MECH 4V96.001, Shop Design

Mechanical Engineering

Erik Jonsson School of Engineering and Computer Science

COVID-19 Test Kit

Last Updated: 03-01-2023

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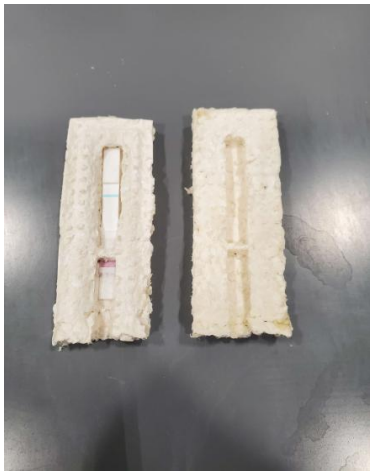
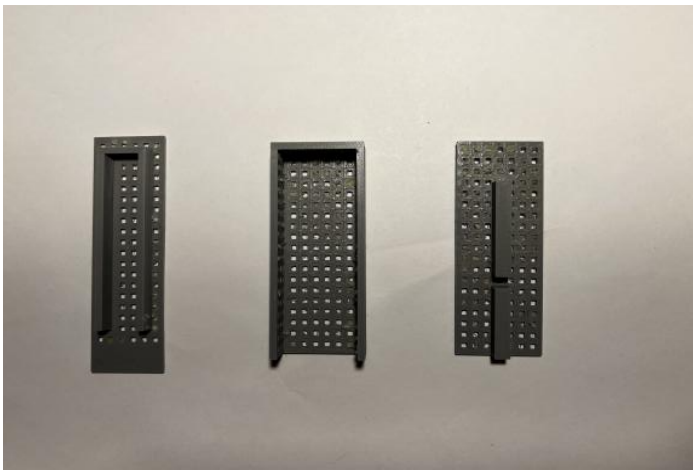
Executive Summary

A plastic mold for COVID-19 test kits was created and put in ECSW 1.160. It can be used to manufacture biodegradable COVID-19 test kits, which cause less environmental damage than the standard kits.



Covid Test Kit



Mold Negatives to fabricate the Test Kit

Section 1: Problem Identification

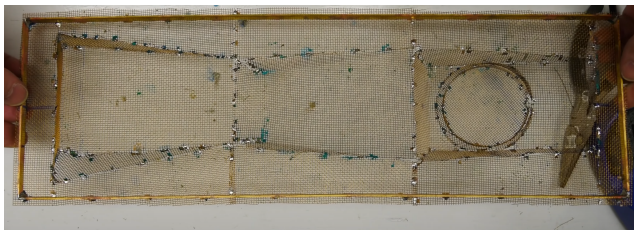
COVID-19 test kits frequently generate lots of plastic waste, which are unsightly and do not decompose, causing negative impacts on the environment.

Section 2: Criteria and Goals

The purpose of this project is to fabricate COVID-19 test kit housings. The criteria applied require that the mold negative designs for the kit housing structure be compatible with casting with paper mache or pulp.

Section 3: Research

The team investigated two methods of fabricating the test kit depending on the viscosity of the pulp material used in casting. For thick pulp, it is necessary to create the pattern out of a metal mesh, before dipping the mesh into the pulp to create the required shape. Once cut out, the mesh pattern is dipped into the material in order to pull a pulp film that covers the mesh pattern to get the desired shape. The film is then set to dry before assembled. An example of a mesh pattern can be seen below. The example is made from a brass mesh and creates a net pattern for a phone stand [1].



If thinner fluids are used, mold negatives can be modeled and then 3D-printed. The fluid pulp can then be poured into the mold and left to set. Afterwards, the housing structure can then be removed.

Section 4: Brainstorm

After deliberation, the team decided to take the second option, to design mold negatives and 3D-print the mold. A morph chart showing all the design choices is shown below, with the chosen options highlighted in green.

