By now, you have run your new 3D printer through its paces as you learned a handful of applications and put together the projects from the previous chapters. Inevitably, there will be things about your printer that can be or need to be improved to make your 3D printing experience more reliable and enjoyable. The great thing about these predominately DIY-centered fabricators is the general sense of openness, both in design and philosophy, which allows us to make and share these improvements on our printers. In our last chapter, we take a broad survey of the various electrical and mechanical upgrades that we can buy, print, and make to improve a few different aspects of our personal 3D printer.

Our second bonus round will cover the following:

- The mechanical upgrades that we can build to make the printer run smoother and keep it running more reliably
- Upgrades of computerless printing electronics and improving the quality of prints using different materials
- Suggestions for handing your filament spools with ease and upgrading that junk-drawer extruder to something classy

Not all of the upgrades in this chapter will work for all printers, so skim through the parts that may not apply to your printer, or look for ways that those upgrades might be modified to work. For example, if you have a new MakerBot Replicator, there may not yet be much out there to improve the printer; whereas if you own a RepRap, then there are many things that we can do with it. So, let’s start with the nuts and bolts of the mechanical upgrades.

**Mechanical Upgrades**

Our personal 3D printers are mechanical machines. They rely on motors, bearings, rods, pulleys, belts, and other mechanical components to work reliably up to a surprisingly high degree of accuracy. As you know, mechanical machines are often prone to failure—cars, lawn mowers, and blenders all have days when they refuse to do what they are intended to do. Your sub-$2,000 3D printer is no different. Depending on the printer, and factoring how it was built and the type of parts used in its construction, invariably, there are things that either need to be replaced for the printer to function or there are things we can do simply to improve the printer’s day-to-day operation.

The mechanical aspects of a 3D printer are never noticed when the printer is working well, but are a constant thorn in your side when things don’t work well. We start this section with a look at arguably one of the best mechanical improvements that you can make on your 3D printer: timing belts and pulleys.
Timing Belts and Pulleys

To move the three axes of a Cartesian robot, your 3D printer will use at least a pair of timing belts attached to the motors on both the x- and y-axes. The belts, essentially flat belts with evenly spaced teeth that mesh with a pulley to provide a positive grip similar to that of a chain or gear, are responsible for translating the rotational movement of the motor to a linear movement for that axis. The possibilities for types of timing belts and pulleys are countless, but upgrading the belts and pulleys might have a measurable effect on the printing quality of your printer.

Tooth Profiles

All timing belts are characterized by their tooth profile, or the shape of the individual teeth found on both the pulley and belt. This profile needs to match on both the pulley and belt, and are defined by the shape of the tooth and the pitch, or spacing between each tooth. Figure 10-1 provides a comparison of two common tooth profiles.

![Figure 10-1. Comparison of two common profiles](image)

In this illustration, we are comparing the shape and size of a T5 timing belt with that of a GT2. These are two common timing belt profiles used in 3D printers. Historically, T5 timing belts have been used in RepRap-style machines because the larger tooth profile, and a pitch of 5 millimeters between teeth, means that it is technically possible to print the timing pulleys needed to use these belts on a 3D printer. This reduces the amount of mechanical parts that must be purchased and saves a little on the overall cost. The problem with this strategy is that even the most precisely calibrated 3D printer cannot produce a timing pulley to the same tolerances of those that have been manufactured. The 15 tooth profile is also not a suitable profile for linear motion, like that used in a 3D printer, because the square shape of the tooth causes backlash in the axis of movement, creating sloppy and inaccurate prints.

The GT2 profile—which are gaining popularity and are used by several kit-based machines, like the MakerBot and Ultimaker printers—features a rounded tooth profile that better fits the matching pulleys to reduce the amount of backlash in linear movement systems. The GT2 profile also has a much finer tooth pitch (generally 2 millimeters, although 3 millimeter pitches are available), giving a greater degree of accuracy at the cost of a more difficult-to-print pulley. Since it is often a good idea to buy manufactured pulleys anyway, the benefits of the GT2 profile more than make up for any additional upfront expense.

Timing Belts

There are many different types of timing belts that might be used in a 3D printer, two of which are shown in Figure 10-2.