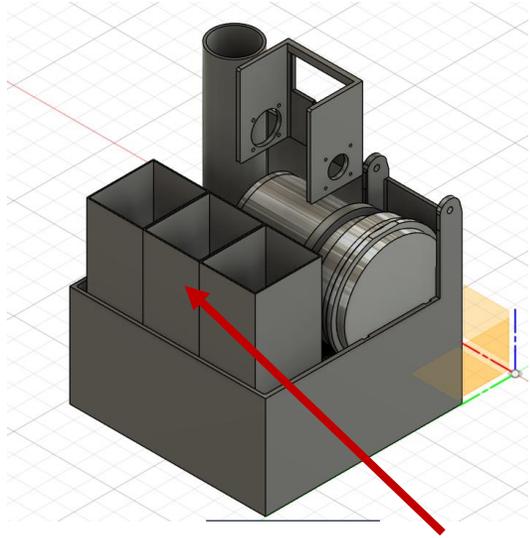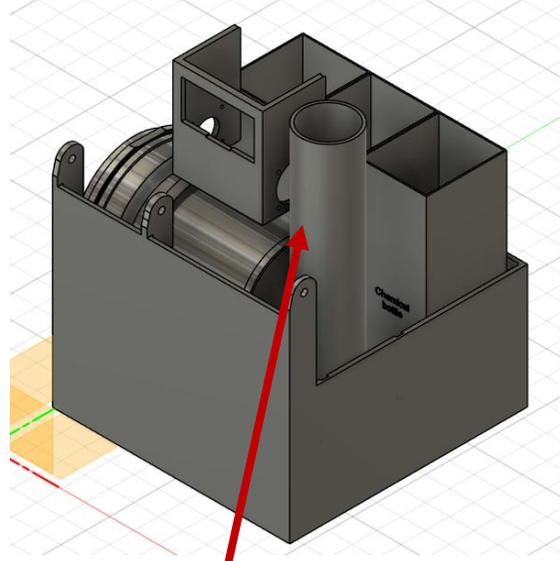# Automated chemical agitation

Purchase chemical bottles (78 mm x78 mm) and sous vide (56mm dia.) carefully making sure they fit in the confined spaces. Sources identified in Bill of Materials.

Chemical bottles place holders

Sous vide tube place holder

As with any electrical device near water, Use only with GFCI circuit!

- By B Marchant brentmarchant1@gmail.com

Quick Start Guide: Automated Chemical Processor
(!IMPORTANT)
ELECTRICAL SAFETY: This device uses electricity near water. **ONLY** plug into a **GFCI-protected circuit** (p. 1).

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1. Preparation Checklist
- **Waterproof Check:** Fill the empty tub with water for **30 minutes** to ensure no leaks before installing electronics (pp. 2, 18).
- **Tank Setup:** Slide the **TPU Paterson Ring** onto your canister; it provides the grip needed for rotation (p. 15).
- **Chemistry Check:** Ensure your bottles are approx. **78mm x 78mm** and your Sous Vide is **56mm** in diameter to fit the slots (p. 1).

2. Rapid Programming (ZK-SMC02)
1. **Enter Setup:** Hold the **Silver Knob** for 3 seconds (Display shows **F-01**) (p. 16).
2. **Set RPM:** Navigate to **F-03** (Forward) and **F-05** (Reverse). Set both to **50.0 RPM** (pp. 16-17).
3. **Set Cycles:** Navigate to **F-06**. Set to **90** for a ~45-minute run (p. 16).
4. **Pulse Calibration:** Navigate to **F-09**. Set to **160** pulses per revolution (p. 16).
5. **Save:** Hold the **Silver Knob** for 3 seconds to exit (p. 16).

3. The "First Run" Sequence
1. **Dry Run:** Place the empty tank on the wheels, lower the **Drive Head**, and press **Run/Stop**. Ensure the tank spins without "walking" off the rollers (p. 19).
2. **Wet Run:** Add water to the tub (level with the top of the axle wheels) and fill your tank with its normal volume (300/600ml) (pp. 4, 19).
3. **Heat Test:** If using a Sous Vide, bring the bath to **38°C (100°F)** to check PETG stability under heat (p. 19).

4. Troubleshooting Basics
- **Motor Vibrates/Hums?** Check the blue terminal block wiring sequence: **Black, Green, Blue, Red** (pp. 9, 18).
- **Tank Slips?** Ensure the **TPU Tire** is clean and the tank isn't floating too high in the water (pp. 18-19).
- **No Power?** Check the **Grey Connector** to ensure the twisted Black (Ground) wires are securely clamped (pp. 10, 18).

Table of Contents

I. Introduction & Preparation

II. Assembly Instructions

III. Electronics & Programming

IV. Troubleshooting & Calibration

Author's Notes

The **automatic agitation film processor** that I developed uses common, easily found parts on Amazon or other online stores. I have gone through several iterations, settling on the simplest unit that does the job and can be mostly printed.

I got the electronics ideas from an online post that I can no longer find. Otherwise, I'd give that person credit for the idea of the stepper motor and associated controller.

The units that I have made have run for many hours but not for extended periods.

Notes: Make sure your printed parts (especially the tub) are waterproof and robust. Start out with your printed tub, placed in a pan that will assure leaked water is contained. If you need to apply a waterproofing to the tub, suggestions online are hot wax dip, epoxy coating, waterproof paint. I used a Gorilla spray waterproofing that didn't work well. Epoxy is probably your best bet. I did have some prints that were waterproof without any extra coating.

There are no warranties or assurances of any type associated with the use of this design. Jump in and have fun with it. Share what you learn with me and other users that have expressed interest on Reddit (r/Darkroom, r/AnalogCommunity).

If you have any questions or problems, post a comment and I'll do my best to help.   I've posted these files for free use. If someone doesn't have a 3D printer, contact me and we'll work something out. (I'm a retired engineer and not trying to make money. This was just a fun project to get in to.)

Files to download:
- This Assembly instruction document (pdf)
- ZK-SMC02 CNC Stepper Motor Driver Instructions from the manufacturer (pdf)
- A bill of materials (.xlsm file)
- STL files.

