

# **Flow Limitation**

## **Progress Report #4**

**Date:** 9/24/2026

**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:**

The team has created a design matrix to evaluate three designs each for the airway geometry, material choice, and alveoli design. These matrices were presented to the client, where the team was able to gain valuable insight into the proposed design outcomes and helped to aid in completion of the matrix criterion and scores for each design.

## **Difficulties/advice requests:**

None at this time.

## **Current design:**

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

## **Materials and expenses:**

None at this time.

## **Major team goals for the next week:**

- Complete the preliminary design presentation and report
- Investigate method for delivering compressed air to the pressure box system

## **Next week's individual goals:**

Lakshika Nanda Kumar Reddy

- Complete assigned sections of the preliminary design report
- Continue researching
- Start experimenting with modeling airway in Solidworks

Julia Shefchik

- Edit and refine assigned sections of preliminary design report
- Start brainstorming on how to model in SolidWorks
- Brush up on SolidWorks interface

Caroline Blust

- Complete sections of preliminary design report
- Order materials (balloons, etc.) and investigate printing with chosen material
- Use vacuum pump/compressed air successfully to create pressure differential

Eliza Kubicek

- Continue work on writing and editing the preliminary design report
- Brainstorm and conduct research on testing methods and types of results to look for
- Begin looking into purchasing materials, especially alveoli materials

Brady Mayer

- Work on the preliminary design report
- Do some research for the preliminary design report
- Look into brainstorming how to approach modeling the design in SolidWorks

Jillian Seibert

- Work on the preliminary design report
- Continue to research about the design we are working on
- Start to work/think about how we will begin designing in SolidWorks

## **Previous week's goals and accomplishments:**

Lakshika Nanda Kumar Reddy

- Worked on assigned preliminary presentation slides
- Created animation for preliminary presentation
- Continued research in preparation for preliminary report

Julia Shefchik

- Completed sections of preliminary presentation slides
- Drafted sections of preliminary report
- Met with Simon Nam to learn about the vacuum system

Caroline Blust

- Finished preliminary presentation slides
- Met with Simon to learn about vacuum pump

Eliza Kubicek

- Worked on and practiced my section for the preliminary presentation
- Began writing preliminary design report

Brady Mayer

- Worked on my section for the presentation
- Practiced presenting for the preliminary presentation
- Began working on research for the design report

Jillian Seibert

- Worked on presentation slides

- Practiced for presentation
- Did any preparation and research for my section of the report

## 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            | 19             |
|                            | 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   |     |      |
| Julia Shefchik | 9/7/2026  | Review previous team's deliverables (final report, PDS, final poster)          | 1   | 4   | 19.5 |
|                | 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 |     |      |
| Caroline Blust | 9/7/2026   | Brainstorm questions and review past project                                                                                         | 0.5 | 1   | 18.5 |
|                | 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 |     |      |
| 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   | 19.5 |
|                | 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   |     |    |
| Brady Mayer | 9/7/2026  | Researched background information and brainstormed questions for client meetings. I also further researched information about the trachea and bronchi and updated lab archives after previous issues. | 2   | 4   | 19 |
|             | 9/9/2026  | I also further researched information about the trachea and bronchi and updated lab archives after previous issues.                                                                                   | 2   |     |    |

|                 |           |                                                                                               |     |   |    |
|-----------------|-----------|-----------------------------------------------------------------------------------------------|-----|---|----|
|                 | 9/15/2026 | Worked on PDS and researched info for it.                                                     | 2   | 3 |    |
|                 | 9/16/2026 | Made PDS edits based on team recommendations.                                                 | 0.5 |   |    |
|                 | 9/17/2026 | Worked on progress report and final PDS edits.                                                | 0.5 |   |    |
|                 | 9/22/2026 | Met with sub-group and discussed design matrices.                                             | 1   | 9 |    |
|                 | 9/23/2026 | Worked on design matrices, research, drawings and explanations.                               | 4   |   |    |
|                 | 9/24/2026 | Completed progress report and design matrices                                                 | 2   |   |    |
|                 | 9/25/2026 | Researched pathological adaptability and added it to labarchives                              | 2   |   |    |
|                 | 9/28/26   | Worked on presentation slides                                                                 | 1   | 3 |    |
|                 | 9/30/26   | Practiced with the group for presentation                                                     | 0.5 |   |    |
|                 | 10/1/26   | Worked on preliminary design report                                                           | 1   |   |    |
|                 | 10/1/26   | Individually practiced for presentation                                                       | 0.5 |   |    |
|                 |           |                                                                                               |     |   |    |
| Jillian Seibert | 9/7/2026  | Added research entries to LabArchives and contributed to research more background information | 1.5 | 2 | 19 |
|                 | 9/7/2026  | Went through previous teams reports and clients powerpoint                                    | 0.5 |   |    |
|                 | 9/11/2026 | Researched more on the math and COPD aspect of project                                        | 1   | 5 |    |
|                 | 9/13/2026 | Researched anything necessary for the PDS                                                     | 1   |   |    |
|                 | 9/13/2026 | Worked on my section of PDS                                                                   | 1.5 |   |    |
|                 | 9/16/2026 | Revised the PDS and updated my labarchives to match with my research for the PDS              | 1.5 |   |    |
|                 | 9/20/2026 | Researched previous groups                                                                    | 1   | 9 |    |

|  |           |                                                                   |     |   |  |
|--|-----------|-------------------------------------------------------------------|-----|---|--|
|  |           | design to figure out problems and solutions                       |     |   |  |
|  | 9/20/2026 | Came up with three design ideas to come to the group meeting with | 1   |   |  |
|  | 9/22/2026 | Researched more for the manufacturing and modeling feasibility    | 1   |   |  |
|  | 9/23/26   | Wrote sections for the airflow design matrix                      | 2.5 |   |  |
|  | 9/24/26   | Wrote sections for the alveoli design sections                    | 1.5 |   |  |
|  | 9/24/26   | Researched for the alveoli design sections                        | 2   |   |  |
|  | 9/28/26   | Worked on slides for presentation                                 | 1   | 3 |  |
|  | 9/30/26   | Group practice for presentation                                   | 0.5 |   |  |
|  | 10/1/26   | Practiced and prepared for presentation                           | 0.5 |   |  |
|  | 10/1/26   | Worked on preparing and researching for my section of report      | 1   |   |  |

## PROJECT TIMELINE

[illegible]

### Materials and expenses:

[illegible]

## 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>
- [5] "Pulmonary Function Testing - PMC." Accessed: Sep. 15, 2026. [Online]. Available: <https://pmc.ncbi.nlm.nih.gov/articles/PMC7158317/>
- [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>