This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Topics:

How to start with 3D printing (3D printing of polymers) NOTES FOR THE LECTURER

14/7/2020

Materials to go through to be inspired

- https://www.prusa3d.com/ebook-basics-of-3d-printing-with-josef-prusa/ - Nice free e-book for beginners
- https://www.thingiverse.com/ - Database of free models, search for inspiration
- https://www.3dhubs.com/guides/3d-printing/ - Relevant source of information
- https://3dprinting.com/ - Relevant source of information
- https://www.sketchup.com/plans-and-pricing/sketchup-free - Easy modelling software with stl conversion
- https://www.autodesk.com/products/fusion-360/students-teachers-educators - Go professional with modelling, free for students

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Topics:

How to start with 3D printing (3D printing of polymers)

14/7/2020

Workshop structure

- What is 3D printing?
- What are the principles used for different materials?
- What are strengths and weaknesses of 3D printing?
- What is a process behind each part?
- How to start?

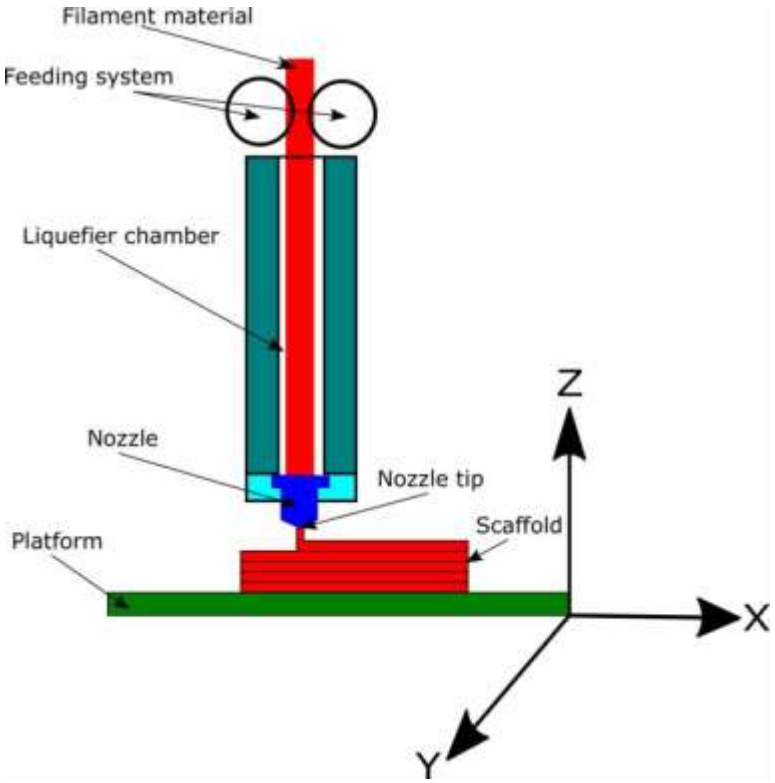
What is 3D printing and how does it work?

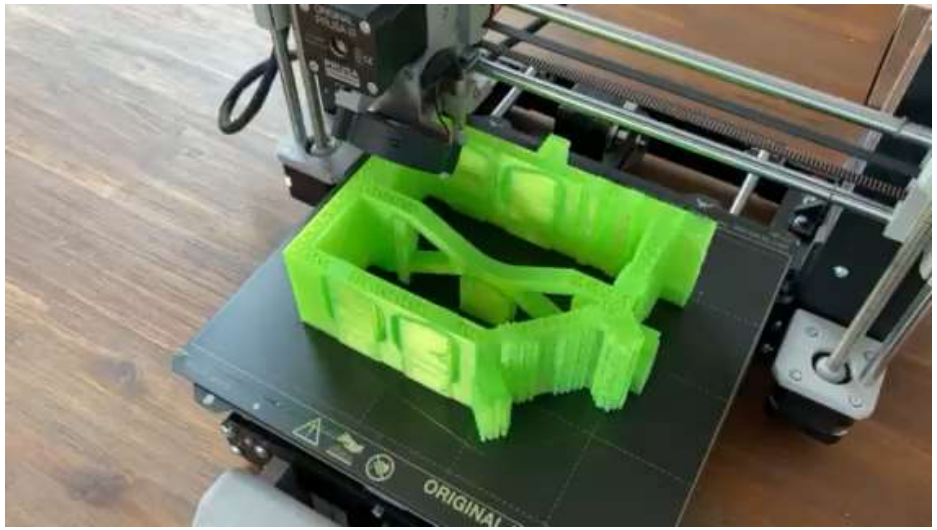
What is 3D printing and how does it work?

- 3D printing or Additive Manufacturing is a process of making three dimensional solid objects from a digital data (model).
- Additive proces means that material is added in layers and object is created by laying down successive layers. Each of these layers are thin horizontal cross-section of the final object.
- 3D printing is another approach to subtractive manufacturing which is typically machining (cutting) out material from stock with tools (milling, turning, grinding) or forming (injection molding).
- 3D printing enables you to produce complex shapes where no special tools are required (for example, a cutting tool with certain geometry or a mold).

https://www.3dhubs.com/guides/3d-printing/#basics

What is 3D printing and how does it work?





What materials and principles are used for 3D printing??

