Kossel Leaf

Instruction Manual

Version 1.0 – January 2018

Introduction

Kossel Leaf is a carriage system for Kossel-style delta robot 3D printers.

It uses 3D printed components, OpenBuilds-style V-wheels, OpenBuilds-style 20mm V-slot aluminium extrusions, and standard metric fasteners.

The carriage is designed to drop in place of an existing Hiwin-style MGN12H (or MGN12C) rail system, only increasing the printer's DELTA_RADIUS by 0.05mm.

To attach belt/arm carriers, the Kossel Leaf carriage uses MGN12H mount layout of M3 screws in a 20x20mm pattern. Provision is given in the source code to easily use MGN12C mount layout of M3 screws in a 20x15mm pattern.

A major factor of Kossel carriage design with wheels is keeping firm and even wheel pressure on the extrusion as the carriage moves up and down. There are various solutions to this including eccentric spacer nuts, carriages which flex to press one wheel into the extrusion, and carriages which press wheels in with springs.

Kossel Leaf uses a 3D printed leaf spring to keep two wheels under tension and pressed against the extrusion firmly and evenly at all points along vertical travel. The leaf spring tension can be modified by printing a part with a thicker leaf, and/or moving the initial inset of the wheels inwards or outwards.

In this way, Kossel Leaf is a re-implementation of the GNU GPL-licensed Cheapskate carriage by SeeMeCNC:

https://www.seemecnc.com/products/injection-molded-cheapskate-carriage-set

Kossel Leaf carriages have an endstop adjustment screw and suit the common Omron SS-5GL style endstop switches.

This endstop adjustment screw can also be used as a mount for a flying extruder if desired.

Bill of Materials – Vitamins

Vitamins describe non-printed parts.

- 9x M5x50 Socket Head Cap Screw (45mm also acceptable)
- 6x M5x25 Socket Head Cap Screw
- 15x M5 Nyloc Nut
- 3x M3 Nyloc Nut
- 3x M3x12 to M3x20 Screw (SHCS, Pan head, Button head all suitable)
- 12x OpenBuilds-style solid V-wheel - 5mm axle, OD 23.9 to 25mm
  http://openbuildspartstore.com/solid-v-wheel-kit/
- 3x OpenBulds-style V-slot 20mm extrusion, length determined by your printer and needs
  http://openbuildspartstore.com/v-slot-20x20-linear-rail/
- 3x Omron SS-5GL microswitch, or other equivalent with M2.5 mounting screws spaced 9.5mm apart
- 6x M2.5x12 to M2.5x20 Screw (SHCS, Pan head, Button head all suitable)
- 6x M2.5 Nut

Bill of Materials – Printed or Vitamin

You can either print or purchase these parts, choose one or the other.

- 12x V-wheel spacer: Height 6.0mm, ID 5.1mm, OD 10mm
  https://www.aliexpress.com/item/10-PCS-for-v-slot-Openbuilds-Isolation-Column-Separate-Pillar-Quarantine-Bore-5-5-1mm-Thickness/32820502527.html
  OR
- 12x Spacer.stl

Bill of Materials – Belt-Arm Carriages

If you wish to use Traxxas 5347 rod-ends on Johann Kossel-style belt-arm holders, included are STLs for Kossel Mini (40mm arm spacing) and Kossel Pro (41mm arm spacing). You could use these, or a different design of Johann-style carriage, or metal belt-arm holders from 3D printer vendors.

- 3x Belt Arm holders, depending on your printer
- 4x M3 Nut
- 4x M3x20 Screw (SHCS, Pan head, Button head all suitable)

If you are using magnetic arms or ball joint arms, you'll need a different belt-arm holder to suit your arms, and probably different screw lengths.

Bill of Materials – Printed Parts

3x Carriage Inner.stl
3x Carriage Outer.stl
3x Leaf Spring Part 1.stl
3x Leaf Spring Part 2.stl
3x Endstop Holder for Omron SS-5GL.stl

Print Material

The carriages can be printed in whatever solid (non-flexible) material you prefer.
Common 3D printer component choices like PLA, ABS, PETG, PC would all be suitable. The stiffer the carriage parts are, the better.

The leaf springs are intended to be printed in PETG. **Do not print the leaf springs in PLA!**

PETG is chosen as it has a high flexural strength, low flexural modulus, and high elongation at yield.
This means that PETG is "bendy" and can be deformed slightly and for long periods without cracking.

PLA leaf springs would be unacceptable. PLA has a high flexural modulus and low elongation at yield.
This means PLA is stronger, but will crack if bent too much or held in tension over time.

From reading material datasheets, polycarbonate (PC) and Taulman T-glase (PETT) appear to be acceptable substitutes for PETG.

ABS, Nylon, or Amphora 1800 (Taulman n-Vent) *may* be suitable. Tried these materials have not been tried at the time of writing.

