LamaPLC: 3D printing

Three-dimensional (3D) printing is an additive manufacturing process that creates a physical object from a digital design. The process works by laying down thin layers of material in the form of liquid or powdered plastic, metal or cement, and then fusing the layers together.

Files for 3D printing

STL

An STL (**stereolithography or Standard Triangle Language**) file is an openly documented format used to describe an object's surface geometry in the form of a triangular mesh. Each STL file consists of a series of linked triangles that defines the surface geometry of a 3D object. The more complex the object being modeled, the smaller the triangles have to be to give an accurate representation of the model. This results in larger files — one of the drawbacks of STL files compared to AMF (additive manufacturing file) files, for example.

STL is the most popular file format for 3D printing. This file format is mainly used in rapid prototyping, additive manufacturing, and computer-aided manufacturing.

Filament types for 3D printing

3D printing filament is the thermoplastic feedstock for fused deposition modeling 3D printers. There are many types of filament available with different properties.

Filament comes in a range of diameters, most commonly 1.75 mm and 2.85 mm, with the latter often being confused with the less common 3 mm.

Filament consists of one continuous slender plastic thread spooled into a reel.

Name	**PLA**	**ABS**	**ASA**	**PETG**	**TPU**
Type of plastic*	thermoplastic	thermoplastic	thermoplastic	-	-
Printing Temperature	180 - 230 °C	210 - 250 °C	240 - 260 °C	200 - 260 °C	190 - 245 °C
Printing bed Temperature	20 - 60 °C	80 - 110 °C	100 - 110 °C	80 - 90 °C	60 - 90 °C
Printing Bed	optional	necessary	necessary	optional	optional

Name	PLA	ABS	ASA	PETG	TPU
Bed Adhesion	medium	medium	medium	bad (use blue tape or PEI)	bad (use blue tape or PEI)
Fumes	few to none	harmful	harmful	harmful	few to none
Strength	medium	good	good	very good (except scratches)	very good
Flexibility	bad	medium	medium	good	perfect
Heat Resistance	bad	medium	medium	good	good
UV-Resistance	medium	medium	medium	medium	good
Water Resistance	medium	medium	medium	good	good
Biodegradable	partly	no	no	no	no
Acetone Treatment	not possible	possible	possible	not possible	possible

*: **Thermoplastics** become liquid (i.e. have a *"glass transition"*) at a certain temperature (105 °C in the case of ABS plastic). They can be heated to their melting point, cooled, and re-heated again without significant degradation.

Instead of burning, thermoplastics like ABS liquefy, which allows them to be easily injection molded and then subsequently recycled.

By contrast, **thermoset plastics** can only be heated once (typically during the injection molding process). The first heating causes thermoset materials to set (similar to a 2-part epoxy), resulting in a chemical change that cannot be reversed. If you tried to heat a thermoset plastic to a high temperature a second time, it would simply burn. This characteristic makes thermoset materials poor candidates for recycling. ABS is also an amorphous material meaning that it does not exhibit the ordered characteristics of crystalline solids.

PLA

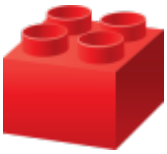
Polylactic acid, also known as **PLA**, is a thermoplastic monomer derived from renewable, organic sources such as corn starch or sugar cane. Using biomass resources makes PLA production different from most plastics, which are produced using fossil fuels through the distillation and polymerization of petroleum.

Despite the raw material differences, PLA can be produced using the same equipment as petrochemical plastics, making PLA manufacturing processes relatively cost efficient. PLA is the second most produced bioplastic (after thermoplastic starch) and has similar characteristics to polypropylene (**PP**), polyethylene (**PE**), or polystyrene (**PS**), as well as being biodegradeable.

PLA polymers range from amorphous glassy polymer to semi-crystalline and highly crystalline polymer with a glass transition 60–65 °C, a melting temperature **130-180 °C**. Heat-resistant PLA can withstand temperatures of **110 °C**.

PLA is biodegradable under industrial composting conditions, starting with chemical hydrolysis process, followed by microbial digestion, to ultimately degrade the PLA. Under industrial composting conditions (58 °C), PLA can partly (about half) decompose into water and carbon dioxide in 60 days.

ABS



Acrylonitrile Butadiene Styrene (ABS) is an opaque thermoplastic and amorphous polymer. ABS is the plastic used in most modern LEGO elements. *“Thermoplastic”* (as opposed to *“thermoset”*) refers to the way the material responds to heat.

ABS is an amorphous material meaning that it does not exhibit the ordered characteristics of crystalline solids.

As part of The LEGO Group's R&D expansion in the late 1950s to early 1960s, a process development lab was started in Billund under the Swiss engineer Hans Schiess. The first major contribution of the newly developed lab was the switch from cellulose acetate (CA) to ABS. For LEGO, the new material provided a plastic that was more stable, more impact-resistant and more colorfast than CA. Additionally it could be easily injection molded to more exacting tolerances than CA.

ASA

Acrylonitrile Styrene Acrylate (ASA) is structurally very similar to ABS. Compared to ABS, ASA is more UV resistant, warps less, and doesn’t smell as much. ASA is significantly more resistant to environmental stress cracking than ABS, especially to alcohols and many cleaning agents. n-Butyl acrylate rubber is usually used, but other esters can be encountered too, e.g. ethyl hexyl acrylate. ASA has lower glass transition temperature than ABS, 100 °C vs 105 °C, providing better low-temperature properties to the material. ASA typically prints with an attractive satin surface finish.

PETG

Polyethylene terephthalate glycol (PETG) is a thermoplastic polyester commonly used in manufacturing. The PET component is what is commonly found in plastic beverage bottles and food products. PETG (also called co-polyester) is a modified version of PET. The added (G) glycol prevents the material from crystallizing and becoming breakable making it an excellent material for 3d printing.

PETG is the most commonly used plastic in the world and it is one of the easiest to recycle, but it isn't biodegradable. Unfortunately, PETG requires somewhat high printing temperatures, which limits the number of compatible printers. Additionally, there are a few common printing and part quality issues, like over-adhesion and stringing, that make the material more difficult to work with.

TPU

Thermoplastic Polyurethane (TPU) is referred to as the bridge between rubbers and plastics. The material appears rubber-like, which means it can be extremely flexible, durable and smooth to the touch. TPU offers superior resistance to high and low temperatures, ozone, grease, oils, chemicals, and abrasion, making it a great replacement for hard rubber. TPU also has greater load-bearing capacity than most comparable materials.