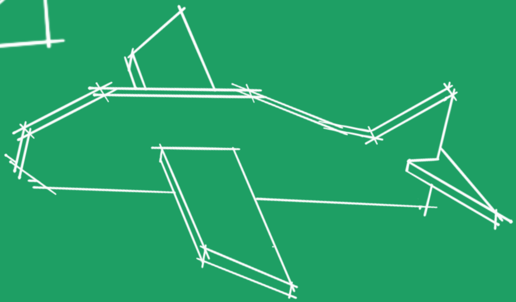

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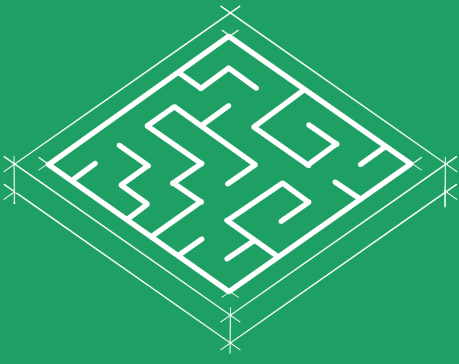
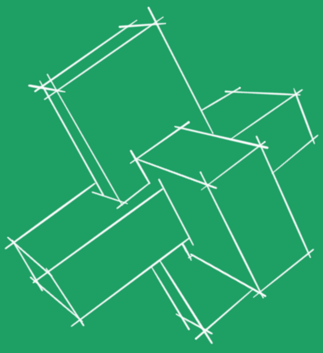
Innovation Guide





Making for Everyone

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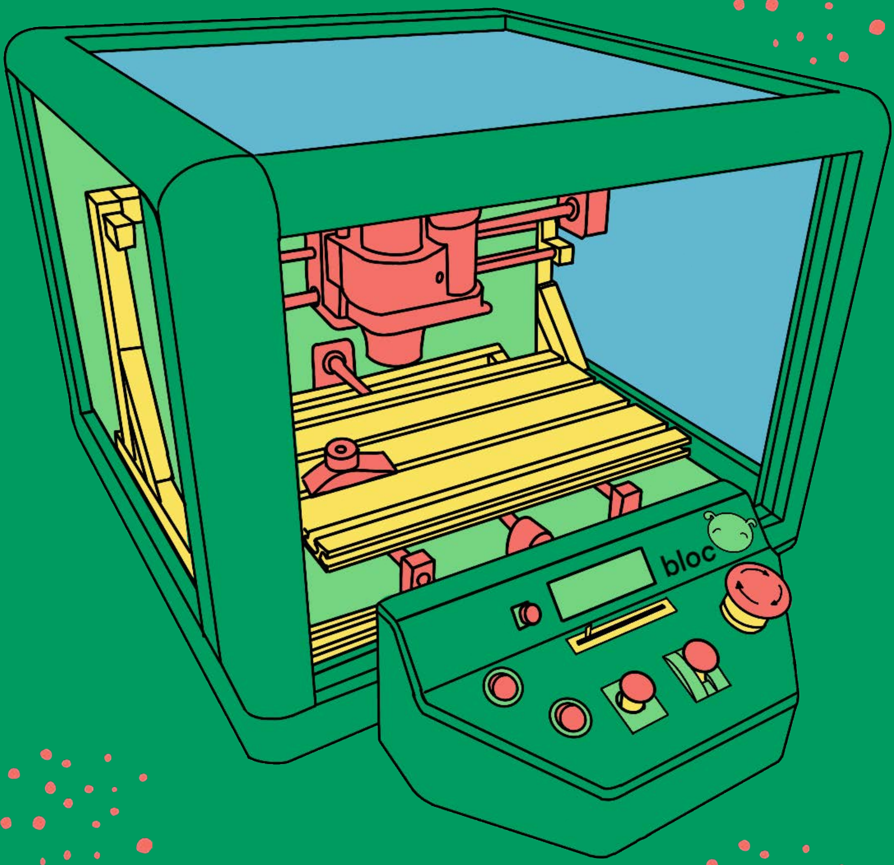
Introduction to Your CNC Journey



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Innovation Guide Learning Objectives

Understand the Basics

- Identifying key components and parts
- Navigating simple tasks and operations
- Selecting the right tools and materials for your projects

Get Hands-On

- Step-by-step guided exercises
- Safe and supported tool exploration
- Build confidence through practice

Learn to Troubleshoot and Reflect

- Embracing failure as part of the process
- Identifying what went wrong and why
- Strategizing improvements and next steps

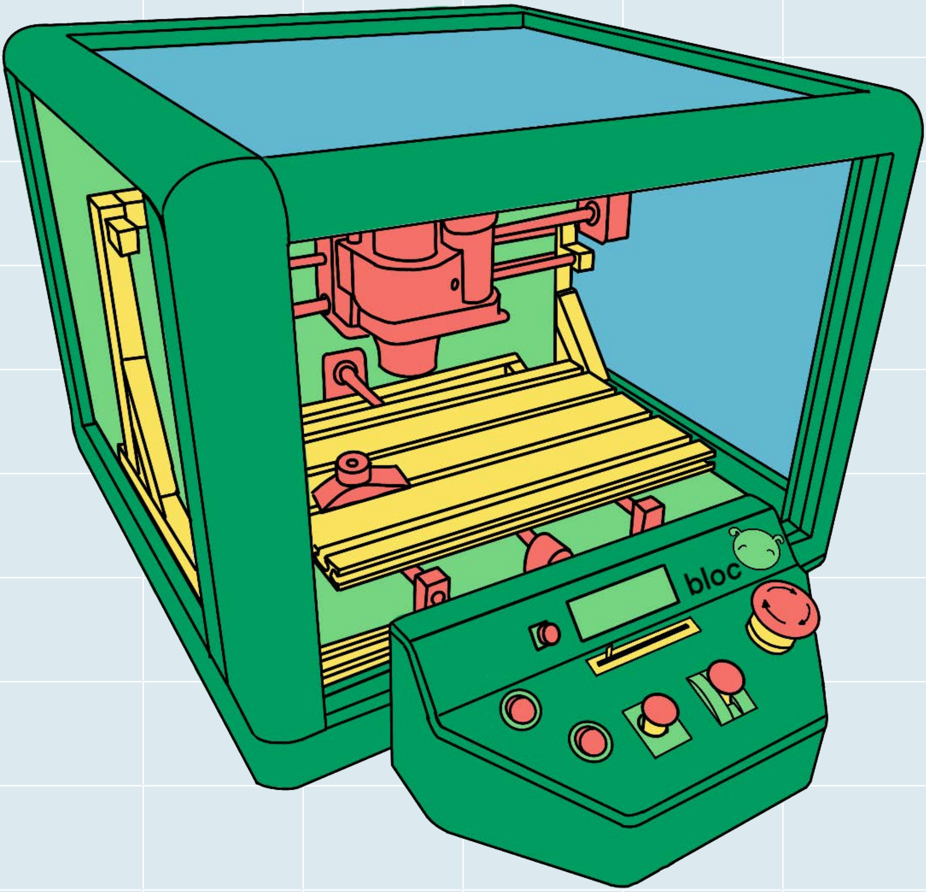
Think Like an Engineer

- Understanding the engineering design process
- Learn how to frame problems and consider end users
- Develop creative solutions grounded in real needs

Scale Up

- Move from guided tasks to self-directed projects
- Push your skills further
- Bring your original ideas to life with confidence and clarity

Section 1.1 Introduction



What is a CNC Machine?

A CNC machine uses various tools to fabricate parts by removing layers of material—a process known as subtractive manufacturing. Unlike additive processes like 3D printing, CNC machines start with a solid block and carve out the final shape. This technology is widely used in manufacturing and prototyping for its precision and efficiency.

Why *bloc*?

Fabrication can be intimidating for beginners, often requiring extensive experience before they can even start creating. *bloc* removes that barrier with a gamified interface and an easy-to-follow innovation guide, making the process approachable and fun. Instead of struggling with complexity, users can dive straight into what truly matters—**bringing their ideas to life.**

Meet the Makers

Gia Boudreau

Design Technologist

Gia is a design technologist from Colorado Springs, Colorado, with a passion for bridging design and development. She earned a B.S. in Creative Technology and Design and a minor in Computer Science from CU Boulder, combining design thinking, technical problem-solving, and creative prototyping to build user-centered experiences.

At CU, she worked as a UI/UX designer for the nonprofit Womenexus and as a learning assistant at the ATLAS Institute, where she supported students in web development and computational foundations.