Tools needed:
2.5mm Allen tool, small Philips head screwdriver
Optional: power drill and 1/16"dia. bit if you add cotter pins to the Top Rod

Brent Marchant 3/10/26
brentmarchant1@gmail.com

Summary of Parts and Tools

- **1. Tools Needed**

- **Assembly Tools:**
  - 2.5mm Allen key (for motor and drive wheel screws) (pp. 2, 7, 11)
  - Small Philips head screwdriver (p. 2)

- **Fabrication Tools:**
  - 3D Printer (for PETG and TPU parts) (pp. 2-3)
  - Metal saw or tubing cutter (to cut rods/axles to length) (pp. 12-13)
  - Wire strippers (to prep the power connector) (p. 9)
  - Optional Drill and small drill bit (optional, for cotter pin holes in top rod) (p. 13)

- **2. 3D Printed Parts**

- **PETG Parts:**
  - Tub (main housing) (p. 3)
  - Vented Head (rotating head) (pp. 3-4)
  - Control Face (pp. 3-4)
  - Drive Wheel (pp. 3, 6)
  - Axle Wheels (4x short shaft, 2x long shaft) (p. 3)
  - Axle Spacers (2x 66 mm) (p. 3)

- **TPU Parts:**
  - Paterson Ring (seals/grips the canister) (pp. 3, 14)
  - Drive Wheel Tire (p. 11) PURCHASED PART, NOT PRINTED

3. Hardware & Mechanical Components
Motors & Motion:
  - Stepper Motor (NEMA 17 or similar with 'D' shaped shaft) (pp. 2, 11)
  - Brass Connector (to adapt motor shaft to Drive Wheel) (pp. 6, 10)
Structural:
  - Metal Rods/Axles (3x total; 2 for bottom wheels, 1 for head hinge) (pp. 3, 12-13)
  - Cotter Pins (optional, 2x for top rod security) (p. 13)
Fasteners:
  - 4x 3mm x 10mm cap head screws (for motor) (pp. 6-7)
  - 4x 3mm x 16mm cap head screws (for fan) (pp. 6-7)
  - 4x 3mm nuts (for fan screws) (p. 7)
  - 1x 3mm screw (for drive wheel/shaft clamp) (pp. 10-11)

4. Electronics & Power
Control:
  - ZK-SMC02 CNC Stepper Motor Driver/Controller (p. 2)
Cooling & Power:
  - Cooling Fan (pp. 4, 7, 9)
  - Power Connector port (DC Jack) (pp. 4, 9)
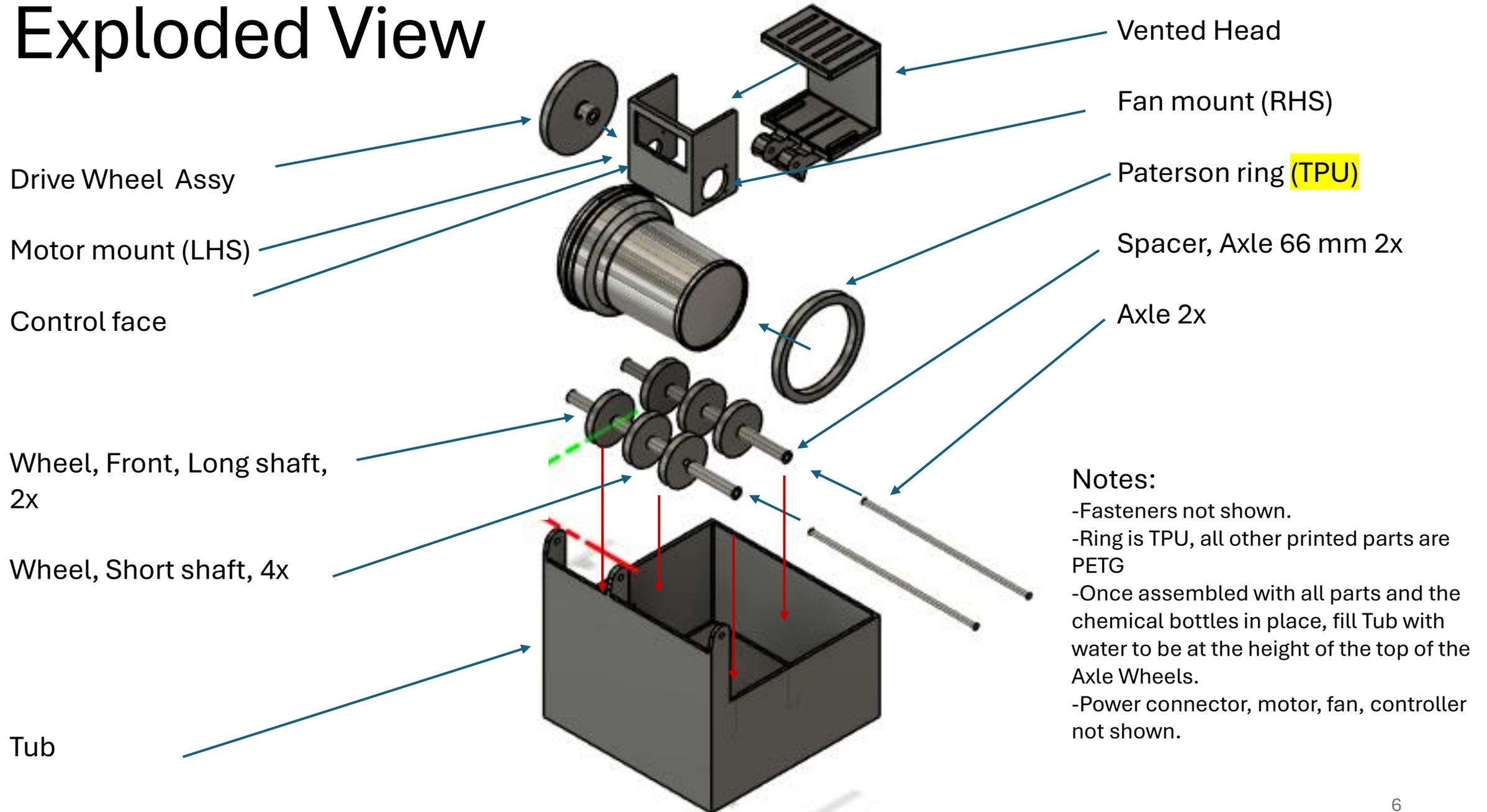 - GFCI Circuit/Outlet (mandatory for safety near water) (p. 1)

