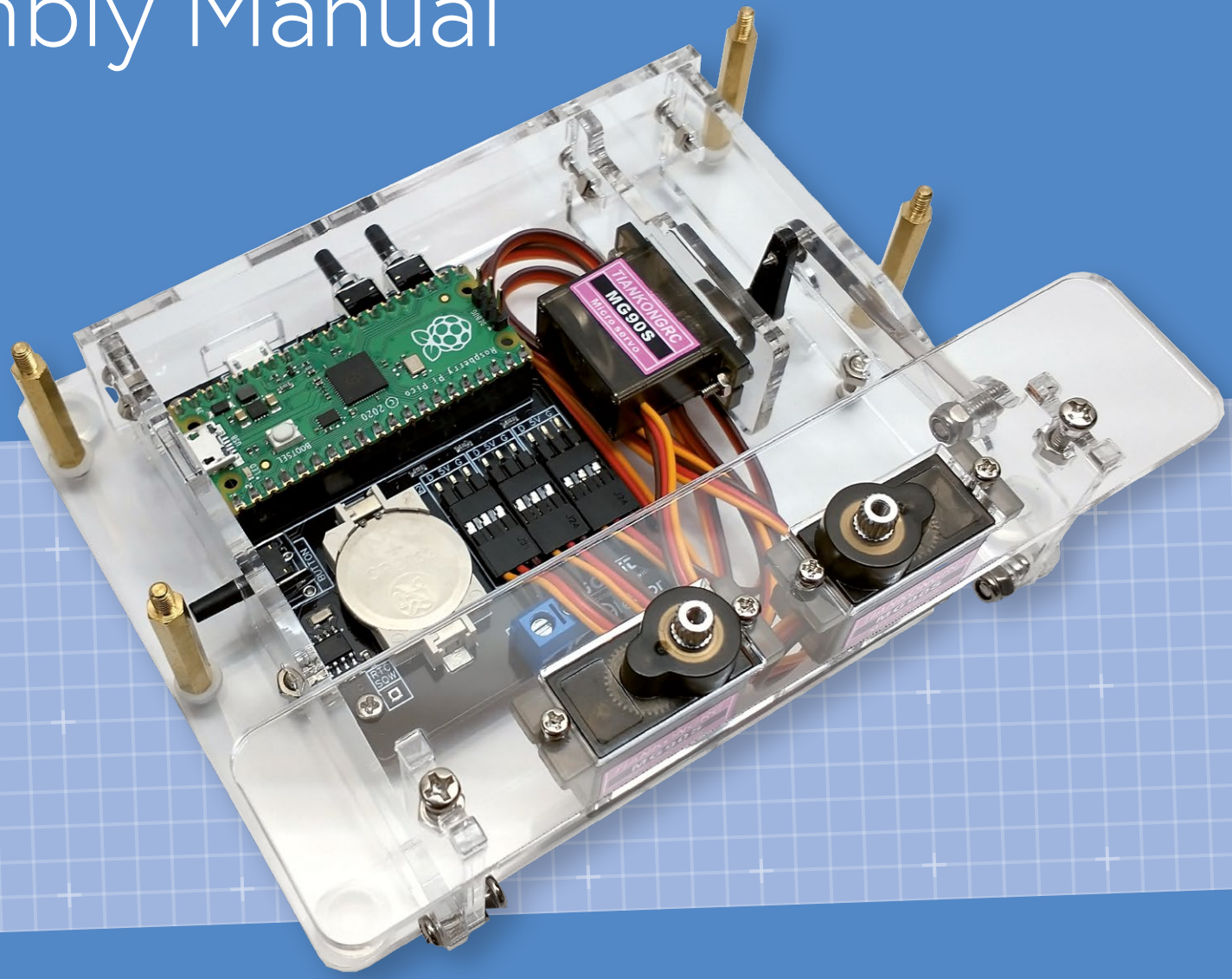
Sand Clock Kit
Assembly Manual



SKU 20679

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Sand Clock Kit
Assembly Manual

Version 1.1 - 2024

Notice

This kit is designed for someone who has intermediate experience with assembling electronics and mechanics.

If you believe that the kit is too complicated for your skill level please do not try to assemble it. Take your time - it takes approximately 1 ½-2 hours to complete this kit.

Ensure your work area is well lit (daylight preferred) and clean.

Assemble the Sand Clock in the order as stated in the instructions - read and understand each step before you perform each operation.

The following tools and materials will be required to assemble the clock:

- A set of pozidrive screwdrivers or a cordless screwdriver with pozidrive bits.
- Long nose pliers.
- Tweezers.
- A pencil sharpener.
- A computer with the Arduino IDE installed.
- A micro-USB power supply 5V/1,5A

In this manual, commands are printed in bold e.g. **svml 1800** (**S**er**v**o **m**ove **l**eft, 1800 microseconds).

The position of a servo motor corresponds with the pulse width of the controlling PWM signal and is expressed in microseconds (µs).

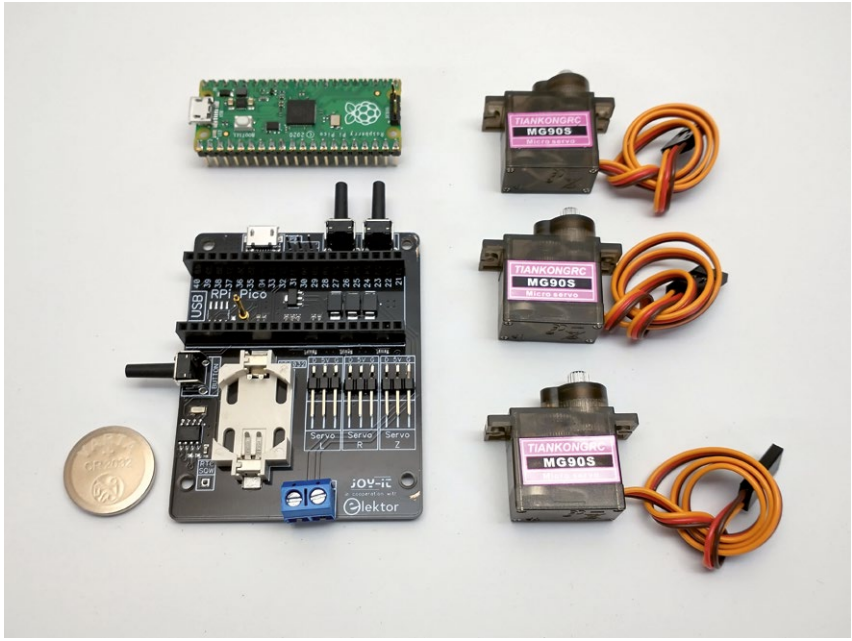
Disclaimer: All pictures are for illustration purpose only. Actual product may vary due to product enhancement.

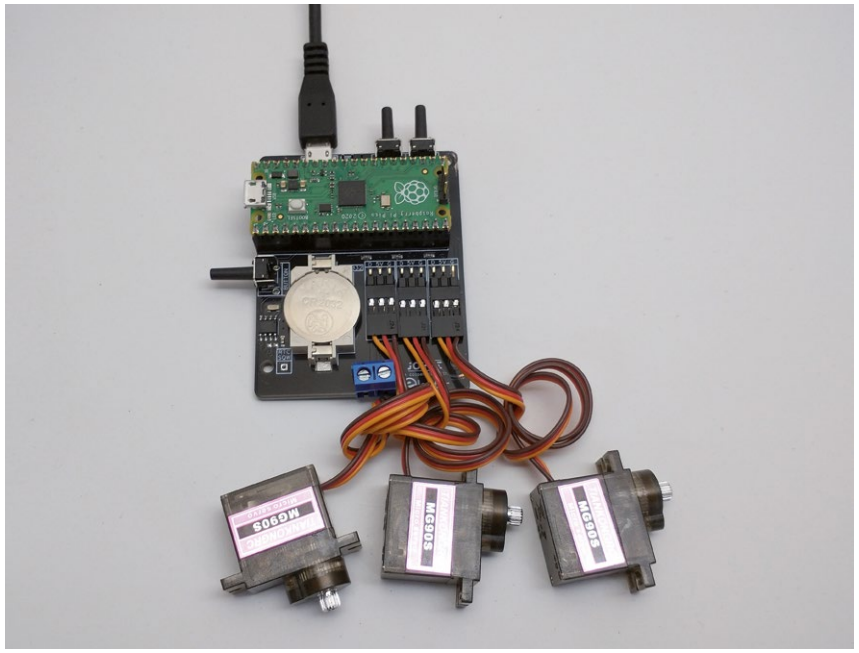
Assembly

Assembling and testing the electronics and servos

Step 1

Attach the Raspberry Pi Pico to the baseboard and connect the three servo motors. The brown wire goes to 'G', the yellow/orange wire goes to 'D'. Insert the CR2032 3V lithium coin cell to the battery holder on the baseboard.