Most recently, as a design technologist for **bloc**, she applied the user-centered design process to enhance the learning experience for makers and beginners. She helped shape a more accessible and intuitive entry point into digital fabrication. When she's not designing, you can find her snowboarding with the CU team—or occasionally eating dirt. She's driven by a commitment to human-centered design in a time of rapid technological change.

Sophia Montie

Industrial Designer

Sophia is a passionate industrial designer focused on merging imagination and functionality. Her degree in Creative Technology and Design and minor in Computer Science gives her a multidisciplinary approach to problem solving, utilizing coding, 3D modeling, and fabrication.

While studying, Sophia worked as an undergraduate industrial design researcher at the ATLAS Institute's Brain Music Lab where she designed and built a public installation that invites passersby to interact and engage with studies for the lab. She guided the prototyping and user testing processes, incorporating feedback to develop a device that would both meet the needs of the lab and participants. In her free time, Sophia participates on her collegiate club swim team travelling all over the country to compete.

As the industrial designer for **bloc**, Sophia has attacked the design process with an iterative approach with sketches, models, and prototypes to create the highest quality experience for the maker. She shows that there are no bad designs, only lessons for better outcomes.

Meet the Makers

Andrew Widner

Product Designer

Andrew is a Creative Technology and Design major from Seattle, Washington who uses his skills in design, CAD, VFX, and machining to create human-centered products and educational content.

Andrew is the president of the CU3D student organization at CU, facilitating learning and accessibility surrounding complex 3D softwares and manufacturing processes.

Andrew hopes to continue making more accessible technology and education like the **bloc** ecosystem post grad, and aims to use his skills in product design and 3D printing to create assistive technology for those with disabilities.

Matt Bloomfield

Product Manager

Matt is a Creative Technology and Design major with a minor in Computer Science from New Jersey, with a passion for fabrication, product development, and hands-on tinkering.

As the project manager for **bloc**, Matt oversaw the development process and took the lead on designing and building the joystick controller—handling everything from the wiring to the code. He's also the president of the CU Skateboarding Club and a content creator for the CU Environmental Center, where he channels his creativity into visual storytelling and environmental advocacy.

Beyond the classroom, Matt is an outdoor enthusiast who spends his time skateboarding, rock climbing, skiing, and woodworking. He works with Trimble in Westminster as a Business Process Management intern, building out an internal Intranet system. Long-term, Matt hopes to create products that not only function beautifully but also make a meaningful impact on society.

Chapter 2

Getting to Know Your CNC Machine

bloc

Onboarding

We’ve taken a tabletop CNC machine and made it safer and more accessible by adding limit switches, custom clamps, a vacuum for cleanup, a full enclosure, and a user-friendly control console. Whether you're working at home or in a makerspace, these upgrades help ensure a smoother, safer experience for all makers.

This chapter is your crash course in CNC fundamentals—covering everything from the structure of the machine and how to “speak CNC,” to choosing the right tools and materials for your projects. We’ll also walk you through the step-by-step process of operating the machine.

It’s tempting to jump right into your first project, and we get that! But getting familiar with how the machine works will give you a solid foundation—and the confidence to customize, modify, and truly make it your own. CNC machining has many layers, and while this guide only scratches the surface, it’s designed to support you throughout your learning journey.

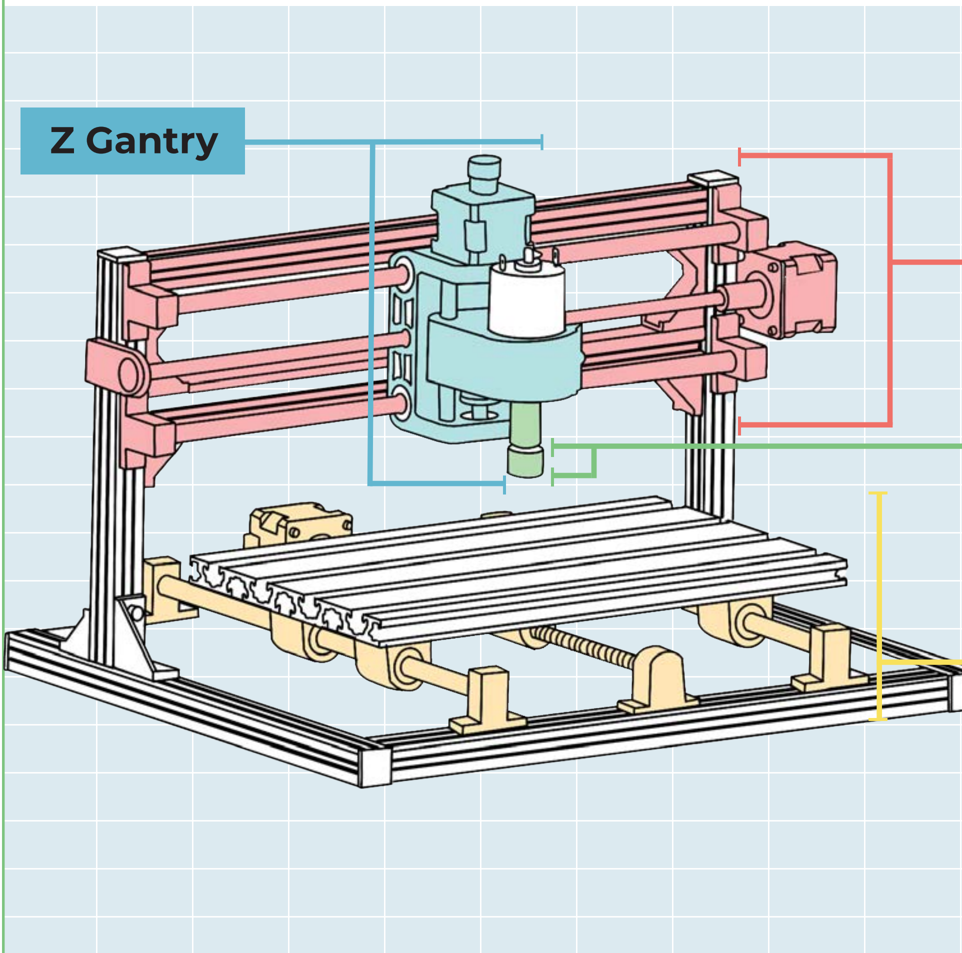
So explore, experiment, and come back to this guide whenever you need it—it’s here to grow with you.

Section 2.1 Meeting the Machine

This is the CNC machine you will be learning to use!

CNC stands for ***Computer Numerical Control***. It operates using digital instructions generated by software, which produces ***G-Code*** that the machine's controller can read.

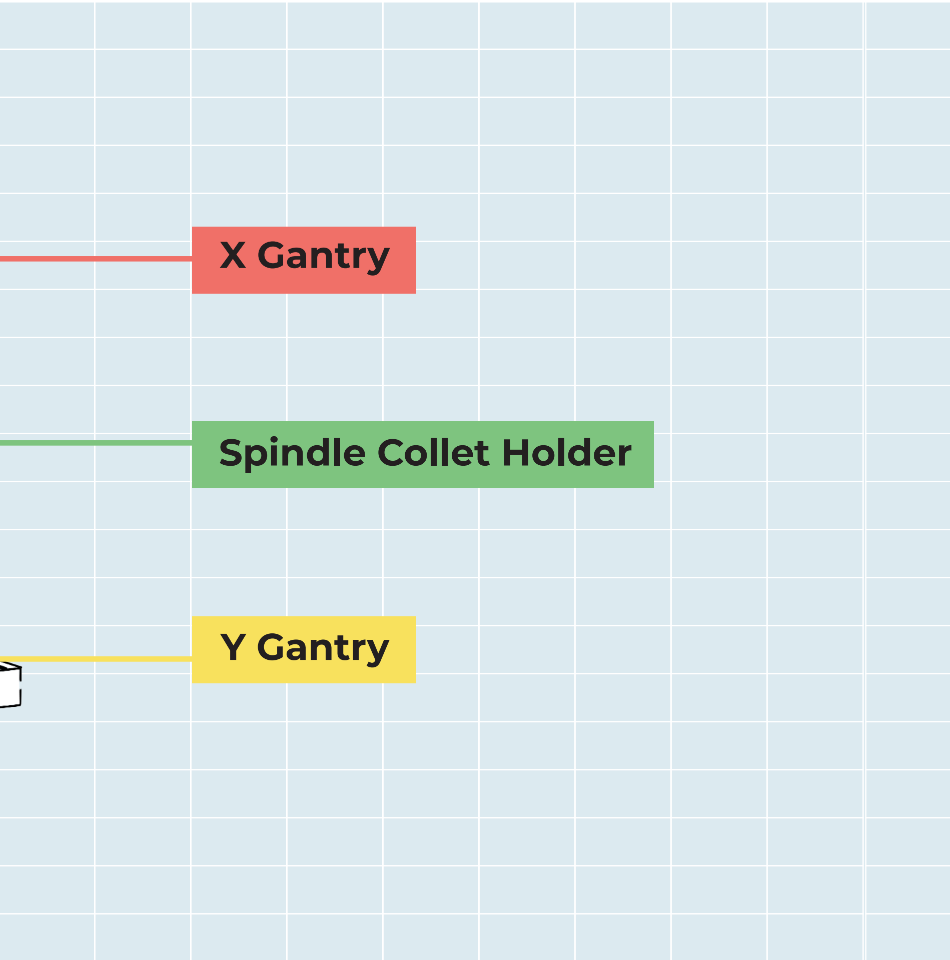
The controller then interprets the design and directs the cutting tools and axes to precisely shape the material.



