

FREE FILES · 3D-PRINTED GEARBOX

Cycloid Drive *25:1*

A compact, high-ratio cycloidal gearbox for a NEMA17 stepper. Print six parts, add off-the-shelf pins and bearings, and you have a 25:1 reducer with about one degree of backlash.



25 : 1

single stage, measured exact

Ø85 × 45 mm

gearbox, without motor

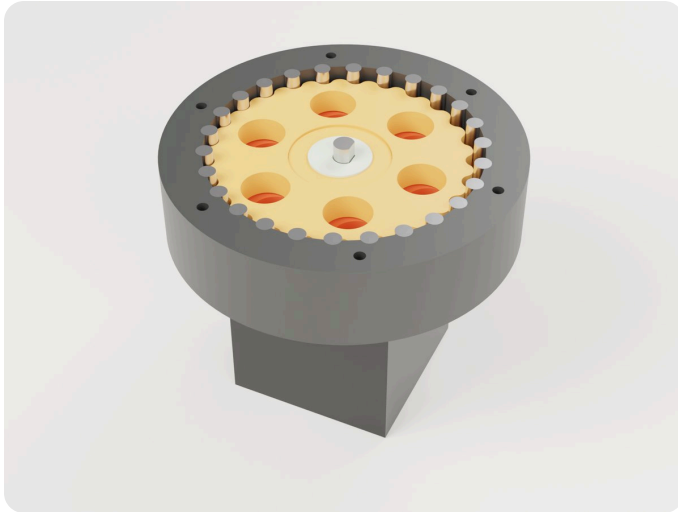
~1.3'

repeatability, measured

3D renders from the real CAD. Colours are illustrative; print it in any colour.

OVERVIEW

What it is and what we measured



A cycloidal drive turns one motor revolution into 1/25 of an output revolution. An eccentric cam wobbles two lobed discs around a ring of 26 steel pins; each motor turn walks the discs back by one lobe, and six rollers carry that slow rotation to the output.

Two discs, 180° apart, balance the wobble. Everything that rolls runs on steel: dowel pins, 684 rollers and sealed bearings.

Measured on our bench (printed in PETG-CF, Oct 2026)

Quantity	Result	How
Ratio	25.000 : 1	Output encoder moved 1.000° per commanded degree over ~10 turns, no lost steps
Repeatability	1.32 arcmin	0 → 90° ten times, same direction (1 encoder count)
Backlash (lost motion)	57 arcmin mean (41–65)	R2 discs (the ones in this pack); R1 discs measured 71
Speed	10–150 °/s output	No drift after one turn at each speed
Torque	not measured yet	We will publish the stall test. Do not rely on a torque figure from us.

These numbers come from one gearbox printed on a Bambu Lab H2C (0.6 mm nozzle). Your result depends on your printer, material and pins. Print the fit test first.

WHAT YOU NEED

Bill of materials

Part	Qty	Spec (what matters)	Tested with	Needed
Ring + output pins	32	Ø4 × 20 mm hardened steel dowel pins (ground). Must measure 3.98-4.00 mm	uxcell 4 × 20 mm dowel pins (measured 3.99 × 19.77)	Yes
Output rollers	12	684ZZ ball bearing 4 × 9 × 4 mm	uxcell 684ZZ	Yes
Eccentric bearings	2	6802-2RS ball bearing 15 × 24 × 5 mm	uxcell 6802-2RS	Yes
Output bearings	2	6808-2RS ball bearing 40 × 52 × 7 mm	Harfington 6808-2RS	Yes
Motor	1	NEMA17 stepper, 5 mm D-flat shaft ≥ 22 mm long, 31 mm M3 hole pattern, 22 mm boss	StepperOnline 17HS19-2004S1 (2 A / 59 Ncm)	Yes
Motor screws	4	M3 × 6 socket head cap screw	M3 SHCS	Yes
Cap screws	6	M3 × 16 socket head cap screw	M3 SHCS	Yes
Grease	1	PTFE grease (thin film)	any PTFE grease	Recommended
Stepper driver	1	TMC2209 module (STEP/DIR), or any stepper driver	BIGTREETECH TMC2209 V1.3	To run it
Microcontroller	1	ESP32-S3, ESP32 or Arduino	ESP32-S3	To run it
Power supply	1	12-24 V DC ≥ 2 A	24 V bench supply (2 A limit)	To run it
Motor-supply capacitor	1	100 µF electrolytic, ≥ 35 V	ALLECIN 100 µF 35 V	To run it
Encoder (optional)	1	MT6701 magnetic encoder + Ø4 × 2 mm diametric magnet	MT6701 board + included magnet	Optional

The exact parts we used are linked at harbeworks.com/parts (also in [BOM.csv](#)). Any equivalent part that meets the spec should work; only the "tested with" parts have been tested.

