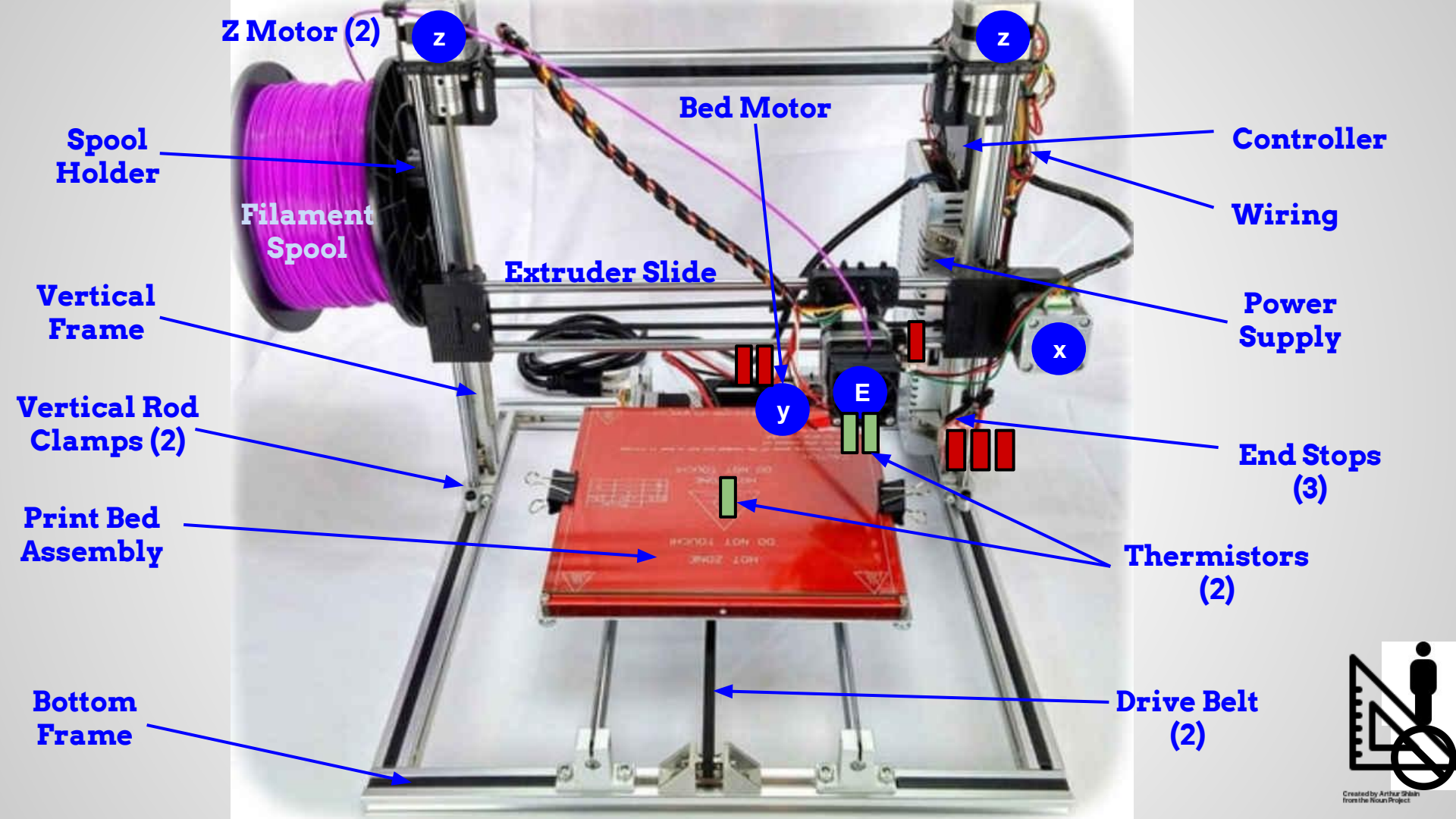
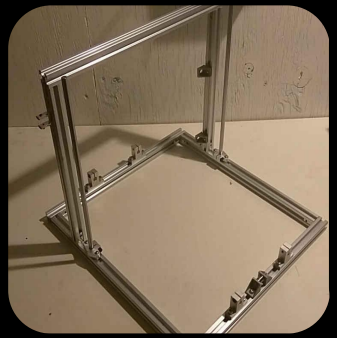
TOC

1. Strategy
2. Build Schedule
3. Part Diagram
4. Build Phases
5. Modules + QC Checklists
6. Module QC
7. Module Scope
8. Finishing Strategy
9. Quality Control
    a. Tools
    b. Time
    c. Quality
    d. Troublespots
10. Overall packing list

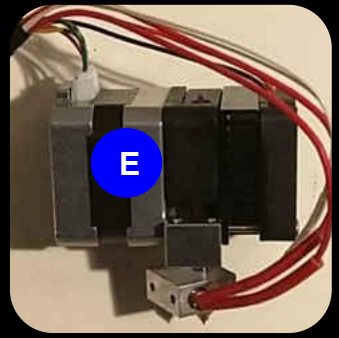

Z Motor (2)
z
z
Bed Motor
Spool Holder
Filament Spool
Extruder Slide
Controller
Wiring
Power Supply
Vertical Frame
x
y
E
Vertical Rod Clamps (2)
End Stops (3)
Print Bed Assembly
Thermistors (2)
Bottom Frame
Drive Belt (2)
Created by Arthur Shlain from the Noun Project

Modules (10)

Frame



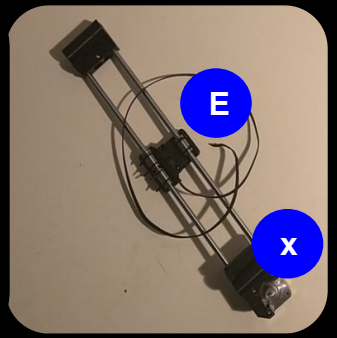
Extruder Assembly



Print Bed



Extruder Slide



Print Bed Motor



Z Motor Assembly (2)



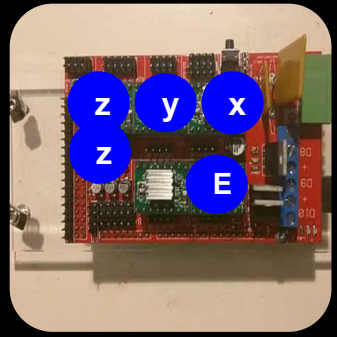
End Stops (2)



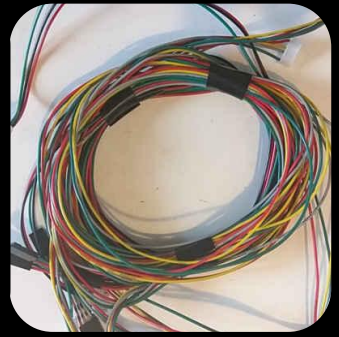
Power Supply



Controller



Wiring Bundle



Module Assembly Order

55:00

Learnings: Total time for assembly of built modules: 55 minutes. Extruder slide belt should be wound around drive and idler prior to mounting. Belt itself took 9:30 - as much as all electronics connections. Note Extruder Slide and Z Motors are put together as one, since Z Motors dictate Extruder Slide width.

1 Frame



2 Extruder Slide

3 Z Motors



5:10

+9:30 belt

Threaded Rods

3:30

4 Print Bed



6:30

5 Print Bed Motor



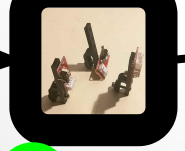
5:08

6 Extruder Assembly



5:20

7 End Stops



5:45

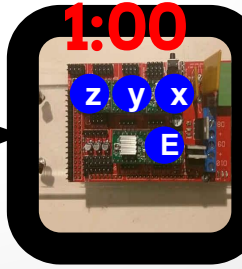
8 Power Supply



2:50

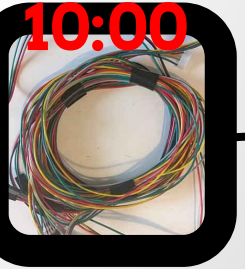
Extruder fan connected to power supply before power supply is mounted.

