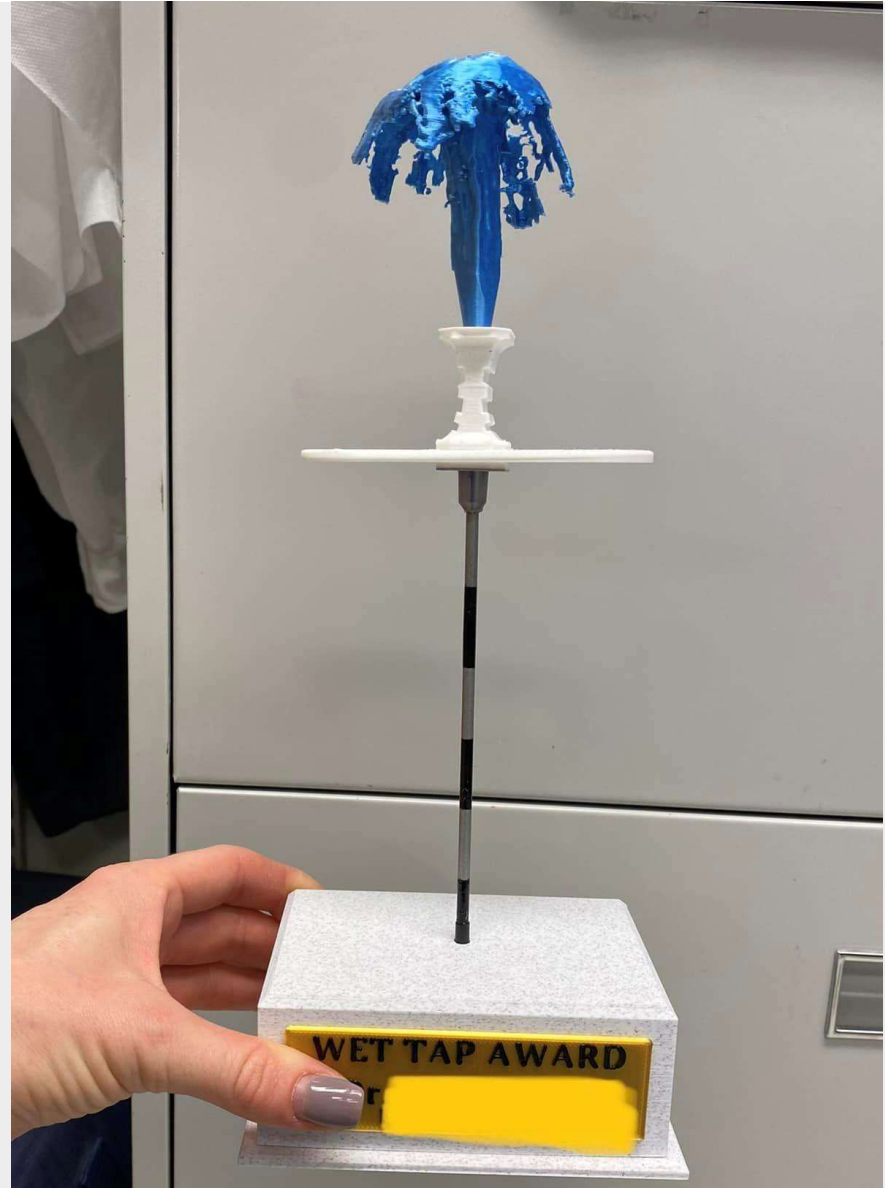

3D Printing for Medical Inventors: Design, Prototyping, and Production

Eric Kramer DNAP, CRNA, FNP-C

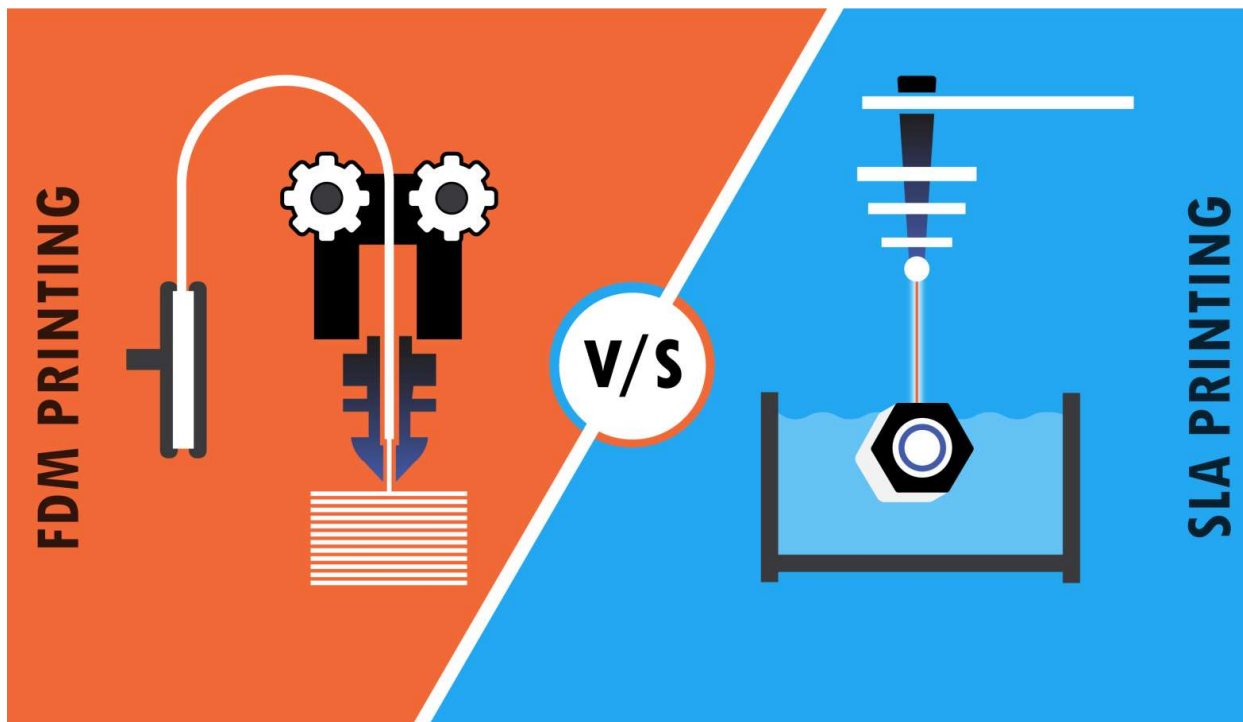


Objectives

- **Demystify the process of 3D printing**
- Discuss basic mechanism of how 3D prints are made, advantages and disadvantages
- Discuss 3D printers available to consumers
- Discuss software options for creating designs
- Review examples of 3d printing in medicine and anesthesia



What is 3D Printing?