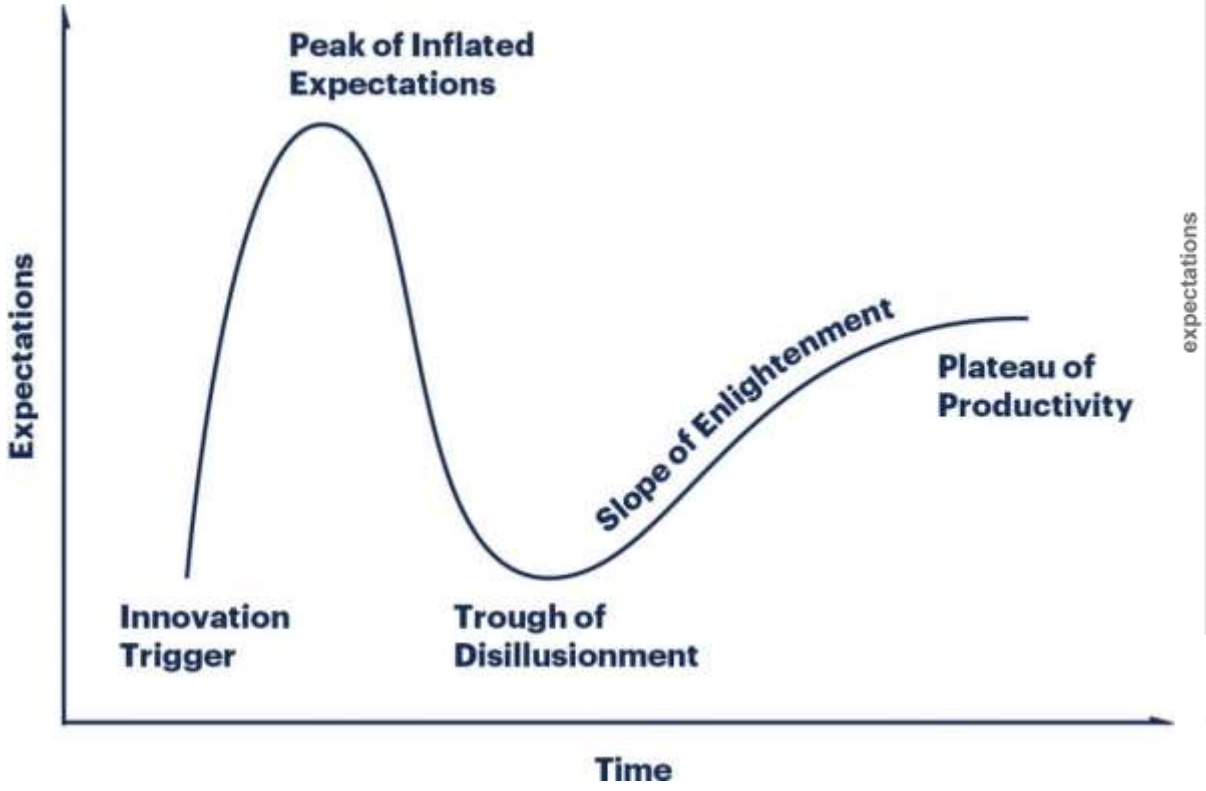
ADDITIVE MANUFACTURING TECHNOLOGIES

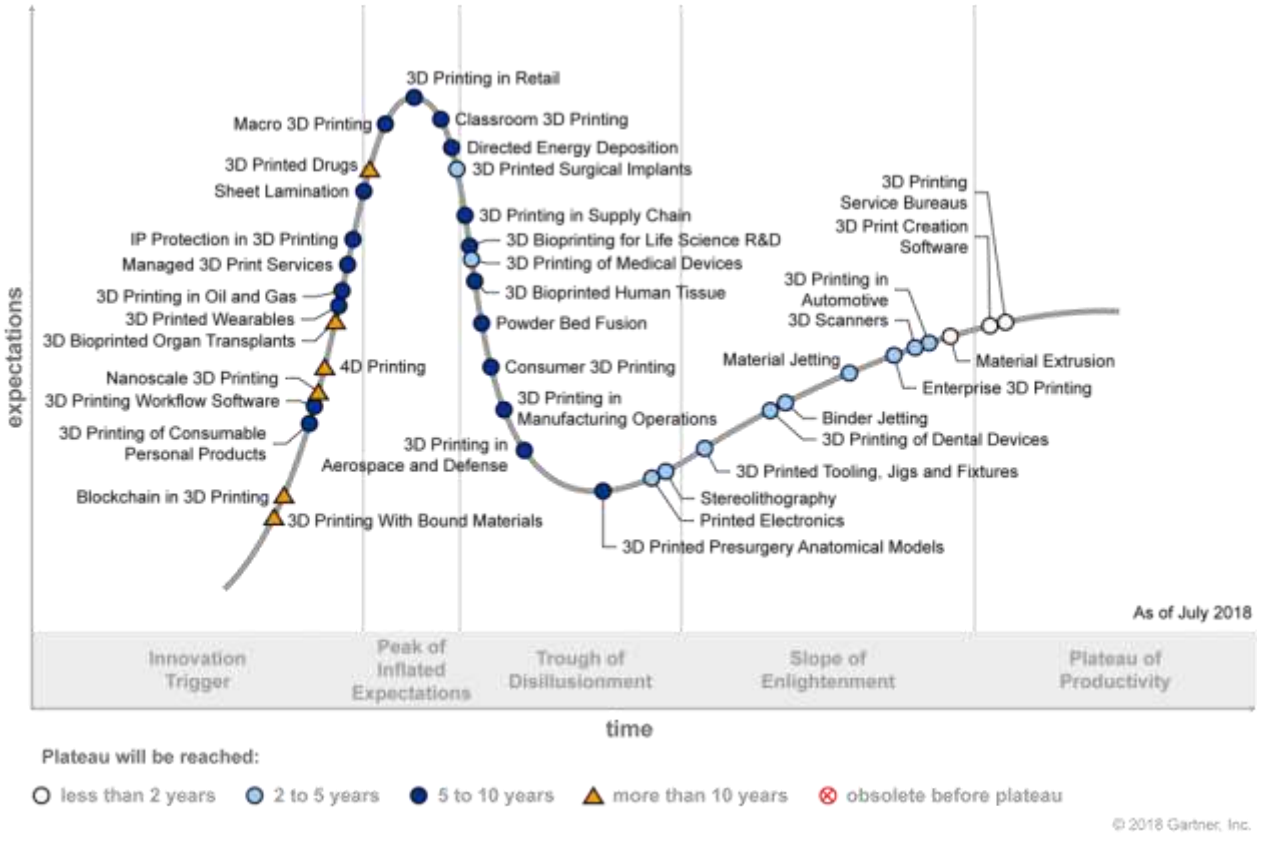
Find out more at **www.3dhubs.com/what-is-3d-printing**

