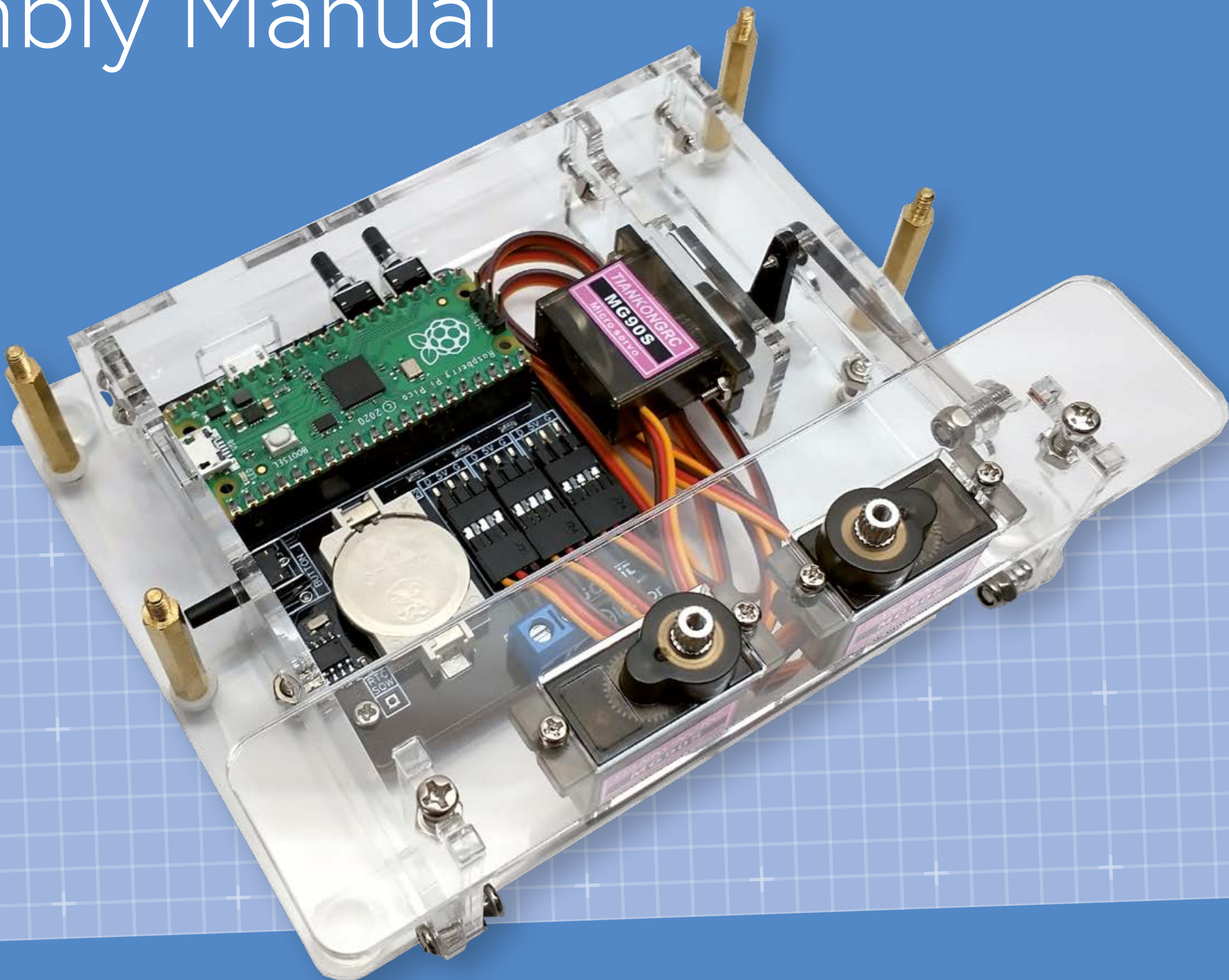
# Sand Clock Kit
## Assembly Manual




SKU 20679

# Sand Clock Kit
## Assembly Manual

**Version 1.0 - 2023**

# 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**ervo **m**ove **l**eft [Servo], 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

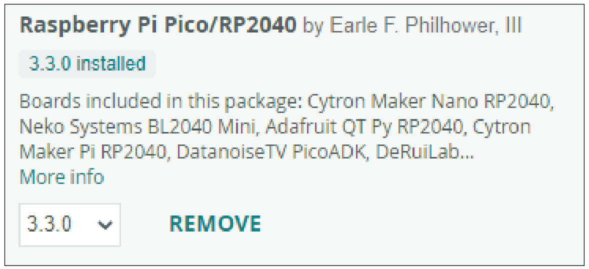
Attach the Raspberry Pi Pico to the shield PCB and connect the three servo motors. Insert the CR2032 3V lithium coin cell to the battery holder on the shield PCB.

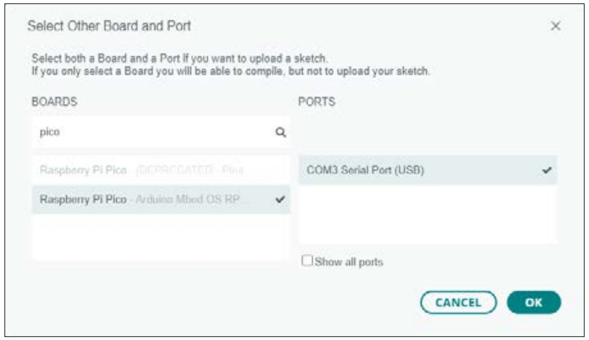
Use a USB-cable to connect the shield PCB

## Step 2

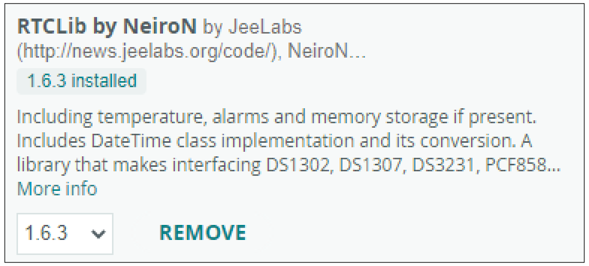
Connect the power connector to the shield PCB and the Pi Pico to your PC via a USB cable. If it asks you to install the boards drivers (usually when it's connected for the first time), do it.