Print Settings

Parts have been tested in both Slic3r and Cura with:

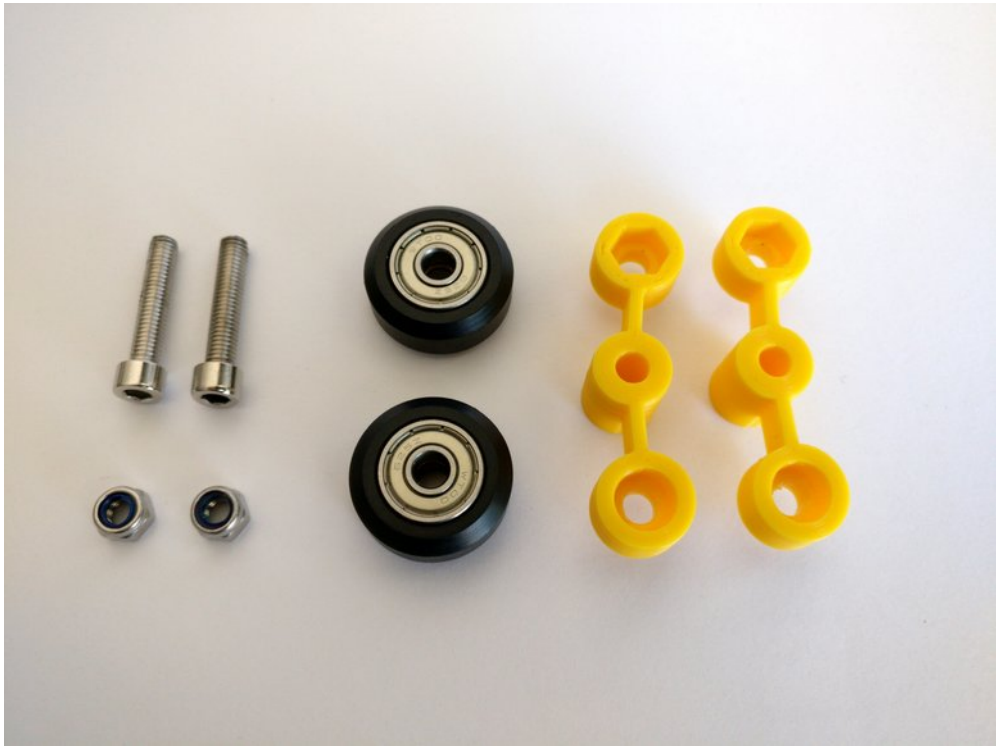
- 0.4mm nozzle
- 0.48mm extrusion width
- 0.25mm layer height
- 4 external perimeters
- 8 top and bottom layers
- 50% infill

If using a finer nozzle where 0.25mm layer height is not possible, ensure the selected layer height can print 0.5mm height accurately.

This means the only other realistic options are 0.125mm or 0.1mm layer heights.

Assembly

Instructions are given for one carriage. The other two carriages are identical, just repeat the steps.

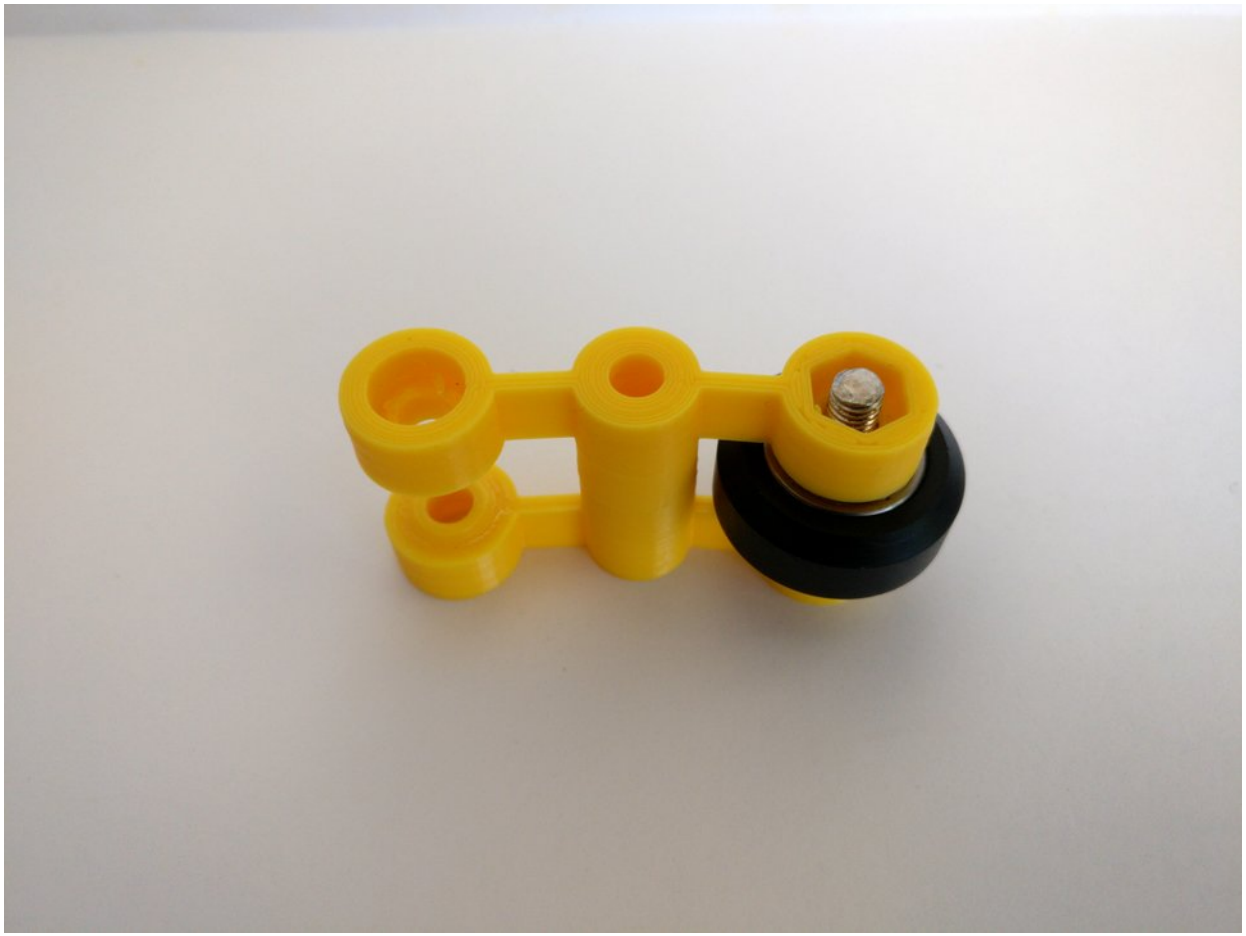


Gather parts pictured:

2x M5x25 SHCS
2x M5 Nyloc Nut
2x Wheel
Leaf Spring Part 1
Leaf Spring Part 2

Insert one screw into the round hole in the Leaf Spring.

Put one wheel on the screw.



Place the other Leaf Spring on top.

The screw end should now be in a hexagonal nut trap.

Insert a nyloc nut and fasten.

Ensure the wheel can still spin.

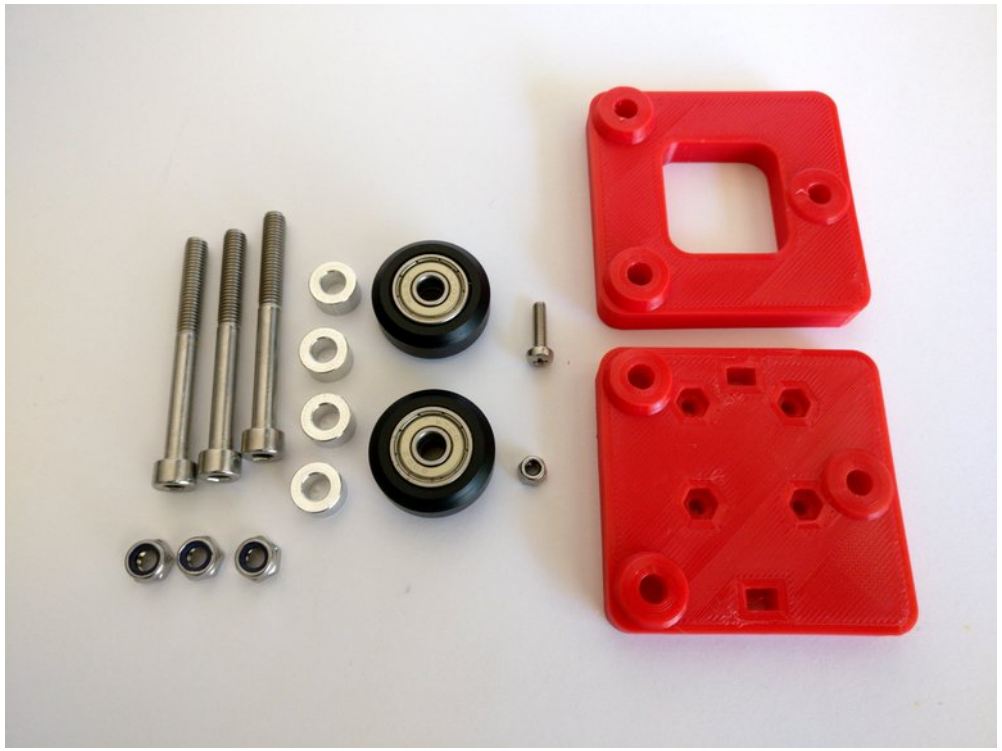
The end of the screw should be about even with the nut body.

Flip the assembly over.

Insert the screw and wheel into the other hole.

