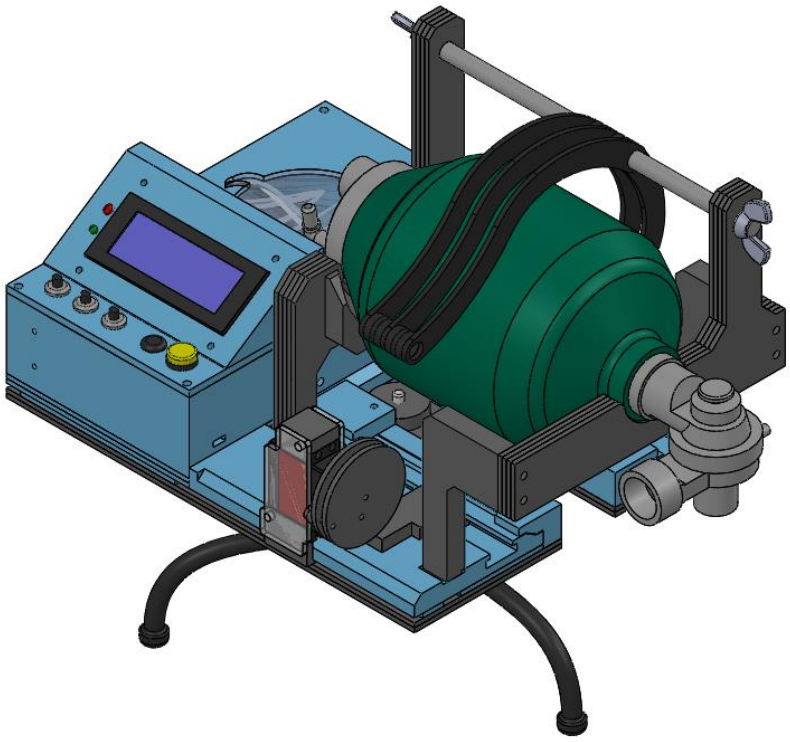
Automatic Inhalation Resuscitator

Assembly Instructions

Originally developed by Connor Simmons, Sam Raisbeck, Brian Mao, and Aditya Matam from The University of Waterloo



****Disclaimer**: The following assembly instructions are made only as a general guide to construct the version of AIR most recently completed as of **April 5, 2020**. As this product will be manufactured quickly, components may be modified or exchanged to fit your specific needs. Any modifications made to the design or its components may result in required variations to the assembly.

Note 1: Please download the entire "Air Full Design" folder, and open the main assembly: "Full Design_V4"

Note 2: Within the provided 3D CAD model, the compression arm models are reference only. This includes the three top arms, two bottom arms, and the bottom arm connector. The dimensions used for the models are reference only and do not fully represent the final manufactured versions. These files are tagged with a "Reference_Only" at the end of the file name.

Note 3: Accurate drawing files for "Reference Only" components can be found in the "AutoCad files" folder. These files are the true manufactured versions for these components. This also includes the logo badge

Note 4: All other components were manufactured according to the dimensions in the CAD model. All dimensions are in mm.

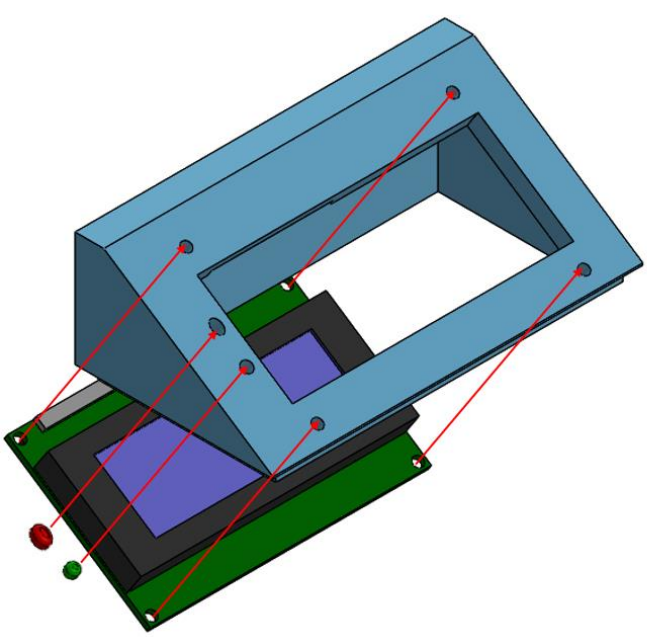
AIR was manufactured using a mixture of 3D printed plastic components, as well as laser cut acrylic. The breakdown of 3D printed vs. laser cut components is listed below. The thickness of acrylic components is also listed, along with a required quantity for each component. The material selections were made with interest to cost and manufacturing time. More complex components were 3D printed, but laser cutting acrylic is often faster and less expensive. Any variations to the materials used is up to manufacturer discretion.

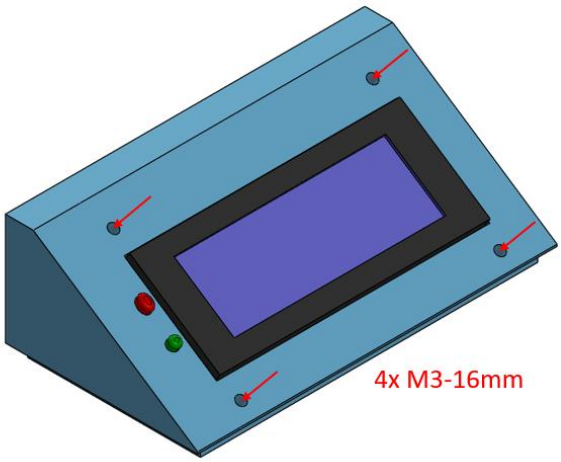
Laser Cut Parts		
Part Name	Thickness (mm)	Qty
Front Support Layer	3	4
Back Support Layer	3	5
Tensioner End Support_Layer	3	4
Control Box Top	4.5	1
Control Box Bottom	3	2
Control_Box_Door	4.5	1
Door_Frame_Bottom	3	1
Door_Frame_Top	3	1
Door_Frame_Left	3	1
Door_Frame_Right	3	1
Control_Box_Spacer	3	1
Frame_Spacer	3	1
Mount_Interface_Plate	3	2
Mount_Interface_Spacer	4.5	1
Servo_Spool_Outside	3	2
Servo_Spool_Inside	4.5	1
Servo_Mount_Plate	3	1
Servo_Mount_Plate_2	3	1
Compression_Arm_Top	3	2
Compression_Arm_Top_With_Connector	3	1
Compress_Arm_Bottom	3	2
Compression_Arm_Spacer	4.5	6
Compression_Arm_Spacer_Thin	3	2
Compression_Arm_Bottom_Connector	3	1
Tensioner_Rod_Spacer	4.5	4

3D Printed Parts	
Part Name	Qty
Base_Frame_V3	1
Front Support Side Legs	2
Servo_Mount_Block_Top	1
Servo_Mount_Block_Bottom_V4	1
Back Support Feet	2
Bag Pullout Support	1
Tensioner End Support_Bottom	1
Box Frame	1
Screen_Mount	1
Mount_Interface_Finger_Left	1
Mount_Interface_Finger_Right	1

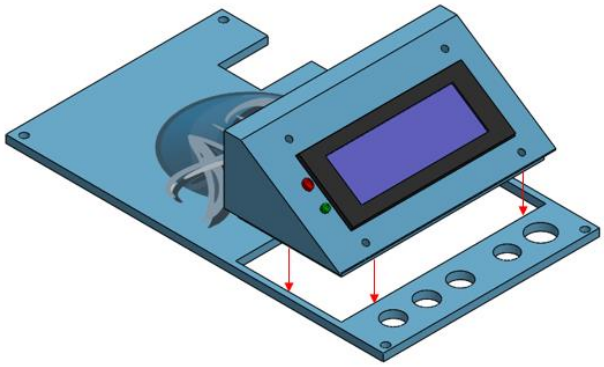
1 – Control Box

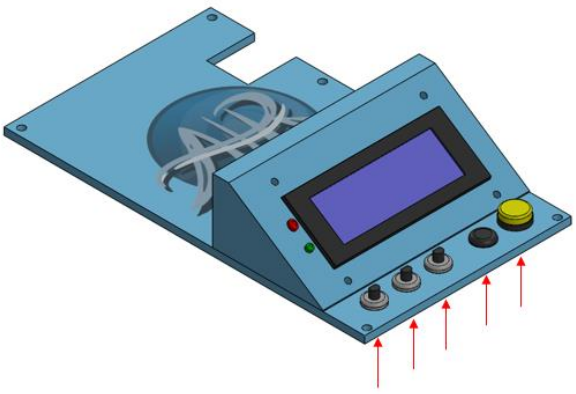
From the underside of the Screen_Mount, insert the LCD and the LED's into the fixture as shown. Secure the LCD with 4 M3 bolts with nuts through the holes indicated.



