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Clinostat Build Instructions

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A published version of this guide can be found at the following link: dx.doi.org/10.17504/protocols.io.5jyl8q348l2w/v1

Note:

These instructions are for building a plate clinostat intended to be used for simulating micro gravity in plant growth experiments. Basic electronic soldering skills, access to a 3D printer and Arduino familiarity as well as some specialised equipment are needed to complete this build. Specific experiments using the clinostat require further material and are outlined in separate experiment material and methods resources.

Tools and Equipment

- 3D Printer
- Phillips head screwdriver
- Needle nose pliers
- Soldering iron
- Wire cutter
- Tweezers
- Multi meter
- Male USB male mini B adaptor cable
- 3rd hand PCB holder
- Solder wick

3D Printed Parts

These parts need to be printed using any hobbyist 3D printer.

- Clinostat frame (link)
- Clinostat plate mount (link)

Parts

- Arduino Nano
- NEMA17 stepper motor with connection cables
- 1x A4988 motor driver
- 1x 12v 55mA 2.1mm DC power adaptor
- 1x 47µF capacitor
- 3 x 2 pin PCB screw terminal 2.54mm pitch
- 2 x 15 pin female header 2.54mm
- 2 x 8 pin female header 2.54mm
- 1 x SPST toggle switch
- 1 x 2.1mm DC bulkhead
- 1 x 25 x 30 experimenters board
  (note: The clinostat housing is designed to fit the JayCar Universal Pre-Punched Experimenters Board – Small CAT.NO: HP9550
- 1m 1.8mm hookup wire assorted colours
- 1m 3mm heat shrink
- 1m 5mm heat shrink
- 4 x M3 10mm Bolts
- 4 x M3 bolt 15mm
- 4 x M3 nut
- 8x M3 washer

Resources

Wiring diagram

3D Print files

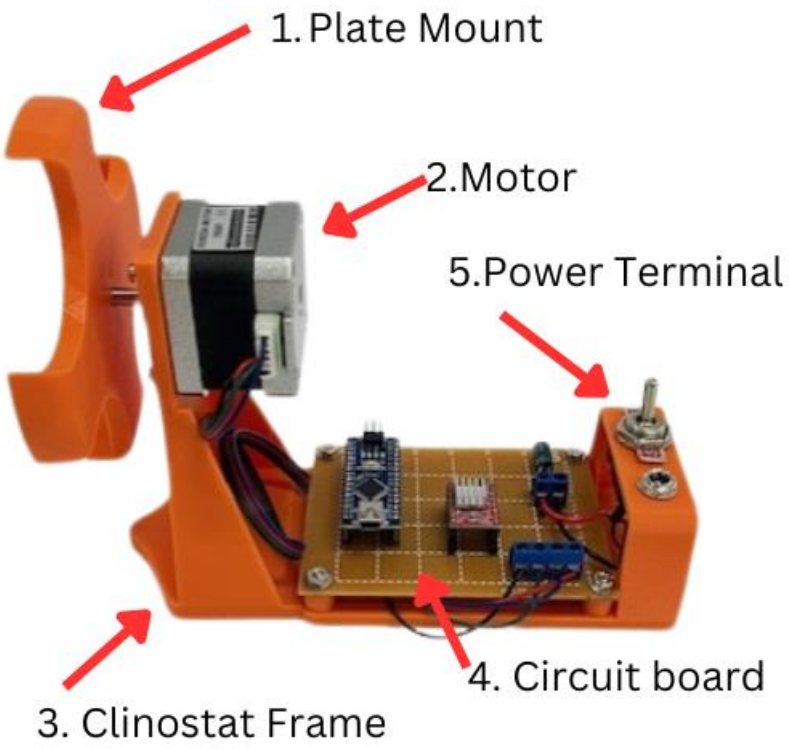
Arduino Script

Soldering tutorial: Soldering Tutorial for Beginners: Five Easy Steps

Multi meter How To : How to Use a Multimeter

Overview

A clinostat is a research tool that is used to rotate a plant on a horizontal axis to conduct growth studies. This clinostat is designed to use a 90mm petri dishes as the growth container. Other growth containers can be used but will require customisation to the clinostat. This clinostat is composed of the 1. plate mount, 2. motor, 3. clinostat frame, 4. control unit circuit board and 5. power terminal.



3D Printing

3D Print the Clinostat frame and the Plate mount. It is recommended that these parts are printed at a layer height not exceeding 2.0 mm. Refer to instruction of 3D printer being used for specific file preparations. After printing remove print supports and debur bolt holes.

Clinostat Frame	Plate Mount
	

Controle Unit

The control unit has two main parts the circuit board and the power terminal. Below are recommended practices and equipment to assist in assembling of the circuit board and power terminal .

