A Robot's Guide to: Sanding — A Rough Road to a Smooth Finish

by Steven Meissner

of

SoloRoboto Industries

Contents

Preface

Who Am I?

My name is Steven Meissner, and I'm the Owner and Lead Artist behind *SoloRoboto Industries*.

Costume and prop making has been a long standing hobby of mine. My mom showed me how to use a sewing machine sometime around 3rd grade, and I've made my own costumes for Halloween ever since. I started building things – guns, swords, helmets — from wood and old junk even earlier, and I've never stopped tinkering with and making things.

I attended my first Comic Con after moving to San Diego, California in 2007, and immediately fell headlong into making props and costumes as a hobby, with the prop-making quickly becoming a passion. By 2009 I was able to take the hobby I love and turn it into a business — *SoloRoboto Industries.* Like most businesses I started small, but as my skill and project list grew I found myself taking on more and more complicated tasks. In 2011 I began making props full time and when, in 2012, I moved from San Diego to Los Angeles and upgraded to a much larger work space, the transition was complete. Prop-making has been my full-time and only occupation since.

Steven Meissner as Ant-Man
Photo Credit: ProjectBazooka

Over the past 7+ years, I've developed something of a specialty in the cosplay and prop-making world: **Chrome Plating**. In 2013 I finished the first chrome-plated Ant-Man helmet for a client — a urethane resin cast plated with a skin of actual chromium metal. By happy accident, along the way I developed a relationship with the same shop that's put chrome on every Terminator skull and Iron Man suit for the studios that make those movies. (The actual process of chrome plating plastics is *highly* toxic and *very* tightly regulated in California — it is not something you can, or should, do outside of a proper facility.)

Cool! and..?

Today, a major portion of my professional work revolves around items that need to be chromed, especially eSports Trophies. If you can name an eSports trophy that's got chrome, gold, or some other metal plating on it, odds are good that I had a hand in it. So I've had a lot of practice ensuring things are as absolutely perfect as possible! I've got over 7 years of experience, tens of thousands of hours of practice, and dozens upon dozens of finished projects under my belt — and that's just in the "chrome-plated" category. And when I'm not assisting with projects for other shops I'm most likely — you guessed it — sanding something for clients of my own.

Leage of Legends Mid Season Invitational Trophy
Photo Credit: RIOT Games

What Is This Book?

This book is my attempt to put as much of my accumulated sanding-knowledge down on paper, in as accessible a way as possible. It's... a LOT. I always knew I had things to say about sanding, but even I didn't know it was this much!

The book you've got in front of you is the result of over a decade's experience doing the thing most makers like least — *sanding*. What started out as an easy-to-reference collection of tips and advice quickly snowballed into the textbook you're reading now. I admit there's a *lot* in here, and I still couldn't get it all in! But don't be overwhelmed – I worked hard to make sure there's something here for everyone, without making you slog through the whole thing.

There's More Coming!

This book is, in many ways, a first pass. Probably 80 grit, maybe 120. I will be polishing and refining it - adding tons of photos, diagrams, and handy charts, as well as more tips, tricks, and specific techniques to save you more time and work.

If there are things you want to see, or questions you have, please let me know!

And you won't have to pay another cent to get any of it! Simply sign up at the link below, and I'll put you on a special list to get every updated version, extra technique, and handy reference I put out. For FREE.

In fact, if you go there RIGHT NOW, you'll get the first "Tips and Tricks" bonus PDF immediately! It's got half a dozen techniques you can put to use immediately to save you time, work, and frustration.

Your password is "justkeepsanding" (without the quotes).

www.SoloRoboto.com/sanding-book-signup

How to Use This Book

This book was written with the intent to make sanding easier for ANYONE, regardless of their level of experience or expertise. That means for a lot of definitions and examples, I'll assume you know NOTHING. My hope is that this way I won't miss anything in my explanation, and that the end result will be that we all start off with the same understanding of words, phrases, and anything else, so that there's no confusion and we're on the same page.

On a similar note, this isn't a step-by-step guide; it's a collection of Tips, Tricks, and Useful Information. Feel free to skip around as much as you like — this book is YOUR tool to use how you want! There were a LOT of ways I could have organized this book, but I decided to try and keep things as modular as possible. Most sections are written to stand more or less on their own, but some will build on earlier parts. If you read anything that makes reference to something you're not familiar with (a specific method or tool, for example) just use the Index to jump to that part to fill in whatever bit of info you're missing, and then carry on!

One last thing to keep in mind — nothing in this book should be taken as the ONLY way to do things. I have years of experience, and tens of thousands of hours of sanding practice, but in the end these are still my opinions. This book is yours to use however you want. If you don't like something I say, feel free to ignore it! Use what you like, and discard the rest. I'm confident there's enough useful info here to justify your purchase even if you decide half of it is nuts. I promise, I won't be (too) offended.

Product Links

Throughout the text, you'll see text that looks like this. These are links. Many are links to specific products – the ones I use personally. In Chapter 8: Tools, nearly every Section- and Sub-Section-Title is also a link, even if it doesn't look like it! And throughout the book, I've dropped cross-reference links to other chapters and sections to make it easier to find your way around.

Regardless of their formatting or where they are, all the product links in this book are Amazon Affiliate links — if you use the link to buy something, Amazon gives me a small kickback. Meaning it's a free and easy way for you to support *SoloRoboto Industries!*

Acknowledgments

I want to thank all the other makers, builders, owners, artists, friends, fans, and Facebook group members who helped me in putting this thing together, but there are quite literally too many of you to put down! You gave me the questions that needed answering, answers that needed giving (so you wouldn't have to again!), quotes, and some really fantastic alternate titles for the book. Not to mention all the advice, knowledge, and assorted skills you've shared with me over the years. This book wouldn't be what it is without your input.

And thank you, book buyer! You're the entire reason this book exists! I hope it helps you out.

On The Cover

Wes Johnson, a.k.a. Wes_IRL, as Marvel's "The Winter Soldier."

Prop Arm by SoloRoboto Industries.

Photo Credit: ProjectBazooka

Chapter 1
Sanding 101: What IS "Sanding"?

Hopefully this sounds like a simple question! But to make sure we're on the same page, I'm going to answer it anyway.

"Sanding" is the word we use to describe the process of using an abrasive tool to physically remove material from another physical surface.

The active verb is "to sand."

In plain English — it means scraping stuff off something else using a scratchy tool.

When we sand something, we may be using actual sandpaper (yes, sandpaper is a tool!). Sandpaper is the most common tool in our arsenal of sanding supplies, which is why it's usually referred to as "sanding." But we can also use files. Or rasps. Or rotary tools. Or razor blades. Or... you get the idea. Anything that can be used to physically remove material from a surface can be used to "sand" that surface.

Other Terms

I'll be using the terms "sanding" and "to sand" pretty interchangeably as a catch-all expression throughout this book. But because of the wide variety of tools and methods that exist for doing similar things, and the way every niche culture has its own phrases and expressions, you may see or hear some of the following (note the meaning is almost always exactly the same as it would be using "to sand" or "sanding" instead)

File / Filing — using a file to sand something.

- **Example:** "FILE that down."

Shave — most commonly used in reference to sanding paint. Shave means the exact same thing as "sand" in these cases, it's just different terminology.

- **Example:** "X-Brand paint SHAVES well using 600 grit paper or higher."

Polish / Polishing — most commonly used in conjunction with materials like clear plastic, acrylic, metals, and precious stones. "To polish" something is technically sanding it, just using much higher grits! But instead of actual sandpaper it's usually accomplished using "polishing compound" and "polishing wheels" — tools designed for creating a high degree of shine on certain materials.

- **Example:** "Polish that aluminum until it shines!"

Buff / Buffing — exactly the same as Polishing, but more commonly used in the automotive world. Often phrased as "buff out" for some reason.

- **Example:** "Buff out the scratches in that clear coat."

Sandpaper

Sandpaper is basically (and often literally!) paper with sand glued to it. The sand acts as an abrasive — something that can be used to scrape away the surface of something else; the paper gives you something to shape and hold onto. There are different kinds of paper, and different abrasive materials besides sand, but the most important thing to look at when buying sandpaper is GRIT.

> Note: To avoid using the phrases "abrasive" or "abrade" constantly, I'll be using "sand" to mean both the action of sanding, and as a stand-in for any other abrasive substance used on sandpaper.

Grits

Sandpaper comes in different levels of abrasiveness — that is, how scratchy / rough it is. These levels are most commonly referred to as "Grit."

- Lower numbers are more ROUGH (have larger grains of sand, and remove more material).
- Higher numbers are more FINE (have smaller grains of sand, and remove less material).

From grits 40-300, the numbers increase by increments of 20 (40, 60, 80, 100, etc.). (The exception being 150 grit, which is common for power sanders for some reason.)

After 300, they increase by increments of 100 (400, 500, 600, etc.) up to 1,000.

After 1,000, they increase by increments of 500.

It's rare to see sandpaper rated higher than 2,000 grit, and the highest I've found is 3,000.

Beyond 2,000 grit, we move away from sand *paper*, and into various rubbing / polishing / buffing *compounds*. These come in different forms — liquid, loose powder, chalk-like sticks, etc. They still work fundamentally the same as sandpaper does, but the bits of abrasive that do the work are so small that they need to be applied differently.

Types of Sandpaper Abrasive

I mentioned that not all sandpaper is made of literal sand like you'd pick up off the ground. In fact, most of it isn't!

Typically it'll be some other abrasive material on your sandpaper. Some common forms of "sand" are Aluminum Oxide, Garnet, Silicon Carbide and Ceramic. All have their pros and cons, but with few exceptions as you go up in quality the materials used become better suited to doing their job.

And for most applications, the exact material won't actually matter! There are exceptions of course, such as polishing metal and sanding certain types of wood, but I'll touch on those in another section for those that want the info.

It's generally good enough to know that the "better" material will (usually) be the one that costs more.

Forms of Sandpaper

Sandpaper comes in 2 basic forms, Sheets and Rolls.

Sheets

- Sheets are almost always the standard 8.5" x 11" (A4) size you're used to from copy / printer / notebook paper.
- This is the most common form you'll find. It's available at every hardware, automotive, do-it-yourself, and big-box store; typically in both small bundles (5-10 sheets) and large boxes (25-50 sheets). Higher grits (over 600) are less common except in automotive stores, but are often sold in single sheets as well as bundles.
- Sheets can be cut, folded, and used in any number of ways.

Rolls

- Instead of coming in rectangular pieces, Rolls are sold as a continuous strip of sandpaper; almost always standardized to 3.5" (7cm) wide, but varying in length from 5 meters up to 50+ meters per roll.
- Not as readily available — you may find it in specialty Auto Body supply shops, but likely won't see it in other physical stores (I buy all mine online).
- Can be cut, folded, etc., but in (obviously) a different range of sizes. This is SUPER helpful, as I'll explain.

Both Sheets and Rolls can be made using different Backing Materials.

The Backing Material is what the paper is stuck to — whether that be simple paper, heavier cardstock, or something like fabric (in the case of Micro Mesh and other high-grit polishing tools), plastic (for some water-proof "papers"), or wax / glue coated (to make the back sticky for easier use with sanding blocks and other tools).

Sticky-Backed For The Win

Some sandpaper comes with a "tacky" back surface which is quite useful:

- it's less likely to slide across itself when folded
- gives you a bit more grip if using it unfolded
- and makes it better than other similar quality Sheets,

> *I've not found any Sheets that are as genuinely **sticky** as the higher-end Rolls I use now, but when I want sheets (and I often still do!) I use **3M "Pro Grade."** It's tacky-backed, 2-3 times as thick (making it far more durable), cuts better, and clogs less often than any other paper I've used. And it's available at the big-box stores. It's also purple, so it stands out on the shelf!*

More on this sticky stuff in the next section, "Why Rolls Rule."

Why Rolls Rule

I made the switch from Paper to Rolls around 2017-ish, after MUCH prodding and encouragement from my other maker friends. I'd used Paper Sheets my entire life (my dad was a house painter for 40 years, so I've been sanding things since I was 5), and I thought they did everything I could ever want.

Using Rolls, however, improves several things.

- Every Roll I've tried has had more stable edges than all but the best paper I've tried; this means less wasted paper and sharper, cleaner, faster sanded lines in most usage scenarios.
- Rolls are far more commonly made of higher-quality material — heavy paper, fiber or cloth-reinforced backing, or truly "sticky-backed" papers. This last is my favorite.

Why is "sticky-backed" so great?

- When folded just once, the paper completely glues to itself — giving you a stable, mechanically sturdy, double-sided piece of sandpaper in whatever size you want.
- If you curve the paper while you fold it, this results in a semi-permanently curved piece of sandpaper, of whatever diameter you want.
- With a bit of pressure, it will stick *semi-permanently* to anything you put it on — so making custom sanding sticks, tubes, and tools is super quick and easy.

  Why semi-permanent? Because at the end of the day, this is still paper we're working with; nothing about it is truly "permanent."

[NOTE: see the section on ***Sanding Sticks*** *later in this book about why they're the greatest tool in your arsenal.*

> *My personal favorite sandpaper is **3M Stickit Blue Rolls**. They cost roughly twice as much as 3M's own next-cheaper option, but I've found them to last 3-4 times as long, cut at least twice as fast, and be almost impossible to clog. I'm nearly positive I've saved both time AND money using this stuff. Plus, because of the above, a roll just lasts **forever!***

QUALITY (AND WHY IT MATTERS)

Sandpaper, like all tools, comes in varying qualities.

If you've ever sanded anything before (since you're reading this, odds are good you have!), you've probably used some of the Common Grits, in paper Sheets, from a big-name manufacturer, probably from a big-box home improvement store. And I bet it worked just fine.

So, why should you care that it *also* comes in rolls, or wax-coated sheets, with different abrasive coatings, and even in different colors?

Let me ask you a question in response:

How much do you value your TIME?

TIME VS MONEY

Let's take a quick detour.

In every book and Tip I write I inevitably bring up the concept of Time vs. Money.

All tools, methods, projects, materials, supplies — they all exist somewhere on a sliding scale of Time vs. Money.

Generally speaking, more expensive options (I won't say "better," since what makes one thing "better" than another is often *very* subjective) will require you to spend less time using them.

A belt-sander is more expensive than some sheets of sandpaper, but it takes off material WAY faster. A really nice belt-sander may do it even faster! Or do it more precisely, so there's less refining or cleanup to do later. Using more expensive belts on either of those belt sanders might save you time because they get clogged up with sanding dust less often, or wear out and need replacing less.

Each of these upgrades costs more money, but saves you some amount of time when you use them, or reduces your future expenses by lasting longer. The tricky part is — how *much* time, vs how *much* money. To somebody with piles of money but precious little free time, buying "the best" tools makes sense — it saves them time (which they lack) and only costs more money (which they have). For the person with all the time in the world, but no extra cash to spend, the opposite is true.

Most of us are somewhere in the middle. Where? That's going to be different for everyone.

Sandpaper is no different.

SKIP THE "CHEAP" STUFF

*(when it makes sense)

Most of the sandpaper you'll find at hardware and home-improvement stores will be made by a big-name company like 3M, and will be pretty much the same wherever you buy it. The reason it's all pretty similar? It's all totally "good enough" — it's solid, hard-working, middle-of-the-road-quality stuff, and it strikes a darn good balance between cost and ease / efficiency of use.

But if you plan to do more than a few hours of sanding, or you'd like to spend less time and energy on it, I highly encourage you to try some of the upgrades listed below. They all offer tangible benefits that are more than worth their extra cost.

- All will "cut" faster, meaning they'll sand things faster despite doing it to the exact same degree of smoothness!
- Most will wear out much slower — all sandpaper starts to lose its grit eventually (the grains of abrasive literally fall off with use), but this stuff will hold out longer — sometimes many times longer!
- Some won't clog up with sanding dust / gunk as fast, meaning it both lasts longer and doesn't need to be cleaned as often!
- Some have special traits, like wax backing, or pressure-activated glue, that make them even more useful in lots of ways!

> ***3M Stickit Blue Rolls do ALL of the above.***

The following is the ONLY time I'll explicitly tell you NOT to buy something:

Do NOT buy sandpaper sheets from Harbor Freight!

The quality of this stuff is almost universally abysmal. It costs a little bit less than the same grit from a big-box home improvement store, but:

- it wears out 3-4 times faster — abrasive just FALLS off
- the paper itself is extra thin and flimsy — even a good tri fold can't make this stuff hold a shape for more than a couple of minutes
- it tends to *crack* when folded — which makes sharp, jagged edges that WILL cut and scratch things (in a very bad way)
- the grit is inconsistent — one piece of 220 may sand more like 120, while another closer to 300; you never know what you'll be working with
- and worst of all — no matter the grit, it tends to SCRATCH the surface you're working on; grit will come loose, edges may fray, sometimes nothing happens at all, but at some point this stuff WILL leave scratches on your project that are many times coarser than they've any reason to be. I've had 500 grit leave marks so deep I had to go back to 120 to get them out.

In short, this stuff will damage your work and slow you down, for a "savings" of just a dollar or two.

Skip it.

Kanshou and Bakuya sword props by SoloRoboto Industries

Chapter 2
How To Use Sandpaper

"Okay," I hear you saying. ***"So I've got my paper folded up like a True Professional. Nice. Now all I've got to do is rub this around on my Super-Awesome-Project™ until I'm done, right?"***

To which I respond, ***"Yes!"***

"But also, 'No.' "

It's time to get down to the nitty gritty details.

Grit Choice and Use

"Which grit is best for this?"

This is a common question, but it doesn't have a predefined answer.

Let me say that again —

There is no "perfect" grit for any given task.

Most of the time, you can pick a grit and go + / - 20 and the new grit will work essentially the same. That is, if you don't have 80 grit, then 60 or 100 will very similarly; if you don't have 120 grit, then 100 or 150 (still not sure why 150 is a thing) will work pretty much the same as 120 would.

Grit Progression

First off, some further notes on Grit. I covered the basic concept in an earlier section, so now we can talk about things from a practical perspective.

You'll almost never see 40 grit (I'm preeeeety sure it exists, but I've never held a piece of it). Rarely even 60 — the Big Box stores carry it sometimes, but I've only bought it once (to create a faux "wood grain" texture in a resin prop).

Which brings us to...

Common Grits

There are "common" grits, and those are what I stick to. My preference for and use of them, originated with my experience of growing up the son of a house painter; in short, they're the grits my Dad used: 80, 120, 220.

But I've found these to be the MOST WIDELY USED grits among makers, auto-body shops, and wood workers. Turns out my Dad probably used them for the same reasons everybody else does!

Start with the lowest grit appropriate for the task at hand, and then work your way up. Using the Common Grits, you'd progress from 80, to 120, to 220.

There is no need to go through ALL the grits!

Since the next highest or lowest grit is going to work pretty much like the one you're on, there's no reason to bother with it. Just skip it. The Common Grits exist for a reason — progressing from one Common Grit to the next is the smallest jump you need to make.

What About Other Grits?

If you can't (or don't want to) use the Common Grits, here are some basic guidelines for picking your own.

The grits I like strike the a balance between Cutting Power and Speed, and what the Cleanup is like.

- **Cutting Power:** how much material gets removed by a grit
- **Speed:** how quickly said material is removed by a grit
- **Cleanup:** how problematic it is to remove sanding-lines made by one grit, by sanding with a higher (finer) grit
- **Note that Cutting Power and Speed are NOT the same thing!** Cutting Power refers to how much material each grain of sand takes off as you move it. This isn't universally the same for all sandpapers of the same grit! Some will "cut" much FASTER at a given grit than another — that's the Speed factor. For example, the 3M Stickit rolls I use get me the results I want roughly 2-3 times as fast as other sandpaper of the same grit — their Cutting Power is the same, but their Speed is not.

For example, let's compare 60 to 80:

- 60 has larger grains, so it removes more material than 80, and technically does it faster. This means less time sanding with 60 to get the shape I want, than with 80.
- But 60 requires more cleanup. Its bigger grains leave deeper grooves (sanding-lines), and those lines take more time to remove than the lines left by 80 do when we move on to a higher grit.
- I've found that the time *gained* by the increased speed of 60, is overshadowed by the time *lost* when cleaning it up vs 80.
- So I've found 80 to be faster (and more efficient) overall, than 60. Thus, I choose 80 over 60.

