## Intro to 3D Printing and Design

We will learn about:

- What is 3D Printing
- Types of 3D Printers
- Types of Filament
- Important Parts of a 3D Printer

- Using a 3D Printer
- Cleaning up Finished Prints
- Finding Printable Objects Online
- Creating and Modifying Objects to Print

WHAT IS A 3D PRINTER?

- 3D printers are devices that create 3D objects layer by layer from a variety of materials, often using computer models to create the objects.

- The programs that create these models are known as Computer-Aided Design [CAD] software.

- 3D printers are often used for manufacturing purposes, but have also been used in the fields of medicine, construction, and baking.
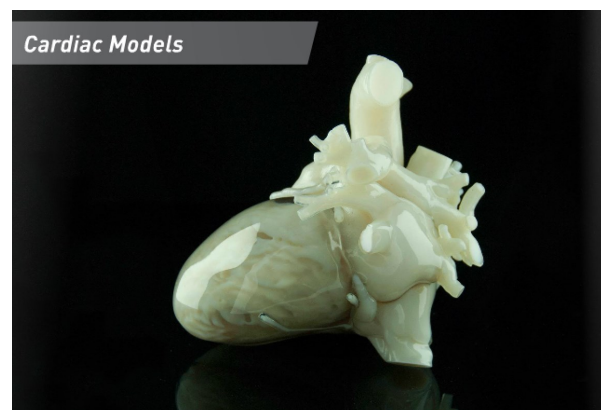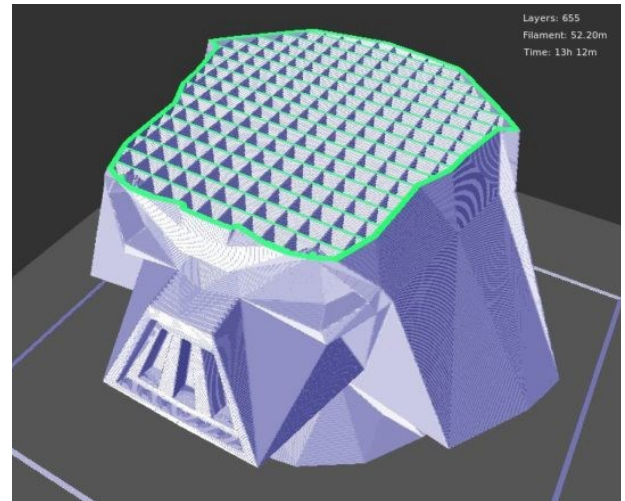
TYPES OF 3D PRINTERS

Fused Deposition Modeling:
Plastics/Metals

- Slow, melts materials and layers them to create objects.
- Advanced methods melts metallic powder in printing to strengthen objects.
- Wide variety of uses, including all types of manufacturing and medical uses.

Stereolithography /Digital Light Processing:
Resin Printing

- Uses liquid resin to build plastic models
- Good for clear parts
- Messy, objects need to be finished through
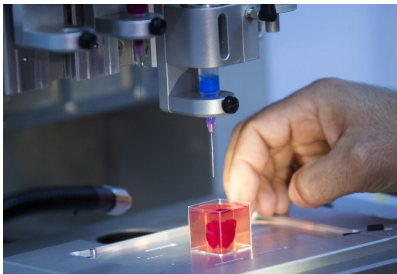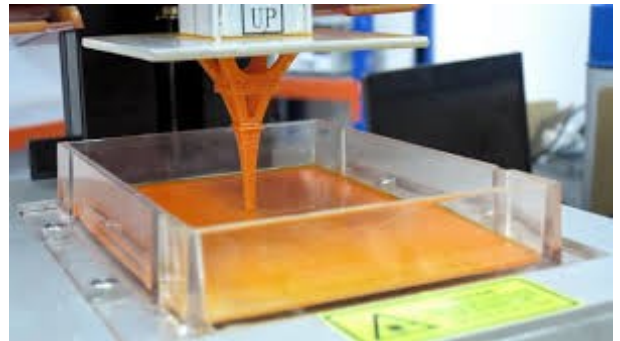
Tissue Printing

- Still in its early stages, medical technology
- Uses tissue and cells from a person to print tissue and organs, using protein and cells

Food Printing

- Wide variety of uses, customizable foods
- Uses proteins, chocolate, cheeses, and other ingredients to create food items

TYPES OF FILAMENT

Polylactic Acid (PLA)

- Eco-friendly, made from biodegradable materials.
- Brittle, stiff material, easy to break and degrade.
- Easy to print with, many options for colors and types, small sweet odor during melting.
- Good for models and solid objects.

Acrylonitrile Butadiene Styrene (ABS)

- Non-biodegradable, oil-based materials. Recyclable.
- Hard, but shock resistant, able to bend.
- Easy to print with, many options for colors and types, harsh toxic odor when melted.
- Good for fasteners and joints, sturdy and multiuse.

Polylethylene Terephthalate Glycol (PETG)

- Non-toxic, but non-biodegradable, made from polymers. Recyclable.
- Durable like ABS and even more flexible, but safe like PLA. Industrial strength.
- Easy to print with, many options for colors and types, no odor. Slightly more expensive.
- Good for all types of objects, but its flexibility makes it less suited for support structures.

Polyamide (NYLON)

- Non-biodegradable, synthetic polymer. Non-recyclable.
- Stronger and more durable than ABS/PLA/PETG.
- Difficult to print with, since it easily absorbs water from the air. Some options for colors and types, toxic odor when melted.
- Good for hinges or high-strength parts.

IMPORTANT PARTS OF A 3D PRINTER

1) Filament Spool Holder

- Holds the spools filament which produces 3D objects.

2) Extruder

- Threads in the filament on top and uses motors to push it down towards the nozzle

3) Nozzle

- Melts the filament so it can easily be formed into thin layers, very hot.

