

# **ROB550**

Winter 2023

# Course Information

- Instructor: Peter Gaskell
  - e-mail: pgaskell@umich.edu
  - office: 3268 FMCRB
- Lecture
  - Tuesday & Thursday 9:30a-10:30a FMCRB1050 and on Zoom (posted on YouTube)
  - All previous years lectures & demos available on YouTube
- Lab
  - Tuesday & Thursday 10:30a-1:30p in FMCRB2010/2020
  - Tuesday & Thursday 1:30p-4:30p in FMCRB2010/2020
  - Access lab anytime

# Course Information

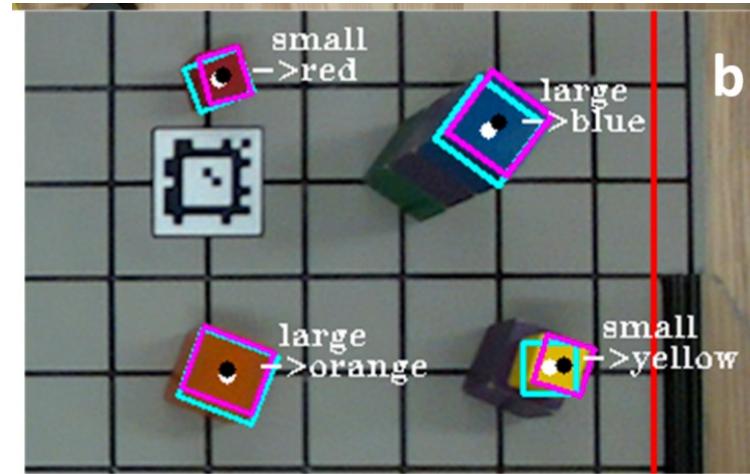
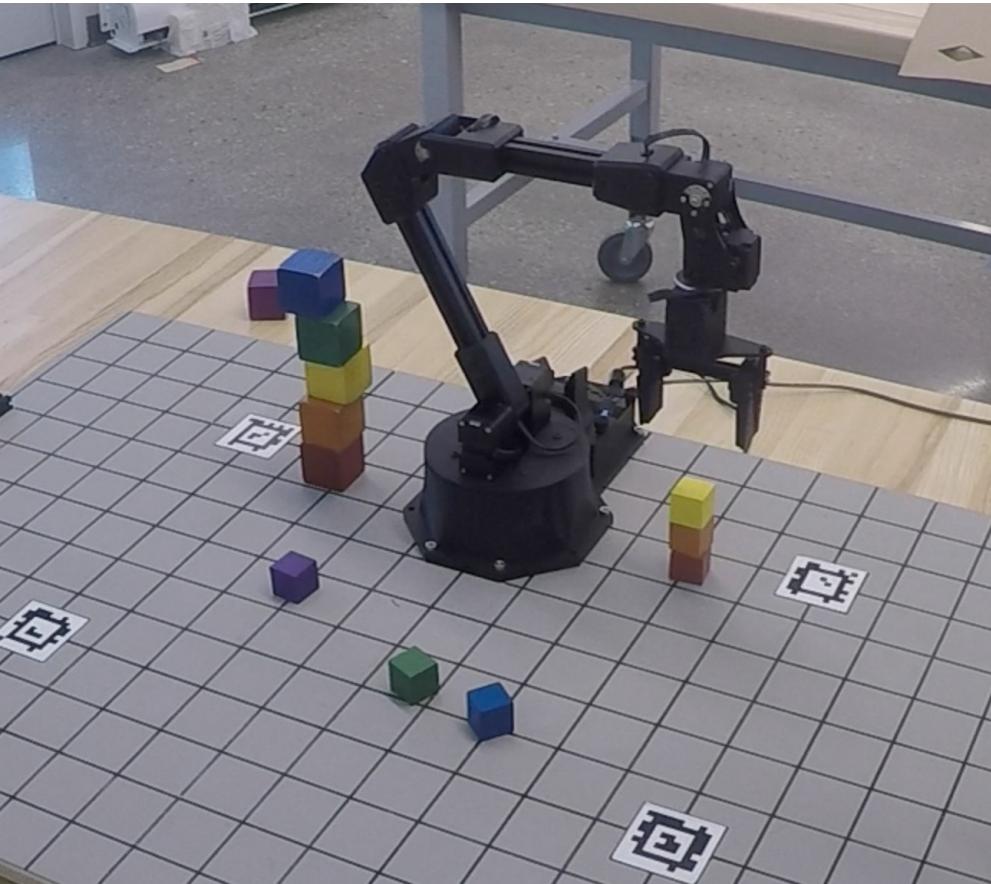
## Part 1: Armlab manipulation project (~7 weeks)

