

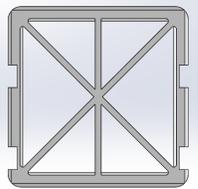
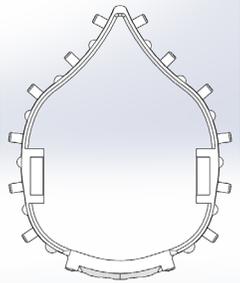
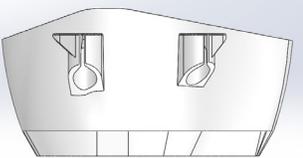
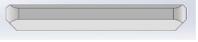
EveryMask – America Makes Submission Details

This document fulfills the required “America Makes Submission Details” as part of America Makes’ [Fit to Face – Mask Design Challenge](#).

Designer Recommendations

Table 1 contains recommended parameters for 3D printing based on fused deposition modeling (FDM). The recommendations are for the FDM process, but the three plastic *EveryMask* components can be printed with other 3D-printing processes. Nonetheless, the *EveryMask* was designed for printing with almost *every* plastic on *every* 3D printer, including personal 3D printers.

Table 1: Recommended parameters for 3D printing

Item	Shell	Square	Retainer
Filename, without Revision letter (*.STL)	“EveryMaskShellSmall” or “EveryMaskShellLarge”	“EveryMaskSquare”	“EveryMaskRetainerSmall” or “EveryMaskRetainerLarge”
Top View, looking down onto print bed (not to scale)			
Side View, looking sideways at print bed (not to scale)			
Filament Diameter (mm)	1.75	1.75	1.75
Filament Length (m)	17.24 (Small) or 19.33 (Large)	2.66	2.64 (Small) or 3.03 (Large)
Material	ABS	ABS	ABS
Process	FDM	FDM	FDM
Infill (Percent)	10	10	10
Layer Thickness (µm)	300	300	300
Speed (mm/s)	80	80	80
Build Time	2 hours, 19 minutes (Small) or 2 hours, 35 minutes (Large)	29 minutes	29 minutes (Small) or 32 minutes (Large)
Brim	None	None	None
Raft	None	None	None

The plastic mask parts can be printed via FDM without supports because those mask components were designed with flat bottoms and overhang angles of typically 45 degrees. Furthermore, the Square could be printed either as indicated in Table 1 or “upside down”, but we recommend printing as indicated in Table 1 so that if there is a slight “lift off” during printing, the top surface of the Square (see Table 1) will still be relatively flat, which is useful for mating with the Shell and creating the best seal of the Shell with the filter patch.

Table 2 contains recommended printers for 3D printing of the *EveryMask* based on FDM. These recommendations are based on a combination of quality and cost.

Table 2: Recommended 3D printers

Order of Preference	Printer Make	Printer Model	Material
1	Fusion3	F410	ABS
2	LeapFrog	Xeed 3D	ABS
3	Stratasys	Fortus 250mc	ABS

Finally, because the *EveryMask* was designed for printing with almost every plastic on every 3D printer, including personal 3D printers, the *EveryMask* was printed successfully on the following printers with (1) no supports, brims, or rafts, (2) a layer thickness of 300 μm , (3) total print time of about 3.6 hours, and (4) the same infill percentages as in Table 1:

- PLA parts were printed on a XYZprinting da Vinci mini w+ and a FlashForge Creator 3
- ABS parts were printed on a FlashForge Creator 3

Bill of Materials

To make **120 duplicates of the *EveryMask***, the following items must be purchased:

Filament

- Product name = Natural ABS Filament (1.75 mm option)
- Vendor = Atomic Filament
- Description = 1.75 mm, 1 kg
- Link = <https://atomicfilament.com/collections/abs-3d-filament/products/natural-abs-filament-1-kg?variant=2548936065>
- Quantity = 10

FDA-Approved Foam

- Product name = Food-Grade Super-Cushioning Foam Sheet
- Vendor = McMaster-Carr
- Part number = 8722K83
- Description = Polyethylene, 54" wide, 8 ft long, 1/8" thick
- Link = <https://www.mcmaster.com/8722k83-8722K404>
- Quantity = 1

Elastic Straps

- Product name = Braided Elastic 144 Yards - White (1/4" Wide)
- Vendor = Amazon
- ASIN number = B06XH4HGC9
- Description = 1/4" wide elastic strapping, 144 yards long
- Link = https://www.amazon.com/Braided-Elastic-144-Yards-White/dp/B06XH4HGC9?ref=ast_bbp_dp
- Quantity = 1

Filters (non-N95, only to be used if permitted)

- Product name = Face Mask Filter
- Vendor = Flowmark/HighTech
- Description = MERV 14 @ 2000 cfm (95 percent down to 1 µm) filter material, precut to 2.25" x 2.25" filter patches, 50 filter patches per package
- Link = <https://www.flowmarkhightech.com/3d-face-mask-filters>
- Quantity = 3 packages = 150 filter patches

Post processing and assembly instruction set

The *EveryMask* requires no post processing of the 3D-printed parts. However, the FDA-approved foam sheet must be cut for use. For further details, please refer to the “Recommendations for Cutting the FDA-Approved Foam” subsection of the “Recommendations for Manufacturing” section in the document titled “EveryMask - Instructions For Use”. The last pages of that document are 1:1 scaled printable patterns to assist cutting of the foam for the sizes of the *EveryMask*.

