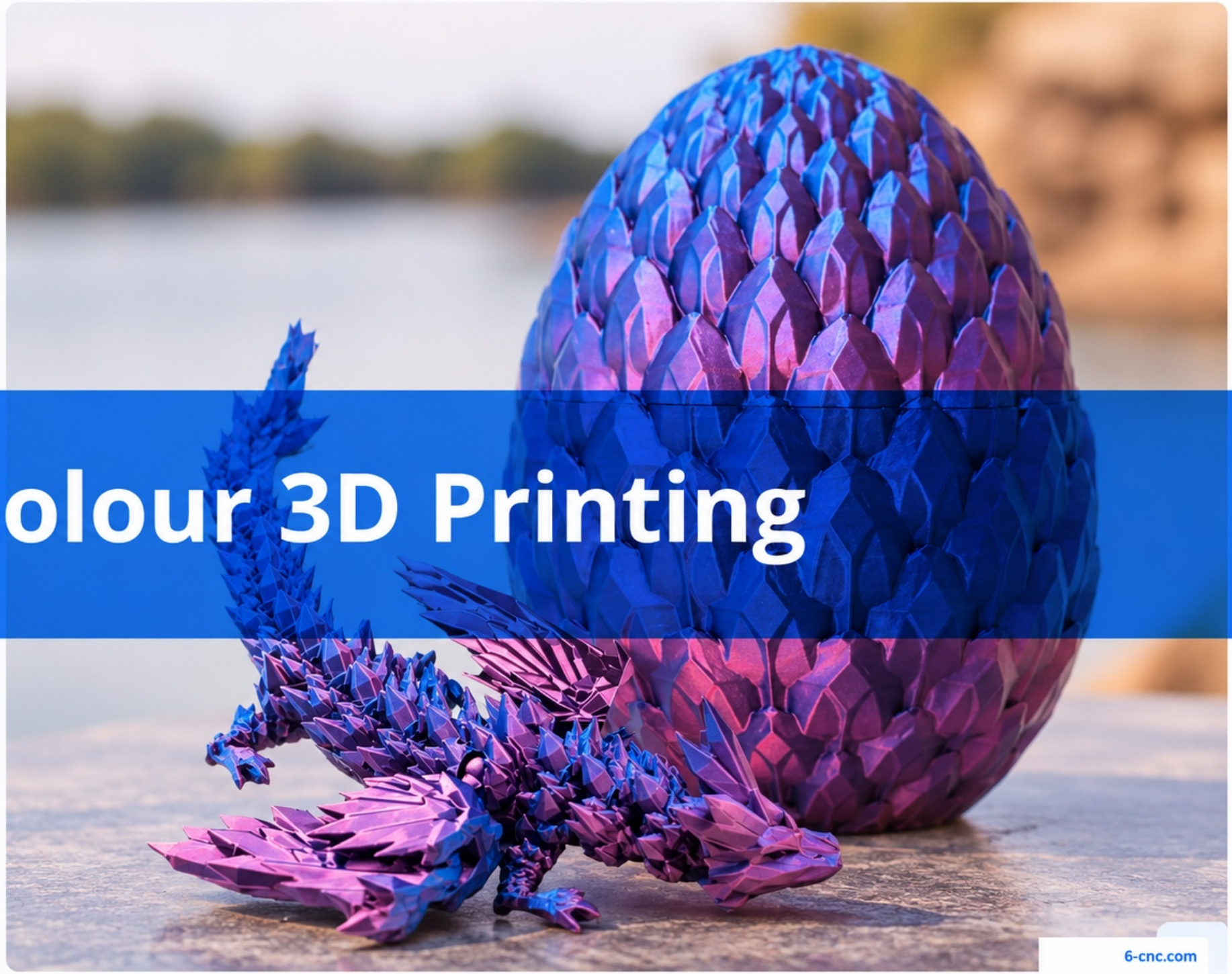
Colour 3D Printing
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