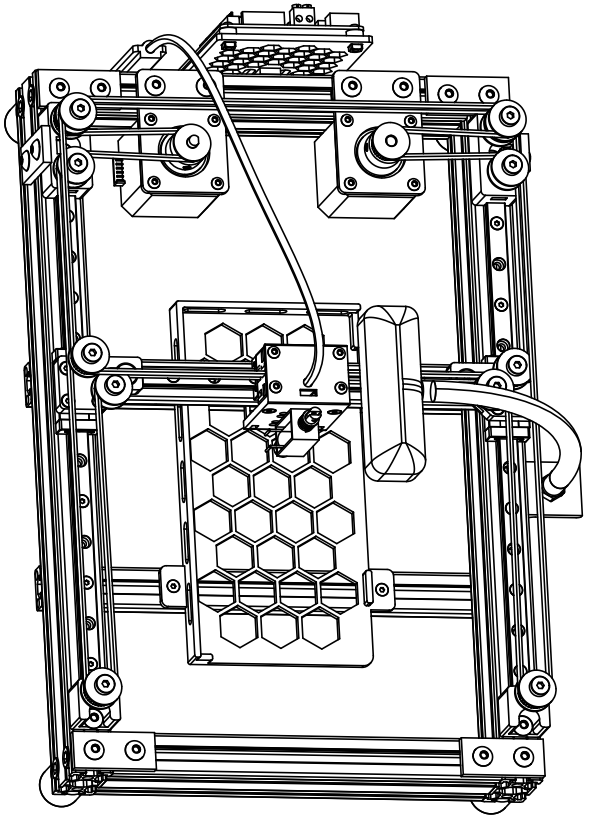
PhysiClaw.ai



PHYSICLAW ASSEMBLY MANUAL

We build agents that interact with you in the real world

VERSION 2026-08-05

TABLE OF CONTENTS

PHYSICLAW

PhysiClaw is a physically-interactive agent: it operates a phone by tapping on its screen, so it needs hardware to carry out those actions. This manual covers the assembly of that hardware. It has three parts: a CoreXY stage that moves across the plane (X/Y positioning), a touch mechanism that presses the screen along the Z axis, and a camera that watches the screen.

BEFORE YOU BEGIN

Before you start, read this manual all the way through, and check the parts you've bought against the bill of materials to make sure nothing is missing. Assembling a PhysiClaw takes about two to three hours, so set aside enough time.

REPORTING AN ISSUE

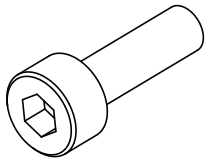
Should you find an error in this manual or have a suggestion for an improvement, please consider opening an issue on GitHub (github.com/physiclaw/PhysiClaw/issues). When raising an issue please include the relevant page numbers and a short description; annotated screenshots are also very welcome. We periodically update the manual based on the feedback we get.

GitHub

https://github.com/physiclaw/PhysiClaw

Docs

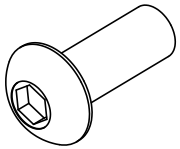
https://docs.physiclaw.ai



SOCKET HEAD CAP SCREW (SHCS)

Cylindrical head, hex drive.

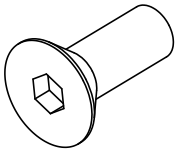
ISO 4762 / DIN 912



BUTTON HEAD CAP SCREW (BHCS)

Domed head, hex drive. Used on surfaces where a lower profile matters but a flush head isn't required.

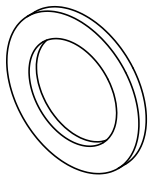
ISO 7380-1



FLAT HEAD CAP SCREW (FHCS)

90° countersunk head, hex drive. Sits flush with the surface, used where nothing can protrude above the part.

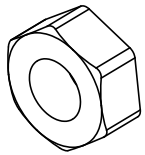
ISO 10642 / DIN 7991



SHIM

5×8×0.5 shim. Stacked under each idler to adjust axial play.

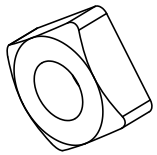
5×8×0.5



HEX NUT

Pairs with a bolt to clamp parts firmly together.

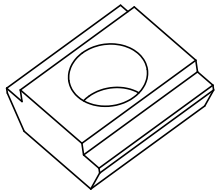
ISO 4032 / DIN 934



SQUARE NUT

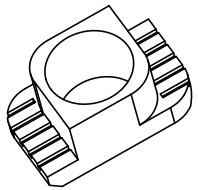
A square nut sits in a pocket of the printed part, letting you tighten a bolt into it.

DIN 557



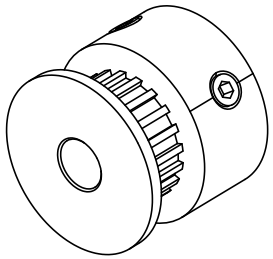
STANDARD T-NUT (SLIDE-IN)

Slides into the slot from the open end of the extrusion. As you tighten the screw, the nut is pulled up and catches on the inner edges of the slot opening.



HAMMER T-NUT (DROP-IN)

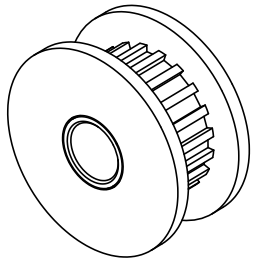
Drops flat into a slot anywhere along its length, then a quarter turn locks it.



GT2 DRIVE PULLEY

20-tooth toothed pulley. One sits on each stepper shaft, locked to the shaft's D-flat with a set screw; it drives the GT2 belt.

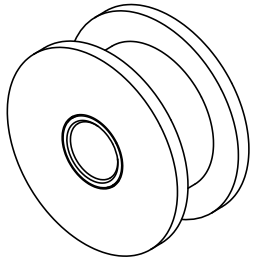
GT2 · 20T · 5 mm bore · 6 mm belt



GT2 IDLER (TOOTHED)

Toothed turning wheel that meshes with the toothed side of the belt as it spins.

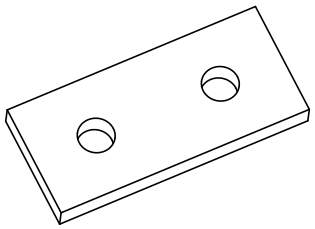
GT2 · 20T · 5 mm bore · 6 mm belt



GT2 IDLER (SMOOTH)

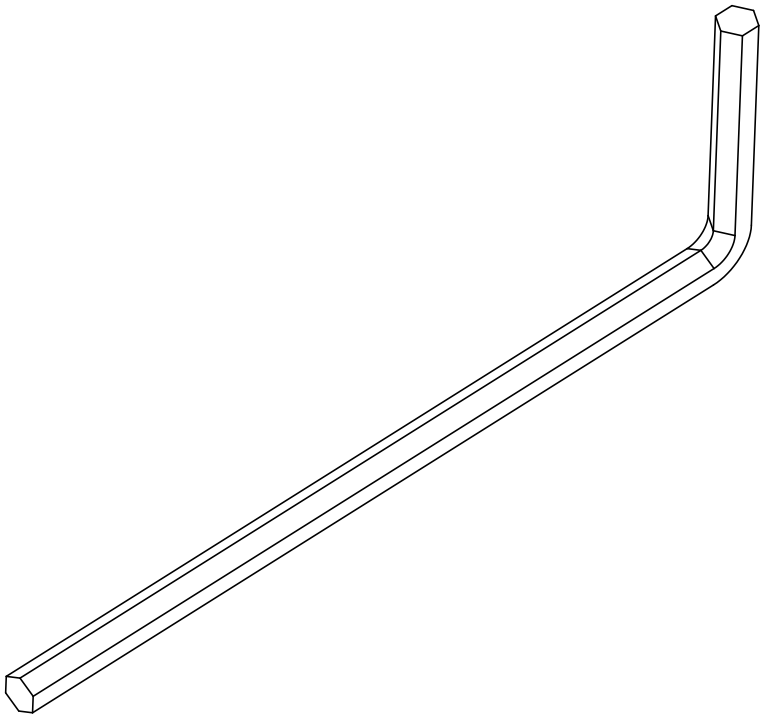
Un-toothed turning wheel that rides on the belt's flat back as it spins.

5 mm bore · 6 mm belt



FLAT BRACKET

Two-hole plate with M5 holes 20 mm apart.



2 MM & 3 MM HEX DRIVERS

The 2 mm and 3 mm hex drivers see the most use in this build. We recommend a quality driver in each size.

DRIVER SIZES

These cover the socket screws used in this build: 2 mm for M3 button/flat head screws, 3 mm for M5 button/flat head screws (BHCS/FHCS), and 5 mm for M6 socket head cap screws (SHCS).

PART PRINTING SETTINGS AND GUIDELINES

PhysiClaw's custom parts are printed by a nylon powder-bed fusion process, either Selective Laser Sintering (SLS) or Multi Jet Fusion (MJF), rather than the common FDM. The powder-bed process fuses nylon powder layer by layer into dense, support-free parts with uniform strength in every direction. These parts carry side holes and overhangs: with FDM the side holes deform and the overhangs sag, so a powder-bed process is required. Match the specifications below when sourcing parts.

3D PRINTING PROCESS

Selective Laser Sintering (SLS) or Multi Jet Fusion (MJF)

PART DENSITY

Solid

MATERIAL

Black PA12 nylon (or equivalent)

DIMENSIONAL TOLERANCE

±0.3% (min ±0.3 mm)

LAYER THICKNESS

100 µm (0.1 mm)

ORIENTATION

Service default

MINIMUM WALL THICKNESS

1.0 mm

SURFACE FINISH

Raw / as-printed

FILE NAMING

Any file whose name ends in **_x#** tells you the quantity of that part required to build the machine. For example, a part named **idler_mount_front_x2.step** is needed two times.

SECTION 01

Frame

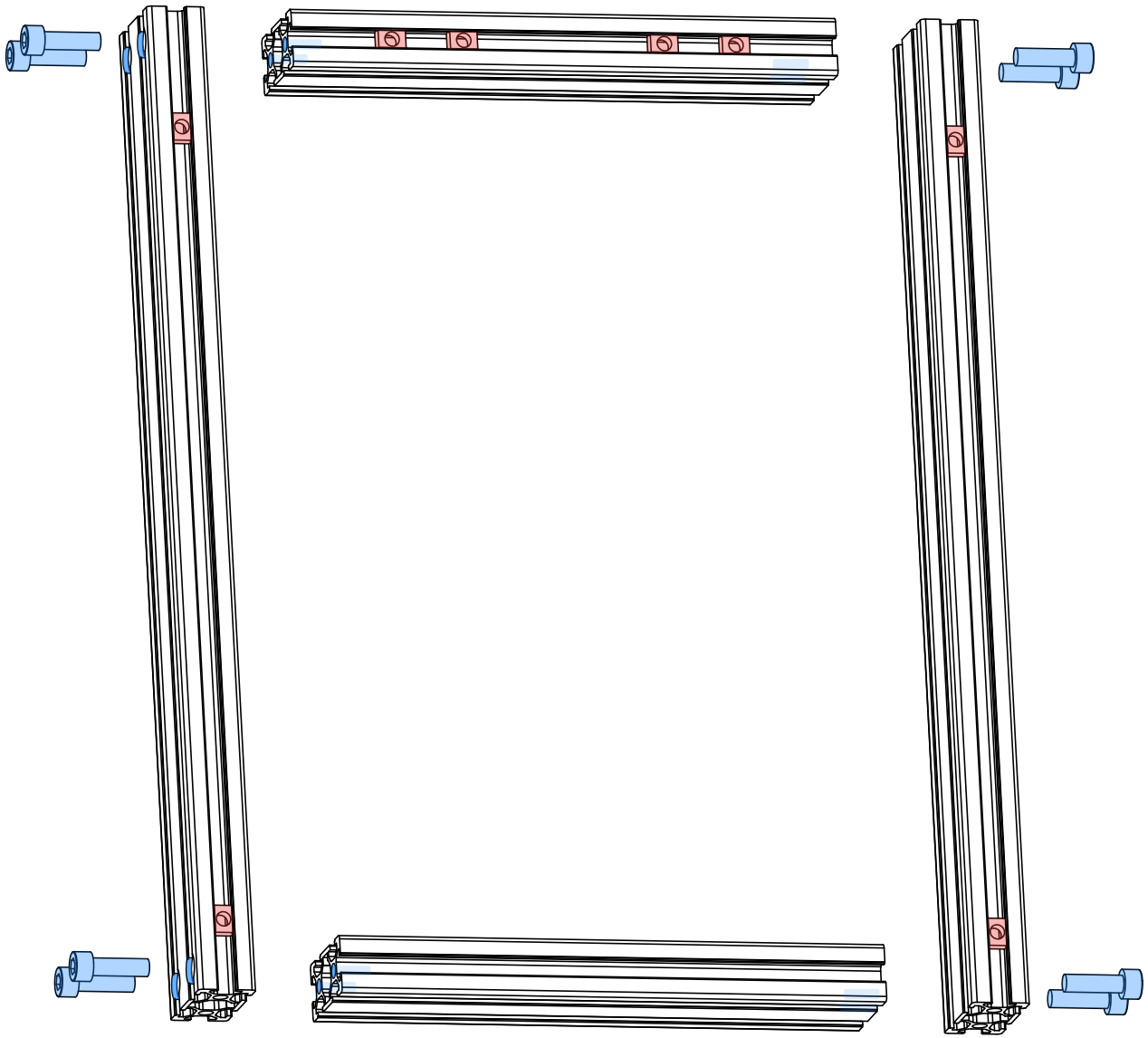
Four 2040 aluminum extrusions form the base frame, and every other part mounts onto it. Make sure all four corners are square. This is the foundation for accurate motion later on.

PRELOAD THE T-NUTS

Slide every T-nut into its slot before squaring the frame.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Extrusion 2040	345 mm · CB	2
Extrusion 2040	190 mm	2
T-nut	Slide-In M5	8



DIRECTION CONVENTION

Top, bottom, left, and right throughout this manual refer to this view.

MIND THE PLACEMENT

The short extrusion carrying the four slide-in T-nuts goes on top.

COUNTERBORES FACE OUT

The counterbored ends of the long extrusions face outboard, each counterbore aligned with the short extrusion's end bore.

SQUARE BEFORE FINAL TIGHTENING

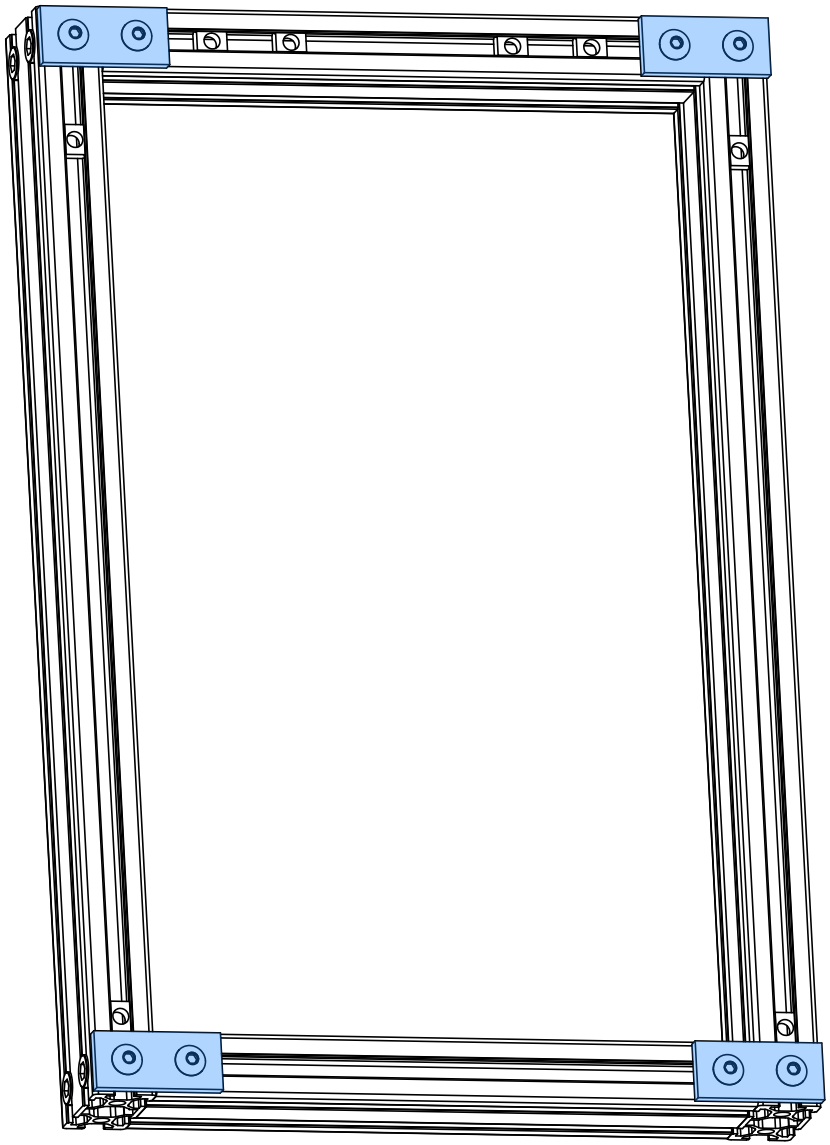
Each M6×20 SHCS drops through the long's counterbore into the short's end hole. Run all 8 in snug, square the frame on a flat surface, then tighten.

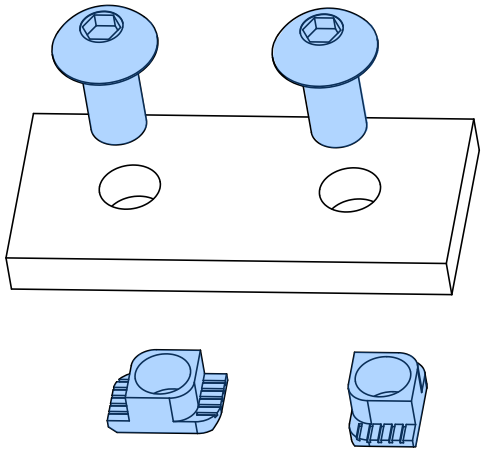
BILL OF MATERIALS

COMPONENT	SPEC	QTY
SHCS	M6×20	8

FRAME

FRAME_30 · FRAME_31





REINFORCE THE FRAME

One joining plate reinforces each corner. Run an M5×10 BHCS through the plate, start a drop-in T-nut on it loosely, drop the assembly into the closed frame, then tighten.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Flat bracket	40 × 18 × 4 mm	4
BHCS	M5×10	8
T-nut	Drop-In M5	8

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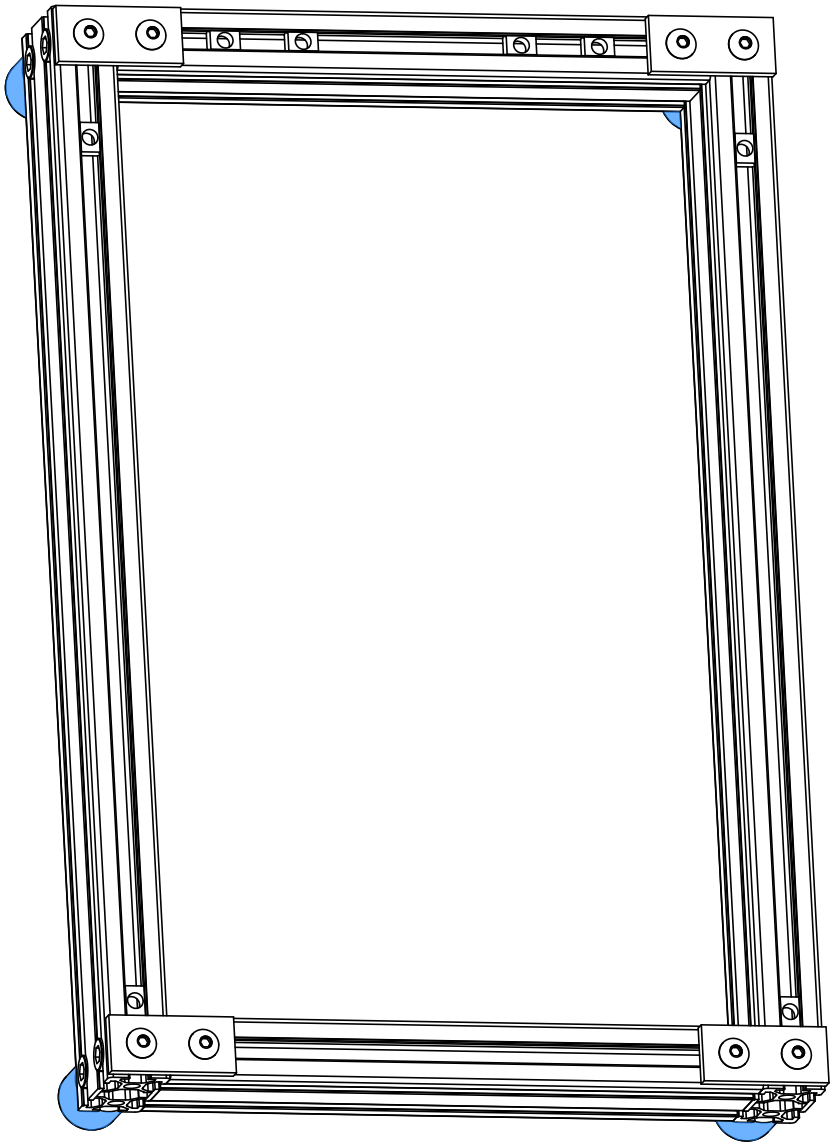
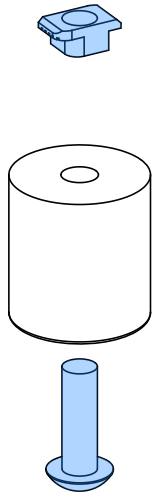
FRAME

FRAME_40 · FRAME_41



USE THE SCREWS THAT COME WITH THE BUMPERS

If the bumpers you bought came with their own screws, use those. They're the right size.



FEET POINT DOWN

The bumpers are the machine's feet, mounted under the four corners of the frame.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Bumper	Ø20 × 22 mm	4
BHCS	M5×16	4
T-nut	Drop-In M5	4

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SECTION 02

Idler

Install one idler assembly at each of the four corners of the frame, all using smooth idlers. They roll against the flat back side of the GT2 belt, redirecting it around each corner.

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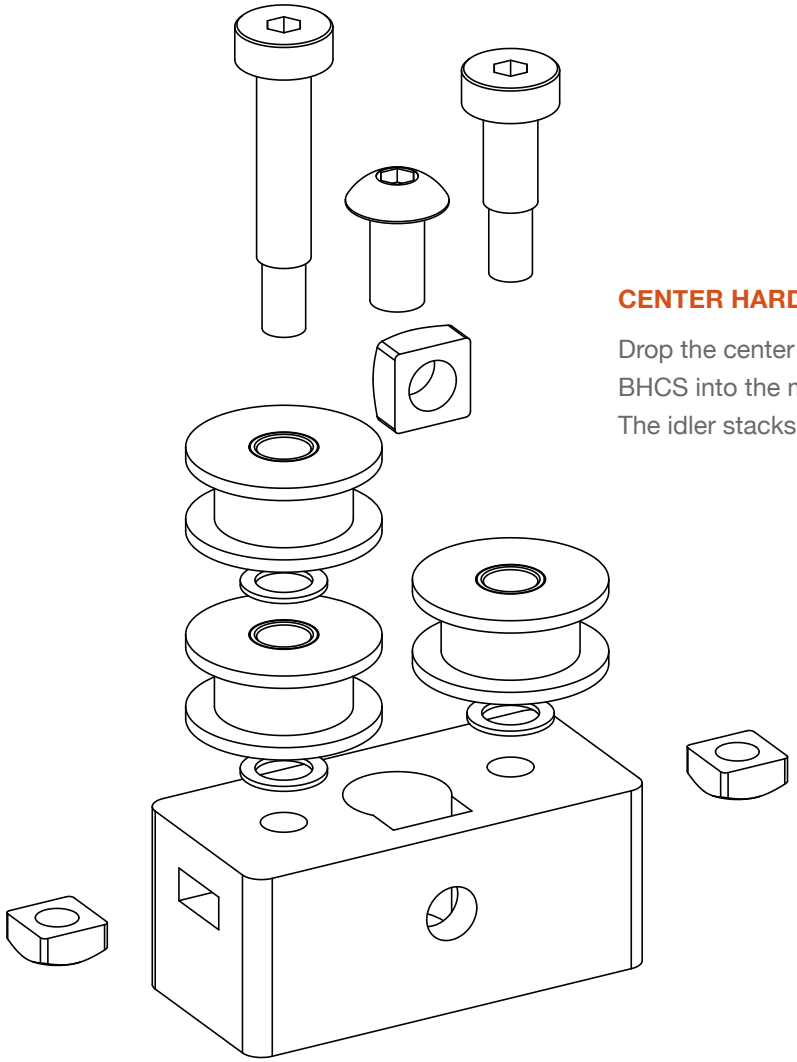
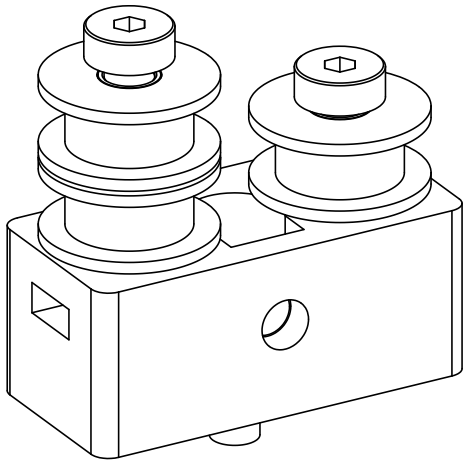


CENTER HARDWARE FIRST

Drop the center M5 square nut and its M5×10 BHCS into the middle counterbore hole first. The idler stacks block access later.



CONFIRM THE IDLER SPINS FREELY

Once installed, check that each idler turns freely.

FLAT FACE TOWARD THE SCREW

Seat each square nut with its flat face pointing toward its screw.

SIDE POCKET HARD TO SEAT?

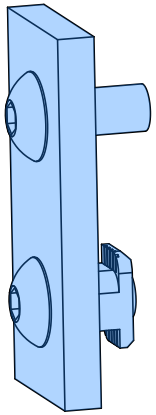
If a side square nut won't drop into place, clear the pocket with a small screwdriver or a pin first. Prints can leave residue in the slot.

