Safety

By entering the FabLab, you hereby accept the risks associated with working in the lab, and agree to behave according to RIT/CAD's shop safety guidelines. Failure to comply will result in loss of access to the FabLab, and subsequent academic disciplinary proceedings. Observe the warnings below when working in the FabLab. For further information, including first aid and emergency response procedures, review the guides at each station or the lab safety manual.

Public Safety EMERGENCY
585-475-3333

Public Safety GENERAL
585-475-2853

Hazards

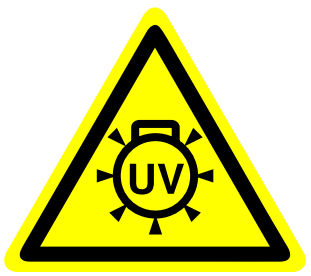
CLASS 1, 2 & 4 LASERS

FLAMMABLE SUBSTANCES

EXTREMELY HOT SURFACES

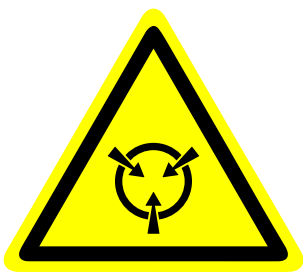
SHARP TOOLS

ENVIRONMENTAL TOXINS



UV RADIATION

MOVING COMPONENTS



SENSITIVE ELECTRONICS

Precautions

CLOSE-TOED SHOES REQUIRED

USE GLOVES WHEN USING CHEMICALS

USE EYE PROTECTION WHEN PROMPTED

AREA UNDER VIDEO SURVEILLANCE

LOOSE CLOTHING AND JEWELERY PROHIBITED

UNTIED LONG HAIR PROHIBITED

OPEN FLAMES PROHIBITED

FOOD AND OPEN DRINKS PROHIBITED

Rev 1,4 2019FEB28

SLA Printing

Safety

HAZARDOUS MATERIALS IN USE. Photopolymer resin is a hazardous substance while in liquid form. Avoid direct contact with eyes and skin with safety goggles and Nitrile gloves. Do not use tools from other non-SLA printing stations at this station, and vice versa. Immediately notify FabLab staff of a resin spill. Discontinue use and seek medical attention if you develop impaired vision, nausea, or irritated skin.

SENSITIVE MATERIALS IN USE. Photopolymer resin is sensitive to ambient light, air and moisture. Keep resin tanks covered and cartridges closed when not in use, and store in a confined space with little ambient light. Never pour resin directly into a tank. Keep unrelated electrical equipment away from the printer at all times.

CLASS 1 LASER IN USE. Do not stare directly into beam, or view directly with optical instruments. Serious and permanent damage may result to optic nerve, cornea or lens due to improper use. Immediately stop use and seek medical attention if you begin seeing spots or experiencing blurred vision.

CLEAN BUILD PLATFORM WHEN FINISHED. After completing a print and removing it from the build platform, remove any residual resin left on the platform with an IPA microfiber wipe. Do not place a build platform with resin still on the build surface back into the printer. Failure to comply will result in suspension of lab privileges.

GLOVES REQUIRED AT ALL TIMES. Always wear disposable Nitrile gloves while setting up, post-processing and cleaning up after an SLA print. While wearing gloves, do not touch or use tools unrelated to SLA printing or post-processing. Dispose of gloves in a chemical waste bin, never in a general waste stream. Wash hands when finished.

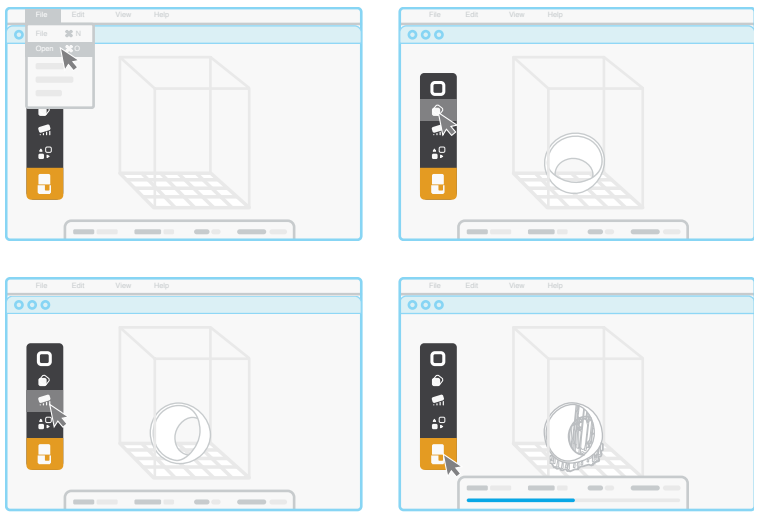
DO NOT TOUCH OPTICAL WINDOWS ON PRINTER OR RESIN TANKS. Avoid touching the windows on the printer and the resin tanks at all times, even with gloves. Hold resin tanks by the brims along the left and right sides, never from the bottom. Always set tanks down on a level clean surface.

DO NOT DUMP RESIN IN A SINK, DRAIN, OR GENERAL WASTE STREAM. Uncured resin, wipes containing resin and Isopropyl, resin tanks and cartridges must be disposed of according to federal chemical waste protocols. Deposit disposable wipes and failed prints in the chemical waste bin. Notify FabLab staff for further assistance.

FOOD & DRINKS IN THIS AREA ARE PROHIBITED. All food and/or beverages of any kind are prohibited from being consumed near or around SLA workstations and printing materials. Even after wearing gloves, wash hands thoroughly after working with SLA equipment before eating or drinking.

1 PREPARE FOR 3D PRINTING

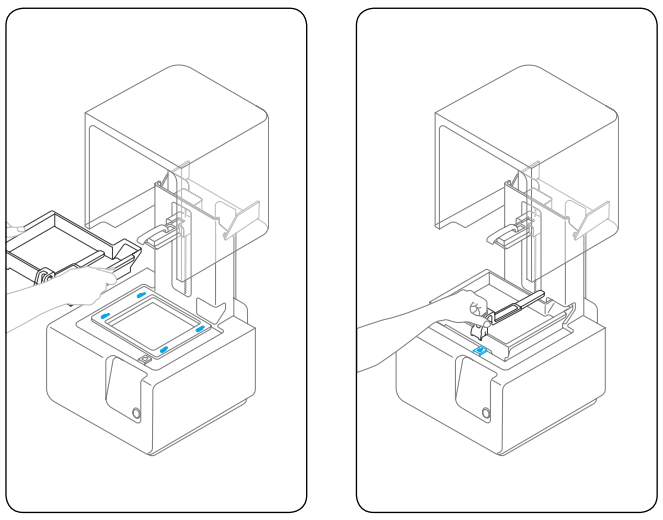
With your 3D model as an STL or OBJ, open the file in PreForm. Orient the part and generate supports. Inspect the touch points so they are not obscuring features and if necessary, add, remove or change point size(s). Safe your PreForm file, and upload it to your assigned printer. Make sure your print file has your name in the title.