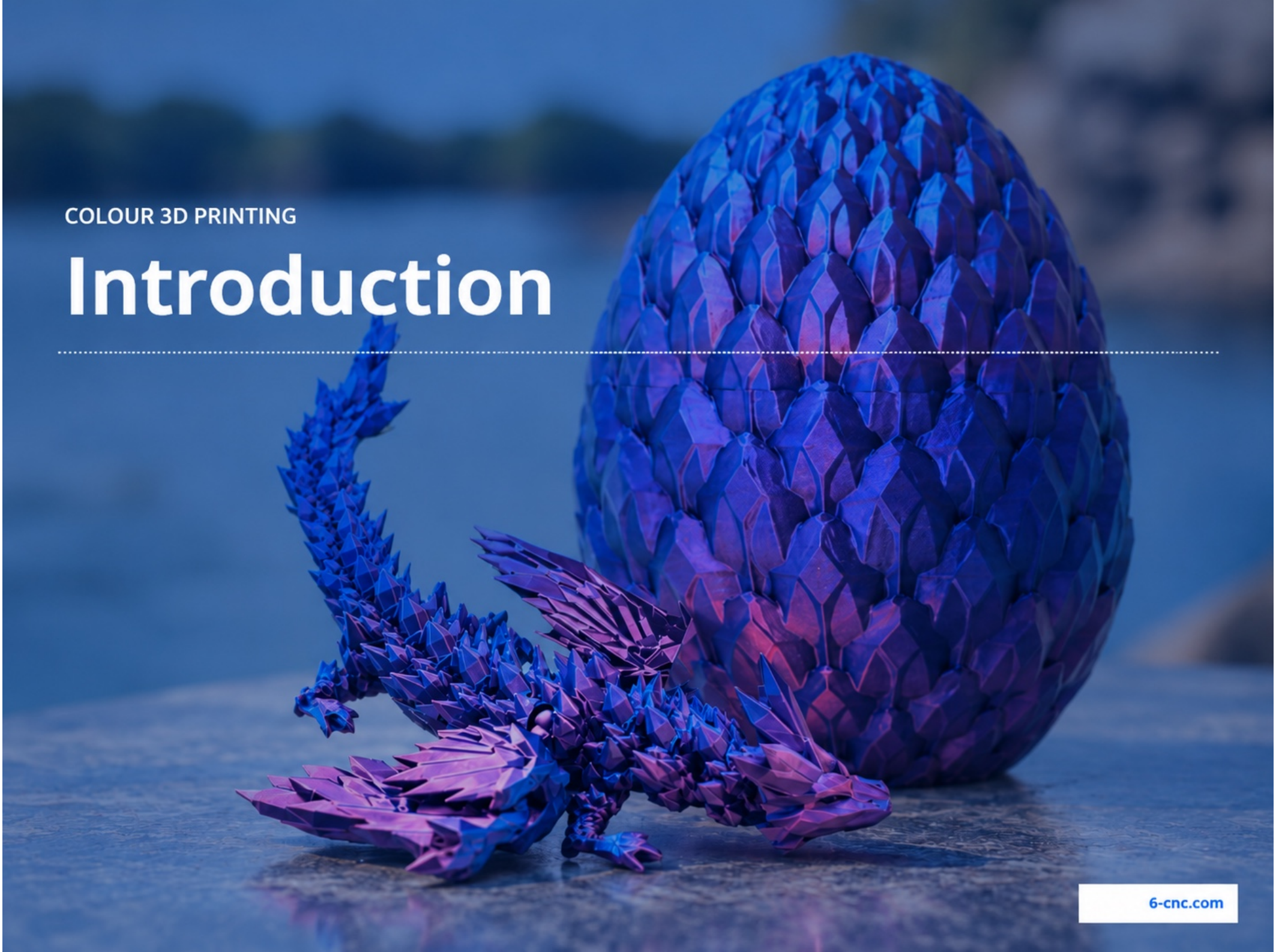
Table of Contents