4) Print Bed

- The surface on which 3D object are printed, heated so prints can stick easily. The bed is also raised and lowered as part of the printing process, and must be leveled.
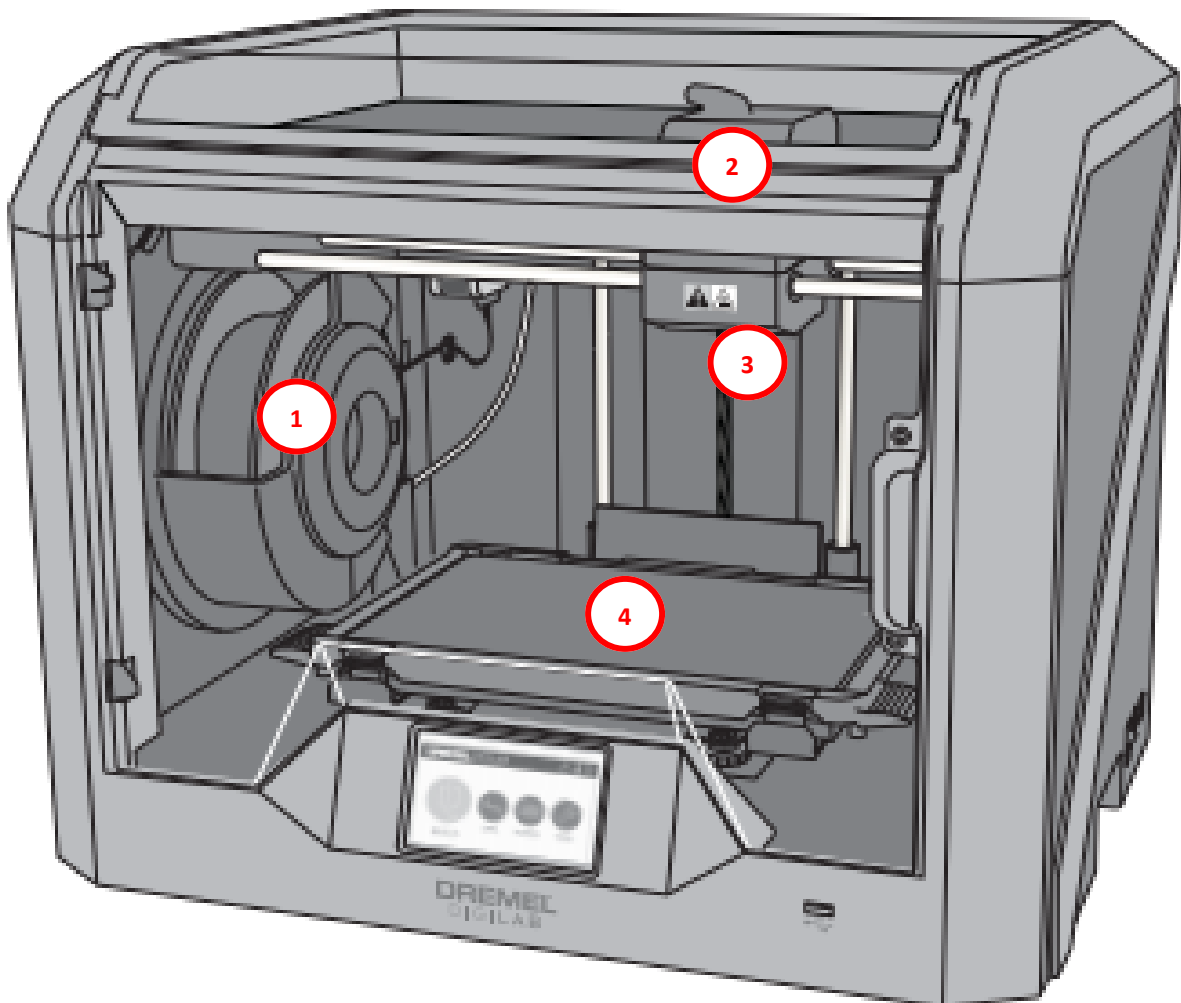
USING A 3D PRINTER

Once you find or create an object to 3D print, you have to load the print to the printer, modify the print settings to your liking, start and monitor the print, and remove the object when finished.

Loading the Print

- The printed object will be a .STL or .OBJ file.

- Load it onto a 3D printer in a variety of ways; some printers allow for wireless/ USB transfer, others need software.

- Once the print is loaded, you can set the objects on the bed and preview the build using the slicing tools.