- Good quality soldering iron that maintains temperature
- Wet sponge for cleaning soldering iron tip
- Solder sucker or solder wick
- PCB third hand
- Ensure work area is well lit
- Use magnifying stand is available
- Organise parts for each step prior to building
- Double check wiring before powering up device
- Tin wires before soldering

The following instructions outline the recommended steps for assembly and order of operations. The location of the components on the circuit board is a suggestion and can

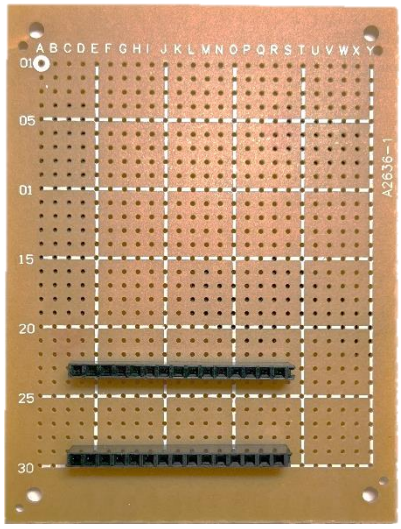
be moved depending on personal preference. Placement location is cited using an X/Y grid reference where the X axis is a denoted by letters and Y axis is number.

When assembling the circuit board refer to the step-by-step instruction, the parts reference chart **Appendix A,** the component placement diagram **Appendix B** and the wiring diagram **Appendix C**.

Soldering Headers, Terminals and Capacitor

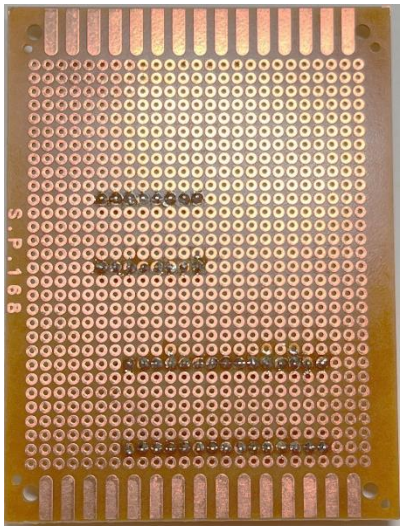
Solder the following components onto the circuit board and refer to **Appendix B**.

1. **Arduino 15-pin female header**



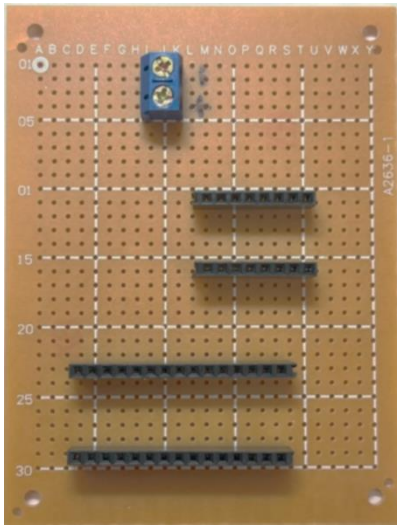
- Solder **15-pin female header**s in the footprint of an **Arduino NANO**.
- One **15-pin female** header from (D,23) to (R,23)
- One **15-pin female header** from (D,29) to (R,29).

2. **A4988 stepper driver 8-pin female headers**



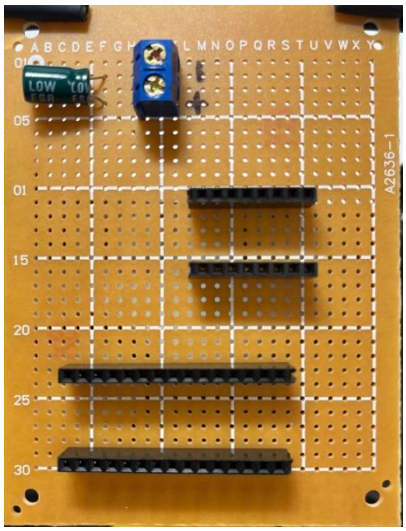
- Solder the **8-pin female headers** in the footprint of an A4988 stepper driver.
- Solder one **8-pin female header** from (M,11) to (T,11)
- Solder one **8-pin female header** from (M,16) to (T,16)

3. **Power connection 2-pin PCB Screw Terminal**



- Solder one **2-pin PBC screw terminal** at (J,2) to (J,4).
- Orient terminal so the wire insert openings are pointed to the right.
- Label (J,2) pin of the terminal and circuit board as ground (GRD or -) and (J,4) side of the terminal as positive (+).