COLOUR 3D PRINTING

Introduction

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Introduction

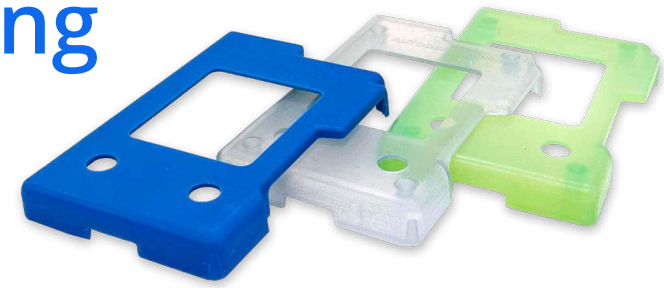
What is Colour 3D Printing?

In the past, when it came to 3D printing in colour, users were limited to printing materials in a set colour or had to resort to post-processes, such as painting, to add colour variety to their prints. Over the years, printing technology has advanced, and it's now possible to print in hundreds of thousands of colours and replicate patterns, textures, and transparency within a single print.

Throughout this guide, we will cover the different methods, technologies, and design techniques related to colour 3D printing so you can get the most out of the current generation of machines and get spectacular-looking coloured prints.

Introduction

Applications of Colour 3D Printing



The ability to print in full colour opens the door to various uses and applications across many industries. Users can print models with accurate colours, patterns, and textures in great detail. From engineers and product designers to artists and architects, each can utilise modern colour 3D printing to their advantage. Below are just some examples of where this technology is applied.

Rapid Prototyping

Functional prototypes can be printed in the exact colours of their final design, offering designers even more insight into improving their products. Colour prototyping can reveal cosmetic issues and strengths without needing painting or other post-processing steps, buying users more time and a better result. Also, key areas of a prototype can be coloured to highlight their functionality or important features within a design.

Education & Medical Models

Models for classrooms and doctor's offices can be fabricated in full, accurate colour with minimal post-processing necessary. Complex, organic geometries can also be made transparent so that bones, veins, or other internal structures can shine through the print without needing removal and colouring.

Architectural

Architectural models can be further improved with real colour mapping, allowing stakeholders to better grasp the architect's vision. With amazing colour accuracy, colour 3D printed models will show designers what their colour choices will look like without the lengthy painting process, allowing them to make faster revisions.

Geospatial Modeling

Terrain and other geospatial maps printed in full colour provide a scaled 3D look at peaks, valleys, and geographic formations in a landscape. Both analysts and students benefit from accurate colour matching to elevation differences, temperature or pressure gradients, or any other geospatial feature that can be superimposed onto 3D printed geography.

Artwork

The ability to produce full-colour parts saves an immense amount of time for artistic endeavors, where priming, painting, and protecting take valuable time away from the creative process. Artists can save time by printing in full colour, using this time to focus on innovating and refining their artistic visions.

COLOUR 3D PRINTING

Categories & Printing Processes

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Categories & Printing Processes

Colour 3D Printing Categories

Colour 3D printing breaks down into categories based on how the machine applies colours during printing. Due to technological differences, some printers create a full spectrum of colour that prints simultaneously for highly detailed results. In contrast, others rely on mixing and blending raw materials of different colours. Each process's approach and subsequent category largely depend on the printing technology and materials.

Full-Colour Printing

Machines that can create thousands of colours and apply them in a single print to create photorealistic results are considered full-colour. These types of printers often utilise printheads to jet tiny droplets of pigmented material or binding agents, similar to how 2D inkjet printers deposit ink to create colourful images. This approach also allows some processes to apply materials with different properties in a single print. When it comes to overall colour fidelity and detail, full-colour printing is at the top.

Multi-Colour Printing

Not to be confused with full-colour, multi-colour printing generally involves mixing, blending, or swapping between multiple coloured raw materials while printing. This approach is more common with filament-based processes like fused deposition modeling (FDM). For instance, a printer with multiple extruders can deposit a different colour for each extruder. It is also possible to splice and fuse other coloured filaments into a single filament with special devices designed for single-extruder machines. While typically an inexpensive way to produce coloured prints, this method is much more limited, can be slow, and may not be suitable for prints requiring precise colour placement or realistic colour details.

Post-Process Colouring

For some processes and materials, colour options are limited or nonexistent. Post-processing can come in handy in this case. For example, selective laser sintering (SLS) printers typically make parts from white nylon, and 6CNC can support dyed colour finishes depending on material and project requirements. Painting is also a viable option to create customised colours and fine details. However, this can be a very time-consuming process depending on the needs and is not considered a scaleable solution.

Categories & Printing Processes

Colour 3D Printing Processes

Now that we understand that there are different ways to achieve colour in 3D printing, let's take a deeper look at some of the most commonly utilised processes for creating colourful prints. When determining which is best for your application, consider the pros and cons of each 3D printing process.

FDM

Fused deposition modeling (FDM) printers offer various colour options and printing methods to achieve multi-colour 3D prints. FDM 3D printing works by extruding a melted plastic filament onto a build plate, patterning the shape of the part on a layer-by-layer basis. In single-nozzle systems, multi-colour 3D printing requires filament swaps between transitions. There are splicing modules that manage and mix multiple filaments before they enter the extruder, offering both multi-material and multi-colour printing for standard single extruder printers. Certain single extruder FDM printers also implement clear filament dyed with CMYK ink cartridges during printing to provide the full-colour spectrum with a single material. In multi-nozzle FDM printers, these filaments can be printed independently of one another through dual extruders, producing 2+ different colours throughout the print and their blended colour profile.

Assembly of colour prints made using FDM

6CNC supports FDM projects for prototypes and functional parts. Material, colour, build size, surface finish, quantity, and lead time are reviewed according to the requirements of each project.