2 LOAD RESIN TANK

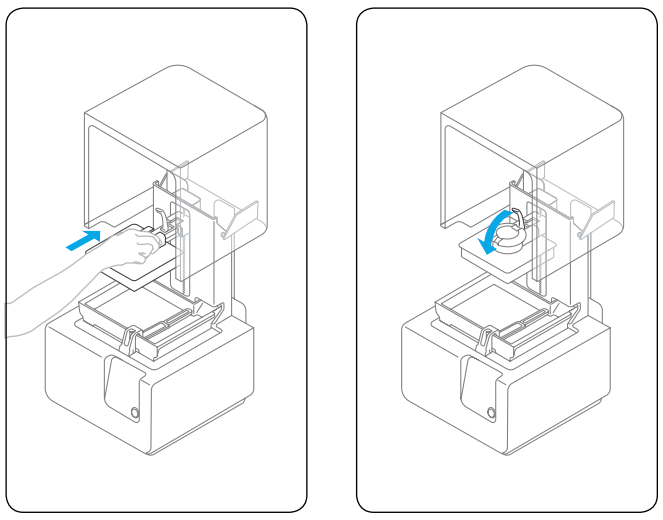
Remove the resin tank lid and align its four feet with the corresponding holes in the tank carrier. Push the tank forward into place with force, then lock the wiper.

NEVER touch the optical windows, either on the tank or the printer. This may result in damage to sensitive components.



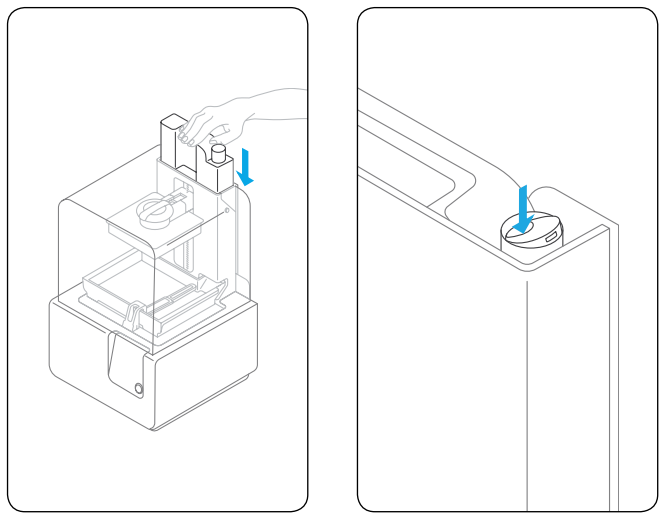
3 LOAD BUILD PLATFORM

Align the build platform with the platform carrier and push it into place, locking the handle down to secure. Always insert the resin tank before the build platform to protect the optical window.



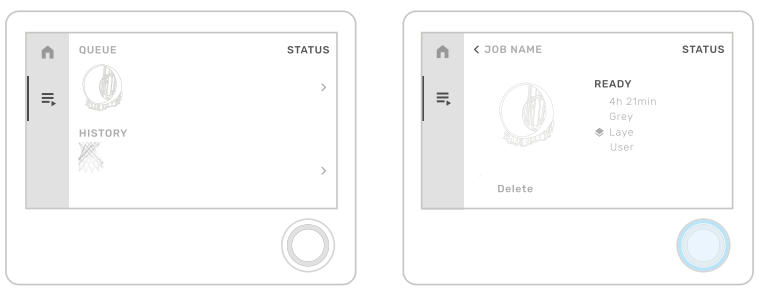
4 INSERT RESIN CARTRIDGE

Align the cartridge with the opening in the back of the printer. Push down until it sits securely. Press the vent cap open, so that your resin tank fills correctly. If your cartridge or resin tank are not recognized by the printer, please speak to a Lab Tech.



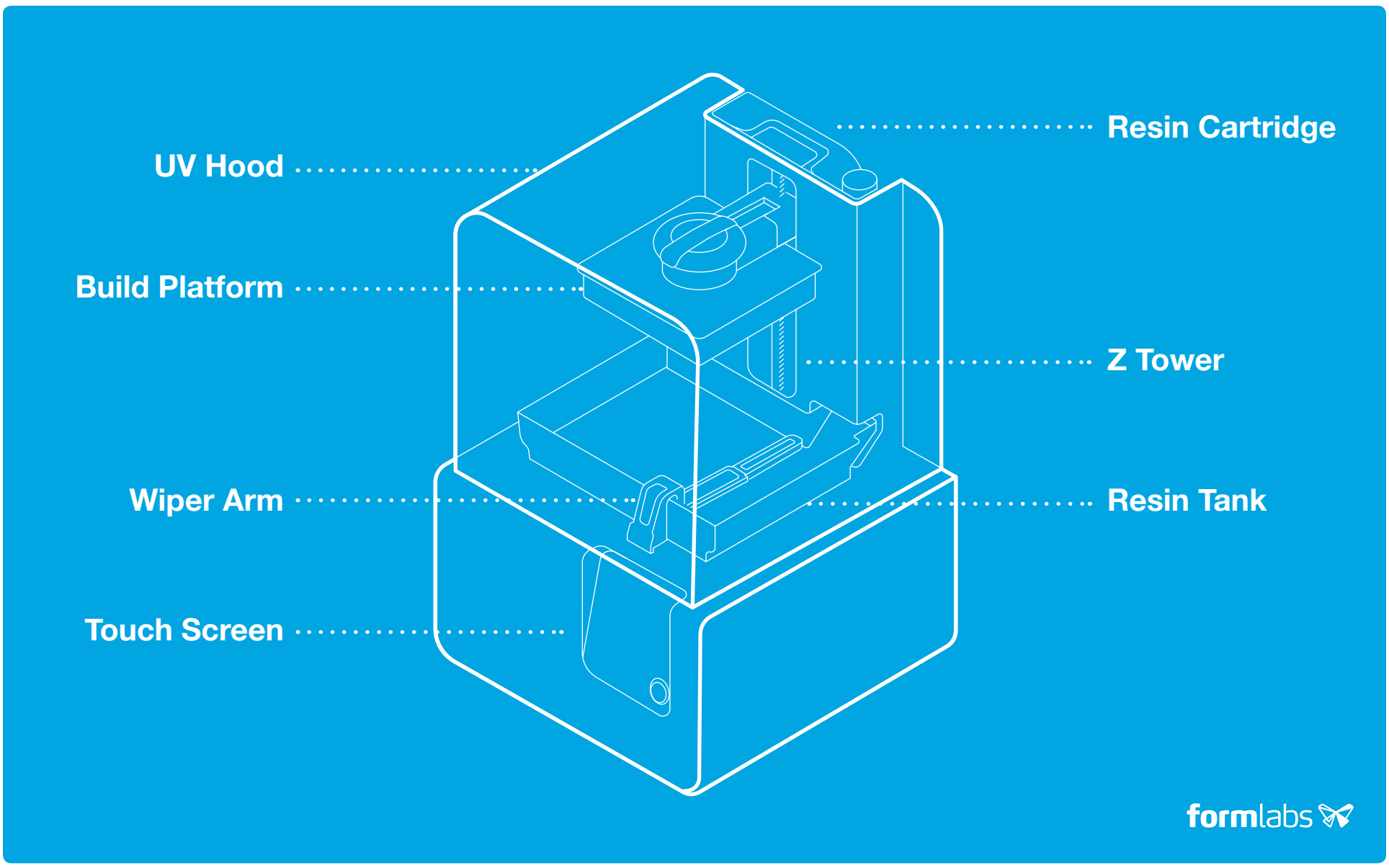
5 START PRINT

You will see your file uploading to the print queue on your reserved printer's touchscreen. Select the file name and confirm the print by pushing the button on your printer.