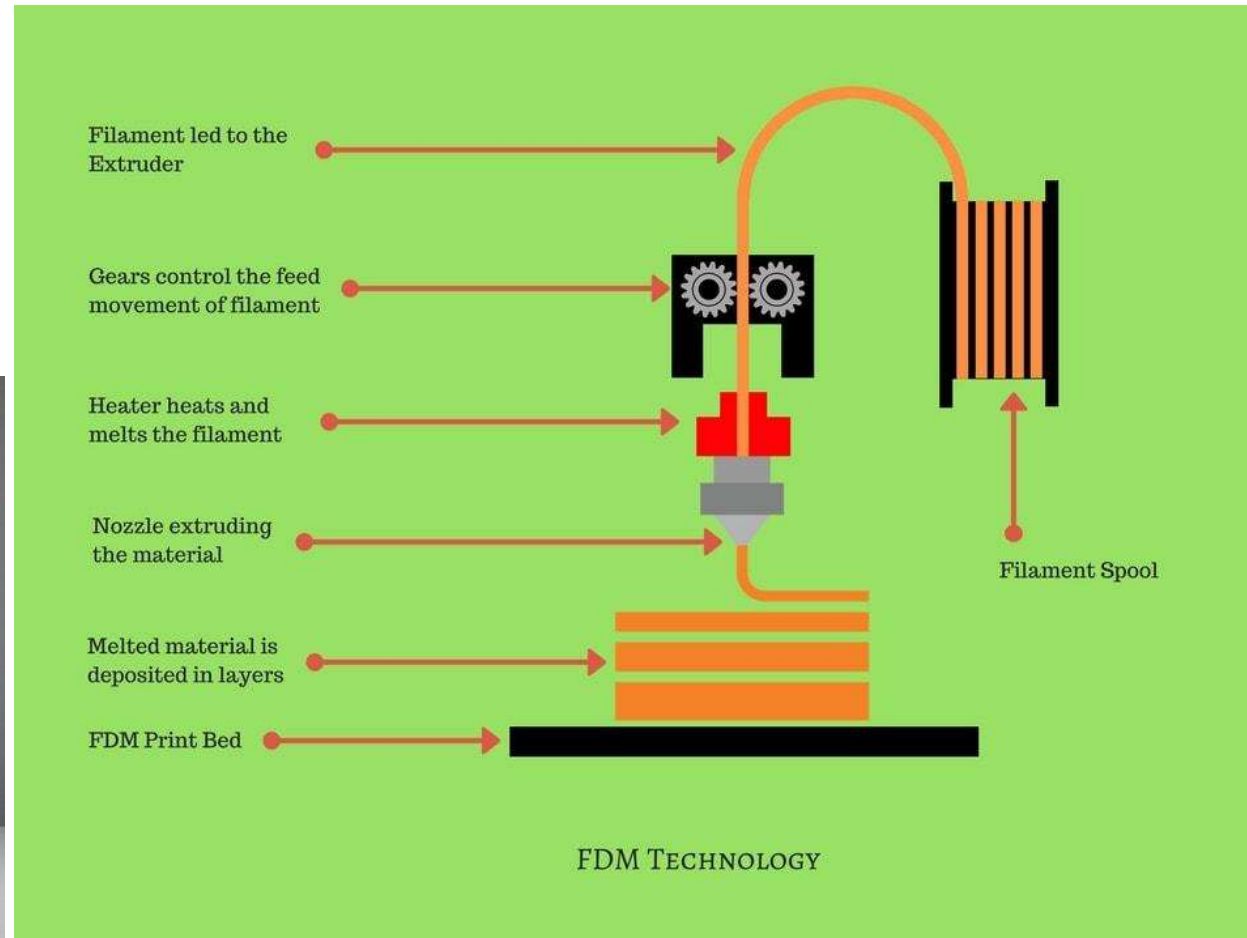
1.FDM (Fused Deposition Modeling)

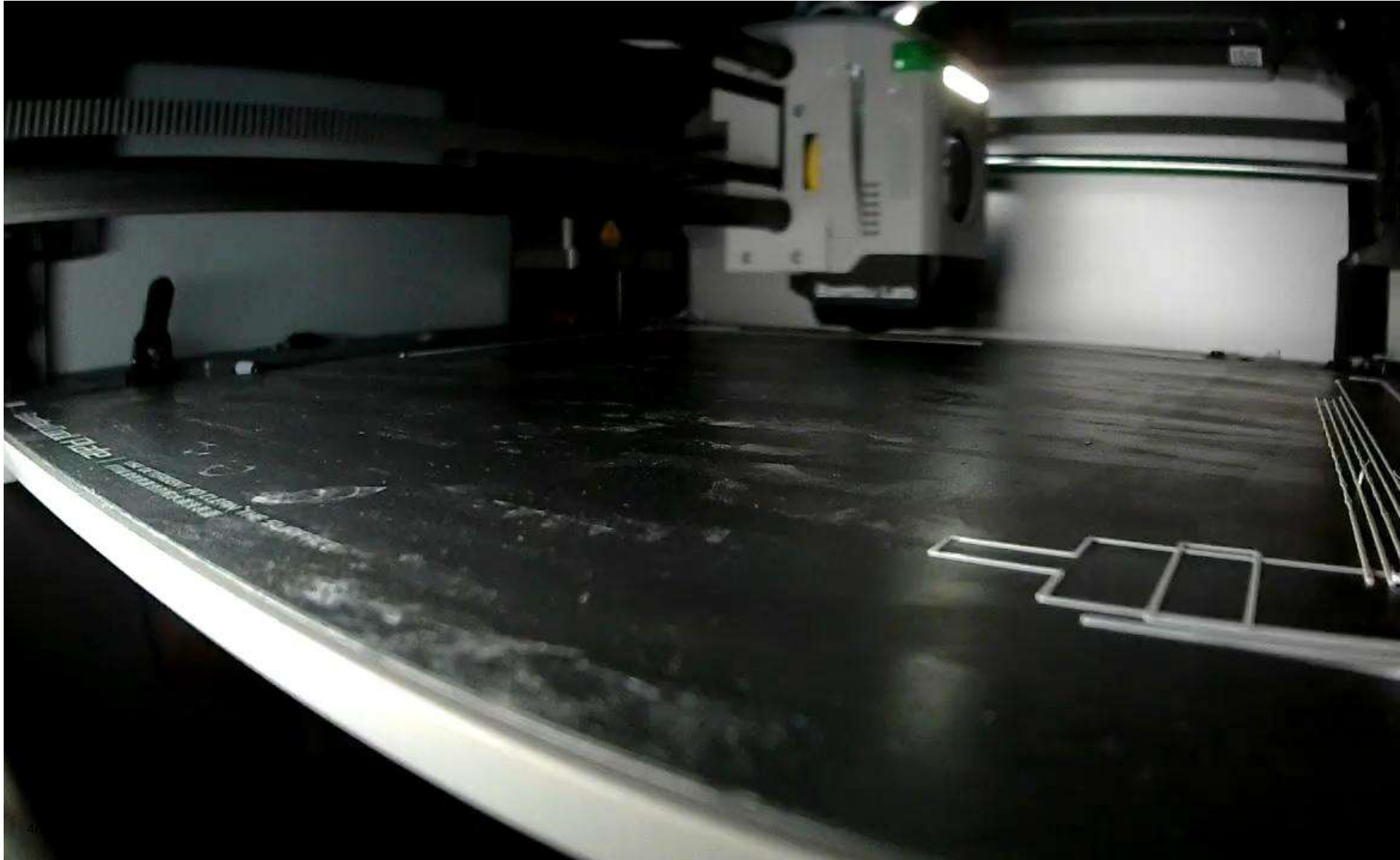
1. An additive manufacturing process that extrudes heated thermoplastic filaments to create an object layer by layer.
2. The most common and accessible form of 3D printing, particularly suitable for prototyping, functional testing, and some final product applications.

2.Resin Printing (SLA/DLP)

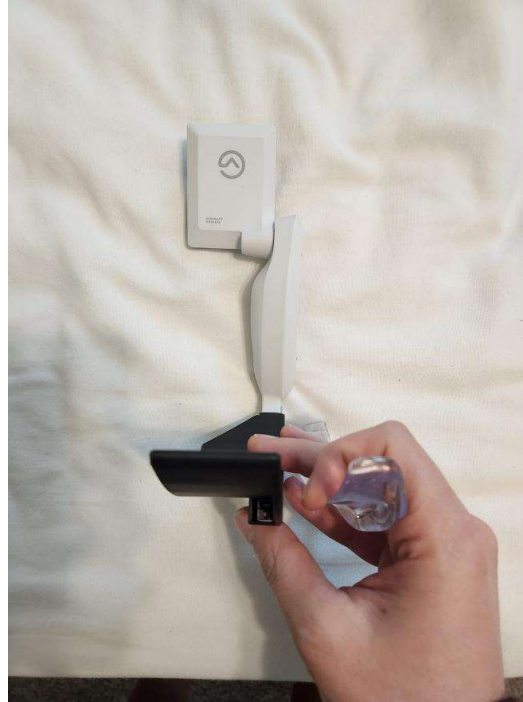
1. Uses a light source to cure liquid resin into hardened plastic in a layer-by-layer process to form objects.
2. Offers high resolution and detail, ideal for intricate designs, such as dental work, jewelry, and detailed prototypes.

