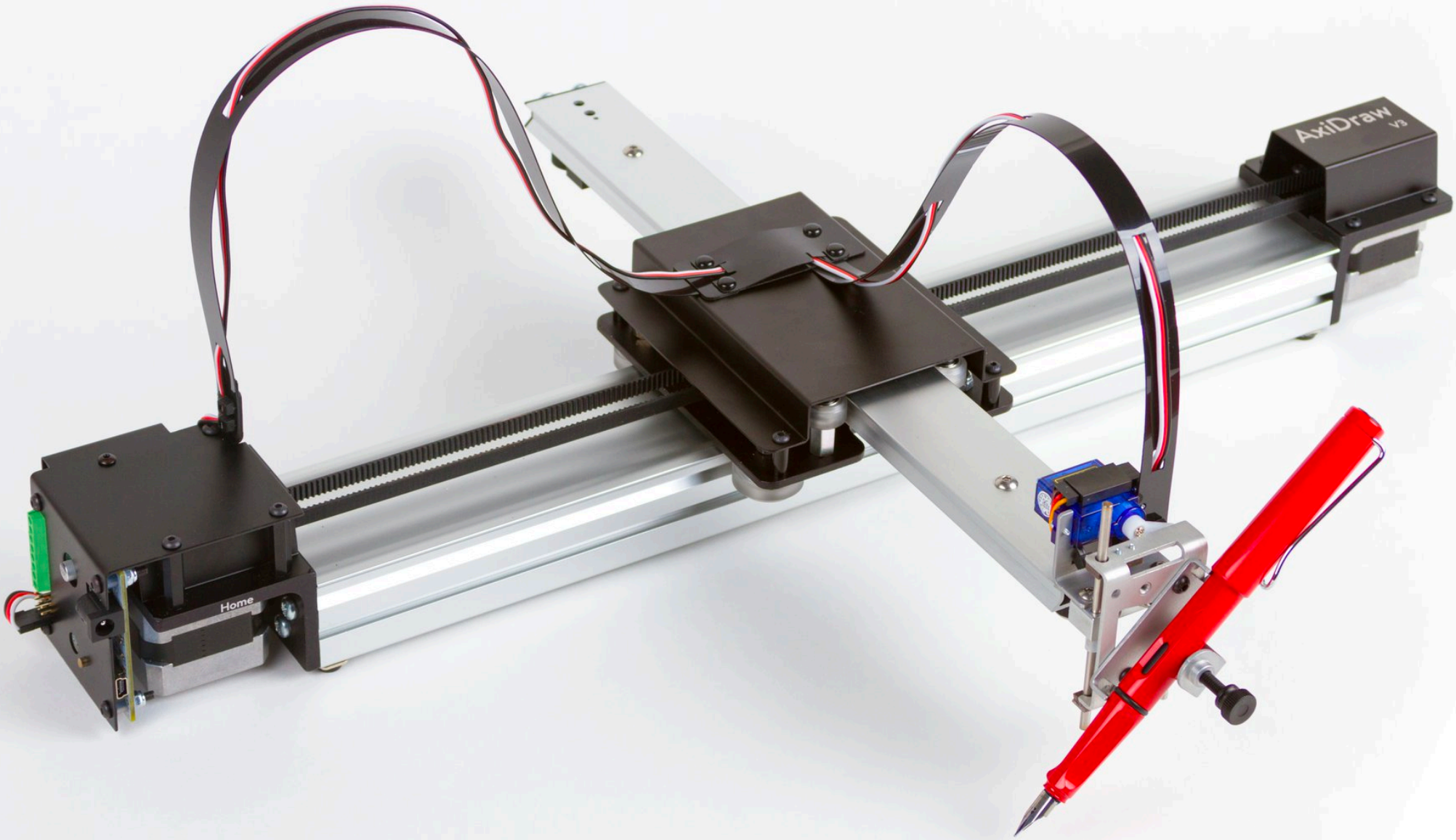
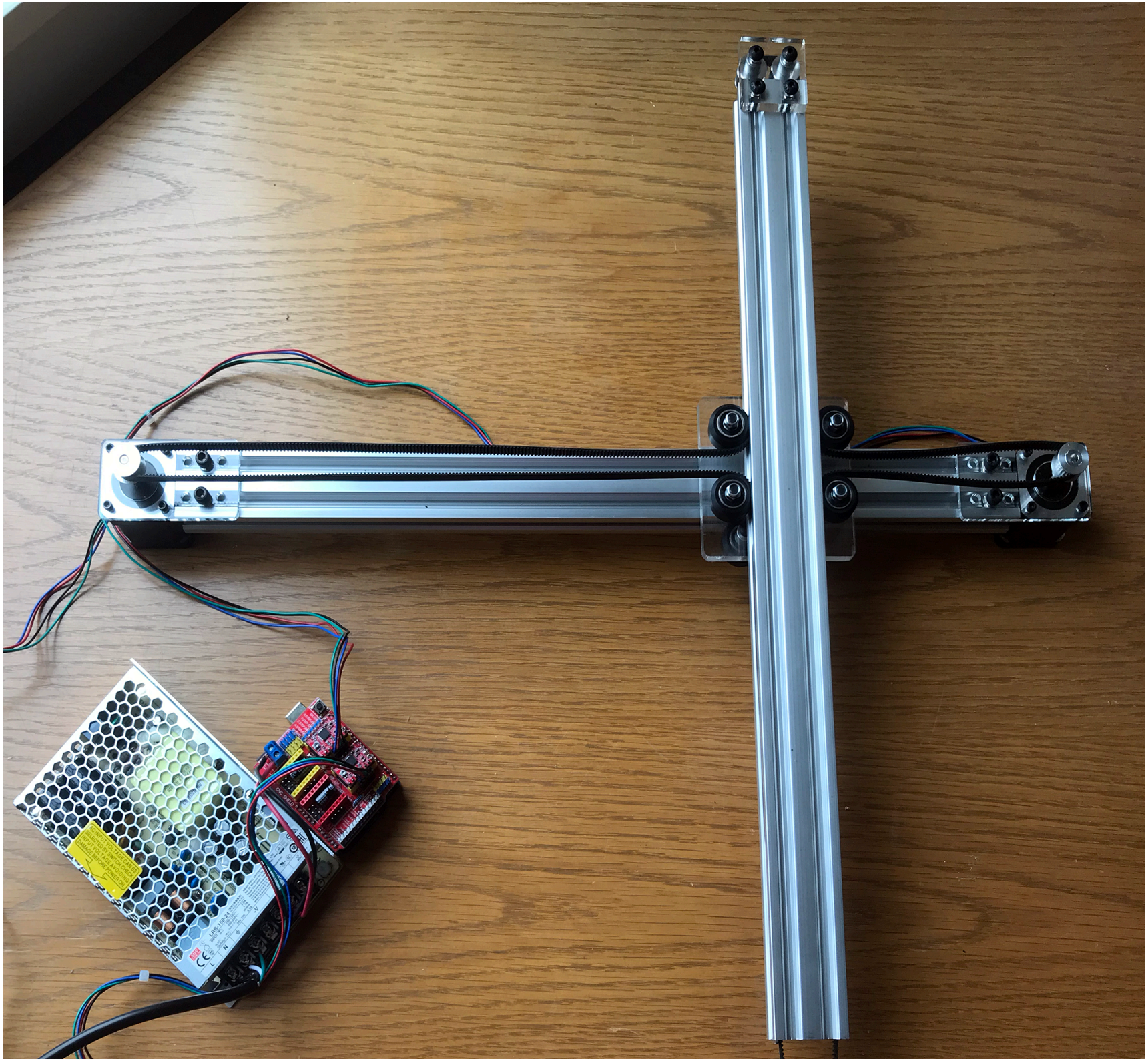
T-Bot Plotter