9 Controller



1:00

10 Wiring Bundle



10:00

- Add glass print surface
- Upload firmware
- Get software
- Test motions + heat
- Level the bed
- Print Calibration Cube

Assembly and Disassembly Times

55

23

Frame



9:45 to parts

Extruder Slide



:10

Z Motors



:41

5:10

Threaded Rods

3:30

:35

:45

+9:30 belt

Print Bed



6:30

1:37



5:08

1:44

Print Bed Motor

5:45



2:30

End Stops



5:20

:43

Extruder Assembly

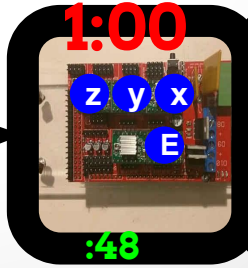
2:50



1:46

Power Supply

1:00



:48

Controller

10:00

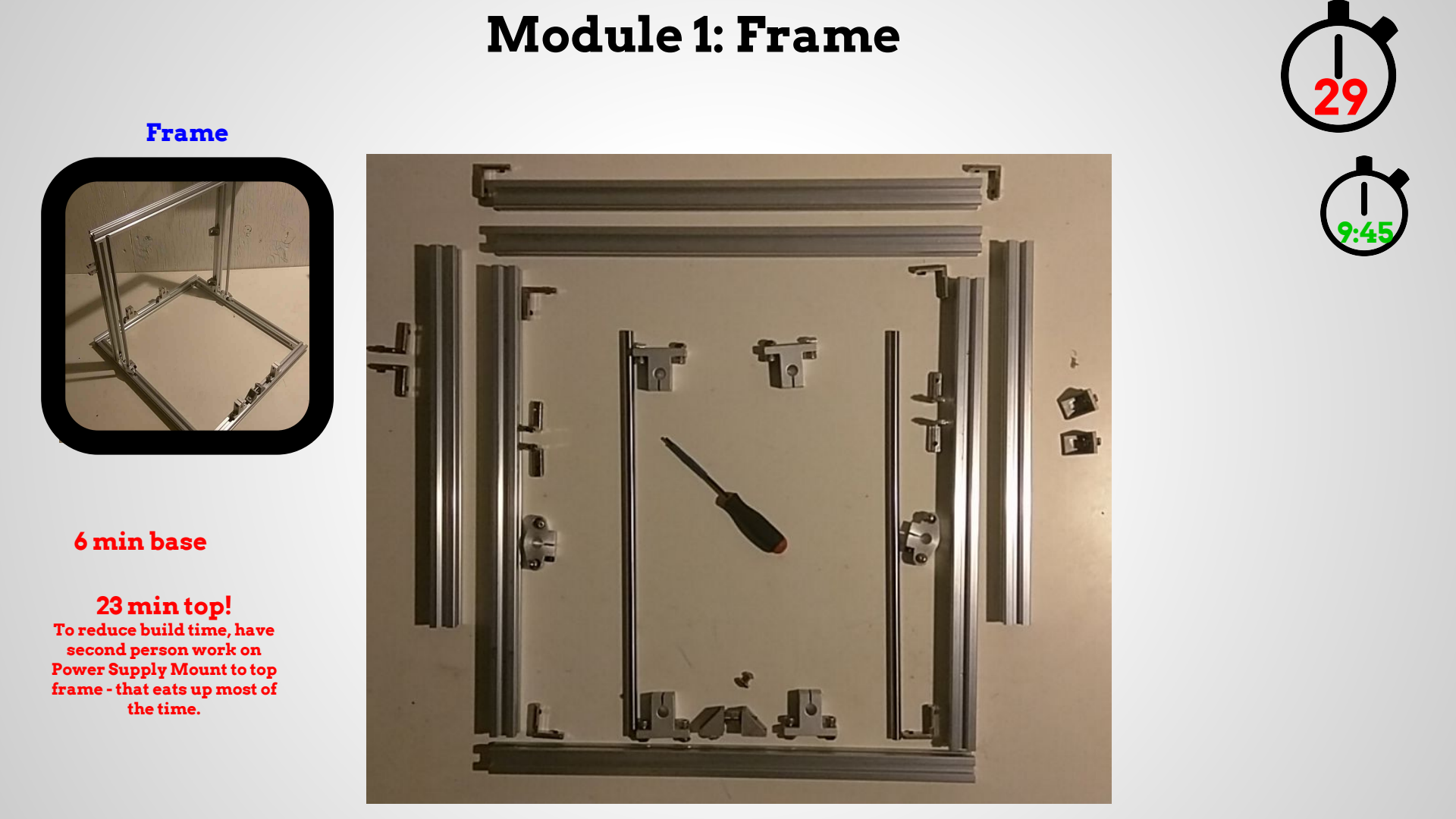


1:49

Wiring Bundle

- Add glass print surface
- Upload firmware
- Get software
- Test motions + heat
- Level the bed
- Print Calibration Cube

Module 1: Frame



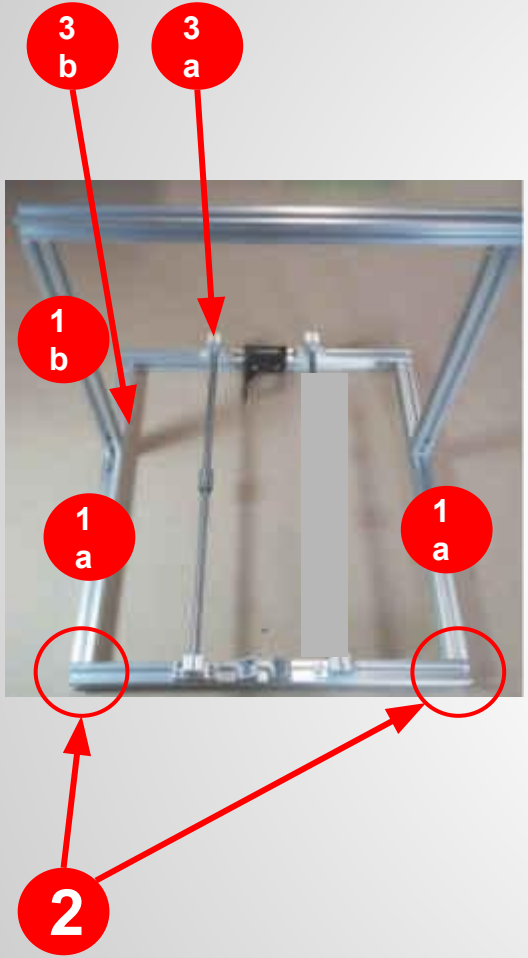
Frame

6 min base

23 min top!

To reduce build time, have second person work on Power Supply Mount to top frame - that eats up most of the time.