216	Feature	Type 1	Type 2	Type 3
2	Material for Kit	Paper Pulp	Paper Mache	
3	Method of Fabrication	Mesh Pattern	3D-Printed	No Filament
3	Mesh Pattern Material Type	Brass	Copper	No Mesh
2	3D-Printing Material Type	ABS	PLA	
2	Cover Design	Cover Included	No Cover Included	
3	3D-Printing Method	3D-Printed as a Net	3D-Printed as an Assembly	No 3D-Printing

Section 5, Analyze Solutions & Develop Requirements

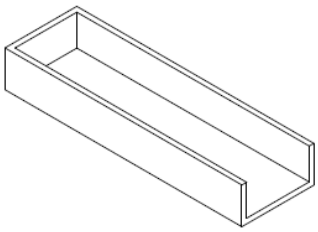
A table of requirements was developed. It is shown below.

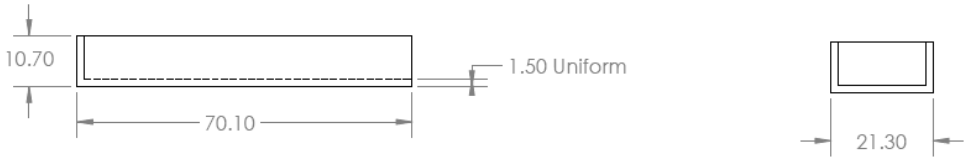
#	Requirement	Pass/Fail
1	Tolerances (<1mm) for tooling molds	Pass
2	Tooling Mold must be 3D printable	Pass
3	Must be easy to replicate	Pass
4	Product holds a purchased COVID-19 Test Strip	Pass
5	Product is biodegradable	Pass

Section 6: Develop & Test Models

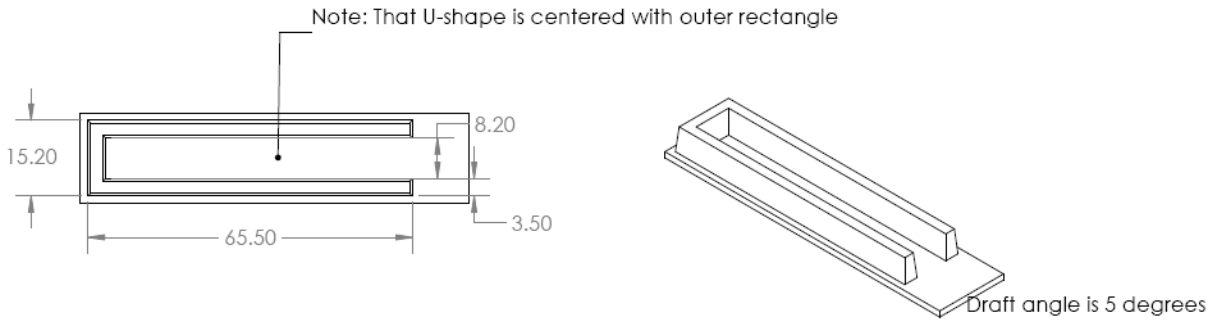
Parts are modeled and assembled using SolidWorks based on paper prototypes and hand sketches. The drawings of the 3D-Parts can be seen below:

