



ENG-A1009 – Practical Work Training with 3D Printers

Instructor

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Schedule – 06.05.2024

9:15 – 11:45 Lecture: Brief background on 3D printing and different technologies > closer look at material extrusion, digital and physical workflow, design guidelines & resources to help you achieve your printing needs and visions

Digital steps: Cura demo

Practical training will take place in 4 sessions as follows:

Session 1 will be held on Monday 06.05 from 13:00 to 14:00.

Session 2 will be held on Monday 06.05 from 14:00 to 15:00.

Session 3 will be held on Monday 06.05 from 15:00 to 16.00.

Session 4 will be held on Monday 06.05 from 16.00 to 17.00.

@ADDLab: Ultimakers in practice, starting a print, filament change, bed leveling, troubleshooting problems

Learning goals & outcomes

- A “surface-scrape” introduction to the world of 3D printing
- What is 3D printing – what could *you* do with it – the possibilities?
- Digital and physical steps of 3D printing
- Hands-on use of the Cura slicing software and Ultimaker 3D printers

For 1 ECTS credit : Small assignment given at the end of the lecture

NOTE: The access to an online calendar to schedule the ADDLAB 3D printers for personal projects is **ONLY given to those who have gained 1 ECTS.**

What is 3D printing and what to do with it?

3D printing ~ Additive Manufacturing

“Additive manufacturing is a process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive and formative manufacturing methodologies.”

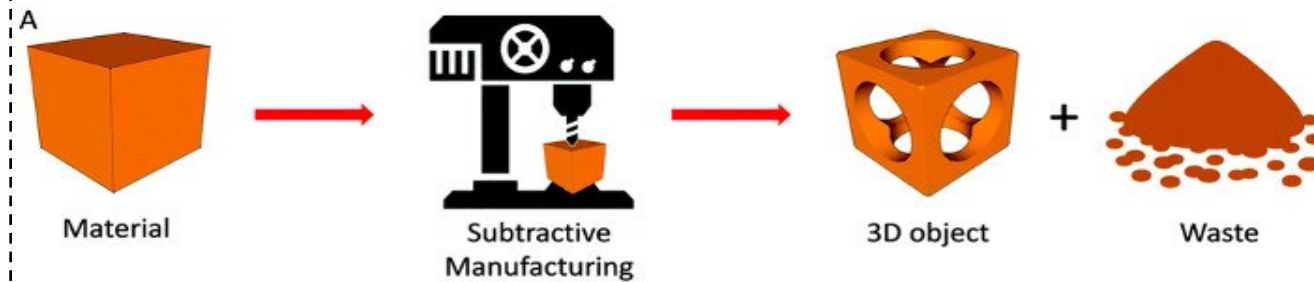
3D printing ~ Additive Manufacturing (AM)



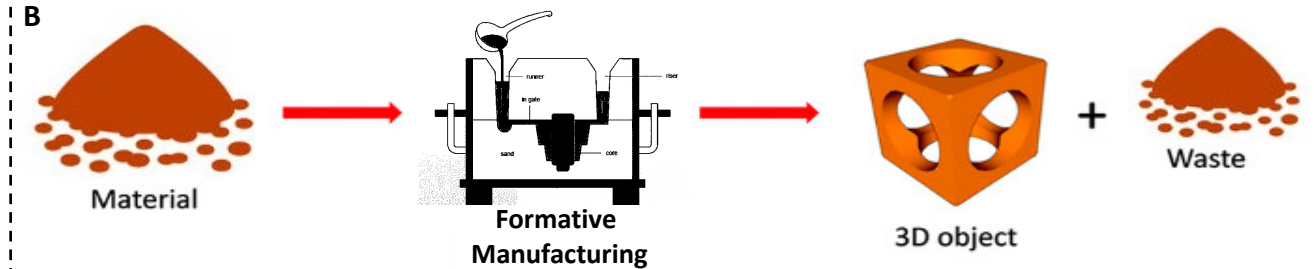
Manufacturing methodologies

Conventional

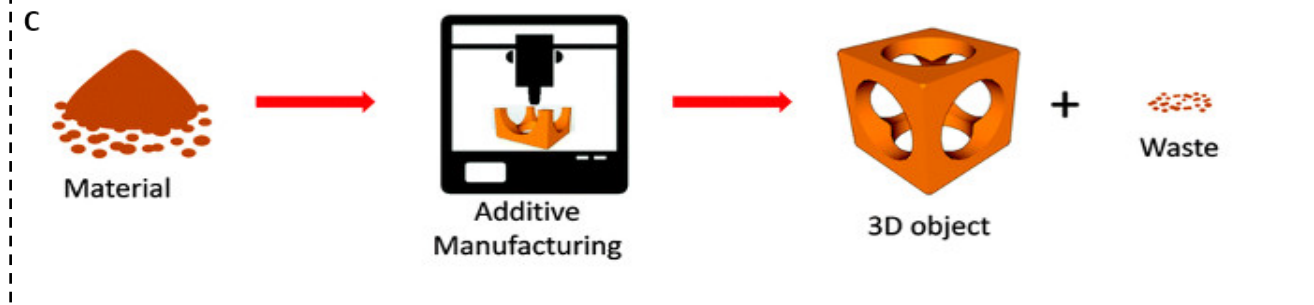
Subtractive
Manufacturing



Formative
Manufacturing



Additive
Manufacturing



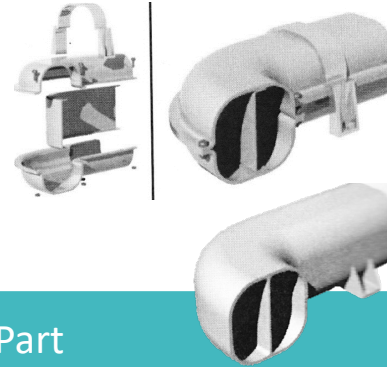
Advantages of 3D Printing



Design freedom



Customization



Part consolidation



Instant assemblies



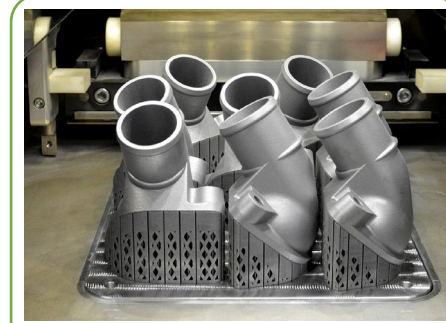
Sustainable production



Faster manufacturing cycles

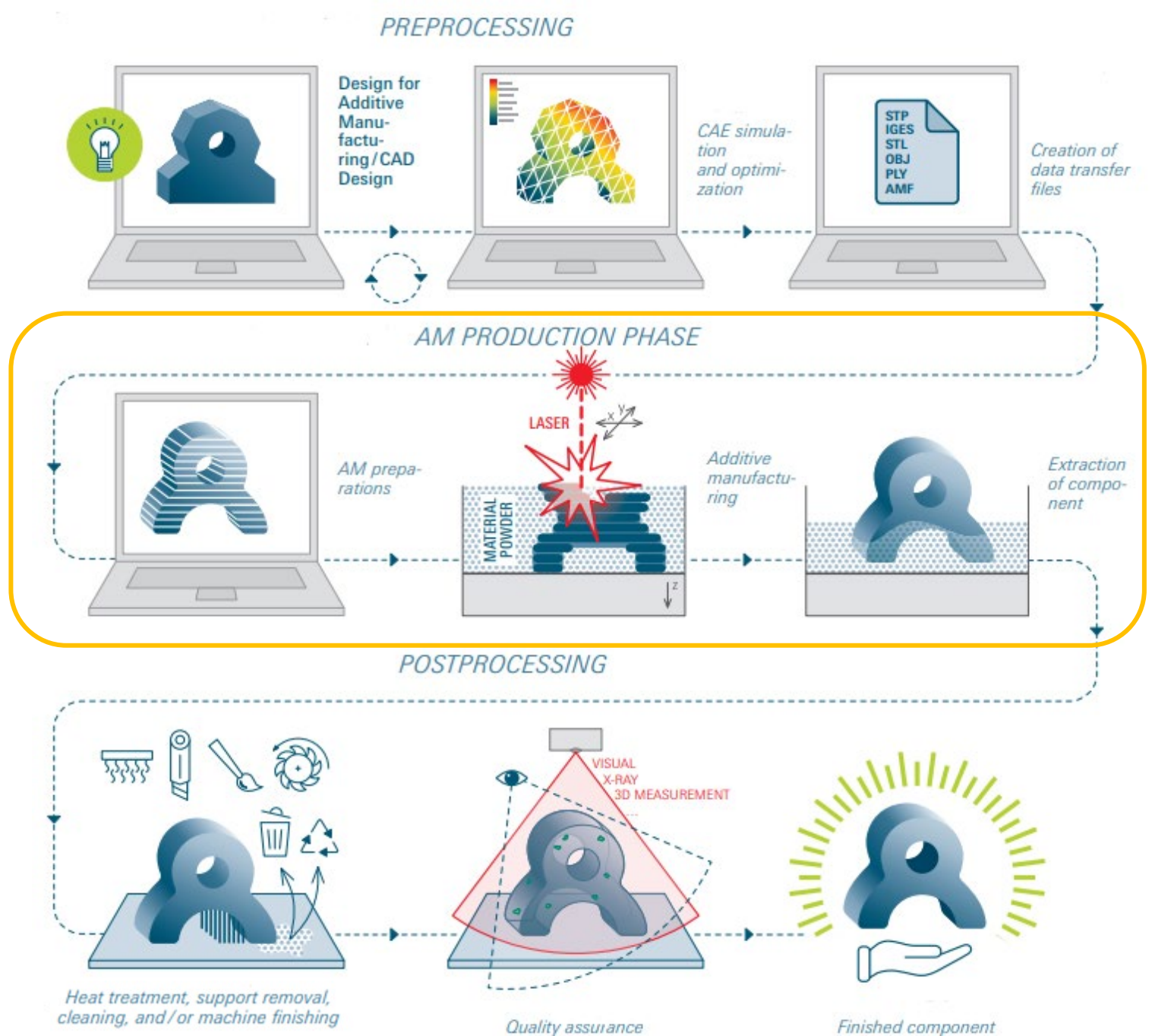


Lightweighting



On-demand manufacturing

3D printing – digital to physical



ADDITIVE MANUFACTURING TECHNOLOGIES



POLYMER



PBF

Powder Bed Fusion*

Fused with agent + energy

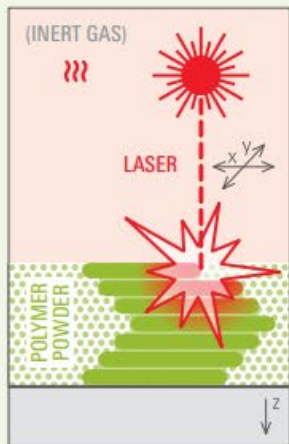
Fused with laser

MJF

Multi Jet Fusion

SLS

Selective Laser Sintering



MEX

Material Extrusion*

Material extrusion Filament

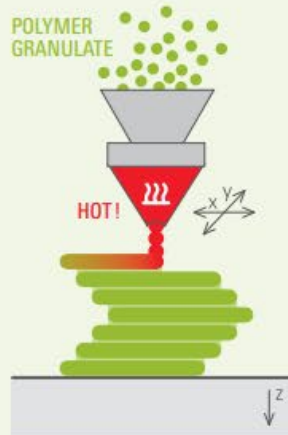
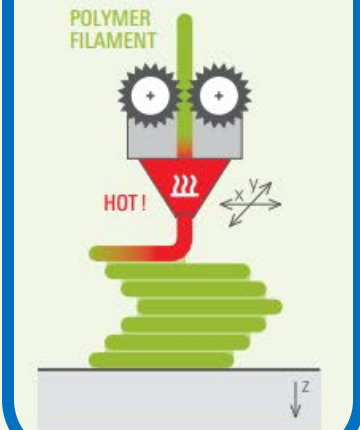
Material extrusion Granulate

FDM

Fused Deposition Modeling

PEM

Pellet Extrusion Modeling



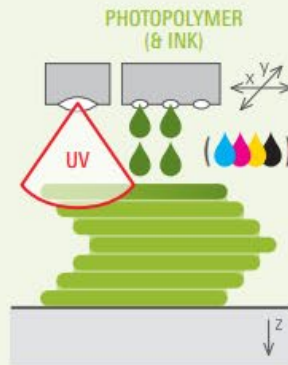
MJT

Material Jetting*

Cured with UV light

MJ

Material Jetting



VPP

Vat Photopolymerization*

Cured with laser

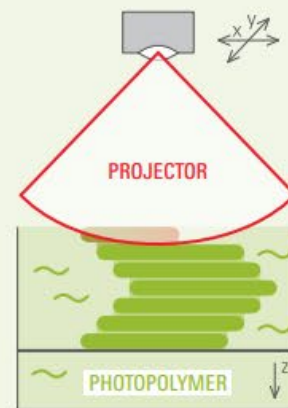
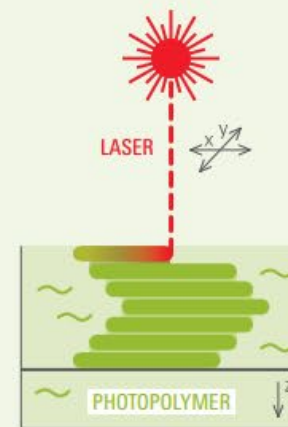
Cured with projector

SLA

Stereo Lithography

DLP

Direct Light Processing





PBF

Powder Bed Fusion*

Fused with laser

SLM

Selective Laser Melting

Fused with electron beam

EBM

Electron Beam Melting



DED

Directed Energy Deposition*

Fused with laser

LENS

Laser Engineering Net Shape

Cold contact welding

MPA

Metal Powder Application

Fused with electric arc

WAAM

Wire and Arc Additive Manufacturing



MEX

Material Extrusion*

Green part is printed to be sintered afterwards

FDM

Fused Deposition Modeling



BJT

Binder Jetting*

Joined with bonding agent to be sintered afterwards

BJ

Binder Jetting



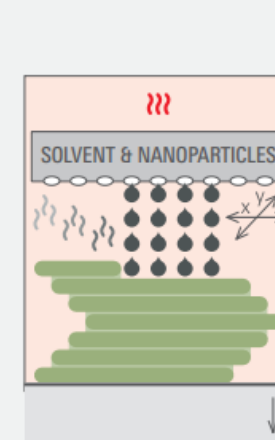
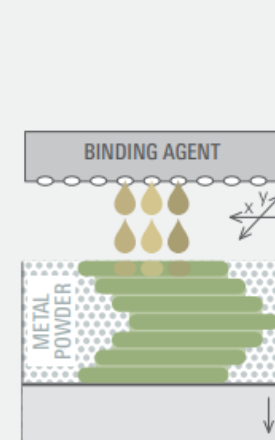
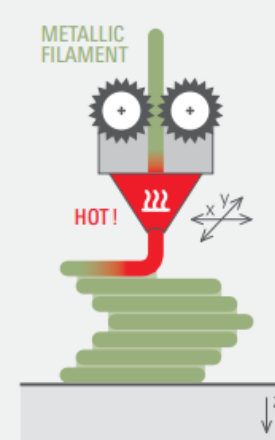
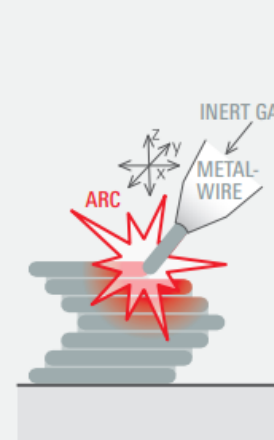
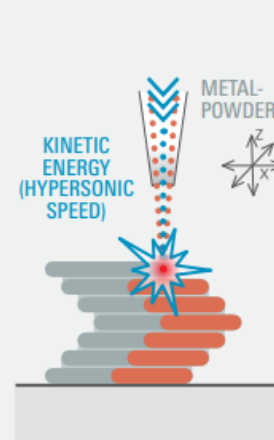
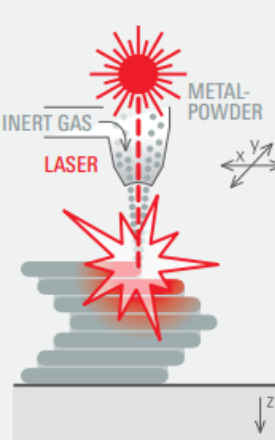
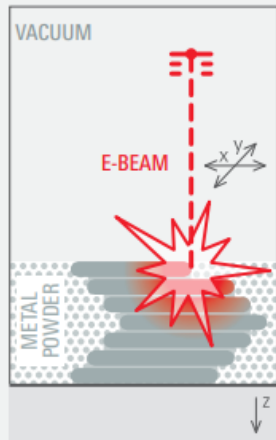
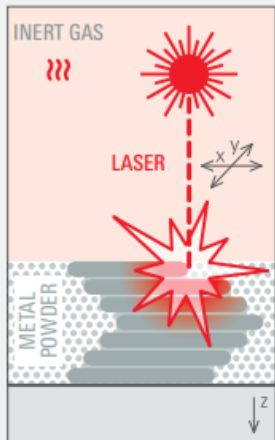
MJT