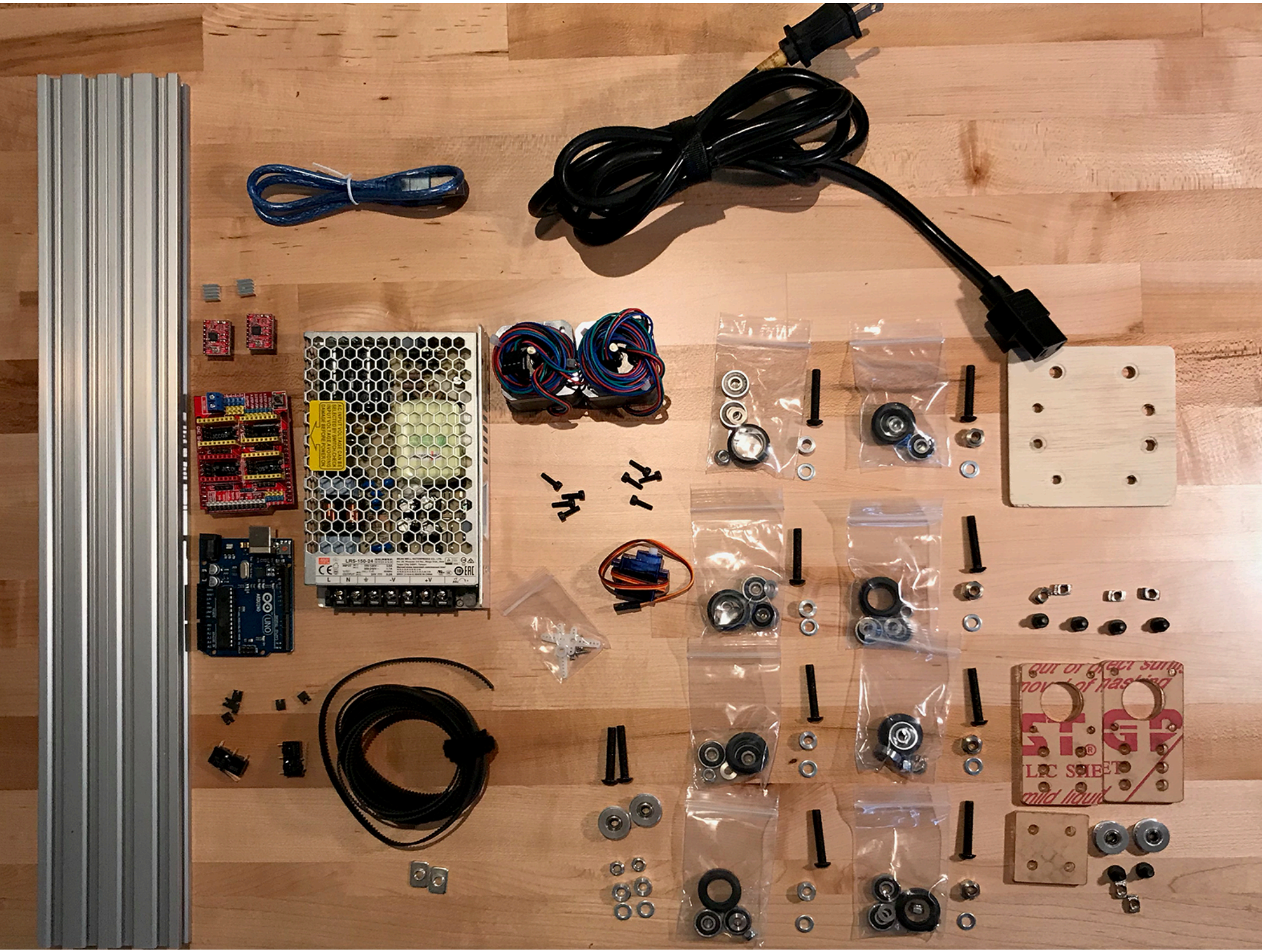
Principles of Operation

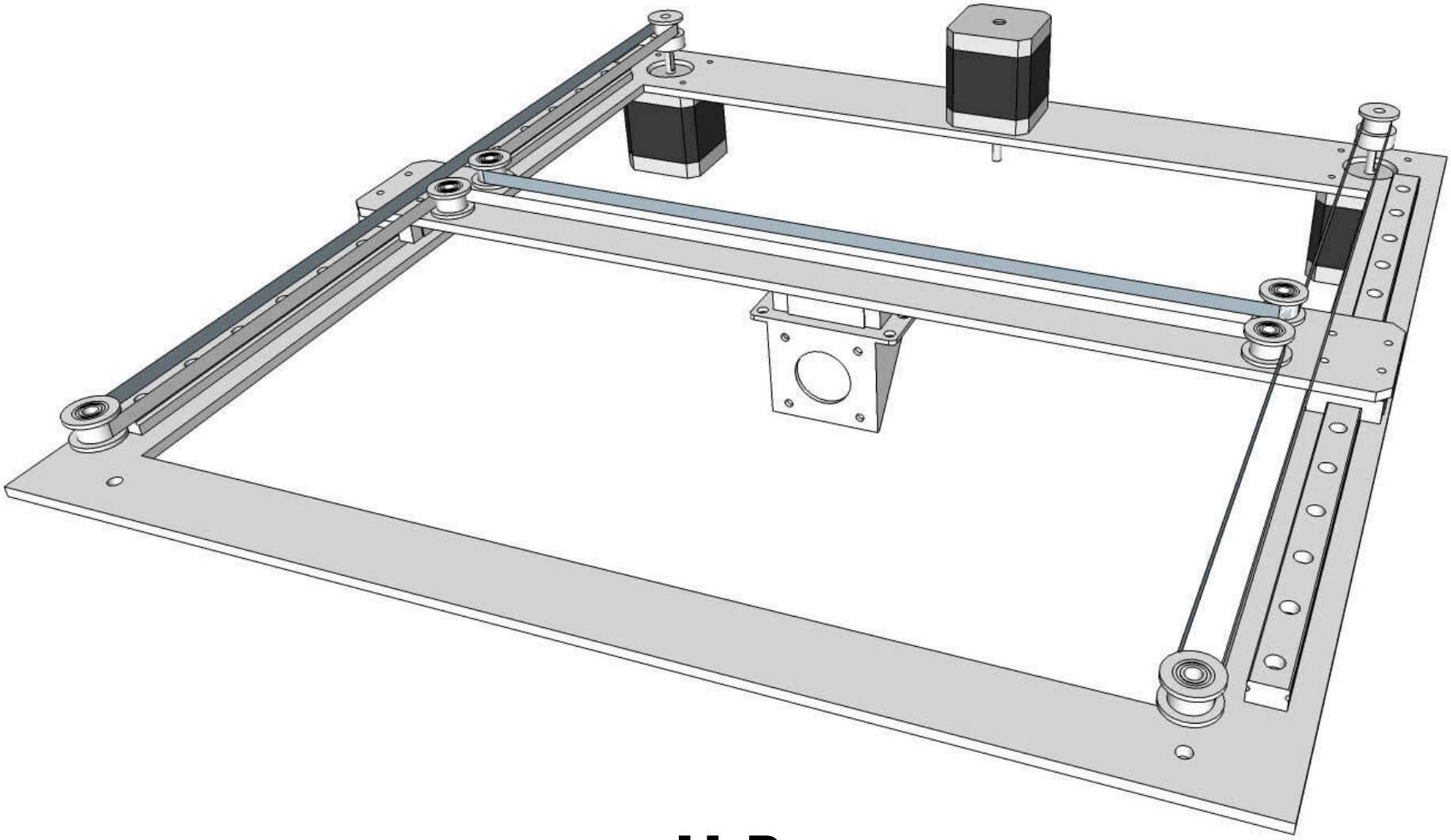
Mechanicals



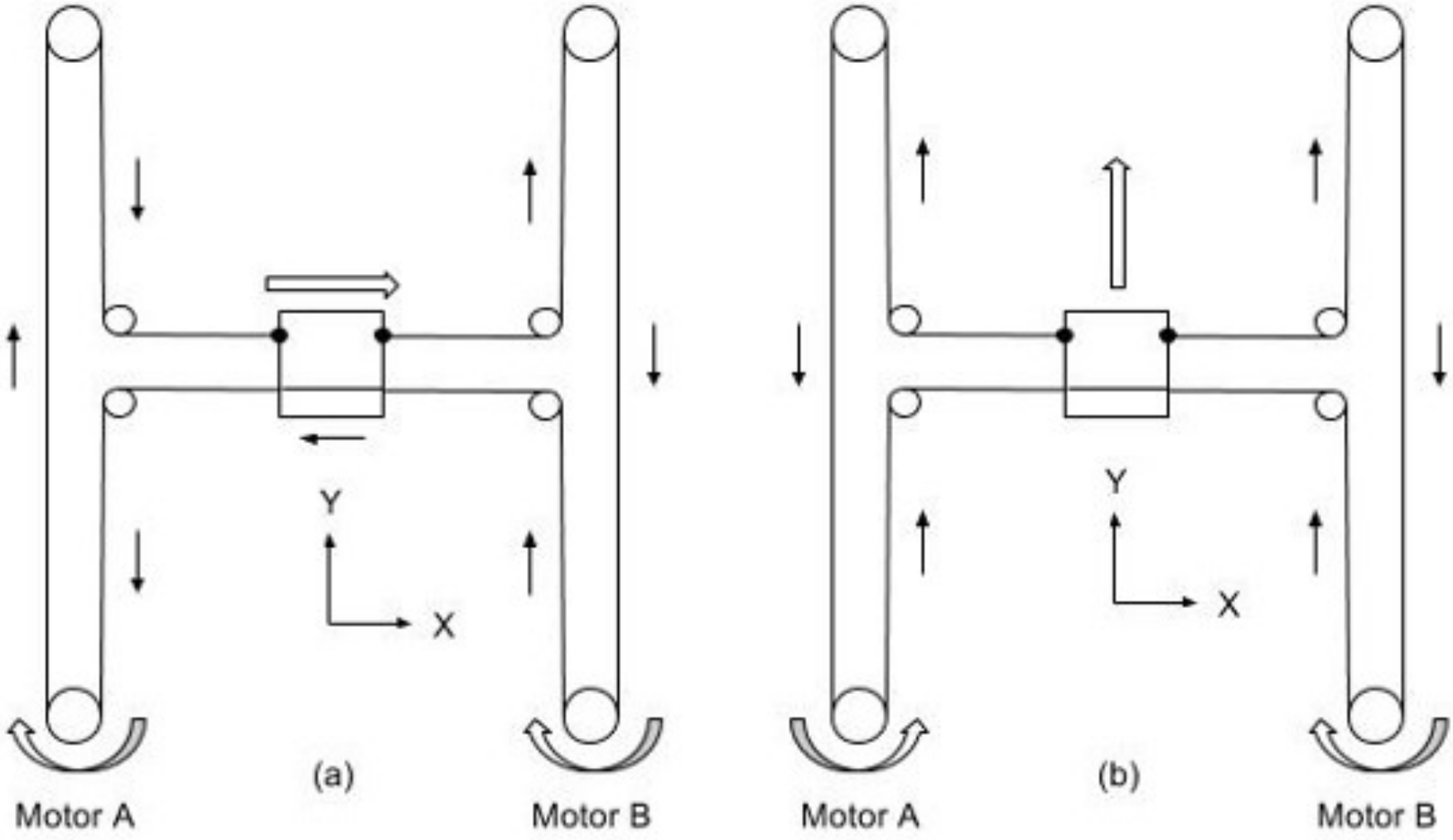
Evilmadscientist Axidraw Pen Plotter



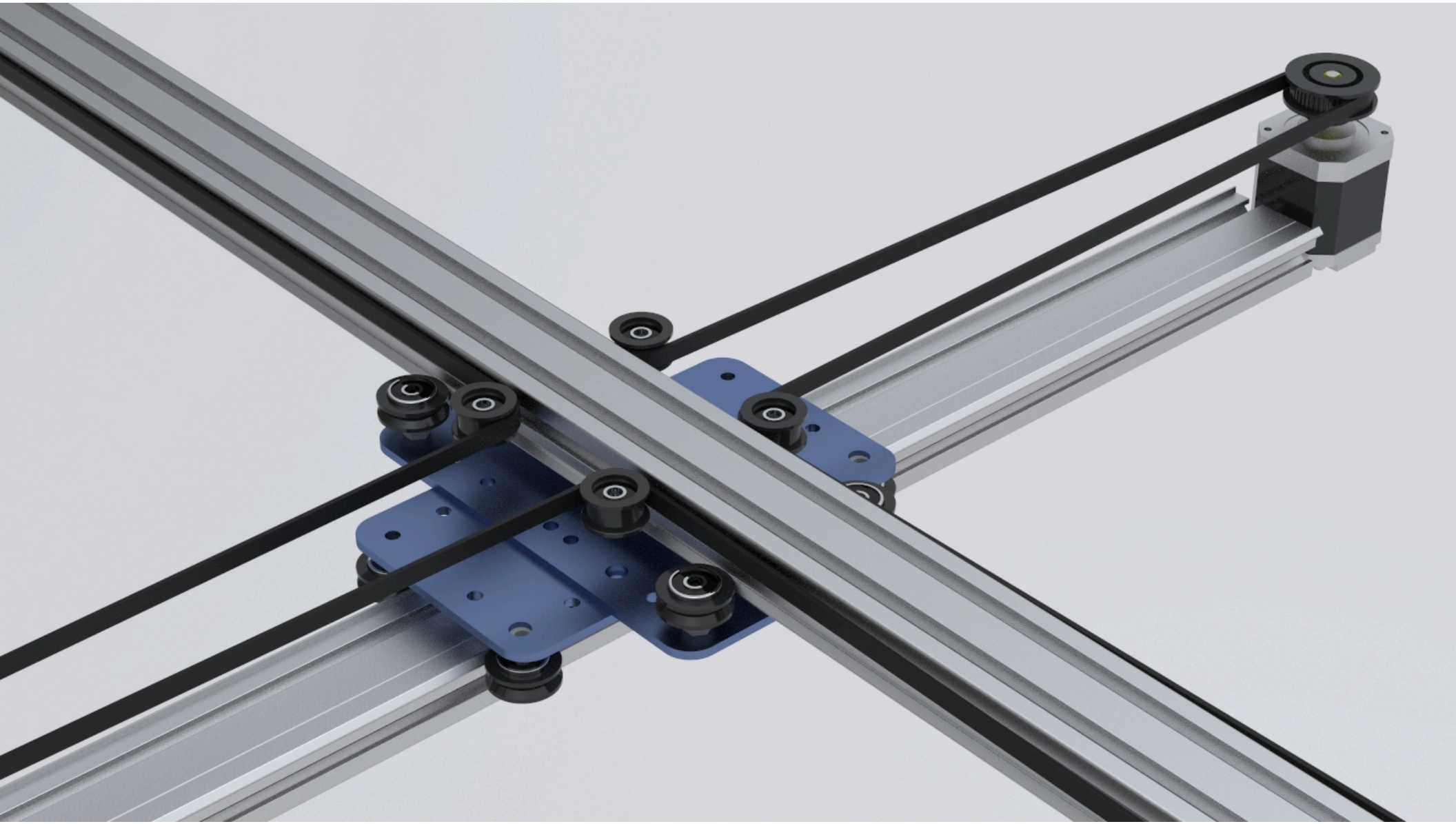




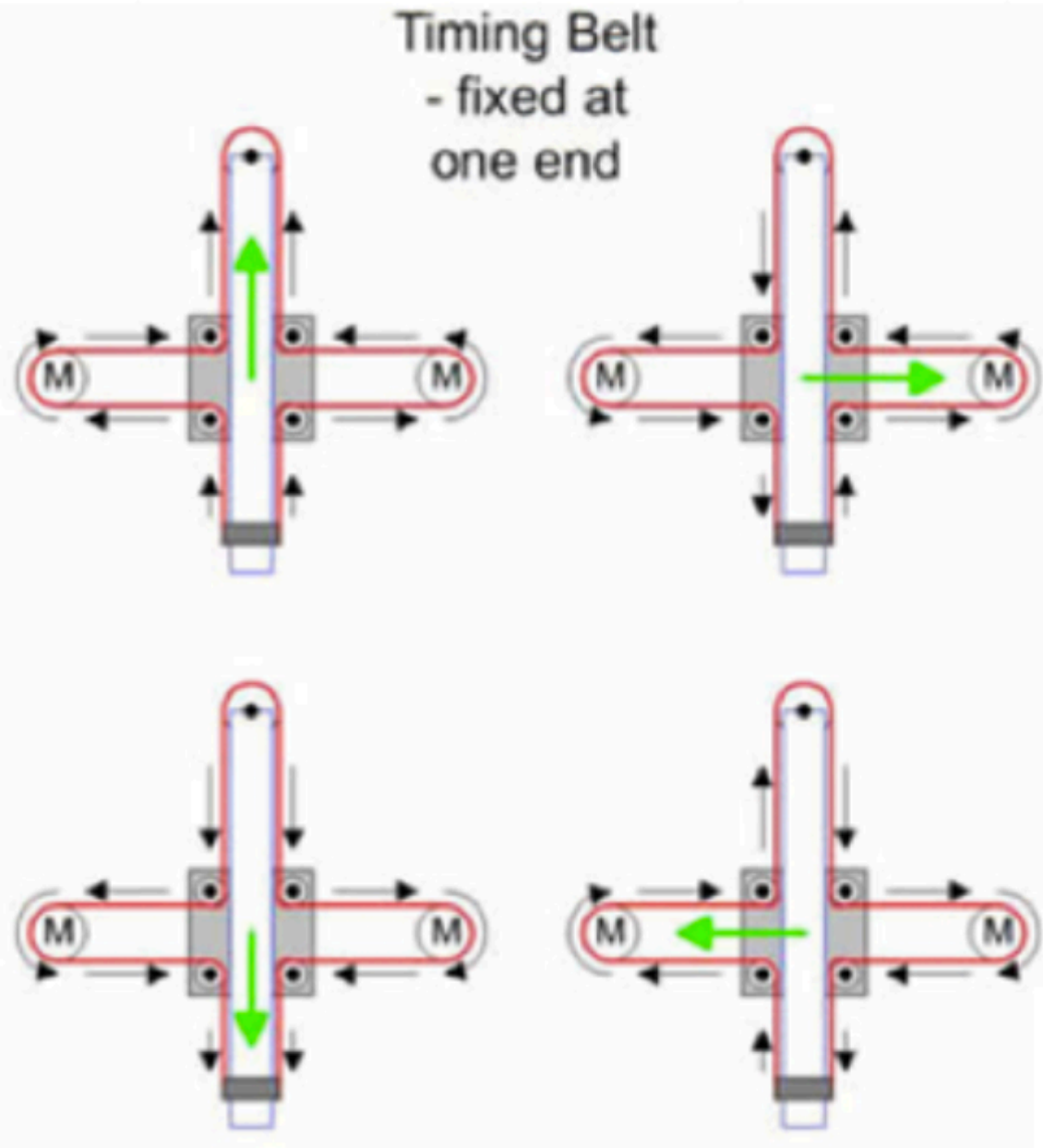