Pros

- Large build volumes up to 900 x 900 x 900 mm
- Wide range of materials to choose from
- Can be suitable for functional prototypes and some end-use applications

Cons

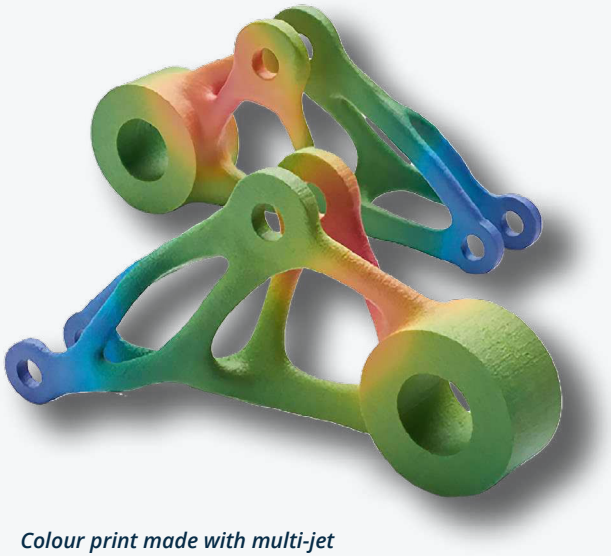
- Relatively low printing resolution with pronounced layer lines on parts
- Limited colour range; generally cannot match specific tones
- Struggles with highly detailed or intricate features and tiny parts
- Requires support structures during printing; susceptible to more print errors

Colour 3D Printing Processes

Multi-Jet Fusion

Developed and patented by Hewlett-Packard (HP), Multi-Jet Fusion (MJF) 3D printers use a multi-agent material jetting process where an inkjet array sprays fusing and detailing agents onto a powder bed of thermoplastic. As the layers deposit, a heating element fuses the part shape, and then a roller places a new layer of powder so the process can repeat until the part completes. Multi-Jet Fusion machines use proprietary blends of PA (nylon), PP, TPA, and TPU, all patented combinations by HP, to ensure ideal results. HP has a variant of their machine capable of applying colour tones to the part; however, most installed platforms provide gray or white parts. Manufacturers can pigment MJF prints by dyeing them.

For MJF projects, 6CNC reviews material, colour, quantity, dimensional requirements, and finishing needs before recommending a suitable production route. Dyed or post-processed colour options depend on the material and specification.



Colour print made with multi-jet fusion

Pros

- High productivity; suitable for batch production runs
- Creates strong, durable parts suitable for end-use applications
- Relatively low-cost process

Cons

- White will appear off-white
- No transparent or translucent options
- Full-colour multi-jet fusion machines were discontinued in 2021 meaning this option will become harder to source as time goes on
- Requires support structures during printing; susceptible to more print errors


COLOUR 3D PRINTING
Creating Files for Colour 3D Printing
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Creating Files

File Formats

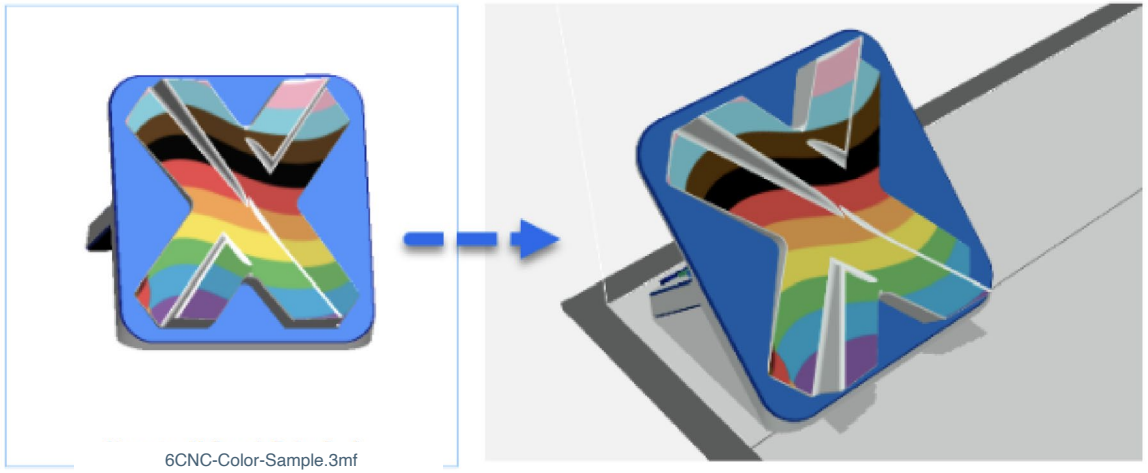
Exporting your files in the appropriate format is crucial to print your full-colour designs successfully. Many standard file types used for 3D printing, such as STL, do not retain texture, scale, or colour data. STL files loaded into printing software will come through as plain, colourless files. Several native and STP file formats store this information; however, they are primarily meant to be used solely within the original design software and should be converted to a format that can be interpreted by 3D printing software.

