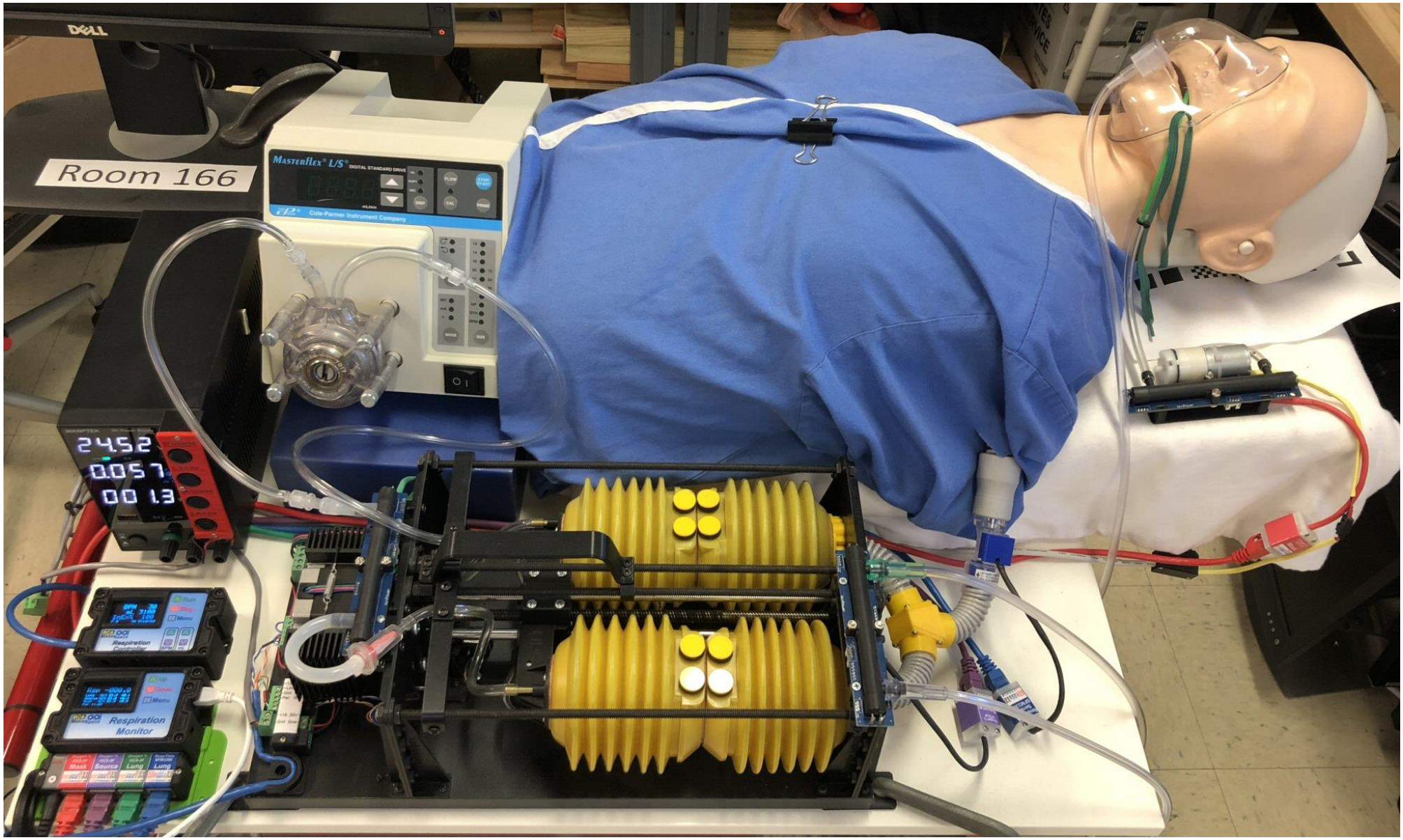
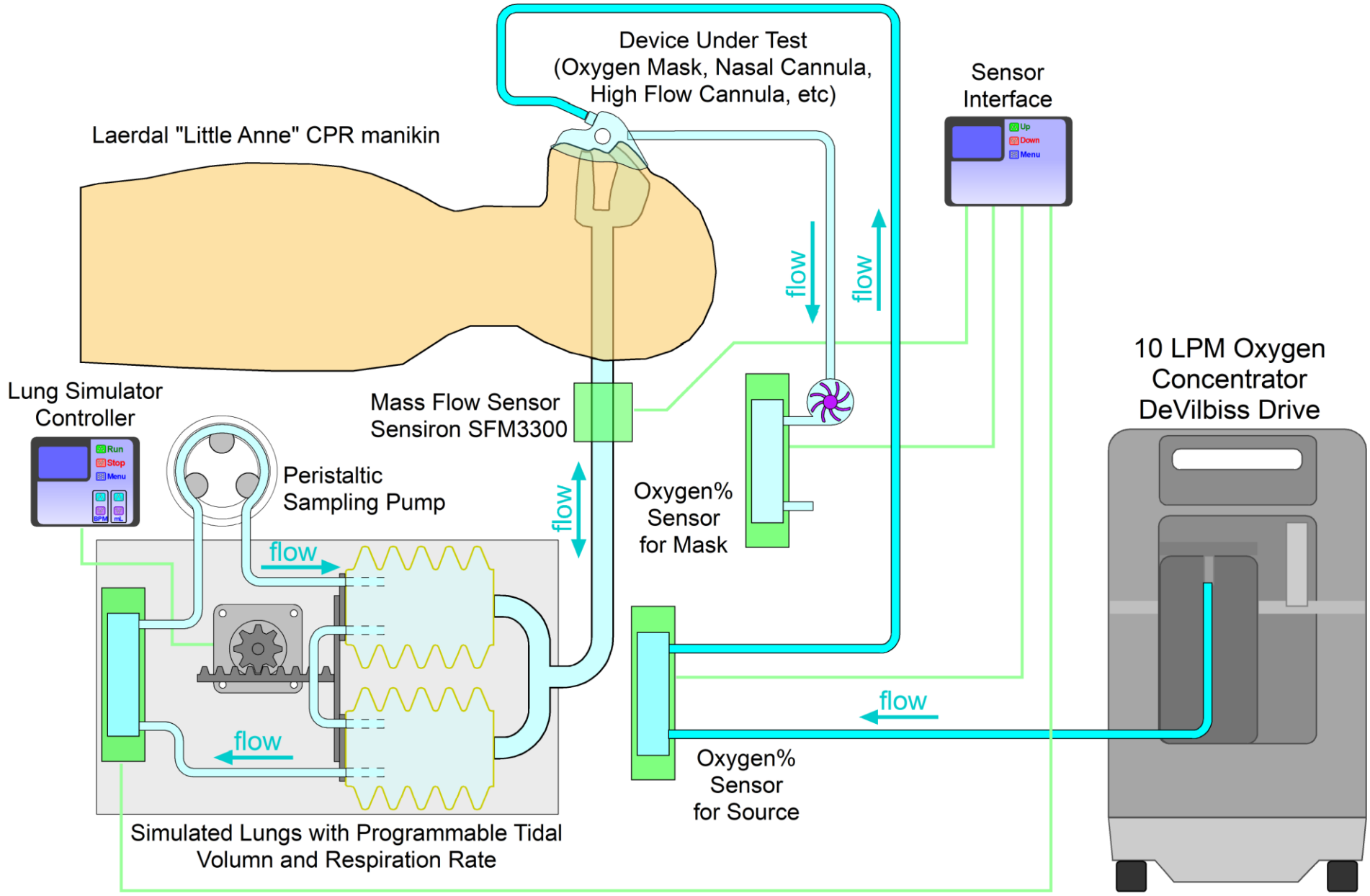
Lung simulator system for measuring oxygen delivery effectiveness

