Flow Limitation

Progress Report #10

Date: 11/13/2026
Client: Dr. Chris Green
Advisor: Dr. Mehmet Orman
Team: "Flow State"

Lakshika Nanda Kumar Reddy: Co-Leader
Julia Shefchik: Co-Leader
Caroline Blust: Communications
Eliza Kubicek: BSAC
Brady Mayer: BPAG
Jillian Seibert: BWIG

Problem statement:

Flow limitation is the phenomenon in which increasing respiratory effort no longer increases airflow beyond a certain point during forced exhalation, because the airway itself becomes the limiting factor rather than muscles driving expiration [1, 2]. During forced expiration, intrathoracic pressure rises sharply and can exceed the pressure inside the airway, resulting in the airway walls, specifically the bronchi, to narrow and eventually reach a choke point past which further effort in exhalation cannot increase flow [3]. This mechanism is central to interpreting spirometry, since flow-volume curves reflect the mechanical properties of airways rather than respiratory muscle effort alone [4, 5]. It is most relevant to obstructive diseases such as asthma, cystic fibrosis, and COPD, where airway walls are more prone to premature collapse or are already narrowed by inflammation, mucus, or loss of elastic recoil. This leads to prominent flow limitation occurring during forced exhalation [6]. This device will model the branching anatomy of the airway and use flexible materials to replicate the compression and collapse that occurs in the affected patient population. This will allow the users to visualize the equal pressure point (EPP) and the resulting choke point as it moves distally through the airway. The device is intended to physically demonstrate flow limitation during forced expiration for use in an educational teaching video. The final video will be used to teach medical fellows and students how these airway mechanics underlie clinical measures such as spirometry, and how they explain and monitor these obstructive conditions that experience flow limitation.

Brief status update:

This week the team modified the SolidWorks model with insight from the previously printed model. The team printed more samples and received advice on MTS testing. Testing will proceed next week along with refinement of the airway model and its dimensions.

Difficulties/advice requests:

None at this time.

Current design:

The box from last year's group project will be used in our current design.

Major team goals for the next week:

- Print the new modified dimensions airway model
- Try new support removal methods on the printed airway model
- Complete MTS testing on sample materials, and compare values obtained by testing 50A and 80A
- Begin pressure testing

Next week's individual goals:

Lakshika Nanda Kumar Reddy

- Get a printed, working prototype for testing
- Finish MTS testing on 80A

Julia Shefchik

- Finalize airway prototype
- Finish MTS testing
- Develop a plan for alveoli testing

Caroline Blust

- Finish airway prototype and test in pressure box
- Develop balloon attachment plan
- Recomplete MTS testing with improved attachment of samples in grips if time

Eliza Kubicek

- Assist in printing airway and removing supports as well as beginning to set up airway in pressure box
- Continue to troubleshoot pressure testing and MTS testing

Brady Mayer

- Prototyping and printing the airway

- Finish MTS testing
- Attend as much group work as possible

Jillian Seibert

- Troubleshoot MTS testing if we have time
- Work on printing and removing supports from airway
- Do testing on water balloons

Previous week's goals and accomplishments:

Lakshika Nanda Kumar Reddy

- Continued circuit debugging
- Met with Dr. N for circuit debugging
- Assisted with MTS testing

Julia Shefchik

- Created a new airway prototype ‘
- MTS testing of 80A

Caroline Blust

- Completed MTS testing on 50A and 80A samples
- Printed two new airway prototypes

Eliza Kubicek

- Learned about MTS testing procedures and how the machines work

Brady Mayer

- Work on prototyping the airway
- MTS testing on materials
- Research as needed

Jillian Seibert

- Worked on MTS testing the 50A material
- Tried to troubleshoot with MTS testing 80A material
- Got some initial numbers for 80A, we may need to retry depending on timing

ACTIVITIES

Name	Date	Activity	Time (h)	Week Total (h)	Sem. Total (h)
Lakshika Nanda Kumar Reddy	9/7/2026	Review previous team's final report	1	2.5	46
	9/7/2026	Brainstorm questions for the client meeting	0.5		

