

A BEGINNER'S STEP-BY-STEP GUIDE

From Idea to Print

3D design and 3D printing for complete beginners, with the free 3D Designer, the 3D Previewer and the makers on 3d-lithophane.com



Lithophane & 3D Printing Tools
www.3d-lithophane.com

15 chapters · 14 projects
every model ready to download

About the author

I built 3d-lithophane.com: the free lithophane makers, the 3D Designer that runs in your browser, and the 3D Previewer. So when this book tells you to click a button, I know exactly what happens behind it.

Hi, I'm Danie

Online you'll find me as DevDannyD. I've been writing software since 1989, and I've never really stopped. I started on mainframes, in COBOL and Pascal. Then came Windows programs in Delphi, Visual Basic and C, then websites and mobile apps, and these days full-stack and Internet-of-Things systems. Over the years I've worked with many clients and put many applications into production: accounting software, learning programs for children (some of them for children with special needs), smart-home and environmental monitoring, travel systems.

I'm an electronic engineer by training, with a master's degree in software engineering, so I tend to end up where software meets hardware. I've designed commercial circuits and PCBs, many of them around the Arduino, for drag racing systems, an aeroplane cockpit dashboard, windmills and all kinds of automation. Before I owned a 3D printer I had designed more than a dozen commercial CNC machines and plasma cutters.

3D printing isn't new to me either. My first printer arrived in 2010: a MakerBot Thing-O-Matic, with a build area of 100 × 100 × 100 mm. The resolution was ugly, but it did the job. Later I designed two commercial 3D printers of my own, based on the RepRap Mendel.

My very first print was a 20 mm calibration cube, and it took me days to get it right. That's why this book starts with the same cube, and why you'll hear me say "take your time" more than once.

The website started with one small idea: turn a photo into a glowing print without having to learn a CAD program. It kept growing. Now it has a full 3D Designer, dozens of makers and tools, a Windows app for browsing your model collection, and members all over the world.



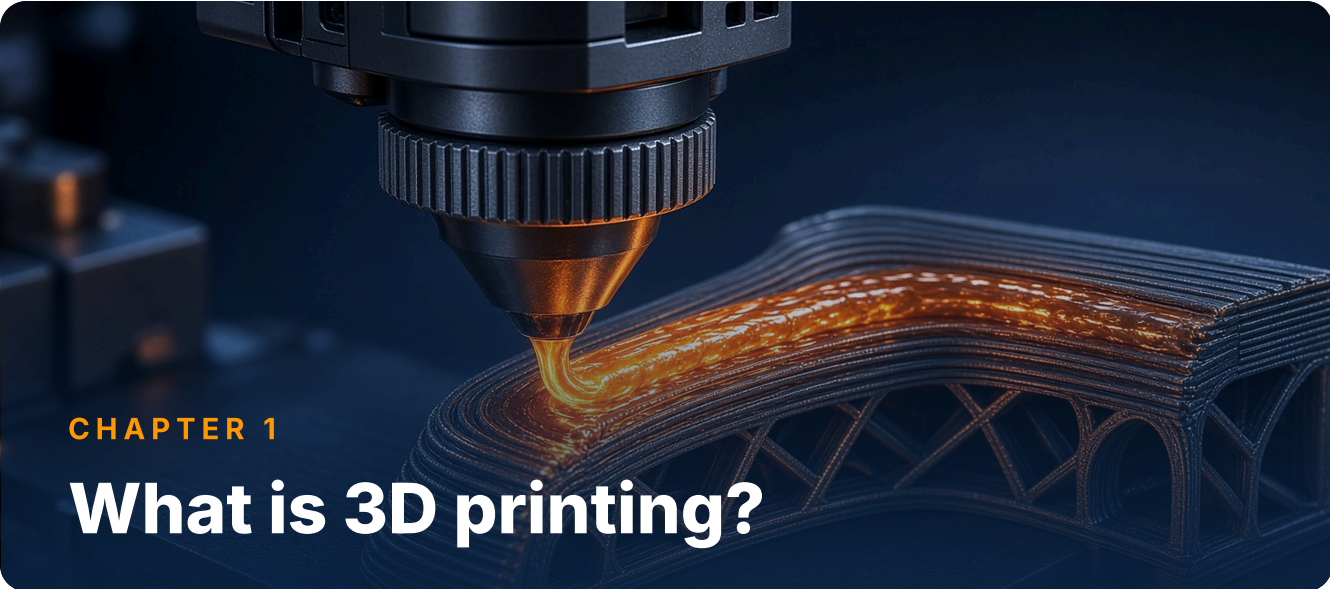
Why I wrote this book. Every week people ask me the same first questions. *Which filament should I buy? Why did my print come off the bed? How do I make my own model?* This book answers them in the order you'll run into them, with a project at every step, using tools you can open in your browser today, for free.