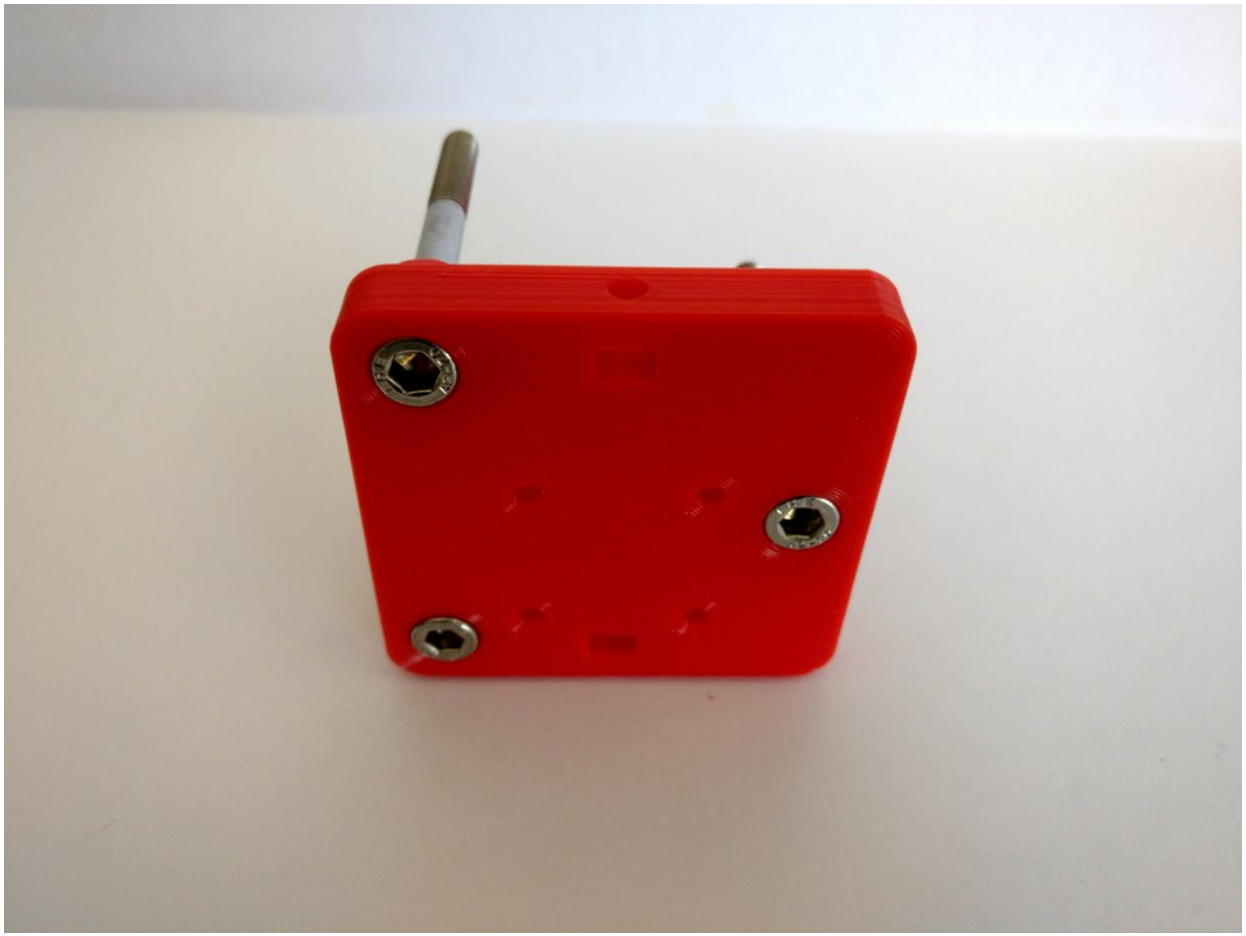
Add the remaining Nyloc nut.

Ensure the two halves of the leaf touch in the middle with no play, the screws are on their nuts with no play, and the wheels can still spin freely.

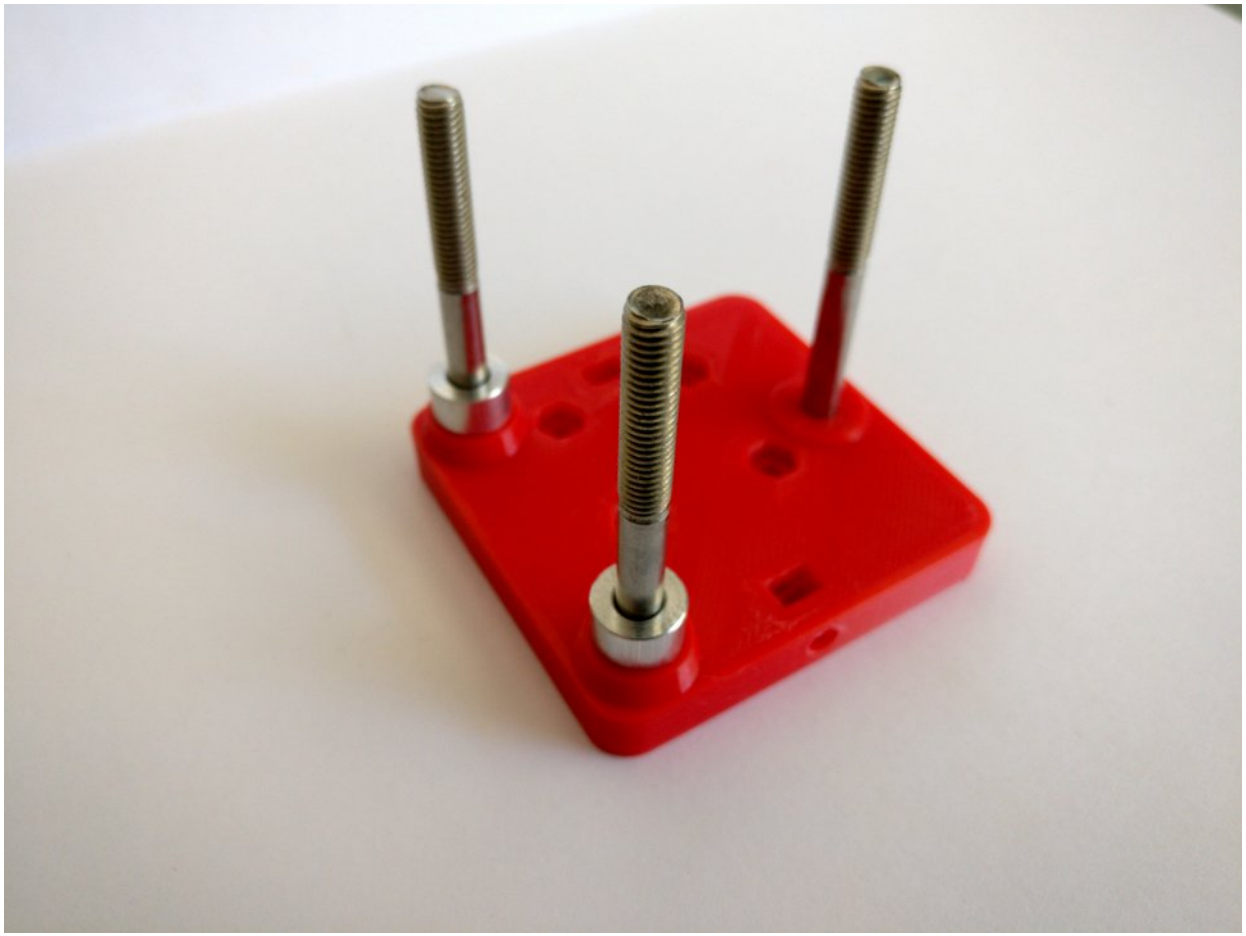


Gather parts pictured:

3x M5x50 SHCS
3x M5 Nyloc Nut
4x 6mm spacer (aluminium spacer pictured, you may have printed these)
2x Wheel
M3x12 Screw
M3 Nyloc Nut
Carriage Outer
Carriage Inner



Insert M5x50 screws into Carriage Inner.

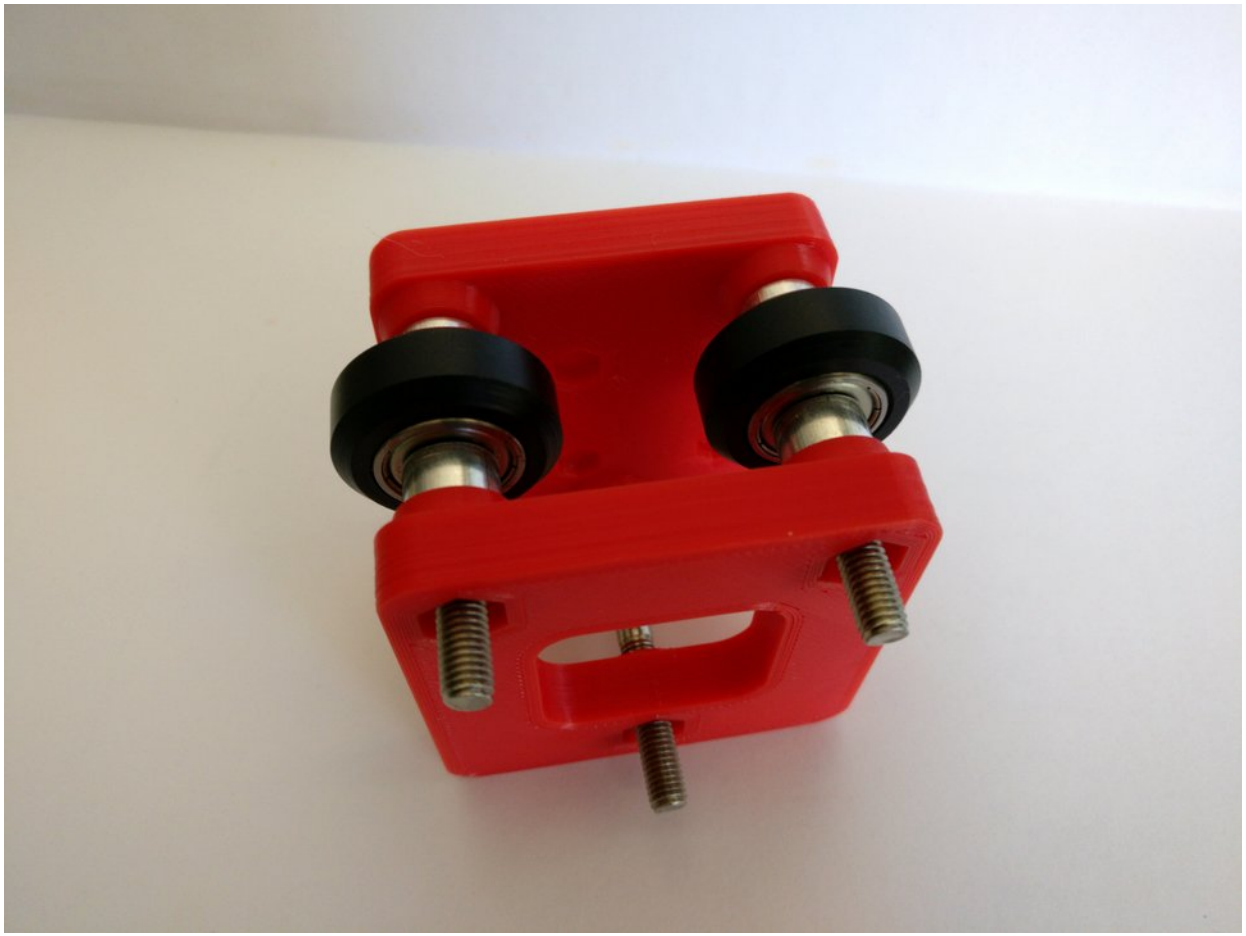


Place 2 spacers onto the tallest carriage pillars.