The lung simulator is a custom 3D printed apparatus, where a stepper motor drives the compression and expansion of two bellows, which are plumbed into the mouth and nasal cavity of a CPR dummy. An oxygen concentration sensor samples gas inside the bellows to measure the percentage of oxygen. This system serves as a test platform to test the effectiveness of various oxygen delivery methods, i.e. mask, nasal canula, high flow canula, etc. It also allows for the evaluation of custom designed masks and “active” devices that can regulate oxygen flow.

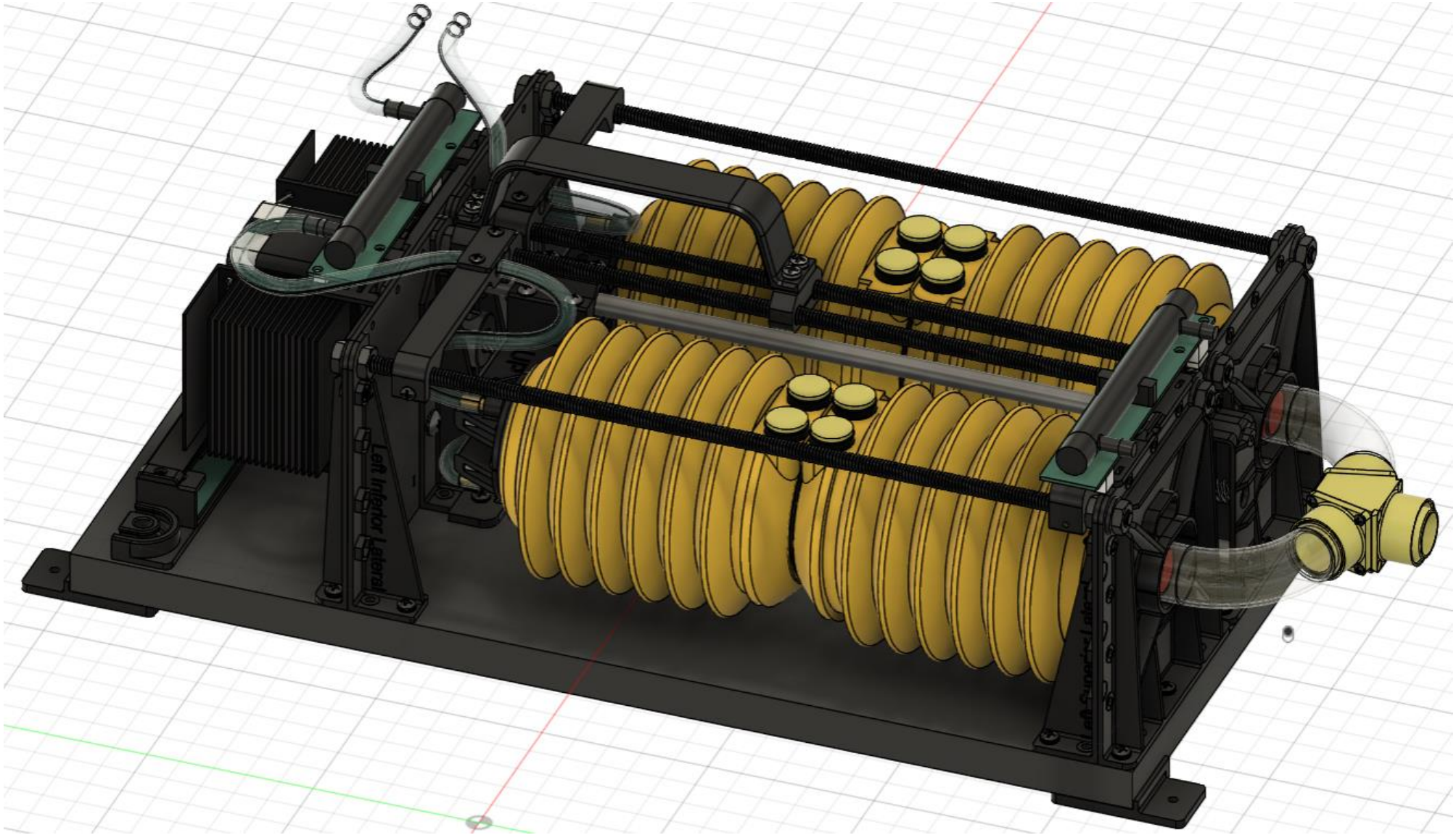


Lung simulator system diagram



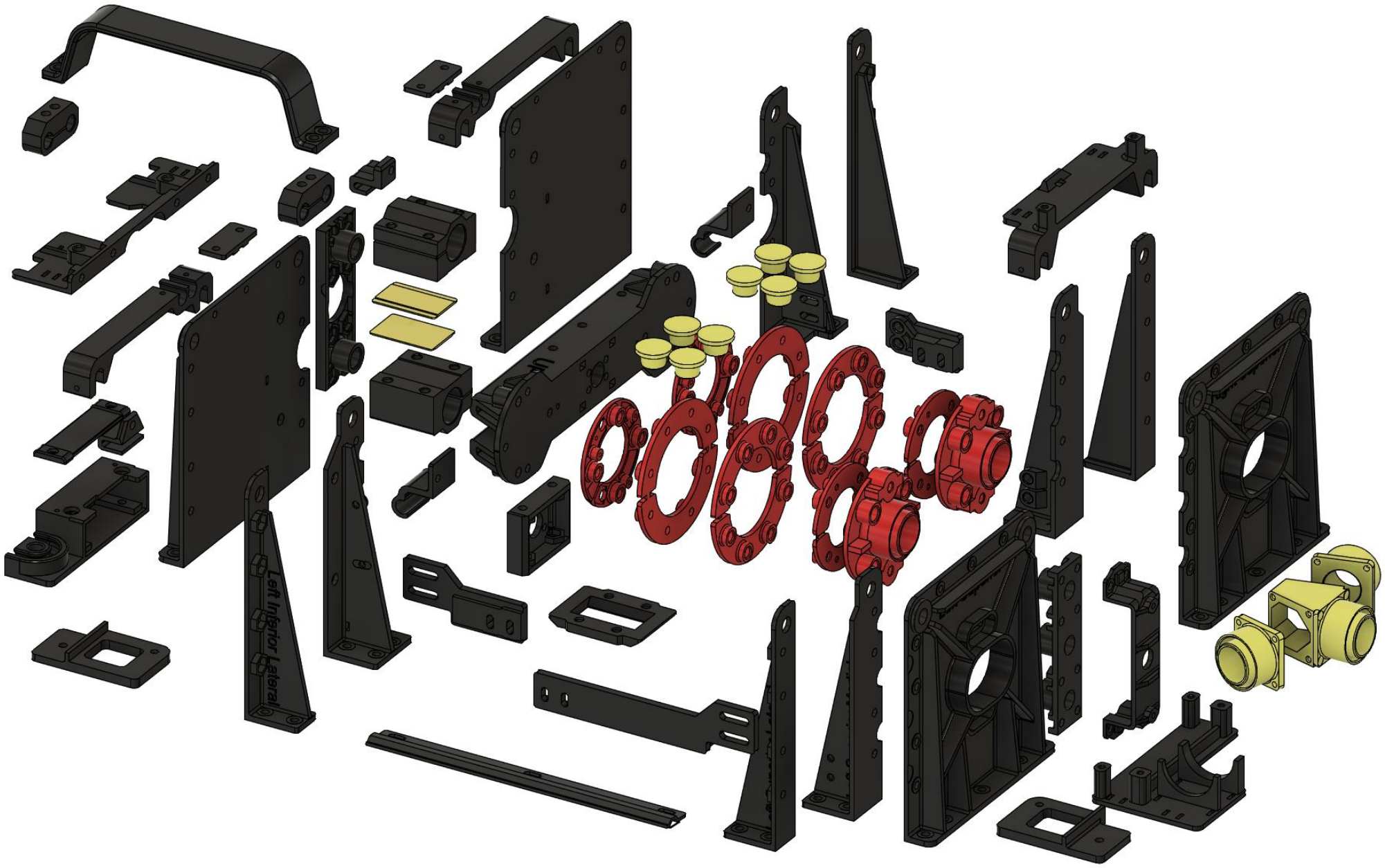
Oxygen% Sensors: Ultrasonic Oxygen Concentration & Flow Sensor Winpower OCS-3F