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




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




Compile the sketch and send it to the 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 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**.

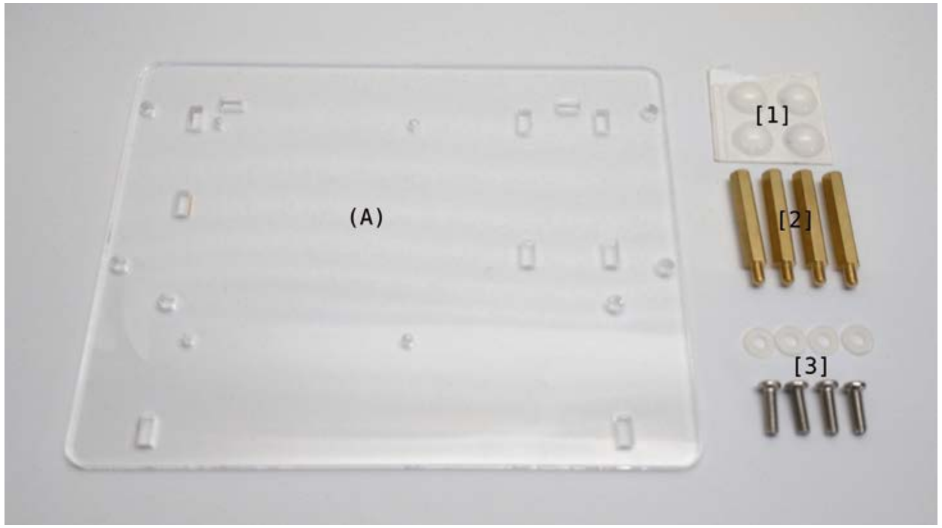
If you have a servo tester you can use that as well to set the servo motors to the middle position. When using a servo tester there is no need to upload the sketch to the Pi Pico now as you can do this later when the clock is almost finished.

Turn off power, disconnect the servo motors.

## Step 3
**Mechanical assembly**

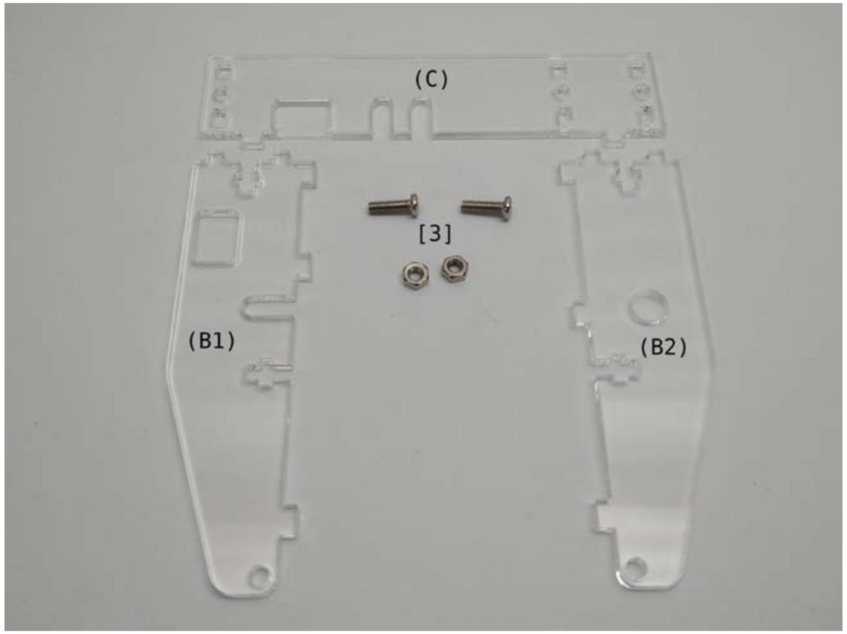
Remove the protective film from the bottom plate (A) and stick 4 adhesive rubber bumpers [1] to the corners. Make sure the orientation of the bottom plate is correct as it is quite difficult to remove and reposition the rubber bumpers in case of an error.

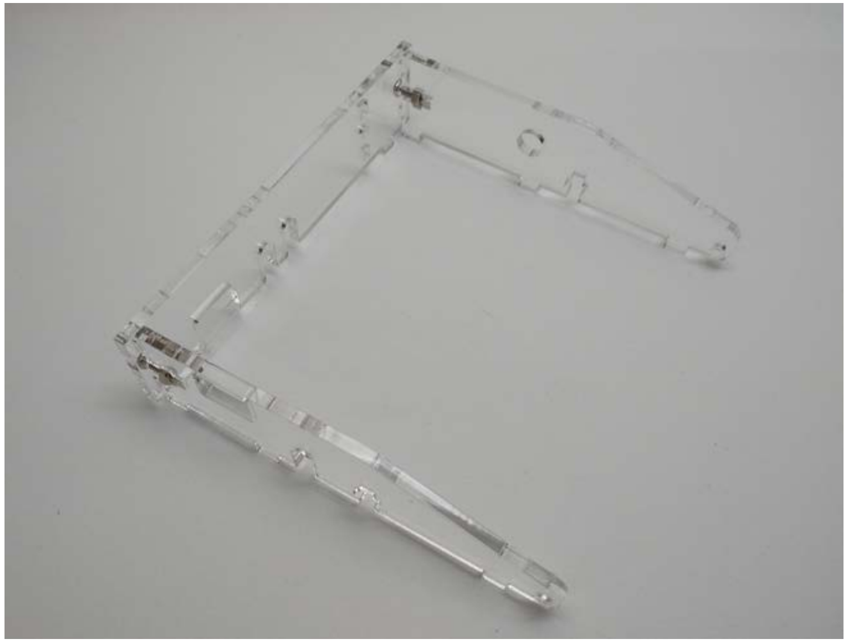
Mount the 4 supports [2] for the sand box using M3x10 machine screws [3] and M3 plastic washers [3]. Hand tighten only.




Remove the protective film from 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 my cause the acrylic to break.