Material Jetting*

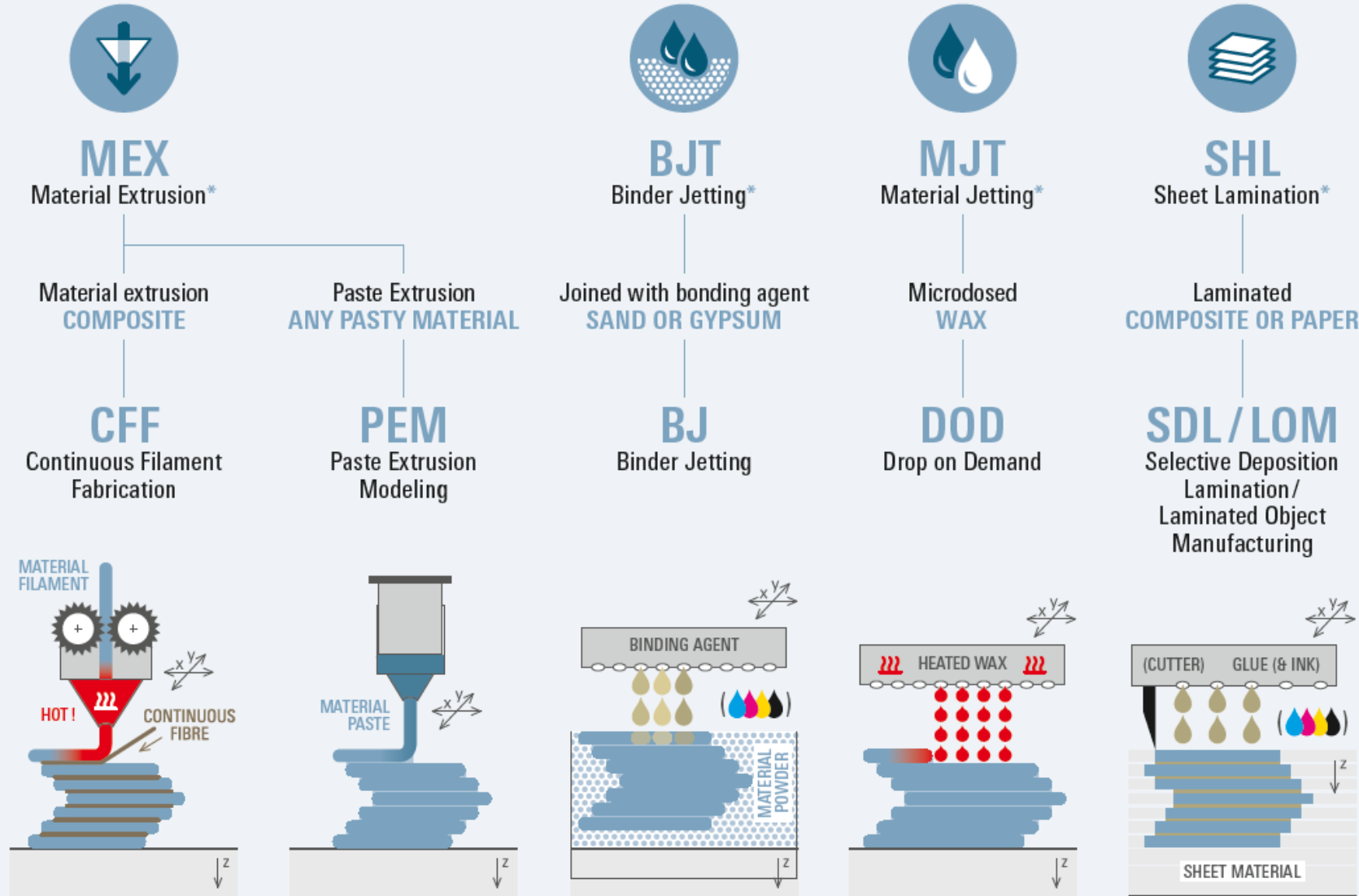
Cured with heat to be sintered afterwards

NPJ

Nano Particle Jetting



OTHER MATERIALS



Photopolymerization

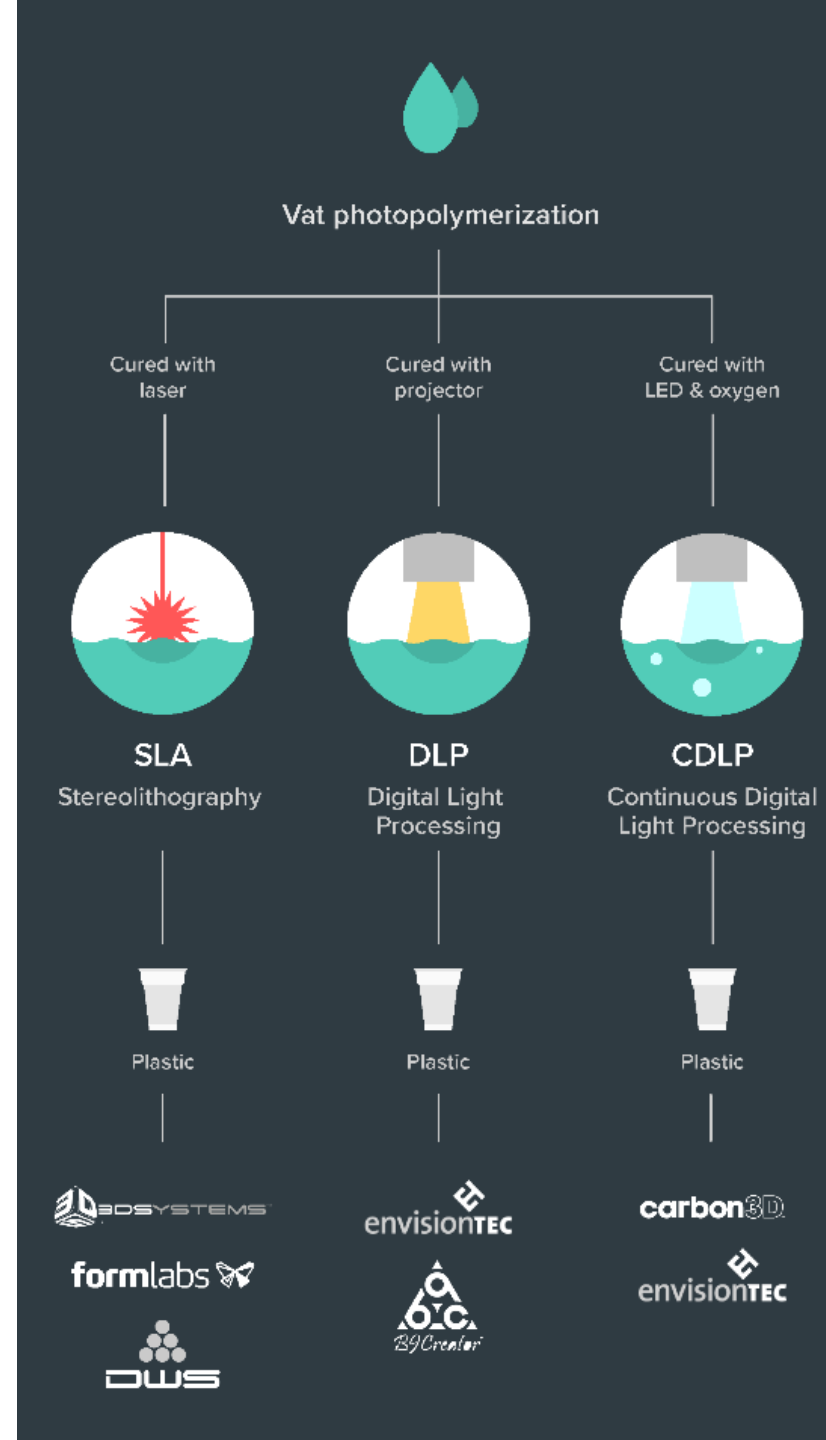
Video 01

Liquid photopolymers solidified with UV-light

The first 3D Printing technology (~1984)

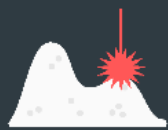
Mostly used for prototyping and investment casting

Often poor mechanical properties and parts may degrade in prolonged UV light without protective coating

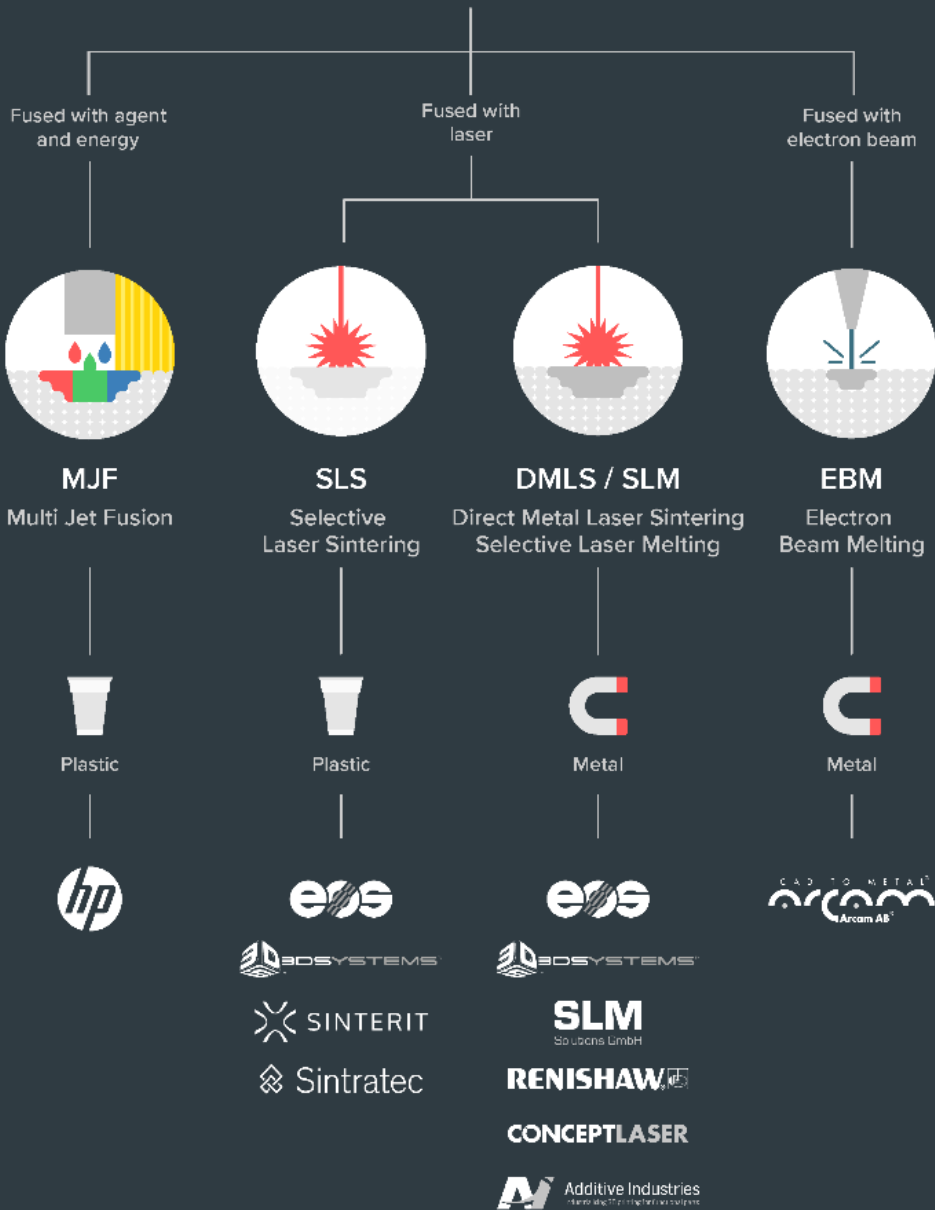




**First Commercially Successful
Stereolithography Machine,
Model SLA-1, 1987,
Chuck Hull – 3D Systems**



Powder bed fusion



Powder Bed Fusion

Video 02

For plastics (MJF / SLS) and metals (DMLS / SLM / EBM)

Material in powder format

High-power, focused laser melts material layer-by-layer

Industrialized technology, end-use products

Parts have good mechanical properties

EOS M290 – behold!



<http://cam.usc.edu/>

Material Jetting

Or Polyjet, [video 03](#)

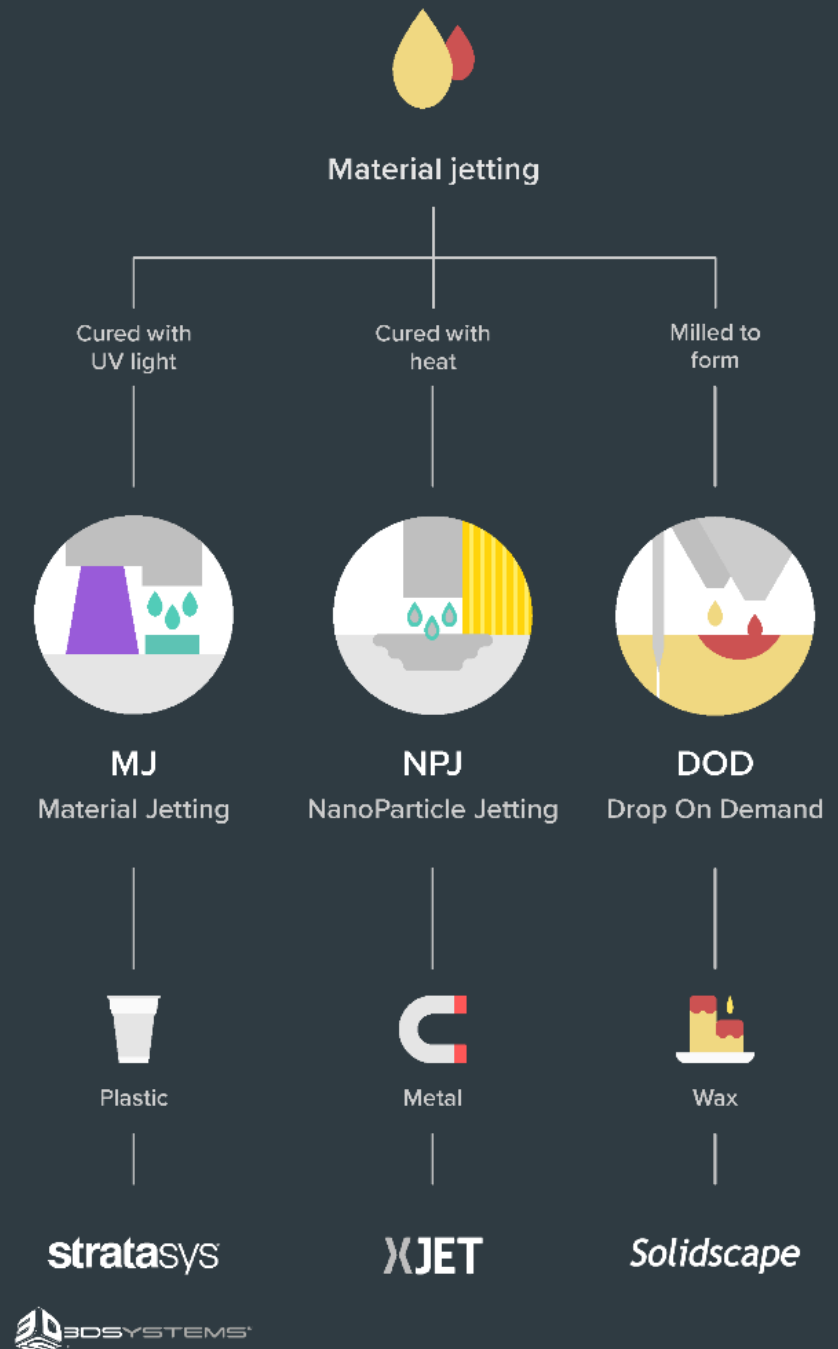
A cousin to photopolymerization : inkjet (2D printing tech) heads are used to drop small photopolymer droplets on the build platform which are then cured with a passing UV-light

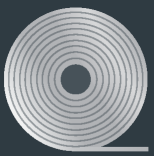
Multi-material possibilities

Very good resolution and fine features

Again, poor mechanical properties and parts degrade with UV

Used for prototyping, medical models, and research





Direct energy deposition

Fused with laser

Fused with electron beam



LENS

EBAM

Laser Engineering
Net Shape

Electron Beam
Additive Manufacturing



Metal



Metal

OPTOMECH

SCIARKY INC

Directed Energy Deposition (DED)

[video 04](#)

Powder or wire fed and melted with a laser, electron beam or a plasma arc

Poor surface finish, machining often required

Large components

Repairs of broken parts

So..., what to do with all
of this ? video_05

Simple, (sometimes) useful everyday objects

Shoe Support



Shoe Support (Source: Mickapouel, via Thingiverse)

Self-Watering Planter



Houseplants dying from neglect? NEVER AGAIN. Put your plants in this self-watering planter, and your conscience will remain clear. Perfect for kitchen herbs, where you can make them last up to a month. Re-potting in this natty device.