Frame QC Checklist



- [ ] 1a Bottom Frame: 2 L-brackets are inserted into each side
- [ ] 1b Top Frame: 2 L-brackets are inserted into left side
- [ ] 2 Side members are ABOVE, and NOT OUTSIDE of front member
- [ ] 3a Left bed bushing is 90 mm from left edge
- [ ] 3b Vertical frame is 90 mm from rear edge
- [ ] 4 corners are tightened on bottom frame
- [ ] 2 corners are tightened on top frame
- [ ] 2 bed bushings are tightened down



Module 2: Extruder Slide

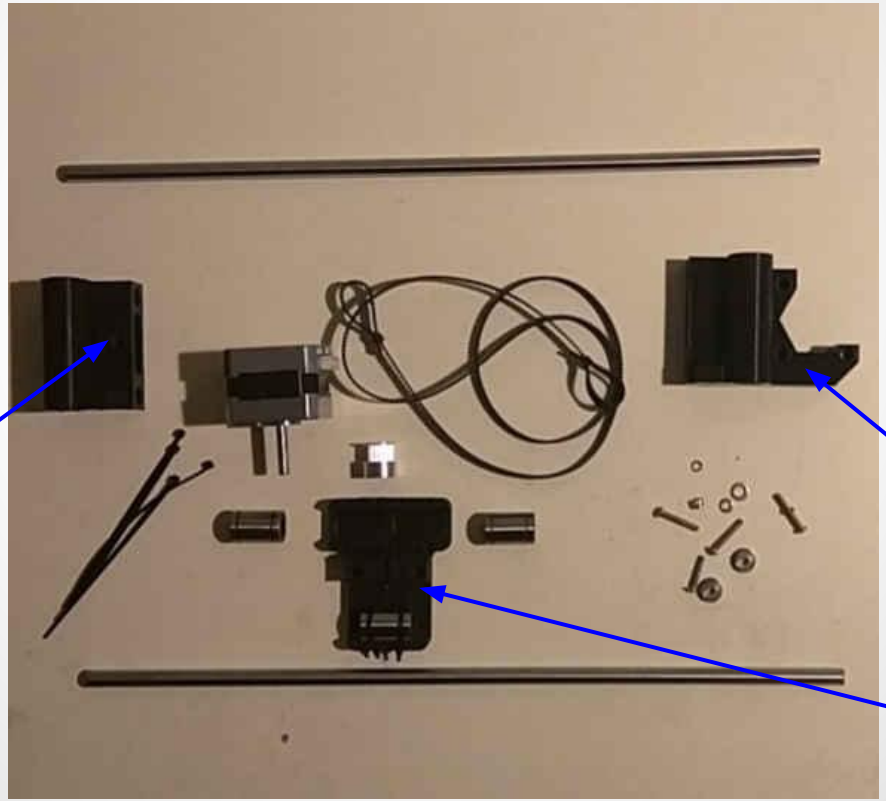


Does not include: snapping bearings into right and left printed pieces, cutting or fastening of belt ends, and snapping in one of the 3 bearings in carriage.



Extruder Slide





Left Printed Piece

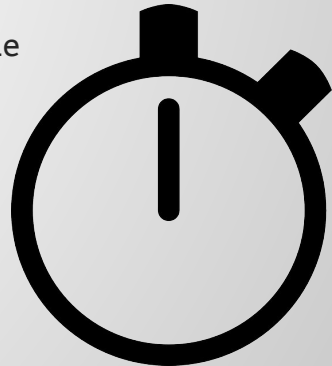
Right Printed Piece

Carriage

Extruder Slide QC Checklist



- [ ] 2 bearings are inserted in left hand printed piece
- [ ] 2 bearings are inserted in right hand printed piece
- [ ] Pulley is inserted so that 3-4 mm of motor shaft are sticking out
- [ ] Pulley teeth are facing towards the motor
- [ ] Belt is wound around the pulley, with belt teeth facing the pulley
- [ ] Flat side of right printed piece, flat side of left printed piece, and flat side of carriage are facing the same way
- [ ] The double bearing of carriage is on the top side
- [ ] Motor plug is facing up



Module 3: Z Motors



Z Motor Assembly (2)

All done. 2:05 hr so far.



8:50

4:30

Check orientation of motors

Z Motors QC Checklist



- [ ] Motor plugs are facing up
- [ ] Lock washers are under every screw
- [ ] 1 screw is in each elongated hole
- [ ] Filament guide is attached



Module 4: Print Bed

Does not include cutting of belts or zip tying them, nor mounting of bearings on 3D printed parts.

Print Bed







Print Bed QC Checklist



- [ ] Double bearing is mounted with rod inside of bearing for alignment
- [ ] Rough side of heated surface is facing up
- [ ] Screw head for bearing holders is on opposide side from bearing holders
- [ ] Belt holder opening faces the bearing pair
- [ ] Belt holder is in the hole pair farther away from the bearing pair
- [ ] Thumb screw is under aluminum, with bolt head on top of the heated surface.
- [ ] Spring is used between two plates om 4 corners
- [ ] Belt is attached on one side
- [ ] All 3d printed pieces are tightened down
- [ ] Thumb screw is tightened so end of bolt is even w/ thumb screw
- [ ] Tape up the wiring every 5” so it’s neat



Module 5: Print Bed Motor

3:45

2

Print Bed Motor



All done.



Make sure of orientation of motor. QC 1:

Bed Motor QC Checklist



- [ ] Set screws tight
- [ ] Screws are both is same slot
- [ ] Teeth of pulley face motor
- [ ] Shaft is flush with pulley
- [ ] T nuts are mounted half way on the bolt
- [ ] Connector faces away
- [ ] Bracket slotted holes are to the right
- [ ] T nuts are mounted on slot closest to you



Module 6: End Stops





In all cases, printed part is standing up.

1: mid hole of endstop holder, plug facing up, bottom right hole of endstop
2: mid hole of endstop holder, plug facing down, mid hole of endstop
3. bottom hole of endstopholder, plug facing down, mid hole of endstop.

End Stops (2)



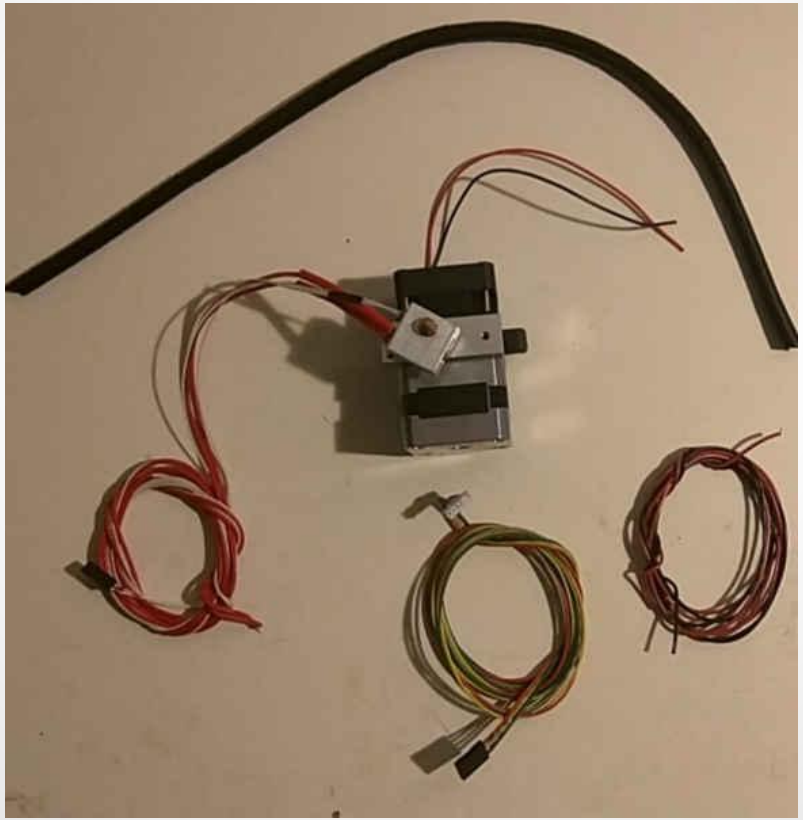
Total: 2 hrs 30 minutes for building all modules, not including prep.