The rest of the Common Grits (and other grits I'll call out explicitly) are similar — they offer enough advantages over their siblings that they're the better choice.

More Common Grits:

Fine Grit

"Fine" is the term typically used to define a surface that is "paint ready" — meaning it's smooth enough that the desired paint will cover any remaining scratches / sanding-lines. Because paint (and top-coat materials in general) can vary widely, so does the meaning of "Fine" grit.

220 is an almost universally accepted number here — you'll even see it called out specifically on cans of paint and stain; it's probably the ONLY grit that directly corresponds to a label like "Fine."

But "Fine" can still refer to any grit from 150 to 500, depending on the criteria and the tool, though the range is more commonly 150 to 300.

Some "Fine" sanding sponges have grits ranging from 180 to 220. Others, from 200-400.

Super-Fine Grit

"Super-Fine" refers to the next general grit range past Fine.

It typically covers grits ranging from 300-600, with the most common tools being Sanding Pads with grits from 500-600.

Ultra-Fine Grit

"Ultra-Fine" is the cool-sounding label manufacturers use to refer to the next step up, with grits typically ranging from 800-1000.

Micro-Fine

The major manufacturer 3M has a 4th classification called "Micro Fine" that covers sanding pads with grits in the 1200-1500 range.

Other manufacturers often refer to products in this grit range as "micro mesh," "sanding cloth." "micro polishing," and similar things.

I personally have found very limited use for products in this range — but I do use them for those 1 or 2 purposes a LOT.

[More on this in Chapter 7: Specific Materials.]

The following chart summarize the progression from one Common Grit to the next.

Grit Range	Common Grit	Purpose
60-100	**80**	large / rough shaping
100-180	**120**	general shaping
180-240	**220**	fine shaping; prep for primer
300-400	**320**	prep for topcoat
400-600	**600**	prep for topcoat / gloss paint
600-1500	**1000**	prep for chrome; prep for polish
1500-2500	**2000**	1st stage polish
Rubbing Compound	—	2nd stage polish (satin finish)
Polishing Compound	—	full polish (gloss finish)

When to Switch Grit

"When do I move to the next grit?"

This is one of the MOST common sanding questions.

And the answer is one of the most fundamental, all-important, paradigm-defining concepts I'll teach you in this book. If you've ever wondered why your things don't look as polished, or finished, or smooth as somebody else's, pay attention.

The answer?

When you're done with the previous one.

That sounds simple, even dismissive, but I promise you — that's it.

"But," you ask next, *"what does that even **mean**?"*

Glad you asked!

What does "Done" mean?

"Done" sounds like an obvious concept, right? But if it was, then nobody would ever ask this question!

You're done using a particular grit when you meet ALL the following criteria:

- You've accomplished as much as this grit can — you've done all the shaping you want, given the ability of this particular grit, and the surface has the exact shape you want it to, within the restrictions of this grit.
- You've removed ALL the sanding-lines the *previous* grit made — 100%, completely, without a trace; the only sanding-lines left are from *this current* grit.
- There is no "timer" for this — no set amount of minutes, or hours, or number of repetitions; the presence of lines from a previous grit means you aren't done yet; go until they're gone!

Removing the sanding-lines left by the previous grit is where most people miss out on getting the results they *want* — they spend some time with 80, move on to 120, then on to 220, all without actually *looking* at what they've actually accomplished with each grit. Then they wonder why they still see lines when they paint their Super-Awesome-Project™.

> ***"Start with 80 grit."***
> ***"Seriously, put down the 220 and fix the shape first."*** - Harrison Krix, Volpin Props

When it comes to this part of sanding, there is no substitute for patience. If you want your Super-

Awesome-Project™ to look a certain way, there is no way around this fact.

Why? Because:

- Sanding-lines don't go away unless you make them.
- Most of the time, more sanding the only way to do that.
- So you have to: Just. Keep. Sanding.

BUT, if you always start with the lowest appropriate grit for the job, and move up from there, and you ONLY move up when you're "done" with the current grit… then the process becomes simple!

[Note: If you still have questions about what this means ***specifically, in actual use****, don't worry! It's covered in detail in its own section in* *Chapter 3: When Are You DONE?**]*

When to Replace Your Paper (vs. Cleaning It)

"How long should I use a piece of sandpaper?"

"When should I replace the piece of sandpaper I'm using?"

"How often should I replace the sandpaper I use?"

These are all variations on another incredibly common question, and the answer may surprise you —

You should be replacing it WAY more often!

- However long you use it is too long.
- Whenever you replace it isn't soon enough.
- However often you replace it isn't frequently enough.

Everyone struggles with this — even me!

Everyone who's ever picked up a piece of sandpaper and used it — and I do mean everyone! — has done this; it starts to wear out, but you just flip it over (assuming you folded it); then you move to a different corner, and another corner; maybe your fold it again to get NEW corners, and wear those out; your turn it over a third, fourth, or fifth time; eventually it's a ragged, floppy mess with more bare paper than grit and you finally, exasperatedly, sigh to yourself and go get *another piece of paper.* *grumble*

We've all done it. Whether it's because we're trying to save money (sandpaper isn't free!), or time (I have to go get another piece, and cut it, and fold it, and…), or we're feeling lazy (I have to stand up / walk over there / pull out fresh supplies). There are lots of valid reasons.

But I'm here to tell you they're not as valid as you think.

Previously, I described *the Time vs. Money scale*, and how it's up to you to decide where you want to land on it. Would you rather spend time? Or money? Where is your ideal balance?

HOW you use your tools works the same as WHICH tools you use — you can run them into the ground to "save" money, but how much time does that waste? And really, how much money do you actually save?

Sandpaper is most likely one of the cheapest tools you have. And it's INTENDED to be disposable. You're not doing yourself any favors by hoarding it and using it until it's a crumpled-up rag with no life left to give.

"So how long SHOULD I use sandpaper?"

You should stop when no more than ⅓ of its "usefulness" is gone.

(This applies to pieces of sandpaper, and any tools you use that wear out like sandpaper does.)

What Does "Usefulness" Mean?

How much USEFUL GRIT is left?

- If you're using the edges, then how much is left on those edges?
- If you're using a fold or crease, then how much is left on that fold or crease?
- If you're using the center, then how much is left in the center?

How well is it holding the SHAPE you need?

- If you're using the edges, are they still stiff and sharp? Or floppy and soft?
- If you're sanding a particular curve, does it still curve the way you want? Or has it gotten wrinkled, kinked, or folded badly?
- Does it still fit in your hand? / Does the tool still work as intended?

How dirty / clogged is the grit?

- Does it come out when you clean it?
- Can you "restore" it to a cleaner state?

If any of these are more than ⅓ gone or used up, move on to a new one! It has outlived its usefulness for that *task*.

Does that mean it's trash? Maybe not!

Note that each of those criteria is specific to a particular task:

- If you needed the edges but not the center, then the center may still be good!
- Conversely, if you used the center, the edges might still be good!
- If you folded it too much and it doesn't fit the curve you wanted it for, it might still fit a different shape just fine!
- If it's all floppy but still has lots of useful grit, it might work great on soft shapes!
- If you can fold it again, it might have a whole new life!

If your sandpaper still has at least 2/3 of usefulness left in one area, you might be able to use it for a different purpose, so don't feel like you NEED to throw it away immediately! But please — don't hoard old sandpaper unless you need to. Even the fanciest, most expensive sandpaper only costs a few cents per tiny, used-up square. And it still takes time and energy to search through old, worn-out bits, looking for a piece you can squeeze just a little more use out of. I used to do this, and it WILL take up more time than just cutting a new piece of paper (or grabbing a new tool) more often than not.

Try to keep used sandpaper only when all of the following are true:

- You KNOW part of it is still good (the edges, the center, the other side, etc.).
- You know WHAT it's still good for (using the edges, getting into small spaces, going over soft corners, etc.).
- You have a JOB IN MIND for it. Unless you only used one side of a piece of folded paper (so you know it's 50% useful or better), don't keep it "just in case" you find use for it; let it go, and get another piece when you need one.

I GUARANTEE this will save you time, energy, and most of all — frustration. There are few things more frustrating when working on a project than when things just don't work how they should — and the best way to avoid that is to STOP USING THINGS when they don't work the way they should!

Why Rolls Rule, Part 2

This is part of the reason Rolls of paper are so much more *efficient* than sheets. Because they're already narrow strips, you only need to make ONE cut — you decide how long the piece should be, and cut it off. Then you fold it appropriately. And you're ready to go! This also results in less waste.

Since you very rarely need LARGE sheets of paper (anything bigger than the palm of your hand), you will always need to cut Sheets of paper into smaller pieces, often multiple times. Getting the cuts right is difficult, and unless you're just cutting squares to use on a specific tool, you never know in advance exactly what size you'll want! Which leads to many pieces being too big, or too small.

- Pieces that are too big are wasteful by themselves — you'll rarely get to take full advantage of them before they wear out.
- Pieces that are too small just aren't useful — many times you'll have to just throw them away to save *yourself* from getting hurt or worn out.

> ***Never use improper tools! That includes things that are too big or too small for the job — you risk hurting yourself.***

Because of all this, Rolls are just harder to waste, so you end up being more efficient with your paper automatically — without even trying!

How to Clean Sandpaper

Yes, you can CLEAN sandpaper (and sanding tools)!

This can massively prolong its usefulness. Which saves you time *and* money!

Every time you can successfully clean your paper, you get to avoid doing any of the things you were avoiding that caused you to use it too long (before you read this book, anyway — now you know better; and you're about to learn another way to be more efficient!).

> ***There is no way to make sandpaper (or other disposable tools) last forever.***

Eventually, it WILL wear out — get too clogged, lose too much grit, something. But the following tricks will extend its useable life a little longer and, used judiciously, save you time as well.

Sanding Dust

As you use sandpaper, the spaces between the grit fill up with dust — "sanding dust." This dust is the tiny, scraped-off bits of whatever it is you're sanding. If you're sanding a 3D print, it's bits of whatever plastic your print is made of. If you're sanding paint, then it's that paint. If you're sanding wood, then… you get the idea.

Most of this dust will fall out of the grit by itself. But some of it will stick and start to clog up the sandpaper. Sometimes the dust stays in place because the dust itself is sticky, or bunches up really well. Sometimes dust just gets so impacted and crowded by new dust that it gets smashed together and forms big chunks.

Regardless of how it happens, when too much dust gets stuck in the grit, there's no place for NEW dust to go, so the paper stops working in those places. Eventually, the paper is too clogged to work well, and you need new paper.

So you can see that WHAT you're sanding will make a HUGE impact on how easy your paper is to clean. Sticky paint clogs sandpaper very quickly; hardwood makes fine floating dust that barely sticks to sandpaper at all.

The QUALITY of the paper also factors in here, big time. Higher-quality sandpaper doesn't clog as quickly as cheap sandpaper does.

How to Smack Away Dust

The easiest way to handle sanding dust is so simple, you're going to laugh if you've never seen it done.

> ***Take your paper, and SMACK IT against something.***

Smack it real good.

I use my leg for this. Yes, really. I'm constantly taking my sandpaper (and sanding sticks, and files, and…) and smacking them against the side of my upper thigh. I've taken to sewing extra fabric on my work pants because I wear holes in them from all the smacking! Don't smack it like you're trying to *spank* something — you want the sandpaper to strike with enough force it makes a nice, clear *smack* sound, but still hits at just enough of an angle that it *keeps moving* past your leg (or the table, or your workbench, or whatever).

The idea is to hit the sandpaper against something to knock loose as much dust as possible. If you slap it flat onto a workbench, there's nowhere for the dust to go! (Maybe out, in a cloud, but you don't want that, either.) So you swing it to hit a surface and keep going — sending the loose dust away in the direction of the smack.

This also helps preserve the shape of your sandpaper. Slapping it directly into things is a good way to crease it, bend it, or break it.

Trust me — this sounds more complicated than it is! A couple of tries with some dusty sandpaper and you'll see just how easy — and effective! — it is.

The trick with this method is you need to do it EARLY, and OFTEN.

- Whenever you notice that your paper is shedding more dust than just what falls off with each pass, or when it feels like it's not sanding as well as a few seconds ago, SMACK IT.

Sand. Smack. Repeat.

You can never smack away 100% of the sanding dust. It's impossible. Maybe as much as 50-80%, if it's *really nice* dust that comes loose easily.

If you wait too long, and your sandpaper is already getting clogged, you'll be fighting a losing battle to make it useful again.

Once paper starts to actually CLOG, there's almost no getting it back — it will get worse *rapidly* after that.

Cleaning Clogged Paper

Clogs will kill any paper they appear on faster than anything else, and there is no way to completely remove them once they start. But these 2 methods will give you a fighting chance against them.

Avoid doing this with PIECES of sandpaper — save this for tools like sanding sticks, files, or custom things that aren't quickly or easily replaced.

1. **Use another piece of sandpaper!**
   - You can use another piece of sandpaper of the SAME GRIT to sand the clog away. It needs to be the same grit, so that the pieces of sand move between each other.
   - This will remove as much as 90% of a clog, depending on how bad it is.
   - This ALSO removes some of the grit, so it WILL wear out the sandpaper, albeit in a different way.
   - The higher the quality of sandpaper, the better this works, and the more practical it is as a way to extend the life of your paper.
2. **Use an Abrasive Cleaning Stick**
   - This is a specialty tool made specifically for removing clogs and gunk from sandpaper, especially on power tools (belt sanders and disc sanders), but it works just as well on sanding sticks and regular paper.
   - It's basically like a pencil eraser, but for sandpaper. The Cleaning Stick gets worn down with use, but it will last a looooooong time (I've had the same one for over 5 years).
   - Cleaning Sticks don't take off really stubborn clogs at all, so they don't work all the time.
   - This doesn't take the grit off sandpaper the way other sandpaper does, so it can be better for your sandpaper — when it works.

How to Give Worn Paper New Life

There are 2 ways to potentially give your worn out paper another shot at being useful, both of which will save you TONS of time and prolong the life of your tools many times over!

1. **Re-Fold It**
   - You can almost always fold paper at least one additional time past the first, initial fold (because you always fold your paper to start, right?).
   - If you've worn out half of a side of paper, but not the other, just fold it to hide the worn-out portion!
   - If you need a new Fold Edge — make one by folding again!
   - Avoid folding paper TOO many times. Some people will fold paper until they have pieces so tiny they can't even hold them anymore; this is unnecessary, and a waste of your time and resources. Once a piece is hard to hold, get a new one — save your hands, and your patience.

2. **Cut the Edges Off**
   - If you're using the Raw Edges and they get worn out, just trim them off! Voila, crisp, new edges! Typically you only need to cut a few millimeters (about ⅛") away — if you find yourself needing to cut more than that, you've used that section of paper too long already!
   - This also works for most custom Sanding Sticks, Emery Board, and pre-made sanding sticks.
   - Stop trimming when doing so would make the tool too small to be useful.

CHAPTER 3
SANDING 201: METHODOLOGY

When you sand something, what are we trying to DO?

What's the GOAL of sanding?

A lot of people get this wrong.

- Sanding isn't just something to check off your project to-do list.
- It's not just one more step on the path to finishing your Super-Awesome-Project™.
- And it's not some task to mindlessly sleep-walk through for some specific amount of time.

Sanding is a *reductive* process — it's the process of taking material AWAY from something. As opposed to an *additive* process — putting more material ON something, like layers of a 3D print, or using putty to patch a hole.

That means that every step of sanding is one of further refinement, of improvement; using finer and finer grit to get the rough shapes, textures, and finish of the previous stage one step closer to *perfect*. Or at least as close to perfect as you want!

So the GOAL of sanding is to make the surface, or the shape, or the texture of your Super-Awesome-Project™ look *however you want it to look.*

The entire point of sanding is to make something LOOK a certain way.

It's how you make something *rough* look *good*.

- 3D print has lines you don't want? *Sanding*.
- Wood not the texture you want? *Sanding*.
- Plastic corners too sharp? *Sanding*.
- Cast resin has seamlines that need fixing? *Sanding*.
- Metal not as shiny as you'd like? *Sanding*.
- Thing not the right shape? ***SANDING***.

WHEN ARE YOU *DONE?*

You're done when you're done.

Don't worry — nobody likes this answer! But it's the truth.

[I touched on this from a different direction in Chapter 2: What Does Done Mean?, and the concepts are very similar.]

How well something is sanded isn't measured in time. (Okay, we all measure how long we worked on something as a sort of marker of how hard it was, but that's different! And also not really useful — but that's a whole other topic.)

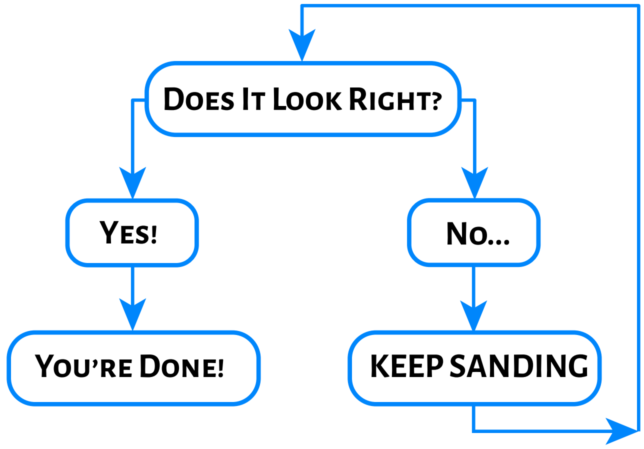
How long you spend sanding doesn't actually matter if you haven't done it well.

The point of sanding is to make a surface LOOK a certain way — normally, that means *smooth*. Or at least, smoother than it was to start. Which means you CAN'T measure results in time. Or number of strokes. Or anything EXCEPT:

Does my Super-Awesome-Project™ LOOK how I want it to yet?

- → If the answer is "no," *then you're not done sanding.*

Here's a handy chart to help you out:



It really is that simple. There's no shortcut to this part — if you don't SEE the results you want, you don't have them. Period.

However long it takes to see those results, is how long it takes.

It's either DONE, or it's NOT.

...you get the idea.

BUT there are shortcuts and tricks to make the *process* faster!

That's what CHAPTERS 4 and 9 are all about.

The Basic Process

Start Rough, and Refine

Sanding always follows the same progression:

1. **Start big and rough.**
2. **Get smaller and finer as you go.**
3. **Stop when you're happy with the results.**

The only real variable is what state your project is in to start.

Let's look at a couple of examples to explain what I mean. Keep in mind these aren't actual step-by-step guides, just very rough examples of how the process might go.

Say you're starting with a raw block of wood and you want to make a cool sculpture:

1. Take your block of wood, and start chopping out big chunks where you know there will be empty space; maybe using a chisel, or a saw. You're hacking out material in big chunks.
2. You take out smaller chunks the closer your shape gets; switching to smaller chisels, or heavy rasps / files. These are more like wood chips and sawdust.
3. Once you project is really taking shape, you start refining; using heavy/low-grit sandpaper (80), files, rasps, and similar tools. You're making lots of sanding dust now.
4. When the shape is basically done, and heavy grit would take away so much material that you'd risk messing it up, you move on to finer grit (120); sandpaper, files, etc.
5. You continue refining until the SHAPE is done, and all that's left is texture that's too rough.
6. Now you're just trying to make the thing as SMOOTH as you want, using Fine grit tools (220), maybe moving into super fine or higher grit tools.
7. When you're happy with how smooth it is, *stop*! You're DONE.

