MAKERBOT 3D PRINTER

The basics.

TERMINOLOGY

FDM®: Fused Deposition Modeling, the 3D printing technology used by MakerBot

Slicing: Turning a 3D model into 2D layers used for 3D printing

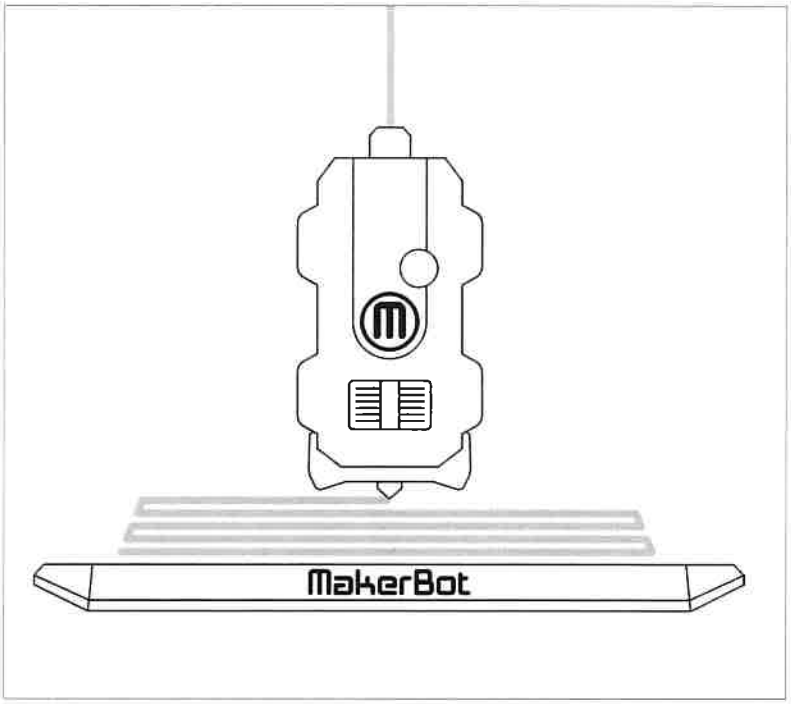
Filament: Material used to build 3D printed parts

Extruder: The "hot glue gun" of your 3D printer; it uses filament to draw out the layers of 3D printed parts

Build Plate: Surface on which 3D prints are built

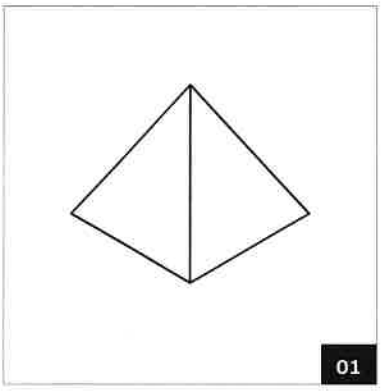
Gantry: Moves the carriage in the x-axis and y-axis

Carriage: Carries the extruder



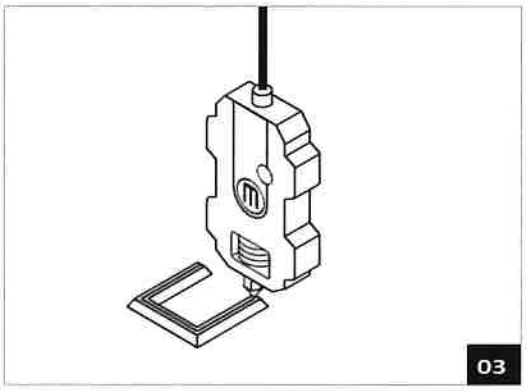
HOW DOES IT WORK?

There are several types of 3D printing technology in use today. The additive manufacturing technology that MakerBot 3D Printers use is called Fused Deposition Modeling, or FDM for short.



01: FDM printing starts with a digital 3D model, most often generated from a 3D modeling program.

02: The 3D model is sliced into 2D layers using a slicing software and then sent to the printer.



