DESIGN FOR 3D PRINTING

Bitfab's quick guide to
design for FDM 3D printing

bitfab

This is a compact guide aimed at technical people to allow them to create products and prototypes that can be produced with FDM 3D printing.

Enjoy the content and send us your questions and feedback to info@bitfab.io.

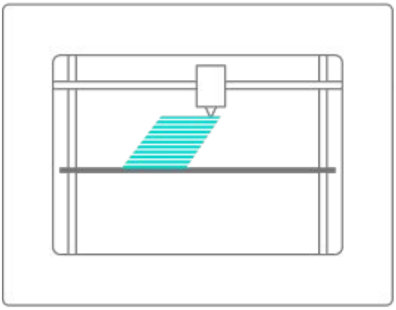
Table of contents

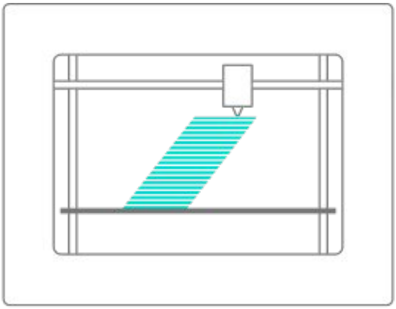
Basics
of FDM 3D printing

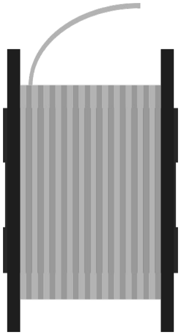
What is FDM 3D printing

FDM (Fused Deposition Modelling), also known as FFF (Fused Filament Fabrication) is a 3D printing technology that builds the part by depositing plastic in successive horizontal layers.

FDM is the most widely available and economical 3D printing technology, used for prototypes and small series production.







Materials

Many thermoplastics, including engineering polymers can be printed with FDM: PLA, PETG, ABS, Nylon, ASA, TPU, PEEK, ULTEM…

Applications of 3D printing

Bitfab helps companies manufacture their prototypes, tooling and production parts using 3D printing.

Prototypes

Rapid prototyping is the most common application of 3D printing.

Order unique parts with lead times of just days, test your design with physical parts and have a faster developing cycle.

Tooling

Create jigs, tooling, templates with 3D printing and have them in your factory or workshop in days.

Jigs can be redesigned and improved over time due to the low cost of producing one off parts with 3D printing.

Components

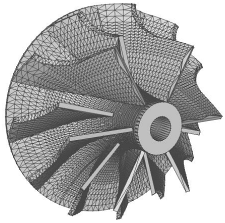
We offer an alternative to traditional manufacturing techniques (CNC, sheet metal, injection molding…) for small production volumes.

3D printing is usually more economical for short series and allow you design more functional parts with faster turnaround times.

3D printing for manufacturing

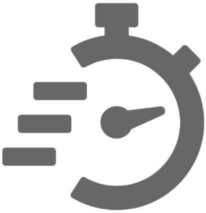
No setup costs

3D printing doesn’t have the setup costs associated with molding or CNC. Very competitive prices for prototypes and small series production.



Complex geometries

Able to produce complex parts, typically requiring 5 axis machining, without added costs. Design your parts for functionality and think less about the manufacturing constraints.



Fast turnarounds

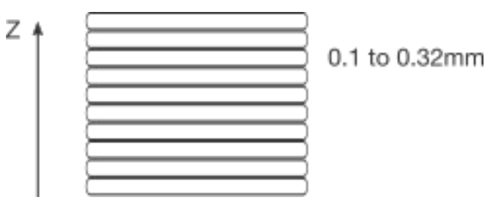
Parts can be ready in as short as 3 days. Speed up your prototyping and manufacturing cycles. Several physical iterations of the prototype or product are possible.