Formlabs Form 2

Stereolithography (SLA) is a 3D printing technology that converts liquid materials into solid parts, layer by layer, by selectively curing them using a light source in a process called photopolymerization. SLA is widely used to create models, prototypes, patterns, and production parts for a range of industries from engineering and product design to manufacturing, dentistry, jewelry, model making, and education.



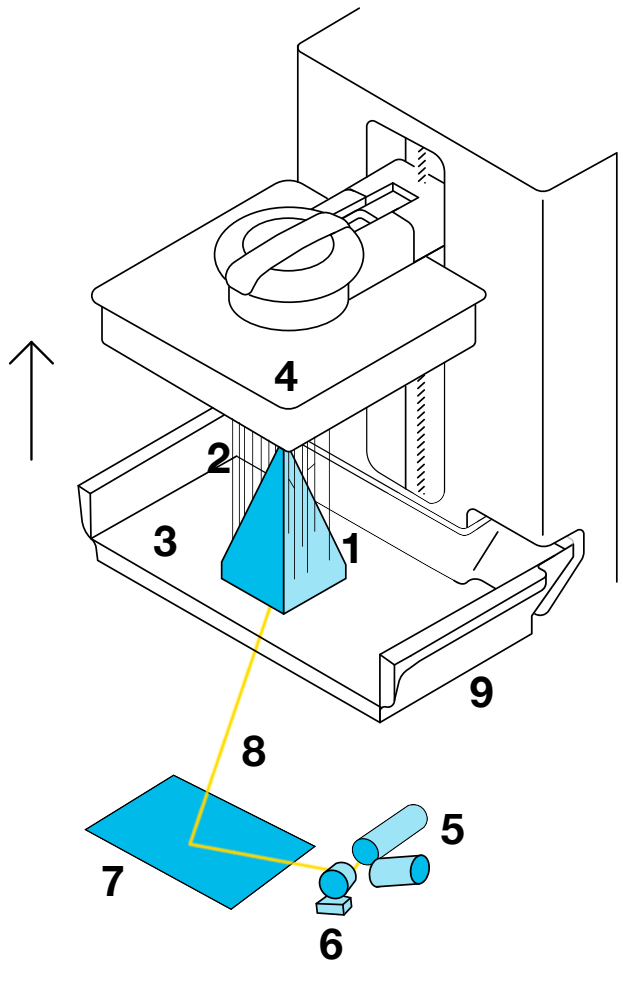
How It Works

The printed part (**1**) and its supports (**2**) are formed when the resin (**3**) is cured onto the build platform (**4**) by a series of UV lasers (**5**). The laser spot is reflected and controlled by galvanometers (**6**), so that the X-Y scaling mirror (**7**) reflects the laser beam (**8**) through a window in the resin tank (**9**).

The laser draws out the profile, infill, and support structures, of the print layer-by-layer. Then, the wiping arm deposits the subsequent layer's resin to be cured.

Once completed, the print is ready to be post-processed with an Isopropyl bath and post-cure in the UV oven.

For more information, ask a FabLab Tech.



Rev 1,1 2019MAY28

Resins

BLACK, GREY, WHITE

- Rich opaque color
- Ideal for small, intricate features, general purpose prototyping, design
- Base for painted parts
- Captures smooth surfaces and details

DURABLE

- Low friction and wear modulus
- High elongation and impact strength
- Ideal for prototyping consumer packaging, bushing and bearings, snap fits and flexures

CASTABLE WAX

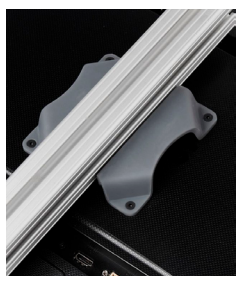
- High precision, lost casting paraffin wax-based resin
- Clean burn-out profiles
- Ideal for jewelry settings, prongs, shanks, intricate surface detail

ELASTIC

- Withstands repeated bending, stretching, compression w/o tearing
- Prototyping substitute for silicone
- Consumer goods, wearables, special effects props and models

CERAMIC

- High precision, operational thermal stability (1000 ºC) chemically inert, high corrosion and wear resistance
- Can be glazed, final print requires scheduled firing in a cone 10 kiln



GREY PRO

- High precision, moderate elongation, low creep
- Ideal for functional prototyping, jigs and fixtures for manufacturing end-use parts, form and fit testing

CLEAR

- High translucency and transparency
- Showcasing internal features
- Polishes to optical clarity
- Ideal for fluidics, mold making, optics, lighting

HIGH TEMP

- High precision, operational thermal stability (238 ºC)
- Ideal for hot air/gas/fluid flow, heat-resistant mounts, housings, fixtures, injection molds, inserts

CMYK COLOR

- Colorful prints without painting
- Field testing product concepts
- Small, intricate features
- Base for painted parts

RIGID

- Very high long-term rigidity and stiffness, reinforced with glass
- High precision, smooth surface finish
- Ideal for jigs, fixtures, tooling, electrical casings, automotive housings

DRAFT

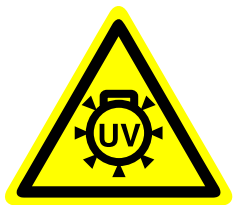
- 300 µm resolution
- Fast print speeds for rapid prototypes of large parts or models
- Maintains accuracy and tolerances of other Formlabs resins

TOUGH

- ABS substitute, sturdy and rugged mechanical strength, tolerates brief periods of stress, strain
- Ideal for sturdy prototypes, interface and press-fits, assemblies

Post-Processing

ISOPROPYL ALCOHOL Form Wash contains highly flammable liquid and vapors. Keep flames, sparks and heat sources away. Causes serious eye irritation, fumes may cause drowsiness or dizziness. Immediately stop use and seek medical attention if in eyes or ingested. To extinguish, use water, carbon dioxide or alcohol-resistant foam.



UV RADIATION Form Cure emits high-intensity ultraviolet radiation. Do not stare directly into UV lamps. Protect eyes and skin from extended exposure to avoid optical nerve and skin damage. Immediately stop use and seek medical attention if you begin seeing spots or experiencing blurred vision.

