PROJECT 1:

Project Title: Residential wind turbine design

Project Description: This project aims to develop a small wind turbine that can harvest wind energy and produces electricity for residential buildings. The main problem in harvesting wind energy in urban areas is the inconsistent and variable wind, which limits the use of conventional applications. The goal of this project is to come up with a novel design that can harvest energy from air coming from any direction with variable velocity. Most of the conventional wind turbines use horizontal-axis configuration (see Fig. 1) and is aligned with the direction that wind is expected to come. Therefore it may be a good idea to consider a vertical-axis wind turbine with unconventional shape and arrangement of blades.

Fig. 1: Conventional wind turbine

Requirements:

1. A strong interest in a practically oriented project
2. Strong background in fluid mechanics
3. Ability to work in a group

Number of students: up to 6 students

PROJECT 2:

Project Title: A pipeline network model for air flow in lungs

Project Description: This project aims to develop a simple model for the air flow and pressure drop in lungs. As the respiratory organ responsible for gas exchange with the external environment, the lung obviously plays an enormous role in health. The human respiratory system is extremely complex in structure and exhibits significant differences for each individual. It consists of two lungs, right and left, situated in the thorax and connected via their primary bronchi to the trachea and upper airway of the nose and mouth as shown in Fig. 2. The bronchi or airways form a branching network mostly as a sequence of birfurcations. Each level of branching is called *a generation* as the trachea being the zeroth generation. In a perfectly birfurcating system, there will be 2^n airway tubes at generation n. From a functional point of view, respiratory system can be divided into the *conducting zone* (generations 0 to 16) where gas is simply conducted and the *respiration zone* (generations 17 to 23) where the O_2-CO_2 gas exchange occurs. The small air sacs start to appear on the walls of airway for generations 17-19, the walls are entirely made of alveoli for generations 20-22, and finally there are the terminal alveolar sacs consisting of clusters of alveoli for generation 23. An alternative geometry based division is also possible as the *extrathoratic*, *upper bronchial*, *lower bronchial*, and *alveolar* regions. It is of fundamental importance to understand the air flow and pressure drop in the airways for diagnosis and treatment of lung diseases.

The air flow is driven by the pressure difference between the inlet (mouth and nose) and the exit (alveoli). The airways can be considered as a network of rigid and circular pipelines. The Weibel model[1] has been widely used in lung simulations mainly due to its simplicity. The Weibel model assumes that each lung generation branches symmetrically into two identical daughter branches.

In this project, we'll assume that the airways are a network of pipelines formed by perfectly bifurcating rigid and circular pipes. Furthermore, the flow is assumed to be steady and is driven solely by the pressure difference.

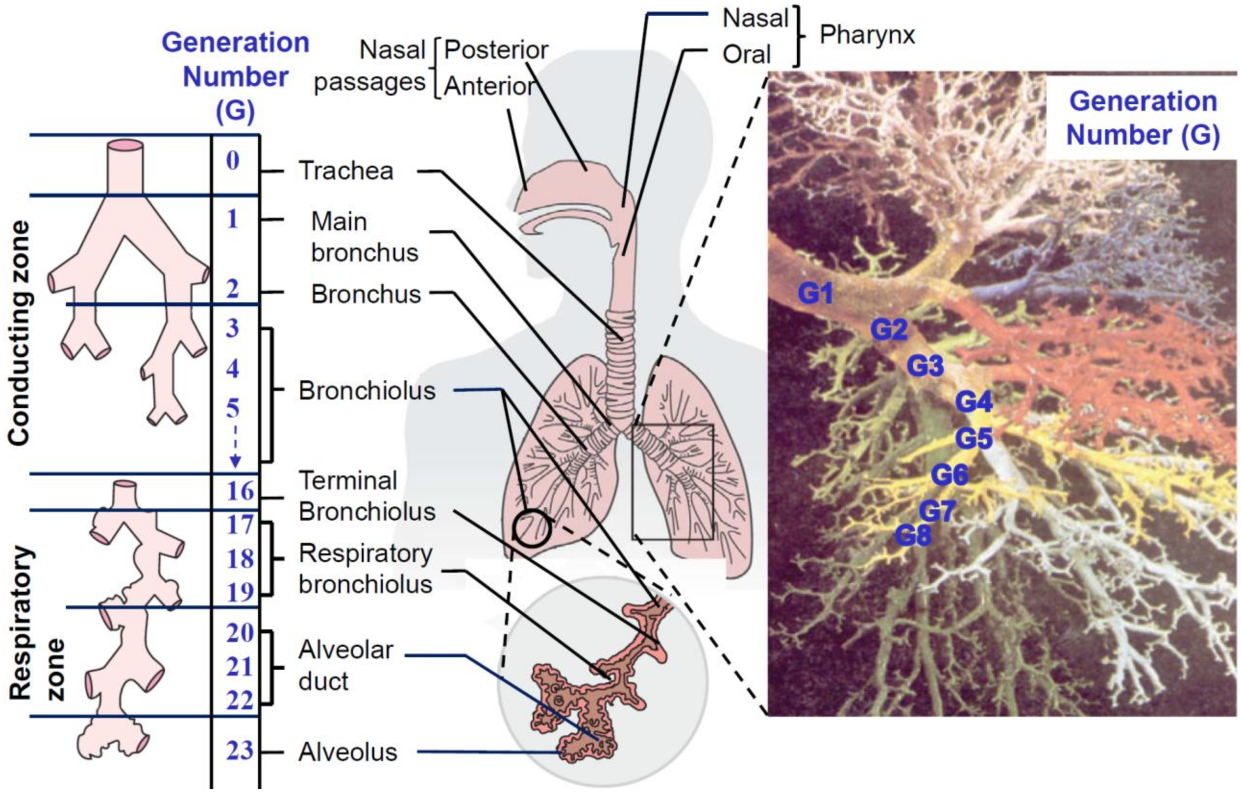

Fig. 2: Schematics of the human respiratory system.

Requirements:

1. Strong background in fluid mechanics and in differential calculus (B or above is required from Mech 301 and Math 204)
2. Strong background in computational methods and experience with MATLAB
3. Ability to work in a group

Number of students: up to 4 students

PROJECT 3:

Project Title: Computational modeling of the leakage of secrations around endotracheal tube cuffs

Project Description: This project is for those students who would like to work on a real life problem. The project will be done in collaboration with A. Murat Kaynar, MD of Harvard Medical School. The problem description and the experimental setup used at Harvard University Medical School are shown in the accompanying power point poster.

[1]Weibel, ER. 1963. *Morphometry of the human lung.* Berlin, New York : Springer Verlag and Academic Press.

We'll study the leakage problem computationally using a commercially available CFD software, i.e., either Fluent or FEMLAB. The project involves the following steps:

- Literature review
- Analytical modeling of the leakage flow using the lubrication theory
- Computational modeling of the leakage flow
    1. Assuming the secration is solid
    2. Assuming the secration is collapsible
- Reporting the results

Requirements:

1. A strong interest in a practically oriented project
2. Strong background in fluid mechanics and in differential calculus
3. Ability to work in a group

Number of students: up to 2 students