Lung Simulator Design in Fusion

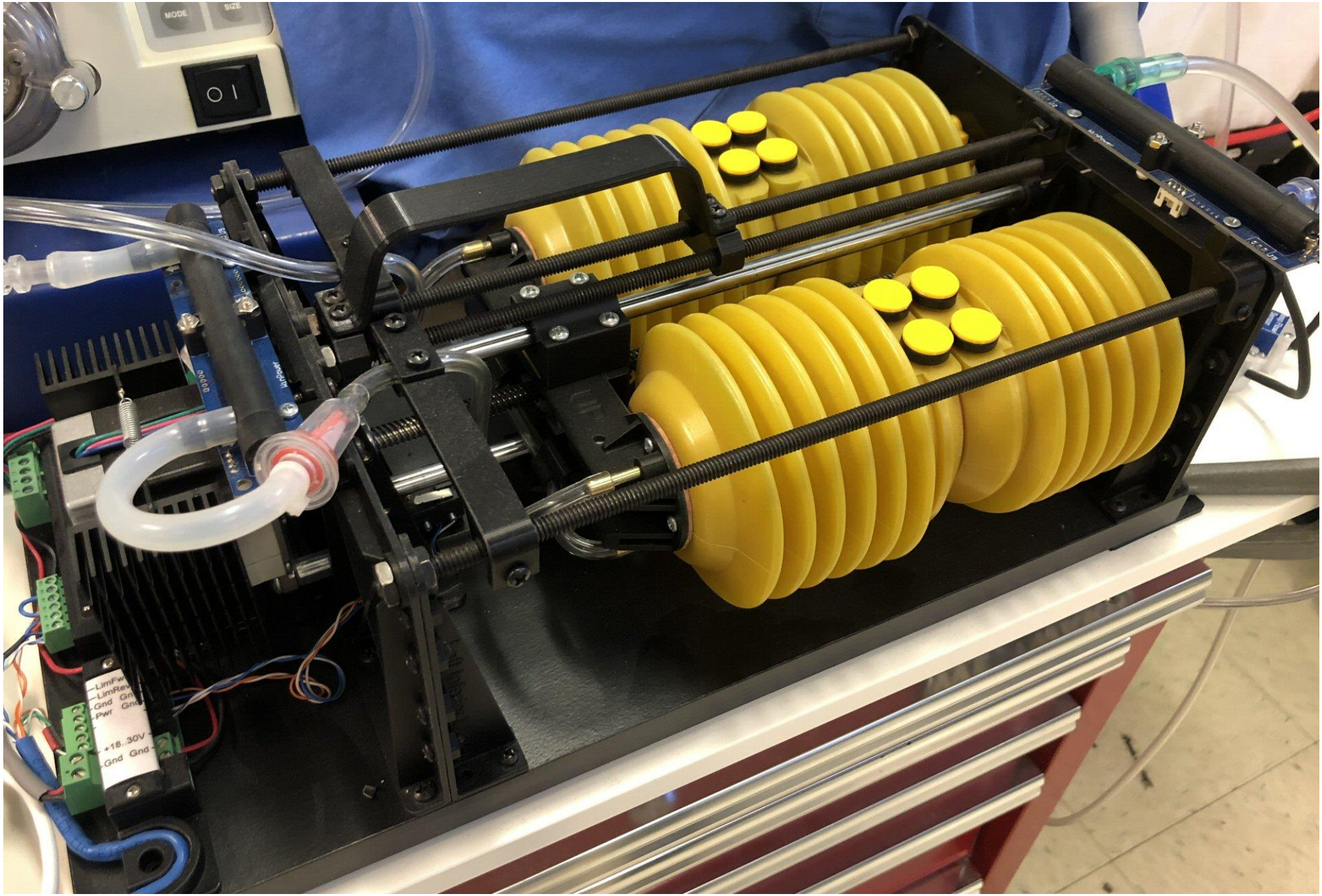


Exploded View of custom 3D printed parts

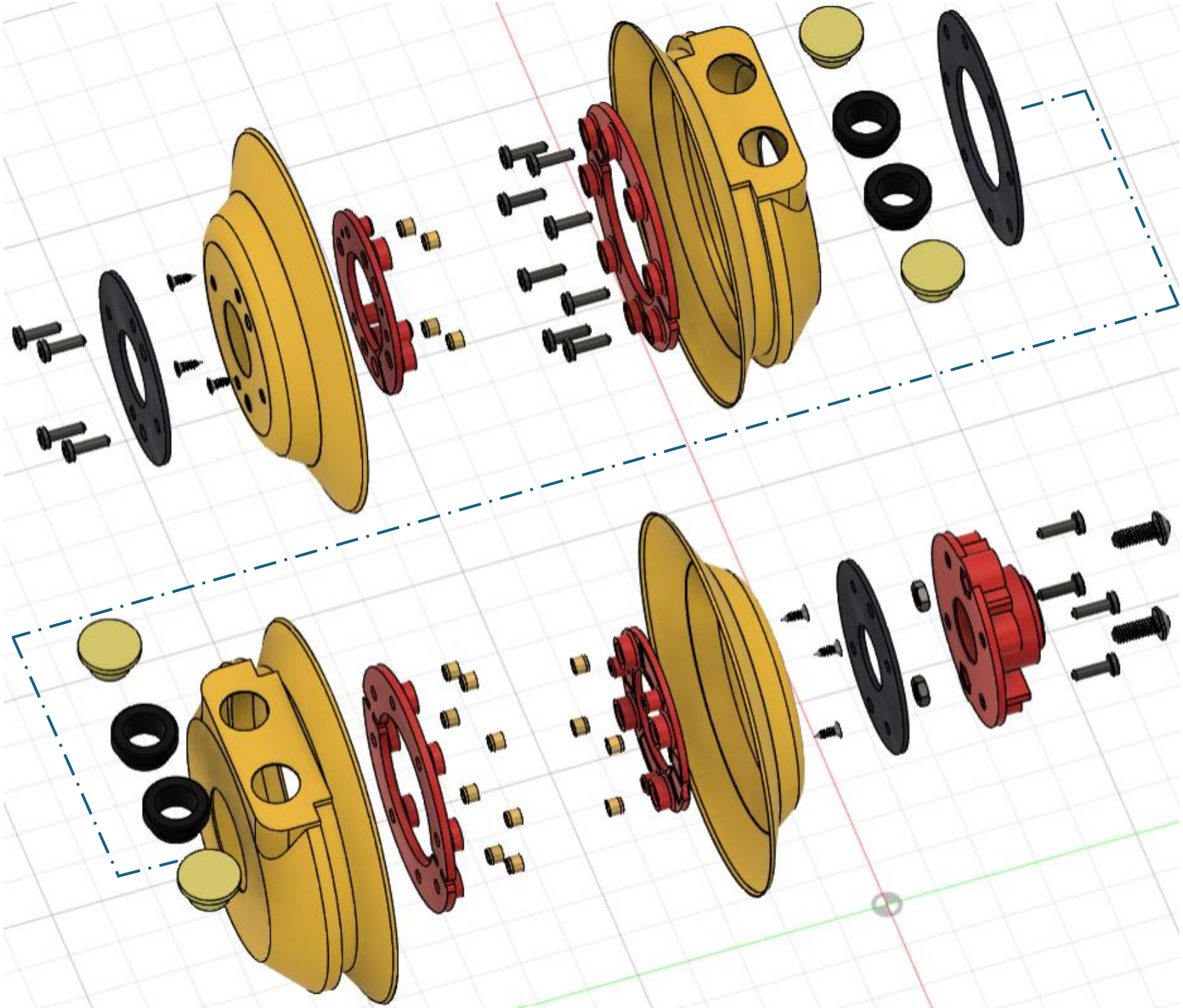