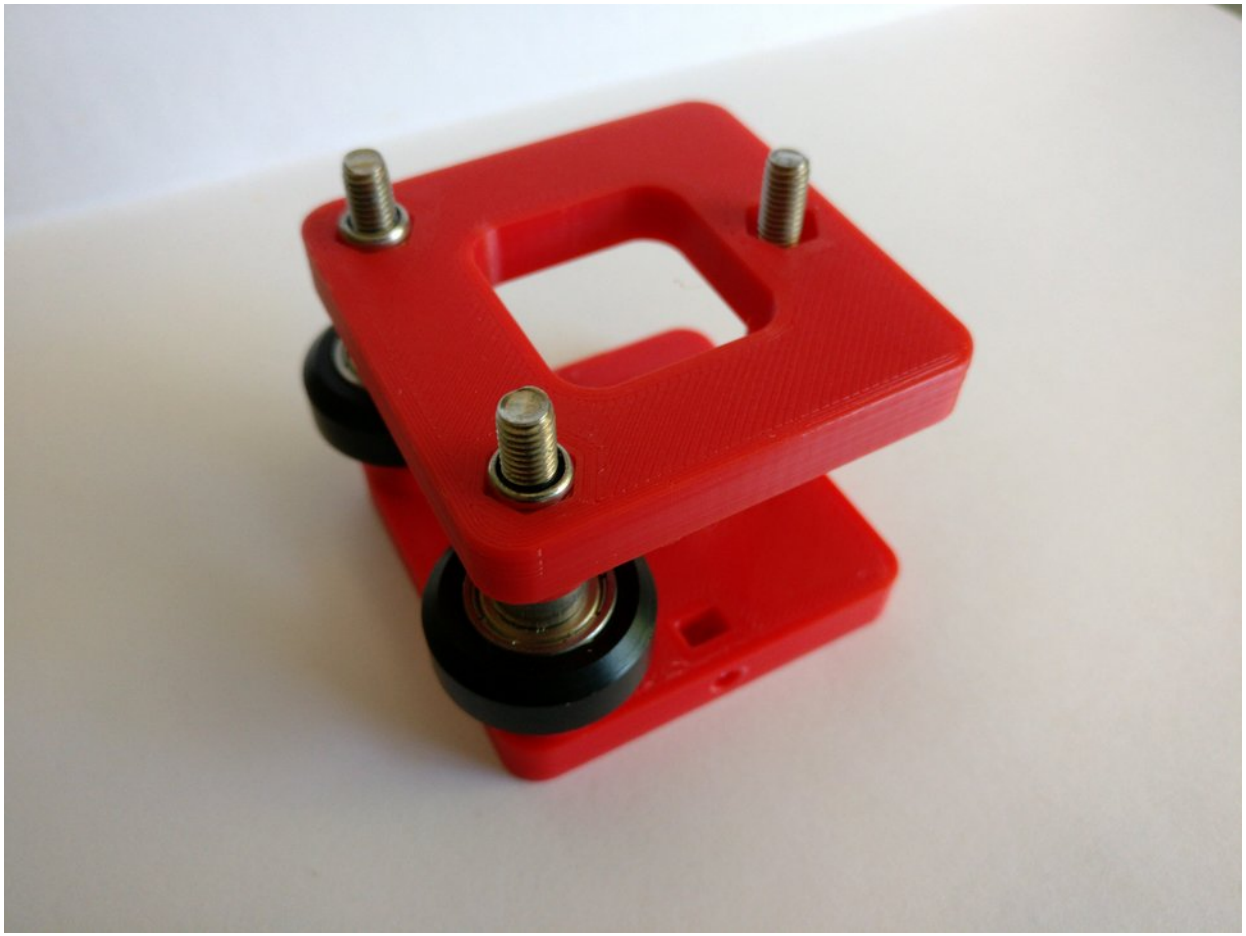
These are the pillars with the fixed (non-leaf) wheels.

Place two wheels on top of the spacers.

Place the other two spacers on top of the wheels.



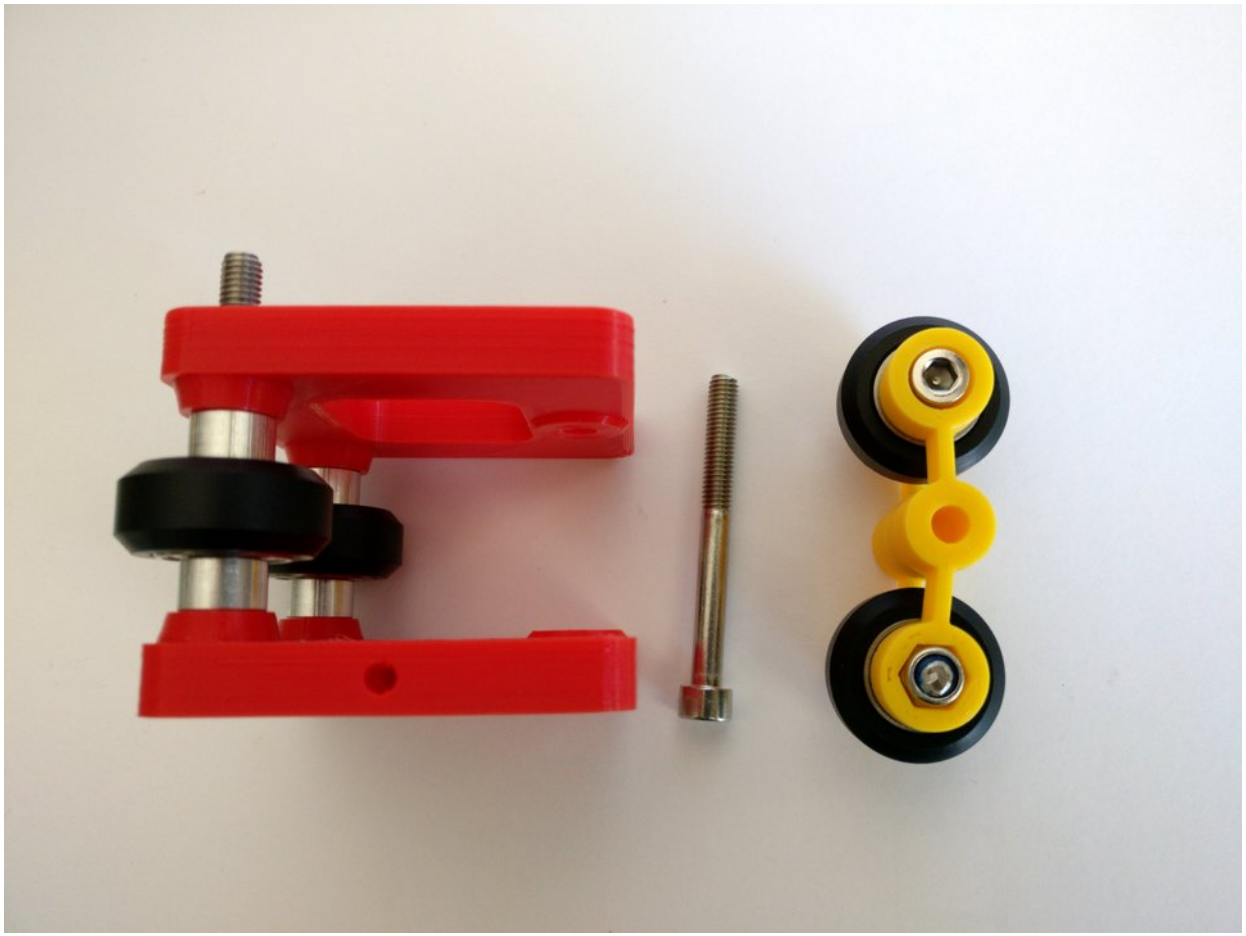
Fit the Carriage Outer to the screws.