5. Finishing & External Items
Waterproofing: Epoxy coating (recommended), hot wax, or waterproof paint (p. 2)
Standard Darkroom Gear:
  - Paterson (or similar) Film Tank/Canister (p. 14)
  - Chemical Bottles (approx. 78 mm x 78 mm) (p. 1)
  - Sous Vide Immersion Circulator (56mm diameter) (p. 1)

Exploded View

Vented Head

Fan mount (RHS)

Drive Wheel Assy

Paterson ring (TPU)

Motor mount (LHS)

Spacer, Axle 66 mm 2x

Control face

Axle 2x

Wheel, Front, Long shaft, 2x

Wheel, Short shaft, 4x

Notes:
-Fasteners not shown.
-Ring is TPU, all other printed parts are PETG
-Once assembled with all parts and the chemical bottles in place, fill Tub with water to be at the height of the top of the Axle Wheels.
-Power connector, motor, fan, controller not shown.

Tub

Main Assembly Summary

1- press the brass connector (not shown) into the Drive wheel so one end is flush with the outer surface.

2- Assemble the stepper motor to the left-hand side (smaller hole) of the Control Face using 4, 3mm x 10mm cap head screws.

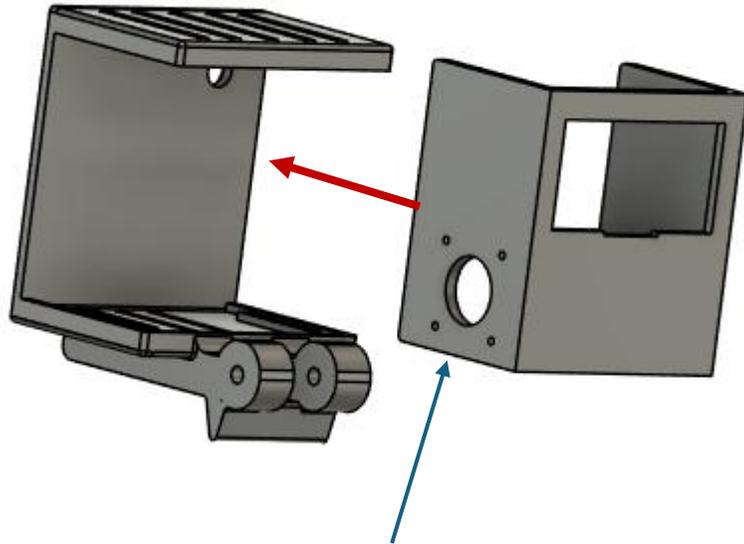3- Assemble the Controller to the front of the Control Face

4- Assemble the fan to the right-hand side (larger hole) of the Control Face using 4, 3mm x 16mm cap head screws.

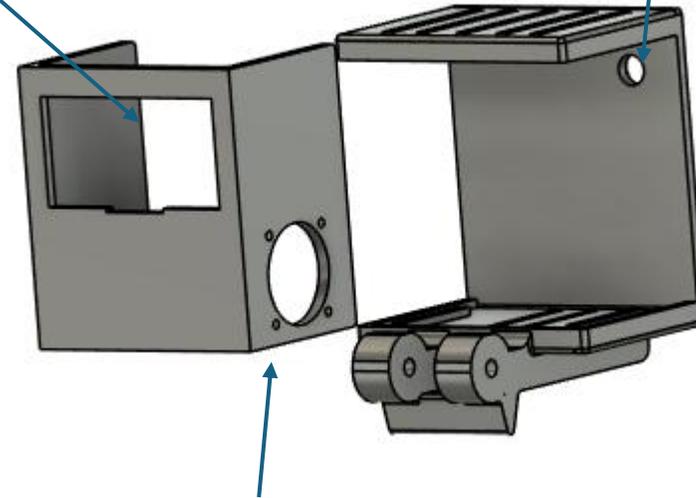5- Assemble the Vented, Rotating Head to the Control Face (snap fit).
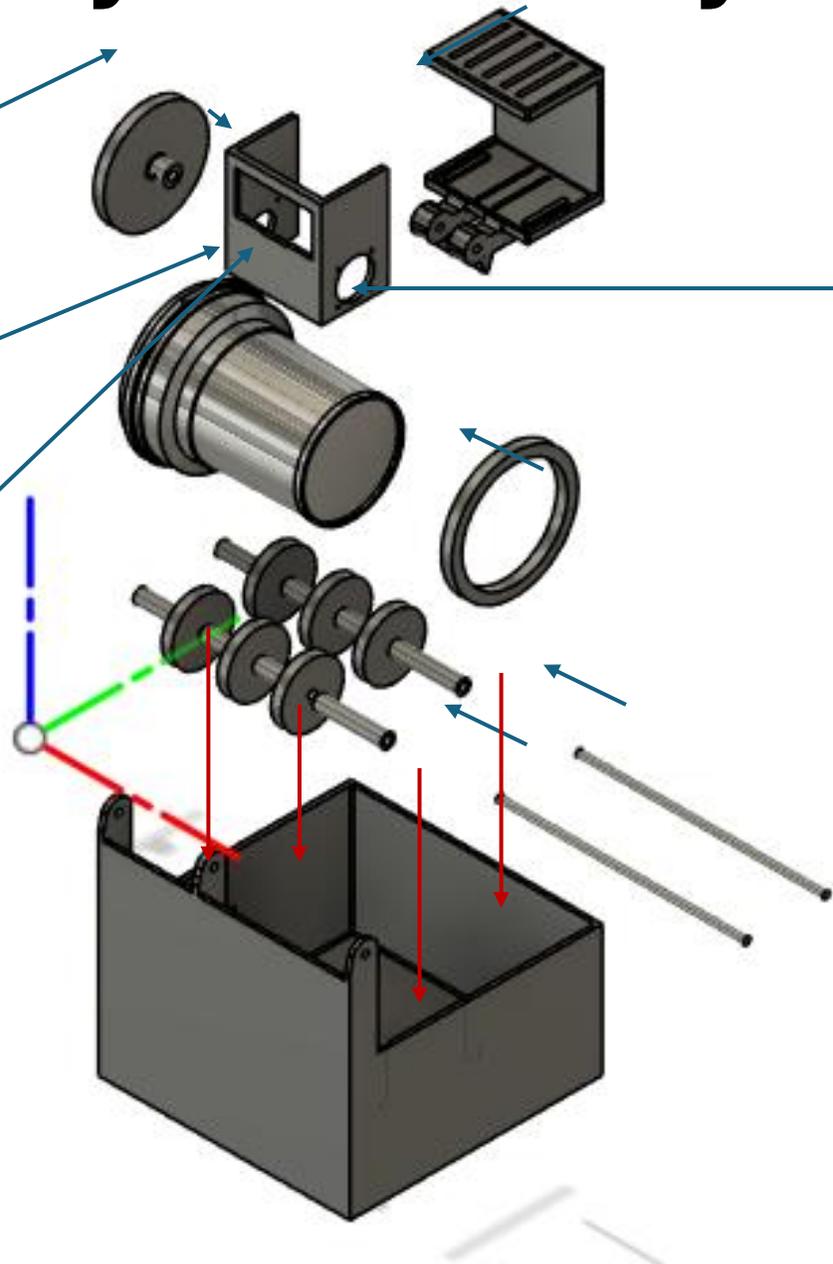
Motor and Fan Housing

