

COPIS Build Instructions

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Inventory

This inventory list consists of enough rails and 3D printed parts for a standard stacked chamber.

Framing and Rails

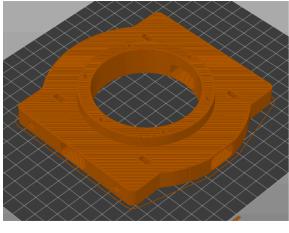
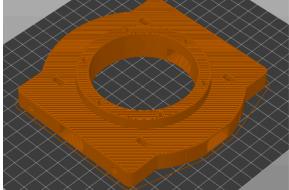
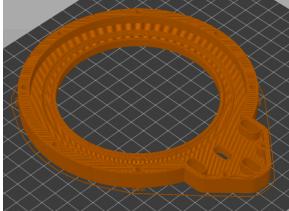
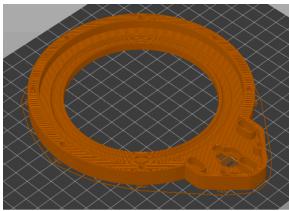
4040 T-Slot Framing

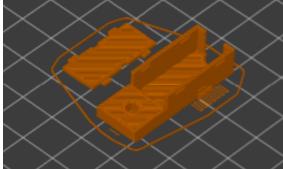
Size Description	Quantity (Top & Bottom)
<input type="checkbox"/> 1135mm Uprights	8
<input type="checkbox"/> 1080mm Sides	6 (2 include control board)
<input type="checkbox"/> 1160mm Sides	6
<input type="checkbox"/> 145mm Mounts	8
<input type="checkbox"/> 125mm Light Mounts	8

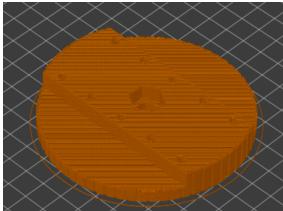
V-Slot Rails

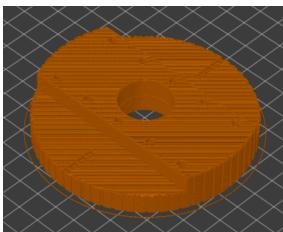
Size Description	Quantity (Top & Bottom)
<input type="checkbox"/> 2060x1000mm	10
<input type="checkbox"/> 2040x1000mm	6
<input type="checkbox"/> 2040x500mm	12
<input type="checkbox"/> 2020x1000mm	1

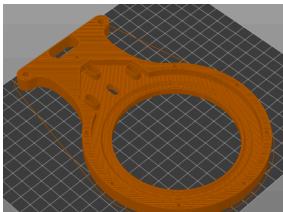
3D Printed Parts

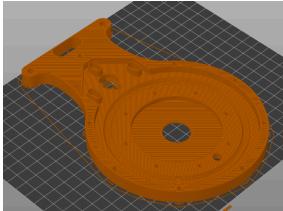
Part Description	Picture	Quantity (Top & Bottom)	STL File Name on GitHub
<input type="checkbox"/> Rail Caps		48	4040_corner_connector_m5.stl
<input type="checkbox"/> Bottom Pan Shoulder Plate (Logo upside down)		3	pan_shoulder_plate_bot_logo.stl
<input type="checkbox"/> Top Pan Shoulder Plate (Logo right side up)		3	pan_shoulder_plate_top_logo.stl
<input type="checkbox"/> Inner Pan Housing		6	pan_housing_inner_side_6_1_d_0_2_fit.stl
<input type="checkbox"/> Outer Pan Housing		6	pan_housing_outer_side_6_1_d_0_2_fit.stl

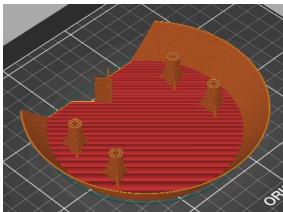
<input type="checkbox"/> Pan Housing Limit Set		6	pan_limit_housing.stl
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<input type="checkbox"/> Bearing Side Tilt Shoulder Plate		6	tilt_shoulder_plate_bearing_side.stl
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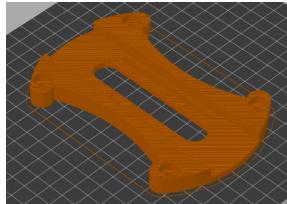
<input type="checkbox"/> Geared Side Tilt Shoulder Plate		6	tilt_shoulder_plate_gear_ed_side.stl
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<input type="checkbox"/> Inner Tilt Housing		6	tilt_housing_inner_side_6_1_d_0_2_fit.stl
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<input type="checkbox"/> Outer Tilt Housing		6	tilt_housing_outer_side_6_1_d_0_2_fit.stl
---	---	---	---

<input type="checkbox"/> Outer Tilt Housing Cover		6	tilt_outer_cable_cover.stl
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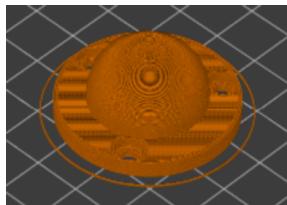
Sliding Tilt Hanger