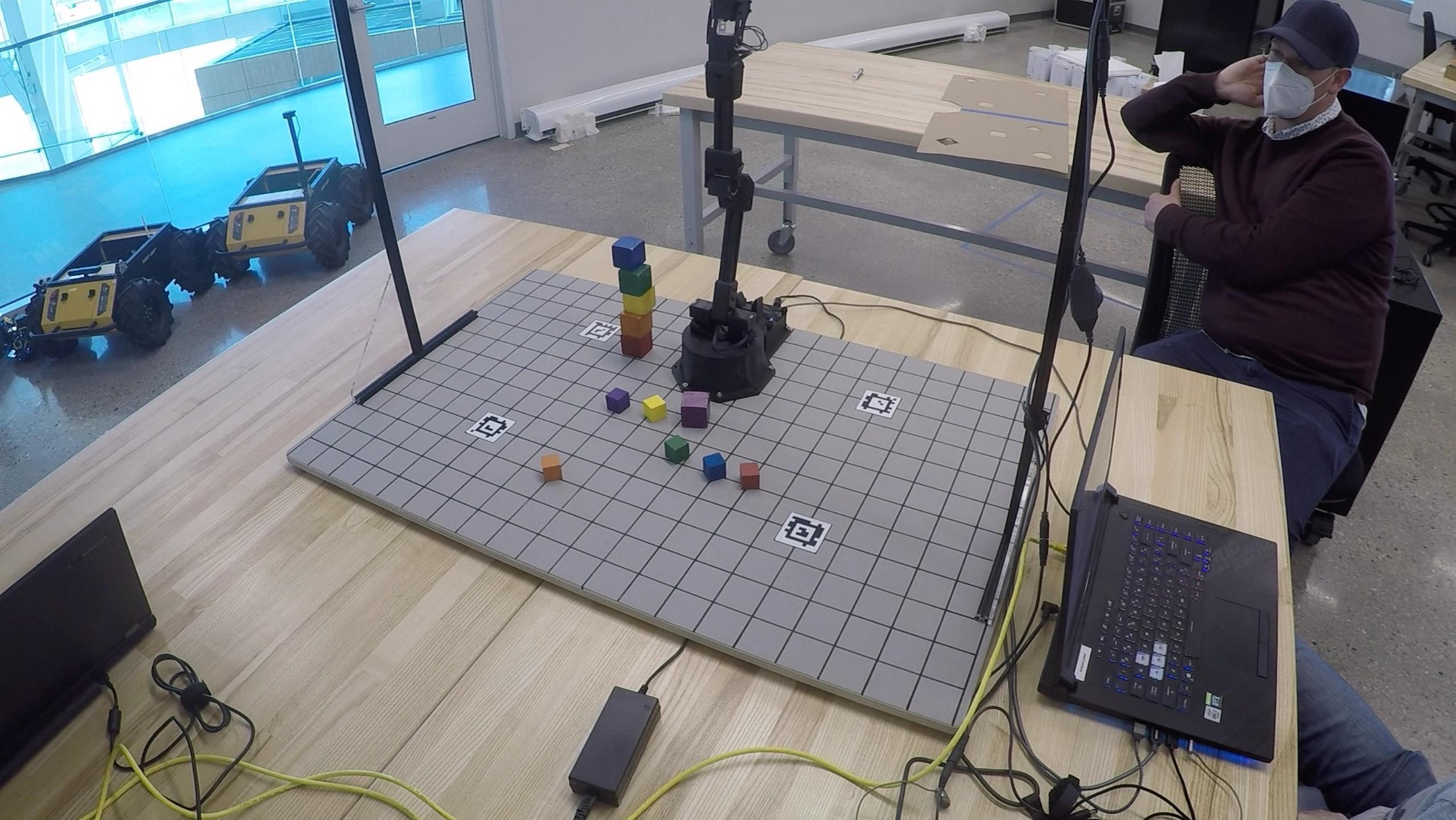
- Learn some rapid prototyping techniques
- Design a gripper
- Control a robot arm
- Use computer vision techniques to locate objects to grasp

## Part 2: Botlab mobile robotics project (~8 weeks)

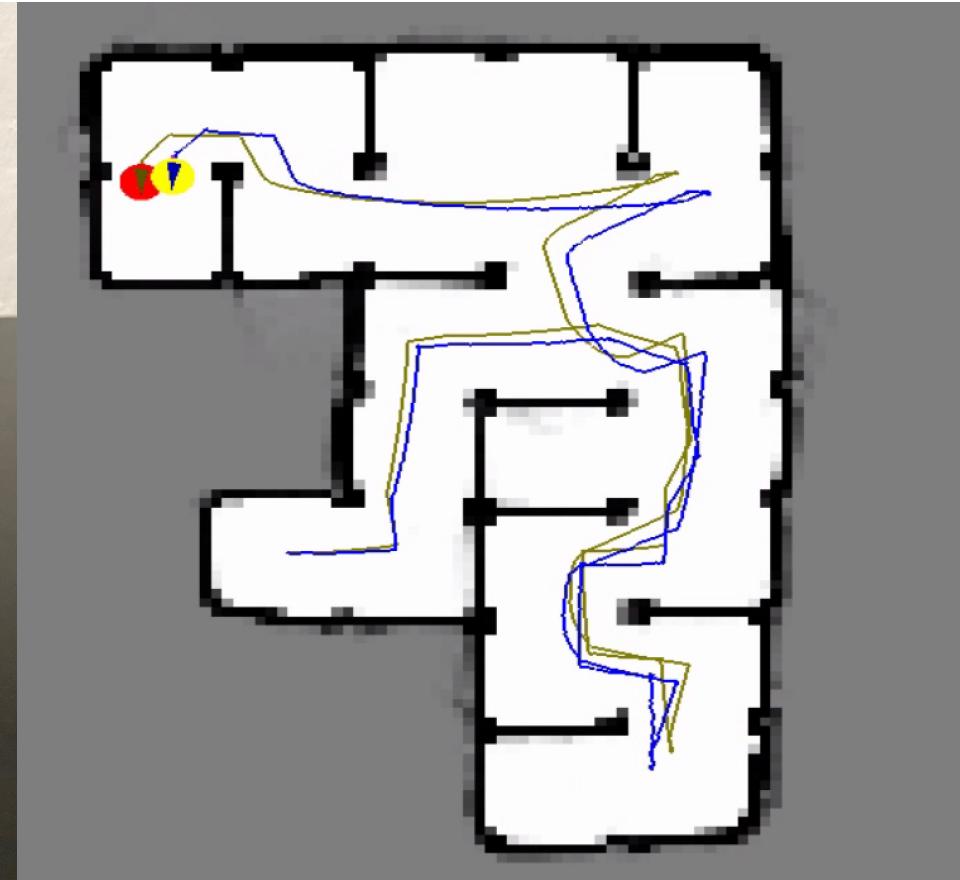
- Complete low-level control & sensor interface system (mobilebot, 3 weeks)
- Complete high level mapping & navigation system (botlab, 5 weeks)