This is a ***3-axis*** CNC machine, meaning it operates using linear motions along the ***X***, ***Y***, and ***Z axes*** for machining.

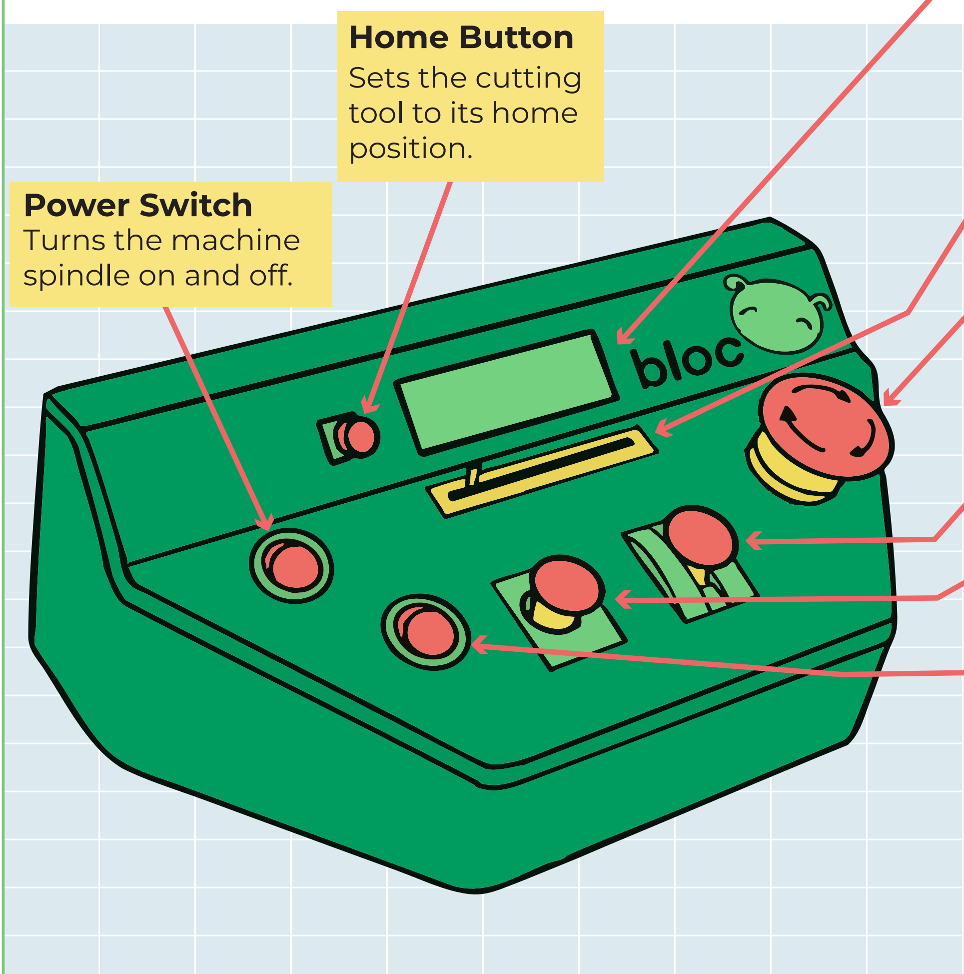
These movements are based on the ***Cartesian coordinate system***, which allows precise positioning.

The figure below illustrates how these coordinates are mapped onto a rigid structure called the ***gantry***, which supports the ***spindle*** and enables movement along the ***X***, ***Y***, and ***Z axes***.



Console Controls

This is the console you'll be using for your projects! It's designed for smaller-scale operations—perfect for learning and prototyping. Unlike large industrial machines, where machinists often operate manually or input instructions using ***G-code*** on a computer, this setup simplifies the process and makes it more hands-on and accessible.



LCD Screen
Keeps track of the machine's X, Y, and Z coordinates, helping you know exactly where the tool is positioned in the workspace.

Spindle Speed Slider
Adjusts the cutting speed for how fast the machine moves while cutting.

Emergency Stop Button
Press this button down to immediately stop the machine in case of an emergency. To reset it, turn the button until it pops back up.

Z-Axis Joystick
Moves the Z gantry up and down, adjusting the vertical position of the tool.

XY-Axis Joystick
Moves the X and Y gantries left, right, forward, and backward, allowing you to position the tool across the surface of your material.

Travel and Cutting Mode Switch
Adjusts the speed of the gantries, which are the moving parts of the CNC machine. Travel mode is faster and is used when making larger adjustments or moving across the workspace quickly. Cutting mode is slower and is used during cutting to allow for greater precision and accuracy.

Section 2.2

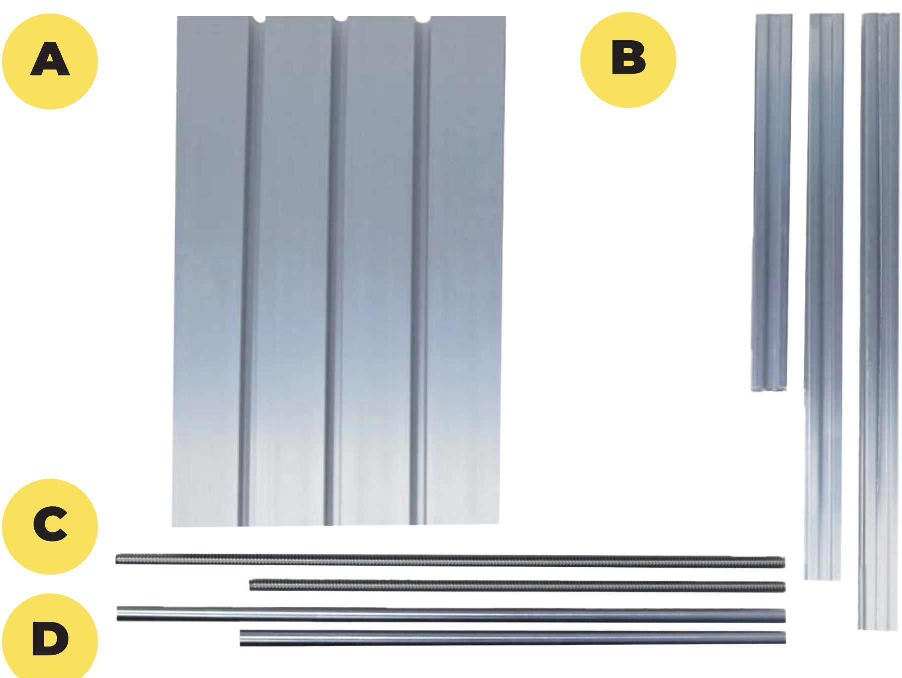
Components and Parts

Let’s dive into what makes a CNC machine tick! These components are the magic behind bringing your designs to life.

Understanding each of these will help you make informed decisions for your work. And once you’ve got the basics down, troubleshooting, customizing, and even upgrading your CNC becomes way less intimidating—and a whole lot more fun!

Aluminum Parts

First, we’ll explore aluminum parts - the structural foundation that keeps everything sturdy and precise.



Many structural components of a CNC machine are made from aluminum due to its lightweight yet rigid properties. Aluminum parts provide stability while keeping the machine agile, reducing vibrations that could affect precision. Their durability also makes them ideal for withstanding the stresses of machining while maintaining accuracy over time.