Who made it: [Parallel Goods](#)

Where to download it: [Cults3D](#)

Toothpaste Tube Squeezer



Squeeze every last drop of toothpaste from the tube with this tube squeezer. It prints in three separate parts, and is wide enough to accommodate most tubes on the market. Not only a cool thing, but also something to keep your breath minty fresh.

Who made it: [Justin Otten](#)

Where to download it: [Thingiverse](#)

Bottle Opener and Cap Gun



Bottle Opener and Cap Gun (Source: 3Deddy, via Thingiverse)

Need a custom tool onboard the International Space Station?

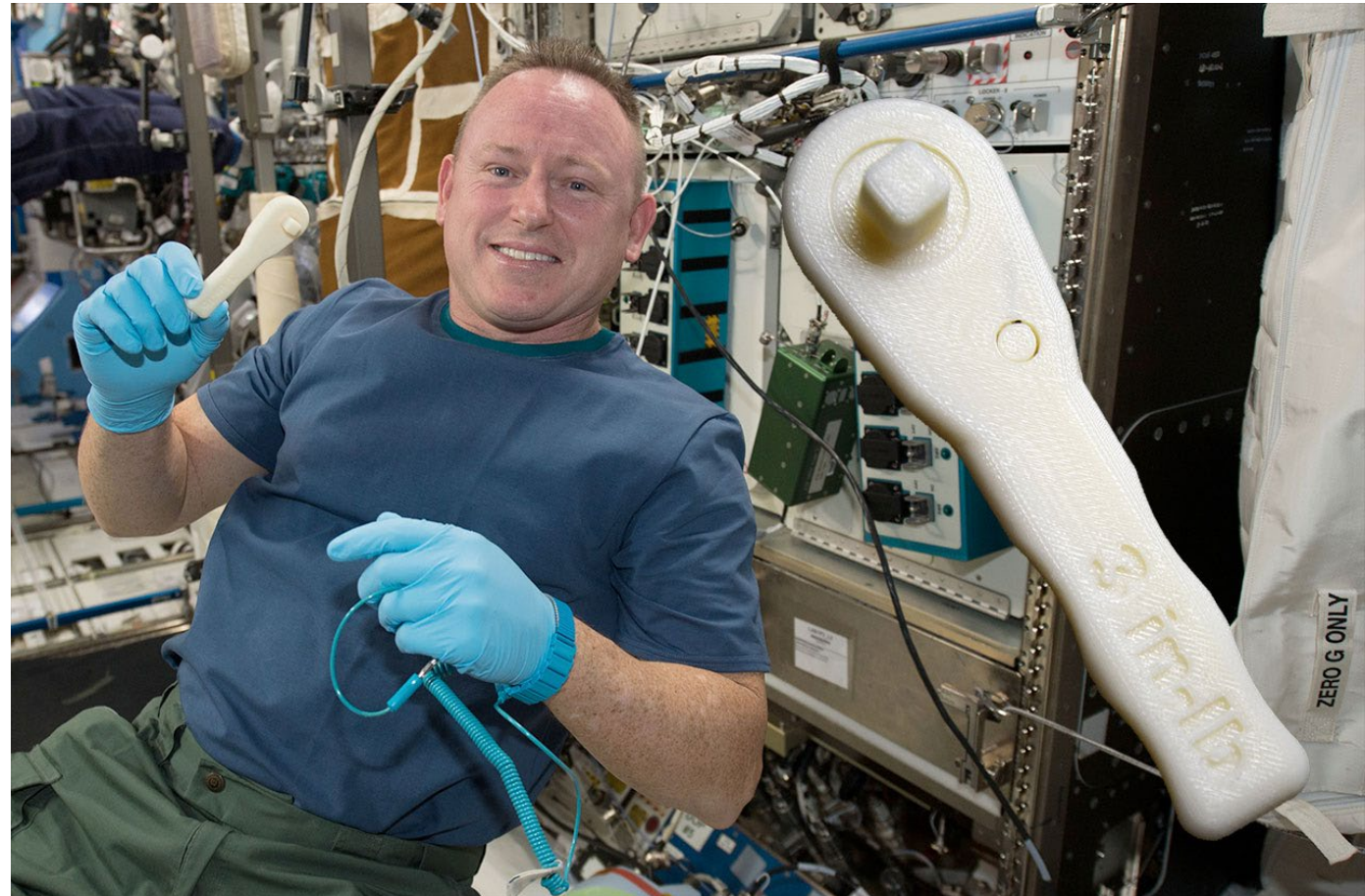
Yes.

-
-
-

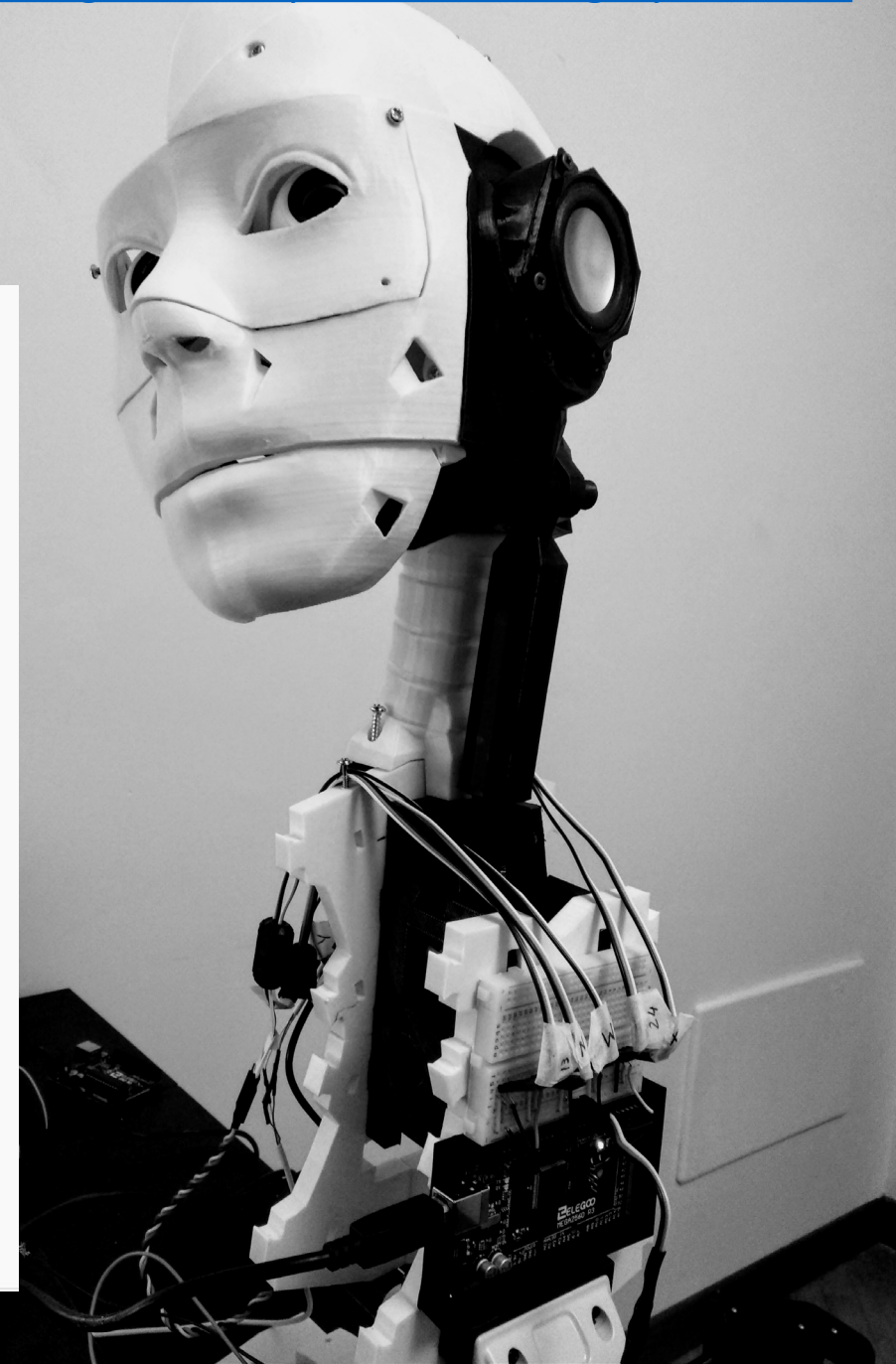
Let me fire up the *Refabricator*.

NASA Artemis program is building habitats on the Moon and later on Mars.

Decreasing Earth-dependance on manufacturing assets in space.



DIY Robotics, video_06



3D Printed Life-Size InMoov Robot

Jukebooth • 2.4K views • 8 months ago

Matt Edminster and Billy Ramey, two New England guys, bought a 3D printer 3 years ago and what started as a hobby became a ...

4K

2:08



Adept open source 3D printed robot based on Arduino

Adept Studio • 616 views • 4 months ago

Adept open source 3D printed robot based on Arduino. Welcome to the website: www.adept.com.

1:52



3D Printed Delta Robot (Arduino Controlled) 2019

isaac879 • 57K views • 9 months ago

If you enjoyed the video please leave a like and consider subscribing for more. I have always loved how delta robots move and ...

16:27



3D printed RC FPV tank rover

Brian Brocken • 12K views • 9 months ago

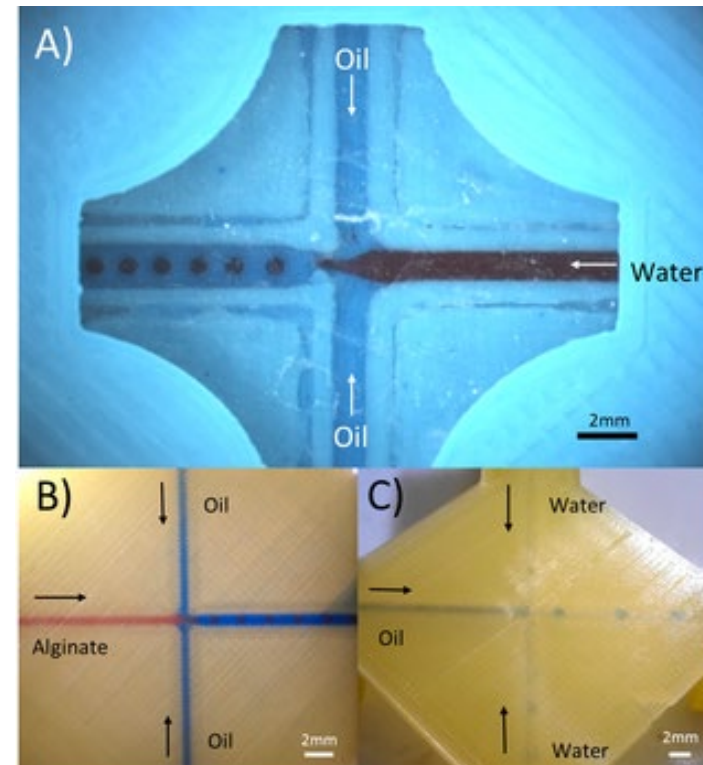
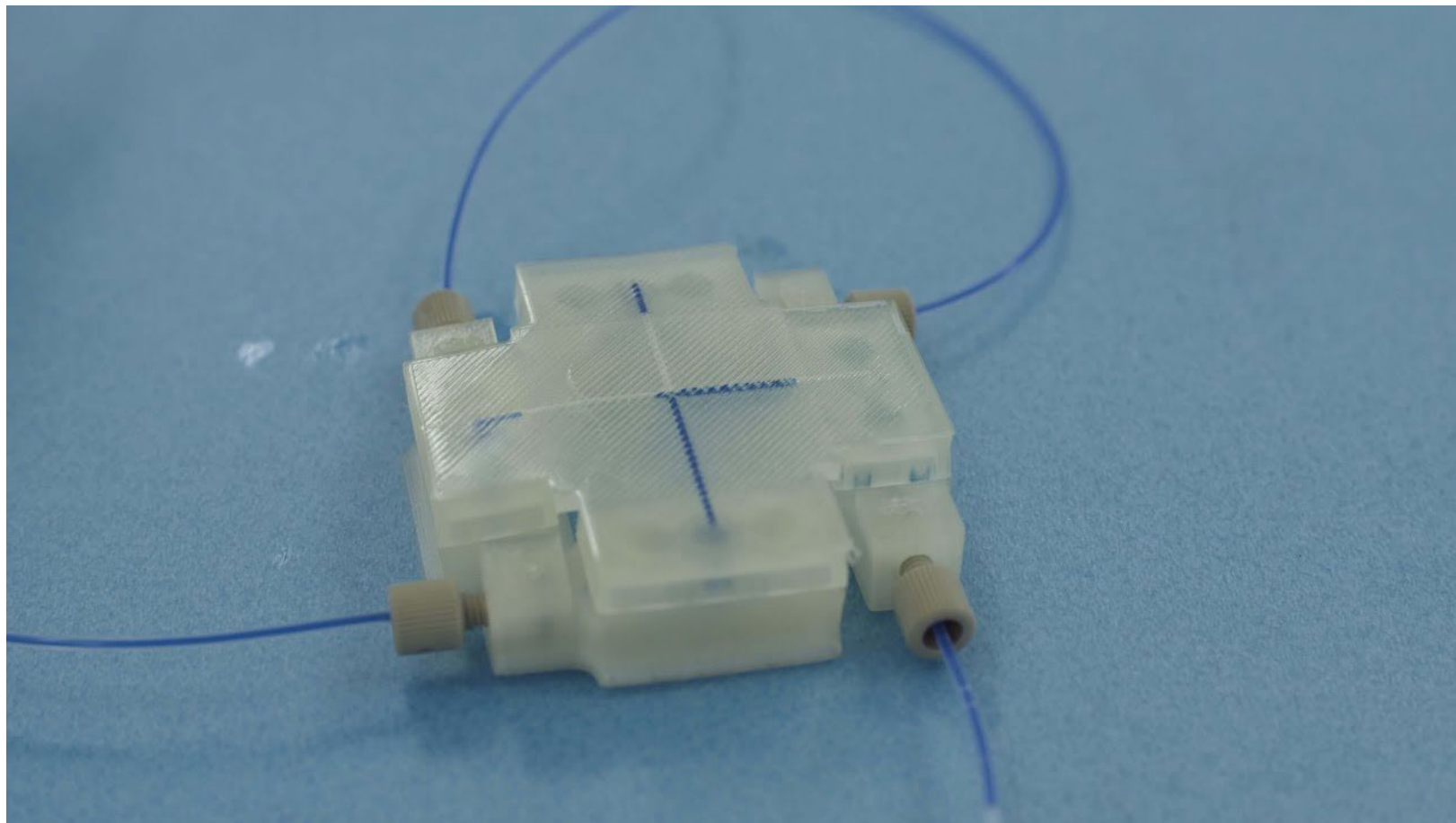
I designed the tank in a way that it can be almost completely 3D-printed. It's of course inevitable to truly completely 3D print the ...



