COVID-19 Swim Mask HEPA PAPR

by qebehsenuef

These are crazy times in the world of the COVID-19 pandemic. In my 24 years as a physician, I could never have imagined a time like now where we as a healthcare community and as a nation would be paralyzed by a disease leading to basic equipment shortages putting myself and colleagues in danger. Long before coronavirus, physicians and healthcare workers are used to putting our own lives and safety at risk in front of sick patients on a regular basis. Now, however, we are confronted with higher exposure risks of contracting the novel coronavirus in the absence of personal protective equipment (PPE). To minimize risk of contracting coronavirus from patients, front line healthcare workers can wear an N95 mask to filter small particulate matter. Unfortunately these masks have recently been in severe shortage. An alternative protective gear is the Powered Air Purifying Respirator (PAPR). A PAPR uses a motorized fan to pass air through a HEPA filter, which removes the contaminant and supplies purified air to a mask or hood. In response to the severe shortage of personal protective equipment that we face to protect ourselves form the novel coronavirus, my son Connor and I have designed and created what we feel is functional PAPR made out of a full face swim mask, tubing, computer fan, HEPA filter and 3D printed parts all powered by a 5V USB powerbank. The goal was to make a device to protect those who put themselves in harms way to protect others. We wanted to make this mask with objects readily obtainable in the community, and with a few parts made from a 3D printer

Supplies:

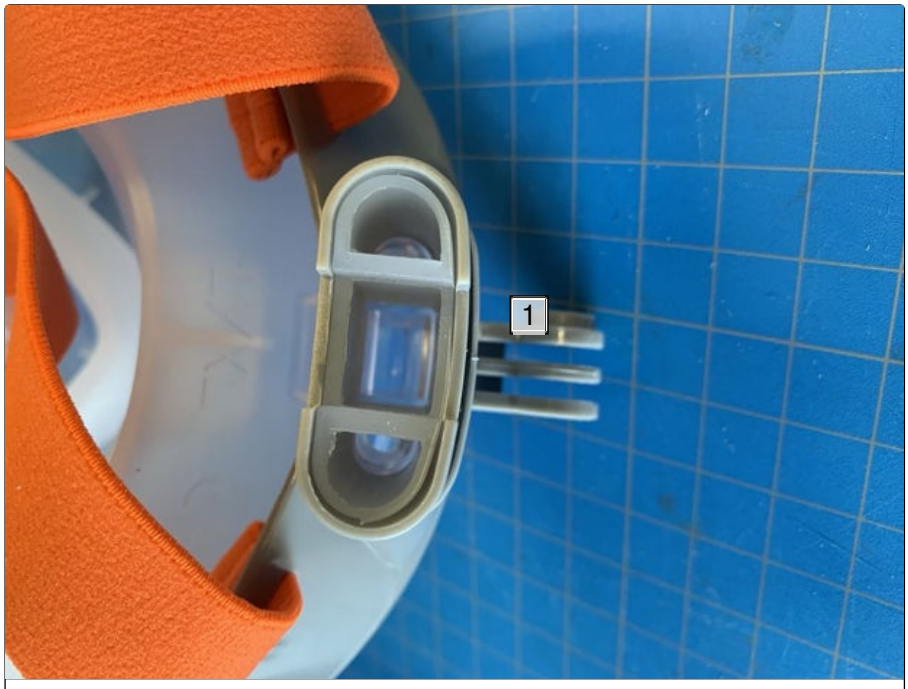
- Full face swim mask
- 1 1/8" flexible bilge tubing- Home Depot
- 5 volt 80mm computer fan
- 5 volt USB powerbank
- DC potentiometer
- HEPA cartridge (for vacuum cleaner)
- wires
- duct tape
- electrical tape
- 3D printed parts

Step 1: Choosing the Mask

We purchased a full face adult swim mask from Amazon. We felt that the swim mask designed to keep out water with a watertight seal is well suited to keep out the coronavirus. Our mask, like most full face swim masks, has a silicon valve below the chin where air can escape under positive pressure when you exhale or when pressure builds inside the mask.

We did not place the snorkel that came with the mask as the snorkel opening at the top of the maks would be used as the air intake.