H-Bot

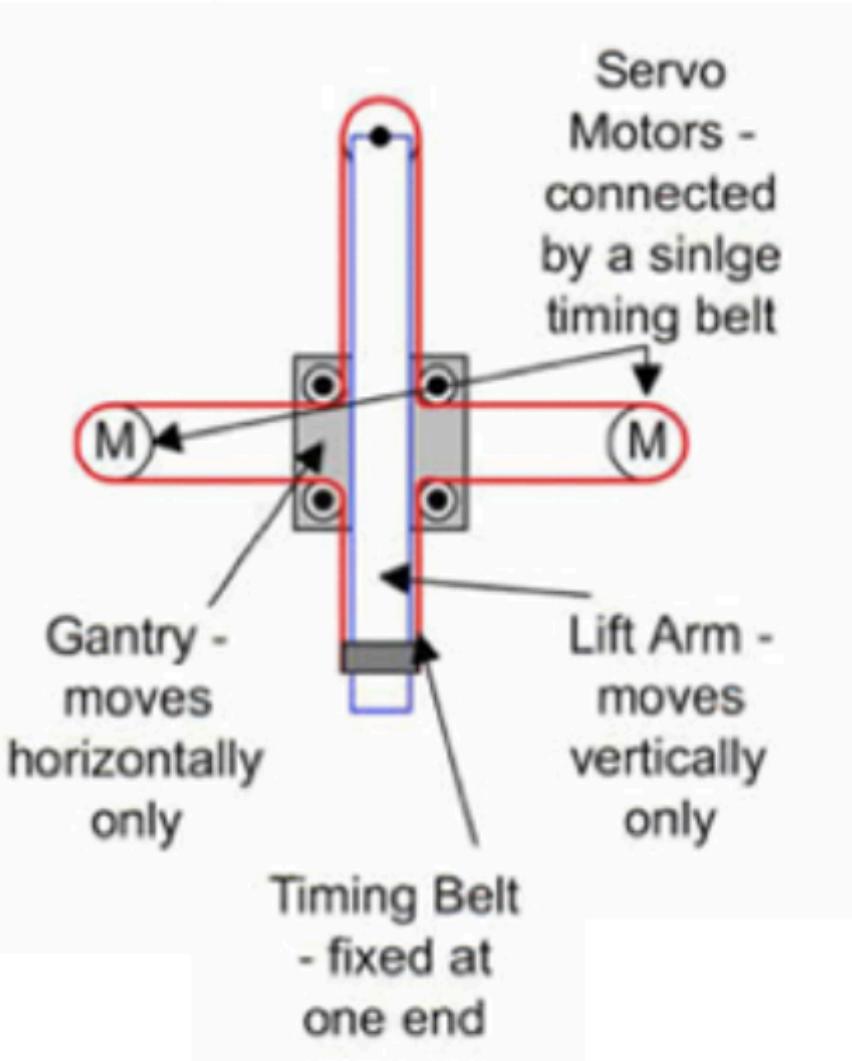


H-Bot



Bart Dring's H-Bot (T-Bot)


Timing Belt
- fixed at
one end
M
M
M
M
M
M
M
M


Servo
Motors -
connected
by a sinlge
timing belt
M
M
Gantry -
moves
horizontally
only
Lift Arm -
moves
vertically
only
Timing Belt
- fixed at
one end