- These loading/preview screens also allow you to view your print job from multiple angles, to make sure it's what you want.
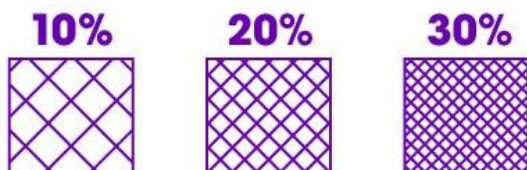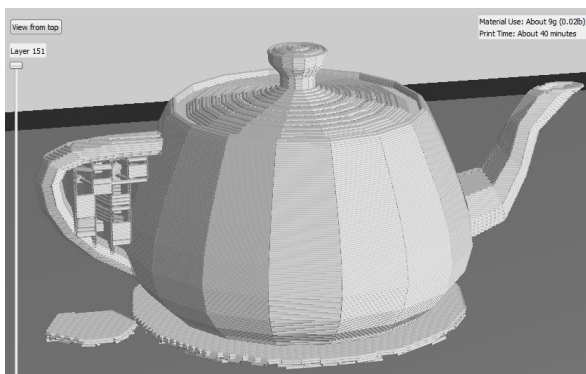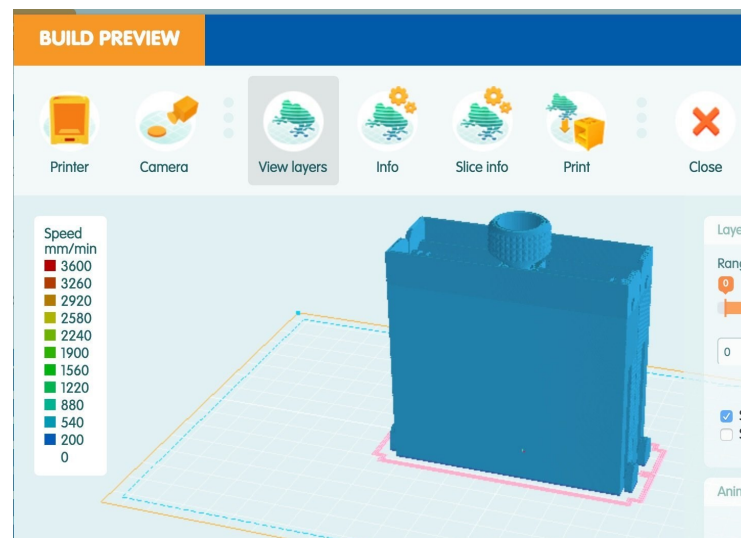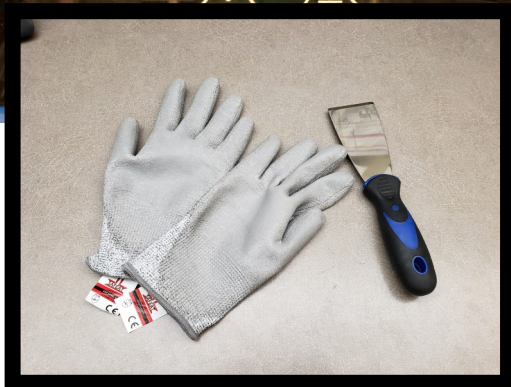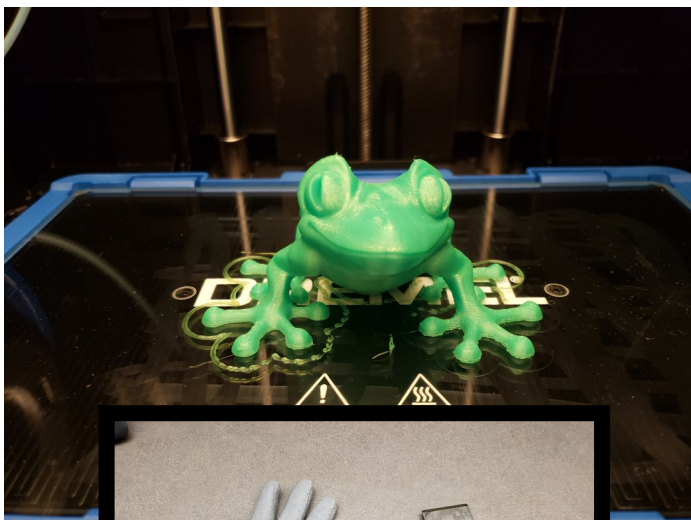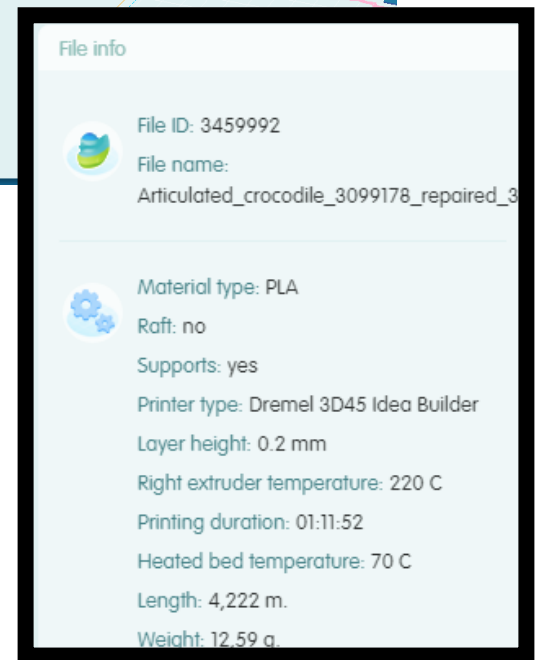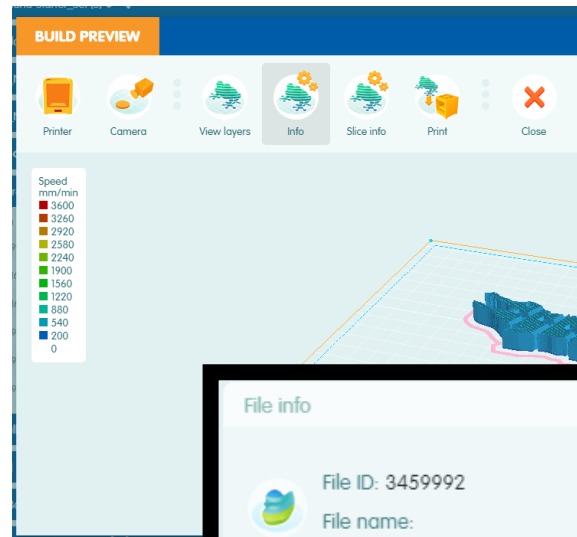

Print Settings

- There are several important settings you can change, such as the size/scale of the object and it's location on the print bed.

- You can add multiple objects to the print bed to be printed at the same time.

- You can choose to build your objects on a small raft, a thin layer of plastic to separate your builds from the print bed.

- Previews also show scaffolding to bridge gaps, which can be modified or removed.

- An important setting is fill level; you can choose the density filled in space your object has, between 1% and 100%.

- Fill level directly relates to the strength, weight, and duration of your build.

USING A 3D PRINTER [CONTINUED]

Starting the Print

- When you click BUILD and start the print(s), you'll get an estimated print time and material use (in grams). Make sure you have enough time and filament to complete your print.

- Depending on the type of 3D printer and print bed, you may have to do extra prep work to get the objects to stick to the bed.

- The print bed and extruder will preheat to their necessary temperatures, and begin printing.

- It's only really important to monitor the print at the very beginning, then only intermittently until it's done.

File info

File ID: 3459992

File name: Articulated_crocodile_3099178_repaired_3

Material type: PLA

Raft: no

Supports: yes

Printer type: Dremel 3D45 Idea Builder

Layer height: 0.2 mm

Right extruder temperature: 220 C

Printing duration: 01:11:52

Heated bed temperature: 70 C

Length: 4,222 m.

Weight: 12.59 g.

Removing the Object

- When the print is done, be sure to let the object(s) and print board cool before attempting to remove them.

- On many 3D printers, you should remove the entire bed, and then the prints from the bed.

- Carefully remove the print(s) using a spatula tool, be sure to wear gloves as many spatulas are sharp.