E

F

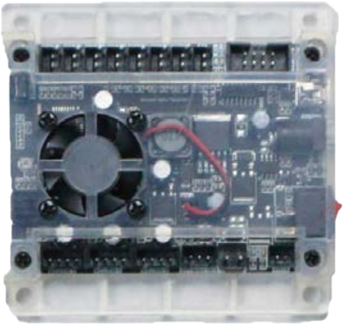
G

Name	Function	Part Entry
A **Aluminum Bed**	The working surface where material is placed for cutting or engraving.	300mm x 180mm
B **Aluminum Extrusions**	Structural frame for CNC, provides support and movement channels.	V-Slot 2020 320mm (x2) 270mm (x5) 230mm (x2)
C **Lead Screws**	Converts rotational motion into precise linear motion.	8mm - 300mm (x2) 100mm (x1)
D **Smooth Rods**	Guides movement of the CNC's moving parts.	8mm - 320mm (x4) 110mm (x2)
E **90° Corner**	Connects aluminum extrusions at right angles to reinforce the structure.	V-Slot Bracket (x16)
F **Linear Shaft Support**	Holds smooth rods in place for linear motion.	SK08 (x8)
G **Linear Ball Bearings**	Allows smooth sliding motion along shafts with minimal friction.	LM08UU (x12)

Electronic Parts

The electronic components are the brains and nervous system of your CNC machine, controlling motion, power, and feedback. This includes the ***control board*** (which processes commands and translates them into machine movements), ***stepper*** or ***servo motors*** (which drive motion along each axis), and the ***power supply*** that keeps everything running. These elements work together to ensure **smooth operation**, **accuracy**, and **responsiveness**.

H



I

J

K

L

M

N

Name	Function	Part Entry
H **Control Board**	Processes G-code and controls CNC movements.	GRBL Shield V3
I **Stepper Motor**	Provides precise controls of CNC movement by setting bit travel per pass in XY and Z planes.	Nema 17, 1.8° (x3)
J **Spindle Motor**	Powers the cutting tool for material removal.	6000 - 12000 RPM 775 DC Motor
K **USB**	Transfers G-code files from a computer to the CNC machine.	USB (x1)
L **Motor Wires**	Powers and signals transmission to move the CNC machine's axes.	2 Pole Motor (x1)
M **Stepper Motor Wires**	Transmits electronic signals from the stepper motor driver to the stepper moter.	4 Pole Motor (x1)
N **USB to MicroUSB**	Direct USB to PC communication.	USB to MicroUSB (x1)

Machining & Hardware Parts

Now let's break down the machining parts and necessary hardware—the backbone of a CNC machine that ensures accuracy and reliability.

O

P

Q

R

S

T

U

V

Each component plays a crucial role in shaping your designs. We'll also cover essential fasteners, clamps, and mounting systems like ***T-nut slots***, ***hex screws***, and ***muff couplings***, which keep everything locked in place during operation. Understanding these elements will help you set up your machine effectively, **minimize errors**, and **maximize precision**.

Name	Function	Part Entry
O **Z-axis Spindle Clamp**	Secures the spindle along the Z-axis and provides stability during the maching process.	GRBL Shield V3
P **Milling Cutters**	Used for cutting, engraving, and shaping materials.	Various sizes
Q **Ball bearings**	Reduces friction in rotating parts.	AR610016 (8x16x5mm) (x3)
R **Muff Coupling**	Connects aligned shafts for efficient power transmission with minimal vibration.	3018-PRO Coupling & Screw Set (x2)
S **Assorted Hex Screws**	Six-sided fastener for secure, high-torque tightening.	M5*10 (x59) M5*8 (x4) M3*6 (x8) M6*12 (x10)
T **Wrenches**	Used to grip and turn fasteners like nuts and bolts for tightening or loosening.	Allen wrench (x1 set) Nut wrench (x1 set)
U **Screws**	Secure stock to the machine bed or fixture for stable CNC machining.	M6*40 (x4) M6*45 (x4)
V **T Slot Nuts**	Enable adjustable mounting for secure stock fastening.	M5-20 (x8) M6-30 (x10)

Introduction to Essential Terminology

CNC terms can be technical and overwhelming, especially for beginners.

So, ***we've created this guide*** to introduce some **common terminology** frequently used in CNC machining.

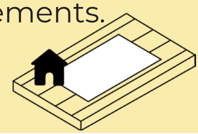
Keep in mind that **this is just the tip of the iceberg**—there are many more terms in CNC machining, and as you gain experience, you'll encounter even more that aren't covered in this guide.

G-Code

A **programming language** that **instructs** CNC machines on **movement** and **cutting**, including the **direction** and **speed**.

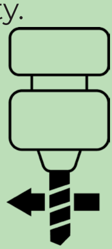
Home Position

The CNC's **default reference point (X = 500, Y = 0, Z = 500)** for all movements.

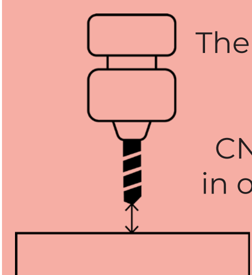


Feed Rate

The **speed** at which the ***X-Y and Z gantries*** move through material on the aluminum bed and affects cut quality.



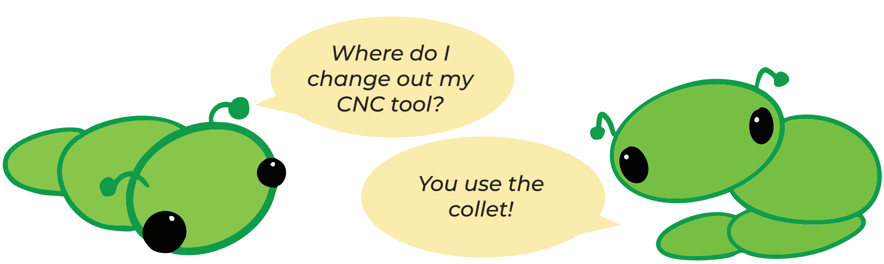
Safe Z Height



The height that the ***cutting tool*** on the ***Z-axis*** **lifts above the stock** for the CNC machining operation in order to not damage the bit.

Jogging

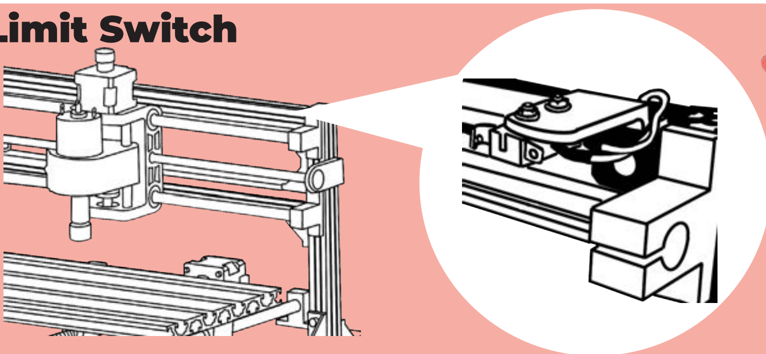
When the CNC operator **manually** moves an axis. Often used during setup, inspection, or when changing a tool.



Section 2.3

Speaking CNC

Limit Switch



A switch or sensor at the machine's edges. These **prevent over-travel** and **collisions** by detecting when a moving part reaches a specific position, then **signaling** the ***controller*** to **stop movement**.

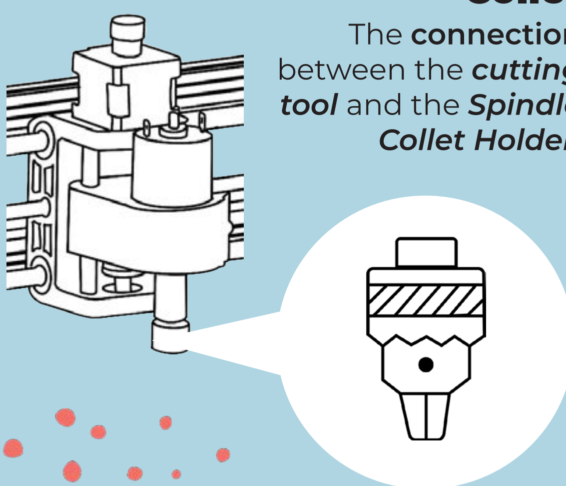
On this machine, there are **five limit switches**. Two on the ***X Gantry*** for “left” and “right” movement, two on the ***Y Gantry*** for “foward” and “back” movement, and one for the ***Z Gantry*** for “up” and “down” movement.
See if you can point them out!

Flutes

The **sharp edges** that rise helically on the CNC bit and do the cutting. The ***shape***, ***spacing***, and ***number*** of flutes **affect the performance** of the end mill or bit and the clearance rate of any debris, and the finish of the stock surface.

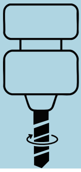
Collet

The **connection** between the ***cutting tool*** and the ***Spindle Collet Holder.***



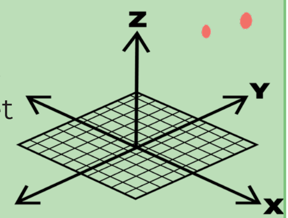
Spindle Speed

The **rotation speed** of the spindle motor, measured in RPM.