(52 unique parts, 70 parts total) - All parts were designed to eliminate the need for supports.



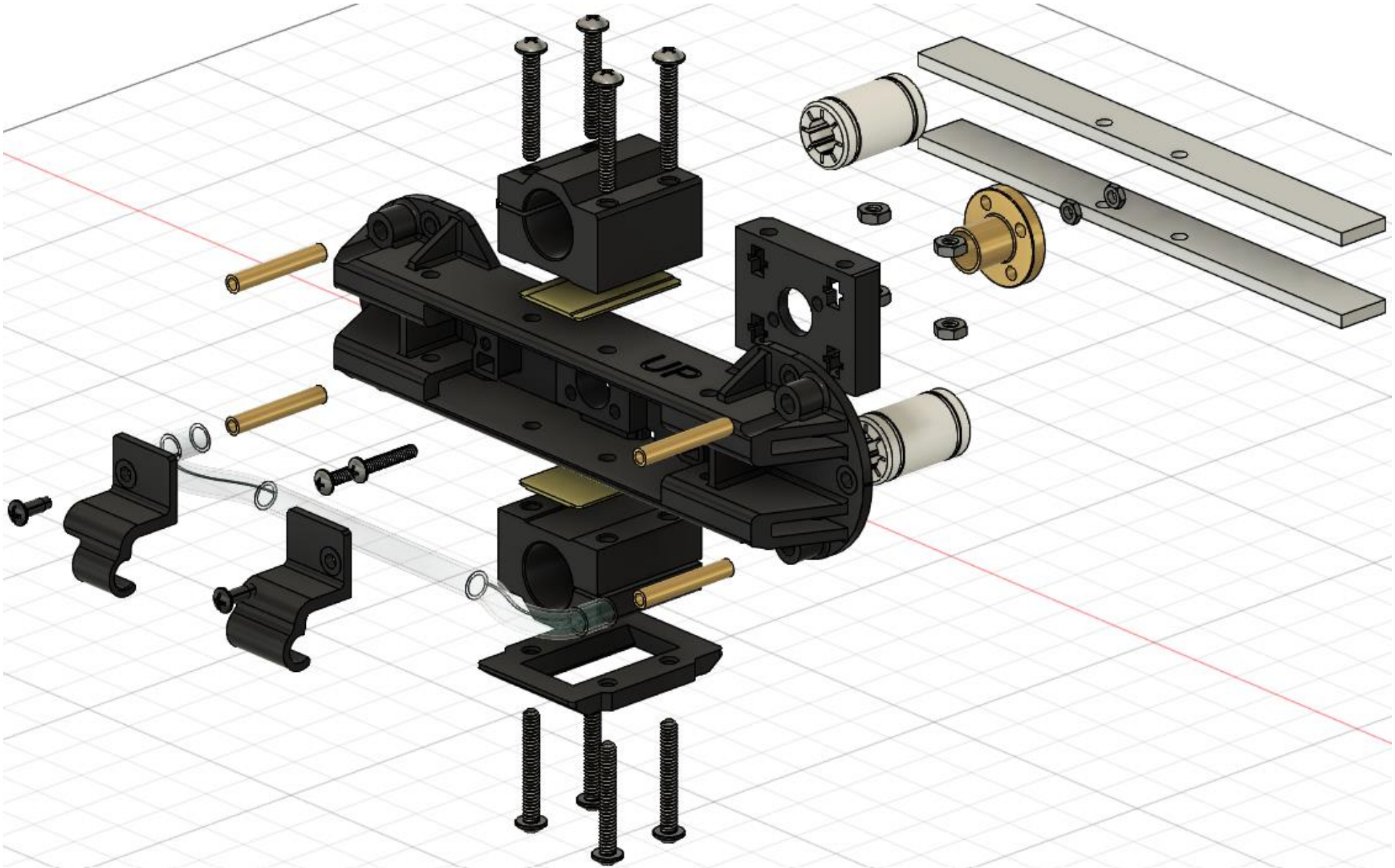
Lung simulator viewed from “motor end”