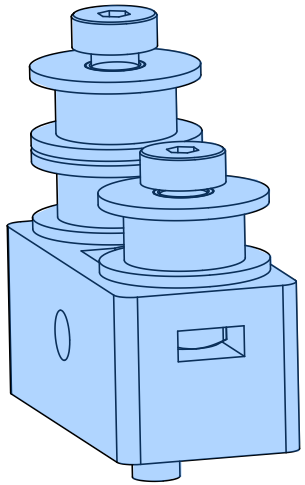
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler mount	SLS/MJF 3D Print	1
Idler	GT2 20T, smooth	3
BHCS	M5×10	1
Shoulder screw	Ø5×10×M4	1
Shoulder screw	Ø5×20×M4	1
Square nut	M4	2
Square nut	M5	1
Shim	5×8×0.5	3

IDLER

IDLER_12



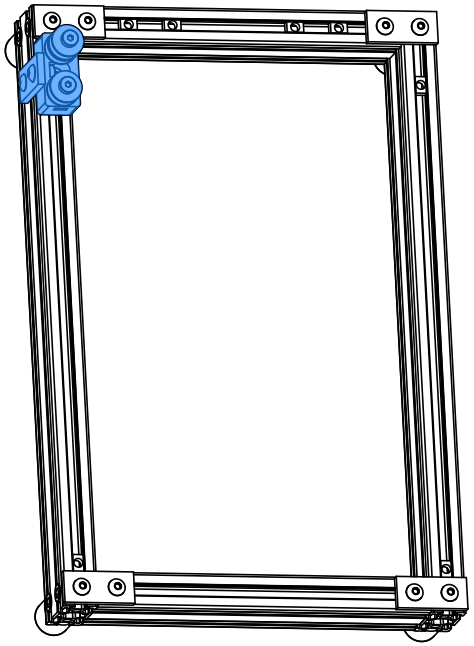


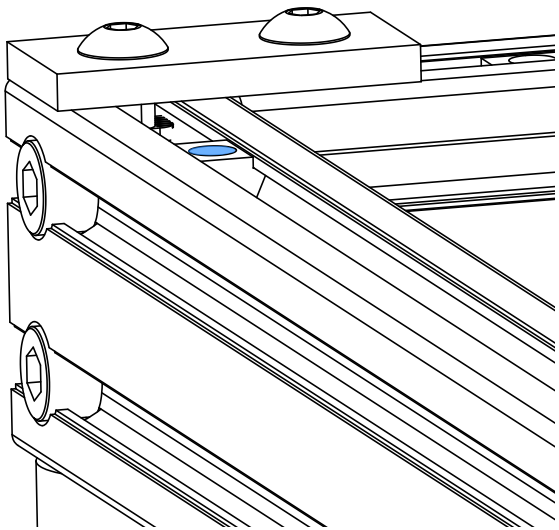
TWO WAYS TO THE FRAME

The block locks to the frame in two places: the middle M5 screw catches a slide-in T-nut in the extrusion slot, and the bracket bridges block and frame. On the bracket, the longer M5×12 BHCS threads into the block's captive square nut; the M5×10 catches the T-nut in the frame slot.

2 MM GAP TO THE CORNER PLATE

Position the block so it sits 2 mm clear of the frame-corner joining plate.





BILL OF MATERIALS

COMPONENT	SPEC	QTY
Flat bracket	40 × 18 × 4 mm	1
BHCS	M5×10	1
BHCS	M5×12	1
T-nut	Drop-In M5	1

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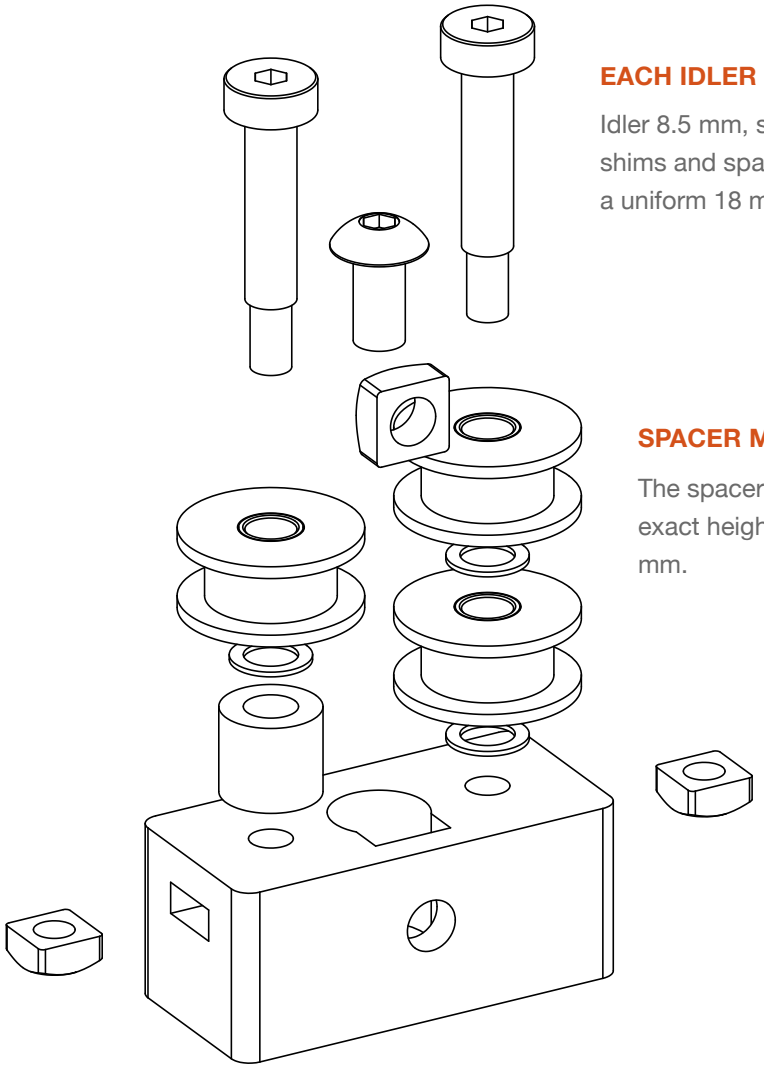
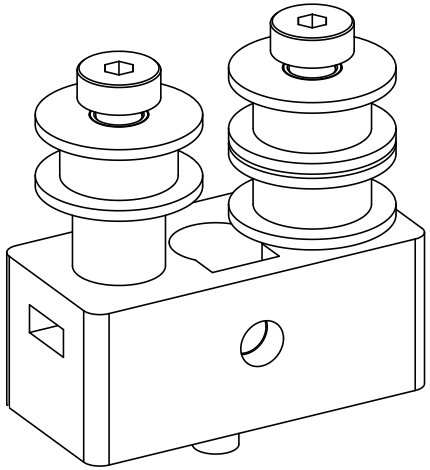


EACH IDLER STACK IS 18 MM

Idler 8.5 mm, spacer 9 mm, shim 0.5 mm. Use shims and spacers to bring every idler stack to a uniform 18 mm.

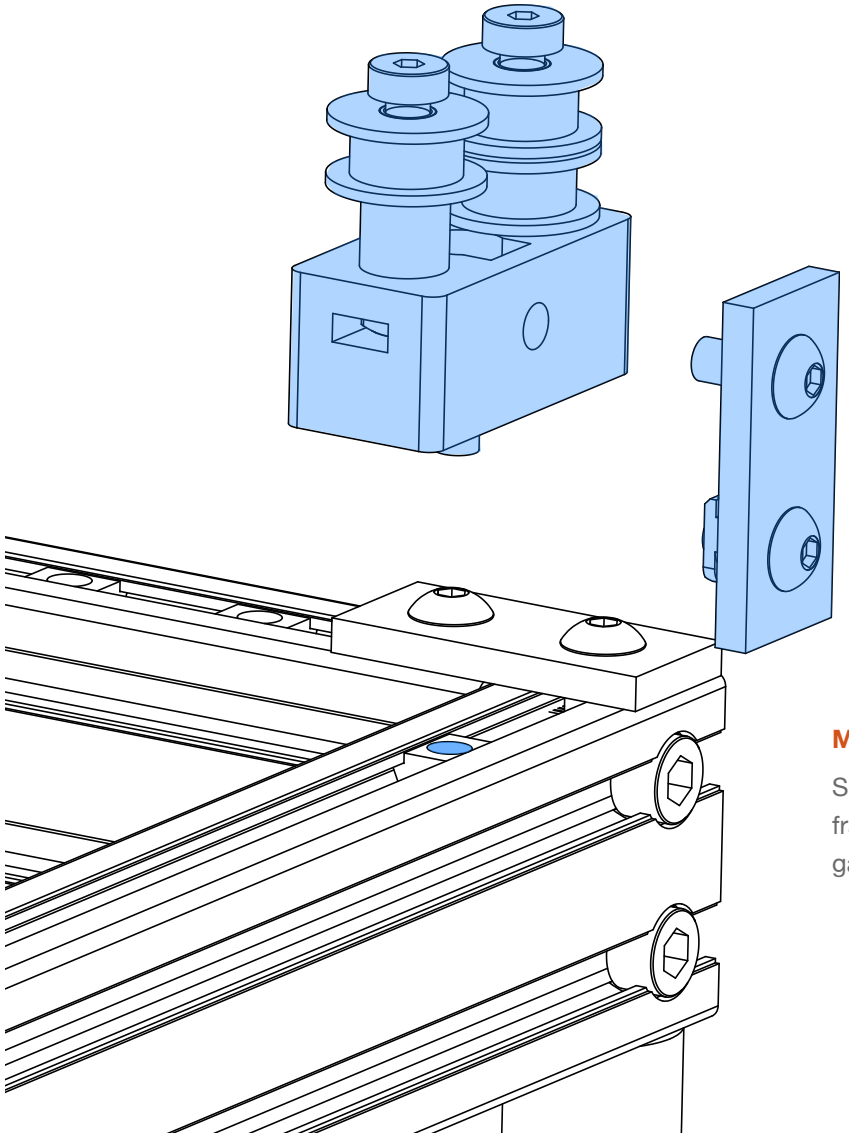
SPACER MUST TOTAL 9 MM

The spacer is 9 mm tall. If you can't buy that exact height, stack shorter spacers to total 9 mm.



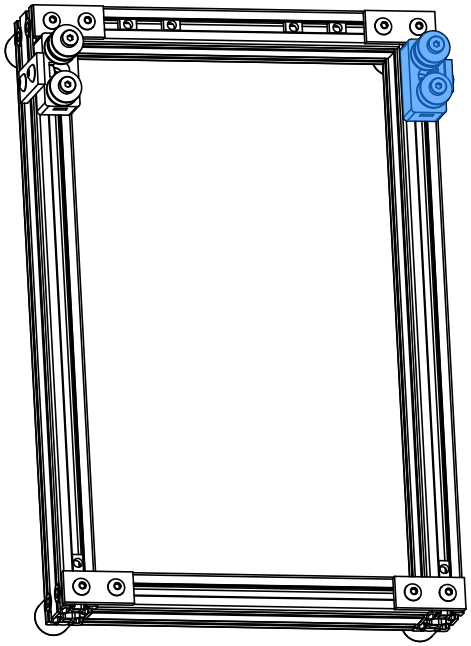
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler mount	SLS/MJF 3D Print	1
Idler	GT2 20T, smooth	3
BHCS	M5×10	1
Shoulder screw	Ø5×20×M4	2
Square nut	M4	2
Square nut	M5	1
Spacer	5×10×9	1
Shim	5×8×0.5	3



LONG SCREW INTO THE BLOCK

Same screw split as the left bracket: the M5×12 BHCS threads into the block's captive square nut, the M5×10 into the frame-slot T-nut.

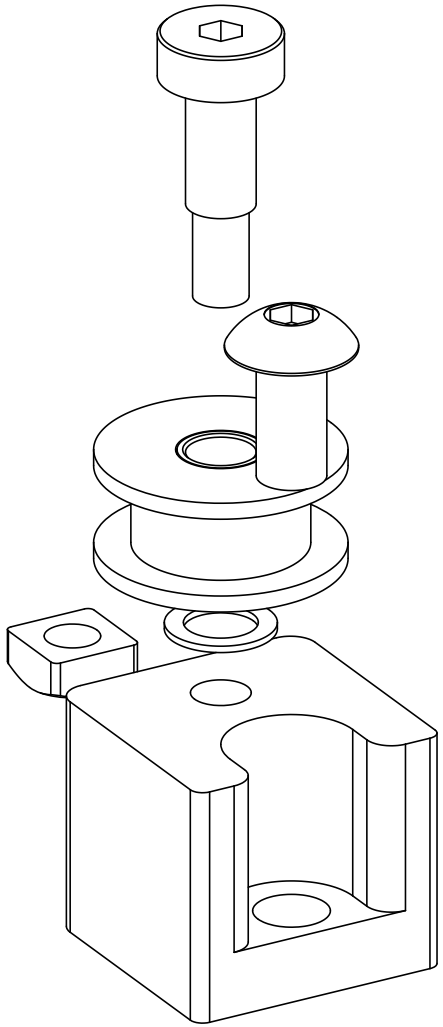


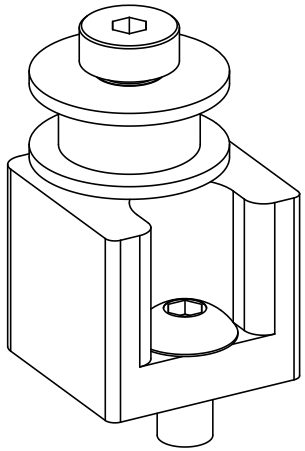
MATCH THE LEFT BLOCK'S GAP

Set the right block the same 2 mm clear of the frame-corner plate as the left block. Keep both gaps equal so the idler stations stay symmetric.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Flat bracket	40 × 18 × 4 mm	1
BHCS	M5×10	1
BHCS	M5×12	1
T-nut	Drop-In M5	1





MOTOR A IDLER — SITS LOWER

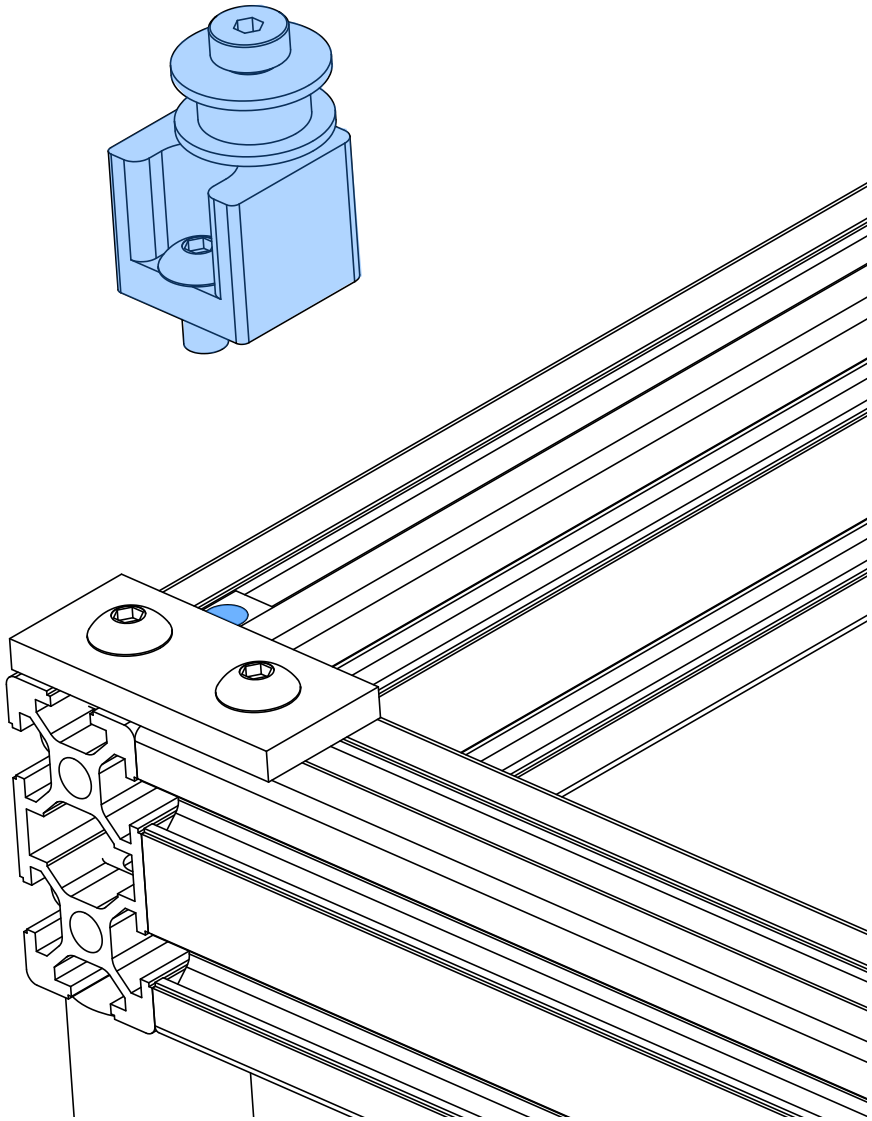
This idler carries Motor A's belt. With no spacer, it rides on the lower belt plane.

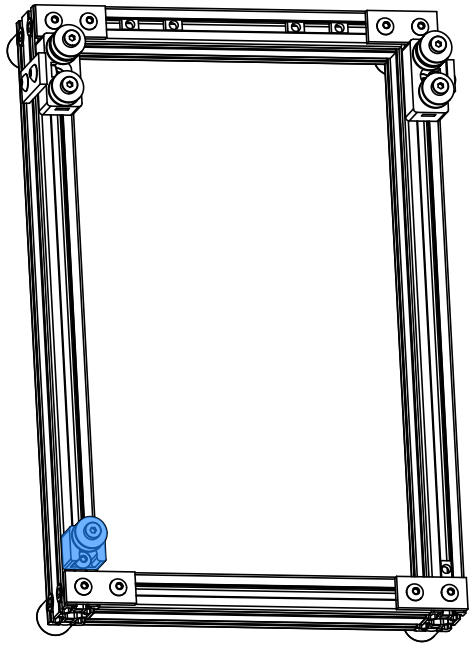
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler mount	SLS/MJF 3D Print	1
Idler	GT2 20T, smooth	1
BHCS	M5×10	1
Shoulder screw	Ø5×10×M4	1
Square nut	M4	1
Shim	5×8×0.5	1

IDLER

IDLER_31





2 MM GAP TO THE CORNER PLATE

Set this block 2 mm clear of the frame-corner plate, the same gap used at every other idler station.

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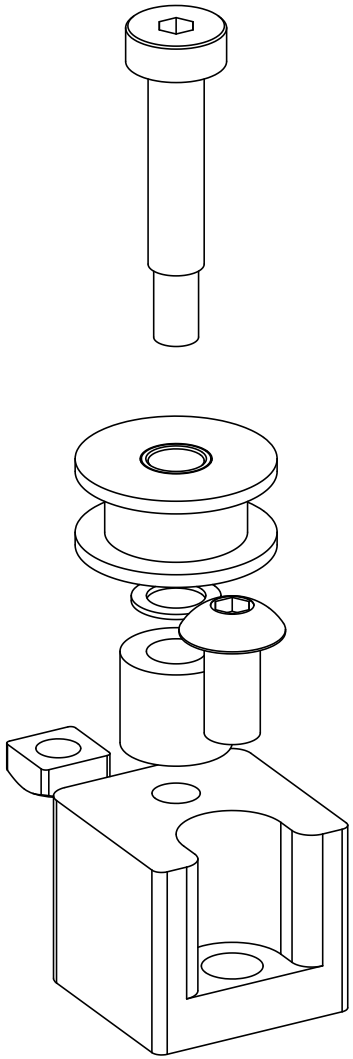
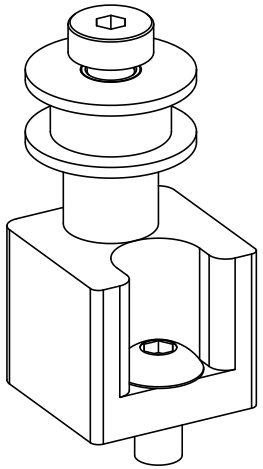


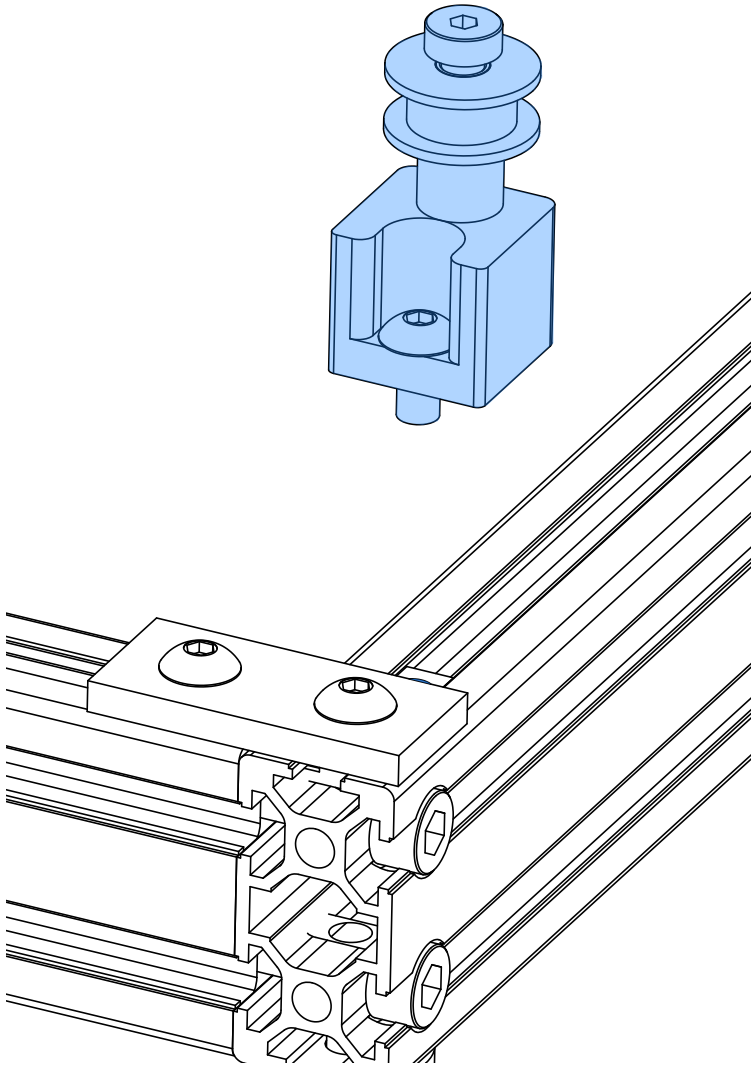


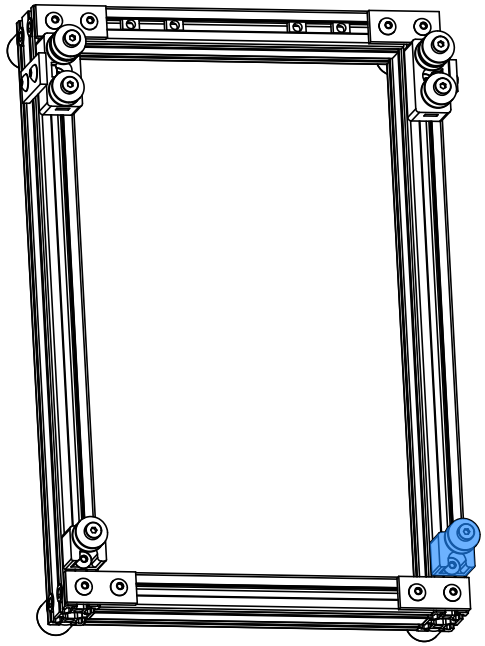
MOTOR B IDLER — SITS HIGHER

This idler carries Motor B's belt. The 9 mm spacer lifts it onto the upper belt plane.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler mount	SLS/MJF 3D Print	1
Idler	GT2 20T, smooth	1
BHCS	M5×10	1
Shoulder screw	Ø5×20×M4	1
Square nut	M4	1
Spacer	5×10×9	1
Shim	5×8×0.5	1





MATCH THE LEFT BLOCK'S GAP

Set the right block the same 2 mm clear of the frame-corner plate as the left block, so the lower idler stations stay symmetric.

SECTION 03

Motor

Two NEMA 17 stepper motors mount on the top extrusions of the frame, one on each side. They drive the CoreXY belts, which move the stylus carriage.

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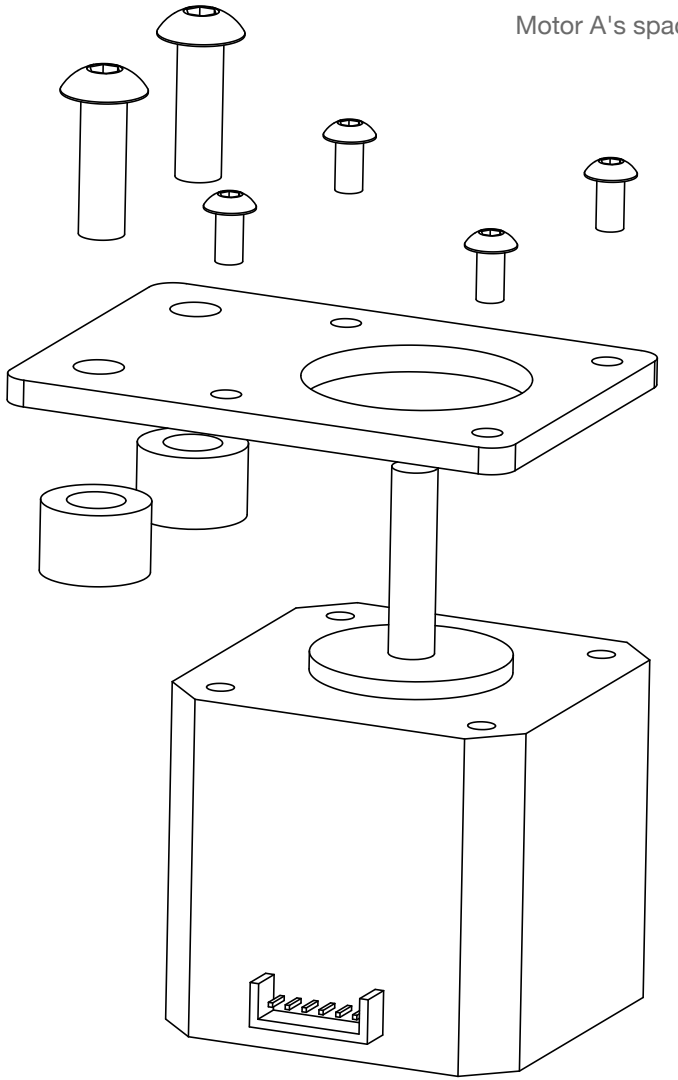
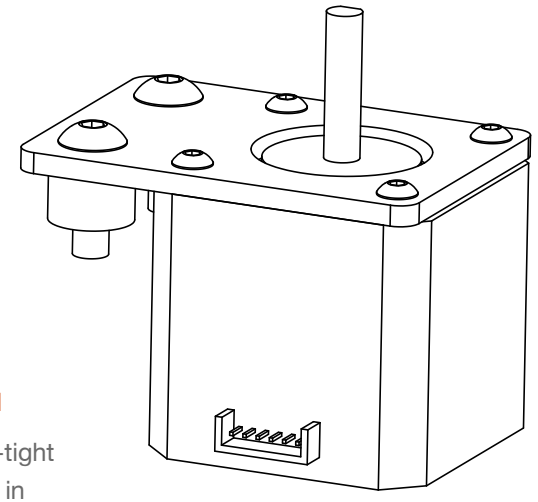


ONLY THE SPACER HEIGHT MATTERS

Motor A's spacer must be 8 mm tall.