T-Bot

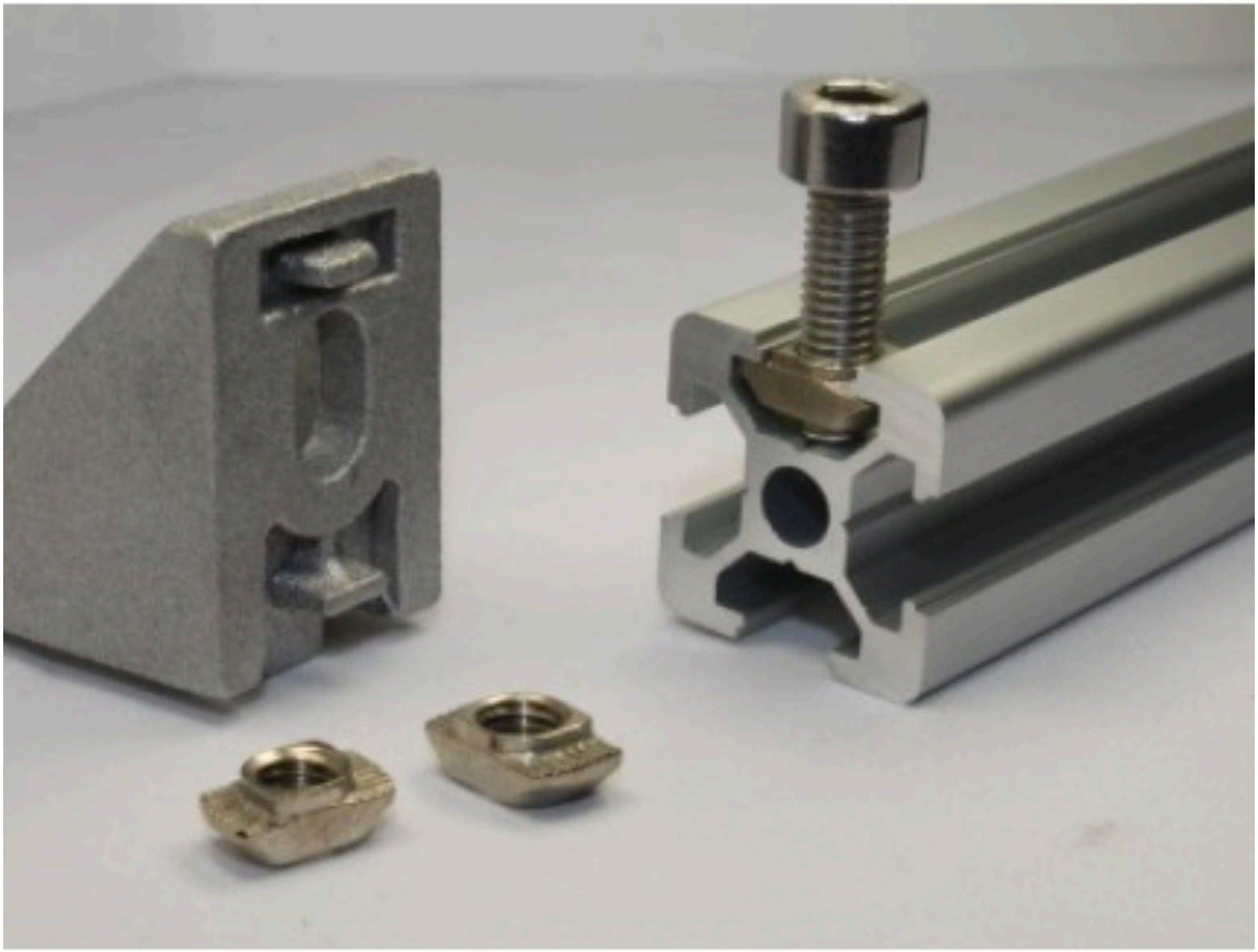
Aluminum Extrusion

8020

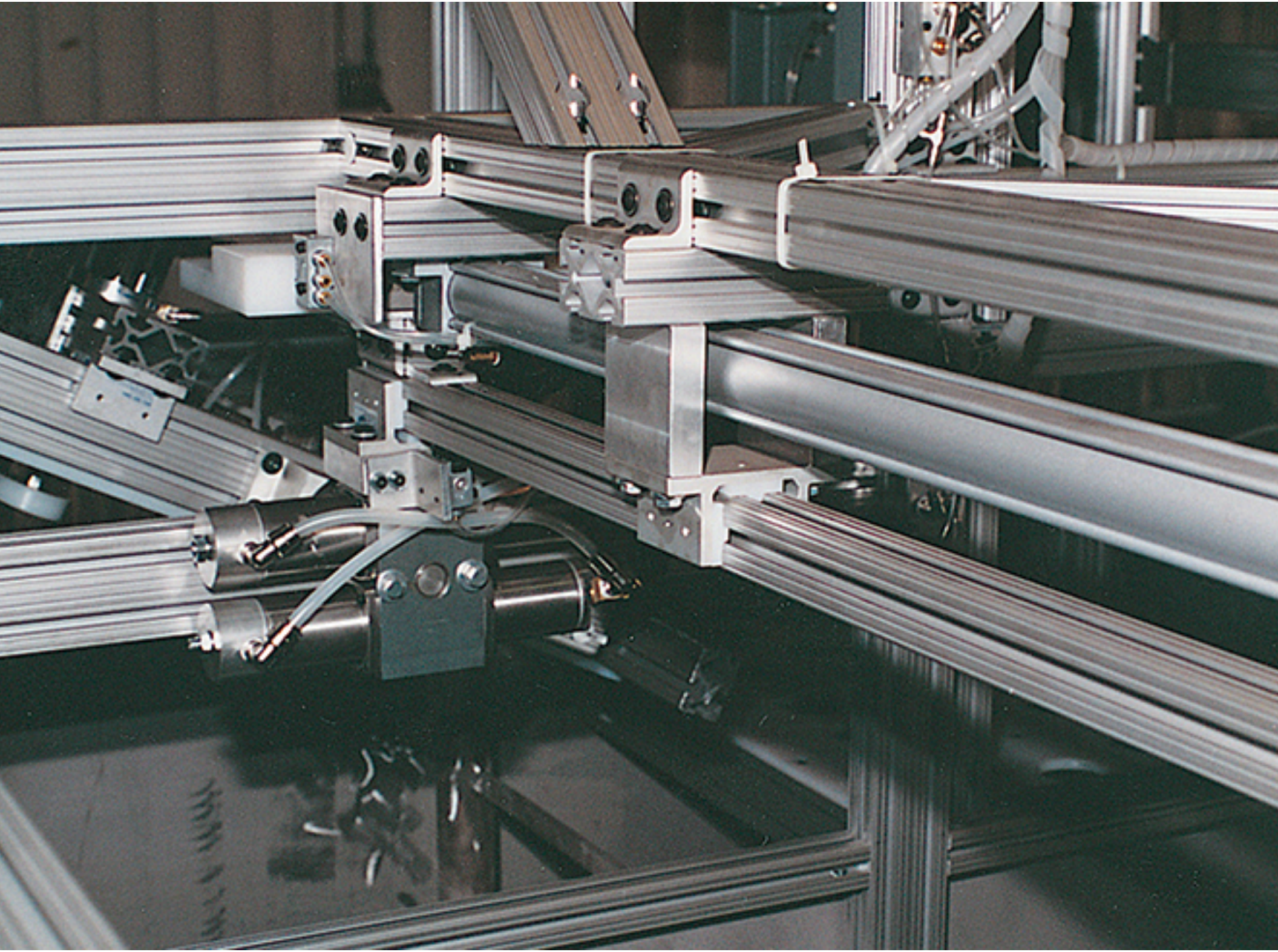
"Adult Erector Set"

Machine Components

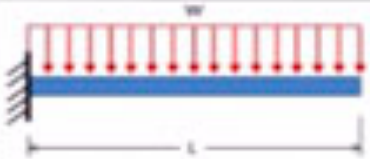
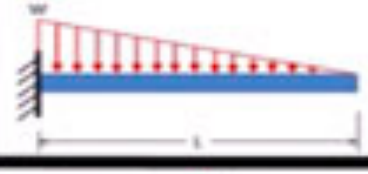
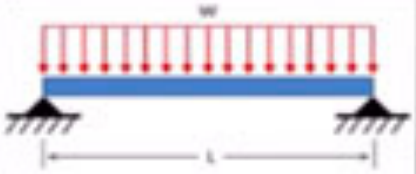
1. Standardized (machine screws)
2. Configurable / modular
3. Customized



Misumi 2020 Series 10



Deflection

SR. NO.	TYPE OF BEAM	MAX. BM	SLOPE	DEFLECTON
1		M	$\theta = \frac{ML}{EI} = \frac{ML}{EI}$	$\delta = \theta \times \frac{L}{2} = \frac{ML^2}{2EI}$
2		WL	$\theta = \frac{ML}{2EI} = \frac{WL^2}{2EI}$	$\delta = \theta \times \frac{2L}{3} = \frac{WL^3}{3EI}$
3		$\frac{WL^2}{2}$	$\theta = \frac{ML}{3EI} = \frac{WL^3}{6EI}$	$\delta = \theta \times \frac{3L}{4} = \frac{WL^4}{8EI}$
4		$\frac{WL^2}{6}$	$\theta = \frac{ML}{4EI} = \frac{WL^3}{24EI}$	$\delta = \theta \times \frac{4L}{5} = \frac{WL^4}{30EI}$
5		$\frac{WL}{4}$	$\theta = \frac{ML}{4EI} = \frac{WL^2}{16EI}$	$\delta = \theta \times \frac{L}{3} = \frac{WL^3}{48EI}$
6		$\frac{WL^2}{8}$	$\theta = \frac{ML}{3EI} = \frac{WL^3}{24EI}$	$\delta = \theta \times \frac{5L}{16} = \frac{5WL^4}{384EI}$

http://engineeringfeed.com/slope-deflection-beams-deflection-cantilever-beam-formula

https://en.wikipedia.org/wiki/Young%27s_modulus

Young's Modulus

$$E = \frac{\sigma}{\epsilon}$$

Stress $\sigma = \frac{F}{A}$

Strain $\epsilon = \frac{\Delta L}{L}$

Aluminum: E = 69 gigapascals

Moment of Inertia

$$I = \rho \int_0^R r^2 \, dV$$

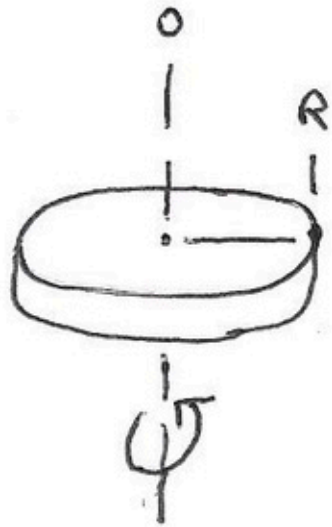
$$= \frac{M}{V_{disk}} \int_0^R r^2 (2\pi h r \, dr)$$

$$= \frac{M}{\pi r^2 h} (2\pi h) \int_0^R r^3 \, dr$$

$$= \frac{M}{\cancel{\pi r^2 h}} (\cancel{2\pi h}) \left[\frac{r^{\cancel{4}\,2}}{\cancel{4}_{\,2}} \right]_0^R$$

$$\boxed{I = \frac{1}{2} MR^2}$$

$$\rho = \frac{M}{V_{disk}}$$

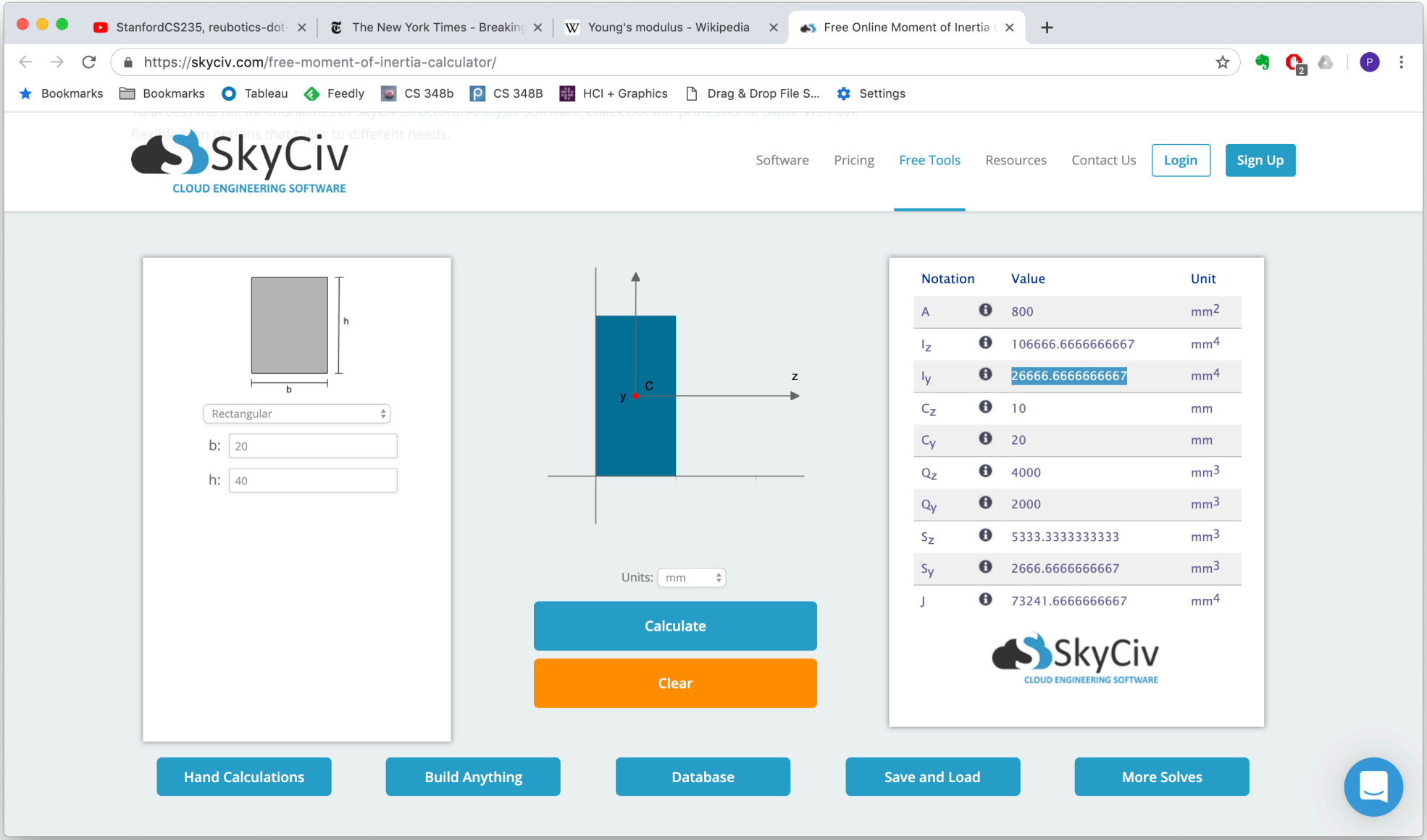


* $V_{disk} = \pi r^2 h$

$dV = 2\pi h r \, dr$

$R = r$

https://socratic.org/questions/how-to-derive-the-formula-for-moment-of-inertia-of-a-disc-about-an-axis-passing-

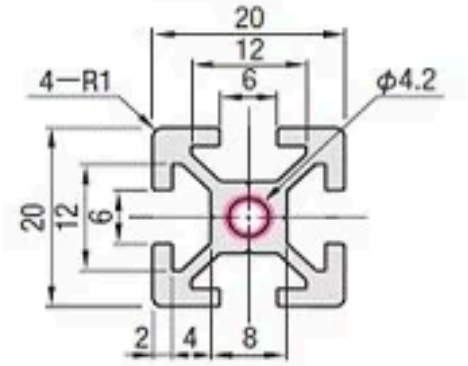


Moment of Inertia

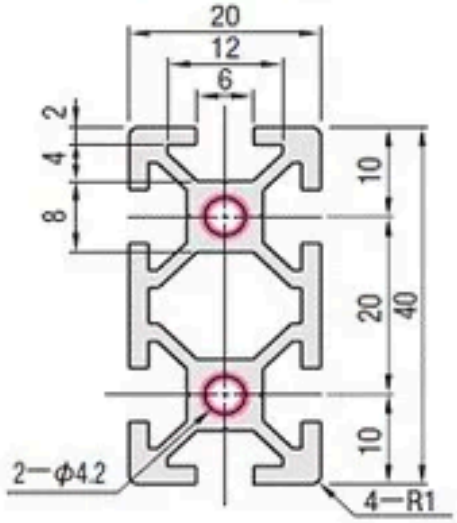
Cross-Section Shape	Cross-Section Area (A)	Second Moment of Area (I)	Computational Comparison of the Same Area
Square  **Width: b Height: h**	bh	$\frac{bh^3}{12}$	b=31.4 and h=10, A=314 **I=2,617** **The bending strength is approximately 1/3 of the circular cylinder listed below.**
Circle (Circular Cylinder)  **Radius: r**	πr^2	$\frac{\pi r^4}{4}$	r=10, A=314 **I=7,850**
Hollow Cylinder  **Outer Radius: R Inner Radius: r**	$\pi (R^2 - r^2)$	$\frac{\pi (R^4 - r^4)}{4}$	R=15, r=11.2, A=314 **I=27,388** **The bending strength becomes approximately 3.5 times more than the above-mentioned circular cylinder for the same cross-section.**