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CHAPTER 1

What is 3D printing?

A 3D printer builds a solid object one thin layer at a time, following a design on your computer. That really is the whole trick. The rest of this book is about getting the design right and getting those layers down cleanly.

Making things layer by layer

For most of history we made things by **taking material away**. You carve wood, turn metal on a lathe, drill a hole. I spent years building CNC machines and plasma cutters that do exactly that, very well. A 3D printer works the other way round: it **adds** material only where it's needed. That's why it's also called *additive manufacturing*.

Think of a cake decorator piping icing. One thin line goes round and round, then the next line goes on top of it. A 3D printer does the same with melted plastic. The line is about half a millimetre wide and each layer is about a fifth of a millimetre high. Stack a few hundred of them and you have a cup, a hook, a toy or a spare part.

The printer just follows instructions, so it doesn't care how complicated a shape is. A hollow ball, a chain with its links already joined, a box with a hinge that opens straight off the printer: things that are hard or impossible to make any other way are everyday work for a 3D printer.

The parts of a 3D printer

Most home printers are **FDM** printers (*fused deposition modelling*, sometimes called FFF). They melt a plastic thread called **filament** and draw with it. Whatever the brand, they all have the same few parts:

What's in an STL

STL comes from *stereolithography*, the very first 3D printing method, back in the 1980s, and the format has hardly changed since. An STL holds exactly one thing: a list of triangles. For each triangle it stores:

- **three corners** (*vertices*), each one three numbers: X, Y and Z;
- **a normal**, three more numbers describing a small arrow that points *out* of the shape, so programs know which side is outside.

That's it. An STL has **no colours, no units and no names**, and it doesn't remember how it was made. Everyone simply agrees the numbers are millimetres. That's why a model sometimes arrives 25.4 times too small: somebody saved it in inches.

Project 2 · Write an STL by hand

PROJECT 2

A pyramid, typed in Notepad

Six triangles and five corners make one real 3D file. It opens in any 3D program and prints in about ten minutes.

Tools Notepad (or TextEdit) · 3D Designer · 3D Previewer **Time** 20 min

File p02-pyramid.stl



Project 2 files

Our pyramid has a square base 30 mm wide and a tip 20 mm up, right above the middle. It has five corners and six faces: four sloping sides, and a square base split into two triangles.

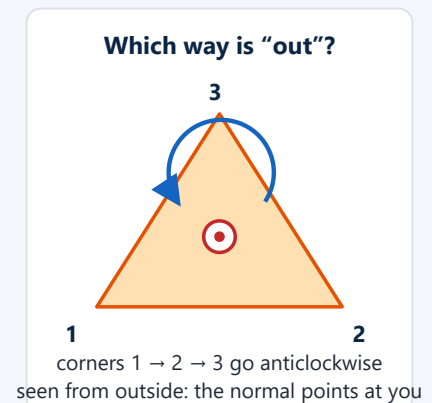
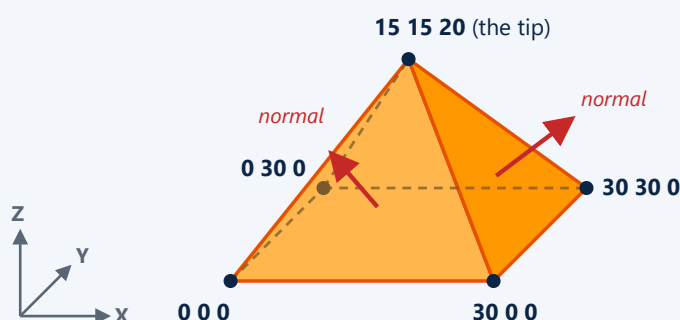


