**Electrical Wiring: Control Box**

| Step | Action | Image |
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| Power Bank Setup | | |
| 1 | Tools: none | Components: USB-A to USB cable, barrel jack pigtail, and power bank |
| 2 | Plug in USB-A from Arduino and barrel jack pigtail into the power bank. The barrel jack pigtail plugs into the 12V port and the USB-A plugs into the 1.0A port. Then place power bank into the control box on the bottom level. |  |
| Ethernet Alterations | | |
| 1 | Tools: soldering iron, solder, wire snips, wire strippers, heat gun, and needle nose pliers. | Components: one male to male Ethernet cable, heat shrink and wire. |
| 2 | Take one female to female Ethernet cable and cut it into two segments using wire snips. These two segments should be 2 inches in length.  \*Note: In place of wire snips scissors can be used. |  |
| 3 | Each Ethernet segment must be stripped at least one inch back to expose the wires. Once the black jacket is removed, carefully cut the clear plastic that was separating the wires. Each wire will need to be stripped so that wires can be soldered to the Ethernet cable to connect to the protoboard.  Set aside one of the cut Ethernet cables for the pendulum assembly.  \*Note: In place of wire strippers a razor blade can carefully be used to strip away the jacket on each wire. |  |
| 4 | When soldering this Ethernet cable be sure to match the wire colors to the Ethernet from the pendulum assembly. This will be important when making connections to the protoboard.  During the pendulum assembly the wire saved from the stepper motor is now soldered to the Ethernet wires. Before soldering the wires together, heat shrink needs to be placed onto each wire. Once the soldering is completed, slide the heat shrink over the soldered area. Use a heat gun on the heat shrink. The heat shrink will shrink to the size of the wire and will no longer be able to be moved. This should only take a couple of seconds.  \*Note: In place of heat shrink, electrical tape could be used. A blow dryer can be used in place of a heat gun |  |
| 5 | The now completed Ethernet cable is plugged into the Ethernet port located inside the control box. Follow the Protoboard Assembly instructions to learn where the Ethernet wires are connected. |  |
| Step | Action | |
| Protoboard Assembly | | |
| 1 | Tools: soldering iron, solder, wire snips, wire strippers, and needle nose pliers.  Solder paste (flux) is optional when soldering to the protoboard | Components: protoboard, stake pins, female header pins, screw terminals of various sizing, 22µF capacitor and wire. |
| 2 | Places stake pins in pins SDA, SLA, 9, 8, 3, 2, 17, 18, and 19 on the Arduino along with 5V, GND, and Vin on the power terminal side of the board. Once the pins are placed lay the protoboard over top the Arduino. Before removing the protoboard solder all the stake pins.  \*Note: When soldering pins to the protoboard do not leave big solder balls. |  |
| 2 | Solder female header pins for the A4988 module and 4 stake pins for the stepper motor. Be sure to remove the A4988 module before soldering the female header pins. |  |
| 3 | Solder screw terminals for the LCD, encoder, encoder switch, and 12V supply. |  |
| 4 | Solder the wire connections for the A4988 module. When soldering power and ground wires, use extra solder. Check each joint to ensure a good connection is made between the wire and pin.  \*Note: Use the wiring diagram as reference when making wire connections. |  |
| 5 | Solder the wire connections for the LCD screen. SDA and SLA pins are run through the pin holes on the protoboard to be soldered onto the top of the board to make the connection to the stake pins. |  |
| 6 | Solder the rotary encoder. 2 screw terminals will be used to go to pins 2&3 and the other 2 screw terminals will go to 5V and ground (GND). Like in Step 5 the wires going to pins 2&3 will be snaked through the protoboard holes to make the connection to the stake pins. |  |
| 7 | Solder the wire connections for the encoder dial/pushbutton to pins 17-19, 5V and ground. |  |
| 8 | Solder the 5V and ground busses to the 5V and GND stake pins. Be sure to use plenty of solder on all connections. |  |