Fusion Deposition Modeling (FDM)



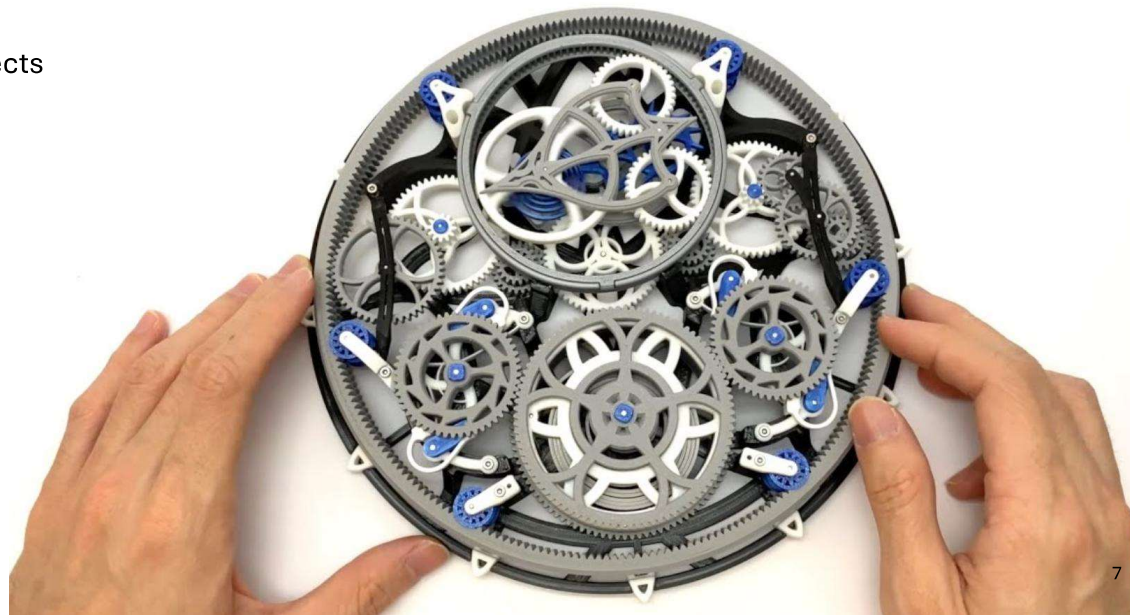


Rapid prototyping at your fingertips



Materials

- Filament is the strands of plastic that's melted by 3d printers into objects
 - 1.75 mm most common size
 - 1 kg rolls most common size
- PLA – bioplastic made of plant starch (corn, sugarcane)
 - The most commonly available
 - Deforms easily in heat
 - Strong/durable
 - Cheap - \$14-22
- TPU – flexible, can be used to make malleable, bendable objects
- ABS/ASA
 - Lego plastic
 - Strong, durable, high heat resistance



Materials

- Nylon
 - Strong, heat resistant
 - Expensive (\$60 +)
- Exotic/combination filaments
 - Polycarbonate
 - Filled filaments
 - carbon fiber, glass, wood, metal (copper etc)
 - Polypropylene



MatterHackers
[NylonX Carbon Fiber Filament - 1.75mm \(3kg\)](#)



\$335⁰⁰ (\$314.06 in bulk)

[Add to Cart](#)



YOU WOULDN'T
 DOWNLOAD A CAR



[10 COLORS/PATTERNS](#)

OVV3D Wood 3D Printer Filament Bundle, Wood PLA
 Filament 1.75mm Bundle, Wood Filament More Than 30%...

★★★★★ ~ 1,490

800+ bought in past month

\$35⁹⁹

\$34.19 with Subscribe & Save discount

Save 15% with coupon

✓prime One-Day

FREE delivery **Tomorrow**

🌱 Lower carbon delivery

What about Printers?



Important Notice

If the item is on Pre-sale/Pre-order, please refer to ETD in the order summary for delivery time.

H2D AMS Combo / Standard will be shipped around ETD: ship around May 07, 2025

Order summary



Pre-order

Ship around May 07, 2025

Bambu Lab H2D × 1

H2D AMS Combo / Standard

\$2699.00

Subtotal

\$2699.00

shipping 3 - 10 business days

\$80.00

Taxes

\$180.63

OHIO 5.75%

\$159.79

STARK 0.75%

\$20.84

Grand total

\$2959.63

Net Payment

\$2959.63 USD



1. Prusa i3 MK4

1. **Overview:** Latest model in the Prusa i3 series known for its reliability and high-quality prints.
2. **Key Features:** Improved extrusion system, auto-bed leveling, filament sensor.
3. **Build Volume:** 250 x 210 x 220
4. **Price:** Kit \$799, assembled \$1099

2. Bambu Lab P1P (X1C, H2D as alternatives)

1. **Overview:** A “newcomer” promising high precision and speed with innovative features.
2. **Key Features:** AI-enhanced printing, multi-material support, built-in camera.
3. **Build Volume:** 256 x 256 x 256
4. **Price:** \$600

3. Creality Ender 3

1. **Overview:** A popular choice for hobbyists, known for its affordability and modifiability.
2. **Key Features:** Large community support, heated bed, wide range of compatible materials.
3. **Build Volume:** 220 x 220 x 250mm
4. **Price Range:** Under \$200

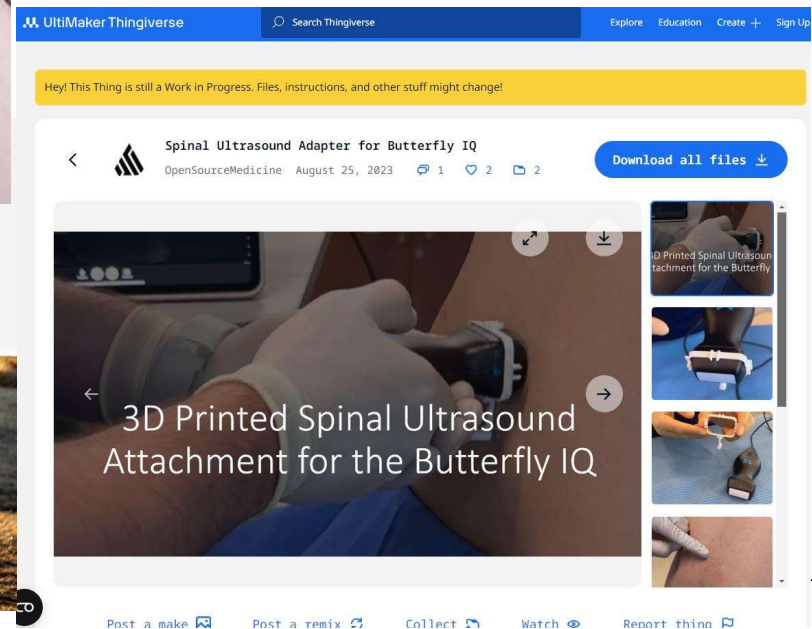
What about multiple color printing?



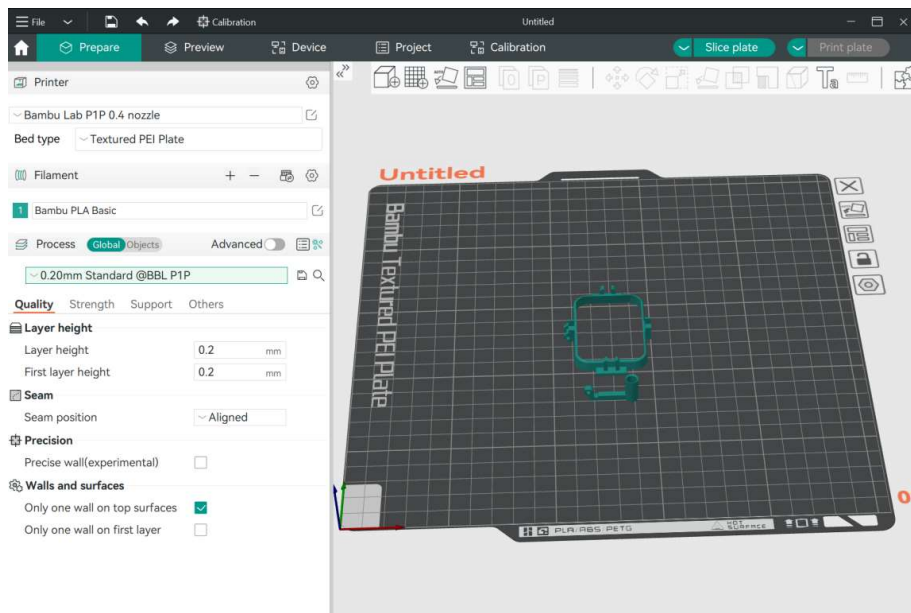
Finding Something to Print



- Downloaded from websites
 - Thingiverse.com
 - Cults3d.com
 - Printables.com
- 3D models can be designed using software
 - Fusion 360, TinkerCad
- 3D models come in various formats
 - STL, and 3MF