Printed parts

File	Qty	Notes
HW-Cycloid25_Housing_Base	1	Floor down. No supports.
HW-Cycloid25_Housing_Cap	1	Top (logo) face down. No supports.
HW-Cycloid25_Disc	2	Flat. Print both from the same file.
HW-Cycloid25_Cam	1	Standing on its end, as supplied.
HW-Cycloid25_Output_Carrier	1	Plate down, hub up.

Tools

Bench vise or clamp (for pressing pins and bearings) · 2.5 mm hex key · calipers · PTFE grease · CA glue (only for the optional magnet)

Print settings and the fit test

Setting	Value	Why
Material	PETG-CF (tested) · PETG or PCTG (should work, untested)	Stiff, low creep, slides well on steel
X-Y hole compensation	OFF (0)	The fits already include the shrink of printed holes
Wall generator	Classic , 3+ walls (0.6 nozzle) / 4+ (0.4 nozzle)	Solid round seats for the bearings and pins
Infill	40% or more (recommended)	The discs and carrier take the load
Layer height	0.2 mm (recommended)	
Supports	None	Every part prints without them in the supplied orientation

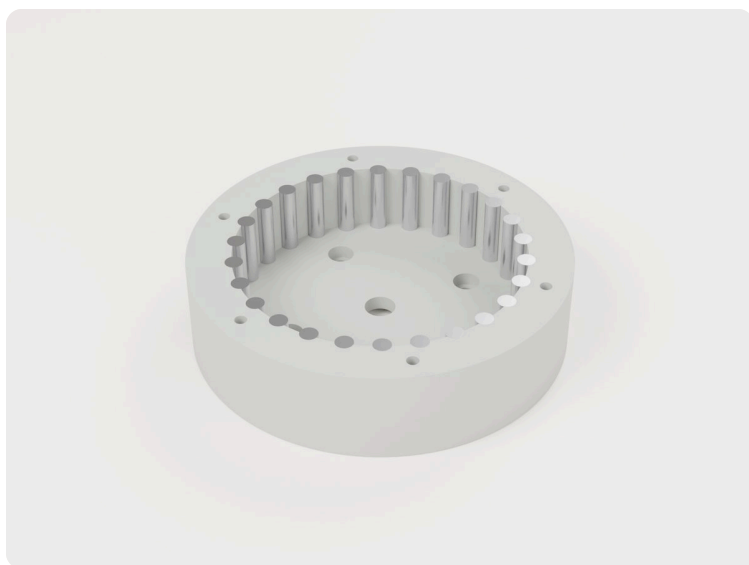
Print the fit test first (folder `fit-test`)

18 small pieces check every fit the gearbox relies on, in three sizes each. Flats ground into the side mark the size: **1 flat = -0.05**, **2 flats = nominal**, **3 flats = +0.05** mm.

Row	Pieces	Test	Good result
1	Ø10 cylinders	Press a 4×20 dowel into the hole	Firm press by hand or vise, no cracking
2	Ø12 cylinders	Slide onto the motor shaft, D-flat aligned	Slides on, no wobble, does not spin on the flat
3	Ø15 posts	Push a 6802 onto the post	Snug slide-on, no rattle
4	Rings, 2 mm lip	Press a 6802 into the seat	Firm press, bearing does not fall out
5	Ø40 tubes	Push a 6808 onto the tube	Snug slide-on, no rattle
6	Rings, 2 mm lip	Press a 6808 into the seat	Firm press, bearing does not fall out

If the nominal (2-flat) piece wins in every row, print the gearbox as supplied. If your printer consistently prefers the 1-flat or 3-flat size, your holes print smaller or larger than ours: adjust your slicer's X-Y hole compensation by ± 0.025 mm and test again, or open the STEP files and change the hole sizes.