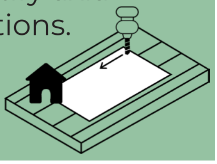
Work Coordinates

The position of the cutting tool on the workpiece, **relative to the home position** set by the user in software. Typically on the top left corner of the aluminum bed.



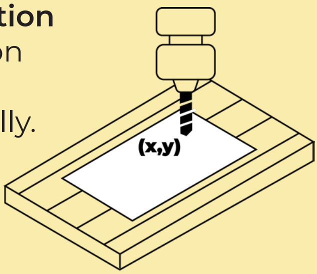
Homing Cycle

The **routine** where the machine's ***cutting tool*** is **positioned at the home position** point on the X-Y or Z axis **aided** by ***limit switches*** to identify axial positions.



Machine Coordinates

The **absolute position** of the tool based on where the home position is set locally.

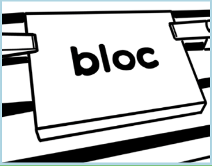


Depth of Cut

The depth of the material that's being removed in a single path as the tool moves.

Stock

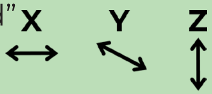
The **material** of what you're cutting into.



Cartesian Coordinate System

A coordinate system the CNC machine uses based on an X-Y and Z axis. This allows the system to move in a specific direction across a specific plane.

X: "left and right"
Y: "forward and backward"
Z: "up and down"



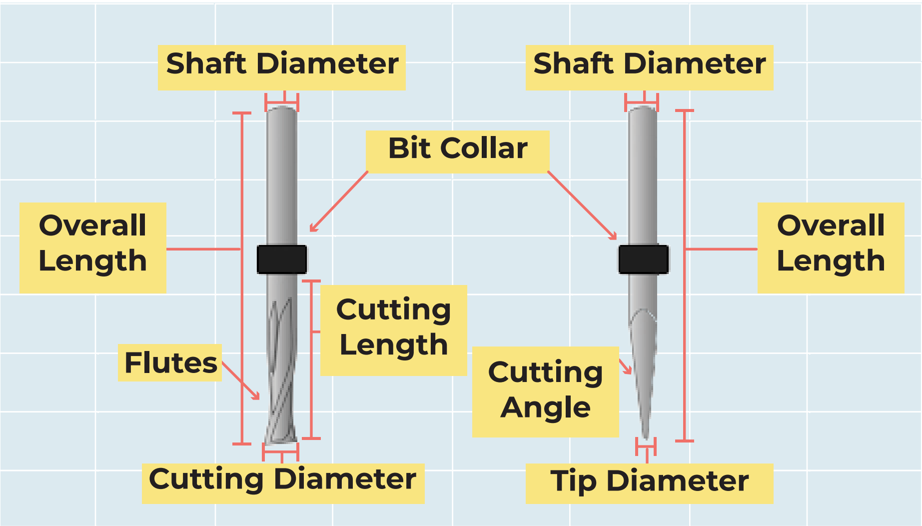
A Quick Guide to CNC Bits

CNC machines are powerful tools, but the real magic happens at the cutting edge—***your CNC bits***. Choosing the right bit isn't just about making cuts; it's about **achieving the best results** for your project. Whether you're engraving intricate details, cutting out parts with clean edges, or sculpting 3D reliefs, the right bit can mean the difference between a perfect finish and extra hours of sanding and cleanup.

For example, if you're carving a custom wooden sign, a V-bit will give you sharp, clean lettering. Need to cut precise holes for assembly? A drill bit is your best bet. If you're working on a smooth 3D sculpture, a ball nose bit helps achieve those soft curves. And for fast material removal in roughing passes, a spiral "O" bit or a corn bit will speed up the process.

Understanding the different types of CNC bits and when to use them ensures you get efficient cuts, better surface finishes, and longer-lasting tools—saving time, materials, and frustration. **Now, let's break down the key parts of a CNC bit and explore the best options for your projects!**

Key Parts of a CNC Bit

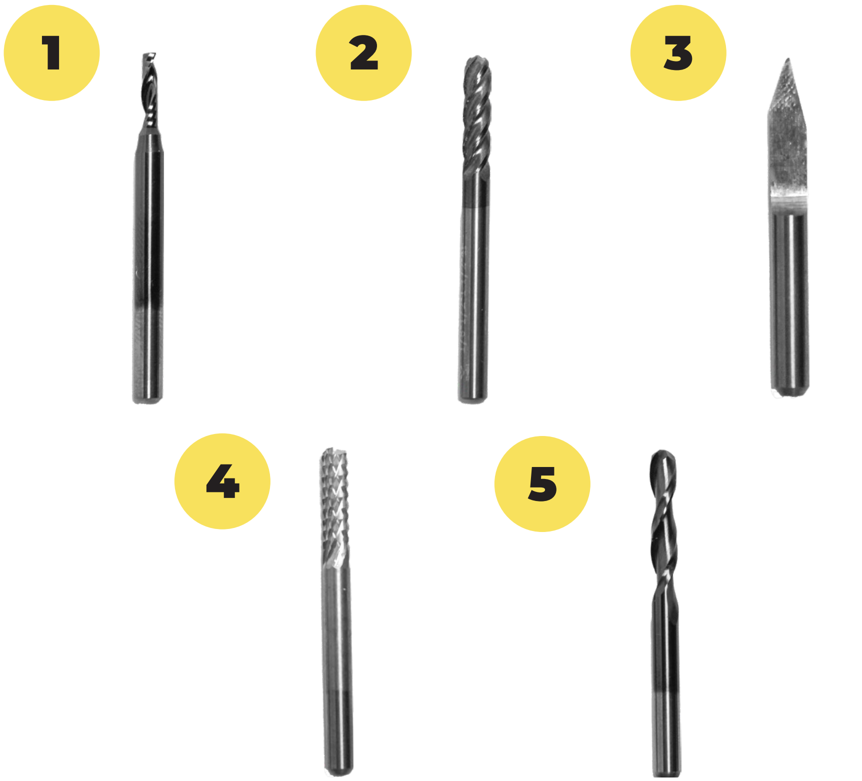


Shaft Diameter	The diameter of the bit's shank that fits into the collet. Ensuring compatibility with the CNC collet is essential.
Cutting Diameter	The width of the cutting portion of the bit, determining the minimum pocket or cut width achievable.
Overall Length	The total length of the bit, including both cutting and non-cutting sections.
Cutting Length	The usable length of the bit for material removal.
Flutes	Spiral sections that facilitate cutting and chip evacuation. Higher flute counts provide a smoother finish but may generate more heat.
Cutting Angle	The sharpness and shape of the bit’s cutting edges influence its strength and precision.

Types of CNC Bits

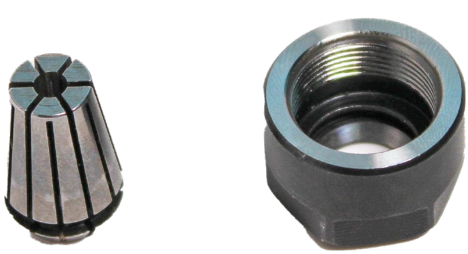
Now let's breakdown some of the CNC bits you can use for your projects. As you continue to use your CNC machine and advance, you can add more CNC bits to your toolkit.

Name	Description	Function
1 **Spiral "O" Bit**	A single-flute bit designed for efficient chip removal and minimal heat buildup.	A dedicated bit for drilling holes, differing from milling bits.
2 **Ball Nose Bit**	A rounded-tip bit typically featuring two flutes, designed for smooth surface machining.	3D carving, relief milling, and curved surface machining.
3 **V-Bit**	A single-flute bit with a sharp tip, ideal for detailed engravings.	Engraving, small detail pocket milling, and relief carving.
4 **Corn Bit**	A bit with multiple small teeth resembling corn kernels, offering high wear resistance.	Drilling, high-wear applications, and material removal.
5 **Drill Bit**	A dedicated bit for drilling holes, differing from milling bits.	Holes, that's it.



Collet and Nut

This is the collet and nut—the part of the machine that holds your CNC bits in place. You'll use it whenever you need to switch tools.
Refer back to Section 2.1 and see if you can identify it on your machine!



Changing Your CNC Bit

Let's go step by step through how to safely and easily change your CNC bit using the collet.

Safety First: Always turn off and unplug your CNC machine before changing the bit!

01 Raise the Spindle

Move the spindle up using your machine's controls (manually or through software) so you have space to work.