Now instead, let's start with a 3D print — it was printed in a hurry off a budget machine, so it's got lots of layer lines, and you want to mold and cast this to make nice, clean copies:

1. You already have the shape DONE — you 3D printed it! So you can skip straight to sandpaper (and files, etc). But those layer lines are pretty bad, so you need to be pretty aggressive to get rid of them — you start with 80 grit paper and some rasps.
2. You sand until the lines that stick out are gone — they're flush with the shape you WANT to have, but not further! You're not sanding grooves or gouging into the shape, because that would mess it up.
3. But the plastic is still all… fuzzy. It has a horrible texture, and it's nowhere near smooth yet. So you move on to 120 grit tools, and start sanding all that texture off.
4. Nice! All the texture from the 80 grit round is gone! You can still see some scratches and sanding-lines, but they're all from the 120 you're using now. Of course, you want *those* gone, too.
5. You move on to 220 tools, and smooth things out even further. You can barely see any lines at all now! The print lines are gone, and your print just has a lightly scuffed look to it from all the Fine grit work you just did. But you want your cast parts to be *shiny*.
6. You paint some good primer onto your print — it fills in all the 220 grit scratches, which is great! But now it looks matte — not shiny at all! So you start using even finer grit; 300, 500.
7. It's getting better, but still not there. You start wet-sanding with 1,000 grit, and then move on to Rubbing and Polishing compounds, really getting every little detail cleaned up just right.
8. Your part is now actually shiny, light bouncing off the curves and corners! It's DONE.

In the wood sculpture example, your first *task* is different — start making a shape — so you start out with different *tools*. The 3D print already *has* a shape, so you start with finer tools. After that, the process is the same for both projects. The core idea is identical no matter where you start — start big, get smaller.

For specific details on how to handle jobs like the ones in these examples:

- The basics of grit progression is covered in Chapter 1: Grits.
- Which grit to use and when to change it, is covered earlier in this chapter.
- How to sand specific materials is covered in Chapter 7: Sanding Specific Materials.
- How to make things shiny is covered in Chapter 5: How Shiny Can You Make It?

CHAPTER 4
BASIC TECHNIQUE

The methods and techniques in this chapter are generally applicable to all sanding tools, grits, projects, materials and goals. They're foundational methods, not shortcuts or time-savers *per se*. But the specific tips and tricks in later chapters assume you're already doing everything in this one; so if you *don't* use them, I'll guarantee you are wasting time you don't need to!

HOW TO FOLD PAPER

You should ALWAYS fold your sandpaper! *

* *With very few, very specific exceptions — for certain methods / tasks.*

Folding increases the structural integrity and mechanical stiffness of what is, otherwise, basically a sheet of paper. This means:

- You get more control (always a good thing!).
- The paper holds its shape better and for longer (saves you both time and money).
- You have both RAW and FOLDED edges to use at any time.
  - **RAW** edges are great for sanding *up to* an adjoining surface but not *into* it, or when you want to put a really smooth curve in your paper.
  - **FOLDED** edges are great for sanding grooves and detail-lines, or when you need extra stability in your paper.

THE TRI-FOLD

My favorite method of folding paper Sheets is to take a sheet and cut it in half (across the short distance, aka "Hamburger Style"), then fold THAT piece into THIRDS. This gives you 2 Raw edges, and 2 Folded edges.

- The 3 layers give you exceptional stability whether you need the paper to remain flat, or you want to curve it without kinking it sharply.
- The tri-fold holds its shape — and prevents each "section" from sliding across the others or flopping around — better than a single-fold does, even without tacky/sticky backed paper.
- When one surface becomes too worn or clogged, you have 2 more to flip to without needing to grab another piece!
- It's also a very convenient size for most projects — it fits easily in the hands of most people, and covers a convenient amount of surface area.

ROLLED PAPER

A square piece of paper isn't always the most useful shape.

Sometimes you need to make shapes that are more concave than can easily be accomplished with flat paper. Sometimes you need to sand inside a tight curve, or a tube, or the inside of a ring or circle.

In cases like these, you want sandpaper that's not just folded, but also rolled up.

Rolling will always work best if you fold the sandpaper FIRST. Folding makes the paper sturdier, and more stable, and will help it hold its rolled up shape without creasing, bending, or unrolling as easily.

There are many ways to roll sandpaper, but the basic concept is simple — curve it to match the shape you're sanding. Usually that means making it a little bit smaller, so it's easy to move. And roll it as many times as necessary to get the stiffness you want for the task.

ANGLES OF ATTACK

You'll often hear people use terms like "with the grain," "against the grain," or say to "always sand in a circular motion."

What does any of that mean?

Each one is a different way to approach sanding, and each has its uses; they're ALL useful under the right circumstance. While "with-" and "against-the grain" are terms that come from woodworking (wood has grain that typically runs in parallel lines throughout it) they're still useful ways to talk about the different methods even when there is no grain involved.

CIRCULAR

It's common advice to beginners to "sand in circles" or "sand with a circular pattern" and there's a good reason for that!

The majority of the time (especially in the prop-making and cosplay world), we're just trying to make something *more smooth*. We're not always aiming to change the shape! And there is no "grain" to think about with materials like foam, resin, or all but a few plastics.

Circular Sanding is the single best way to avoid leaving sanding-lines — grooves / scratches created by sanding — that we can't fix later.

That's because sanding in a straight line almost always means going over the same path, the same surface, over and over, making more lines in the same place, and making existing lines deeper. We don't always want that (but sometimes we do! — that's next).

Sanding in circles is always a bit random — humans aren't robots, and we are inherently BAD at making circles. So the lines don't overlap, they go different places, and maybe even more importantly — they CROSS EACH OTHER. This crossing helps to erase sanding-lines *as you make them*, leading to less cleanup later. Talk about efficient!

This makes Circular Sanding the single best way to erase sanding-lines, and to smooth out a surface (or buff / polish one).

To emphasize how useful random circles are — the most common hand-held power sander in the automotive world (where they care the most about making things smooth and shiny!) is the Random Orbit Sander — it's a powered circle of sandpaper that spins, but has an axis that also moves, so that every rotation isn't a perfect circle, but a *random* curve.

[More on the Random Orbit Sander, and other tools, in Chapter 8: Tools]

Circular Sanding is also the best way to remove large amounts of material from odd shapes, concave curves, and anything else that isn't best handled using a Straight Path approach.

Any sanding using tools that are Fine grit or higher should almost always be done using Circular Sanding.

PARALLEL, OR WITH THE GRAIN

Let's take the simplest use of With the Grain sanding, it's original use in wood.

Wood has "grain" that runs throughout the material. This grain is usually visible as curving but mostly-parallel lines of different colors. More importantly for sanding purposes, the different fibers of the grain have different physical traits — meaning they sand differently! One part is usually softer, and the other usually harder.

Sanding WITH the grain just means to move the sandpaper PARALLEL to the grain in the wood.

For materials that are *not* wood, it means the same basic thing — sanding PARALLEL to the shape, edge, line, or surface you're working on.

When is this useful?

- **You want to make a STRAIGHT line, groove, or edge;**
- **You want a surface to be FLAT;**
- **You want a consistent BEVEL on a straight line, groove, or edge.**

Sanding Parallel is the best way to accentuate the flatness of a surface, create consistent shapes over long distances, or just make a straight line, groove, or edge.

If you want something to be straight, you need to sand parallel to the line you want. This is also true when making surfaces as flat as possible, or when trying to round over long edges.

It's easier to repeat the same motion when sanding in a straight line, than it is in a circle or curve (because humans are bad at circles; we just are).

If you have a rectangular shape, and you want to make one side really flat — you'd sand in a straight line parallel to the long side of the rectangle.

If you want to make round over a long edge, especially on a curved surface, you'd wrap your tool around that corner and sand parallel to it — keeping the same shape as you go to create a consistent bevel.

If you had a detail line or groove in that shape, you'd insert your tool into the groove and sand in the same direction the groove goes — moving parallel to the grove, NOT across it.

Perpendicular, or Against the Grain

Take everything just said about sanding Parallel, and spin it 90 degrees. That's sanding Perpendicular, or Against the Grain.

When is this useful?

- **You want to SOFTEN or ROUND an edge, corner, peak, or other sharp shape.**
- **You want to CUT DOWN a high spot as fast as possible.**
- **You want to make a SHARP or CRISP EDGE.**

Sanding Perpendicular is the best way to make sharp, crisp edges, remove material as quickly as possible, and round or soften corners and small edges.

If you want to make something like a sword edge, or a crisp corner on a long rectangle, you'd sand perpendicular to that edge — starting from the edge and moving across it towards the objects center.

If you want to soften a corner or edge, you'd sand across it — using gentle strokes to cut the corner off a little bit with each pass until it was as rounded or soft as desired.

If you want to alter a shape by turning a high point into a flat one as quickly as possible, you'd use a rigid tool (file, rasp, sanding stick) and sand across that high point — perpendicular to it.

Tool Orientation

Always orient your tool, whether it's sandpaper, files, sticks, or anything else, according to these two rules, and sanding will go MUCH easier (and faster, and cleaner, and less stressfully)!

- **Always sand PARALLEL to VALLEYS.**
- **Always sand PERPENDICULAR to PEAKS.**

VALLEYS are anything lower than the surface around them — grooves, detail lines, or any concave curve that follows some sort of path (as opposed to just a low spot).

PEAKS are anything higher than the surface around them — rough textures, 3D Print lines, sharp corners you don't want to be sharp, or any convex surface that shouldn't be as convex as it is.

As with everything, there are exceptions to the rules, but I'll note those when they come up.

Tool Pressure vs. Repetition

If there's one recurring theme throughout this book, it's that sanding takes time. A *lot* of time. So much time, you bought a book that promises to shorten that time! But I haven't talked much about how *hard* you should work. So here we go!

[Note: This chapter is rife with potential innuendo — apologies in advance, but words are what they are.]

"Should I just sand harder? Or sand for longer?"

These are the only two ways we have to take off more material:

- **Sand Harder —** exert more (harder) pressure with each pass of the tools, attempting to remove more material at the same grit through pure force
- **Sand Longer —** use a consistent (easy) pressure, but sand for a longer period of time, resulting in more passes of the grit across the surface

That's it!

Both are technically "more work," they're just different sides of the equation.

All that power tools do is increase the number of repetitions performed in the same period of time. A belt sander, for example, works the same as a big sanding block — but because it moves so quickly, the same bits of sand pass over a given surface many more times in a given time-period than they would if you worked by hand. That's the only real difference in terms of sanding *efficiency* between your hands and a power tool.

Certain tools (including powered ones) can decrease how much physical effort you have to exert to create the same amount of force on a surface — through things like longer handles, sturdier surfaces, and other bits of engineering that come down to simple physics. But even then it's still up to YOU to decide how much force you use — how HARD you sand.

So, which way is better? Harder? Or Longer (more repetitions)?

You might think Longer is better, since the entire point of power tools is to basically cram more repetitions into the same time-frame. And mostly you'd be right.

- Sanding Longer takes more TIME.
- Sanding Harder takes more PHYSICAL EFFORT.
- Sanding Harder typically results in deeper, harder-to-cleanup sanding-lines; Sanding Longer does not.

BUT, there are times when sanding Harder is actually much more efficient.

- **You're using a heavy rasp or power tool with high torque.**
  - Certain tools — like speed-rasps, heavy files, and many power tools — will leave the same sanding-lines no matter how you use them. In those cases, it's often best to lean on them as hard as they can handle, and take off as much material per pass as possible.
  - If the cleanup will be the same either way, then it may be less work overall to exert more force over a shorter time — to sand Harder.
- **Extremely difficult-to-reach shapes that need a lot of work.**
  - You may find yourself needing to remove a lot of material from a hard-to-reach or oddly shaped surface — something that makes it difficult to sand *at all*. Since every repetition will be difficult, it may be more efficient (or at least easier or faster) to sand HARDER with each pass, to keep the number of frustrating / difficult passes to a minimum.
- **You have a shape, material, or tool that just does not result in much sanding happening; material doesn't come off easily, no matter how many times you pass over the surface.**
  - In these cases, you NEED to sand Harder, or you'll make no progress at all. These situations aren't always easy to spot, but they're easy to test — if you're not making progress, try moving both UP and DOWN a grit. If neither the rougher nor the finer grit are any more effective, then all that's left is more force. Proceed carefully, working a bit harder until you start to make noticeable progress; these stubborn surfaces can be tricky, and often have a fine line between "doing nothing" and "ruining everything."

Flat vs. Curved Surfaces

Flat surfaces are the simplest to sand — but not the easiest!

The technique is simple:

- **The flatter you want the surface to be, the flatter (and more precise) your tool.**
- **Large surfaces require large tools; the bigger, the better.**
- **Small surfaces can be sanded with any size tool that works.**

The most common tool for flat surfaces are sanding blocks, and all their assorted relatives — files, rasps, and sanding sticks.

The most basic sanding block is, quite literally, a block with sandpaper on it. The block can be anything — a scrap of wood, a paint stick, scraps of foam or plastic, even a sheet of sandpaper taped or glued to your workbench.

Whatever the tool, ideally it should be BIGGER than the surface you're sanding. For perfectly flat surfaces, the bigger the better.

My favorite sanding block, when I need a really precise surface that's not much bigger than my hands, is a scrap of hardwood wrapped in sandpaper. It's a few inches across, a foot long, and has nice, crisp, 90 degree corners and perfectly planed (flat) sides. A friend uses an old aluminum block — it's even wider and MORE precisely machined; the perfect sanding block.

I also love scraps of thick acrylic plastic — it's perfectly flat, rigid, lightweight, and easily cut to convenient sizes; all great traits for sanding crisp, well-defined shapes and edges.

1. **Decide if it will be easier to move your Tool across the Project, or the Project across the Tool.**
   A. Try orienting things both ways — Tool on Project, Project on Tool. Use whichever way allows you to both:
      I. More easily TELL where things SHOULD go (Remember, things aren't perfect yet! You're still trying to make them that way, so the surface you have may not actually be at the angle or in the shape you *want*); and
      II. CONTROL the angle of sanding (there's no point in knowing how your Tool and Project should be oriented if you can't physically move them to accomplish that!).
   B. For anything that easily fits in your hands, it's usually easier to move your Project across your Tool. This is because it's almost always easier orient your Project relative to a stable surface than it is to estimate where the Tool should be in relation to the Project to do what you want
      I. If moving the Project across a Tool, secure the Tool to something; put a sanding block on your workbench and hold it, clamp it, glue it, whatever is convenient; I have literally taped multiple sheets of sandpaper to my workbench to make 2x2 foot sanding "blocks" for large shapes before — it works great!

         The point is to make your Tool as stable as possible so you can focus on moving just ONE THING, your Project.

         The fewer variables you have when trying to make something truly flat (and *which thing* is moving — Tool or Project — is a big variable!), the easier it will be!
   C. For anything else, do the reverse.
      I. Secure your Project, if at all possible. Clamp it, tape it, have someone else hold it, or just lean on it really hard — whatever you can do to keep its potential for movement to a minimum.
      II. The same concept applies here as above — the fewer variables you have, including movement, the easier your job will be.
2. **Once everything is oriented correctly, Sand in ONE DIRECTION.**
   A. Sand in straight lines.
   B. Start at one end, sand to the other, LIFT your

Tool (or Project) and return it to the start, then repeat.

C. This establishes a consistent movement pattern, as well as a consistent pattern of material removal.

I. That means it does a better job of actually making things FLAT.

II. The more precisely you execute this movement, and the more precisely you COPY it with every pass, the more accurate your surface will be.

III. Moving back and forth (from one end to the other) or in circles invites randomness and error — it leads to more unpredictable high and low spots, and a LESS FLAT surface.

3. **Repeat as needed until you have the desired SHAPE.**

4. **Once the SHAPE is DONE, you can move onto cleaning it up with higher grits (using Circular Sanding to remove all your sanding-lines).**

HARD VS. SOFT CURVES

Sanding flat surfaces is pretty straightforward — use something else flat! Bigger surface? Get a bigger tool! Simple.

But what about curved surfaces?

Helmets? Beveled edges? Long, sloping sword blades? Pointy corners that could be a *little* less pointy so they stop snagging on everything?

How do we handle those?

First, let's break them down:

Hard Curves

- These can be anything from the softly (but precisely) curving blade of a fantasy sword, to the exact 90 degree corner of a steel cube. A "hard curve" is any line that has precise angles, edges, or lines you can see and/or feel. It doesn't need to necessarily *curve* — the main thing is that it's got to be precise, it has a start, and an end, and the boundaries between it and other shapes is clearly defined.

Soft Curves

- The gentle slope of a domed helmet, the soft wobbles of an organic sculpture, the smooth feel of a perfectly beveled edge. A "soft curve" is any shape that doesn't have Hard Curves. Where Hard Curves have clearly defined edges, Soft Curves fill in all the blanks. Most shapes are Soft Curves.

And how do we handle the 2 kinds of Curved surfaces?

Hard Curves require different techniques than Soft Curves. Specifically, they need different *tools*.

- Hard Curves need *hard* tools — sanding sticks, blocks, files, rasps, anything rigid that will hold its shape. To make crisp, clean lines and edges (the chief aspect of Hard Curves), you want tools that will *force* the surface you're working on to match the *tool's* shape — **in the fight between Tool vs. Surface, you want the tool to *win*.**

Soft Curves require a lighter touch, more forgiveness, and some finesse.

- Soft Curves need *soft* tools — sandpaper, sanding sponges and pads, flexible sanding sticks, anything with some degree of flex, bend, or give in its shape. When making curves soft, you want tools that will give in to the surface — to a point! You want to be able to exercise control over your tool, so that you determine what is sanded off — **but in the fight between Tool and Surface, you want a *compromise*.**

There are, as always, gradations between Hard and Soft. When I say Hard, I typically mean only those curves that meet the above definition. Everything else is some degree of Soft. Some Soft Curves are nearly as hard as Hard Curves! But they're still technically Soft Curves, which is why it's easiest to define Hard Curves first, and leave the rest to be Soft Curves.

How much finesse you need for a Soft Curve, or how much inflexibility you need with a Hard Curve, will vary from project to project, and task to task.

And while it is entirely possible to do EVERYTHING with a simple sheet of sandpaper, it's much, MUCH easier to use tools more suited to the specific task.

Simply try to match how crisp, hard, or sharp you want your surface to be with an equally hard, straight, even tool.

For Soft Curves, choose similarly — the more subtle, more gradual the curve, the softer and more pliable the tool.

How to Maintain Detail

Sanding is always about making things look *better* — cleaner, nicer, *more refined*. But what "better" means isn't always the same.

So far everything we've talked about has been directly applicable to making things smooth — start big, go smaller, continue until done.

But what do you do when your goal is actually cleaning up little imperfections without losing the shapes and details you want to keep?

What if you have a 3D print, and it's got lots of little greeblies, panel lines, raised knobs and doo-dads, but they're all surrounded by print lines? What if the dome of the helmet you're making has a subtle curve that abruptly stops at a sharp, protruding block?

Can you sand those things the same way?

Yes, yes you can. With just a few, small changes.

Tools

- Your tools need to change as the task does. Don't try to sand the inside corner of a recess the size of your fingernail with the same sandpaper you just used to sand the flat of a sword blade! Match the size of the tool to the task.
- Small areas use smaller, detail-oriented tools — small bits of sandpaper, custom sanding sticks, sanding twigs, needle files and rasps, jewelers attachments for rotary tools, and my personal favorite, Riffler Files. [more on all of these in the Tools CHAPTER]

Technique

- Technique doesn't change!
- The same patterns, methods, and approach you used up to this point still work.
- In the case of sanding around existing details, you just need to work SMALLER and MORE PRECISELY (your tool selection will help immensely with this).
- Going smaller often means going SLOWER. That's okay! Take your time here to avoid damaging anything. ***It's almost always faster to preserve a detail than to try and fix it later!*** (I am constantly fighting this battle myself.)
- Don't overdo it! ***Only sand off what you need to.*** This will save you time later, and help prevent the heartache that can happen when you get the final paint (or whatever) on your Super-Awesome-Project™ only to realize your details were sanded down, flattened, or covered up with paint.

That's it!

Preserving details just means you'll be moving between techniques a lot more — sanding a flat surface between things one moment, sanding the sharp concave corners around them the next, etc., not that any of the techniques themselves will change.

Chapter 5
How Shiny Can You Make It?

This question usually gets asked in a more specific way — "*How do I make THIS shiny?*" But it gets asked so often it deserves its own section.

