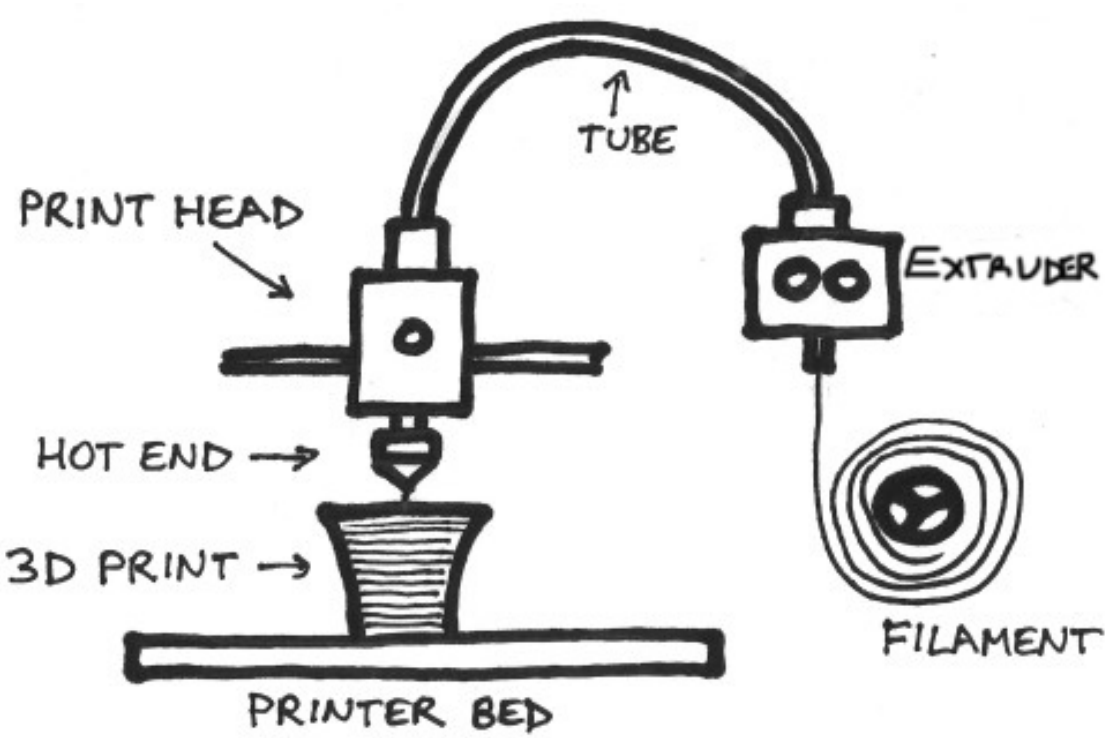
3D PRINTING INSTRUCTIONS

Who is allowed to use the B+C|A 3D Printer?

- This semester, the 3D printers are available to approved users only. Contact the department at architecture@barnard.edu if you would like to inquire about using our printers.

ANATOMY OF A 3D PRINTER

- Ultimaker 2.0+ is an FDM type of printer (fused deposition modeling.) This type of machine works very similarly to a 2d printer, there is a print head that moves on the X and Y axes, and a heated bed that moves in the Z axis. The filament is the material that is melted and deposited layer by layer by the printer. There are different nozzle aperture sizes as well as different filament diameters. We currently have 0.4mm nozzle and use 2.85mm filament. The smaller the nozzle, the higher resolution your print will be. The printer bed is also called the build plate, in our case it is a heated bed which helps the prints adhere and it needs to be periodically removed for cleaning.



MATERIALS

B+C|A department provides free PLA filament in neutral colors for 3D printing. If you wish to use a different material, please consult with the department beforehand.

- **PLA** – FDM printers use extruded filament thermoplastics, mainly PLA plastic (polylactic acid) which is bio-derived and biodegradable, and quite flexible. When the material is heated to upwards of 250°C some fumes will be smelled, but PLA is a very safe material, so extra ventilation is not required. PLA prints are quite sensitive to temperature and should not be left out in the sun.

- **ABS** – Another popular material is ABS plastic (acrylonitrile butadiene styrene). It is more durable than PLA and a little more difficult to print but once printed the models are very sturdy and dimensionally stable. ABS produces more fumes and better ventilation is required. Different colors of ABS greatly affect the print settings, for example, white is easier than black to print.

- **PET** – PET (polyethylene terephthalate) is the most commonly used plastic in the world. PETG (glycol modified) is popular for 3d printing because it is more flexible than PLA but easier to print than ABS.

- **Nylon** – it is a synthetic filament that is very popular in 3D printing and in general industrial applications because of its mix of flexibility, strength, and durability. It has the unique capability of being able to be dyed after the print is completed.

- **TPU** – thermoplastic urethane is very flexible, like rubber. Although a little difficult to print the results can be amazing with the Ultimaker 2.0+. Common filament brands are Ninjatek's Ninjaflex (very flexible) and Cheetah (less flexible than Ninjaflex but still very flexible.)