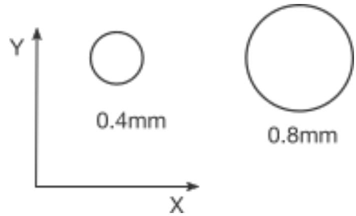
Easy order process

Quotation is generated directly from the 3D model (usually with an STL file) and the customer requests. No need to generate drawing or manufacturing documentation.

Understanding the FDM process

Understanding how the parts are produced in an FDM printer is important to know how the parts will look and perform. Parts are built layer by layer by a circular nozzle that deposits the plastic.



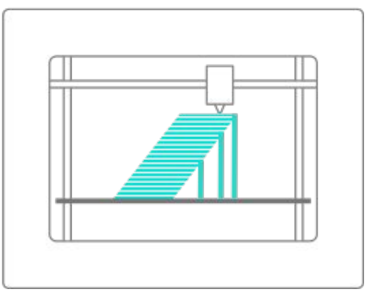


Layer height (Z resolution)

0.1 to 0.32mm (typical value 0.2mm)

Nozzle diameter (XY resolution)

0.4 or 0.8mm and above (typical value 0.4mm)



Support structures

Due to the layer by layer nature of the process, the printer will create support structures below features that otherwise would print mid air.

Support material will affect appearance of the supported surfaces.

Bitfab takes care of determining the optimum layer height, nozzle diameter and support structures to obtain the best result according to your specifications.

How FDM parts are priced

Similarly to other manufacturing technologies, 3D printed parts are quoted using the costs related to setting up and running the machine, as well as the cost of material used.

- **Setup costs.** Costs derived from processing the file, loading it in the machine, unloading and processing the parts… These costs are usually charged in a flat price per part or per job, but are much smaller than with other manufacturing methods (injection molding, CNC…).
- **Hourly costs.** Costs derived from the hourly operation of the machine (amortization, operator salaries and electricity costs). Hourly cost is the main contributor to part cost.
- **Material costs.** Cost of the filament used in the part, including support structures.

Cost per cm3. Some 3D printing service providers such as Bitfab offer simplified flat rates per cm3, which allow customers to know the costs of the parts before sending the quotation.

Quotations

For part quotations and help with your project you can go to our webpage bitfab.io or send us an email to info@bitfab.io.

Design software

Any CAD software can be used to design parts for 3D printing since they all can export to STL. STL is the most widely used file extension used to share designs in the 3D printing sector.

If you or your company still don't use a design software our recommendation is Autodesk Fusion 360, which is a powerful tool for creating engineering parts.

Fusion 360 (Windows and Mac) is a very powerful and versatile software. Free for non-commercial use, students, educators and companies with annual revenue below 100.000 USD.

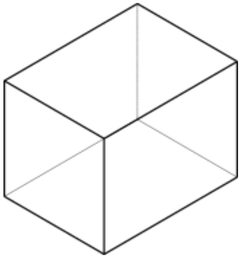
Includes features such as CAD, sculpt workbench, CAM, FEM, rendering…

Other 3D design software tools:

- **CAD software:** Solidworks, Autodesk Inventor, CATIA, PTC Creo, Siemens NX, SketchUp, FreeCAD
- **Organic modelling**: Blender, Maya, 3DS Max, ZBrush.
- **Online**: Onshape, Tinkercad
- **Mesh processing**: Meshmixer, Meshlab

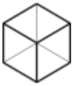
Design guidelines for FDM 3D printing

Part size



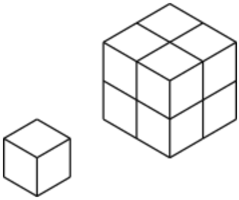
Maximum part dimensions: 400 x 300 x 300 millimetres (X, Y, Z axis)

Bigger parts can be printed on demand or spit in several print jobs.



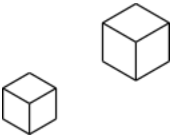
Small parts. Small parts less than 20 x 20 x 20 millimetres can be hard to print with FDM technology.

Such small parts should have simple geometries in order to be printable.