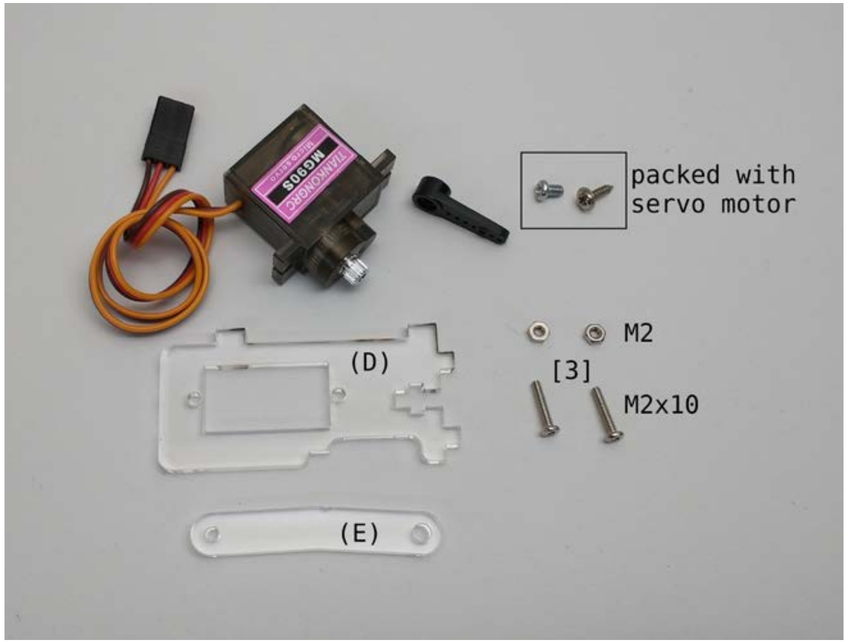



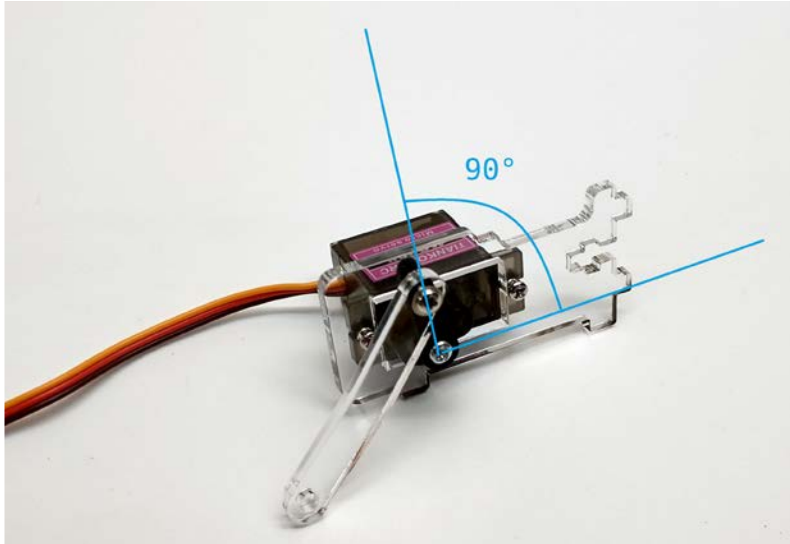
**Step 4**

Remove the protective film from 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 horn to the servo shaft using the M2.5 machine screw packed together with the servo accessories.

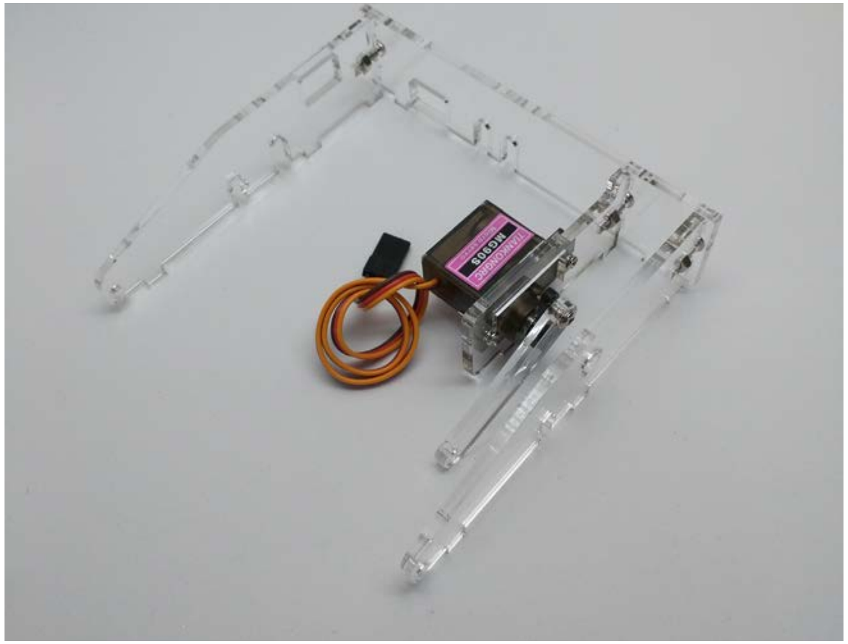
The servo horn should point more or less upright at an angle of 90 degrees. Don't worry if you can't get it exactly at 90 degrees due to the teeth of the servo shaft and the servo horn.

The acrylic lift servo lever (E) has 2 holes. Screw it with the smallest hole to the servo horn 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 last or third last hole in the servo horn.