Module 7: Extruder Assembly



Extruder Assembly







Includes:

- **Tinning of ends**
- **Hooks on fan motor wire**

Module 8: Power Supply



Power Supply

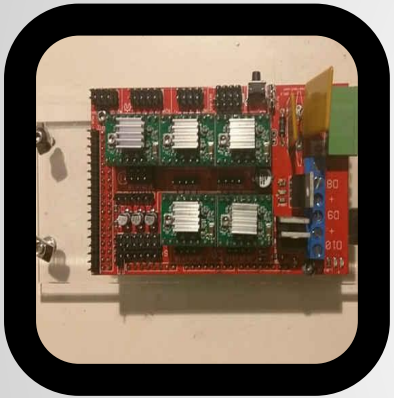


20:30

5:00

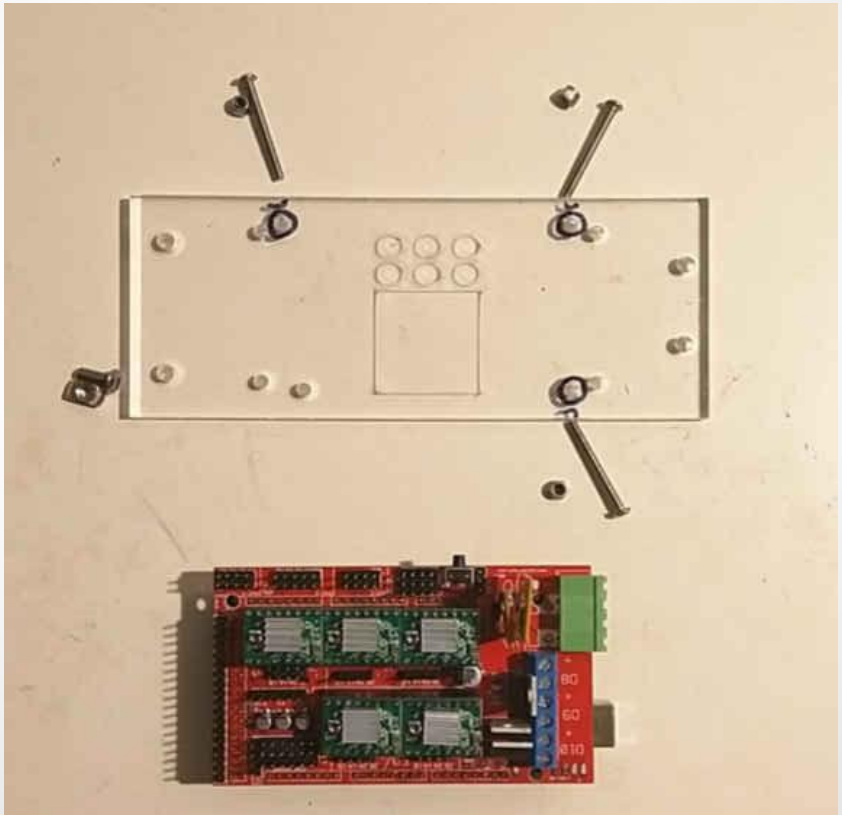
Make sure of + and -, and check plug polarity

Module 9: Controller



Controller

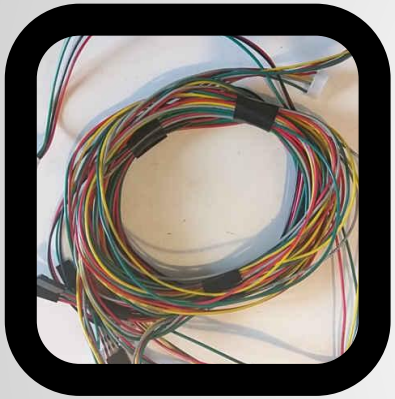
All done.







Module 10: Wiring Bundle



Wiring Bundle

All done.



12:40

2:40

Make sure all wires are labeled prior to winding

3D Printer Build Optimization

OSE Prusa i3 Build Based on a Modified Folgertech Prusa i3

Thesis Statement: (something proposed to be proven) - There is a cultural hunger for tangible productivity in a world where virtual reality is taking over many areas of life. Cultural transformation towards realizing one's productive capacity can be accelerated significantly by rapid-learning, immersion build experiences. Such a model of production can be economically significant. To test this, we are proposing the Distributive Enterprise on the 3D printer as an initial example of cultural shift towards economically-significant mass creation of right livelihood activity, which has an immediate potential of rapid scaling. Such economic significance can be measured by observing the market spread of this distributive enterprise social production model.

Abstract: The goal for OSE's 3D printer build is to enable a 6 hour build of 3D printer by using parallel, collaborative team work based on OSE's Extreme Manufacturing. We are testing what it takes to reduce the build to a 4 hour optimized duration, up to the successful first print of a calibration cube, such that under a more relaxed setting, the build fits in a single day workshop. To do this, we are: (1) optimizing the Depth of Modularity for the parallel build, (2) preparing turnkey software for running the 3D Printer, (3) working as a mixture of swarm prep, pair build, and mutual assistance, (4) modifying build order to take advantage of a crowd build, (5) installing a rapid learning environment where accelerated learning is diffused through the build teams, and (6) and installing a self-actuating quality controlmechanism. The intended outcome of the first event is: (1) 24 people building 12 3D printers in a single day; (2) to demonstrate that the learning environment that is created can scale to as many 3D printers as allowed by space, under the guidance of a single event Master of Ceremonies; (3), that the productivity of such an event leads to a viable economic model of production; and (4), that this novel production model of open source Distributive Enterprise can be used to fund transformative projects.

Keywords: Extreme Manufacturing. Social Production. Open Source Ecology. Introducing advanced production to the masses. Economic Significance. Cultural Transformation. Economic innovation.

Strategy

General Strategy: Workshop leaders manage timing and QC. (1) Modules are have well-defined boundaries and scope, and firm build schedule exists; (2) Material inventory is done with Visual Inventory Cheatsheets; (3) pair up on Module Build; firm schedule and cutoff exists for each module, and one person in team finishes up as other person continues to next module; (4) work in pairs during Module Assembly. (5) diffuse learnings and work as a group to achieve fusion.
QC Strategy: QC occurs at build stations by: (1) prepared checklist rintouts; participants checking offworkshop leaders. Once all modules are built, they go to a quality control table, and are controlled as a group of 12 identical modules. Statistics are taken: number of errors per batch.
Definition of Success: EVERYONE finishes in time up to successful print of a calibration cube. This is a Team Effort. Fusion is defined as instructors not being a bottleneck - towards the point where the build runs itself by diffusion of learning.

Build Schedule Detail

Schedule:

- 8 AM: Introduction. Personal goals + OSE Intro
- 9-Noon: Build Session 1
  - Module 1 - Frame - 9-9:45 (45 min)
  - Carriage - 9:45-10:30 (45 min)
  - Z Motors - 10:30-10:40 (10 min)
  - Print Bed - 10:40-11:10 (30 min)
  - Print Bed Motor/End Stops - 11:10-11:15 (10 min)
  - Extruder Assembly - 11:15-11:35 (20 min)
  - Module 8 -Power Supply - 11:35-11:55 (25 min)
  -
- Lunch
- 1-4: Build Session 2
  - Module 9 - Controller - 1-1:05 (5 min)
  - Module 10 - Wiring bundle - 1:05-1:25 (20 min)
  - Overall Assembly - 1:25-4 (2:35 hours)
- 4-5: Pre-Power check, up to Calibration Cube (1 hour)
- 5-6: Dinner
- 7-8:30: Learning Discussion

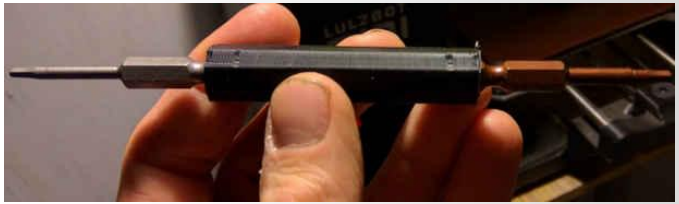
Build Times: Jonathan, Marcin, Catarina, Torbjorn

Tools

Critical:

- **Combination square**
- **2-ended 2 & 2.5 mm hex wrench (3DP)**
- **3 mm + 4 mm hex wrench**
- **5.5 mm wrench**
- **Philips screwdriver**
- **Soldering iron + solder**
- **Heat shrink + heat gun**
- **Flush cutter**







Overall Workshop List

- 10 part trays, 1 per printer
- Tripod + camera - for time lapse
- Computer
- Demo 3D printer
- Demo module set for 3D printer
- Joshua's printer
- 12 printer sets
- Visual BOM sheets
- 1 tray of tools
- Soldering station + Solder
- Electrical tape
- Portable printer for printing out QC instructions
-

Build Phases: Overview

Build Phases:

- Inventory - 2 minutes per module
- Module Builds - **3 hours**
- Module Assembly - **3 hours**
- Calibration and First Print - **1 hour**

Then:

- Organizational Learning - over dinner.