Volkswagen : [video 07](#)
Jigs and fixtures to help
assemble cars

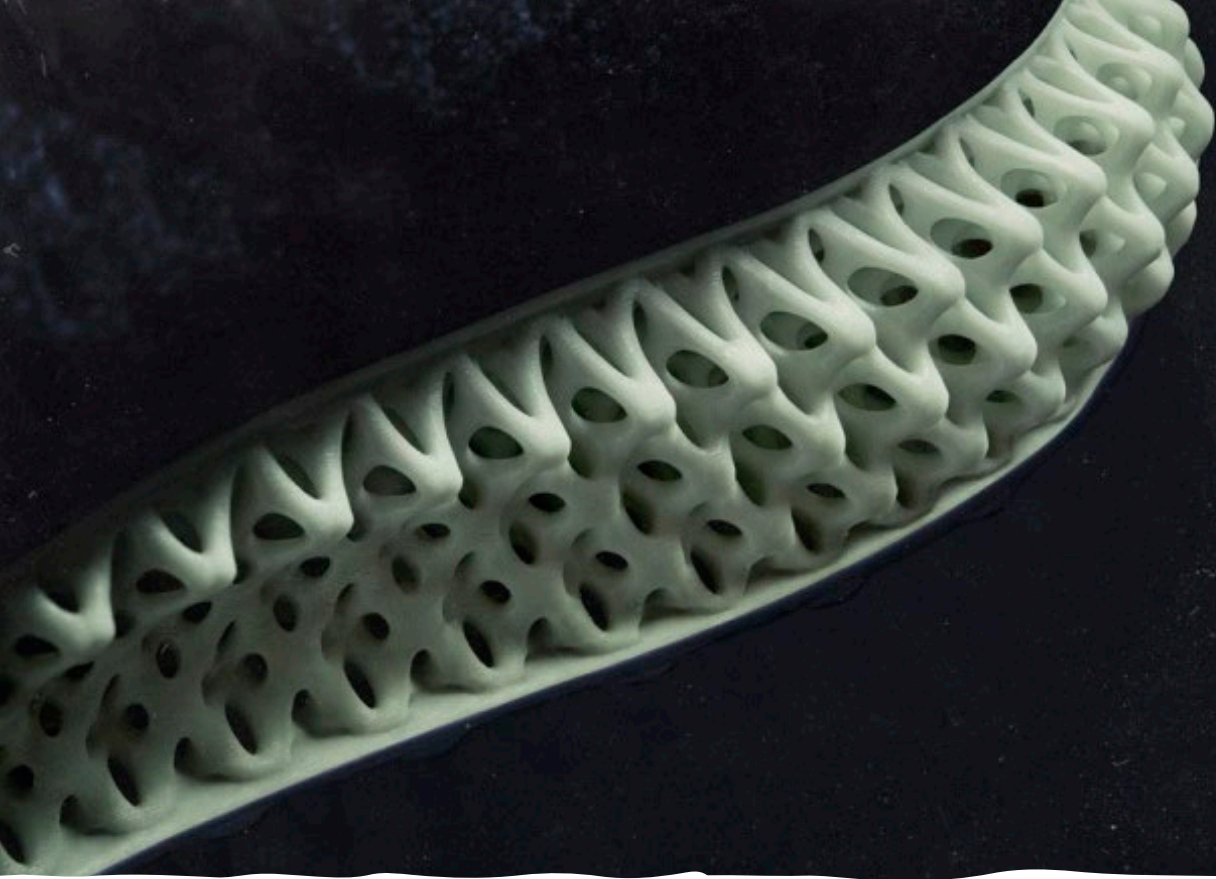
- <https://www.tctmagazine.com/can-you-jig-it-volkswagen-ultimaker-3d-printing/>

Microfluidic devices with an Ultimaker



<https://ultimaker.com/learn/cardiff-university-accessible-3d-printed-microfluidic-devices>

Morgan, A. J., San Jose, L. H., Jamieson, W. D., Wymant, J. M., Song, B., Stephens, P., ... & Castell, O. K. (2016). Simple and versatile 3D printed microfluidics using fused filament fabrication. *PloS one*, 11(4).



Adidas

- <https://3dprintingindustry.com/news/adidas-to-release-a-new-version-of-3d-printed-shoe-alphaedge-4d-155578/>

Kalevala Koru – jewellery with 3D Printing



Also this can be a goldsmith's tool. The 3D model of the Snow Flower is being prepared using the drawing pad and the computer.



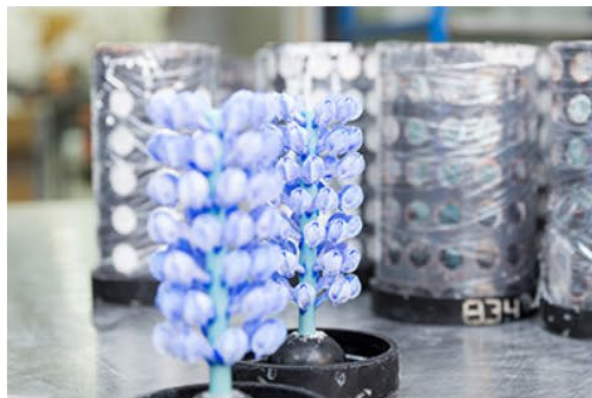
Snow Flowers printed in blue wax with a 3D printer.



Some of the wax models are still created traditionally by hand. Hot wax is injected inside a rubber mold and the solidified wax model is carefully removed from the mold.



The wax flowers are ready for the next stage.



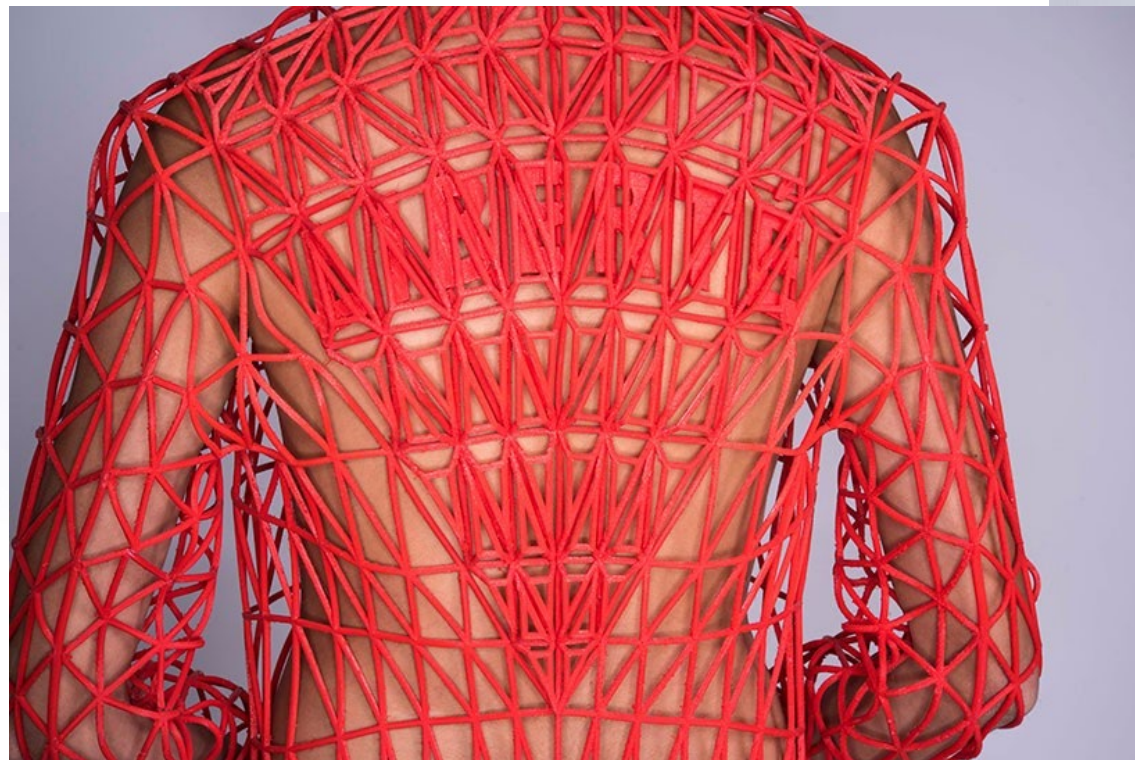
The wax models are attached to a wax pole forming tree-like structures. The trees are placed inside a cylinder which is then cast with plaster. Numbers on the cylinders mark the different treatments each cylinder receives depending on the jewelry model that is being produced.



The wax has been melted off from the cylinder and replaced with molten metal.



3D Printing in Fashion

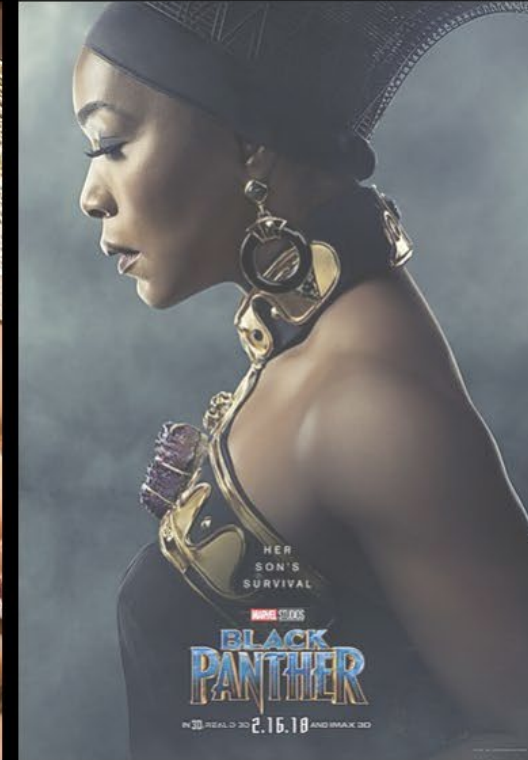


Danit Peleg



JULIA KÖRNER

SALZBURG | LOS ANGELES



BLACK PANTHER

Glass / Ceramics / Concrete 3D printing



Neri Oxman



Ashish Mohite



Company 'Concreative'



3D printed house in Dubai



Eco-sustainable 3D printed house (local and recycled materials) -
Tecla, 3D printed by WASP

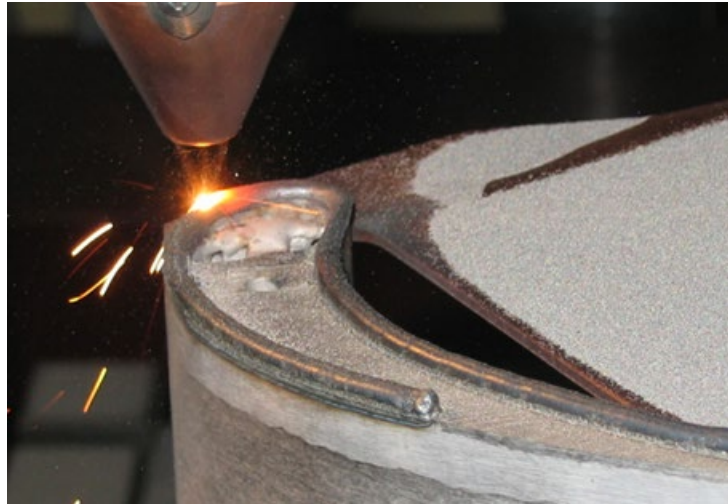
<https://www.youtube.com/watch?v=w9sXqxccRPM&t=12s>



MX3D Smart Bridge

World's first 3D-printed steel pedestrian bridge.

Repair of blades



Repairing blades of different kinds is a common application of DED. The worn tips are regrown and machined to shape.

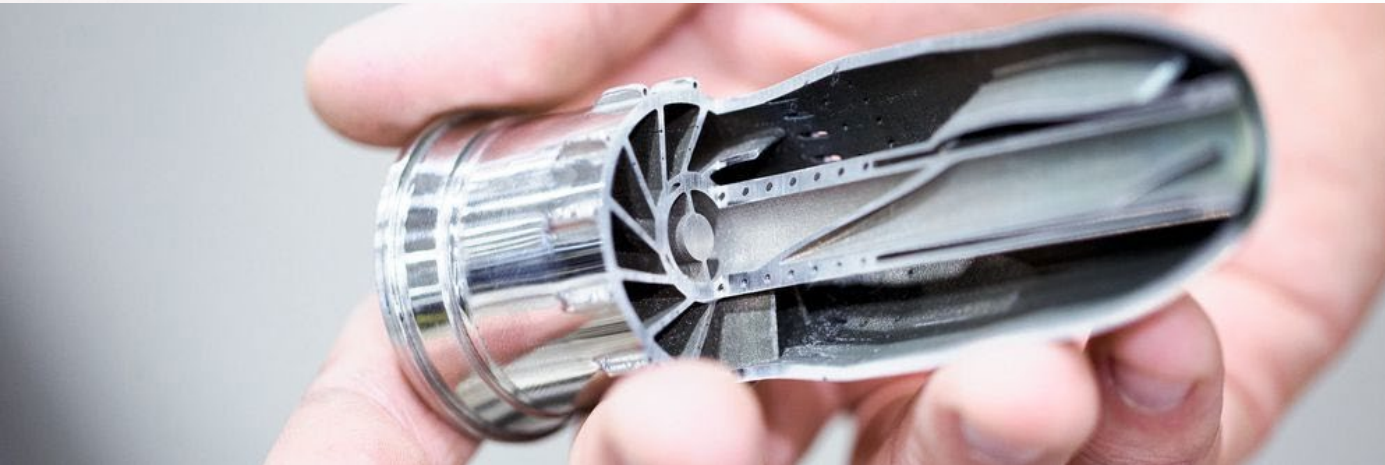
Sources: <https://www.oerlikon.com/metco/en/products-services/coating-services/coating-services-laser-cladding/component-manufacturing-and-repair//>

LEAP fuel nozzle

Part Consolidation - previously almost 20 parts welded together, now 1 single part : 3D printed, machined, and heat treated. Already 30 000+ made.

<https://www.geaviation.com/commercial/engines/ge9x-commercial-aircraft-engine>

<https://www.ge.com/reports/heirs-gutenberg-ge-adding-next-chapter-3d-printing-push-germany/>



<https://www.ge.com/reports/all-the-print-thats-fit-to-pitt-new-additive-technology-center-opens-near-steel-town/>

Jet Engine Parts

AEROSPACE

BOEING 777X: GE9X ENGINES WITH 300 3D PRINTED PARTS POWERS LARGEST TWIN-ENGINE JETLINER IN FIRST FLIGHT

ANAS ESSOP - JANUARY 28TH 2020 - 11:55AM ↗ 0 💬 0

Let's take a break!

Remember to register for practical sessions!