The answer depends on a number of things, but I'll start with some generalizations:

- **The harder and denser a surface, the shinier you can make it.**
- **The more rigid and inflexible a surface, the easier it is to make shiny.**

And conversely:

- **The softer or more porous a surface, the less shine you can give it.**
- **The more flexible or pliable a surface, the harder it is to make it shiny.**

To really boil it down — *Hard Things CAN be shiny, Soft Things CAN'T.* *

If you learn nothing else from this section, please soak this lesson into your bones:

- **Hard Thing = SHINY**
- **Soft Things = NOT SHINY**

* *[Not exactly. It technically IS possible, but it always takes special coatings, additives, or chemical processes, many of which aren't even commercially available; it also always takes **exponentially more work** than making an equivalent, hard surface shiny.]*

> ***NOTE: This is a conceptually challenging topic!***
>
> I'm presenting the information here for those that want to try and understand the "why" of it all, and to help those who want to get the absolute most out of their materials. If you don't understand it all, that's okay! Feel free to skim it, or just skip ahead to my tips on getting the best shine for each material in Chapter 7: Sanding Specific Materials.

The single biggest factor in making something shiny is DENSITY. Shine is a matter of texture — the less visible texture there is on a surface, the shinier it can be. From a different perspective — the closer together (the more *densely arranged*) the particles that make up a surface are, the less texture that surface has, and the shinier it can be.

The more dense a material is, the more brittle it is. When something is brittle, it tends to break before it bends. This is the core problem we run into when trying to make things that aren't *already dense* shiny.

So if we make an abbreviated list of materials, and rank them from Best to Worst in terms of both how shiny we can make them and how easy it is to do, it looks something like this:

Metal, Acrylic, ABS: very hard, extremely dense, rigid; if not shiny to start, can easily be brought to a high-gloss shine with polishing; no other sanding required.

Cast Resin, Resin 3D Printed Parts: typically hard, usually dense, varying degrees of flexibility; if shiny to start, can easily be brought to a high-gloss shine with polishing; if satin-finish to start, fine to high-grit sanding is required first.

Smooth Plastics (styrene, PETG), Body Filler: medium hardness, flexible, but dense; often shiny to start; respond well to high-grit sanding and polishing; can be brought to high-gloss finish.

Semi-Rigid Plastics and Resins: flexible, often rubbery; may respond to high-grit sanding and manual (by hand / low speed) polishing; typically only satin- or semi-gloss finish without additional coatings.

Foam (EVA), Rubbers: flexible, often porous; can't be polished; do not respond well to most high-grit sanding techniques; satin finish at best without additional coatings.

Most rubbery materials can't be made shiny by themselves. Why? Because they're not dense enough — their surface simply will not get shiny because the material itself won't allow it. To overcome this, you have to coat them with another material that is more dense and more capable of producing a shiny finish.

The same is true of porous materials like foam.

You can coat a non-shiny surface with any of the materials described in the Chapter 6: Additive Smoothing section, but that brings with it new restrictions and complications.

Any coating used this way needs to be more dense than the surface it's coating, otherwise using it would be pointless! That means it's going to have different characteristics than the material you're putting it on. Almost every surface coating is more rigid, more dense, and more brittle than the material you want to put it on.

Most materials that work well for achieving a high-gloss finish are impossible to use on flexible materials — spot putty, body filler, 2K or filler primer, most resin coatings, and almost all "high-gloss" paint. Every single one is too brittle to take more than a couple of degrees of flex before it cracks, shatters, breaks, or pops loose and falls off your base material.

So while it's entirely possible to simply put high-gloss paint on just about anything, it will not STAY high-gloss. It will crack, or shatter, or fall off, just like any other surface coating.

With very few exceptions, it's basically impossible to simply put a permanent high-gloss material on a flexible surface.

[Though not completely impossible! More on that in the next section.]

But by and large, it's not a viable option.

Foam armor prop by *SoloRoboto Industries*
Lots of shine, but not TRULY glossy

CHAPTER 6
SPECIAL TECHNIQUES

WET-SANDING

As we move up into higher and higher grit abrasives, the space between the bits of sand become correspondingly smaller and smaller. This makes the likelihood of clogged and worn-out paper increase as well.

To avoid this problem almost entirely, we use a technique called Wet-Sanding. Which is exactly what it sounds like — sanding something that's wet!

The concept is simple — fluid acts like both a washing agent and a lubricant, keeping dust out of the paper, and helping the grit slide across the project surface a little easier, preventing wear.

Some materials benefit from special compounds or fluids here — different types of oil for different metals, for example — but we'll focus on the most common and easiest to use: water.

HOW TO DO IT

Do a little googling and you'll find LOTS of recommendations for how to wet-sand, many of them complex, involved, or just plain messy. I've done things very stupidly, made tons of messes, and learned from many other professionals along the way. So here's what I do:

Start with tools made for wet-sanding!

- This should be obvious, but not all paper will hold up well to water. It is, after all, *paper*. Even some that seem sturdy use adhesives for their sand that don't like being wet, and it will literally just fall off.
- Sandpaper manufacturers make this easy for you. Paper will be labeled "wet / dry" or "suitable for wet-sanding" or "waterproof" if it's suitable. If it doesn't say it on the package (or just as likely, on the back of the paper itself), it's not.
- Most sanding sponges work just fine with water. Most do NOT work with other liquids, like alcohol (test an old one if you're not sure).

Make sure your surface can be wet-sanded!

- If you're sanding a material directly, this is rarely a problem — plastic, body filler, cast resins, foam, etc., don't respond to water at all, as they're already water proof.
- Some wood, however, will swell up and expand when wet; some metals may oxidize (rust). You don't want either of those, so make sure you're safe to use water before you start.
- Most paint does NOT like to be wet-sanded! This is also true of primer. If you're sanding a painted or primed surface, carefully read the label of your paint and make sure it says something like "may be wet-sanded" or "wet-sand after X minutes." If it doesn't, then proceed with caution.
- Paint can absorb water (much like paper or wood can), and swell up, become soft, peel off the surface it's on, or more insidiously — hold that water in secret, until you're ready to put the final paint on your perfectly sanded surface and then — BAM! — release it so that it ruins the top coat of paint, forcing you to strip away everything down to the raw material underneath.

  - Sometimes, even paint that isn't listed as "wet-sandable" may be wet-sanded — IF you give it ample time to dry out before doing whatever else you need to do with it. "Ample time" could be hours to days — and you'll have to experiment to find out. But if you have the time, it may still be an option.

Prepare your workspace.

- Put down a towel or something to soak up excess water, I guarantee at some point you'll splash something; basically be prepared to make a mess *just in case* (though if you do things my way, you won't!).
- Get yourself a shallow tray or bucket of some kind, ideally with an opening that's larger than the size of whatever you're sanding.
- This container will hold your water.
  - You don't need a lot of water! Only enough to quickly and easily submerge your sanding tools to rinse them off — usually just a couple of inches. Use warm (but not hot!) water with a just little bit of dish soap (the soap and heat help keep the tools from clogging, and add a bit of lubrication without decreasing the cutting power of the tools).
  - If you can, place your project DIRECTLY IN your tub. This is why you want a container that's both shallow, *and* will fit your project. (If you can't, then skip ahead for the alternative.)

Get to work!

- Start sanding! Dunk your tool into the tub, and make a few light passes over the surface you're working on to get it wet. Once it's thoroughly wet, start sanding in earnest.
- Make sure your TOOL stays wet! This is *wet* sanding, remember? The point is to have water on the tool at all times. ***You don't need to drown the sanding surface!***
- ***Your surface does NOT need to be underwater!*** Please don't do this.
- Just keep things lubricated with water — your tools are designed to work while *wet*, not *submerged*. They will perform better when used as designed.
- Doing this will be MUCH easier (and less messy!) than any other method, guaranteed.

> *I like using **this rectangular rubber tub intended for washing dishes** — it's a good size (most projects fit in it!), is about 5" deep (just right to hold water without splashing, but still easy to work in!), and has handles to carry it around (convenience!).*

If you CAN'T fit your project into a tub or shallow bucket, do this instead:

- Place it on a pile of absorbent towels, or somewhere that can take a LOT of water.
- Get a small tub or container — something you can quickly and easily submerge your tools in completely, with a little wiggle room.

> *I use big mixing cups, or old plastic food containers I don't mind trashing.*

- Fill it with warm water and soap, leaving enough room that it won't overflow when you dunk your tools (and your hand) in it.
- Follow the remaining instructions above, but make doubly sure to keep the sandpaper wet.

Regardless of the setup, the process is the same.

Keep the tools wet (water is your lubricant, make sure you have enough to accomplish that task, but not so much you're flinging water everywhere!).

You'll likely learn to feel the difference when your tools get too dry, or too clogged.

Since they're wet, you can't SMACK your tools — but you also don't need to! You have water for that. Just dunk your tools every time they start collecting dust. The other purpose of the water is to keep the dust moving away, so make sure you do that by using it to keep your tools (and surface) clean while you work.

It can be very hard to tell how smooth the sanding surface is while it's wet — water makes everything look smoother, shinier, and glossier. So from time to time, check your progress by rinsing off the surface (remove any lingering dust) and drying it off. Once dry, you'll be able to much more easily see and feel your progress.

Sandpaper still wears out while wet-sanding. Some of it gets soggy, and creases are prone to extra cracking. So don't forget to monitor the state of your tools as well, changing them following the same criteria you would for dry ones.

Polishing / Buffing

The terms "Polishing" and "Buffing" are used exactly the same way, have the same meaning, and refer to the same process, but they are commonly used in different industries. But I like the word "polishing" best, so that's what I'll be using.

Polishing IS sanding. The same methods, techniques, and ideas still apply. The only differences are the degree of polish (how smooth the surface is), and the materials / tools used.

"What Does 'Shiny' Mean?"

This is an important question, because before we can talk about how to make things shiny, we have to know what we're trying to do!

Most people, me included, will use "shiny" and "glossy" interchangeably. In either case, what we usually mean is that light will bounce off a shiny surface very well. In fact, the degree of shine or "gloss" can be measured by how well light bounces off a surface. We're not talking just visible light, like how well you *see* the surface — we're talking specific points of light.

A Note On Gloss

The best way to measure this is with black glossy objects, using a square or rectangular light source (like overhead fluorescent lighting). If it's got any shine at all, you'll see the shape of the light reflected in the black surface. The glossier the surface, the better defined the shape of the light will be — satin is a vaguely gray blur; semi-gloss is a fuzzy/soft-edged rectangle; high-gloss is crisp rectangle with perfectly defined edges.

Gloss is created by TEXTURE. The smoother the texture, the higher the gloss. Simple, right? This is where a lot of people make a big mistake — they think they can simply put a "high-gloss" finish (paint, clear coat, etc.) on their Super-Awesome-Project™ and BAM! it'll be shiny and chrome, eternally.

Well, not quite.

Texture: Micro vs. Macro

- Texture exists on both a ***micro*** and a ***macro*** level.

There's the micro level of paint, for example — glossy paint lays down in such a way that it makes a wonderfully smooth, glossy surface. The better the paint is at this, the glossier it looks (there's a reason real automotive grade clear coat costs a lot more than the "high-gloss" clear sold in rattle cans at home improvement stores!). ...right? Again, *almost*.

Even the best paint can only do so much when it comes to smoothing things out on the *macro* level. This is the texture that exists below roughly 300 grit. If there's too much macro texture, the paint layer will still be glossy, but it will just make all the *texture* glossy.

Here's an example you've probably done yourself, or at least seen:

You want to make something a nice, high-gloss black. So you buy some Gloss Black spray paint at the store. You don't have a special place to do your painting, so you put an old, fuzzy blanket down on the ground, lay your project on top, and spray that paint.

The project looks great! Nice and shiny. But you also got a lot of black paint on the blanket — and some of it is actually kind of shiny! But most of it just looks... black and fuzzy.

Looking closely, you can see the individual fibers of the blanket are all shiny, glossy black — but stepping back just a little bit, it looks like a fuzzy, un-shiny black mess.

Why is that?

At the *micro* level — the fibers — the paint covered everything up and made it nice and smooth, creating a glossy finish. But on the *macro* level — the blanket, the paint wasn't enough to cover up all the texture — to glue the individual fibers together — so it IS black, but it's not glossy.

> ***This is true of everything, from plastic to foam to metal.***

Most gloss paint won't fill anything rougher than 220 grit sanding-lines, and most glossy paint even less. So if you don't sand enough, you'll end up with very shiny, and very obvious, texture in your paint.

Nobody wants that.

So follow the instructions on your paint. Most primer will say what grit to "finish" it to, and most good paint will say what level of sanding "prep" it needs to go down smooth and not show any lines — if paint says it only covers scratches finer than 300, then DO THAT. And make sure to sand things until they are DONE.

That will make sure you match the *macro* texture of a surface to the next *micro* one, and things will look MUCH better.

When to Polish

The only time polishing something is necessary is when you want a truly glossy surface *without* any paint or other topcoat. If you're going to paint something, there's almost never any reason to sand past 300 — and very rarely even past 220, depending on the paint.

But when you *do* want that high-gloss finish — if it's an item to be molded and cast, or some gemstones, or metal, or plastic surface — how do you do it?

You use the right materials for the job.

Rubbing / Polishing Compound

Sandpaper technically goes up in grit past 2000, but its use is exceedingly rare and specific (for example, polishing sapphire lenses in medical calibration machines). If it's necessary to smooth something past 1000, it's almost always more efficient to move onto a specialty material.

Those materials are collectively termed Rubbing or Polishing Compounds.

While rubbing and polishing compounds technically have some grit, they're never labeled with a number. Instead you'll see them typically broken down into descriptive categories.

In the automotive world you'll commonly you'll see bottles and jars of liquid labeled as:

- Rubbing Compound / Speed Compound (Semi-Gloss finish)
- Polishing Compound / Scratch Remover / Swirl Remover (High-Gloss finish)

In the jewelry and fabrication worlds you'll see them referred to as "rouge" along with a color, which come in solid, chalk-like sticks or pads. The different colors correspond to the degree of polish (but colors are somewhat inconsistent, so always check whatever you have to see which order to go in).

In the plastics world, the most common polishing "system" has 3 stages:

1. **Heavy Scratch Remover**
2. **Fine Scratch Remover**
3. **Plastic Cleaner / Polish**

Heavy remover and Fine remover are functionally almost identical to the automotive Rubbing Compound and Polishing Compound, respectively. (I've used them interchangeably.)

Both the liquid and solid compounds work the same way — they're a very, very fine grit abrasive suspended in some other material, and you use appropriate tools to apply that abrasive to a surface and sand it!

By Hand or By Tool

It's entirely possible to polish things by hand. In fact, some items it's impossible to do otherwise (because of shape, or size, or something). Polishing by hand is simple — apply your Compound to an appropriate material (typically a cloth or a sponge for liquids; a buffing wheel or solids), and get to work. Follow any specific instructions on your compound of choice. (I use automotive compounds, as they're easy to get, affordable, last a long time, and are easily applied with a shop towel or rag.)

But polishing takes a LOT of repetitive work — it's one of the exceptions where Sanding Longer is always the correct way. There's no shortcut to a nice, bright polish. Except to use power tools.

Liquid vs. Solid Compound

Liquid Compounds

- Primarily used in the auto industry, where the surfaces tend to be large and mostly flat. So the tools are designed with those surfaces in mind as well — Polishers, Waxers; the names are quite literal. Both are basically sponges, sometimes with a cloth cover, that spin in a random-orbit pattern. Basically, they mimic Circular Sanding, but at a much higher speed (and with a LOT less manual labor on your part!).

Solid Compounds

- Intended to be used with specialized Buffing Wheels. The wheels are usually made of cotton cloth or batting (depending on the size), and attach to existing power tools — bench grinders, angle grinders, drills, and rotary tools. Specialized "Bench Polishers" or "Benchtop Buffers" also exist, which are just higher-speed bench grinders with buffing wheels pre-installed.

In either case, the idea is the same — move some compound across the surface to be polished really, really fast.

Different tools move at different speeds, because the surfaces (and materials) they're designed for respond better to different rates of polishing. For example, auto Waxers spin fairly slow, because going too fast over automotive paint can actually damage it. Whereas Benchtop Buffers often spin at astronomical rates, because they're intended for polishing materials like steel and precious stones — things that can be polished very aggressively without risk of damage.

Match your tools (and your speed) to the compound, and the surface you're polishing — nearly everything you buy will have some instructions.

But as a general rule:

- **Go slower on softer materials —** paint, soft plastics
- **Go faster on harder materials —** hard plastics like acrylic, cast resin, metal

As always, start "rough," then refine.

And polish until you're done.

Additive Smoothing

Sanding is, by definition, a reductive procedure — it's the process of taking material away until you're happy with the results.

But what do you do when your low points are *too* low? When those 3D print lines aren't just raised *up*, but also offset *in*? Or when your surface has imperfections you just can't sand out — holes, scratches, cracks?

Sometimes, you need to add a little material first, so you've got something to take away and smooth out.

There are many, MANY ways to accomplish this and I've decided to refer to them, collectively, as *Additive Smoothing*.

The Additive Cycle

Regardless of the substance used, the basic process is always the same:

1. **Put down MORE material than needed**
2. **Remove excess material**
3. **Repeat until new desired surface / shape is achieved**

The key is to put down more material than you need. Why? Because it is impossible to put down the perfect amount of material to exactly fill a crack, patch a hole, or make a new shape (no matter your skill level — even I do this, and I am *very* good at it).

Basically, you create new *high* points, and then knock those down to the level you actually *want*.

With more sanding.

Paint / Primer

First up is the most common method people use to cover up sanding-lines, small scratches, and sometimes pinholes — paint.

Unless you're putting the final coat on your project, you should be using Primer. It's made to stick to many raw surfaces, dries fast, and is often designed to fill small cracks and be sanded smooth. The kind of primer should match your project — there's no universal here. Different surface materials require different primers, especially if you're working with plastic or metal. *READ the labels on your paint!* They will always say what they're compatible with, and what they're not.

Primer Upgrade

If you have a lot of sanding-lines or other texture — like 3D print lines — you may want to consider Filler Primer.

Filler Primer comes in rattle cans, is typically a similar price to other "automotive" primers, and has the excellent benefit of spraying on 2-5 times as thick as standard primer. The biggest downside is that it can take much longer to dry — often over 24 hours, versus most auto primer's 2-8 hour dry time. But if you know you have a lot to cover, it will save you time — just spray one coat, then do something else!

Not all brands and products are created equal — I personally like and have used Rustoleum Filler Primer (it's readily available at nearly all home improvement and hardware stores in the U.S., and is half the price of comparable "auto" brand filler primers.

My second DO NOT BUY recommendation also happens to be for primer.

Do NOT Buy Rustoleum brand "Sandable Primer."

It's the worst paint I've ever used. EVER.

It doesn't stick to anything (worthless as primer), it does not sand — it does nothing but instantly clog any and all sandpaper it comes in contact with, and it takes 12+ hours to dry to a rubbery, tacky surface. It's garbage. You're better off using literally any other paint.

Generally Recommended (except as noted)

2K Upgrade

If you have the capacity, switching from rattle can or airbrush primer (which is all air drying, aka 1K) to a 2K (a.k.a., catalyzed, 2-part chemical system) primer is one of the best things you can do to make sanding easier.

Good 2K primer is fully cured in 2-4 hours ("curing" is based on a chemical reaction — so it's much more tightly and reliably controlled; whereas "drying" is the process of letting the solvents that keep paint liquid evaporate out into the air — a highly variable process that may take far longer). It also lays down thicker — most 2K primer acts about like Filler Primer unless it's thinned down, and sands easier, faster, with less mess, and is always wet-sandable.

Even middle-of-the-road 2K primer can make processing something like a 3D print infinitely faster — it will cover scratches up to and including 80 grit, so a rough pass of sanding is all that's needed before primer. It will stick better than most rattle-can paint, sand faster and easier, and to a higher degree of polish — all with a SINGLE coat of primer. The time savings more than make up for any additional cost.

[Note the actual volume of paint you get in a 1-quart or 1-gallon pale, compared to a rattle-can, if you ever feel like doing the price-per-ounce math; the rattle can loses almost every time.]

Urethane 2K primer is superior to Polyester 2K primer in all these areas, and despite its higher price is more than worth the upgrade. I use ***Transtar 2K Urethane Primer****.*

When using any variation of 2K primer, gloves and a chemical respirator are required PPE.