TIGHTEN IN A CROSS PATTERN

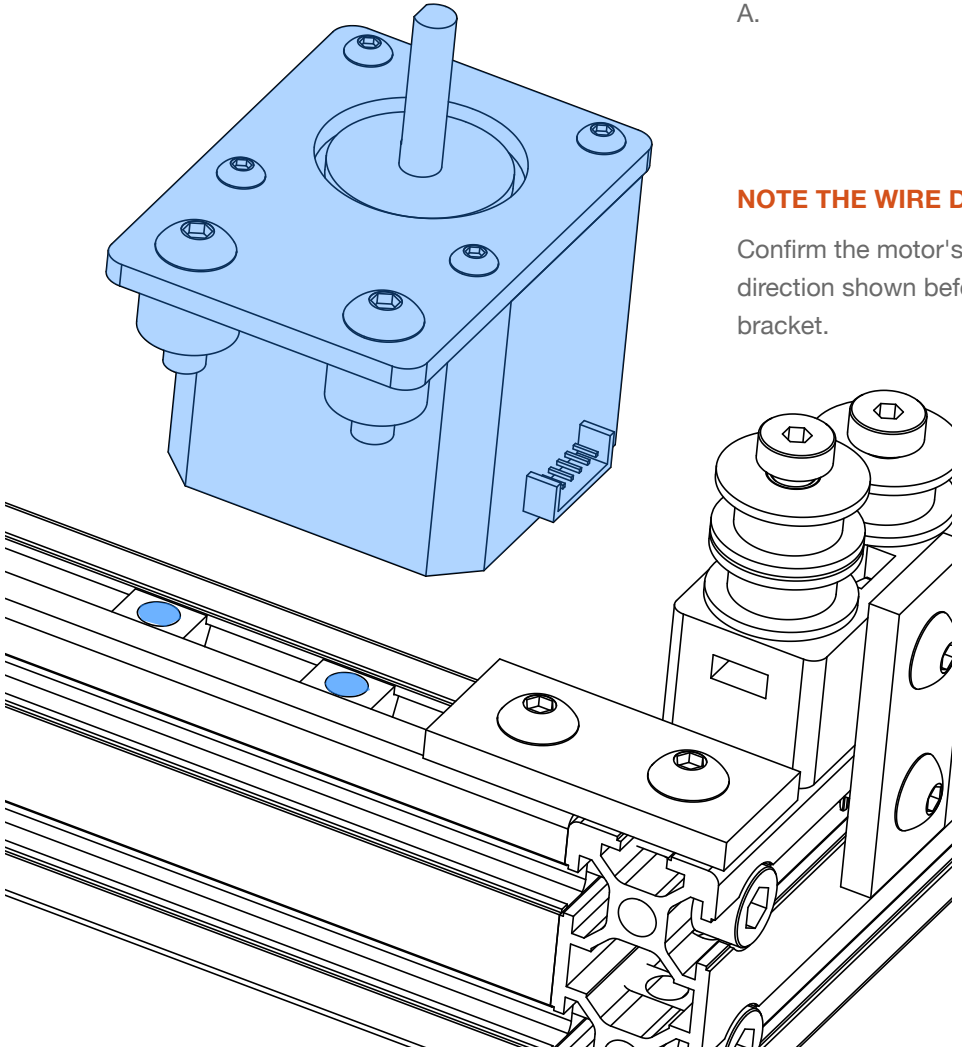
Run all four motor screws in finger-tight first, then tighten opposite corners in pairs. This pulls the motor flat against the bracket instead of tilting it to one side.

NOTE THE MOTOR WIRE DIRECTION

Check which way the motor's wires face and match the orientation shown. That orientation sets the wiring clearance later.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Motor bracket	60×42×3	1
Motor	NEMA 17 stepper, 38 mm height	1
BHCS	M3×6	4
BHCS	M5×16	2
Spacer	6×12×8	2

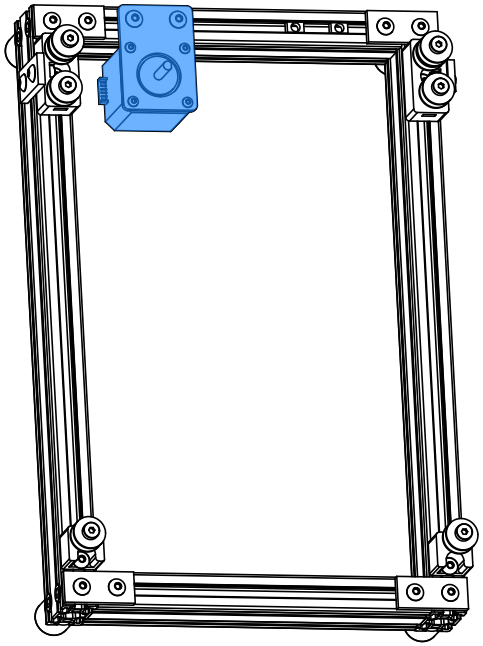


MOTOR A

We refer to the left motor as Motor A.

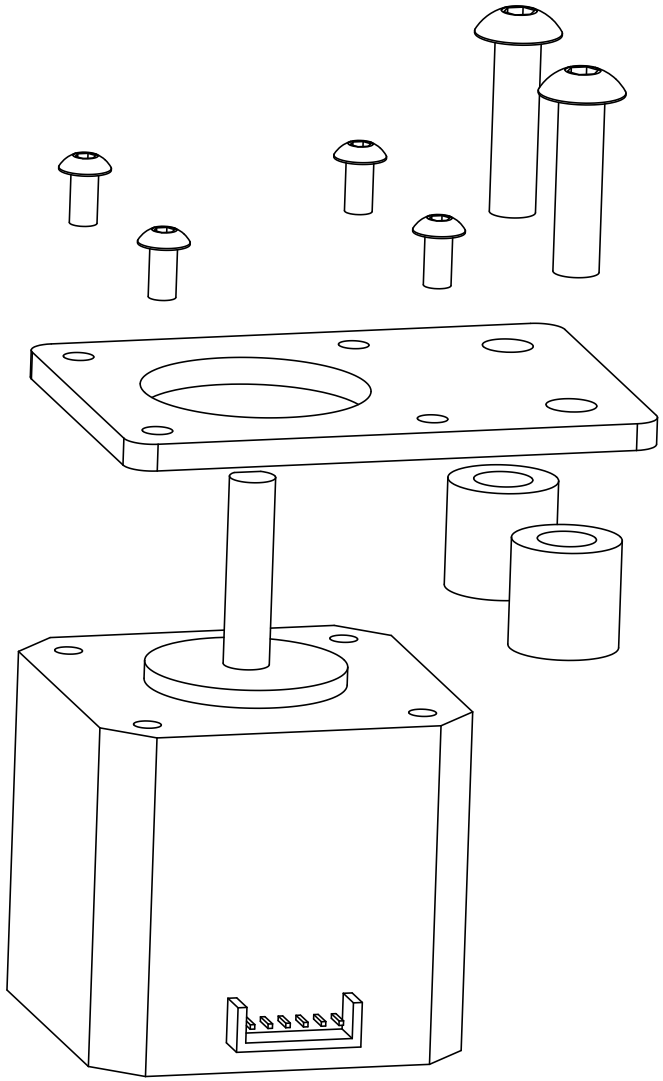
NOTE THE WIRE DIRECTION

Confirm the motor's wires face the direction shown before fixing the bracket.



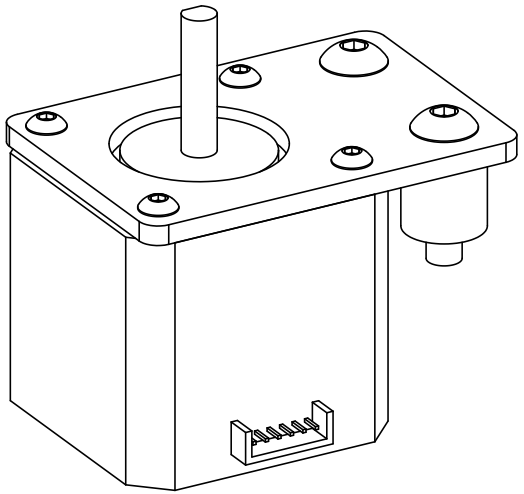
LEAVE THE BOLTS LOOSE

Don't fully tighten the motor mount yet. You'll slide it later to tension the belt.



A TALLER SPACER HERE

Motor B's spacer must be 12 mm tall.

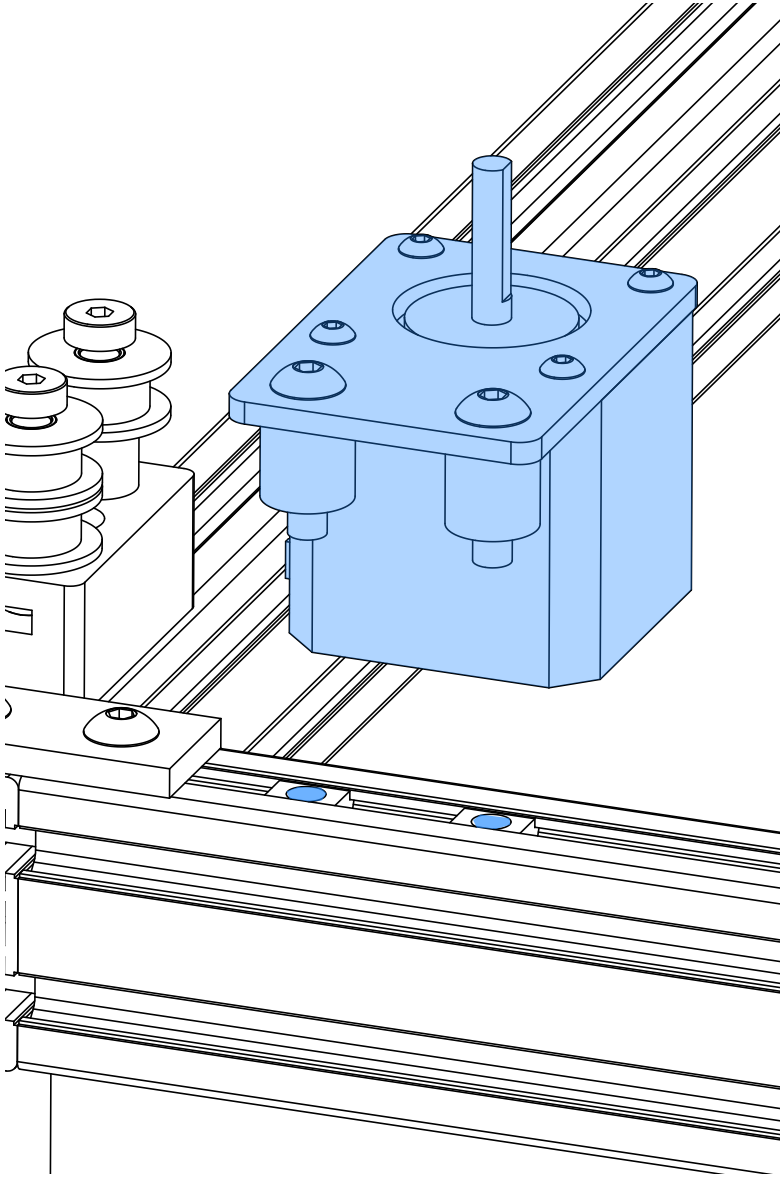


RIGHT MOTOR — MIRROR IMAGE

Built like the left motor, but mirrored: the cable connector faces right.

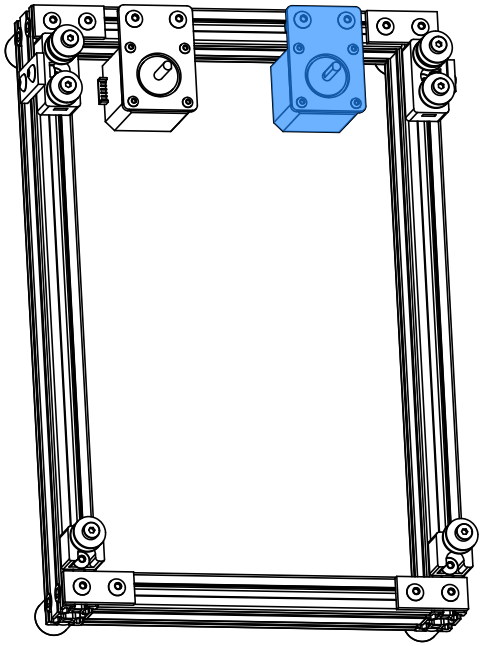
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Motor bracket	60×42×3	1
Motor	NEMA 17 stepper, 38 mm height	1
BHCS	M3×6	4
BHCS	M5×20	2
Spacer	6×12×12	2



MOTOR B

We refer to the right motor as Motor B.



MIRROR

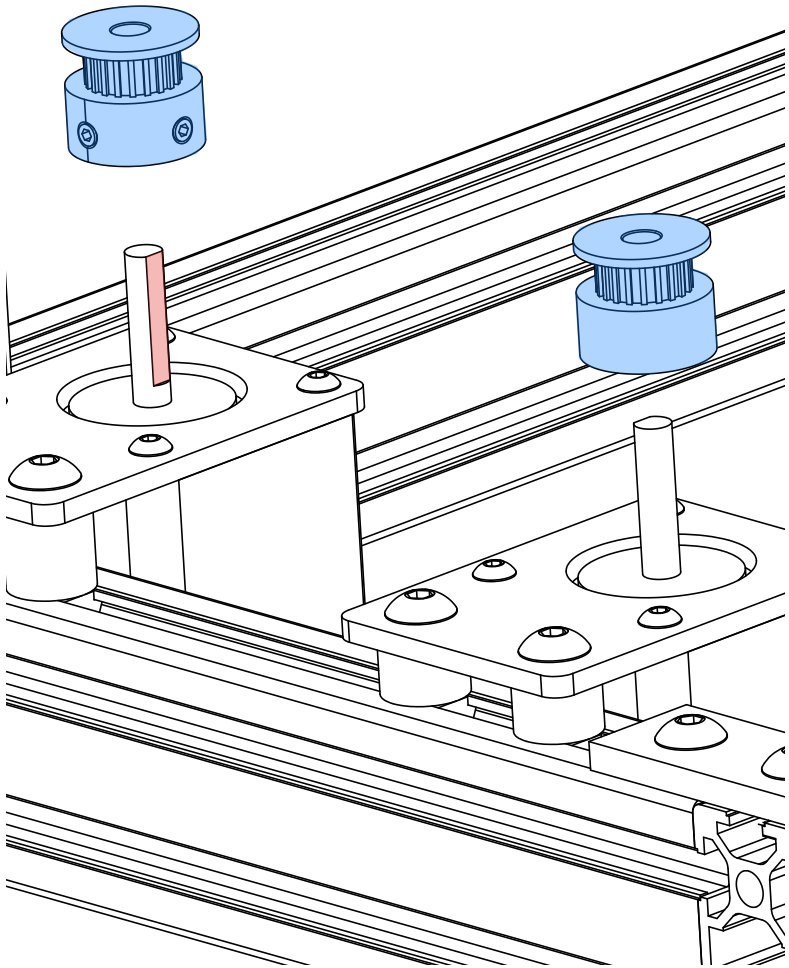
This is the right motor, a mirror of the left. The cable connector faces right.

LEAVE THE BOLTS LOOSE

Snug only. Final torque comes after belt tensioning.

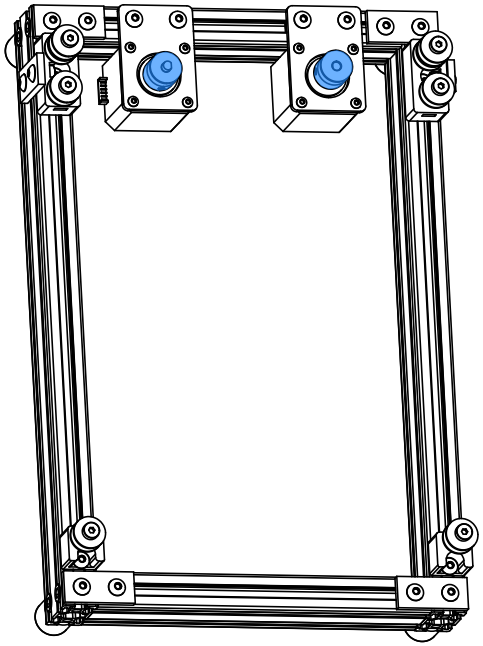
TWO HEIGHTS

The A and B belts sit at different heights: Motor A's pulley (left) is coplanar with the lower idlers, Motor B's pulley (right) coplanar with the upper idlers. Slide each pulley along its motor shaft into position, then lock it down with the set screw.



SET SCREWS

Tighten one set screw onto the shaft's D-flat first, then tighten the other.



THREADLOCKER

Apply threadlocker to every set screw. A loose pulley throws off motion accuracy and is the single most common issue users report. Before you do, though, make sure the pulleys and idlers are aligned. You can also hold off on the threadlocker and apply it after the belts are installed.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Pulley	GT2 20T, 6 mm	2

SECTION 04

Linear motion

PhysiClaw's X/Y motion uses a CoreXY arrangement, guided by three MGN9H linear rails: two run left and right as the Y axis, and one spans between them as the X axis. Each of the two points where the X axis meets the Y rails carries two idler assemblies.

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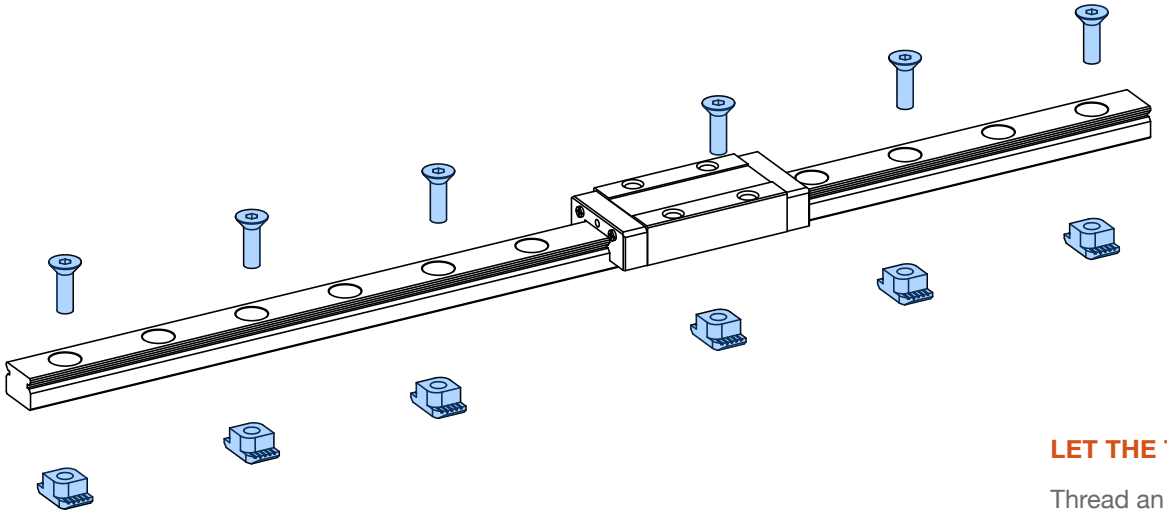
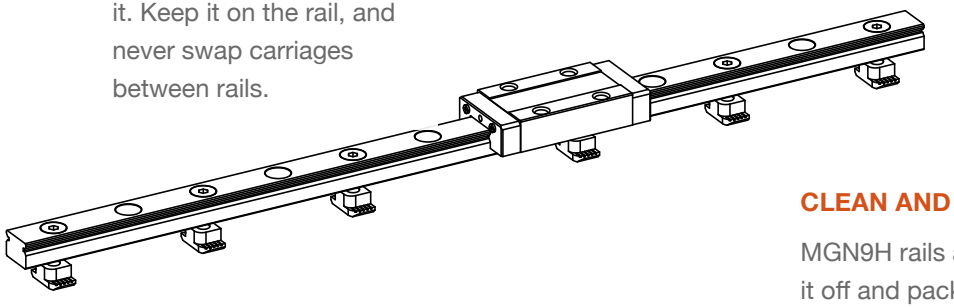
BUILD TWO Y RAILS

The Y axis uses two identical rails. Assemble both the same way.



MIND THE CARRIAGE

The carriage slides off the rail end with little effort, and a dropped one spills its ball bearings, ruining it. Keep it on the rail, and never swap carriages between rails.



LET THE T-NUTS HANG

Thread an M3×10 FHCS into every other hole and let its drop-in T-nut dangle on the screw tip. Lower the whole rail onto the extrusion slot, then tighten to draw the nuts up snug.

CLEAN AND GREASE THE RAILS

MGN9H rails arrive coated in shipping oil. Wipe it off and pack the carriage with fresh grease before mounting. That's what gives smooth, long-lasting motion. Prep every rail the same way.

BILL OF MATERIALS

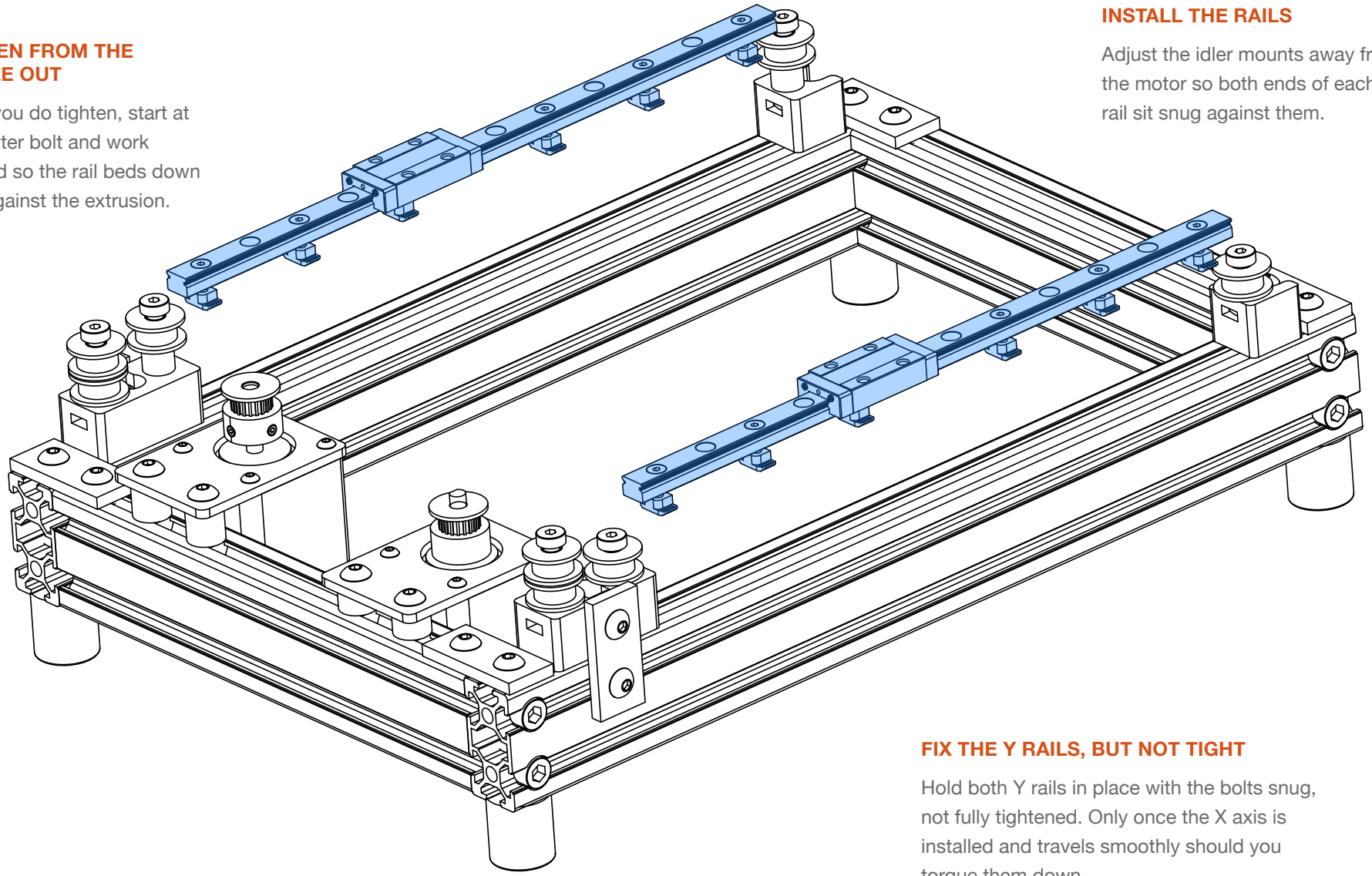
COMPONENT	SPEC	QTY
Linear rail	MGN9H, 240 mm	2
FHCS	M3×10	12
T-nut	Drop-In M3	12

TIGHTEN FROM THE MIDDLE OUT

When you do tighten, start at the center bolt and work outward so the rail beds down flush against the extrusion.

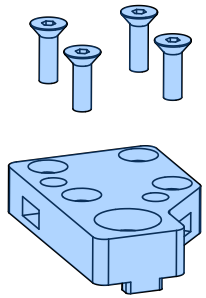
INSTALL THE RAILS

Adjust the idler mounts away from the motor so both ends of each Y rail sit snug against them.



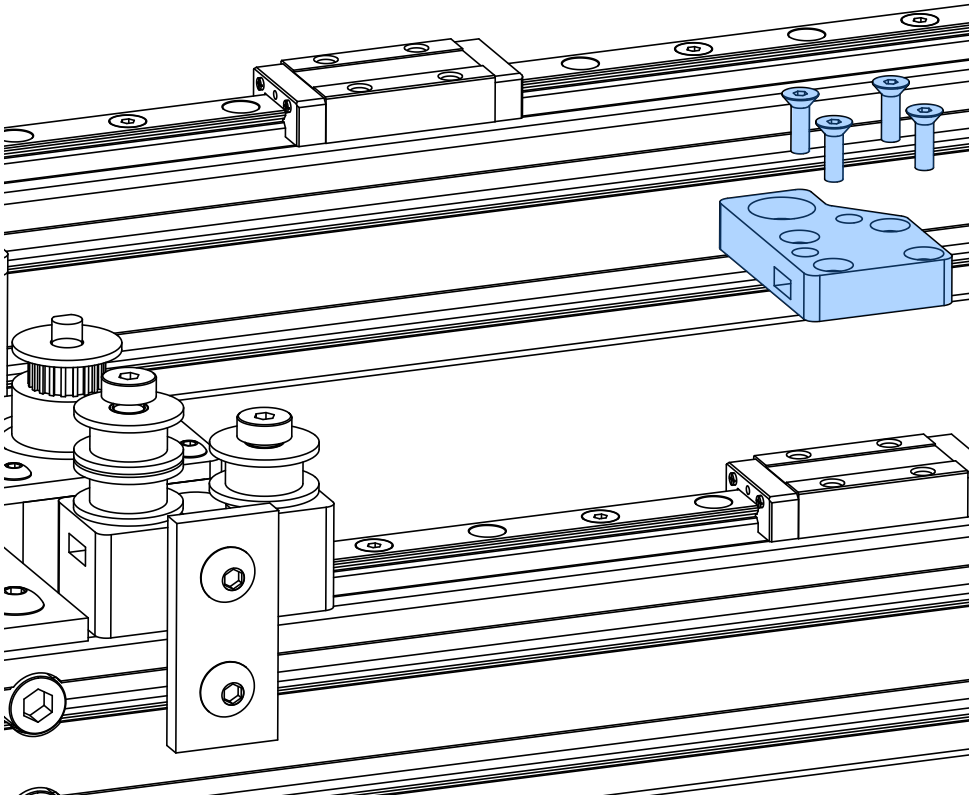
FIX THE Y RAILS, BUT NOT TIGHT

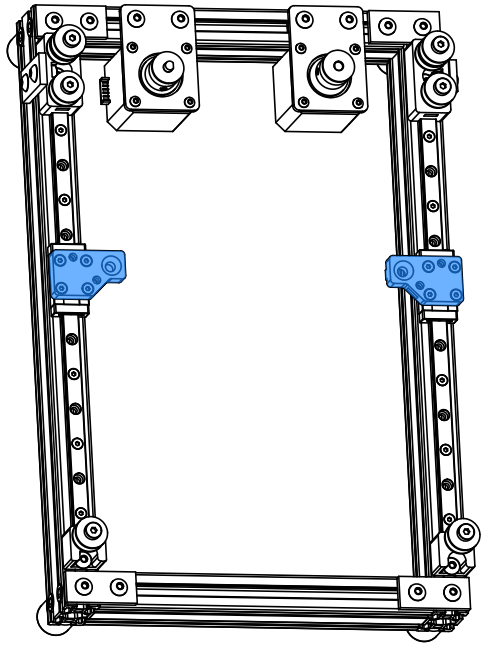
Hold both Y rails in place with the bolts snug, not fully tightened. Only once the X axis is installed and travels smoothly should you torque them down.