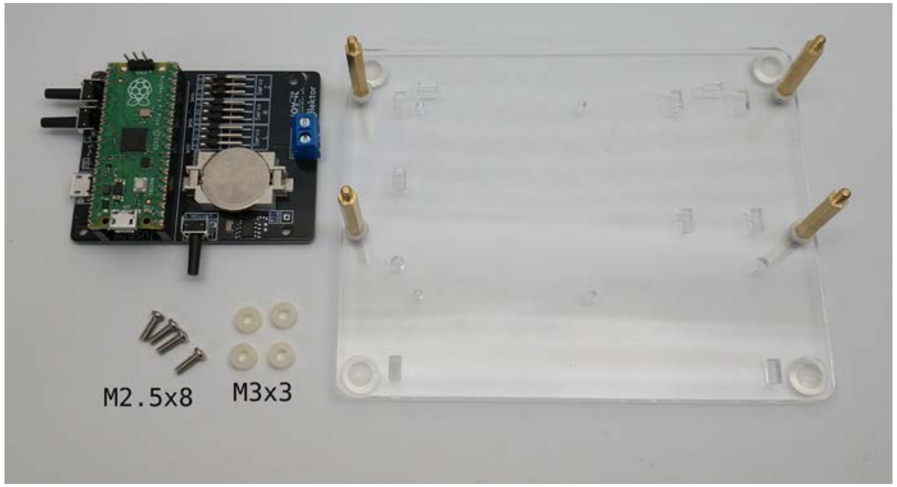




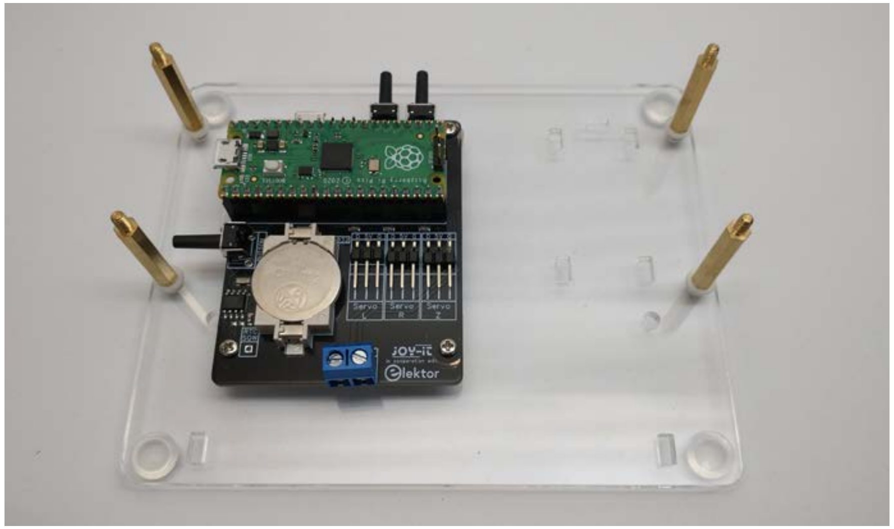

**Step 5**
Attach the lift servo mechanism to the frame using an M3x10 machine screw and an M3 nut.

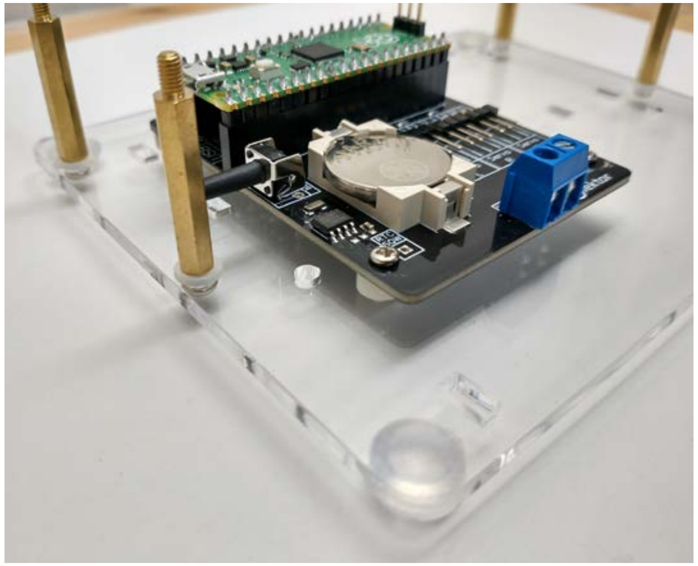



Mount the Shield PCB to the base plate using M2.5x8 machine screws and 3 mm plastic spacers. Tighten the screws loosely so the PCB can still move a bit.

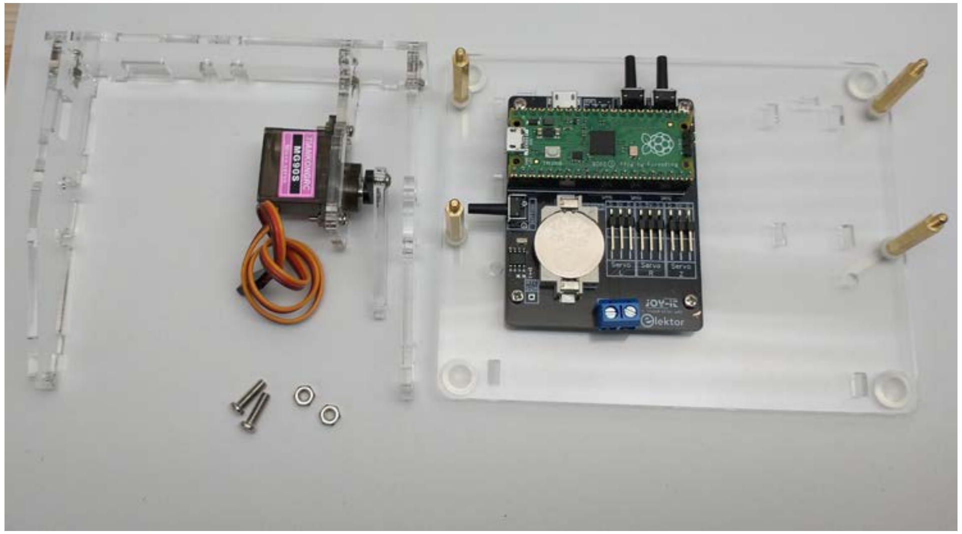


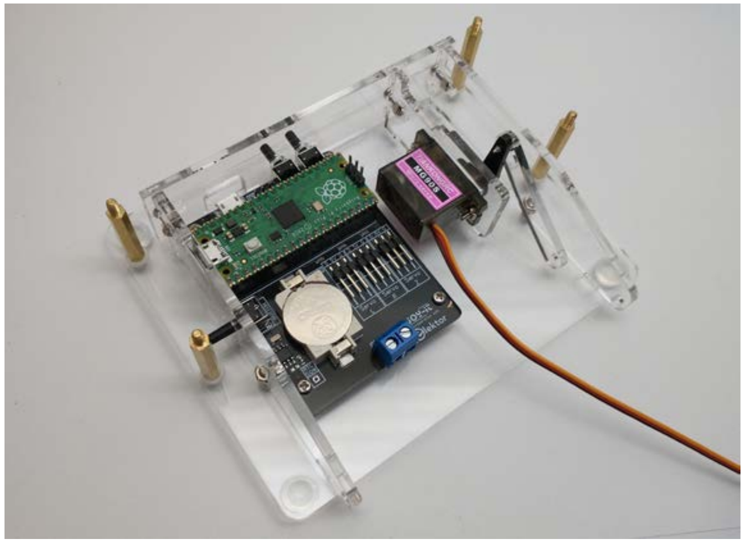
Note that the screws are tapped into the base plate, nuts aren't required.