Bending Moment to Weight

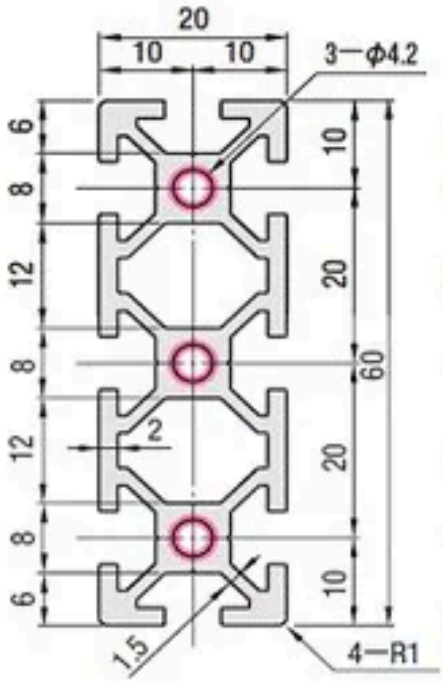
HFS5—2020
HFSB5—2020 (Black Anodize)



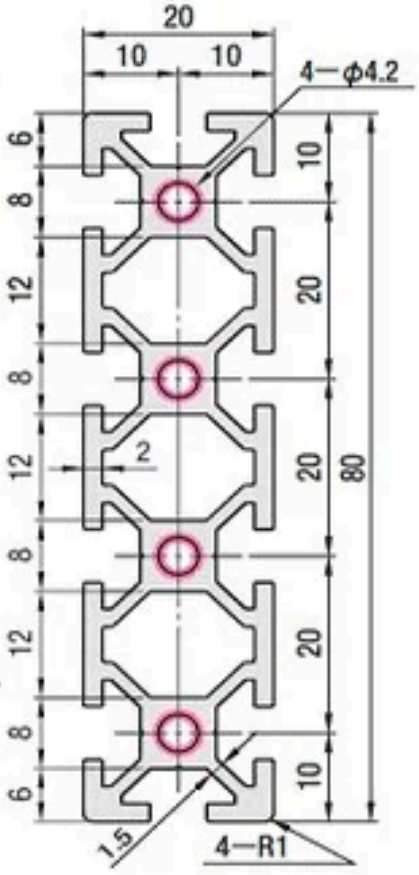
HFS5—2040
HFSB5—2040 (Black Anodize)



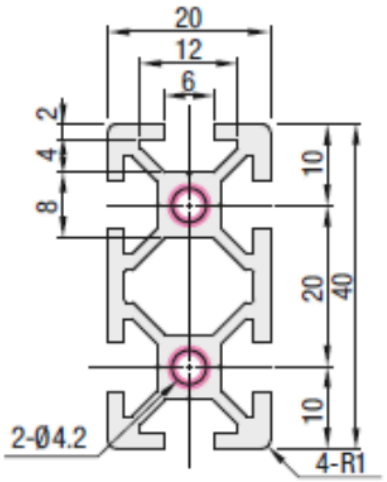
HFS5—2060



HFS5—2080



2020 Technical Data

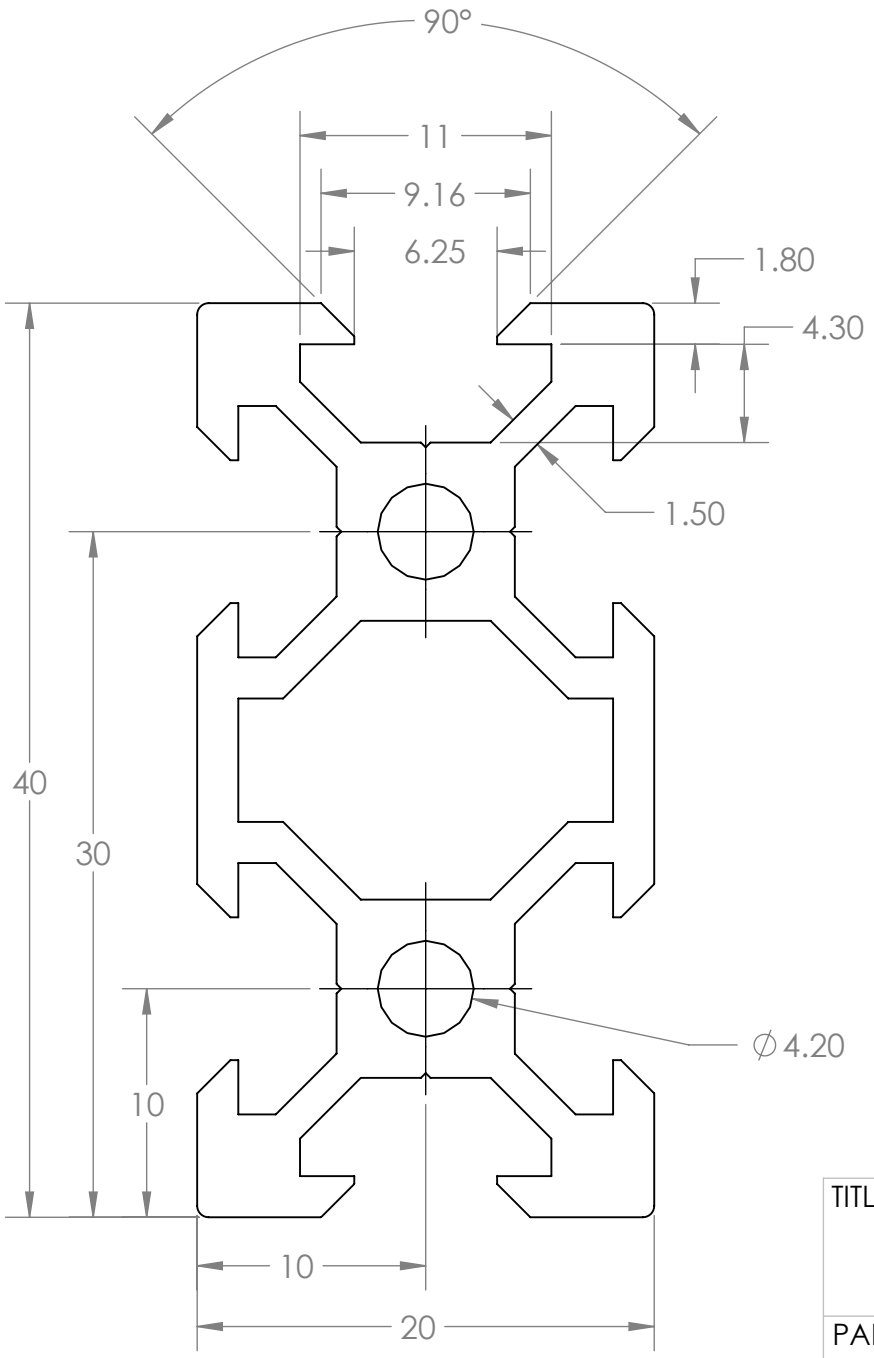


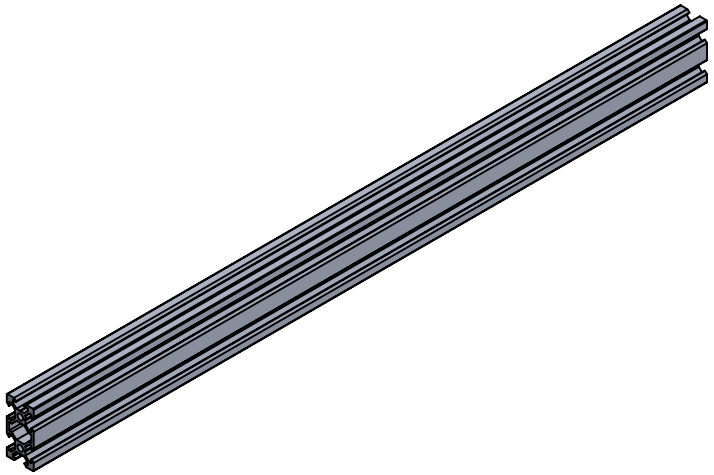
Specifications

Part Number	-	L
HFS5-2040	-	800
KHFS5-2040	-	1000
KHFSB5-2040	-	4000

■Configurable Length Extrusions

Type	[M]Material	[S]Surface Treatment	Part Number	L 0.5mm Increment	Mass kg/m	Sectional Area mm^2	Cross Sectional Moment of Inertia mm^4	
							ℓx	ℓy
HFS	A6N01SS-T5 6005A-T5 Aluminum Alloy	Clear Anodize	HFS5-2040	50~4000	0.88	324	$1.358x10^4$	$5.13x10^4$
HFS	A6N01SS-T5 6005A-T5 Aluminum Alloy	Black Anodize	HFSB5-2040	50~4000	0.88	324	$1.358x10^4$	$5.13x10^4$
HFS	A6N01SS-T5 6005A-T5 Aluminum Alloy	Clear Coating (Anodize + Clear Coating)	CAF5-2040	50~4000	0.88	Screenshot	$1.358x10^4$	$5.13x10^4$





Length	Part#
500	155-LP
1000	195-LP
1500	215-LP

TITLE: V-Slot 20X40 Linear Rail

PART#

MATERIAL: Aluminum

OPENBUILDS

V-Slot DeflectionV3

Search Sheet

Home | Insert | Page Layout | Formulas | Data | Review | View | Share

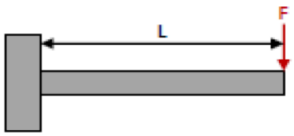
Paste | Calibri (Body) | 11 | General | Conditional Formatting | Format as Table | Cell Styles | Insert | Delete | Format | Sort & Filter

E3

	Profile	lx	ly	Option
3	20x20	6.988	6.988	
4	20x40	48.163	12.305	x
5	20x60	149.336	17.622	
6	20x80	336.224	22.938	
7	40x40	81.407	81.407	
8	C-Beam	117.76	565.546	

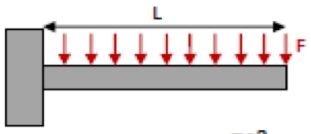
10	Weight of Load (Kg)	2	
11	Length in M	1	
14	F	19.62	N
15	Length in M	1	m
16	E	6.89E+10	
17	Inertia on X	4.8163E-08	
18	Inertia on Y	1.2305E-08	

Cantilever beam with a concentrated load



Maximum deflection = $\frac{FL^3}{3EI}$

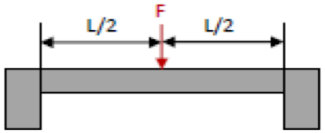
Cantilever beam with a distributed load



Maximum deflection = $\frac{FL^3}{8EI}$

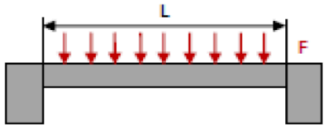
F is the total force distributed evenly across the length

Simply supported beam with a concentrated load



Maximum deflection = $\frac{FL^3}{48EI}$

Simply supported beam with a distributed load



Maximum deflection = $\frac{5FL^3}{348EI}$

F is the total force distributed evenly across the length

20	**Simply supported beam with a concentrated load**			**Simply supported beam with a distributed load**			**Cantilever**
21	**Deflection X**	**0.12**	**mm**	**Deflection X**	**0.08**	**mm**	**Deflection**
22	**Deflection Y**	**0.48**	**mm**	**Deflection Y**	**0.33**	**mm**	**Deflection**