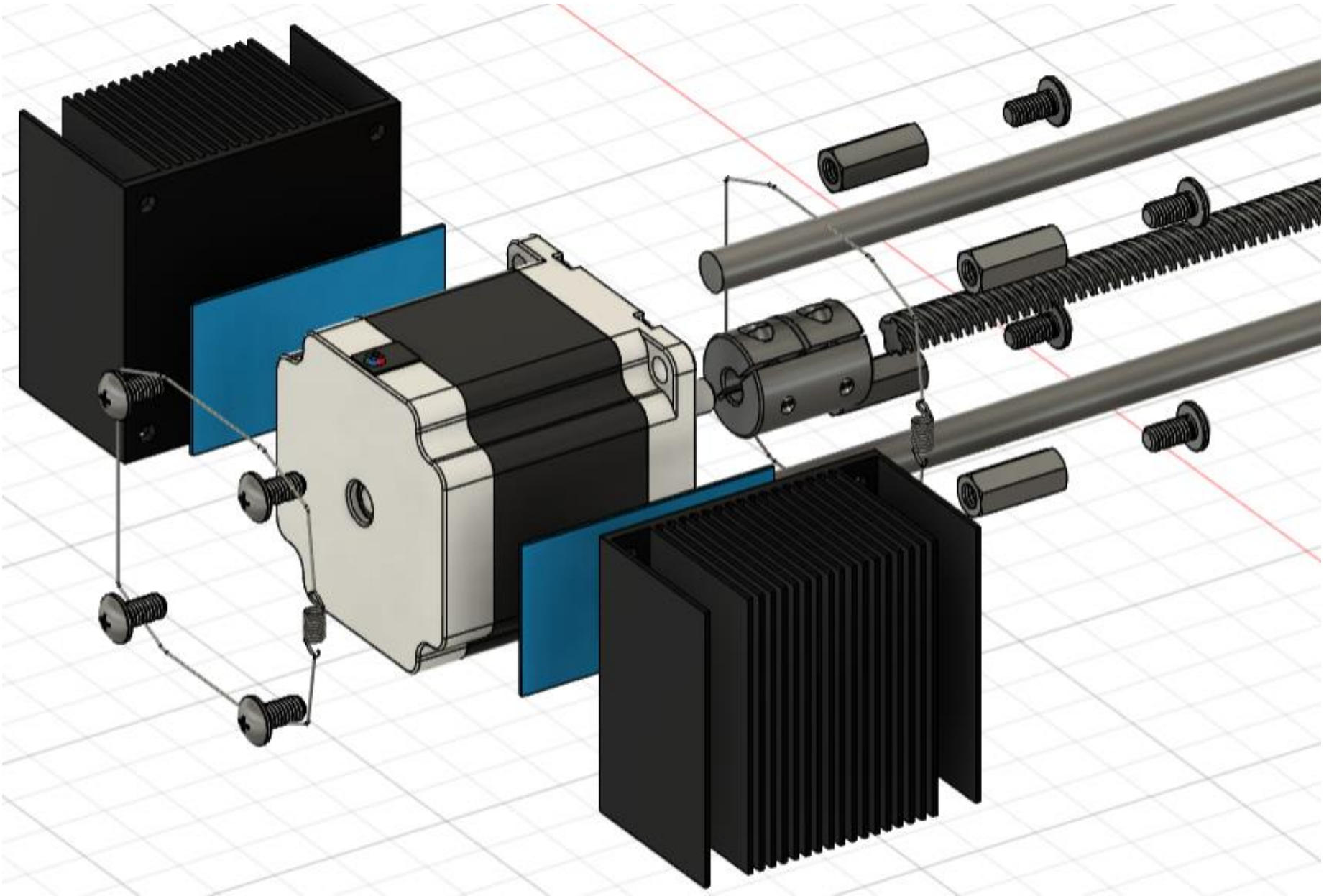
Bellows Assembly – Exploded (centers of bellows cut away)



Slider Assembly



Stepper Motor Assembly



Primary Components

Foot pumps (used for bellows)

Yes. Four of these cheezy foot pumps were used. After a long search, there just didn't seem to be a better option and they work well. They seem to always be available on Amazon from multiple vendors. Sometimes they will be sold with a black bottom, but the yellow bellows section will be the same. Only the yellow bellows section is used, as well as two rubber grommets for the check valves. There is also a large interal spring that gets removed.