12

tilt_sliding_hanger.stl

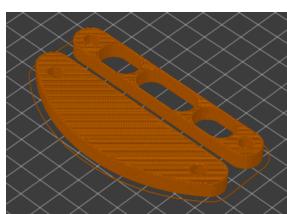
Tilt Bearing Screw Cover



6

tilt_bearing_screw_cove
r.stl

Tilt Cradle Off-Set and Spacer Set



6

tilt_hanger_7mm_offset
_spacer.stlcradle_7mm_offset_spa
cer.stl

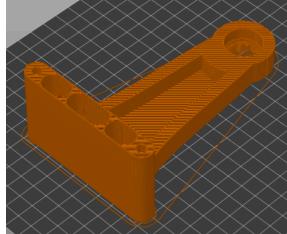
Tilt Limit Housing Set



6

tilt_limit_housing_v2_to
p.stltilt_limit_housing_v2_bo
t.stl

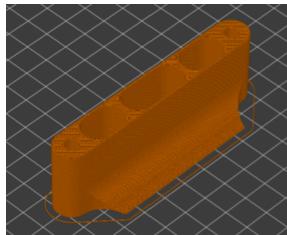
Pan/Tilt Hanger Arm



6

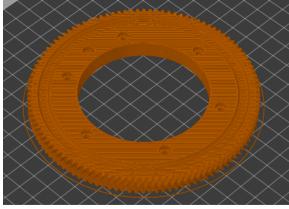
pan_tilt_34_5_hanger_a
rm.stl

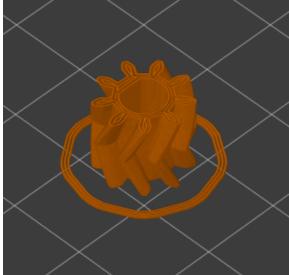
Pan/Tilt Spacer

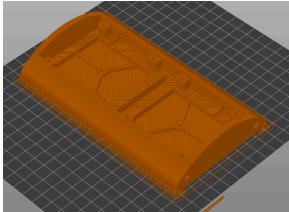


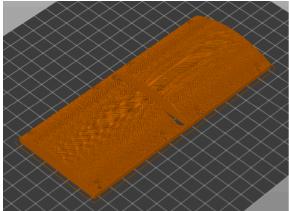
6

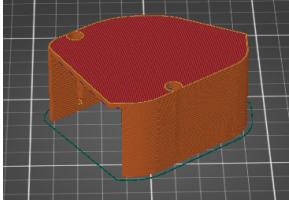
pan_tilt_29_1_spacer.stl

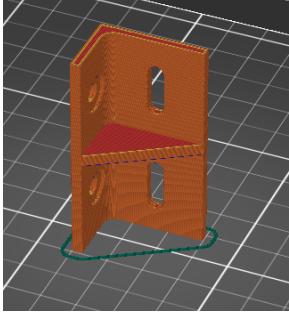
<input type="checkbox"/> Large Gear		12	pan_tilt_gear_6_1d_53.stl
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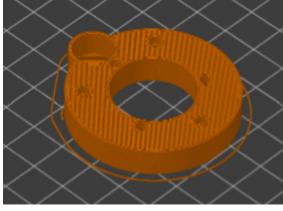
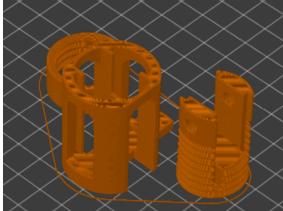
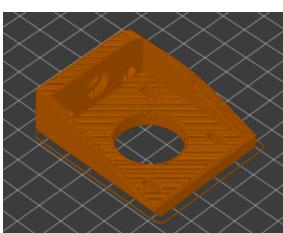
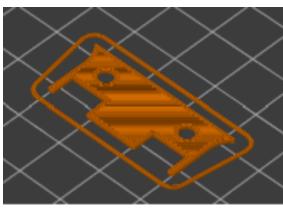
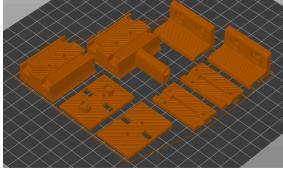
<input type="checkbox"/> Small Gear		12	pan_tilt_gear_small.stl
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<input type="checkbox"/> Camera Cradle		6	cam_cradle.stl
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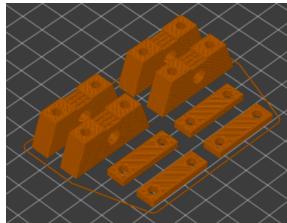
<input type="checkbox"/> Camera Cradle Lid		6	cam_cradle_lid.stl
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<input type="checkbox"/> Camera Power Adapter Holder		6	cam_power_supply_bracket.stl
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<input type="checkbox"/> Drag Chain Support Bracket		6	x_axis_drag_chain_support.stl
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<input type="checkbox"/> Slip Ring Adapter		6	slip_ring_adapter_cosm au.stl
<input type="checkbox"/> X-axis Idler Set		6	x_axis_idler_screw_cra dle.stl
			x_axis_idler_screw_inse rt_m24.stl
			x_axis_idler_end_nut.stl
<input type="checkbox"/> X-axis Motor Mount		6	x_axis_motor_mount.stl
<input type="checkbox"/> X-rail Plate Spacer Shim		24	x_rail_plate_spacer_1m m_shim.stl
<input type="checkbox"/> X-rail Spacer Set & Limit Housing		6	x_rail_plate_spacer.stl
			x_rail_plate_spacer_lid. stl
			x_rail_plate_spacer_ma g.stl
			x_rail_plate_spacer_lid_ mag.stl
			z_axis_limit_housing_to p.stl
			z_axis_limit_housing_ba se.stl