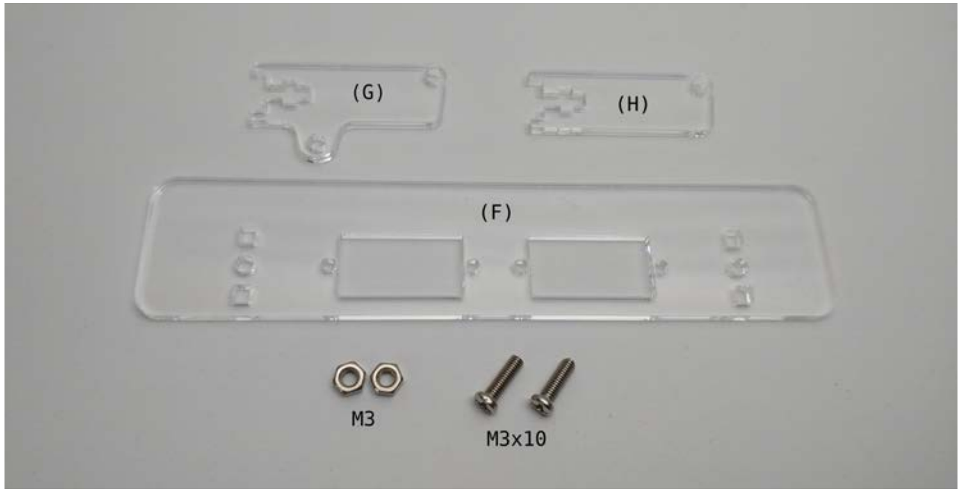


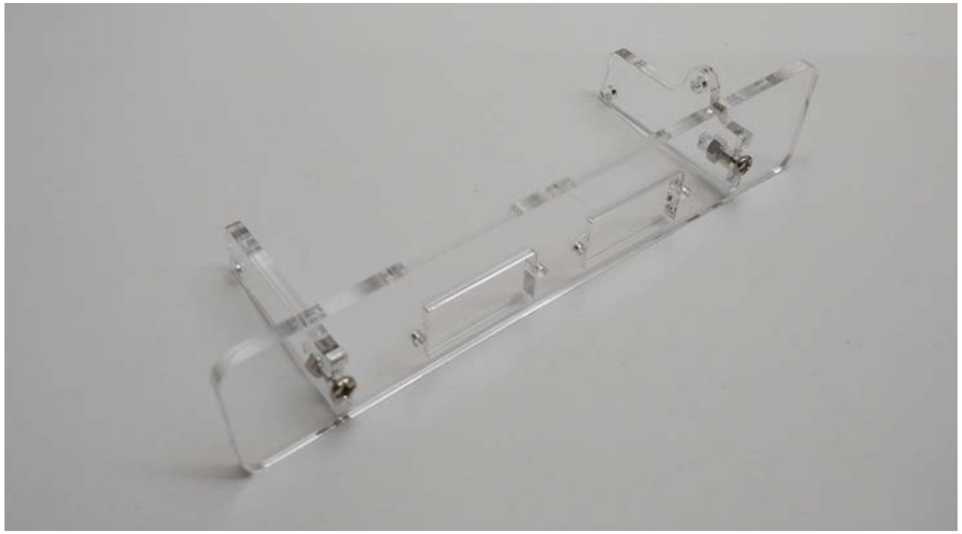
Now attach the frame with the lift servo mechanism to the bottom plate using two M3x10 machine screws and an M3 nut . Finally tighten the PCB mounting screws.



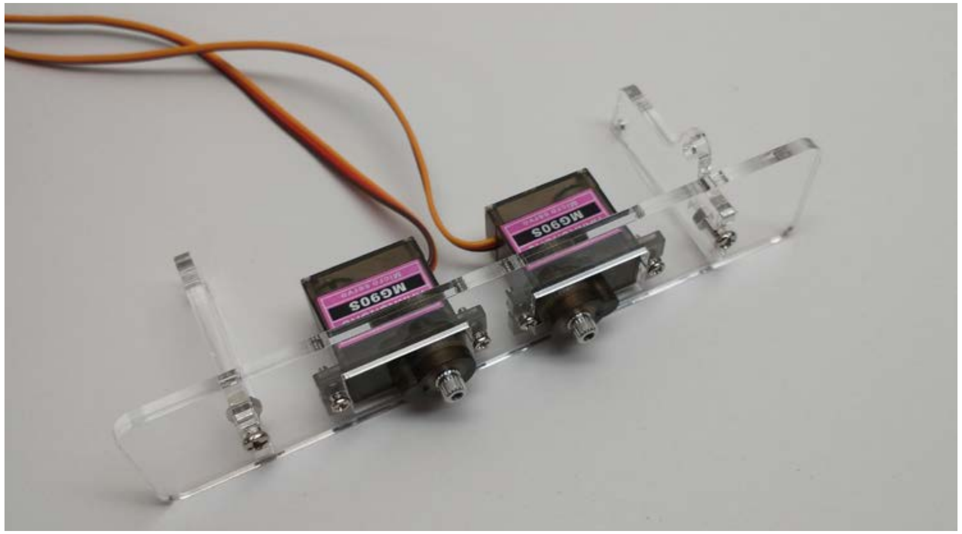


**Step 6**
Attach the hinges (H) and (G) to the pantograph servo motors mounting plate (F) using M3x10 machine screws and M3 nuts.