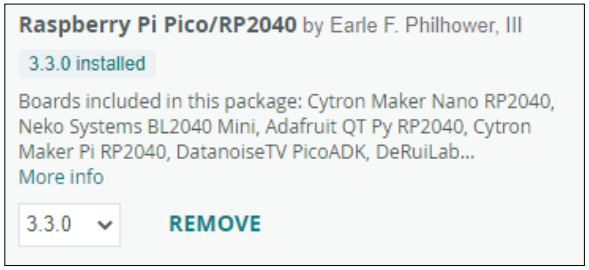


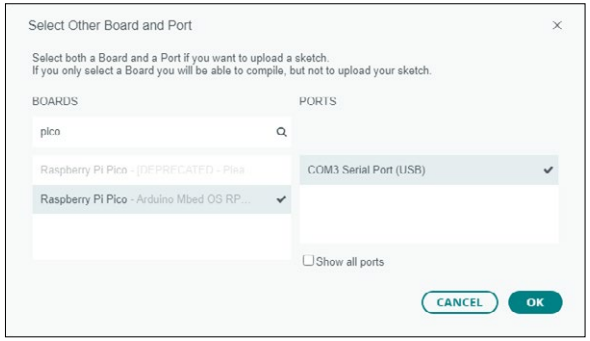


Step 2

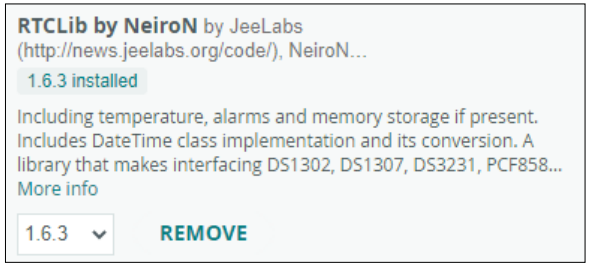
Connect a micro-USB power supply to the baseboard and connect the Raspberry Pï Pico to your PC with the USB cable included in the kit.

You will have to install the boards package "**Raspberry Pi Pico/RP2040** by Earle F. Philhower" in the "boards manager" and select the connected Raspberry Pi Pico and its port.
https://github.com/earlephilhower/arduino-pico





Install the library "**RTCLib by NeiroN by JeeLabs**"
https://www.arduino.cc/reference/en/libraries/rtclib-by-neiron/



Download the program for the Sand Clock from the Elektor website (https://www.elektor.com/20679) and open it in the Arduino IDE. Compile the program and upload it to the Raspberry Pi Pico.

When the sketch starts up, it first checks if there's valid calibration data in the EEPROM. When there's no valid data, which is the case when the Raspberry Pi Pico is used for the first time in a Sand Clock, the sketch drives all three servo motors in the middle position i.e. a pulse width of 1500 µs.

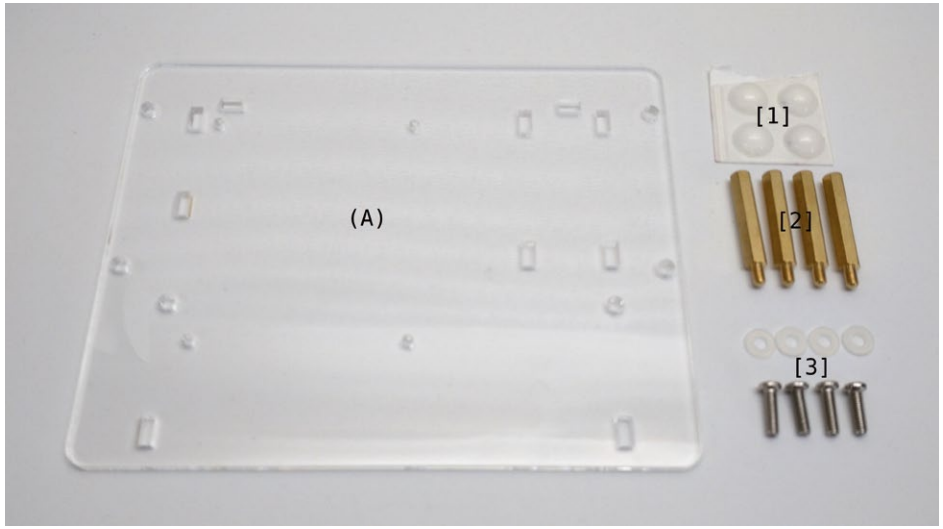
If you wish, you can check the position of the servo motors as follows: open the serial monitor in the Arduino IDE, select a non-empty character sequence as line ending (carriage return, newline/linefeed, or both), and send command **svd**. The response should indicate all three servo motor channels have a pulse width of 1500 µs. If not, you can drive the servo motors in the middle position yourself by sending commands **svml 1500**, **svmr 1500**, and **svmp 1500**.

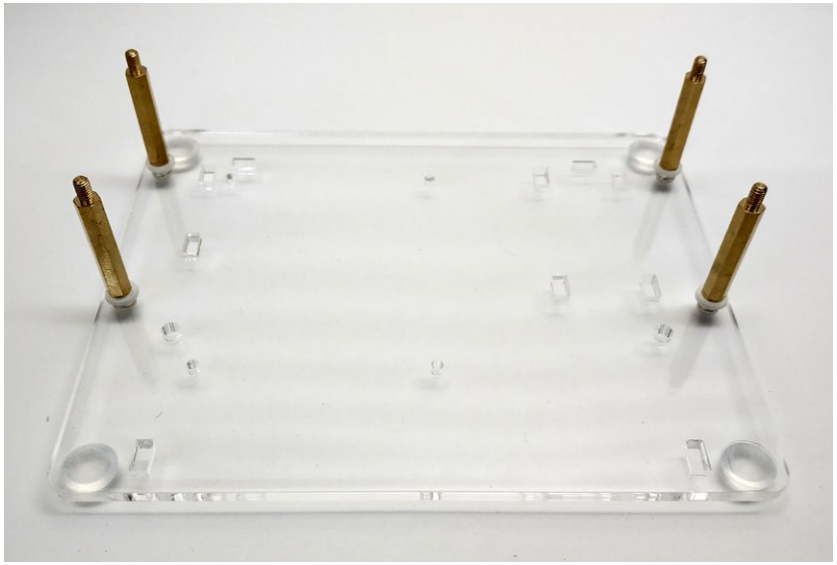
Turn off the power, disconnect the servo motors.

Step 3
Mechanical assembly

Remove the protective film from both sides of the bottom plate (A) and stick 4 adhesive rubber bumpers [1] to the corners. Make sure the orientation of the bottom plate is correct as it is quite difficult to remove and reposition the rubber bumpers in case of an error.

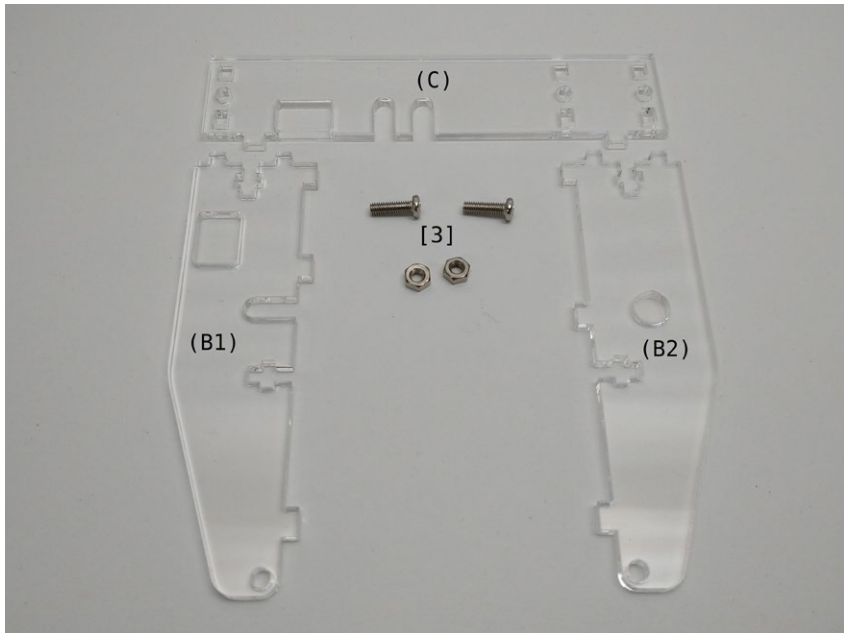
Mount the 4 standoffs [2] for the sand box using M3x10 machine screws [3] and M3 plastic washers [3]. Hand tighten only.