Press the Control Face Assy. into the Vented Head. (Snap fit)

Mount Power connector port to the rear side of the Vented Head

Mount Controller to center window of Control Face

Mount motor to LHS of Control Face (small hole)

Mount fan to RHS of Control Face (larger hole)

Motor and Fan Housing-1

Assemble the motor to the left-hand side (LHS) of the Control Face using 4, 3mm x 10mm cap head screws using a 2.5mm Allen key to attach the screws, through the Control Face print, to the motor.
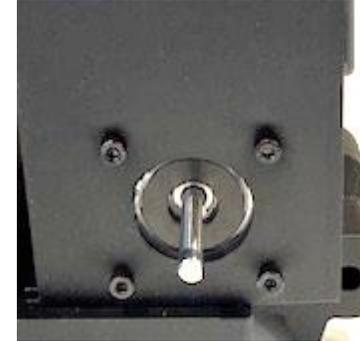
Assemble the Fan to the right-hand side (RHS) of the Control Face using 4, 3mm x 16 mm cap head screws. Use 4 nuts on the back side of the fan to fasten the fan.

Assemble the Controller to the Control Face (snaps in).
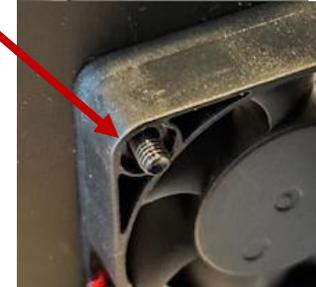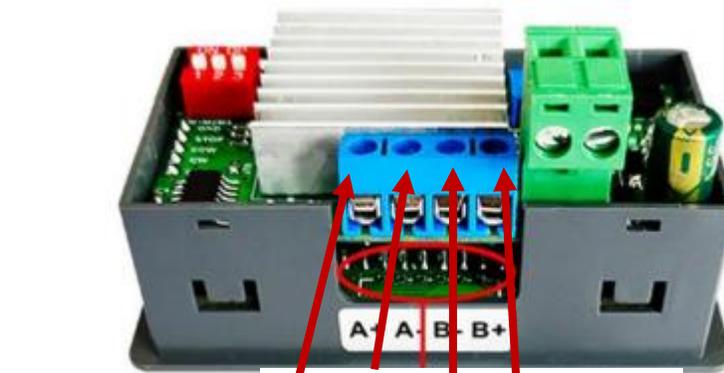
Electrical Connections for Controller to Motor and Fan

Blk Grn Blu Red
1- Motor wire connections to Controller
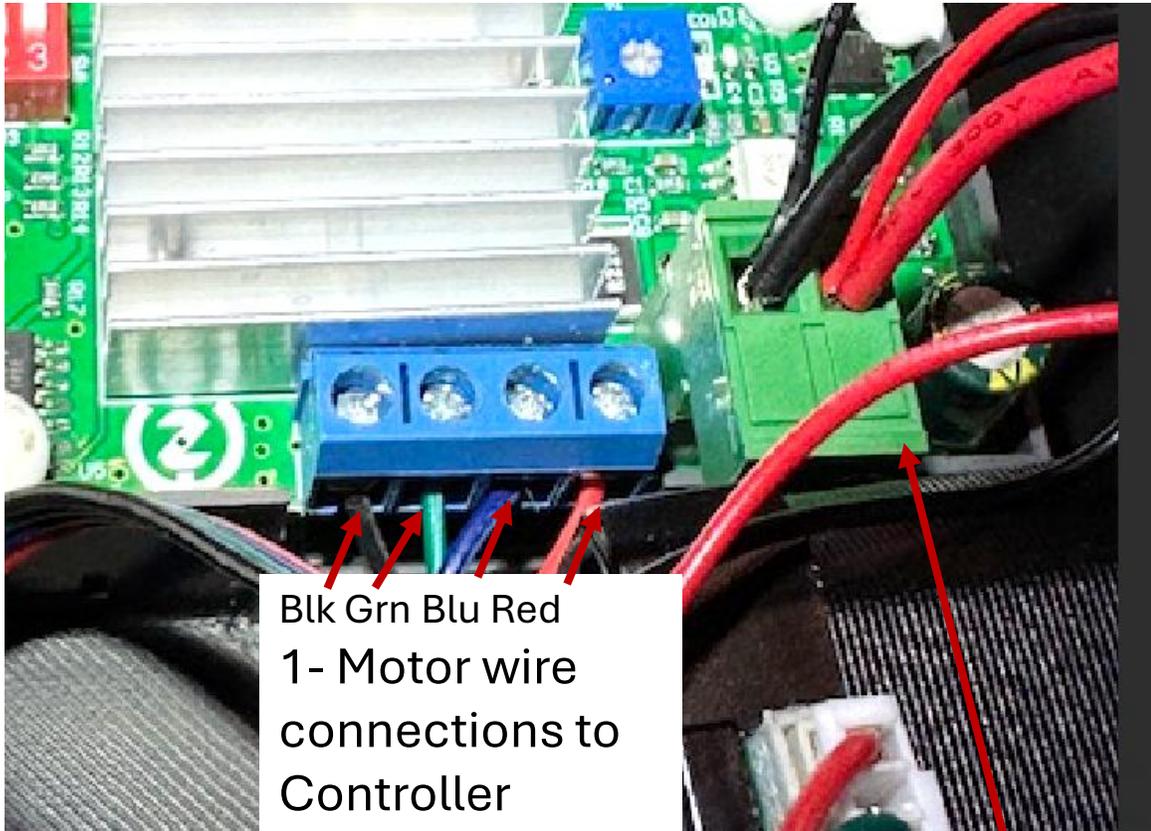
Grey connector