Click to see full view

Foot Pump - Sports Inflatable Pump for Inflatables, Yoga, Bed, Mattress, Inflatable Boat, Exercise Ball, Balloon, Balls, Swimming Ring&Toys

Brand: Granfo

3.9 ★★★★☆ (369) | Search this page

50+ bought in past month

-6% $8.45

List Price: $8.99 | Price history

prime Two-Day

FREE Returns

Save up to 14% with business pricing. Sign up for a free Amazon Business account

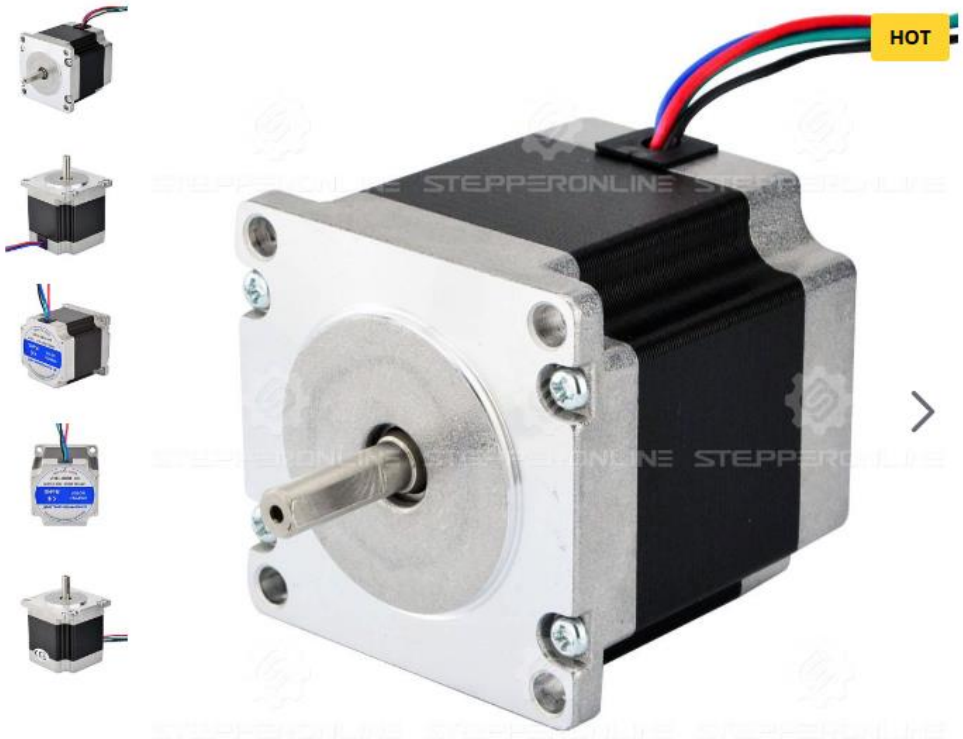
Stepper motor

How does it work?

Theory 1: The wires extending from the rear of the motor are attached to internal racket mechanism. When a wire is pulled up the shaft will turn slightly. Additional pulls of the same wire will continue to advance the rotation. Another wire acts similarly, but results in an opposite rotation. When the other two wires loop around the internal shaft. When they are both pulled, the friction prevents the shaft from turning.

Theory 2: There are two windings (coil of wire) with each winding being attached to two wires. When voltage is applied to a coil, a current results, which produces a magnetic field. This field interacts with the field from a permanent magnet to rotate the shaft a small amount. The two coils are arranged so that "sequencing" the field by reversing the current in one windings at a time will continue to rotate the shaft by a consistant angle for each "sequence". Reversing the sequence will rotate the shaft in the opposite direction. Maintaining a continuous current will prevent the shft from turining from an external torque.

Nema 23 Bipolar 1.8deg 1.24Nm(175.6oz.in) 2.8A 57x57x56mm 4 Wires



27 reviews - Write a review

$13.37

5 + $12.74
10 + $12.17
50 + $11.65
100 + $11.17

In Stock: 200

- Model: 23HS22-2804S
- Gross Weight: 0.77kg
- Certificated: ISO, CE, UKCA, RoHS

Click country for live stock

Ships from *

China | United States | Germany | Japan

1 Add to Cart

Add to Wish List Compare this Product

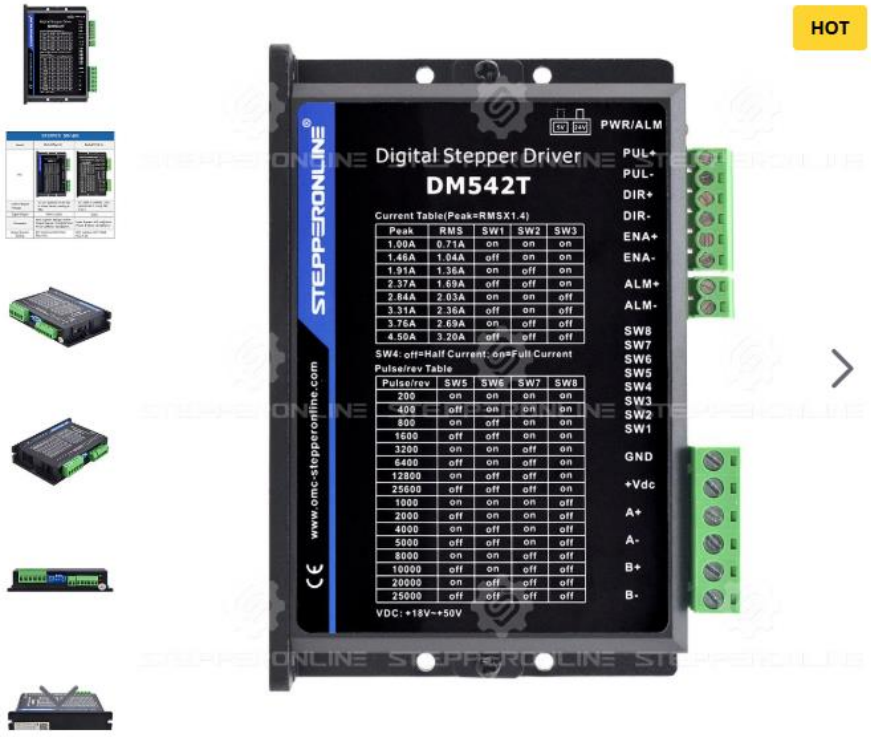
Stepper motore driver.

How does it work?

Theory 1: Wires that come in through the side are linked to lever arms attached to a lever mechanism. When the wire entering the PUL+ position is pulled it the wire at A+ to be pulled in. If the DIR- wire is pulled before the PUL+ wire is pulled, the A- wire will be pulled in instead. A switch can be set so that when the PUL+ wire has not been pulled in the last second, the B+ and B- wires will be pulled in to brake the attached motor.

