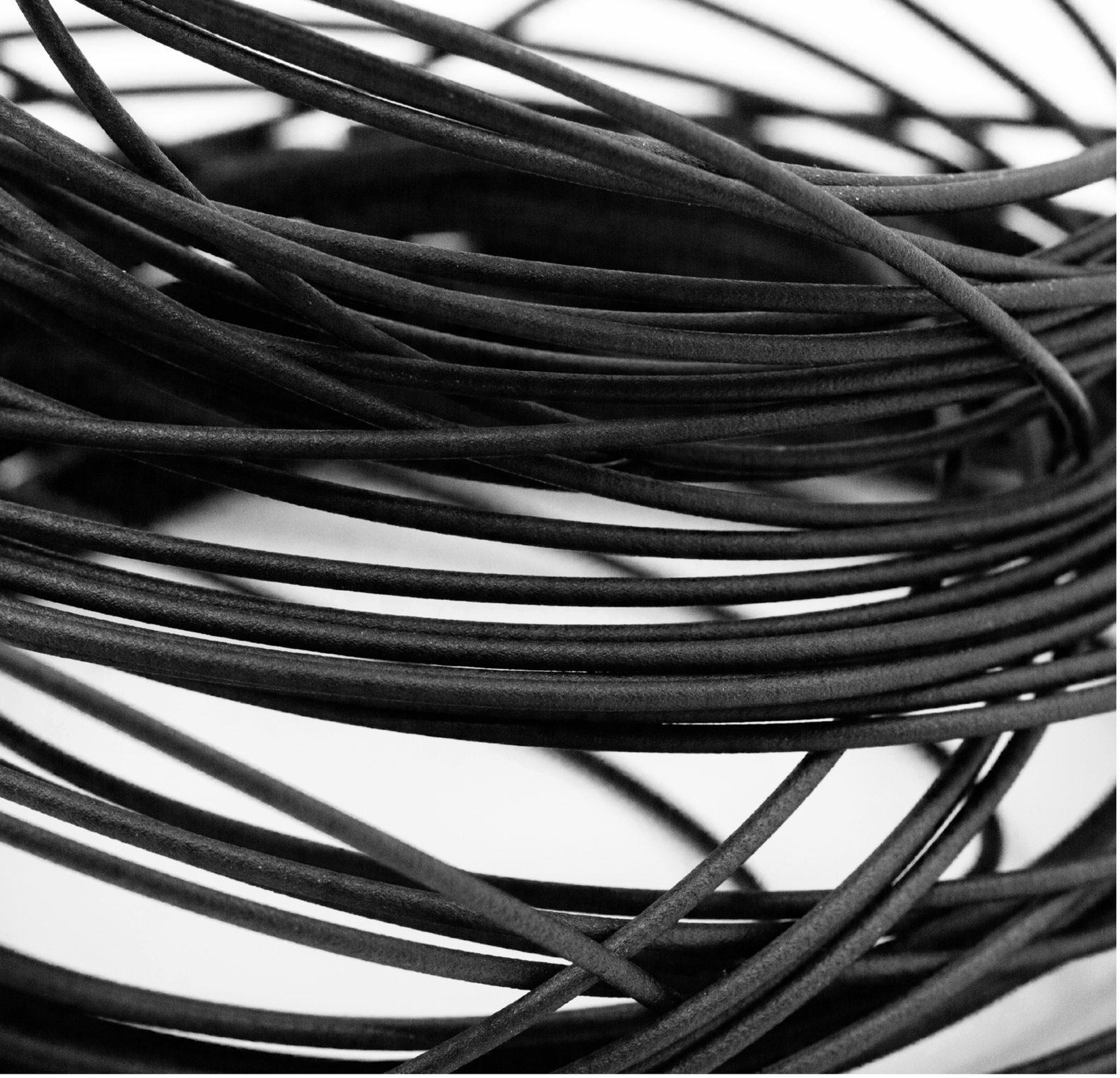
Markforged

$200 vs. $20,000

The Real Difference Between Hobbyist and Professional 3D Printers



From futuristic concept to creative hobby to new industrial revolution, 3D printing has had a tumultuous journey of self-actualization since it first emerged in the 1980s. Originally conceived as rapid prototyping technology during the expansion phase of 3D CAD, early 3D printers rarely saw use outside of form modeling in well-funded R&D centers. The specialized labor requirements (3D CAD was still considered a rare skill in the 90s!) and high costs made it prohibitively expensive for the average prototype. As the technology matured through the 1990s and 2000s and early patents neared expiration, 3D printers proliferated through open source initiatives like RepRap and became commercially available.