Highly Recommended (if you have the capacity)

Body Filler

A.k.a., Bondo. I literally wrote my first book, *A Robot's Guide to: Bondo*, on this stuff, and how to do everything from mix to apply to sand and shape it as efficiently as possible, so I won't go into detail here. But I'd be remiss if I didn't at least mention it.

Body filler is commonly used in the automotive and FX industries to do everything from fill low spots on plastic, resin, fiberglass, and metal; to "sculpting" entire projects before molding (see my book or social media accounts for personal examples of this). It's a plastic based, spreadable putty / filler / goop that sticks to things well and sands super easy.

If you have a shape that you need to alter, holes to fill, or surface you need to just *redo*, Body Filler is great. It cures in as little as 15 minutes (it's a 2-part chemical compound, so you can control how fast it gets hard by altering the mix ratio), and goes through several stages that, if properly taken advantage of, can cut your sanding time by 75% or more. It can be shaped with just about any tool, and is generally very user-friendly.

The biggest downside is that it's HIGHLY toxic, and wearing a chemical respirator and gloves while working with it is a requirement.

No Recommendation — if you need it, there's no substitute; but if you don't, you don't.

Spot Putty

Body Filler's little brother, spot putty comes in both 1-part (1K, air drying) and 2-part (2K, chemical catalyzed) versions. The 1K being far more common, and what I use personally.

Unlike body filler, spot putty can only be put down in very thin layers — typically less than ⅛" or about 2mm thick. But that's what it's designed for — covering sanding-lines; filling pinholes; skinning low spots just a little bit. It's not made for big fixes or filling large holes or gaps. It's great on many materials, but has little to no flexibility and tends to crack easily.

The best version is 3M's "Acryl Green" Putty. Technically just called "Acryl" because of its chemical base, since the Green version indicates how fast it dries (there's also a Red version that dries 5-10x slower, I've never heard why that's useful).

The chemical properties of Acryl Green are complex, but the main point is that it's chemistry allows it to chemically bond to many plastics, including some 3D printed ones like ABS. It also means it can be further thinned with acetone. Thinning is useful, because it can then be brushed onto a surface (using a disposable, natural fiber brush, or "Acid Brush") almost like filler primer. Doing this over a part 3D printed in ABS results in an easily, rapidly sandable layer that's chemically bonded to the raw plastic in about 15-30 minutes.

It smells terrible, and a chemical respirator is highly recommended (if mixing with acetone, it's required).

Highly Recommended

Liquid Resin Coatings

There are numerous 2-part liquid compounds that harden to a solid coating which can be used for smoothing over problem areas, or just for altering the surface to be sanded. Most include a base liquid (Part A), and a catalyst — usually referred to as an "activator" or "hardener" (Part B). Mix the correct amount of Part B with Part A, and the chemicals react over some period of time until they become stable.

Polyester Based

The *"Fiberglass Resin"* sold at many hardware and home improvement stores is typically a polyester resin (fiberglass resin isn't actually an accurate descriptor, as fiberglass can be used with ANY type of resin; but that doesn't stop stores and manufacturers from labeling things this way). Polyester based products are cheaper than similar products made from urethane or epoxy — price is their main draw.

Polyester is very stinky, and its smell may linger for days or months. A respirator is required. It sticks to surfaces simply by virtue of being decently sticky. It has a bit of flexibility, but is typically very brittle on its own. Because so many plastics are also made from a polyester base, the solvents in polyester resin will literally melt many plastics and foams — dissolving, eating, or otherwise scarring them in cool gross ways.

It sands very badly — despite being both brittle and quite hard, it has an annoying rubber-like quality when sanded, making it very challenging to remove substantial material or to get it very smooth even after the desired shape is painstakingly reached.

Generally Not Recommended.

Epoxy Based

Epoxy comes in a wider array of options than polyester, from crystal clear to opaque colors, soft and pliable to steel-like hardness, and everything in between. While it typically has little to no smell, epoxy fumes are *highly* dangerous and a respirator is still highly recommended.

Unlike many other catalyzed compounds, epoxy does not react with most other substances — even while it is still reacting with itself. That means it can safely be applied to almost any surface, even normally fragile materials like Styrofoam and other expanded polystyrene foams, or EVA. It bonds to surfaces much more strongly than polyester resin (you've most likely seen Epoxy in its glue or adhesive forms, as it's one of the most versatile adhesives in existence).

Depending on the variety of epoxy used, it can sand as poorly as Polyester or even some rubbers (if a very flexible version), or as easily as soft wood (for harder, laminating versions, many of which are specifically intended for “tooling” — cutting and sanding).

All of which makes it an ideal coating for both hard and soft surfaces if you want either a different surface entirely, or want a level of smoothness / polish that the existing surface wouldn’t normally be capable of. For example, coating EVA foam with certain epoxies can maintain most of the foam’s flexibility, and give you the ability to sand it like a hard plastic — all without adding significant weight.

> ***Highly Recommended.***

XTC3D

Smooth-On’s XTC3D is a product specifically manufactured and sold for the express purpose of coating 3D printed parts as a shortcut to removing print lines and making them smooth.

It is, in fact, just an easily mixed, “self leveling” epoxy. That means it works fundamentally like other epoxy coatings, but that it sticks well to a surface, and smooths itself out very well (that’s the self-leveling part), all while not dripping very much (drips suck to sand out).

It goes on clear, ostensibly so you can see what you’re doing, but this often makes it hard to tell how much XTC3D you’ve actually applied. Being about as viscous as honey or maple syrup, it still pools in corners and crevices — so while it may “smooth” your 3D printed parts, it will also obliterate any detail or sharp angles/lines. It does not sand very well, either, being somewhat gummy. Overall, it does a poorer job of speeding up the process of smoothing out 3D printed parts than other options listed here — Spot Putty, Filler or 2K primer, and even other epoxy coatings sold by Smooth-On are better options.

> ***Not Recommended***

Chapter 7
Sanding Specific Materials

Every material responds to sanding a little bit differently, following the rules outlined in the previous chapter, namely:

- **Harder, denser things sand better / faster / shinier**
- **Softer, less dense things sand harder / slower / less shiny**

Everything I cover in this book applies to sanding *in general*, so in this chapter I'll just point out what makes a material different, how you should change your approach when sanding it (if at all), and what tools work especially well (or not at all). I'll also mention any additional safety precautions you should follow.

Plastic

Acrylic

Acrylic is an extremely dense, rigid, brittle plastic. It comes in a huge array of colors, thicknesses, and opacities from totally transparent (like glass) to completely opaque, and is fantastic to work with. Standard Acrylic comes with a high-gloss finish, but "frosted" (matte) versions exist as well.

Acrylic sands EXCELLENTLY, and is one of my favorite plastics to work with for this very reason. Its density makes it very, very easy to deal with. It also produces sanding-dust that is more like fine sand — it doesn't float or drift through the air, so cleanup is easy. Because it starts out glossy, any sanding you do will mar the surface dramatically. If you want to get the acrylic itself back to a high-gloss shine, you will need to progress through all the necessary grits and up through rubbing and polishing compounds to do so. Although Acrylic also takes paint fairly well, so using Primer and Paint is a perfectly viable option.

- It responds well to all grits, from 80 up through rubbing compounds, and can be polished to a high-gloss, mirror-like shine with no additional coatings whatsoever.
- It takes most tools very well: sandpaper, needle files, sanding sponges and pads, and polishing compounds.
- However, it does not respond well to anything coarser than 80 grit. That means most metal files (except diamond-coated files), rasps, and similar tools won't work; they're more likely to break or crack Acrylic than sand it.

The main thing to be aware of when working with Acrylic is that it will melt when it gets too hot. Specifically, the point in contact with the sanding tool will phase-shift from falling away as dust, to a molten glob of semi-liquid plastic. This plastic is more than hot enough to burn you (it's comparable to glue straight out of a hot-glue-gun). It will also continue building into an ever-larger mess until you stop sanding it, let it cool, and remove it.

This means that when using power tools you need to keep the speeds low, or contact with the tool restricted to short bursts. For example, while Acrylic sands great with sandpaper, a Belt Sander will quickly start to heat up the sanded surface, and you'll rapidly start getting large melted chunks of Acrylic at the point of contact. If you're not careful, a power tool can fling those molten globs of plastic right off — possibly hitting you; if one hits your skin, you *will* get burned.

This can be avoided by simply removing the Acrylic from the Belt Sander (or whatever tool) when you first notice the Acrylic start to melt, letting the glob cool until it's hard and *almost cold*, and then flicking or cracking it loose. Try to remove the glob too soon, and you'll be pulling strings of melted Acrylic — like freshly melted cheese on a pizza. Let it cool completely, and if the glob is too big you'll have to cut or sand it off (Acrylic will happily meld with itself when melted).

The same is true of cutting or drilling Acrylic — keep tool speeds low so that the surface continues to grind away cleanly into dust; too fast and it will melt away instead, forming ridges and possibly undoing your work.

DO NOT rapidly cool Acrylic when it is hot! It *will* crack, or possibly even shatter. Neither looks good, and both are potentially very dangerous.

> ***Hot Acrylic also releases toxic fumes — if using power tools to sand Acrylic, it's necessary to wear a chemical respirator.***

Expanded PVC Foam, aka Sintra

Sintra is the brand name for "expanded PVC foam" or "PVC foam board" plastic sheeting, so called because it is a porous plastic, filled with small air pockets. This makes it extremely light while remaining fairly rigid, easy to cut and heat shape, and overall very easy to work with. It has a very noticeable "eggshell" texture, which can be sanded down somewhat, but not eradicated completely without adding a coating of some kind (although primer and paint are typically more than enough).

- Sintra sands very easily. Its low density and porous structure mean you can sand through it quickly and with minimal effort. It does have a very slightly rubbery texture to it when it gets hot, but because it's so porous even most power tools don't produce enough heat to cause problems.
- It responds well to grits from 80 up through Fine and Super-Fine, but beyond that the material itself is simply too grainy to be sanded further.
- It takes most tools well, including sandpaper, files, rasps, and most power tools. Even coarser wood-rasps and surform-files can be effective, though not as effective as finer tools. High-speed tools, like rotary tools and disc sanders, can melt Sintra if a single point is left in contact with them too long.

When Sintra melts, it resembles melted marshmallow — gooey, stretchy, with dozens of random strings of molten plastic if it's stretched. Edges will quickly warp and deform, spreading rapidly up to an inch or more away from the point of contact. If using a high-speed tool, use caution and avoid prolonged sanding in one area.

Because Sintra is porous, exposed edges are roughly 50% air — to make edges smooth will require sealing them. I like using Spot Putty, but sometimes primer is enough.

Sintra has just the right amount of flexibility in that it can take almost any paint, and still retain its flex without causing the paint to crack. This means it can be smoothed with primer and sanded to a high-gloss finish if you're willing to put in the work.

Styrene

The proper name of this plastic is High Impact Polystyrene, or sometimes HIPS (High Impact Poly Styrene). While "Styrene" isn't technically accurate, it's the name I and most makers use, so it's how I'll refer to it here.

- Styrene is a fairly flexible, dense but soft, easily bendable plastic with a slightly rubbery surface quality. It cuts easily, but the process of forming Styrene sheets results in a definite "grain" to the plastic, which impacts how it sands. The grain is invisible, as styrene is most commonly opaque white or black. Cutting Styrene usually leaves a raised edge bordering the cut. Sanding this ridge off can be a special challenge, because of the "grain" mentioned.
- Styrene takes most paints very well, so well that bending Styrene often doesn't result in cracking the paint as one might expect, although this varies among paints. Primer and paint are an excellent option to get a high-gloss finish.
- Styrene sands fairly well, with some unique traits. It responds well to grit from 120 up through Fine. 80 grit tends to shave off strings of plastic as opposed to actually sanding it, and Super Fine and higher have no real effect; the plastic is too rubbery to respond to such fine abrasion.

Styrene responds to most manual tools in the grit range listed above, but does not respond well to power tools, with a few exceptions. The speed of most power tools creates too much heat, causing Styrene to melt and warp in unpredictable and irreparable ways; far worse than Acrylice. The speed required to cause distortion is so low as to render most power tools pointless; although there's rarely any need for them when working with Styrene anyway.

The exceptions are powered hand sanders — Square Sanders and Random Orbit Sanders. Neither of these move fast enough to cause problems, and the fact that they really only work on broad surfaces means they're unlikely to come in contact with the small edges of Styrene — which are the areas most prone to heat-warping and melting.

Sanding the surface of Styrene is easy — simply progress through the grits mentioned as you would for most hard surfaces, but apply less pressure / use a lighter touch, as the surface of Styrene is much more prone to being easily gouged or scratched than most plastics.

NOTE: If using any polyester-based coatings to fill scratches on Styrene (non-acryl spot putty, polyester resin) additional drying time is required — often double or triple normal dry times.

Because Styrene is also a polyester-based plastic, the solvents in these chemicals will often soften the plastic, even melting it with enough exposure. But once the solvents "flash off" (dry out) everything will return to its normal, solid state.

Cleaning up the ridges left from cutting Styrene, or rounding / beveling its edges in general, poses a unique complication. To start, cut edges tend to be *sharp* — sharp enough to cut skin and slice paper if you're not careful.

The "grain" inherent in Styrene means that edges are more likely to shave off like wood shavings or peel away like loose thread, than to grind down into sanding-dust.

Sanding with 120 grit almost always results in shaving off these "threads"; 220 works better, but you can't predict if sanding Parallel or Perpendicular to the edge will be more effective — it seems to vary from piece to piece based on the invisible grain. Higher grit, as mentioned, doesn't accomplish much, as is as likely to be cut by the Styrene edge as to sand it down.

My preferred method to removing the raised edges along Styrene cuts is to start with a hobby knife.

1. I place the knife blade across the Styrene edge with the blade roughly parallel to the Styrene surface, and the blade's cutting edge at a ~45-degree angle facing AWAY from the direction I'll be moving it.
2. Then I DRAG (don't push) the knife away from me.
3. I don't try to CUT with the blade, I'm simply dragging the blade edge across the sharp / raised part of the Styrene I want to remove. This scrapes the raised portion of the Styrene off in long stringy shavings.
4. Repeat as needed until you've roughed out the curve, then move on to 220 grit to finish (if necessary — on thinner Styrene, scraping is usually all that's needed).

> ***Styrene, like most plastics, will release fumes if heated. If using power tools, a chemical respirator is highly recommended.***

Resin

Note that "resin" is a generic term — the resin used in 3D printing is very different from the urethane resin used in casting parts, epoxy resin used as an adhesive, or polyester resin used in laminating fiberglass.

Urethane Casting Resin

Most parts cast from a mold are made of some variety of Urethane Resin. The material is so fine-grained that it can reproduce every detail of the mold it comes out of — down to fingerprints. It will have the same surface quality as whatever was molded, so it can vary from rough and textured to high-gloss.

Often off-white in color, Urethane Resin is typically extremely dense, rigid, and somewhat brittle. Different formulas will have different characteristics, but the most common Urethane Resins, like Smooth-Cast 300 or Smooth-Cast 320, both from Smooth-On, are all very similar when it comes to sanding them. Those that don't, will follow the same rules outlined in Chapter 5: How Shiny Can You Make It? — softer, more flexible resins are more difficult to sand and harder to make shiny, while harder, more dense ones are easier.

- Urethane Resin typically sands excellently, and responds very well to all grits, including polishing compounds. It takes all tools well, including coarse rasps and files, and all power tools. Any tool or sanding implement will work with typical Urethane Resin.
- The more flexible varieties respond less well, or not at all, to higher grits and to high-speed tools.
- Urethane Resin takes paint very well, although paint designed for plastic or automotive surfaces works best. Primer can easily be used to achieve a high-gloss finish. Spot Putty and Body Filler are also explicitly designed for use on urethane, and work extremely well.

Typical Urethane Resin (excluding semi-rigid, flexible, and other so-called "high performance" resins) is the ideal surface to sand. No special methods, tricks, or accommodations need to be taken when working with it.

Urethane rarely releases fumes or smells when sanded, but dust is still quite unhealthy. Sanding-dust is typically light and "fluffy," and tends to both drift through the air and stick to metal and plastic surfaces because of static electricity.

> ***A dust mask or particle respirator is highly recommended.***

3D Printed Resin (DLP, SLA)

Both DLP and SLA resins work similarly, and have similar characteristics. Variations between brands of 3D Printed Resin will have different characteristics — hardness, flexibility, strength — that result in changes to how they sand. But the most common "standard" 3D Resins are similar enough to lump together.

3D Resin is most commonly used to 3D-print objects with very fine details or very smooth surfaces. It is typically very dense, quite hard, and very brittle. This makes it excellent for sanding when needed.

- Printed parts that have smooth, semi-gloss or similar surfaces can easily and quickly be polished to a high-gloss using Polishing Compounds and an appropriate power tool (typically a Buffing Wheel on a Bench Grinder or similar rotating tool), often with little to no prior sanding required.
- It takes all grits, and all tools, including power tools. However, because it is typically more brittle than most other materials, you should always use extra caution around small details and sharp edges / corners — as these are prone to breaking or snapping off. This brittleness also makes the use of coarse metal rasps and files risky — while they may still work, they are not recommended (nor should they be needed, as parts printed in 3D resin should require minimal alteration to begin with).
- 3D Resin takes most paint well, and because it is so inflexible there is little risk of paint cracking after application. However, because no two formulas are exactly the same and standards are still being developed, you should always test the compatibility between your resin and any paint you plan to use.

Most 3D Resins do not smell after proper curing, and do not release strong fumes when sanded. Sanding-dust is very fine, but tends to be easily contained.

> ***A particle respirator or dust mask is highly recommended.***

Epoxy

Epoxy resins come in a dizzying array of varieties — from rubbery glues to metal-filled adhesives with the rigidity of steel; from lightweight laminating resins for use with fiberglass and carbon-fiber to filled resins designed explicitly for "tooling" and shaping; to coatings designed to do everything from harden soft materials to simply skin flexible rubber ones. But there are 3 commonly used Epoxies.

One of the biggest potential drawbacks to Epoxy (of all kinds) is the challenge of painting it. While Epoxy can be made to stick to nearly anything, fewer things like to stick to *it*. Automotive paints are better suited, but even then be sure to check the labels on any paint you plan to use, as some will require special prep or primer to work over Epoxy.

Epoxy Adhesive

While still a whole family of its own, the most common Epoxy Adhesive is the "5-Minute" variety found in hardware and home-improvement stores. It usually cures to a slightly rubbery, glossy surface.

While 5-Minute Epoxy can be cut with a sharp knife, it does not sand well.

- It's too rubbery to respond well to grits above ~220, and grits below 120 tend to grind the surface into a rough, sandy texture full of loose bits of cured epoxy.
- Wet-sanding is possible with higher grit, but only over already smooth surfaces — large drips or similar protruding edges and sharp corners tend to rip / tear away before they sand down.

> *I don't recommend this Epoxy for smoothing surfaces, or doing anything besides gluing parts together — just use it for the task it was made for.*

> *In fact, I recommend NOT trying to sand it at all — clean it up before it cures (as per instructions), or cut away any excess after it's cured completely, using a sharp hobby knife.*

All epoxy gives off fumes that are highly toxic, even when it doesn't smell. Most epoxy adhesives smell *very* bad.

> ***A chemical respirator is highly recommended.***

Epoxy Laminating Resin

Epoxy Resin is frequently used instead of Polyester Resin when laminating fiberglass, whether for making molds or finished cast parts. This process often includes use of a "gel" or "beauty" coat — Epoxy Resin thickened with an inert filler that makes it thicker, more viscous, and easier to "tool" (cut, sand, and shape).

Both Laminating Resin and Gel Coat sand very well, though Gel Coat sands faster and easier (the fillers that make it different are used for this exact purpose). Epoxy Laminating Resin is dense, fairly hard, and moderately brittle.

- It takes the full range of grits, all tools, and can be polished to a high-gloss finish. Laminating Resin is a bit stickier and more flexible than Gel Coat, so it is slower to work with, but it still responds well.
- Epoxy Laminating Resin is harder than many other materials, so more force and/or more time are often required to get similar results. This makes it ~10-20% slower to sand Epoxy than something like Urethane Resin, so power tools are highly recommended when available — there are no downsides or additional risks to using power tools with Epoxy Laminating Resin.