TIGHTEN IN A CROSS PATTERN

Thread all four screws in first, then tighten opposite corners in pairs. This seats the joint flat on the slider.



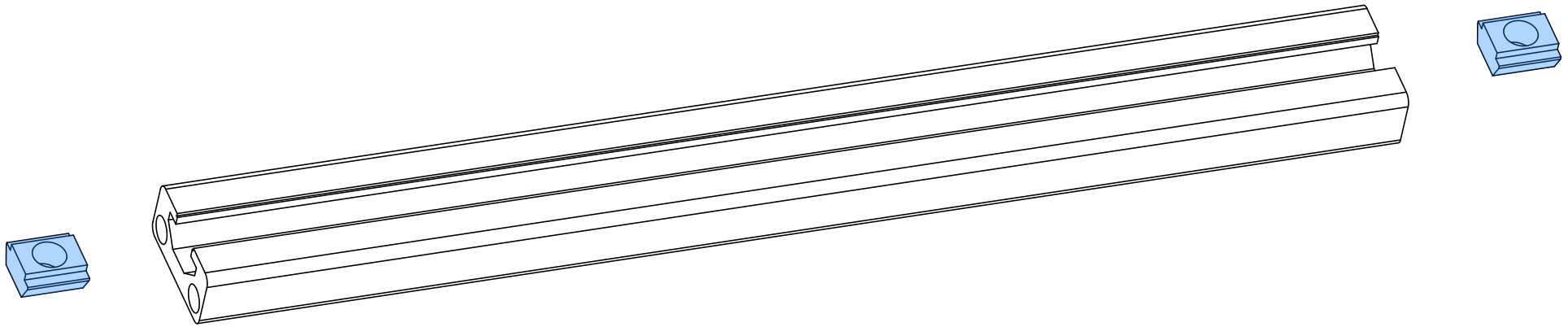


STRAIGHT SIDE TOWARD THE MOTOR

The left and right joints are mirrored. Mount each one with its straight side facing the motor.

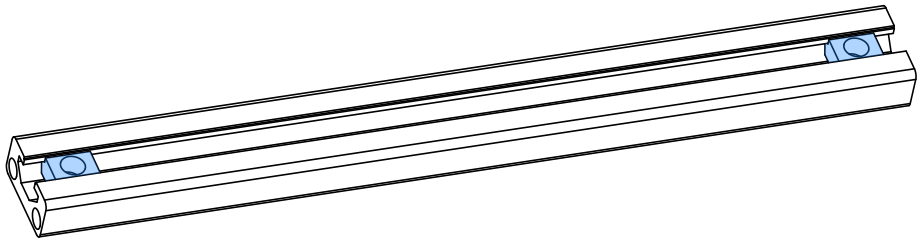
BILL OF MATERIALS

COMPONENT	SPEC	QTY
XY joint (left)	SLS/MJF 3D Print	1
XY joint (right)	SLS/MJF 3D Print	1
FHCS	M3×10	8



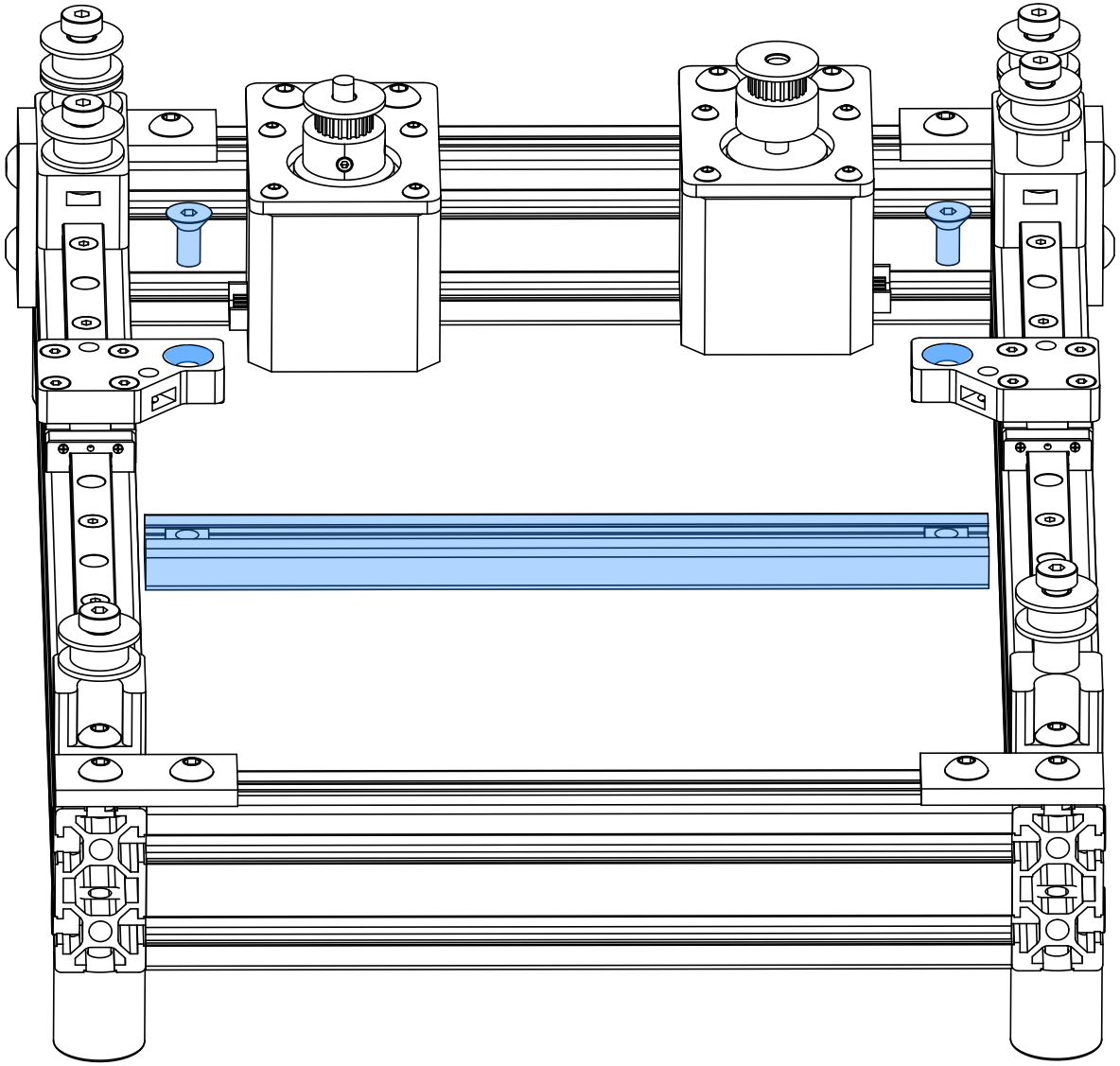
PRELOAD THE X-BEAM T-NUTS

Slide the two M5 T-nuts in, one from each end.



BILL OF MATERIALS

COMPONENT	SPEC	QTY
Extrusion 1020	185 mm	1
T-nut	Slide-In M5	2



CHECK THE X BEAM SLIDES SMOOTHLY

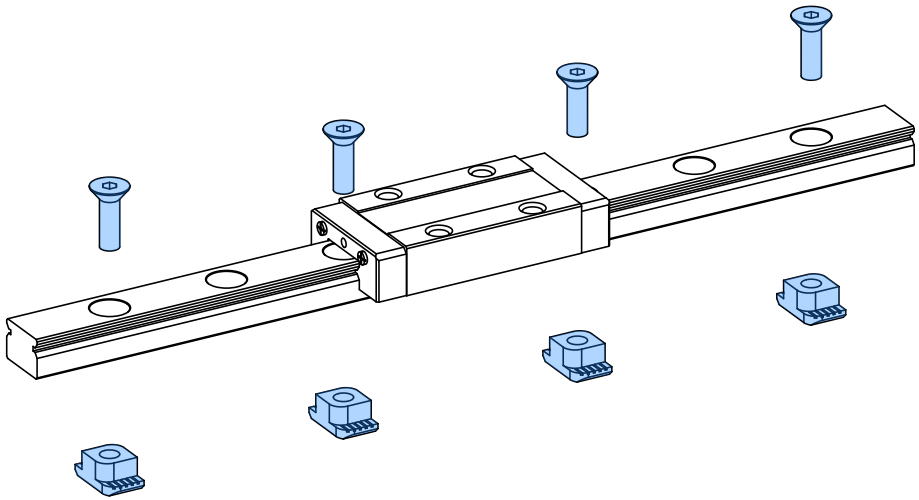
The X beam should glide freely along the Y rails. If it binds, realign the Y rails until it runs smoothly, then tighten them from the center bolt outward.

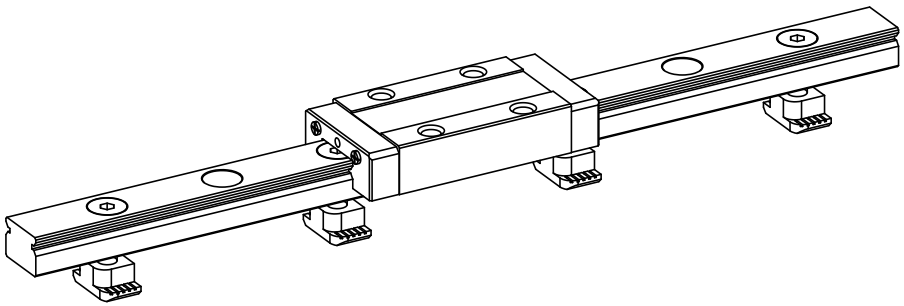
BE PATIENT

Don't expect to get it in one pass. Snug a few screws, slide the X beam to feel the resistance, then nudge the Y rails and try again. It can take a few minutes of back-and-forth before the beam glides smoothly.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
FHCS	M5×12	2



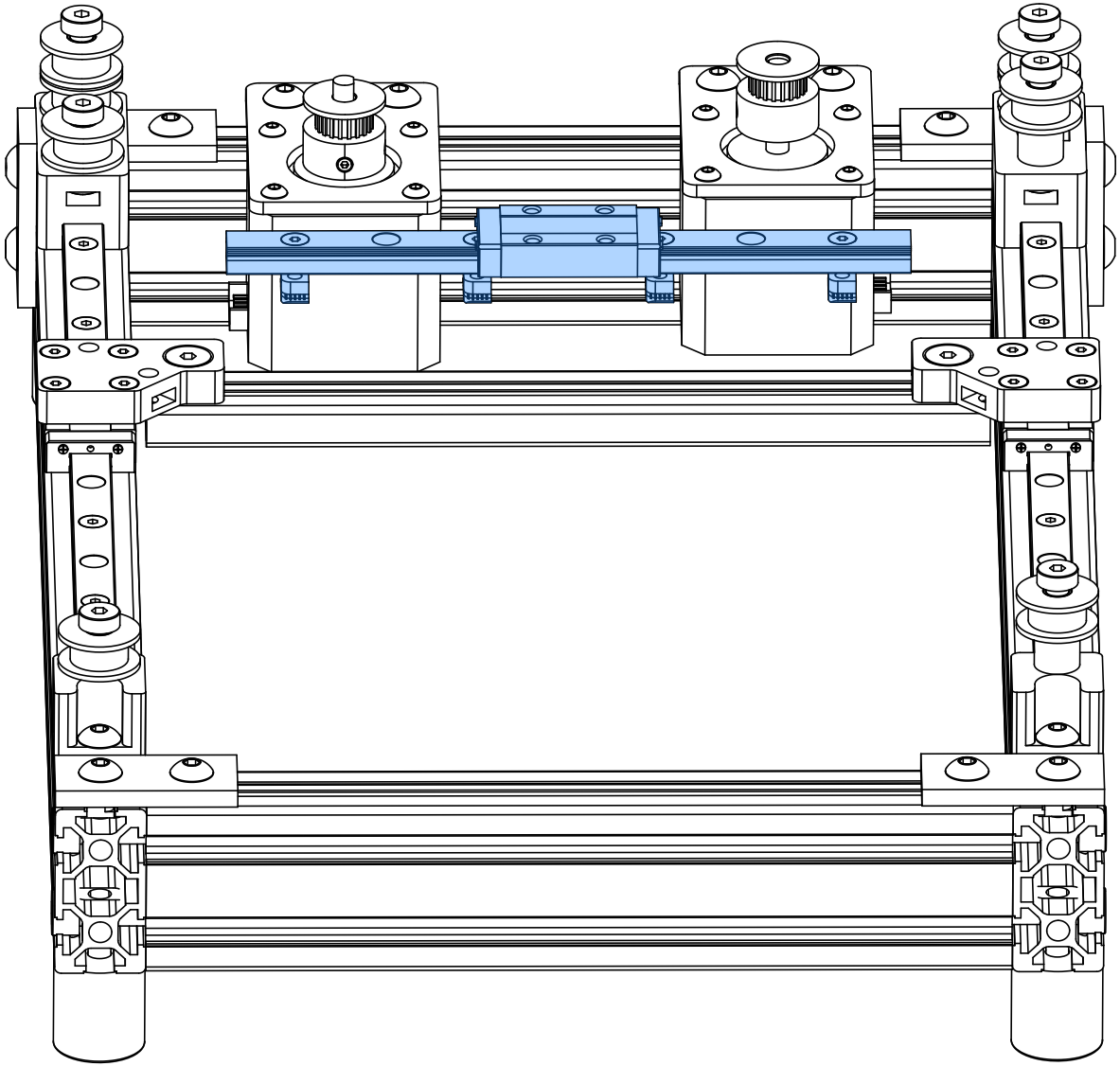


X RAIL

Mount this rail just like the Y rails: let the T-nuts hang loose, lower the rail into the slot, then tighten.

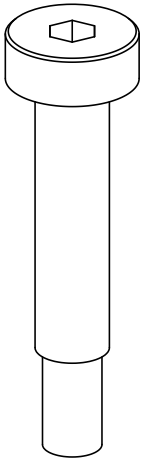
BILL OF MATERIALS

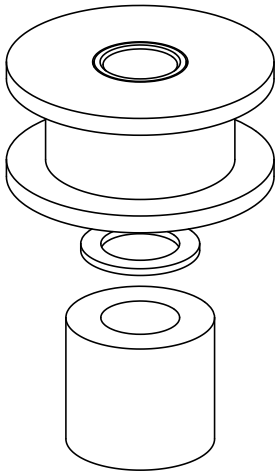
COMPONENT	SPEC	QTY
Linear rail	MGN9H, 150 mm	1
FHCS	M3×10	4
T-nut	Drop-In M3	4



CHECK BOTH AXES MOVE FREELY

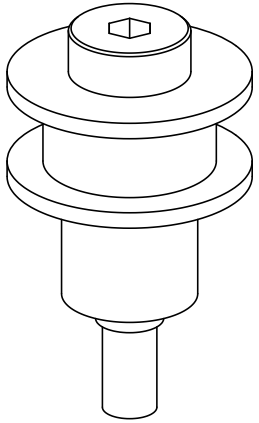
The X rail is now mounted on the X beam. Confirm its carriage slides smoothly along the X rail, and that the whole beam still travels freely along the Y rails. If either binds, realign that rail and retighten from the center out.





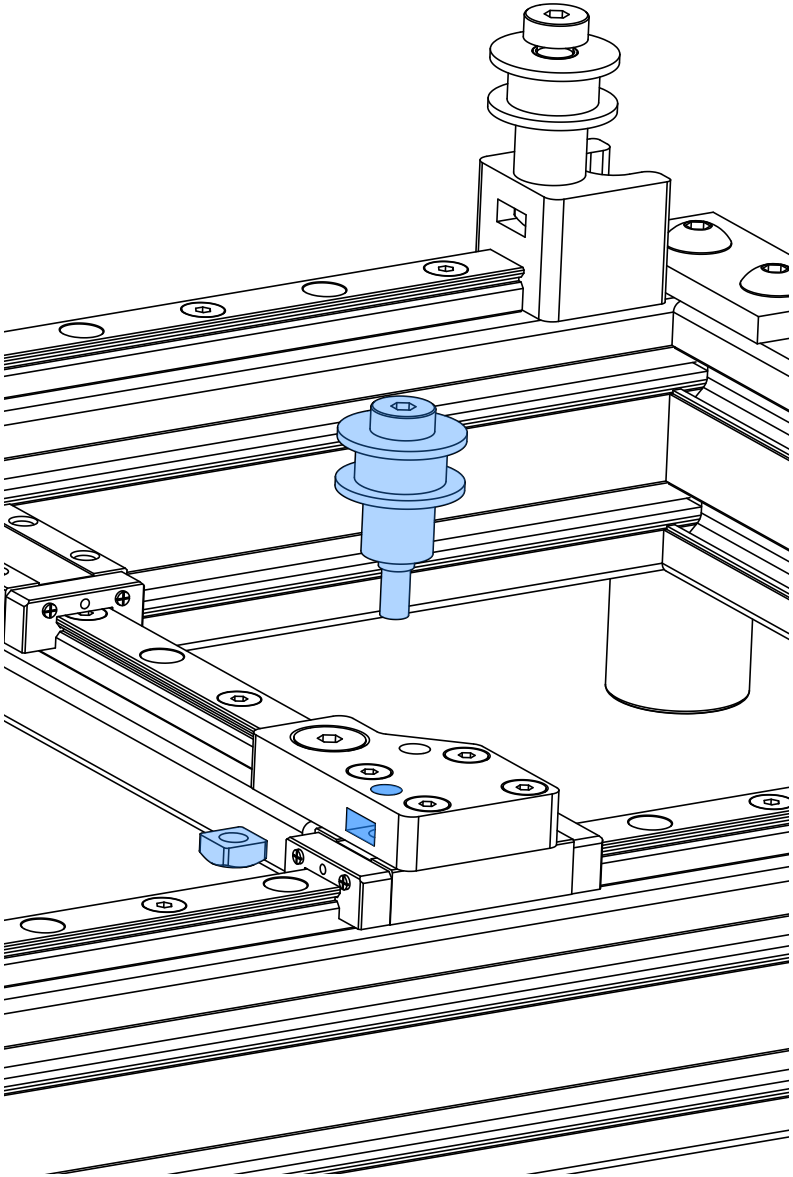
MOTOR B IDLER — SITS HIGHER

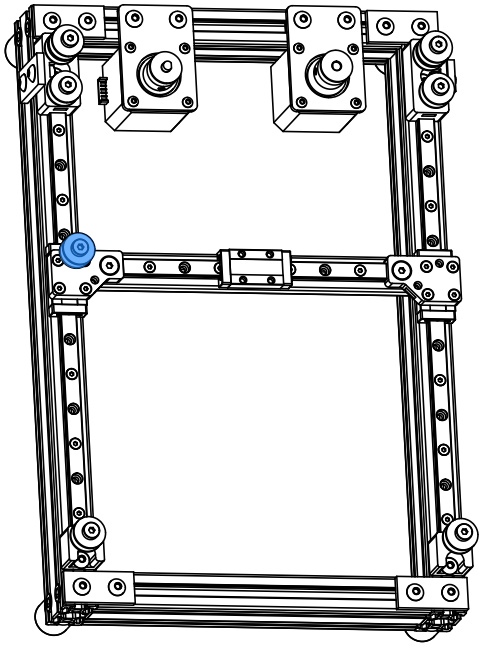
This idler carries Motor B's belt on the left joint. The 9 mm spacer lifts it above the others, keeping its belt on the upper plane.



BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler	GT2 20T, smooth	1
Shoulder screw	Ø5×20×M4	1
Spacer	5×10×9	1
Shim	5×8×0.5	1



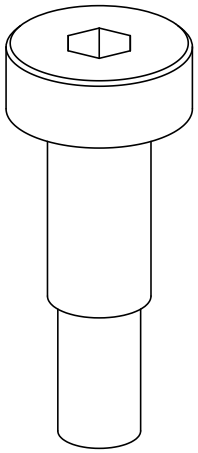


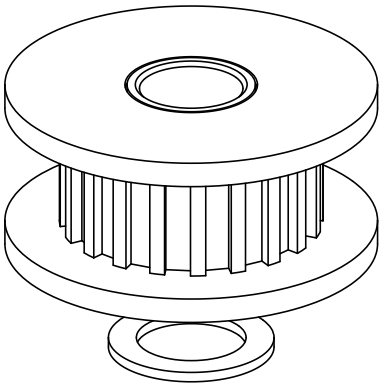
USE THE CORRECT HOLE

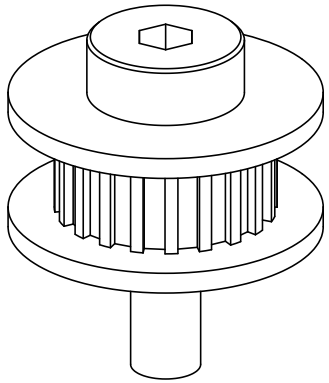
The idler mounts in the top hole of the left joint.
Take care not to use the wrong one.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Square nut	M4	1







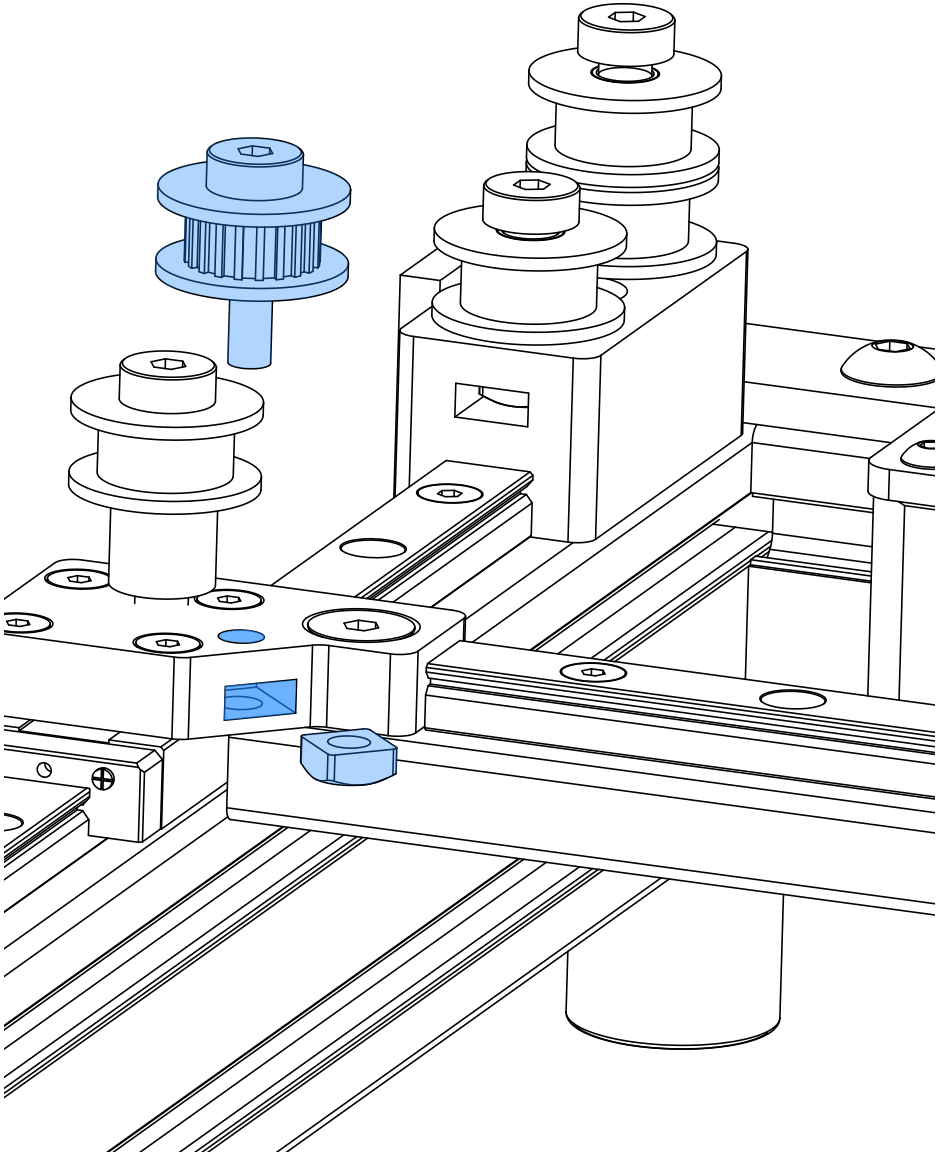
MOTOR A IDLER — SITS LOWER

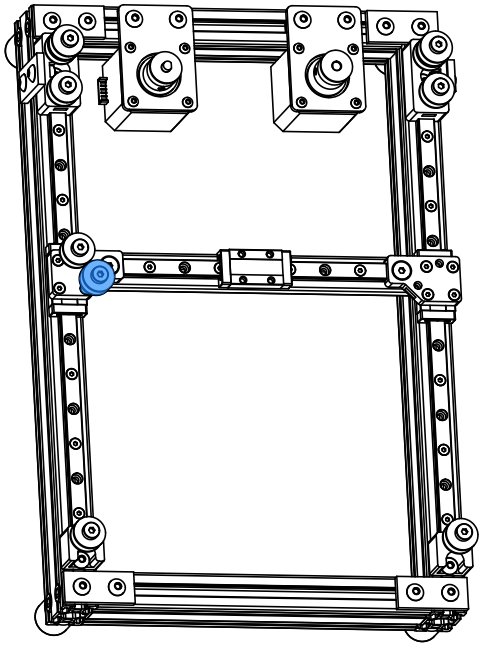
Use the toothed idler here, not the smooth one.