3D HUBS

What are strengths and weaknesses of 3D printing?

Gartner hype cycle





http://www.globalstockpicking.com/2019/06/09/3d-printing-part-1-hype-has-died-time-to-invest/

What are strengths and weaknesses of 3D printing?

Benefits of 3D printing

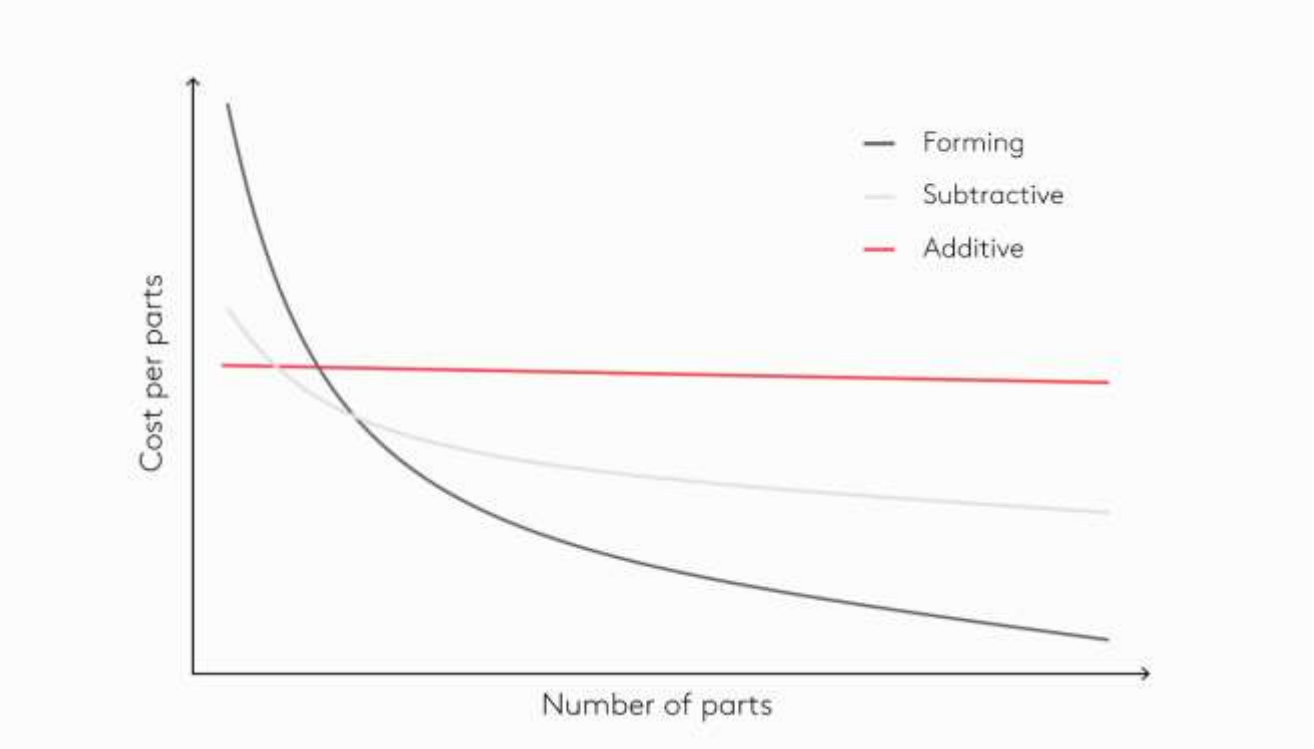
- Geometric complexity at no extra cost
- Very low start-up costs
- Customization of each and every part
- Low-cost prototyping with very quick turnaround
- No special tools, molds needed
- Fast growing range of materials

