



# USING FASTENERS WITH 3D PRINTED PARTS

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V05112015

# BUILD SPECS

3D printed parts can be used with a wide variety of traditional fasteners when additional strength or versatility is required. Below, we'll discuss 13 traditional fasteners, each paired with two popular 3D printed materials:

TECHNOLOGY	PRINTER	MATERIAL USED	LAYER THICKNESS	OTHER MATERIALS AVAILABLE
<b>Fused Deposition Modeling</b>	Stratasys Fortus 900mc	ABS-M30	0.01-inches	<a href="#">View All Additive Technologies &amp; Materials</a>
<b>PolyJet</b>	Stratasys Connex3	VeroGray RGD850	16-microns	

# PART ONE

## THREADED INSERTS

Metal-threaded inserts provide a durable surface for threaded fasteners, improving wear resistance and preventing stripping and cross threading. Common types of threaded inserts include press-fit, heat-set, helical, and externally threaded, all of which are widely available from suppliers such as McMaster-Carr.

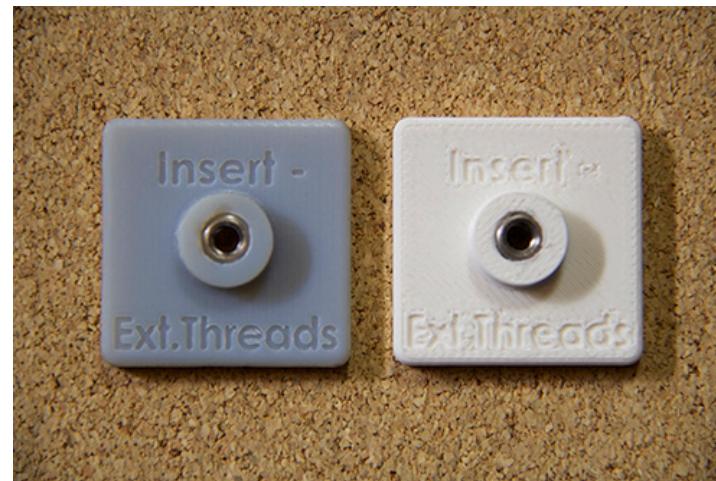
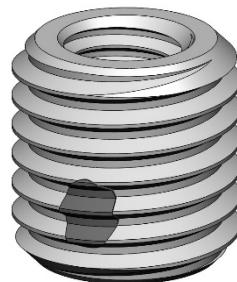


# INSERT WITH EXTERNAL THREADS

Threaded inserts with external threads provide a bridge between a narrow machine screw pitch and a wider pitch more suitable to plastics—typically 24 threads/inch or less. Holes for inserts with external threads need to be tapped prior to insertion and generally provide good pullout strength.

Brittle plastics like the PolyJet materials can easily crack or chip when they're not tapped slowly and carefully, and poor tap alignment can compromise the integrity of the joint.

Applying a small amount of glue to the external threads prior to insertion can prevent them from inadvertently rotating or even unscrewing.