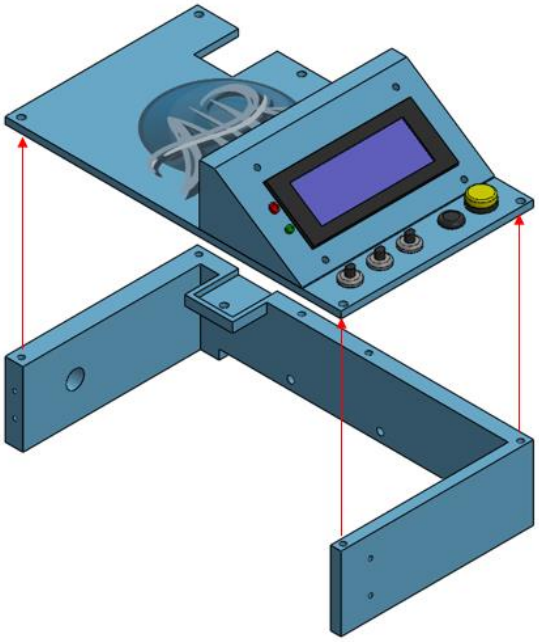


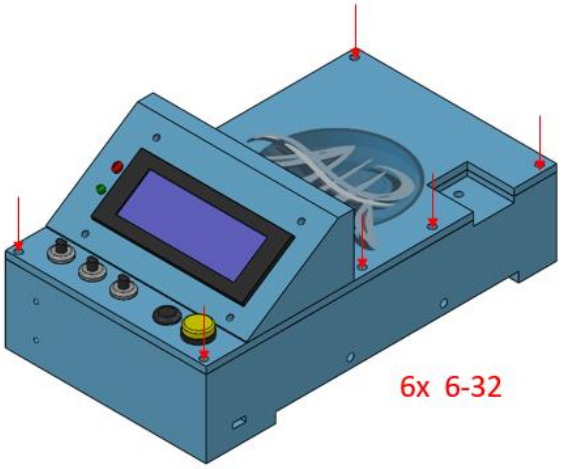
Insert the Screen_Mount into the slot available on the Control Box Top. Insert the potentiometers and buttons into the included holes on the Control Box Top. Add glue where required to hold in place.



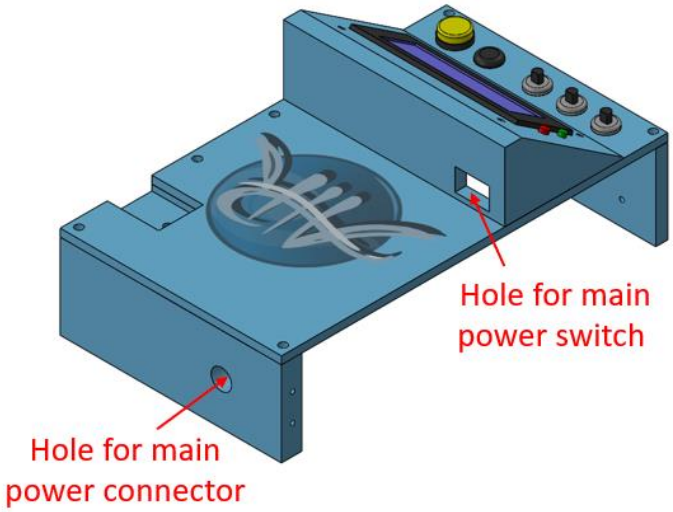


Attach the Control Box Top to the Box Frame through the 6 screw holes indicated.

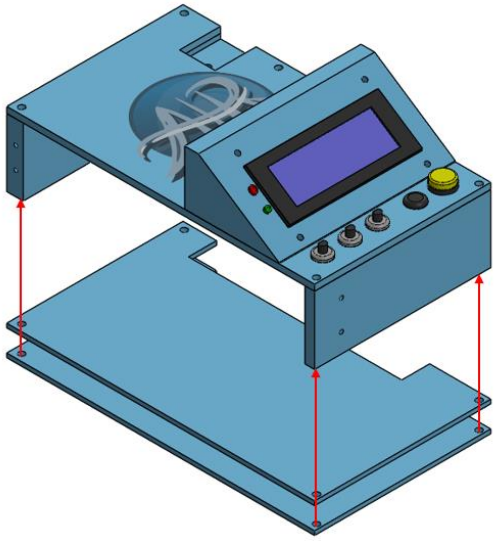


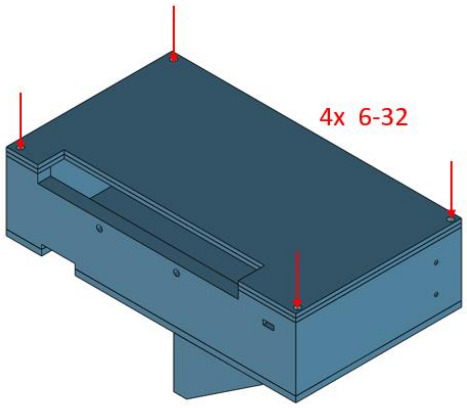


At this point it is recommended that the control box electronics be fully wired. This includes the connections from the controls to the Arduino, the power supply connector, current, sensor, etc. These connections can be found in our electrical schematic, which is also available for download. A rear view of the control box is included below to indicate the use for the cut-outs on the box frame

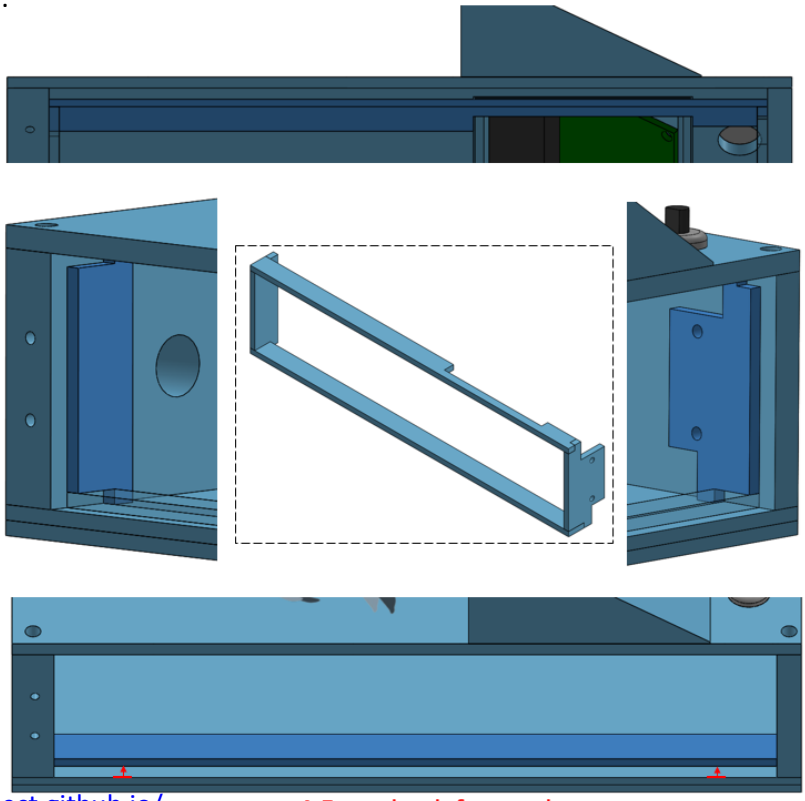


Attach 2 layers of the Control Box Bottom in the manner shown to the underside of the control box, through the 4 screw holes indicated.

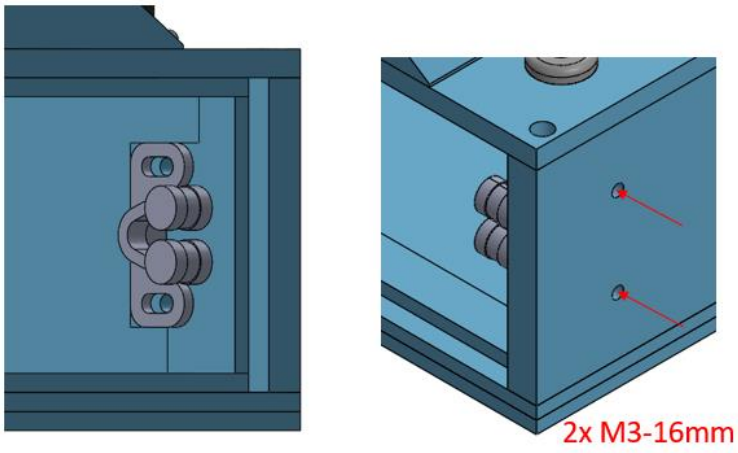




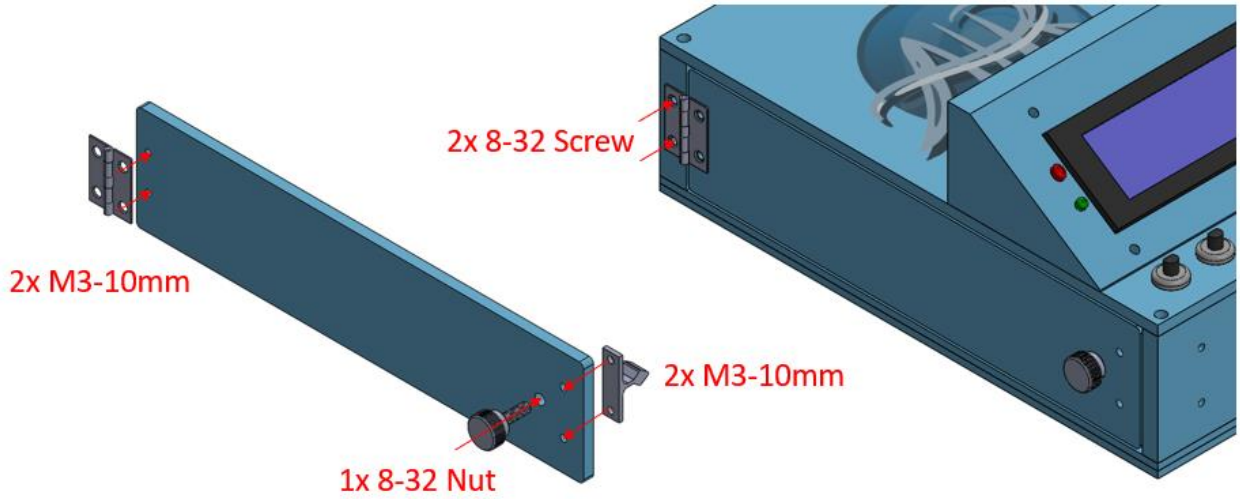
Place the Door_Frame_Bottom inside the control box, 4.5mm back from the edge of the Control Box Bottom. Add glue where required to hold in place. Repeat for the Door_Frame_Left, Door_Frame_Right, and Door_Frame_Top. If the bottom frame was installed correctly, the remaining frame pieces should fit together nicely with their included cut-outs. Check the placement and orientation of all pieces before gluing into position.