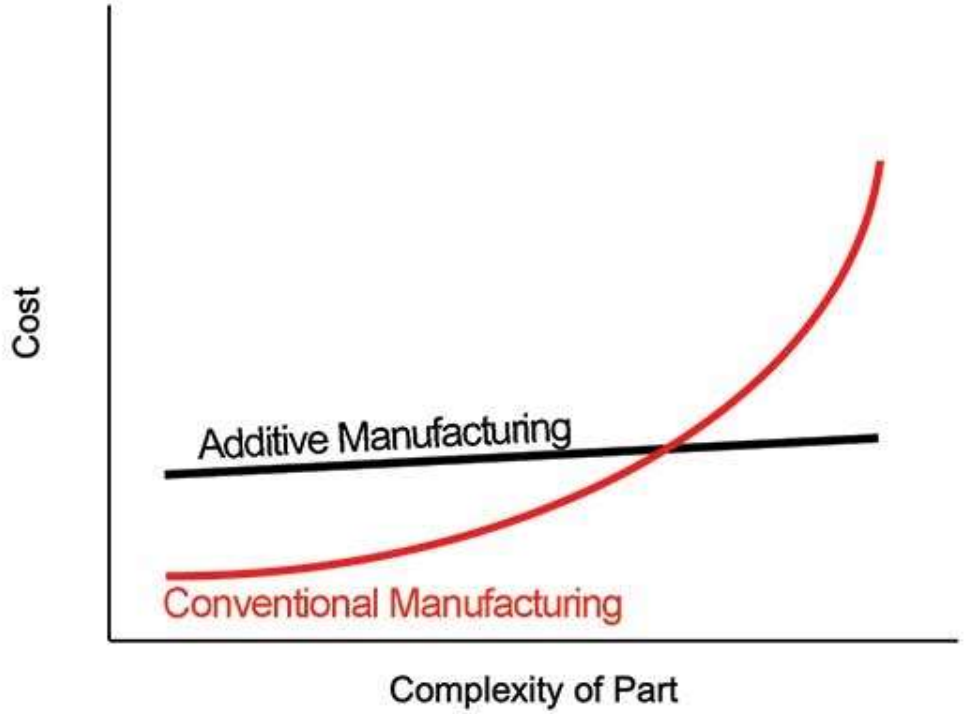
Limitations of 3D printing

- Lower strength & anisotropy of material properties
- Less cost-competitive at higher volumes
- Limited accuracy & tolerances
- Surface roughness and texture
- Post-processing & support removal
- On hi-tech parts machining is still needed

https://www.3dhubs.com/guides/3d-printing/#basics

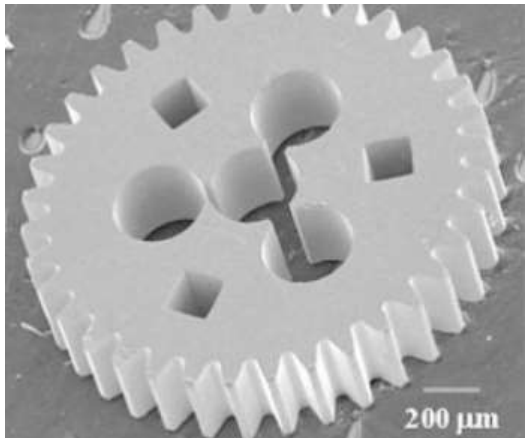
What are strengths and weaknesses of 3D printing?

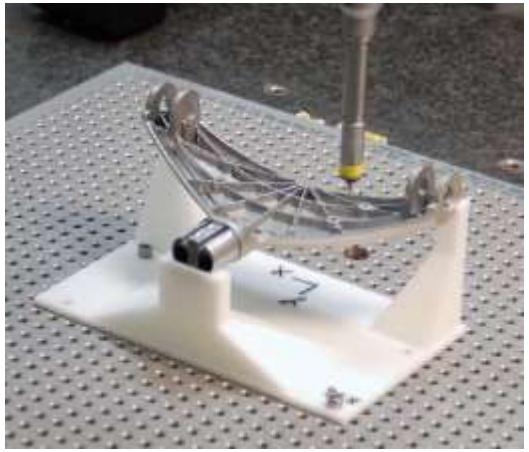




https://www.3dhubs.com/guides/3d-printing/#basics

Current applications





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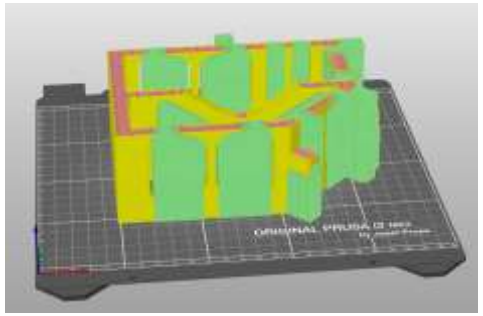
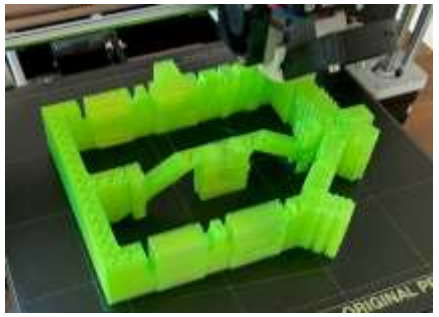
https://www.3dhubs.com/guides/3d-printing/#basics

What is 3D printing process?

How to get from model to part?