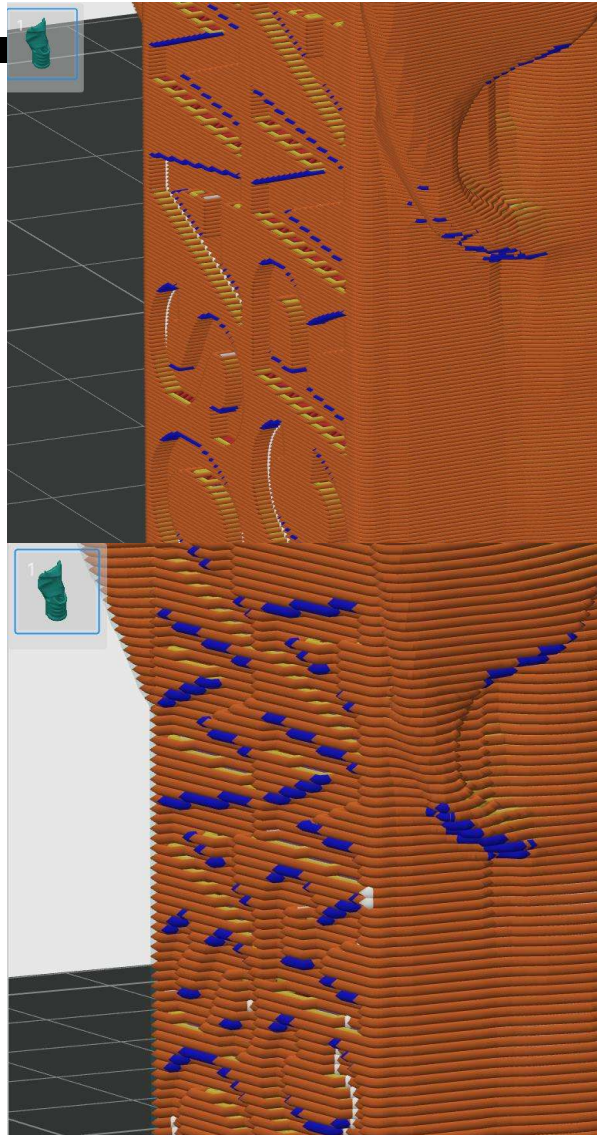
Slicing



- “Slicers”: Programs that tell the 3D printer how to print a 3D model
- Many slicers available
 - Cura
 - PrusaSlicer
 - BambuSlicer
 - OrcaSlicer
- Variables such as strength, model density, detail level can all be adjusted in the slicer
- After customizing the settings for your print, the program will “slice” the model
 - Develops step by step instructions for the printer:
 - What pattern to lay down plastic
 - How many layers of plastic to stack
 - How hot to heat the nozzle
 - What speed to move the print head
 - How to cool down the melted plastic as it prints

Slicer basics: Layer Height

Strength vs detail



Quality Strength Support Others

Layer height

Layer height 0.2 mm

First layer height 0.2 mm

Seam

Quality Strength Support Others

Layer height

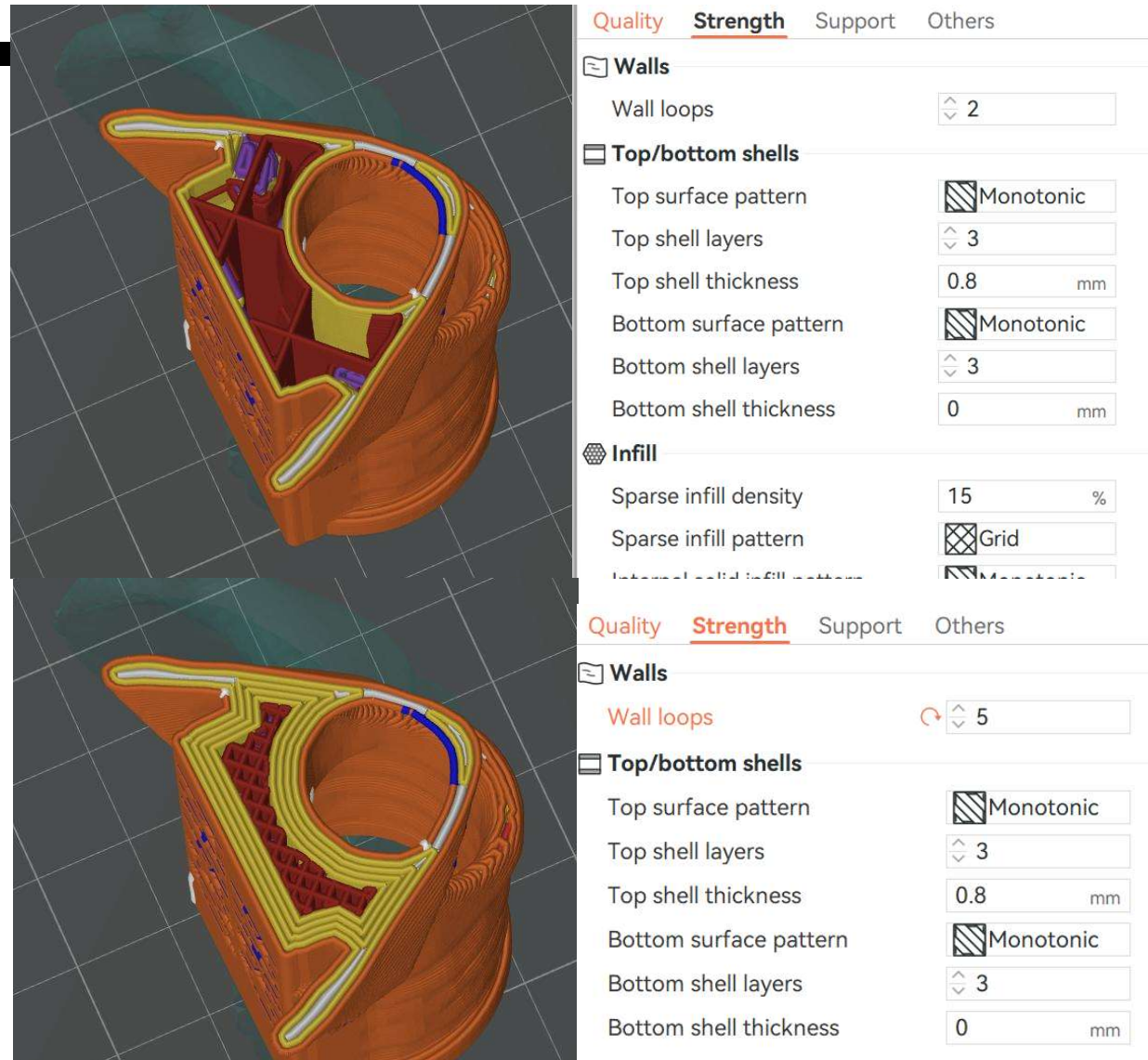
Layer height 0.56 mm

First layer height 0.4 mm

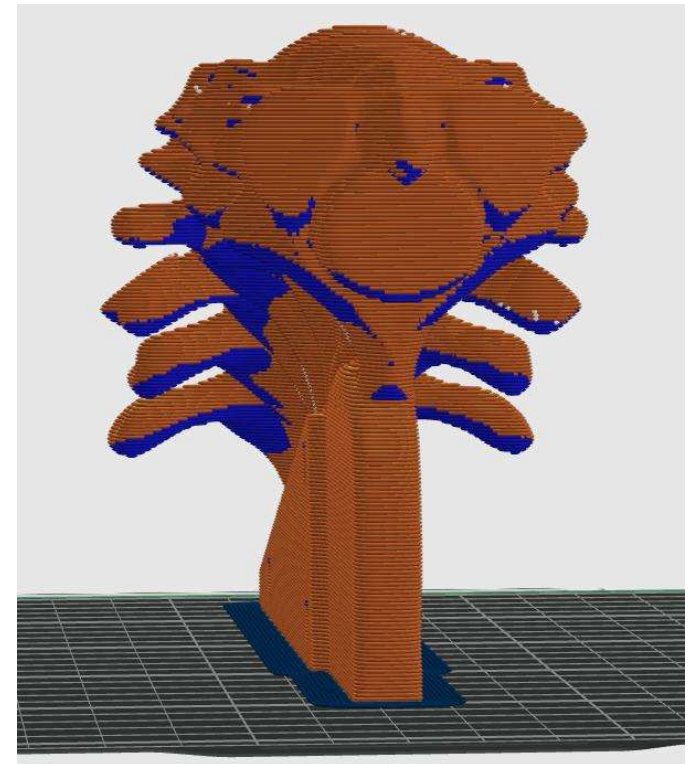
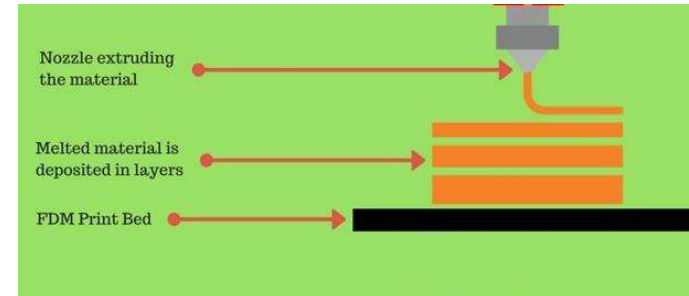
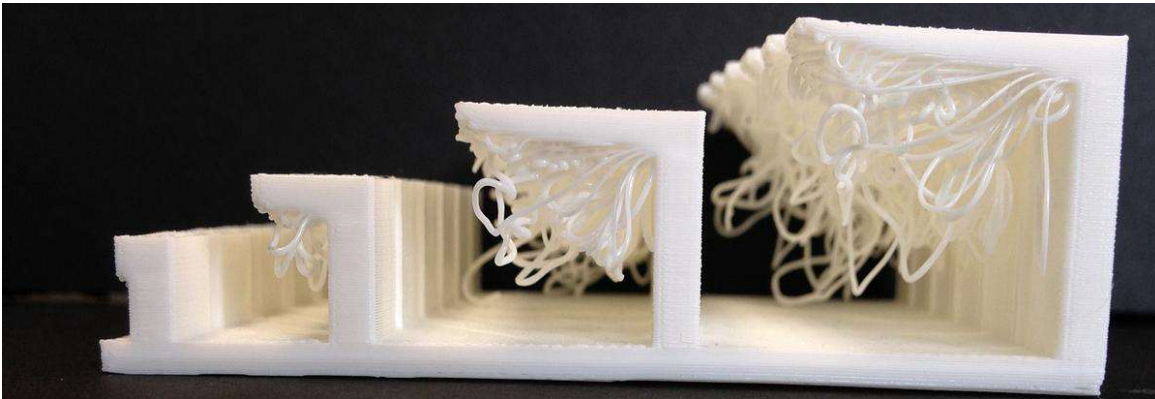
Seam