- **Specialty filaments** – you can purchase metal/PLA blends, nylon/carbon fiber, polypropylene, wood/PLA. Specialty filaments require a bit of tweaking and may even need a specialty hardened nozzle.

- **Cleaning filaments** – useful to have to run through and clean out leftover filament from the machine as well as lubricate parts.

TOOLS

- **Pliers / Wire Cutters** – extremely important for cutting the filament and making it perfectly straight when inserting into the printer's extruder. If the filament is stripped in any way it will not work. You must cut the end of the filament and squish it so it's almost perfectly cylindrical when feeding the filament into the extruder.

- **Wire Brush** – used to clean the hot end of melted filament that remains.

- **Spatula / Palette Knife and Rubber Mallet** – used to pry off the print once it is completed. Note that once the bed cools the prints just come off, so you will only need these tools when you're in a hurry and need to remove your print immediately after it is completed.

- **Glue Sticks** – applied to the bed, regular glue will greatly help the print adhere to the bed.

- **Blue Scotch Masking Tape** – applied to the bed, tape will also help prints adhere. Used mostly when printing with PLA.

- **X-acto/ Olfa Knife** – 3d prints will need a bit of post-processing to clean up supports and adhesion geometry such as skirts and brims which help the part adhere to the bed.

- **Sandpaper** – also used in post-processing to smooth out the surface of the model.

- **Tweezers** – used to clean up the hot end of stuck filament.

- **SD card reader** – it is the easiest way to get your files into the Ultimaker, as they are independent and do not need to be attached to a computer.

STEPS IN CREATING A 3D PRINT

- **Model Creation** – create your model in a CAD program, such as Rhino.

- **Format** – files need to be polygonal meshes (not solids, not surfaces!) and this is a simple command in Rhino. Save as .STL format (standard tessellation language.)

- **'Watertight'** – models need to enclose an entire volume, without holes. Cura software will attempt to close your holes if they exist, but it is better to think of this step before.

- **G-code** – Cura will transcribe your STL file into G-code, which is a language that guides the printer. G-code is not editable so if you have special settings it is wise to take note of them or create a new preset. DO NOT override the automatic settings by Cura, only save your presets individually when needed.

SETTINGS

- **Slicing** – when converting from STL mesh to G-code, your model goes through a "slicing" process where each vertical layer is calculated. Cura is by far the fastest slicing software available.

- **Layer Height** – smaller increments mean more precise prints (and longer print times.) A "fine" print is 0.1mm to 0.06 mm height.

- **Shells** – the "outside" of your print.

- **Infill** – the "inside" of your print. This is a setting that you will likely personalize. 100% infill means your model will be totally solid, 0% infill means it is a hollow shell. 20% is a good middle ground, but it all depends on your intended purpose.

- **Supports** – the "extra" parts added that are not technically part of your model's design but only exist to support overhanging parts and apertures. Figuring out what kind / how much support you need is more of an art than a science, so be prepared for a trial-and-error process here. The 45-degree rule is a good benchmark – anything that overhangs at 45° or more will definitely need supports.

- **Y shapes** are good to go with less than 45°.

- **H shapes** are called bridges, will definitely need supports.

- **T shapes** are called roofs, will definitely need supports.

- **"Touching Build Plate"** means the supports will only touch the bed and not your model.

- **"Everywhere"** means supports can connect parts of your model to each other.

- **Retraction** – the process of pulling the filament back into the hot end when the print head passes over an area that is not being printed. The automatic settings are usually good enough for this. Retraction is what causes a loud noise when printing.

- **Bed Adhesion Type** – the extra material that is not a part of your model, which will help it stay stuck to the bed as it prints.

- **Skirt** – does not touch the model – it merely primes the printer by depositing a ring around your model.

- **Brim** – like a hat, a brim connects a flat layer on the outside perimeter of your model. This width can be customized but note that it will require post-processing to cut off the extra parts.

- **Raft** – a raft is a type of cushion under your model, this means your model does not directly touch the build plate, useful for certain geometries of if you want to avoid that perfectly flat and shiny first layer of your print.

- **Initial layer thickness** – the thickness of the first few bottom shells touching the bed, before any infill.

FILAMENT STORAGE

- Filaments should never be left in the printers when you are not actively printing. This causes clogs and could even potentially require a new nozzle. Filaments are hygroscopic, meaning they absorb water and thus degrade over time. They also deteriorate under direct sunlight. Once a filament is opened from the vacuum plastic it immediately begins to degrade. A good rule of thumb is that an opened filament will last about one year. Even after 2 or 3 months filaments can become very brittle and almost unusable in high humidity and in direct sunlight.

- Humidity control is key for having dimensionally stable filaments. A good plastic box that is watertight, like Ziploc weathershield or Pelican case are recommended. Desiccant packages and/or a dehumidifier like Eva-Dry are highly recommended.