Place the Door_Latch_Plate inside the control box on the Door_Frame_Left, and secure from the outside of the control box through the indicated screw holes with 2 M3 bolts with nuts.

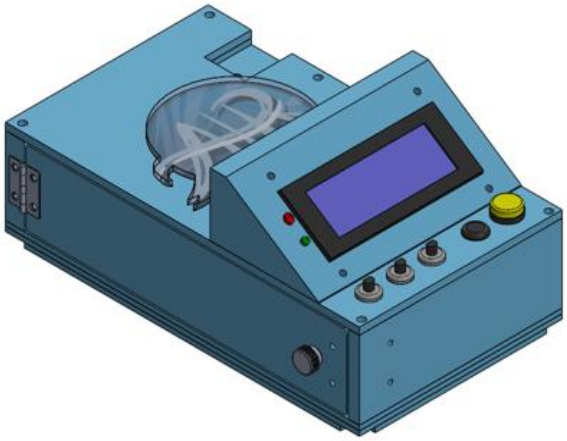


On the Control_Box_Door, secure the Door_Latch_Strike using 2 M3 bolts, with nuts. Secure the Door_Knob_Small from the other side through the door with a nut. Attach one side of the Door_Hinge to the door with 2 M3 bolts, with nuts. Then, attach the other side of the hinge to the control box with 2 screws. All bolt heads should be on the outside of the door.



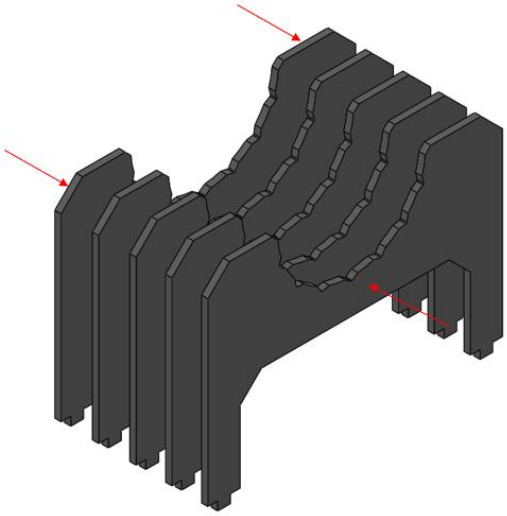
Available for download are our personal AIR logo and the AutoCad file for the logo badge. If willing, print and cut out the logo, and place on the control box with a little amount of glue. Then, place the logo badge overtop to protect the logo and provide a 3D effect. Add small drops of glue periodically around the perimeter of the badge once in place to secure. Only use small amounts around the outside as excess glue may seep underneath and effect the logo presentation.

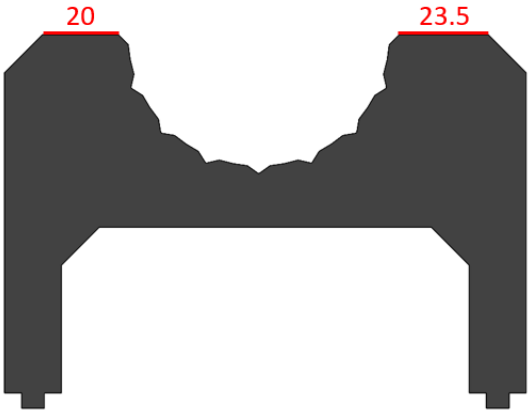
The logo is sized properly in the AIR_Logo_Sized document.



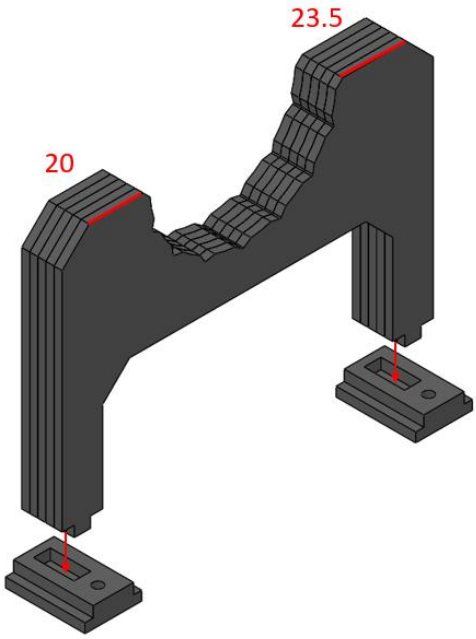
2 – Back Support Assembly

Place 5 Back Support Layers together, add glue where required to hold in place. Take special note that the support is NOT symmetric. The two top edges have slightly different lengths as indicated

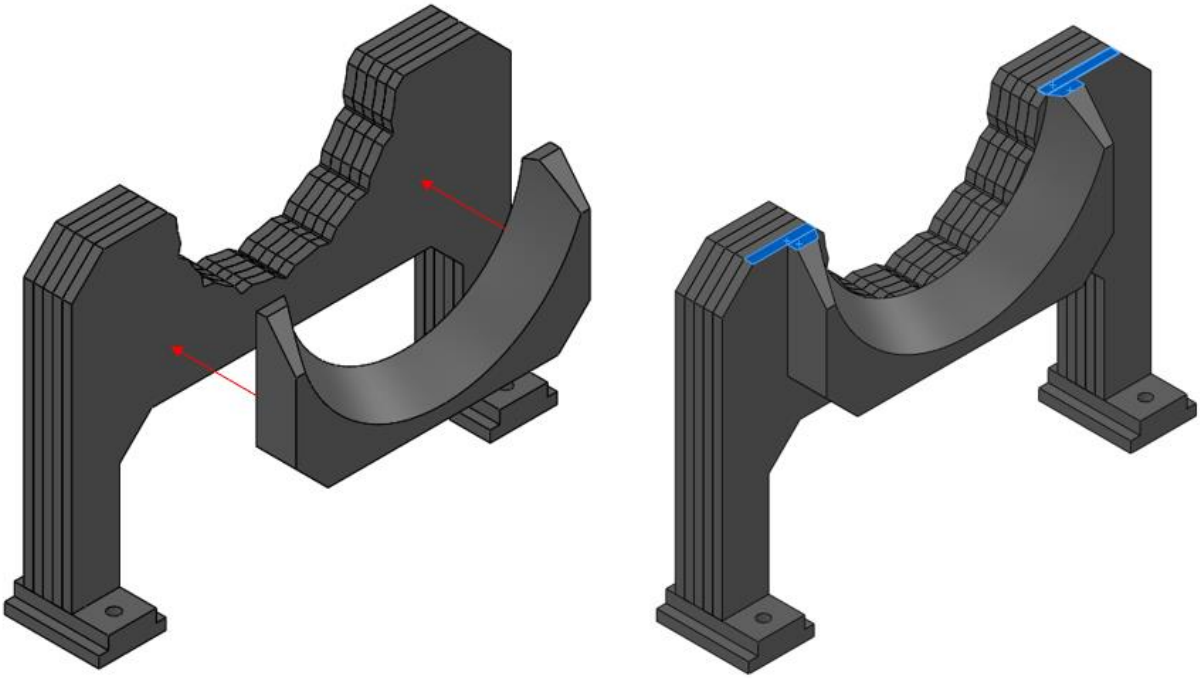




Take the combined layers and attach the 2 Back Support Feet by fitting the protruding nub on the bottom of the support legs into the notch on the feet as indicated. Note the orientation of the feet in relation to the edge lengths of the top of the support. Add glue to the notch to fully secure.

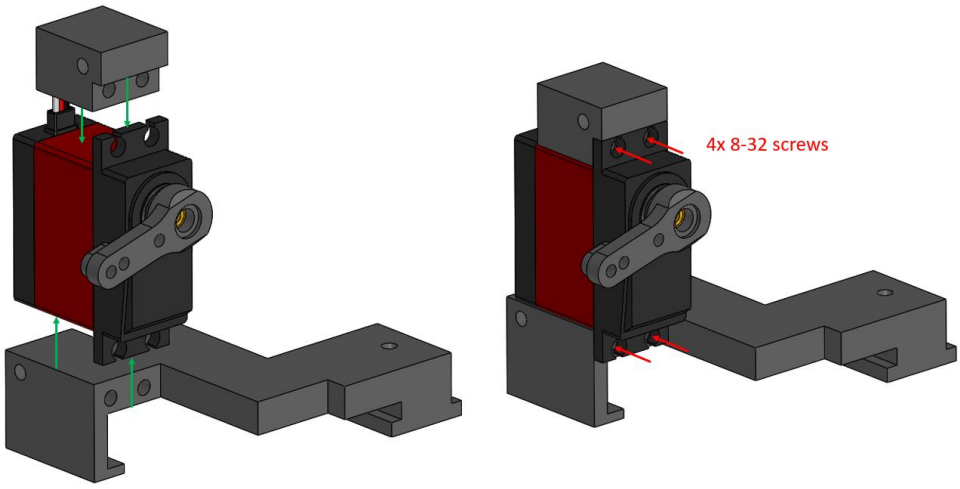


Attach the Bag Pullout Support to the support layers as indicated, add glue where required to hold in place. The flat edges at the top of the Pullout Support should be aligned with the top edge of the support layers as shown highlighted in blue.