Times & Temps

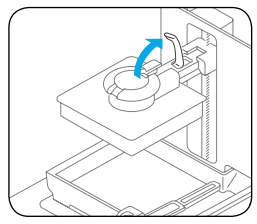
RESIN	NAME	IDENTIFIER	WASH (MIN)	CURE (MIN)	TEMP (ºC)
Standard	Black, Grey, White	FLGPBK##	10	30 - 60	60º
	Clear	FLGPCL##	10	15	60º
	Color	FLGPCB##	10	30 - 60	60º
	Draft	FLDRBL##	10	0 - 5	60º
Functional	Durable	FLDUCL##	10	60	60º
	Elastic	FLELCL##	20	20	60º
	Grey Pro	FLPRGR##	10	15	80º
	High Temp	FLHTAM##	6	30 - 60	60º
	Rigid	FLRGWH##	10	15	80º
	Tough	FLTOTL##	20	60	60º
Specialty	Castable	FLCABL##	10	240	60º
	Castable Wax	FLCWPU##	10 - 15	None	60º
	Dental SG	FLDGOR##	10	20	80º
	Dental LT	FLDLCL##	10	20	80º
	Model	FLDMBE##	10	30 - 60	60º

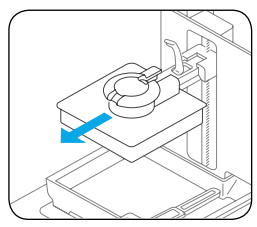
Rev 1,3 2019MAY28

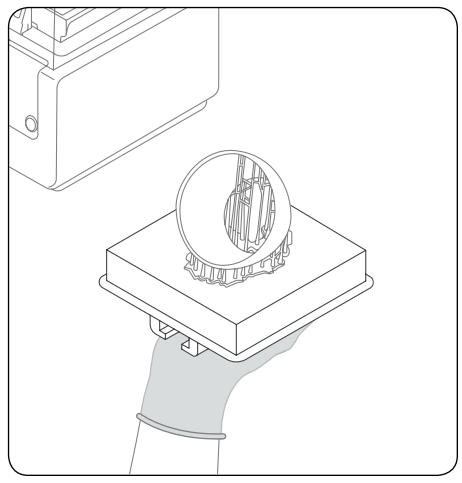
Washing & Curing

1 REMOVE FINISHED PRINT

Always remove the build platform before the resin tank. Lift the locking handle and remove the build platform, flipping it vertically to avoid dripping uncured resin, then close the printer's UV hood.

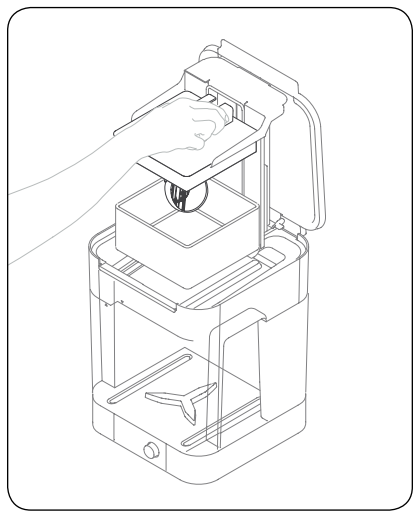






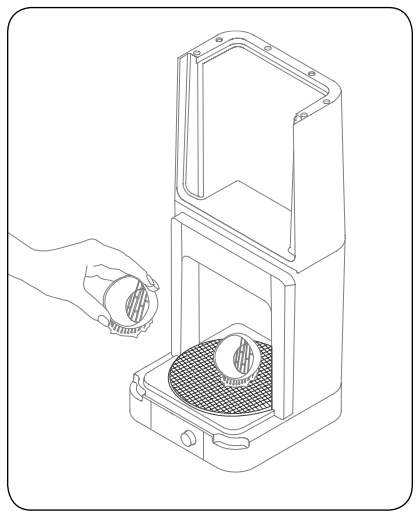
2 WASH YOUR PRINT

Open the Form Wash and place the build platform with the still attached print on the platform mount, then set the recommended cycle time for your material. After washing, use the removal tool to separate the part from the build platform, then let dry for 30 minutes. Alternatively, remove your prints from the build platform and place them in the Wash's basket. Close the Wash lid when finished.



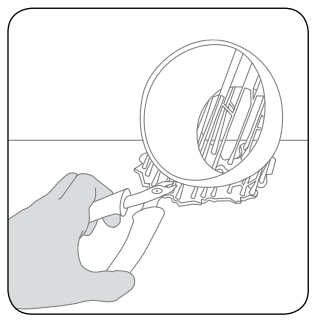
3 CURE YOUR PRINT

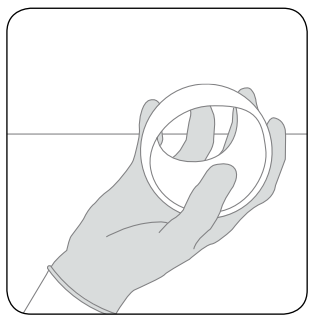
Ensure your part is completely dry before curing. Post-curing with light and heat is a key step for SLA printing. Using Form Cure, place your dry part on the turntable and set to the recommended time and temperature settings for your material. Alternate curing methods will produce different material properties, requiring additional experimentation.



4 FINISH YOUR PRINT

After post-curing, remove supports and sand, prime, or paint if desired. Remember to clean up any shrapnel resulting from post-processing. For finishing guides, visit the FabLab Confluence.





FDM Printing

Safety

EXTREMELY HOT SURFACES AND TOOLS. The build plate and printing nozzles can be extremely hot. Avoid contact with either components when the printer is not in an idle state, and check that the Print Core LEDs are blue before reaching into the build area. Do not remove prints before prompted.

MOVING COMPONENTS POSE CRUSHING HAZARD. Do not reach into the build area during printing or warm-up. Keep hands clear of moving components at all times. Disconnect power before proceeding with maintenance. Failure to comply may result in serious injury.

MACHINES MAY START AUTOMATICALLY WITHOUT WARNING. FDM printers may begin initialization procedures without warning. Prior to preparing a machine for use, check its queue via 3DPOS dashboard, and confirm all tools and the build plate have completed cool-down processes.

SENSITIVE MATERIALS IN USE. FDM filaments are hygroscopic and susceptible to ruination if not properly stored at all times. Always use a printing drybox when using Nylon or anything with fiber reinforcement. Store hygroscopic filaments in the dehumidifying cabinet when not in use.

CONFIRM JOB SETTINGS MATCH THE ACTIVE MATERIAL(S) AND TOOL(S). Prior to starting a job, double-check that the material(s) and print core(s) you are using correspond to the settings applied to the print file. Failure to apply the correct settings may result in permanent damage to the printer.

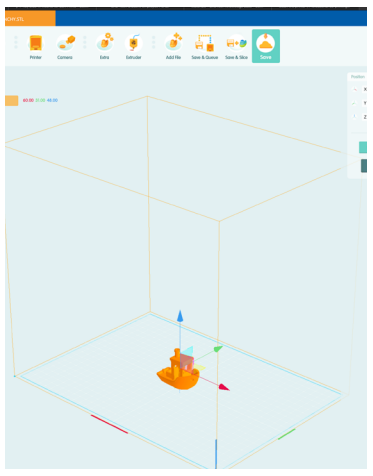
EYE PROTECTION REQUIRED WHEN POST-PROCESSING. To avoid eye injuries resulting from washing a print or removing supports, wear shatter-proof Polycarbonate eye protection. Prescription eyeglasses are sufficient, however they do not provide side impact or shrapnel protection.

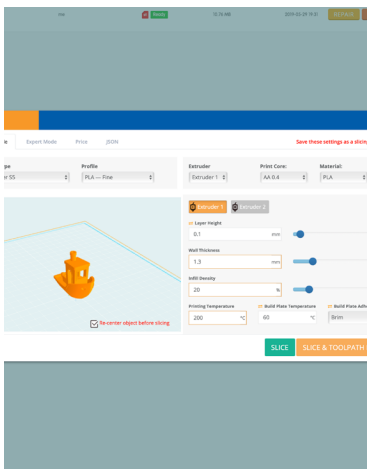
LOOSE CLOTHING, JEWELERY, LONG HAIR AND HEADPHONE CABLES ARE PROHIBITED. Tie back long hair with an elastic. Tuck-in/pull-back any baggy or loose clothing, sweatshirt drawstrings, ties, head or neck scarfs. Do not listen to music while running the CNC, and remove any headphone cables. Close-toed shoes are required.