For assembly instructions of the *EveryMask*, please refer to the “Assembly Steps” subsection of the “Point of Care Assembly and Cleaning Instructions” section in the document titled “EveryMask - Instructions For Use”.

'Point of Use' Assembly Instructions

Please refer to the "Assembly Steps", "Donning and Doffing the Face Mask", and "Preparing the Supplementary Face Mask for Reuse" subsections of the "Point of Care Assembly and Cleaning Instructions" section in the document titled "EveryMask - Instructions For Use".

Additionally, if using the non-N95 filter material in the *EveryMask* as described in the "Bill of Materials" section, the filter has two sides: a non-flat side and a flat side. The non-flat side of the filter should be assembled in the *EveryMask* as facing towards the outside of the face mask, away from the user's face, while the flat side of the filter should face towards the inside of the face mask, towards the user's face.

Cleaning Instructions

Please refer to the “Recommended Cleaning” subsection of the “Point of Care Assembly and Cleaning Instructions” section in the document titled “EveryMask - Instructions For Use”.

Design Description

The *EveryMask* was designed for widespread dissemination as a reusable 3D-printed mask that accepts a square piece of almost every type of filter material and can be printed with almost every plastic on every 3D printer while forming a seal with almost every type of face. Key points supporting this claim are listed here:

Every Filter

- The *EveryMask* accepts filter material up to 0.035" in thickness, which is inclusive of N95-filters as well as alternative filter materials. Two sides of the Square of the *EveryMask* deflect more or less to accommodate for different filter thicknesses.
- The mask accepts filter material with a nominal size of 2.25" x 2.25" but also as small as 2.12" x 2.12"; the 0.13" tolerance is useful for hand-cut filter materials.
- Because the filter material is square and much smaller in area than typical FDA-approved masks, for emergency situations, typical masks can be cut into two or more squares for use within the *EveryMask*.

Every Plastic

- Only the FDA-approved foam is touching the skin for long-term use; the 3D-printed parts do not touch the user's face. Since the plastic material of the *EveryMask* is not in direct contact with the user's skin, the 3D-printable parts may be made from most plastic materials, including ABS and PLA.

Every Printer

- The plastic mask parts can be printed via FDM without supports because those mask components were designed with flat bottoms and overhang angles of typically 45 degrees.
- The *EveryMask* was designed with printing tolerances in mind, so the three 3D-printed parts mate to each other via deflection of part flexures, in order to account for different geometric accuracies among printed parts.
- The parts are 3D-printable at normal to low quality settings, since the three 3D-printed parts mate to each other via deflection of part flexures and reasonable 3D-printing variations of the part dimensions do not alter part functionality within the assembly.

Every Face

- Each size of the *EveryMask* was designed for use on multiple NIOSH headforms.
- The FDA-approved foam conforms to the face with little force, making the mask comfortable for long-term use.
- The FDA-approved foam forms a proper seal to faces of various shapes and sizes; the *EveryMask* is a true respirator.

The *EveryMask* achieves these goals because of its unique design. Noteworthy design elements are the following:

Deflection for Design

- The Square has two sides that are flexures and two sides that are more rigid. The two flexure sides have 45-degree walls, so whenever the two sides flex underneath the corresponding slanted triangular crevices of the Shell, the Square is pushed down to compress the filter material. The forces are transferred to the two non-flexure sides because of their rigidity. The result is a Square that has an interference fit with the Shell with the filter patch squeezed along its edge, as needed for an effective respirator.
- The Retainer holds the FDA-approved foam via deflection of the foam and the Retainer. Because its wall thickness is only about 0.1", the Retainer is essentially one large flexure. Whenever the Retainer is pushed down into the foam, the foam and the Retainer deflect together. The result is that the foam is locked into place. To help ensure that the Retainer holds down the foam, the Retainer has unique semi-circular protrusions built into its bottom that are deflected into or out of an undercut groove in the Shell. Such a feat is possible only because of the deflection of the Retainer.
- The FDA-approved foam deflects, compresses, and conforms to the human face, even with the variations of human face shapes and sizes. The Shell and the soft FDA-approved foam work together in a sense to create a proper seal to render the *EveryMask* as a respirator. The Shell gives a nominal shape to the Foam and helps to push down the foam along the face at certain spots, while the foam deflects to form the needed seal.

Sounds for Design

- The Square and the Retainer both "snap" into place, so the user has an audible clue to whenever the parts are properly assembled. The Square hits a wall when it is pushed by the user to either clamp down the filter or to release the filter. Also, the semi-circular protrusions of the Retainer "snap" into the groove of the Shell when the foam is clamped down.

Cleaning

- No adhesives or permanent bonds are used, so the mask can be disassembled, sanitized, and then reassembled for reuse, including the FDA-approved closed-cell foam.

Ears

- On each of the four ears, two small elliptical holes allow for tension adjustment of elastic strapping, and one large hole with a slot enables the user to insert a piece of elastic strapping after it has been knotted. Therefore, for ease of use, strapping materials can be knotted or adjusted for tension without knots.

Groove

- The foam rests in a tapered U-shaped groove of the Shell, but the user can look through the rectangular cutouts of the wall of the groove to visually inspect if the foam is properly in place.
- The groove was specifically designed for the foam to overlap along the chin to ensure a good seal along the chin of the user. The Retainer compresses the foam into the groove and the tapered U-shaped cross section of the bottom of the groove helps to maintain a proper seal for the respirator.