Figure 3.2 The pyramid's corners in millimetres (X Y Z). Each face's normal points outwards. The box on the right shows the rule every STL follows.

- 1 **Open a plain text editor.** On Windows that's **Notepad**. On a Mac use **TextEdit** and choose **Format > Make Plain Text**. Don't use Word, because it adds hidden formatting.
- 2 **Type the listing below** exactly as it is, or copy it from the book's page. The spaces at the start of the lines only make it easier to read; programs ignore them.

Project 4 · A honeycomb coaster

PROJECT 4

A coaster with a honeycomb pattern

A round coaster, 90 mm across and 4 mm thick, with seven hexagons sunk 1 mm into the top. It uses three shapes, one copy tool and one cut.

Tools Shapes · Toggle hole · Ring array · Apply holes

Print time about 45 min **File** p04-honeycomb-coaster.stl



Project 4 files

- 1 **Set your printer** under **Printer & bed**, as above.
- 2 **Add a cylinder.** **Shapes** > **Cylinder**. It arrives at 20 × 20 × 20 mm.
- 3 **Size it.** In **Selected** > **Size (mm)**, type **90** in X, **90** in Y and **4** in Z, pressing **Enter** after each one. Your coaster is now floating in mid-air (Figure 5.3), because its centre stayed 10 mm up.
- 4 **Drop it.** Press **F** and it settles on the bed. Position Z now reads 2, half of its 4 mm thickness.

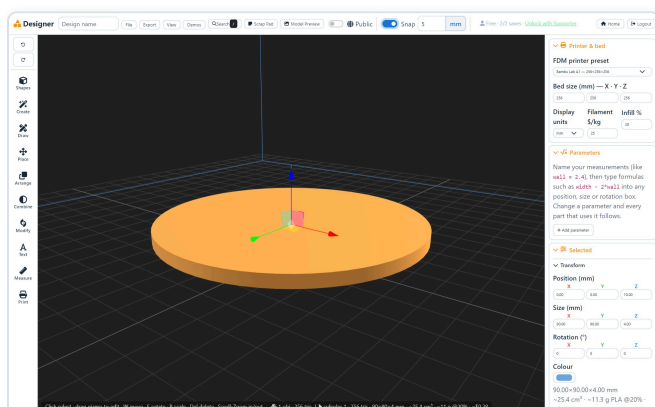


Figure 5.3 90 × 90 × 4 mm, but floating.

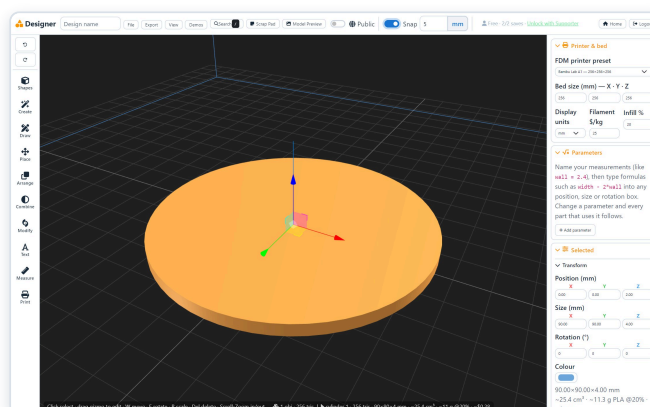


Figure 5.4 After **F**: on the bed.