FOOD & DRINKS IN THIS AREA ARE PROHIBITED. All food and/or beverages of any kind are prohibited from being consumed near or around FDM workstations and printing materials. Even after wearing gloves, wash hands thoroughly after working with FDM equipment before eating or drinking.

1 SETUP FILE

Login to 3DPOS and upload your model as either an STL or OBJ file. Set the print orientation by clicking “Layout”. Next, slice the model using “Slicer 3” (“Extras” > “Slicer 3”). Select one of the preset profiles, or generate your own if you have advanced privileges. Make sure to select the correct material(s), extruder(s) and print core(s) before sending your file to the print queue.





2 UN/INSTALL PRINT CORE(S)

Using the touch screen, initiate the print core loading procedure for either *Extruder 1* or *2*. Follow the on-screen instructions for un/installing the print core(s). Make sure you hear an audible “click” when installing a core, otherwise it will not register. When finished, store the inactive print core(s) in the print station’s drawer.

3A LOAD MATERIAL 2

If using two materials, load *Extruder 2* first. If not, skip to **3B**. Remove the guide arm, place spool all the way back on the holder, with filament end pointing clockwise and upward into *Extruder 2*. Lift the handle, insert the filament until you see it inside the boden tube, then lower the lever. On the touch screen, start the loading procedure for *Extruder 2*.

3B LOAD MATERIAL 1

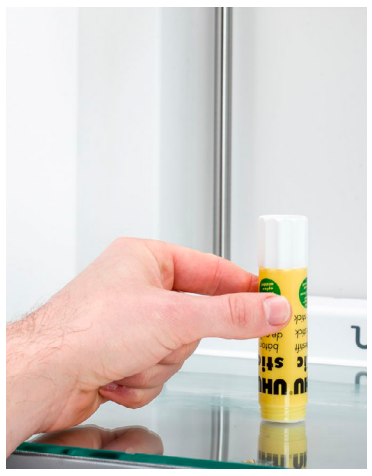
Remove the guide arm and insert it into the spool, so that the filament end is pointing counterclockwise and upward into *Extruder 1*. If guide arm does not fit spool, set it aside. Place the spool onto the holder. Lift up the handle on *Extruder 1*, insert the filament until you see it inside the boden tube, then lower the lever. On the touch screen, start the loading procedure for *Extruder 1*.

4 PREP BUILD CHAMBER

Check for and clear away any debris on the print core nozzle(s), on the build plate itself, or in the cabinet. To clean print core nozzle(s), manually set the temp to 150ºC, then use a brass wire brush to gently scrub any crud off. Additionally, use tweezers to pluck away smaller scraps. Avoid gouging or damaging the silicone nozzle cover.

5 PREP BUILD PLATE

Inspect the build plate: there should already be a thin layer of glue from previous prints. Make sure this is in the entire active print area (where your model will be printed). If there is too much glue, use Formula 409, a putty knife and a disposable microfiber cloth to clean the plate completely. Make sure to re-apply a small amount of glue where needed. If using PC, PP or CPE/PET, thoroughly clean the build plate and affix an adhesion sheet. When ready, re-install the build plate and lock the clips on the Z-stage.



6 PREFLIGHT CHECK & PRINTING

Confirm with a FabLab tech that your job file has been correctly setup for your machine and optimum printability. Once complete, the job will be released from the queue and sent to the printer. Before leaving the print to run unattended, observe construction of the first several layers. If an issue develops, abort the print and run it again via the touch screen.

7 REMOVAL

Once printing has finished, your part and the build plate need to first cool down. Do not touch the build plate, the platform, or your print until a “Finished Printing” message appears on the screen. When ready, unlock the plate clips, remove the plate, and carefully use the print station’s putty knife to remove your print. Avoid using sharp blades that may cut you, or damage the print and/or the print plate.

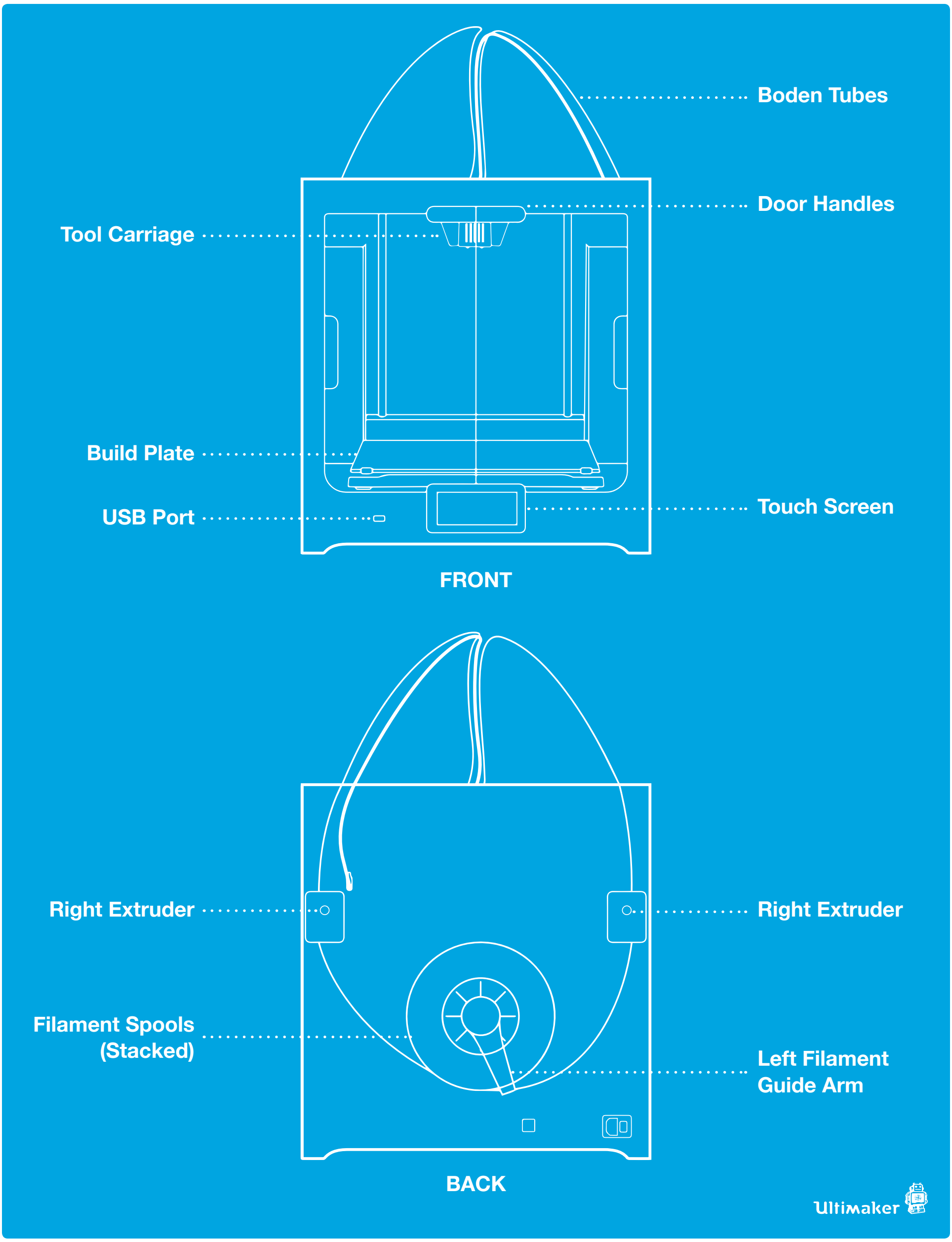
8 CLEAR BUILD CHAMBER

After re-installing the plate, confirm the prints removal by touching the “Confirm Removal” button. Finally, unload your filament(s) and dispose of any scraps or debris from your session.