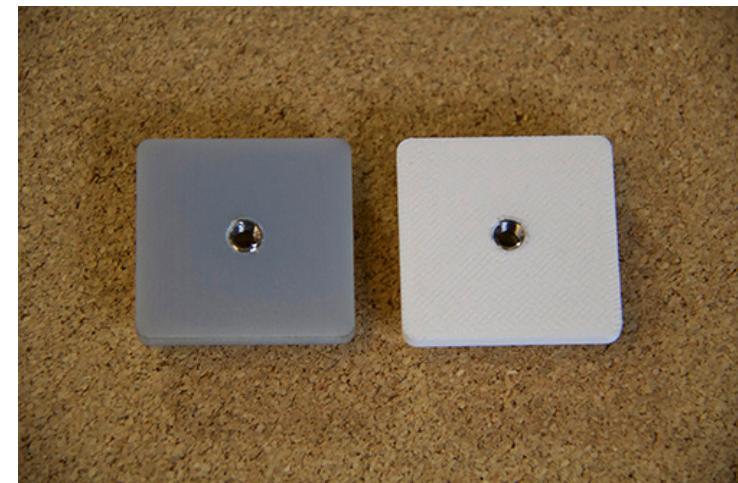
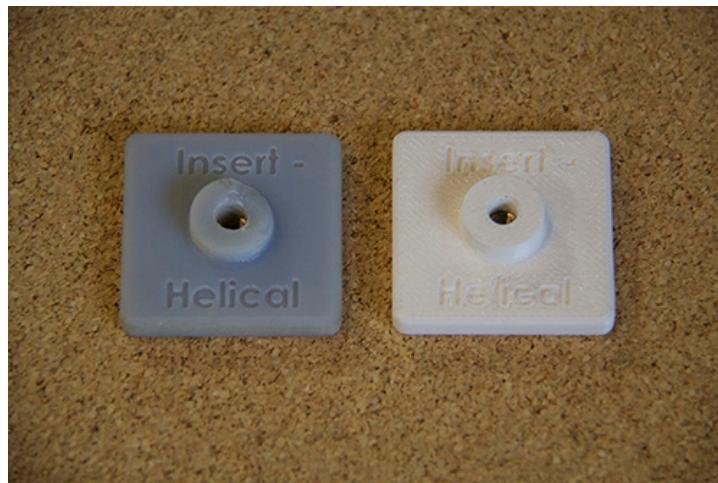
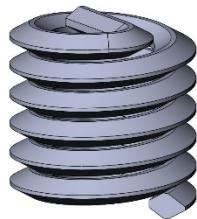


**FIGURE 1 //** Externally threaded inserts in VeroGray (left) and ABS (right).

# HELICAL INSERT

A helical insert is a coil of wire with square or diamond cross-section. They are designed primarily to be inserted into damaged metal threads, restoring their function. However, they work well in tapped 3D printed plastic by replacing tapped plastic threads with metal ones.

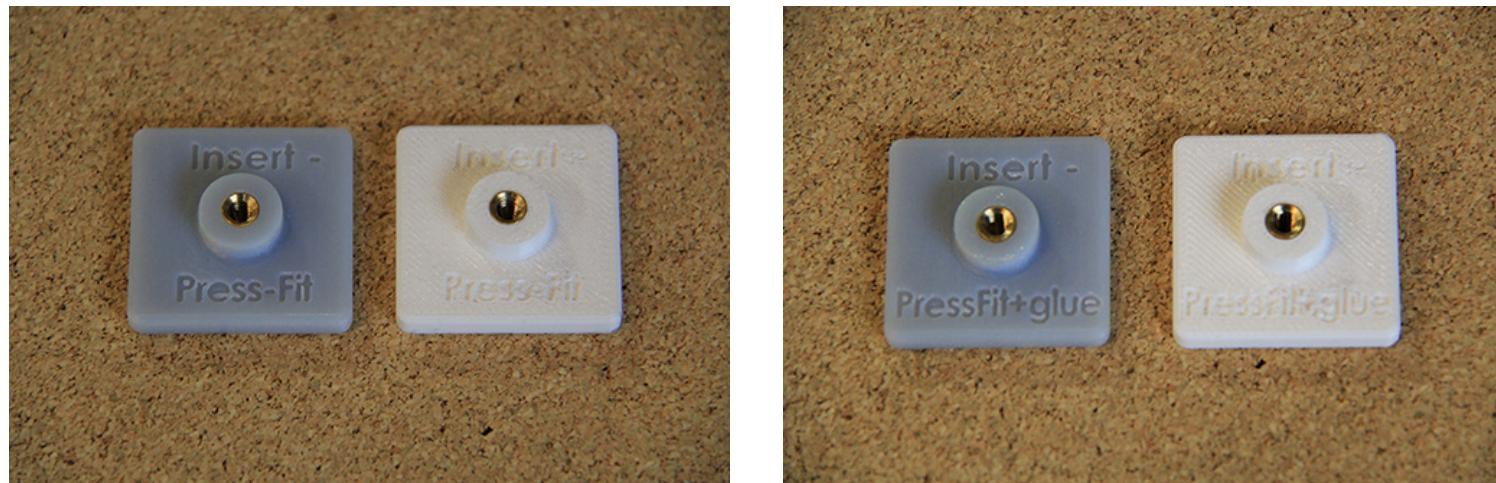
Like externally threaded inserts, helical inserts require carefully tapped holes and have the potential to unscrew. However, they are among the thinnest and least obtrusive insert options available.