- 5 **Add a hexagon.** **Shapes** > **Hex prism**. Leave its width and depth (19.05 × 22) alone and only change **Size Z**, to **2**.
- 6 **Sink it 1 mm into the top.** Set **Position Z** to **4**. The hexagon now runs from 3 to 5 mm, so its bottom millimetre is inside the coaster.
- 7 **Make it a hole.** Click **Toggle hole** under **Actions**, or press **0**. The hexagon turns grey and see-through, which means it will be cut away instead of added.

Project 9 · A pair of gears that turn

PROJECT 9

Two gears on a base

A 12-tooth gear driving a 24-tooth gear, each on its own peg. Turn the small one with your finger and watch the big one follow at half the speed.

Tools Create > Gears · Match selected gear · Turn the gears

Print time about 2 hours, all three parts

Files p09-gear-12.stl · p09-gear-24.stl · p09-gear-base.stl



Project 9 files

- 1 The first gear.** Create > Gears > Gear / ring gear... (or Shapes > Gear). The gear bar opens with a preview: Gear, 12 teeth, Outer Ø 26, Thick 8 and a round 8 mm hole. Leave all of that and click **+ Add**.

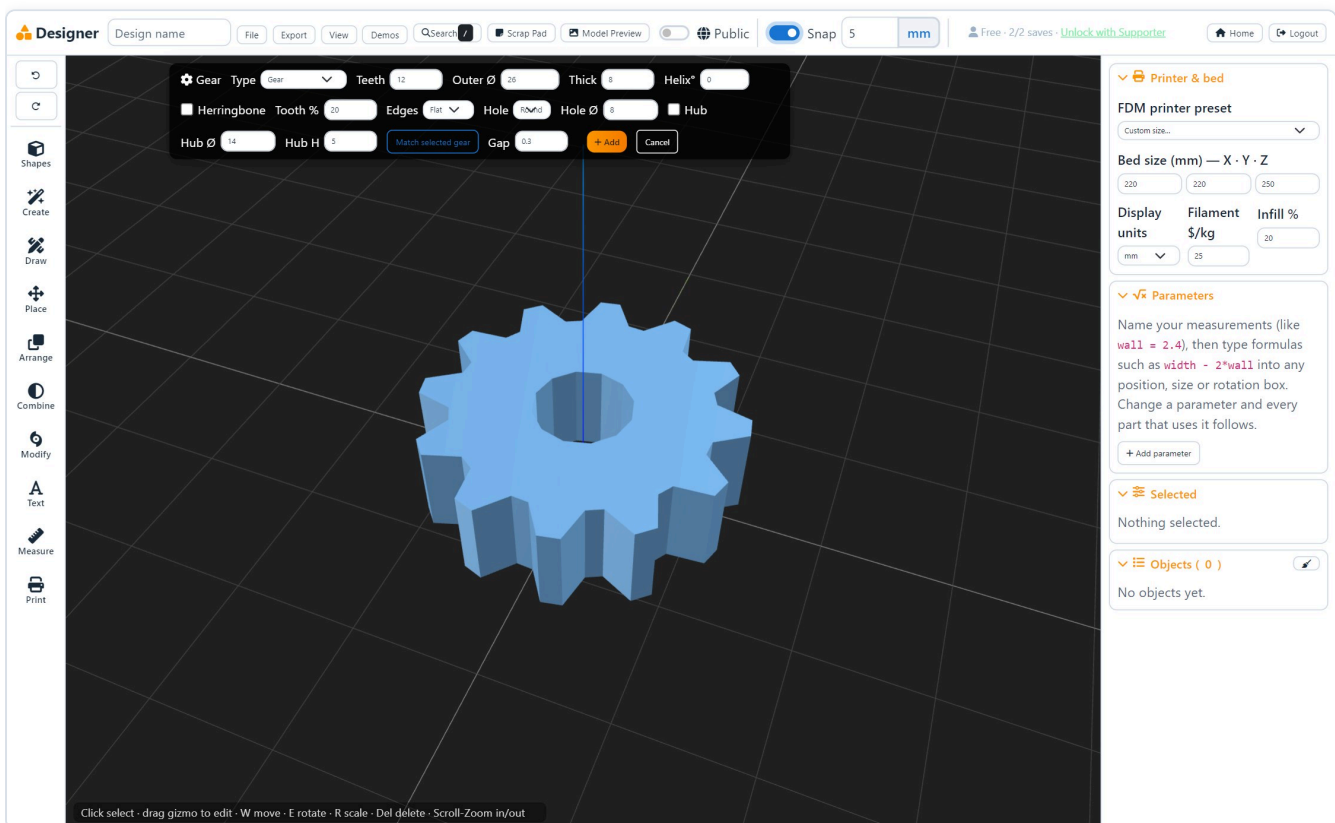


Figure 9.1 The gear bar and its preview, with the default settings.