Rev 1,0 2019MAY28

Ultimaker S5

Fused-Deposition Modeling (FDM) is a 3D printing technology that involves melting and extruding thermoplastics layer-by-layer to form 3D objects. Unlike SLA, FDM materials can be melted repeatedly—either for post-processing or recycling—and more than one can be used per print. FDM materials are already used in industrial, automotive, consumer and healthcare products world-wide, making it easy to design FDM prints for end-use applications.



Ultimaker

Rev 1,0 2019MAY28

Filaments

PLA

- Prints crisp details down to 60 µm
- Ideal for dual-extrusion with PLA, TPU or PVA supports
- Limited prototyping functionality

PC

- Heat-deflection temp. of 110ºC
- Withstands repeated blunt-force impacts, bucking
- Transparent options available

PVA

- Non-toxic, water-soluble support structures for detailed models with extreme overhangs, preserves details
- Expensive, can double estimated print time and cost

PET/CPE

- Excellent chemical resistance
- High toughness, dimensional stability, long-term impact strength
- Great detail registration, ideal for functional, pre-production prototyping

TPU

- High wear and tear resistance
- Rubberized texture and appearance
- Great for grips, gaskets, slip pads, bands, wearable prototypes or end-use parts

PP

- Strong, durable, withstands repeated sheering, torsional forces well
- Great for living hinges, snap-fits, bands or straps
- Chemically inert plastic, acid friendly

NYLON 6 (PA/PA6)

- Mildly flexible, durable, handles mechanical stress and fatigue well
- Ideal for semi/fully-functional prototypes and end-use parts
- Not compatible with PVA supports

CF NYLON (CF30-PA6)

- Rigid, high tensile and flexural strength
- Heat-deflection temp. of 145ºC
- Can replace metallic parts in low-temp design environments
- Not compatible with PVA supports

GF NYLON (GF30-PA6)

- Rigid, high tensile strength with minor flexural elasticity
- Good chemical resistance to bases, weak acids, oils, detergents
- Not compatible with PVA supports

Laser Cutter

Safety

CLASS 2 & 4 LASER IN USE. Exposure to laser beam may cause physical burns and severe eye damage. Do not stare into beam directly, or with optical instruments. Serious and permanent damage may result to optic nerve, cornea or lens due to improper use. Immediately stop use and seek medical attention if you begin seeing spots or experiencing blurred vision.

MATERIALS CAN IGNITE AND COMBUST DURING OPERATION. Exposure to the laser beam may cause ignition of combustible materials which can lead to a fire. Maintain unobstructed access to a fire extinguisher at all times, and stop operation immediately if you begin seeing smoldering or glowing embers.

NEVER LEAVE MATERIALS IN THE LASER SYSTEM AFTER LASER PROCESSING HAS FINISHED. Remove all material from machine after use, including material that collect in the removable cutting table to reduce the risk of fire. Allow scrap materials to cool prior to leaving the work area.

DO NOT OPERATE WITHOUT FUME COLLECTION SYSTEM ACTIVE. Fumes, smoke and dust from the engraving process must be extracted from the laser system and filtered via the adjacent air handler. Check filter date regularly, and replace if strong odors develop in the workspace.

SOME MATERIALS PRODUCE TOXIC AND CORROSIVE FUMES WHEN PROCESSED. Obtain the Safety Data Sheet (SDS) from the manufacturer of any new material(s) processed in the laser system. Discontinue use of any material that causes chemical deterioration of the laser system such as rust, metal etching or pitting/peeling paint, or produces thick colored smoke.

BE PREPARED TO STOP OPERATION WITH LITTLE OR NO WARNING. Keep the emergency stop button in-hand when running the tool. If scraps or debris obstruct the working area, or smoke, embers or flames develop, immediately stop operation and proceed with caution.

INSPECT AND CLEAN OPTICS SYSTEMS REGULARLY. Periodically check that all mirrors and lenses are free of debris and off-gassing stains that may degrade optical performance, or permanently damage the lens. Always disconnect the power before preforming any maintenance procedures.

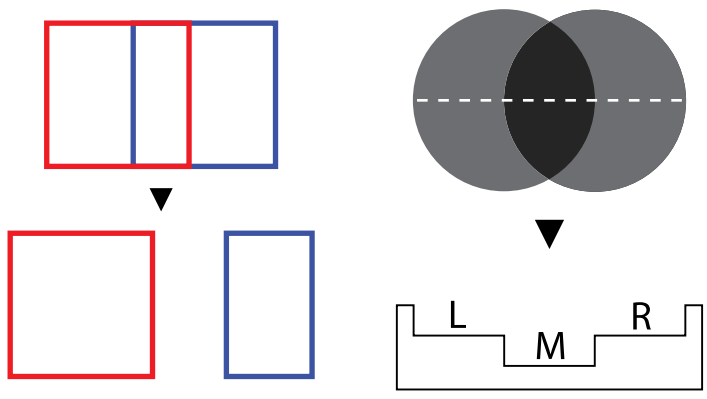
NEVER LEAVE LASER CUTTER RUNNING UNATTENDED. Constant supervision by trained personnel is required when operating the laser system. If the operator needs to briefly step away, pause the current operation using the software “Pause” button, then resuming by clicking the same button again.

Laser Cutter

Vector vs. Raster

A vector object is interpreted as a *cutting* operation, while a raster file is interpreted as an *engraving* operation.

For cutting, create a zero-fill profile using a stroke of **0.001” (0.0254 mm)**. Note the color of the stroke effects the operation. When creating complex shapes, cut and remove extraneous strokes. Covered or masked strokes will not be removed from the job and therefore result in unintentional cut paths.

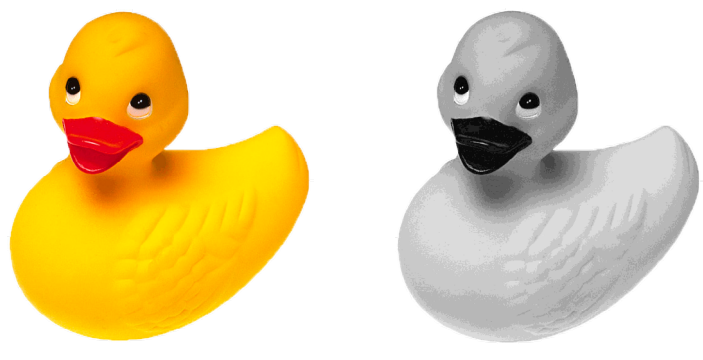


Overlapping vector (left) and raster (right) objects with their resulting outputs.