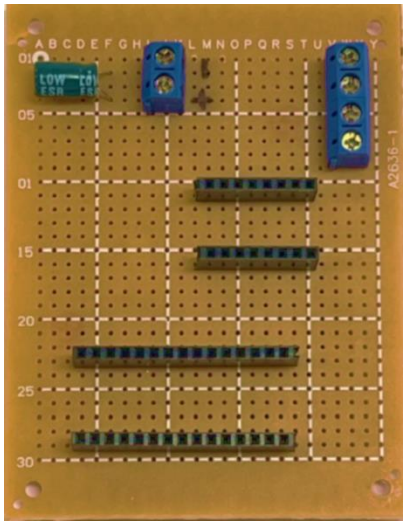
4. Soldering the 47µF Capacitor Terminal



- Insets the **47µF capacitor** into (F,2) and (F,4). Ensure the (–) pin is inserted into (F,2) and (+) pin is in (F,4).
- Bend the pins to the GRD / - pin and + pin of the 2-pin PCB screw terminal. Trim to length and solder to the 2-pin PCB screw terminal pins.

Note: The polarity of the capacitor will be marked on the side.

5. Stepper motor connection 4–pin PCN Screw

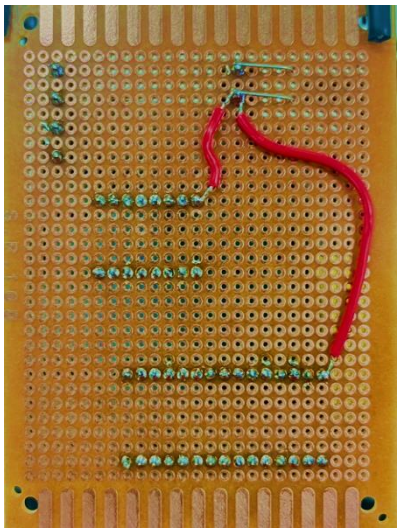


- Solder the **4-pin PCB screw terminal** (for motor connections) from (W,2) to (W,8).
- Orient header so that the terminal openings are pointer outwards.

Wiring the Circuit

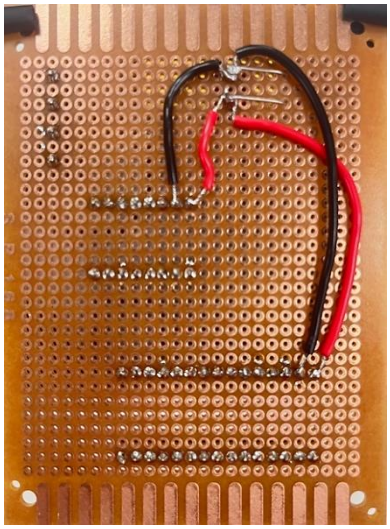
Solder the below connections using hook up wire that has been cut to length and the ends have been stripped and tinned. Multiple colours of wire are used to keep polarity and connections organised and to aid in trouble shooting. Use the wiring diagram **Appendix C.**

6. Power connections



6.1

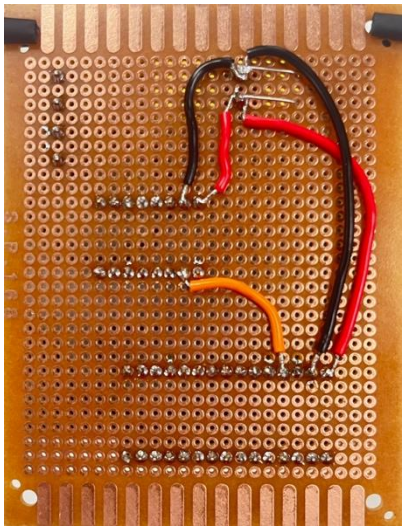
- Connect one red wire from **+** pin of the **2-pin PCB screw terminal** (J,4) to **NANO VIN** (D,23)
- Connect one red wire from + pin of the **2-pin PCB screw terminal** (J,4) to **A4988 VMOT** (M ,11)



6.2

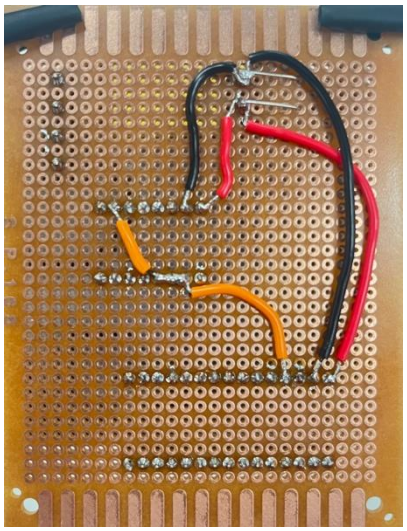
- Connect one Black wire from the GND pin of the **2-pin PCB screw terminal** (J,2) to **NANO GND** (E,23).
- Connect one Black wire from the GND PCB Screw Terminal (J,2) to A4988 GND (N,11).