Material extrusion | The printers you will use today



Material extrusion



FDM

Fused Deposition Modeling



Composite Plastic

Plastic

stratasys

printrbot

Ultimaker



MakerBot

LULZBOT

zortrax

Composite (CFP)

PRUSA
RESEARCH
by JOSEF PRUSA

Markforged

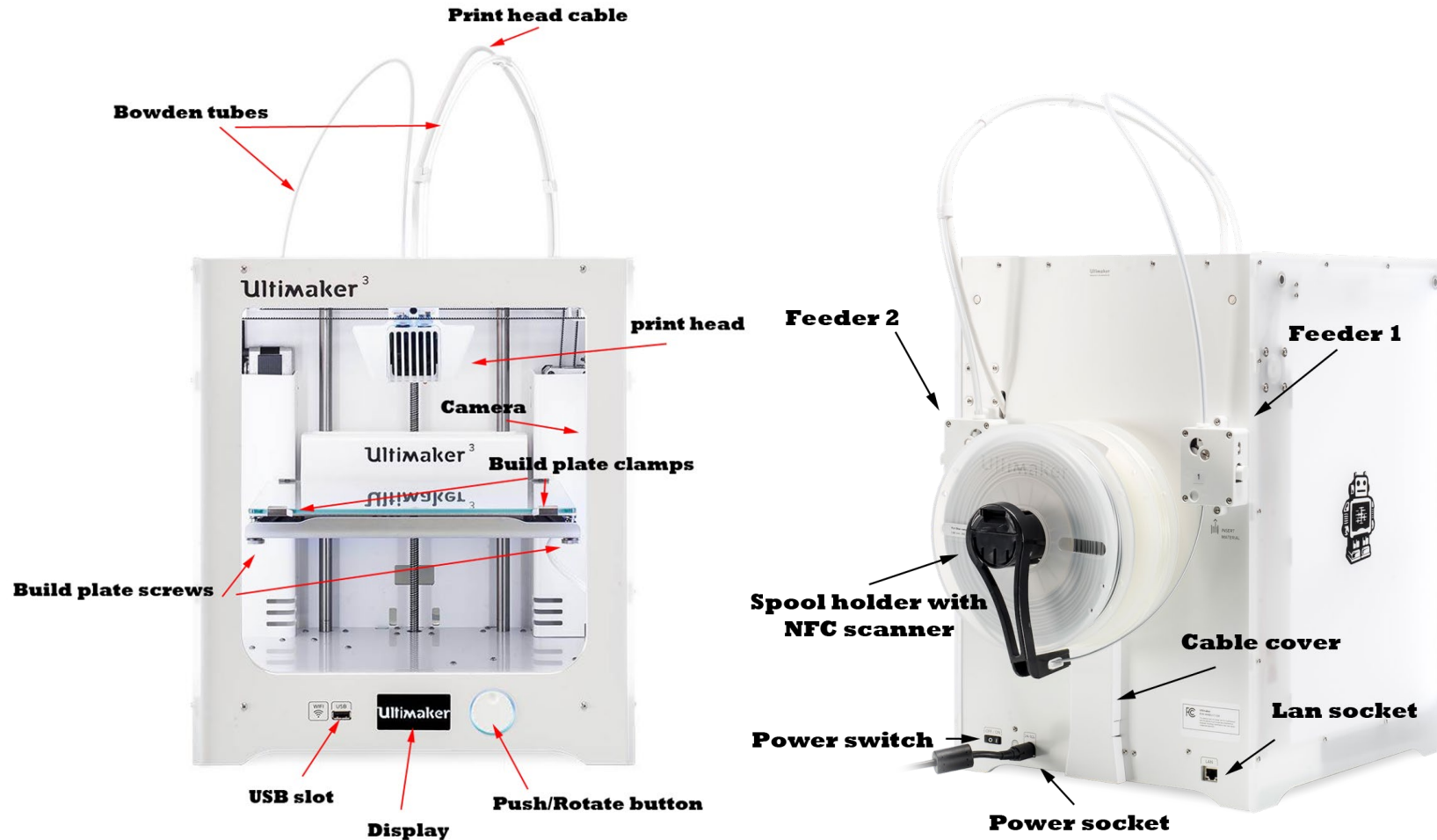
Material Extrusion (FDM)



Material Extrusion (FDM) – [video 09 1](#), [video 09 2](#)



Ultimaker – what is what



Ultimaker 3:

<https://ultimaker.com/en/resources/45871-anatomy-of-an-ultimaker-3>

Ultimaker 2:

<https://ultimaker.com/en/resources/22131-anatomy-of-an-ultimaker-2>

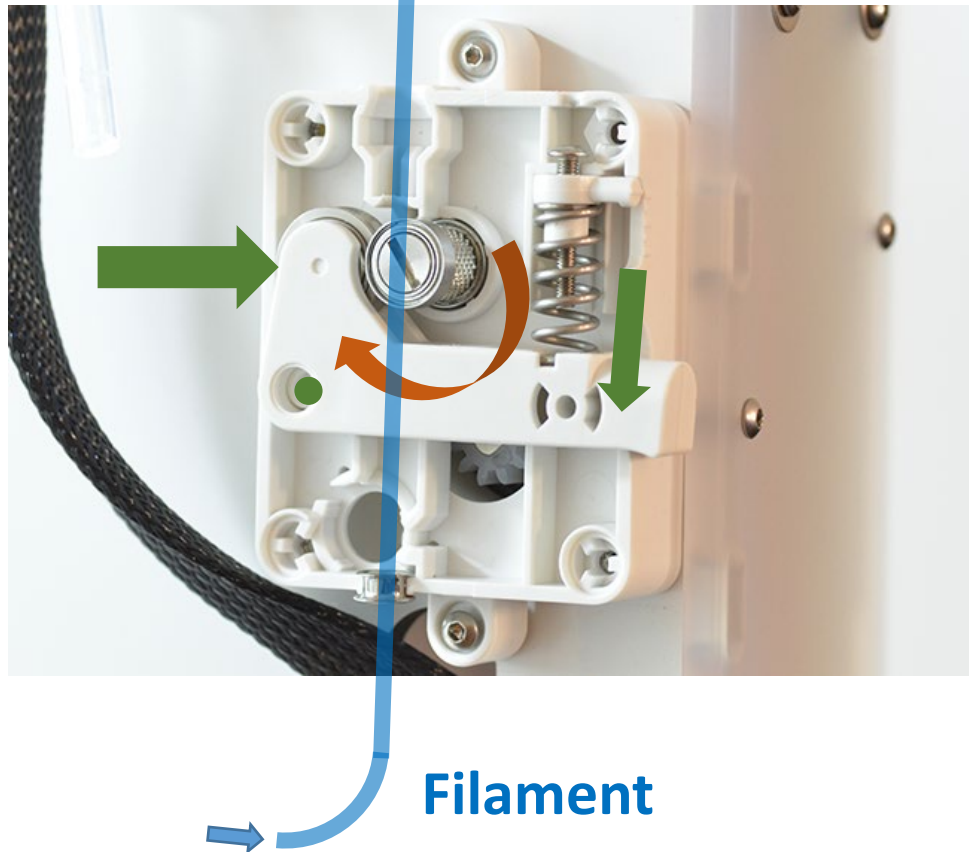
Material Extrusion Systems

Main differences:

- Movement of the extruder, the build plate or both:
Cartesian or polar coordinates, delta arrangement or with an industrial robot
- *Extruder type; filament-, plunger- and screw-based*
- *Bowden or Direct extruder*
- *Open or Closed build volume*
- No heating, Heated build plate and/or heated build volume
- Higher temperature nozzles for more exotic materials (like PEEK, ULTEM, PPSU)



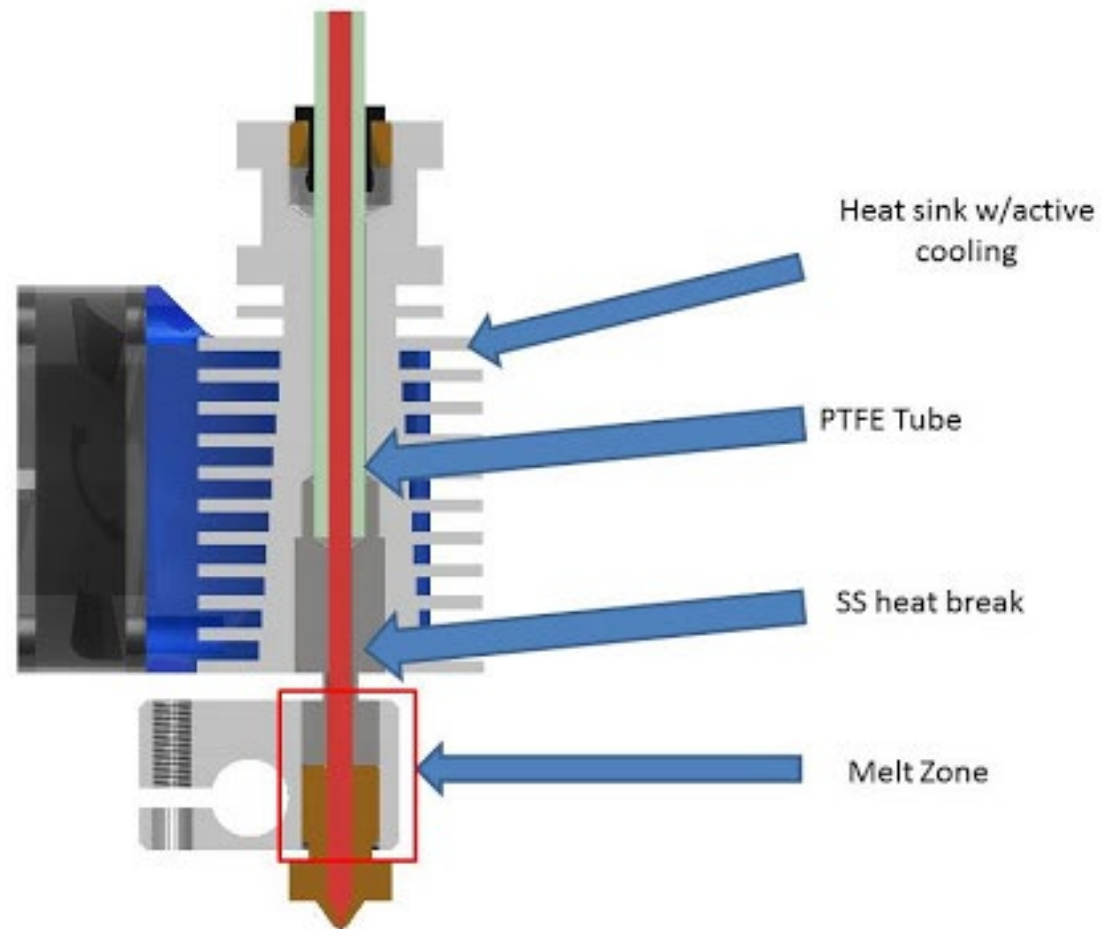
Feeder assembly (bowden)



Stepper motor (geared) rotates feeder screw
Spring loaded arm + bearing compresses filament
against the feeder screw to move it towards the
extruder

**! Please do not adjust or open the Feeder boxes
yourself. In case of a problem, ask the ADDLAB
staff to do it !**

Extruder assembly (example)



Digital workflow, software & design

3D printing – digital to physical



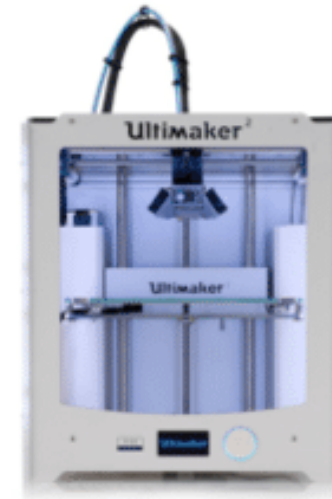
Computer Aided Design



.STL file



Toolpath file (G-code)



3D printer

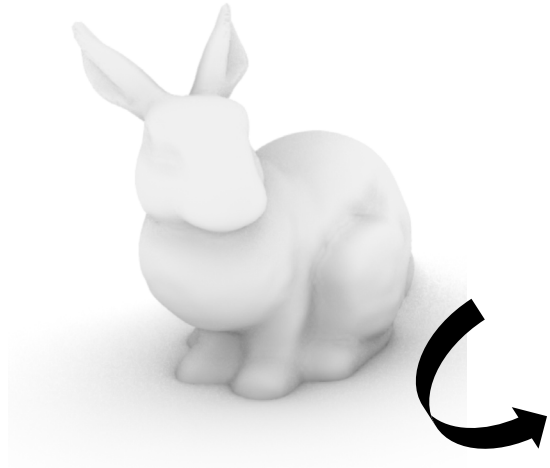


Printed object

CAD model or scan, 3D

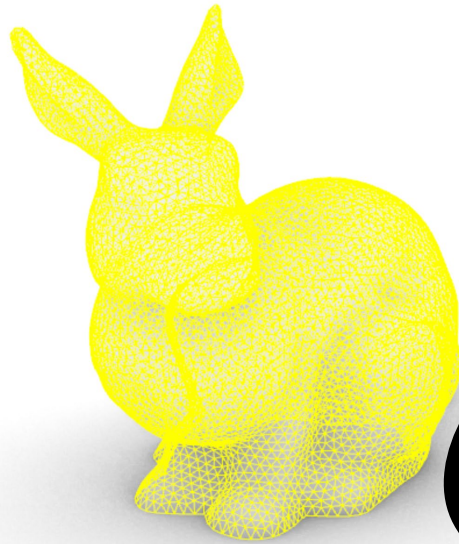
Cura slicing software, 2D slices out of 3D

From 3D model to printable file



1. Original 3D model

File format examples:
.OBJ, .STEP, .IGES, .PRT,
.SLDPRT, ...

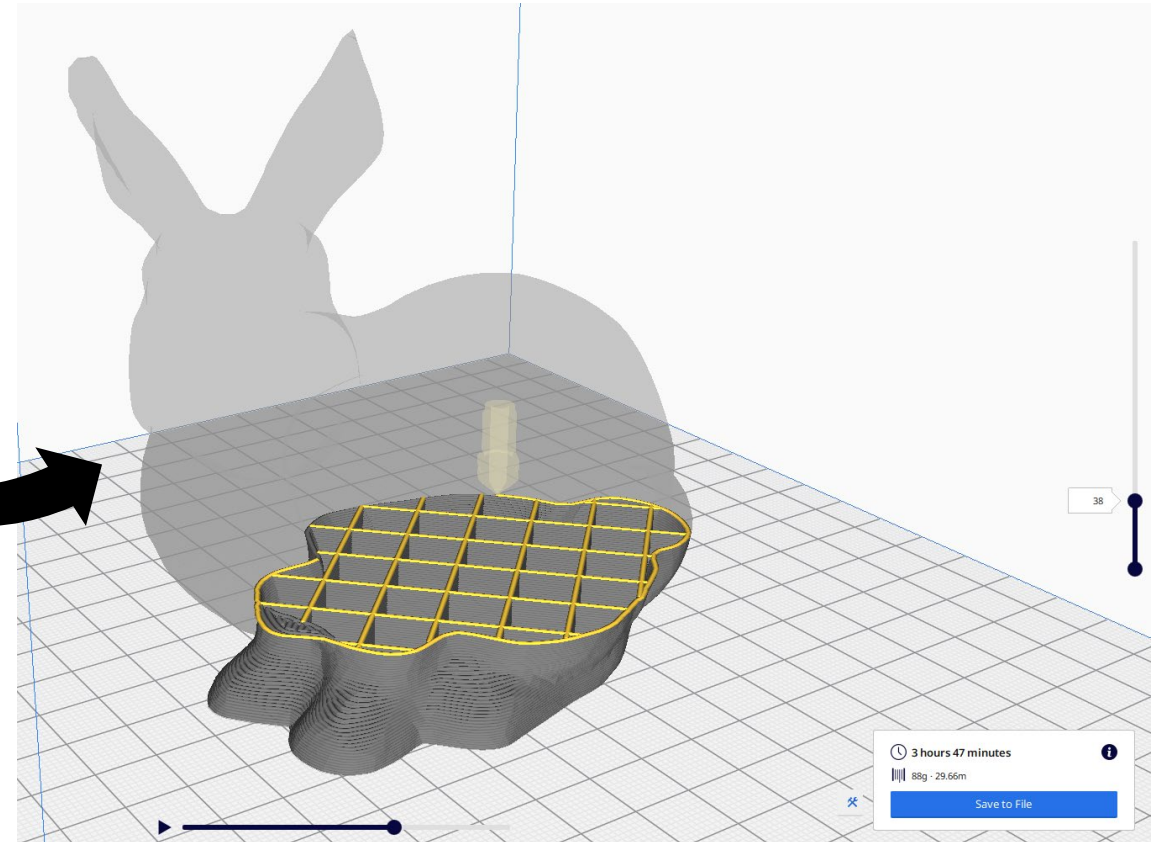


2. STL conversion

Standard Triangle/ Tessellation Language

Current industry standard
for 3D printing

3. Sliced to 2D layers and G-code created
Layer thickness-, nozzle / bed temperature-,
infill-, support-, etc. .. settings