Overlapping raster objects will have their non-visible bodies automatically mapped so only the visible elements will be engraved.

Engraving Photos

To engrave a photo, you first need to convert your image to black and white, then posterize the values to a range to greater than 8 but less than 20. This helps create a simpler range of contrast for the laser to engrave. Otherwise, a color photo is immediately interpreted by the laser cutter’s software as black and white, obscuring details of the image indiscriminately.



The original image (left) compared to the engraving-ready image (right) that’s been posterized to 15 levels.

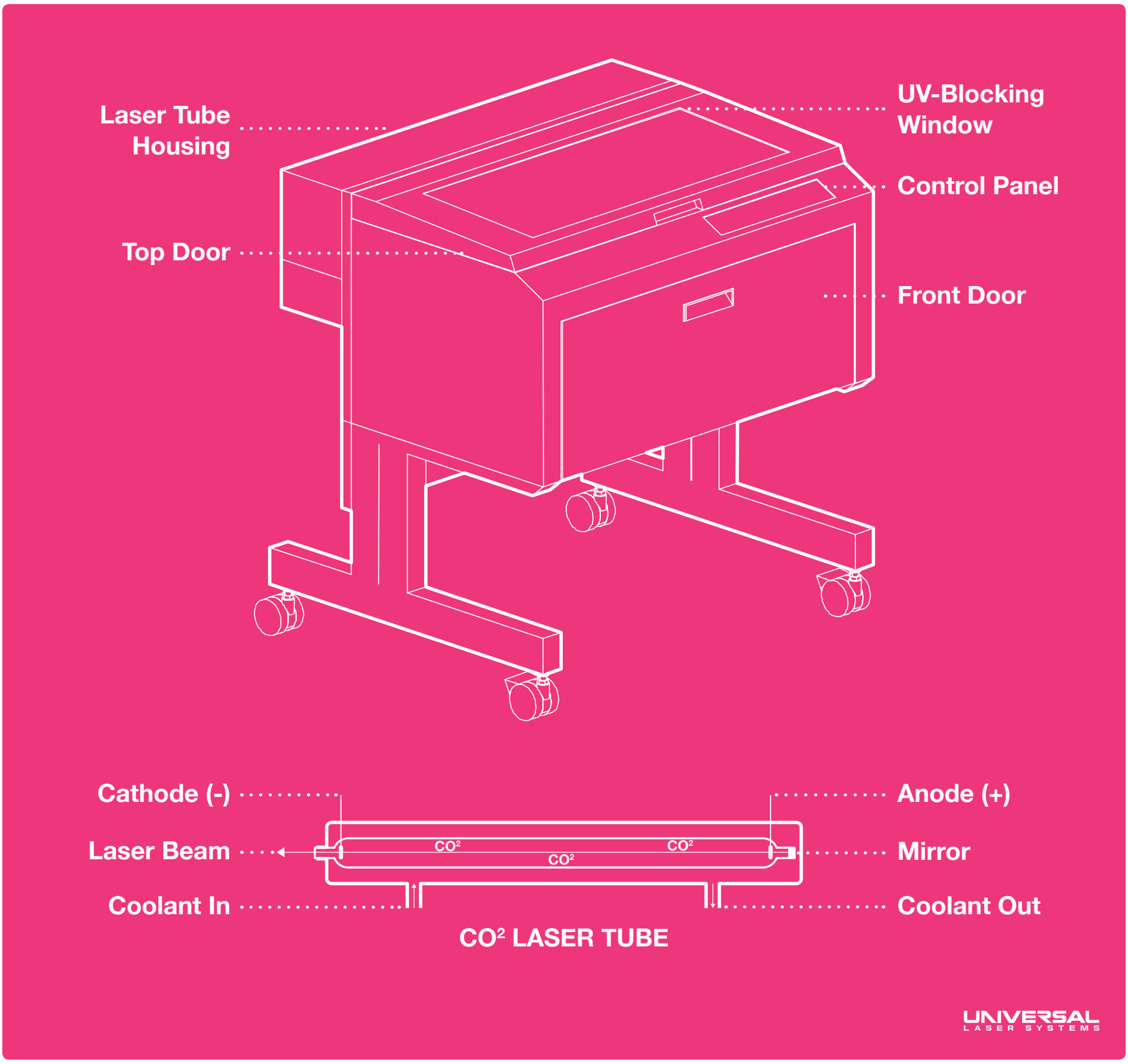
In Photoshop, first convert your image to black and white (Image > Adjustments > Black and White...). Observe the contrast between the elements you’re trying to preserve and adjust the sliders accordingly. More contrast will increase the legibility of the image when engraved.

Next, posterize your image (Image > Adjustments > Posterize...). Play around with how many black levels define enough of your image to make it legible. Too many levels will flatten the engraved image. Once your image is set, insert and embed it (as in store the image within the AI file) into the ULS V460 Illustrator template.

Observe how the black and white version, with the yellow and red values tweaked to increase the contrast of the body and bill, translates into a posterized image.

ULS V460

Laser cutters focus photons generated by electrifying an inert gas—such as CO^2—into a concentrated beam that can cut, sinter and engrave a variety of materials. The tube itself is housed behind the device, while a series of mirrors direct the beam to the lens carriage. CNC'd lasers are commonly used in mass-production for welding, cutting, engraving, sintering and curing.



UNIVERSAL LASER SYSTEMS

Materials

All the materials depicted below are safe to use for vector and raster engraving, as well as vector cutting (except for glass). Your stock should be no larger than 24” x 18” and 1/4” thick. The following materials are **NOT PERMITTED** due to toxic emissions or mechanical hazards to the laser: PET, PS, ABS, Vinly, PVC, Nylon, Delrin, Foamcore, bending Plywood, Corian, casting wax and tropical hardwoods.

CORRUGATED CARDBOARD

- Cheap, east to obtain
- Ideal for quick/rough prototypes, flat-pack designs
- Limited prototyping functionality

BALSA/BASSWOOD

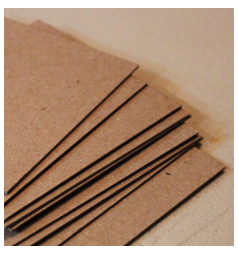
- Cheap, useful for quick prototypes, models not requiring stability
- Can be surfaced, stained, painted
- Sheets warp in humid environments

UNCOATED PAPER

- Cheap, easy to obtain
- Great for greeting, business cards, labels, decoration
- Variety of colors available

DOMESTIC HARDWOODS

- Exotic appearance, can be finished with stains, waxes
- Sturdy, rigid even with thin sheets
- Expensive, depends on type, supplier

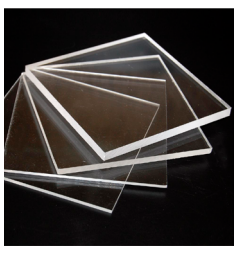


CHIP/MATBOARD

- Rigid, provides marginal structural support, bracing for flat-pack designs
- Relatively inexpensive
- Easy to glue, draw on