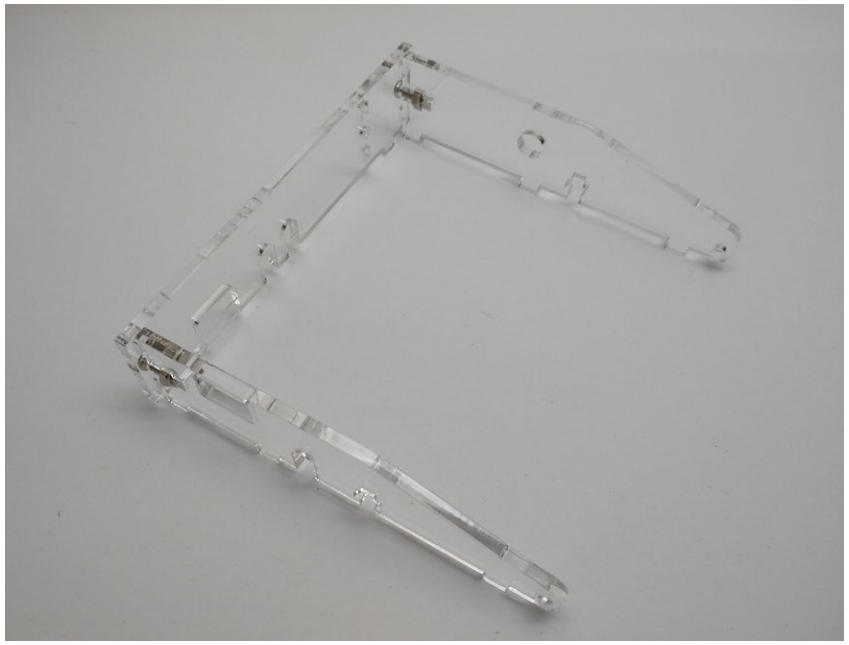




Remove the protective film from both sides of the side panels (B1, B2) and the rear panel (C) of the frame. Screw the panels together in a right angle using an M3x10 machine screw [3] and an M3 nut [3].

Do not over tighten the screws as this may cause the acrylic to break.



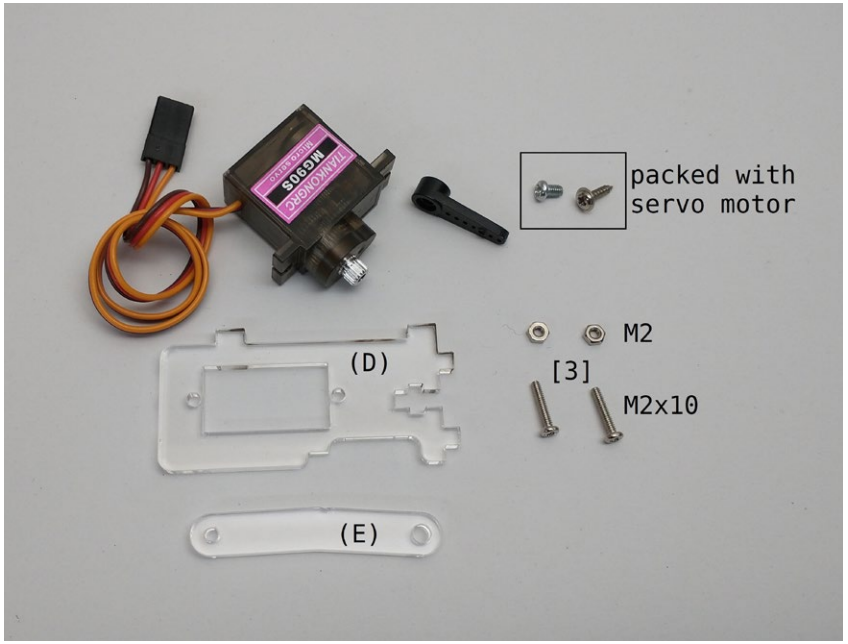


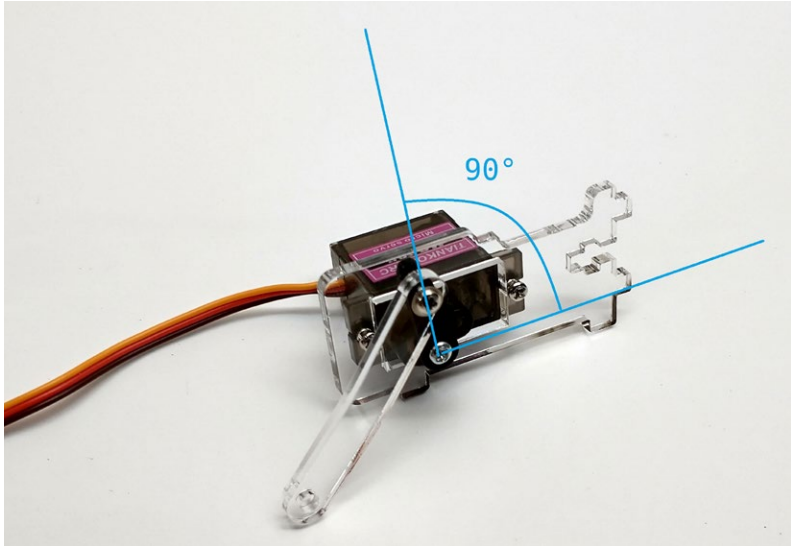
Step 4

Remove the protective film from both sides of the acrylic parts. Attach the lift servo to lift servo panel (D) using two M2x10 machine screws [3] and M2 nuts [3]. Attach the servo arm to the servo shaft using the M2.5 machine screw packed together with the servo accessories.

The servo arm should point more or less upright at an angle of 90 degrees. Don't worry if you can't get it exactly at 90 degrees due to the teeth of the servo shaft and the servo arm.

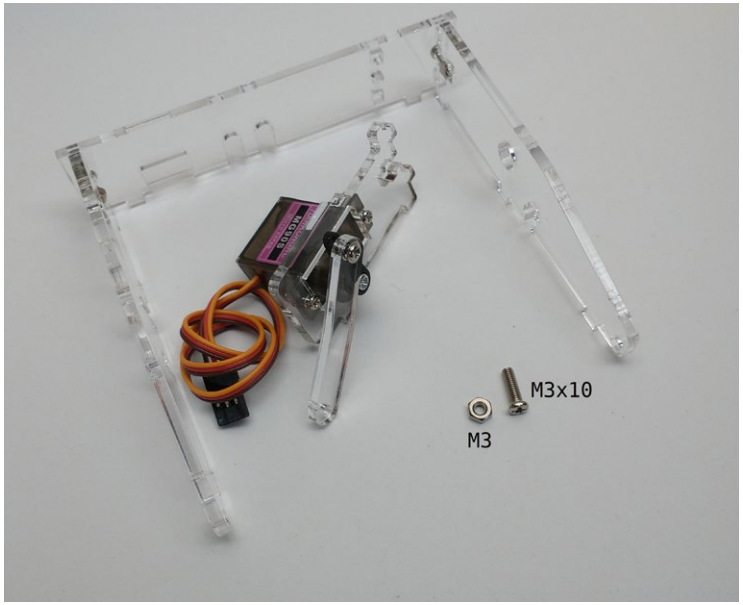
The acrylic lift servo lever (E) has 2 holes. Screw it with the smallest hole to the servo arm using a self tapping plastic screw from the servo accessories bag. Tighten the screw so the lever can turn freely with as little slack as possible. The distance between the center of the servo shaft and the mounting point of the lever should be +/- 13 mm. This is usually the second or third last hole in the servo arm.