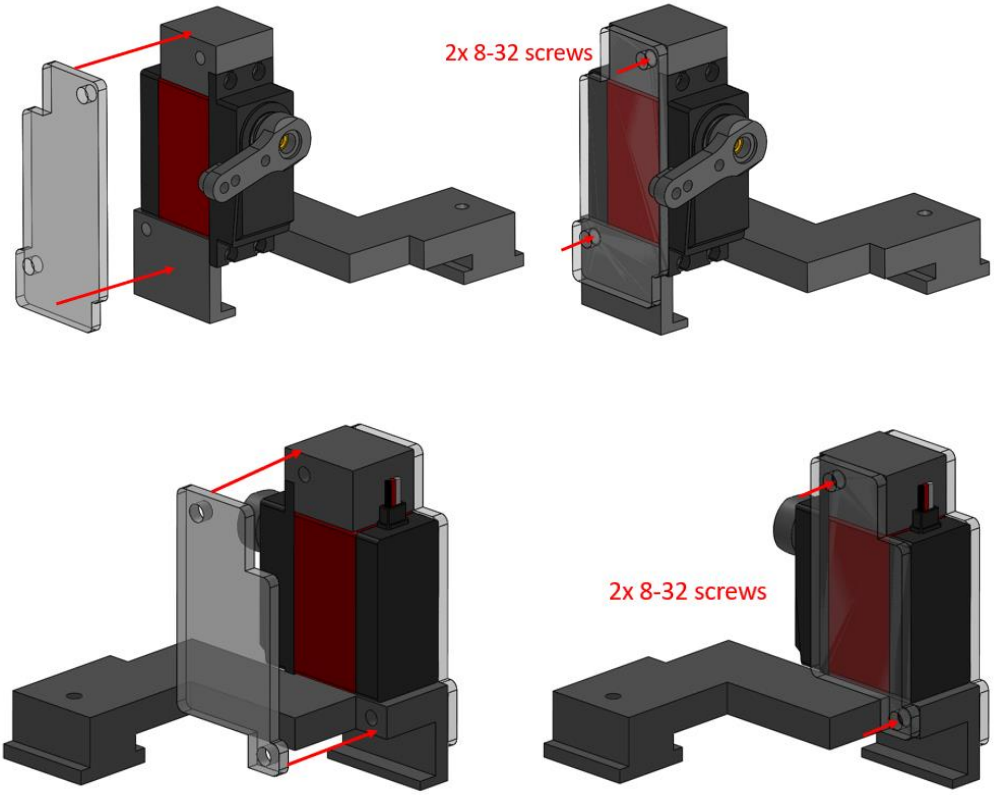


3 – Servo Assembly

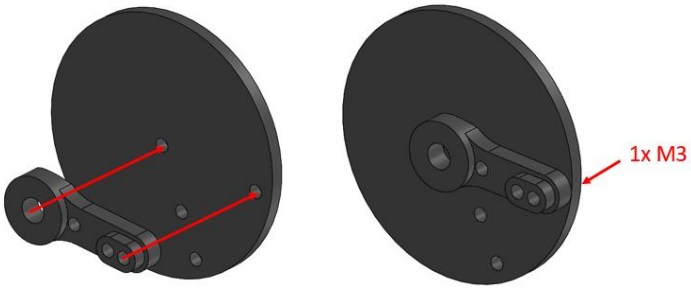
Place the Servo_Mount_Block_Top and Servo_Mount_Block_Bottom_V4 on the servo in the positions shown. Secure in place using 4 screws in the locations shown, but **DO NOT** tighten fully.



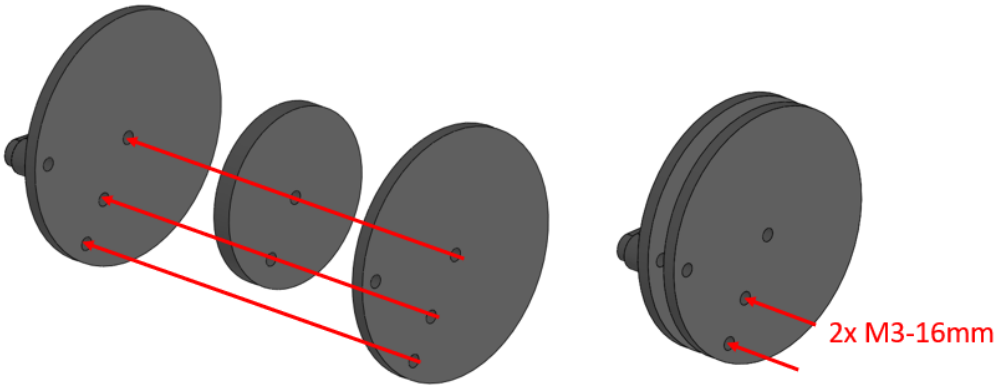
Add the Servo_Mount_Plate in the position and orientation shown. Secure to the servo mount blocks in the indicated screw locations. Again, **DO NOT** tighten fully. Repeat for Servo_Mount_Plate_2. Once both plates are secure, go back and tighten all 8 screws.



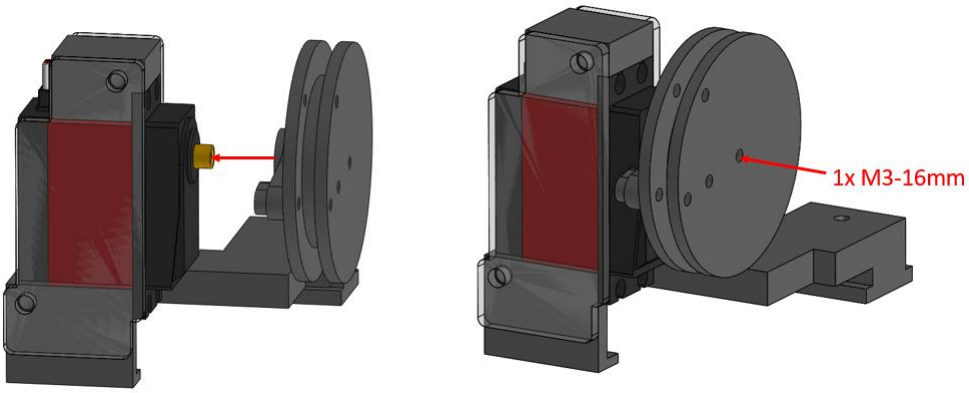
To assemble the spool, take the servo arm and attach to a Servo_Spool_Outside, aligning the center of the servo arm with the center hole on the spool, and the furthest hole on the servo arm with the singular hole near the rim of the spool. Secure the arm using only the 1 screw provided with the arm in the hole furthest from the center. If a screw was not provided, an M3 bolt can be used



Next, place the Servo_Spool_Outside and servo arm pair together with another Servo_Spool_Outside on either side of a Servo_Spool_Inside. Align the set of 3 in-line holes as indicated. Secure the spool components together by 2 M3 bolts, with nuts. The bolt closer to the center will go through all 3 layers. The bolt near the outer rim goes through only the 2 outer spool layers.

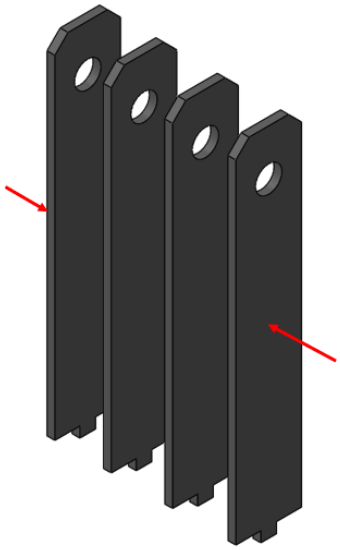


Attach the servo spool to the servo using the servo arm. Align the large center hole on the servo arm with the shaft of the servo. Secure the spool to the servo using an M3 bolt through the center hole on the spool as shown.

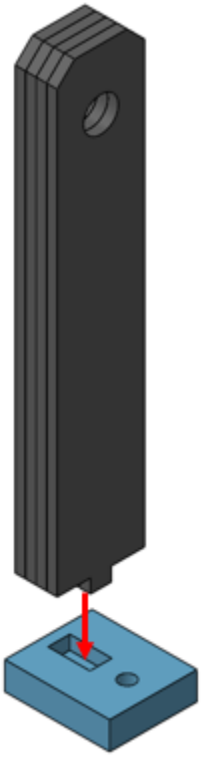


4 – Tensioner End Support Assembly

Place 4 Tensioner End Support Layers together, add glue where required to hold in place