In the section below, you will find our top picks for the best formats for full-colour printing, as well as information about each so you can decide what is best for you.

3D Manufacturing Format (.3MF)

The 3MF format is relatively new compared to other 3D file formats, but it is quickly becoming one of the go-to options for 3D printing. There is a good reason for its growing popularity--3MF encompasses information about materials, colours, textures, support structures, dimensions, and more, all within a single file. 3MF files typically are smaller file sizes than STL without compromising resolution. We

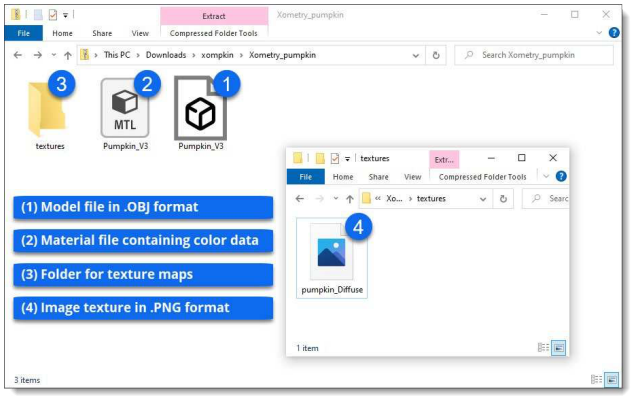
than STL without compromising resolution. We recommend using 3MF for full-colour projects because it can package material, colour, texture, scale, and other print information in one convenient file for engineering review.



File Formats

Wavefront OBJ (.OBJ)

OBJ is well-adopted and widely supported among CAD and 3D design software. These files define objects by their vertex positions and UV texture coordinates. Unlike 3MF, Wavefront OBJ files do not store the material and texture information inside a single file; instead, they rely on material libraries and companion files to complete the job. They cannot also store unit information that defines exact dimensions. For full-colour 3D printing, this can lead to issues such as colours and textures not coming through properly or parts coming in at incorrect sizes. When using OBJ, the associated companion files (e.g., material files, images for textures, etc.) must be in the same directory or folder as the OBJ itself.



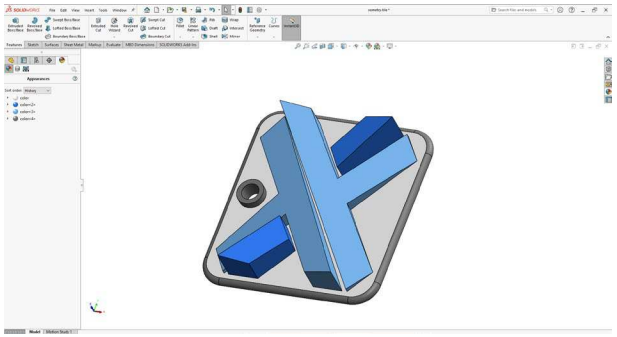
Example of OBJ and supporting files

Pro Tip:
The best way to provide an OBJ to a manufacturer for full-colour printing is to put all the necessary files in a folder, then compress the folder into an archive (e.g., a .zip file), which can be uploaded or emailed.

Methods for Creating Colour Models

3D CAD & Design Software

3D CAD and free-form modelling design software offer the most versatility for creating digital designs suitable for printing. Computer-aided design software such as SOLIDWORKS and Autodesk Fusion 360 utilise parametric modelling techniques to develop precisely dimensioned models. This makes them a common choice for engineers and product designers who must ensure their models have exact specifications. Typically, modelling software enables you to change the design's appearance using colours and textures that the software retains for printing when you export the file in an appropriate format.