	9/10/2026	Conducted research on flow limitation and took notes	1		
	9/15/2026	Worked on PDS	1	5.5	
	9/15/2026	Researched FV curves, obstructive diseases, and flow limitation for PDS	2		
	9/16/2026	Edited PDS	1.5		
	9/16/2026	Researched materials for design ideas	1		
	9/21/2026	Started preliminary research on material ideas for 3D printing and alveoli	1	7.5	
	9/22/2026	Caroline/Eliza meeting for materials	1.5		
	9/23/2026	Conducted intensive research on 3D printing materials and alveoli materials	2		
	9/23/2026	Wrote the assigned sections of the design matrix	1		
	9/24/2026	Edited and reformatted all three design matrices to have cohesiveness through the documents	2		
	9/28/2026	Created Preliminary Presentation Slides	0.5	3.5	
	9/28/2026	Created initial flow limitation animation	1		
	9/28/2026	Met with Simon Nam to figure out applying compressed air and vacuum air to box	0.5		
	9/30/2026	Team Practice for Preliminary presentation	0.5		
	10/1/2026	Created final flow limitation animation	1		
	10/3/2026	Wrote sections of preliminary report	2	8.5	
	10/4/2026	Provided feedback on sections of the preliminary report	0.5		

	10/4/2026	Met with team to go over comments in prelim report	1		
	10/4/2026	Created protocol for pressure testing phase 1 and wrote protocol in report	2		
	10/8/2026	Met with Makerspace Staff for fabrication protocol of airway with Caroline	0.5		
	10/8/2026	Completed Airway fabrication protocol and started working on pressure testing phase 2 protocol with Caroline	1.5		
	10/8/2026	Created draft of pressure testing phase 2 protocol	1		
	10/12/2026	Researched I2C Architecture	1	2	
	10/13/2026	Met with Dr. Green	0.5		
	10/13/2026	BPAG Sheet	0.5		
	10/18/2026	MatLAB mathematical model + research	2	5	
	10/21/2026	Grab Materials from University Hospital	1		
	10/22/2026	Started Base pressure sensor testing	2		
	10/26/2026	Meeting with Caroline to print 2 airways: 1 whole and 1 split	1.5	4.5	
	10/26/2026	Worked with Eliza to work on testing digital gauge pressure sensor from last year	1		
	10/28/2026	Worked on running both BMP sensor and digital gauge pressure sensor together	2		
	11/4/2026	Worked on debugging	1	2	
	11/5/2026	MTS research	1		
	11/10/2026	MTS Tensile Testing	2	10	
	11/11/2026	Circuit Debugging	2		
	11/11/2026	Reprinting, and removing supports of current print	1		

	11/12/2026	Get second print and remove supports	2		
	11/12/2026	Brainstorm ways to keep 80A in MTS machine, and attachment of water balloons to airway	2		
	11/12/2026	Meet with Dr. N to go over circuit issues	1		
Julia Shefchik	9/7/2026	Review previous team's deliverables (final report, PDS, final poster)	1	4	44
	9/7/2026	Brainstorm questions for the client meeting	0.5		
	9/9/2026	Annotated and read a review article on Expiratory Flow Limitation	1.5		
	9/9/2026	Researched mechanical properties of the Airway Tree	1		
	9/13/2026	Worked on PDS	1	4	
	9/14/2026	Research standards and worked on PDS	2		
	9/16/2026	Edited PDS	1		
	9/21/2026	Preliminary research to support design ideas	1	7.5	
	9/22/2026	Research on physiological airway models and balloon materials	2		
	9/23/2026	Work on design matrices	3		
	9/24/2026	Edit design matrices	1.5		
	9/28/2026	Worked on preliminary design presentation slides and drawings	1	4	
	9/28/2026	Met with Simon Nam to learn about vacuum system	0.5		
	9/30/2026	Team practice for presentation	0.5		
	9/30/2026	Brainstorm testing ideas and draft sections of preliminary report	2		

