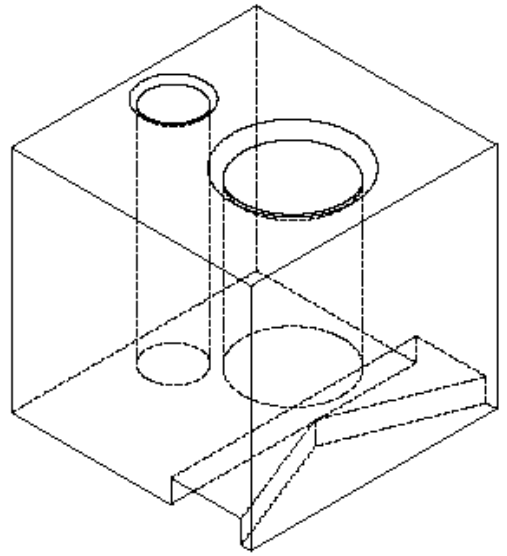


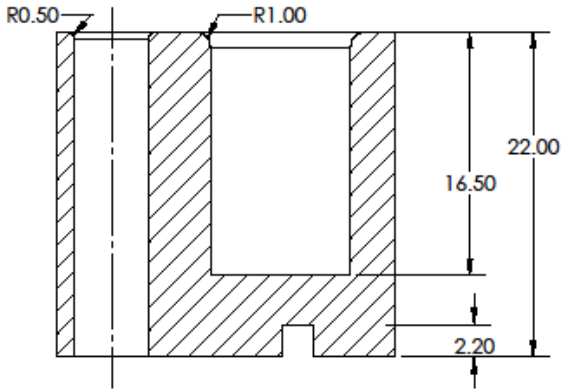




UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN Millimeters TOLERANCES: ± 0.1mm	TITLE: Top
INTERPRET GEOMETRIC TOLERANCING PER: ASME Y14.5	
MATERIAL	SIZE B / DWG. NO. / REV
FINISH	
DO NOT SCALE DRAWING	SCALE: 1:1 / WEIGHT: / SHEET 1 OF 1

