



Markforged X7 Protocol

Fused Deposition Modeling (FDM) Overview:

FDM or 3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material. Additive manufacturing is defined by ASTM as the "process of joining materials to make objects from 3D model data, usually layer upon layer.

FDM begins with a software process, which processes an .stl file (stereo lithography file format), mathematically slicing and orienting the model for the build process. If required, support structures are automatically generated. The Markforged X7 uses the same material for both model and support.

Markforged X7 – Machine Specifications:

- Build Volume: 330 mm x 270 mm x 200 mm (13" x 10.6" x 7.9")
- Model and Support Material: Onyx (*nylon + carbon fiber*)
- Continuous Fiber Options: Fiberglass, Carbon Fiber, Kevlar, HSHT (*high strength high temperature*) Fiberglass
 - Only one continuous fiber may be applied to any single part.
 - While continuous fiber options significantly increase the strength of a part, they are not necessary as the machine can print with Onyx only
- Available Layer Thicknesses: .05 mm (.002"), .1 mm (.004"), .2 mm (.008")
 - *Layer thicknesses will be dictated by choice of continuous fiber*
- Programming: Prints are programmed via Eiger.io software

How to Submit a 3D Printing Job Request:

Please include the following items in your request:

- Accepted file format: .stl
- .pdf drawing of part including dimensions and number of parts desired
- Infill style and fill density (*See Infill Style and Fill Density section below*)
- Layer thickness (*see Machine Specifications below – choose from 3 thickness options*)
- Please email your print requests to meshops-me@berkeley.edu
- Once we receive your request, we will respond back with a quote including the cost of materials and an approximate time needed to complete your job. Payment is required at the time of pick up. Acceptable forms of payment include credit/debit cards, checks made out to "UC Regents", or an approved and signed IOC (interdepartmental charge) form.

Current charges and other additional information on next page

Current Charges:

- \$1.00 per cubic cm for Onyx
- \$3.00 per cubic cm for fiberglass
- \$4.00 per cubic cm for HSHT Fiberglass and Kevlar
- \$6.00 per cubic cm for carbon fiber

Infill Style and Density:

There are 4 options to choose from when selecting an infill style. Within each of these you may have the option to specify the infill density:

- Triangular: Great option for optimizing balance between material usage and structural integrity. *Infill Density Range: 28-55%*
- Hexagonal: Similar to triangular infill option, but this has a greater density range. *Infill Density Range: 18-60%*
- Rectangular: This option provides the greatest range of infill density options to allow users to best optimize a balance between material usage and structural integrity. *Infill Density Range: 0-92%*
- Solid: This option fills in every possible void within a layer with model material. This option uses the most material, but typically yields higher structural integrity. *Infill Density Range: 100%*

Materials Used:

Model and Support: Onyx is a proprietary combination of nylon and chopped bits of carbon fiber. The Onyx filament is liquefied and deposited by an extrusion head, which follows a tool-path defined by the CAD file. The material is deposited in layers as fine as 50um (0.002") thick and the part is built from the bottom up – one layer at a time. The support material (also Onyx) is used for making temporary supports while manufacturing is in progress. The support material is manually removed by hand at the completion of the build.

Continuous Fibers: The Markforged X7 has the ability to integrate a continuous strand of fibrous material at any given layer within a model (*continuous fiber layers can only be printed in the XY plane*). Only one continuous fiber may be applied to any single part. Users can choose from one of four available continuous fibers: Fiberglass, HSHT (*high strength high temperature*) Fiberglass, Kevlar, and Carbon Fiber.

Materials specifications for the Onyx material and all Continuous Fibers can be found [here](#).

Additional Notes:

- **No secondary machining allowed! Due to the presence of carbon fiber in the onyx material, we do not allow or recommend any type of secondary machining.**
- While designing your parts, we have found that parts can have a **minimum thickness** of 1-1.5 mm (0.040-0.060"). Thinner features will not print successfully.
- Consider using fillets in the corners to add strength.
- Due to limited resolution, circular parts will not be perfectly round. If you plan on having mating pieces, there needs to be a minimum clearance of 0.178 mm (0.007").
- Expect external features to print larger than designed (Eg. Outer diameters).
- Expect internal features to print smaller than designed (Eg. Inner diameters).