Slicer Basics: Strength

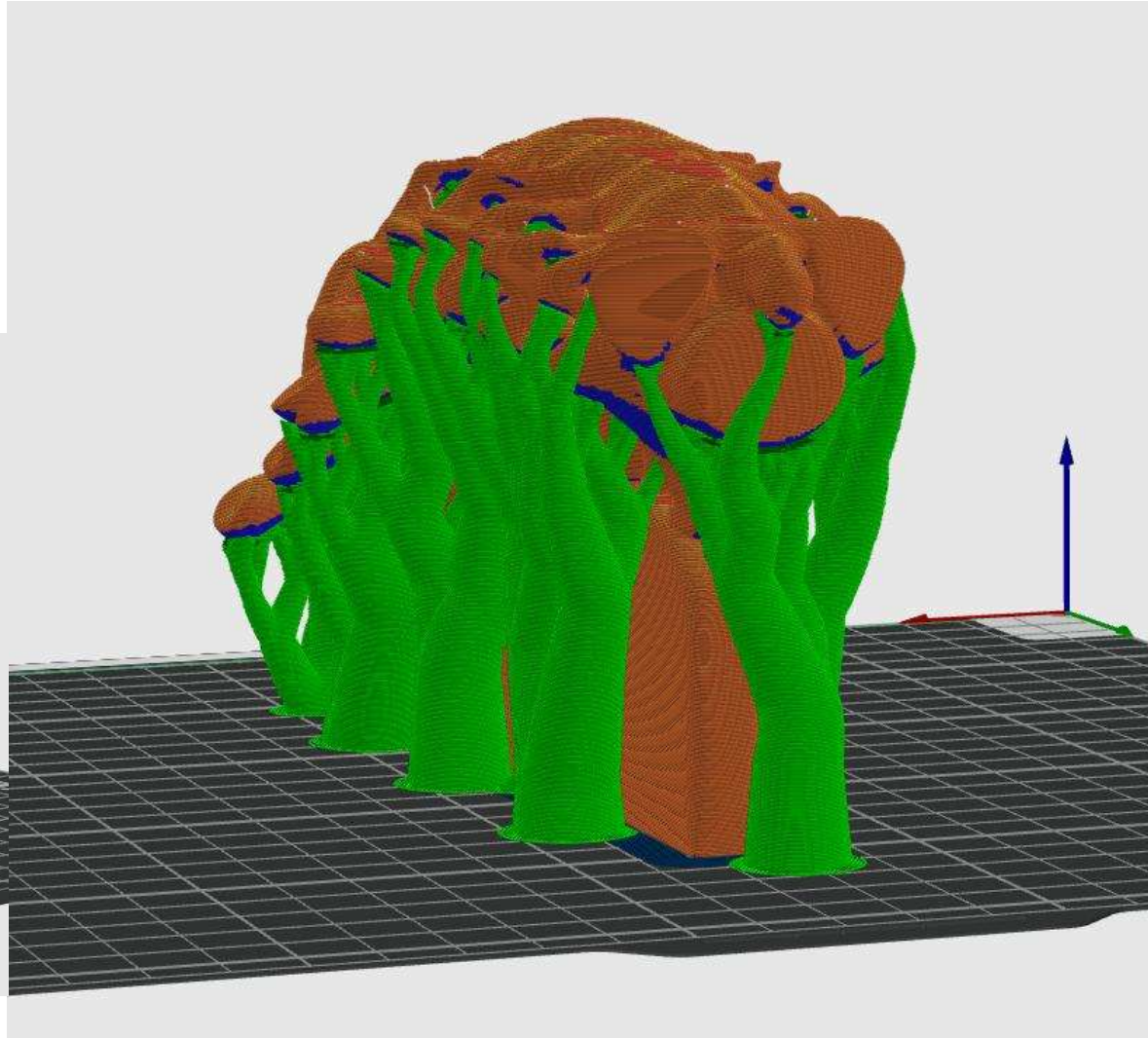
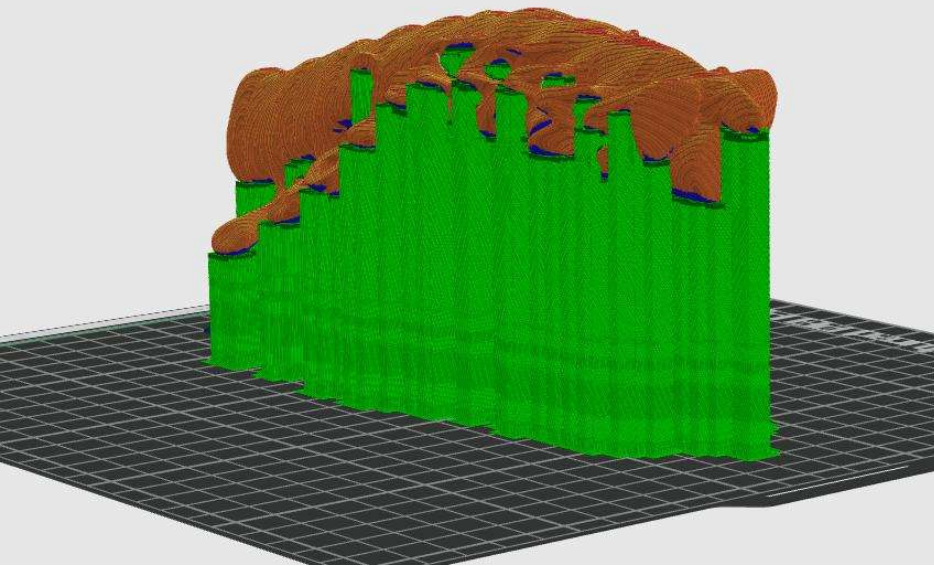
- Walls: how many perimeters of plastic make the edge of the model
- Infill: how solid the model is
- Decisions about these settings depend on purpose of the model



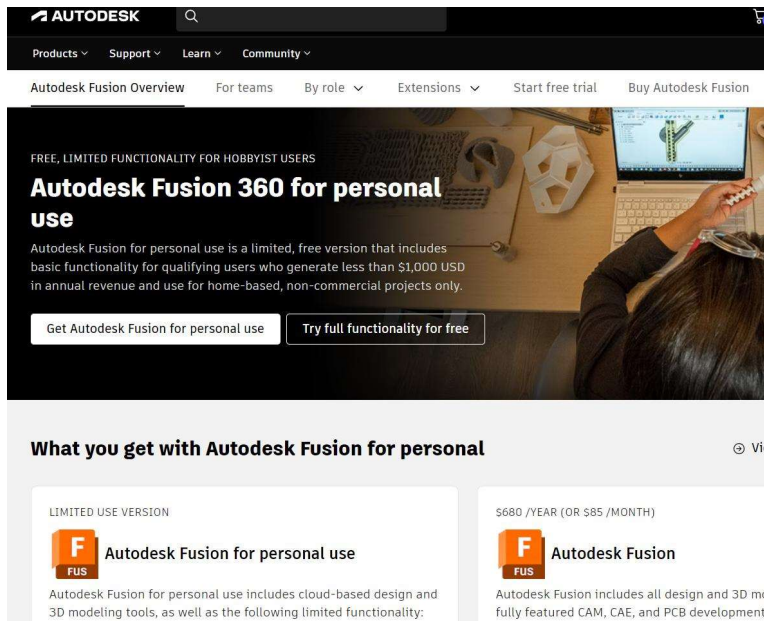
Slicer Basics: Orientation and Overhangs



Slicer Basics: Supports



What about designing my own models??