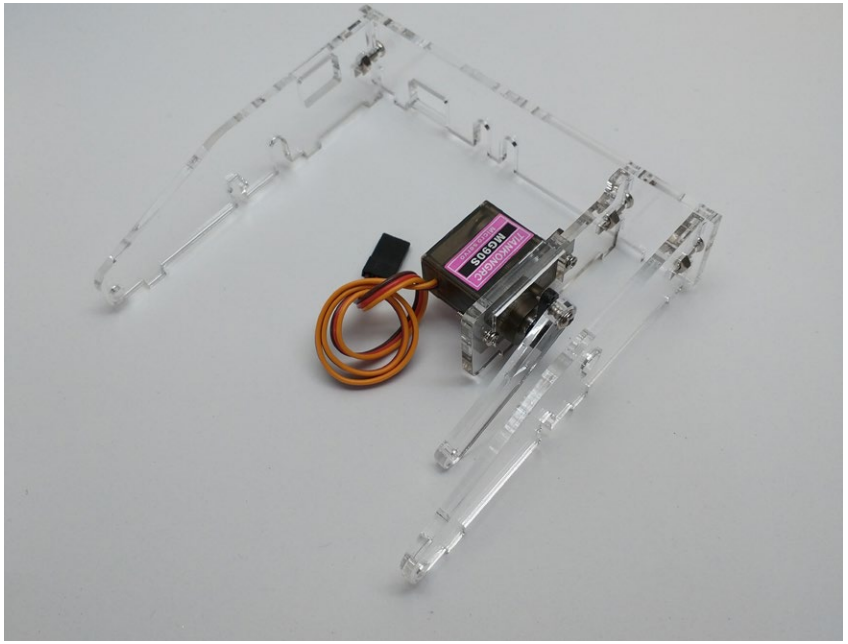




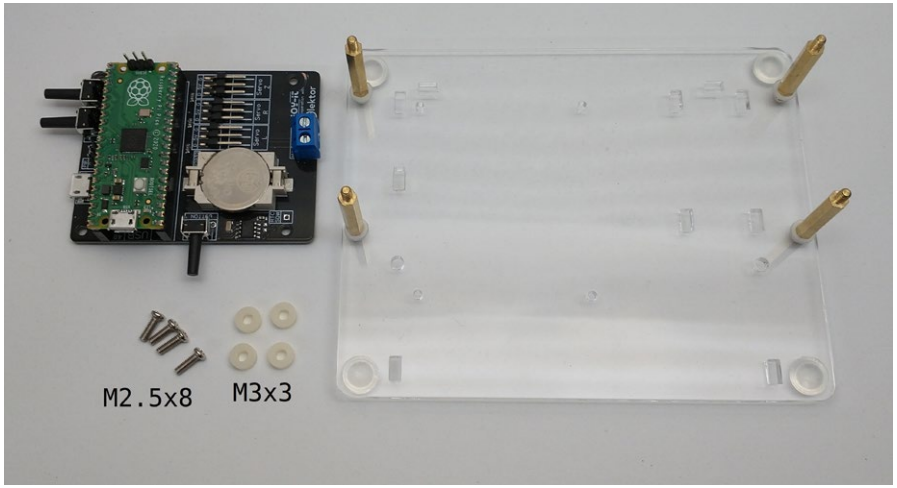
Step 5

Attach the lift servo mechanism to the frame using an M3x10 machine screw and an M3 nut.

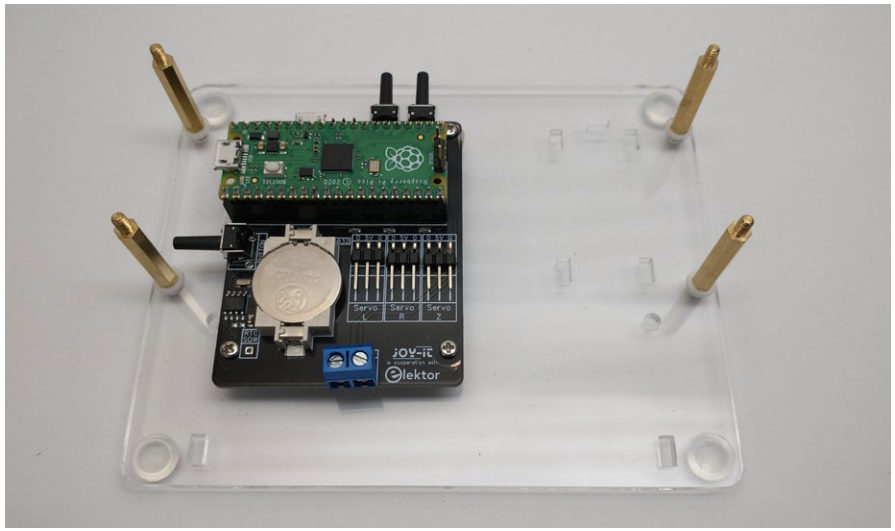


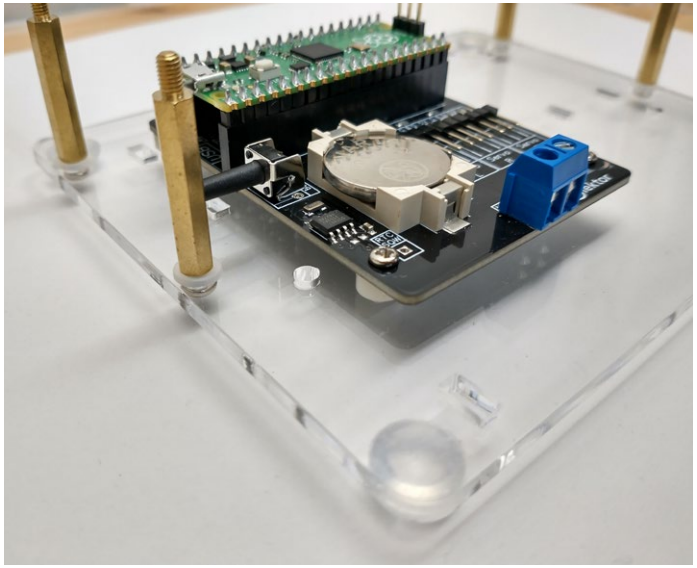


Mount the baseboard to the baseplate using M2.5x8 machine screws and 3 mm plastic spacers. Tighten the screws loosely so the board can still move a bit.

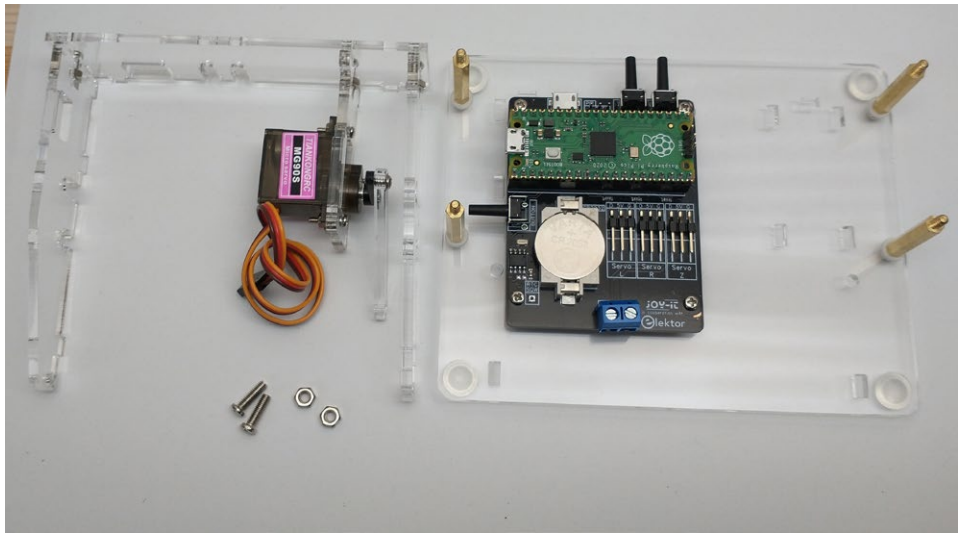


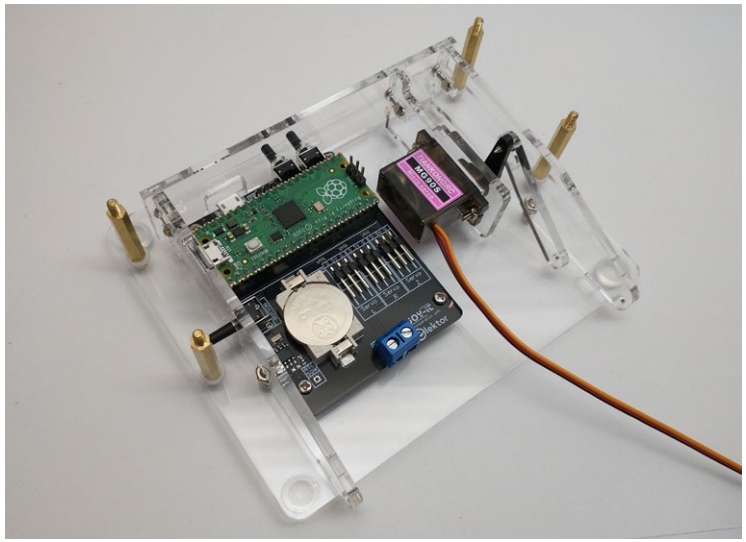
Note that the screws are tapped into the baseplate, nuts aren't required.





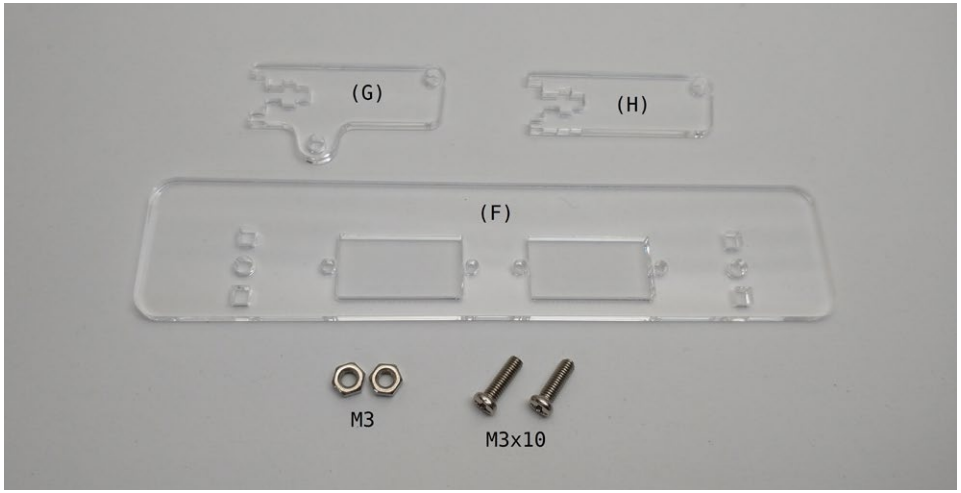
Now attach the frame with the lift servo mechanism to the baseplate using two M3x10 machine screws and an M3 nut . Finally tighten the baseboard mounting screws.