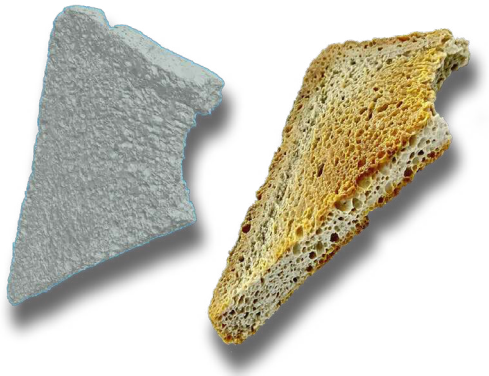


A part within SOLIDWORKS

Polygonal modelling software such as Blender and ZBrush rely more heavily on freeform tools to shape and sculpt models from polygonal meshes. This type of software excels at creating organic geometries and characters. Additionally, they often have very in-depth colouring, and texture mapping features allowing users to control appearances precisely.

3D Scanning

The process of digitising real-world objects or environments into a three-dimensional file using a 3D scanner is known as 3D scanning. The process works by scanning objects at all possible angles with scanning equipment. Most scanners use a combination of lasers and sensors to measure the surface of an object and create a point cloud that generates polygonal 3D meshes. With scanning, it's possible to make highly detailed and accurate models of existing things. When paired with full-colour 3D printing, this is an excellent process for creating life-like replicas or miniature models. For example, one could 3D scan a one-of-a-kind historical artifact, then 3D print copies of it to distribute to museums worldwide for display and educational purposes. As a less practical example, you could also use this process to fool friends and colleagues with fake food, as we've done with the piece of toast shown to the right.



Example shown using PolyJet multi-colour 3D printing. Process availability should be confirmed for each project.

Methods for Creating Colour Models

While 3D scanning allows you to create highly detailed objects relatively quickly, it does have its limitations. The primary is that you are limited to only scanning real-world objects; non-existent items must be created manually with 3D design software. Since scanning requires you to move around an object physically, it is unsuitable for replicating substantial objects (e.g., statues and buildings). Bright lighting conditions and shiny or reflective objects can also pose issues for scanners and may require coating surfaces to create a clean scan. Finally, most 3D scanned models need manual touch-up work with modelling software to join two halves of an object together or remove file errors that made their way into the scan data.

Photogrammetry

Like 3D scanning, photogrammetry is a method to create 3D models from actual objects. Instead of scanning and measuring an object with light sources, photogrammetry relies on gathering data from photographs. The process works by taking photos at various angles and loading the images into photogrammetry software that uses specially designed algorithms and math to align the photos, create plot points and calculate distances to form a point cloud. Similar to scanning, software constructs polygonal meshes from scanned point clouds. Photogrammetry is much more accessible, as you only require a camera to take photos and software designed for the task. Some applications, such as Polycam, allow you to perform photogrammetry right from a smartphone or tablet.

This technique also makes it possible to create models and capture textures of much larger objects. For example, you can theoretically digitise entire buildings or city blocks using aerial imagery from planes or drones, given you have enough photographic data. That said, photogrammetry shares many pain points around lighting conditions and reflections as 3D scanning. Since it relies on images and software to approximate distances, photogrammetry is generally less accurate than 3D scanning and is more prone to geometric errors. Like scanning, additional manual touch-up work is often required with the models before they are suitable for printing.

Example of a scan made using photogrammetry


COLOUR 3D PRINTING
Adding Colour to Models
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Colour

Adding Colour to Models

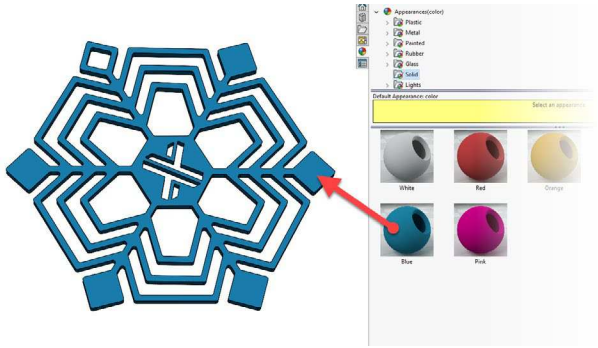
Designers can use several techniques to directly assign colours in a 3D model for full-colour 3D printing. Your specific use case will determine the best and most efficient choice. In most cases, colouration can be done directly in the software you used to create your model; be sure to look for appearance or material features within your program. We'll take a closer look at a few colouring techniques below.