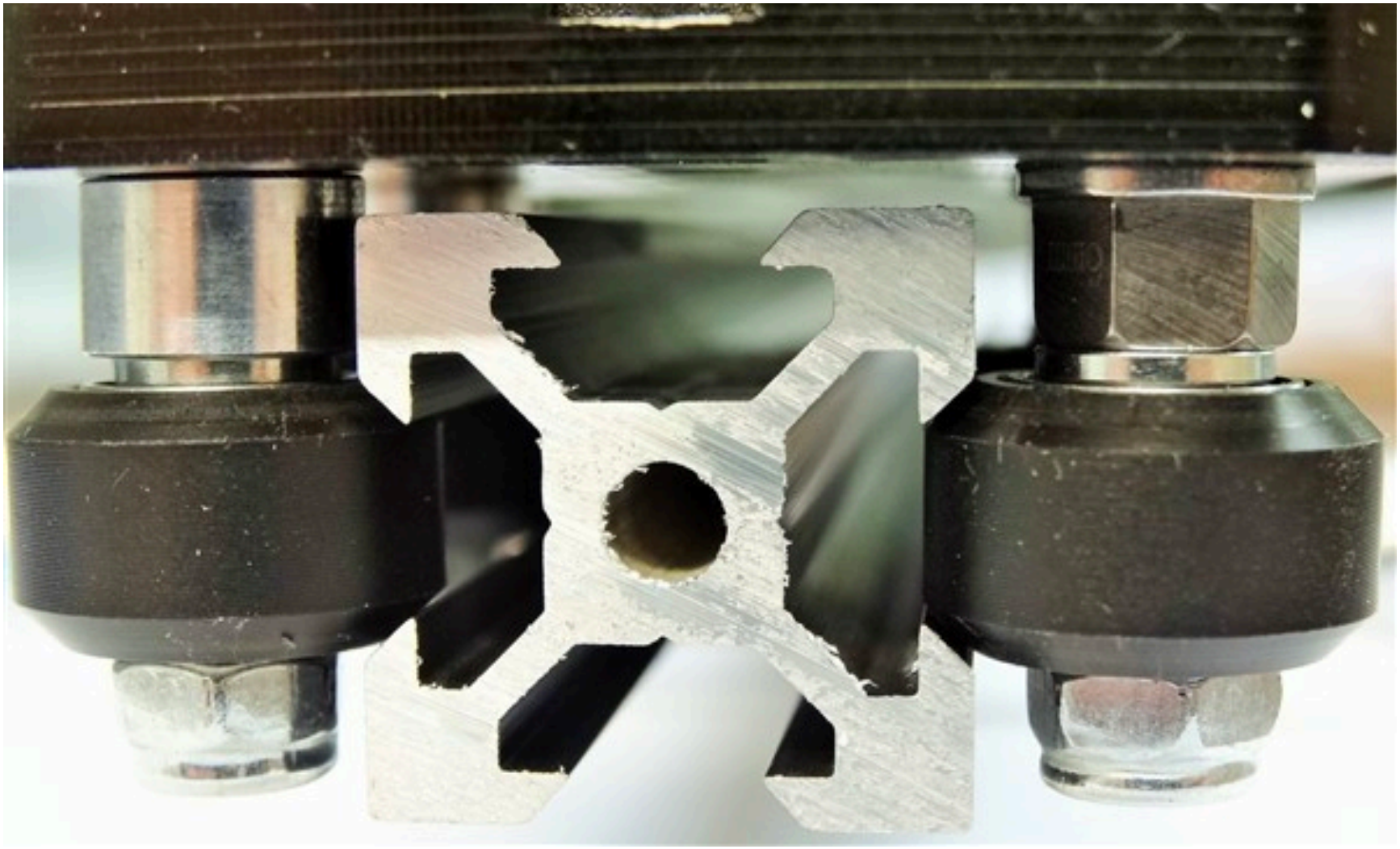
Sheet1

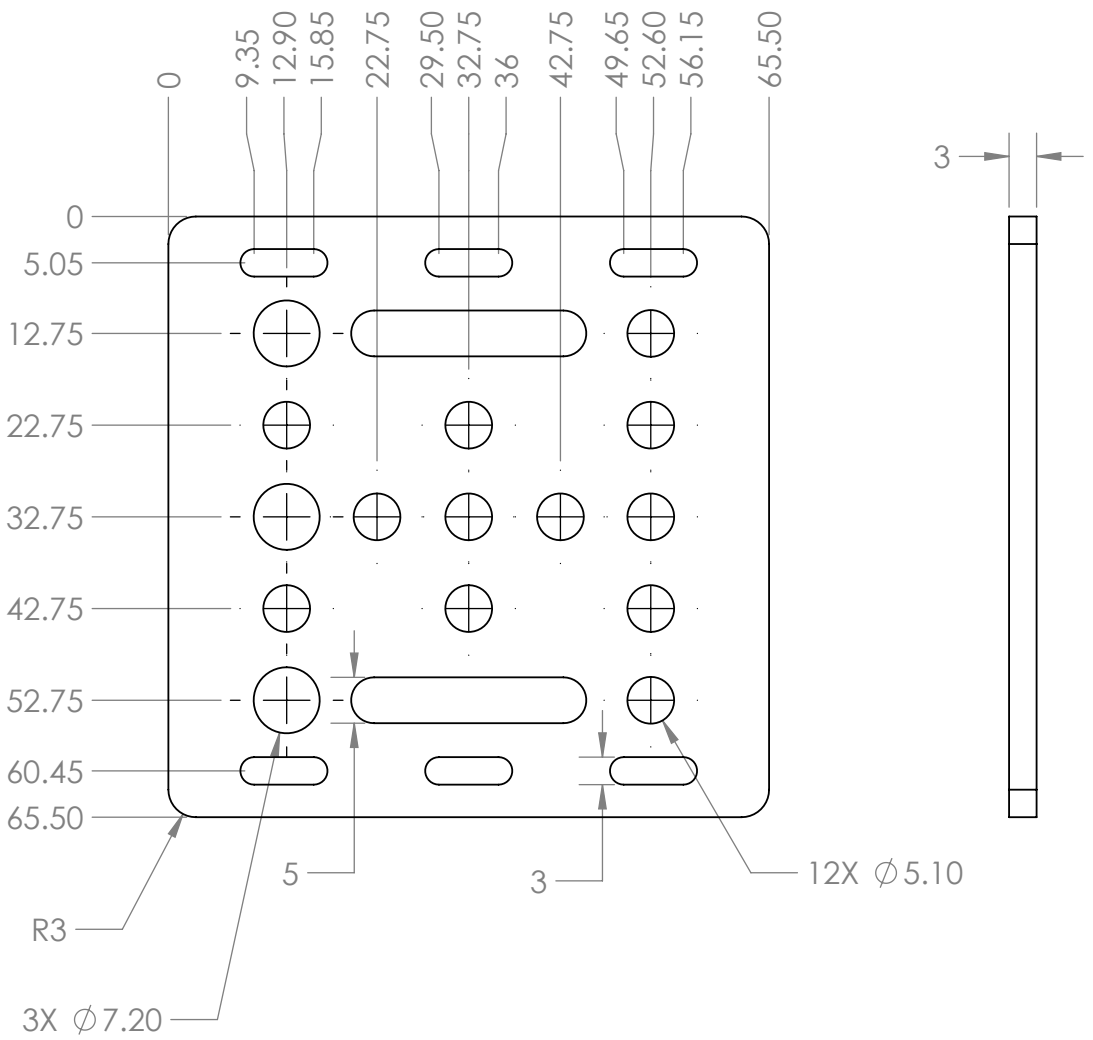
Ready

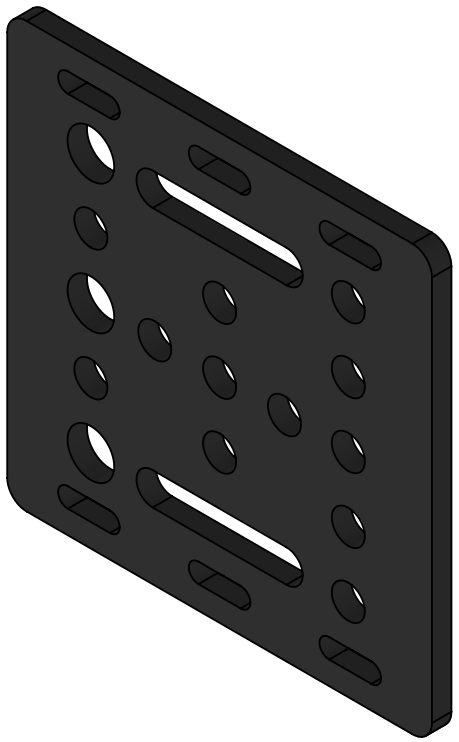
145%

V-Slot Linear Slides


Linear Slides

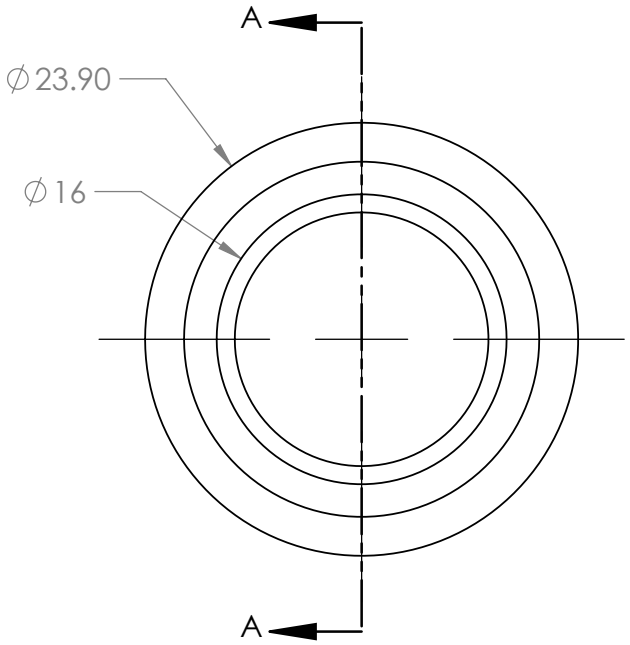


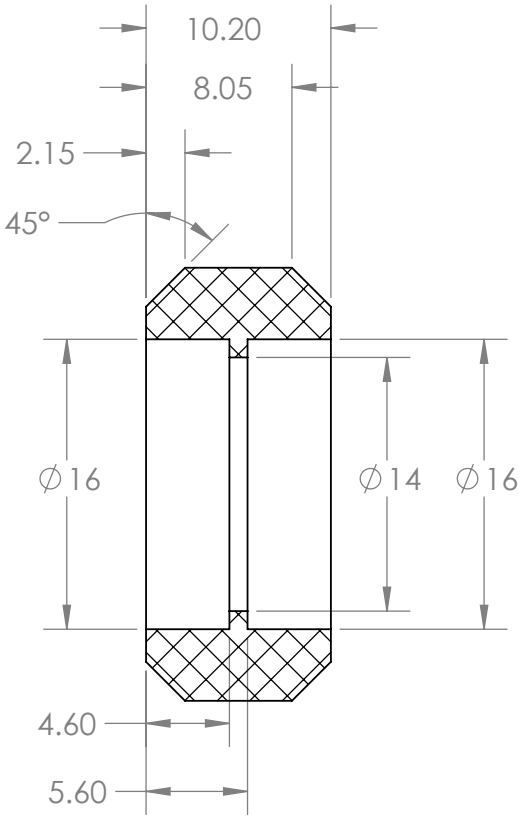




TITLE: V-Slot Gantry Plate 20mm		
PART# 935	MATERIAL: Aluminum	

OPENBUILDS





SECTION A-A

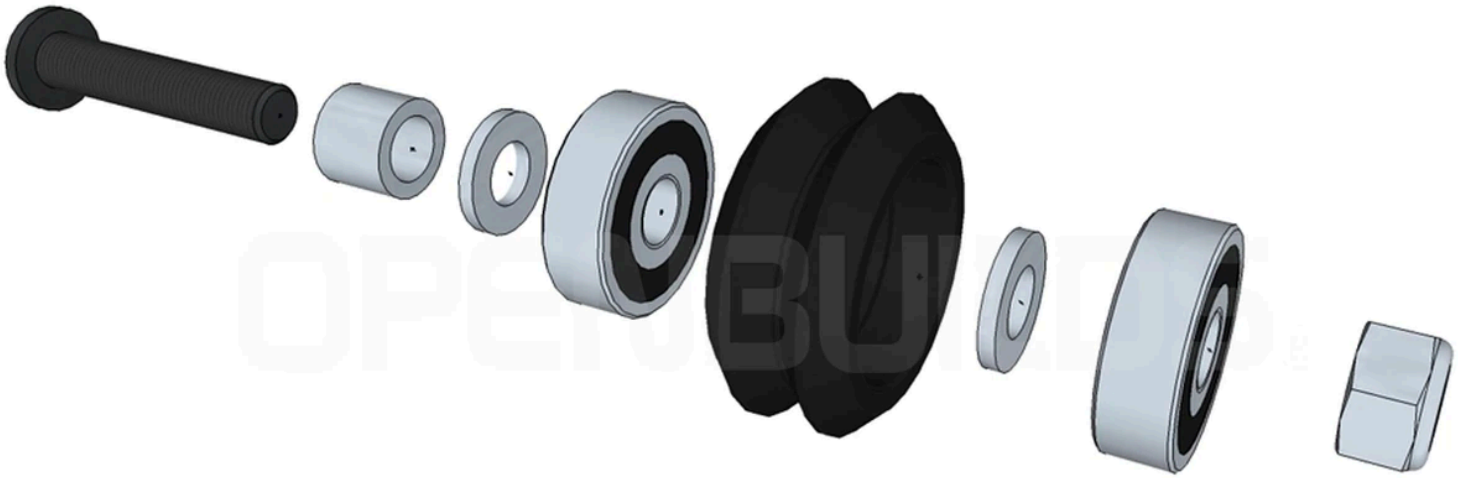
Material	Part#
Delrin	45
Polycarbonate	55

TITLE: Solid V Wheel	
PART#	MATERIAL:

OPENBUILDS

Ball Bearing