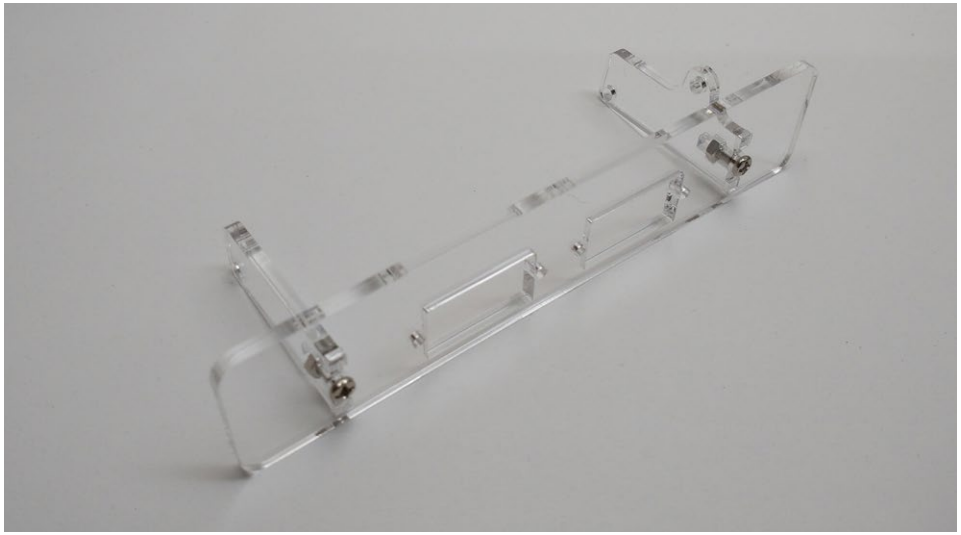




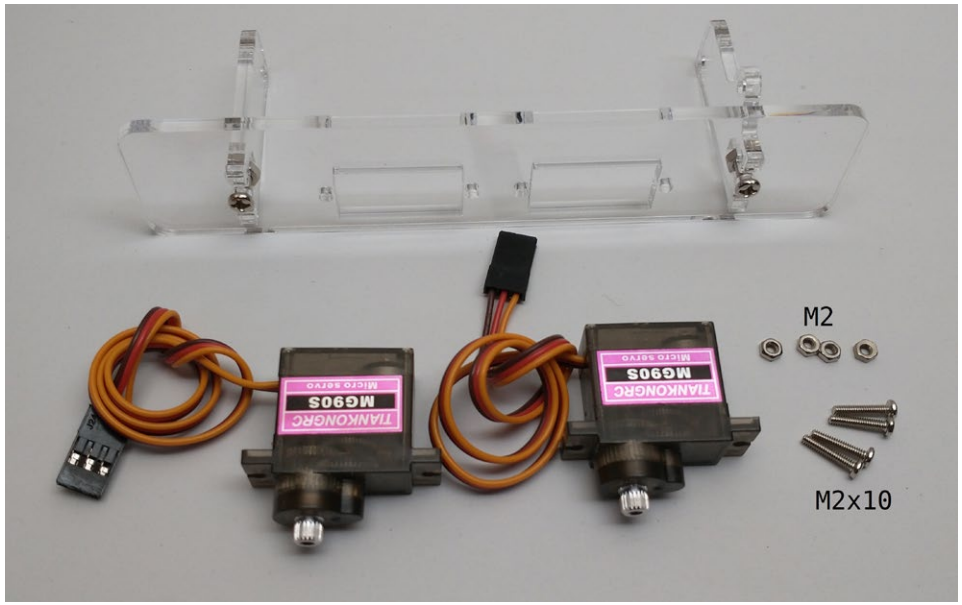
Step 6

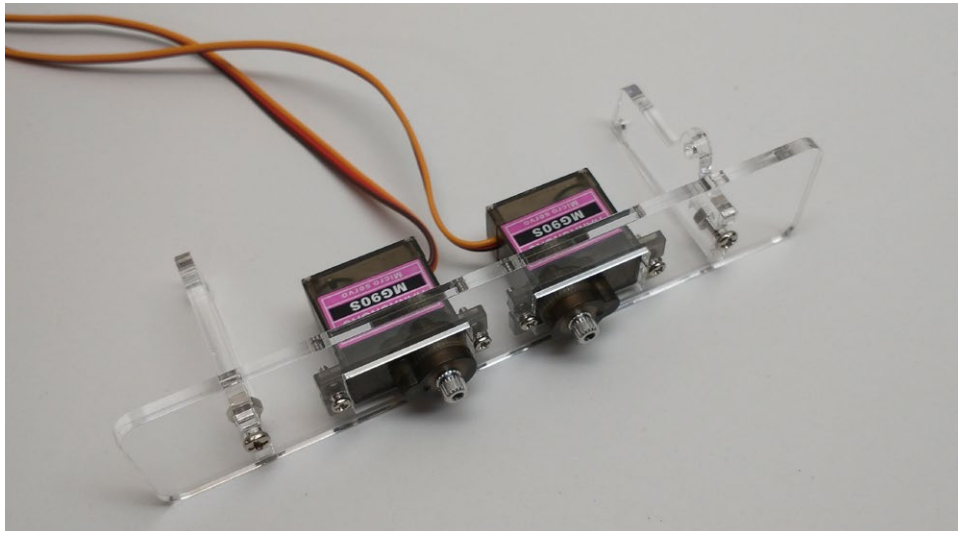
Remove the protective film from both sides of the acrylic parts (F), (G) and (H). Attach the hinges (H) and (G) to the pantograph servo motors mounting plate (F) using M3x10 machine screws and M3 nuts.





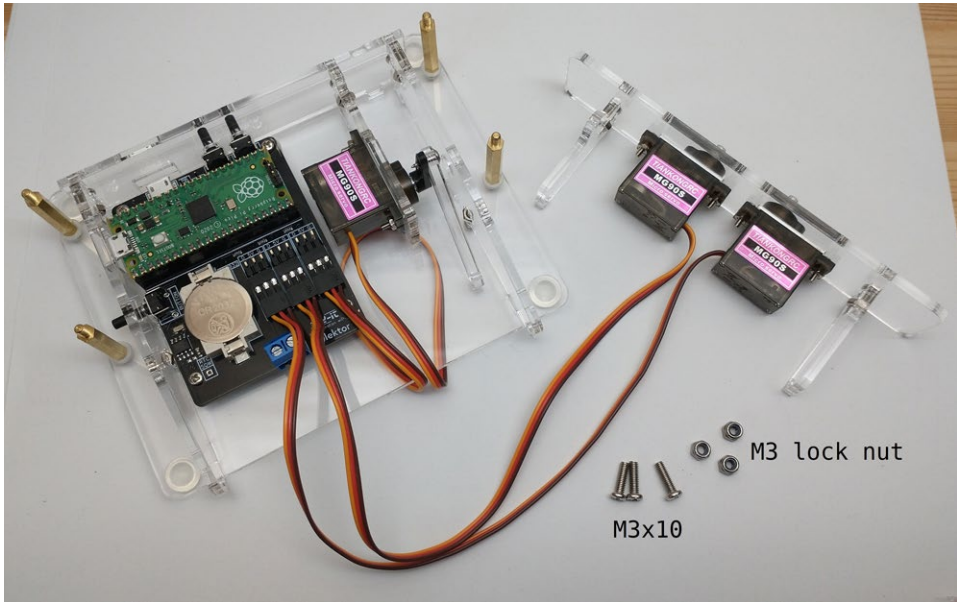
Mount both servo motors using M2x10 machine screws and M2 nuts.