1.CAD – creation of model → 2.Conversion of model to STL → 3.Preparation of print data in „slicer“ → 4. 3D printer setup → 5.Print → 6.Postprocessing → 7.Part

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How to start at home

Free CAD modelling for students

SketchUp

AUTODESK® FUSION 360™

1.CAD – creation of model → 2.Conversion of model to STL → 3.Preparation of print data in „slicer“ → 4. 3D printer setup → 5.Print → 6.Postprocessing → 7.Part

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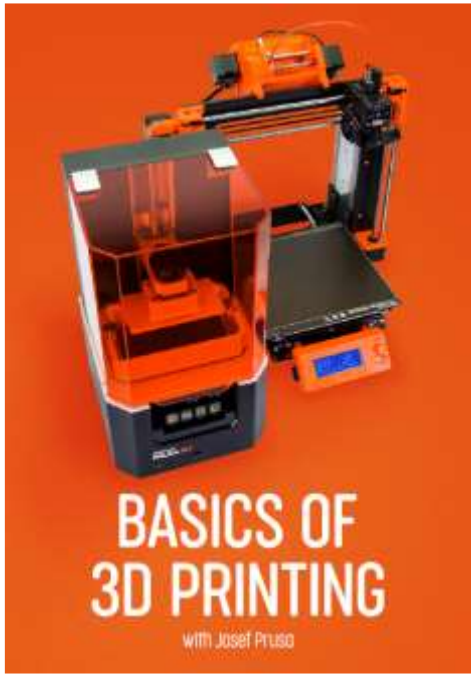
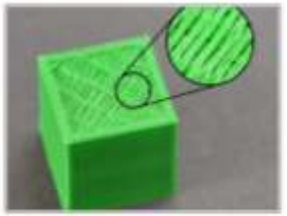
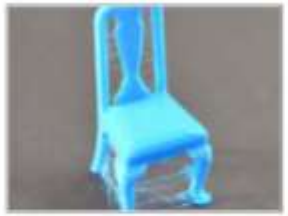


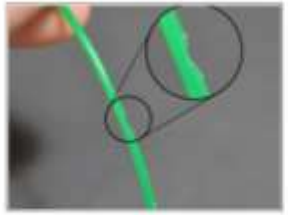

Gaps in Top Layers


Stringing or Oozing


Overheating


Layer Shifting


Layer Separation and Splitting


Grinding Filament


Clogged Extruder


Stops Extruding Mid Print

SAM
SECTOR SKILLS STRATEGY
IN ADDITIVE MANUFACTURING

What are the 3D Printing Skills?

1. 3D Thinking : Ability to use space geometry.
2. Design Vision : Creativity in design of new components specifically for AM.
3. Intelligence in Mechanics : Knowledge and appeal in statics, dynamics, strength and powder metallurgy.
4. Precision Insight : Ability to make accurate and sensitive dimensional measurements and tolerances.
5. Go from Digital to Physical : Ability to coordinate virtual 3D data and the real-life physical object.
6. Topology Optimization : Ability to apply topology mathematics in AM.

1.CAD – creation of model → 2.Conversion of model to STL → 3.Preparation of print data in „slicer“ → 4. 3D printer setup → 5.Print → 6.Postprocessing → 7.Part

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http://www.skills4am.eu/3dprintstudents.html
https://www.simplify3d.com/support/
https://www.prusa3d.com/ebook-basics-of-3d-printing-with-josef-prusa/#_ga=2.242676737.247051190.1595838488-295721172.1588599037

How to start at home

Convert your model to STL or download STL made by someone else

1.CAD – creation of model → **2.Conversion of model to STL** → 3.Preparation of print data in „slicer“ → 4. 3D printer setup → 5.Print → 6.Postprocessing → 7.Part

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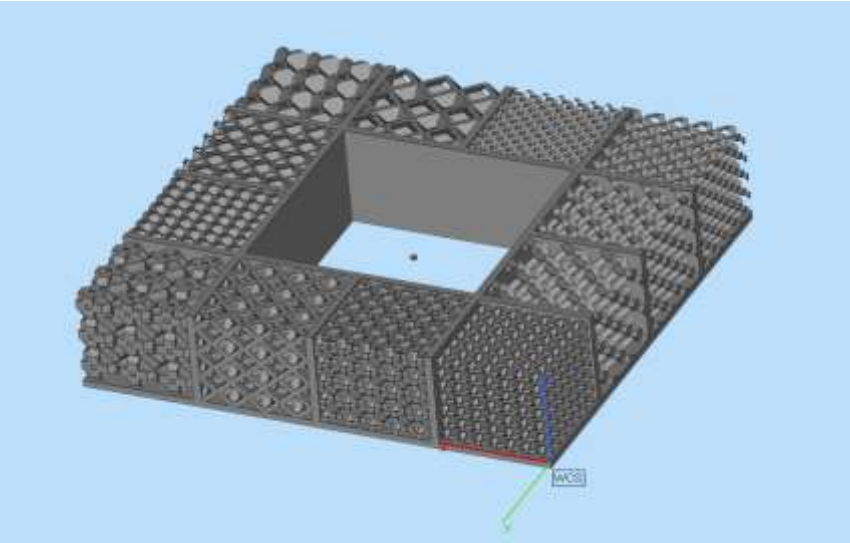
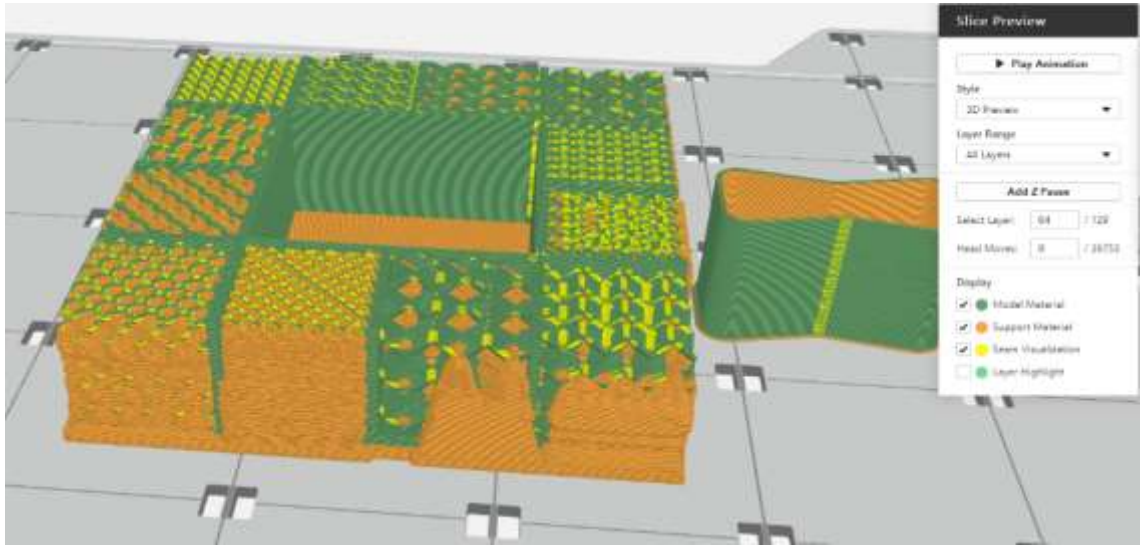
How to start at home