02 Loosen the Collet Nut

Use the provided wrenches to loosen the collet nut holding the current bit.
One wrench holds the spindle in place, the other turns the nut.

03 Remove the Old Bit

Once loose, gently pull the bit out.
If it's stuck, wiggle it slightly—don't force it.

04 Insert the New Bit

Slide the new bit into the collet (the small sleeve inside the nut).
Make sure it’s inserted deep enough to be stable, but not so deep it touches the spindle or bottom of the collet.

05 Tighten the Collet Nut

Hold the spindle with one wrench and tighten the nut with the other.
It should be snug but don’t overtighten—just enough to secure the bit firmly.

06 Zero Your Z-Axis

Because the new bit might be longer or shorter, always re-set the Z-axis zero to match the new tool length.
Use your machine’s jog controls to do this.

Choosing the Right Material

CNC machines can work with a wide variety of materials—from plastics to metals—making them great for all kinds of projects. But before you start machining, it's important to understand how the material you choose can affect your process and results.

So, how do you choose the right material for your CNC project?

A Crash Course on Material Selection

Each material has **different properties** that determine how easy it is to cut, what tools you'll need, and what kind of finish you can expect. For beginners and hobbyist machines like the one you're using, **the main things to consider are**:

Machinability
How easy is it to cut and shape the material? This depends on the material's physical and chemical makeup, as well as how your machine is set up (cutting speed, feed rate, and the type of tool you're using).

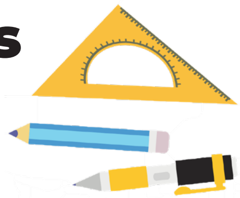
Hardness
How resistant is the material to being scratched or dented? Harder materials are more difficult to cut and may wear down tools faster.

Temperature resistance
Mainly important when working with plastics. Some plastics can melt or deform if they get too hot during machining.

These properties not only affect how easy the material is to work with but also how clean and polished your final project will look.

While industrial CNC machines can handle large, tough materials, hobbyist machines like yours are better suited to softer, more manageable options—perfect for prototyping and learning. **As you gain experience, you'll be able to take on more complex materials and projects.**

Design Considerations



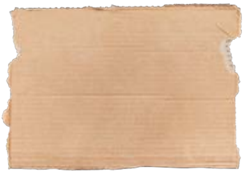
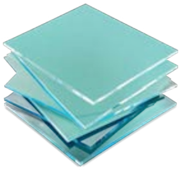
Detail Resolution
Harder materials (like aluminum or hardwoods) can capture fine details more precisely. Softer materials (like foam or soft plastics) might lose sharp edges or small features due to tool vibration or material flexing.

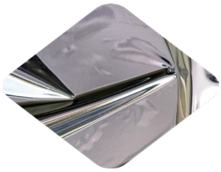
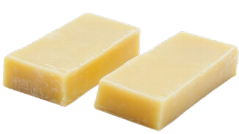
Surface Finish
Some materials (like acrylic) can come out glossy and clean with the right settings. Others (like plywood or MDF) often need sanding or post-processing for a smooth finish. Consider how much finishing work you're willing to do—this can influence your material choice.

Cost
Some materials are more expensive, especially metals or specialty plastics. Think about the cost of mistakes: if you're prototyping, go for something cheap and easy to machine before committing to premium materials.

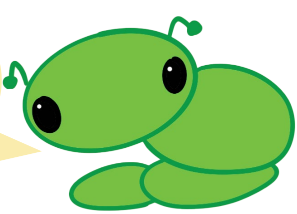
Materials Guide: Properties and Uses

Here's a list of common materials, along with their key properties and typical uses—things you'll want to consider when planning your CNC projects.

Material	Properties	Best For
	**Cardboard** *Lightweight, flexible, easy to cut*	◦ Prototyping ◦ STEM projects ◦ Packaging design
	**Balsa Wood** *Soft, lightweight, easy to shape*	◦ Model making ◦ Engraving ◦ Small parts
	**Foam Board** *Lightweight, rigid foam sandwiched between paper*	◦ Prototyping ◦ Architectural models ◦ Lightweight structures
	**Acrylic** *Hard, brittle, transparent or colored*	◦ Signage ◦ Display cases ◦ Detailed engraving
	**MDF Wood** *Dense, smooth surface, uniform texture*	◦ Signage ◦ Carving ◦ Detailed engraving

	**Plywood** *Strong, layered wood, various thicknesses*	◦ Structural projects ◦ Engraving ◦ Furniture making
	**Soft Metals** *Harder materials, require slower feeds*	◦ Machining ◦ Metal engraving ◦ Custom parts
	**PVC Sheet** *Rigid plastic, weather-resistant*	◦ Signage ◦ Industrial applications ◦ Precision cutting
	**Wax Block** *Soft, carvable, low melting point*	◦ Prototyping ◦ Mold-making ◦ Jewelry design
	**Sponge** *Soft, porous, easily compressed*	◦ Padding ◦ Craft projects ◦ Soft engraving

Some woods (like treated lumber) and plastics release toxic fumes—never cut these. Always check for safety data and recommended machining practices.



Section 2.6

The Art of Operating

Operating Your Machine

Now that you've been introduced to the machine, explored its components, learned about materials and drill bits for your projects, and picked up some of CNC terminology, it's time to operate the machine.

Part One: Set Up

Make sure to read ALL directions before starting your project

01

Machine Inspection

Check the CNC machine for dust, waste, or debris.

- Inspect the spindle, lead screws, and work area for obstructions.
- Ensure the clamps, bearings, and moving parts are clean and free of dust buildup.
- If necessary, use the provided compressed air or a soft brush to remove debris.

Figure 2.6.1: Overall view of workspace setup

Figure 2.6.2: Opening the enclosure for inspection

02

Prepare Your Design

Decide on your engraving or cutting design.

- **Option 1:** Draw your design on paper to transfer over, or directly to the workpiece.
- **Option 2:** Freestyle your design directly with the CNC (manual control mode).
- Ensure the design fits within the machine's work area. 300mm x 180mm.

Figure 2.6.3: Freestyling a design

03

Load the Stock

Place sacrifical board under the stock onto the CNC bed.

- The sacrifical board helps support the stock and protects the CNC bed.
- Use the provided clamps to secure the stock firmly.
- Double-check that the stock does not shift or wobble when pushed by hand with a strong amount of force.

Figure 2.6.4: Loading the sacrifical board

Figure 2.6.5: Using the clamps to secure the stock

Figure 2.6.6: Adjusting the position of the clamps as needed

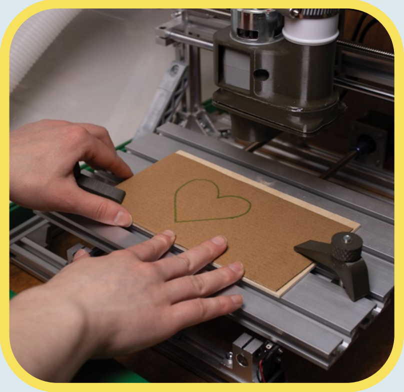


Figure 2.6.7: Applying force to ensure stock is secure in place

Part Two: Powering the System

04

Plug in the System
Plug in and power up in the correct order:

- Microcontroller → USB → Computer
- Console controller → USB → Computer
- CNC machine →Outlet

Figure 2.6.8: Console controller connection to computer

Figure 2.6.9: Microcontroller and Console Controller to Computer

05

Set Up in Candle

Ensure that the software is connected for use.

- Configure the serial port to connect to the correct USB
- Click on connect to the machine.
- Ensure that the **baud** is set to **115200**.

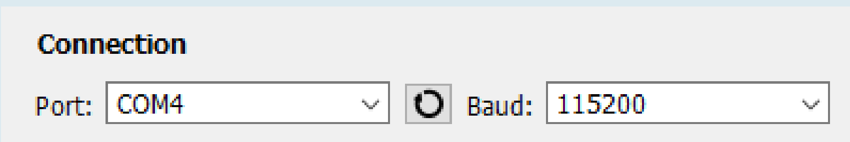
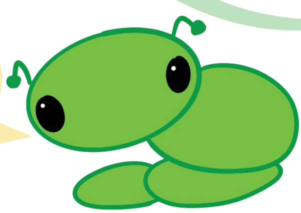


Figure 2.6.10: Candle screenshot of the connection.

Watch this video for Candle onboarding!



06

Home the Machine

Ensure the CNC is in its Home Position.

- Press the Home button in the console controller to move the spindle to X = 500, Y = 0, Z = 500.
- Do not interrupt the homing sequence. Once complete, the machine is ready for setup.