03: On the printer, filament is fed into an extruder that draws out each slice, layer by layer, onto the build plate. Over time, these 2D layers stack on top of each other to build a 3D print.

MAKERBOT 3D PRINTER

HOW TO USE A 3D PRINTER

These are the 3 basic steps to print on a MakerBot 3D printer.

1: Design. In order to 3D print, you must start with a 3D file. Here are a few ways to get one:

› **Design** a model to print in a 3D design software or computer-aided design (CAD) program.

› **Scan** an existing physical object with a 3D scanner.

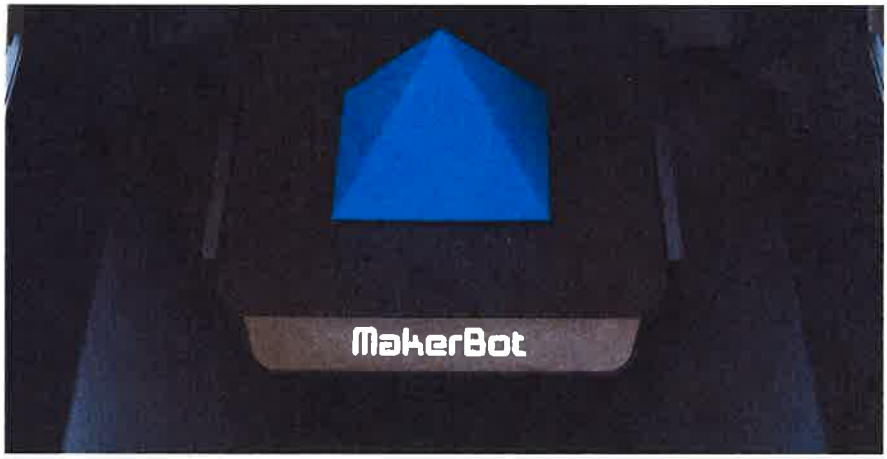
› **Find** a model online from websites like thingiverse.com or grabcad.com

2: Slice. Before printing a model, prepare the file in MakerBot® Print™. Follow these steps:

› **Edit** the print settings.

› **Decide** if you want to print more than one part.

› **Slice** the model to prepare for printing, which translates the model(s) into a language the 3D printer can understand.



3: Print. Send your sliced file to your MakerBot 3D printer for printing.

The print time will depend on many factors, including:

› Your print settings

› The size and complexity of the model

SHELLS AND INFILL

Print settings can dramatically change the strength, appearance, print time, and other properties of your printed parts.

Shells are the perimeter on each layer; they make up the walls of your part. Infill is the internal structure of your part. You can set the infill of your part to be anywhere from 0% (hollow) to 100% (solid). Increasing the infill and number of shells will make your parts stronger, but will increase print time and filament use.

PRINTED PYRAMID
10% Infill / 02 Shells
without supports

PRINTED PYRAMID
0% Infill
08 Shells

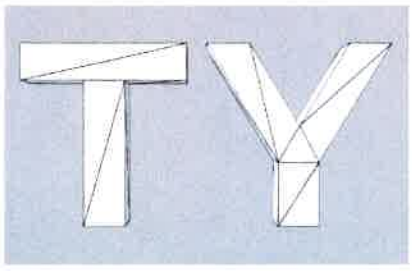
PRINTED PYRAMID
25% Infill
02 Shells

PRINTED PYRAMID
02% Infill
02 Shells

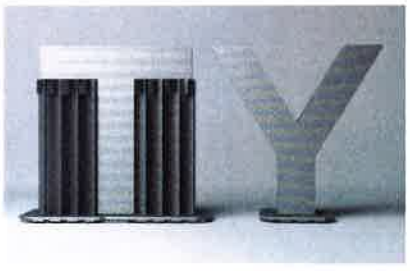
PRINTED PYRAMID
50% Infill
02 Shells

SUPPORTS AND RAFTS

Supports are printed scaffolding for overhangs. If your model has overhangs greater than 68 degrees (measured from the vertical axis) then you will need to print with supports. A raft helps the part adhere to the build plate by laying down an even, flat foundation to print on.