Colour by Object

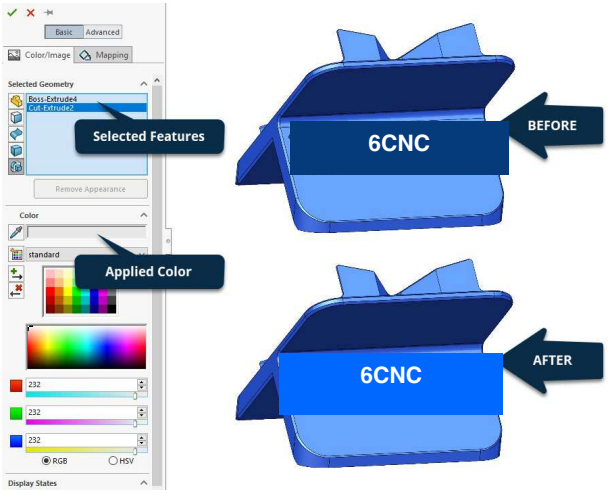
This method is best for making your entire object one solid colour—making parts specific colours can help differentiate part configurations, aid in assemblies, or for aesthetical purposes. Solid-coloured models work well with either full-colour or multi-colour types of printing. However, if you are looking for a custom colour or as close to a colour match as possible, full-colour technology is still the best option. In your design software's material or appearance menus, apply the desired colour to your entire object.

Colour by Face

Assigning colour by face means selecting a particular triangle, face, group of polygons, or feature in your design software and giving it a specific colour. Colouring by face is an excellent technique for giving embossed or engraved text contrast and giving features unique colours on the same object. The selection method may vary depending on your design software. Still, the core idea is to select specific areas of your model instead of the entire thing and assign a colour or material to each.



Example of assigning colour by objects



Example of assigning colour by faces and features

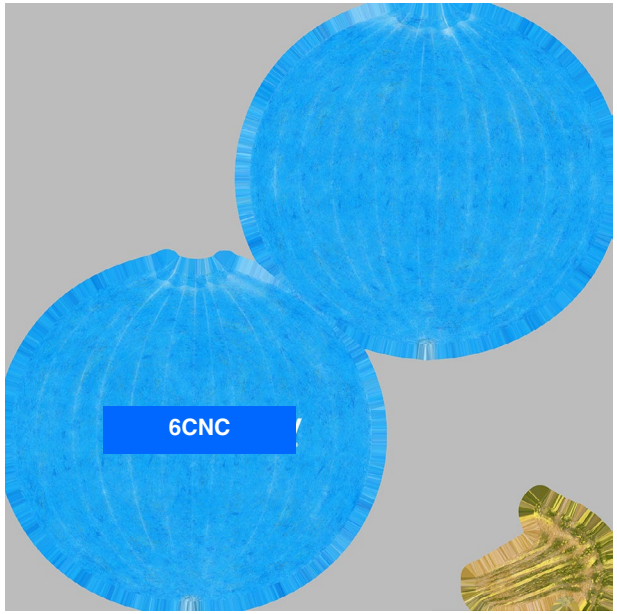
Adding Colour to Models

Colour by Texture Mapping

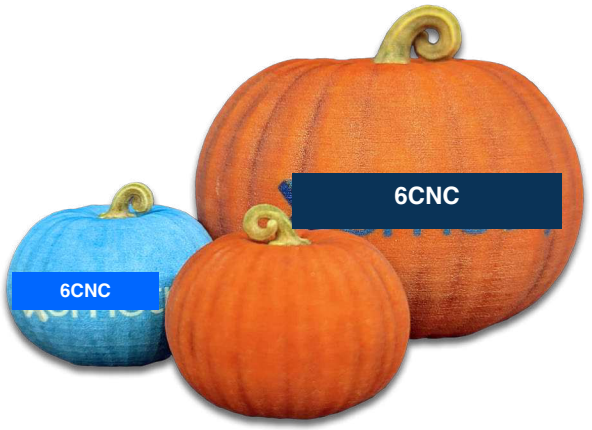
Applying a texture map to an object is the best way to create highly detailed and realistic coloured prints. However, it can also be one of the most challenging techniques and could require learning additional skills to utilise it to its highest potential. Texture mapping requires a 2D image or graphic applied or overlayed on top of the 3D model to alter its appearance. Textures can allow you to overlay logos and text on your parts or even mimic the look of other materials, such as wood grains, textiles, and more. The level of detail makes texturing excellent for producing miniatures, art replicas, and product prototypes that look real.

An object's UV coordinates relate the information in the texture map to corresponding mesh coordinates, dictating how a texture is applied. Taking your object's 3D mesh and flattening it into a 2D map is called "UV Mapping" or "Unwrapping" a model. Some design software has UV mapping capabilities built-in; otherwise, you may need to use separate software dedicated to texturing to UV unwrap and wrap a model properly. If you are new to texture mapping, we recommend searching for online resources, such as UV mapping tutorials specific to your design software.