- If your builds have rafting, they'll be easier to the remove from the bed, but the rafting can be tricky to remove.

CLEANING UP AND FINISHING PRINTS

- If your finished builds have rafting or scaffolding, remove them carefully with wire cutters or pliers. Wear gloves when working with these sharp tools

- You might need to use sandpaper to get off any residual filament or rafting, or to smooth out your objects. Acetone can be used to dissolve excess rafting that can't be removed otherwise.

- Once you have removed all excess filament and scaffolding, you can finish your prints by sanding and painting them.

- You might choose to use a cheap sandable epoxy to fill in any gaps or if the print still looks rough after initial sanding.

- Acrylic paints and water-based paints should do well for PLA/ABS/PETG objects. Nylon objects need a primer before painting.

FINDING PRINTABLE OBJECTS ONLINE

There are many amazing websites that contain .STL or .OBJ objects that are already ready to be download and 3D printed. Downloaded prints can be modified with CAD [computer aided design] software if needed, if you wanted to make modifications to the design.
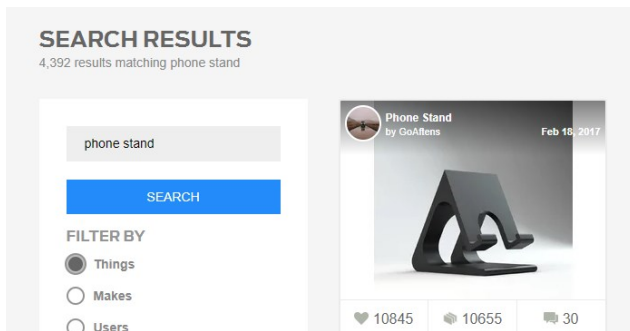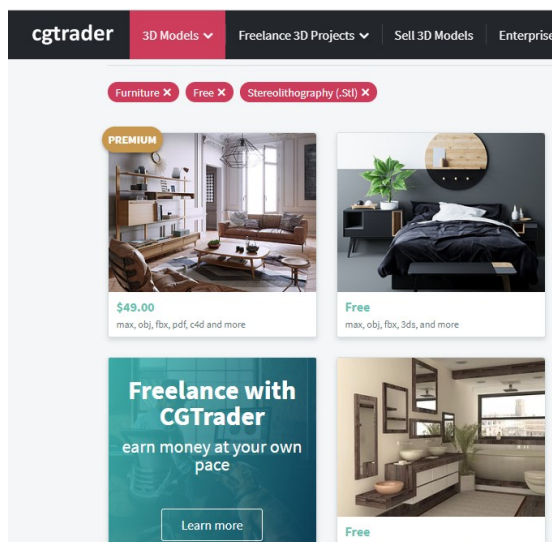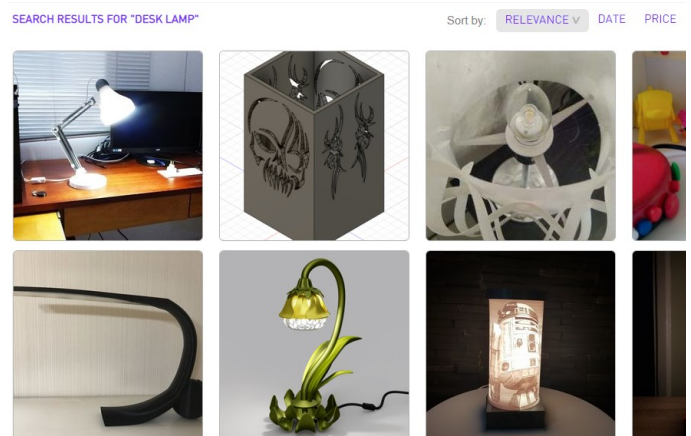

Thingiverse [thingiverse.com]

- Extremely large browsable/searchable database of all types of 3D printable objects.
- All objects on site are free to download and print immediately.

Cults3D [cults3d.com]

- Large browsable/searchable database of all types of 3D printable objects.
- Objects on site are either free or purchaseable for download and printing.
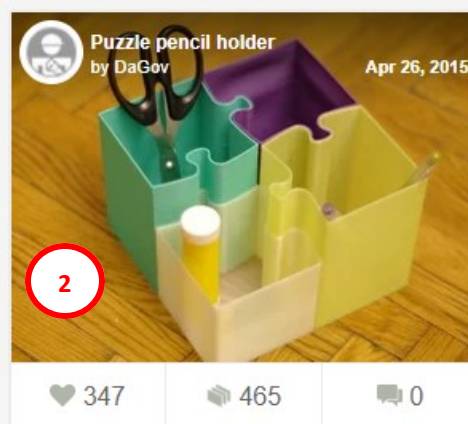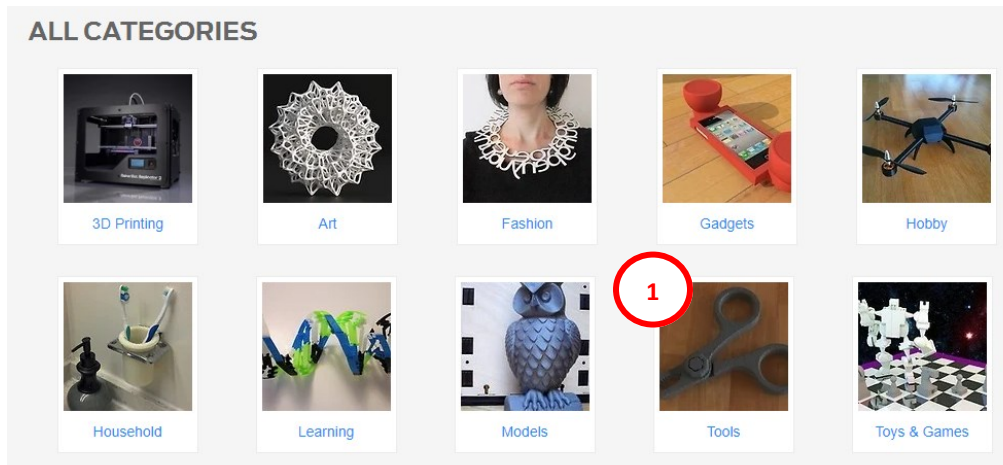- You can filter your searches by free objects.