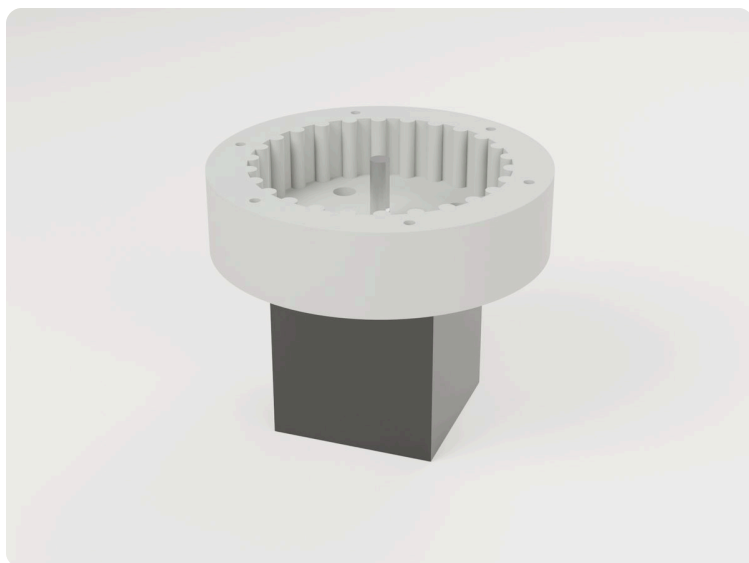
Steps 1-2



1 Ring pins into the base

1. Press all **26 dowel pins** into the ring of holes until each top is flush with the rim.
2. Use a vise or a flat block and a small hammer. Keep the pins vertical.

If a pin goes in by hand with no force, your printer prints holes large: check fit-test row 1.



2 Motor onto the base

1. Seat the motor's round boss in the recess under the floor.
2. Fit **4 × M3×6** from inside the cavity, heads in the counterbores. Tighten evenly.

Steps 3-4



3 Bearings into the discs

1. Press one **6802-2RS** into the centre of each disc.
2. Push on the bearing's **outer ring only**, and centre it in the 6 mm disc.

Both discs are the same part: print it twice.



4 Discs onto the cam

1. Slide disc 1 onto the **bottom** (motor-side) journal from below.
2. Slide disc 2 onto the **top** journal from above.
3. A disc cannot pass over the other journal: the two journals are offset 2 mm. Do this before the cam goes on the motor.

Steps 5-6



5 Cam stack onto the motor shaft

1. Spread a **thin film of PTFE grease** on the ring pins, the disc lobes and the disc output holes.
2. Lower the cam onto the shaft with its D-key on the flat.
3. Turn each disc until its lobes drop between the pins. The stack settles about 0.3 mm above the floor.



6 Output pins and rollers

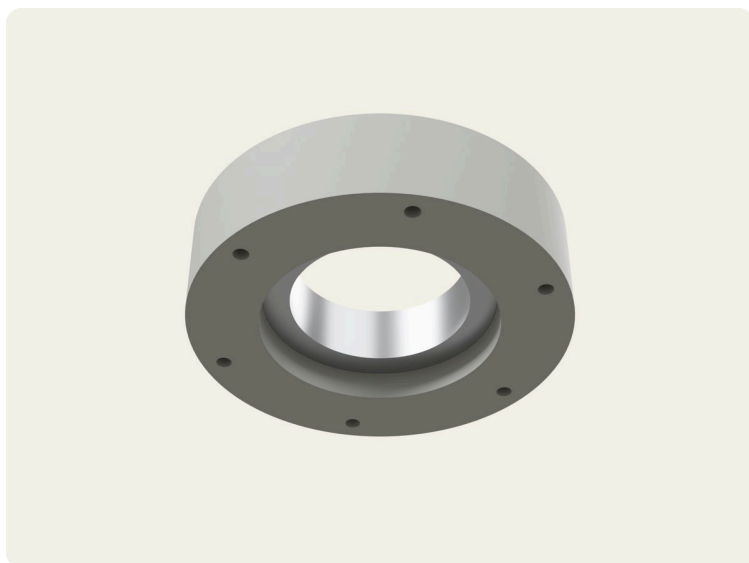
1. Press the **6 output pins** into the carrier pockets until they bottom.
2. Slide **2 × 684ZZ** onto each pin (12 total).