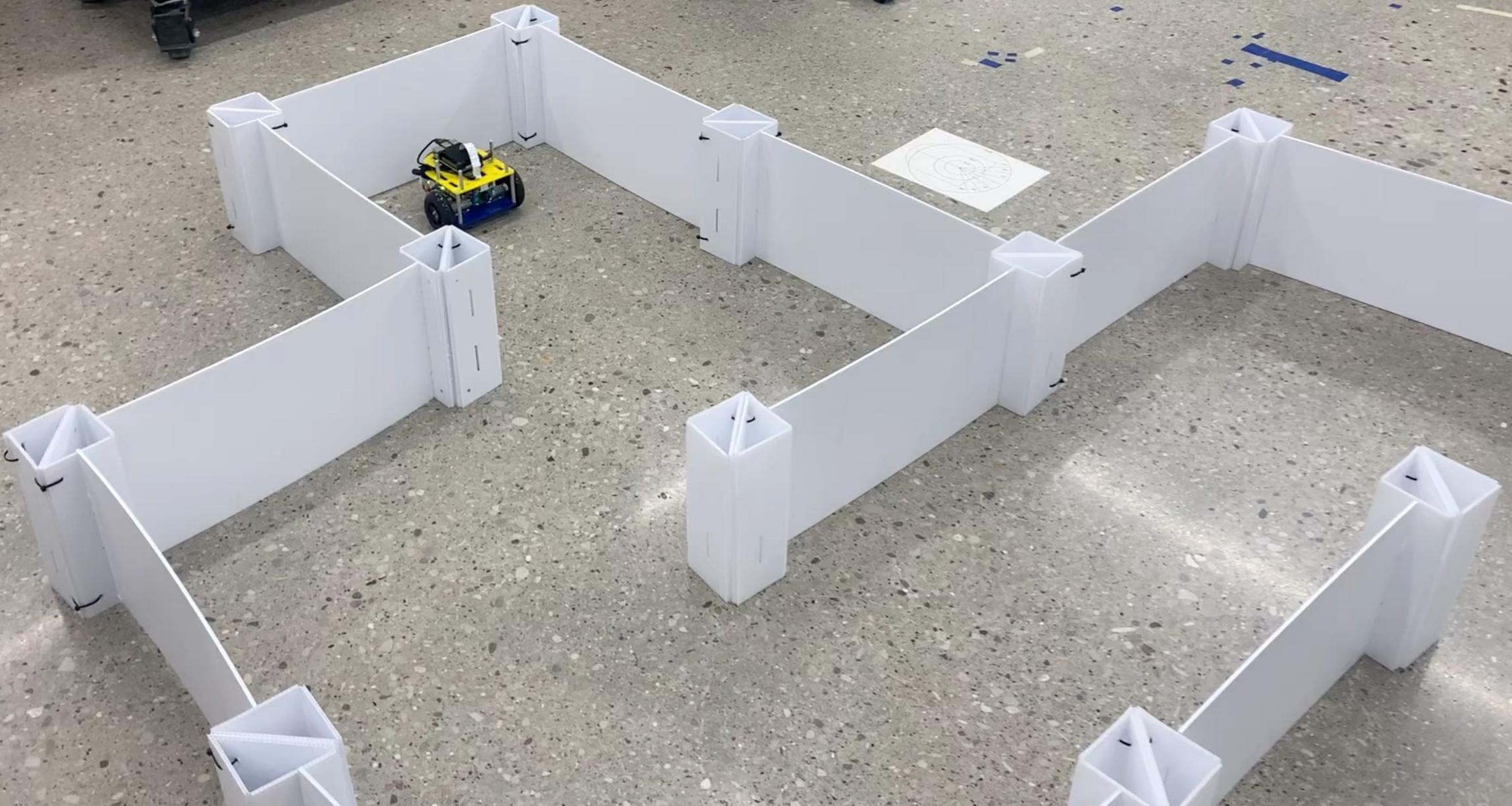
# Armlab





# Botlab





pi@mbot-master: ~/team2/botlab-f22/system\_compilation/bin

File Edit Tabs Help

\* pi@mbot... x

pi@mbot-m... x

pi@mbot-m... x

pi@mbot-m... x

```
Stopping SLAM...
[SLAM] SLAM completed.
pi@mbot-master:~/team2/botlab-f22/system_compilation/bin $ ./slam --num-particles 1000 --localization-only -
-map ~/team2/botlab-f22/scripts/python/new_map.map --random-initial-pos
[SLAM] SLAM initialized in mode 2
Starting SLAM...
^CStop signal received
Stopping SLAM...
[SLAM] SLAM completed.
pi@mbot-master:~/team2/botlab-f22/system_compilation/bin $ ./slam --num-particles 1000 --localization-only -
-map ~/team2/botlab-f22/scripts/python/new_map.map --random-initial-pos
[SLAM] SLAM initialized in mode 2
Starting SLAM...
Segmentation fault
pi@mbot-master:~/team2/botlab-f22/system_compilation/bin $ ^C
pi@mbot-master:~/team2/botlab-f22/system_compilation/bin $ ./slam --num-particles 1000 --localization-only -