Y-axis Belt Clamp Sets

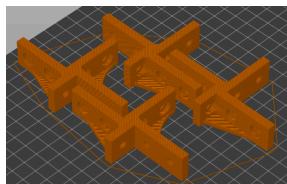


8

y_belt_clamp_a.stl

y_belt_clamp_b.stl

Y-axis Framing Set



8

y_axis_framing_mount.stl

y_axis_framing_mount_mirrored.stl

Y-axis Limit Housing Set



2

y_axis_limit_housing_cams1n_top.stl

y_axis_limit_housing_cams1n_bottom.stl

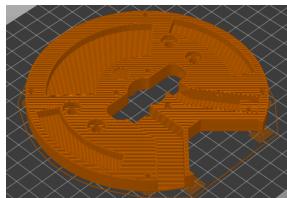
y_axis_rail_magnet_housing.stl

y_axis_plate_magnet_housing.stl

y_axis_limit_housing_cams0_top.stl

y_axis_limit_housing_cams0_bottom.stl

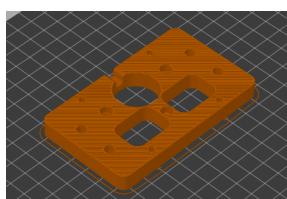
Z-axis Bottom Plate



6

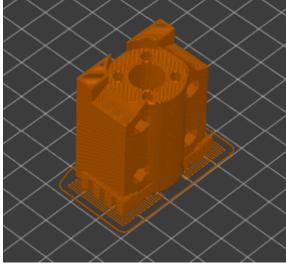
z_axis_bottom_plate.stl

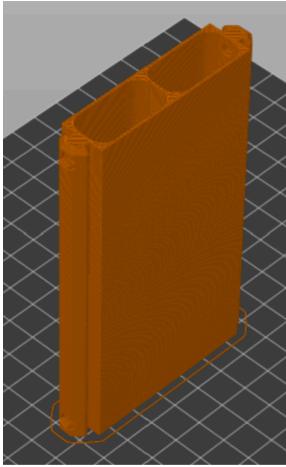
Z-axis Motor Plate

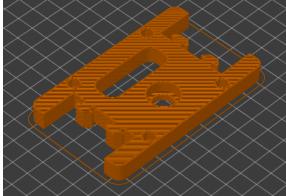


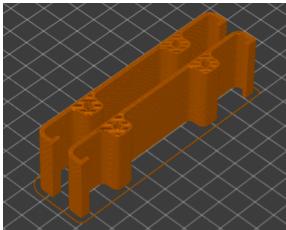
6

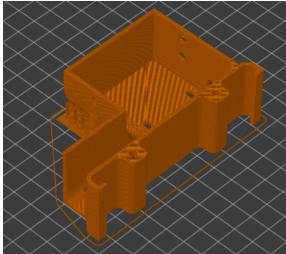
z_axis_motor_plate.stl

<input type="checkbox"/> Z-axis Nut Block		6	z_axis_tr8_nutblock.stl
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<input type="checkbox"/> Z-axis Raceway		18	z_axis_raceway_115mm.stl
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<input type="checkbox"/> Z-axis Top Plate		6	z_axis_top_plate.stl
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<input type="checkbox"/> Z-axis Top Plate Spacer		9	z_axis_top_plate_space_r_30mm.stl
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<input type="checkbox"/> Z-axis Top Plate Spacer with Drag Chain		3	z_axis_top_plate_space_r_30mm_with_dragchain.stl
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Preparation

Tapping

Many of the rails and 3D parts need to be tapped prior to assembly. Refer to the list below for the name of the part, how many of them, how many holes, and how many required tap turns it needs.

V-Slot Rails - M5

Description	Quantity (Top & Bottom)	Number of Holes	Number of Tap Turns (x180°)
<input type="checkbox"/> 2060x1000mm	10	60	Full Tap Length
<input type="checkbox"/> 2040x1000mm	6	24	Full Tap Length
<input type="checkbox"/> 2040x500mm	12	48	Full Tap Length
<input type="checkbox"/> 2020x1000mm	1	2	Full Tap Length

3D Prints - M3

Description	Quantity (Top & Bottom)	Number of Holes Per Print (Holes x Quantity)	Number of Tap Turns (x180°)
<input type="checkbox"/> Geared-side Tilt Shoulder Plate (Flat side)	6	6 (12)	25
<input type="checkbox"/> Geared-side Tilt Shoulder Plate (Raised side)	6	10 (60)	45
<input type="checkbox"/> Bearing-side Tilt Shoulder Plate (Raised side)	6	10 (60)	35
<input type="checkbox"/> Inner Tilt Housing	6	8 (48)	35
<input type="checkbox"/> Outer Tilt Housing (Bottom Holes)	6	6/8 (36)	25
<input type="checkbox"/> Camera Cradle	6	8 (48)	20

<input type="checkbox"/> Pan/Tilt Hanger Arm (Head)	6	3 (18)	30
<input type="checkbox"/> Inner Pan Housing	6	5/9 (30)	35
<input type="checkbox"/> Pan Shoulder	6	6	35
<input type="checkbox"/> Z Bottom Plate (Pan Limit Sensor M3 hole)	6	1 (6)	10
<input type="checkbox"/> Slip Ring Adapter (Opposite Z screw drive notch side)	6	3 (18)	20

Pre-Assembly

The outer framing requires pre-install t-slot nuts and rail caps prior to stacking. Some of the 3D parts are able to be assembled prior to putting the machine together. Certain parts of this section may require you to repeat them depending on the number of camera gantries you are planning to build. **Please note that some rails have two slots on each side. Divide the number of pre-install t-slot nuts between the two so that they have the same amount.**

Outer Framing

Description	Quantity
<input type="checkbox"/> Pre-install T-slot Nuts	368
<input type="checkbox"/> Rail Cap Prints	48

1. Install the listed number of pre-install t-slot nuts into the following frames. These will shift in place, but will be stopped from sliding out once the rail caps are installed. There are post-install t-slot nuts that can be put in later during assembly if any are forgotten during this step.
 - a. 8 pre-install t-slot nuts on one side of all of the 1135mm Upright Frames
 - i. 12 pre-install t-slot nuts on the adjacent side of the 1135mm Upright Frames. This side is where the 145mm Mount Frames are going to be connected to.
 - b. 2 pre-install t-slot nuts on two adjacent sides of the 145mm Mount Frames
 - i. 4 pre-install t-slot nuts on an adjacent side of the 145mm Mount Frames
 - c. 8 pre-install t-slot nuts on three sides of two of the 1080mm and 1160mm Side Frames. These are the bars that will go in the middle of the stacked chamber.

- d. 8 pre-install t-slot nuts on one side and an adjacent side of four of the 1160mm Side Frames
 - e. 8 pre-install t-slot nuts on one side of four of the 1080mm Side Frames. Two of these frames have the control board connected to them and should have the t-slot nuts on the top.
 - i. 8 pre-install t-slot nuts on the opposite side for four of the 1080mm Side Frames.
 - f. 2 pre-install t-slot nuts on two opposite sides for all eight of the 125mm Light Mounts.
2. Install rail caps on both ends of the following frames. This may require force as it is a snug fit and is recommended to use a rubber mallet to make sure the rail cap is secure.
 - a. 1135mm Uprights
 - b. 145mm Mounts
 - c. 125mm Light Mounts

Assemble Tilt Mechanism

This section is broken into smaller builds necessary to assemble the entire tilt mechanism.