Theory 2: There is a group of MOSFETs (a super duper fast relay) that can connect A+ or A- wires to either GND or Pwr. This will control the current and direction in a motor winding connected to A+ and A-. Because these MOSFET are super duper fast, they can turn on and off very quickly to adjust the current. There is a second MOSFET group for B+ and A-. The PUL+, DIR+, ENA+ inputs connect to the anodes of LEDs in opto-isolators. The PUL-, DIR-, ENA- input connect to the cathodes of these LEDs through current limiting resistors. A common use scenario could have PUL-, DIR-, and ENA- connected to Gnd. Every time PUL+ becomes 5V, the current controlled through A-, A+, B-, and B+, will change to sequence the windings of the connected stepper motor. When DIR+ becomes 5V, the sequence will change direction. ENA+ should be 5V to allow current control. If ENA+ is 0V, current will be cut off.

Digital Stepper Driver 1.0-4.5A 18-50VDC for Nema 17, 23, 24 Stepper Motor



84 reviews - Write a review

$19.65

5 + $19.02
10 + $18.43
50 + $17.88
100 + $17.35

In Stock: 200

- Model: DM542T
- Gross Weight: 0.39kg
- Certificated: ISO, CE, UKCA

Click country for live stock

Ships from *

China | United States | Germany | United Kingdo

1 Add to Cart

Add to Wish List Compare this Product

Oxygen concentration sensor

These are sold on Ebay by several vendors. They are powered by 12VDC and draw less than 50mA. Their logic-level (0-5V) serial output send data every 0.5 seconds, which includes oxygen concentration with a resolution of 0.1% and specified range of 21-95.6%, flow (0-10 LPM) and temperature output.

How does it work?

Theory 1: An insect lives in the tube that makes high-pitched squeking sounds with a freucencies, durations, and repeat rates that correslates the oxygen concentration. The ultrasound transducers listen to the squaks and convert this to oxygen concentrartion.

Theory2 : The black tube on top of the PCB has a transducer at each end and uses ultrasound to measure the speed of sound of the sampled gas and thus the concentration. The mix of oxygen and nitrogen will result in a variation in gas density that will affect the speed of sound. A temperature sensor is likely used to correct for the effect of temperature. It the circuitry alternates between which trnsducer acts as a transmitter and which acts as a receiver, the difference in travel time of the pulse could reveal flow.

1PCS NEW FOR Ultrasonic Oxygen concentration Flow Sensor OCS-3F

Condition: New

Bulk savings: Buy 1 $68.18/ea | Buy 2 $67.50/ea | Buy 3 $66.82/ea

Quantity: 1 4 or more for $66.13/ea

9 available / 1 sold

Price: US $68.18/ea

Buy It Now

Add to cart

Flow sensor

How does it work?

Theory 1: A tiny windmill powers a generator inside the sensor. The generated voltage gets converted into a flow value.

Theory 2: A tiny thermal element is heated and its temperature is measured. As airflow increases, the greater amount of forced convection will cool the sensor. This would measure the "mass flow", which could be converted to a "volumetric flow", by also measuring temperature and pressure and applying the ideal gas law. Note the use of "slm" for the units. This stands for "standard liters per minute". The "standard" part means standard temperature and pressure. (20 C, 1013.25 mbar) Because there shouldn't be much of a ambient pressure variation during use, pressure "compensation" could be ignored. Two thermal elements in close proximetry can extend the functionality to also determine the flow direction.

SENSIRION
THE SENSOR COMPANY

Datasheet SFM3300-D
Datasheet SFM3300-AW
Digital Flow Meter for medical applications

- Flow range: ± 250 slm, bidirectional
- Small dead space < 10ml
- Single use (-D) version
- Re-use (-AW) version
- Very fast update time (0.5ms)

Note that this is the disposable version that we want. The reusable version is over $200 because it is made with materials that can survive autoclaving in a hospital setting before equipment using this part can be used for a different patient. Below is the listing from Mouser.

Mfr. Part # SFM3300-D ***Mouser Part #*** 403-SFM3300-D	Sensirion	Flow Sensors 250 slm, Bidirectional Digital Flow Meter designed for Medical Applications - Disposable Single Use Version Learn More	Datasheet	804 On Order View Dates	1 $40.10 5 $36.84 10 $35.60 30 $34.01 60 View

Hosing

This hose is easiy cut to provide the pathways from the lung simulator to the mouth and nasal cavity of the CPR dummy.

Snugell CPAP Hose Universal Tubing (6 ft) – Compatible with CPAP, BiPAP, and BiLevel Machines – Minimizes Mask Leaks, Reduces Discomfort – Durable, Flexible, and Designed for Restful Sleep

Visit the Snugell Store

4.6 ★★★★½ (6,164) | Search this page

Amazon's Choice

$9.99 ($9.99 / count)

Price history

Our patient

There seem to always be used CPR dummies listed on Ebay. Remember to buy her a gown.

LAERDAL LITTLE ANNE TORSO WHITE CAUCASIAN EMT CPR ADULT MANIKIN TRAINER

US $90.62

Sold by: gadgets-plus

Lung Simulator BOM (Bill of Materials)