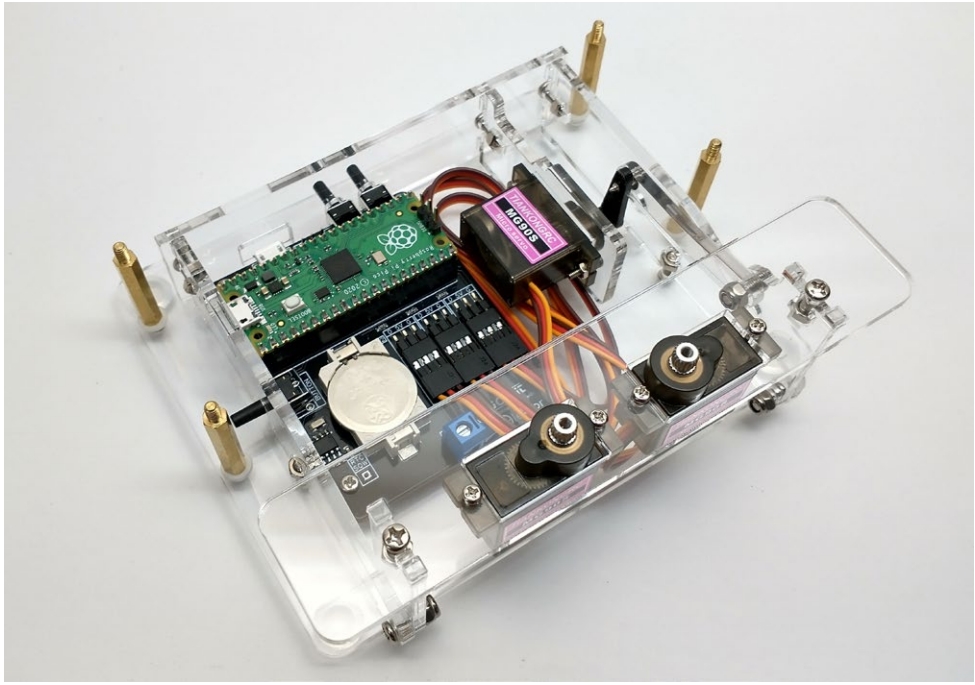




Step 7

Attach the pantograph servo mechanism to the base of the clock using 2 M3x10 machine screws and 2 M3 lock nuts. Tighten the screws so the pantograph mechanism can rotate freely with as little slack as possible. Route the servo wires under the lift servo and connect them to the baseboard. Respect their polarity. Turn the pantograph servo mechanism upright and attach it to the lift servo lever using an M3x10 machine screw and a M3 lock nut. Tighten so the mechanism can operate freely with as little slack as possible.



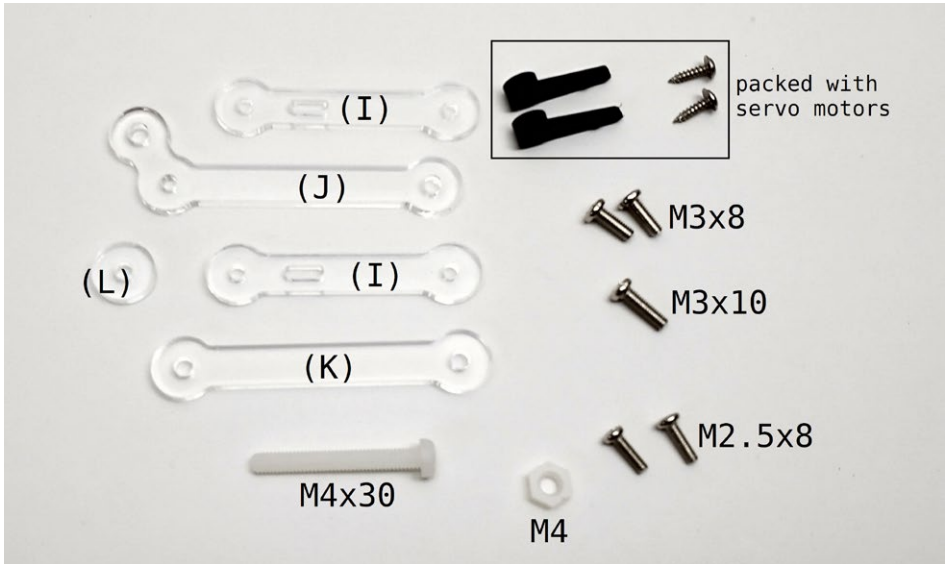


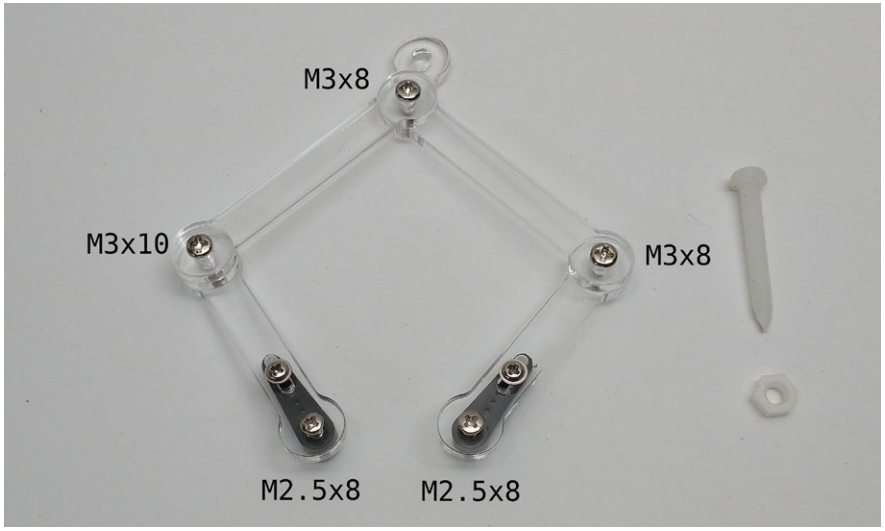
Step 8

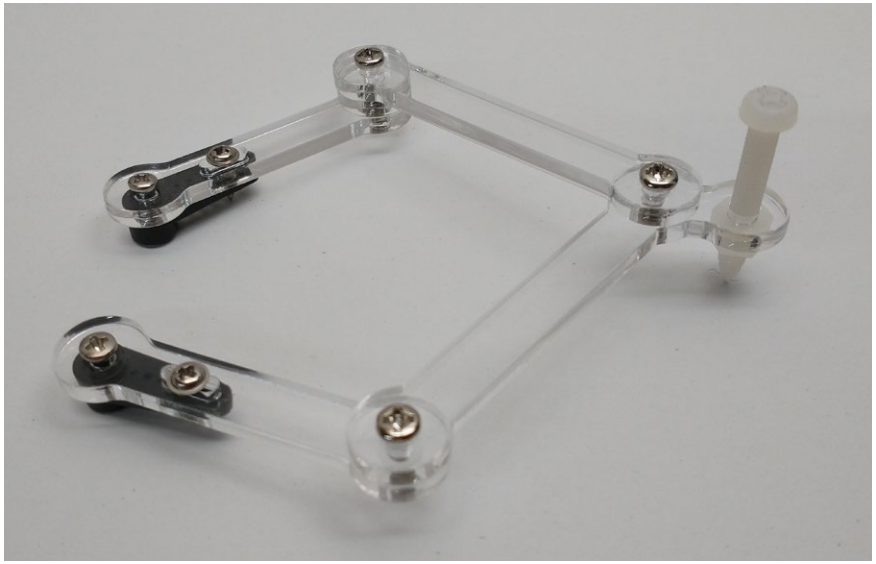
Remove the protective film from both sides of the acrylic parts (I), (J), (K) and (L). Assemble the pantograph arms. Screw part (J) on top of one of the parts (I) using an M3x8 machine screw. Then screw part (K) on top of part (J) using an M3x8 machine screw. Finally screw the other side of part (K) on top of the second part (I) with the round acrylic disc (L) in between using an M3x10 machine screw. Make sure the orientation of part (J) is as shown in the photo.

Tighten the screws so the arms can rotate freely with as little slack as possible. Be gentle and do not use excessive force as the acrylic may break. Finish the assembly of the pantograph arms by attaching the servo arms. Temporarily fit an M2.5x8 machine screw through the holes in the acrylic and the servo horns. Then secure the servo arms to the acrylic arms (I) using 2 plastic screws supplied with the servo motors.

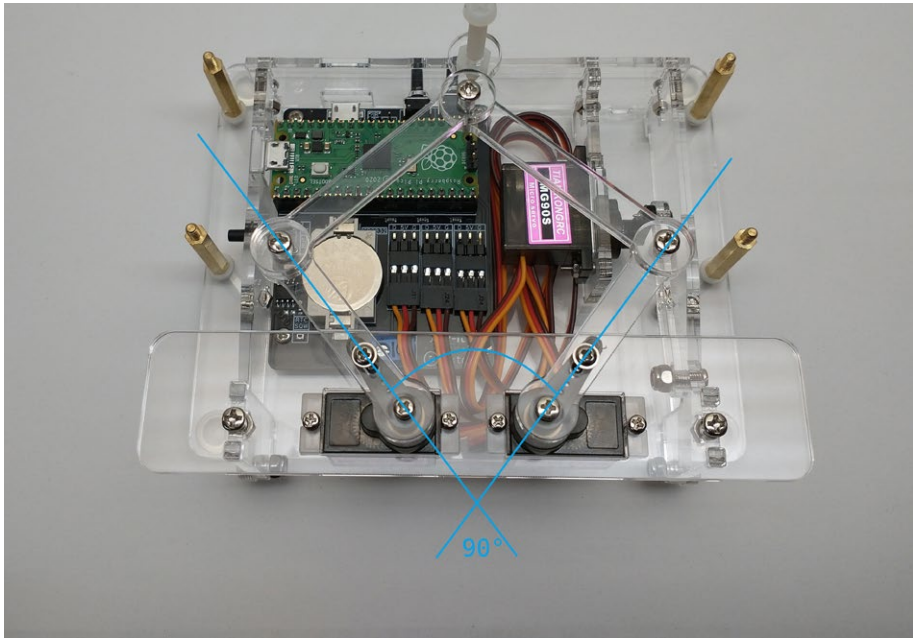
Carefully sharpen the plastic M4x30 machine screw with a pencil sharpener and fit it together with an M4 nut to the pantograph assembly.