Around the same time, Maker culture made a comeback in the form of makerspaces and fablabs across the world, as whitecollar workers sought a tangible escape from spreadsheets and paperwork. A second wave of 3D printing entrepreneurs rose from the Maker movement, invoking imagery of the Star Trek replicator, and championing the democratization of manufacturing. 3D printing was hyped up in the media with promises of liberation from large corporations

and futuristic innovations that would change the world; yet, by the time the bubble finally burst in 2015, most of the industry had not progressed beyond form models, home DIY projects, and tabletop figurines.

In the last several years enterprises began to see 3D printing through a new lens; one of business opportunity, process efficiency, and solution scalability. While some 3D printer companies focused internally on cutting costs to improve the value of their product offerings, others focused externally on new materials and system capabilities that would unlock industrial applications for 3D printing.

The result is an industry in dichotomy.

There is 3D printing, the hobby — and 3D printing, the engineering tool.

Organizations across various industries are beginning to familiarize themselves with the idea of 3D printing. However, a home 3D printer can only go so far. These days, hobbyist printers capable of printing models and parts for home improvement projects can be had for $200, while $20,000 professional printers can print parts in carbon fiber composites strong enough to replace metals.

This guide compares beginner and professional 3D printing machines to help define the divergence in 3D printing technology, and better understand the proper applications for two unique sets of printers.

There is 3D printing, the hobby — and 3D printing, the engineering tool.

THE BIG 3 IN A 3D PRINTER

Given the advanced technology of 3D printing and the many brands and models of 3D printers available, comparing one 3D printer to the next can be complex — but it doesn't have to be. You know that any 3D printer will run on the same foundational process of designing an object digitally and printing layers of material from the bottom up to produce it in real life. So, we can simplify 3D printing into three facets:

Software

3D printing software, aka the slicer, powers the hardware. Software serves four key functions in 3D printing: importing the part file from CAD into the software, turning that imported part file into a printable file, sending one or more of these files to your printer, and managing your printer to maximize uptime and throughput.

Hardware

In any device, the parts, pieces, and the processor of the printer are crucial to its performance. The components need to be durable, reliable, high-quality, and expertly assembled.

Materials

3D printing filament, or the material used to produce a 3D printed object, has grown to encompass many different options. Again, there is a divide between what is suitable for hobbyist use vs. industrial production.

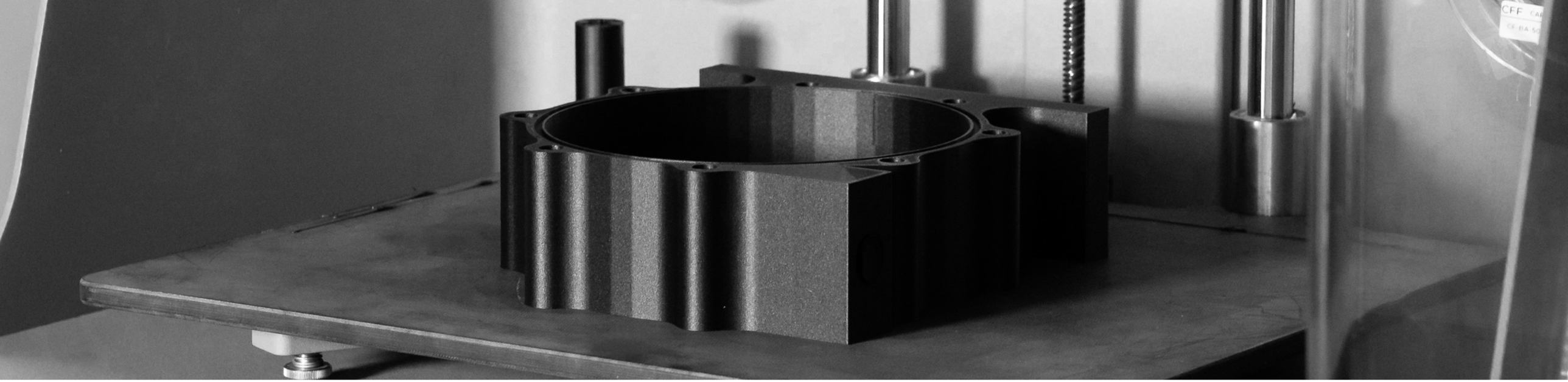
While each of these three areas can and should be analyzed individually, successful 3D printing requires fine-tuning between software, hardware, and material. Changes to one can impact those others, potentially creating printing issues.