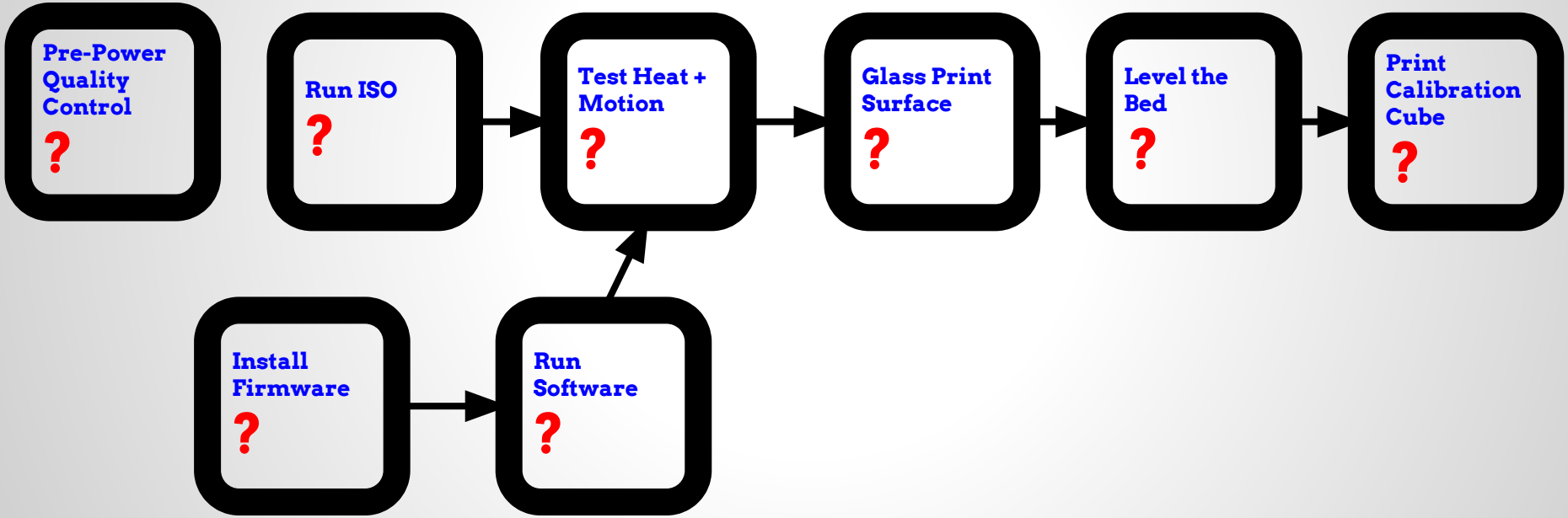
Troublespots

- Front idler - prepped, and with larger washers
- Extruder Slide Module - small bearing laid flat ‘on shelf’, then screw slipped in through bottom.
- Controller: place screws in first, let them fall into the correct holes
- Ream out holes on bed bearing holders so screws slip in
- Ream out extruder carriage holes so screws go in right away
- Tin and solder with one person - much faster
- Label all wires for quick connection
- Oversize bearing holders - easy insert of bearings
- Vertical rods go with extruder carriage, not frame
- Cut back of RAMPS board and end stops boards

Calibration



Scope: Starting with built machine, what do the calibration steps take?



Module Scope 1



Frame

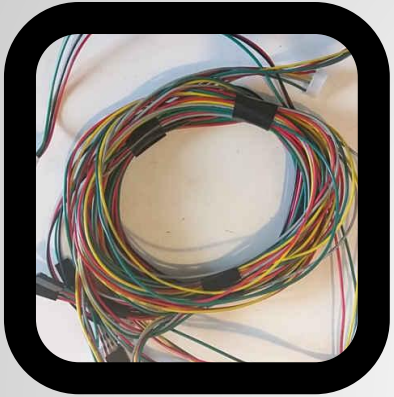
Scope: Base and vertical frame, [4] Bed Clamps, Idler, 2 Vertical Rod Clamps, Power Supply Mount Brackets, Spool Holder Brackets, Everything tightened including rod holders to base and rods to rod holders. [2] right Bed Clamps are not inserted. Note: does not include Vertical Rods, nor Bed Rods.
Interface Design: Connection for Bed, Power Supply, Z Motors, Bed motor and belt, Extruder Slide, Spool.
Interface Robustness: Self-aligning frame. Extruder Slide adjusts in width to fit.



Extruder Slide

Scope: Carriage with 3 linear bearnings that rides on 2 smooth rods. Smooth rods are mounted on 3D printed end pieces, which have linear bearings that ride on the vertical smooth rods of the frame. Includes stepper motor and idler, and drive belt connected to the extruder carriage on ONE side. Includes vertical rods
Interface Design: 2 holes for vertical rods; 2 holes and nut catchers for threaded rod. 2 bolt connection to Extruder Assembly.
Interface Robustness: The module is largely self-aligning, and can fit onto vertical smooth rods because the length is extensible depending on how far the smooth rods of the Extruder Slide are pushed in.

Module Scope 2



Wiring Bundle

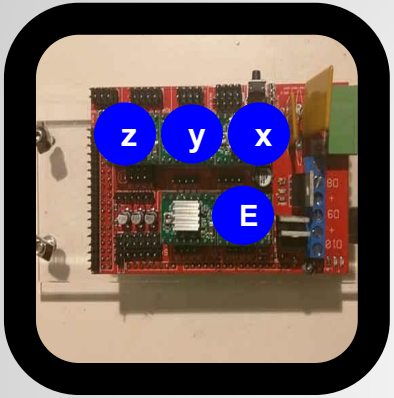
Scope: [4] Motion Motor connectors, [3] Endstop wires.
Interface Design: 3 wire connectors; 4 wire connectors; hanging from power supply. 3 points of connection - motors, endstops, and controller.
Interface Robustness: Endstop end of endstop wires can be connected only one way. Rest have orientations that need to be considered.



Extruder Assembly

Scope: Extruder + Fan; all wiring to Controller and Power Supply. Wire shroud.
Interface Design: [2] 3x40mm screws for mounting to carriage. Controller Connection: 2 wire connector for thermistor; 4 wire connector for motor. Power Connection: 2 wire tinned for heater element; 2 wire tinned/hooked for fan.
Interface Robustness: Connection to motor can only be made one way. Polarity on thermistor and heater wires doesn't matter; Fan power and motor connection to power supply and controller matters.

Module Scope 3



Controller

Scope: RAMPS board and Arduino connected to acrylic mount with 3 screws.
Interface Design: [2] screws to frame. [5] motor connections, [3] endstop connections, [2] thermistor connections; power plug from power supply; Power connection to heated bed and extruder heater.
Interface Robustness: Polarity has to be attended to in most places. Burnout is possible by mis-connecting endstops.