	10/1/2026	Individual practice for design presentation	0.5		
	10/2/2026	Worked on sections of preliminary design report	2	6.5	
	10/3/2026	Edited preliminary design report	1		
	10/4/2026	Research on testing for preliminary design report	1		
	10/4/2026	Met with the team to discuss edits	1		
	10/4/2026	Editing and refining sections of the preliminary report	1.5		
	10/13/2026	Review team client meeting notes and material choices	0.5	2	
	10/15/2026	Work on SolidWorks testing tubes and begin work on airway model	1.5		
	10/20/2026	SolidWorks airway research and stochastic model	1	5	
	10/21/2026	SolidWorks modeling	4		
	10/24/2026	Rebuild SolidWorks model for printing and easy refinement	2	3.5	
	10/28/2026	Write and prepare for show and tell	0.5		
	10/29/2026	Try to find new potential measurements for airway	1		
	11/4/2026	SolidWorks update model	1.5	3.5	
	11/4/2026	LabArchives update	1		
	11/4/2026	Flow modeling research	1		
	11/8/2026	Create a new airway model in SolidWorks	1	4	
	11/11/2026	Print airway 2 and fix dimensions	1		
	11/12/2026	MTS 80A testing and airway 2 support removal techniques	2		

Caroline Blust	9/7/2026	Brainstorm questions and review past project	0.5	1	44
	9/7/2026	Add research entry to LabArchives	0.5		
	9/11/2026	Researched project concepts and summarized client article	1.5	6	
	9/15/2026	Worked on PDS	3		
	9/15/2026	Further research	1		
	9/16/2026	PDS edits	0.5		
	9/21/2026	Materials research and design matrix initial brainstorming	1	8.5	
	9/22/2026	Lakshika/Eliza materials matrix meeting	1.5		
	9/23/2026	Materials matrix research and writing	3		
	9/24/2026	Materials/alveoli matrix work	2		
	9/24/2026	Final edits on matrices	1		
	9/28/2026	Worked on preliminary presentation	1	3	
	9/29/2026	Met with Simon Nam to learn how to use vacuum pump	0.5		
	9/30/2026	Presentation edits/practice	1		
	10/01/2026	Final edits/citations	0.5		
	10/03/2026	Preliminary report edits and feedback	1	6	
	10/05/2026	Worked on preliminary report	0.5		
	10/07/2026	Feedback fruits	0.5		
	10/08/2026	Preliminary report final edits/citations and additional research for pressure testing	4		
	10/11/2026	Feedback fruits	0.5	2.5	
	10/12/2026	Communicated with contacts about ordering materials	0.5		
	10/12/2026	Confirmed and finalized	0.5		

		materials table			
	10/13/2026	Client meeting and pressure testing protocol discussion	1		
	10/22/2026	Research into MTS testing and tensile test standards	2	4	
	10/22/2026	Solidworks and printing of Die C for MTS testing	2		
	10/26/2026	Finalized two versions of initial airway test print and sent to printer	2	3.5	
	10/28/2026	Picked up airway test print and worked on removing supports	1		
	10/29/2026	Experimented with use of AI in generating model of chokepoint formation	0.5		
	11/2/2026	MTS testing standard and protocol research	1.5	3	
	11/2/2026	Printed new die samples	1		
	11/5/2026	Checked on die samples and started reprinting	0.5		
	11/10/2026	Printed airway2 and MTS testing research	1	6.5	
	11/10/2026	MTS machine setup and testing on 50A	2.5		
	11/10/2026	MTS testing on 80A	0.5		
	11/11/2026	Picked up printed sample and started reprint	0.5		
	11/12/2026	MTS testing on 80A, experimentation with balloon attachment method	2		
Eliza Kubicek	9/5/2026	Read through last semester's final report documentation and took notes on previous work and potential starting points in LabArchives	2	6	37.5
	9/7/2026	Brainstormed questions for the client meeting	0.5		

	9/7/2026	Conducted research on flow limitation during forced expiration and took notes in LabArchives	2		
	9/9/2026	Conducted research on tube law and physical properties of human airways for future design use and took notes in LabArchives	1.5		
	9/14/2026	Outlined PDS sections	0.5	4	
	9/15/2026	Conducted research for and wrote PDS sections	2.5		
	9/16/2026	Edited PDS based on feedback	0.5		
	9/16/2026	Updated LabArchives with research findings used in writing the PDS	0.5		
	9/21/2026	Conducted research on possible materials to model the bronchi and alveoli	2	6	
	9/22/2026	Met with Caroline and Lakshika to work on the materials design matrix	1.5		
	9/23/2026	Worked on the materials and alveoli design matrices	1.5		
	9/24/2026	Finalized my assigned parts of the materials and alveoli design matrices	1		
	9/27/2026	Worked on slides for the preliminary presentation	1	3.5	
	9/30/2026	Practiced with the team for the preliminary presentation	0.5		
	10/1/2026	Worked on the discussion section of the preliminary design report	2		
	10/4/2026	Finalized the discussion section of the preliminary report based on feedback	1	2.5	
	10/4/2026	Met with the team to discuss the preliminary report	0.5		