7. Logic connections



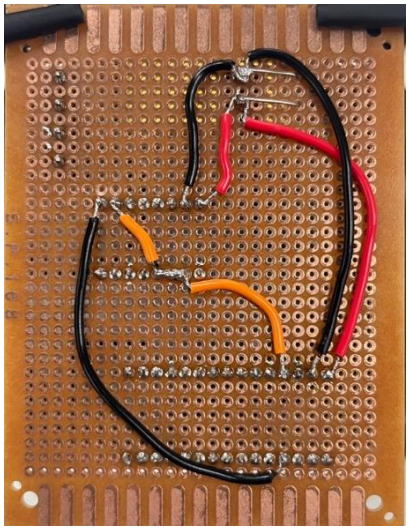
7.1

- Connect one Orange wire from **NANO 5V** (G,23) to **A4988 MS1** (N,16).



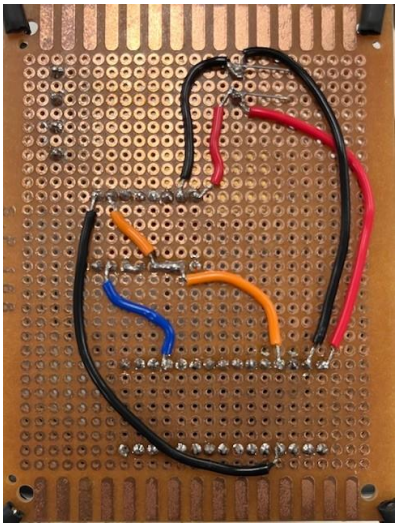
7.2

- Bridge **A4988 MS1** (N,16), **MS2** (O,16), **MS3** (P,16) together with a solder bead.
- Connect one Orange wire from **A4988 MS3** (P,16) to **A4988 VDD** (S,11).



7.3

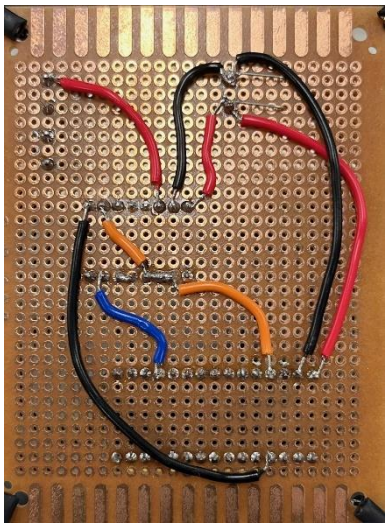
- Connect one Black wire from **NANO GND** (G,29) to **A4988 GND** (T,11))



7.4

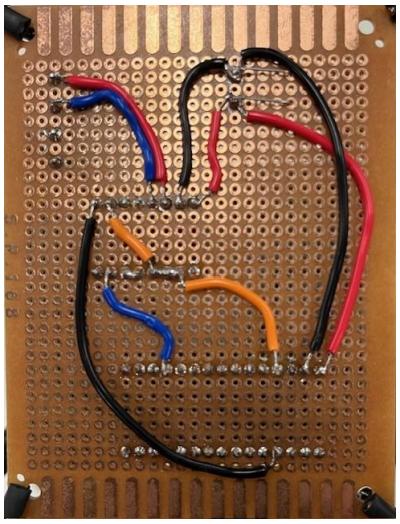
- Bridge **A4988 RST** (Q,16) and **A4988 SLEEP** (R,16) with a bead of solder.
- Connect one Blue wire from **NANO AO** (P,23) to **A4988 STEP** (S,16).

8. Motor connections



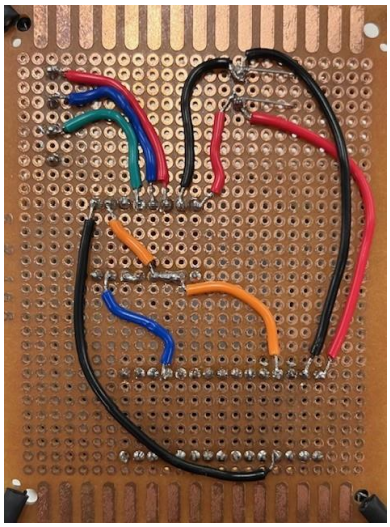
8.1

- Connect one Red wire from **A4988 B2** (O,11) to **4-pin PCB screw terminal** (W,2)



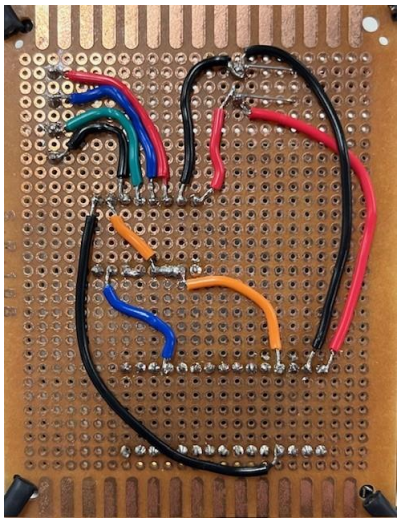
8.2

- Connect one Blue wire from **A4988 A2** (P,11) to **4-pin PCB screw terminal** (W,4)



8.3

- Connect one Green wire from **A4988 A1** (Q,11) to **4-pin PCB Screw terminal** (W,6)



8.4

- Connect one Black wire from **A4988 B1** (R,11) to **4-pin PCB Screw terminal** (W,8)

Power Terminal

9. DC bulkhead jack and Toggle switch

9.1

- Solder one end of a 3 cm length of prepared Red wire to the positive tip terminal of the 2.1mm **DC bulkhead jack**.
- Protect solder joint with a piece of 3mm heat shrink.