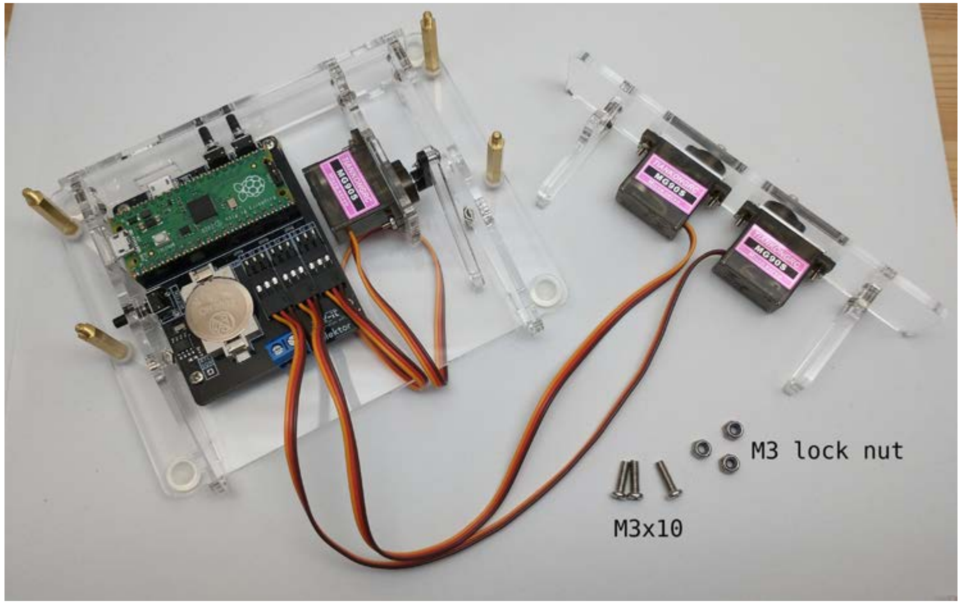



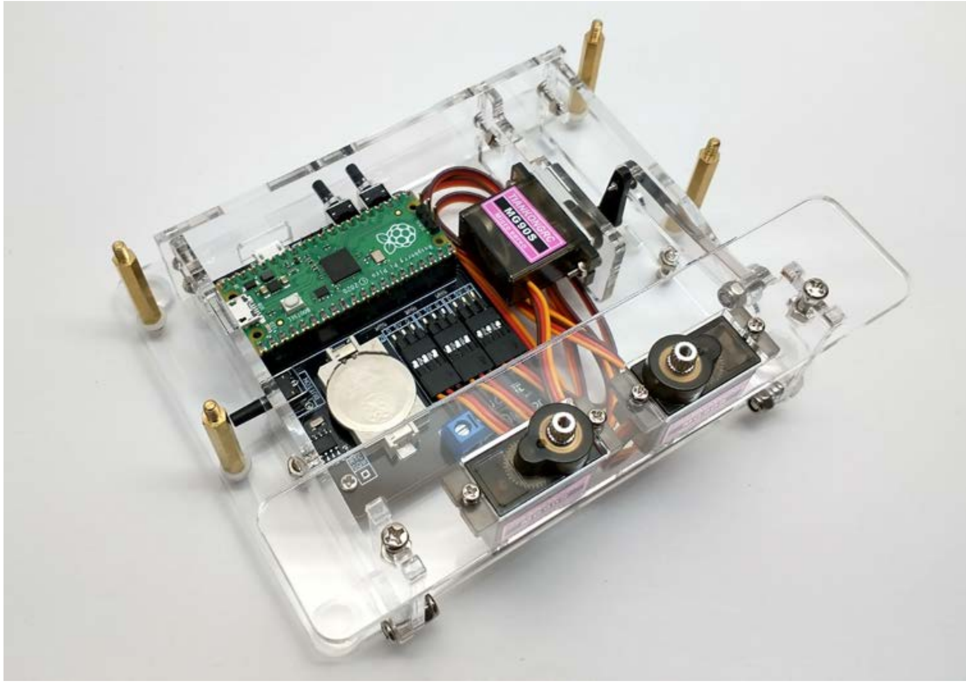
Mount both servo motors using M2x10 machine screws and M2 nuts.

**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 shield PCB. 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.