For example, one Reddit user wrote[1]:

> "Vibration is not mostly a hardware issue; it is a combination of hardware and software. The vibration is a product of both the motion commands sent to the printer (i.e., software) and the printer's mechanical structure. Therefore, vibration issues can be solved by modifying the motion commands or the machine's hardware or both."

This is just one example of the many daily forum exchanges in which users are constantly balancing software updates, hardware performance, and material selection. As we compare hobbyist and professional 3D printers, we will ultimately return to these three pillars.

[1] https://www.reddit.com/r/Creality/comments/kagb9c/software_for_creality_to_make_3d_printing_faster/



THE HOME 3D PRINTER HONEYMOON

Home 3D printers have entered an exciting era for consumers looking to learn the hobby. There are $1,000 machines on the market in 2021 that perform comparably to the $50,000 machines of a decade ago. That's not to mention the first Stereolithography (SLA) printers of the late 1980s, which cost $300,000 at the time (equivalent to $650,000 today, calculating for inflation).

With a hobbyist machine, it will feel like you have infinite options for filament, software, and hardware upgrades. Home 3D printers are great for printing a few items such as Benchies or Baby Yodas, but those printers have some drawbacks. Home 3D printers can be difficult to use. You may find yourself reprinting once, twice, three or four times to get it right. Some may find satisfaction in finally getting the perfect print, others may not, but that's exactly why these printers are perfect for hobbyist applications — they take extra time. Hobbyist users are looking for an activity, a way to spend time. Conversely, professional 3D printers are built for efficiency, built to save time. With a home 3D printer, spending time is the goal. For a professional printer, time costs money.

$200 HOME 3D PRINTER SPOTLIGHT: CREALITY ENDER 3

Let's take a closer look at the Creality Ender 3, a popular low-cost, home 3D printer. Priced just under $200, the Ender 3 is touted for being easy to assemble and use — "the perfect gift to spark a lifelong love for science and engineering and provide a deeper understanding of machinery and robotics," as Creality describes on its website. While the statement is aimed at a younger audience, it certainly applies to adults as well.

Affordability is undoubtedly the top benefit of the Ender 3, considering its reputable quality, volume, and compact design. All3DP wrote:

> There are a number of features that make the Creality Ender 3 one of the most popular machines currently on the market. It has a build volume of 220 x 220 x 250mm, a BuildTak-like heated build plate, power recovery mode, and a tight filament pathway that makes it easier to print with flexible materials. These are attributes that are difficult to find in even more expensive printers ...
>
> As for printing performance, the Creality Ender 3 exceeded our initial expectations. We experimented with PLA, PETG, ABS, flexible and exotic filaments, and while there were some adhesion and warping issues with ABS, along with some wood filament difficulties, we managed to print successfully with all of the materials at the end of the day

TechRadar also applauds the Ender 3, writing

> This is nothing short of a simply amazing device. The Creality Ender 3 makes high-quality 3D printing affordable in a way that it wasn't just a year ago. 3D printing is still a steep learning curve to climb, but the latest Ender 3 is an excellent base camp from which you can start out on that adventure.