CGTrader [cgtrader.com]

- Large browsable/searchable database of all types of 3D printable objects.
- Objects on site are either free or purchaseable for download and printing.
- You can filter your searches by free objects.

Downloading Objects on Thingiverse

1. Go to the website [www.thingiverse.com]

2. Use the Search Bar or Explore Tab to find an object to print.

3. Click on the object to view info on it and the files for downloading. Some objects contain multiple files for printing.

CREATING AND MODIFYING OBJECTS

There are several great CAD [computer aided design] programs on the market, some are free like FreeCAD and TinkerCAD, others like Rhino and AutoCAD cost thousands a year (though AutoCAD is free for students/educators/facilities). Let's focus on the free, cloud based service of TinkerCAD today.

Using TinkerCAD

1. Go to the website [www.tinkercad.com] and sign in.
2. Click on CREATE NEW DESIGN to pull up a blank workspace. You'll need to do this even if you want to upload an object for modification.
3. Click the LEARN tab to take lessons to learn more about developing objects on the site.
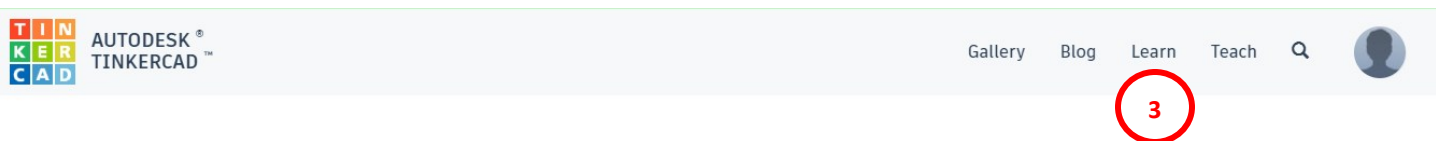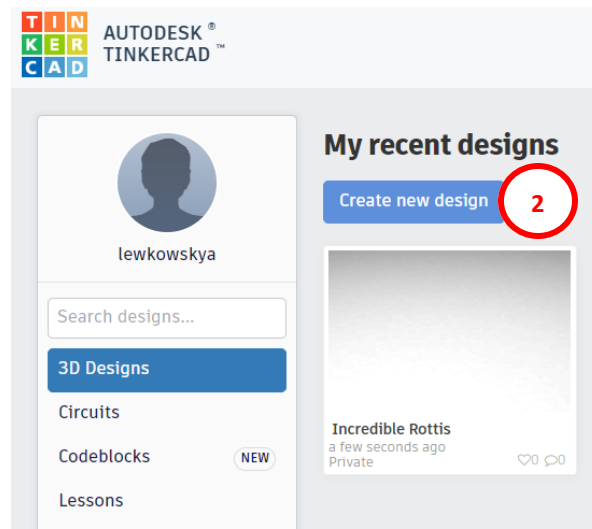
Starters define basic 3D design functions, and link to relevant Lessons to develop your skills.

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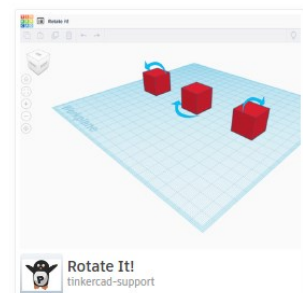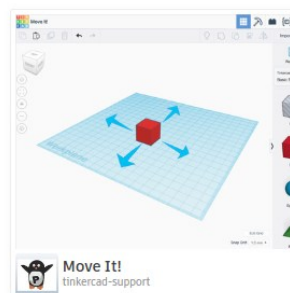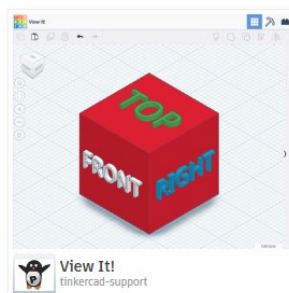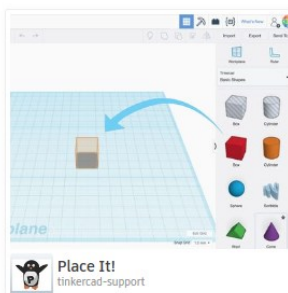
CREATING AND MODIFYING OBJECTS [CONTINUED]

Creating an Object

1. When on a blank workspace, click onto objects/shapes/text to move them to the workspace area.

2. Click on individual objects/shapes/text in the workspace to modify their dimensions. You also can modify what is written in text this way.

3. Change the angle at which you view the workspace by right-clicking and moving the mouse, or clicking the box in the upper left-hand corner.

4. When you have all everything placed how you want, select them all by drawing a box around everything and click on the GROUP button to make it one object.