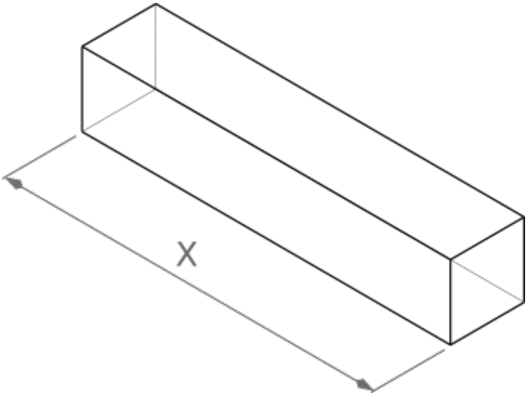
Large parts costs. Since the volume increases rapidly when scaling the part dimensions (volume increases with the cube of the length) very large parts are expensive to produce.

When printing large parts we can offer costs optimizations such as large nozzles, higher layer heights, etc.



80% rule. To reduce the part volume to approximately half, scale the part to 80% of the original dimensions.

This is a measure to reduce costs of parts that can be scaled without affecting functionality (not very common in engineering parts).



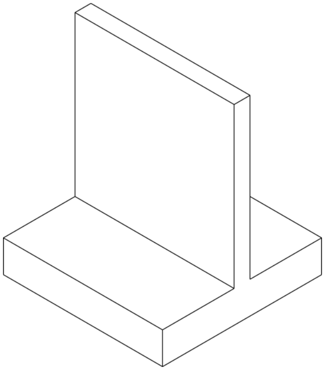
Dimensional tolerance: ±0.5%, with a lower limit of 0.5mm

Part tolerance for large dimensions is usually constrained by the shrinkage of the material during the cooling process. We review files according to our customers specifications to compensate for the shrinkage effect.

Part tolerance for small dimensions is usually affected by machine vibrations, flow control in the nozzle… The lower limit is ±0.5mm due to this effects.

See holes, assembly, etc for further info to better understand how tolerance in 3D printing will affect your designs.

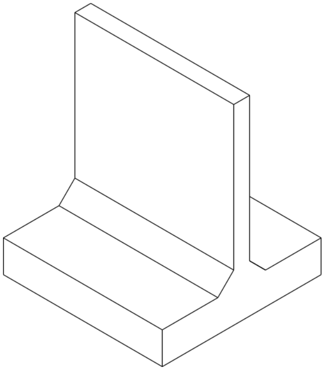
Walls



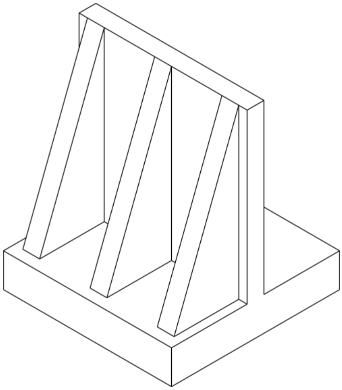
Thinnest walls: 0.8mm. Designing parts with large thin walls will affect strength of the part.

Recommended: 2.4mm and thicker walls.

When designing thin walls use 0.4mm multiples (nozzle diameter) for walls for them to be completed in a whole number of passes and increasing strength.

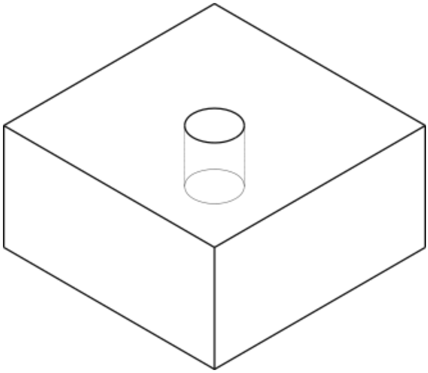


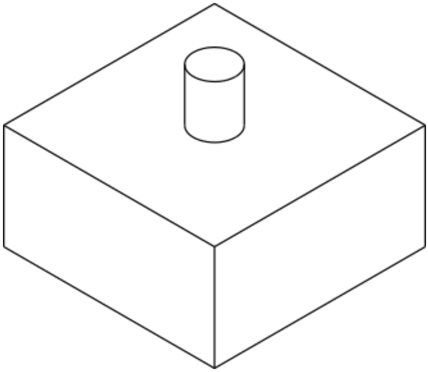
Fillets and chamfers. Adding fillets or chamfers to the base is advisable to increase section and reduce stress concentration.