Electrical Connections: Motor to Controller

Blk Grn Blu Red
1- Motor wire connections to Controller

Electrical Connections (continued)

Electrical Connections:

Power Connector and Fan to the Controller

Assemble the Power Connector to the back of the Vented Head. Cut off OEM connector and strip the wire ends.

Twist the Black Power Connector wire to the Black Fan wire and fasten them in the INBOARD slot of the Grey Connector in the Controller.
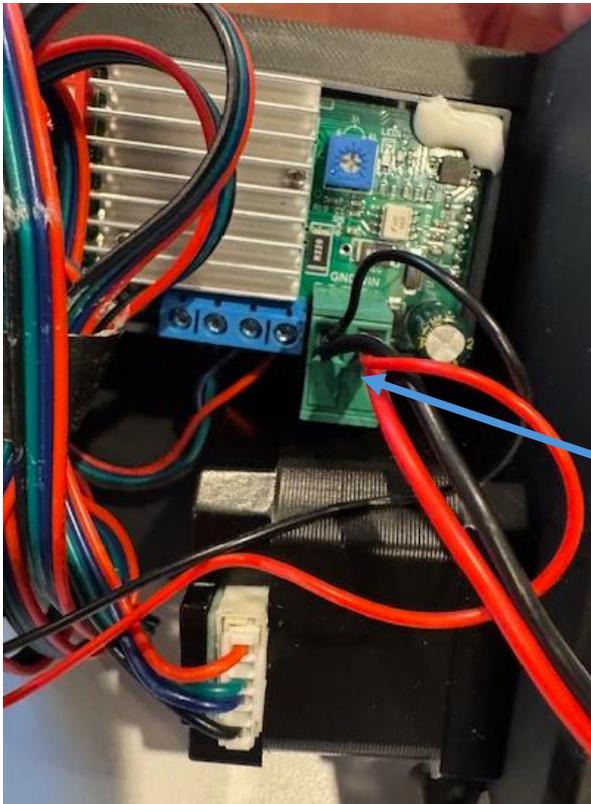
Power connector

Grey connector

Fan & Power Connections to the Controller:

Connect Blk lead from Power Connector to Blk lead from fan and fasten the twisted leads into the INBOARD connection on the grey connector.

Connect Red leads from Power Connector to the OUTBOARD connection on the grey connector

Controller, Motor and Fan Housing Assembly
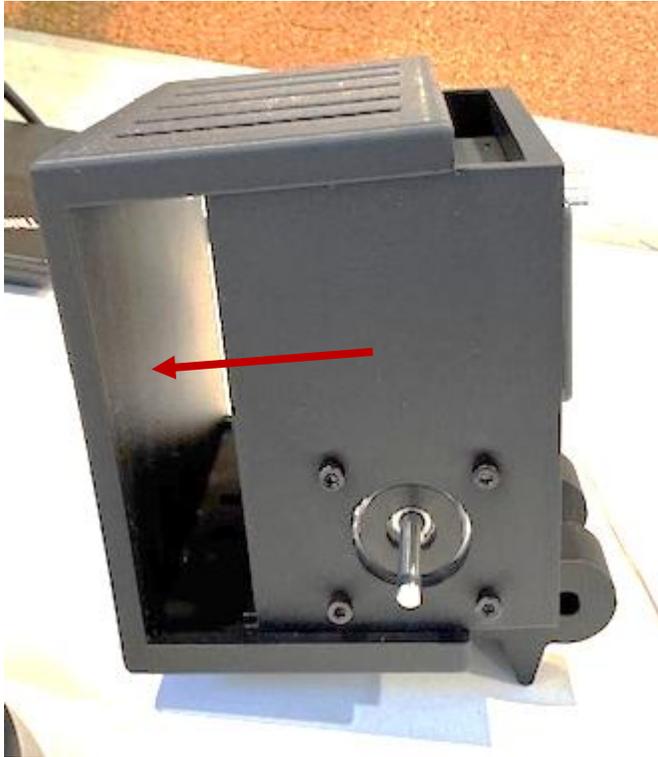
Assemble the Control Face Assy to the Vented head by expanding the Vented Head and pressing the Control Face into it. It will snap into place and be securely held.

Press a Brass Connector into the Drive Wheel center until the connector is flush with the outside of the wheel.
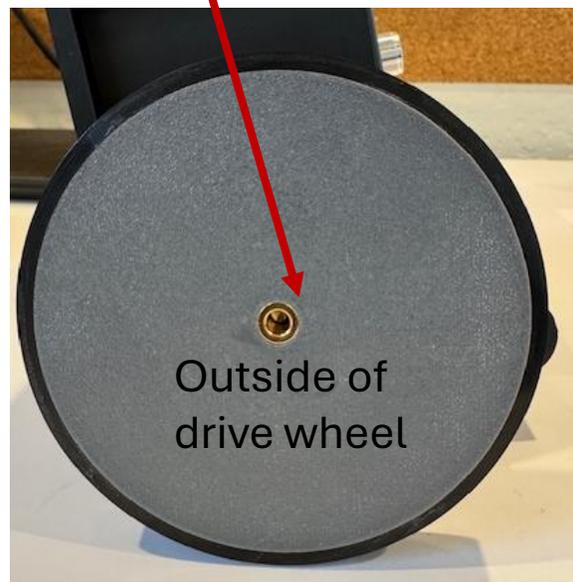
Make sure the brass connector holes align with the Drive Wheel holes to allow a 3mm screw to connect the two parts together

Outside of drive wheel

Inside of drive wheel, connection to motor shaft

Drive Wheel Assembly to Motor

Assemble the Drive Wheel (slip fit) to the motor shaft ('D' shaped) so that the 3mm screw clamps down on the shaft. Tightly fasten the 3mm screw to the shaft, fixing the wheel to the motor.
The Drive Wheel Tire can be pressed onto the wheel. (An adhesive can be used to keep the tire in place but I found that adhesive is not needed.)