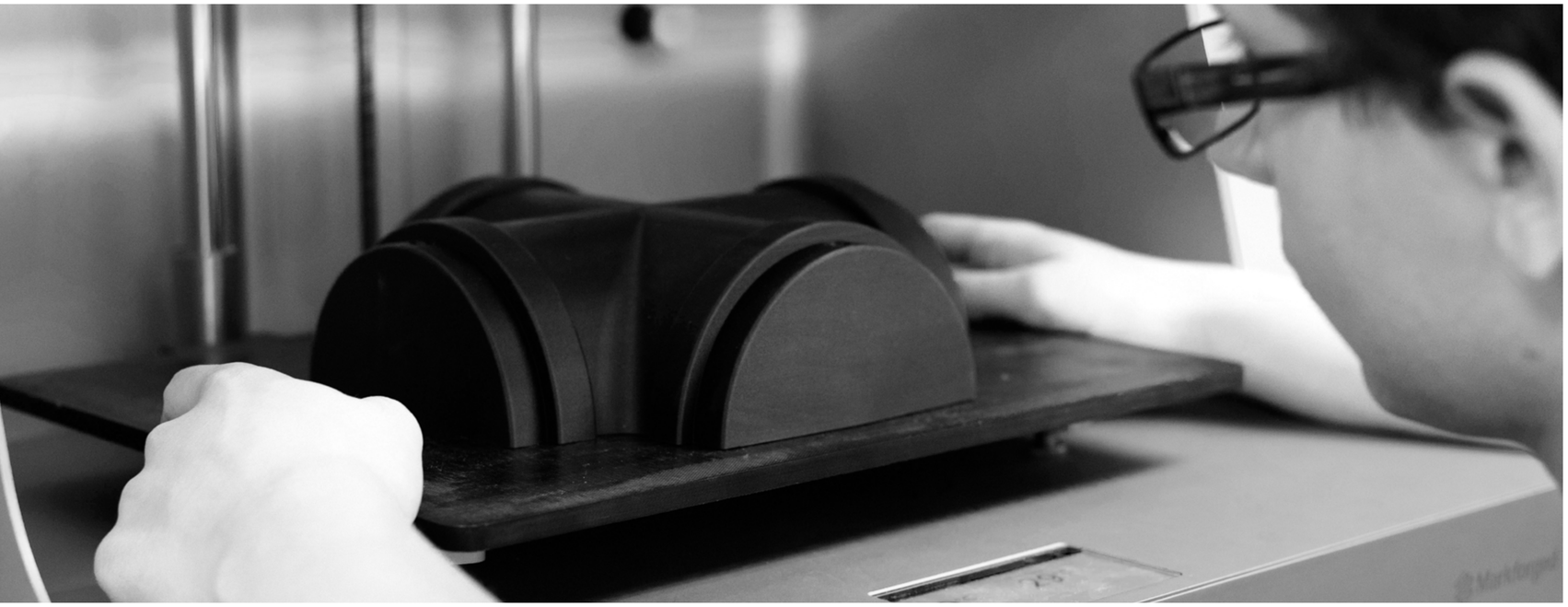
Software

Take your pick of popular free or paid slicer software to use with the Ender 3 — Cura, PrusaSlicer, Simplify3D — most offer more dials and knobs than the average user can possibly use, but the learning curve is steep and routinely requires some trial and error to work well with each new material. This set of calibrations also varies across printer makes and models, so wanting to print the same part on two different machines may require different slicer profiles for each model and each material you use. In the event that you scale up to more

machines or implement upgrades, you may find that the same slicer settings that worked yesterday may not produce the same results due to variances in build quality or component wear. Today's slicers are powerful for tuning things just like you want them, but as a result this means getting good prints may require putting in effort with each print to ensure that things work out the way you want.

Hardware

Like most printers in its price range, the Ender 3 has no enclosure and is made largely of aluminum extrusion. A large online user community mods and upgrades their printers, which means lots of pathways forward. It also implies the machine is not ideal out of the box for material besides PLA.



Materials

PLA is most common for the Ender 3, but PETG is growing in popularity. Users frequently investigate new materials as their favorites change price or become unavailable due to high demand or supply chain challenges. As supply chains are strained during the pandemic, you also are not guaranteed material availability or material quality from batch to batch. Early on, while you develop a sense for choosing print settings, you'll spend just as much time reading forum posts as you spend running test and calibration prints for new materials to get the perfect benchy. That's totally normal, and part of the hobby.

OTHER POPULAR HOME 3D PRINTERS

+ Budget: Phrozen Sonic Mini ($309)

  "The Phrozen Sonic Mini is an ideal printer option for not only beginners because of its user-friendliness, but also for professionals because of its precise and exquisite printing quality. The fact that the printer is very easy on the pocket and still [offers] such great specs, makes it one of the top printers in the market."

  — 3DPrinterly

+ Step Up: Prusa i3 Mk3S ($749)

  "The Mk3S is capable of delivering consistent quality prints and PrusaSlicer does a great job at prepping STL files. Pair them up with proprietary Prusa filament (Prusament) and you've got yourself an excellent 3D printer that can provide professional-grade results."