Note: Refer to DC bulkhead product information sheet to determine positive and negative terminals or use a multimeter to determine polarity. To test polarity with a multi meter connect bulkhead jack to power source. Test bulkhead terminals with multi-meter probes until a 12v reading registers.

9.2

- Thread a piece of 5mm heat shrink onto Red wire attached to **2.1mm DC bulkhead jack**.
- Solder the free end of Red wire to one terminal of the **SPST toggle switch**.
- Protect solder joint with the 5mm piece heat shrink.

9.3

- Solder on end of a 4 cm length of prepared black wire to the negative sleeve terminal of the **2.1mm DC bulkhead jack**.
- Protect solder joint with a piece of 3mm heat shrink.

9.4

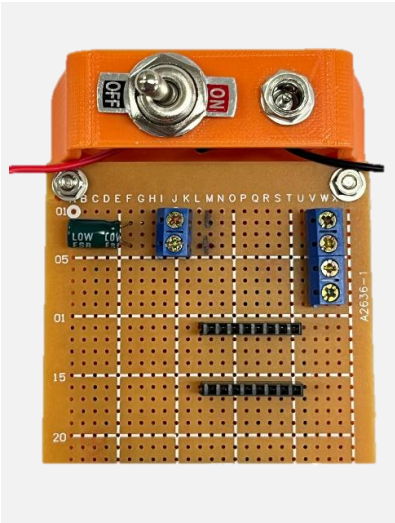
- Solder on end of a 4 cm length of prepared red wire to the wire free terminal of the **SPST toggle switch**
- Protect solder joint with a piece of 5mm heat shrink.

Clinostat Assembly

10. Circuit Board and power terminal installation

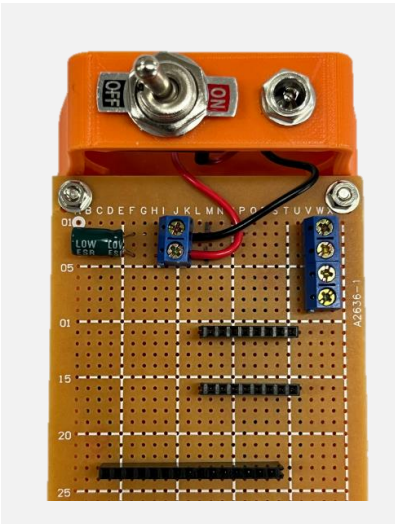
10.1

- Place the circuit board on the clinostat frame with the **2-pin PCB Screw terminal** side of the board being closest to the bridge.
- Secure it with M3 nuts and 15mm bolts.



10.2

- Anchor the toggle switch and DC bulkhead assembly into the raised bridge on clinostat frame.
- Secure using the threaded nuts included on each component.



10.3

- Insert the **+ (red)** wire from the toggle switch into the + side of the PCB pin screw terminal and secure.
- Insert the **- (black)** wire from the 2.1mm DC bulkhead into the GRD side of the PCB pin screw terminal and secure.

11. Stepper Motor Installation

11.1

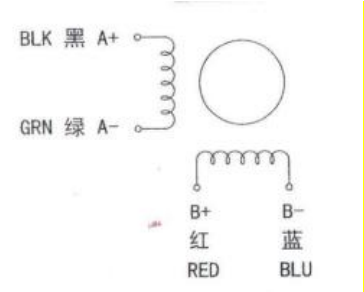
Start by referring to the stepper motor's product data sheet, which is often available for download from the retailer's website. This will indicate which wire in the motor's harness corresponds to each motor coil and phase.

Use this information to correctly connect the motor to the 4-pin PCB screw terminal. Record the coil connections, polarities, and corresponding wire colours in the provided matrix, using the motor data sheet as a reference.