Insert and fasten Nyloc nuts for the two fixed wheels.

Ensure the screw has no play back and forth, and that the wheels can spin freely.

Don’t put a nut on the other screw just yet!

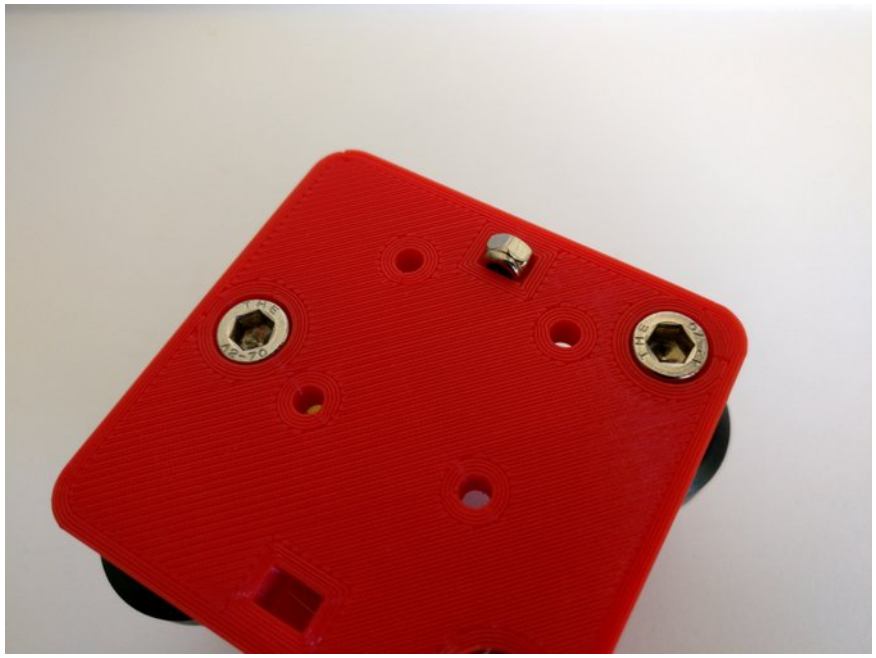


Remove the remaining M5x50 screw, and get the leaf spring assembly created earlier.

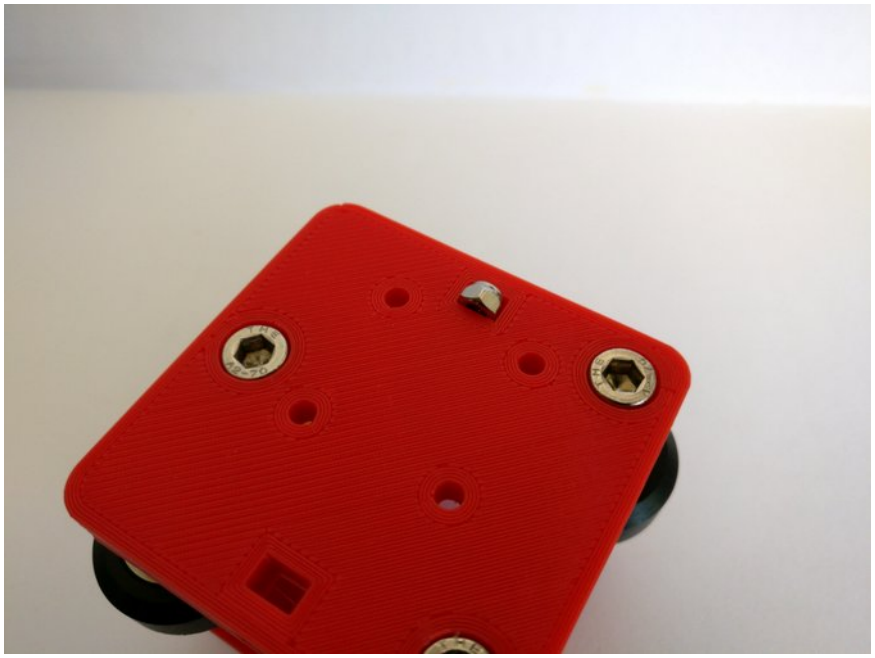
Install the leaf spring assembly in between the carriage plates.