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```

Completed Exploration

Failed Exploration

Reset Exploration States

# ROB550 Grading

## Part I: Manipulation & Computer Vision

- Armlab Project:
  - Checkpoints 30%
  - Report 30 pts
  - Competiton Bonus 70 pts
  - Competiton Bonus +1, +3, +5 pts
- Quiz: 15%

Complete Makerspace Training 5%

Participation Grade: 5%

## Part II: Mobile Robotics

- Botlab Project: 30%
  - Checkpoints 30 pts
  - Report 70 pts
  - Competiton Bonus +1, +3, +5 pts
- Quiz: 15%

# Course Resources

- Canvas
  - Submissions / grading / major announcements
- Google Drive
  - Documentation / lab instructions / schedule
- Gitlab
  - Project templates / install scripts / tutorial repositories
- Discord
  - Instructor help / minor announcements / team collaboration
- Zoom
  - Livestream lecture / live demos
- YouTube
  - Lecture recordings / demo recordings

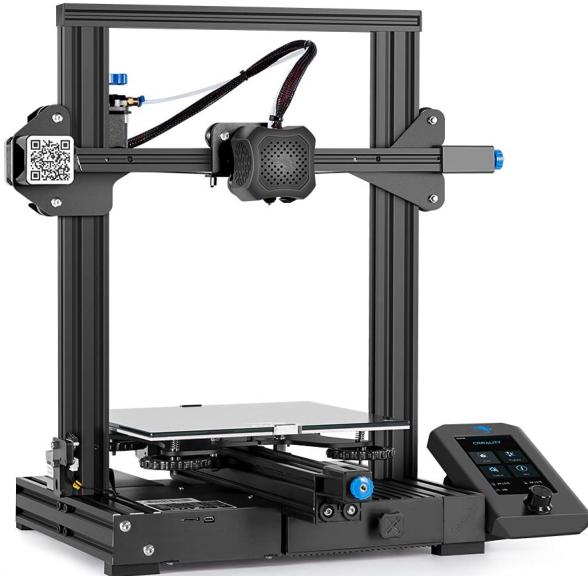
# Robotics Shop Tools

Lecture 13

# 3D Printers - FDM



Zortrax M200



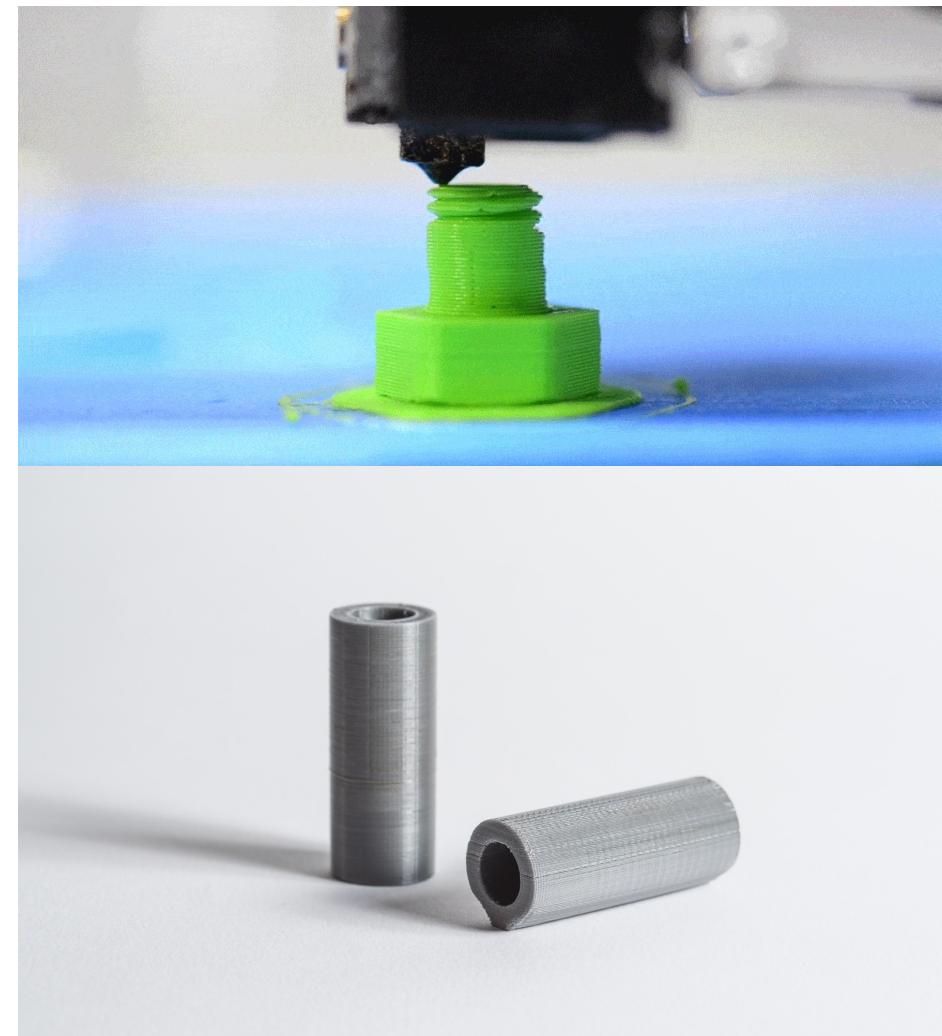
Ender 3 V2



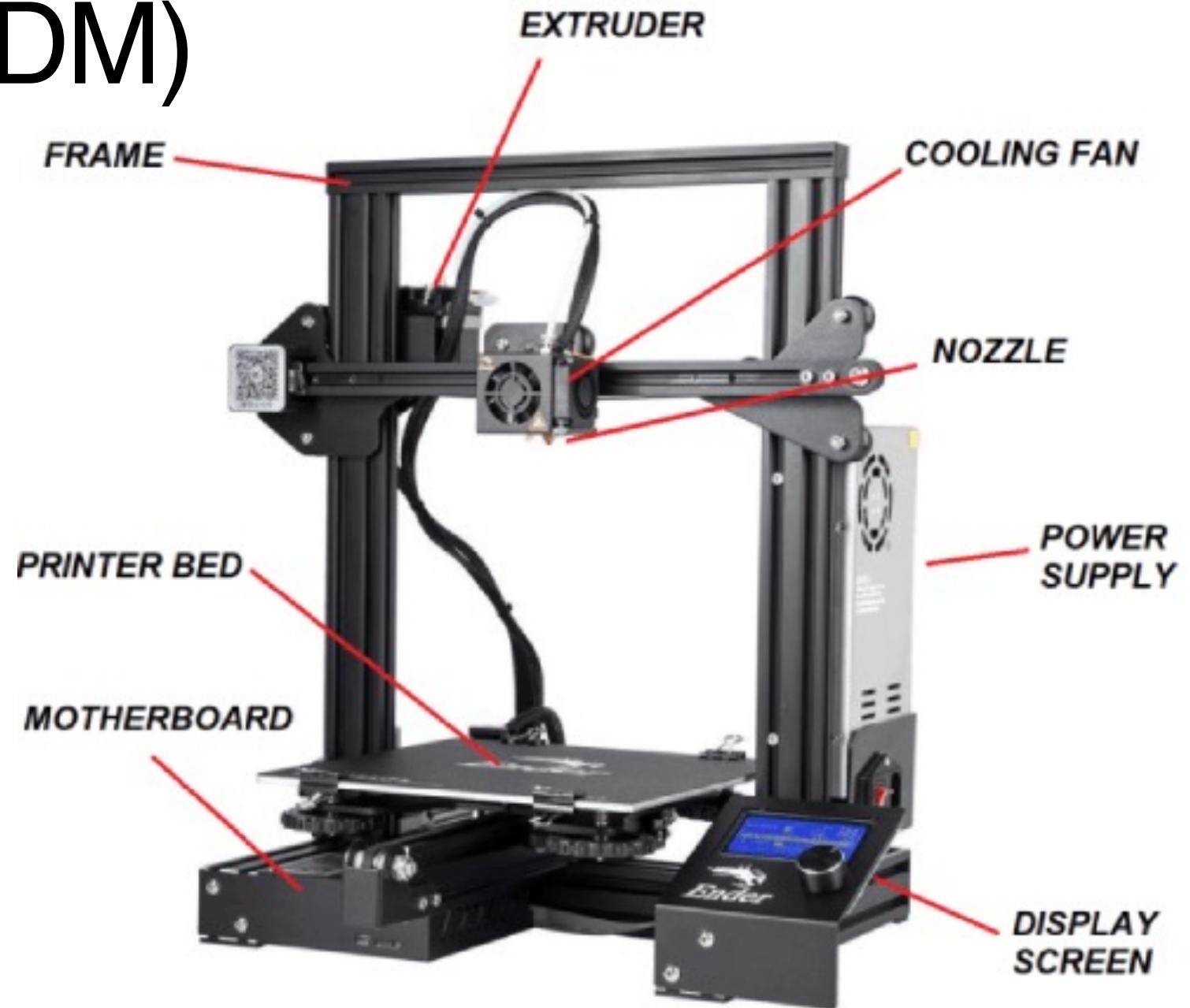
Lulzbot Taz-5

# FDM – Fused Deposition Modeling

- Nozzle extrudes molten plastic and deposits layer by layer
- Low cost, very easy
- 1h to >12h build time depending on size
- ABS (Zortrax)
- PLA (Ender 3V2 & Lulzbot) *Corn!*
- Anisotropic (will break more easily between layers)
- Choosing and designing for build orientation very important

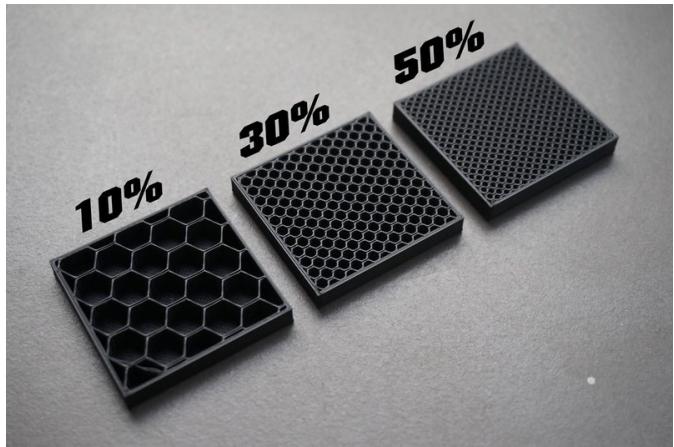


# 3D Printer (FDM)

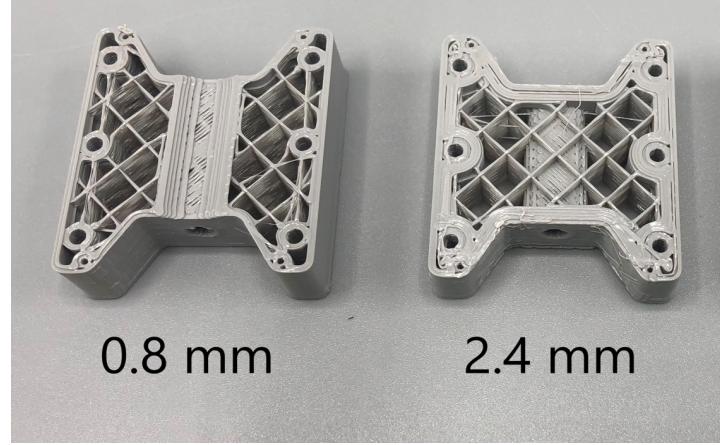


# FDM Concepts

- Layer thickness (0.09 – 0.29mm)
- Minimum feature size ~ 0.8 mm (2x nozzle diameter)
- Infill - parts are hollow with variable support inside
- Shell Thickness – how many solid layers form the outside of the part
- Support – areas that are unsupported need breakaway supports