  — Aniwaa

THE HOME 3D PRINTER CEILING

The marvel of creating a physical object from thin air never gets old. In fact, quite the opposite. As hobbyists more skilled in 3D printing, they find themselves wanting to take on new projects, create more intricate prototypes, streamline the process, and increase the output of home printers.

But even the best home 3D printers have shortcomings.

All3DP reported poor filament loading and print bed leveling in the Creality Ender 3, and reliability issues in long-distance prints using the Prusa i3 Mk3S. 3DPrinterly noticed vibrating and noise from the Phrozen Sonic Mini. As futuristic as consumer printers may appear, they are limited in their applications and lack the sophistication of industrial 3D printers.

Consumer 3D printers simply are not designed with features or firepower for industrial production, and users generally accept the limitations to material properties, print quality, and system dependability as tradeoffs for lower cost. Home 3D printers also come with a lot of work, so be ready for a project. If you don't have a specific problem in mind to solve using 3D printed parts but want to learn about the 3D printing process, a beginner machine is not a bad place to start. If you like the prospect of building your own upgrades, and spending time fiddling with part settings to determine intermittent issues with your printer, a low cost home 3D printer could be an attractive option for a curious tinkerer like you. A professional 3D printer like the Mark Two, which is already dialed in with optimal print settings and a simple, intuitive user interface is great for solving problems using 3D printing, but not necessarily the best for learning about 3D printing.

But even the best home 3D printers have shortcomings.

MOVING INTO ADDITIVE MANUFACTURING

On the surface, 3D printing may appear synonymous with additive manufacturing. But within the industry, the two terms are sharply different. Additive manufacturing is the industrial application of 3D printing to create efficiencies and solve real-world challenges. It requires greater accuracy, repeatability, and scalability than hobby 3D printing. It is a burgeoning field of research, development, and production among leading global enterprises and engineers. With this

powerful technology, many objects and parts can be manufactured through 3D printing. As market conditions like raw material cost and labor availability are frequently shifting, businesses must adjust their approach to manufacturing in order to stay relevant. The increased flexibility and lower labor involvement for additive manufacturing enables manufacturers to stay ahead of competitors.

For example, British automotive manufacturer Dunlop Systems converted its tooling to 3D printed carbon fiber in place of the costly and unpredictable process of outsourcing replacements to third-party toolmakers. After reducing one department's tooling costs by nearly 50 percent, the company is now in the process of updating all of its tooling to 3D printing.

Additive Manufacturing Media wrote

Now, we are beginning to see companies committing to additive manufacturing so fully that they are ramping up entire facilities oriented around this method of making production parts.

Dunlop Systems' 3D printer of choice is the Markforged Mark Two, a professional continuous carbon fiber 3D printer for aluminum-strength parts.

$20,000 PROFESSIONAL 3D PRINTER SPOTLIGHT: MARKFORGED MARK TWO

The Markforged Mark Two enables designers and engineers to replace machined aluminum tooling with stronger parts for a fraction of the price. It combines unique continuous carbon fiber reinforcement and distinctive software with industrial 3D printing, for versatile parts that are ready for immediate use, with up to 26 times the strength of standard 3D printing materials like ABS.

All3DP called the Mark Two "a magnificent piece of engineering all around," writing, "Sometimes traditional 3D printing just doesn't cut it — that's where the Mark Two from Markforged comes in! Using continuous fiber inlays together with high-performance Nylons, it creates parts that can compete with metal."

Consider the Mark Two through the three facets with which we began:

Software

The Mark Two runs on browser-based Markforged Eiger 3D printing software, which stands as the only connected additive manufacturing platform on the market. The system is simplified by design and intended to get users from design to print as quickly and painlessly as possible. Eiger is also built for scale, making it easy to bring new machines and users online with printer management, a part library, version control, real-time monitoring, and several other features. The software is rigorously tested on the Markforged print farm, which achieves 75% uptime over a 24-hour day running six days a week. From All3DP:

> "Essentially, you open up a Chrome browser, upload your STL files to their service and all the hard work happens on Markforged's side from then on out. Eiger will suggest print settings based on your part's geometry, such as infill ratios or extra support material, and there's not much else for you to go in and tweak or tune, as you would be able to do with most other 3D printers. I do like the simplicity of the interface, it provides the right options that you'd use regularly and leaves everything else locked-down for Markforged to optimize."

