How to 3D print a replacement part

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Abstract. Seven steps from broken part to fitted print: check it is legal, find a model, measure to 0.01 mm, add 0.15 to 0.40 mm clearance, pick a filament, orient it, test-fit.

Keywords: replacement-parts, reverse-engineering, home-repair, slicer-settings

Table 1. The steps and their numbers

Step	Tool or setting	Typical value	Source
1. Check it is legal and safe	Patent status; what the part does	A US utility patent runs up to 20 years from filing; brakes, steering and other safety-critical car parts are never printed	35 U.S.C. § 154
2. Find a model	Manufacturer support pages, then Printables and Thingiverse	Search by brand plus the model or part number	none needed
3. Measure	Digital caliper, 0 to 150 mm (Mitutoyo 500-151-30)	Resolution 0.01 mm, accuracy ±0.02 mm	Mitutoyo catalog
3. Model in computer-aided design (CAD)	Clearance on the printed side of each fit	0.15 to 0.20 mm snug, 0.20 to 0.25 mm sliding, 0.30 to 0.40 mm loose	Marston Makerspace, University of Florida
4. Choose material	Heat deflection temperature (HDT) at 0.45 MPa	PLA Basic 57 °C (135 °F); PETG Basic 71 °C (160 °F)	Bambu Lab data sheets
5. Orient	Load along the layers, not across them	PETG Basic: 51 MPa tensile in XY, 35 MPa in Z	Bambu Lab data sheet
6. Perimeters	Walls (wall loops in Bambu Studio)	Prusa profiles use at least 2; add more for strength	Prusa Knowledge Base
6. Infill	Sparse infill density	10 to 20 % in Prusa profiles; rarely worth more than 40 %	Prusa Research blog
7. Test-fit	Tolerance test print, then a coupon of the real feature	Printer accuracy 0.3 mm in X and Y	Prusa Knowledge Base FAQ

1 How do you 3D print a replacement part?

Check that the part is safe and legal to print, then look for an existing model. If none exists, measure it with digital calipers and draw it in CAD with 0.15 to 0.40 mm of clearance. Pick a filament for the part's heat, sun and load. Orient it so the load runs along the layers, add perimeters, and test-fit.

1.1 The steps and their numbers

Figures from 35 U.S.C. § 154, Mitutoyo's caliper catalog, the University of Florida makerspace tolerance guide, Bambu Lab's PLA Basic and PETG Basic data sheets, and Prusa Research's Knowledge Base and blog.

1.2 Why the steps run in this order

Each step rules something out before it costs print time. Never print a car part that steers, stops or restrains: brakes, steering, suspension, seat belts, airbags, the fuel system or wheels. A patent or a logo can rule out selling copies, and the rules for printing one for yourself are on is it legal to 3D print replacement parts. A ready-made model skips step 3.

Clearance goes in because the printer is far less precise than the caliper. Prusa Research puts a well-assembled Original Prusa at 0.3 mm in X and Y, thirty times the caliper's 0.01 mm resolution. A hole drawn at the measured size can print small and jam. The fit bands and the calibration settings behind them are on how to match tolerances on a replacement part.

The material and the orientation decide whether the part lasts. The 57 °C HDT of PLA (polylactic acid) rules it out of a dishwasher or a hot car. The condition-to-material table is on which filament to use for a replacement part. A printed part is weakest across its layers: Bambu Lab's PETG (glycol-modified PET) Basic loses about a third of its tensile strength in Z. Lay the load along the layers, as the orientation rule explains.

Walls beat infill. Prusa's Knowledge Base says a model's strength is mostly defined by the number of perimeters, not the infill. Prusa's own infill testing settled on 10 to 20 % for its profiles, and Prusa says extra perimeters raise toughness more than denser infill.

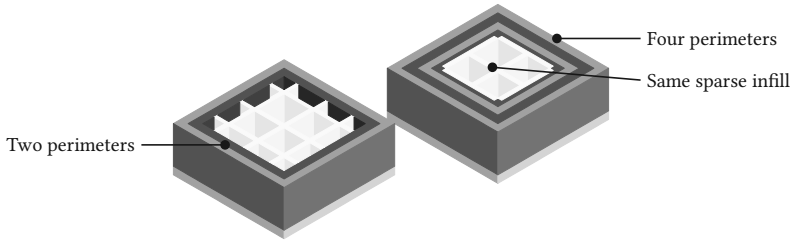


Figure 1. Both parts have the same sparse infill; Prusa says a part's strength comes mostly from its perimeters, so extra walls do more than denser infill.

1.3 How to 3D print a broken part

1. Glue the broken pieces back together with superglue (cyanoacrylate) so you can measure the part whole. The joint will not hold in use, but it holds still under calipers.
2. Measure what broke from the part it mated with. A snapped peg is defined by the hole it sat in, a cracked tab by its slot. The full caliper method is on how to measure a broken part without a 3D scanner.
3. Round each reading to the value the designer most likely drew, then add the clearance from the table.
4. Make the feature that broke thicker if the space allows. It failed once at the original section.

1.4 Where to find 3D printed spare parts files

Check the manufacturer's support or parts pages first. Then search model libraries such as Printables and Thingiverse by brand plus the model or part number printed on the appliance's rating label. Measure a downloaded model against the original before you print: a user-made file was drawn for someone else's unit and someone else's printer. A downloaded file is someone's design and comes with its license, which matters if you plan to sell prints.

1.5 How to check it on your own part

1. Print a tolerance test before the part. Bambu Studio ships one as the built-in model ksmFDMTest; its nested pins must all come out. On other printers, a downloaded stepped-clearance test does the same job.
2. Print a coupon of only the critical feature (the peg, the bore, the clip) in the final filament and orientation.
3. Trial-fit the coupon on the mating part. It should go on without force and without play.
4. If it sticks, enlarge the clearance one band; if it rattles, close it one band. Reprint the coupon, not the part.
5. Print the full part and fit it. Then stress it by hand past its working load. A crack along a layer line calls for a new orientation or more perimeters.

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