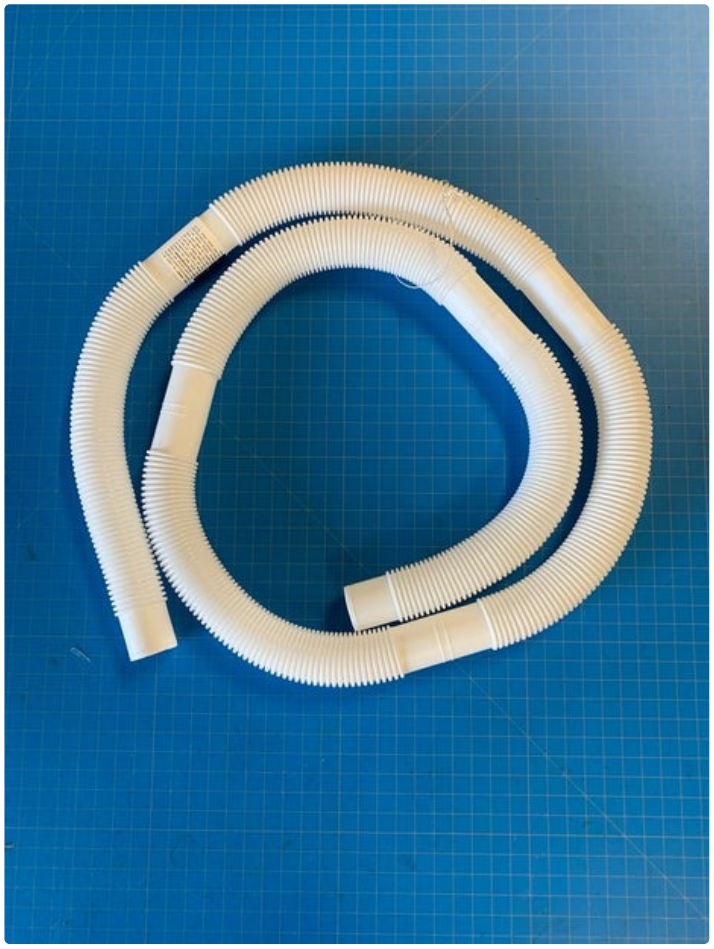
We identified the center opening as our air intake and covered the side openings with 3D printed exit plugs although electrical tape can also be used to cover and make an airtight seal.

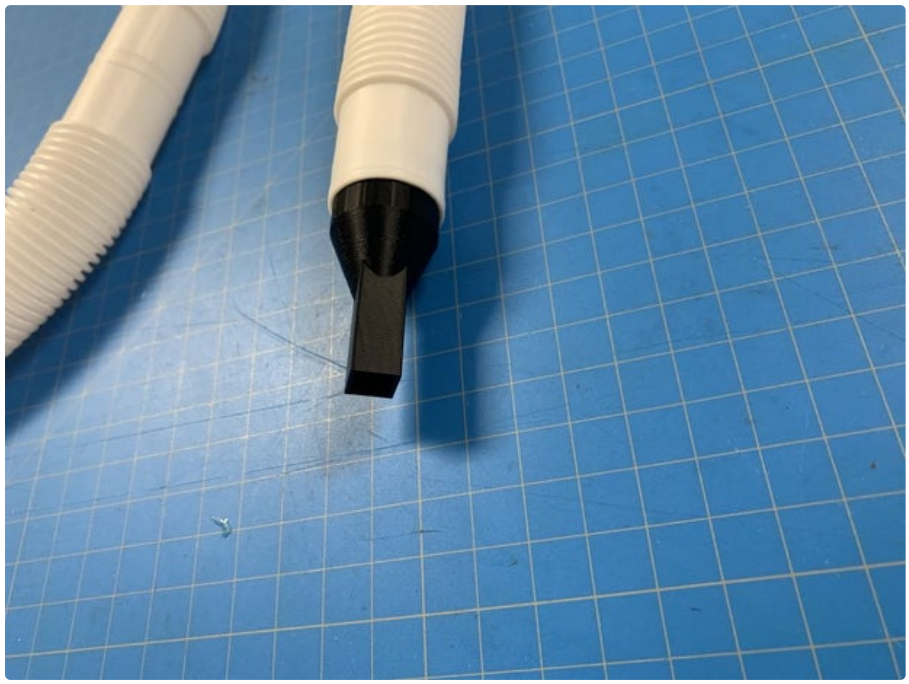


1. Air intake at top of mask

Step 2: Fitting Hose to Mask

We measured the snorkel opening and the opening to flexible tubing we purchased from the big box hardware store and printed an a hose adapter