5. Download your object to a printable .STL or .OBJ file using the EXPORT button.
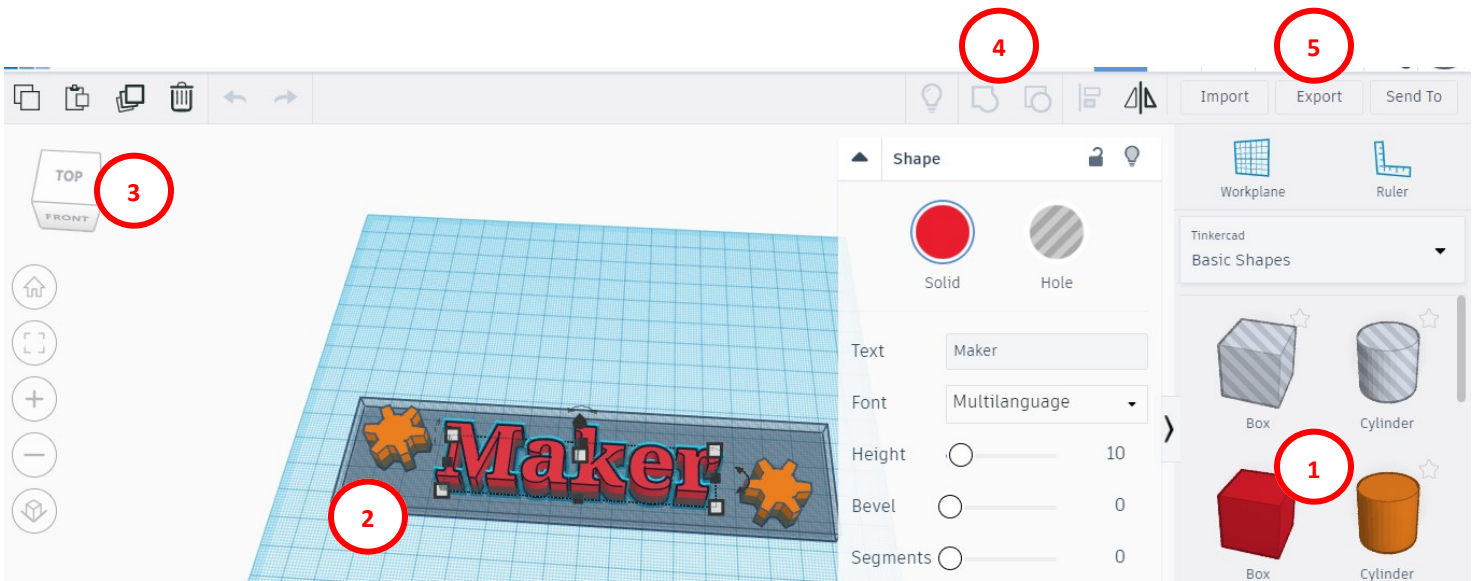
Uploading and Modifying Objects

1. When on a blank workspace, click the IMPORT button to choose a file to modify.

2. Click on the object to modify its dimensions, or add more shapes/objects/text to it from the right-hand panel.

3. Once you've got the object modified to your liking, select it all, click GROUP, then click EXPORT to download the new file to be printed.
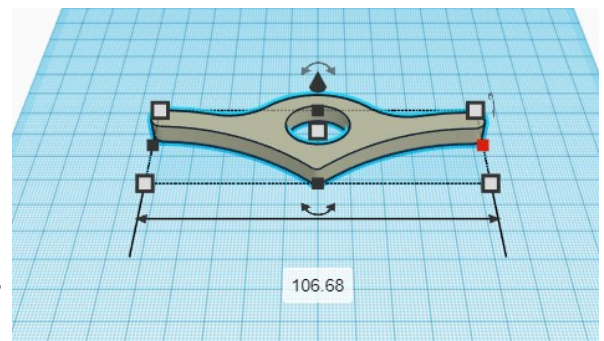
TinkerCAD Shortcuts

Duplicating Objects

1. Click on an object (or select multiple objects) and Duplicate them with **CTRL-D**.
2. You can then move the new object(s) around with arrow keys to separate them.
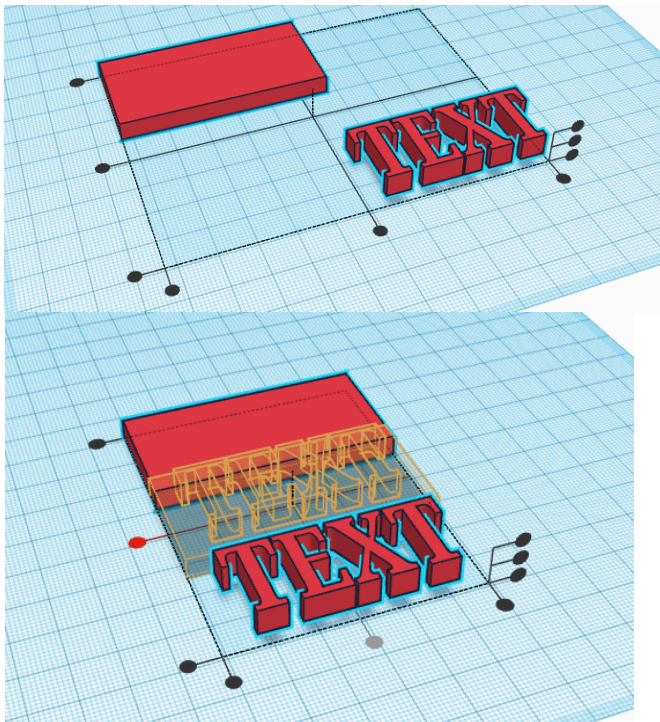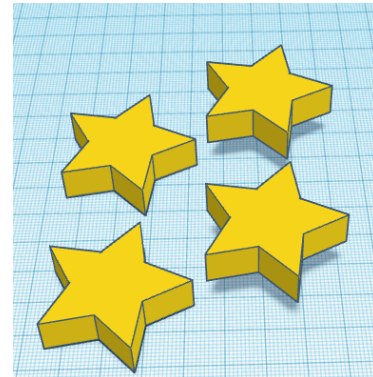
Aligning Objects

1. Select multiple objects and type **L** to align them all in any dimension (by clicking dots).
2. You can align objects in up to three places (left/right, bottom/top, lower/upper, or center) in any dimension.
3. Clicking on a dot will align the objects to that area in that dimension.
4. If you hover over a dot before clicking, it will show you what the new alignment will look like.

Mirroring Objects

1. Click on an object or objects, and type **M** to mirror it in any dimension (clicking arrows).
2. If you want both an original and mirrored object, you may want to duplicate it before mirroring it to save time.
3. If you hover over an arrow before clicking, it will show you what the new mirrored version will look like.
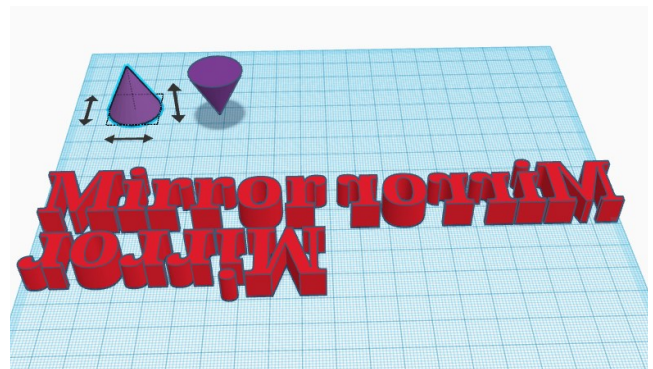
TinkerCAD Projects