Ribs. Large thin walls can be prone to warping, add ribbing or increase thickness.

Holes, pins and small sections





Minimum hole diameter: 2mm

Undersized holes. Holes and inner diameters in FDM 3D printing are usually printed smaller than the nominal dimensions.

- Small holes (up to 10mm diameter). Add 0.4mm to the diameter. When tight tolerances are required, drilling or reaming to final size can be required.

- Large holes. For large holes that require fitting of another component, specify this requirement in the quotation and we will prepare the file in the review process.

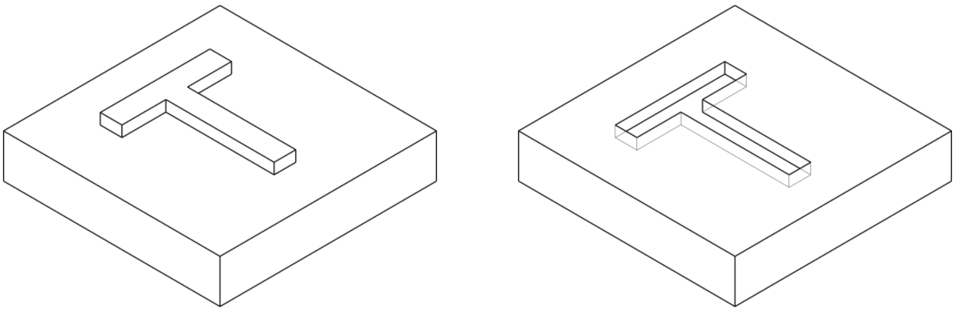
Minimum pin diameter: 4mm for short pins. Longer pins will be more prone to breaking and should be thicker.

Other small sections. Any other similarly small section of the parts can be unprintable or break during the service life of the part.

Design the part so this small features and sections don't support large loads.

Embossed and engraved details

Text and other details can be embossed and/or engraved in your 3D printed parts.



Embossing min width: 1.2mm

Height: 0.4 mm

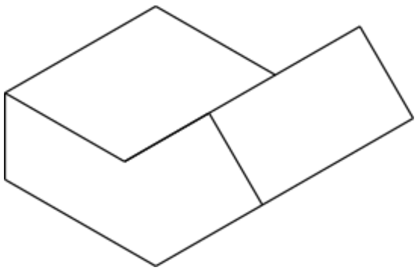
Width multiples of 0.4 mm are recommended for best results (multiples of the nozzle diameter, to complete the feature in a whole number of passes)

Engraving minimum width: 1.2mm

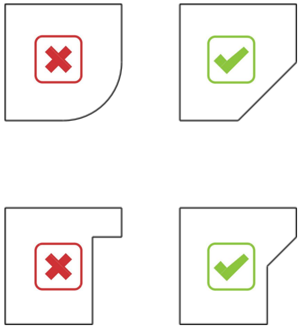
Depth: 0.4mm

When possible, engrave your text or details instead of embossing them.

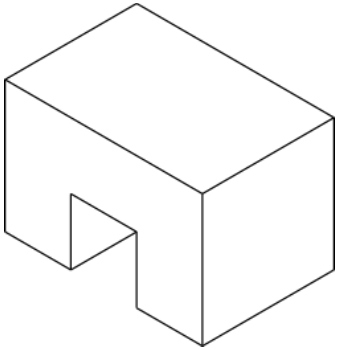
Overhangs and bridges



45 degree rule. Overhangs with an inclination lower than 45º will require support material.