**FIGURE 2 //** *The PolyJet part cracked during installation. Tap slowly and carefully to prevent this from happening.*

# PRESS-FIT EXPANSION INSERT

These inserts are pressed into a hole and expand when a screw is installed, pressing knurls into the plastic. The inserts require a tight fit, creating a greater risk of cracking more brittle plastics. This risk can be mitigated by increasing the screw boss diameter, or by gluing the insert into a slightly larger hole.

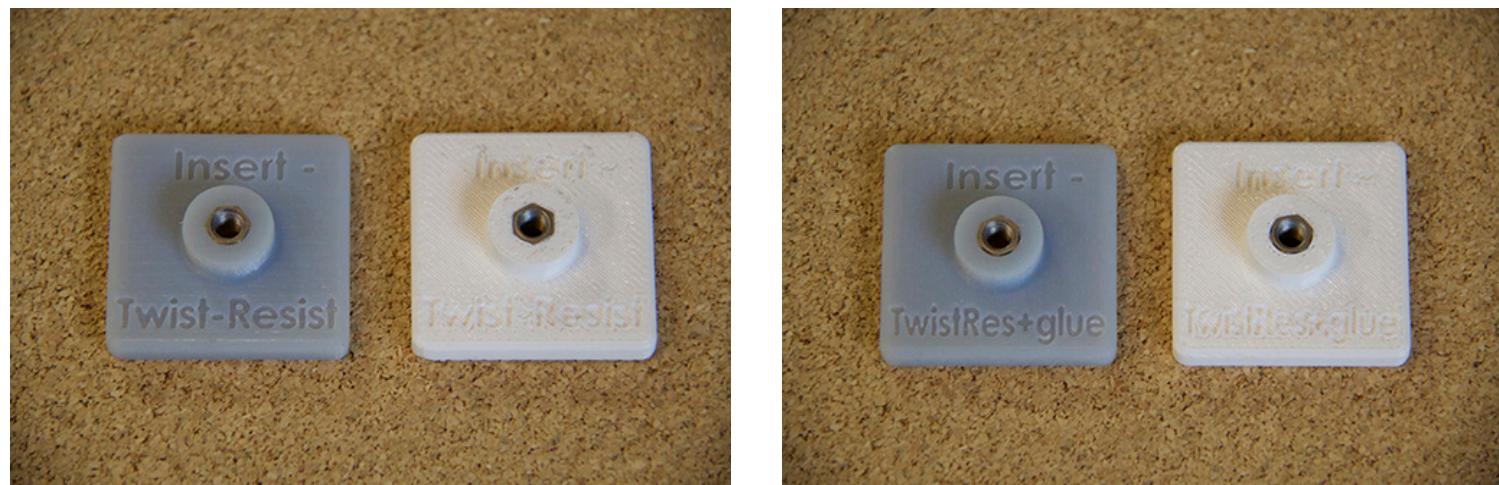
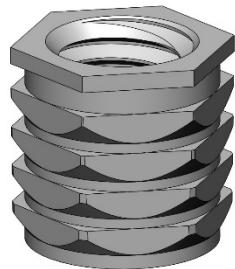


**FIGURE 3 //** Press-fit inserts without glue (left), and with glue (right)

# TWIST-RESISTANT PRESS-FIT

A variant of the press-fit expansion insert has a hexagonal “barbed” external profile that provides high torque-out as well as pull-out strength.