Figure 2.6.11: Setting the spindle to home position

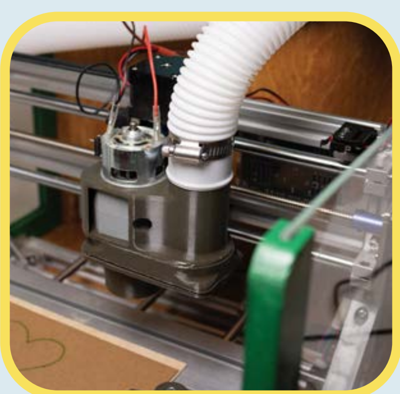


Figure 2.6.12: Spindle in home position

07

Attaching the Vaccuum

Attach the vacuum hose to the spindle mount and connect it to the shop vacuum for dust collection.

- Secure the vacuum hose to the designated bracket on top of the spindle. Make sure it's snug and properly aligned so it doesn't interfere with the tool path.
- Plug the other end of the tube into the shop vacuum's intake port. Ensure the connection is tight to maintain suction.
- Make sure the vacuum hose has enough slack and isn't kinked, tangled, or in the machine's way.

Figure 2.6.13: Connecting vacuum hose to top of spindle

Figure 2.6.14: Connecting other end of tube to shop vacuum

08

Position the Spindle to Starting Point

Manually move the spindle from Home to the starting position.

- At this point, you should have your tool selected for your project. **Refer to Section 2.4 on changing your bit**. console switch to travel mode to adjust feed rate to 500 mm/min.
- Use the X/Y joystick to position the spindle next to the stock.
- Use the Z joystick to lower the spindle until the bit is just above the stock, careful to not touch it.

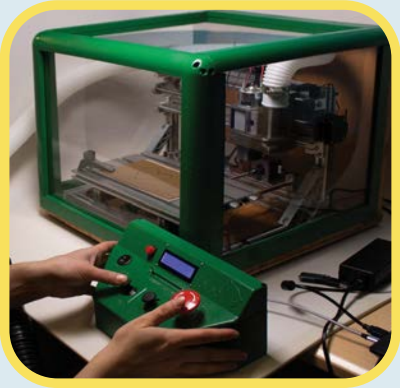


Figure 2.6.15: Using console controller to move the spindle

Figure 2.6.16: Ensuring drill bit is at starting point

09

Prepare for Cutting

Before starting your CNC job, make sure everything is safely set up and ready to go.

- Ensure the CNC machine's enclosure is securely closed to protect you from debris and noise.
- Power on the vacuum system to begin dust collection. This helps maintain a clean workspace and improves visibility.

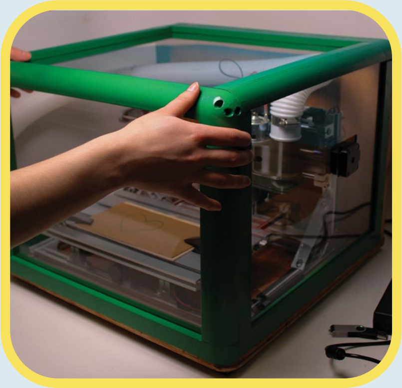
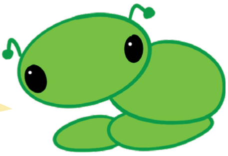


Figure 2.6.17: Closing the enclosure

Make sure the spindle does not press into the stock to avoid tool breakage.



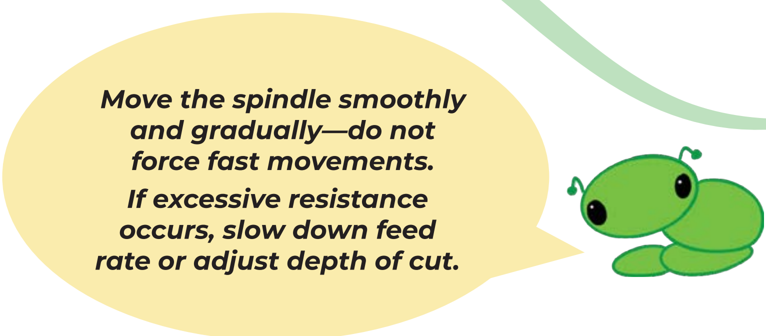
Part Three: Start Machining

10

Start the Spindle

Turn on the spindle and set the correct speed.

- Press the spindle **ON/OFF button** to start the motor.
- Set console switch to **cutting mode** to adjust feed rate to 100 mm/min.
- Use the X/Y joystick to move the spindle along your drawn path.
- Use the Z joystick to control depth as needed.



Part Four: Finishing Up

11

Shutting Down and Cleaning the Workspace
Follow the shutdown process and remove any leftover debris.

- Ensure the spindle is OFF.
- Raise the Z-axis above the stock.
- Press the Home button to return the spindle to Home Position.
- Unplug CNC machine and computer connection.
- Open the enclosure and remove the stock.
- Use brush to clean any remaining dust from the enclosure.
- Wipe down the machine bed and components.

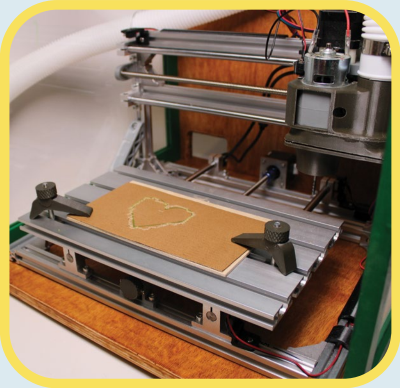
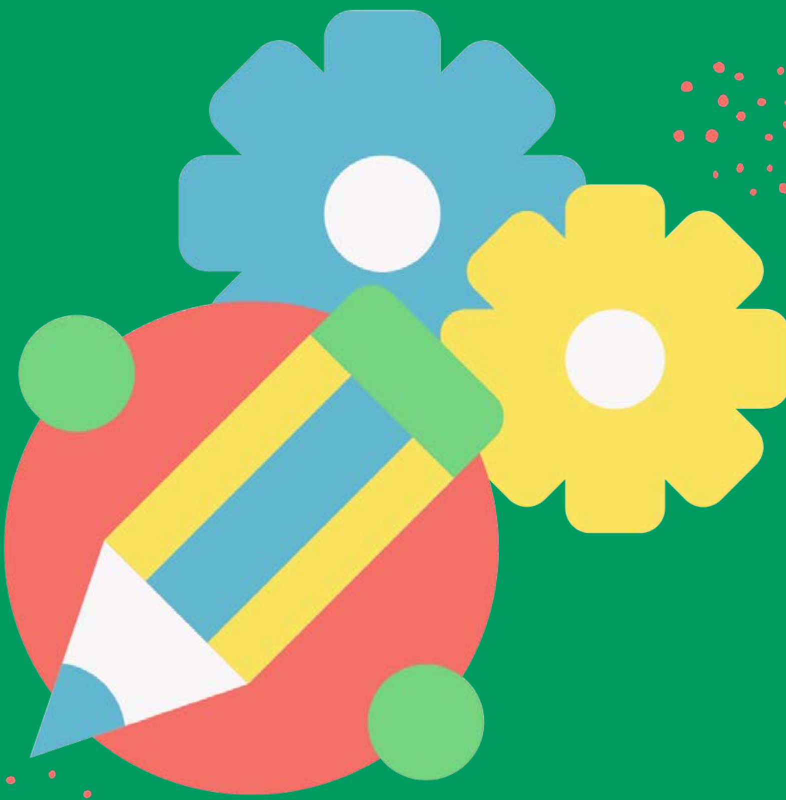


Figure 2.6.18: Final cut

Chapter 3

Beyond the Machine



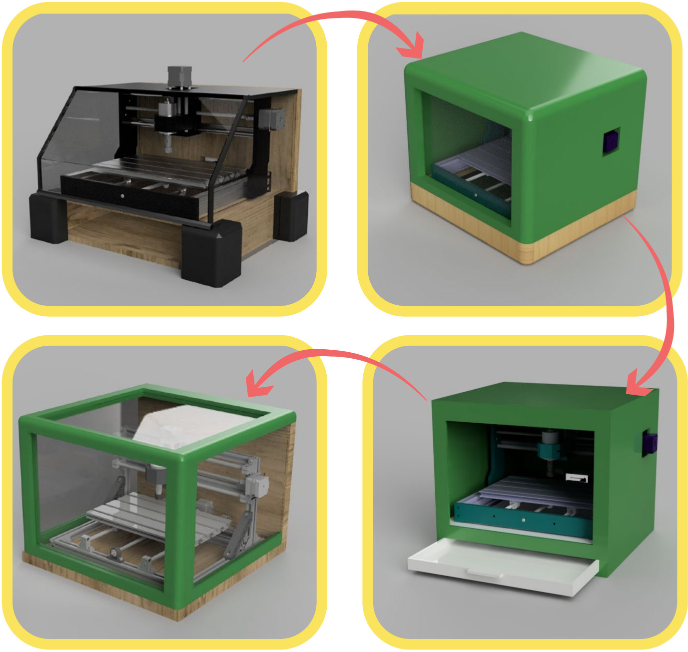
bloc

Think Like an Engineer

This section covers the **engineering design process**. This refers to the series of steps that guides engineering teams as we solve problems. The design process is **iterative**, meaning that we repeat the steps as many times as needed, making improvements along the way as we learn from failure and uncover new design possibilities to arrive at great solutions.