Tom Sanladerer, All3DP wrote

Can we just take a second to appreciate how well this entire thing is built and how gorgeous it looks?

Starting with little things like how they use tiny dowel pins to align the linear rails; the way they've got machined aluminum and brass everywhere on the machine ... it just becomes this minimalistic tech piece that's going to look good pretty much anywhere.

Unlike hobbyist software that invites and encourages tinkering, the purpose of Eiger is simple: Prep. Print. Manage. Scale.

Hardware

A unibody aluminum chassis and precision-machined components make the Mark Two an industrial-grade 3D printer with reliability through thousands of print hours. It's made with user-friendliness in mind, including easily accessible wear components and a replaceable print bed.

Sized at 23 x 13 x 14 inches, the Mark Two maintains desktop size despite its industrial output.

Materials

Material selection is where the Mark Two makes its, well ... mark. It's built to print strong, durable, high modulus engineering materials for use as alternatives to metal components. Markforged has patented the continuous fiber reinforcement process to excel far beyond Polylactic Acid (PLA), polyethylene terephthalate glycol (PETG), and other hobbyist or low-grade industrial materials that may be used for modeling but not for performance. PLA, for example, is a brittle material which degrades in heat, rendering it unsuitable for industrial uses. It can barely survive a hot car in the summer, let alone the factory floor.

Carbon fiber has a high strength-to-weight ratio, making it an ideal composite for lightweight, yet durable 3D printed parts. As a continuous strand, carbon fiber boosts the strength, stiffness, and dimensional stability of a part to increase its performance.

The Mark Two can print carbon fiber, nylon, fiberglass, Kevlar, and HSHT fiberglass. The flagship Markforged material, Onyx, is a micro carbon fiber-filled nylon that yields accurate

parts with an impeccable surface finish. It can be used for plastic part replacement, housings, sensor mounts, functional prototypes, and many other applications.

Dexter robotic arm manufacturer Haddington Dynamics uses Onyx in the 7+ axis robotic arms that it supplies to NASA, GoogleX, Toshiba, and other high-profile customers. Alongside upgrades in strength and durability from the PLA material it was using prior, the company is saving 58% in costs by making Dexter almost completely from Markforged 3D printed parts.

The nylon base resin for all Markforged materials is resistant to heat, wear, and impact. When carbon fiber reinforcement is used, it is hard to believe that the parts were produced on a desktop printer and not a machining center.

Performance

Markforged designs 3D printers such as the Mark Two with deep consideration of the interaction between software, hardware, and materials. Evaluating these three aspects in unison not only equates to better performance of the printer itself, but also superior knowledge, support, and insight from the people behind its creation.

Engineers, designers, and manufacturers all over the world rely on Markforged metal and composite printers for tooling, fixtures, functional prototyping, and high-value end-use production.