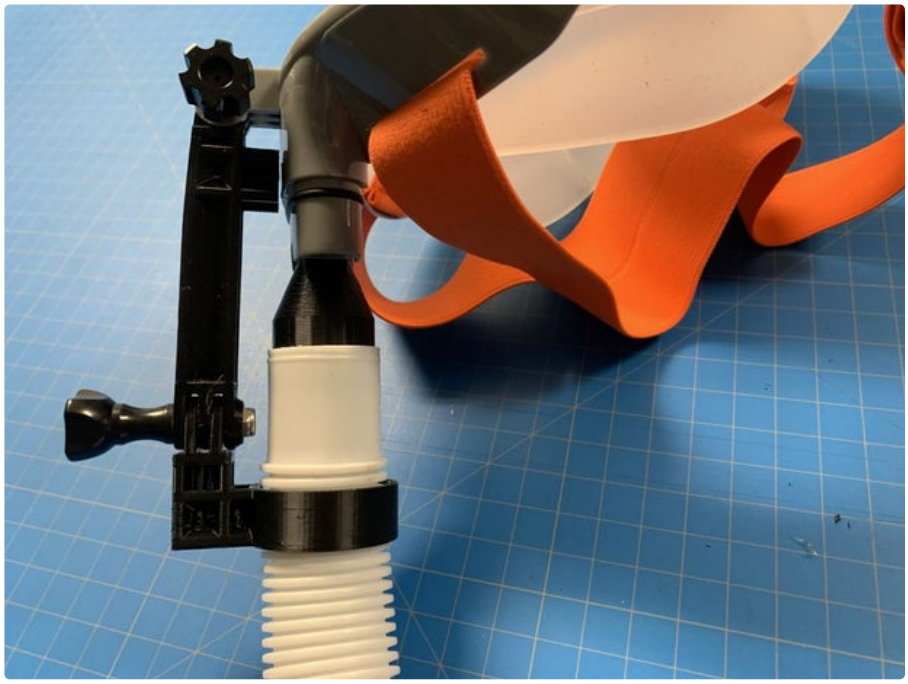




Step 3: Supporting the Hose-mask Joint

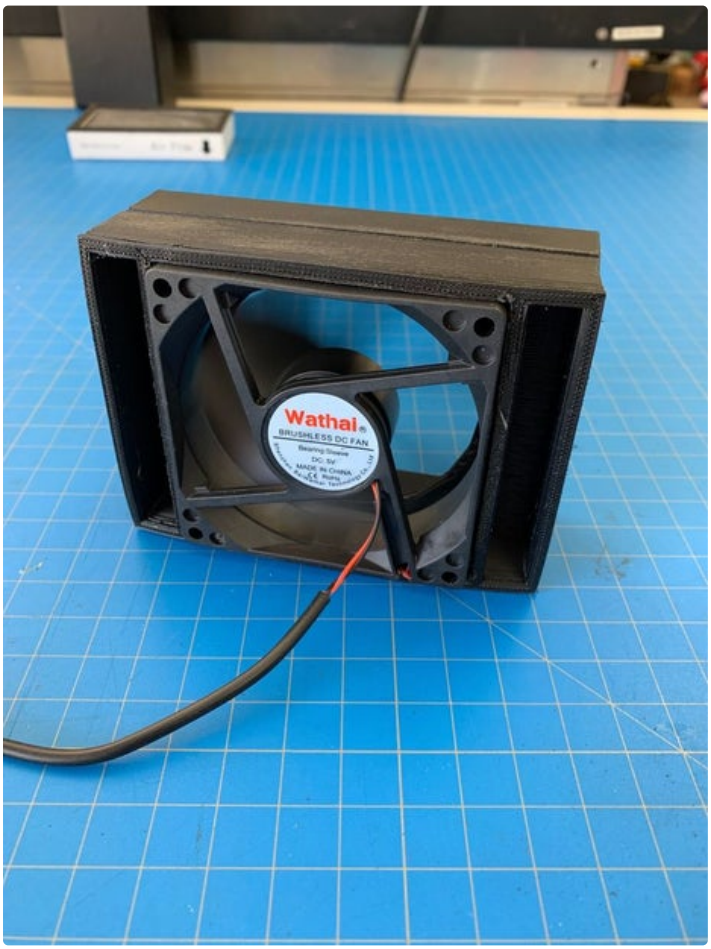
The 3D printed adapter connecting the hose to the mask's snorkel opening goes from a large diameter to a smaller one and is at risk for breaking. We wanted to support the hose at this critical juncture. Fortunately our mask, like