Assemble Camera Cradle

Description	Quantity
<input type="checkbox"/> Sliding Tilt Hanger Print	2
<input type="checkbox"/> Camera Cradle Print	1
<input type="checkbox"/> Camera Cradle Lid Print	1
<input type="checkbox"/> Tilt Cradle Spacer Print	1
<input type="checkbox"/> 1/2-20x5/8 Captive Screw	1
<input type="checkbox"/> Split Washer	1
<input type="checkbox"/> M5 Nuts	4
<input type="checkbox"/> M5x55mm screws (Shorter screws down to 35mm on geared side and 45mm on bearing side could also be used)	4
<input type="checkbox"/> M3x6mm screws (M3x8mm will also work)	8

1. Attach 1/2-20x5/8 captive screw to camera cradle. Thread split washer in the screws' threads to the base of the cradle.
 - a. It is recommended to use a long needle nose plier to hold onto the split washer while threading since it is very sharp.
2. Insert 4 M5 nuts into captive nut traps in the camera cradle.
 - a. The M5 nuts may fall out when trying to position the spacer and sliding tilt hangers. Do one at a time and make sure they are in when putting in the screws.
3. Attach the spacer and one sliding tilt hanger to one side of the cradle and one sliding tilt hanger only to the other side of the cradle using 4 M5x55mm screws (shorter screws down to 35mm on geared side and 45mm on bearing side could also be used).
 - a. *Use the hole for the captive screw as a reference point. The camera should be facing in the direction of the hole and the widest side of the camera should be on the side with the spacer.
 - b. ***NOTE:** This is the assembly for the ideal placement of the camera. If assembled backwards where the camera is facing away from the hole, it should still work as intended.
4. Attach camera cradle lid with 8 M3x6mm screws (M3x8mm will also work).

Assemble Tilt Housing

Description	Quantity
<input type="checkbox"/> Geared-side Tilt Shoulder Plate Print	1
<input type="checkbox"/> Large Gear Print	1
<input type="checkbox"/> Small Gear Print	1
<input type="checkbox"/> Outer Tilt Housing Print	1
<input type="checkbox"/> Inner Tilt Housing Print	1
<input type="checkbox"/> Tilt Limit Sensor Housing Print	1
<input type="checkbox"/> Pan/Tilt Bearing Screw Cover	1
<input type="checkbox"/> NEMA 17 Stepper Motor	1
<input type="checkbox"/> Radial magnet 0.236"DIA X 0.098"H CYL	1
<input type="checkbox"/> M3x10mm screws (8mm screws can be used for three of them)	5
<input type="checkbox"/> M3x12mm screws	6
<input type="checkbox"/> M3x16mm screws	8

(8mm screws can be used for three of them)

<input type="checkbox"/> M8x35mm screws	1
<input type="checkbox"/> Bearing Balls	84

1. Attach geared-side tilt shoulder plate to large gear with 6 M3x12mm screws. Position the large gear so that the side with the magnet hole is on the bottom and faced down. Place the geared-side tilt shoulder plate on top with the raised side vertical and faced up.
2. Insert radial magnet 0.236"DIA X 0.098"H CYL into large gear (use a bit of double sided tape if it is not snug).
3. Slide small gear into NEMA 17 shaft, greased and oriented to couple with tilt (large) gear.
 - a. There is a flat edge on the shaft of the motor that will match up to the hole shape of the small gear.
 - b. For the correct orientation, the grooves of the small gear should fit into the groove of the large gear.
4. Attach the motor to the outer tilt housing with 3 M3x10mm screws (8mm screws can be used). Position the motor so that the attached cord is upwards, either on the left or right side.
5. Attach inner and outer tilt housings together, encasing a greased large gear with 42 bearing balls on each greased side raceway, with 8 M3x16mm screws (18mm can also be used).
 - a. Press the inner and outer tilt housings very tightly together when putting in the final screws.
6. Place limit sensor with cable in tilt limit sensor housing and attach to outer tilt housing using 2 M3x10mm screws (limit housing screw holes may need to be enlarged to 3mm)

Attach Camera Cradle and Tilt Housing

Description	Quantity
<input type="checkbox"/> Assembled Camera Cradle	1
<input type="checkbox"/> Assembled Tilt Housing	1
<input type="checkbox"/> M3x6mm screws	3
<input type="checkbox"/> M3x12mm screws	8
<input type="checkbox"/> M8 Bearings	2
<input type="checkbox"/> Spacers	4
<input type="checkbox"/> M8 lock-nut set	1

1. Use 4 M3x12mm screws and washers to attach the motor side tilt shoulder to the sliding tilt hanger. Attach it on the side of the cradle that does not have the spacer.
 - a. Line up the holes on the geared-side tilt shoulder plate with the spaces in the sliding tilt hanger. Put the screws in the middle and bottom two holes.
2. Attach bearing side tilt shoulder plate to the pan/tilt hanger arm with 2 M8 bearings and 3 to 4 spacers (1 or 2 spacers between the bearings, 1 spacer between the shoulder and plate and 1 spacer between the lock-nut and shoulder) and 1 M8x35mm screw and M8 lock-nut set.
3. Attach pan/tilt bearing screw cover with 3 M3x6mm screws.
4. Attach the bearing side tilt shoulder to the sliding tilt hanger using 4 M3x12mm screws and washers.
 - a. Line up the holes on the geared-side tilt shoulder plate with the spaces in the sliding tilt hanger. Put the screws in the middle and bottom two holes.

Assemble Pan Mechanism

Description	Quantity
<input type="checkbox"/> Outer Pan Housing Print	1
<input type="checkbox"/> Inner Pan Housing Print	1
<input type="checkbox"/> *Pan Shoulder Plate Print	1
<input type="checkbox"/> Large Gear Print	1
<input type="checkbox"/> Small Gear Print	1
<input type="checkbox"/> NEMA 17 Stepper Motor	1
<input type="checkbox"/> M3x10mm screws (8mm screws can be used)	3
<input type="checkbox"/> M3x16mm screws (12-18mm screws can be used)	6
<input type="checkbox"/> M3x18mm screws (16mm screws can be used)	5
<input type="checkbox"/> M5 nuts	4
<input type="checkbox"/> Radial magnet 0.236"DIA X 0.098"H CYL	1