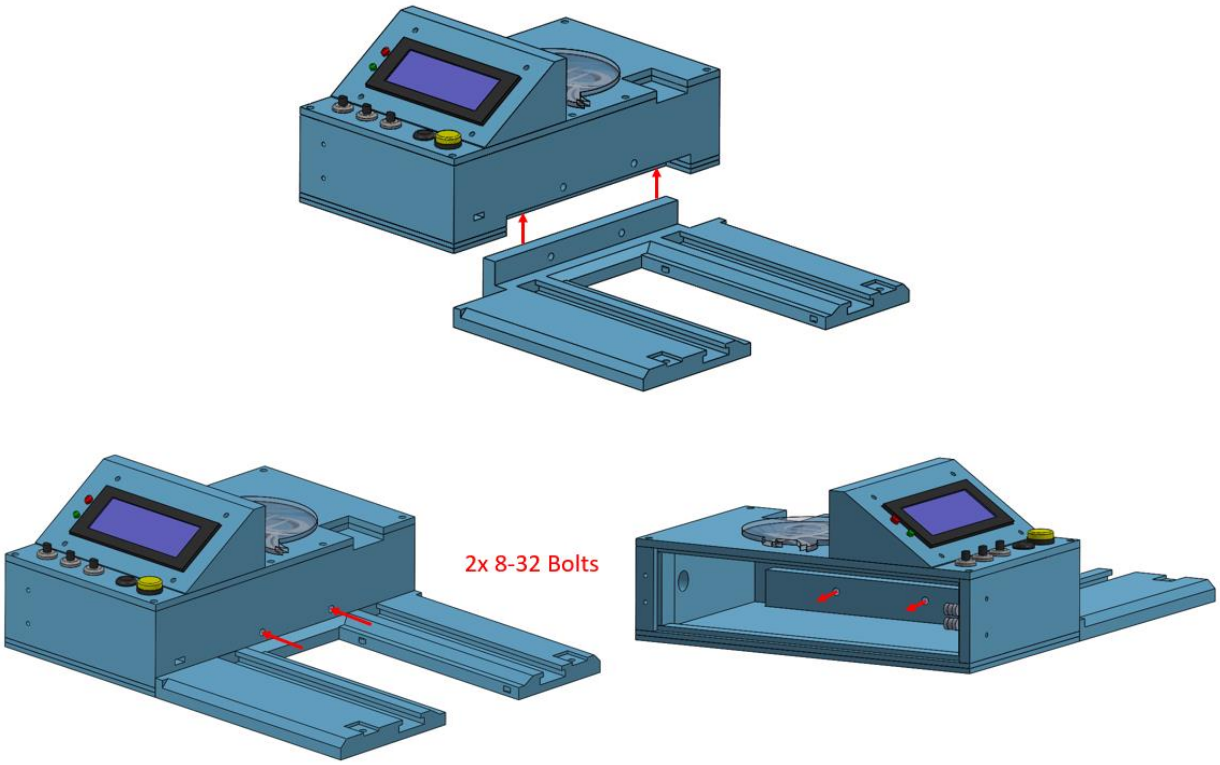


Take the combined layers and attach the Tensioner End Support_Bottom by fitting the protruding nub on the bottom of the support legs into the notch on the foot as indicated. Add glue to the notch to fully secure.

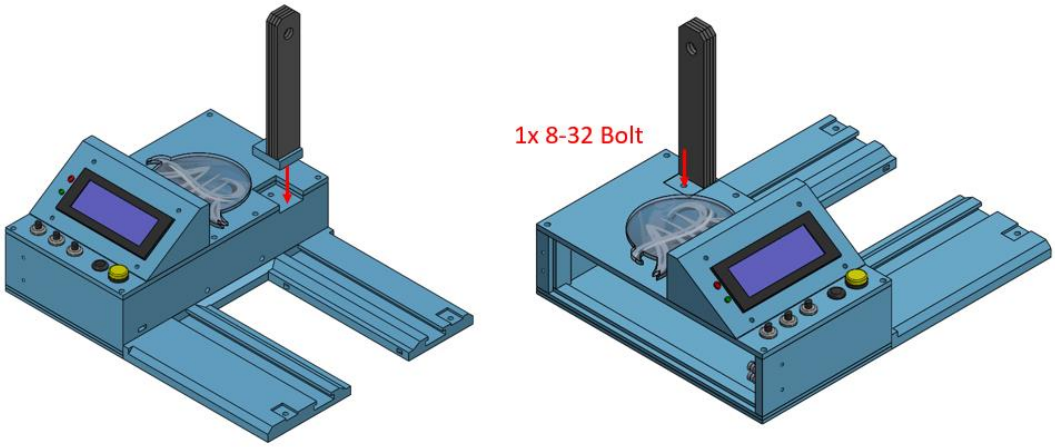


5 – Full Frame Assembly

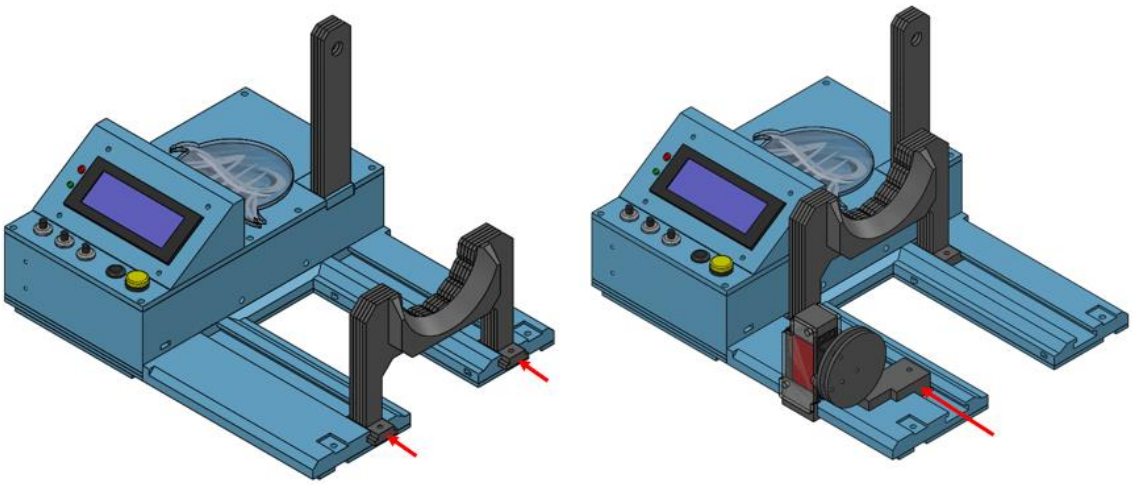
Take the Base_Frame_V3 and insert into the open slot at in the front of the control box assembly from the underside. Secure the frame to the box using 2 bolts through the indicated holes and attach with nuts from the inside of the control box.

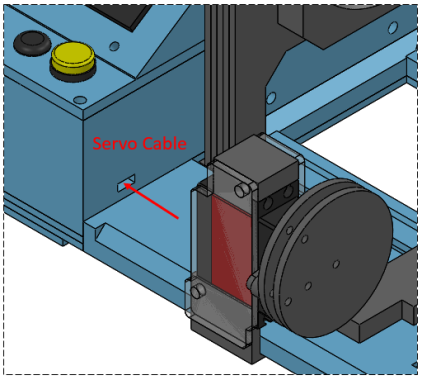


Insert the Tensioner End Support Assembly into the slot on the top of the control box. Secure to the box using 1 bolt through the Tensioner Support Assembly base, and attach a nut from the inside of the control box.

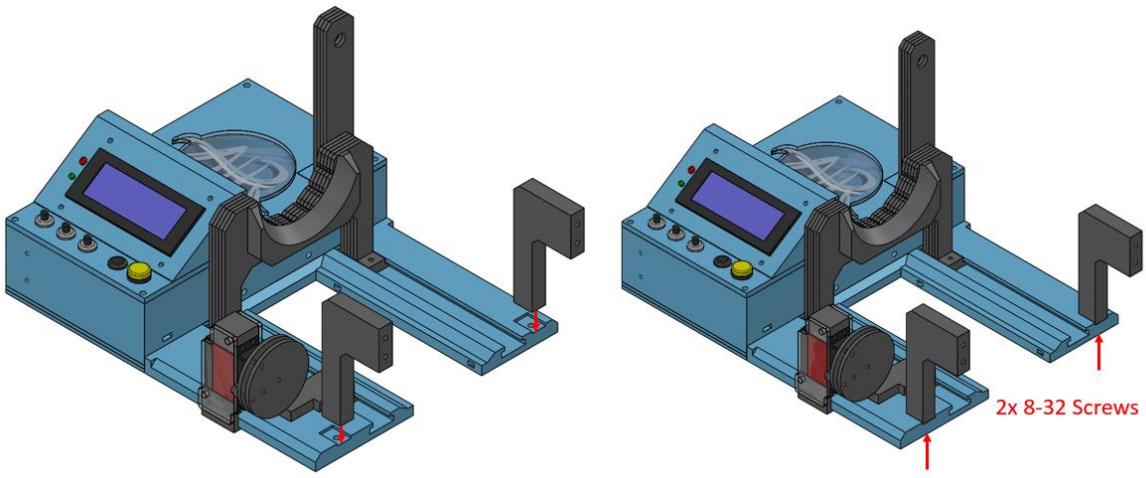


Take the Back Support Assembly and slide the support feet into the channels on the Base Frame as shown. Slide the support all the way to the end of the channel, or the approximate distance for the size of your Bag Valve Mask being used. Slide the Servo Assembly into the left side channel as shown. Insert the cable for the servo through the small square hole on the side of the control box.