Stepper driver terminal & Screw terminal position	Circuit board Wire Colour	Coil and polarity	Motor Wire colour	Motor coil & Polarity
B1 (y,12)	**Red**	Coil 1 Polarity B		
A1 (y,12)	**Blue**	Coil 1 Polarity A		
A2 (y,12)	**Green**	Coil 2 Polarity A		
B2 (y,12)	**Black**	Coil 2 Polarity B		

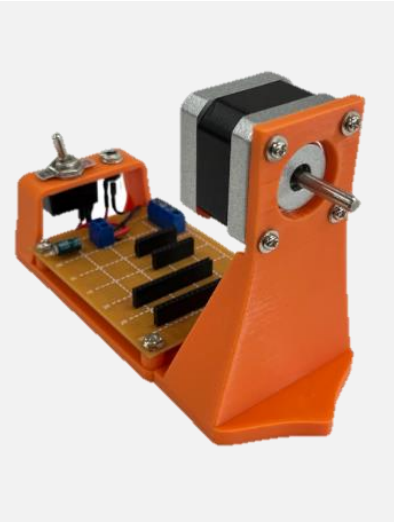
Example:

Motor Diagram from Data Sheet



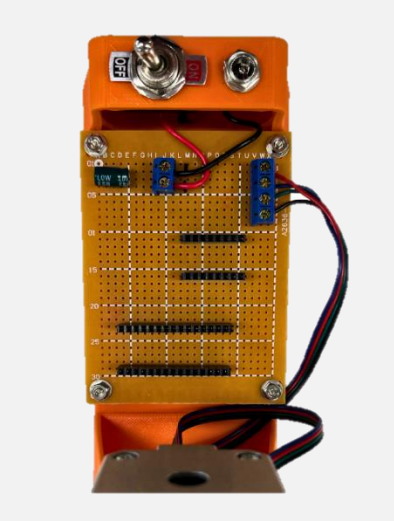
Stepper driver terminal & Screw terminal position	Circuit board Wire Colour	Coil and polarity	Motor Wire colour	Motor coil & Polarity
B1 (y,12)	**Black**	Coil 1 Polarity B	Red	**A+**
A1 (y,12)	**Green**	Coil 1 Polarity A	Blue	**A -**
A2 (y,12)	**Blue**	Coil 2 Polarity A	Green	**B-**
B2 (y,12)	**Red**	Coil 2 Polarity B	Black	**B +**

Note: This is for the specific motor used in these instructions. There is no standardisation of labelling or wire colouring, and variations can occur due to different manufacturers.



11.2

- Mount the Stepper Motor onto the clinostat frame using four 10 mm bolts and 2 washers per bolt.
- Connect the supplied 4 wire cable to the stepper motor.



11.3

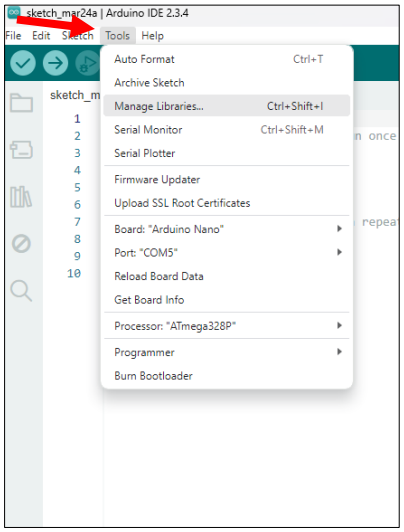
- Trim, strip and tin Stepper motor cables so that they reaches the **4 Pin PCN Screw Terminal** on the circuit board with some slack (~15 cm).
- Using wiring matrix completed in step 11.1 connect the motor wires to the appropriate terminal in the **4 -Pin PCB Screw Terminal.**

11.4

- Press the 3D printed **Plate Mount** onto the motor axel so that the axel end is flush with the plate. The hole for the axel may need to be cleaned so that the axel fits. Be aware not to enlarge the hole as this is a friction fit.

Arduino Set-up and Programming

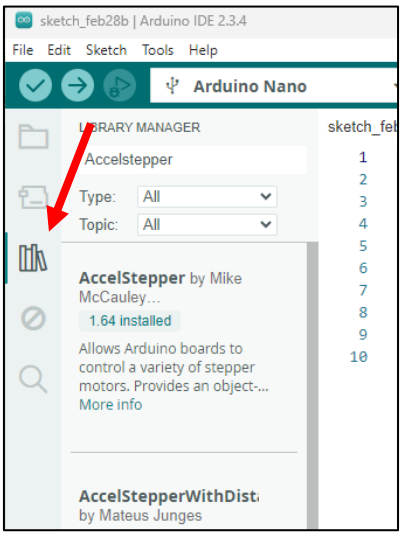
12. Arduino Set-up



12.1

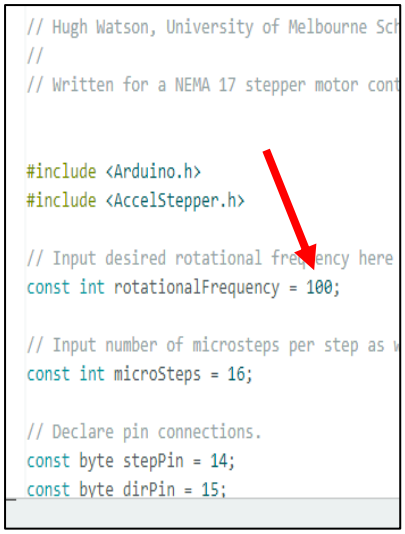
- Download the provided Clinostat Script
- Connect Arduino to a computer using USB cable.
- Open Clinostat Script
- In Tools menu select:
  - Board: Arduino Nano
  - Processor: ATmega3280
  - Port: COM _#

- Note: To determine what port to select unplug Arduino see which Com # is removed from the list and then plug back in.