It carries Motor A's belt and, with no spacer, rides on the lower belt plane.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler	GT2 20T, toothed	1
Shoulder screw	Ø5×10×M4	1
Shim	5×8×0.5	1



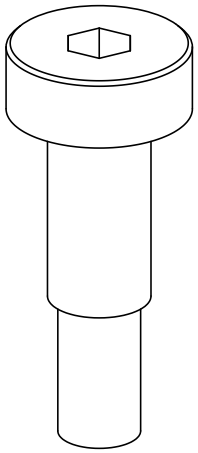


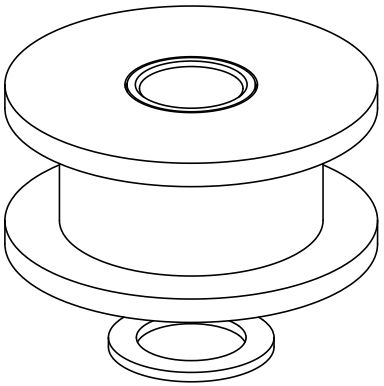
INSTALL IN THE RIGHT POSITION

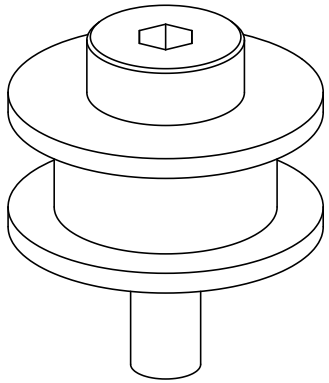
Before tightening, confirm the idler is seated in the correct position on the joint.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Square nut	M4	1





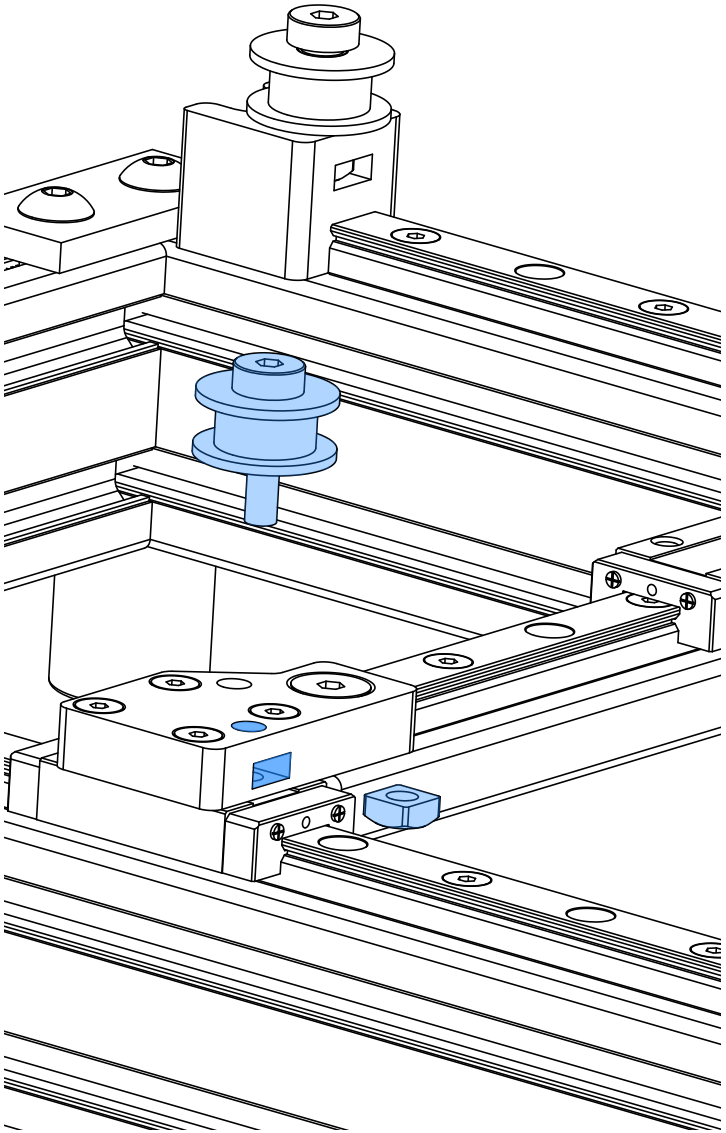


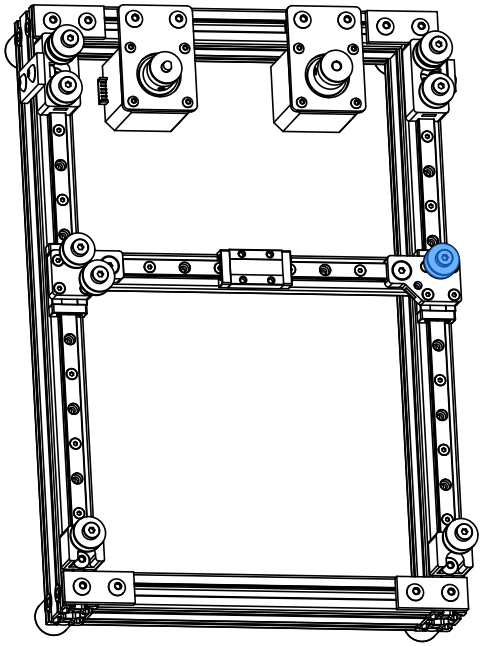
MOTOR A IDLER — SITS LOWER

This idler carries Motor A's belt on the right joint, in the top hole. With no spacer, it rides on the lower belt plane.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler	GT2 20T, smooth	1
Shoulder screw	Ø5×10×M4	1
Shim	5×8×0.5	1



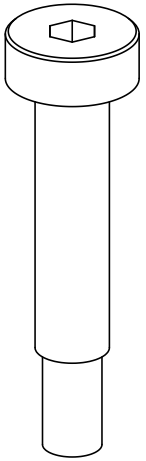


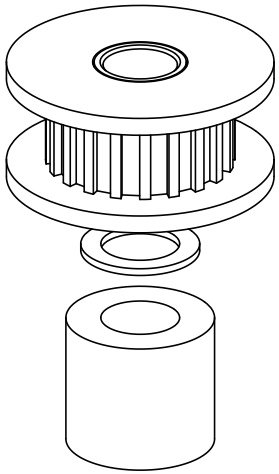
INSTALL IN THE RIGHT POSITION

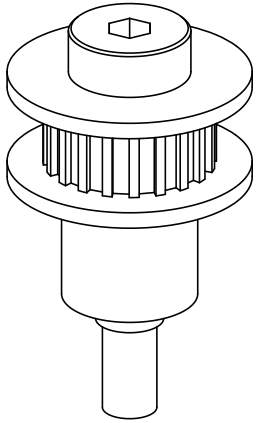
Before tightening, confirm the idler is seated in the correct position on the joint.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Square nut	M4	1







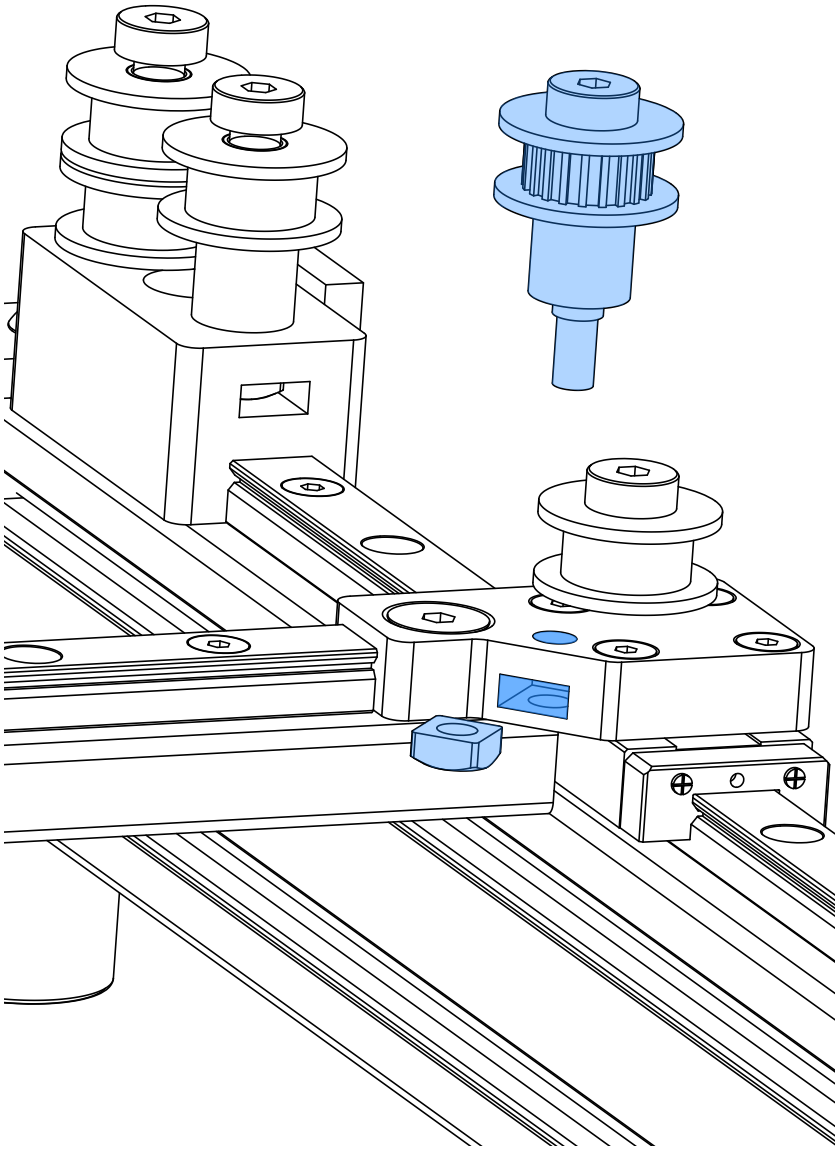
MOTOR B IDLER — SITS HIGHER

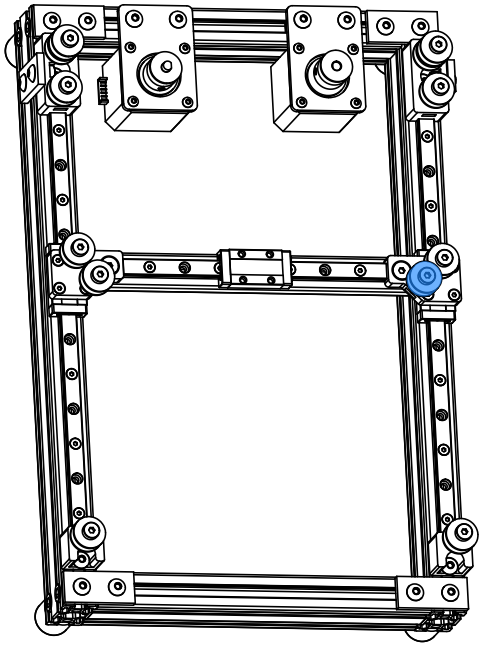
Use the toothed idler here, not the smooth one.

It carries Motor B's belt and, with the 9 mm spacer, rides on the upper belt plane.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Idler	GT2 20T, toothed	1
Shoulder screw	Ø5×20×M4	1
Spacer	5×10×9	1
Shim	5×8×0.5	1





CHECK ALL FOUR IDLERS

All four idlers are now mounted on the XY joints. Recheck that each one sits in its correct location.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Square nut	M4	1

SECTION 05

Belt path

PhysiClaw's CoreXY drive runs on two GT2 belts, A and B, set on two stacked planes so they never cross. The two belts must be tensioned equally to keep the motion accurate.

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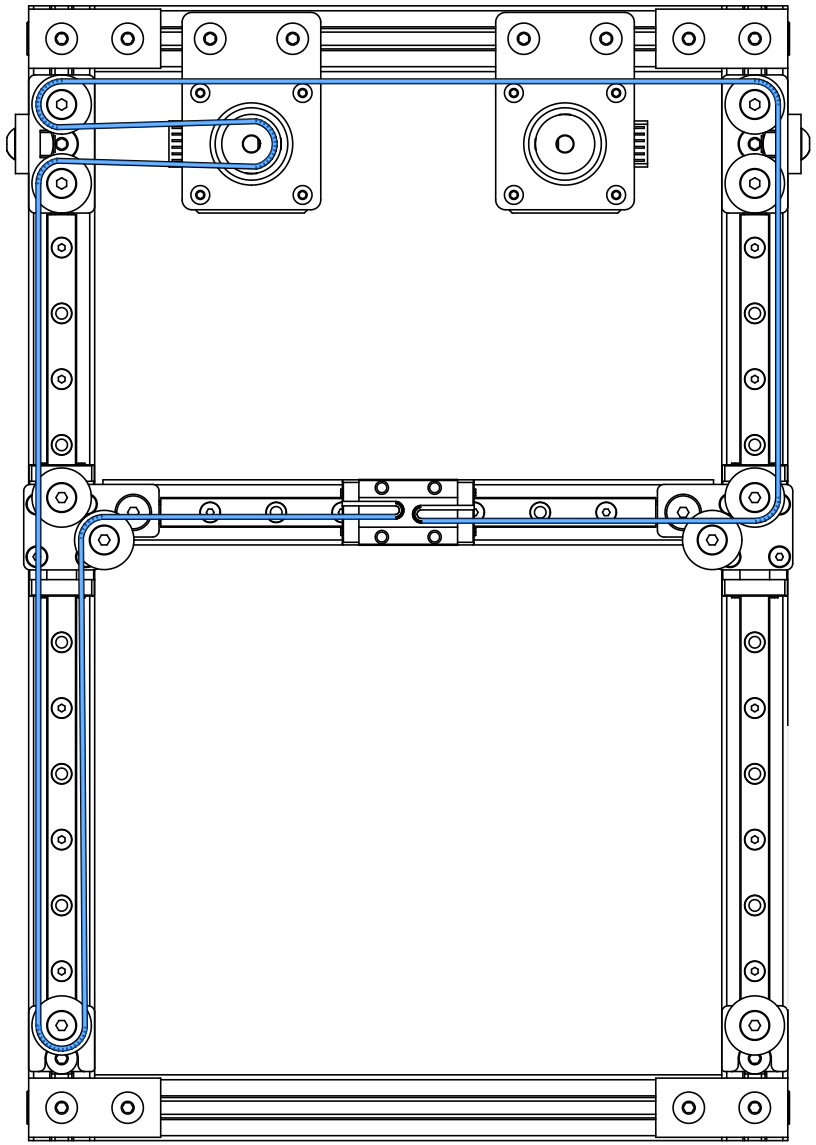
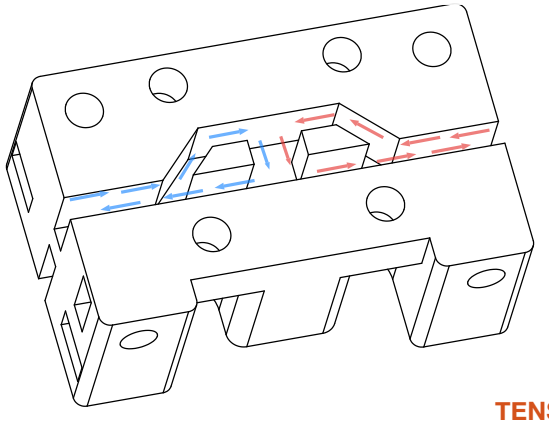
BELT PATH

BELT_10 · BELT_11



INSTALL BELT A

The Motor A belt is a single open length with both ends clamped to the X carriage. It must stay flat in one plane and never twist along the way. The teeth grip the toothed pulleys; the smooth back rides on the smooth idlers.



TENSION BY SLIDING THE MOTOR

Leave Motor A's two M5 screws loose, clamp both belt ends into the clamp, then slide the motor to pull the belt tight.

THE CLAMP SELF-LOCKS

Feed each belt end into the clamp's bottom slot, loop it around the post, and fold it back against itself so the teeth mesh. That teeth-on-teeth grip holds the belt with no extra fasteners.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Timing belt	GT2–6 mm, open-ended	1

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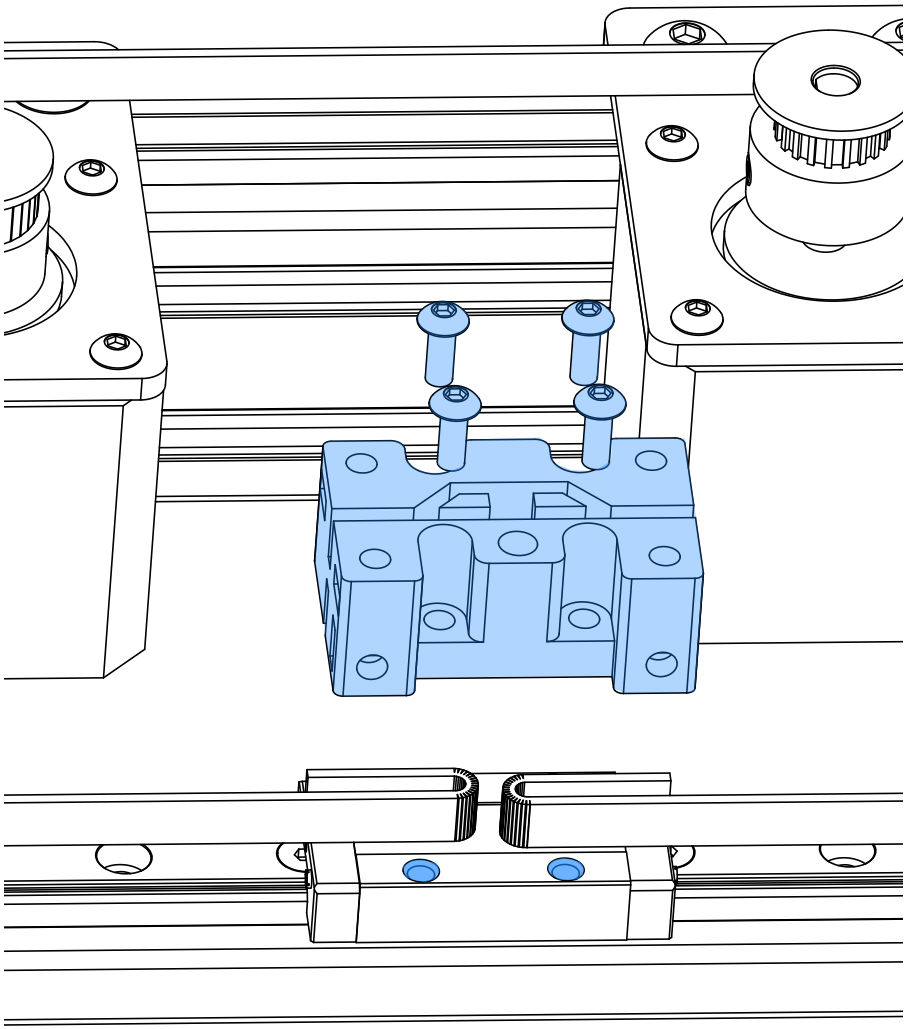
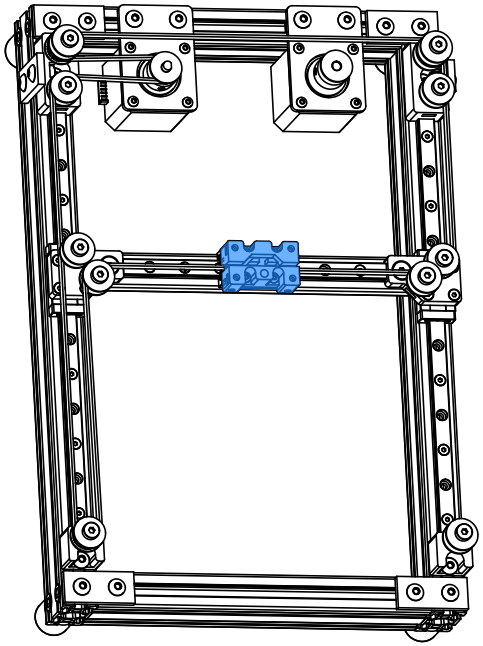
BELT PATH

BELT_20



MATCH THE MOTOR B BELT LENGTH

Before fitting the Motor A belt into its clamp, cut the Motor B belt to match it. Both must be the same length.



CLAMP THE BELT BEFORE MOUNTING

Make sure the Motor A belt is seated in the clamp's bottom slot before you fix the clamp to the X carriage.

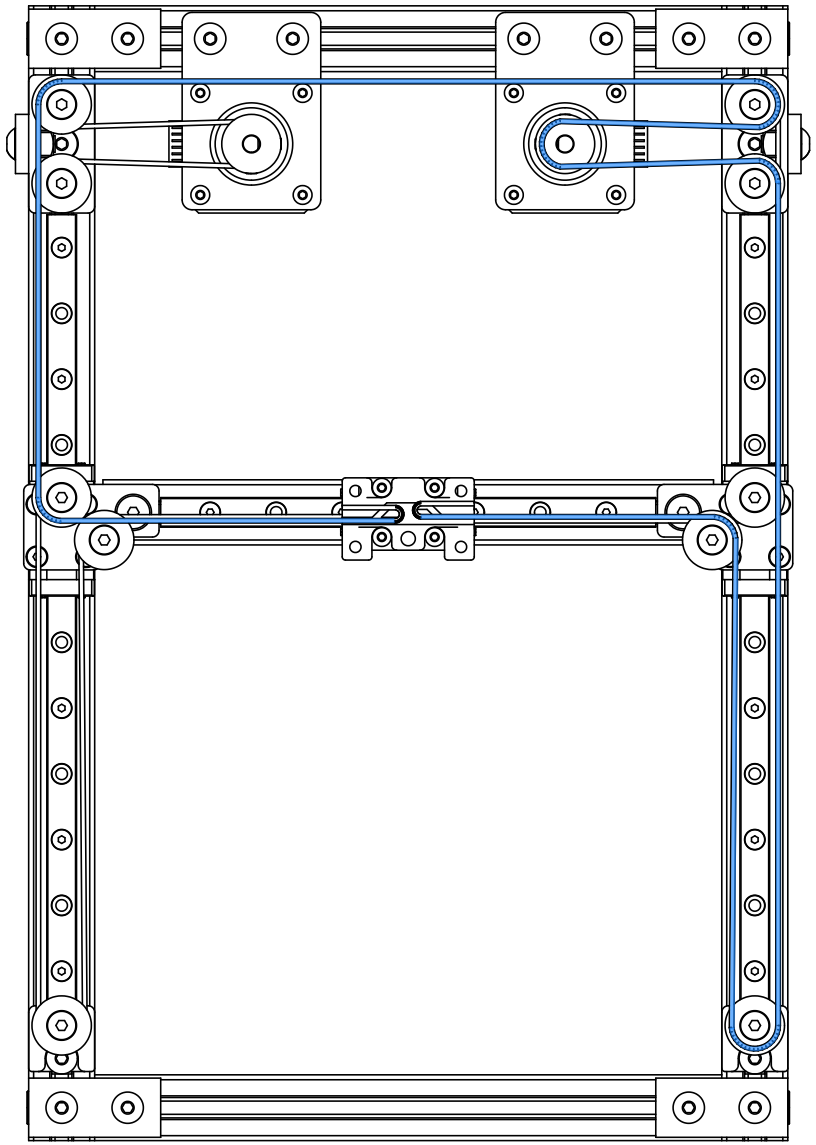
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Belt clamp	SLS/MJF 3D Print	1
BHCS	M3×8	4

46

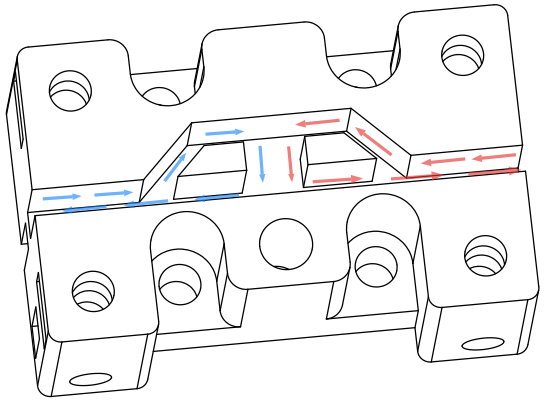
BELT PATH

BELT_30 · BELT_11



INSTALL BELT B

Route the Motor B belt on the upper idler plane. It must not cross belt A. Clamp both ends to the X carriage, the same way as belt A.



CHECK THE BELTS

With both belts installed, push the carriage by hand through its full travel in every direction. It should move smoothly with the same, even resistance throughout. That resistance is just the motors. Confirm there's no sticking, no interference, no twisted belts, and no odd noises, with the two belts on their separate planes.

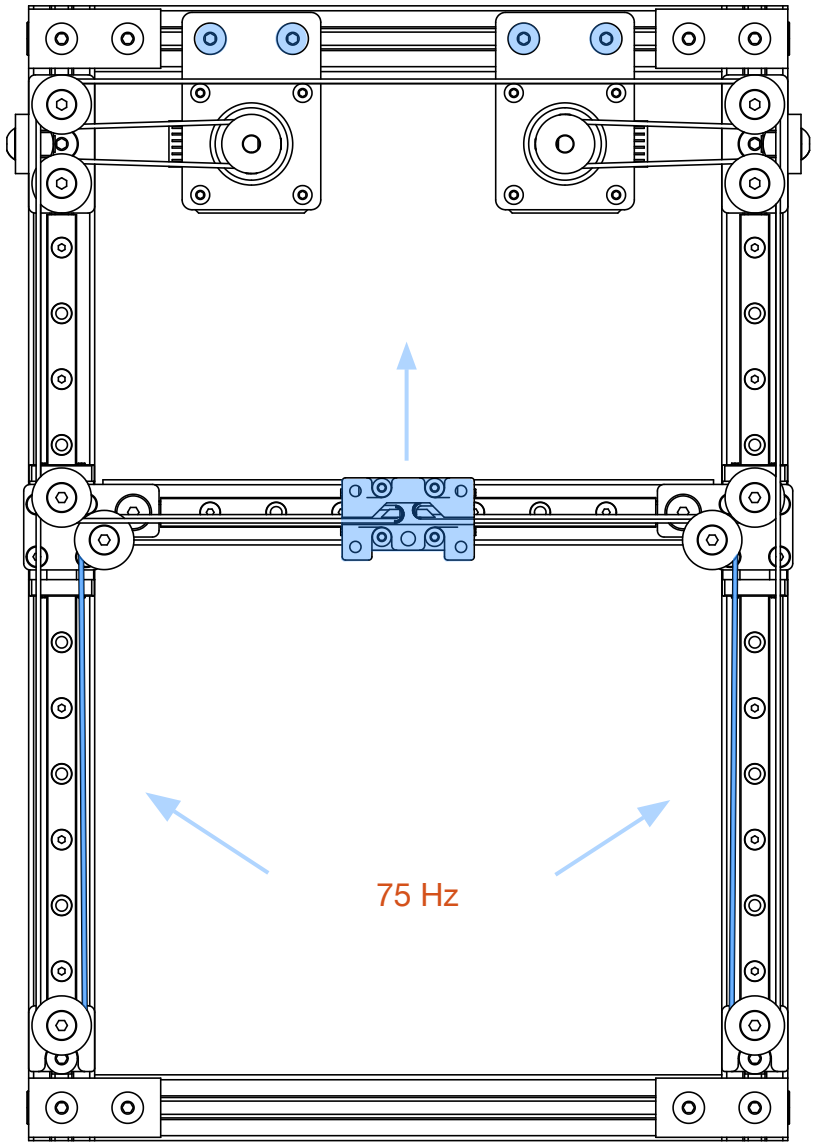
THREADLOCKER

If the pulley set screws have no threadlocker yet, apply it now that the belts run smoothly.