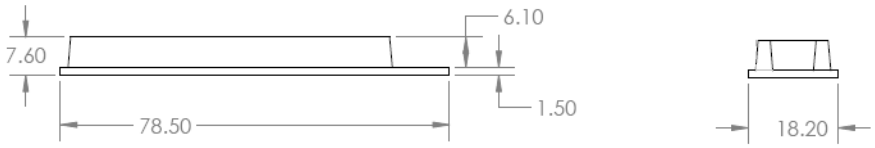
Wall Mold Negative



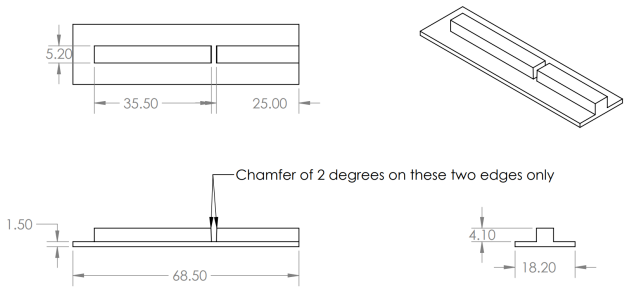


Bottom Mold Negative

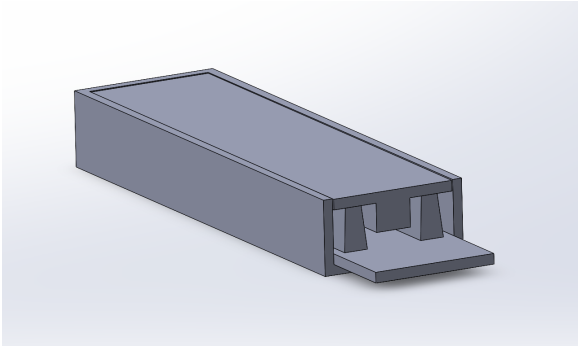




Top Mold Negative

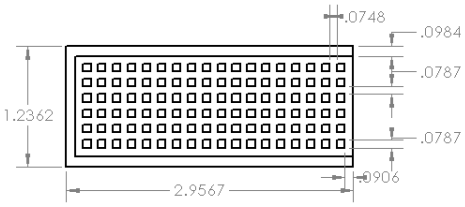


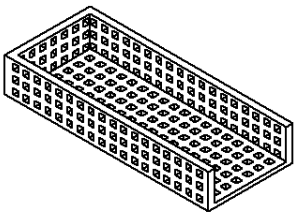
SolidWorks Assembly of Mold Positive:

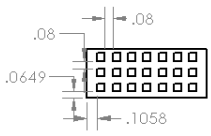


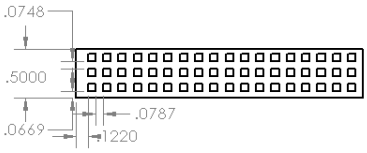
This model was created and tested. However, it took several days for the kits to dry. A new, scaled-up model was therefore created, with several holes in the side to allow for quicker ventilation and therefore faster drying. Negatives and SolidWorks assembly for the final model are shown below.

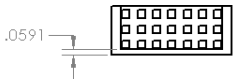
Wall Mold Mesh Negative:



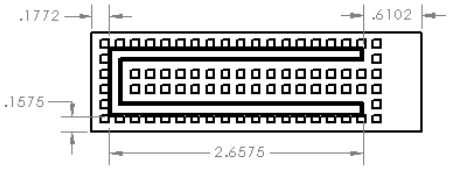


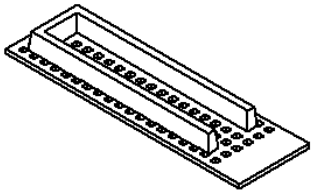


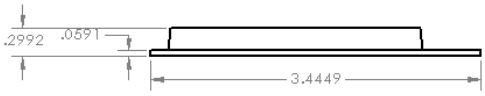


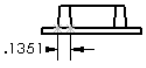


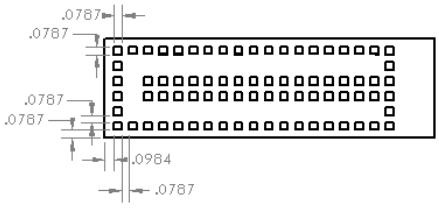
Bottom Mold Mesh Negative:



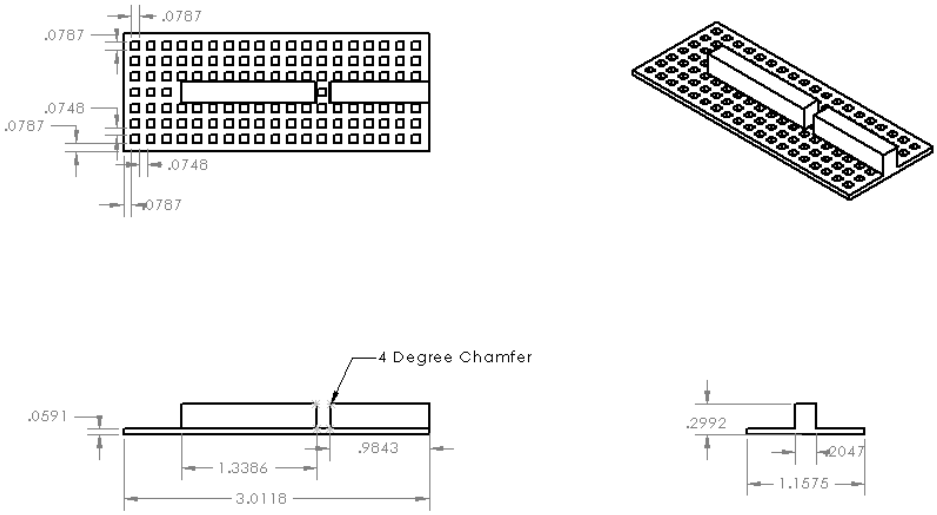




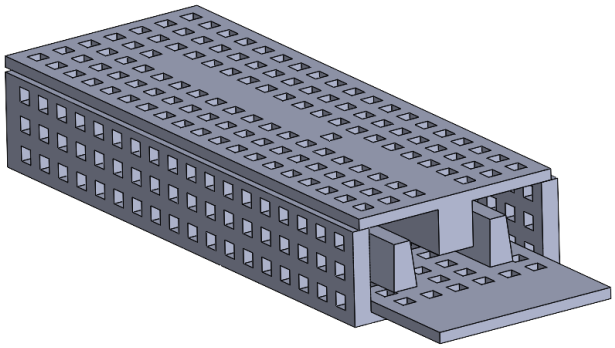




Top Mold Mesh Negative:



Assembly of Mold Positive:



Section 7: CDR Presentation

A CDR presentation was given on Friday, February 3, 2023. In attendance were Dr. Dani Fadda, along with the other students in MECH 4V96.001.

The comments received during the CDR were:

1) Is it likely that the material will stick to the inside of the mold?
2) Is it possible that COVID-19 may be spread via the kits?
3) Will the design look better than the kits that can be purchased elsewhere?
4) How will the team acquire the vacuum if the mesh-based method of fabrication is used?

These comments are addressed, with details included in section 9.

Section 8: Communicate & Specify

A bill of materials and operation was finalized. It can be found below. The Paper Mache Pulp purchase link can be found in Section 11, listed as link 2.

A bill of materials can be seen below to produce 50 test kits. The Nara Paper Mache can be bought from link [2]. Plastic for manufacturing can be done with any 3d-printer material. In the case of the prototype, PLA was used and bought from amazon[3]. The Tooling mold kits are 18.52g of filament to print or about $0.47 of PLA filament. One bag of NARA paper mache pulp is 1lb of paper mache and one kit is about 1-2 cups of pulp per kit, so one bag produces an estimated 50-80 kits for about $0.14 - $0.09 respectively.

Item	cost	Consumable?	Overhead Cost	Operating Cost	# of Product
NARA Paper Mache Pulp	$6.99	Yes	$0.00	$6.99	50-80 Covid Kits
1kg PLA filament for Tooling Molds	$24.99	No	$24.99	$0.00	54 Tooling Molds
Total:			$24.99	$6.99	
Grand Total:				$31.98	

Section 9: Implement

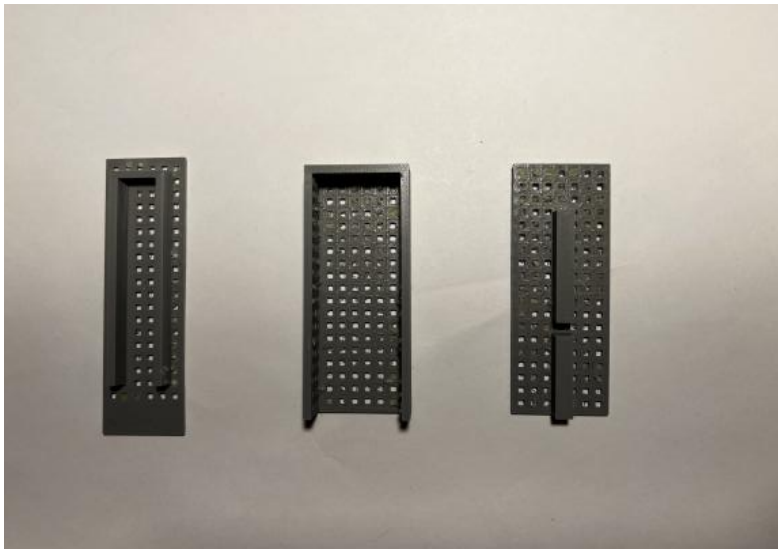
9.1: CDR Feedback Response

Each question brought up in the CDR was considered and resolved:

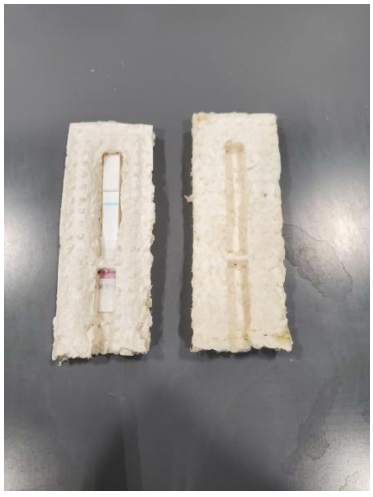
1) Is it likely that the material will stick to the inside of the mold?
    - It sticks a little bit, but the team found that spraying PAM cooking spray to the inside of the mold made it unlikely that it would stick much.
2) Is it possible that COVID-19 may be spread via the kits?
    - As per a recent study from the National Library of Medicine[1], though COVID-19 can spread via contaminated surfaces, this occurs much less often than respiratory transmission. The team recommends that anyone who uses the kits for COVID-19 testing should wear a mask while handling the kit and should wash their hands for at least 20 seconds after testing [4].
3) Will the design look better than the kits that can be purchased elsewhere?
    - The test kit will look similar to an egg carton so it will look quite visually monotone. However, it will be far easier to use than other purchasable kits. Since the kit will have no folds, it will be easy to use and therefore has significant advantages over the other available options.
4) How will the team acquire the vacuum if the mesh-based method of fabrication is used?
    - The vacuum is not completely necessary for the mesh-based method of production, and since the team is using the other approach, there is no need to acquire a vacuum.

9.2: Images

Test Kit Housing Structure Negatives:



Test Kit Housing Structure Prototypes



The kit with the test strip was made without the non-stick spray. The kit on the right was made with the spray. Note that both are rigid, however they can be snapped with force and misuse.

9.3 Assembly

After releasing the housing structure, to insert the testing strip into the structure, a slit needs to be cut under the wall in the central channel of the kit. Once this is done the testing strip is inserted and stays without glue.

Section 10: Review and Assess

SolidWorks part files, along with STL files for the completed mold, can be found online at the project workshop webpage [5].

For a more water resistant housing structure for more humid and rain prominent regions, polyurethane or an alternative sealer can be used on the kit. This may not guarantee being fully waterproof but will make the structure more resistant. Further, for future improvement, a metal mesh tooling mold or a tooling mold that allows for more constant airflow could be considered for quicker drying times as well as a less dimpled, smoother design. Tests with biodegradable plastics or different glue, pulp, and water ratios may also improve strength in the mold.

Section 11: Links and Resources

1) https://www.youtube.com/watch?v=R3ArpZRAChw
2) https://www.hobbylobby.com/Crafts-Hobbies/Clay-Molding-Sculpting/Molding/Paper-Mache-Paper-Pulp/p/20766?gclid=Cj0KCQjwuLShBhC_ARIsAFod4fKwxitz4B_wxPLKrwpjh1RYlPfqvShxa5R-ZqqwFhaUFU1bIY62kyIaAhQXEALw_wcB
3) https://www.amazon.com/AmazonBasics-Printer-Filament-1-75mm-Silver/dp/B08894NK7S/ref=sr_1_1_ffob_sspa?hvadid=177275152769&hvdev=c&hvlocphy=9026948&hvnetw=g&hvqmt=b&hvrand=6733481183137380372&hvtargid=kwd-22136215895&hydadcr=18002_9841951&keywords=pla+filament&qid=1680744871&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyNU41M1dGN0hJQ0QmZW5jcnlwdGVkSWQ9QTA2ODMwMjVXNkNNMzRYOTYyREYmZW5jcnlwdGVkQWRJZD1BMDAyMDgyNDEwSFdUWDlEWUYzWDImd2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl
4) https://www.ncbi.nlm.nih.gov/books/NBK570437/
5) https://personal.utdallas.edu/~dzf091000/workshop/