Like the knurls of the press-fit expansion insert, the barbs of the twist-resistant press-fit do not fully engage with the more brittle VeroGray. While the addition of epoxy alleviated this problem, the twist-resistant insert provides little advantage of other inserts, when used with brittle materials.



**FIGURE 4 //** Twist-resistant press-fit inserts without glue (left), and with glue (right)

# HEAT-SET INSERT

Heat-set inserts are pressed into an interference hole with the help of a soldering iron. Heated plastic flows into the insert's ridges and knurls, then solidifies to prevent twisting and pull-out. This mechanism of installation limits their use to thermoplastics like ABS and other FDM materials. These should not be used with the thermoset PolyJet materials.

Figure 5 (left insert) shows the result of attempting to use a heat-set insert in the thermoset VeroGray. Heat caused the boss to crack, and the hole became enlarged and discolored. In thermoplastics, heat-set inserts are easy to install and provide good pullout strength, making them a popular choice for FDM parts.



**FIGURE 5 //** In the PolyJet part (left), browning is visible where the hot insert burned the thermoset VeroGray, and a small fracture (not visible) formed during heated insertion. In the FDM part (right), the ABS melted and solidified, securing the insert.

# PART TWO

## JOINT / PIVOT-TYPE FASTENERS

The following fasteners can be used to sandwich two or more pieces together, or to create revolute joints and hinges.



# CHICAGO SCREW

Also called a barrel nut, sex bolt, or post-and-screw, the Chicago screw is an internally threaded boss with a head. It functions well as a hinge pin and is often chosen for its low profile.

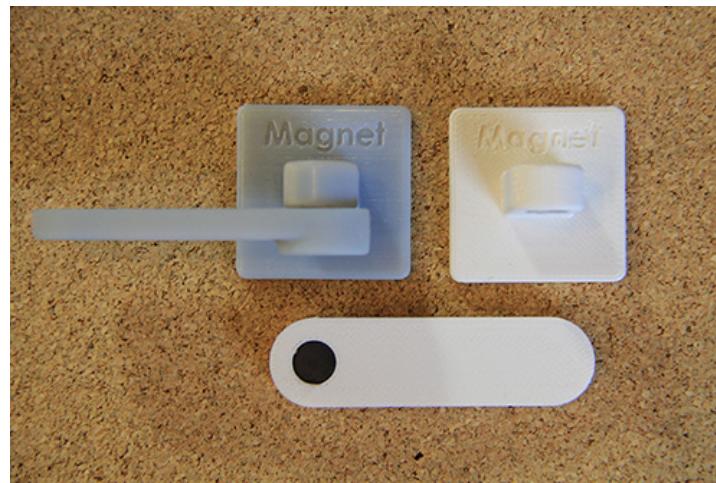


**FIGURE 6 //** Chicago screws in VeroGray (left) and ABS (right).

# MAGNETS

While not often thought of as “fasteners,” magnets set in 3D printed parts can provide a versatile range of solutions, including fastening two halves of an enclosure and creating breakaway hinge joints.

The 0.35-inch diameter, 0.25-inch thick ceramic magnets in Figure 7 provided an easily separable pivot joint between a 3D printed arm and base. Magnets were glued in place using a cyanoacrylate adhesive which bonded well with both ABS and VeroGray parts.