Pro Tip:
A good way to ensure your textures are correctly applied and will come through is to open your printing file (e.g., 3MF) in Microsoft's 3D Viewer, a program that comes pre-installed with Windows 10 and later.



UV texture map of a blue 6CNC pumpkin

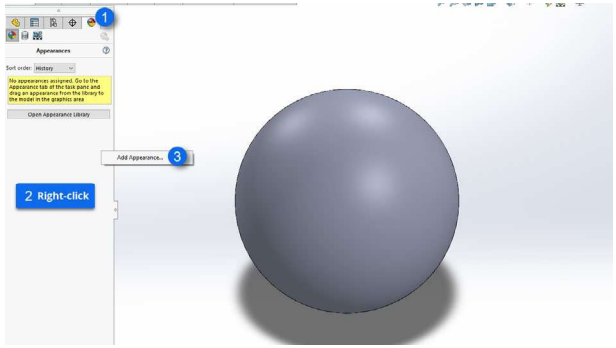


Full-colour prints using texture mapping

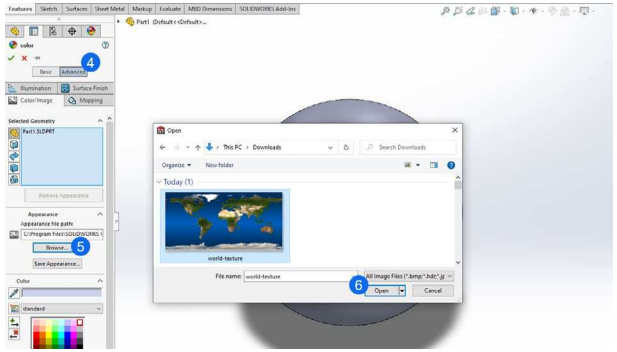
Adding Colour to Models

Texturing Walkthrough

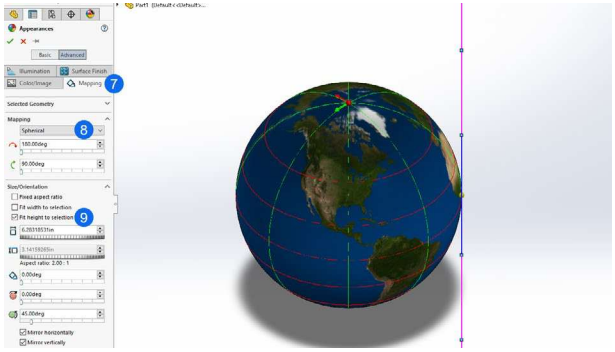
We'll go through a basic example of texturing a part. In this case, we are working within SOLIDWORKS, and our goal is to texture a sphere with a world map, making it appear like a globe. We'll start by going into the "DisplayManager" (1) and right-clicking in the area under appearances (2), and selecting the "Add Appearance..." option (3).



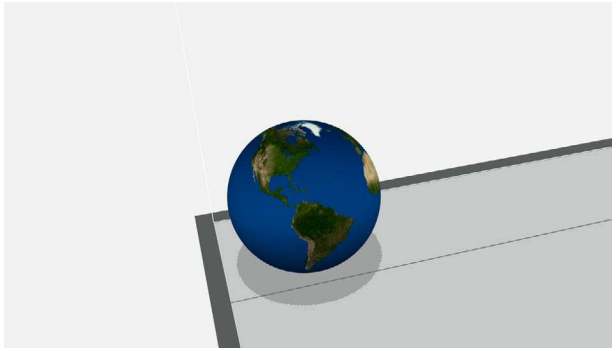
At the top of the appearance pane, make sure "Advanced" is toggled (4), so we can see all the appearance settings. In the selected geometry section, we can choose specific faces or features to apply the texture, although we will stick with the whole part in this case. Next, we click on "Browse..." under the "Appearance File Path" section (5). From the file browser that opens, navigate to and open your texture (6). Our example will use a world map image as the texture.



At first, the texture may not look right, but that's okay. We can adjust the texture mapping options by clicking the "Mapping" tab (7). We selected "Spherical" (8) as the mapping type for our example part since this best fits our parts' geometry. From here, you may need to experiment with the "Size/Orientation" options (9) to get the map to fit best to your part. We checked the boxes for fit to width and height and the mirroring checkboxes to get our texture to look correct.



Now that our part has a texture map applied, we can export it as a 3MF file, and it will be ready for printing! Here is how the 3MF file looks loaded into our printing software.



COLOUR 3D PRINTING

Additional Resources

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Additional Resources at 6CNC

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- 3D printing process selection
- Material selection guidance
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