The image shows the Autodesk Fusion 360 for personal use webpage. The header includes the Autodesk logo and navigation links for Products, Support, Learn, and Community. The main content area features a large image of a person working on a laptop with a 3D model of a mechanical part. Below this, there is a section titled "Autodesk Fusion 360 for personal use" with a description of the limited functionality version. A button labeled "Try full functionality for free" is visible. At the bottom, there is a comparison table between the limited use version and the full version of Autodesk Fusion.

AUTODESK

Products Support Learn Community

Autodesk Fusion Overview For teams By role Extensions Start free trial Buy Autodesk Fusion



FREE, LIMITED FUNCTIONALITY FOR HOBBYIST USERS

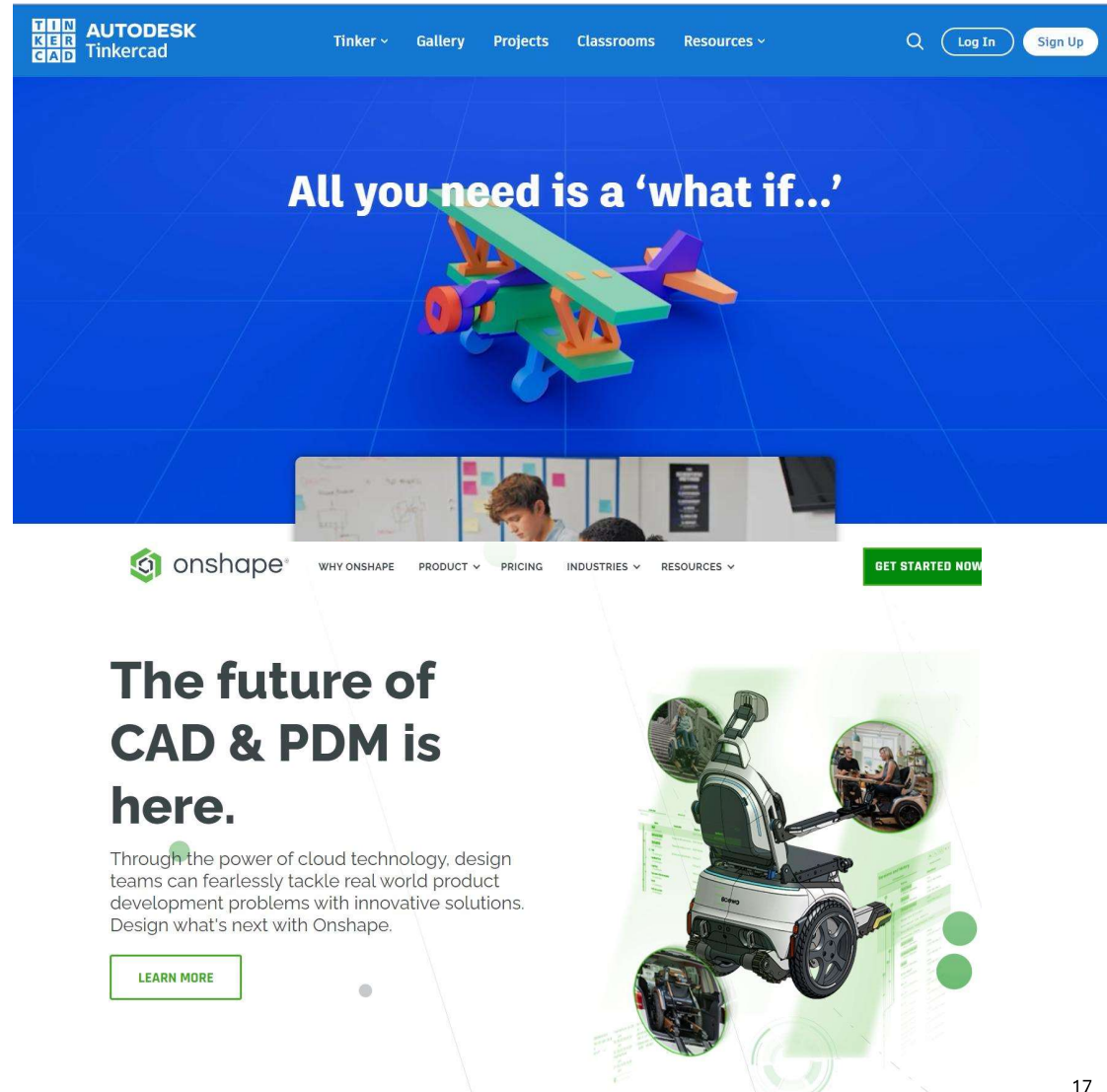
Autodesk Fusion 360 for personal use

Autodesk Fusion for personal use is a limited, free version that includes basic functionality for qualifying users who generate less than \$1,000 USD in annual revenue and use for home-based, non-commercial projects only.

Get Autodesk Fusion for personal use Try full functionality for free

What you get with Autodesk Fusion for personal

LIMITED USE VERSION	\$680 /YEAR (OR \$85 /MONTH)
 Autodesk Fusion for personal use Autodesk Fusion for personal use includes cloud-based design and 3D modeling tools, as well as the following limited functionality:	 Autodesk Fusion Autodesk Fusion includes all design and 3D modeling tools, as well as the following full featured CAM, CAE, and PCB development



The image shows the Onshape website header and main content. The header includes the Onshape logo and navigation links for Tinker, Gallery, Projects, Classrooms, and Resources. The main content area features a large blue banner with the text "All you need is a 'what if...'" and a 3D model of a mechanical part. Below this, there is a section titled "The future of CAD & PDM is here." with a description of Onshape's cloud-based design and manufacturing capabilities. A button labeled "LEARN MORE" is visible. On the right side, there is a 3D model of a robot or vehicle with various components highlighted.

TINKER CAD **AUTODESK** Tinkercad

Tinker Gallery Projects Classrooms Resources

Log In Sign Up

All you need is a 'what if...'

onshape

WHY ONSHAPE PRODUCT PRICING INDUSTRIES RESOURCES

GET STARTED NOW

The future of CAD & PDM is here.