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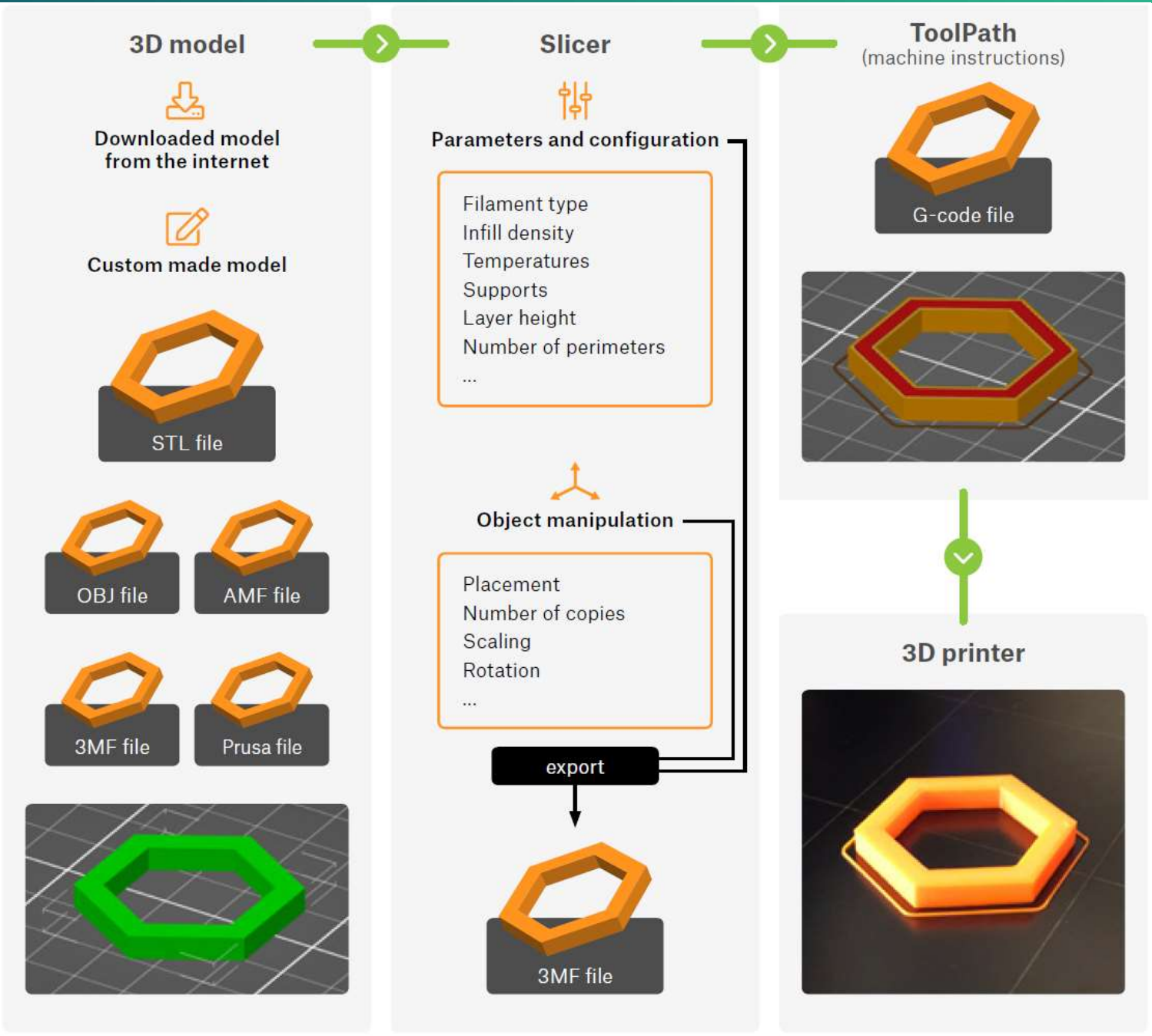
How to start at home