- 2 Its partner.** Keep the new gear selected and open **Gear / ring gear...** again. Type **24** in **Teeth** and click **Match selected gear**. The Designer works out the tooth size and the diameter (49.4 mm) and puts the new gear right next to the first one, already meshed. It says *Matched, placed beside it*. Click **+ Add**.

CHAPTER 11

Lithophanes: photos made of light

Hold a lithophane up to a window and a photograph appears, in soft shades of grey. Switch the light off and it's just a white plate with a bumpy surface. This is where my website began: I wanted a way to turn a photo into a glowing print without anyone having to learn a CAD program. It's still my favourite thing to print, and the one people most often give as a gift.

How a lithophane works

White plastic lets light through, but the thicker it is, the less gets through. A lithophane uses exactly that. Where the photo is dark, the plastic is thick, and where the photo is light, the plastic is thin. Put a light behind it and the thicknesses turn into shades.

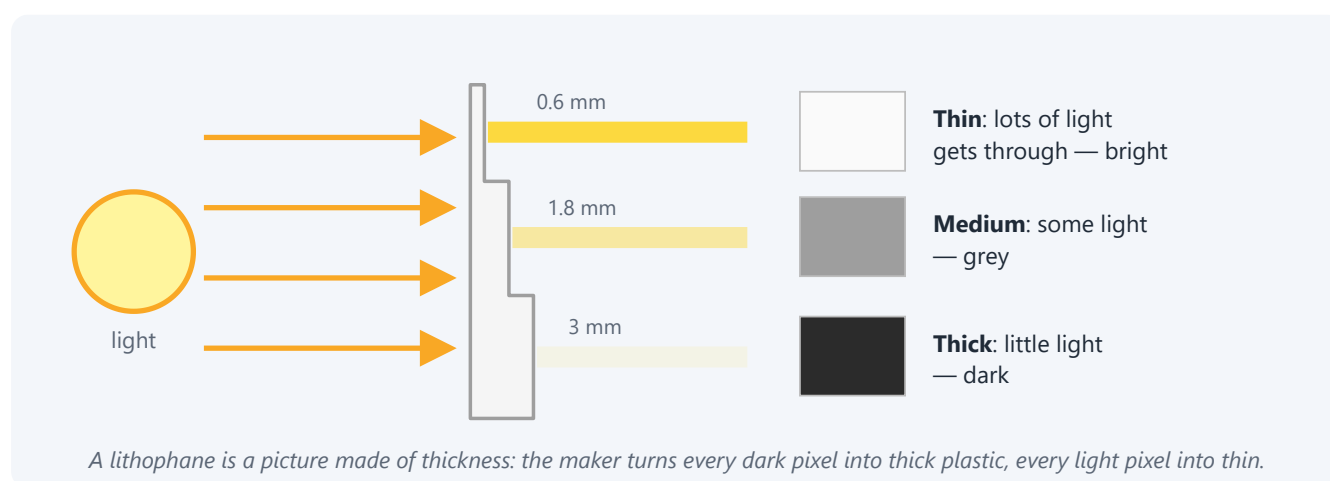


Figure 11.1 A lithophane in cross-section. Between 0.6 and 3 mm of white PLA gives the full range, from bright to dark.