- Overhang – parts built with overhangs < 20° w/o support
- Raft – deposit an area of plastic to facilitate bed adhesion, breaks off when done
- Slicing – software that takes an STL file and calculates toolpaths for the machine (Cura / Z-Suite)
- Bed Leveling – Print bed must be levelled to prevent part peeling off during print



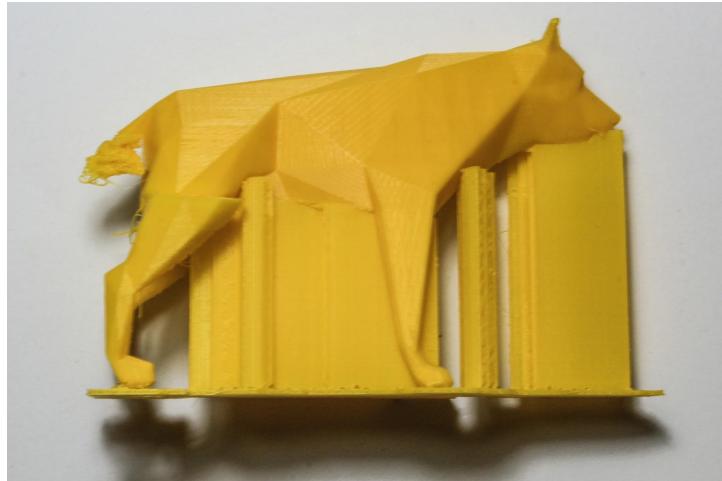
*Infill*



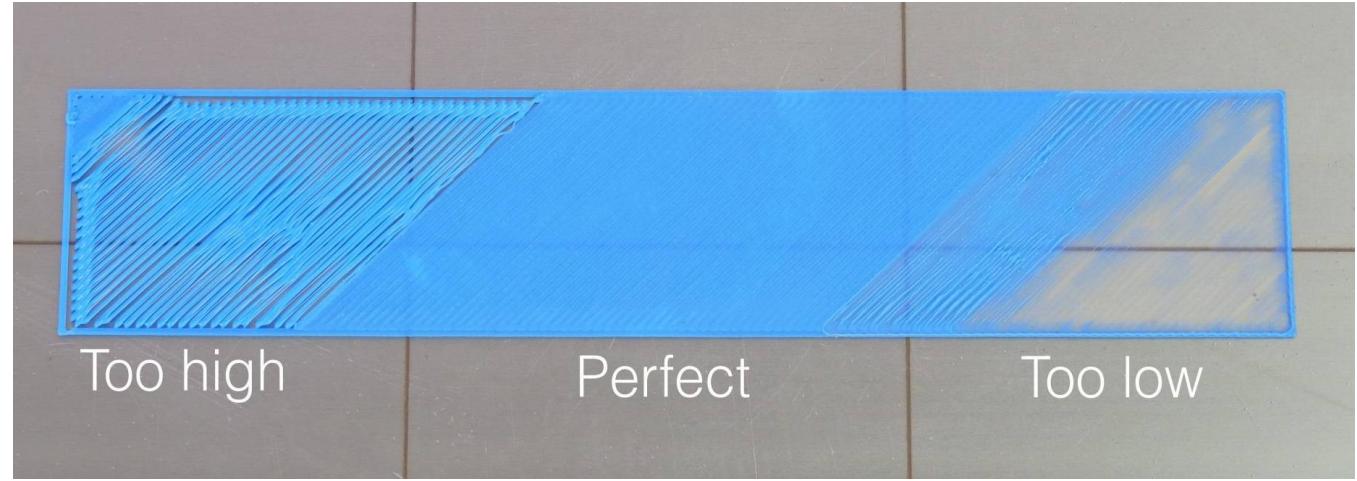
*Shell Thickness*



*Raft*

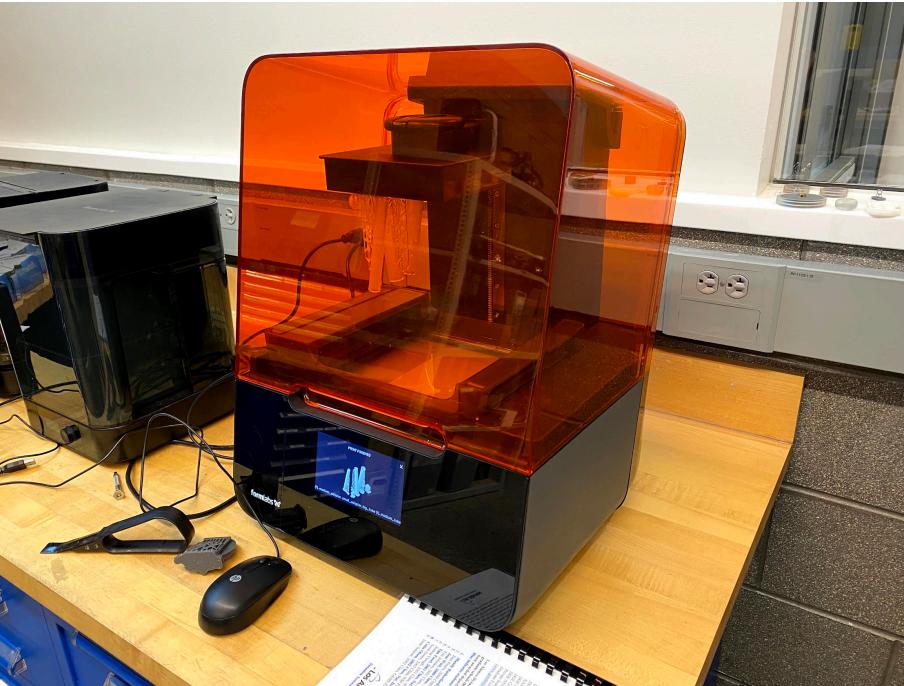


*Support*



*Bed Level*

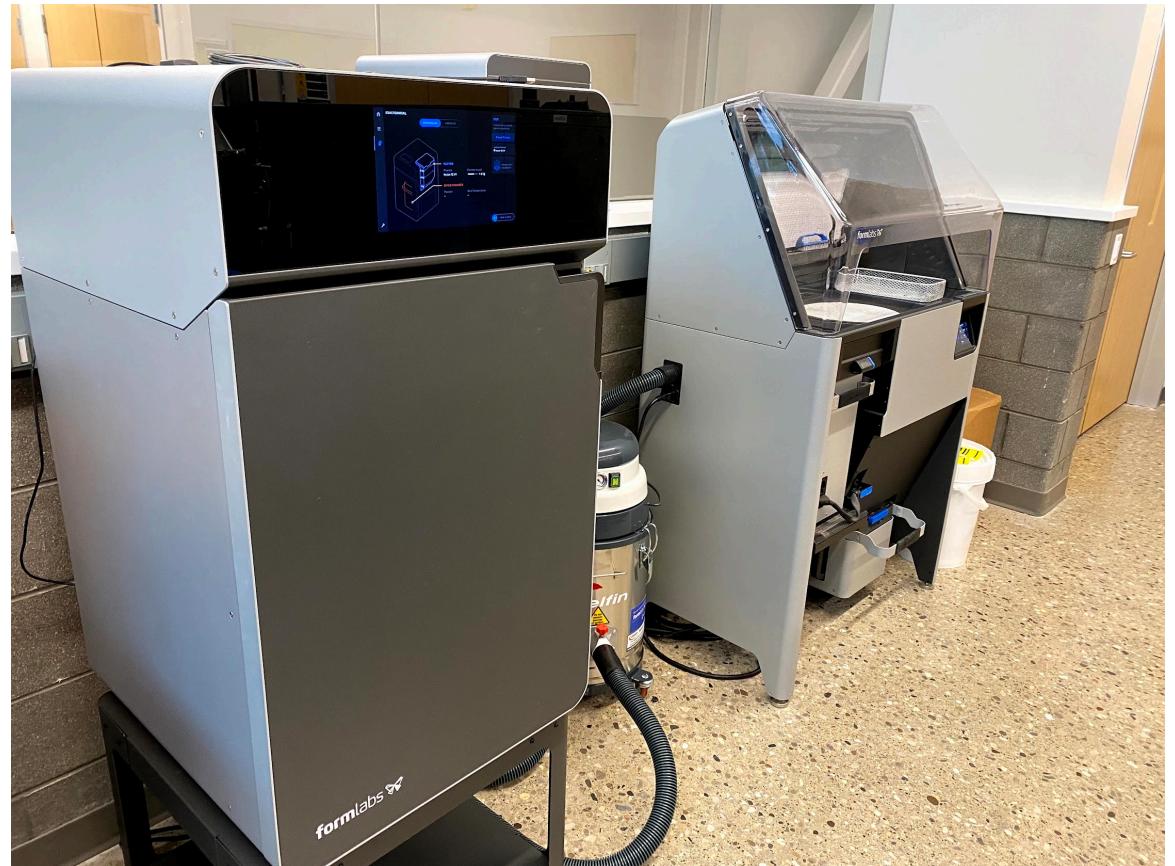
# Sterolithography (SLA) – Form3



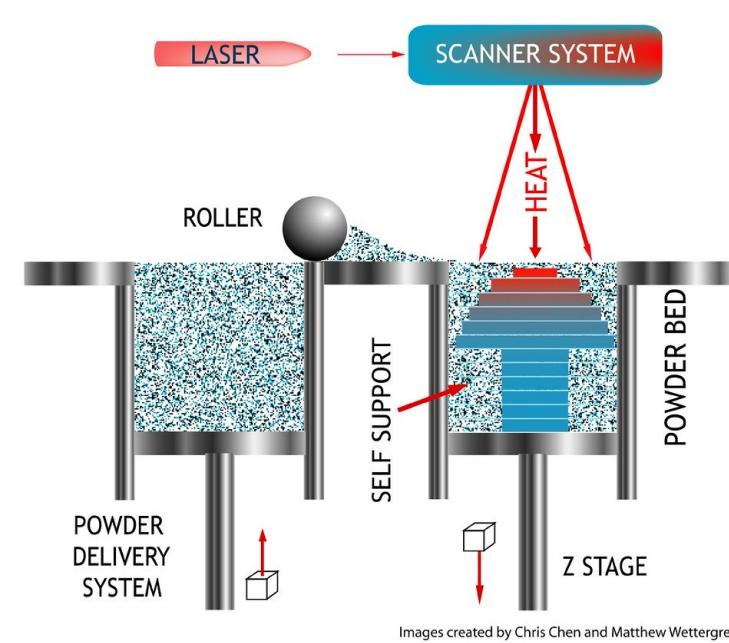
- Uses UV laser to cure resin layer by layer
- Multiple resins available (standard, durable, flexible etc.)
- Pulls part from the liquid as it is cured
- Post processing involve acetone wash and UV cure
- Medium cost

# Selective Laser Scintering -- Fuse

- Melts nylon based engineering plastic powder layer by layer