Data preparation by
Prusa 3D



How to start at home

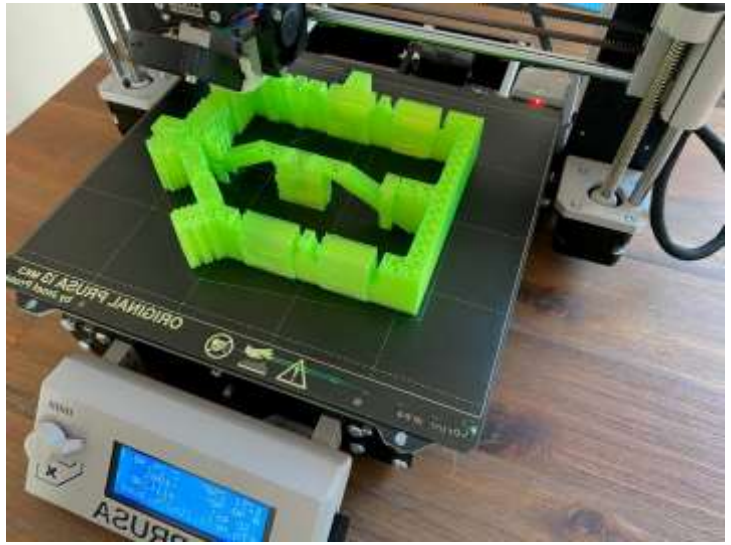
FDM - Put selected material into a printer and start.

1.CAD – creation of model → 2.Conversion of model to STL → 3.Preparation of print data in „slicer“ → **4. 3D printer setup** → 5.Print → 6.Postprocessing → 7.Part

Ultimate 3D Printing Materials Guide by Simplify3D

	 ABS	 Flexible	 PLA	 HIPS	 PETG	 Nylon	 Carbon Fiber Filled	 ASA	 Polycarbonate	 Polypropylene	 Metal Filled	 Wood Filled	 PVA
	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More	Learn More
Compare Selected	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ultimate Strength	40 MPa	26 - 43 MPa	65 MPa	32 MPa	53 MPa	40 - 85 MPa	45 - 48 MPa	55 MPa	72 MPa	32 MPa	20 - 30 MPa	46 MPa	78 MPa
Stiffness	5 / 10	1 / 10	7.5 / 10	10 / 10	5 / 10	5 / 10	10 / 10	5 / 10	6 / 10	4 / 10	10 / 10	8 / 10	3 / 10
Durability	8 / 10	9 / 10	4 / 10	7 / 10	8 / 10	10 / 10	3 / 10	10 / 10	10 / 10	9 / 10	4 / 10	3 / 10	7 / 10
Maximum Service Temperature	98 °C	60 - 74 °C	52 °C	100 °C	73 °C	80 - 95 °C	52 °C	95 °C	121 °C	100 °C	52 °C	52 °C	75 °C
Coefficient of Thermal Expansion	90 µm/m-°C	157 µm/m-°C	68 µm/m-°C	80 µm/m-°C	60 µm/m-°C	95 µm/m-°C	57.5 µm/m-°C	98 µm/m-°C	69 µm/m-°C	150 µm/m-°C	33.75 µm/m-°C	30.5 µm/m-°C	85 µm/m-°C
Density	1.04 g/cm³	1.19 - 1.23 g/cm³	1.24 g/cm³	1.03 - 1.04 g/cm³	1.23 g/cm³	1.06 - 1.14 g/cm³	1.3 g/cm³	1.07 g/cm³	1.2 g/cm³	0.9 g/cm³	2 - 4 g/cm³	1.15 - 1.25 g/cm³	1.23 g/cm³
Price (per kg)	$10 - $40	$30 - $70	$10 - $40	$24 - $32	$20 - $60	$25 - $65	$30 - $80	$38 - $40	$40 - $75	$60 - $120	$50 - $120	$25 - $55	$40 - $110
Printability	8 / 10	6 / 10	9 / 10	6 / 10	9 / 10	8 / 10	8 / 10	7 / 10	6 / 10	4 / 10	7 / 10	8 / 10	5 / 10
Extruder Temperature	220 - 250 °C	225 - 245 °C	190 - 220 °C	230 - 245 °C	230 - 250 °C	220 - 270 °C	200 - 230 °C	235 - 255 °C	260 - 310 °C	220 - 250 °C	190 - 220 °C	190 - 220 °C	185 - 200 °C
Bed temperature	95 - 110 °C	45 - 60 °C	45 - 60 °C	100 - 115 °C	75 - 90 °C	70 - 90 °C	45 - 60 °C	90 - 110 °C	80 - 120 °C	85 - 100 °C	45 - 60 °C	45 - 60 °C	45 - 60 °C
Heated Bed	Required	Optional	Optional	Required	Required	Required	Optional	Required	Required	Required	Optional	Optional	Required
Recommended Build Surfaces	Kapton Tape, ABS Slurry	PEI, Painter's Tape	Painter's Tape, Glue Stick, Glass Plate, PEI	Glass Plate, Glue Stick, Kapton Tape	Glue Stick, Painter's Tape	Glue Stick, PEI	Painter's Tape, Glue Stick, Glass Plate, PEI	Glue Stick, PEI	PEI, Commercial Adhesive, Glue Stick	Packing Tape, Polypropylene Sheet	Painter's Tape, Glue Stick, PEI	Painter's Tape, Glue Stick, PEI	PEI, Painter's Tape
Other Hardware Requirements	Heated Bed, Enclosure Recommended	Part Cooling Fan	Part Cooling Fan	Heated Bed, Enclosure Recommended	Heated Bed, Part Cooling Fan	Heated Bed, Enclosure Recommended, May Require All Metal Hotend	Part Cooling Fan	Heated Bed	Heated Bed, Enclosure Recommended, All Metal Hotend	Heated Bed, Enclosure Recommended, Part Cooling Fan	Wear Resistant or Stainless Steel Nozzle, Part Cooling Fan	Part Cooling Fan	Heated Bed, Part Cooling Fan