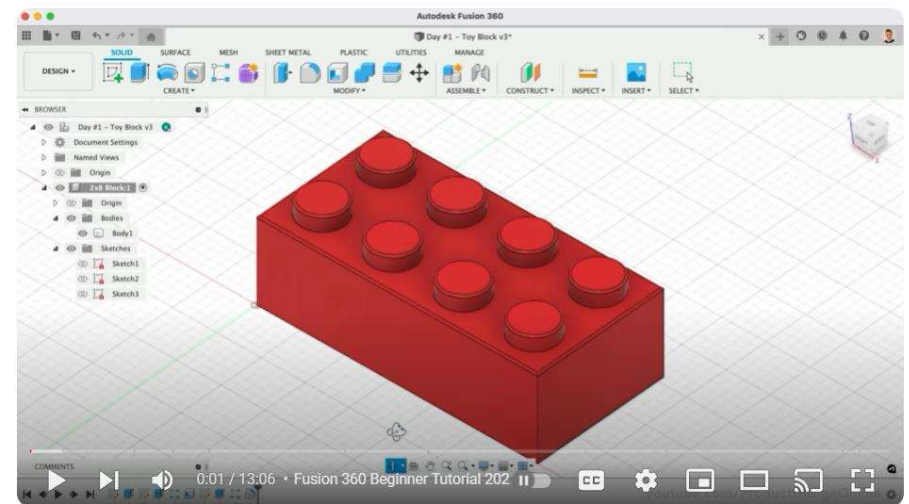
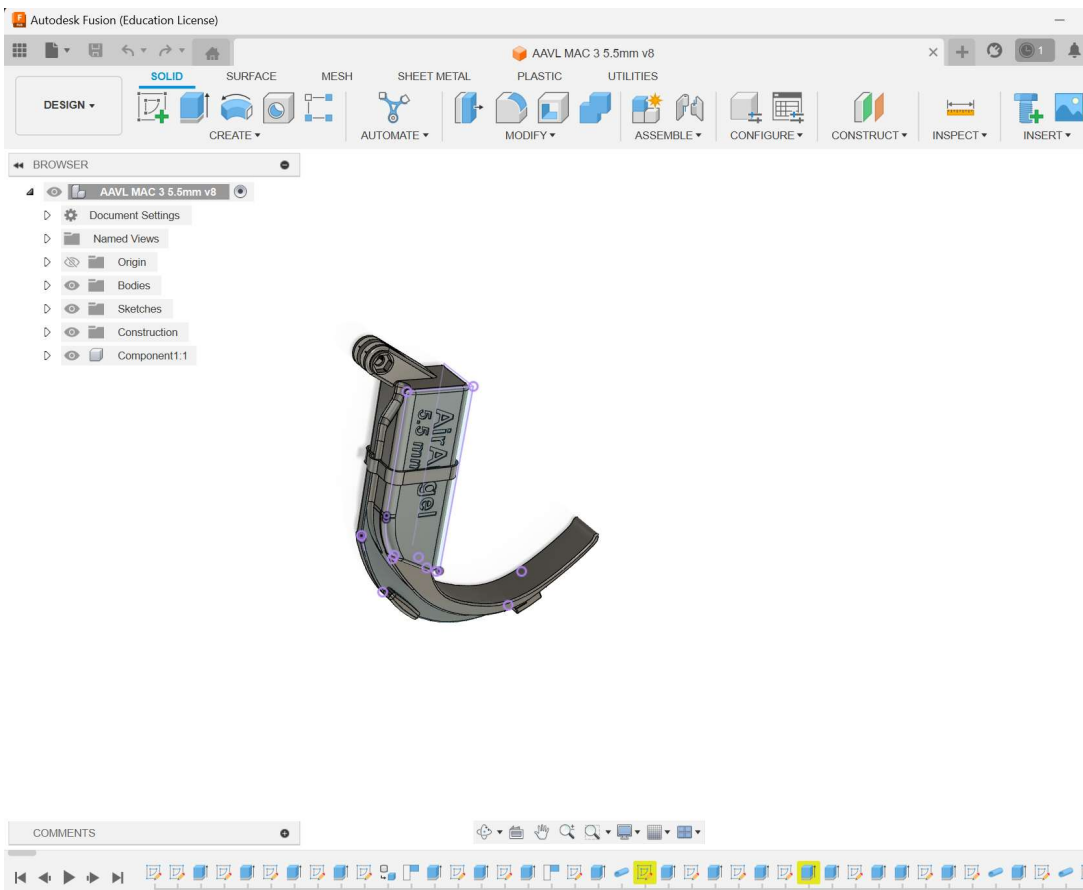
Through the power of cloud technology, design teams can fearlessly tackle real world product development problems with innovative solutions. Design what's next with Onshape.

LEARN MORE

Sample Footer Text

My Favorite? Fusion!

- Free for personal use
- Powerful design capabilities
- Tons of YouTube tutorials
- It's like learning a language – it takes time and effort



Day 1 of Learn Fusion 360 in 30 Days for Complete Beginners! - 2023 EDITION



Stop! Example Time!

(Fusion 360 model design and slice)



Welcome to The AirAngel Project

Created for developing countries, medical missions, and simulation training.



- \$30-50 to make
- Wireless, wired, dedicated monitor
- For low resource/developing countries

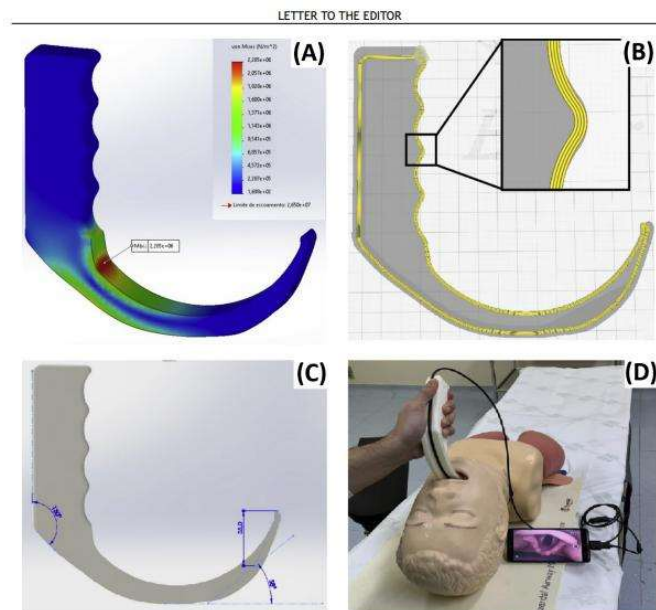


Figure 1 (A) Statistical analysis of tension; (B) Cross-section of printing layers; (C) Main angles and distances; (D) Video laryngoscope test on training dummy airway.



Trends in Anaesthesia and Critical Care
Volume 40, October 2021, Pages 35-40



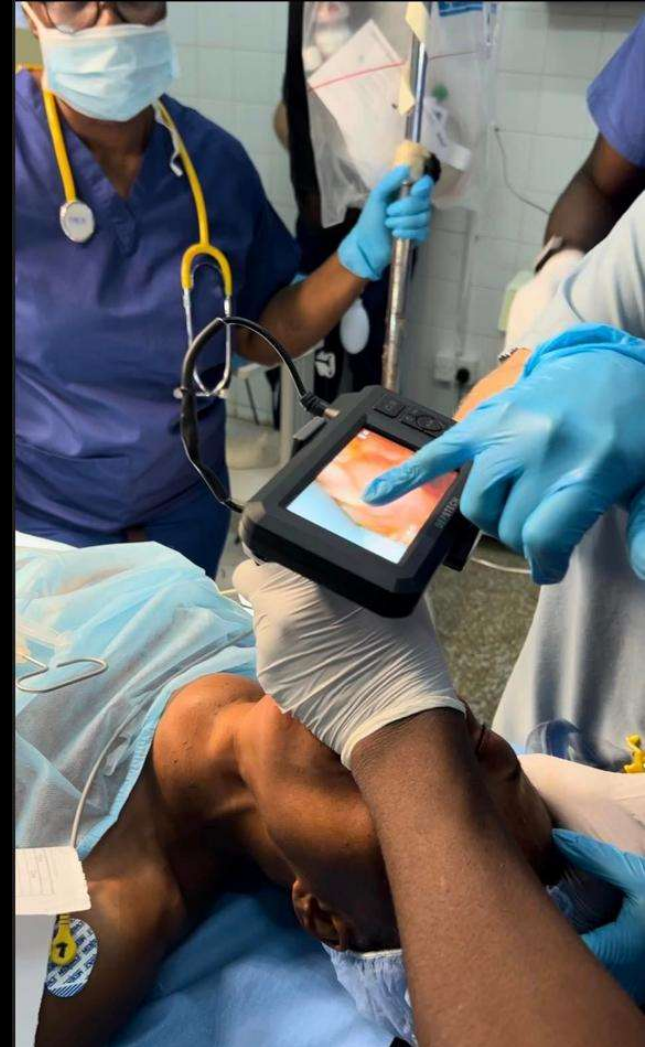
Comparison of a commercial 3D fabricated laryngoscope (Airangel ®) with a widely-used video laryngoscope (Glidescope®): Randomized controlled cross-over study

The manuscript has been presented 16th Turkish Emergency Medicine Congress (oral presentation) at the 20–22 November 2020, TATKONONLINE, Turkey