Iterative Design

We have implemented iterative design throughout the design of **bloc** through multiple iterations that have been tested through prototypes. Check out how far our design has come!



The Engineering Design Process

Design is rarely a straight line—it's a cycle of curiosity, creativity, and continuous improvement. Here's a breakdown of the key steps engineers follow to create meaningful, human-centered solutions:

Ask

Start by observing the world around you and asking thoughtful questions.

- What is the problem or need?
- Who experiences this problem?
- Why is it important to solve?

Asking the right questions lays the foundation for a solution that matters.

Research

Explore how others have tackled similar challenges.

- What existing solutions are out there?
- What works well and what could be better?
- What can you learn about users or the audience you're desiging for?

Research can help uncover opportunities for innovation.

Imagine

Brainstorm as many solutions as possible.

- Don't settle on your first idea.
- Push your thinking in new directions.
- Collaborate, sketch and let creativity flow.

The best ideas often emerge when you explore unexpected possibilities.

Plan

Choose the most promising idea baased on your research and design goals.

- Identify how it solves the problem.
- Consider materials, tools, and constraints.
- Sketch out your idea or create a simple storyboard to visualize how users will interact with it.

Planning gives your creativity structure and direction.

Section 3.1 Iterative Design

Create

Build a working version of your solution.

- Use simple or accessible materials, it doesn't have to be perfect.
- Focus on functionality over polish.
- Think of it as a tool for learning, not a final product.

Prototypes help you test your ideas in the real world.

Test

Try your solution with real users.

- Observe how they interact with it.
- Ask for feedback and take notes.
- Look for patterns for what works and what doesn't.

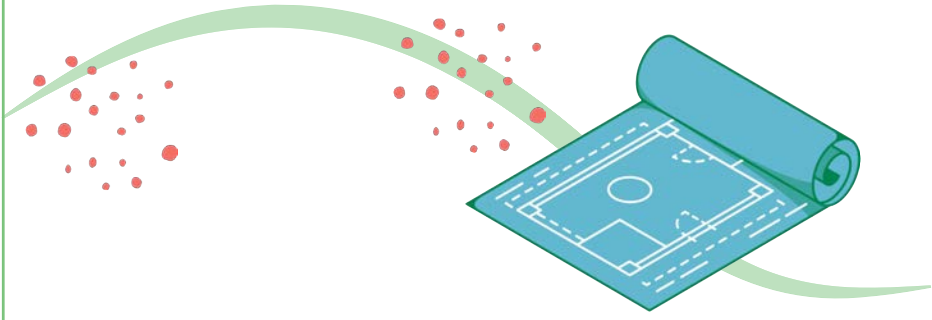
Testing brings your design closer to its full potential.

Improve

Use what you've learned to refine your solution.

- Fix problems.
- Make improvements.
- Repeat as needed.

Design is iterative—each version brings you closer to something great.



The Power of Reiteration

Every failure is feedback. Every version brings you closer to a solution that is not only functional, but meaningful.

Reflection

Use these prompts to guide your thinking after each prototyping or fabrication attempt.

- What worked well and why?
- What didn't go as planned?
- How did the material respond to the cut/tooling?
- Were there unexpected limitations in your design?
- What would you change if you had to do it again?
- How might a user interact with this differently than expected?

Post- Processing

Finishing your project is just as important as cutting it out. Thoughtful post-processing can elevate your prototype into something you're proud to show off.

- Deburr or sand rough edges for safety and clean aesthetics.
- Test-fit components before committing to glue or fasteners.
- Use adhesives, finishes, or coatings to add durability or polish.
- Label parts and document the process—future you (or your teammates) will thank you.
- Photograph your build at different stages—you never know when a “work in progress” shot will tell a better story than the final one.

Tips From the *bloc* Team

Fabrication and making can be challenging—but that's part of the art. Things don't always work out on the first try, and that's exactly why we emphasize the engineering design process. It's all about problem-solving, reflecting, and learning through iteration.

We've gathered some tips based on our own experiences to help you along the way. As you gain confidence and skill, you'll develop your own insights and techniques, too. That's the beauty of making—it's a process of continuous learning.

Plan Before You Cut

- Sketch out your idea before you jump into CAD or CAM.
- Test your materials—scrap pieces are your best friend.
- Measure twice, cut once—seriously, it saves time and frustration.

Iterate and Refine

- Refine and test your design often—no one nails it on the first try.
- Even if parts are "designed to fit," real-world tolerances can surprise you.

Use Tools

- Simulate your cut path—trace the design with the tool (without cutting) to ensure alignment and clearance.
- Don't skip post-processing! Sanding, finishing, and assembling are just as important as the cut.

Leverage Open Source

- Start with existing designs, you'll learn a lot and save some time
- Get designs from source companies:
  - **Prusa Research**
  - **Thingiverse**

Farewell *(for now)*

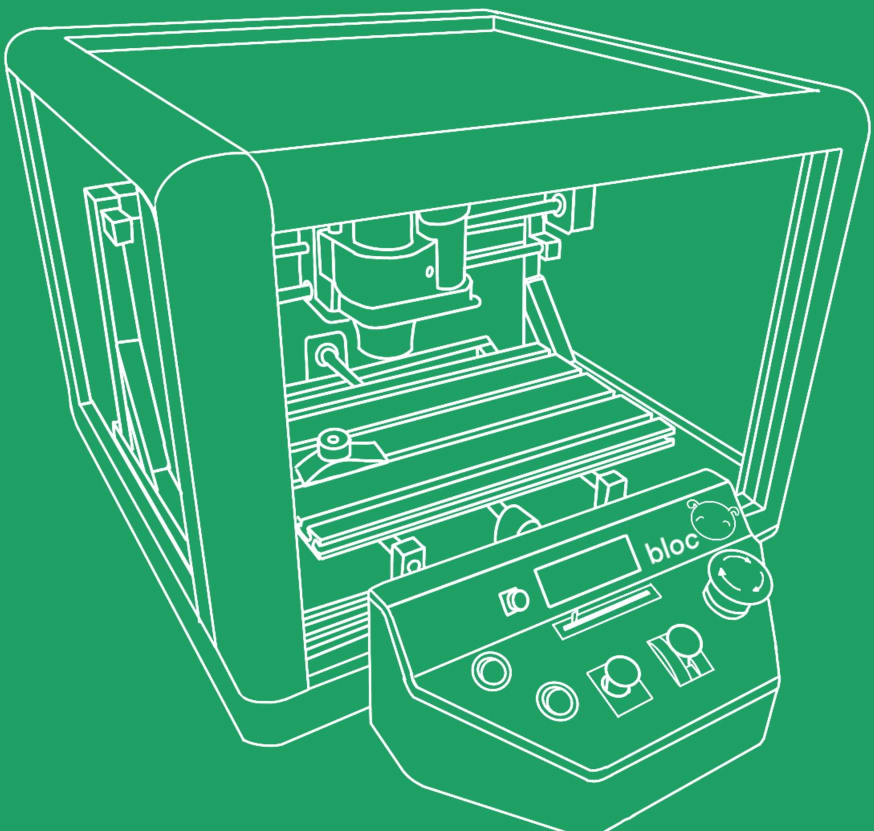
You've just taken your first steps into the world of digital fabrication—and that's no small feat. From learning the basics of CNC machining to embracing the power of iteration, you've explored not just how to make things, but how to think like an engineer, a designer, and a creative problem solver.

Our goal with **bloc** has always been to empower makers—especially those just getting started, with no prior experience. No matter your background, you carry something incredibly valuable: curiosity, excitement, and a willingness to learn.

Remember: **making is a journey**. You'll mess up, learn, try again, and keep getting better. That's part of the process—and part of the fun. As you continue building, sketching, testing, and refining, don't forget to stay curious, ask questions, and trust your ideas.

We can't wait to see what you create next.
Keep making. Keep learning. Keep iterating.

— The *bloc* Team



Making for Everyone