'D' shaped shaft
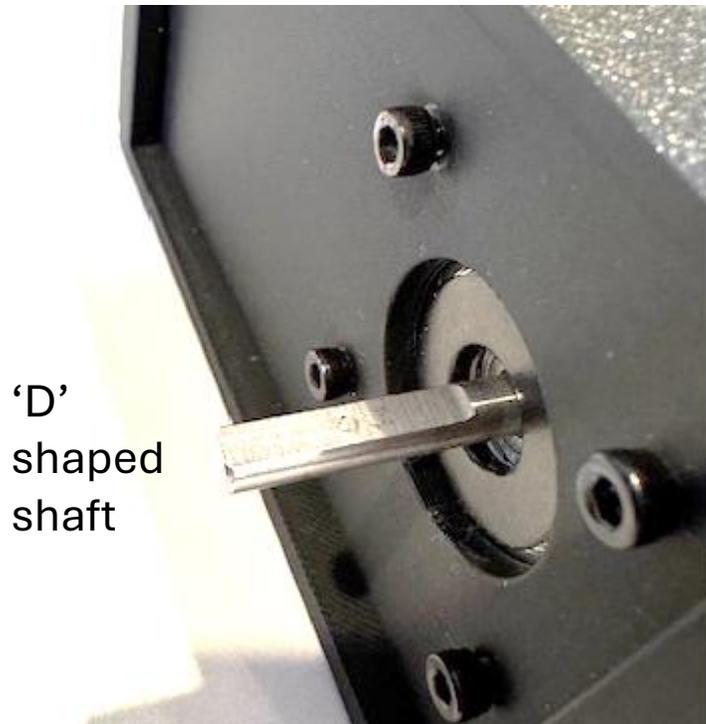
Axles to Tub Assembly

Cut the rods and assemble the wheels and spacers as shown on Page 3 exploded view.

Insert the Rod/Wheel assy. into the vertical slots in the Tub. The rods will slip horizontally into a position that will keep them in place once the water is filled in the Tub. (The plastic wheels tend to want to float the Rod/Wheel assy.)
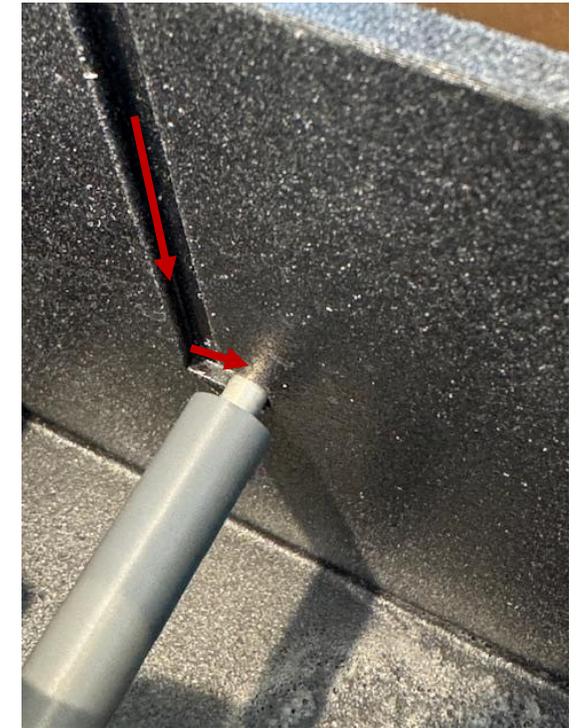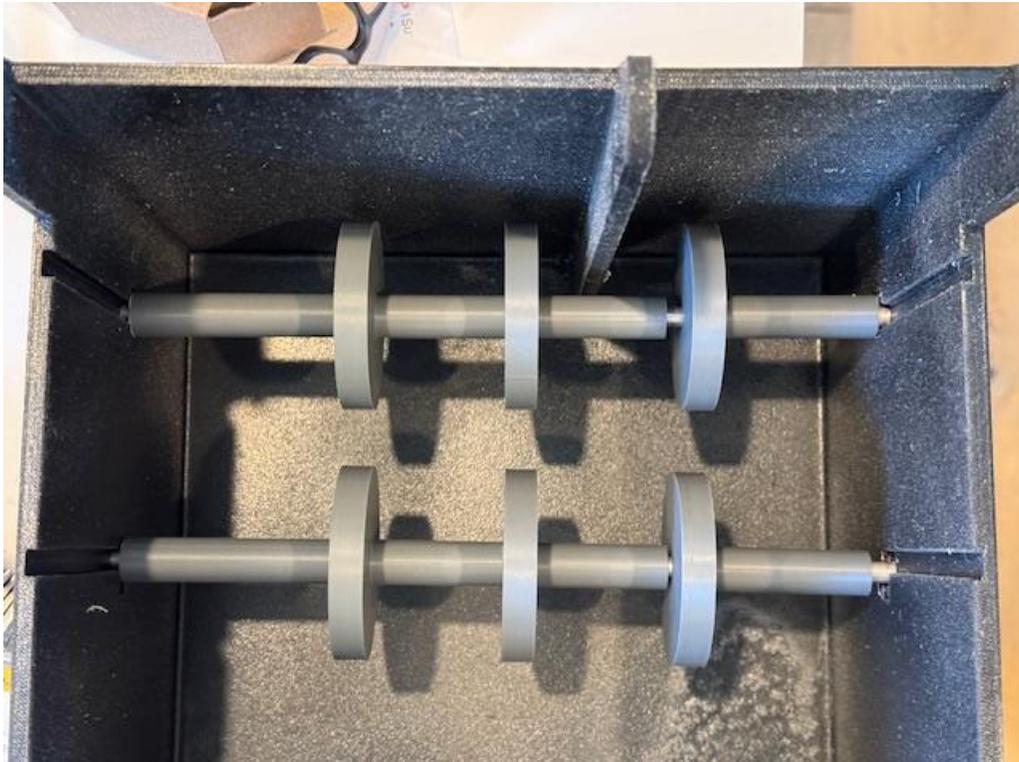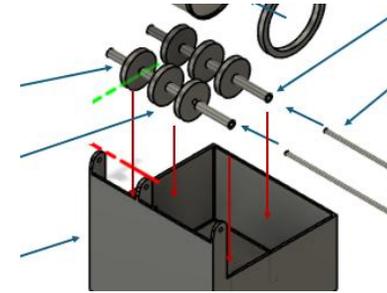
Controller, Motor and Fan Assembly to Tub

Cut the top rod to length or leave it full length. Insert the top rod through the tub vertical holders and through the Stacked Head Assy rotational connectors as shown.