Pencil Cup

1. Create a solid object (I suggest rectangular or cylindrical objects). Duplicate it.
2. Make the duplicate slightly smaller, and bring it slightly higher than the workplane.
3. Make the duplicate a "hole" (type **H**), and align it to the center of the solid object.
4. Group the objects together to finish up.
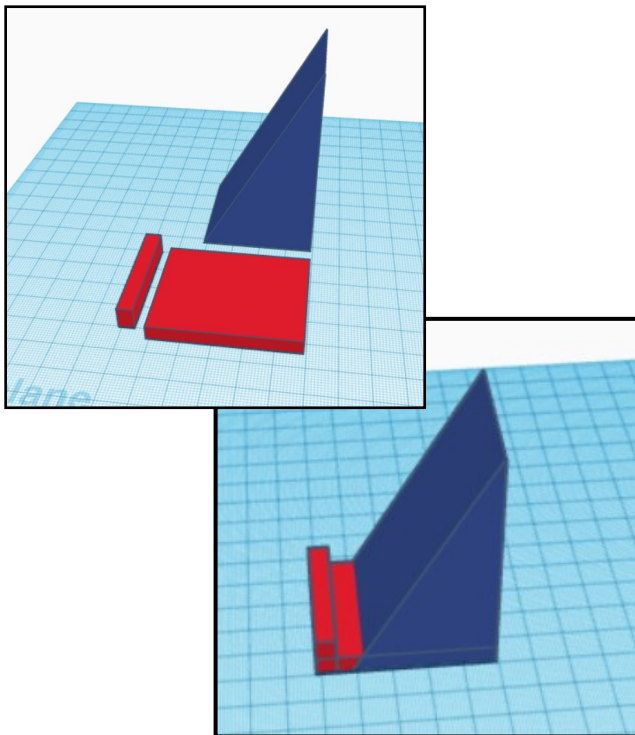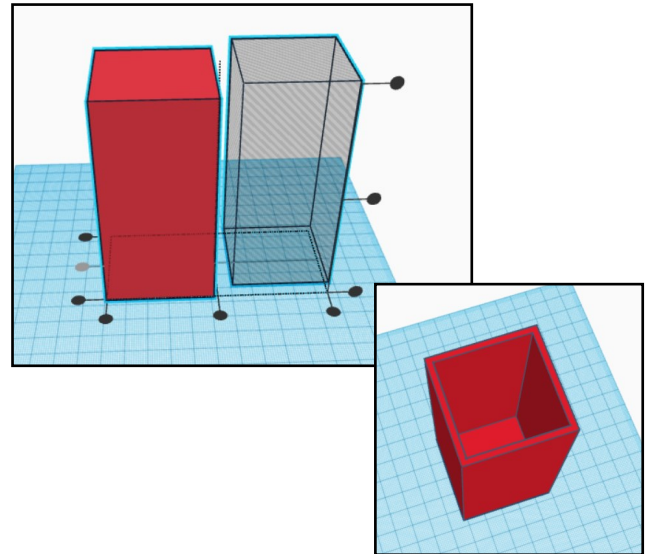
Phone/Tablet Stand

1. You need three objects to group together for the phone stand. A wedge shape, a short rectangular box, and a slightly taller but thin rectangular box.
2. To get the right angle, you'll want the wedge to be approximately 60 degrees, or about 1.75 times as high as it is long/wide.
3. I made the base of the wedge a square, the short box as wide as the wedge but a little longer (for the width of the phone), and the thin box about 2 to 3 times taller than the short box.
4. Align the objects up so the flat surface of the wedge is at the back of the short box, and the thin box is at the front.
5. Group the objects to finish up.

Instructable: Name Keychain

1. There's a fun and easy Instructables walkthrough on making a keychain from a name (or any text), involving adding letters individually, overlapping them, and grouping them together with a loop.
2. Check it out at: https://www.instructables.com/Name-That-Keychain-1/
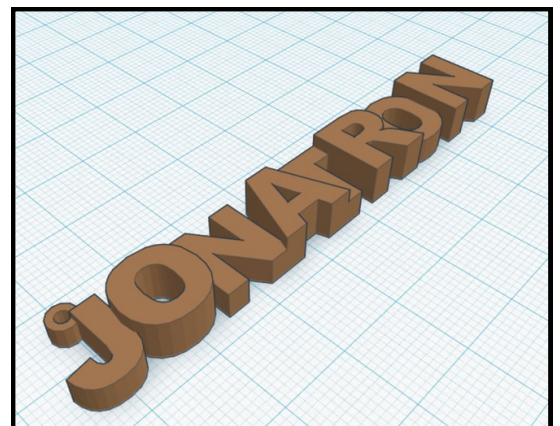
Lithophanes

What is a Lithophane?