47

BELT PATH

BELT_30



BELT TENSION

Equal tension on both belts is essential for a CoreXY motion system. Even a slight difference between the two will skew the gantry's motion. You can adjust a motor's position to fine-tune the tension of its belt.

PLUCK THE BELTS

For a quick check, move the X carriage fully to the motor side and pluck the indicated belts with a finger. The two should feel and sound about the same. Matching pitch means roughly equal tension.

75 Hz at 220 mm

For a precise check, measure each belt with a tuning app on your phone while the X carriage is parked at the marked position. Pluck the belts and aim for 75 Hz. If both read the same frequency, the tension is correct.

48

SECTION 06

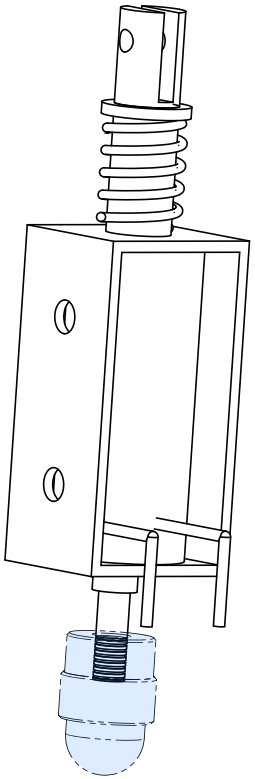
Touch end

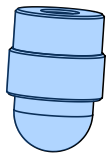
Mount the capacitive stylus tip onto the push-pull solenoid, then install the two together onto the X carriage.

49

TOUCH END

TAPZ_10



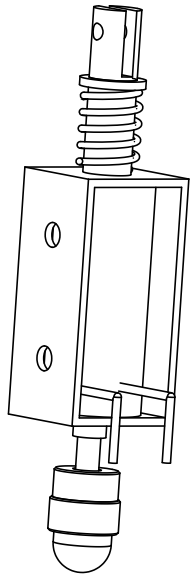


FIT THE STYLUS TIP

The solenoid ships with a nut on its bottom end. Remove that nut, then thread the stylus tip on in its place.

SOLENOID MOUNT HOLES

Two M3 holes, 15 mm apart.



BILL OF MATERIALS

COMPONENT	SPEC	QTY
Solenoid	12 V, 2×M3, 15 mm pitch	1
Stylus tip	Conductive fabric tip, Ø7 mm	1

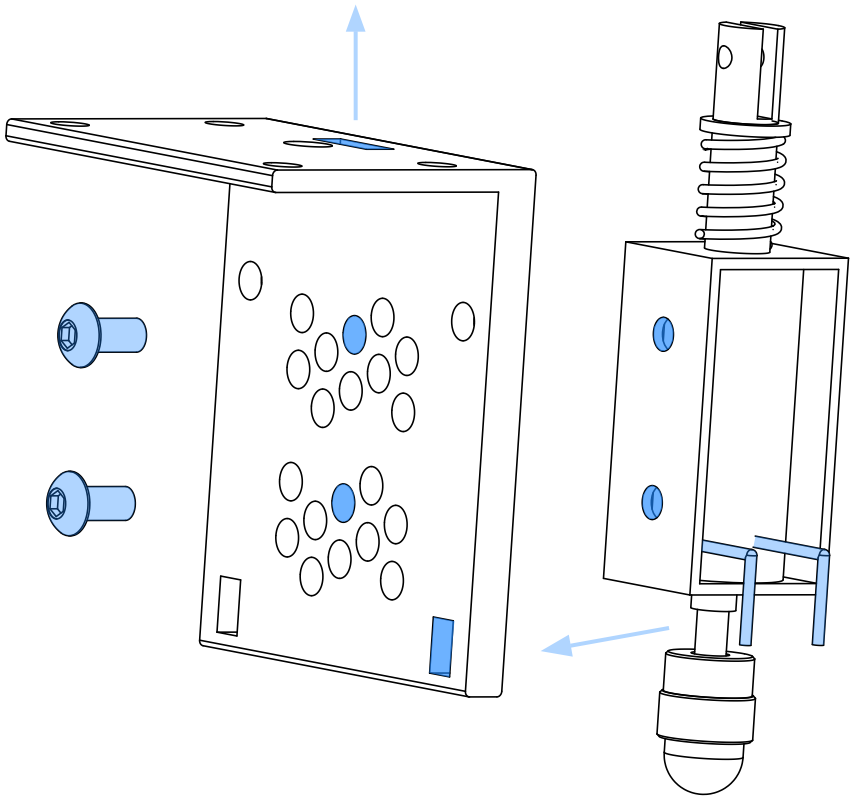
50

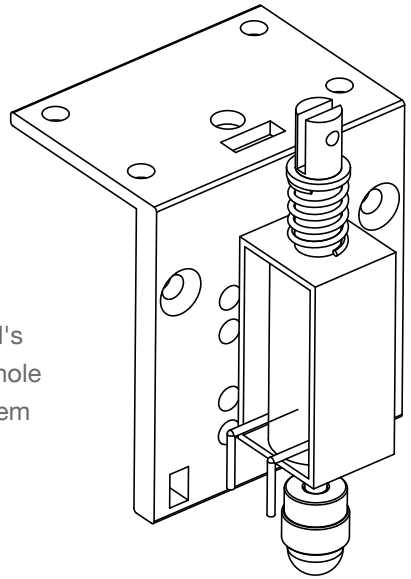
TOUCH END

TAPZ_11

10 HOLE PAIRS FOR HEIGHT TUNING

The mount has 10 pairs of holes, spaced 1 mm apart. Pick a pair now, and you can later raise or lower the stylus in 1 mm steps.





ROUTE THE POWER LEADS

As indicated, feed the solenoid's +/– leads into the rectangular hole on the mount side, then run them up and out through the rectangular hole at the top.

GROUND THE SOLENOID

Clamp the ground wire's bare copper between the solenoid housing and the mount, then tighten a screw to pin it. This grounds the solenoid. Run the ground wire out through the other rectangular hole below to join the power leads.

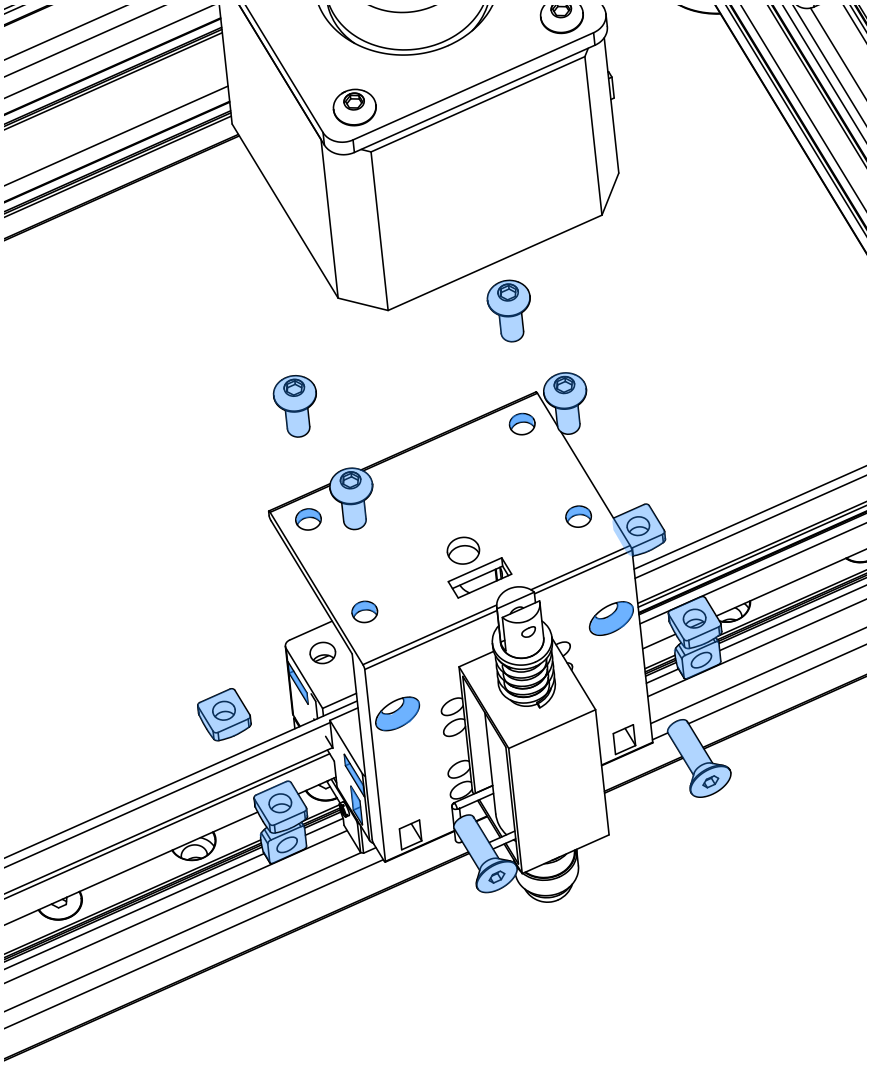
BILL OF MATERIALS

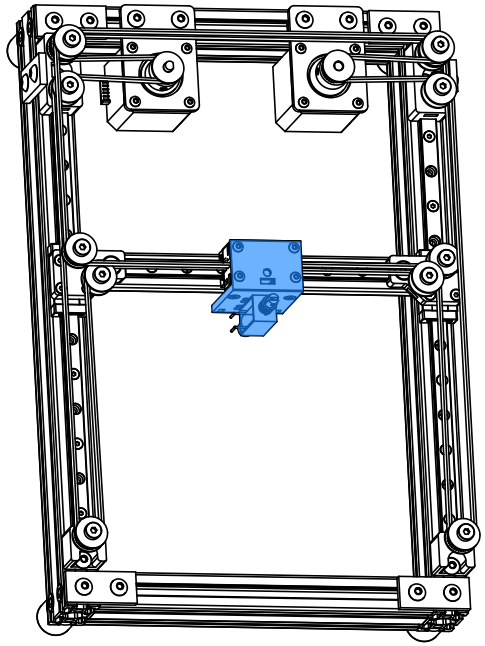
COMPONENT	SPEC	QTY
Solenoid mount	SLS/MJF 3D Print	1
BHCS	M3×6	2

51

TOUCH END

TAPZ_20





MOUNT THE SOLENOID TO THE CLAMP

Six screws hold the solenoid assembly to the clamp. To adjust the stylus height later, undo them and refit at a different hole pair.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
BHCS	M3×8	4
FHCS	M3×10	2
Square nut	M3	6

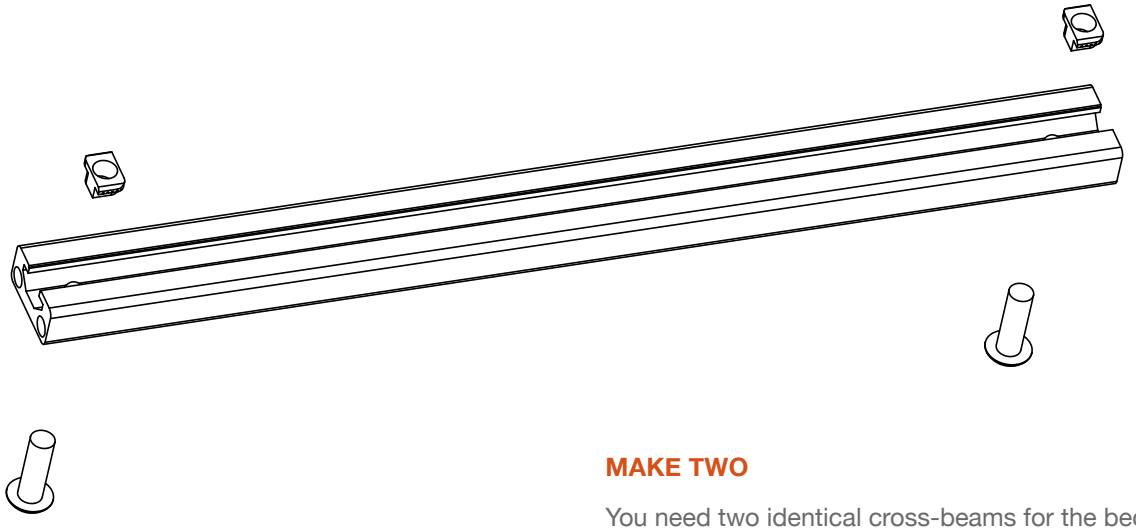
52

SECTION 07

Phone bed

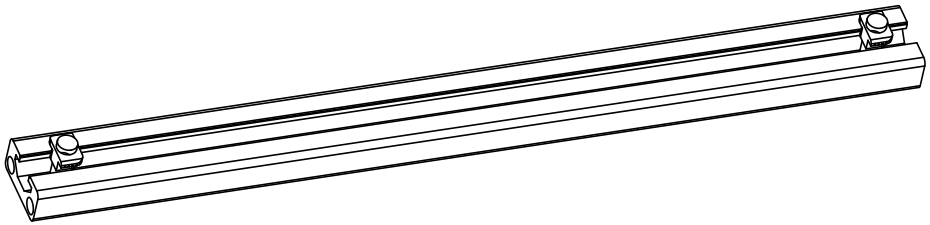
Two cross-beams mount under the frame and carry the printed phone bed. The phone lies in the bed screen-up, its top-left corner seated against the bed's corner, level under the stylus.

53



MAKE TWO

You need two identical cross-beams for the bed.

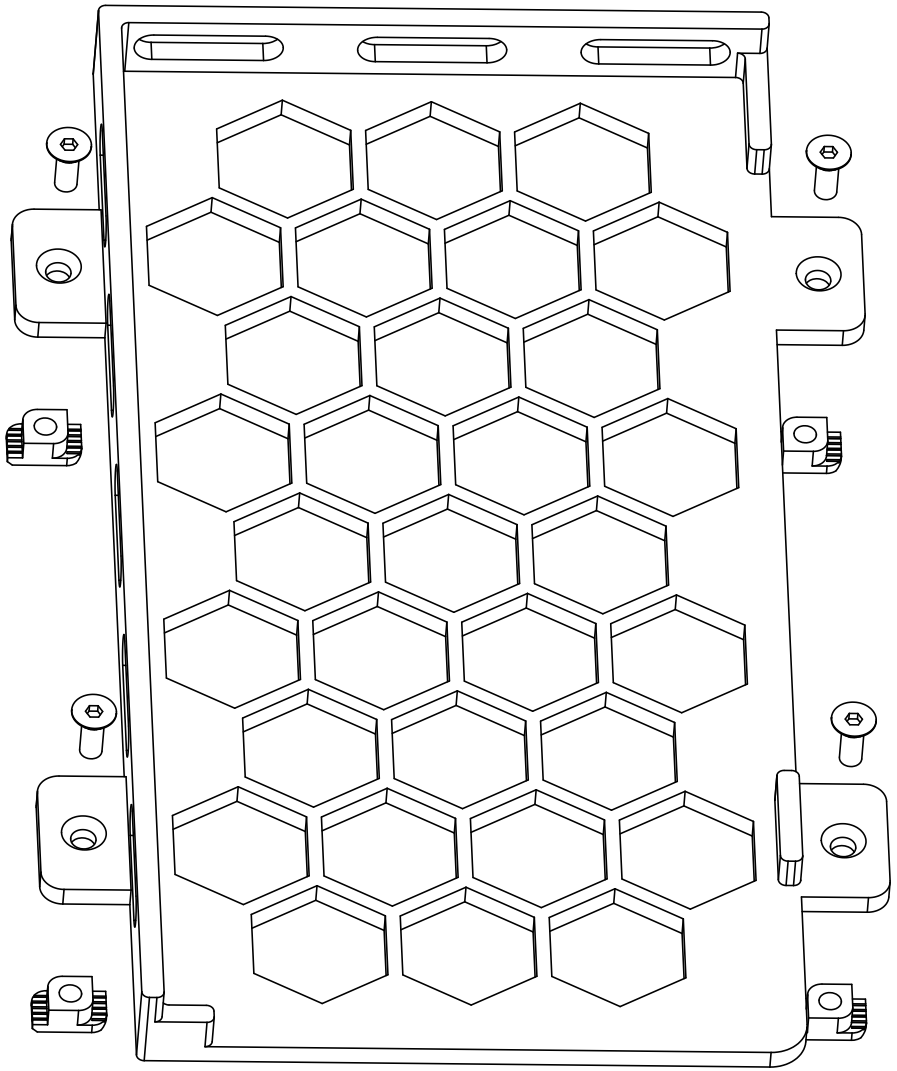


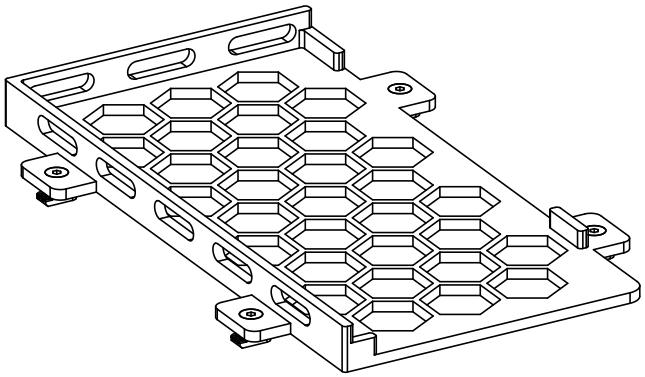
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Extrusion 1020	230 mm, M5 end holes	2
BHCS	M5×16	4
T-nut	Drop-In M5	4

PHONE BED

PHONE_20

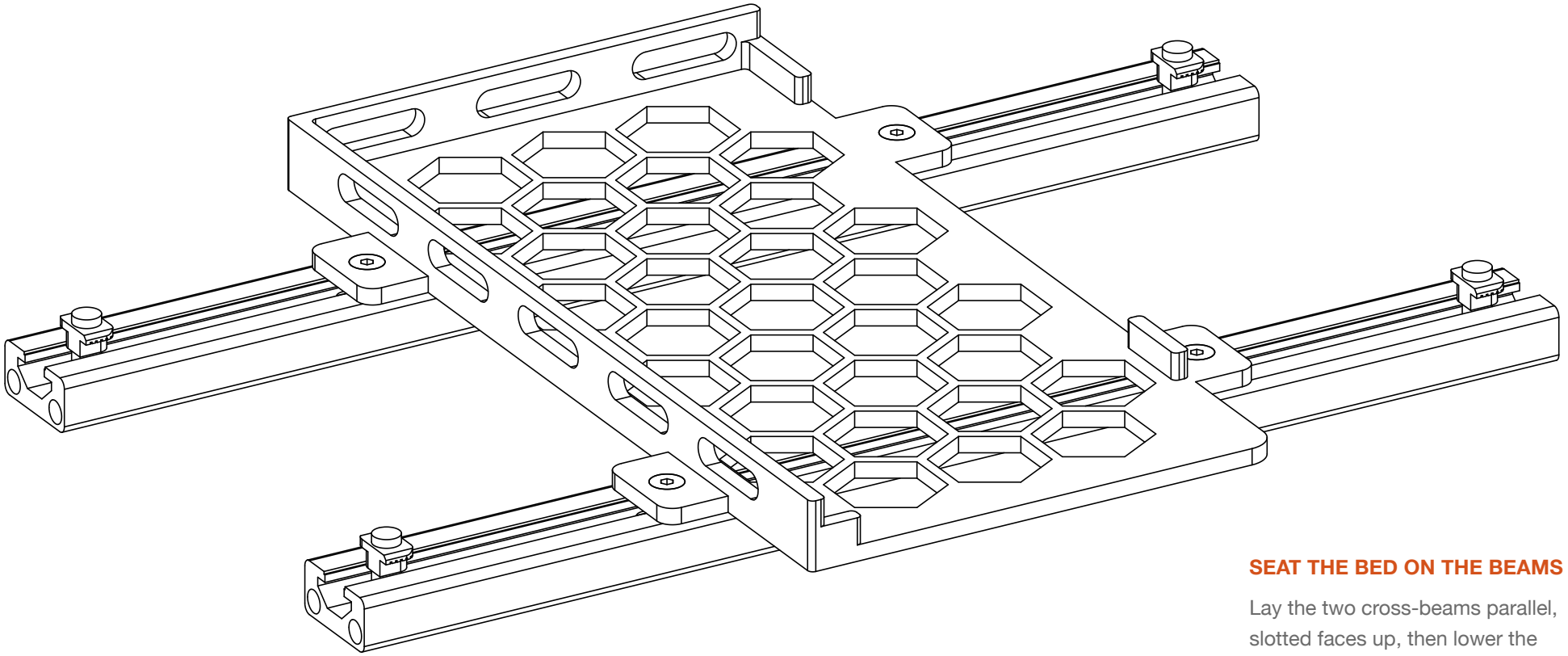




BILL OF MATERIALS

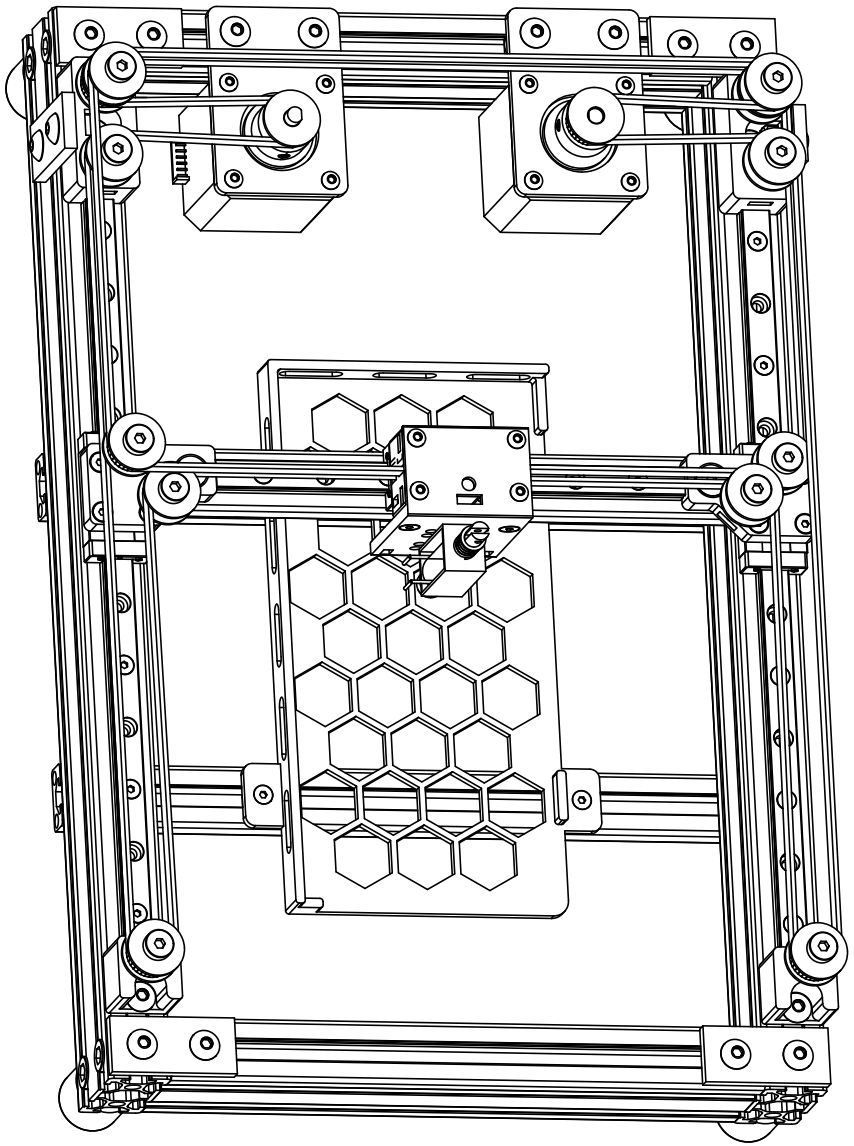
COMPONENT	SPEC	QTY
Phone bed	SLS/MJF 3D Print	1
FHCS	M3×8	4
T-nut	Drop-In M3	4

55



SEAT THE BED ON THE BEAMS

Lay the two cross-beams parallel, slotted faces up, then lower the bed's hanging T-nuts into the slots and tighten.



INSTALL THE PHONE BED

Stand the frame on end first. It's far easier to work vertically. Then slide each beam's T-nuts into the slots on the frame's underside.

POSITION THE PHONE

Place a phone on the bed, pushed into the top-left corner. Move the X carriage around and check the stylus tip can reach every part of the screen.

SET THE SOLENOID HEIGHT

Set the solenoid's mounting height so the stylus tip just makes stable contact with the screen. Too low, and the solenoid can't pull in fully: the magnetic force is then too weak to hold the tip down, so the tip springs back and both long-press and swipe fail. Too high, and the tip can't reach the screen or the contact patch is too small. Fine-tune until the tip makes stable contact with the screen.

KEEP THE SCREEN FLAT

The rear camera bump lifts one corner, so the phone won't lie flat. Slip a thin shim or a few sheets of paper under the low edge until the screen is level and facing straight up. Make sure the phone can't rock or shift when the stylus taps. Any tilt or wobble can make it miss.

SECTION 08

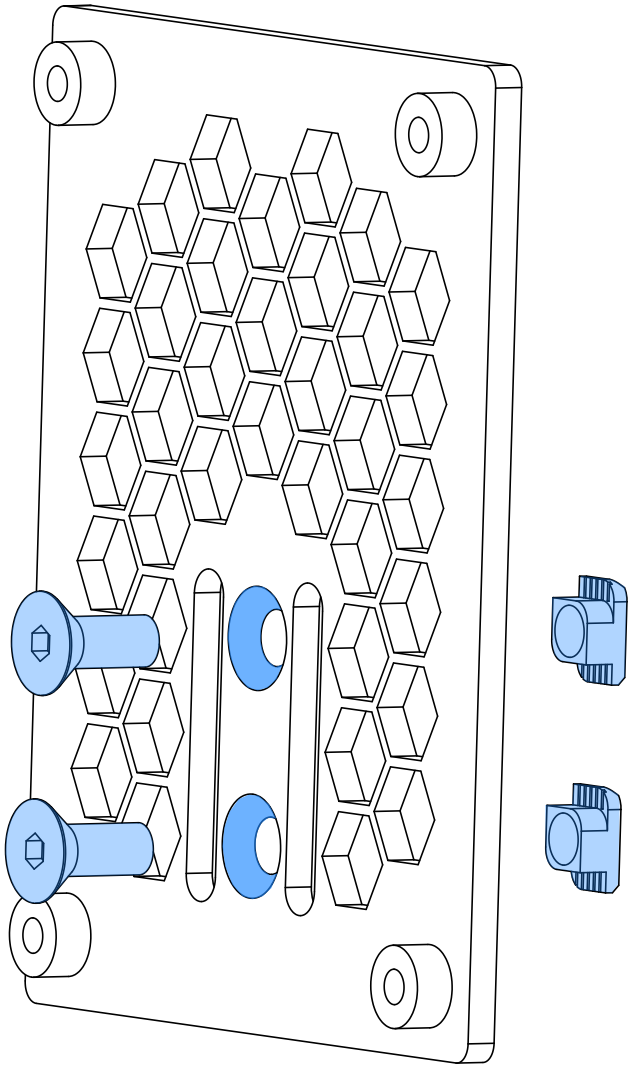
Control board

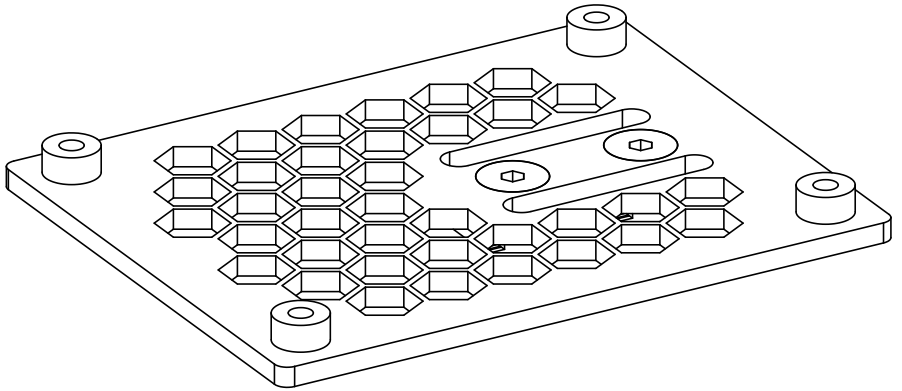
The control board mounts at the front of the frame. The solenoid's wires are spiral-wrapped to a Teflon tube that stiffens the bundle so it holds its shape, clear of the motors and belts. The tube anchors to a frame-mounted holder and to the carriage.