Note that the Stacked Head Assy has a feature that does not allow the Head to rotate downward into the water in the tub.

If you want to secure the rod in place, drill a hole in each end of the rod and insert a cotter pin in the rod. (Preferred but not shown in picture.)
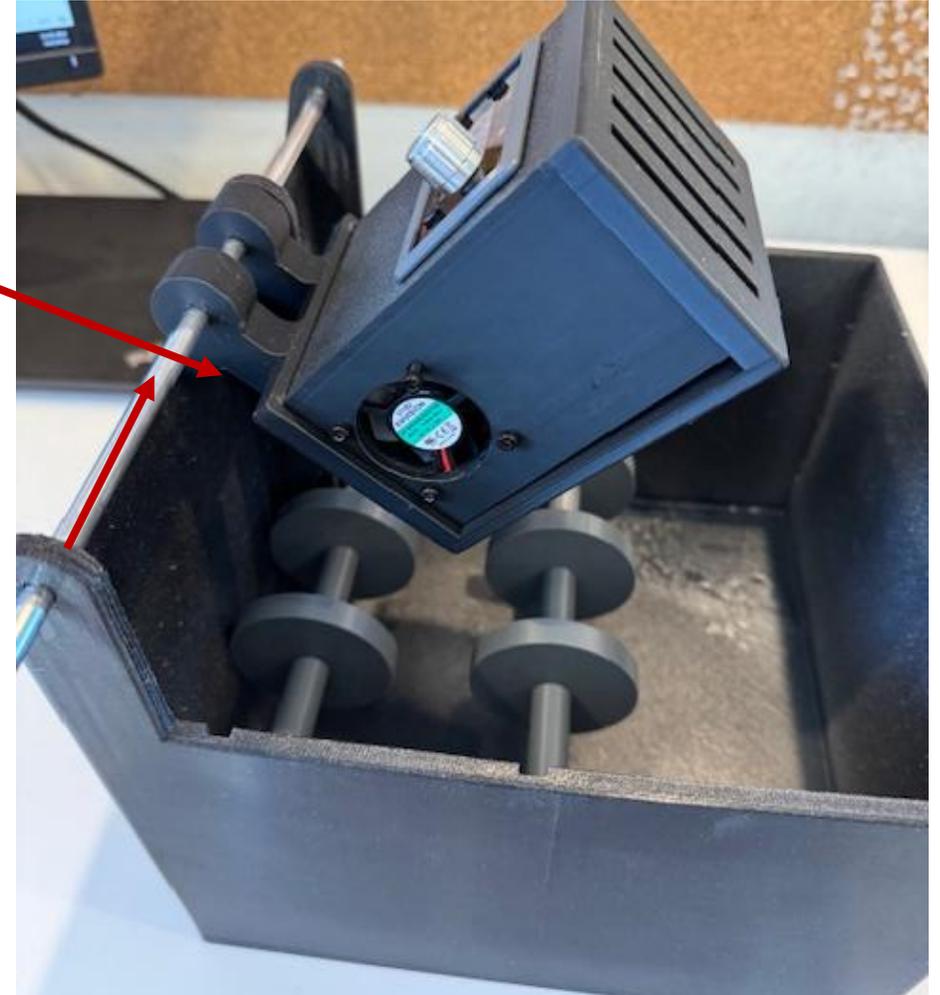
Paterson Ring (TPU) to Canister Assy

Press the Ring into position on the Canister, as shown. This Ring is the only part that is TPU.

You may want to print the Paterson ring slightly smaller if you find that it doesn't stay in place.

This Ring, along with the Axle Wheels keep the Canister in place during agitation.

Controller Programming Instructions: Wordy

Programming instructions PDF in files. Below is a quick summary of steps:

1) Press-hold button on Controller for 3+ seconds to enter programming mode.
    a) Display shows F-0**1,** P06.
2) Twist silver knob to display F-0**3**
    a) Press Run/Stop button to change the display to the desired forward RPM (50.0 RPM is what I've used). Your rotation speed can be whatever you want it to be.
3) Press Run/Stop to display F-0**3**. Rotate the silver knob to change display to F-0**4**.
    a) Press Run/Stop and twist knob to adjust change the display lower value to 9622.
4) Press Run/Stop to display F-04 then twist the knob to show F-05.
    a) Press Run/Stop then twist the knob to adjust the reverse RPM (50.0 rpm is what I've used).
5) Press Run/Stop then twist the knob to show F-06.
    a) Press Run/Stop then twist the knob to show the number of fwd/reverse cycles you desire. I set it at 90 which provides approx. 45 minutes of automatic cycling.
6) Press Run/Stop then twist the knob to F-07.
    a) Press Run/Stop to activate the lower display field and adjust the number to reflect the Forward in-position delay seconds (I used 1).
7) Press Run/Stop to activate the upper display field and adjust the number to F-08.
    a) Press Run/Stop to activate the lower display field and adjust the number to reflect the Reverse in-position delay seconds (I used 1).
8) Press Run/Stop to activate the upper display field and adjust the number to F-09.
    a) Press Run/Stop to activate the lower display field and adjust to 160. (# of pulses for one revolution)
9) Press Run/Stop to activate the upper display field and adjust to F-10. (Sets display parameters)
    a) Press run/Stop and adjust to 1. (upper display line is rotating speed RPM, lower display line is the #of cycles).
10) Press Run/Stop to activate the upper display field and adjust to F- 11.
    a) Press Run/Stop to activate the lower display and adjust to 0 .
11) Press Run/Stop to activate the upper display and adjust to F- 12.
    a) Press Run/Stop to activate the lower display and adjust to 001, the slowest accel/deceleration level.
12) Press-hold the silver knob to save return to normal display mode.