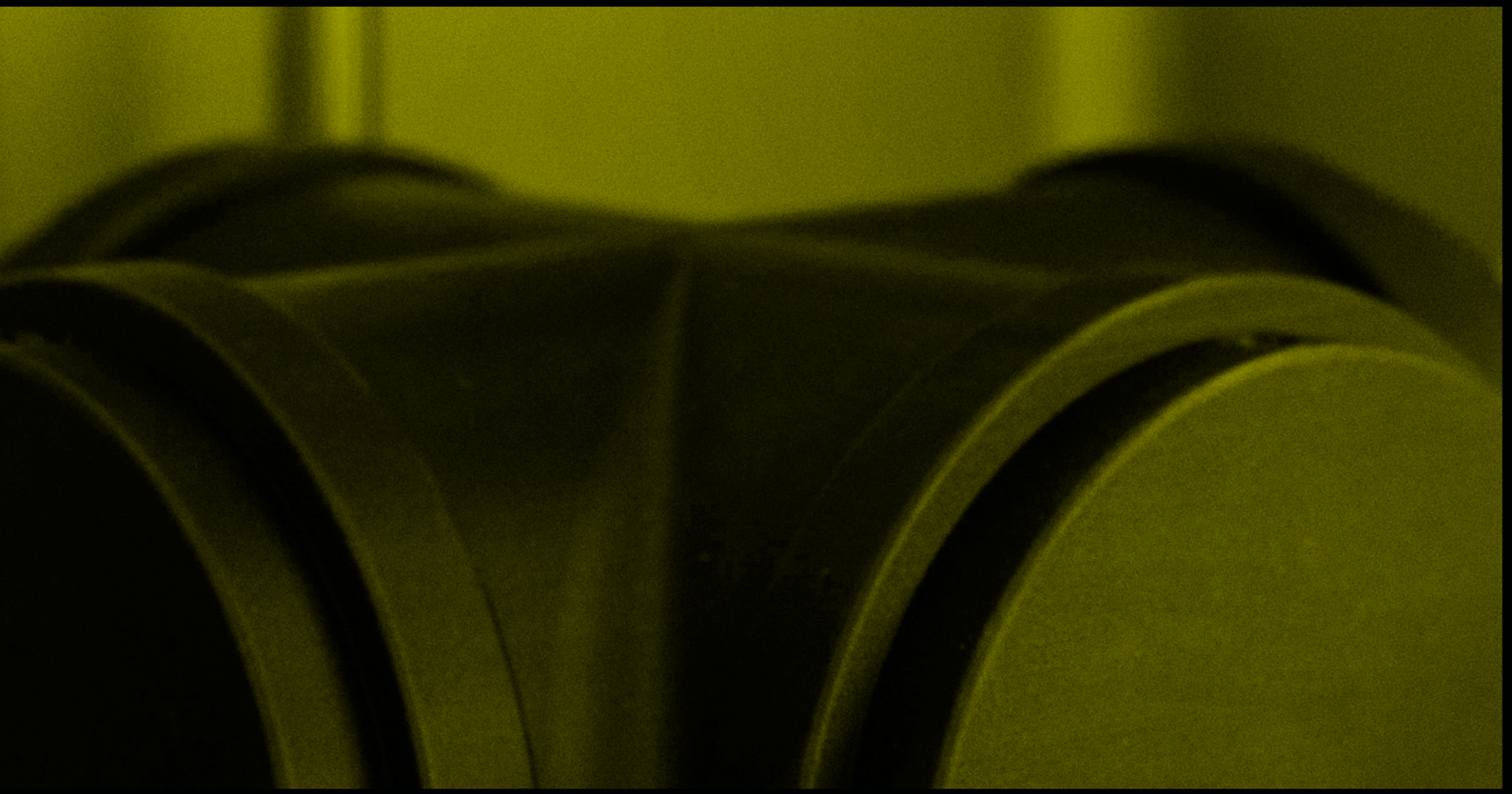
The Mark Two carbon fiber 3D printer is engineered to address the shortcomings of 3D printers for functional use, and addresses this in three major ways.

+ It prints using advanced materials unique to Markforged, for a beautiful surface finish and parts 10x stronger than achievable by the nearest competitor.
+ The hardware is engineered with precision and serviceability in mind, for a system that can be trusted to deliver lights-out reliability over thousands of print hours.
+ The software prioritizes ease of use, and operates on a cloud-first infrastructure for instant software updates and intuitive printer management.

The Mark Two is the solution for businesses looking to enter into the additive manufacturing industry. This 3D printer presents the opportunity to make a significant investment in a professional machine priced within reach and positioned at the forefront of industrial additive manufacturing.

$200 VS $20,000: THE FINAL VERDICT

Simply put, if you want to create more problems to solve, try a hobbyist printer. If you want to solve problems, get a professional printer. The 3D printing industry continues to grow and the technology behind printers like the Mark Two grows with it, seeking to find better solutions to harder problems, while the hobbyist 3D printers focus on a race to the most inexpensive.



Markforged transforms manufacturing with 3D metal and carbon fiber printers, capable of producing parts tough enough for the factory floor. Engineers, designers, and manufacturing professionals all over the world rely on Markforged metal and composite printers for tooling, fixtures, functional prototyping, and high-value end-use production. Founded in 2013 and based in Watertown, Massachusetts, Markforged has about 300 employees globally, with $137 million in both strategic and venture capital. Markforged was recently recognized by Forbes in the Next Billion-Dollar Startups list, and listed as the #2 fastest-growing hardware company in the U.S. in the 2019 Deloitte Fast 500.

To learn more about Markforged, please visit:
markforged.com

Markforged