PROJECT TIMELINE

Task	Sept			October					November				Dec	
	11	18	25	2	9	16	23	30	6	13	20	27	4	11
Project R&D														
Preliminary Research	X	X	X	X										
Detailed Final Design					X									
Testing Plan						X								
Show and Tell								X						
Fabrication							X	X	X	X				
Testing														
Deliverables														
Progress Reports	X	X	X	X	X	X	X	X	X	X				
PDS		X												
Design Matrix			X											
Prelim presentation				X										
Preliminary Deliverables					X									
Final Poster														
Final Deliverables														9th

Meetings														
Client		X	X	X		X				X				
Advisor	X	X	X		X	X	X			X				
Website														
Update	X	X	X	X	X	X	X	X	X	X				

Materials and expenses:

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Airway Materials										
FormLabs Flexible 50A Resin	Elastic resin used to print on FormLabs SLA printers.	FormLabs	N/A	DI Lab	N/A	TBD	TBD	$0.29/g	TBD	Link
Assorted Water Balloon	Multi-color latex 3” water balloons 100ct	Arcady	N/A	Amazon	N/A	TBD	1	$4.94	$4.94	Link
Loctite Super Glue Ultra Gel Control	Tough silicone gel super glue	Loctite	N/A	Amazon	N/A	TBD	1	$4.49	$4.49	Link
Pressure Testing Materials										
BMP388 Precision Barometric Pressure and Altimeter	Pressure sensor, accurate up to 8 Pascals	N/A	N/A	Amazon	N/A	TBD	1	$16.99	$16.99	Link
STEMMA QT / Qwiic JST SH 4 pin to premium male headers cable	Connector from QT to Male Headers for Arduino	N/A	N/A	Amazon	N/A	TBD	1	$6.70	$6.70	Link
ELEGOO 120pcs Multicolored Dupont Wire M-F, M-M, F-F for Breadboard Jumper	Female-Male Connector Jumpers for Breadboard	N/A	N/A	Amazon	N/A	TBD	1	$6.98	$6.98	Link
Basketball Football Volleyball Water Polo Rugby Exercise Sports Ball Balloon Swim Inflatables	Balloon Pump with extension attachment	N/A	N/A	Amazon	N/A	TBD	1	$6.99	$6.99	Link
D-NYX 6 Rolls E Tape Multi Colored Vinyl	Tape for Electronic Attachments	N/A	N/A	Amazon	N/A	TBD	1	$4.99	$4.99	Link

Electrical Tape 3/5in x 26ft Waterproof Strong Adhesive Indoor Outdoor 6 Colors Durable Easy Wrap Professional Grade Electric Wire Repair 7 Mil										
										TOTAL: $52.08

References

[1] C. Tantucci, “Expiratory Flow Limitation Definition, Mechanisms, Methods, and Significance,” Pulm Med, vol. 2013, p. 749860, 2013, doi: 10.1155/2013/749860.

[2] T. C and G. V, “Flow limitation: an overview,” PubMed, Accessed: Sep. 15, 2026. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/10546481/

[3] Z. Ms, “The physiology of forced expiration,” PubMed, Accessed: Sep. 15, 2026. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/16263442/

[4] “Lung Flow Volume Curve - an overview | ScienceDirect Topics.” Accessed: Sep. 15, 2026. [Online]. Available: https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/lung-flow-volume-curve

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[6] R. L. Dellacà et al., “Detection of expiratory flow limitation in COPD using the forced oscillation technique,” Feb. 2004, Accessed: Sep. 15, 2026. [Online]. Available: https://publications.ersnet.org/content/erj/23/2/232