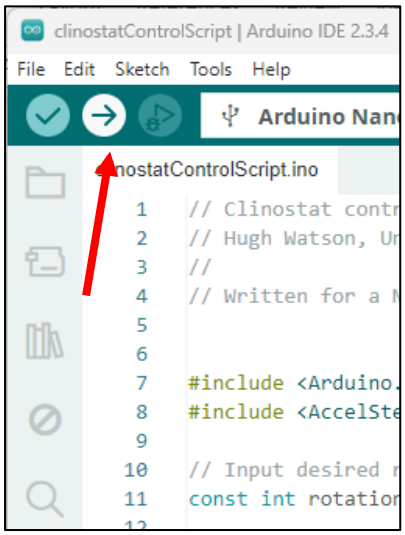
12.2

- Select the Library Manager
- In Library Manager Search for “Accelstepper”
- Install AccelStepper



12.3

- The rate of rotation of the clinostat plate can be adjusted in the script by changing the “Rotational Frequency” This is measured in rotation per minture (RPM).



12.4

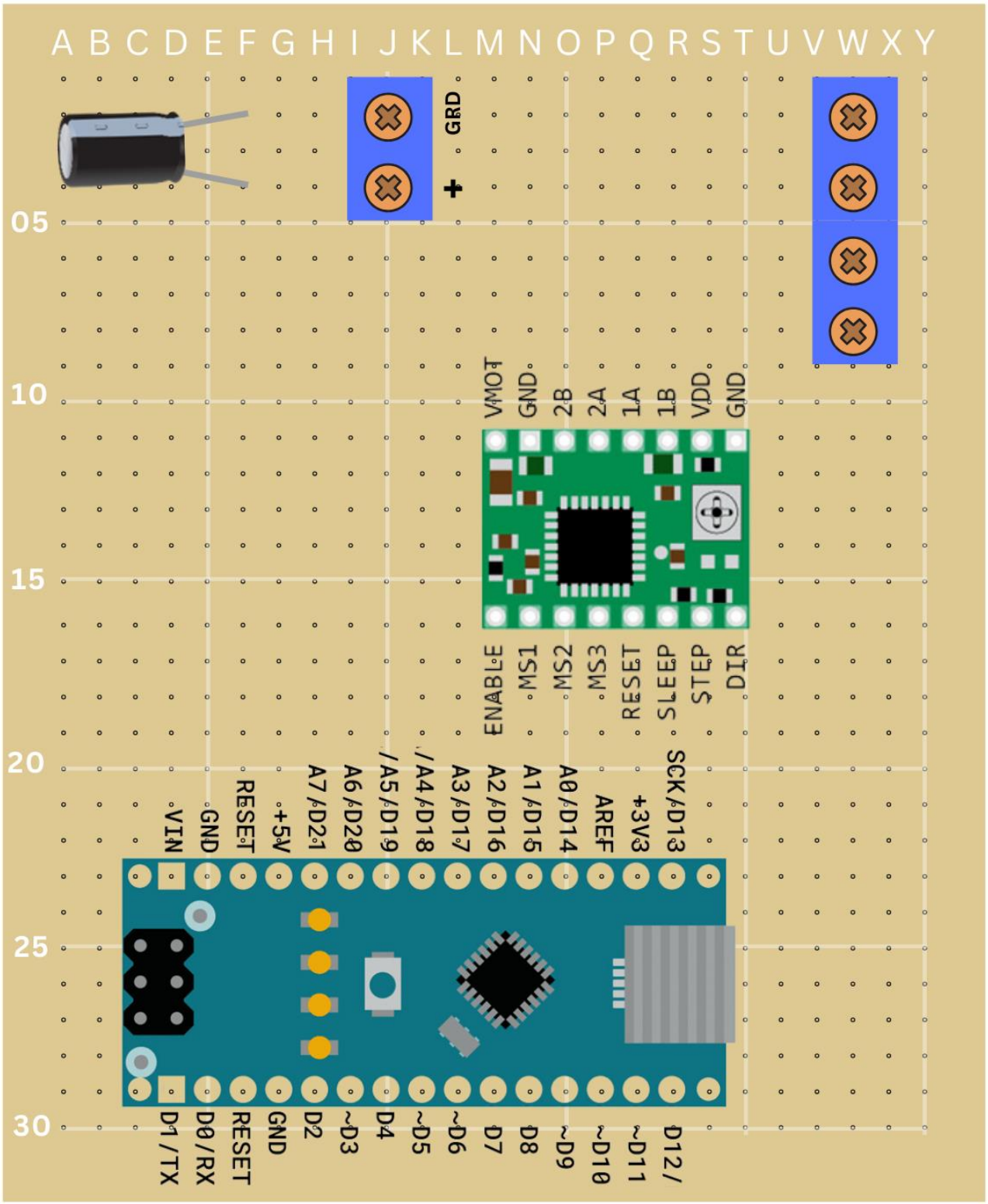
- Upload Script to Arduino button by pushing upload button.