- Very fine and very strong features
- High cost, high performance

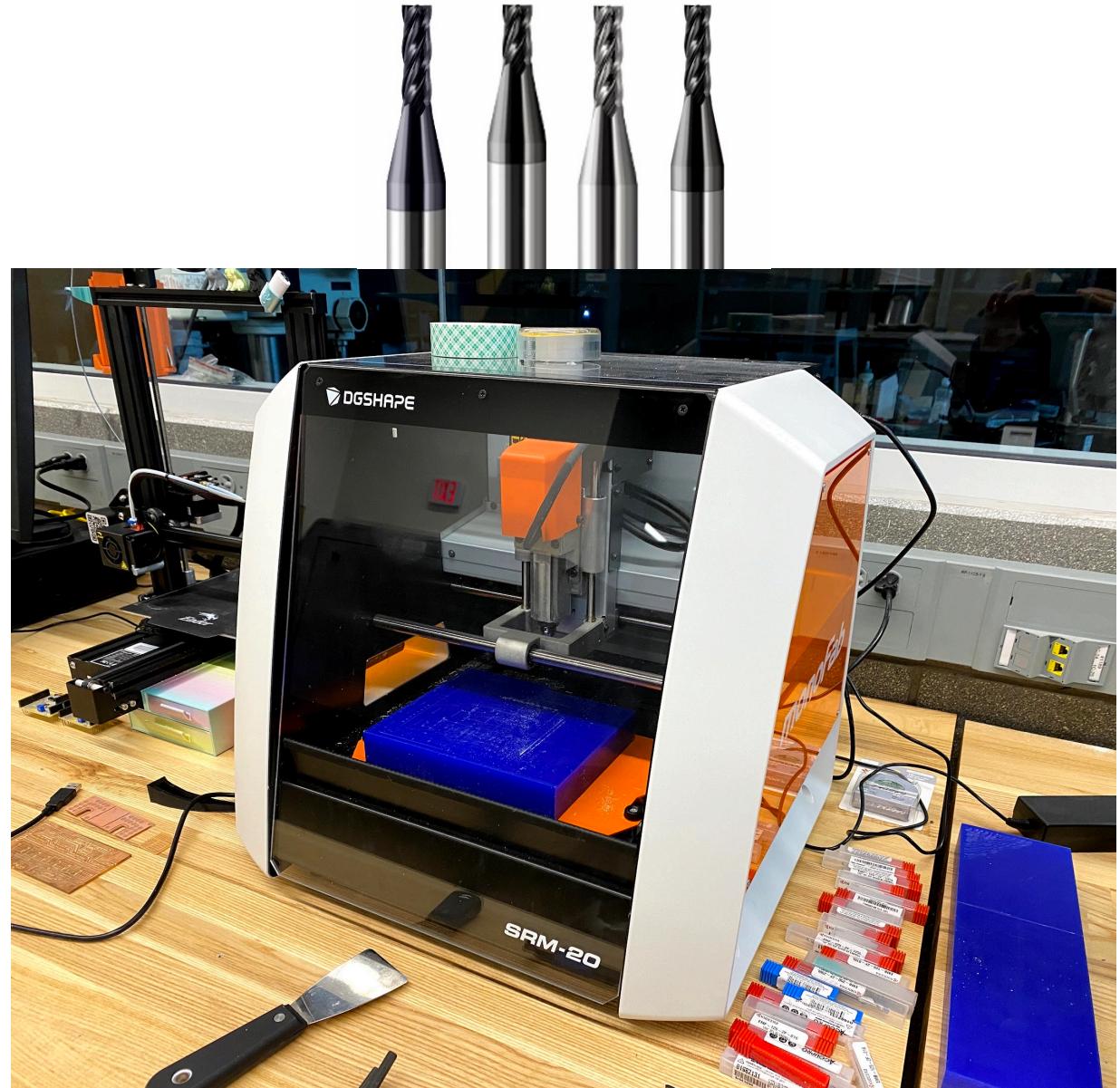


# Selective Laser Scintering



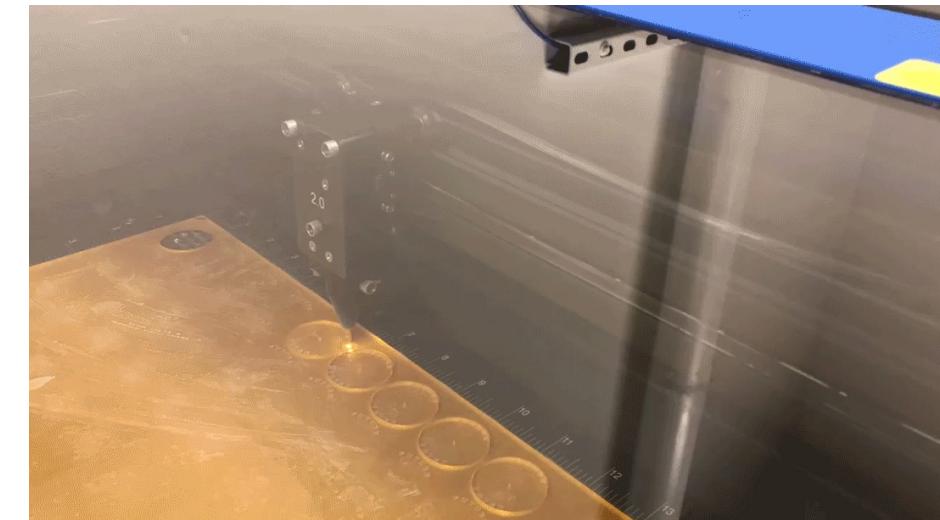
# Micro Mill

- Uses micro endmills & routing bits
- Printed circuit boards
- Small plastic parts
- Wax for lost wax casting
- 8" x 6" x 2" work area



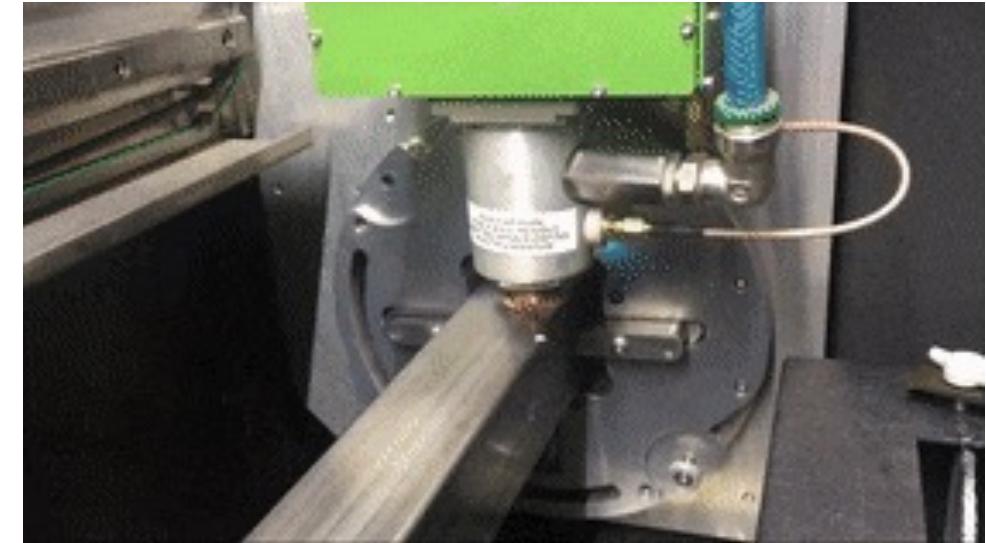
# CO<sub>2</sub> Laser Cutter

- Cuts and etches plastics, woods, & cardboard
- Feature size < 1mm
- Work area 36" x 24"
- Example: MBot chassis
- Input is 2D drawing
- Export from CAD as dxf
- Use earliest version for best compatibility



# Fiber Laser Cutter

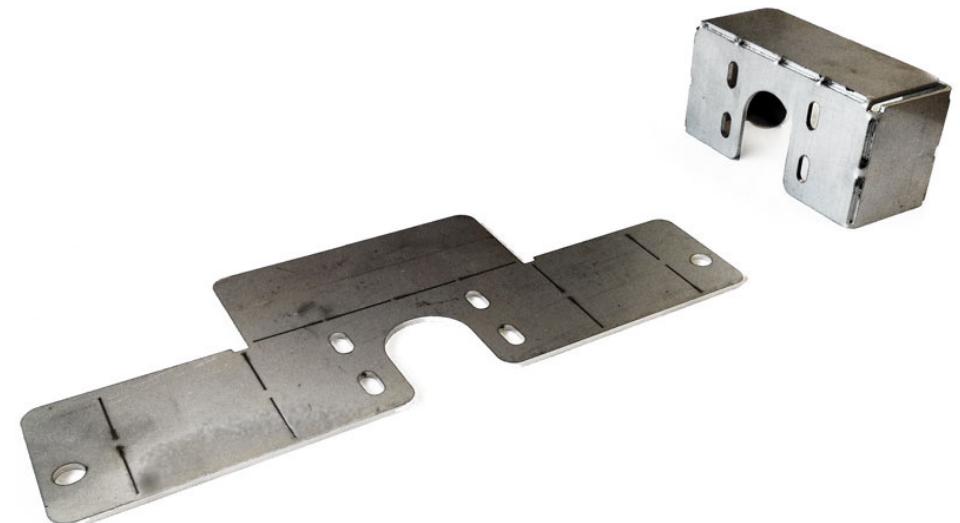
- Cuts & stitches sheet metals
- Aluminium up to 1/8" thick
- Steel up to 1/8" thick
- Feature size <1mm
- Work area 25" x 50"
- Very fast & easy to use
- Uses dxf files



# Metal Brake



- Bend sheet metal parts
- 1/16" Steel