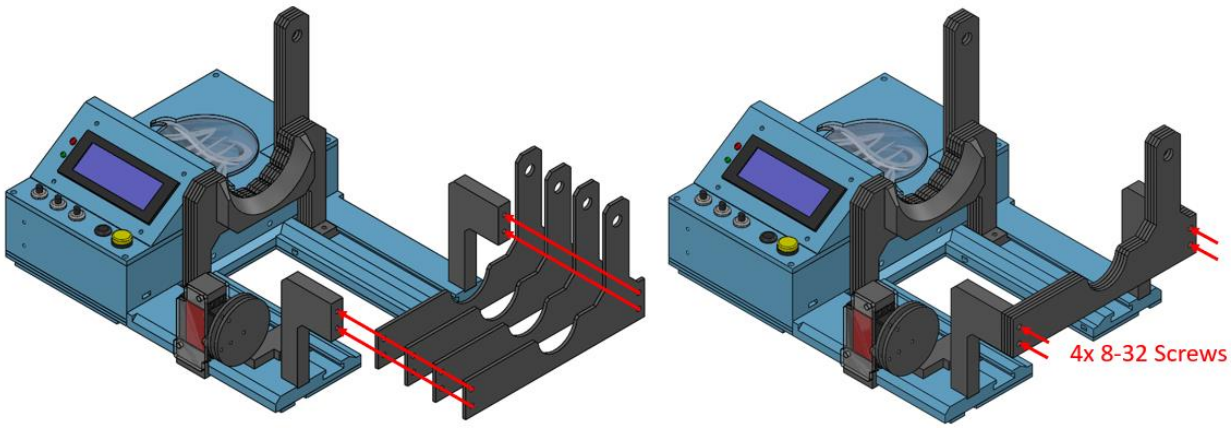




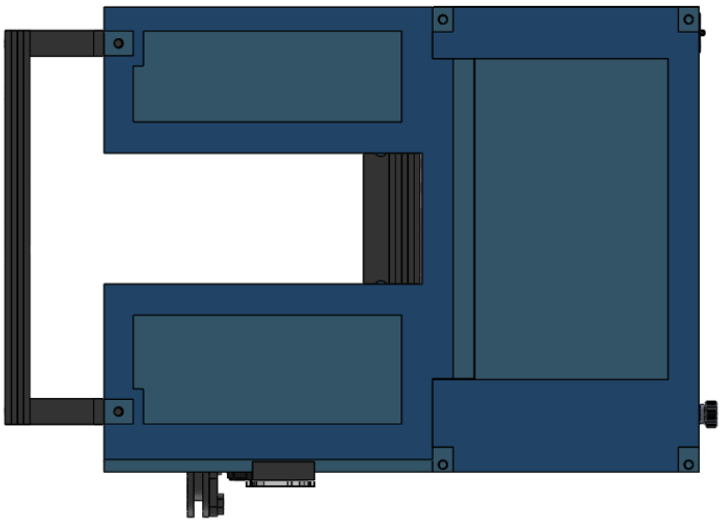
Take 2 Front Support Side Legs and insert them into the indented slots at the front of the Base Frame. Secure from the underside using 2 screws.



Place 4 Front Support Layers together against the Front Support Side Legs and secure from the front using 4 screws.

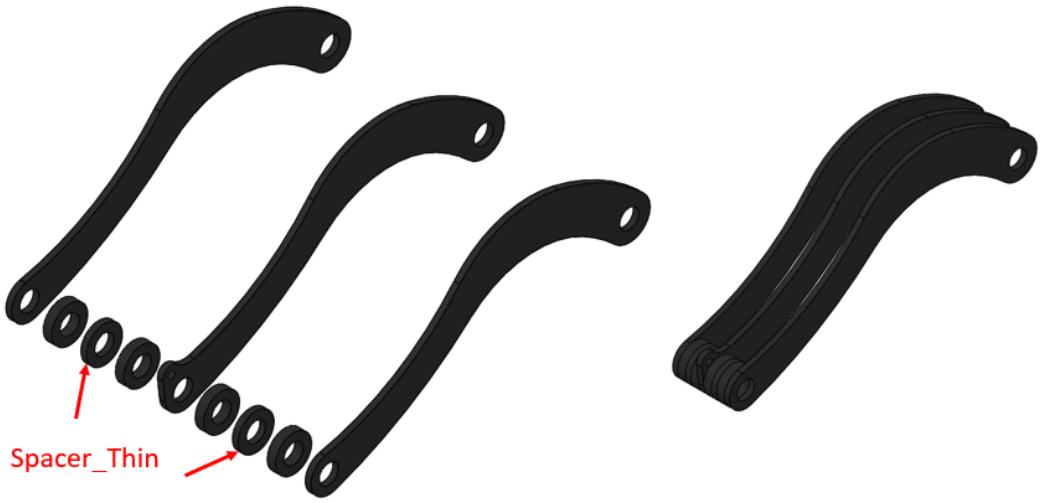


Align the Control Box Spacer and the Frame Spacer as shown on the underside of the frame. Add glue where required to hold in place

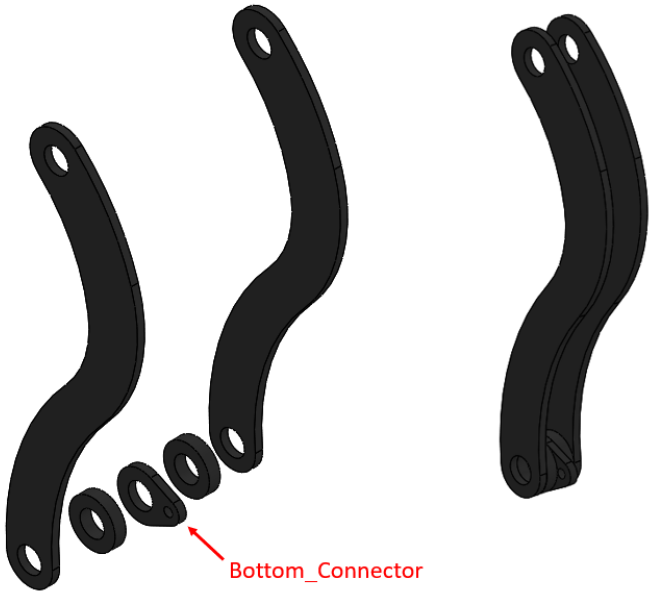


6 – Compression Arms

For the top compression arms, combine them together with the spacers only on the bottom side in the pattern shown. The compression arms must be arranged so the arm with the additional connector nub is in the middle, and the two regular arms the outside. In between, use 4 Compression_Arm_Spacers and 2 Compression_Arm_Spacer_Thin in the pattern indicated. Ensure all holes at both ends are aligned concentrically. Add glue where required to hold in place.

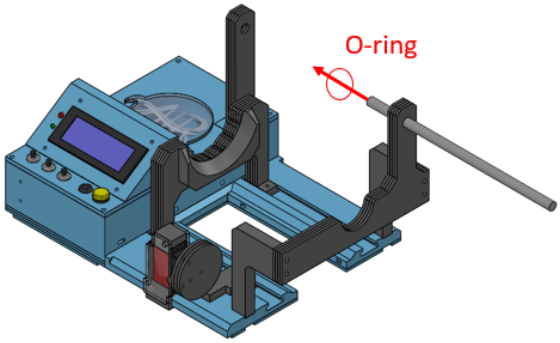


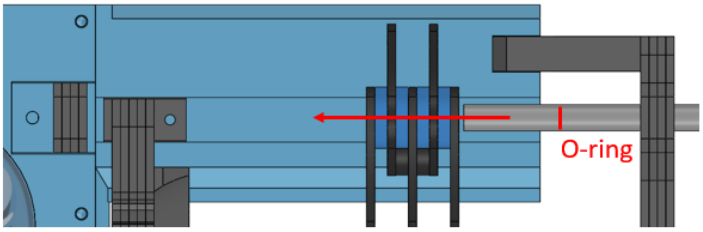
For the bottom compression arms, combine them together with the spacers only on the bottom side in the pattern shown. The compression arms are arranged on the outside, with the spacers and the additional connector in between. Use 2 Compression_Arm_Spacers and the connector piece in the pattern indicated. Ensure all holes at both ends are aligned concentrically. Add glue where required to hold in place.



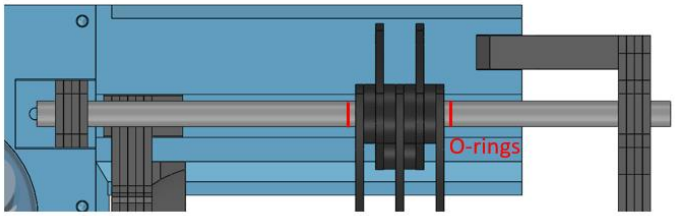
Slide the Tensioner_Rod through the hole in the Front Support Assembly. Add an O-ring before adding the combination of compression arm assemblies and spacers as shown. The 3 top compression arms and 2 bottom compression arms fit together at the open ends as shown, with a Tensioner_Rod_Spacer in between each arm (highlighted in dark blue between the black arms). It is important not to glue these spacers as they need to be free to rotate relative to each.

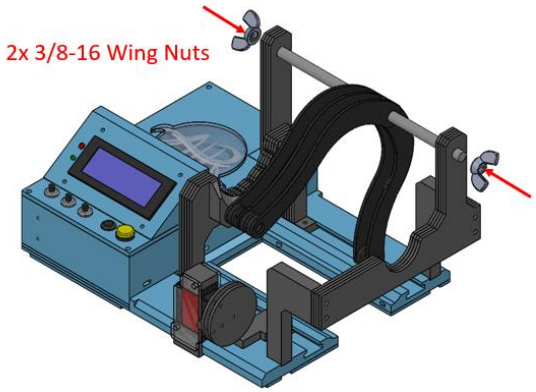
Note: The tensioner rod is 3/8" Aluminum, with 1-inch long threaded sections at the ends (3/8-16 thread)