Power Supply

Scope: Power Supply, Power Cord, Controller Power Plug, 2 screws for frame brackets
Interface Design: [2] screws for frame. Wall plug. Power Plug to controller.
Interface Robustness: One-way plugs.

Module Scope 4



End Stops (2)

Scope: Printed parts with circuit, and mounting screw.
Interface Design: Clamp-on with screw connection. One-way plug.
Interface Robustness: Robust with one-way plug. Mechanical connection needs adjustment.



Print Bed Motor

Scope: Motor, mount, sprocket, and 2 mount screws
Interface Design: 2020 extrusion mounting; belt connection to bed. Located against rod.
Interface Robustness: 3 points of connection. Tensioning required.

Module Scope 5



Print Bed

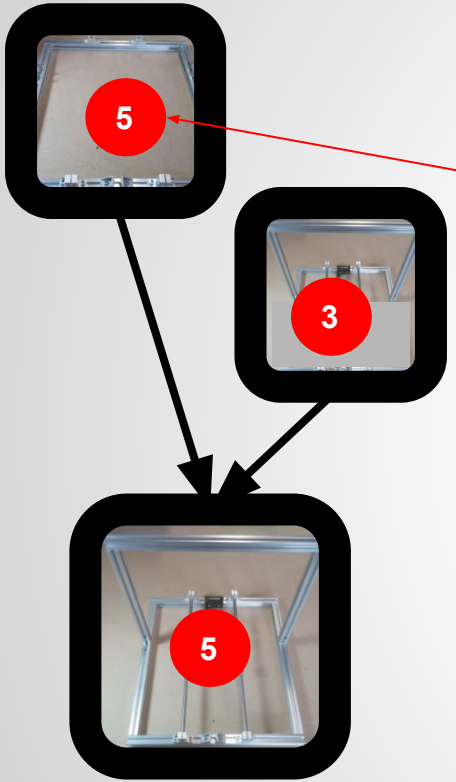
Scope: Aluminum plate, heater surface, (4) adjustment screws thermistor, heater and thermistor wires, (3) bearings, and (2) rods
Interface Design: Connection to frame via rod clamps. Wire connection to controller.
Interface Robustness: Robust with one-way plug. Mechanical connection needs adjustment.



Z Motors

Scope: Motor, Angle Mount, plexiglas face, coupler
Interface Design: [2] screws to frame, adjustable up and down. One way plug to controller. [1] smooth rod goes into plexiglas face. Threaded rod goes inside coupler, tightened with 2 coupler screws..
Interface Robustness: 5 points of connection. Robust plug. Other connection points are located automatically via geometry.

Build Instructions 1: Frame



1. **Make Base Frame**. Use [4] 2020s. QC - long pieces front and back, short are superior of the front.
   a. **QC 5**: (1) [1] 'square' frame, (2) [4] Bed Rod Holders, and 90 mm from left edge, (3) [1] idler assembly, (4) [4] vertical L Brackets, (5) [2] Vertical Rod Clamps.
2. **Make vertical frame.** Use [3] 2020s. Assemble z flat, then stand it up. Use a standard combination square. Do a preliminary mounting of power supply. Take off the power supply but leave the mounting brackets. (It is more difficult to mount the supply later with other parts in place). Include [2] L Brackets for Spool Holder.
   a. **QC 3**: (1) 3-piece frame, (2) [2] L Brackets for Spool Holder. (3) [2] Power Supply mounts are attached.
3. **Combine Vertical Frame with Base Frame**. 90 mm from back of vertical to back of bottom.
   a. **QC 5**: (1) Vertical is square to +- ⅛" over length of members; (2) 90 mm measurement for verticals; (3) Left Bed Rod Holders is tightened to frame, but right is loose. (4) Vertical Rod Clamps are tightened to frame. (5) Spool Holder L Brackets are loose.

Build Instructions 2

Z Rods +







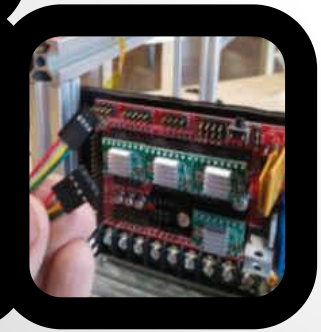
4. **Make Extruder Slide.** This includes Slide Motor but not Extruder Motor.
5. **Make Z Motor Assemblies (2)**.
   a. **QC:** All the way to coupler mounting
6. **Mount Extruder Slide.** Insert z rods into Vertical Rod Holder with Extruder Slide on them.
7. **Mount the z motors.** Do not include their threaded rods. Start on the left, and tighten the left Z Motor Assembly parallel to Vertical Frame. Vertical Rod Clamp determines the location of Z Motor Assembly. Slide z motion up and down freely. Let smooth up-down motion determine the location of the right side Z Motor Assembly, and tighten on the right side.
   a. **QC:** A this time, we have the full Vertical and Extruder Motion without the drive - extruder motion belt and z motion threaded rods.
8. **Install Z Threaded Rods**.
   a. **QC:** (1) Keep Extruder Slide towards the top, so Print Bed can be worked on easily. (2) Level the height of the two Extruder Slide sides by spinning the Z Motor Coupler by hand. (3) Make sure Threaded Rod Nut falls into place into the Nut Hole.
9. **Install Extruder Motion Belt**.
   a. **QC:** Now Vertical and Extruder Motion is complete.

Build Instructions 3



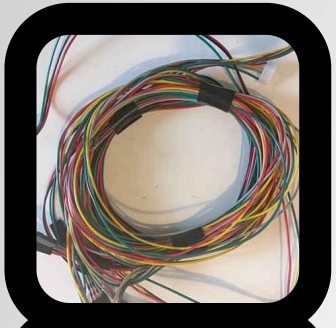






10. **Build Print Bed Assembly.**
    a. **QC**: (1) Do not attach glass yet.
11. **Install Print Bed Assembly**.
    a. **QC**: (1) Tighten the [2] right side Bed Rod Clamps to frame after bed slides smoothly back and forth. (2) Tighten the [4] rod clamps to rods
12. **Install Print Bed Drive**. Attach motor. Attach drive belt.
    a. **QC**: (1) Motor back side touches rod. (2) Belt is stretched and makes a sound like a guitar string. (3) Adjust Belt Idler location and tighten.
13. **Build End Stops**.
14. **Mount end stops**. Use dimensions given. Z stop is fine-adjusted during calibration.
15. **Mount Controller**. Includes acrylic, mount and controller mounted to frame. (note: heat sinks should be in Swarm Prep work)