While Epoxy gives off little to no fumes once fully cured, the sanding-dust it makes is very light, tends to drift long distances (across an entire garage or small workshop, especially when flung off by a power tool), and is *highly toxic* — if it gets into your lungs, it will be there until the day you die.

> ***A particle respirator or dust mask is required.***

Epoxy Coatings

In Chapter 6: I discussed XTC3D, which is an epoxy coating designed for smoothing out 3D printed parts. Other Epoxy Coatings exist for coating foam, rubber, latex, and most other materials. They vary from ultra-dense and rigid to highly flexible.

Like all the materials covered here, the more flexible coatings are harder to sand and harder to make shiny. Flexible Epoxy Coatings are easier to sand than similar Urethane Coatings, however, and often respond well to high-grit and/or wet-sanding.

Many Epoxy Coatings continue to release fumes for days or weeks, and sanding dust is *highly toxic*.

> ***A chemical respirator is highly recommended.***

Polyester Resin

Commonly sold in hardware and home improvement stores as "fiberglass resin" or "laminating resin," Polyester Laminating Resin is much cheaper than Epoxy Laminating Resin. It stinks like hell for weeks or months, melts any polyester-based materials on contact (most rigid foams, styrene, some 3D printing filament, Styrofoam), and sands like old tree sap.

> ***I DO NOT recommend using this stuff for anything that needs to be sanded to any kind of nice finish.***

If you're unfortunate enough to need to sand Polyester Resin, stick to low to medium grits (80-220), use rigid tools as much as possible (sanding sticks especially), and power tools when available.

Polyester Resin always acts somewhat tacky during sanding, no matter its age. This can be made worse if it's not properly catalyzed during application, but not improved. It is both extremely brittle (tends to crack and snap off at sharp angles when stressed) and rubbery (when sanded). Sanding actually removes some of this tackiness and helps make the surface easier to deal with, but it will clog sandpaper and tools very quickly. Do not attempt to stretch the life of this paper, simply accept that Polyester Resin will eat it.

If you really need to, here's how to make Polyester Resin actually look good:

1. Once you've sanded to 220, *stop*.
2. Dust off the sanded Polyester Resin, grab some Super Glue (liquid cyanoacrylate, aka CA — the "thin" or "fast" variety if you have it, NOT the thick gel variety), and put on rubber gloves (new ones without holes in the fingers — you should be wearing them already!).
3. Grab some scraps of paper towel and have them within reach.
4. DO NOT place your head directly over the surface for the next steps! Things will go badly for you if you do.
5. Put some CA on the surface you just sanded — enough that when spread around it will coat the whole surface, but not so much it drips off.
6. Use your GLOVED finger to spread the CA over the surface, keeping it thin. You'll need to do this FAST, as cyanoacrylate loves polyester resin (and fiberglass) — it will react almost instantly, getting hot, and releasing tons of noxious fumes. If you're not wearing a chemical respirator and safety glasses, you MUST to do this where there is not just ample airflow, but an actual breeze. The fumes can burn your eyes. Yes, really. Use a fan if necessary.
7. Grab a scrap of paper towel and wipe the surface off FAST — going one direction, without scrubbing. You want to remove any excess CA that was still pooled on the surface; but CA loves paper even more than Polyester and will grab onto it almost instantly if given the chance.
8. Double-check that you don't have any CA drips and didn't get any CA elsewhere, especially that you didn't leave any fingerprints with your CA covered finger.
9. Hit the surface with some CA accelerator if you have it. Otherwise, let it sit to dry completely.
10. Your surface is now completely sealed, and shiny! But not ready for gloss — any sanding texture is still present, remember?

At this point, you can sand some more — sometimes this will reveal high spots, or bits of fiberglass that you thought were just dust will be sticking out ready to stab you. Or you can give it one more light scuffing with 220 and move on to Primer (or Spot Putty or another surface coating).

I do this to the flanges of mold jackets I make, to make sure there's no loose fiberglass left to impale me, and on some props to seal in the polyester smell. (This process also 100% locks away the awful polyester stink permanently!)

Because Polyester Resin is almost always used in conjunction with fiberglass, you will most likely be sanding through that as well.

> ***If sanding by hand, protective work gloves (rubberized fabric, or leather or canvas) are highly recommended.***

> ***If not, then rubber (nitrile or latex) gloves are required.***

> ***Protective eyewear is required.***

> ***A particle respirator or dust mask is required, and a chemical respirator is highly recommended.***

Performance Resin

So-called "performance resins" exist in a huge variety, but most of the time what's meant by "performance" is something that will take a lot of abuse. And most of the time *that* means they're more flexible — since something that bends before it breaks is less likely to break when dropped, hit, or mishandled. Performance Resins can be either Urethane- or Epoxy-based, but fill similar roles.

It's tough to generalize Performance Resins because they exist in so many forms, but the general rules about Density and Flexibility still apply. So, most of the time, these are difficult to sand. Some are nearly impossible.

When evaluating a Performance Resin — the more it *feels* like rubber, the more it will *sand* like rubber (i.e., badly). Surface feel is typically more important than the actual degree of flexibility or traits on a chart. Ask for samples, and give them a scratch with your fingernails — you'll be able to feel if the surface responds more like rubber, or like hard plastic.

Smooth-On, for example, produces the "Task" series of resins — most of them are categorized as "semi-rigid urethanes," meaning that they're not completely rigid once cured, but remain somewhat bendy. Most of them are VERY bendy. They're still different from a urethane "rubber" because they do not stretch — you *can't* pull them apart like elastic, but you *can* bend them like a metal spoon. Most of the Task series is notoriously difficult to paint. (The chemistry required to get the traits they have makes it hard to get paint to even stick.)

Despite not being fully rubber-like, they do have a rubbery surface — the flexible Task resins sand about as well as a bicycle tire. It can be done with lots of patience and some high-grit wet-sanding, but it is tedious work.

The harder Task resins sand more like Epoxy Laminating Resin — they're often dense and hard, so results (once achieved) are excellent, but they still have a slight rubberiness that makes sanding them far slower than standard urethane resins.

Fiberglass

Many resins, especially Epoxy and Polyester Laminating Resins, are used in conjunction with fiberglass in the production of molds, props, tools, and structures like boats or auto body parts. Because of this, you'll often be sanding *both* Resin and Fiberglass at the same time.

Resin-coated fiberglass can be razor sharp, and snag skin and cloth as easily as a sharp sawblade. It will cut you, stab you, and scratch you. Little pieces may fly off and try to blind or maim you. Fiberglass splinters are common. Fiberglass sanding-dust is actually tiny glass shards that may give you splinters or, at best, make any exposed skin extremely itchy.

Here are some tips to deal with all that.

- **Wear PPE.** Rubber gloves, protective eyewear, and a particle respirator or dust mask are required *at a bare minimum*. Heavier work gloves (leather, canvas, or rubberized) are highly recommended. A chemical respirator is also highly recommended — Polyester stinks and release noxious fumes.

- **Wear Long Sleeves, if practical.** Preventing exposure to as much fiberglass as possible is the best option. Remember that your clothes will be covered in tiny (often invisible) glass splinters — don't bring them into your house, around children or pets, or anywhere they could transfer to sensitive areas. Dust them off somewhere safe, and change clothes after working with Fiberglass if possible. Many pros use coveralls to help with this.
- **If Long Sleeves aren't an option, coat your skin with Baby Powder.** Yes, really. You can also use Talc, Corn Starch, or anything else similar. The fine powder will settle into the same places on your skin that Fiberglass "dust" would, effectively displacing it. This is an incredibly effective option commonly used in FX shops.
- **Use tools instead of sheets of paper whenever possible.** Fiberglass tears and shreds sandpaper like… paper, and you'll burn through it simply because it keeps falling apart. Using tools also puts that much more distance between your hands and the flesh-seeking splinters and razor sharp edges of cut or broken fiberglass you're probably sanding, making it a little less likely you'll end up with splinters or scratches.
- **Use power tools.** This just cuts down the time spent sanding Fiberglass. Which you want to do, because sanding Fiberglass sucks.
- **Contain your dust.** Use whatever means you can to keep Fiberglass sanding-dust contained. This stuff is murder on your lungs. (It's literally shards of glass, remember? It can slice up sensitive lung tissue, and will stay inside you forever — your body can't break it down.) Clean up the dust, and yourself, as soon as possible (while still in all your PPE!) to avoid spreading it around later.

If you can't tell — sanding Fiberglass sucks. But sometimes it's necessary. It's easily one of the most dangerous materials on this list based on exposure-through-sanding, so please, be careful.

3D Prints (FFF / FDM)

Layer lines — we all hate them. How do we get rid of them?

Here are some common tips that should work regardless of the particular filament (plastic) your part is made of.

1. **ALWAYS sand first; never go straight to coating / primer.** This should go without saying, but you should always sand your project before adding Primer or another coating, no matter what it is. This is doubly true of 3D prints, which have a combo of both *high* and *low* spots (print lines are rarely just one or the other). If you *know* you have high spots to sand down (and with 3D prints, you do), there's no reason to waste time *adding* material to sand off before you even start.
2. **Start with 80 grit.** ***Maybe 120.*** Again, you know you'll need to take down some layer lines, don't waste time trying to make something smooth before the basic shape is even right. Unless you have an exceptionally nice or finely tuned printer spitting out truly clean parts with a layer height below .2, start with 80. If the part *is* that clean, or very detailed, start with 120. NO HIGHER.
3. **Move on immediately to filling.** Just like the previous step, but in reverse — if you *know* you have low spots that will need filling (and with 3D prints, you do), there's no reason to waste time trying to sand down to their level. Just get those low spots filled. The best option is 2K primer — it will fill 80 grit sanding-lines instantly, and can be sanded all the way to a high-gloss, no further rounds of "primer, sand, repeat" necessary; just sand until completion. Next best is either Spot Putty or Filler Primer — my preference is Spot Putty, because it dries faster and I have more control over where it goes, so I don't need to slather it on the WHOLE part unless I want to. Regular Primer is also an option, but it doesn't fill much.
4. **Sand again with 120 or 220.** If you know you're still working on those lines, or if you put down any of the recommended fillers, start with 120 — you're not smoothing out a surface yet,

you've still got material to remove. If you put down regular Primer, or you're at the "check how smooth things are" stage, 220 works.

5. **Evaluate.** Look at your surface — can you see problems? Does it feel how you want it to? If it does, move on in grit and finish it up! If not, repeat the last 2 steps — fill, and sand, until it *is* good enough.

Pay attention to small details. It's easy to accidentally cover small details with Fillers, so keep an eye on them. Clean them off if you can, and sand them back to the correct shape with every pass. Focus on FILLING low spots, as opposed to sanding AWAY material. Avoid sanding into the plastic itself or you'll lose detail and fidelity quickly.

Use *Diamond-Coated* Needle Files (_not_ etched / grooved ones!). The grit on Diamond-Coated Needle Files will actually *sand* the soft plastics used in 3D printing. Whereas the coarse lines and grooves that make standard files abrasive will do little more than scuff the plastic and (with enough time and labor) knock down the highest of high points.

Needle Files just work *better* on plastics like those used in 3D printing. Besides being more efficient, they're better at sanding into small details (since you have lots of little grit, instead of a few coarse lines), will give you a better finish, and come in different grits (up through 400!).

PLA

> ***"PLA sands like a brick."*** **—** Harrison Krix, *Volpin Props*

It does. It really, really does.

There are few materials that sand as poorly as generic PLA. It's tough, but has a rubbery surface. It scratches easily, but doesn't abrade well. Plastic bits will shave *loose*, but not come *off*. Sanding PLA typically results in an ugly, scratchy, *fuzzy* surface that may technically have fewer highs and lows than it started with, but is hardly a significant improvement.

The first time I had to sand a PLA printed part, I nearly gave up on 3D printing forever. And I routinely spend hundreds of hours sanding projects before they're finished. I hate this stuff even more than I hate Polyester Resin.

So, how do you handle this obnoxious material?

1. **Start with 80 grit.** And sand harder than normal. You need to be really aggressive with PLA, it will fight you at every step. It's going to get fuzzy / scratched / messy-looking. Accept it, then move on.

2. **Move on to 120.** I know what I said above — PLA is a jerk, so this is what you do. You've got to try and remove some of that horrible fuzz you just made using 80 grit. 120 is how you do it.

3. **Add Filler.** If you want your PLA print to be smooth and clean, this is NOT OPTIONAL. The same recommendations as above apply. If you only have ordinary Primer, prepare to repeat this process. A lot.

4. **Evaluate, then Sand Again.** You're trying to decide if that awful fuzz is completely sealed under your Filler yet. If it is, you *may* try 220, but I recommend you use 120 for at least the first 2 rounds of this.

5. **Repeat.** If you can use 2K or Filler Primer, you should only need to do this once — Sand, Fill, then Sand until Done. If you're using Spot Putty, you'll probably have at least 2 rounds. If you're using ordinary Primer… expect a minimum of 3 rounds. I won't give you a maximum number — it could be 5, it might be 15. Like all sanding — this process isn't done, until it's DONE. And however many passes it takes is *what it takes*.

ABS

ABS is GREAT. It sands like a softer (but not more flexible) version of Urethane Resin or Acrylic, with nearly all the perks of either (probably because it shares many chemical traits with Acrylic). It's just soft enough that sanding it takes little physical effort, but not so soft that it acts rubbery like PLA or simply scratches like Styrene. It makes sanding dust like Acrylic does — fine but heavy, so it doesn't drift through the air. It responds to all grits and tools but, like Acrylic, will melt if heated too much from friction.

The only specific thing to keep in mind when sanding Acrylic is that it can melt if overheated — so keep power tools to lower speeds, or use them in short bursts to minimize extended contact.

It takes all grits, all tools (with the exceptions noted already), and takes paint extremely well. ABS is, hands down, the easiest 3D printing filament to post-process (sand, and everything that comes after).

- When using Fillers, especially Acryl Spot Putty, allow extra time for the putty to dry. Acryl Green and ABS have a similar chemical base, and the thinners used in Acryl Green will soften or melt ABS. Simply give it adequate time to dry (roughly 1.5x the normal), and everything will return to a stable solid.
- The same is true if using acetone for anything involving ABS. Acetone will melt ABS, and while it will quickly dry on the *outer surface*, ABS can soak up a lot of solvent, meaning it may actually takes hours or days for the acetone to completely evaporate. Acetone vapors can cause problems with paint, mold materials, and lead to warping and cracking of printed parts if it's extreme enough.
- If you thin Acryl Green with acetone and apply it to ABS prints, be more careful than normal to keep your layers thin so that everything dries quickly.

PETG

> ***"I don't have to change any of my tools or technique [from ABS]."*** — Michelle Sleeper, *Overworld Designs*

This stuff has a growing reputation as some sort of "wonder" material — it's supposed to print as easily as PLA, but sand as easily as ABS. I've never worked with it myself (I print exclusively in ABS), so I conducted a survey of other skilled, experienced, professionals whom I trust.

And by most reports, the reputation is deserved.

> ***On a scale from 1 (PLA) to 10 (ABS), PETG is about a 7. It sands very much like ABS, just not quite as easily. And unlike PLA, it doesn't require any special methods or excessive ~~frustration~~ patience.***

So if using PETG, simply follow the same methods you would for most other plastics, but have a little more patience.

Seaming 3D Printed Parts

This isn't strictly a sanding-specific topic, but comes up a lot when trying to make 3D printed parts look clean:

> ***"What's the best way to put 3D printed parts together so that they LOOK GOOD, and CONTINUE to look good?"***

You can, of course, glue them together with any number of things. Super Glue (cyanoacrylate) is often a great choice, especially for smaller parts, or anything that won't move much (like statues or display pieces). Epoxy is also common, but tends to add a lot more material between parts and oozing out of seams, which may not be ideal.

There are amazing industrial adhesives, like Methacrylate, that will chemically bond ABS to itself in just a few minutes, but those are more costly and require special applicators.

> *If you've got the resources, I can't recommend **Methacrylate** enough.*

For most purposes, and any budget, the best method is to literally weld the parts together.

This is easier than it sounds.

1. **Tack your parts together using CA —** it's fast, and takes up almost no space; but keep the amount of glue small, you don't want it oozing all the way to the edges if you can avoid it.
2. **Grab some scrap filament.** This works with any filament, since they're all quite literally designed to be melted down and stick to themselves.

3. **Grab a Soldering Iron, Hot Knife, Wood Burner or similar tool.** (If you don't have one, the [cheapest budget wood burner you can find] will work great, and is usually under $10.) These all do the exact same thing — make the tip HOT. Use a point that you don't mind dedicating to this purpose forever — it's going to get covered in plastic and generally be useless for anything else after this.
4. **Using your Hot Tool, melt the edges between the parts.**
5. **While the edges are still melty, start melting your filament into the seam.** Try to lay down excess filament, so that when you're done you have a ridge instead of a valley.
6. **Continue until welded together.** That's it. Getting the technique and flow of the process will take some practice, and every material is a little bit different, but what you're doing is melting the two previously distinct parts, into one piece, using extra filament to fill the gap.

   You're welding. With plastic!

If you successfully created a raised weld along the length of your seam, you can now sand it down the same as you would anything else! This will leave you with a seamless surface, made all of the exact same material.

The advantages of this approach over other methods include, but aren't limited to:

- **Zero risk of shrinkage:** Shrinking can lead to warped, twisted, or cracked and broken parts. Unlike chemical welding (for example, using ABS and acetone slurry), which may lead to shrinking as solvents evaporate out of the material over time, Plastic Welding only uses solids; there's nothing to shrink.
- **Zero risk of cracks due to different expansion rates:** Different materials expand and contract at different rates when they get hot or cold, sometimes this difference leads to stress at the seam, and can lead to cracking. Sometimes cracks appear right away, and can be fixed; sometimes they don't appear until well after final paint is done, at which point repairs are painful and frustrating.
- **Greater Strength and Stability:** Nothing is quite as strong as having a single, unbroken piece of material. No matter how sturdy your adhesive is, any place you have a difference in structure (like seams) is a weak spot. Keeping the same, continuous material is the single best option to avoid stress fractures or breaks.
- **Best Cleanup Options:** You just made your surface all the same material! No need to deal with differences in hardness or sanding technique because of a different material in one spot — it's all the same, and you can treat it that way.

You're certain to actually burn some plastic, creating smoke, and if you hit any CA you'll release some really noxious fumes that can chemically burn sensitive tissue (like around your eyes and *inside your nose*).

> ***This will release more than just plastic fumes, so no matter what your thoughts on the safety of 3D printing, a chemical respirator is required.***

XTC3D

I don't like this stuff, but it's designed for smoothing out 3D Printed Parts, so it gets a spot in this section.

I covered this specific epoxy resin coating in detail in the Chapter 6: XTC3D sub-section, so if you'd like the full breakdown of why it's not worth your time or money, give that a read. Otherwise, simply stick to more useful materials for smoothing your 3D Printed parts — Spot Putty and Filler (or 2K) Primer.

> ***Not Recommended.***

Foam

AKA EVA foam, Craft Foam, Foam Rubber, etc. There's actually a whole family of different "foam" materials and rubbers, with some really wildly different chemical makeups and properties, but most of the time you either won't know what the specifics of your foam are, or won't care. If you do…

then it'll be easier to replicate results later on once you've got a system and techniques down. But similar advice applies across the board.

Foam is flexible, bendy, porous, pliable, and squishy. So right away you should be assuming (since you read the General Rules at the start of this chapter, right?) that it's just *not* going to sand as well as anything else. Because it won't. Physically, it simply *can't*. It's not physically possible to make foam look like a plastic or body-filler'd surface.

Most of the time, that's not the *point* of foam, so it doesn't matter! Instead, you just want to make foam look as smooth as it *can* look. And for those of you who really want to make it shiny, there's still hope.

But if you're holding your breath, waiting to know...

"How do I make foam look like chrome?!"

Depending on your experience, the answer may, or may not, surprise you:

You can't.

Sorry to break your heart.

Now, before you start writing me angry letters, it is *technically possible* to put chrome and chrome-like surfaces on foam, and sometimes to even still have it stay foam-like (bendy, soft, etc)! But it takes specialty chemicals, processes, and equipment. Anyone who tells you "it's easy and cheap!" is lying, or has forgotten that they invested in the necessary setup, tools, and chemicals for something *else* already. It's not something most people will ever have the capacity for — and it has almost nothing to do with smoothing or preparing the foam itself, anyway.