13

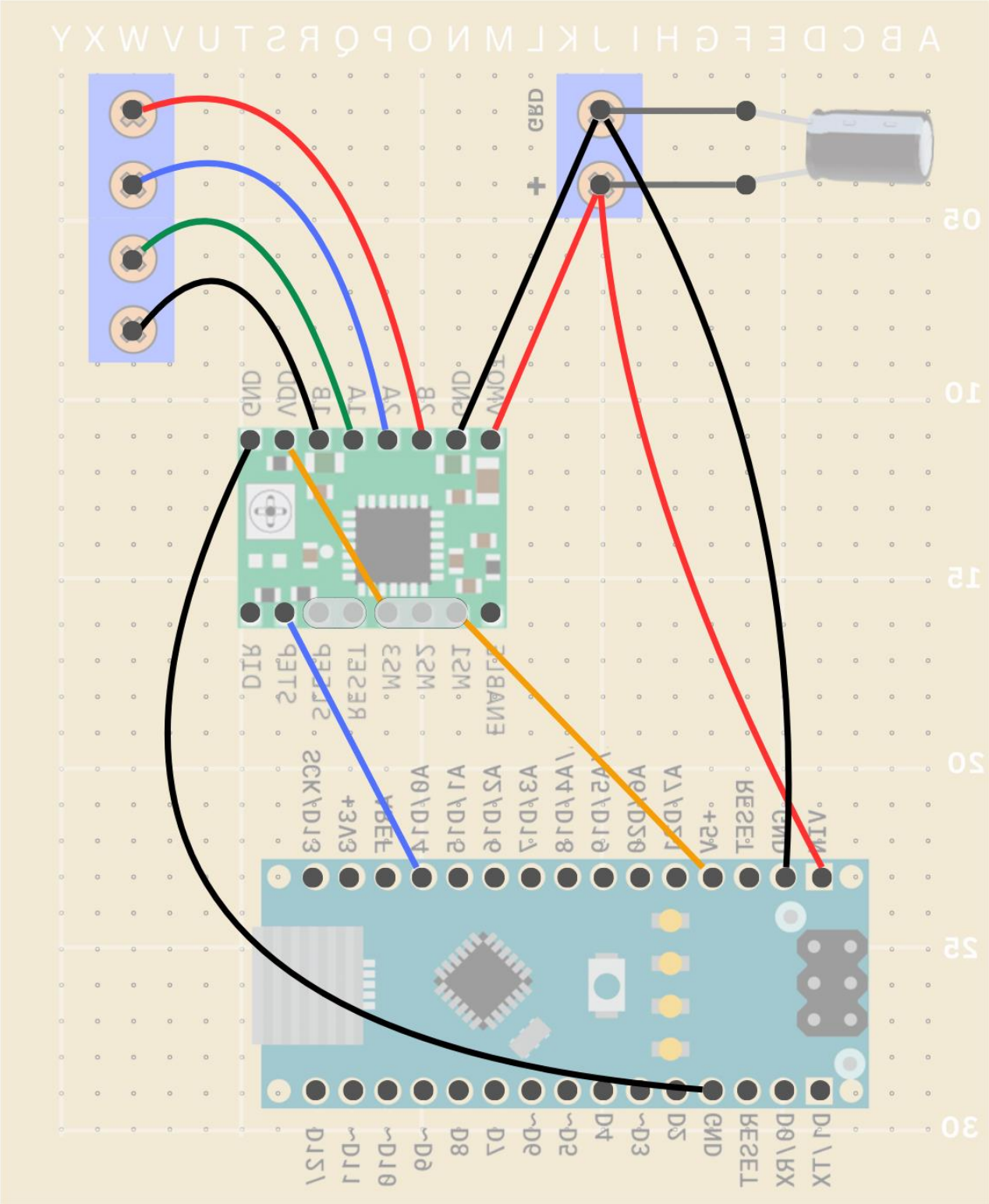
- Instal the Arduino and the A4988 driver onto the clinostat control unit by gently press each component into the headers. Refer to the component position diagram (Appendix B) to orient the Arduino and driver in the correct position.
- Attach provided heat sink to Driver Chip

The clinostat is now complete and can be connect to power using the 12 AC Power adapter. Use rubber bands or hook and loop tape to secure growth plates to the plate mount when conducting experiments.

Appendix B Components Placement Diagram



Appendix C



Clinostat Wiring Diagram