Build Instructions 4





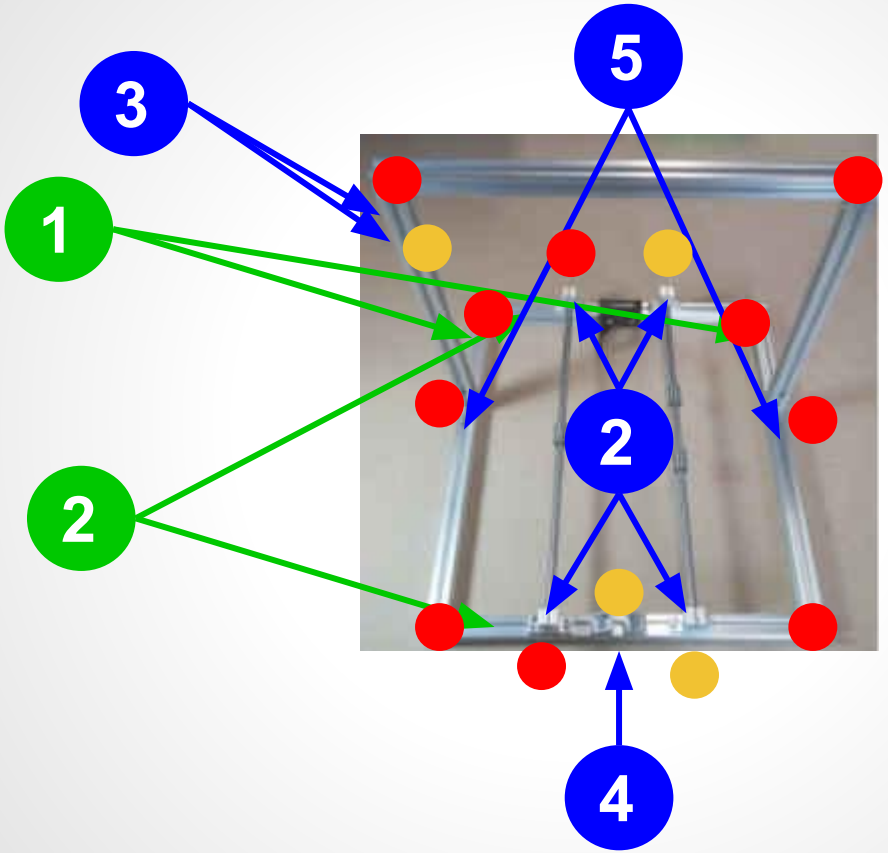


16. **Build Wiring Bundle**.
17. **Build Extruder Assembly**. Includes Fan required in next step.
18. **Wire the power supply**.
    a. **QC**: (1) Power Cord; (2) Controller Power Connector; (2) Fan Power
19. **Mount Extruder Assembly**.
20. **Mount the power supply**.
21. **Complete the wiring.** Connect Motors, Heat Bed, Thermistors, and End Stops to both the Controller and Power Supply. Connect Controller to Power Supply
22. **Run the Control Software**. Boot up Live Linux, or pre-installed software.
23. **Test Electronics.** Test the motion, heat bed, and extruder heater. Test the extruder. Mount the glass print surface. Level the bed.
24. **Print a Calibration Cube**. Make any adjustments if necessary.

Frame QC

Key:

- Distance
- Parts
- Tightening
- Loose

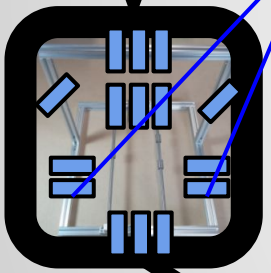


Frame

10



1. [1] Bottom Frame with [4] L Brackets
2. [4] bed bushings
3. [1] belt idler - leave it loose
4. [4] vertical L Brackets.

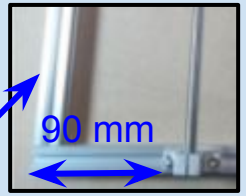


1. [1] Vertical Frame connected using [2] L Brackets
2. [2] L Brackets for Filament Spool Holder
3. [2] L Brackets located and attached for the Power Supply

These 2 frame pieces are connected together. 2 Definition of done is when Z rod holder is in place, and everything is tightened down, ready for Z motors

1 Tighten 4 corners, but leave vertical L Brackets loose until Vertical Frame is fastened. Verify it is perpendicular to +- ¼".

2 Distance from left bed bushing to left edge is 90 mm (front + back)



3 Side member is the shorter member - and is above front frame member.

4 Make sure spool holder L Brackets are inserted



5 Back of vertical is 90 mm from back of base

Wiring Bundle





[2] motor X, Z - 12"
[2] motor Y, Z - 24"

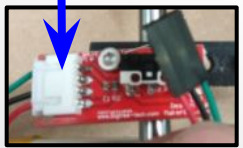


[4] motor - 6"



[3] endstops - 6"

Bundle



[3] endstops - 12"