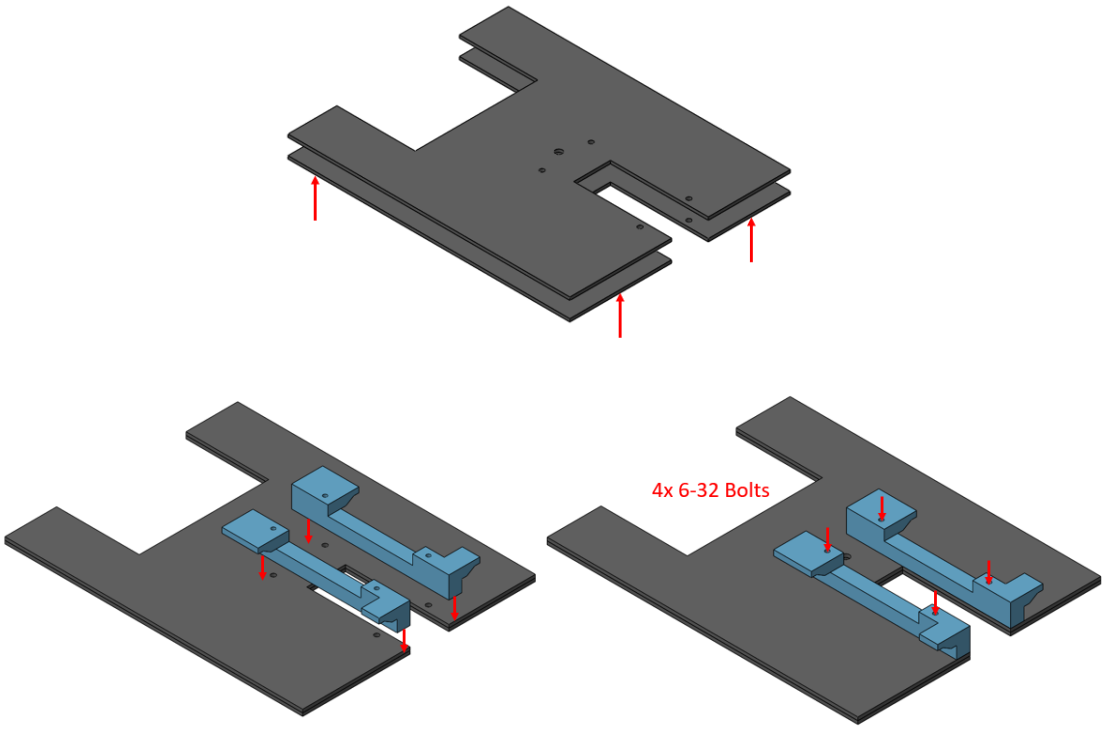
Add another O-ring after the compression arm assemblies, and feed the tensioner rod though the tensioner end support assembly. Secure the rod in place at both ends with 2 wing nuts.



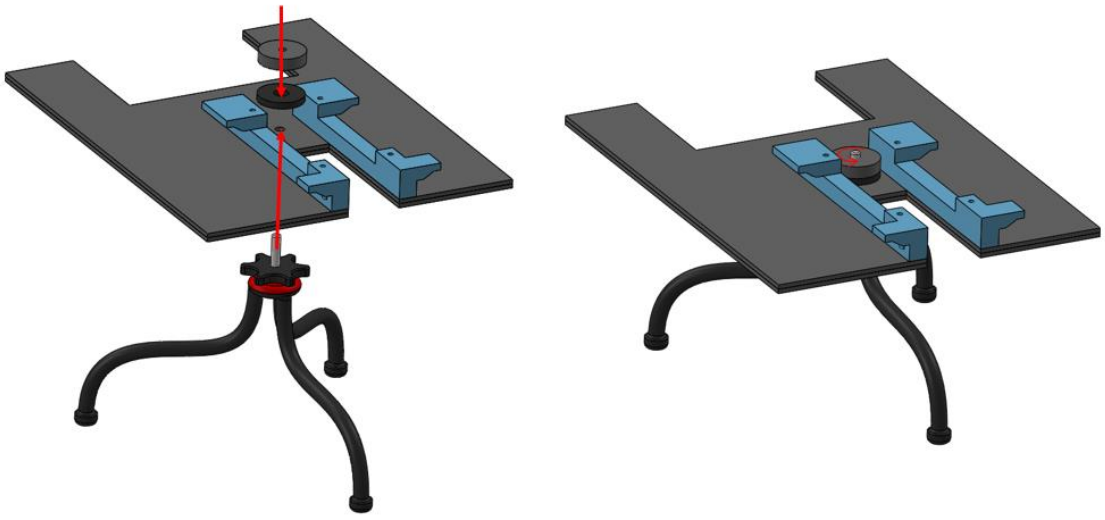


7 – Mount Interface Assembly

Place 2 Mount_Interface_Plate layers together, add glue where required to hold in place. Place the left and right mount interface fingers in the positions shown and secure from the top with 2 bolts each, with nuts underneath the plates.

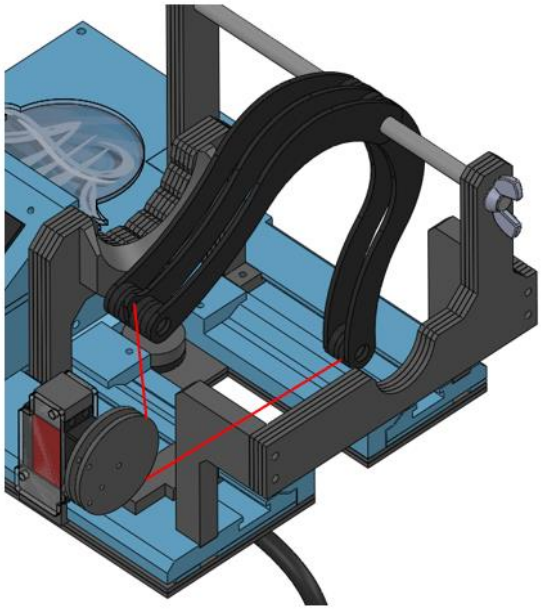


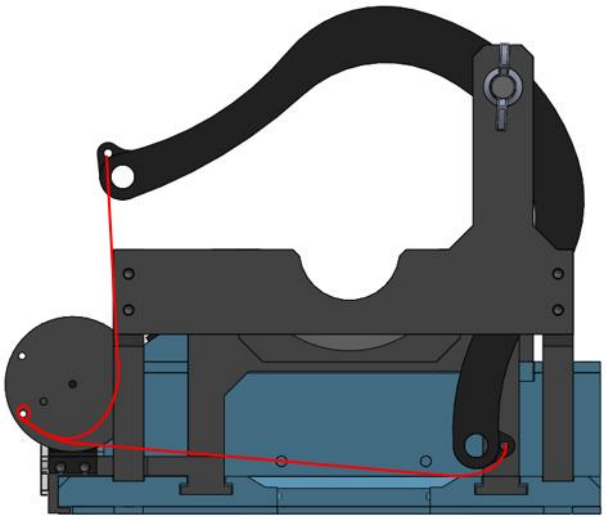
Insert the shaft of the tripod through the center hole on the interface plates from the bottom. Insert the interface spacer and the securement disk that came with the tripod from the top. Alternatively, a 1/4 nut can be used to secure the tripod.

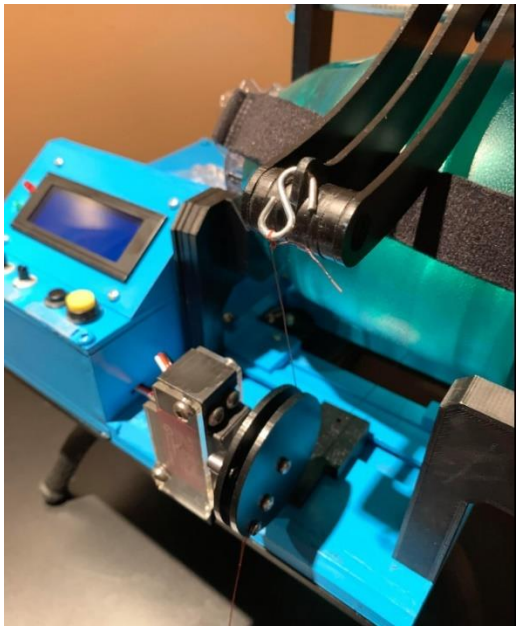


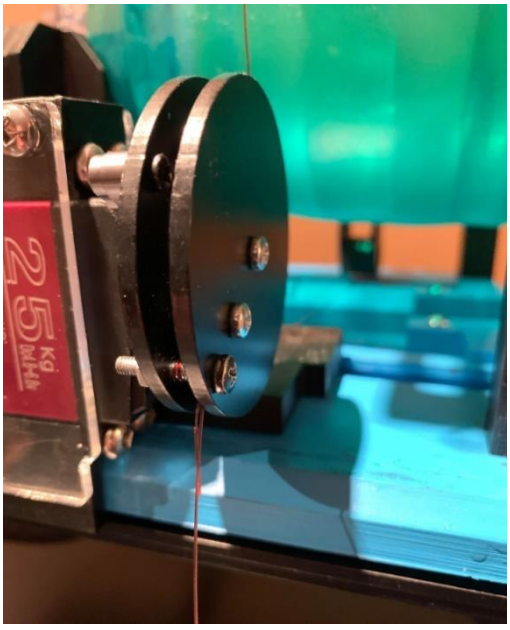
8 – Getting Ready to Use

To attach the compression arms to the servo spool, nylon wire is used. Tie one end of a piece of nylon wire around the connector on the lower compression arm set. Tie the other end of the wire around the outermost screw on the servo spool, with the spool in the approximate orientation shown. Repeat this for the upper compression arms, except instead of tying the wire directly to the arm connector, tie it to one end of the hook as shown. The other end of the hook can then be fed through the connector on the middle upper compression arm.