1. Insert 4 M3 nuts in the pan housing without a motor mount (inner).
2. Insert radial magnet 0.236"DIA X 0.098"H CYL into large gear (use a bit of double sided tape if it is not snug).
3. Slide small gear into NEMA 17 shaft, greased and oriented to couple with the tilt (large) gear.
 - a. There is a flat edge on the shaft of the motor that will match up to the hole shape of the small gear.
 - b. For the correct orientation, the grooves of the small gear should fit into the groove of the large gear.
4. Attach the motor to the pan housing with 3 M3x10mm screws (8mm screws can be used). Position the motor so that the attached cord is upwards, either on the left or right side.
5. Attach inner and outer pan housings together, encasing a greased large gear with 42 bearing balls on each greased side raceway, with 5 M3x18mm (or 16mm) screws.
 - a. Press the inner and outer pan housing very tightly together when putting in the final screws.
6. Insert 4 M5 nuts into the captive nut slots of the pan shoulder. Use a screw to "lock" them in place into the inner recess of the slot.
 - a. *Make sure to take notice that there is a difference between the pan shoulder plate for the top and bottom camera gantries.
7. Attach the pan shoulder to the pan housing with 6 M3x16mm screws (12-18mm can be used). Position the magnet closest to the motor.

Assemble the Solid V Wheel

The wheel assembly comes in a package that includes the necessary hardware for a single wheel.

Description	Quantity
<input type="checkbox"/> Solid V Wheel	<input type="checkbox"/> 1
<input type="checkbox"/> Ball Bearings 625 2RS 5x16x5	<input type="checkbox"/> 2
<input type="checkbox"/> 5mm Spacer	<input type="checkbox"/> 2
<input type="checkbox"/> M5 Lock Nut	<input type="checkbox"/> 1

1. Push 1 of the ball bearings into one side of the solid v wheel.
2. Place 1 spacer on the inside of the wheel.
3. Push the other ball bearing into the other side of the wheel.
4. The leftover spacer and lock nut will be used when attaching the wheel to the plates in

the following steps:

- a. [Assemble 2060 X/Z Plate](#)
- b. [Assemble 2040 X/Z Plate](#)

Assemble Z-Axis Nut Block

These need to be assembled prior to assembling the 2060 and 2040 X/Z Plates.

Description	Quantity
<input type="checkbox"/> Z-Axis Nut Block print	1
<input type="checkbox"/> M3x40mm screws	4
<input type="checkbox"/> M3 Nuts	8
<input type="checkbox"/> Brass Nut	1

1. Insert 8 M3 nuts into the nut block.
2. Insert the brass nut into the nut block.
3. Secure the brass nut into the nut block with 4 M3x40mm screws.

Assemble 2060 X/Z Plate

*Refer to [Assemble the Solid V Wheel](#) section for the extra nuts and washers that will be used when attaching the wheels to the plates.

Description	Quantity
<input type="checkbox"/> 2060 X/Z Plate	1
<input type="checkbox"/> Assembled Z-Axis Nut Block	1
<input type="checkbox"/> M3x22mm screws	4
<input type="checkbox"/> M5x25mm screws (27mm can be used)	8
<input type="checkbox"/> M3 washers	4
<input type="checkbox"/> *Wheel Assemblies	7
<input type="checkbox"/> Spacers	8
<input type="checkbox"/> Eccentric Nuts	3

1. Attach the nut block to the 2060 X/Z plate with 4 M3x22mm screws and 4 M3 washers placed on the other side of the plate. It does not matter which side you first put it on. The

brass nut of the nut block will go up towards the top of the plate.

2. Refer to [Assemble the Solid V Wheel](#) section for the assembly of the wheels within each package.
3. Use M5x25mm or 27mm screws for mounting each of the wheels.
4. Attach 3 wheels on the outside, the 2 top ones with spacers and the bottom one with an eccentric nut. There is a bigger hole that will fit the eccentric nut at the bottom.
5. Attach 4 wheels on the inside, 2 with spacers and 2 with eccentric nuts, in a vertical arrangement. There are bigger holes that will fit the eccentric nuts on one side.

Assemble 2040 X/Z Plate

Description	Quantity
<input type="checkbox"/> 2040 X/Z Plate	1
<input type="checkbox"/> M5x25mm screws (27mm can be used)	3
<input type="checkbox"/> M3 washers	4
<input type="checkbox"/> *Wheel Assemblies	3
<input type="checkbox"/> Spacers	8
<input type="checkbox"/> Eccentric Nuts	3

1. Use M5x25mm or 27mm screws for mounting each of the wheels.
2. Attach 3 wheels on the outside, the 2 top ones with spacers and the bottom one with an eccentric nut. There is a bigger hole that will fit the eccentric nut at the bottom.

Bind 2060 X/Z Plate and 2040 X/Z Plate (TOP)

*Please note that the assembly for the 2060 and 2040 X/Z Plates are the same for the top and bottom camera gantries. The only difference is the orientation when binding them together.

Description	Quantity
<input type="checkbox"/> X-rail Plate Spacer with Magnet Print	1
<input type="checkbox"/> X-rail Plate Spacer with Magnet Lid Print	1
<input type="checkbox"/> X-rail Plate Spacer Print	1
<input type="checkbox"/> X-rail Plate Spacer Lid Print	1
<input type="checkbox"/> Radial Magnet 0.236"DIA X 0.098"H CYL	1

<input type="checkbox"/> M3x12mm screws (Up to 18 mm can also be used)	4
<input type="checkbox"/> M3x16mm screws	2
<input type="checkbox"/> M3 washers	4
<input type="checkbox"/> M3 nuts	2
<input type="checkbox"/> M3x16mm screws	2
<input type="checkbox"/> Spacers	6

1. Insert 2 M3 nuts into the back of each X/Z plate spacer.
2. Attach the plate spacer lids with 2 M3x16mm screws per plate spacer.
3. Insert radial magnet 0.236"DIA X 0.098"H CYL into the plate spacer with a magnet hole shaft.
4. Slide 4 M3 nuts into the captive nut chamber on the back per plate spacer. Turning the nut should help it go in.
 - a. The M3 nuts may fall out when trying to position the plate spacers for binding the plates together. Do one at a time and make sure they are in place when putting in the screws.
5. Bind the 2040 plate to the 2060 plate with 2 plate spacers (1 with a magnet hole shaft and 1 without) using 4 M3 washers and 4 M3x12mm screws (up to 18 mm can also be used). The rectangles on both sides of the plate spacers should match up with the oblong holes on the plates.
 - a. The plate spacer with the magnet hole shaft should be facing up towards the four top wheels and use the top two holes on both the 2060 and 2040 plates (closest to the four top wheels) for the screws.