It doesn’t matter which way you install the spring, it can rotate to the “correct” and “incorrect” orientation.

Insert the M5x50 screw to hold the leaf spring in place. Fasten with the remaining M5 Nyloc nut (not pictured).



Correct



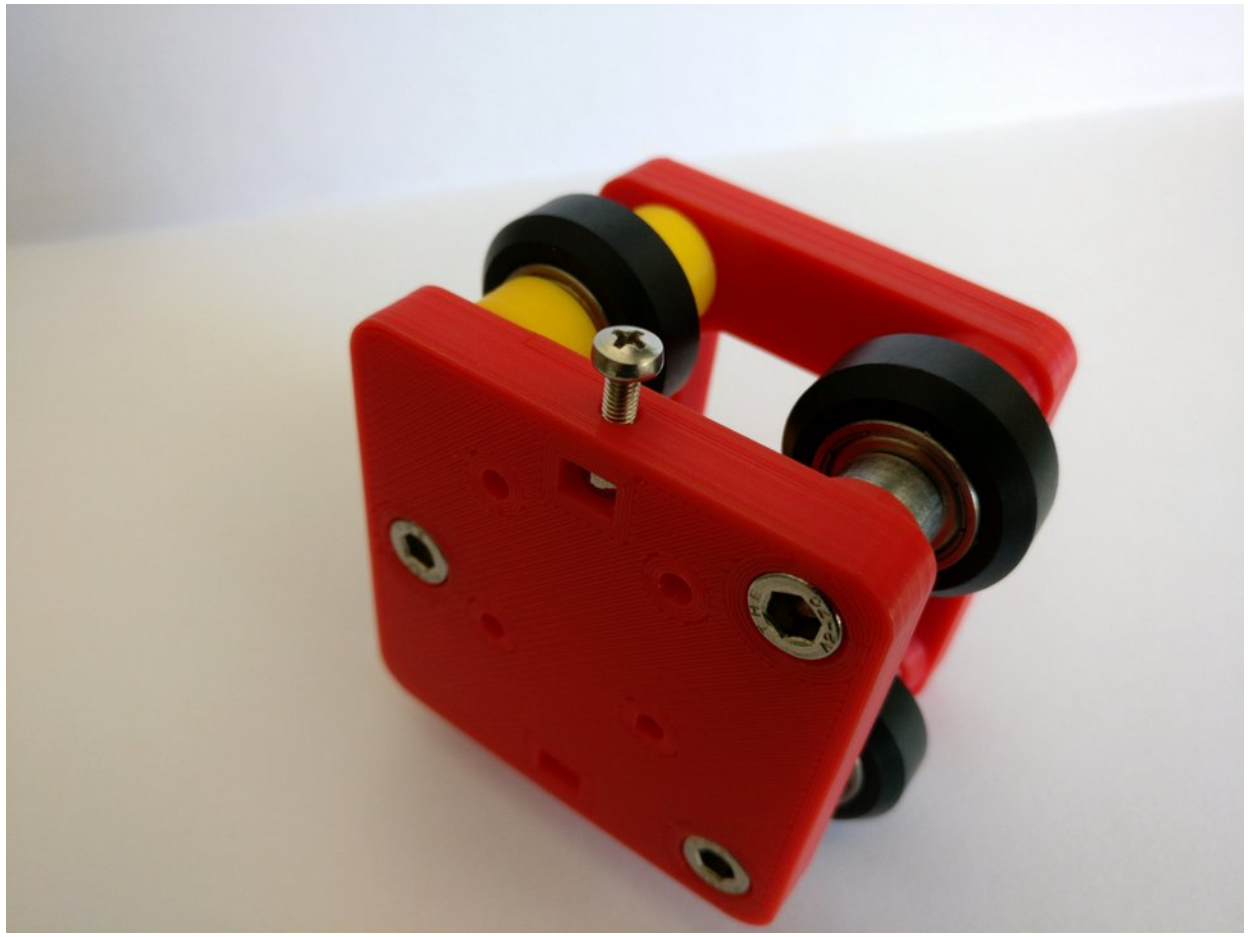
Incorrect

Install the M3 Nyloc nut for the endstop adjustment screw.

The M3 thread goes to the outside of the carriage. Pictured are both the correct and incorrect installation method.

There are holes in both the “top” and “bottom” of the carriage for the nut to fit.

Which is the “top” depends on the arm design you are using. Closest to the mounting holes (pictured) is better if using Johann-style belt-arm carrier.



Install the M3 endstop adjustment screw.

Ensure the M3 Nyloc nut cannot rotate.

If the nut can rotate, remove it and wrap it with something like kapton tape or blue tape to increase the nut diameter.

Ensure the nut is really strongly fixed in there and cannot move at all.

Install the entire assembly onto V-slot extrusion.

Ensure the wheels press firmly on the extrusion.

If the wheels are sloppy and the carriage can rattle around, remove the carriage, rotate the leaf spring 180 degrees on its axle, and reinstall onto the extrusion.

Assembly complete.