3D Model: The T model has overhangs greater than 68 degrees and needs support material. The Y model does not need support material.



Supports: After printing, the T will needs support material removed. Both printed with rafts.

Final Print: Final parts after removing supports and rafts.

When exploring how to best use your 3D printer, you don't have to go it alone. There's a massive online community of millions of 3D printing educators and makers that actively offer advice, answer questions, and contribute their designs for others to use freely. This community is Thingiverse.

Thingiverse is built on the principles of sharing, learning, and making. It's a community where users from all over the world can download free 3D models and 3D printing lesson plans for any age group or subject. MakerBot founded Thingiverse in 2008 while developing the first desktop 3D printers, and several years later it's grown to an enormous size and stands in support of the entire 3D printing industry.

TERMINOLOGY

Thingiverse®: The largest online 3D printing community and library of printable files, accessible at thingiverse.com

Thing: A 3D model uploaded to Thingiverse, this can be a single object or several, and typically comes with pictures and printing instructions

Thingiverse Education™: 3D printing projects and lesson plans for different grades and subjects

Remix: A cornerstone of Thingiverse. This is when a user edits or builds upon a Thing to customize it in some way while providing attribution to the original designer

Licensing: Describes how a designer permits the community to use his/her creation (i.e. whether it can be remixed or sold commercially)

Makes: When a user downloads and prints another designer's model, then uploads a picture of it to demonstrate its appearance and printability

Collection: A curated folder of Things by users, and a great way to organize Things for your class

THINGIVERSE, A UNIVERSE OF THINGS

Thingiverse is a great place to go for inspiration when creating your own 3D models. Instead of designing a hinge or spring from scratch, there are plenty of Things you can look to for guidance, or download and modify to suit your own project.

Several designers use Thingiverse the way photographers use Instagram; designers upload 3D models to share with others and get feedback and recognition for their work. Take some time to explore the more active users' portfolios – you're sure to find some amazing and inspirational Things!

Be mindful of the licensing features that the original designer has chosen when downloading and printing 3D models. In some cases, you are free to use the model however you'd like. However, in others, you may not be allowed to remix or use the model commercially, such as selling prints of the model. In all cases, you must provide attribution to the designer, especially when you remix another designer's model.

THING BADGES

When searching Thingiverse, keep an eye out for these icons to help you identify standout Things:

Verified Thing: 3D model has been print tested and verified to print successfully.

Featured Thing: This Thing has been featured on the Thingiverse homepage.

Challenge Winner: This Thing was the winning entry in a Thingiverse Challenge.

Thingiverse Education: This Thing is an educational project.

MAKERBOT 3D PRINTER

3D DESIGN SOFTWARE

Learning how to design in 3D is essential to creating custom 3D printable models. The broad capabilities of the printer will push you to design increasingly complex objects. Once you begin to experiment, you'll discover the unique advantages that different 3D design programs offer for different applications.

We recommend starting with easy solid modeling programs before branching out to digital sculpting or parametric modeling as you become more comfortable. No single program is right for everyone, and it may take a few tries before you find one that you're comfortable with.

There are a lot of 3D design programs available, all with different strengths and weaknesses. When looking at 3D modeling programs, you'll find that all of them fall into three major categories; **solid modeling**, **digital sculpting**, or **polygon modeling**. The projects in this guidebook focus mainly on free programs.

TERMINOLOGY

Solid Modeling: Define and construct solid objects with real world dimensions

Digital Sculpting: Simulate clay sculpting. Push and pull surfaces to create detail and texture

Polygon Modeling: Define outer surfaces like edges and corners to create intricate models

Parametric Modeling: A feature in 3D design programs, use dynamic variables for object parameters so that entire designs can be easily altered or scaled

Mesh: The collection of vertices, edges, and faces that make up the surface of a 3D model

Watertight: A continuous outer surface with no holes in it, necessary for successful 3D printing

Perspective View: Objects further away appear smaller than objects closer to the viewpoint

Orthographic View: Fixes the point of view to a single perspective, where similarly sized objects appear the same size regardless of their distance from the viewpoint

SOLID MODELING

Solid modeling programs work well for creating models with real-world dimensions and are used to make functional parts. In some of the advanced programs you can form complex assemblies of objects and run simulations.