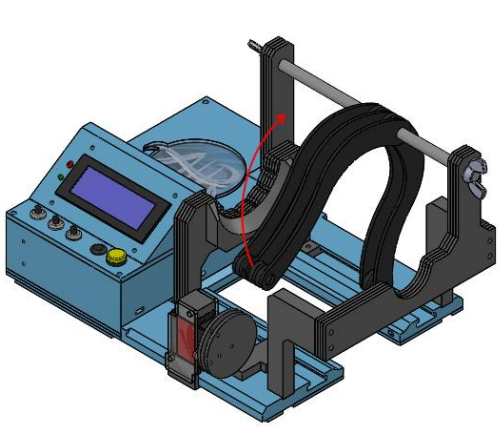


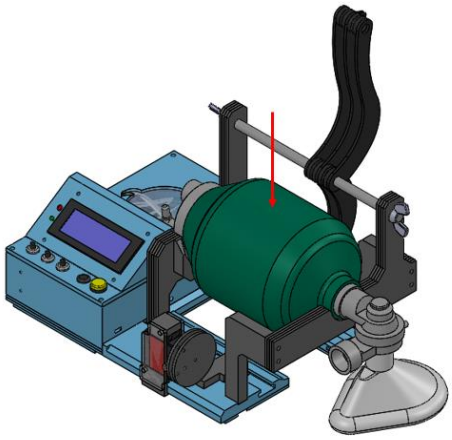






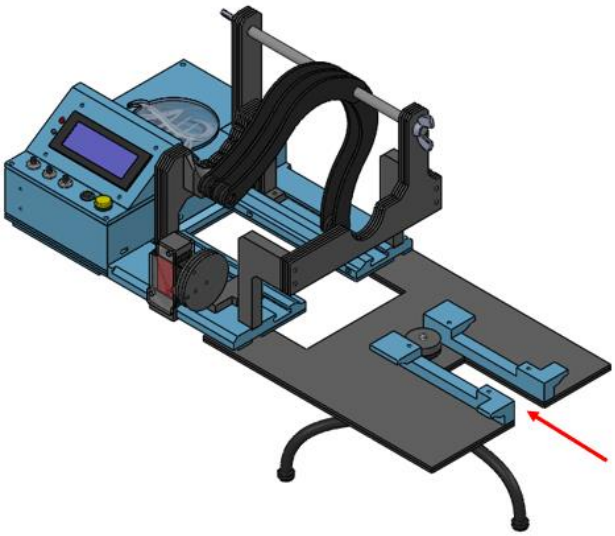
Remove the hook, lift and rotate the top compression arms out of the way. Place the Bag Valve Mask inside the device as shown. The upper arms can then be lowered, and the hook can be re-attached.

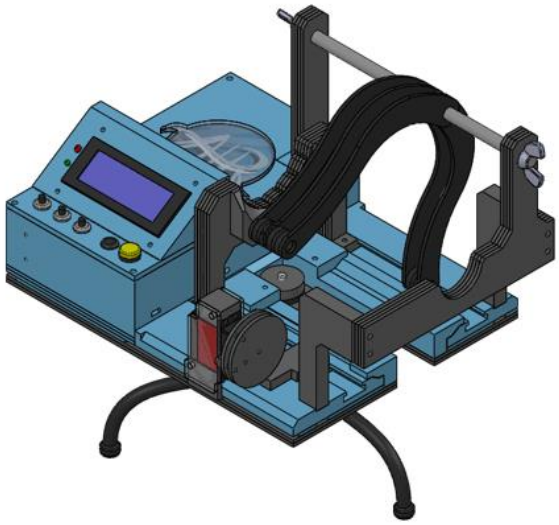




It is important the wires connecting the compression arms to the servo spool are taught when the bag is fully uncompressed and the servo is in its start position. Some trial and error by the user will be required during setup to achieve proper results. It is recommended that the device be turned on and run through 1 compression to see the start/stop location of the servo. Then, with the device off, the servo spool should be carefully removed using the center screw and rotated to ensure the wires are taught in this position before reattachment. Starting from the approximate servo orientation mentioned previously should help. Note that the servo will be rotating clockwise form this view during compression.

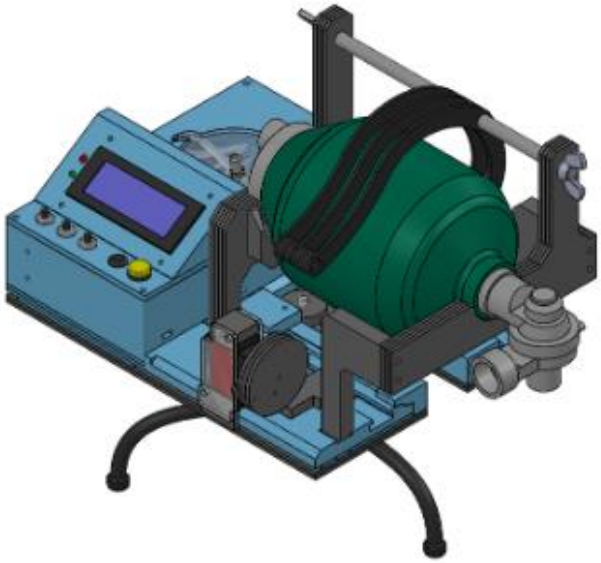
If a user would like to attach the mounting interface, simply slide it into place on the frame as shown. Bend the legs of the tripod as required to adjust height and positioning of the device. The mount can be removed in the same fashion.

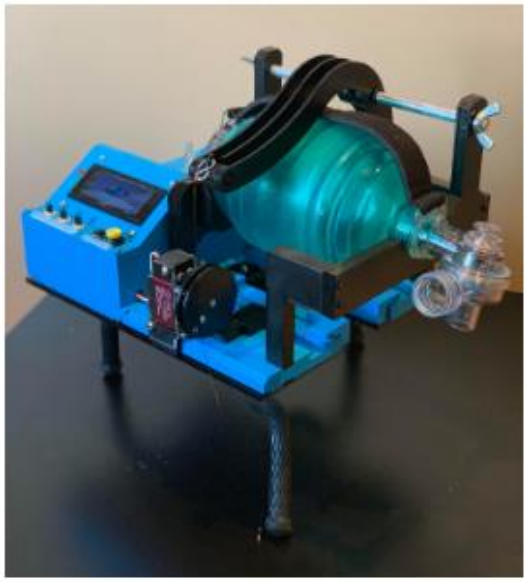




These assembly instructions are a guide only. They are also subject to change due to any changes in the design or its components. Use own discretion when implementing changes.

Please see the demonstration video on our website for proper operation:
https://the-air-project.github.io/





Automatic Inhalation Resuscitator

Assembly Instructions

Originally developed by Connor Simmons, Sam Raisbeck, Brian Mao, and Aditya Matam from The University of Waterloo

Bill Of Materials

MAIN DEVICE					
Item	Item Number	Supplier	Unit Cost	Quantity	Total Cost
3D printed parts	N/A	N/A	$36.51	1	$36.51
Acrylic parts	N/A	N/A	$10.72	1	$10.72
LCD Screen	B071Y6JX3H	Amazon	$14.99	1	$14.99
Green LED	151031VS06000	Digikey	$0.23	1	$0.23
Red LED	CT0W0BB1	Digikey	$0.20	1	$0.20
Potentiometer	P120PK-F17BR5K	Digikey	$0.91	3	$2.73
Black Button	SCAD-1450A	Sayal	$1.50	1	$1.50
Yellow Button	SCAD-1422	Sayal	$2.95	1	$2.95
Power Switch	EG5617-ND	Digikey	$0.77	1	$0.77
Arduino Nano	B07L2CFV9C	Amazon	$8.54	1	$8.54
Current Sensor	B07B4G3VT3	Amazon	$12.55	1	$12.55
Servo	B07GK1G5FV	Amazon	$33.99	1	$33.99
Wall power adapter	PAJ-3718B	Sayal	$19.95	1	$19.95
Power connector inside device	GAK-2232AC	Sayal	$1.95	1	$1.95
Voltage Regulator	LM2596	MESS	$2.83	1	$2.83
Protoboard	EXN-23403-PCB	Digikey	$7.76	1	$7.76
Support Bar, 3/8 in x 9.31 in long. With 1" long 3/8-16 threads	N/A	N/A	$2.07	1	$2.07
Wing nuts, 3/8-16	3392	Home Depot	$0.69	2	$1.38
Hinge	1603A3	McMaster Carr	$2.37	1	$2.37
Door Knob	91830A304	McMaster Carr	$7.65	1	$7.65
Door latch	1659A2	McMaster Carr	$1.46	1	$1.46
Resisters, 220 Ohms	CF14JT220RCT-ND	Digikey	$0.06	2	$0.12
Fishing line	077-2589-6	Canadian Tire	$0.08	1	$0.08
Hook	2392280	Home Hardware	$0.26	1	$0.26
Wire	WAA-1685A	Sayal	$0.51	1	$0.51
O-rings	M3761	Home Depot	$0.93	2	$1.86
6-32 screws	1289	Home Depot	$0.46	10	$4.60
8-32 screws (for servo and hinge)	3266	Home Depot	$0.27	10	$2.70
8-32 screws (for front support)	2289	Home Depot	$0.50	6	$3.00
M3 bolts, 10mm	2122001	Home Hardware	$0.60	4	$2.40
M3 bolts, 16mm	2122003	Home Hardware	$0.60	9	$5.40
M3 nuts	2146028	Home Hardware	$0.92	10	$9.20
8-32 bolts	3512	Home Depot	$0.28	3	$0.84
8-32 nuts	5636	Home Depot	$0.18	4	$0.72
				Total	$209.44

MOUNTING STAND					
Item	Item Number	Supplier	Unit Cost	Quantity	Total Cost
3D printed parts	N/A	N/A	$3.46	1	$3.46
Acrylic parts	N/A	N/A	$4.39	1	$4.39
Camera Stand	B073GW4ZWM	Amazon	$29.99	1	$29.99
Screws, 6-32	846-722	Depot	$0.13	4	$0.52
Nuts, 6-32	2282	Depot	$0.37	4	$1.48
				Total	$39.84

** If manufactured in large quantities, final device cost is expected to decrease, due to purchasing components such as fasteners in bulk quantities.

Revision Table

Revision Date	Revision Description	Relevant Page Number(s)

** The following revision table will be used by members of the AIR team if updates to our manufacturing and assembly are made. The document will be replaced on our organization webpage with the included revisions. Feel free to use the table to keep track of your own changes if desired.