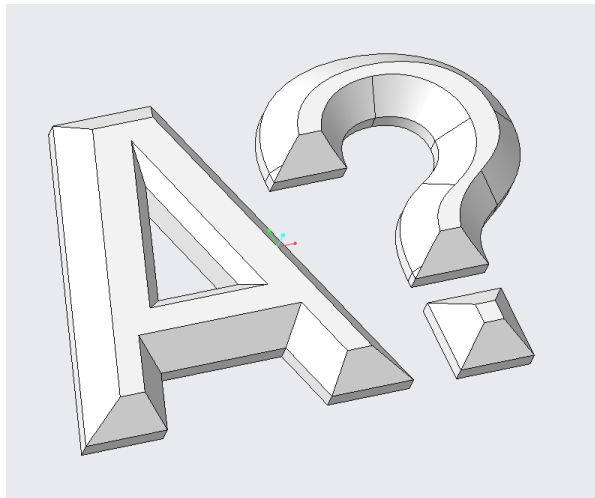
STL conversion (3D model to .stl)

STL (**S**tandard **T**essellation **L**anguage) [https://en.wikipedia.org/wiki/STL_\(file_format\)](https://en.wikipedia.org/wiki/STL_(file_format))

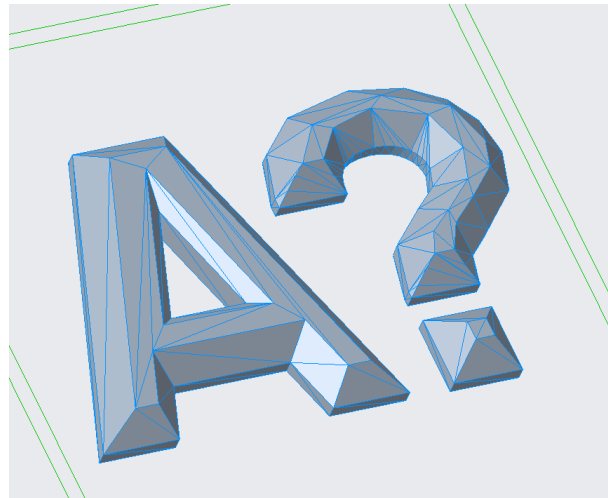
Approximates a surface of a solid 3D model by dividing it into triangles and normal vectors

Is the most common file format that the slicing software understands

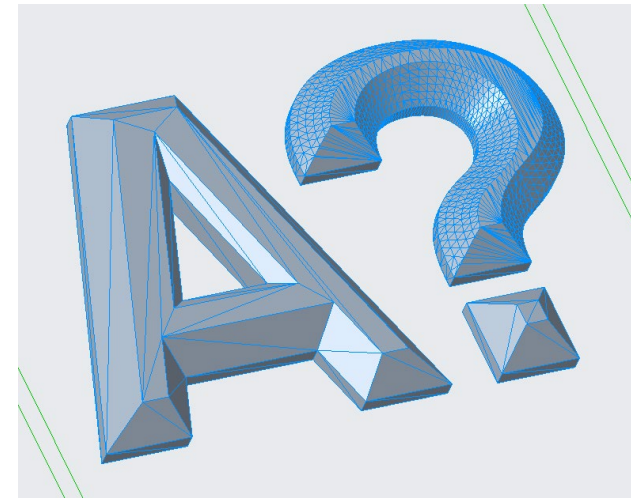
Supported by almost all 3D modeling software



3D model (Creo .prt), **143 KB**



.stl coarse settings, **14 KB**



.stl fine settings, **96 KB**

G-code – commands for the printer

```
G0 X12           ; move to 12mm on the X axis
G0 F1500        ; Set the feedrate to 1500mm/minute
G1 X90.6 Y13.8 E22.4 ; Move to 90.6mm on the X axis and 13.8mm on the Y axis while extruding 22.4mm of material
```

Some example G-code commands (RepRap):

G0 – rapid move

M109 – Set extruder temperature

G1 – linear move

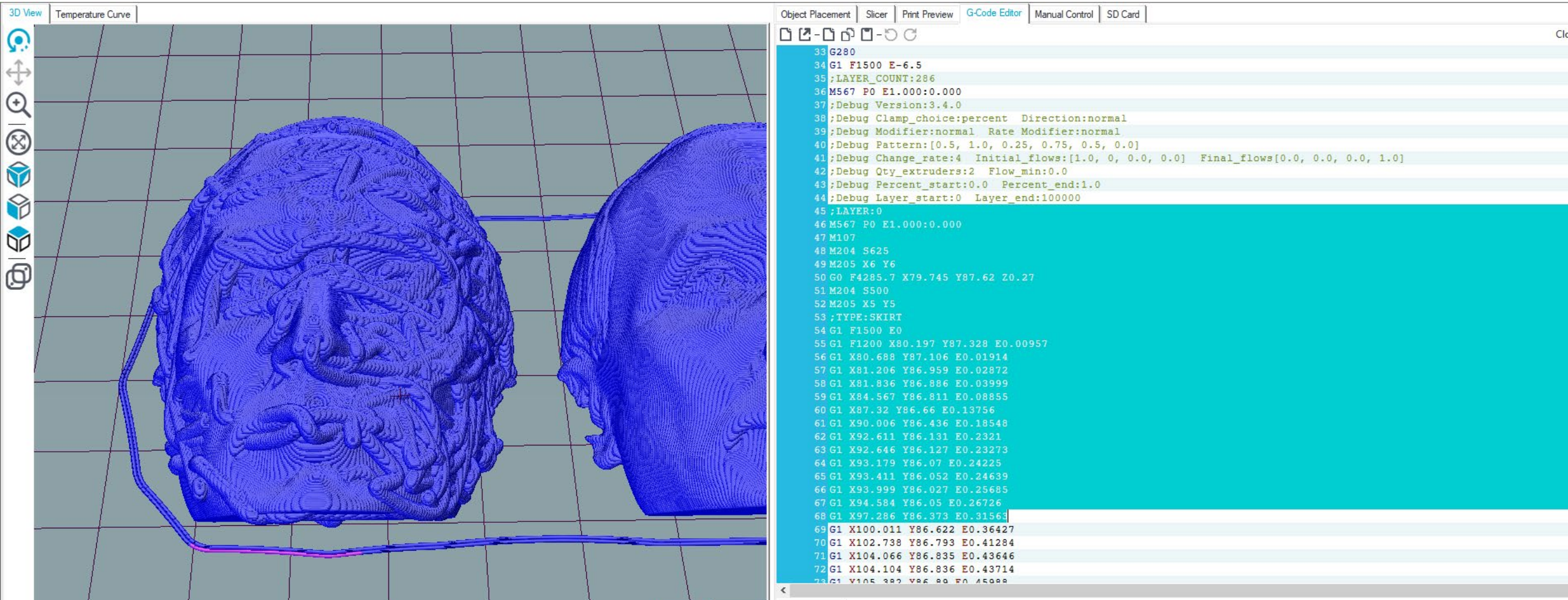
M204 – Set default acceleration

G28 – move to Origin (Home)

... etc. refer to <https://reprap.org/wiki/G-code>

If you want to learn more about G-code and different "flavours": <https://all3dp.com/g-code-tutorial-3d-printer-gcode-commands/>,
<https://ultimaker.com/en/resources/20996-gcode-flavours-reprap-vs-ultigcode>, <https://reprap.org/wiki/G-code>, <https://marlinfw.org/meta/gcode/>

G-code – commands for the printer



Those who are interested to better visualize, understand, and edit G-code, Repetier-Host: <https://www.repetier.com/> (free)

Where to get 3D models?

The Internet is full of printable 3D files: maker communities, databases, 3D model shops: Google “3d models for printing” → **Thingiverse, Cults, Pinshape, GrabCAD, MyMiniFactory...** https://reprap.org/wiki/Printable_part_sources

- 3D scan an existing geometry for 3D printing
- 3D model your own parts
 - Ask a friend to 3D model for you
 - Pay a friend to 3D model ..
 - Pay a company to 3D model ..

3D Modeling Software

BEGINNERS

TinkerCAD (free) - <https://www.tinkercad.com/>

Meshmixer (3D Sculpting and mesh modifications, free, being replaced by Fusion 360) - <http://www.meshmixer.com/>

FreeCAD - <https://www.freecadweb.org/downloads.php>

Autodesk Fusion 360 (free license for students and makers) - <https://www.autodesk.com/campaigns/fusion-360-for-hobbyists>

Onshape (cloud-based CAD) - <https://www.onshape.com/education-plan>

Solidworks, Creo, Siemens NX (Aalto student license) - <https://download.aalto.fi/student/>

Blender (free, from mesh-based modeling to producing an animation movie) - <https://www.blender.org/download/>

Rhinoceros (Installed in some ARTS computer classes, Grasshopper included for algorithmic design)

ADVANCED








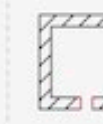



Autodesk Netfabb, Altair Inspire (Lattice design and topology optimization, student licenses available on request)

Options for programmatic 3D modeling: **OpenSCAD, ImplicitCAD, Matlab, etc.**

3D Scanning for a printable model, video_10



DESIGN RULES FOR 3D PRINTING

	Supported Walls	Unsupported Walls	Support & Overhangs	Embossed & Engraved Details	Horizontal Bridges	Holes	Connecting /Moving Parts	Escape Holes	Minimum Features	Pin Diameter	Tolerance
	Walls that are connected to the rest of the print on at least two sides.	Unsupported walls are connected to the rest of the print on less than two sides.	The maximum angle a wall can be printed at without requiring support.	Features on the model that are raised or recessed below the model surface.	The span a technology can print without the need for support.	The minimum diameter a technology can successfully print a hole.	The recommended clearance between two moving or connecting parts.	The minimum diameter of escape holes to allow for the removal of build material.	The recommended minimum size of a feature to ensure it will not fail to print.	The minimum diameter a pin can be printed at.	The expected tolerance (dimensional accuracy) of a specific technology.
											
Fused Deposition Modeling	0.8 mm	0.8 mm	45°	0.6 mm wide & 2 mm high	10 mm	∅2 mm	0.5 mm		2 mm	3 mm	±0.5% (lower limit ±0.5 mm)
Stereolithography	0.5 mm	1 mm	support always required	0.4 mm wide & high		∅0.5 mm	0.5 mm	4 mm	0.2 mm	0.5 mm	±0.5% (lower limit ±0.15 mm)
Selective Laser Sintering	0.7 mm			1 mm wide & high		∅1.5 mm	0.3 mm for moving parts & 0.1 mm for connections	5 mm	0.8 mm	0.8 mm	±0.3% (lower limit ±0.3 mm)
Material Jetting	1 mm	1 mm	support always required	0.5 mm wide & high		∅0.5 mm	0.2 mm		0.5 mm	0.5 mm	±0.1 mm
Binder Jetting	2 mm	3 mm		0.5 mm wide & high		∅1.5 mm		5 mm	2 mm	2 mm	±0.2 mm for metal & ±0.3 mm for sand
Direct Metal Laser Sintering	0.4 mm	0.5 mm	support always required	0.1 mm wide & high	2 mm	∅1.5 mm		5 mm	0.6 mm	1 mm	±0.1 mm