- 1/8" Aluminum



# Vinyl Cutter



- Drag knife cuts vinyl sheets (stickers)

# ShopBot Buddy



- CNC Router
- Endmill / Routing Bits
- Drag knife
- Wood / Plastic / Foam
- 2' x 4' work area

# SawStop Tablesaw

- Cuts big flat things
- Doesn't cut off your fingers



MakeAGIF.com



MakeAGIF.com

# Horizontal Bandsaw

- Cut bar stock, pipes, Aluminum extrusions



# Drill Press

- Puts holes in things (what more do you want?)
- Can tap (put threads in) holes using by hand using taps



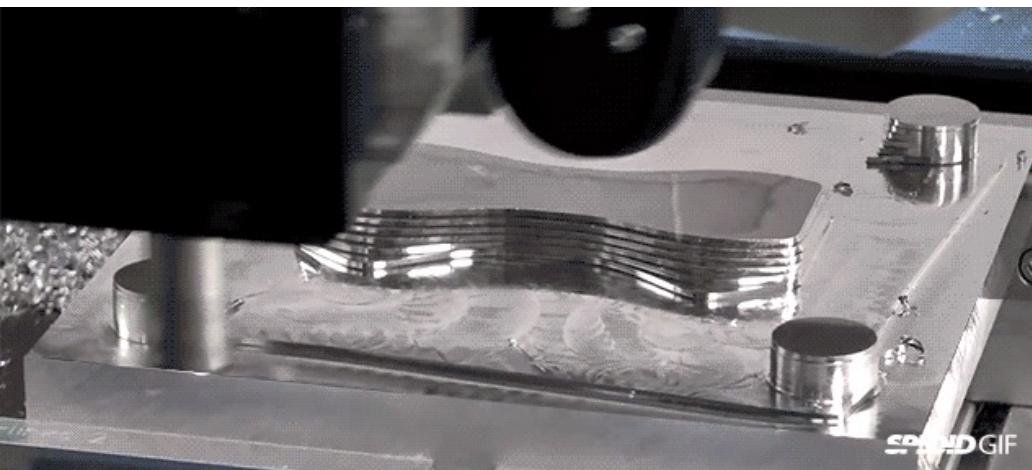
# Waterjet



- Uses abrasive suspended in water & high pressure to cut
- Cuts thicker metal sheets up to 1"
- Features >1mm
- Carbon fiber sheets
- Thick plastics
- 12" x 12" work area

# 3-Axis Verticle Mill

- “Subtractive” manufacturing
- Tool rotates in precision spindle
- Precision to 1mil (25um)



# Lathe

- Used for rotationally symmetric precision parts
- Workpiece rotates and tool is fixed