58

CONTROL BOARD

BOARD_10





FIT THE T-NUTS

Leave them loose for the next step.

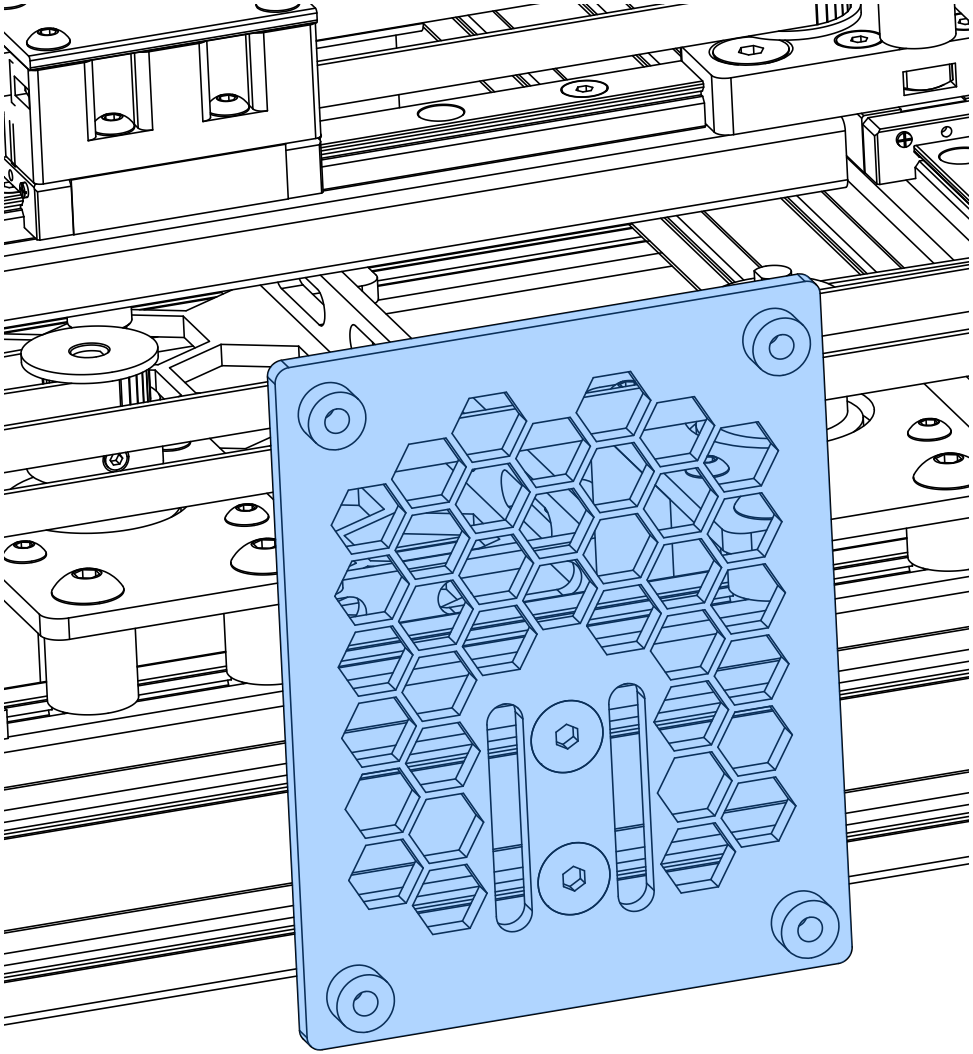
BILL OF MATERIALS

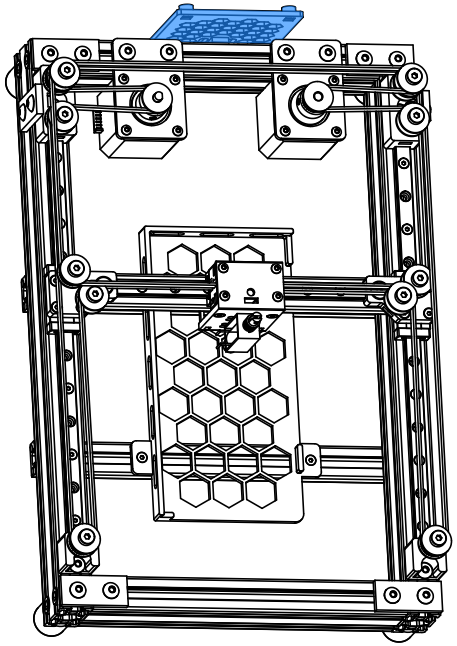
COMPONENT	SPEC	QTY
Control board holder	SLS/MJF 3D Print	1
FHCS	M5×12	2
T-nut	Drop-In M5	2

59

CONTROL BOARD

BOARD_20





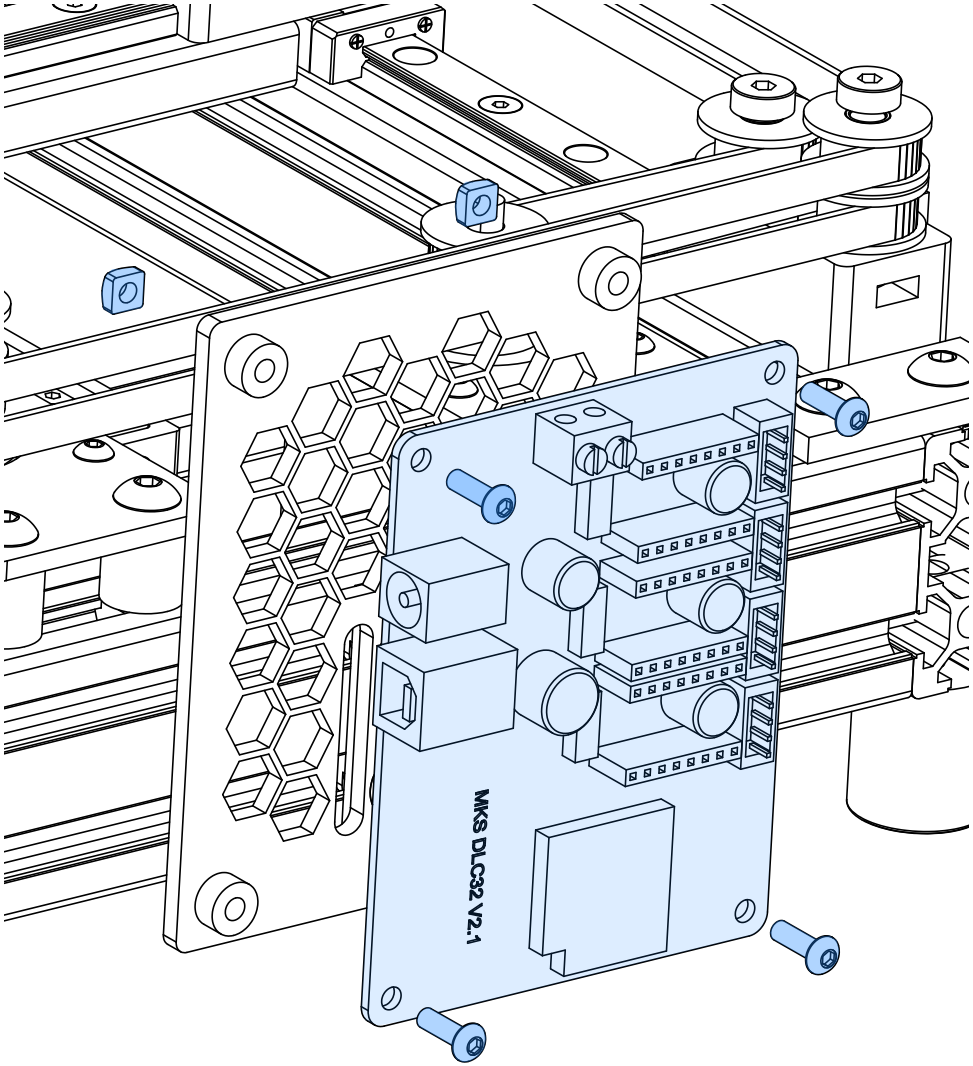
MOUNT THE CONTROL BOARD HOLDER

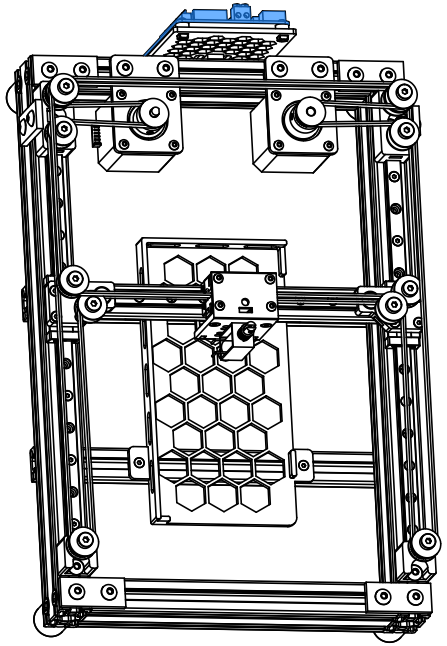
Mount it on the top extrusion's outer face.

60

CONTROL BOARD

BOARD_30





FASTEN THE CONTROL BOARD

Four screw–nut pairs. The lower two nuts are obscured and not drawn.

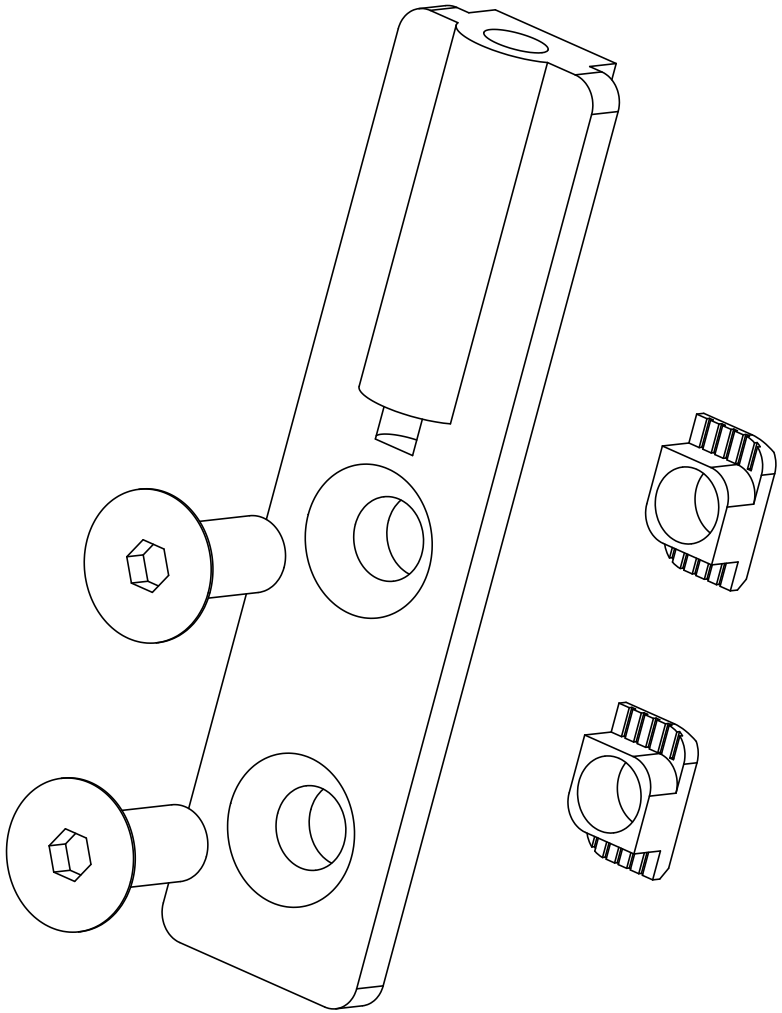
BILL OF MATERIALS

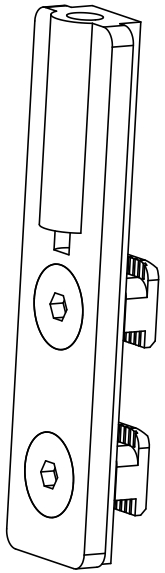
COMPONENT	SPEC	QTY
Control board	MKS DLC32 V2.1	1
BHCS	M3×10	4
Square nut	M3	4

61

CONTROL BOARD

BOARD_31





FIT THE T-NUTS

Two M5 FHCS into hammer T-nuts. Leave them loose for the next step.

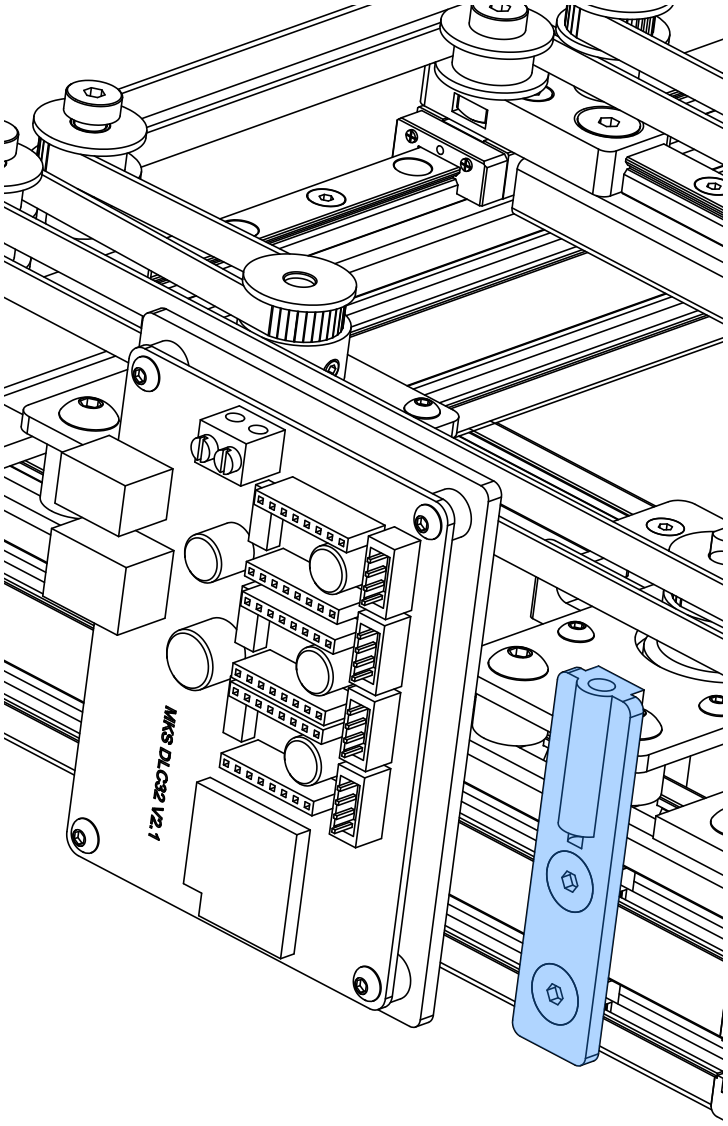
BILL OF MATERIALS

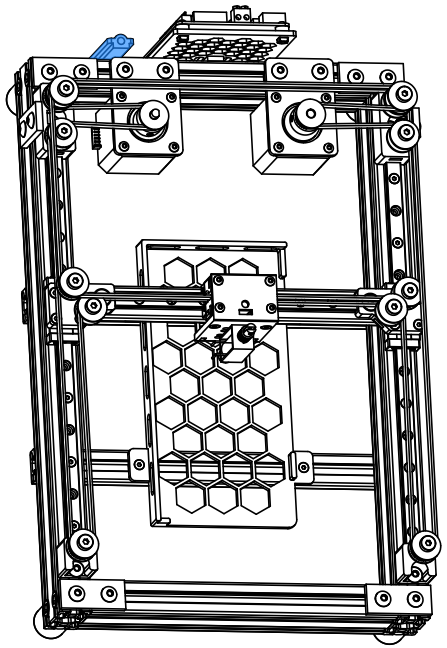
COMPONENT	SPEC	QTY
Tube holder	SLS/MJF 3D Print	1
FHCS	M5×12	2
T-nut	Drop-In M5	2

62

CONTROL BOARD

BOARD_32

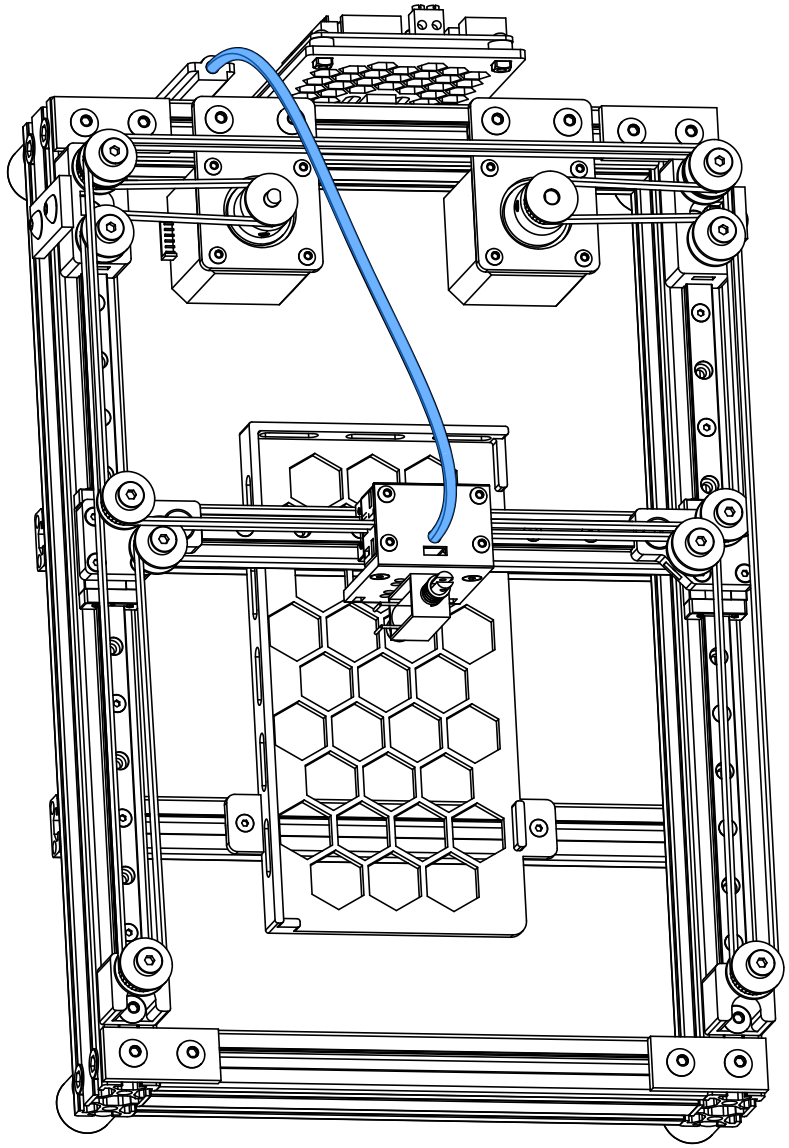




MOUNT THE TUBE HOLDER

Mount it on the top extrusion beside the control board. Its 4 mm socket anchors the fixed end of the Teflon tube.

63



ROUGH LENGTH

Make the tube about 400 mm, long enough to reach from the tube holder to the X carriage at its farthest position.

ANCHOR THE SOLENOID LEADS

Cable-tie the solenoid leads to the tube holder, so the solenoid's travel can't shake the wire at the control-board terminals. Constant shaking works the contact loose, and the solenoid stops tapping the screen.

PTFE VS FEP

Either tube works here: PTFE (milky white) or FEP (clear). The Ø4 tube's stiffness is enough to hold the wire bundle's shape.

SPIRAL-WRAP THE TUBE

Spiral-wrap the solenoid wires to the Teflon tube along its length. The wires don't go inside. The tube just stiffens the bundle so it holds a clear path past the belts and motors.

BILL OF MATERIALS

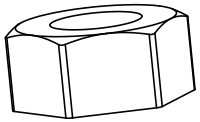
COMPONENT	SPEC	QTY
Teflon tube	`Ø4/2, 400 mm`	1
Spiral wrap	`Ø4, ~400 mm`	1

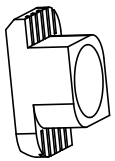
SECTION 09

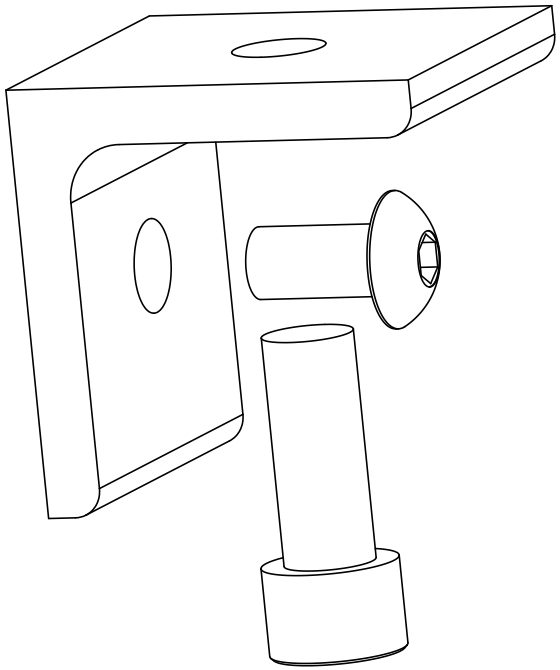
Camera

The camera is mounted on the right side of the frame, facing the phone screen.

65

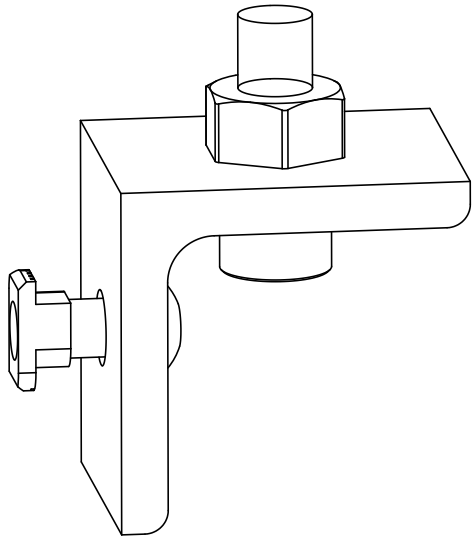






1/4-20, NOT METRIC

The socket screw and hex nut that the gooseneck mounts on are 1/4-20, the imperial tripod thread (≈ 6.35 mm). Don't substitute an M6.