10

1 Motor end of wire

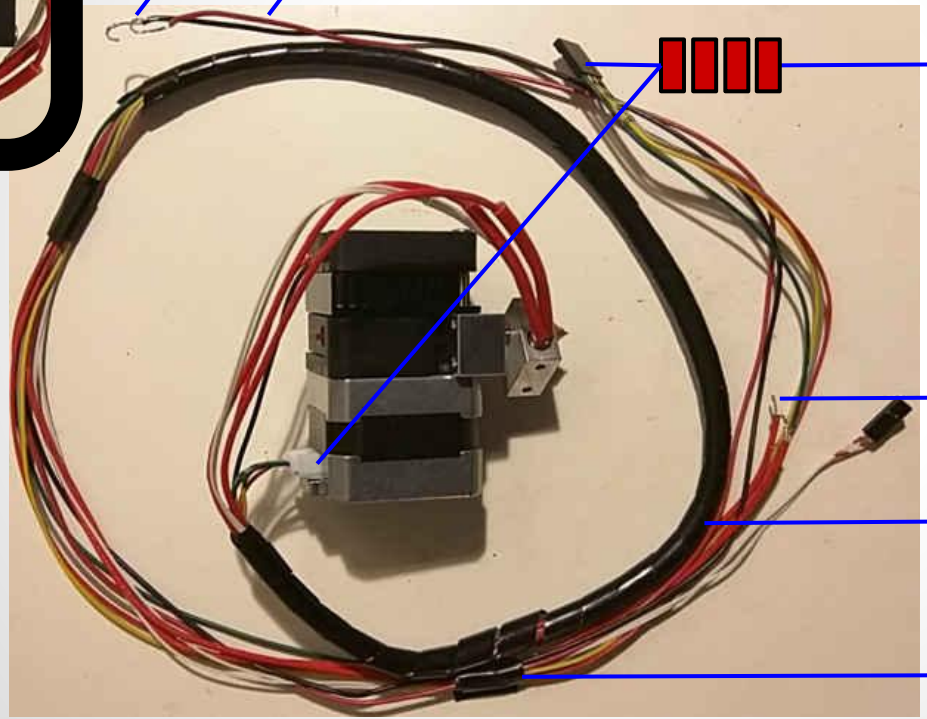
2 Controller end of motor wire

3 Controller end of endstop wire

4 Endstop side of endstop wire

Extruder



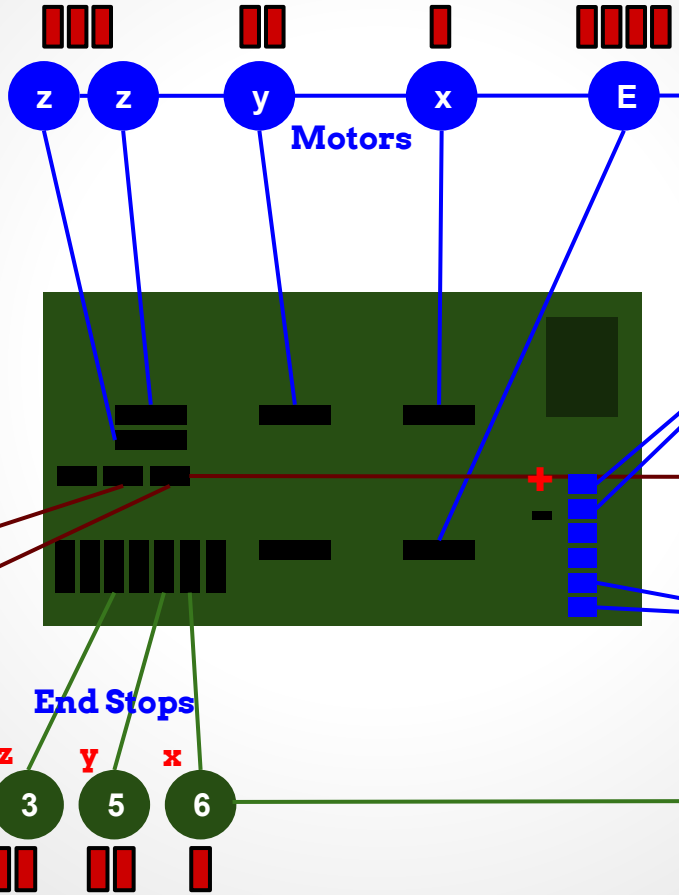


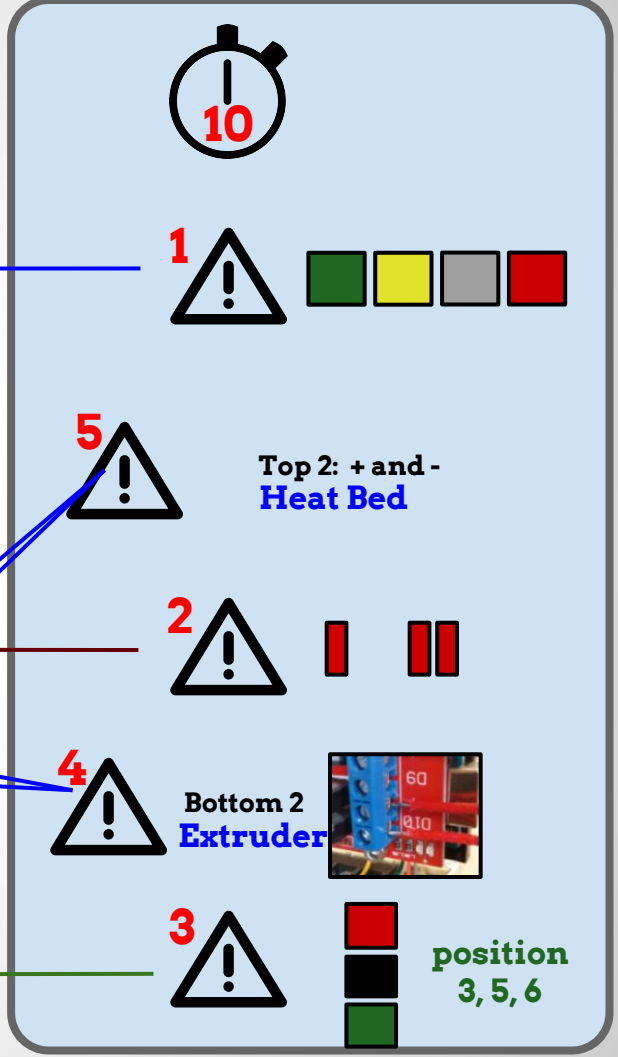
1. Tin and hook fan wire
2. Solder fan wire extension, and use heat shrink
3. Connect 1 Motor Wire to motor, and label with 4 lines on far end
4. Tin 2 heater element wires
5. Wire wrap the wire bundle
6. Tape wire bundle in 2 more places

10

Wiring

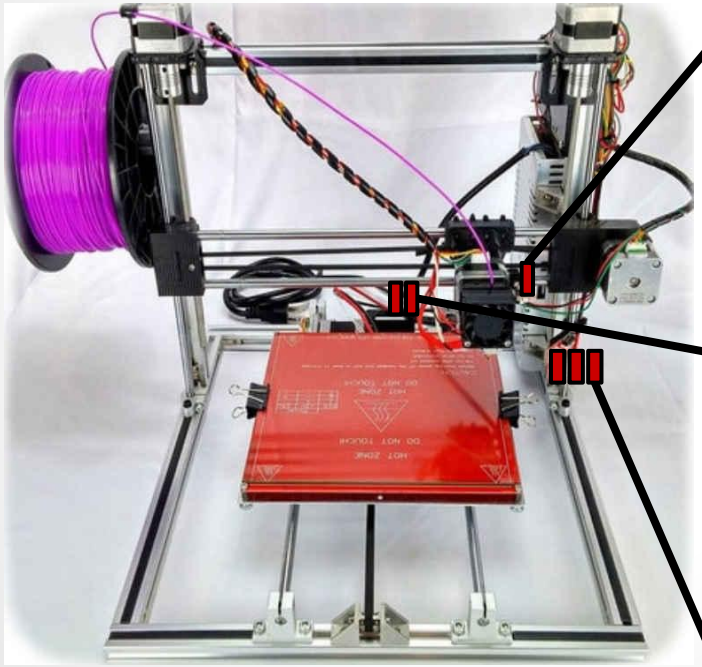



z
z
y
x
E
Motors
Thermistors
1
2
End Stops
z
y
x
position
3
5
6


10
1
5
Top 2: + and -
Heat Bed
2
4
Bottom 2
Extruder
3
position
3, 5, 6

End Stops (3)

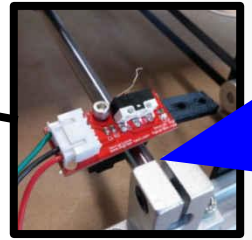




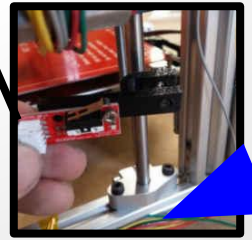
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½”



1-¼”



3-¾”
(from bottom of frame)

Print Bed



Print Bed



Size: 7-⅞”x8-½” glass









Print Bed



Print Bed

Size: 7-⅞”x8-½” glass

10

1

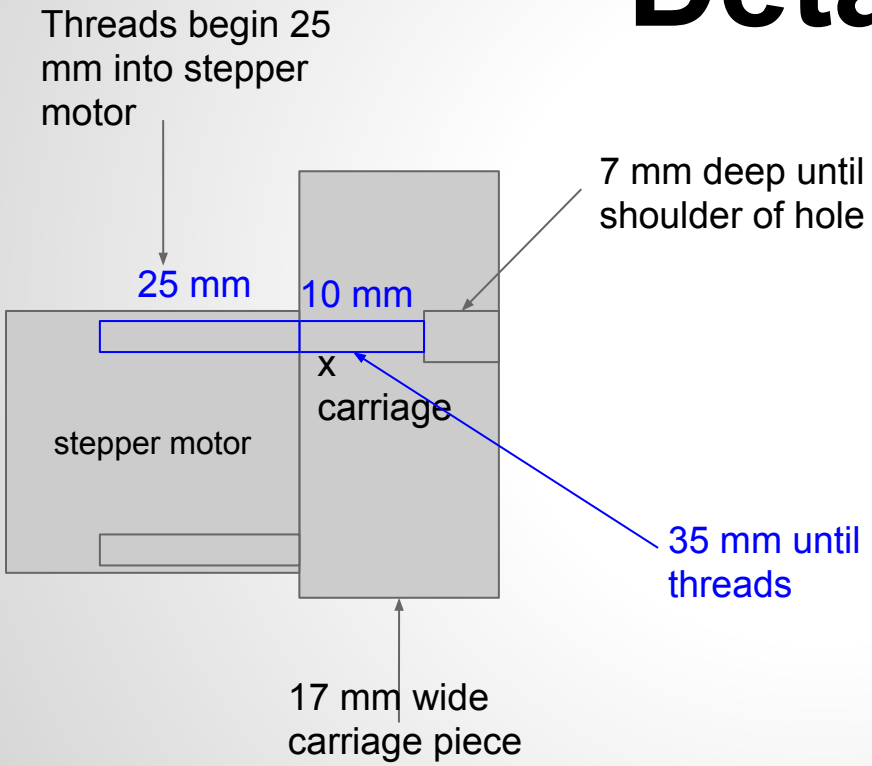
2

3

Credits

Ruler by Arthur Shlain from the Noun Project
Warning by Melissa Halterman from the Noun Project

Extruder Motor Mount Detail



Notes







Bottom Frame



Vertical Frame