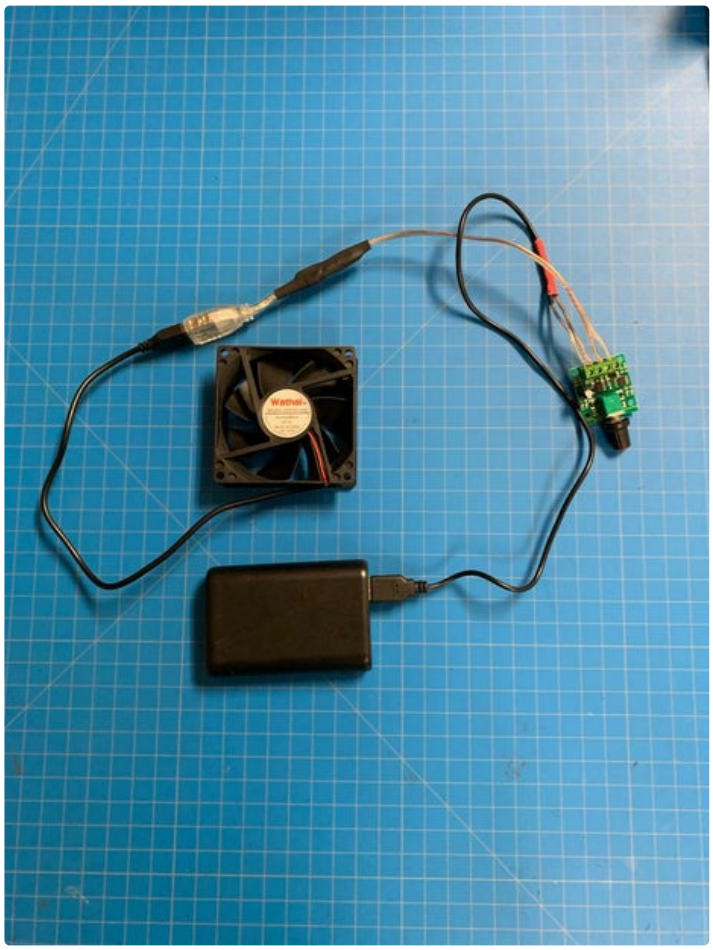
many other full face masks, had a GoPro attachment on the top. We 3D printed pieces to work with the GoPro attachment and support the hose.



Step 4: Powering the PAPR

We chose to use a 5 volt 80mm computer fan to power the PAPR As it is rated at greater than 35 cubic ft per minute which is equivalent to the rate of flow of the commercial PAPR. The 5v computer fan can be directly powered by a USB power bank. It is more common to find 12v computer fans in the stores and on Amazon. If you are purchasing a computer fan you should specify 5v. In our example we chose to put a potentiometer in between the fan and the power bank to control the rate of speed of the fan. This is an optional but not necessary step.