Industries: Engineering, industrial design, architecture
Free software: Autodesk Tinkercad™, Autodesk® Fusion 360™, Onshape® and more
Paid software: SolidWorks ®, Autodesk Inventor®, Rhinoceros

QUADCOPTER DRONE:
Created in Rhinoceros

STRENGTHS

- Creating mechanical structures with dimensions
- Building assemblies
- Simulating real-world conditions
- Access to material property libraries

WEAKNESSES

- Poor organic shape creation
- Difficult to create detailed surface textures and patterns

DIGITAL SCULPTING

ROSE: *Created in Sculptris*

Digital sculpting simulates the process of sculpting with physical clay. Users can push and pull digital clay to create organic, highly detailed and textured models.

Industries: Film, video games, art
Free software: Sculptris™, SculptGL
Paid software: ZBrush®, Mudbox®, 3D-Coat

STRENGTHS

- Highly detailed models
- Organic shapes
- Digital painting

WEAKNESSES

- Creating functional parts is difficult
- Often requires additional hardware like a drawing tablet
- Difficult to design for manufacturing

POLYGON MODELING

RUNNING SHOE: *Created in Blender*

Polygon modeling gives users direct control of the mesh, faces, vertices, or edges of a model. This allows for the creation of highly detailed and intricate 3D models. These models can be organic or inorganic.

Industries: Animation, visualization, film, video games
Free software: Blender ', Wings 3D
Paid software: Maya', 3DS Max', Cinema 4D'

STRENGTHS

› Highly detailed, intricate models

› Direct control of the mesh

WEAKNESSES

› Steep learning curve

› Models aren't always watertight

SC

SCULPTRIS™

Difficulty: Easy

Type: Digital Sculpting

Platform: Mac, Windows

Price: Free

Push and pull object surfaces. Great for organic, high-detail models. Use SculptGL for a browser-based version.

SK

SKETCHUP'

Difficulty: Easy

Type: Solid Modeling

Platform: Mac, Windows, Online

Price: Free/$

Draw objects with dimensions. Good for accurate, geometric forms, especially architectural models.

TC

TINKERCAD™

Difficulty: Easy

Type: Solid Modeling

Platform: Online

Price: Free

Design in-browser by combining and resizing simple shapes and holes.

3D MODELING APPLICATIONS

If you're just getting started, here are some recommended free 3D Design program options to try out.

BR

BLENDER *

Difficulty: Advanced

Type: Polygon Modeling, Digital Sculpting

Platform: Mac, Windows, Linux

Price: Free

Supports modeling, rigging, animation, simulation and even video editing and game creation.

AF

AUTODESK® FUSION 360™

Difficulty: Intermediate

Type: Solid Modeling

Platform: Mac, Windows

Price: Free/$

Powerful software for creating and analyzing complex geometries and assemblies.

AM

AUTODESK® MESHMIXER

Difficulty: Intermediate

Type: Polygon Modeling, Digital Sculpting

Platform: Mac, Windows

Price: Free

Manipulate meshed objects in preparation for 3D printing. Create custom supports, fix mesh errors, and add detail.

MO

MORPHI*

Difficulty: Easy

Type: Solid Modeling

Platform: Mac, iOS, Windows

Price: Free/$

Create 3D designs on mobile devices with this simple and intuitive program.

ON

ONSHAPE*

Difficulty: Advanced

Type: Solid Modeling

Platform: Online

Price: Free/$

Browser-based software for creating and analyzing complex geometries and assemblies.

OS

OPENSCAD

Difficulty: Intermediate

Type: Solid Modeling

Platform: Mac, Windows, Linux

Price: Free

Use code to define object dimensions and dynamic variables for easy resizing and alteration.