Bind 2060 X/Z Plate and 2040 X/Z Plate (BOTTOM)

*Please note that the assembly for the 2060 and 2040 X/Z Plates are the same for the top and bottom camera gantries. The only difference is the orientation when binding them together.

Description	Quantity
<input type="checkbox"/> X-rail Plate Spacer with Magnet Print	1
<input type="checkbox"/> X-rail Plate Spacer with Magnet Lid Print	1
<input type="checkbox"/> X-rail Plate Spacer Print	1
<input type="checkbox"/> X-rail Plate Spacer Lid Print	1
<input type="checkbox"/> Radial Magnet 0.236"DIA X 0.098"H CYL	1

<input type="checkbox"/> M3x12mm screws (Up to 18 mm can also be used)	4
<input type="checkbox"/> M3x16mm screws	2
<input type="checkbox"/> M3 washers	4
<input type="checkbox"/> M3 nuts	2
<input type="checkbox"/> M3x16mm screws	2
<input type="checkbox"/> Spacers	6

1. Insert 2 M3 nuts into the back of each X/Z plate spacer.
2. Attach the plate spacer lids with 2 M3x16mm screws per plate spacer.
3. Insert radial magnet 0.236"DIA X 0.098"H CYL into the plate spacer with a magnet hole shaft.
4. Slide 4 M3 nuts into the captive nut chamber on the back per plate spacer. Turning the nut should help it go in.
 - a. The M3 nuts may fall out when trying to position the plate spacers for binding the plates together. Make sure they are in place when putting in the screws.
5. Bind the 2040 plate to the 2060 plate with 2 plate spacers (1 with a magnet hole shaft and 1 without) using 4 M3 washers and 4 M3x12mm screws (up to 18 mm can also be used). The rectangles on both sides of the plate spacers should match up with the oblong holes on the plates.
 - a. The plate spacer with the magnet hole shaft should be facing down away from the four top wheels and use the bottom two holes on the 2060 plate (away from the four top wheels) for the screws. The holes used on the 2040 plate should be the same as it was for the top. The top wheels on both plates will no longer be on the same level.

Assemble Y-Axis End Plates

*Refer to [Assemble the Solid V Wheel](#) section for the extra nuts and washers that will be used when attaching the wheels to the plates.

Description	Quantity
<input type="checkbox"/> Y-Axis End Plates	2
<input type="checkbox"/> X Motor Mount Print	1
<input type="checkbox"/> *Wheel Assemblies	4
<input type="checkbox"/> Spacers	4

<input type="checkbox"/> NEMA 17 Stepper Motors	1
<input type="checkbox"/> GT2 Gear	1
<input type="checkbox"/> M3x8mm screws	4
<input type="checkbox"/> M3 washers	6
<input type="checkbox"/> M3 nuts	2

1. Attach 2 wheels to the inside of each Y-axis end plate at the top with spacers:
 - a. Use M5x25mm or 27mm screws for mounting the wheels.
2. Attach a motor with GT2 gear onto one of the Y-axis end plates using 4 M3x8mm screws and 4 M3 washers. Position the motor in the center with the motor cord pointed down. The GT2 gear should be on the side of the plate with the wheels.
 - a. Make note of the orientation of the GT2 gear. The screw hole of the gear should be close to the base of the motor. The screw hole should also be positioned on the flat side of the motor shaft.
3. Attach the X motor mount to the other Y-axis end plate using 2 M3x10mm screws with 2 M3 nuts and 2 M3 washers. It should be attached to the top right corner of the Y-axis end plate on the side of the wheel screws.

Assemble Z-Axis

Description	Quantity
<input type="checkbox"/> M3x6mm screws	4
<input type="checkbox"/> M3x10mm screws	3
<input type="checkbox"/> M3x12mm screws	3
<input type="checkbox"/> M3x40mm screws	4
<input type="checkbox"/> M3x45mm screws	4
<input type="checkbox"/> M5x8mm screws	6
<input type="checkbox"/> M5x18mm screws	4
<input type="checkbox"/> 8mmx16mmx5mm bearing	2
<input type="checkbox"/> M3 nuts	15
<input type="checkbox"/> Brass nut	1

1. Insert 3 to 4 printed support spacers with cable raceways between the v-slots.
2. Insert the Z top plate, with the bearing groove facing down towards the cable raceway and the cable opening matching the cable raceway opening.
3. Attach a motor to the Z motor plate with 3 M3x10mm screws.
4. Attach the shaft coupler to the motor shaft.
5. Insert the Z motor plate.
6. Secure the Z motor plate with 4 M5x18mm screws.
7. Insert an 8mmx16mmx5mm bearing into the Z top plate.
8. Install the threaded rod into the Z axis with the nut block and 2 lock collars onto the Z-axis shaft.
9. Insert an 8mmx16mmx5mm bearing into the Z bottom plate.
10. Insert 3 M3 nuts into Z bottom plate.
11. Attach the Z limit sensor housing to the v-slot, above the plate spacer with a magnet, using 2 pre-install t-slot nuts and 2 M5x8mm screws.
12. Attach the Z bottom plate.
13. Secure the Z bottom plate with 4 M5x18mm screws.
14. Attach the slip ring adapter with 3 M3x12mm screws.
15. Attach the pan limit sensor with connection wiring and cover to Z-Bottom Plate, with an M3x6mm screw.
16. Thread slip ring cables up the cable raceway, through the Z motor plate; then attach the slip ring to the adapter with 3 M3x6mm screws.
17. Insert both Z top spacers (or 1 regular spacer and 1 drag chain integrated spacer; optional for top chamber Z axes) and secure with 4 M3x45mm and 4 M3 nuts.

Assembly

Instructions for putting together a standard stacked chamber.