https://en.wikipedia.org/wiki/Ball_bearing



V-Wheel Assembly

Ball Bearings

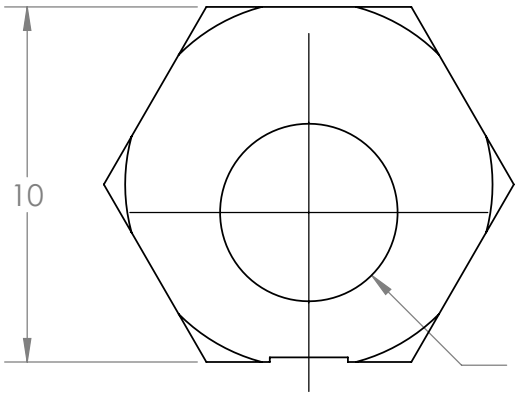
Two functions

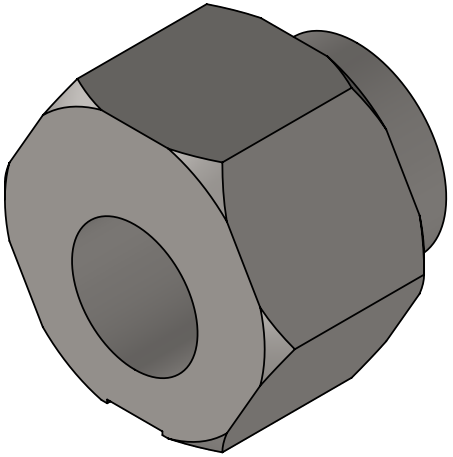
- **Reduce friction**
- **Constrain motion**

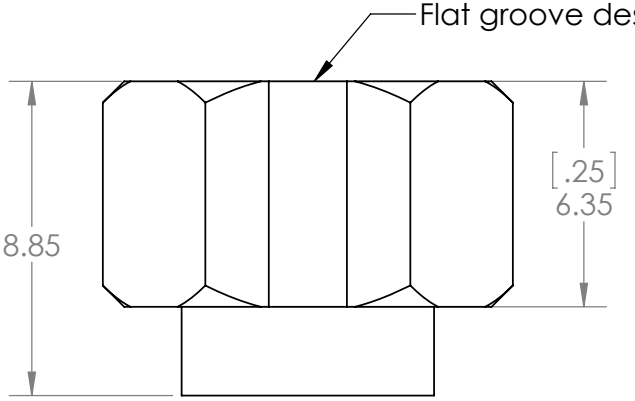
Use two bearings

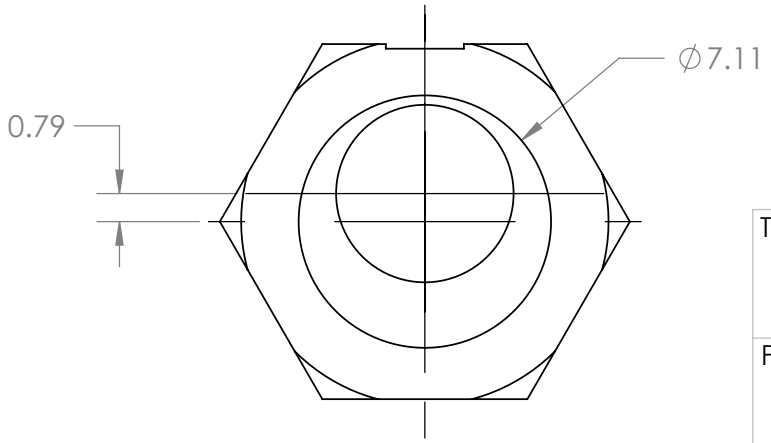
Balls are loose, pre-load

Inner race, precision shim, shaft collar





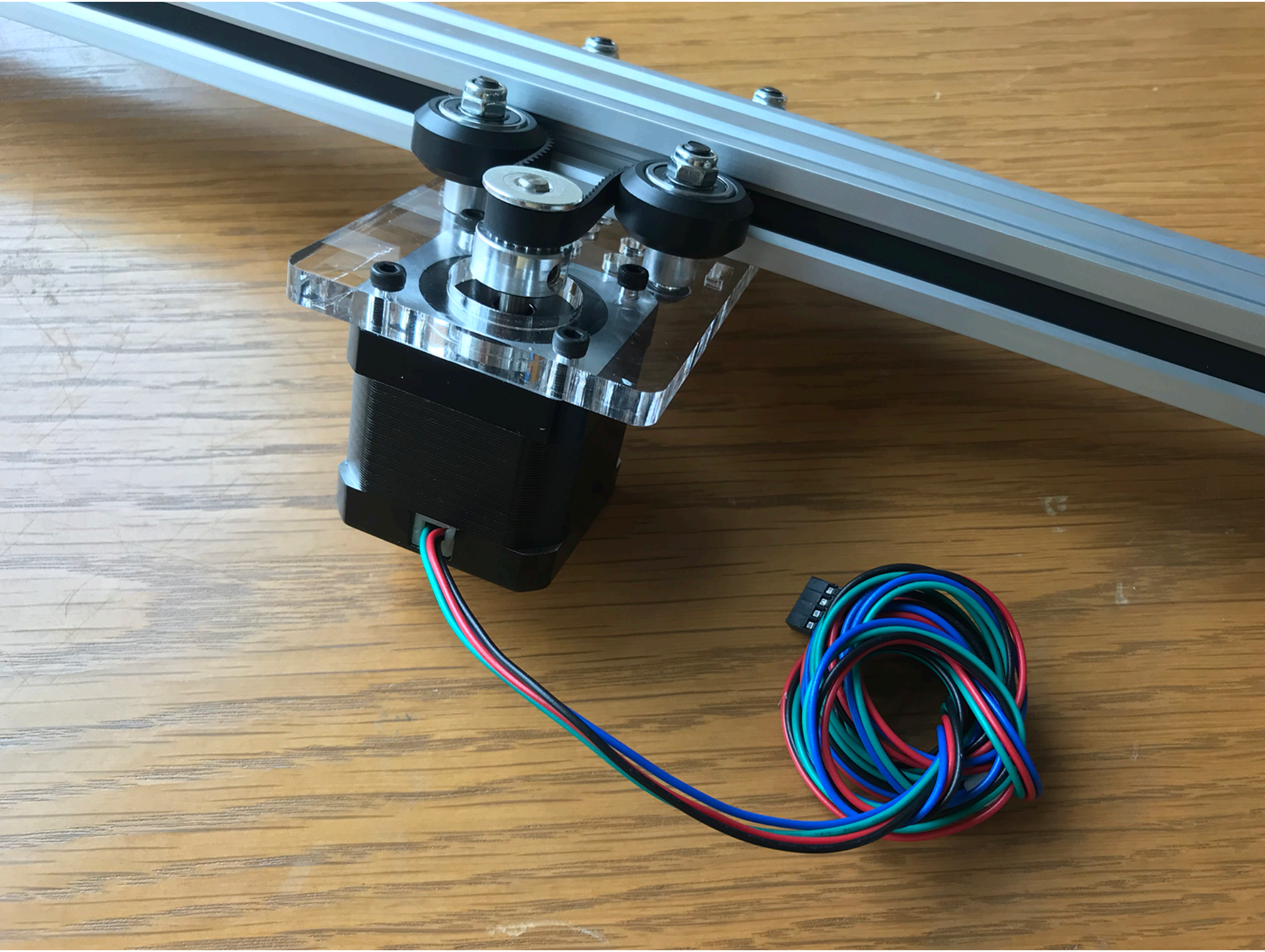




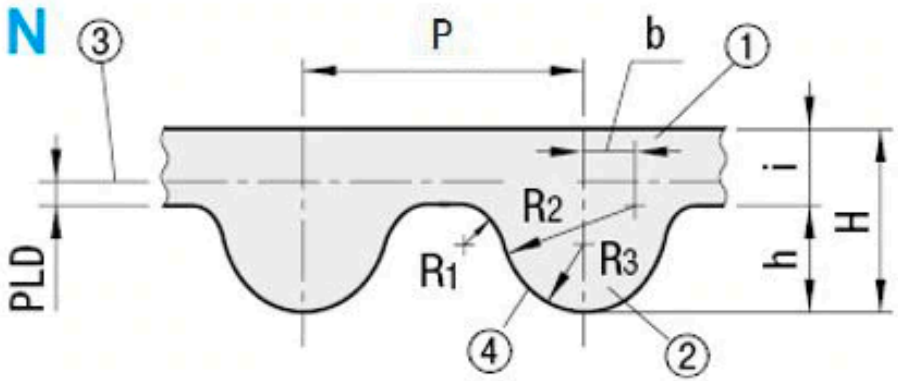
TITLE: Eccentric Spacer 0.25in		
PART# 70	MATERIAL: Stainless Steel	