A number or letter in Red indicates that it is blinking at that step.

Summary Controller Programming Checklist. OEM instructions document (PDF) is in the folder.

Pre-Programming Mode
- **Enter Setup:** Press and hold the **Silver Knob** for **3+ seconds**.
  - *The display should show **F-01**.*

Parameter Settings Checklist
Follow these steps in order. Use the **Silver Knob** to navigate between "F" menus and the **Run/Stop** button to enter/edit values.

Menu	Parameter Description	Targeted Value	Done?
F-03	Forward Rotation Speed	50.0 RPM	☐
F-04	Lower Value Adjustment	9622	☐
F-05	Reverse Rotation Speed	50.0 RPM	☐
F-06	Total Cycles (Fwd + Rev)	90 (~45 mins)	☐
F-07	Forward Delay (Pause)	1 Second	☐
F-08	Reverse Delay (Pause)	1 Second	☐
F-09	Pulses Per Revolution	160	☐
F-10	Display Mode	1 (RPM/Cycles)	☐
F-11	Startup Mode	0	☐
F-12	Accel/Decel Speed	001 (Slowest)	☐

Exit and Save
- **Return to Normal:** Press and hold the **Silver Knob** for **3+ seconds**.

Troubleshooting

Before you power up your processor, use this guide to double-check your work. Stepper motor drivers like the **ZK-SMC02** are sensitive to wiring errors, which can cause the motor to vibrate without moving or even damage the controller.

1. Stepper Motor Connections

The document shows a **Black, Green, Blue, Red** sequence on the blue terminal block (p. 8).

- **Identify Coil Pairs:** Stepper motors work in pairs (Coil A and Coil B). If your motor wires aren't the standard colors shown, use a multimeter to find the pairs (a pair will show continuity/resistance, non-pairs will show an open circuit).
- **The "Vibration" Test:** If the motor just vibrates or moves back and forth in place, you likely have one wire from Coil A and one from Coil B swapped. Ensure one pair is in the first two slots and the other pair is in the last two.
- **Direction Issues:** If the motor spins the wrong way, do not rewire the whole thing. Simply **swap the two wires of one coil** (e.g., swap the Red and Blue wires) to reverse the direction.

2. Power & Fan (Grey Connector)

The instructions specify twisting the **Black (Ground)** wires from the power port and fan together into the **INBOARD** slot (p. 9).

- **Polarity Check:** Ensure the **Red (Positive)** wire from your power source goes to the **OUTBOARD** slot. Reversing these can instantly "magic smoke" the controller.
- **The "Tug" Test:** Since you are twisting two wires into one small slot, they can easily slip out. Gently tug on the black wires to ensure the screw clamp is biting into the metal of *both* wires, not just the insulation.

3. Thermal & Mechanical Safety

- **Fan Operation:** The fan should spin as soon as the unit has power. If it doesn't, check that the bare wire ends are actually touching the metal plates inside the grey connector.
- **Binding:** Before turning the motor on, spin the **Drive Wheel** by hand (with power off). It should move smoothly. If it feels "notchy" or stuck, check if the 3mm set screw is hitting part of the 3D-printed housing.
- **The Waterproofing Check:** As noted on page 2, the tub **must** be waterproof (p. 2). Before adding the electronics, fill the tub with water for 30 minutes to check for slow leaks.

Troubleshooting Table

Symptom	Most Likely Cause
No lights on display	Power polarity reversed or loose DC jack connection.
Motor vibrates/humming	One coil pair is split across the connector incorrectly.
Motor skips steps	Mechanical binding or F-12 (Accel) is set too high.
Fan not spinning	Black/Red fan wires swapped or loose in the grey connector.

Dry and Wet Calibration Procedure

To ensure your first run is successful and doesn't end with a leak or a stalled motor, follow this **Dry & Wet Calibration Procedure**.

Phase 1: The "Dry" Mechanical Test

Before adding any water or chemistry, test the mechanical movement.

1. **Tank Placement:** Place your empty Paterson tank (with the **TPU ring** installed) onto the axle wheels.
2. **Engagement:** Lower the **Stacked Head** so the **Drive Wheel** makes firm contact with the tank.
3. **Manual Rotation:** Rotate the drive wheel by hand. The tank should spin freely without "hopping" or slipping.
4. **Power On:** Turn on the controller. The fan should start immediately (p. 9).
5. **Test Cycle:** Press **CW or CCW**. Observe the forward and reverse cycles.

1. *Check:* Does the tank stay centered on the wheels, or does it "walk" toward one side? If it walks, check the alignment of the axle spacers and the Paterson tank Ring(p. 3).

Phase 2: The "Wet" Load Test

Water adds significant weight, which changes how the motor performs.

1. **Fill the Tub:** Fill the tub with room-temperature water until it reaches the **top of the axle wheels** (p. 3).
2. **Check for Leaks:** Let it sit for 10 minutes. Ensure no water is weeping through the 3D print. It is best to contain the unit in a sink or external waterproof container to assure no leakage occurs.
3. **Load the Tank:** Fill your Paterson tank with the volume of water you usually use for film (e.g., 300ml or 600ml).
4. **Calibrate RPM:** Start the cycle.

1. **If the drive wheel slips:** Ensure the tank, wheels, and tire are aligned. Check that the "Stacked Head" isn't being lifted by the buoyancy of the tank or has some interference from stray items.

Phase 3: Thermal Calibration

If you are using a **Sous Vide** for temperature control:

1. **Install Sous Vide:** Place the unit in the tank (p. 1).
2. **Safety Check:** Ensure you are plugged into a **GFCI circuit** (p. 1).
3. **Heat Test:** Bring the tub water to **38°C (100°F)**—the standard for C-41 processing.
4. **Verify PETG:** Watch the 3D-printed parts for any softening. PETG is usually stable at these temps, but it's good to verify the structural integrity under heat.

Final Tip: If you notice the Paterson tank "floating", there is either too much water in the bath (above the tops of the wheels, or there is insufficient chemical in the Paterson tank.