Lithophanes are thin images etched into a surface, that allows a picture to be seen when backlit. The objects were originally etched into pottery and porcelain in France in the early 1800s, although historians believe Chinese crafters developed a similar technique maybe 1000 years earlier. Modern lithophanes can be easily made through 3D printing, where online software converts images into a thin printable lithograph object to print.
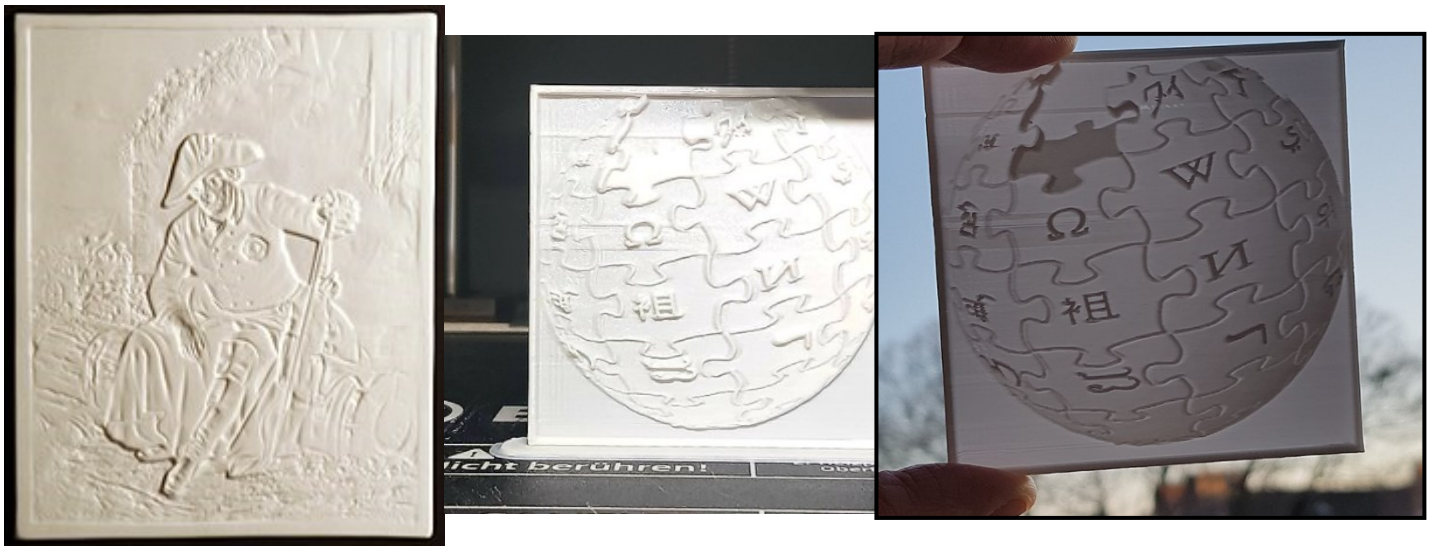
Creating a Lithophane Online:

There are many sites that let you upload images to create free lithophanes, often in many shapes or styles, that you can download immediately as a print-able object. Here are a few to check out:

- **https://3dp.rocks/lithophane/**
- **https://itslitho.com/**
- **https://lithophanemaker.com/**
- **https://products.aspose.app/3d/lithophane**

The two lithophanes to the right were both created using the library's logo on different sites. The top was from itslitho.com and the bottom was from 3dp.rocks. As you can see, they're very different despite being from the same source.

Websites About 3D Printing:

The Best 3D Model Databases:

https://vagon.io/blog/3D-model-databases-for-visualizations-and-3D-printing/

Best Free CAD software for 2021:

https://all3dp.com/2/best-free-cad-software-for-3d-printing/

All3DP—Online Home for all things 3D Printing:

https://all3dp.com

TinkerCAD Projects:
https://www.instructables.com/id/Tinkercad-Learn-Projects/

Image to Lithophane Genorator:

https://lithophanemaker.com

Challenges

1. Search the Thingiverse website and check out some of the free objects they have for printing. Pay attention to objects that have multiple parts, and how they connect together.

2. Upload an object file (.stl) that you find on Thingiverse to TinkerCAD, and try to modify it in some way.

3. Log in to TinkerCAD and play around with some of the design shapes. The website has a tutorial section, and other sites (like Instructables.com) also give detailed instructions on making projects in TinkerCAD.

4. In TinkerCAD, note that every object gives you the possibility to use the shape as a hole, letting you reshape solid objects through grouping.

Websites About Designing 3D Models:

https://support.shapeways.com/hc/en-us/articles/360023915713-Modeling-for-3D-printing-a-guide-for-beginners

https://www.cnet.com/how-to/new-3d-printer-heres-how-to-create-your-own-printables/

https://all3dp.com/best-3d-printing-tutorial/

YouTube Video Training:

You'll be surprised at how many free quality video tutorials you can find on YouTube. Go to YouTube.com and search for info on 3D printing, printers, filaments, and 3D design.

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AUTODESK
TINKERCAD

KEYBOARD SHORTCUTS

Legend: ⊞ Ctrl · ⌘ Cmd / ⊞ Alt · ⌥ Option

MOVING OBJECT(S)
(Using keyboard)

Move along X/Y axis	◀ / ▲ / ▼ / ▶
Move along Z axis	Ctrl · ▼ / ▲
×10 Nudge along X/Y axis	Shift · ◀ / ▲ / ▼ / ▶
×10 Nudge along Z axis	Ctrl · Shift · ▼ / ▲

KEYBOARD + MOUSE SHORTCUTS
(Press and hold the keys, then click and drag the mouse)

Duplicate dragged object(s)	Alt + Drag left mouse button
Select multiple object(s)	Shift + Left mouse button
45° rotation	Shift (Hold while rotating)
Scale in one direction	Alt + Hold side handle
Scale in two directions	Alt + Hold corner handle
Uniform scale	Shift + Hold corner handle
Uniform scale in all directions	Alt · Shift + Corner handle
Uniform scale in all directions	Alt · Shift + Top handle

VIEWING DESIGNS
(With the help of a mouse or a mouse pad)

Orbit the view	Right mouse button
Orbit the view	Ctrl + Left mouse button
Pan the view	Shift + Right mouse button
Pan the view	Ctrl · Shift + left button
Zoom the view in or out	Mouse scroll wheel
Zoom-in	+
Zoom-out	−
Fit selected object(s) into view	F

OBJECT SETTINGS

Transparency toggle	T
Turn object(s) into **Holes**	H
Turn object(s) into **Solids**	S
Lock or **Unlock** object(s)	Ctrl · L
Hide object(s)	Ctrl · H
Show all hidden object(s)	Ctrl · Shift · H

TOOLS AND COMMANDS

Copy object(s)	Ctrl · C
Paste object(s)	Ctrl · V
Duplicate object(s) in place.	Ctrl · D
Delete object(s)	Del
Undo action(s)	Ctrl · Z
Redo action(s)	Ctrl · Y
Redo action(s)	Ctrl · Shift · Z
Group object(s)	Ctrl · G
Un-group object(s)	Ctrl · Shift · G
Align object(s)	L
Flip/Mirror objects(s)	M
Select all object(s)	Ctrl · A
Place a **Ruler**	R (Shift toggle midpoint/center)
Place a **Workplane**	W (press Shift to flip direction)
Drop object(s) to workplane	D