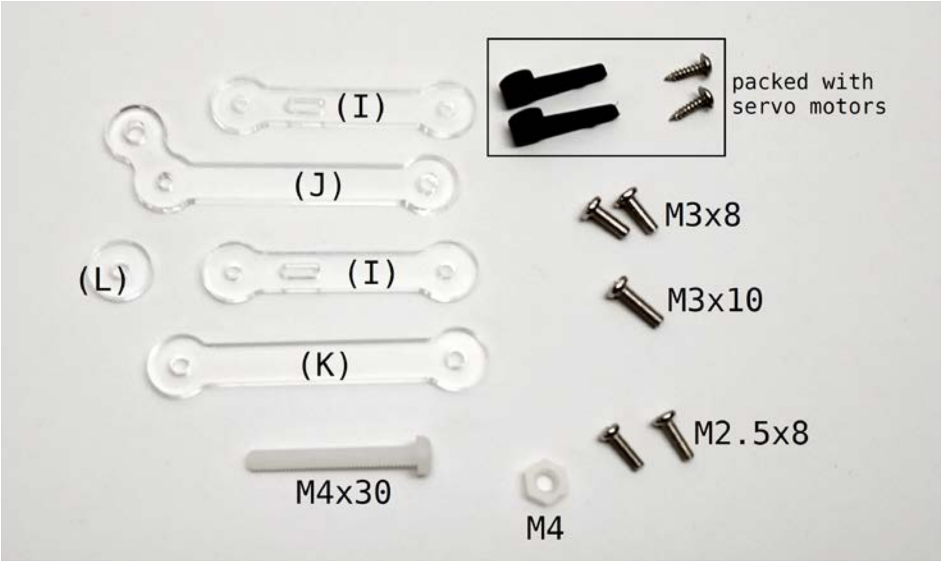



**Step 8**

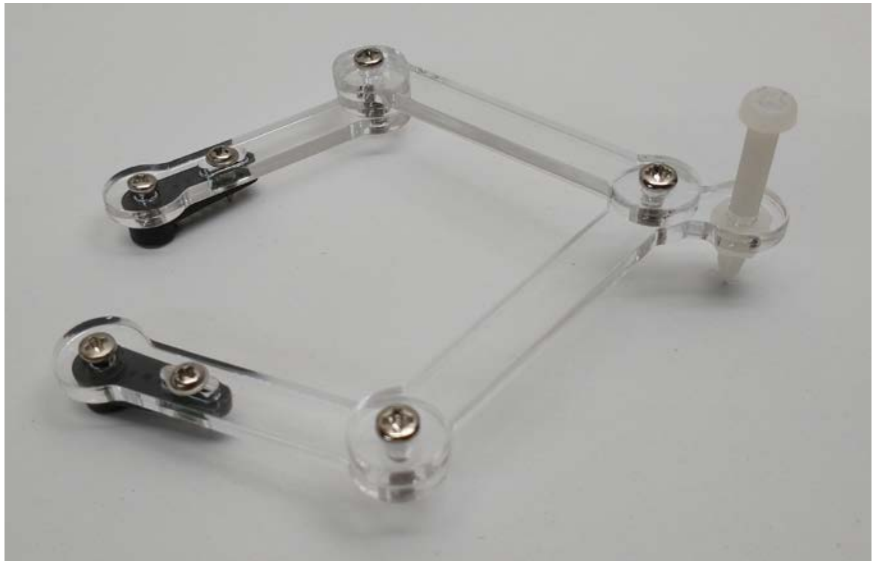
Assemble the pantograph arms. Screw part (J) on top of one of the parts (I) using an M3x8 machine screw. Then screw part (K) on top of part (J) using an M3x8 machine screw. Finally screw the other side of part (K) on top of the second part (I) with the round acrylic disc (L) in between using an M3x10 machine screw.

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 horns. Temporarily fit an M2.5x8 machine screw through the holes in the acrylic and the servo horns. Then secure the servo horns to the acrylic arms (I) using 2 plastic screws supplied with the servo motors.

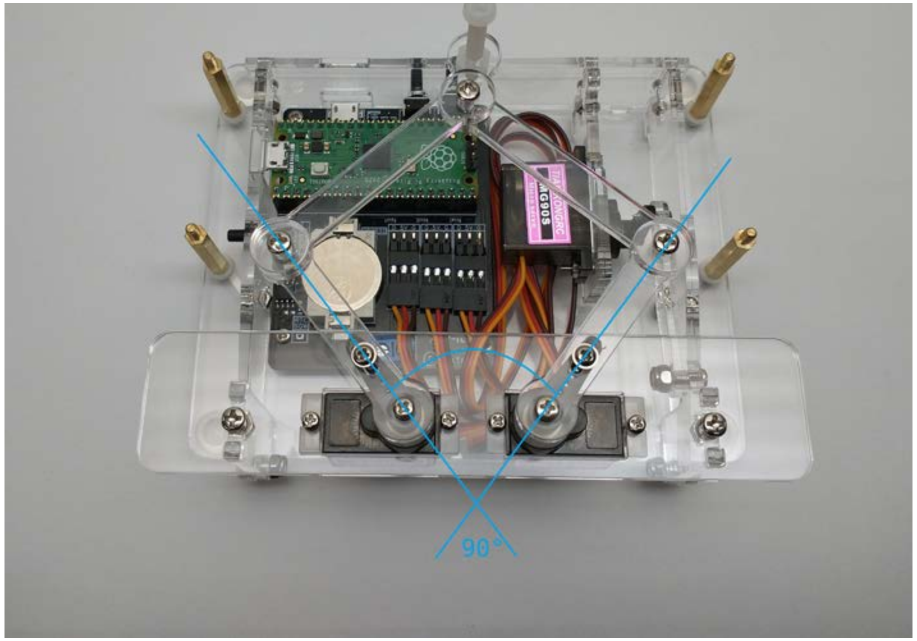
Carefully sharpen the plastic M4x30 machine screw with a pencil sharpener and fit it together with an M4 nut to the pantograph assembly.