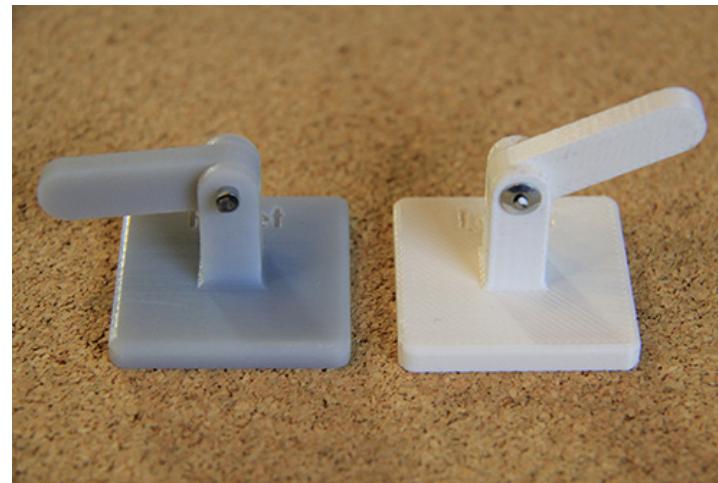


**FIGURE 7 //** In each material, a magnet in the base couples with one in an arm, creating a rotating, easily detachable member.

# BLIND RIVETS

The only permanent fastener examined, rivets can be used to create hinge joints or sandwich multiple pieces together. Blind rivets have an advantage over screw/nut combinations as only one side needs to be accessible for installation. A rivet is installed in a narrow range of lengths, necessitating careful matching of the rivet to the application.

The rivets in Figure 8 were barely long enough to fasten the two parts. Slightly longer rivets would allow for washers, and thus more robust joints. Instead, the rivet tool had to be operated carefully to prevent undue stress on the plastic part, and to keep the rivet from flaring into the plastic.



**FIGURE 8 //** Blind rivets create permanent joints in VeroGray (left) and ABS (right).

# GROOVED CLEVIS PIN

The grooved clevis pin is another fastener that functions well as a hinge pin with the added benefit of requiring very little clearance over the grooved end for installation. Snap-ring or needle-nose pliers are used to install or remove the retaining ring; a process which may scratch the plastic surface.

Clevis pins have a set length, so it's important to design the part accordingly. Spring (wave) washers can be used to maintain tension with a longer clevis pin. Clevis pins are typically used in shear-loading applications rather than in tension, due to the thin retaining ring and its shallow groove. Thanks to their solid cross-section, clevis pins have the greatest shear strength of the fasteners examined here.