Outer Framing

Assemble top and bottom chambers separately then combine together. Instructions start with the top chamber. The order of building the top and bottom does not matter. The pre-install t-slot nuts are used for screws so keep in mind where they are when assembling and placing the corner brackets. Use a level to assure the frames are positioned straight.

Top Chamber Materials

Size Description	Quantity
<input type="checkbox"/> 1135mm Uprights	4
<input type="checkbox"/> 145mm Mounts	4
<input type="checkbox"/> 1080mm Sides	2
<input type="checkbox"/> 1160mm Sides	2
<input type="checkbox"/> Corner Brackets	12
<input type="checkbox"/> M5x10mm Screws	96

Bottom Chamber Materials

Size Description	Quantity
<input type="checkbox"/> 1135mm Uprights	4
<input type="checkbox"/> 145mm Mounts	4
<input type="checkbox"/> 1080mm Sides	4
<input type="checkbox"/> 1160mm Sides	4
<input type="checkbox"/> Corner Brackets	32
<input type="checkbox"/> M5x10mm Screws	256

Assemble the Top Chamber

[\(Refer to the Full Chamber Model Folder for Reference\)](#)

1. Laying a 1135mm Upright Frame on the floor, line up the 1080mm Control Board Side Frame
 - a. It should be 21.1cm from the top of the 1135mm to the top of the 1080mm.
 - b. The side of the control board with the holes should face outward and towards the floor.
 - c. Secure the position of the 1080mm Control Board Side Frame with a corner bracket and 8 M5x10mm screws each. The bracket should be on the same side of the control board.

2. Repeat this with the other side of the 1080mm Control Board Side Frame with another 1135mm Upright Frame.
3. Line up a 1160mm Side Frame on both sides of the 1080mm Control Board Side Frame.
 - a. It should connect to make a right angle.
 - b. Secure the position of the 1160mm Side Frames with a corner bracket and 8 M5x10mm screws each. The bracket should be on the underside of the 1160mm Side Frame.
4. Line up 1135mm Upright Frames at the ends of both of the 1160mm Side Frames.
 - a. Secure the position of the 1135mm Upright Frames to the 1160mm Side Frames with a corner bracket and 8 M5x10mm screws each. The bracket should be on the underside of the 1160mm Side Frame.
5. Connect the two 1135mm Upright Frames with a 1080mm Side Frame at the same height as the others.
 - a. Secure the position of the 1080mm Side Frame with a corner bracket and 8 M5x10mm screws each. The bracket should be on the underside of the 1080mm Side Frame.
6. Once all the side frames have been secured, slowly position the structure upright and off the floor.
7. Under the 1080mm Control Board Side Frame, line up a 145mm Mount Frame on the 1135mm Upright Frame.
 - a. Connect the 145mm Mount Frame to the inside of the 1135mm. It should be horizontal in the same direction as the 1160mm Side Frames.
 - b. It should be 56cm from the top of the 1135mm to the top of the 145mm.
 - c. Secure the position of the 145mm Mount Frame with a corner bracket and 8 M5x10mm screws each. The bracket should be on the underside of the 145mm Mount Frame.
8. Repeat this with the other 145mm Mount Frames with one on the other side of the 1135mm Control Board Upright Frame and on the opposite side under the other 1080mm Side Frame.

Assemble the Bottom Chamber

[\(Refer to the Full Chamber Model Folder for Reference\)](#)

1. Laying a 1135mm Upright Frame on the floor, line up the 1080mm Control Board Side Frame
 - a. It should be 39.2cm from the bottom of the 1135mm to the bottom of the 1080mm.
 - b. The side of the control board with the holes should face outward and towards the floor.
 - c. Secure the position of the 1080mm Control Board Side Frame with a corner bracket and 8 M5x10mm screws. The bracket should be on the same side of the control board.

2. Repeat this with the other side of the 1080mm Control Board Side Frame with another 1135mm Upright Frame.
3. Line up a 1160mm Side Frame on both sides of the 1080mm Control Board Side Frame.
 - a. It should connect to make a right angle.
 - b. Secure the position of the 1160mm Side Frames with a corner bracket underneath and 8 M5x10mm screws each.
4. Line up 1135mm Upright Frames at the ends of both of the 1160mm Side Frames.
 - a. Secure the position of the 1135mm Upright Frames to the 1160mm Side Frames with a corner bracket and 8 M5x10mm screws each. The bracket should be on the underside of the 1160mm Side Frame.
5. Connect the two 1135mm Upright Frames with a 1080mm Side Frame at the same height as the others.
 - a. Secure the position of the 1080mm Side Frames with a corner bracket underneath and 8 M5x10mm screws each.
6. Once all the side frames have been secured, slowly position the structure upright and off the floor.
7. Under the 1080mm Control Board Side Frame, line up at 145mm Mount Frame on the 1135mm Upright Frame.
 - a. Connect the 145mm Mount Frame to the inside of the 1135mm. It should be horizontal in the same direction as the 1160mm Side Frames.
 - b. It should be 52 6/10cm from the bottom of the 1135mm to the bottom of the 145mm.
 - c. Secure the position of the 145mm Mount Frame with a corner bracket underneath and 8 M5x10mm screws.
8. Repeat this with the other 145mm Mount Frames with one on the other side of the 1135mm Control Board Upright Frame and on the opposite side under the other 1080mm Side Frame.

Assemble the Full Chamber

[\(Refer to the Full Chamber Model Folder for Reference\)](#)

Would recommend having more than one person to help

1. Carefully raise the top chamber structure and place the ends of all the 1135mm Upright Frames on top of the ends of all the 1135mm Upright Frames of the bottom chamber structure.
 - a. The two control board frames should be on the same side.
 - b. Make sure all the 1135mm Upright Frames are flush with one another.
2. Position a 1080mm Side Frame in the middle of the two 1135mm Upright Frames at 112cm from the floor. Start with the side the control boards are on.
 - a. Hold it in place while securing the position with a corner bracket underneath and 8 M5x10mm screws each.
 - b. Repeat with the other side of the 1080mm Side Frame.