So how do you make Foam look as good as you can, without all that? I won't cover how to cut, shape, or glue Foam despite the fact that all those things contribute to having "nice", "clean", "smooth" seams, and seams are the most common problem-area. Basically, you need your construction to be on-point *first*, or else very little I say can help you.

The following advice applies to MOST Foam but is not universal, since every brand, distributor, and even density of Foam acts a little bit different. But they are the best place to start — adjust and adapt if necessary.

- **Shape with 80, but expect it to be messy** Both in terms of dust flying everywhere, and in all the harsh sanding-lines you'll make, and all the ragged bits of foam that will stay attached to those sanding-lines — coarsely sanded Foam will be *fuzzy*.
- **Foam doesn't respond great to 120** You'll likely still need it, just to get rid of all the fuzz, but don't spend much time here. Unlike most other things, where 120 is your bread-and-butter grit, on Foam it's barely a stepping stone. Knock off that fuzz and keep moving.
- **SOME Foam responds well to Heat** The fuzz on some Foam will practically disintegrate under direct flame. HD Foam from SKS Props is one example. Some will *not*. If you have a butane, propane, or similar controlled torch, it's a great tool to try. Aim the flame ACROSS the fuzz, not directly at it, and keep the flame MOVING. It takes a lot of heat to actually burn Foam (which is what you're doing) and actual fire does that very quickly, so it works great — but linger too long and you'll burn the surface instead (you *don't* want that).

  NOTE: This is NOT the same as "heat sealing" Foam! At this point you're just removing the annoying fuzz you made sanding.
- **Foam responds well to High Grit** Fine to Super Fine actually works well! Denser foam sands better (of course), but even the softest will clean up quite well with 220, and ALL of them wet-sand well above that.
- **Foam responds well to High Speed** power tools, especially rotary tools, are GREAT for foam. Put on your smoothest grit sanding drums or belts, and go to town. The heat created (and Foam *will* get hot) typically helps, instead of hurts, this process.
  - Many people use sanding drums that have been ground smooth — some even going so far as to intentionally grind the grit off.

- Alternatively, use those "stone" bits that you've never found a use for. They work excellent for smoothing out foam this way as they have very little grit and can take the heat very well.
- Belt, Disk, and Random Orbit Sanders all work great as well with 220 or higher grit to smooth Foam.

- **Sand in one direction as much as possible —** This is one of the biggest reasons power tools work so well. Foam doesn't grind down like harder substances do — you're essentially peeling off small bits because it's so rubbery. So sanding in the typical "back and forth" or Circular motions just squishes bits of Foam around, and moves the fuzz from side to side — like grain blowing in the wind. Go one way, and it'll come off *much* faster and cleaner.
- **Use Sanding Sticks** — These do 2 things:
  - Give you a much longer surface to sand with, making it easier to sand one way.
  - They're hard, so you get to sand a soft surface with a hard thing, which is infinitely more effective than mashing 2 soft things together. You need to force the Foam to move enough that you take some of it *off* (i.e., to sand it), and that gets easier the less your tool bends to accommodate the Foam.

Foam "Chastity Belt" prop by [SoloRoboto Industries]
Note that it looks like aged metal, *not* chrome!

- **Use your Rotary Tool AGAINST the spin —** You'll get very different results if you're sanding "with" vs. "against" the spin of the tool. "With" means you're moving the tool such that, if you let it go, the tool would roll in the same direction down your Foam as you're moving it. "Against" is the opposite — you're typically pulling the tool counter to the direction of spin.
  - Going "with" seems easier, but tends to not remove enough material to do more than make the foam fuzzy. And if you go over an edge / across a corner, you're almost guaranteed to catch it and *whip* that Foam right out of your hands — and wreck that corner, as well.
  - Going "against" is potentially more risky, as it will remove Foam must faster and mroe aggressively. But it will also give you the greatest control (once you learn to exercise propper control yoursel), as well as the cleanest results. *Don't be afraid to practice!*

- **You can Wet-Sand Foam —** Yes, really! Now, not everyone likes the particular finish wet-sanded Foam has. I do, and I highly recommend it.
  - The "trick" is to not use water — use rubbing (isopropyl) alcohol. 90% if you can get it. Most sandpaper won't survive very long soaked in alcohol (it'll eat the glue), and almost no Sanding Sponges / Pads will (they expand, crack, and never quite return to normal), so your paper *will* die even though you're just sanding Foam.

Specialty Coatings / Fillers

Since Foam itself is such a pain to get smooth, there are a handful of specialty coatings that will make getting a smooth surface *much* easier.

Epoxy Coatings

I've covered these already, but they serve a sort of dual-purpose here. Essentially, they put a hard(er) surface on top of the Foam — one that you CAN sand nicely. Most are quite rigid, so you will lose some (if not all) of the flexibility of Foam. Even those that *bend*, do not *stretch* (these are different things — a paperclip can bend, a rubber band stretches). So you get a surface you can actually sand to a high-gloss, and you change one of the basic characteristics of Foam (how much it moves).

Both Smooth-On's Epsilon, and Epsilon Pro are ***highly recommended*** for this purpose. The Pro version has more flex to it once cured, but can be a bit harder to get smooth as a result. Depending on your goals, either can work very well, and they're very easy to use. Mix as per instructions, then apply with a brush or one of those foam craft brushes, and let cure. Then sand away!

Creature Cast

This is a specialty FX material, designed explicitly for coating Foam and Rubber of all kinds. It's essentially neoprene rubber in liquid, water-soluble form. You can brush it or spray it on (using an airbrush, even), and you can sand it once it cures. It's theoretically possible to smooth it with acetone as well, but I've had mixed results with that. It sticks to Foam exceptionally well, and is literal rubber. It comes in 3 different levels of rigidity — the most rigid being the easiest to sand (obviously).

Being literal rubber, it sands much like Foam does, but it is so finely grained, and it responds to wet-sanding so much better, that it's entirely possible to get a glossy finish with Creature Cast. NOT a high-gloss finish, but close.

- Do NOT sand wet-sand with water, as it will break down into an ungodly mess. Use alcohol as you would for Foam. Otherwise, follow the general tips above for hard surfaces, but be patient — it's still rubbery.
- It paints well, but keep in mind that any paint will still need to handle whatever degree of flexibility your project has.

Rapid Fill & Fine Finish

Made by Prop Monkey Studio, this stuff is basically very thin Foam Clay, watered down. It will stick to Foam extremely well, dries quick, and sands *super* fast.

The creator also has an excellent set of videos on exactly how to use it, so I won't go into depth here — just watch those.

YouTube.com/user/thearrogantartist

> *This is my personal favorite surface coating for foam. It comes in 2 "levels," with very self-explanatory names.*

- The ease with which this stuff sands is probably its only "downside" — until you get used to it, it's very easy to sand it off your surface completely. It does sand easier than most foam, meaning it's possible to sand it *out* of a messy surface, leaving the surface exactly as it was *before* you applied it. Start slow, follow the instructions, and work your way up to the shine you like.
- Start with the Fine version. Most people won't need Extra Fine. Brush it on, let it dry, and sand it down with 220 or higher. It responds very well to sanding sponges and pads, up to and including Super Fine.
- When wet-sanding these, a little water goes a long way. Start very slow, sand very lightly, and check your work often — at least until you get the hang of it. The Extra Fine comes off even quicker than the Fine, and it's easy to strip it from a surface entirely with a little water and some elbow grease, especially if you've been sanding Foam all day and are used to that.

Body Filler

There aren't any real tricks to sanding Body Filler, as it's essentially the ideal hard surface, and responds to every tool, grit, and technique there is. If there were a "standard" surface that this book was written for, Body Filler is it — everything else is essentially described in comparison. So all the general advice I've put in here applies.

So why does it get a section? Because it's technically its own material, with its own quirks — *especially* when it comes to applying and using the stuff (and also because if I left it out I know I'd get asked "why?"). But going into detail on that is well outside the scope of this book. In fact, I've written an entire other book on the subject of Body Filler, so if you plan to use it I highly recommend you grab ***A Robot's Guide to: Bondo***.

> *If you want a recommendation, I like* ***Evercoat Rage****.*

Star-Lord Helmt prop by SoloRoboto Industries
This whole thing was made almost entirely from body filler!

Chapter 8
Tools

The following is a list of tools, with notes on what they're good for. These aren't ratings or rankings — I'm not saying there's a "best" tool for something — just descriptions of what tasks / materials a given tool is suited for. "Good" doesn't mean a tool is better than another, just that it does that thing well. Similarly, "Bad" doesn't mean the tool is bad, just that it does a bad job at that particular thing.

I split tools into Hand and Power categories. Nearly every Power Tool is just a faster, motorized version of an existing Hand Tool — they do the same things that Hand Tools do, just *faster*. Power Tools are never necessary. In fact, *none* of these tools are! But they will all make sanding easier, faster, more efficient, or less frustrating; often all four.

Descriptions are intentionally brief. If you want to know how a particular tool works — and I haven't covered it elsewhere in this book — type its name into Google and you're sure to find plenty of instructions and advice.

Section titles in this section are also PRODUCT LINKS — never say I don't try to make things easy!

> *Where I can, I've provided **links** to the specific tools I've either used or actually own myself. (Those notes will look like this.) If I don't have a specific recommendation, I've tried to at least provide links to searches that will point you in the right direction.*

Hand Tools

Sanding Blocks

Essentially anything you can slap a piece of sandpaper on to make your work easier.

"Automotive" Blocks

Automotive Blocks come in different shapes, with different traits, for different purposes. Most will be the width of a Roll of sandpaper, but you can cut Sheets to fit. Typically rubber, with different degrees of hardness for different tasks. Some have clamps to hold paper, others have nothing and are intended for use with "sticky-backed" Rolls. May have a soft foam side for a little extra cushion to shape smooth curves; or not. Usually about the size of your hand, but may vary.

> *I recommend you visit a local auto-body supply store (not a chain "Auto Store," but a place that just supplies paint and auto-body tools), and look at what they have on their shelves. You'll get a better idea of what's available, and you can FEEL the blocks before buying.*

Best For: sanding gentle or large curves; mostly-flat surfaces; any time you want something more rigid than a Tri-Folded sheet of Paper but don't want the rigidity of a wooden block.

Less Good For: soft curves; complex / small shapes or curves. They are typically too rigid or large for this.

Sanding Sponges

As the name says — sponges covered with sanding grit. Typically about the size of ⅓ sheet of paper, sometimes with different angles but most commonly square blocks. Available in grits from 60 up through 1000, but most commonly 80-220, with grit on 4 of their 6 sides.

Sponges will clog *much* faster than paper, and cut slower than good paper at the same grit; they act like paper of the next highest grit category, despite making sanding-lines and smoothing at the listed grit. But their size and squishiness still make them extremely useful in many situations, and having both raw and gritted corners is great.

Higher grit (over 220) often clog up too quickly and sand too slowly to work well for very long.

(Low Grit) Good For: Low grit sanding when you don't want to change the shape very much (i.e. 3D prints or coated objects you want to hit with 80; Primer)

(Medium Grit) Good For: Further smoothing soft curves and shapes. The give of sponges makes for a nice middle-ground between Paper and Sanding Blocks /Sticks.

(High Grit) Great For: Cleaning up flaws in primer / paint; smoothing fine surfaces; wet-sanding smooth curves.

(Fine Grit) Great For: Sanding soft curves, rounding corners, similar soft shapes; any time you want the cutting speed of Paper but with just a little more give so you don't have to focus so close on keeping the surface shape the same. These make Fine+ sanding much easier, both in terms of physical work and mental effort.

Sanding Pads

Cousins of the Sanding Sponge, these are spongey pads usually ~ 6" square and ~¼" thick. Typically with grit on just one side, ranging from 120 up through Micro Fine.

Because they're thinner, they're much softer and more pliable than Sponges, but with similar give and fluff to them, they're closer to Paper than a Sanding Sponge. Being in the middle makes them exceptionally useful. Their squish gives you a literal buffer between your hand and the surface, which also means you've got a mental buffer — you don't have to pay as much attention to every stroke, you can just *keep sanding*.

> *My favorites are **3M's Fine and Super Fine**, cut in half so they fit in the hand better.*

> *I also keep a small stash of **Tamiya** brand ones, as those come in specific grits (600, 1000, 1500), but cut much faster than similar grit paper. The 1000 and 1500 sand Createx's "Wicked" / "Auto-Air Colors," as well as Tamiya's own "Fine Surfacer" Primer exceptionally well, even without water, practically erasing drips, dirt, and other imperfections that make their way into paint, in seconds.*

Custom Sanding Blocks

Anything you can put sandpaper on can be a Sanding Block — blocks of wood, metal, plastic, whatever. Anything that is flat, square, and as precise and smooth as possible will work — the more precise the block, the more precise the jobs it can do.

Sticky-back sandpaper is ideal for these — just slap it on! (it also tends to be removable if you want to, making the sticks re-usable when paper wears out). If you don't have it, you can use spray-glue (3M's Super 77 is common and affordable), or tape the paper down at each end. Whatever you do, make sure it's not going to fly off when in use or snag too easily and frustrate you.

> *I keep a few hardwood blocks (scraps of old furniture) around for this use. They vary in size from a few inches across to the size of a 2x4. Another well-known pro uses an old **chunk of aluminum**. Acrylic plastic also works well since it's perfectly flat.*

Great For: Precise sanding on hard curves, flat edges, sharp corners.

Good For: Hard curves; any time you want a truly hard tool to work with.

Sanding Sticks

Handmade sanding sticks are basically smaller sanding Blocks. They work like files, except in whatever size and grit you want.

The most common base are wooden "*mixing sticks*" or "*paint sticks*" as they're a great size, shape, have a bit of flex to them, and are cheap.

Tongue Depressors or *Popsicle Sticks* also make for great, smaller-sized sanding sticks, and are easily cut to different shapes — like 45-degree angles for getting into areas or making the Stick just easier to hold.

> *I like to wrap* ***sandpaper*** *¾ of the way around my sanding sticks, and trim the paper completely flush with the bare side. This gives me 2 flat sides, 2 corners to sand with, and one bare edge in case I want to sand just one half of an inside corner (put the bare side against the surface you don't want to sand, and you can sand the other without worrying if you're moving the corner or changing the shape too much).*

> *With Popsicle Sticks I like to do the same, but trim the paper flush around one curved side, and cut the other end at a 45-degree angle. This gives me a flat center, and both round and pointed ends to work with, depending on the task at hand.*

> *I also routinely use wooden* ***Coffee Stir Sticks*** *— at under ¼" wide they perfectly bridge the gap between Popsicle Sticks and Sanding Twigs.*

Great For: Almost everything. You should be using these as frequently as you do bare sandpaper; if you're not, you're wasting time, energy, and wearing yourself out.

They're easier to hold, and can be used more efficiently than sandpaper. Think in physics terms — your hand covers X distance with each arc you make, determined by the distance from your wrist to the edge of the sandpaper.

Sanding sticks cover a longer arc — the distance is from your wrist to the end of the Stick — so they can sand *more* material with every stroke, or do the *same amount of sanding* with *less* work.

Good For: Foam seams. The size makes them ideal for this, and you can choose the grit. Infinitely easier than cleaning up seams with just paper.

Not Good For: Soft curves.

Emory Board

Basically the same as (often literally identical to) disposable nail files — the kind used to sand and shape fingernails.

Usually about ½" wide by 4-6" long, with curved ends. Typically made of layers of plastic and foam with grit on both sides (sometimes different grits). Fairly rigid, but with a bit of flex, and sometimes some cushion because of the layering. Most commonly available in medium to Fine grit. Can be easily cut into new shapes, or when one end wears out.

> *Those who routinely file their nails (or have them "done") will recognize these immediately. I didn't learn about them for years... Possibly because my wife uses the Sanding Sticks in my shop more often than not to clean up her nails.*

Good For: Sanding. These are basically pre-made sanding sticks in the Popsicle Stick size or smaller, but with a little more flex and maybe some cushion / softness. May be better for medium to soft curves than Sanding Sticks.

Sanding Twigs

Cut Emory Board into tiny strips, and you've got these.

Typically ⅛" or so wide by 4-6" long, these are very narrow. Commonly available in grit from 60-400.

> *These are tiny, but are indispensable if you work with small details often.*

Great For: small details where a truly rigid tool (like Needle Files) would be too aggressive; anywhere you wish you could use sandpaper but literally can't fold it that tight or make a Sanding Stick that small.

Not Good For: anything much bigger than they are

Custom Shapes

You can stick sandpaper on anything, remember?

Pipes and tubing are useful shapes when you want to sand a convex curve, or sand inside another tube.

But the sky is the limit — if you have a specific shape or angle you need to sand, make a tool to fit it. Sheets of plastic, wood, or even 3D printed shapes are all great options.

Great For: That specific job / task you made it for.

Files and Rasps

These come in a huge variety of sizes, shapes, and styles, with intended uses from wood to metal to plastic. They are also NOT the same thing, although the names are constantly mixed up.

Files

Most "standard" files are metal, with grooves cut/etched into them. They can be parallel grooves ("single cut"), or grooves cut at angles to each other ("diamond cut," "cross cut").

Best For: Metal.

Bad For: Sanding — the "grit" on standard files simply won't remove material from most other things, except the occasional hard plastic or unusual body-filler project.

Rasps

Some definitions make Rasp a subtype of File, except for Wood. Some make them a different thing entirely. Everyone agrees — they're designed for wood, and have raised "teeth" of some variety, from low square bumps to curved metal points.

> *I have a **huge, ancient one** (from probably the '50s) that I use quite frequently when I'm sculpting with Bondo. That's it's only job, and it's never used for anything else, but it does that job better than anything else — even power tools.*

Best For: Rough / fast shaping of Body Filler and similar materials like Urethane Tooling Foam, or other rigid but easily removed materials (like wood, their intended target) — they will gouge the hell out of things, and take a lot of cleanup work, but if you want to remove material *fast,* they're great.

Bad For: Anything else. These things are just *aggressive*.

Needle Files

Small "single cut" files, typically 4-8" long, typically under ¼" wide. The shape is ideal for working in small spaces, around details. Come in bundles, usually with several shapes ranging from flat, to round, to half round, in different sizes.

> *I have a single set of these, and I can't remember the last time I used them.*

OK For: Coarse sanding in small spaces, carving grooves / detail lines.

Not Good For: Much anything else. These are commonly recommended for sanding 3D printed parts — they suck at this. **Use *Diamond-Coated* Needle Files instead.**

Diamond-Coated Needle Files

DON'T confuse these with standard Needle Files! Though they are the same size and shape — typically 4-8" long, typically under ¼" wide. The shape is ideal for working in small spaces, and around details. Come in bundles, usually with several shapes ranging from flat, to round, to half round, in different sizes.

Unlike Needle Files, these come with actual grit on them, typically in the form of a "diamond-coating," and range from 120 up to ~400. 120 is the most common, followed by 220.

If you're making props, costumes, 3D printed projects, or anything with details smaller than your fingers, these are the single best tool you can buy.

> *I have 5 different sets — 2 [different](#) [sizes](#), in 2 [different](#) [grits](#) each, plus a specialty one.*

Best For: Sanding in small spaces. Wherever you'd use sandpaper of the same grit but can't reach, or where you need a harder / more rigid shape.

Not Good For: Foam; most paint. Even at "400" the grit itself is often too coarsely applied to sand very delicate surfaces cleanly — it may only leave 400 grit sanding-lines, but it does so *aggressively*, and the grit can catch or grab onto things, which can strip paint off a surface.

Riffler Files / Rasps

Look at all the shapes!

These are Needle Files designed for odd shapes, applications, getting into hard-to-reach spots. Usually 4-10" long, and under ½" wide. Available as slightly large metal rasps (with curved metal teeth), to ~400 in diamond-coating.

> *These are the single greatest piece of hand-powered sanding hardware ever made — if you've ever found yourself fighting to get even needle files or scraps of sandpaper into a weird space, or found your fingers cramping up from contorting them into odd angles because nothing will work, you'll love these.*

> *I have a **Small set**, a **Medium set**, and a set of **Riffler Rasps**.*

Great For: Reaching weird spaces, getting into details, grooves, detail lines, working at odd angles, sanding inside things, small spaces.