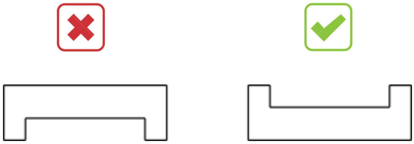


Minimize support. Design your parts using the 45º rule to minimize support material. Support increases the cost of the part and affects the quality of supported surfaces.



Bridges. Bridges smaller than 10mm in length will be printed without supports.

Longer bridges will require support material.



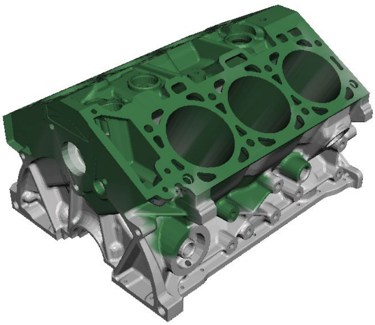
Unsupported flat surfaces. Large horizontal surfaces suspended on air in the bottom of your part can be considered large bridges. Avoid large surfaces that will require support and affect the surface quality.

Printing orientation

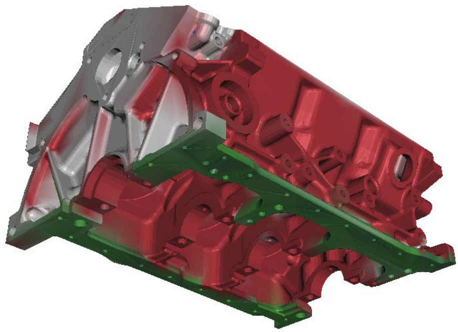
- Printing orientation and part finish
- Printing orientation and part strength

Printing orientation and part finish

Depending on the printing orientation some of the model faces may need support material or will be printed on air, which can affect surface quality.



Top and vertical faces will have the best surface finish.



Overhanging, unsupported, sloping faces may require support material and will have coarser surface finish.

The bottom plane is printed directly on the bed surface and will have good surface finish.

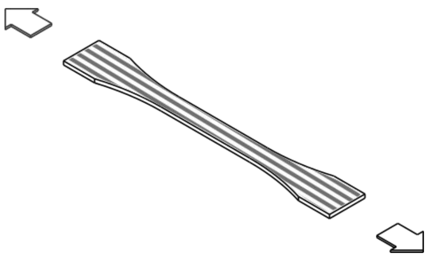
Design your part with a printing orientation in mind. Try to avoid sharp overhangs and place the most detailed features in the top faces of your object.

Parts usually need to have a lower flat surface to be printable. If there is not a bottom surface, the software will generate support structure to fix the part to the build plate.

If not possible, split your design in several parts, each of one optimized for printability.

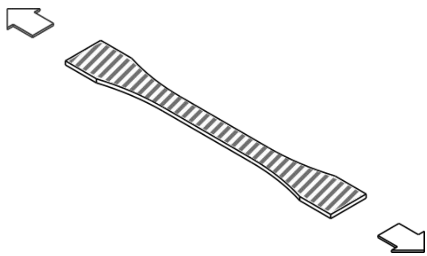
Printing orientation and part strength

Parts produced with FDM 3D printing technology are stronger along the layer plane (X and Y axis of the machine) and weaker at the interface between layers (Z axis of the machine).



The part will resist higher loads in the layer plane (X and Y axis) along the printed paths.

When possible, design your parts so the main loads are applied in the layer directions.



The part will resist lower loads in the layer plane (Z axis) since the layer interface is the weakest point of a 3D print.

Design your part minimizing the loads applied in the Z direction or increase the section of the features in this orientation.

Avoid long pins and salient features that are oriented in the Z direction.

Avoid critical sections coincident with layer interface planes.

Do you need more information about 3D printing?

Do you want a quotation for a 3D printed part?

Contact us, we will be glad to help you

info@bitfab.io

https://bitfab.io