- c. Secure with a second corner bracket on top and 8 M5x10mm screws each on both sides.
- d. Repeat this with another 1080mm Side Frame on the opposite side of the machine.
- 3. Repeat Step 2 with a 1160mm Side Frame in the middle for the other two sides of the machine.
- 4. Position a corner bracket at each intersection of the middle 1080mm and 1160mm Side Frames and secure with 8 M5x10mm screws each.

Camera Gantry

Assemble one camera gantry and repeat for all 6 gantries required for the top and bottom chambers of the machine.

Attach Pan and Tilt Components

Description	Quantity
<input type="checkbox"/> Assembled Pan Mechanism	1
<input type="checkbox"/> Assembled Tilt Mechanism	1
<input type="checkbox"/> M5x80mm screws	4
1. Attached the assembled pan & tilt housings to each other with 4 M5x80mm screws. Use the printed pan spacer on the geared side and the housing spacer (from the tilt cradle offset spacer set) on the bearing side of the tilt housing.	

Attach Pan/Tilt to Z-Axis

Description	Quantity
<input type="checkbox"/> M3x30mm screws	4
1. Use 4 M3x30mm to attach Pan/Tilt To Z-Bottom Plate	

Attach X Rails to Plates

Description	Quantity
<input type="checkbox"/> X-Axis Idler Screw Cradle	1
<input type="checkbox"/> M3x8mm screws	48

<input type="checkbox"/> M3x10mm screws	6
<input type="checkbox"/> M3x12mm screws	22
<input type="checkbox"/> M5x8mm screws	10
<input type="checkbox"/> M5x15mm screws	18
<input type="checkbox"/> M5x25mm screws	3
<input type="checkbox"/> M3 nuts	2
<input type="checkbox"/> Pre-install t-slot nuts	10
<input type="checkbox"/> Eccentric Nuts	
<input type="checkbox"/> Wheels	3
<input type="checkbox"/> Spacers	60
<input type="checkbox"/> Washers	48
<input type="checkbox"/> GT2 belt	3,520mm

1. Attach a Y axis framing mount on each end of each Y rail (2 per chamber) with a total of 2 M5x15mm screws, 2 pre-install t-slot nuts and 2 M5x8mm screws per Y rail.
2. Mount Y rails to support rails with 2 pre-install t-slot nuts and 2 M5x8mm screws per Y rail.
3. Attach X limit sensor to the inner side (side facing the 2060 rail) of the 2040 rail using 2 pre-install t-slot nuts and 2 M5x8mm screws. Ensure that the sensor is closest to the side you wish to home X toward. Ensure that the bottom of the sensor (the side where 2 M3 screw heads are visible) faces the Z axis assembly, preferably with the limit wire facing upward.
4. Attach the Y plate with the X motor mount to 2040 and 2060 rails with 5 M5x15mm screws and 5 M5 washers onto Y rails.
 - a. The Y plates are interchangeable when installing the gantry. However, the Y plate with the X motor mount needs to be on the side where it will be the closest to the Controller Boards - The cables won't be able to reach otherwise.
5. Attach the Y plate with only the stepper motor to 2040 and 2060 rails with 2 M5x15mm screws and 2 M5 washers onto Y rails.
6. Attach the X-axis idler screw cradle to the Y plate onto the Y rail with 3 M5x15mm screws. It should be on the other side of the motor.
7. Attach the X-axis idler end nut onto the X-axis idler screw insert. Place two ball bearings together with spacers on the outside. Line the stack of ball bearings and spacers with the holes on the inside of the idler screw insert. Use a screwdriver to keep it aligned with

the idler screw insert and then squeeze tightly to keep in place after removing the screwdriver. Insert the idler screw insert with the stack into the idler screw cradle on the Y plate. Use the screwdriver again to keep the stack aligned after inserting into the idler screw cradle. Use a M5x30mm screw and M5 lock nut to secure the idler screw insert and stack in the cradle.

8. Attach Y limit sensors and magnet holders with a total of 10 M3x12mm screws per chamber.
9. Attach a motor with GT2 gear onto X motor mount using 4 M3x10mm screws.
10. Attach a motor with GT2 gear onto the center of the Y plate with the motor mount using 4 M3x8mm screws and 4 M3 washers.
 - a. Make note of the orientation of the GT2 gear. This motor has a GT2 gear in the opposite orientation than the motor in the motor mount. The screw hole of the gear should be close to the base of the motor and on the flat side of the motor shaft.
11. Attach a Y axis belt clamp assembly (2 pieces held with 2 M3x12mm screws and 2 M3 nuts) on each end of each Y rail (2 per chamber) with a total of 2 M5x15mm screws per Y rail.
12. Cut and install 2,200mm of GT2 belt per X axis.
13. Cut and install 1,320mm of GT2 belt per Y rail.

TBA

Description	Quantity
<input type="checkbox"/>	

Light Mounting

These instructions are for installing the mounts where the lights will attach from. Lights can be mounted from any position of the machine in any quantity. These are two mount setups for a standard stacked chamber.

Materials

Size Description	Quantity
<input type="checkbox"/> 125mm Light Mounts	8
<input type="checkbox"/> L-Brackets	16
<input type="checkbox"/> M5x8mm Screws	64

Harvard Light Setup

1. Position a 125mm Light Mount in the middle on top of both of the 1080mm Control Board Side Frames.
 - a. The light mount should go outward, opposite of the 145mm Mount Frames.
 - b. Secure the position with an L-bracket on either side and 4 M5x8mm screws each.
2. Repeat Step 1 on the other 1160mm and 1080mm Side Frames.
 - a. Position at similar lengths since these do not have control boards.

Yale Light Setup

1. Position two 125mm Light Mount on top on either side of the control board of both of the 1080mm Control Board Side Frames.
 - a. The light mount should go outward, opposite of the 145mm Mount Frames.
 - b. Secure the position with an L-bracket on either side and 4 M5x8mm screws each.
2. Repeat Step 1 on the other 1080mm Side Frames.
 - a. Position at similar lengths since these do not have control boards.

Diffuser Sheets

All four sides of the diffuser sheets need to be hemmed prior to putting them up on the chamber. It is recommended that it be sewed rather than using fabric glue for a cleaner appearance.

Materials

Size Description	Quantity
<input type="checkbox"/> Velcro Strips	8
<input type="checkbox"/> Scissors	1