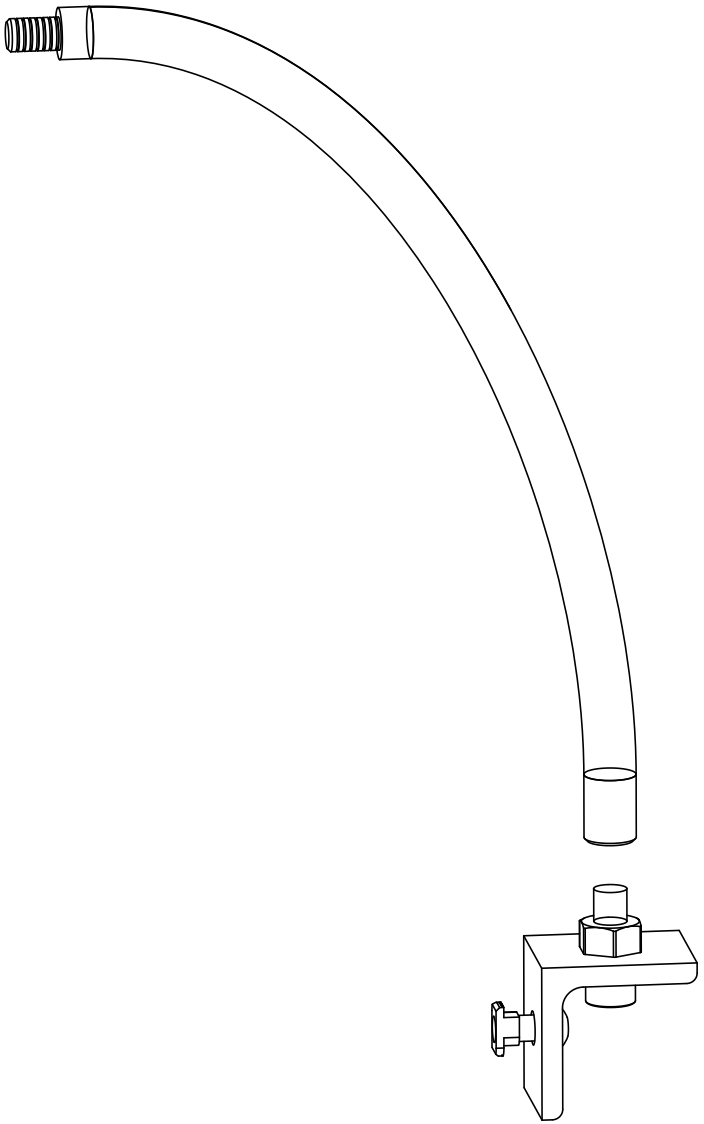


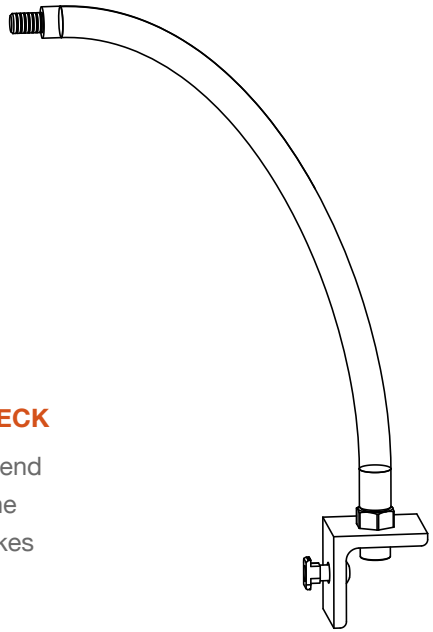
IMPERIAL TOOLS

SHCS 1/4-20 takes a 3/16" hex key; hex nut 1/4-20 takes a 7/16" (or metric 11mm) open-end wrench. Needle-nose pliers you already have will also do the job. There's no need to buy tools just for this.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Corner bracket	2×Ø6.5 mm	1
BHCS	M5×10	1
T-nut	Drop-In M5	1
SHCS	1/4-20×16 (imperial)	1
Hex nut	1/4-20 (imperial)	1





THREAD ON THE GOOSENECK

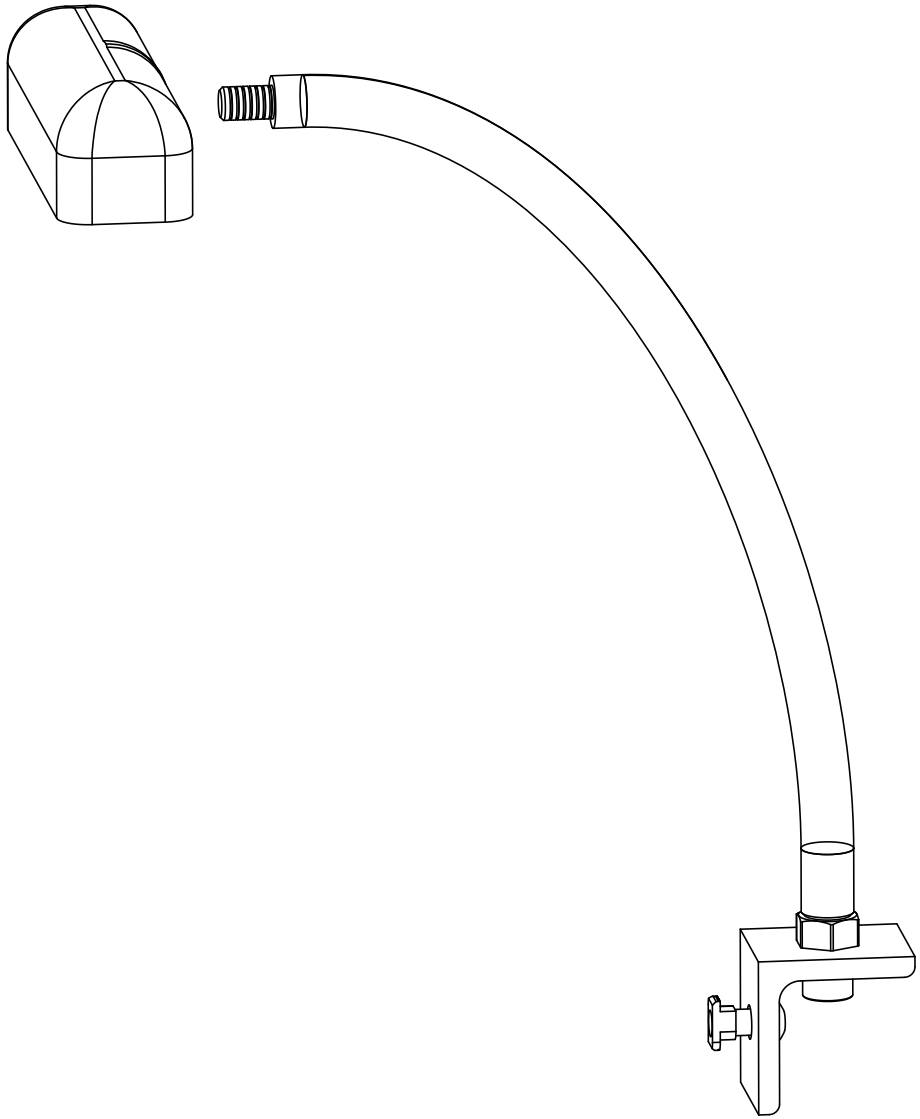
Spin the gooseneck's female end onto the stud, snug against the hex nut. The free male end takes the camera next.

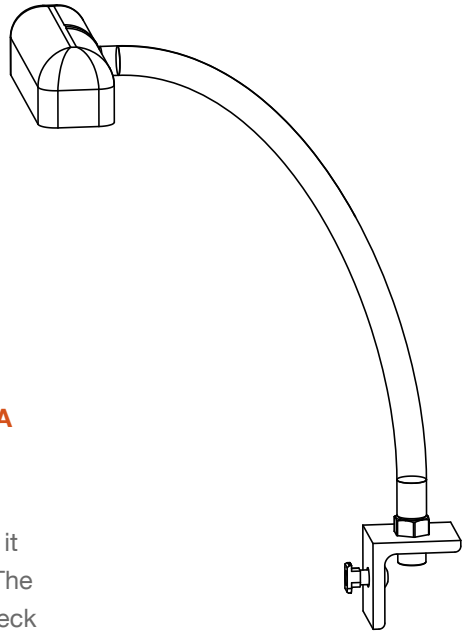
BILL OF MATERIALS

COMPONENT	SPEC	QTY
Gooseneck	Ø10×300, 1/4–20 M/F	1

CAMERA

CAMERA_30





THREAD ON THE CAMERA

Thread the camera's 1/4-20 female socket onto the gooseneck's male stud until it bottoms on the stud collar. The camera now hangs off the neck tip.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Camera	4K HD, autofocus	1

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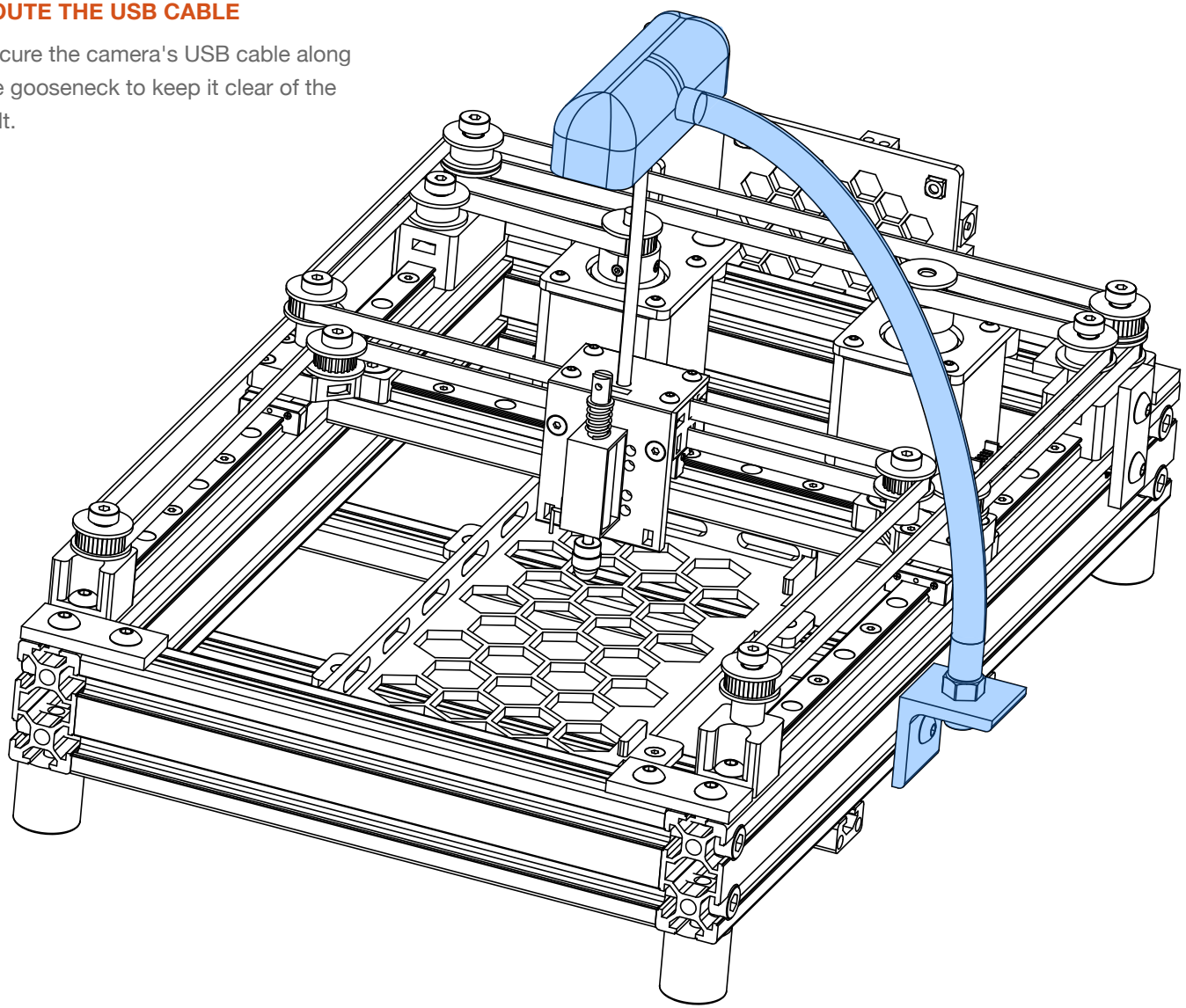
ROUTE THE USB CABLE

Secure the camera's USB cable along the gooseneck to keep it clear of the belt.



USE THE LOWER SLOT

Mount the corner bracket on the lower slot of the right extrusion's outer face.

ORIENT THE CAMERA

Bend the gooseneck so the camera points squarely at the phone screen, and align the sensor's long edge with the phone's long edge.

LOCK IT DOWN

Make sure the camera is held firm. It shouldn't drift or wobble.

SECTION 10

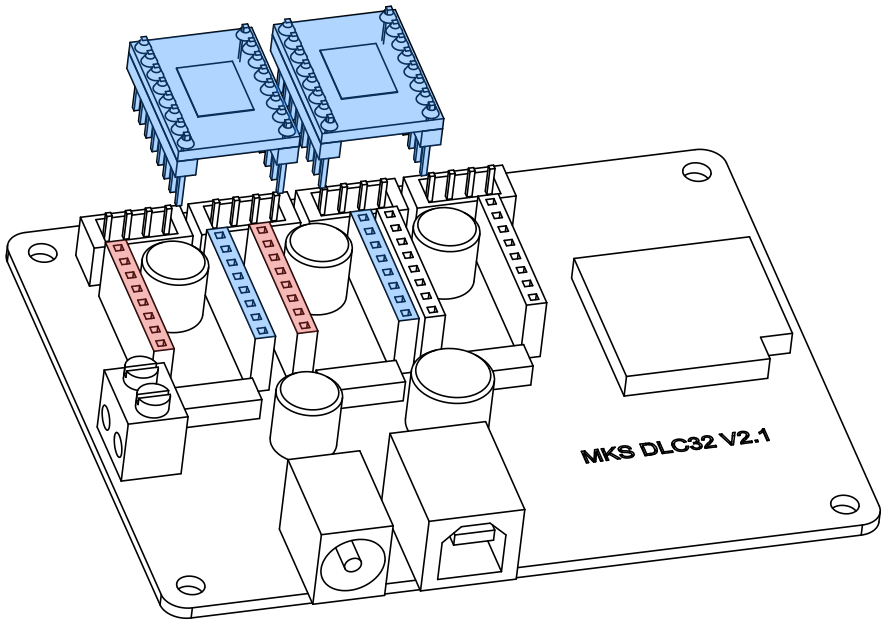
Wiring

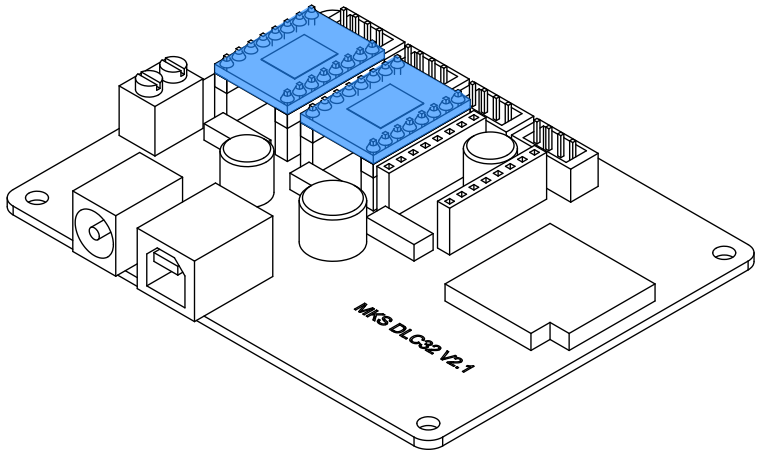
Connect the control board's stepper driver outputs to the motors. Wire the solenoid to the spindle output, and ground it.

70

POWER OFF FIRST

Never plug in or remove a driver while the board is powered.





MIND THE ORIENTATION

Match each driver's pin labels to the board silkscreen before pressing it home. A reversed TMC2209 can burn out on power-up.

RULE OF THUMB

Colored to colored, black to black.

HEATSINK

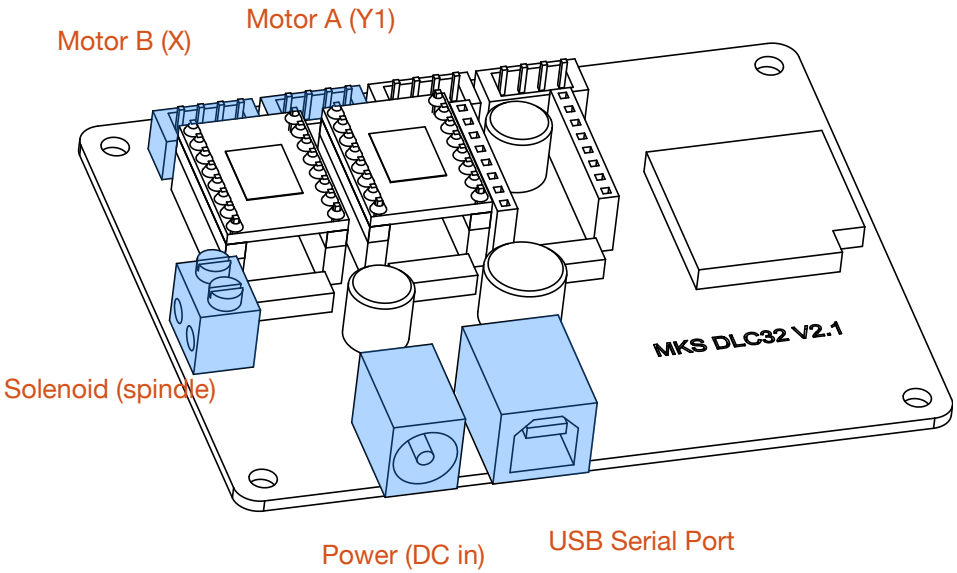
TMC2209 driver modules typically include a heatsink that can be stuck onto the top of the driver chip.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Motor driver	TMC2209	2

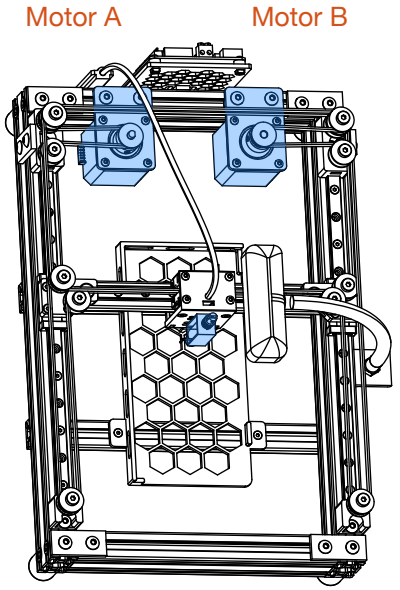
NO POLARITY

The Spindle output (to the solenoid) is not polarity-sensitive. Either lead can go to either terminal.



MOTOR CABLE CONNECTORS

Motor side: 6-pin PH2.0 (2.0 mm pitch), with two pins empty and only four used. Board side: 4-pin XH2.54 (2.54 mm pitch).



CONNECTIONS

The board uses standard GRBL axis outputs, remapped as follows: the X-axis motor driver drives Motor B, the Y1-axis motor driver drives Motor A, and the Spindle output drives the solenoid (in place of a spindle).

BILL OF MATERIALS

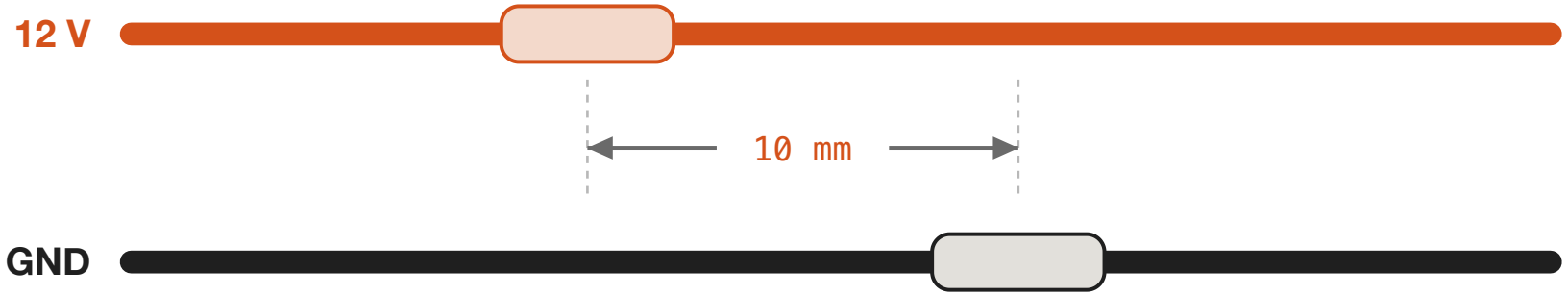
COMPONENT	SPEC	QTY
Power adapter	12 V 2 A	1
Motor cable	XH2.54	2
Data cable	USB serial	1

EXTEND THE LEADS

The solenoid's stock leads don't reach the control board. Splice extra hookup wire onto both the 12 V and GND leads.

KEEP THE STOCK LEADS UNDER 50 MM

Cut the solenoid's stock leads back to 50 mm or less before splicing, so the joints sit clear of where the cable bends most. A joint that flexes with every gesture fatigues and snaps.

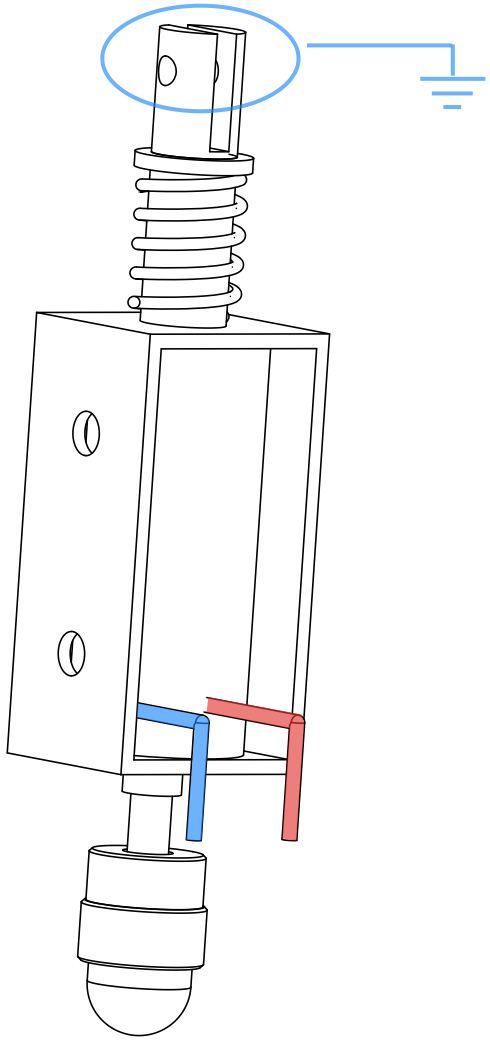


STAGGER THE SPLICES

Solder each joint and cover it with heat-shrink. Offset the two splices about 10 mm so the insulated joints don't sit side by side.

BILL OF MATERIALS

COMPONENT	SPEC	QTY
Lead wire	0.3 mm²	1



GROUND THE STYLUS

The stylus rides on the solenoid's iron core, and the core is tied to the housing through the metal return spring, so grounding the housing grounds the core, and the tip with it. Give it a real ground reference. Do not use the control board's GND.

WHY IT MATTERS

A capacitive screen senses a touch through capacitive coupling to ground. A finger works because the body is a large conductor tied to earth; the arm's stylus couples to earth too weakly, so a tap shifts the screen's charge distribution only slightly, and the phone registers the touch unreliably. Tie the stylus to a solid ground to restore that coupling and steady the touch.

HOW TO GROUND IT

Connect the housing to the power supply's common ground. The simplest option is to clip the wire to bare metal on a desktop PC chassis that is grounded through a three-prong outlet. The chassis reaches earth through the mains, giving a stable reference.

THREE WIRES

Three wires run from the solenoid: positive (+), negative (–), and ground. Use spiral wrap to bind all three wires together with the Teflon tube into one bundle, and run it up to the control board holder, then connect + and – to the control board's Spindle terminal and the ground wire to the power supply's common ground.

WARNING

Never put the ground wire into a wall socket. Mains voltage (220 V/120 V) is lethal. Touching the live terminal instead of earth can cause a fatal shock and instantly destroy your phone and equipment. Connect only to a verified ground point.

SECTION 11

Bill of materials

This is the complete parts list for the whole machine. Use it to gather everything before you start assembling.

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BILL OF MATERIALS

11 — BOM

CLASS	COMPONENT	SPEC	QTY	APPLICATION
Frame	European Standard Anodized Black Aluminum Profile Extrusion 2040 T Slot	Length 345 mm, counterbored 10 mm from each end on the 40 mm-wide face for M6 SHCS	2	Frame side rails
		Length 190 mm, both ends tapped M6	2	Frame end rails
	European Standard Aluminum Profile Extrusion 1020	Length 185 mm	1	Gantry X beam
		Length 230 mm, M5 through-hole 10 mm from each end	2	Phone bed support
Custom parts	3D printed parts	Selective Laser Sintering (SLS) or Multi Jet Fusion (MJF), PA12 nylon (or equivalent), black	11	Idler mount (4 pc), XY joint (left), XY joint (right), Belt clamp, Solenoid mount, Phone bed, Control board holder, Tube holder
Linear guide	MGN9H rail	Rail length 240 mm	2	Y-axis rails
		Rail length 150 mm	1	X-axis rail
	MGN9H carriage	H-type long carriage, 4×M3, 15 × 16 mm mounting hole pitch	3	One per rail
Motion components	Pulley	GT2 20T, 5 mm bore, 6 mm width	2	Motor drive pulleys
	Idler	GT2 20T smooth, 5 mm bore, 6 mm width	10	Redirect the CoreXY belt
		GT2 20T toothed, 5 mm bore, 6 mm width	2	Redirect the CoreXY belt
	Timing belt	GT2, 6 mm width, 5 m/roll	1	CoreXY belt

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BILL OF MATERIALS (CONT.)

11 — BOM

CLASS	COMPONENT	SPEC	QTY	APPLICATION
Electronics	Control board	MKS DLC32 V2.1 (incl. USB cable)	1	Main controller
	Stepper driver	TMC2209	2	Motor drivers
	Power supply	12 V 2 A adapter, 5.5×2.1 mm barrel plug	1	System power
	Camera	4K HD USB webcam, autofocus	1	Overhead phone-screen view
Wiring / Cables	Motor cable	XH2.54, 4-pin, 200 mm	2	Stepper motor → control board
	Lead wire	0.3 mm² stranded flexible wire, pure copper core, 2 m	1	Solenoid GND + lead ext.
Actuators	Stepper motor	NEMA 17, 38 or 40 mm height	2	Drive motors
	Solenoid	12 V, 0.8 A, 10 mm stroke, 0.2–6 N push-pull, 2×M3 mounts, 15 mm pitch	1	Drives the stylus tip to tap
Hardware	Flat bracket	40 × 18 × 4 mm (L×W×T), 20 mm hole pitch, M5 holes	6	Frame & idler joints
	Motor bracket	60 × 42 × 3 mm (L×W×T)	2	Motor mounts
	Corner bracket	2-hole right-angle bracket, 26 mm long, 30 mm leg, 2×Ø6.5 holes	1	Camera arm mount
	Bumper	Cylindrical, 20 mm diameter, 22 mm height, incl. machine screw	4	Frame feet
	Stylus tip	M3 female thread, Ø7 mm fabric tip, Ø8.5 mm OD, 12.5 mm height	1	Screen-tapping tip
	Teflon tube	2 mm ID, 4 mm OD, 1 m, PTFE or FEP	1	Backbone for the solenoid wire so the run holds its shape
	Spiral wrap	Ø4 mm, ~0.5 m	1	Binds the wire to the tube
	Gooseneck	360° adjustable, 1/4-20 M/F, 300 mm long, 10 mm OD	1	Camera arm

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BILL OF MATERIALS (CONT.)

11 — BOM

CLASS	COMPONENT	SPEC	QTY	APPLICATION
Fasteners	BHCS	M3×6 (thread dia × thread length)	10	Motors & stylus
		M3×8	8	Belt clamps & stylus
		M3×10	4	Control board mount
		M5×10	15	Frame, idlers, camera base
		M5×12	2	Idler-mount brackets
		M5×16	10	Frame, phone bed & Motor A mount
		M5×20	2	Motor B mount
	FHCS	M3×8, length = overall (incl. head), not thread length	4	Phone bed
		M3×10	26	Gantry & stylus
		M5×12	6	Gantry, control board & tube holder mount
	SHCS	M6×20	8	Frame joints
		1/4–20×16, imperial (≈ 6.35 mm), not interchangeable with M6	1	Camera arm
	Shoulder screw	Ø5×10×M4 (shank dia × shank length × thread)	4	Idler
		Ø5×20×M4	6	Idler

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BILL OF MATERIALS (CONT.)

11 — BOM

CLASS	COMPONENT	SPEC	QTY	APPLICATION
Fasteners	**T-nut**	Drop-In M3	20	Gantry & phone bed
		Drop-In M5	23	Frame, idlers, phone bed, control board holder, tube holder, camera base
		Slide-In M5	10	Frame & gantry
	Square nut	M3, 5.5 mm square, 2.4 mm thick	10	Stylus holder & control board holder
		M4, 7 mm square, 3.2 mm thick	10	Idler
		M5, 8 mm square, 4 mm thick	2	Idler
	Hex nut	1/4-20, imperial (≈ 6.35 mm), not interchangeable with M6	1	Camera arm
	Shim	5 mm ID, 8 mm OD, 0.5 mm thick	12	Idler
	Spacer	5 mm ID, 10 mm OD, 9 mm height	4	Idler
		6 mm ID, 12 mm OD, 8 mm height	2	Motor A bracket standoff
		6 mm ID, 12 mm OD, 12 mm height	2	Motor B bracket standoff
Tools	**Hex key**	2 / 3 / 5 mm	3	M3, M5, M6 screws
Other	**Grease**	Lithium grease, NLGI 2	1	Rail lubrication
	Threadlocker	Loctite 243 or equivalent — medium strength, blue	1	Lock pulley set screws
	Heat shrink tubing	Ø3 mm	2	Insulate and protect wire splices

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END OF MANUAL

Next, tell PhysiClaw what you'd like it to do.

> “PhysiClaw can do anything you can do on your phone: it looks at the screen and touches it, just like you.”