Less Good For: Flat surfaces, long curves / lines

Surform File

Sometimes called a "Speed Rasp" or "Surform Plane", it's basically a cheese-grater in a different shape. Comes in 6" and 12" sizes, in flat (plane) or half-round versions.

> *I have 3 of these explicitly for working with body-filler: a grimy one half-covered in chunks of body-filler for when it's still soft, a **clean one** for when it's harder, and a **big one** for really going to town on large shapes.*

Great For: Cutting down partially-cured body-filler. I spend a good chunk of time in ***A Robot's Guide to: Bondo*** explaining why this is the single best tool for working with body-filler.

Good For: Shaping urethane tooling foam, urethane foam board (rigid insulation foam).

Less Good For: Shaping cured body-filler, shaving wood.

Saw File

Made for sharpening the teeth of handsaws, these are triangular metal files. Available in different sizes and lengths, they are perfectly straight for most of their length but taper at the point.

> *I keep several of these, but the most useful is only ~3mm wide on each side, and the front end is cut very crisp. It's another tool that only does a couple things, but saves tons of time when I need it.*

Great For: Both gouging / carving grooves in stuff like body-filler (using the points at the end), and for smoothing out those same curves (using the grit of the file).

Not Good For: Anything besides body-filler or similar material.

Saw Blade

The blade. From a handsaw. Yes, really.

Hacksaw blades (especially from the small, 6" ones sold in some department store "Home Supply" sections); scroll-saw or coping-saw blades (especially broken ones with the connectors missing); these Xacto "Precision Razor" saw blades.

> *ALL the detail lines on my Winter Soldier Arm were outlined, and then etched, by hand, using a broken blade from a tiny hacksaw.*

Good For: Gouging / carving grooves, detail / panel lines; accentuating existing detail lines; removing filler (Primer, Spot Putty, etc.) from details. Broken blades are especially useful, since the broken end usually has at least one sharp corner that's big enough to remove material (unlike a Hobby Knife, which will just slice through it), but still sharp enough to not make a mess of things.

Not Good For: Actually cutting things. The blades that are most useful for the aboe are either too fine, or actually broken, making them bad at *this* job.

Power Tools

Power tools do the exact same things as hand tools —only *faster*!

Belt Sander

Spins a continuous strip of sandpaper (called a "belt") over a large, flat surface. "Standard" Belt Sanders use belts that are 4" wide by 36" long, but you can find larger ones (6" wide by 48" long), as well as ones with skinny belts (1" wide by 30" long) that move through open air — the latter are mostly aimed at metal workers and similar. Belts can be found in most grits up through at least 400, with 80 through 220 being common in most hardware and home-improvement stores.

This is probably the most common power tool for sanding, and with good reason. It's just sandpaper moving really fast, on a heavy machine that doesn't move. Turn it on, hold your thing against it, and watch the material fly off.

A cheap Belt Sander (i.e. Harbor Freight / Central Machinery) will work fine for anything rough, but the "upgrade" to a more common brand (WEN, Ryobi) comes with far more stability and precision for a marginal increase in cost — which will quickly balance out when you don't wear through sanding belts (cheap machines tend to wobble and rattle, leading to wear in the same places — to the point belts get stripped or tear). There's no need for a "high end" version unless you go the bigger size — then it may be worth your while (these benefit a lot from larger motors and heavier parts).

> *I used a "standard" belt sander for years, and recently invested in **the larger 6x48" size** — it seems like overkill on most projects, but it works exactly the same, and when I want to sand a BIG thing (I can fit a 12" by 6" piece flat on the belt) it's got me covered.*

Best For: Removing large amounts of material quickly (with low grit); shaping large objects.

Good For: Quickly making convex curves or flattening shapes; rounding edges/corners (with medium to fine grit); on foam it's **Great** at this.

Less Good For: Fine shaping (too aggressive; may sand grooves/lines into objects — the belts spin in a flat circle so grit travels the same path repeatedly); shaping small objects (tends to grab objects from your grasp, possibly throwing them across your shop to be lost forever).

Disc Sander

A spinning disk of sandpaper. Available in different sizes. Discs available in all grits. Typically has a shelf or "fence" for sanding at specific angles. Very commonly attached to Belt Sanders, but available in free-standing options as well.

Best For: Making flat shapes at specific angles (any grit). Rough shaping convex curves on small objects.

Good For: Removing material quickly (larger disks, lower grit). Quickly making convex curves or flattening shapes.

Less Good For: Shaping small objects (typically too aggressive). Fine shaping (may sand grooves/lines into objects– the belts spin in a flat circle so grit travels the same path repeatedly).

Oscillating Spindle Sander

Basically a spinning tube of sandpaper that also moves up and down ("oscillates") to prevent sanding grooves in surfaces. (The grit doesn't travel the same path every time). Usually come with a range of cylindrical drums, but may include cones. Both are available in a variety of grits, with 80 through 220 being common.

Best For: Making complex shapes, especially in large objects (any grit). Creating smooth surfaces on curves (due to oscillation).

Good For: Quickly removing material from or refining complex shapes (any grit).

Less GoodFor: Shaping small objects (smallest drums typically ½" diameter); making convex shapes (since you're sanding with a cylinder).

Ridgid's Oscillating Edge Sander

Ridgid's unique version combines an oscillating spindle sander with 90 degree belt sander.

Has attachments to use either a smaller size belt sander (4" wide by 24" long), or the same spindles used an Oscillating Spindle Sander. This gives you most of the functionality of a Belt Sander (but not all, since the belt is attached perpendicular to the table) but with the added benefit of oscillation (no sanding-lines!), plus a full-fledged Oscillating Spindle Sander.

> *This is the power tool I use most — tied with my rotary tool. Yes, I use it that much.*

Great For: All the same things as a Spindle Sander and Belt Sander.

Less Good For: Large objects, or objects that need to pass across the belt for sanding. The 90 degree orientation of the belt option means that some things will run into the table, making sanding them impossible. Not a total replacement for a belt sander for this reason.

Square / Finish Sander

Vibrating square pad that holds ¼ of a sheet of Paper. Works like a Sanding Block or Sponge strapped to a motor. Accepts all sandpaper.

> *If you get one of these, DON'T buy the pre-cut paper carried in stores! These are made to take ¼ sheet of anything — just use the paper you already have.*

Best For: Quickly sanding flat objects.

Good For: Rough shaping convex curves and flat shapes.

Less Good For: Removing material quickly. The Paper essentially vibrates, so it doesn't travel much, meaning very little material removed with each pass; paper will also clog quickly at the corners as there's no way to remove sanding dust as it's made.

Mouse Sander

Like a Square Sander, but with a pointy end — vibrates specialty sheets of sandpaper in place very quickly.

The pointed end means it can reach into corners and recessed areas better than other power tools, and can even do some concave curves. Some have "finger" extensions that increase this ability. Requires specialty hook-and-loop paper, often in proprietary shapes by brand and model. Grit varies based on availability, but 80 through 220 are common.

> *I have a **Black & Decker Mouse Sander,** and I love it — it's got dust collection, a quickly-changed "finger" extension option, and even moderate dust collection — but finding replacement paper for it is a pain. Seems that the model changes every few years, and the paper for it needs to change to fit as well. If I could reliably find paper for my model it'd easily be one of my Top 3 favorite sanding tools.*

Good For: Quickly sanding flat objects, smooth curves, and moderately sized details (depending on the Mouse's shape and "finger" options).

Less Good For: Removing material quickly. The Mouse Sander works the same way a Square Sander does, and has the same drawbacks.

Random Orbit Sander

Handheld spinning disc of sandpaper that wobbles — the center axis for the disc is *also* on a rotating disc, so the pad holding the sandpaper makes random circular "orbits" as it moves. Usually has a flat, semi-rigid rubber pad that takes pre-cut circular paper. Electric typically use a hook-and-loop (Velcro) system to hold paper in place on motorized models, while air-powered models use sticky-backed paper. Some have dust collection (vacuum up dust as they go), some can be used to wet-sand (higher end auto-body, air powered models). Auto-body style paper is available in every grit imaginable. Hook-and-loop comes in 60 to at leat 500, with 80 to 320 beinc common.

> *Of all the handheld "power sanders" (Square, Circular, Mouse) this is my favorite. I bought my first used DeWalt in 2009 (it was my 3rd power tool ever! After a cordless Dremel and a corded drill) and ran it into the ground — it died in 2018 and I replaced it with the **variable speed DeWalt** I use now (95% of the time on max speed). Before I had space for a Belt Sander, Spindle Sander, or anything else I did all my powered sanding with this guy.*

Best For: Refining shapes on large objects (with 80 through 120 grit); sanding smooth / soft curves, and large objects. The "random orbit" function means far fewer sanding-lines than other power tools.

Good For: Making and refining complex curves on large objects (any grit); shaping objects that aren't easily manipulated by hand.

Okay For: Quickly removing material. Less aggressive than a spindle or belt sander, but more aggressive than square sander.

Less Good For: Fine shaping or working on anything smaller than the sander (circular motion is aggressive; may sand grooves/lines into objects).

Oscillating Tool

A small, interchangeable "tool" piece attached to a large body that houses the motor. The tool rotates on an axis, typically bouncing back and forth through a 15-30 degree arc — like a metronome at high speed. These come in all sorts of shapes with different "tools" for things other than sanding, but all come with sanding attachments.

The amount of movement, and the available "tool" heads, greatly affect the usefulness of these tools.

Most move either too much (a tool that covers an arch a full 1" across can't be used inside a space smaller than 1") or too little (if it just vibrates, it can't actually remove material in a meaningful or constructive way). A Mouse Sander with a "finger" attachment is usually a better option.

> *I've tried several of these, and I always WANT to like them, but most of the time the motor / body itself is too large / heavy to effectively use on the smaller details you want to sand, and there are the problems with actual tool movement — but I still **keep one around** for the rare situations when it's the best choice.*

OK For: Quickly sanding inside small spaces or corners, especially with coarser grit; saving labor / time roughing out some convex shapes.

Not Good For: Much else. They're too small to handle big surfaces; too imprecise to handle details, hard edges, sharp corners, or flat surfaces; simply clog most paper over 120 because of the movement pattern, leading to unevenly sanded surfaces (and frustrating imperfections).

Micro Sander

Detail sanding (sanding inside small spaces, tight corners, recessed areas — really anywhere you can't reach your fingers) sucks, and there are no power tools that can do it — enter the Micro Sander! Right? Not really.

The most common of these is the Proxxon Micro Sander, which is essentially a miniaturized version of the Oscillating Tool — but specifically for sanding.

It has removable tool heads with different shapes (circle, triangle, square, etc.), attached to posts at different angles. Comes with pre-cut, sticky backed paper in varying grits from 120 to 600 or more, though it's of course possible to stick your own sandpaper on it (especially if you have sticky-backed already).

The size of a Micro Sander means the tool HEAD can fit into small spaces — but just like the Oscillating Tool, it needs to MOVE inside that space. Too much movement, and it can't work in the space at all.

But it also needs to move enough that it actually removes material from the surface; too little movement, and nothing gets done. The Proxxon does both things at once — it moves just enough to push it out of most spaces you'd want to use it in, but *at the same time* doesn't move enough to clear the sanding-dust underneath itself; if you hold it still, it will literally make a small hill as it sands around the edges of the tool head but not in the middle, because of its particular movement pattern.

> *These aren't cheap — most require both a proprietary power supply and the tool-body, plus whatever heads and paper you want to use with it. I had a Proxxon, and after trying to use it on a dozen different projects (I always found Diamond-Coated Needle Files or Sanding Sticks to work faster, cleaner, and generally better), I sold it off.*

OK For: Fine sanding in small-ish detailed areas, particularly soft curves and inside corners / recessed spaces.

Not Good For: Sanding flat spaces, especially small ones; sanding spaces more than 2" across or smaller than ½" across. Hand tools will do jobs outside that very narrow range more quickly, with similar labor / effort, and generally less frustration.

Bench Grinder

A heavy motor with 1 or 2 axles that spin at *exceptionally* high speeds. Most come with stone grinding wheels installed for working with metal, but you can swap those out for Nylon or Polishing Wheels. "Benchtop Polishers" are a specialized version of these that spin even faster and come with different polishing attachments pre-installed.

Great For: polishing things (assuming polishing wheels).

Good For: things that need serious grinding, like metal; similar uses as Nylon Abrasive Wheels above but with differently oriented access to the tool.

Rotary Tool

EVERY MAKER should have a rotary tool!

Dremel is the quintessential brand in rotary tools, so much so you'll often just hear these tools called "a dremel" whether they're made by Dremel or not. Dremel makes more varieties than anybody else — corded, battery-powered, tiny "engravers" to "industrial" speed hanging versions.

All rotary tools work fundamentally the same — they take tiny attachments on metal rods and spin them around an axis really, really fast, like tiny Belt Sanders or Spindle Sanders. Rotary tools can be equipped with sandpaper, diamond-coated bits, stone bits, abrasive cutting wheels, actual circular saws, drill bits… it's a huge list.

For most purposes any rotary tool will do, even the most budget versions. If you want a real workhorse, brands like Foredom make hanging tools designed for hours of constant use. Battery-powered tools can be very useful when a cord would get in the way.

> *I have a **Foredom** that's my workhorse — it's constantly getting used. But I also have a **battery-powered Dremel** I keep for some smaller tasks, and I used a dirt-cheap, no-name knock-off of a budget-brand tool for 6 years before it died, even after I got my Foredom. If you don't have one, just get one — anything will work.*

Great For: Complex shapes; fine details; quickly removing material from small spaces or inside hollow objects; working in unusual or hard to reach spaces; trimming plastic parts.

Good For: Rounding corners / beveling edges; any / all Foam shaping; shaping small to medium sized surfaces.

Less Good For: Fine shaping (finest grit "sanding drums" available are typically 120, diamond coated bits in 220 to 400 exist but are rare; spinning motion typically leaves grooves / sanding-lines which isn't ideal for final surfaces); shaping large objects (very small working area).

Rotary Tool Accessories / Bits

All rotary tools accept a multitude of accessories, or bits — the actual things that insert into the rotary tool and interact with your project surface. Dremel (and most similar tools or knock-offs) use the same size shaft. Other tools (like some Foredom models) use differently sized "jeweler's bits." Some take a range.

Make sure whatever you buy will work with your tool.

Sanding Drums

Rubber tubes that accept sandpaper tubes of different grit — usually just labeled "Coarse" (80) or "Fine" (120). The Dremel "EZ Drum" is tool-less, which is 100x easier than using those tiny wrenches / screwdrivers.

Great For: Anything sndpaper is great for; your to-to options.

Diamond-Coated Bits

Identical surface to Diamond-Coated Needle Files, and in similar grits (120 to 400), but in a variety cylindrical and spherical shapes.

Good For: When you need a different angle, or finer finish, than Sanding Drums will give you.

Rotary Burrs

Like a cross between Diamond-Coated Bits and Rasps. Solid metal (material varies, Tungsten Carbide is a favorite as it doesn't wear down as quickly). "Cross Cut" will work in any direction of spin (useful for Foredom and similar tools that can be reversed). Come in useful shapes from Ovoid to Triangular.

Great For: Medium to hard surfaces, like Urethane Plastic and Body Filler — the metal surface can't clog up like sandpaper. With a powerful enough tool (like a Foredom) these can really "hog out" excess material in a truly aggressive way.

Cut-Off Wheels

Spinning discs of abrasive material that cut through metal and plastic by grinding it away. Dremel's "EZ Lock" system reigns supreme here.

Great For: When you want to trim plastic parts of all kinds, or cut through metal without a hacksaw; cut-off wheels are THE option for rotary cutting.

Flap Discs

A central hub with squares of sandpaper sticking out of it, so that when spun the sandpaper "flaps" against a surface. Available in different grits from 80 to ~220. These work like sanding drums, but larger, and potentially with a softer impact — unlike Drums, which remove material in *exactly* the shape of the drum (because they're solid), these are sheets of paper so the shape is less precise; at least until most of the paper comes off, and they act like oversized sanding drums that throw sanding-dust with excessive force. Come in 1/2" and 1/8" wide sizes.

Great For: Cleaning up sanding-lines left by Sanding Drums and Burrs when hogging-out the inside of surfaces and cast parts, or similarly aggressive tasks.

Stone Wheels

Like Sanding Drums, but made of "stone" — usually some sort of ceramic or brick-like stuff, different colors are supposedly correspond to different hardness, but you're unlikely to notice a difference. They come in every "Accessory Kit" and nobody ever knows what to do with them.

Good For: Smoothing Foam seams / edges; on rare occasion worthwhile for something else random.

Polishing / Buffing Wheels

Usually foam or cotton pads that screw onto a metal shaft, can be used with rubbing / polishing compounds.

Great For: Polishing very small things, just be careful of the speed since the surface area is very small and can quickly burn through compound, resulting in scratched surfaces instead of nicely polished ones.

Rotary Tool Extras

Not sanding tools themselves, but if you have a Dremel or Dremel-knock-off, these will change your life.

They're even available on Amazon as a COMBO DEAL.

Dremel Flex Shaft

- Exactly what it sounds like — a flexible extension with a small, pen-sized Bit holder that connects to a Dremel (or any other Rotary Tool with the same threaded "head" and shaft-size).
- No more holding the entire Rotary Tool! Just a 6", lightweight Tool instead!
- Except in very rare circumstances where you want to get into weird angles and the shaft fights against you, your sanding-life just got 10x better.

Dremel Keyless Chuck

This awesome little "chuck" fits Dremels and all tools with the same threads. It replaces the standard collet system inside most Rotary Tools that require you to use a wrench to secure Bits, and different sized collets for different sized Bit shafts.

- It works like a standard drill — with 3 moving "teeth" that move closer or further apart as you tighten the outer ring.
- Now you can swap bits *by hand*, without tools, in half the time! *And* you can use Bits with both larger and much smaller shafts — including micro-drill bits (less than 1mm in diameter)

Drill / Drill Press Attachments

You can use a hand drill or drill press to hold spinning Bits, too!

Drum Sander

Exactly the same as the Sanding Drums for smaller Rotary Tools, but BIG. These come in diameters from ½" up to 2", with grits commonly ranging from 80 to 220.

Okay For: The same tasks as an Oscillating Spindle Sander (in a Drill Press); same tasks as a Rotary Tool (in a Hand Drill). The difference is that in Drill Press there's no oscillation, so sanding-lines may be an issue; and in a Hand Drill you have a LOT to hold onto, so physical control can be a major limiting factor.

Abrasive Nylon Wheel

They're similar to Flap Discs, except instead of pieces of Paper they have nylon bristles coated with abrasive of different grits (I've seen 80 through 1000). The bristles are semi-rigid, so they will bend and separate to accommodate all sorts of different shapes, and work from any direction.

Mount one of these in a Drill Press, and you have a tool that will take the surface and rough edges off any medium-hard to soft surface you want. You have little control over where exactly the bristles go, so it's imprecise but excellent for overall surface sanding.

Also available as attachments for Bench Grinders.

> *One of the best perks / surprises is that, even at 80 grit, these aren't aggressive enough to tear through nitrile gloves without extended contact (unlike Sanding Drums, which will rip through gloves, and the skin underneath, in the literal blink of an eye). So you can hold onto your Super-Awesome-Project™ with just your gloved hands without excessively worrying if you'll rip your fingernails off!*

Great For: Sanding 3D prints with many curves but few details or sharp edges. Use an 80 grit Nylon Wheel to take most of the sanding-lines off a raw ABS 3D print in almost no time, with zero work (just hold on tight!). Follow up with a 200 grit Wheel, and you're 90% done (assuming no corners or convex details the Wheel couldn't reach are left to sand).

Good For: Sanding small to medium sized objects you can hold in our hands; anything without a lot of detail; anything with rough, coarse, or raised sections you want to just sort of "smooth over" into a more even curve.

Less Good For: Plastics like Sintra, Styrene, and Acrylic. They just don't respond well to this kind of sanding.

Genuine-24K-gold-plated Wonder Woman armor by *SoloRoboto Industries*
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