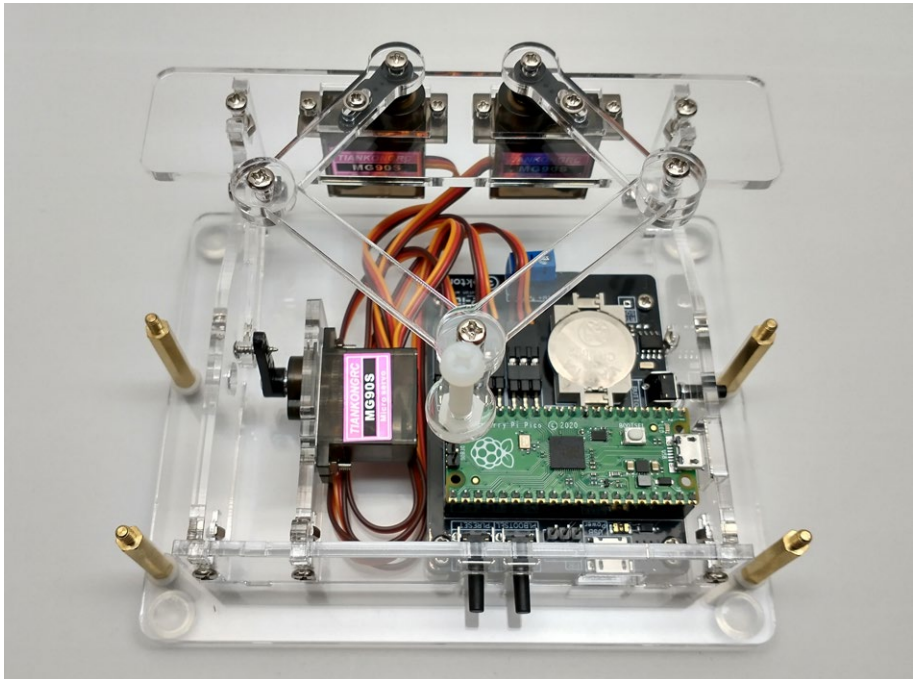






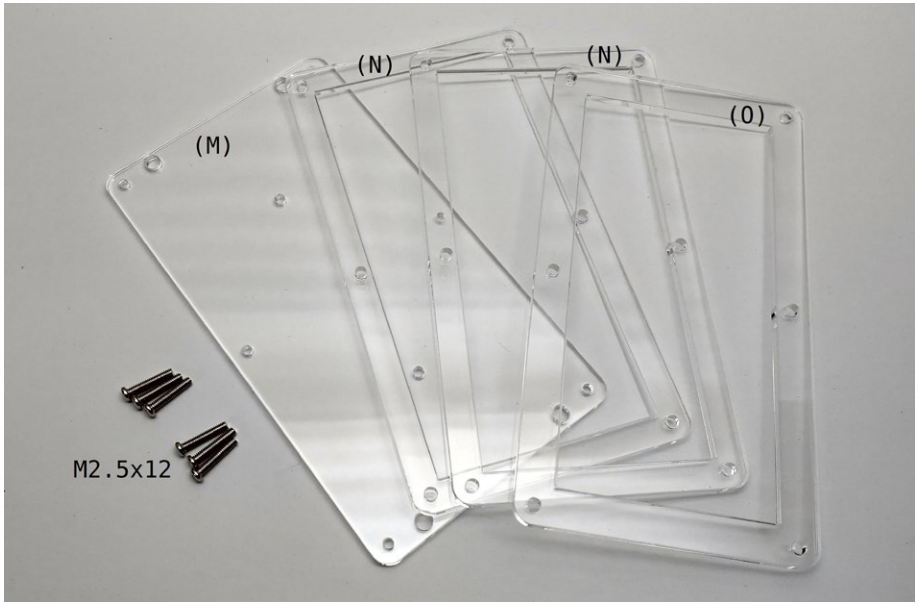
Attach the pantograph mechanism to the pantograph servo motors using the M2.5x8 machine screws. Mount the arms so they form an angle of 90 degrees. Don't worry if you can't position them exactly to 90 degrees due to the teeth on the servo motor shafts and the servo arms. This will be compensated after calibration.

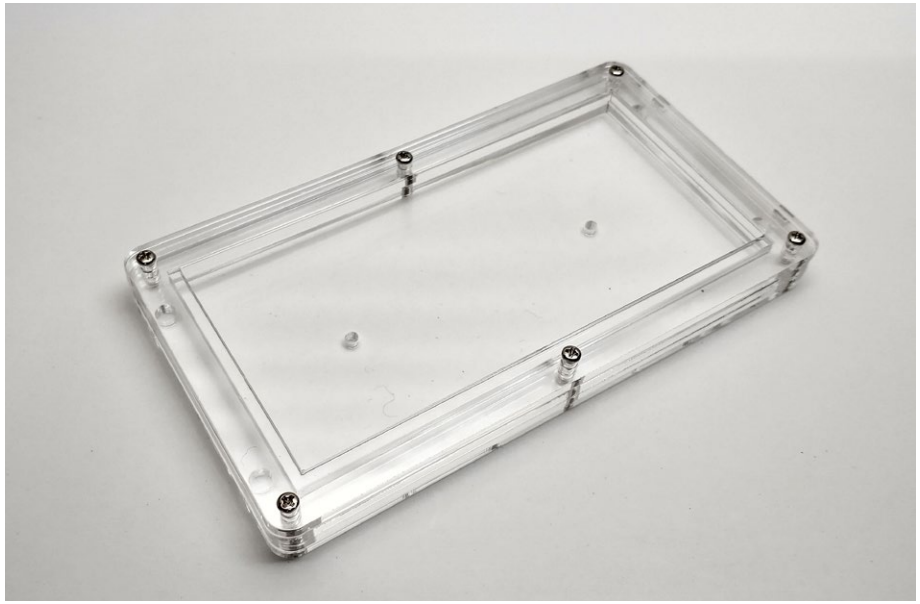




Step 9

Remove the protective film from both sides of the acrylic parts of the sandbox (M), (N) and (O). The part with the widest rim (O) goes on top. Screw the panels together using 6 M2.5x12 machine screws. Make sure the panels are secured firmly against each other without over tightening the screws.





Step 10
Calibration procedure

The calibration procedure involves sending commands to the clock. Connect a micro-USB power supply to the baseboard and connect the Raspberry Pi Pico to the computer with the included USB cable. All servos should now be at 1500 µs (this may not be the case if you've written settings to the EEPROM before).

Open the serial port using Arduino IDE's Serial Monitor. Select a non-empty character sequence as line ending (carriage return, newline/linefeed, or both). Now you're set up to send commands.

During the procedure you can always query the current settings and the position of the servo motors by sending command **sed** and command **svd** respectively.

Calibration steps:

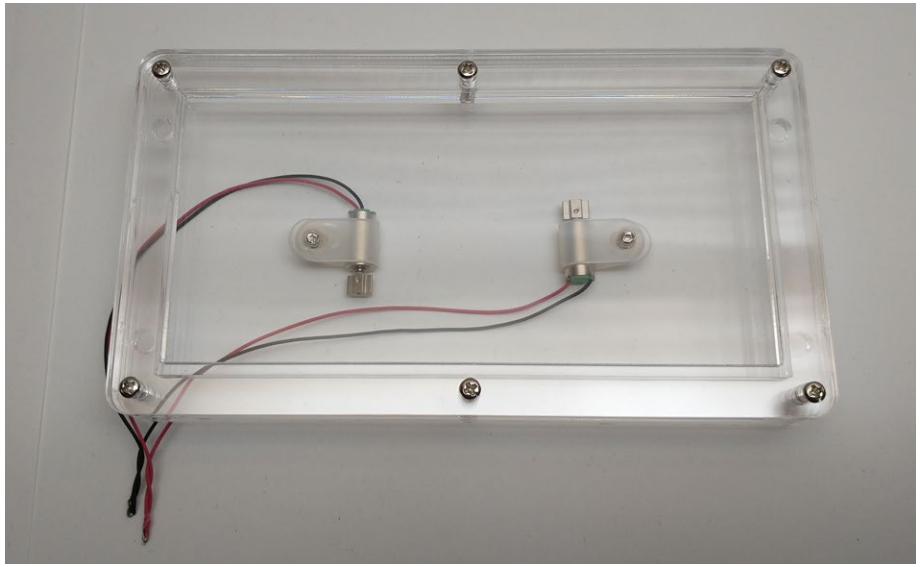
- Move the left servo motor to its vertical position (towards 1000 µs), e.g. **svml 1080**. Send this command with various values until you've determined the most accurate position.
- Store the setting: **svslv**.
- Move the right servo motor to its vertical position (towards 2000 µs), e.g. **svmr 2050**. Send this command with various values until you've determined the most accurate position.
- Store the setting: **svsrv**.
- Move the left servo motor to its horizontal position (towards 2000 µs), e.g. **svml 1940**. Send this command with various values until you've determined the most accurate position.
- Store the setting: **svslh**.
- Move the left servo motor back to its vertical position using **svml** with the value previously determined earlier. You can query the correct value using **sed**.
- Move the right servo motor to its horizontal position (towards 1000 µs), e.g. **svmr 1080**. Send this command with various values until you've determined the most accurate position.
- Store the setting: **svsrh**.
- Move pen up: **svmp 2000**.
- Set pen position: **ps 0 40**.
- Place the partially finished sandbox on the standoffs and make sure it lies perfectly flat on all 4 standoffs. In case the sand box wiggles on the standoffs, twist it slightly diagonally until it lies perfectly flat.