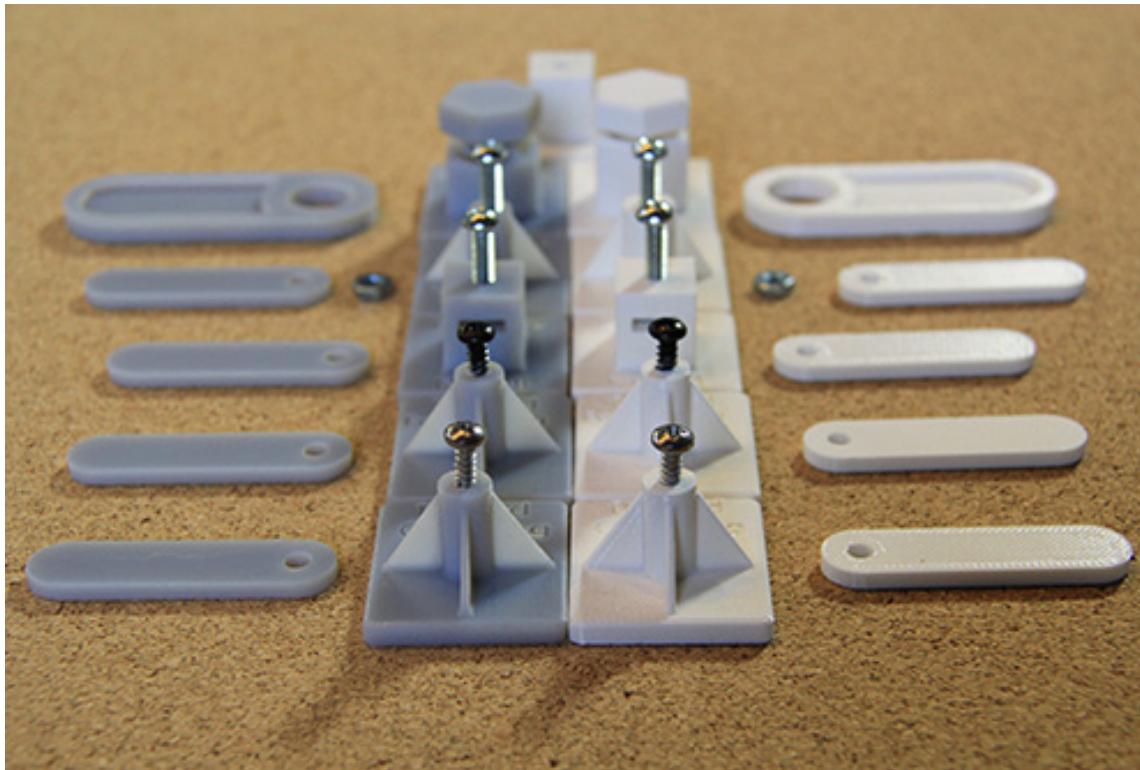


**FIGURE 9 //** Clevis pin joints in VeroGray (left) and ABS (right).

# PART THREE

## STATIONARY FASTENERS

The following fasteners do not require inserts, nor are they particularly well-suited to forming revolute joints such as self-tapping screws and screw-and-nut combinations.



# THREAD-FORMING SCREW

Thread-forming screws are self-tapping screws that work well with softer plastics like PolyJet materials. Blunt threads push material out of the way to form threads in a non-threaded hole. The lack of material loss generally results in a higher pullout strength than thread-cutting screws or tapped holes.

Thread-forming screws can be removed and installed a few times without significantly damaging threads in ABS. However, the thread-forming process loads the part with internal stress, which could lead to failure when the part is subject to loading. In brittle plastics like VeroGray (Figure 10, left insert), these internal stresses are likely to crack the screw boss during installation.



**FIGURE 10 //** Thread-forming screws installed in un-tapped bosses in VeroGray (left) and ABS (right).

# THREAD-CUTTING SCREW

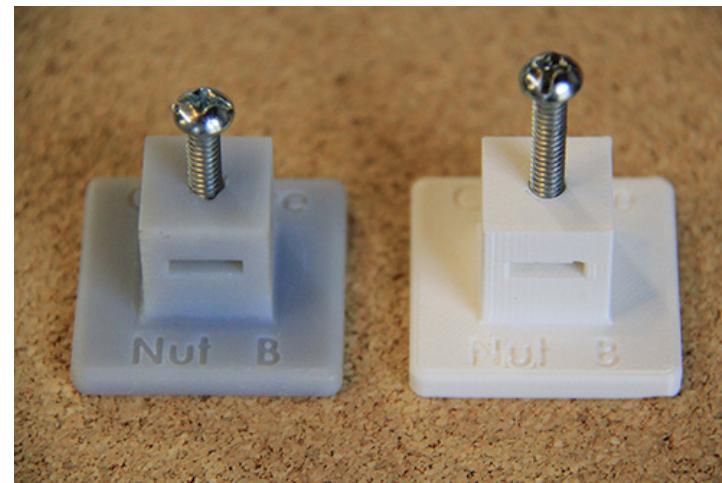
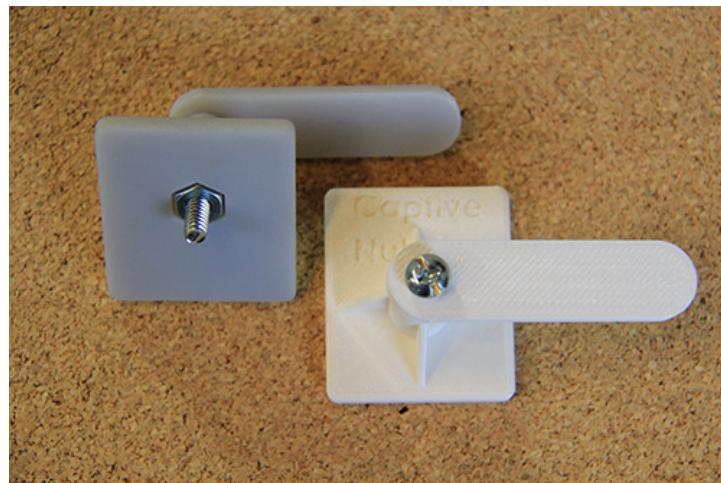
During installation, the sharp threads of a thread-cutting screw cut permanent threads into a non-threaded hole by removing material. In comparison to thread-forming screws, this process produces less stress in the part and is less likely to crack brittle plastics. Thread-forming screws create stronger threads, provided the part material is tough enough to withstand the tapping stress, thus as a general rule, use thread-forming screws with FDM materials, and thread-cutting screws with PolyJet materials. Multiple removals and reinstalls tend to create cross-threading in the hole, so thread-cutting screws should be treated as permanent fasteners.