DFAM

- Anisotropy



Load perpendicular to layers - Part is weaker



Load parallel to layers - Part is stronger

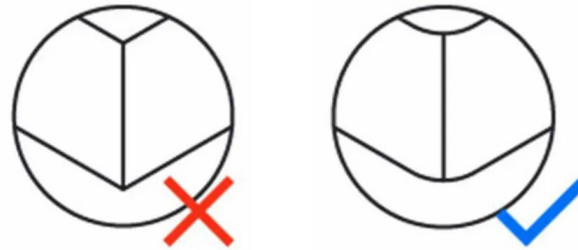


Load perpendicular to layers - Part is stronger

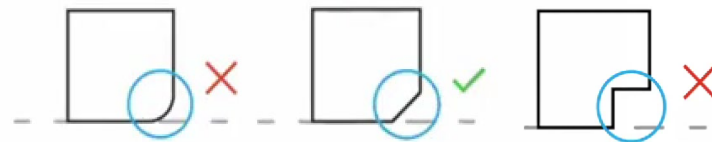


Load parallel to layers - Part is weaker

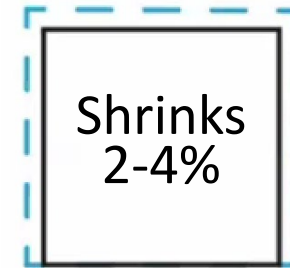
- Avoid sharp corners



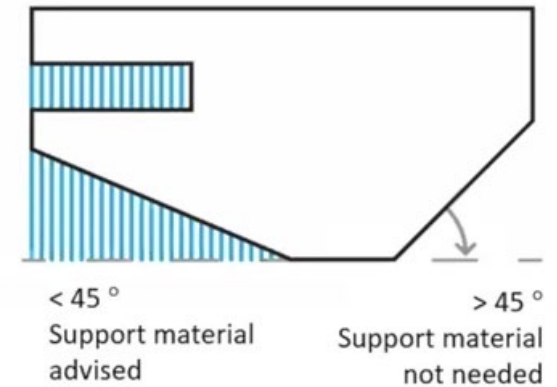
- Avoid fillets at base



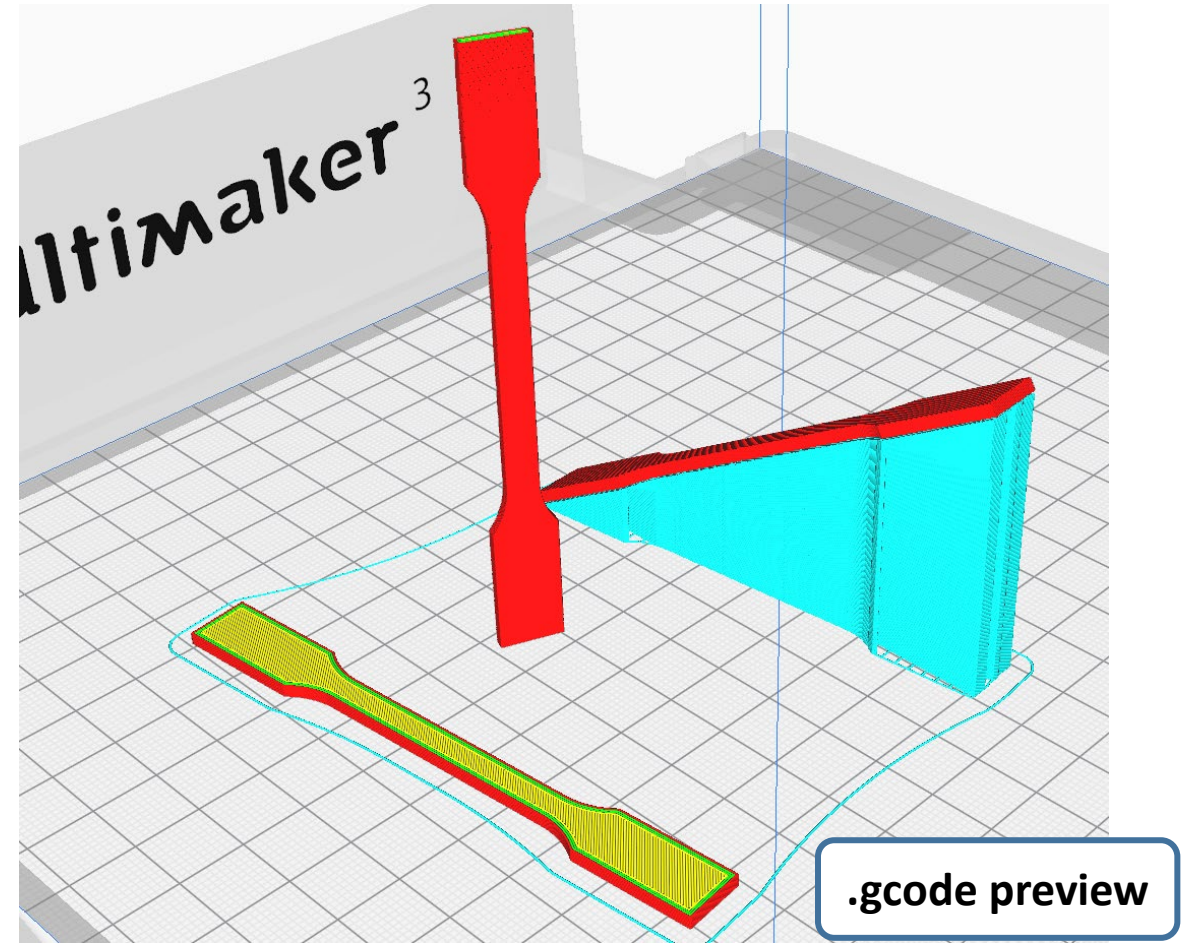
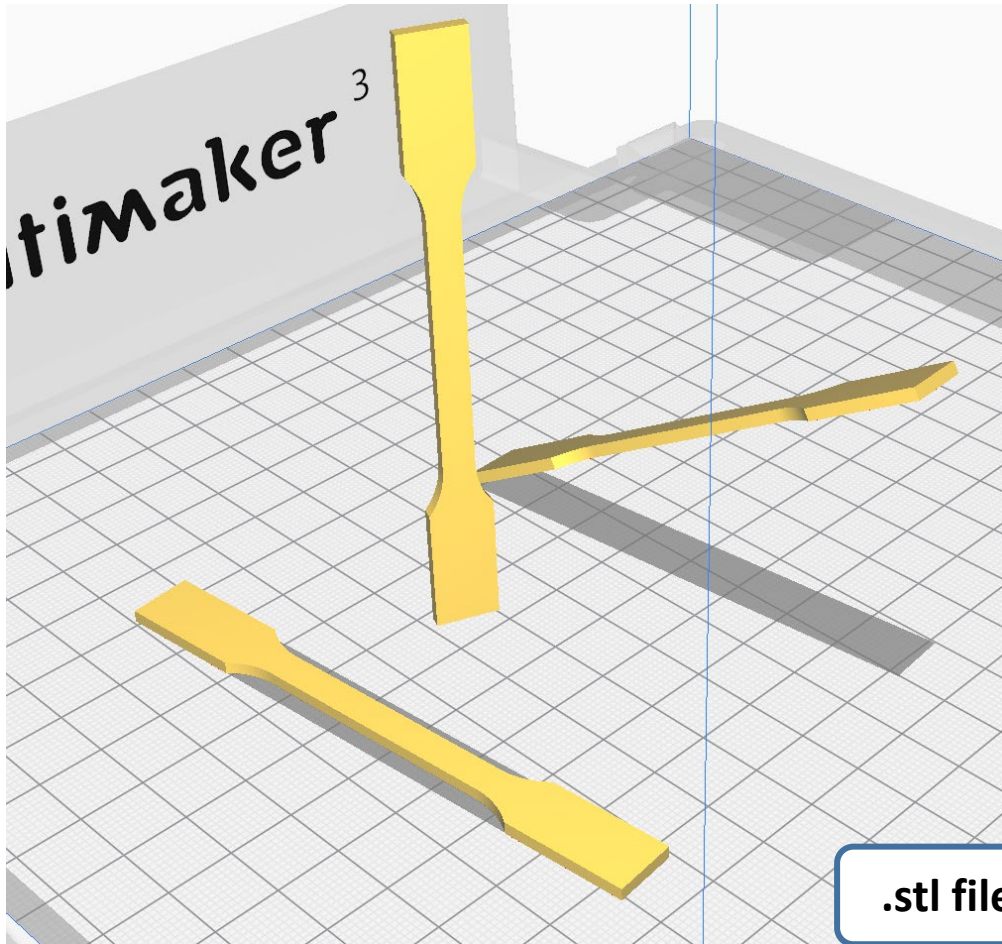
- Tolerances



- Supports



Build orientation, overhangs, support structure



.STL files brought into Cura,
different build orientations



Slicing operation and support
generation

Slicing in Cura (.stl to .gcode)

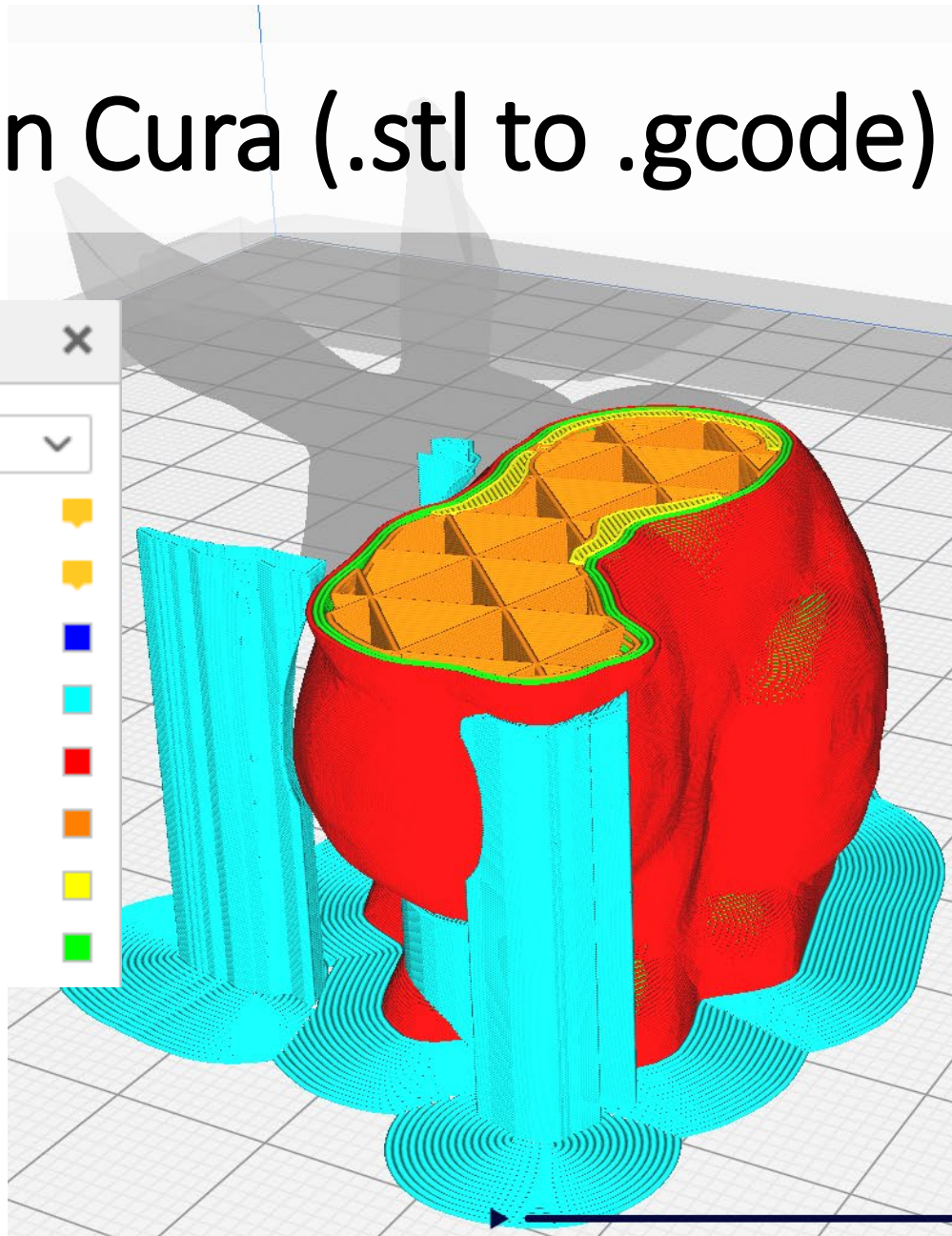
Color scheme

Line Type

- Extruder 1
- Extruder 2
- Travels
- Helpers
- Shell
- Infill

Top / Bottom

Inner Wall



Print settings

Profile: Normal 0.15mm

Quality

Layer Height: 0.15 mm

Shell

Wall Thickness: 1 mm

Wall Line Count: 3

Top/Bottom Thickness: 1 mm

Top Thickness: 1 mm

Top Layers: 7

Bottom Thickness: 1 mm

Bottom Layers: 7

Horizontal Expansion: 0 mm

Infill

Infill Density: 20 %

Infill Pattern: Triangles

Material

Speed

Travel

Cooling

Support

Build Plate Adhesion

Dual Extrusion

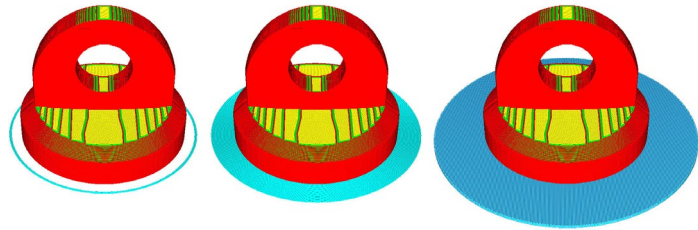
< Recommended

1 hour 52 minutes

15g · 1.88m

Save to File

Adhesion, Layers and Infill



Skirt

Brim

Raft

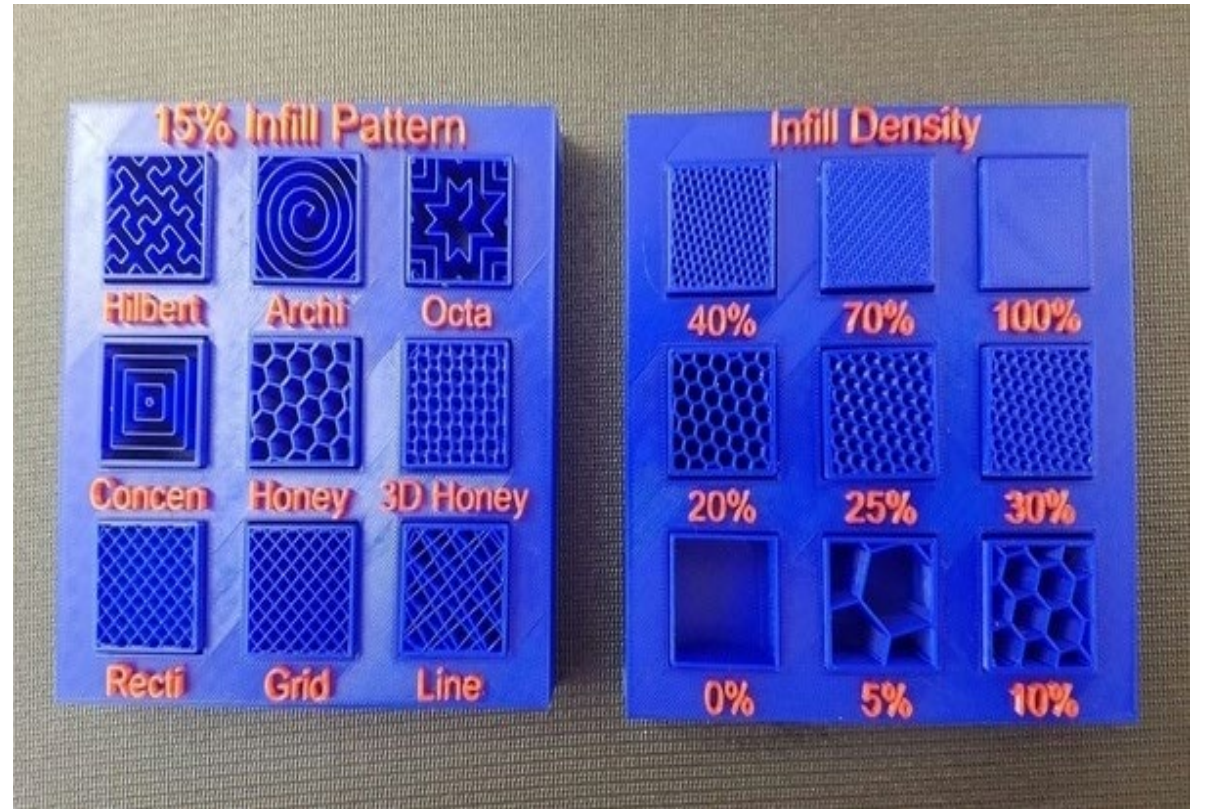
Quality (layer-height difference)



Layer height: 0.06mm
Approx print time: 30mins

0.1mm
18mins

0.2mm
9mins





Cura demo:

Software Overview &
preparing an .STL file for printing

- <https://ultimaker.com/software/ultimaker-cura>

“Just press play and pick the finished part later”
aka 3D Printing Troubleshooting :

Nozzle Height & Build Plate Adhesion

Too High



Too much distance will cause the filament to extrude into the air. This will not stick to the bed.

Perfect



The tip of the nozzle is adding slight pressure to the top of the filament, greatly increasing how much filament is securely sticking to the bed and subsequent layers.

Too Low



The filament is not flowing properly, which can cause retrograde extrusion. Layers are predominantly choppy and short. Continued printing in this manner will likely cause a jam.

Under- / over extrusion

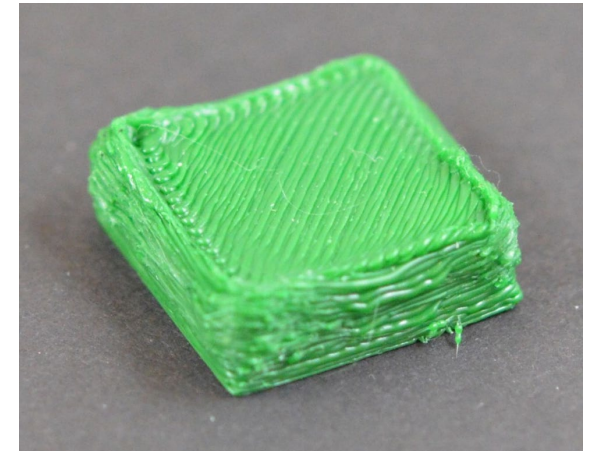
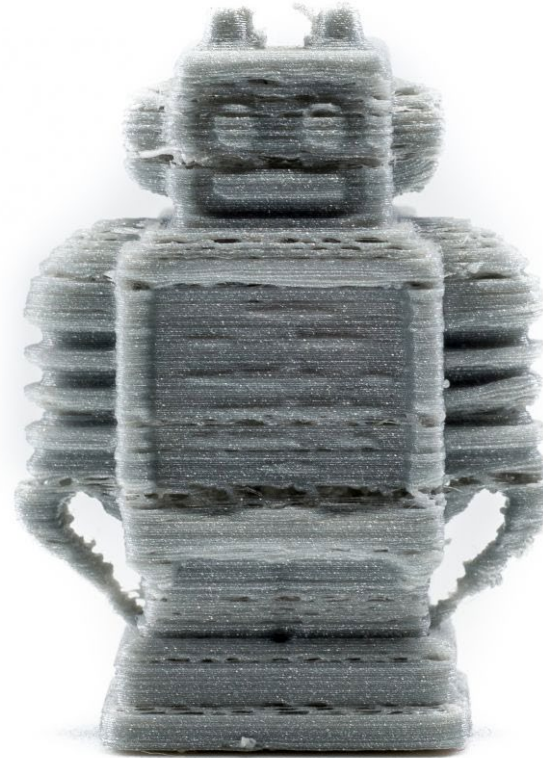
Not enough / too much material flow