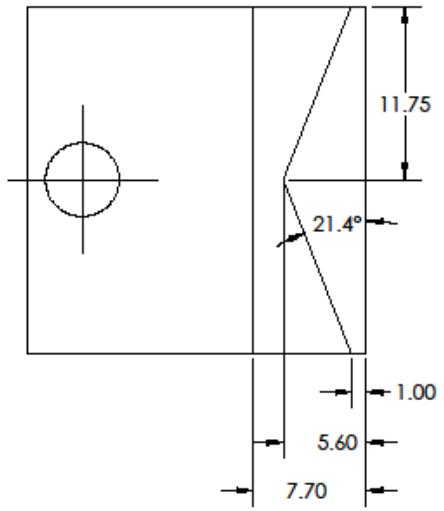




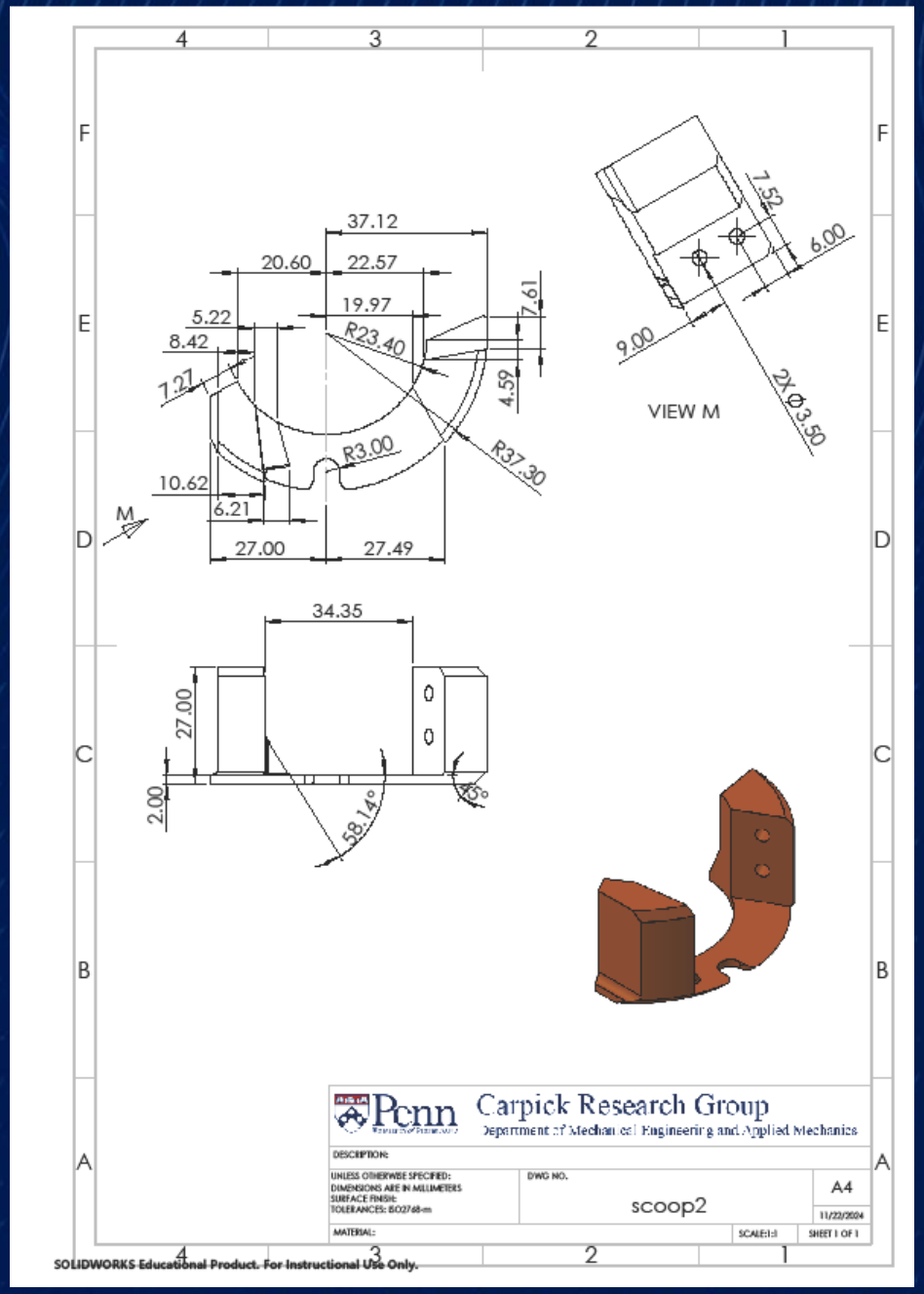


SECTION A-A
SCALE 3 : 1

BOTTOM

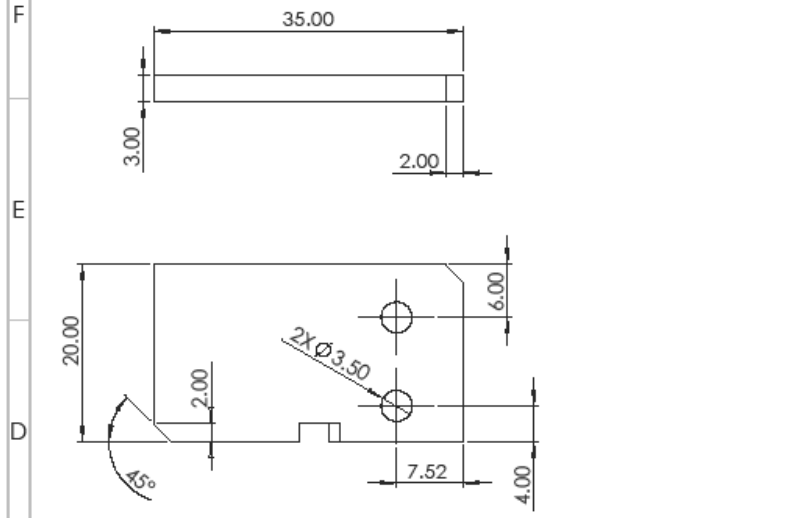


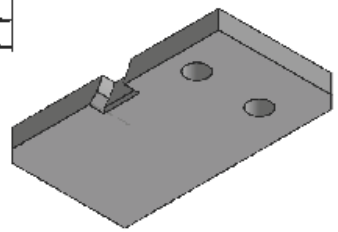
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN Millimeters TOLERANCES ± 0.1mm INTERPRET GEOMETRIC TOLERANCING PER: ASME Y14.5	TITLE: Grease Scoop		
MATERIAL FINISH	SIZE B	DWG. NO.	REV
DO NOT SCALE DRAWING	SCALE: 3:1	WEIGHT:	SHEET 1 OF 1



Penn Carpick Research Group
Department of Mechanical Engineering and Applied Mechanics

DESCRIPTION:		
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: ISO 2768-m	DWG NO. scoop2	A4
MATERIAL:	SCALE:1:1	11/22/2024 SHEET 1 OF 1





Penn Carpick Research Group
Department of Mechanical Engineering and Applied Mechanics

DESCRIPTION:		
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: ISO 2768-m	DWG NO. squeegee_v2	A4
MATERIAL:	SCALE:2:1	11/22/2024 SHEET 1 OF 1