Ali Kaan Ataman^a ✉, Emel Altıntaş^b 👤 ✉

Show more ▼

+ Add to Mendeley 🔗 Share 🗨 Cite



AirAngel Project Presents

The AirAngel V3 User Manual



Eric Kramer DNAP, CRNA, FNP-C

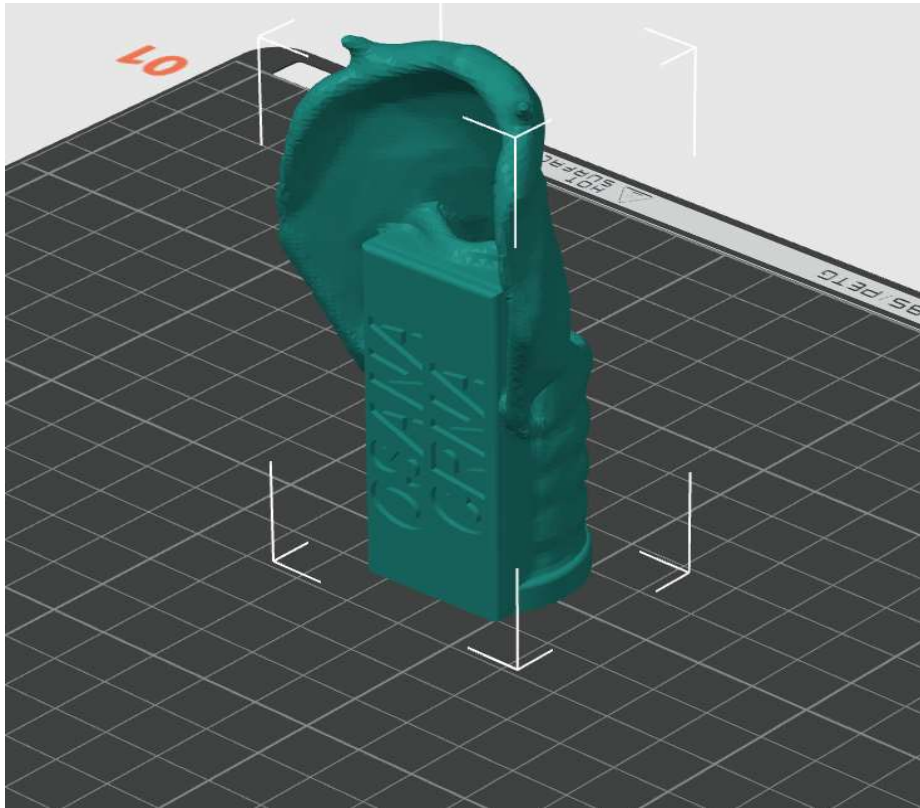
- Research studies to be done:
 - What method is best to sterilize blades?
 - Ideally, hospital would have printer and they'd be one time use
 - Measure bacteria content after sterilization procedure
 - Do blades absorb fluid after soaking?
 - Blades weighed after soaking
 - Ideally, would test strength as well
- Laryngoscope blades can be disinfected with:
 1. 90% isopropyl alcohol
 2. 96% ethanol
 3. Cidex,
 4. Clorhexidine scrub
 5. 5000 ppm bleach solution (high level disinfection):
 - 1 cup (250ml) 5% household bleach mixed with 9 cups (2250 ml) of water
 - A. Wear gloves while handling solution
 - B. Leave solution on blade for minimum of one minute. 10 minutes of contact with disinfectant for high level disinfection is recommended. Submerging with a timer is acceptable
 - C. Thoroughly rinse with water after disinfecting, let dry
 - D. Once mixed, bleach solution is good for 24 hours. Mix new solution each day

Cricothyrotomy



-
- Motor memory is key
 - Fine motor degrades with high stress
 - Any procedure that's not practiced will be difficult to perform under pressure
 - Is it worth it if it will save one life in your career?





4/28/2025

How to practice bougie-blade cricothyrotomy with a 3D printed cric

24

Brachial Plexus Model



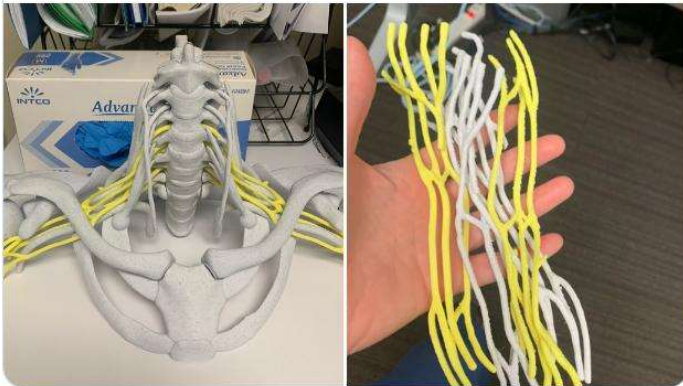
Tobi Hunter @TobiHunterDNP · Feb 15, 2023

This **3D printed brachial plexus** is beyond cool! @EMARIANOMD can we print one?



Catherine Curtin @ccurtinprs · Feb 14, 2023

Great day in clinic my patient gave me a 3-D printed plexus!!! Also a bunch of pocket plexi so you are always ready for whatever comes your way 😊 #brachialplexus #nervenerds

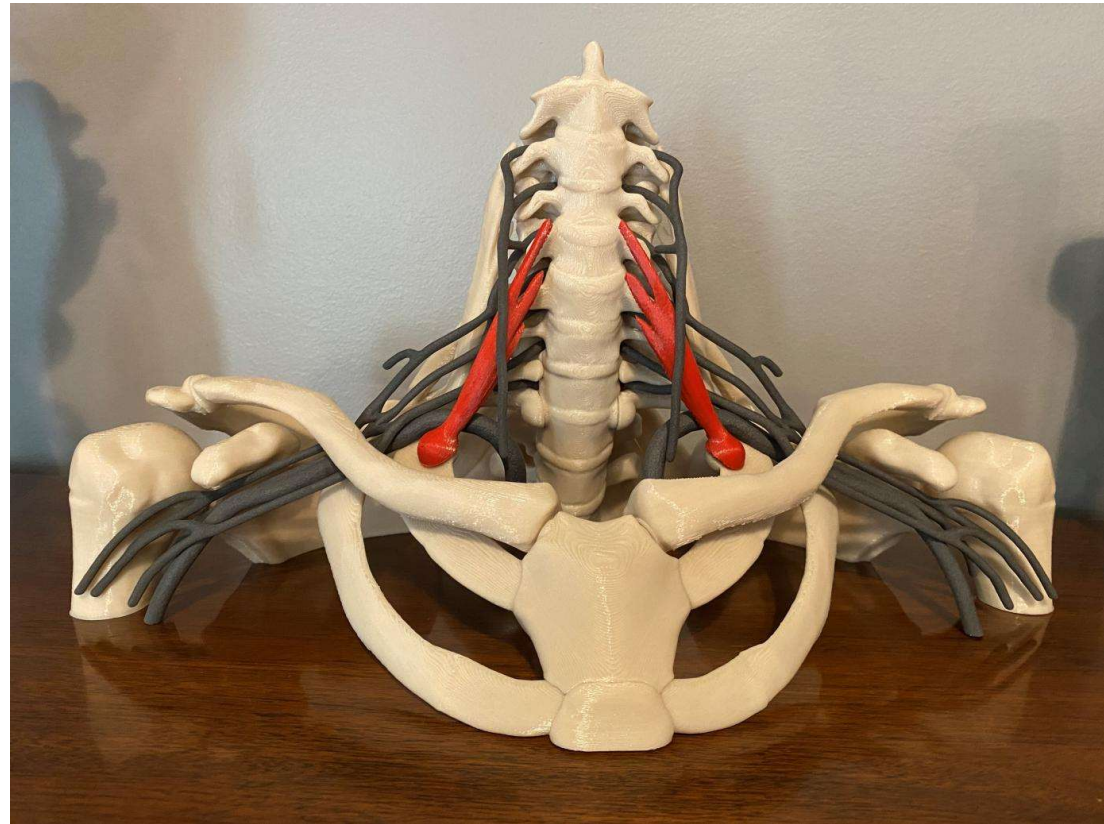


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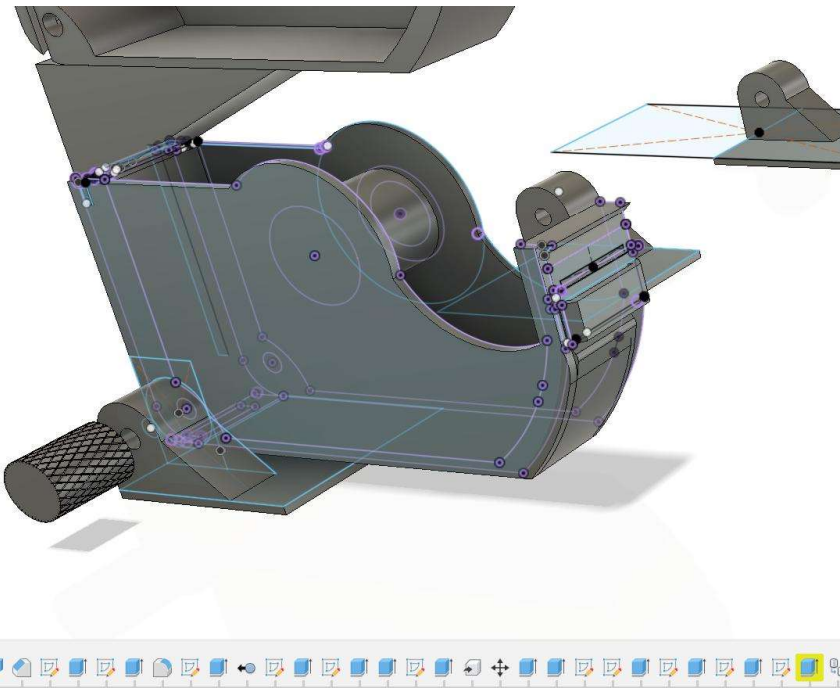
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1.1K



Sample Footer Text

Label Dispensers



Don't give up.