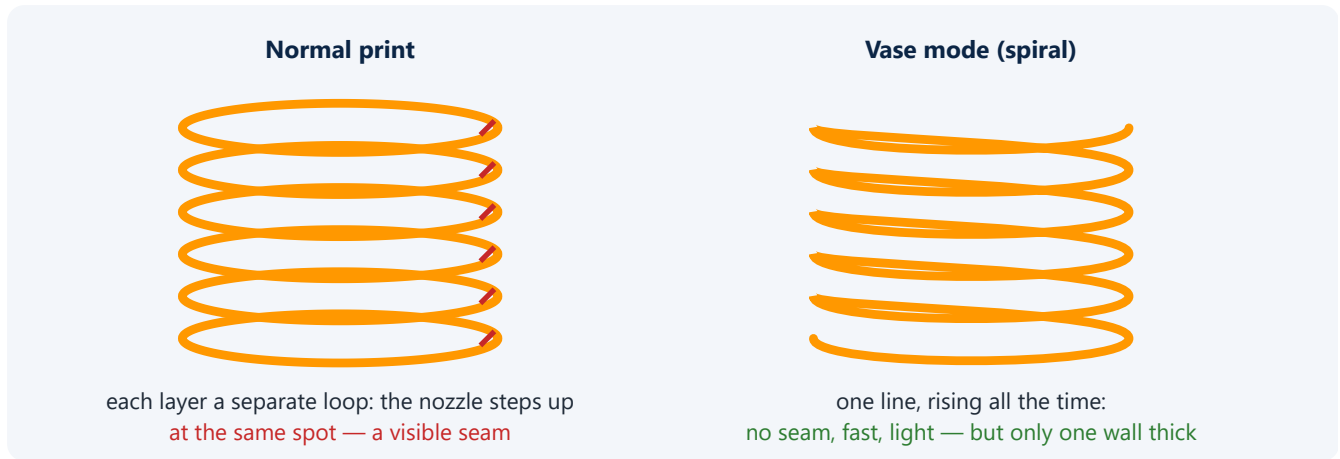


Figure 12.2 Normal printing compared with vase mode. The spiral has no seam and no travel moves, so it's fast and very smooth.

	Hollow	Vase mode
Walls	As thick as you set (2 mm ...)	One line, about 0.4–0.8 mm
Holds water	Yes (in PETG, or sealed)	Not reliably. Good for dried flowers, pens, lamp shades
Time and filament	Normal	Much less of both
Looks	A seam up one side	Seamless and glassy smooth

Project 12 · A twisted vase in vase mode

PROJECT 12

A hexagon that turns as it rises

150 mm tall, twisted 60° and printed as a single spiral. In a translucent or silk filament it looks like glass.

Tool Vase & pot maker **Print time** about 1½ hours

File p12-twisted-vase.stl



Project 12 files

- 1 Start from Twisted hexagon.** It fills in the outline (90 mm at the bottom, 110 at the belly and 100 at the top), a hexagon cross-section and a 60° twist.
- 2 Make it 150 mm tall** in *Size and outline*. It prints quicker than the standard 180.
- 3 Look at the style.** The **Twist** slider reads 60°. Try some ribs or a pattern if you like, and the preview will follow.

THAT WAS THE FREE SAMPLE

There's a lot more where that came from

You've just seen 9 of the book's 107 pages. The full book takes you from your first calibration cube to gears that turn, a photo lithophane and a vase that prints as one spiral, with a screenshot for every step.

- **15 chapters, 14 projects**, all of them on a free account
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Thanks for reading. I hope I'll see you in Chapter 1.

Danie