OPENBUILDS

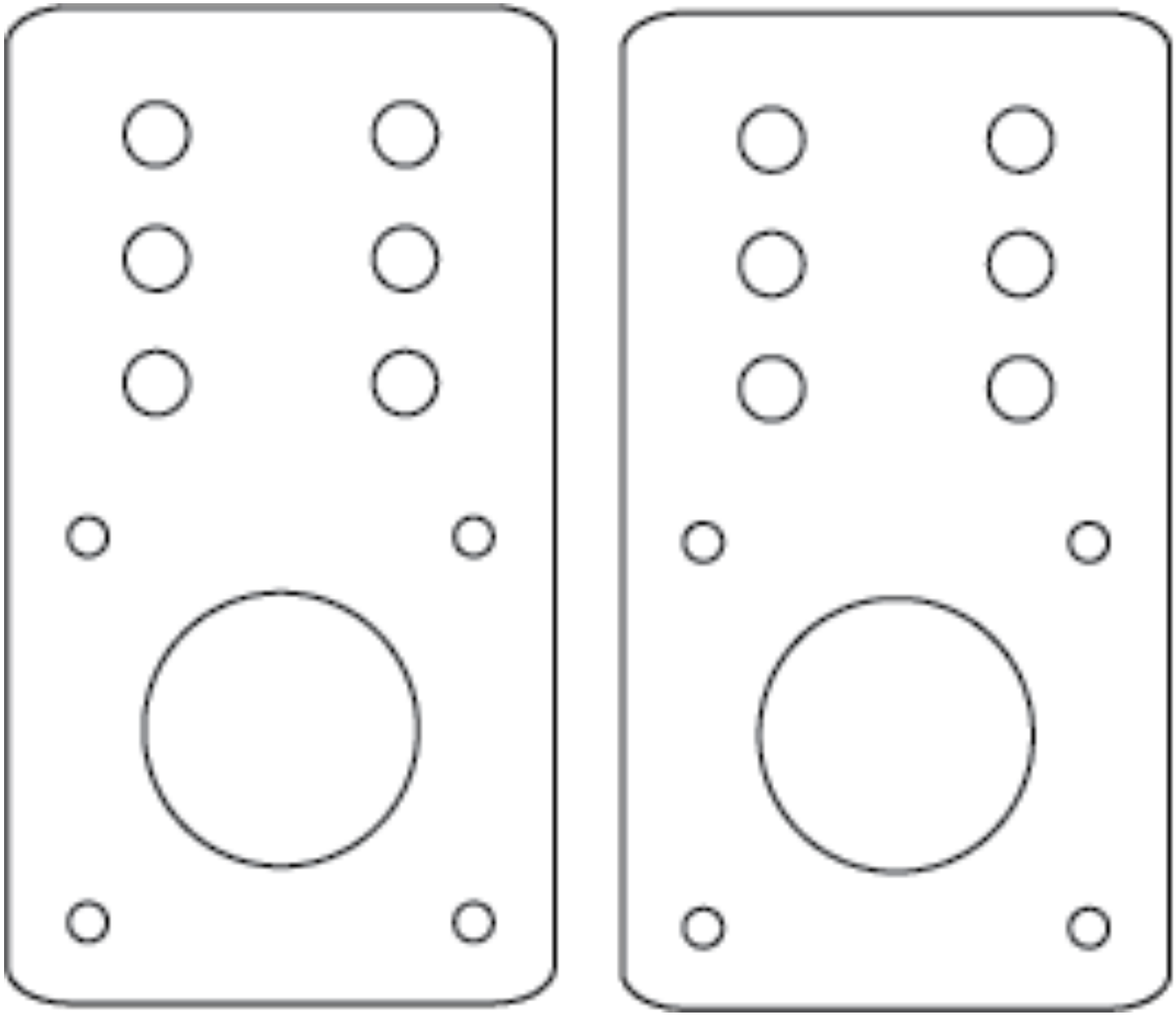
Timing Belt and Pulley



TYPE	P	R_1	R_2	R_3	b	H	h	i	PLD
2GT	2	0.15	1.00	0.555	0.40	1.38	0.75	0.63	0.254
3GT	3	0.25	1.52	0.85	0.61	2.40	1.14	1.26	0.381



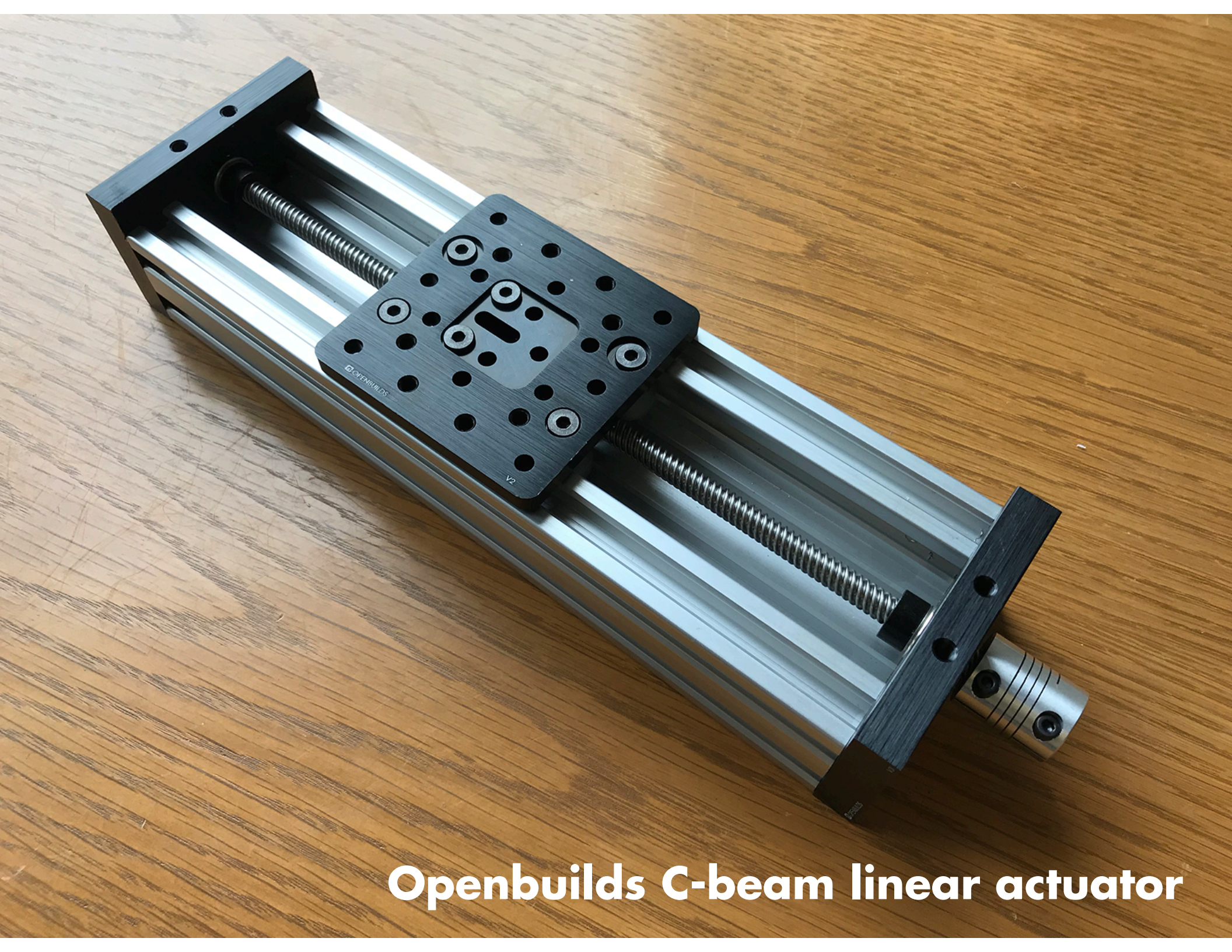
TOLERANCES			
belt type	think(H:mm)	width(mm)	pitch length
3GT-5	2.4±0.15	5±0.2	±0.66mm/m
2GT-5	1.38±0.15	5±0.2	±0.66mm/m
3GT-240-9	2.4±0.15	9±0.4	±0.4mm



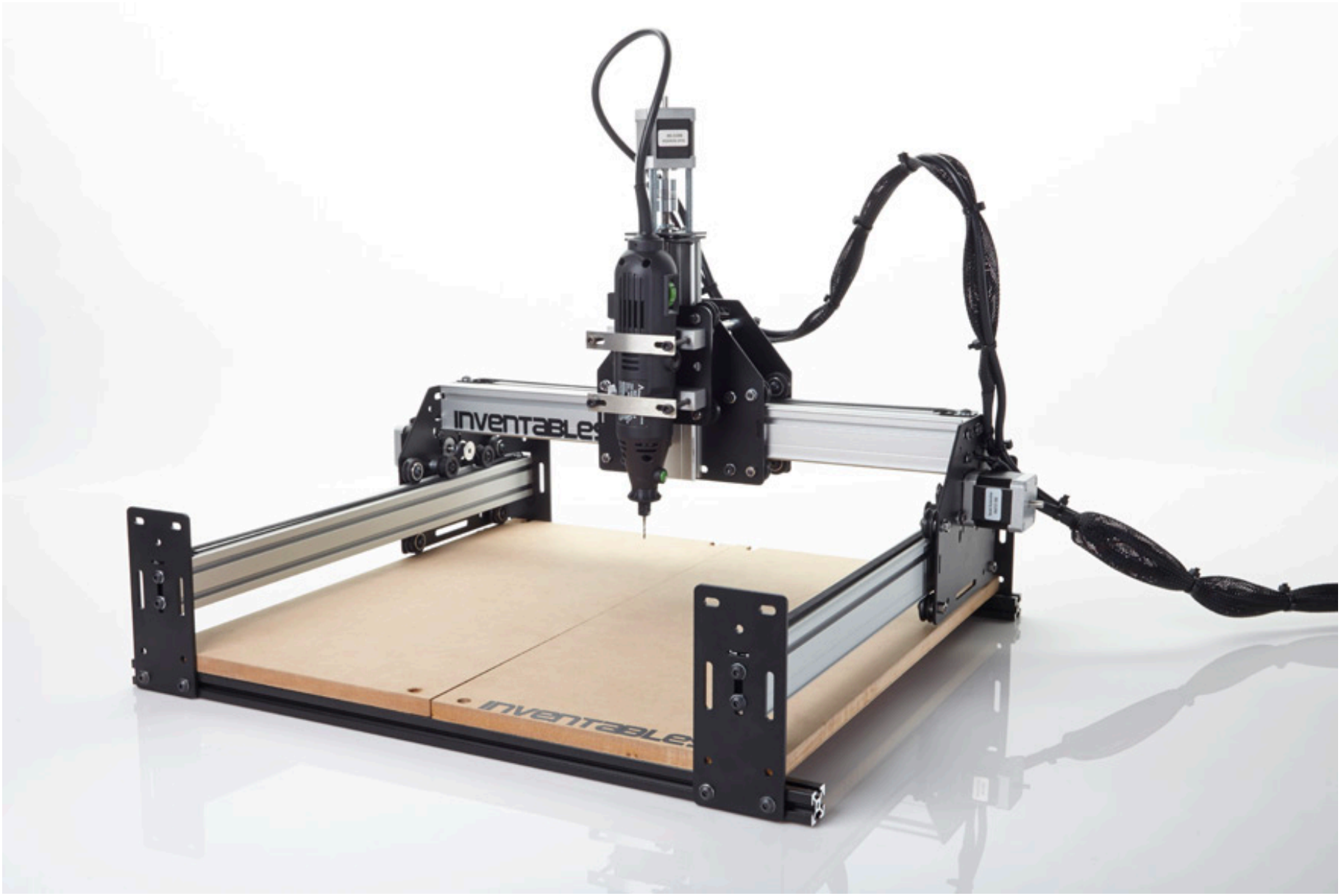
NEMA 17 motor mount bracket

Lead Screws


400mm 8mm Lead Screw
•Diameter: 8mm
•Length: 400mm
•Spacing: 2mm
•Range: Reprap makerbot 3d printer accessories
4-start
Lead vs Pitch


Openbuilds C-beam linear actuator

V-Slot Machines



Shapeoko 2

Openbuilds Acro Laser Engraver

Creality 3D Ender-3

OpenBuilds