How to start at home



Printing may take some time so:

- Do something else
- Enjoy your virtual friends
- Watch sports on TV
- Worse case scenario do something real outside ☺

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How to start at home

FDM

SLA

DMLS

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How to start at home

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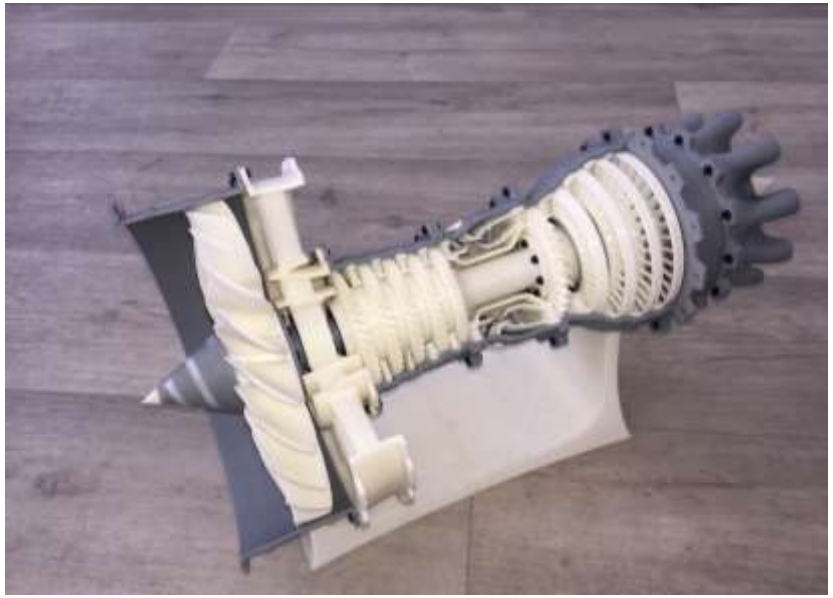
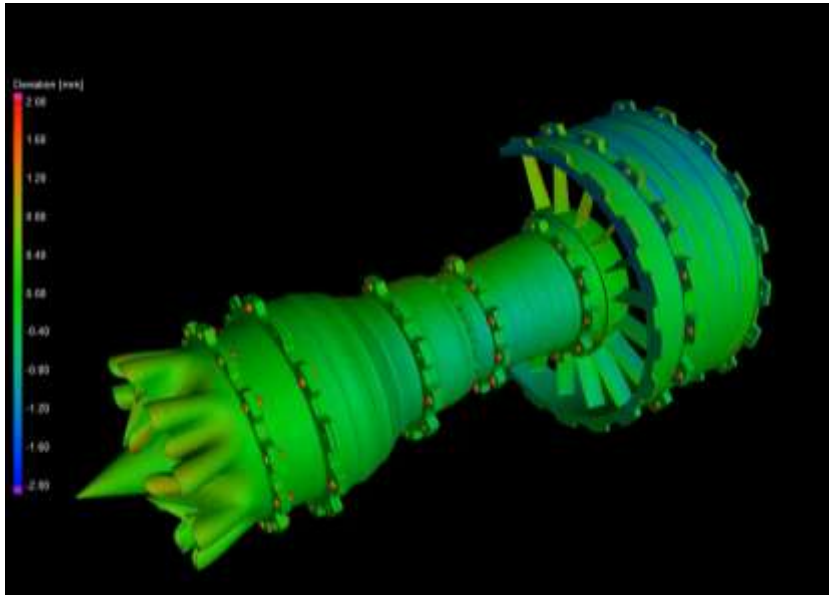
How to start at home

Enjoy and improve your part





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Sources

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https://www.sketchup.com/plans-and-pricing/sketchup-free
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https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DT64LZFQ_T3Q&psig=AOvVaw3h2A4h45ri9EEAtHJ3Sksx&ust=1595922664492000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCOjak7j57OoCFQAAAAAdAAAAABAV

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.productdesigny.com%2Fmedia%2Fviewer%2Fdigital_fabrication__3DP_Prusa&psig=AOvVaw1hEr7P9hemJ2O9A7VkY9JH&ust=1595922510612000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCLjomPz57OoCFQAAAAAdAAAAABAD

https://www.google.com/url?sa=i&url=https%3A%2F%2Fsupport.formlabs.com%2Fs%2Farticle%2FAdvanced-Support-Removal-Techniques&psig=AOvVaw0SKJdBgFpV5NDlW-0rUDb_&ust=1595922320542000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCICk7o767OoCFQAAAAAdAAAAABAL