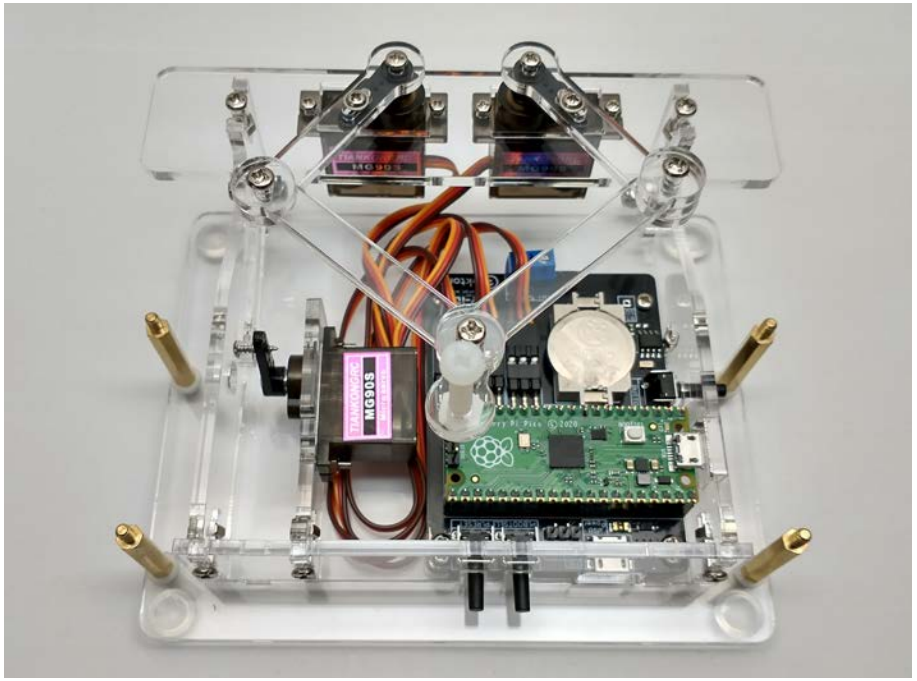






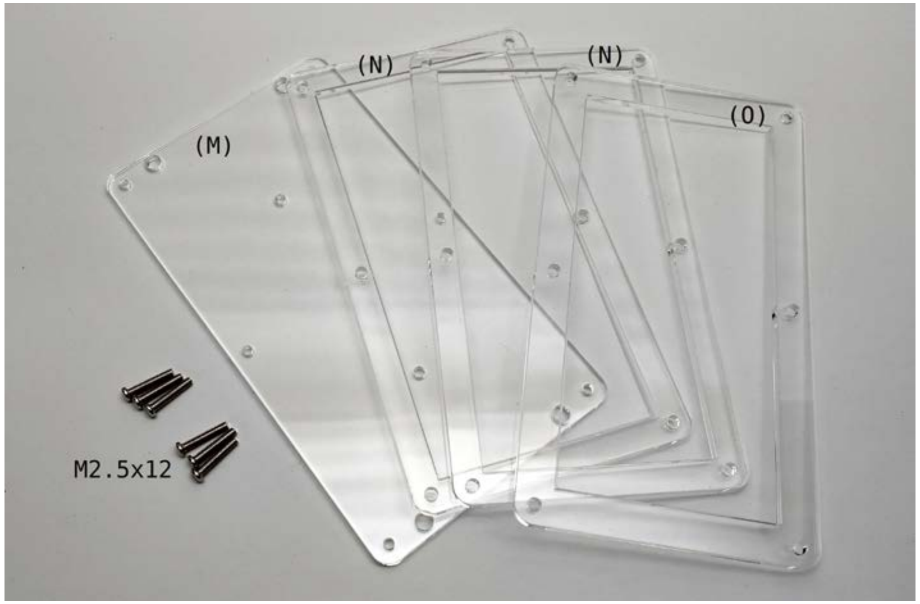
Attach the pantograph mechanism to the pantograph servo motors using the M2.5x8 machine screws. Mount the arms so they form an angle of 90 degrees. Don't worry if you can't position them exactly to 90 degrees due to the teeth on the servo motor shafts and the servo horns. This will be compensated after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



## Step 9

Remove the protective film of the acrylic parts of the sand box (M), (N) and (O). 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

If you used a servo tester earlier to set the servos to their center positon, install the Arduino sketch to the Pi Pico now (Step 2).

### Calibration procedure

The calibration procedure involves sending commands to the sketch. Power on the Arduino board and connect it to your computer via USB. 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 the 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 the 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 the 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 the vertical position using **svml** with the value previously determined earlier. You can query the correct value using **sed**.
- Move the right servo motor to the 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 sand box on the supports and make sure it lies perfectly flat on all 4 supports. In case the sand box wiggles on the supports, 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 surface of the sand box. 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 sand box:
  - 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 2016 08 27 18 40 00**. Note that a CR2032 battery must be installed.

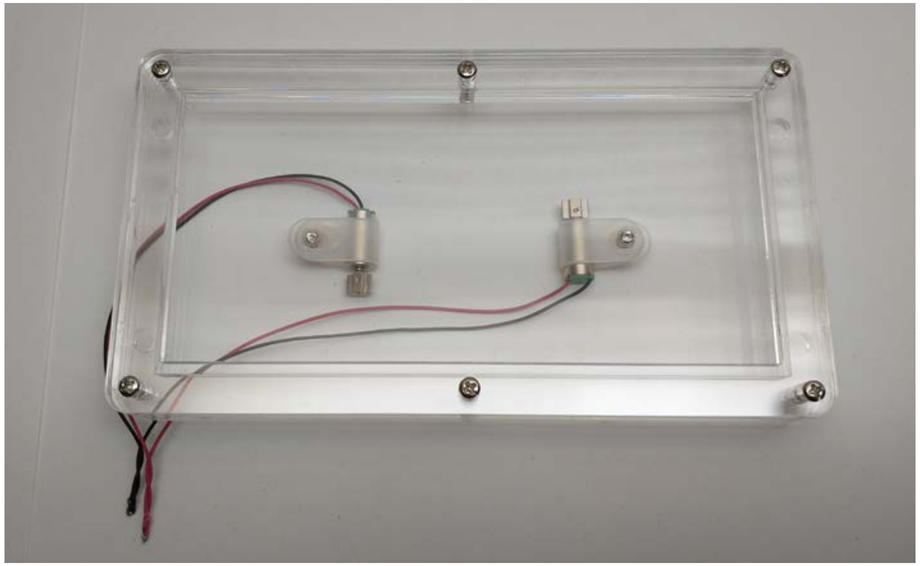
- Check date and time with **cr**.

- Lift pen up with **plu**.

- Power off the sand clock.

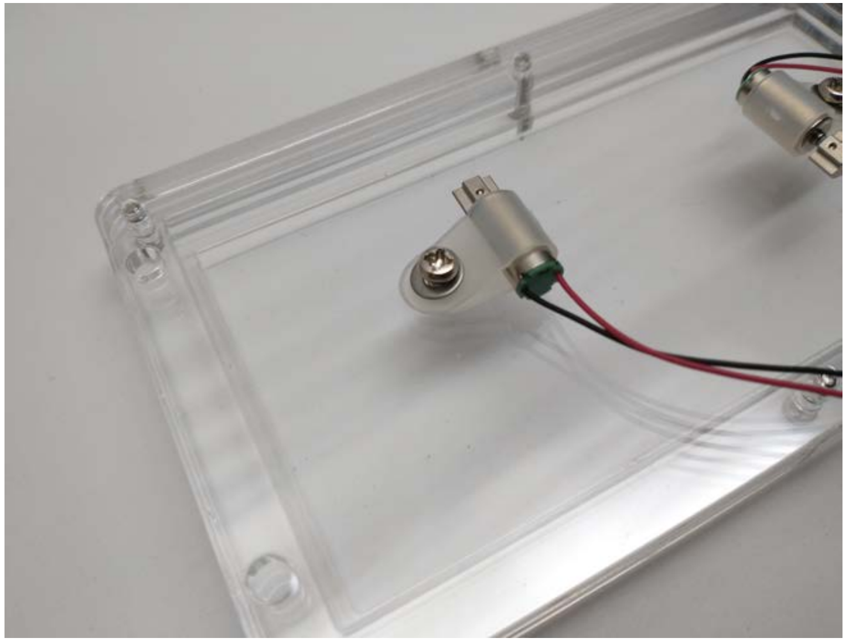
### Step 11
Mount the plastic clips on the bottom side of the sand box using 2 M3x6 machine screws and 2 M3 steel washers. Do not tighten the screws completely yet.

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.

Normally there will be 4 plastic M3 washers left over from bag. In case one of the clip mounting screws should touch the lift servo motor holder, you can insert these between the base plate (A) and the sand box supports to lift the sand box slightly.

## Step 12

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

Place the sand box on top of the supports 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 sand box. 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 sand box.

## 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:

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