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| 9 | 2 screw terminals are placed on the board for the start and reset buttons. For the start button solder connections to pin 13 on the Arduino and ground. The reset button has solder connections from the reset pin on the Arduino and ground.  A 22µF capacitor is soldered to the 12V screw terminal for filtration.  This completes the protoboard assembly. Place the completed board back onto the Arduino as seen in the images from Step 1. |  |
| Step | Action | |
| Connections to Protoboard | | |
| 1 | Tools: small Phillip’s screwdriver | Components: prepped Ethernet cable for the control box, LCD screen, encoder dial/pushbutton, A4988 module, and male to female wires. |
| 2 | The A4988 module can be placed back into the female header pins. Be sure to check the solder connections to confirm module orientation. The 4 female wires on the Ethernet cable will connect to the 4 stake pins next to the A4988 module. |  |
| 3 | Attached 4 male to female wires to the LCD screen. The female end of the wire will connection to the stake pins on the back of the display.  The male end of the wire will be placed in the screw terminals for the LCD. Use a small Phillip’s screwdriver to tighten the terminal until the wire is secure. |  |
| 4 | The 4 male wires on the Ethernet cable are for the rotary encoder. Repeat Step 3 for the rotary encoder. |  |
| 5 | Attached 5 male to female wires to the encoder dial/pushbutton and repeat Step 3. |  |
| 6 | Repeat Step 3 for the barrel jack pigtail.  \*Note: When connecting the wires be sure to confirm which pin is power and ground on the A4988 module to screw terminal. |  |

**Electrical Wiring: Pendulum**

| Step | Action | Image |
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| Rotary Encoder Modifications | | |
| 1 | Tools: small Phillip’s screwdriver, soldering iron, solder, wire snips, wire strippers, and needle nose pliers.  \*Note: solder sucker or de-soldering copper wire is required for de-soldering in Step 3. | Components: rotary encoder and slip ring. |
| 2 | Around the black casing for the encoder are 3 small screws. Unscrew them and along with the nut on the side holding the black cable. Once everything is unscrewed, carefully remove the black casing from the encoder to expose the circuit board. |  |
| 3 | Using the soldering iron carefully heat each joint to de-solder the wires for 5V, GND, A, and B.  Keep the removed black cable for later steps.  \*Note: use either a solder sucker or de-soldering copper wire for de-soldering |  |
| 4 | Trim the slip ring wires to the needed length to solder onto the encoder. Once the wires are trimmed, use the black cable jacket from Step 3 to cover the slip ring wires that are located outside of the black casing.  Place the trimmed black cable jacket over the slip ring wires and then slide the nut over the wires. |  |
| 5 | Run the slip ring wires through the black casing. Each wire will need to be stripped enough to place in the 4 locations on the circuit board. After stripping the wires, solder them to the circuit board. Be sure to make note of what color wire is soldered to each joint. This will be needed moving forward with other connections.  Imperative to not touch the disk found under the circuit board with the soldering iron. Damage to the disk will result in a damaged encoder. |  |
| 6 | Re-attached the black casing and the nut for the black cable.  This completes the modifications to the encoder. Once done secure the encoder to the encoder mount on the pendulum. |  |
| Step | Action | Image |
| Ethernet Connections | | |
| 1 | Tools: soldering iron, solder, wire snips, wire strippers, heat gun, and needle nose pliers. | Components: slip ring, stepper motor, cut Ethernet cable, and heat shrink. |
| 2 | The slip ring wires found inside of the pendulum will need to be trimmed and stripped. Be sure to leave enough wire so the access door of the pendulum can still easily be opened. After each wire is trimmed and stripped, heat shrink will need to be placed on the wires. |  |
| 3 | Cut the stepper motor wire leaving about 8 inches of wire. Keep the discarded wire for it will be used with the control box Ethernet cable. |  |
| 4 | Solder the stepper motor wires to the prepped Ethernet cable. Once the soldering is completed, slide the heat shrink over the soldered area. Use a heat gun on the heat shrink. The heat shrink will shrink to the size of the wire and will no longer be able to be moved. This should only take a couple of seconds.  \*Note: In place of heat shrink, electrical tape could be used. A blow dryer can be used in place of a heat gun |  |
| 5 | Solder the slip ring wires to the Ethernet cable. Repeat Step 4 when placing the heat shrink. |  |
| 6 | Plug the completed Ethernet cable into the Ethernet port located on the access door of the pendulum. |  |

**Electrical Wiring: Pendulum to Control Box**

| Step | Action | Image |
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| Ethernet Connection | | |
| 1 | Using the male to male stretch coiled Ethernet cable, connect the pendulum to the control box via the Ethernet ports. |  |