MDF/MASONITE

- Strong, durable, minimal flex, can be surfaced, painted easily
- Great for furniture, cabinets, working prototypes requiring strength
- Easily chips on unfinished edges



ACRYLIC

- Can be flexible or rigid depending on thickness, cut geometry
- Available in numerous colors, transparencies, performance specs
- Cuts, engraves well with vectors, images, QR codes

VEGETABLE TANNED LEATHER

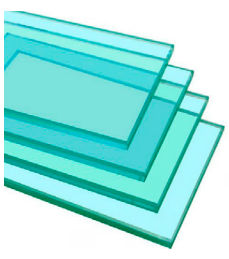
- Relatively inexpensive
- Free of Chrome salts, aniline dyes
- Engravings look like branding, cuts with clean edges
- Veg. dyes can rub off easily

UNMOUNTED LINOLEUM

- Linseed oil-based only, cannot be mounted to a base
- Ideal for printmaking, stamping
- Retains sharp details from vector , raster engraving

CORK

- Soft, textured surface, useful for human factor prototypes
- Engraves well with raster objects
- High combustion risk, pieces could become scorched



GLASS

- Engraving only
- Can be etched raw or with glaze
- Transparent, great for decoration

ShopBot

Safety

MOVING COMPONENTS POSE CRUSHING AND ENTANGLEMENT HAZARDS. Stand back from the gantry and table, as they may change speed and direction without warning. Keep hands away from exposed gears. Observe operation from behind guard walls or a safe distance. Disable motion system before preforming maintenance.

SHARP ROUTER BITS POSE PUNCTURE HAZARD. Keep hands clear of router bit's path along the z-axis. Before changing bits or collets, disable the router's power with the red breaker switch, and the motion system once the spindle is accessible. Always re-zero the z-axis after adjusting or changing bits before resuming operation.

DO NOT OPERATE WITHOUT DUST COLLECTION SYSTEM ACTIVE. Before running, start the dust collector and attach the debris shroud to the router. Check the collector's filter health and bin contents regularly, and empty as necessary. Wear a P95 or better personal respirator and eye protection when handling waste contents.

EYE AND EAR PROTECTION REQUIRED. Do not operate without using adequate ear and eye protection. Music ear/headphones are not acceptable, and prohibited from use while supervising the CNC. Shatter-proof prescription glasses are inadequate eye protection, unless equipped with supplemental side and shrapnel protection.

BE PREPARED TO STOP OPERATION WITH LITTLE OR NO WARNING. Keep the emergency stop button in-hand when running the CNC. If work detaches from the table, an unexpected or erroneous move is executed, immediately stop operation and proceed with caution. Disable motion system before preforming subsequent maintenance.

SECURE ALL MATERIALS THOROUGHLY BEFORE RUNNING. Use plastics nails and a pneumatic nail gun to thoroughly secure large stock to the table before running. If stock is bowing, secure it with plastic nails in its center and double-check that the mount points are not interfering with tool paths.

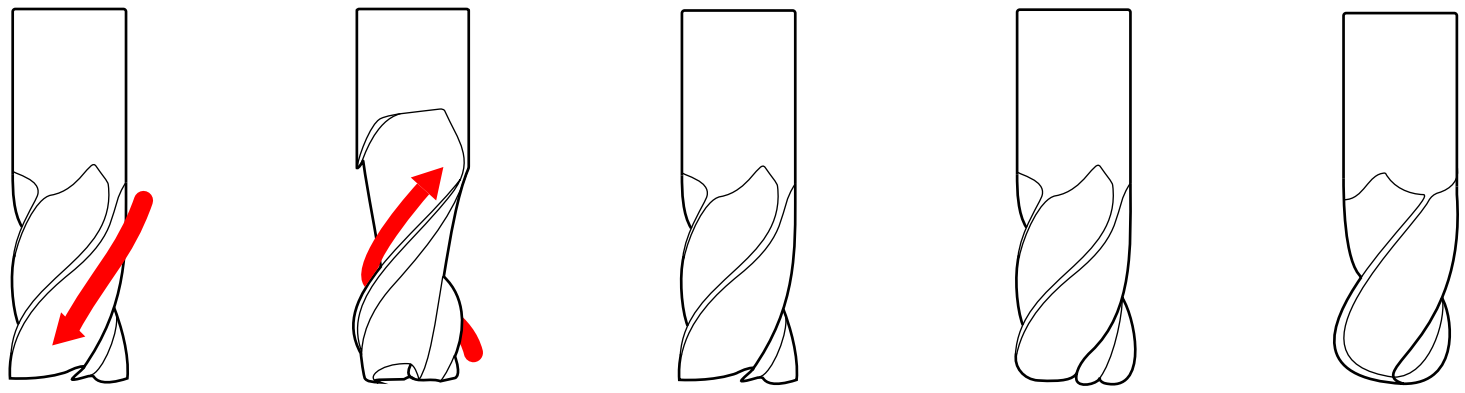
NEVER LEAVE CNC RUNNING UNATTENDED. Constant supervision by trained personnel is required when operating the CNC. If operator needs to step away, pause the job, disengage and take the lockout key. When finished, turn off the router's power, close the control software, lock the computer, disengage and return the lockout key.

LOOSE CLOTHING, JEWELERY, LONG HAIR AND HEADPHONE CABLES ARE PROHIBITED. Tie back long hair with an elastic. Tuck-in/pull-back any baggy or loose clothing, sweatshirt drawstrings, ties, head or neck scarfs. Do not listen to music while running the CNC, and remove any headphone cables. Close-toed shoes are required.

ShopBot

Speeds & Feeds

For best results, use the Chip Load calculator, found in the ShopBot controller (Tools > Chip Load calculator) for calculating speeds and feeds. Remember to leave enough clearance for the tool to completely cut through the stock, and avoid leaving too little of the bit loaded in the collet.



Downcut | Upcut | Flat End | Radius End | Ball End

STOCK	TOOL	FLUTES	CHIP LOAD, LEADING EDGE	FEED RATE, (IN/SEC)	SPEED (RPM)
Soft/ Hardwood, Laminate/ Plywood	1/8” (0.125”) Tapered Upcut Ball End Mill	2	0.003 - 0.005	1.80 - 3.00	18,000
	1/4” (0.25”) Upcut Carbide End Mill	2	0.007 - 0.009	4.20 - 5.40	18,000
	1/4” (0.25”) Downcut Carbide End Mill	2	0.007 - 0.009	3.00 - 4.20	18,000
Pink/Blue Foam Insulation	1/8” (0.125”) Tapered Upcut Ball End Mill	2	0.003 - 0.005	XXX - XXX	18,000
	1/4” (0.25”) Upcut Carbide End Mill	2	0.006 - 0.008	XXX - XXX	18,000
	1/4” (0.25”) Downcut Carbide End Mill	2	0.005 - 0.007	XXX - XXX	18,000
MDF	1/8” (0.125”) Tapered Upcut Ball End Mill	2	0.003 - 0.005	1.80 - 2.50	18,000
	1/4” (0.25”) Upcut Carbide End Mill	2	0.006 - 0.008	3.60 - 4.80	18,000
	1/4” (0.25”) Downcut Carbide End Mill	2	0.005 - 0.007	3.60 - 4.80	18,000