- Move the pen servo motor to the down position (towards 1500 µs), e.g. **svmp 1525**. Send this command with various values until you've determined the most accurate position. The clock moves to pen to the down position when it wants to write something in the sand. The pantograph arms should be perfectly horizontal and the tip of the pen should hover approximately 1 – 2 mm above the bottom of the sandbox. If necessary, mechanically adjust the pen by screwing it up or down. Use the M4 nut to lock it in place.
- Store the setting: **svspd**.
- Check the pen down position in relation to the sandbox:
  - Pen position 1: **ps 0 30**.
  - Pen position 2: **ps 0 55**.
- Adjust the pen servo motor if needed.
- Set the pen in a neutral position: **ps 0 40**.
- Move the pen servo motor to the middle position (towards 1800 µs), e.g. **svmp 1700**. Send this command with various values until you've determined the most accurate position. The clock moves the pen to the middle position when it needs to move the pen above the sand between continuous strokes.
- Store the setting: **svspm**.
- Move the pen servo motor to the top position (towards 2100 µs), e.g. **svmp 2150**. Send this command with various values until you've determined the most accurate position. Your goal is to move the pen to highest position possible (servo horn in line with the acrylic lever). The clock moves the pen to the top position when it's not writing the time.
- Store the setting: **svspu**.
- Set the vibration period (seconds), e.g. **vms 5**.
- Review the settings with sed. Modify settings if needed. Note that start-up program mode should be set to **command**. Don't change the mode at this point.
- Store settings in EEPROM: **sew**.
- Set date and time in realtime clock, e.g. **cw 2024 08 27 18 40 00**. Note that a CR2032 battery must be installed.
- Check date and time with **cr**.
- Lift pen up with **plu**.
- Power off the sand clock.

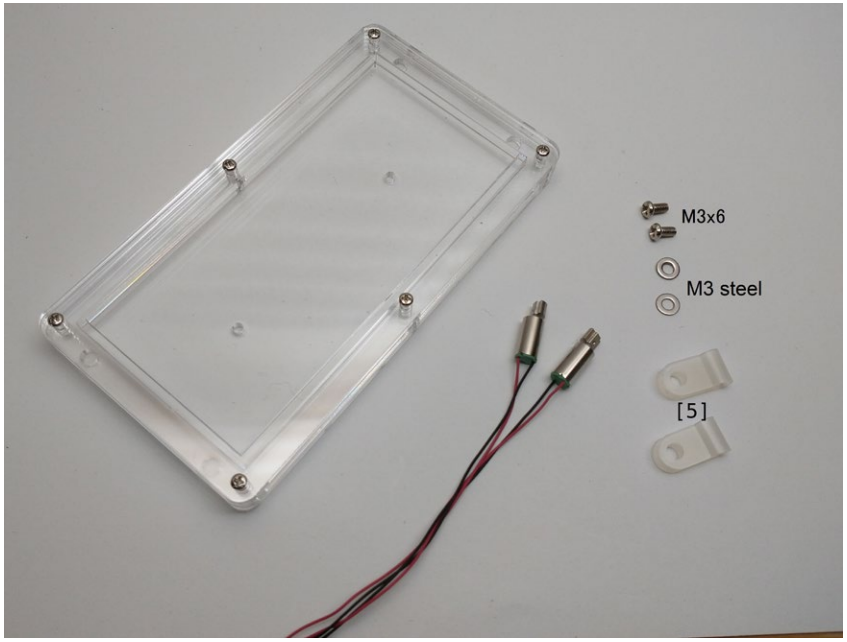
Step 11

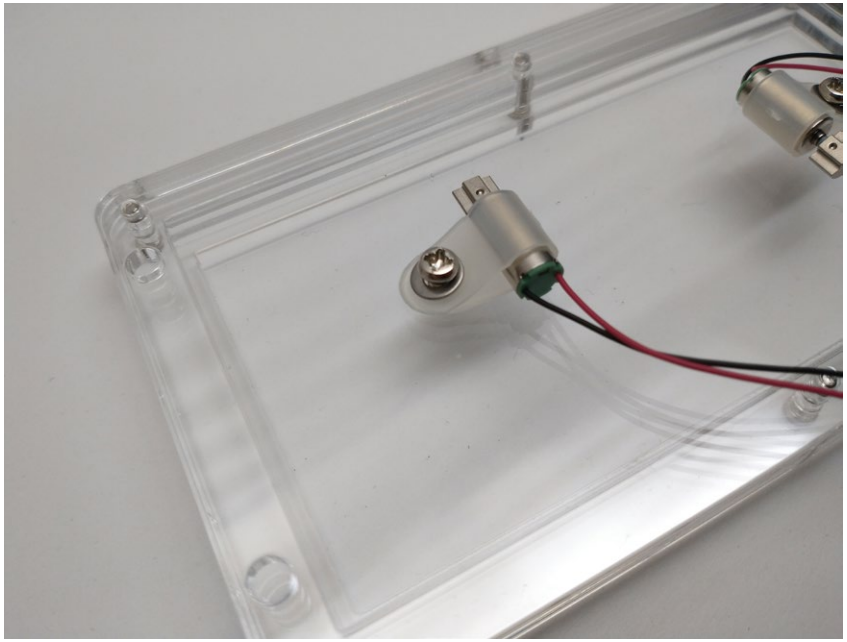
Mount the plastic clips on the bottom side of the sandbox using 2 M3x6 machine screws and 2 M3 steel washers. Do not tighten the screws completely yet.

Slide the vibration motors in the clips and position them as shown in the picture below.



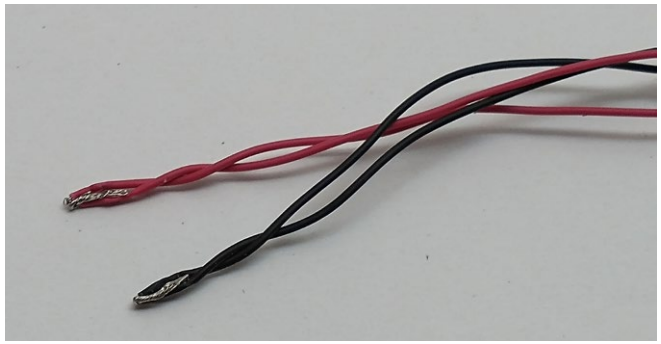
Now tighten the screws until the vibration motors are firmly in place and the clips cannot rotate easily anymore. You can try different alignments of the vibration motors to discover how it effects the distribution of the sand while vibrating.





Step 12

Connect the wires of the vibration motors together and attach them to the connector on the baseboard. Check the polarity.



Place the sandbox on top of the standoffs and make sure wires are not touching the rotating parts of the vibration motors. Rearrange wires if necessary. Test the clock without sand to make sure everything works well.

Step 13

Add the sand to the sandbox. A layer of 4 – 5 mm will be sufficient, be sure to spread it out evenly.

If you wish you can also color the sand using food coloring. Put the sand in a small jar and add a few drops of food coloring. Shake vigorously until the sand gets evenly colored.

Repeat until you get the desired color intensity. Make sure the sand has dried completely before you pour it in the sandbox.

Step 14

Final calibration

Power on the Sand Clock again. The device starts up in command mode.

Calibrate the pen further if necessary. The following commands draw an "8" in the sand:

ps -10 25

pg 8 1 1

Select the start-up mode. This is the mode that takes effect every time you power up or reset the clock.

Send command **msa** for autonomous mode (normal clock behavior) or **msc** for command mode (use serial monitor to control the device).

Send command **sew** to program the selected start-up mode and other settings into EEPROM.

Send command **ma** if you want to immediately switch from command mode to autonomous mode.

Congratulations, your Sand Clock is now finished

For more information and software downloads:

www.elektor.com
www.joy-it.net