**FIGURE 11 //** Thread- cutting screws installed in untapped bosses in VeroGray (left) and ABS (right).

# CAPTIVE NUT

Instead of using one of the threaded inserts above, a slot can be designed into the part to accommodate a conventional hex nut. The nut can slide into a pocket perpendicular to the screw axis, or it can sit in a hexagonal deboss. The ease of installation, excellent pullout strength, and use of more easily available fasteners are clear advantages over specialized threaded inserts. However, using a captive nut may have a greater impact on part design than lower-profile options like Chicago screws or threaded inserts.

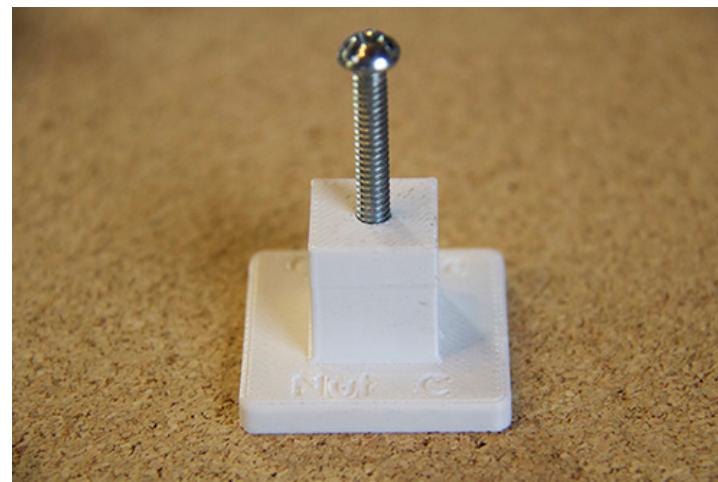


**FIGURE 12 //**  
*Most easily installed fasteners.*

# OVERPRINTED CAPTIVE NUT

Overprinting, as shown in Figure 13, demonstrates one of the unique possibilities of 3D printing. The customizable toolpaths of the Fortus machines grant added flexibility, including the option to insert a nut into a 3D printed part mid-build. Not only is this fully-captive nut securely and permanently held in place, it potentially has less impact on the geometry and aesthetics of the finished part than an open pocket.

Using Insight software, Fortus toolpaths were customized to delete support material where the nut would fit, and to insert a pause in the build process so that the nut could be inserted by hand. A coat of primer on the nut helped the extruded ABS adhere to it after the pause, and a small amount of glue was used to prevent the nut from shifting.



**FIGURE 13 //** An ABS part containing an overprinted nut. Once the part is printed, the nut is no longer visible or accessible.