Steps 7-8



7 Carrier into the discs

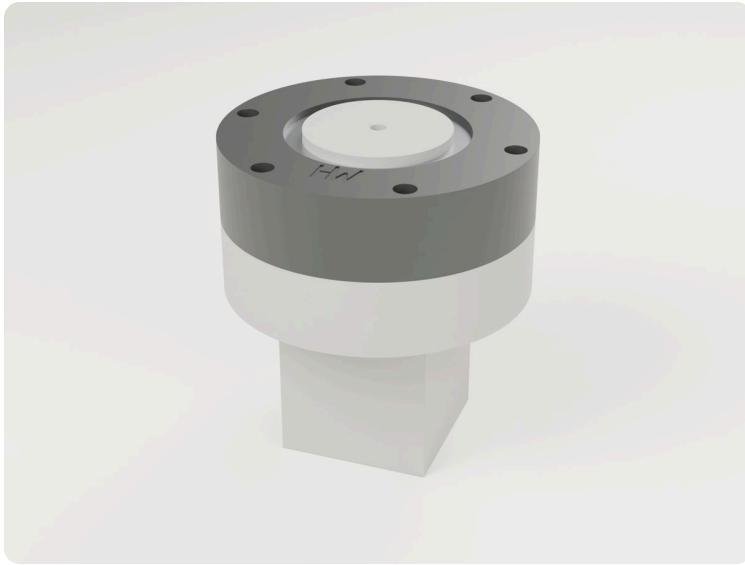
1. Lower the carrier, rollers down, into the discs.
2. Turn it slowly until all 12 rollers drop into the disc holes.



8 Output bearings into the cap

1. Press both **6808-2RS** into the cap, **outer ring only**, up against the lip.

Step 9



9 Close it up

1. Lower the cap, bearings inside, over the carrier hub (a snug slide).
2. Fit **6 × M3×16**; they self-tap into the base. Snug, not tight.
3. Spin test: turn the motor shaft or jog the motor at low current. It should turn smoothly with no tight spots over a full output turn. Back-driving the output by hand is stiff: that is normal at 25:1.

Optional encoder: glue the diametric magnet flush into the hub pocket with a drop of CA.

Wiring and test sketch

From	To	Notes
Motor coil A (black / green)	TMC2209 A1 / A2	Check $\sim 1.4 \Omega$ across each pair with a meter
Motor coil B (red / blue)	TMC2209 B1 / B2	Colours are for the tested StepperOnline motor
12–24 V supply + / –	VM / GND	Put a $100 \mu\text{F} \geq 35 \text{ V}$ capacitor across VM–GND at the driver
ESP32-S3 3V3 / GND	VDD (VIO) / GND	Common ground with the supply
GPIO 4 / 5 / 6	STEP / DIR / EN	EN low = enabled. Classic ESP32: 25/26/27. Uno: 3/4/5
MS1, MS2	leave open	1/8 microstep = 40 000 steps per output turn

Never plug or unplug the motor while the driver is powered. Set the driver current before running (BTT V1.3: $I_{\text{rms}} \approx 0.71 \times V_{\text{ref}}$; we started at $V_{\text{ref}} \approx 1.4 \text{ V} \approx 1.0 \text{ A}$).

Test sketch: `firmware/CycloidDrive_TMC2209`

No libraries. Open the Serial Monitor at 115200 baud and type:

Command	Does
<code>a 90</code>	Move the output to $+90^\circ$ (absolute)
<code>r -45</code>	Move the output by -45°
<code>s 60</code>	Output speed in $^\circ/\text{s}$ (1–150; tested 10–150)
<code>z</code>	Call this position zero
<code>off</code> / <code>on</code>	Release / hold the motor

Troubleshooting

Symptom	Likely cause	Fix
Tight spot once per output turn	A ring pin not fully seated, or a proud roller	Re-press the pin flush; check every roller drops into its hole
Tight everywhere	Holes printed small (fit test prefers +)	Increase X-Y hole compensation or reprint the discs
Bearings fall out of the seats	Holes printed large (fit test prefers -)	A drop of CA on the outer ring, or reprint with less compensation
Motor skips under load	Driver current too low / speed too high	Raise V_{ref} a little, slow down, add acceleration
More backlash than $\sim 1^\circ$	Undersized pins or worn disc lobes	Use 3.98–4.00 mm ground pins; grease; reprint discs
Cam slips on the shaft	D-flat too short or bore too loose	Check fit-test row 2; the flat must start ≤ 9 mm above the motor face

Safety

A 25:1 gearbox multiplies torque. Keep fingers and cables out of the output while it is powered, clamp the motor down, and start with low current. Printed parts can crack; inspect them and stop if you hear grinding. You assemble and use this at your own risk.

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