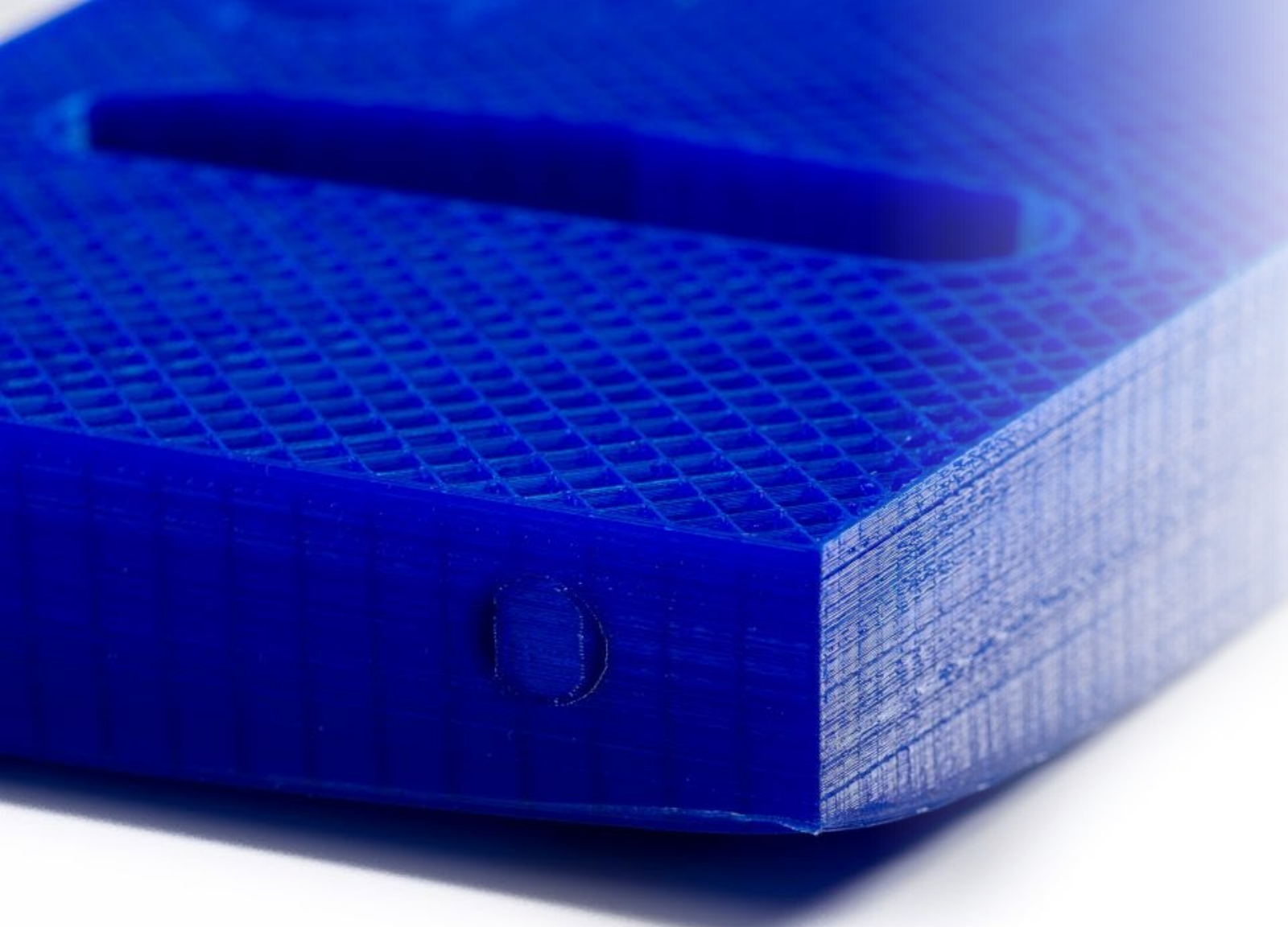
Good material flow is a balance between nozzle diameter, print speed, temperature, and material flow rate

> double-check the Cura settings

Might be caused by feeder issues, or a clogged hot-end

> Use another Ultimaker and report a problem to the ADDLAB staff





Warping

- Caused by material shrinkage
- Avoidable with good build plate leveling, adhesion to the plate (first layers), and proper but not excessive cooling.
- A 'brim' or a 'raft' can help (See Cura settings)
- Large, flat 3D designs will warp more likely !

Filament skipping or grinding

Feeder spring tension either too low or too high

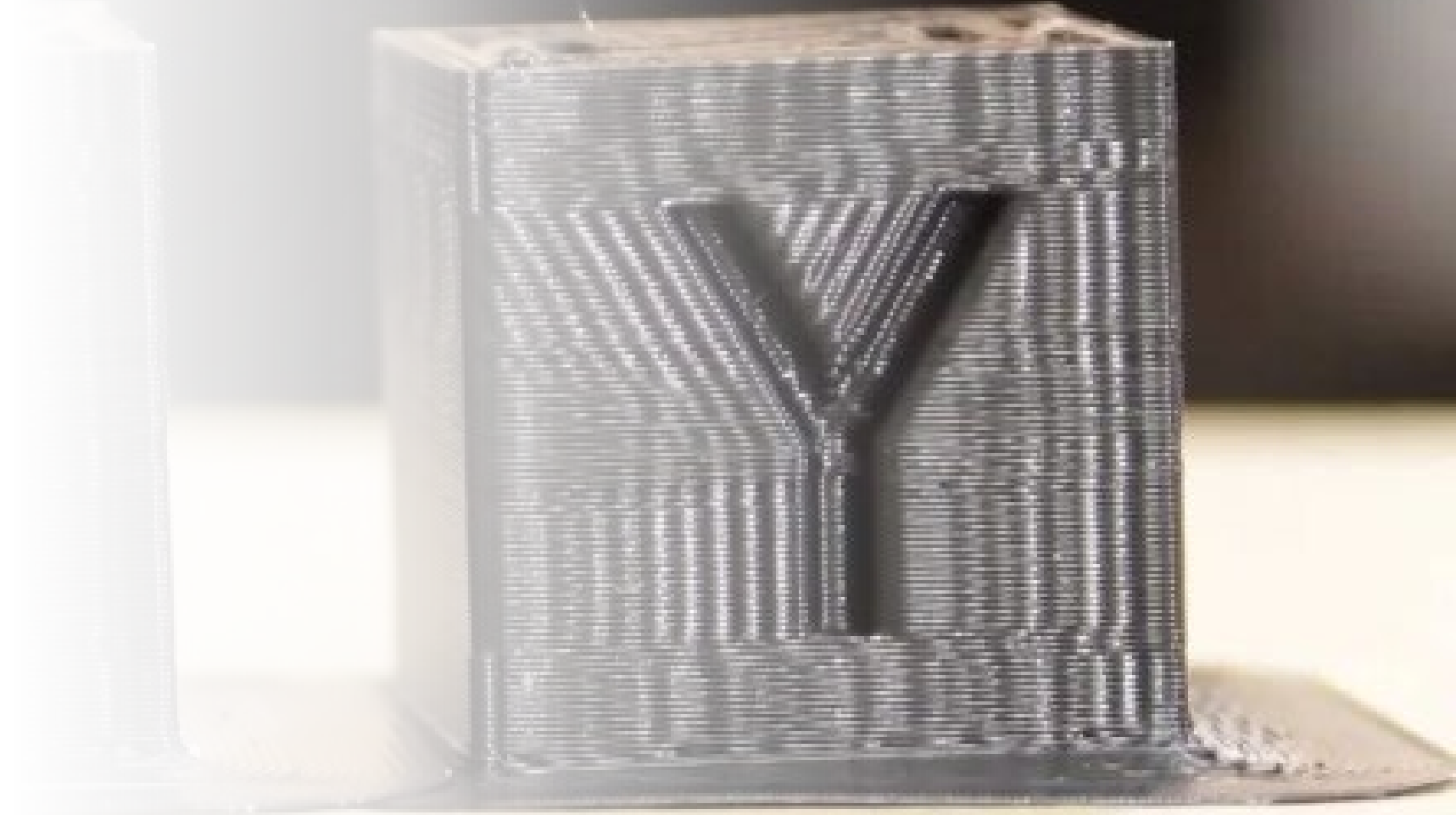
Too many retraction moves (in a complex print) can cause grinding

Too low nozzle temperature : material is not properly melted, and more pressure is required to push the filament => grinding



Ghosting/Ringing

- visual waves or rippling on the print surface
- Problem - Vibrations and speed
- Reduce the speed
- And oil the bearings





Stringing

- Caused by material leaking during print head travel movements
- Affected by printing temperature (more strings with higher temperature), print speed (+ travel speed) and 'retraction' settings
- 'Retraction' means a small recoil, or counter movement. The extruder will drive filament back to prevent leaking.

Cracking

- layer will not stick to the previous layer
- happens when the top layers begin to cool faster and there is less adhesion between the individual layers
- Change material
- Reduce layer height



Online help

<https://community.ultimaker.com/>

<https://rigid.ink/pages/ultimate-troubleshooting-guide>

YouTube tutorials

ADDLAB and 3D Printers

Booking the Ultimakers

After the workshop, you could get access to “ADD DMF Google Calendar”, check which printers are available, and make reservations.

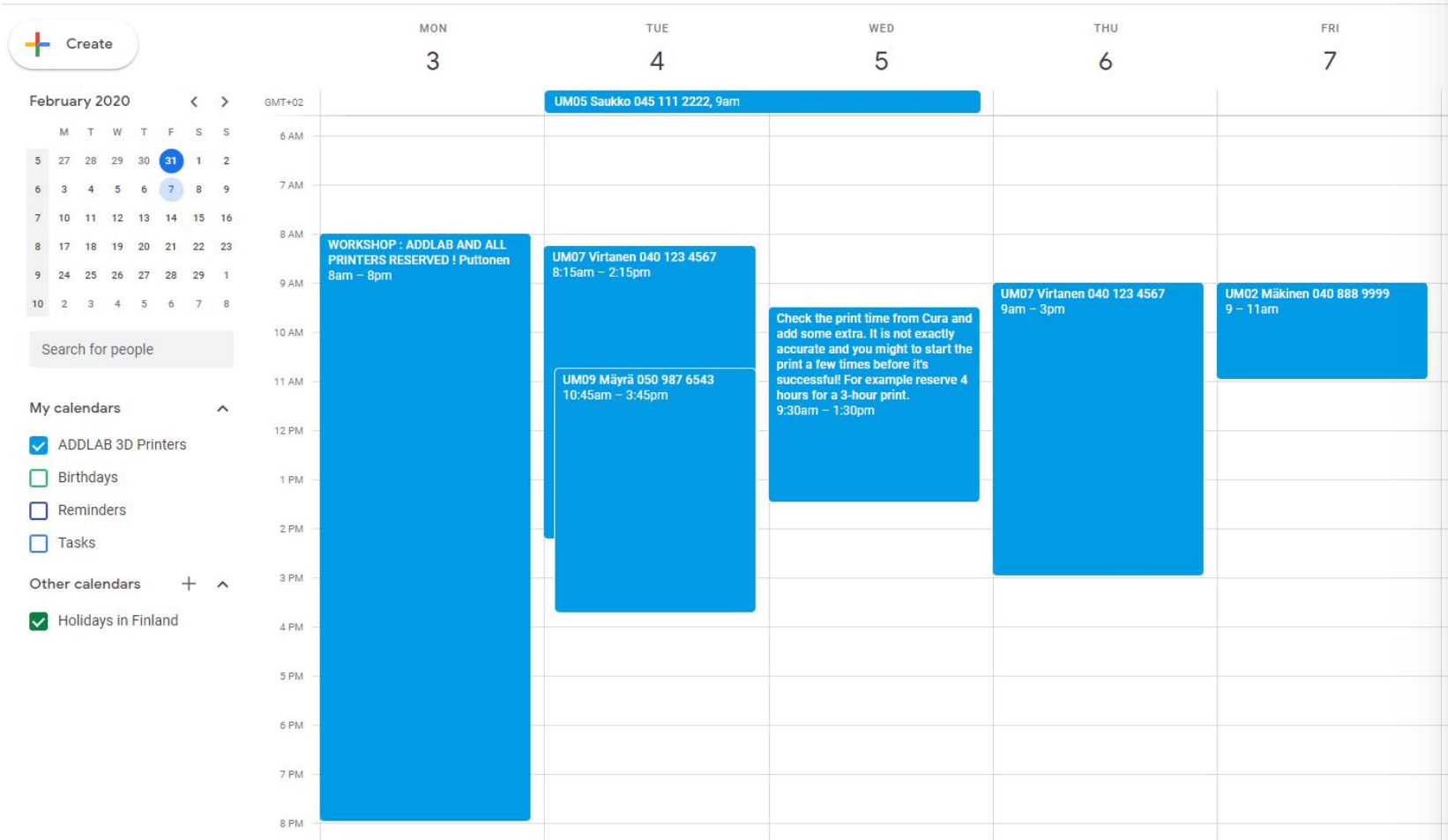
Write (clearly) your email in the participation list, we will send a link to join the calendar.

To reserve a printer for a time slot, simply add an entry in the “ADD DMF Google Calendar” (*not in your personal Google Calendar*) with:

The printer number, your name, your phone number:

Example: [UM22_Bond_James_040xxxxxxx](#)

Booking the Ultimakers



UM07 Virtanen 040 123 4567
9am - 3pm

ADDLAB - code of conduct



- Treat everyone and everything respectfully :)
- Don't make a mess. Clean your workspace before you leave
- Return all tools to their own places
- **Report broken things**
- Ask and give help
- Minimize the amount of new plastic waste to the world

Learn more about 3D Printing

- Go to **ADDLAB**, 3D print more, and learn by doing
- MEC-7006 Advanced Manufacturing course (5 credits), organized every Spring
- [MEC-E7009 - Design for Additive Manufacturing L](#) (5 ECTS), organized every Spring
- <https://ultimaker.com/en/resources/education/getting-started-with-an-ultimaker>
- <https://www.youtube.com/user/Ultimaker3D/videos> and numerous other info / tutorial videos on YouTube
- **Redwood, B., Schffer, F., & Garret, B. (2017).** *The 3D printing handbook: technologies, design and applications*. 3D Hubs.

Scientific sources:

- **Gibson, I., Rosen, D. W., & Stucker, B., Khorasani, M. (2021).** *Additive manufacturing technologies*. New York: Springer.
- **Ngo, T. D., Kashani, A., Imbalzano, G., Nguyen, K. T., & Hui, D. (2018).** Additive manufacturing (3D printing): A review of materials, methods, applications and challenges. *Composites Part B: Engineering*, 143, 172-196.12-224.
- **DeRoy, T., Wei, H. L., Zuback, J. S., Mukherjee, T., Elmer, J. W., Milewski, J. O., ... & Zhang, W. (2018).** Additive manufacturing of metallic components—process, structure and properties. *Progress in Materials Science*, 92, 1
- <https://scholar.google.com/> and search 'additive manufacturing'

Assignment

Assignment (1 credit)

Please note:

The part that needs to be printed for the assignment **must be different** from what you print for the workshop session.

Reserve an ADDLab 3D printer with the “ADD DMF Google Calendar”, 3D print a part of your selection, and **prepare a short report** (max 1-2 pages) including:

- **A screenshot of the part from the Cura slicer software** (in the *Cura Preview mode*) with the print orientation and main print parameters visible + **a picture of the finished 3D-printed part**
 1. Description of the part and its function
 2. What difficulties or problems did you face while 3D printing? How did you solve them?
 3. How could you reduce the printing time of your part (e.g., via adjusting Cura parameters, print orientation, or modifying the 3D design of the part)?
 4. How could you maximize the quality and surface finish of your part (e.g., via adjusting Cura parameters, print orientation, or modifying the 3D design of the part)?
-
- Add the report to the Assignment submission tab on MyCourses, title: “*ENG-A1009 Assignment_ your name*” – **deadline Fri 24.05.2024.**
 - For any queries, write to kirsi.kukko@aalto.fi.

See you at ADDLab !

K4 building seafront

Access from Sähkämiehentie 4 J
Corridor to the end and U-turn – voilà !

https://www.aalto.fi/en/locations/addlab-hourslocation?check_logged_in=1