Line	Qty	Type	Description	Source	Part Num	Price	Notes
1	8	screw	10-32 3/8" PanHead SteelZinc	McMaster-Carr	90272A827	$3.57(100)	
2	4	screw	8-32 7/16"L PanHead Steel Zinc	McMaster-Carr	90272A193	$6.27(100)	
3	7	screw	6-32 3/8"L PanHead Steel BlackOxide	McMaster-Carr	92224A133	$5.79(100)	
4	2	screw	6-32 1/2"L PanHead Steel BlackOxide	McMaster-Carr	92224A135	$5.86(100)	
5	5	screw	6-32 1" PanHead Steel Zinc	McMaster-Carr	90272A153	$3.97(100)	
6	1	screw	6-32 1-1/4" PanHead Steel Zinc	McMaster-Carr	90272A155	$3.98(100)	
7	4	screw	6-32 3/4"L PanHead Steel BlackOxide	McMaster-Carr	92224A138	$7.33(100)	
8	6	screw	4-40 5/8" PanHead Steel Zinc	McMaster-Carr	90272A112	$2.65(100)	
9	32	screw	4-40 3/8"L PanHead Phillips Steel BlackOxide	McMaster-Carr	92224A114	$5.71(100)	
10	2	screw	4-40 5/8" PanHead Steel Zinc	McMaster-Carr	90272A112	$2.65(100)	
11	24	screw	#6 1/2"L RoundHead Phillips SheetMetal	McMaster-Carr	90935A148	$4.40(100)	
12	10	screw	#4 5/16"L RoundHead Phillips ThreadForming Steel BlackOxide	McMaster-Carr	90417A117	$7.67(100)	
13	12	screw	#2 1/4"L FlatHead Phillips 18-8Stainless	McMaster-Carr	90065A077	$2.62(100)	
14	8	screw	#2 3/8L BluntSheetMetal RoundHead Phillips BlackZincPlated	McMaster-Carr	92295A112	$9.80(100)	
15	1	screw	Lead 8mmDia 300mmL 2mm Pitch 4 Starts	Amazon	B08JPPC1TZ	$11.99(2)	Note1
16	14	nut	6-32 SmallPattern Steel BlackOxide	McMaster-Carr	90760A170	$4.16(100)	
17	14	nut	1/4-20 ThinProfile 7/16W 5/32T 18-8SS BlackOxide	McMaster-Carr	98514A029	$9.25(50)	
18	4	nut	8-32 1/4"W 3/32"H Hex Narrow-Profile Steel Zinc-Plated	McMaster-Carr	90760A009	$3.73(100)	
19	1	nut	LeadScrew 8mmDia 2mmPitch 4Start Brass	Amazon	B08JLV1NF1	$4.99(2)	Note1
20	2	nut	4-40 3/16"W Narrow Steel ZincPlated	McMaster-Carr	90760A005	$2.83(100)	
21	4	spacer	8-32 5/16"Hex 3/4" Steel-Zinc	McMaster-Carr	91920A241	$1.78(1)	
22	37	insert	4-40 0.135"L HeatSet Brass	McMaster-Carr	94459A250	$9.91(50)	
23	1	tube	5/32"OD 0.128"ID Brass260 1ft	McMaster-Carr	8859K21	$2.30(1)	
24	4	rod	Threaded 1/4-20 MedStrengthSteel Black-Oxide 1ft	McMaster-Carr	94210A003	$5.96(1)	
25	2	rod	8mmx300mm Hardened Linear Motion Shaft Amazon	Amazon	B07DPF612G	$9.99(2)	Note1
26	2	spring	Extension 0.172"OD 0.5"L 30SS	McMaster-Carr	9433K418	$2.45(1)	
27	1	coupling	Rigid 6.35mm-8mm 20x25mm StepperOnline	StepperOnline	GX2025-6.35-8	$1.37(1)	
28	1	motor	Stepper Driver 1.0-4.2A 20-50VDC StepperOnline	StepperOnline	DM542T	$19.65(1)	
29	1	motor	Stepper Nema23 Shaft 6.35mm 2.8A 175.6oz-in StepperOnline	StepperOnline	23HS22-2804S	$13.37(1)	
30	3	sensor	Ultrasonic Oxygen Sensor Winpower	Ebay	OCS-3F	$45.00(1)	
31	4	pump	Foot Pump for Inflatables Amazon	Amazon	B07JV7KBXM	$8.09(1)	
32	2	heatsink	2.4W 2.28L 1.4H CrosswiseAirFlow Aavid	Aavid	241214B92200G	$8.74(1)	
33	1	wood	10"x24"x0.63" Black Laminate (cut to 8"x16")	HomeDepot	1010708638	$10.98(1)	
34	2	pad	Thermal Pad 100x100x1mm Amazon (cut to 2.2 x 1.25)	Amazon	B086W119D	$5.98(1)	
35	2	switch	MicroSwitch LeverWithRoller SolderTerminals Honeywell	Honeywell	ZM50E70F01	$2.09(1)	
36	2	gasket	Superior NeopreneFoam 1/16"T 12"x12"	McMaster-Carr	1601N212	$7.12(1)	Note2
37	2	gasket	Middle NeopreneFoam 1/16"T 12"x12"	McMaster-Carr	1601N212	$7.12(1)	Note2
38	2	gasket	Inferior NeopreneFoam 1/16"T 12"x12"	McMaster-Carr	1601N212	$7.12(1)	Note2
39	2	bearing	Linear 8x15x24mm Amazon	Amazon	RJ4JP-01-08	$9.38(10)	

Note1	These parts are commonly sold together as a kit.
Note2	These gaskets will be cut from a single 12"x12" piece

Lung Simulator BOM (Bill of Materials) – 3D printed parts

Line	Qty	Type	Description
40	1	printPLA	WireGuide-Base
41	4	printPLA	Foot
42	1	printPLA	BaseMount-Superior
43	1	printPLA	BaseMount-Inferior
44	1	printPLA	Plate-LeftSuperior
45	1	printPLA	Plate-RightSuperior
46	1	printPLA	Bracket-LeftSuperiorLateral
47	1	printPLA	Bracket-LeftSuperiorMedial
48	1	printPLA	Bracket-RightSuperiorMedial
49	1	printPLA	Bracket-RightSuperiorLateral
50	1	printPLA	RodMount-Superior
51	1	printPLA	RodStop-Superior
52	1	printPLA	Plate-LeftInferior
53	1	printPLA	Plate-RightInferior
54	1	printPLA	Bracket-LeftInferiorLateral
55	1	printPLA	Bracket-LeftInferiorMedial
56	1	printPLA	Bracket-RightInferiorMedial
57	1	printPLA	Bracket-RightInferiorLateral
58	1	printPLA	Mount-SlideRodsInferior
59	1	printPLA	WireGuide-InferiorLimitSwitch
60	1	printPLA	WireGuide-InferiorLowStepper
61	1	printPLA	WireGuide-InferiorHighStepper
62	8	printPLA	Bellows-Plug
63	2	printPLA	Bellows-SuperiorTubeCoupler
64	2	printPLA	Bellows-TubeCouplerRing

Line	Qty	Type	Description
65	2	printPLA	Bellows-CouplerRingLargeNutSide
66	2	printPLA	Bellows-CouplerRingLargeScrewSide
67	2	printPLA	Bellows-CouplerRingSampling
68	1	printPLA	Bellows-Link
69	2	printPLA	LinearBearingMount
70	2	printPLA	LinearBearingMountShim
71	1	printPLA	MoveBarNutMount
72	1	printPLA	TubeHolder-LeftInferior
73	1	printPLA	TubeHolder-RightInferior
74	1	printPLA	LimSwitchBump
75	2	printPLA	TubeHolder
76	2	printPLA	TubeHolder-Plate
77	1	printPLA	Conn-Housing
78	1	printPLA	Conn-LabelMount
79	1	printPLA	Handle
80	2	printPLA	HandleMount
81	1	printPLA	Template-LinkArmEnd
82	1	printPLA	Template-BellowsCouplingRing
83	1	printPLA	Template-FrameHolesInferior
84	1	printPLA	Template-FrameHolesSuperior
85	2	printPLA	Y-Connector-Port
86	1	printPLA	Y-Connector-15deg
87	1	printPLA	SrcSensorMount
88	1	printPLA	LungSensorMount
89	1	printPLA	MaskOxygenSensorMount