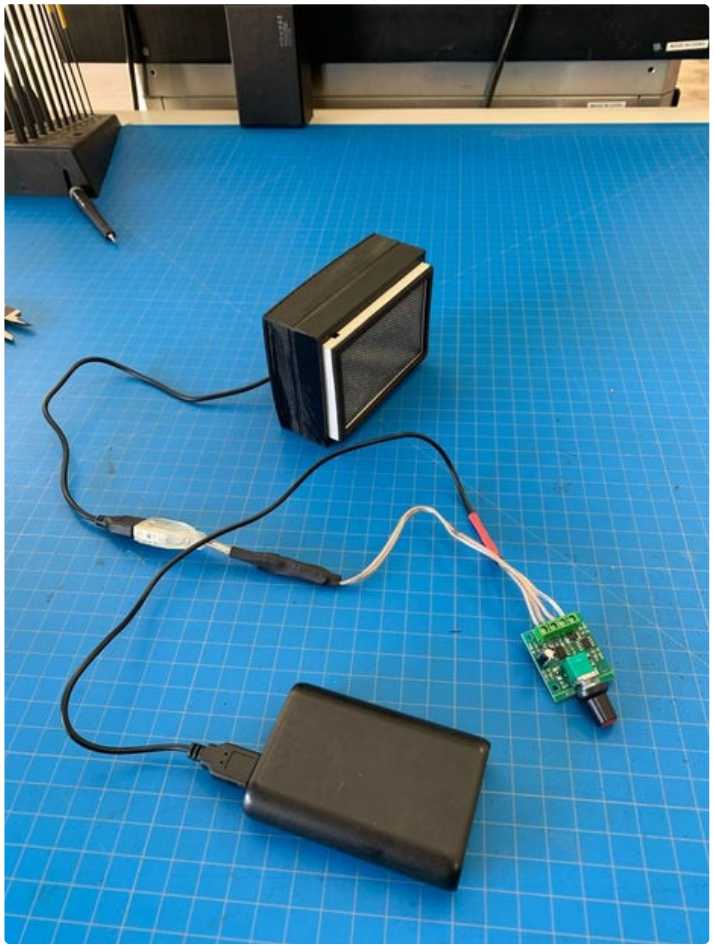




Step 5: Setting Up the HEPA Filter

We purchased the smallest HEPA filter we could find. We found the HEPA vacuum cartridge for canister vacuums to be an acceptable size measuring 3 x 4 x 3/4 inches. A 3D printed base holding both the HEPA filter and fan was made. The fan is placed right up against the HEPA filter to drive air through the HEPA and into the next chamber. We then 3D printed an rel="nofollow">enclosure with an attachment to the mask hose and this was pushed up against the fan to create a filtered air enclosure. The filter base and enclosure were then sealed airtight with electrical tape and duct tape so that the only air in the tubing is filtered air coming through the HEPA filter.


Air Flow



Step 6: Putting It All Together

The filtered air hose was attached to the top of the mask and the filter unit was taped to the rear mask strap with duct tape. Flip the switch or just plug the USB into the power bank and you have your own PAPR.

Step 7: Thoughts:

This device is sound in concept and theory but has not been tested. This device in no way is meant to replace existing and approved masks and devices such as N95 mask and commercial PAPRs when they are available. If you make this device or use the concepts of a wearable powered HEPA filter you do so at your own risk. This device is designed to be used as a 'crisis capacity strategy' for PPE as defined by the CDC when the surge in demand for PPE leads to severe shortage or unavailability of the approved protective equipment. As a physician I have worn multiple types of N95 masks and PAPRs and I find our mask is easy to use and breathe in. The HEPA filter should successfully filter the coronavirus. Although distance between fibers in the HEPA filter is 0.3 microns and the corona virus is smaller at .12 microns in size, the HEPA is able to filter close to 100% of coronavirus sized particles. The HEPA filter accomplishes this based on the multiple methods of capture the filter uses and the speed of which air is forced through the filter. Almost counter intuitively, the slower the velocity of the air passing through the filter, the more efficient the HEPA filter becomes at removing even the smallest particles in the air. Although very technical, the science behind this concept is illustrated here in this scientific paper by NASA engineers.

We like the use of the swim mask because it works as a face shield and creates a 'airtight' seal around the face. In the event there is not a complete seal, the positive pressure of the PAPR pushes air away from the mask preventing outside particles from gaining access to inside the mask. In addition those who have used a PAPR with the hood know how difficult it is to hear inside the hood with the fan on. Our design leaves the ears outside the mask for better hearing. Because of this design, our mask can be used with a stethoscope, a feat that cannot be accomplished with a traditional PAPR hood. The unit is also easily deconstructed and the mask can be washed with soap and water and/or appropriate cleanser and reused.

This project is a work in progress and will most surely evolve, as does our fight with coronavirus, and we will update the product design as we improve it. Any suggestions or comments are welcome.

Lastly we understand that this build might not be for everyone as they may not be able to obtain the necessary resources and or have the technical capability to manufacture the device. For those who want to help in our fight I would like to direct you to Team Shield. We have partnered with Team Shield who are a an energetic group of students from Davis and Roseville California that have come up with a surprisingly simple yet brilliant solution to PPE equipment shortages. Their products and equipment are currently in use at Northern California hospitals. Please check them out because through Team Shield anyone can help our frontline healthcare workers by making shields or making donations.

Thank you for sharing! I saw something similar the other day, it's neat to see how to do this :)