BE 508: Quantitative Studies of Respiratory and Cardiovascular Systems

Spring Semester, 2017

Classes: Monday & Wednesday 4:30-6:15 pm, EPC 204
Laboratory: take home computational labs

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Textbooks:
Chapters from Handbook of Physiology (will be distributed)
Lung Mechanics, Jason H.T. Bates, Cambridge University Press, 2009.
Biomechanics: Circulation, Y.C. Fung,Springer-Verlag, 1997.

Additional Material:
Research papers from various journals (will be distributed)

Goals: 1. To provide an introduction to the structure-function of the respiratory system
2. To provide an introduction to the structure-function of the pulmonary vasculature
3. To introduce quantitative models of the cardio-pulmonary system

Main Topics:
1. Introduction (1 lecture)
Probability and scaling concepts in physiology (1 lecture)

2. Branching structure of the airways and some design principles (1 lecture)
Quantitative one-, two- and three-dimensional airway tree models

3. Introduction to structure-function in the pulmonary circulation (1 lecture)
Structure and function of the pulmonary arterial and venous trees

4. Introduction to fluid mechanics (1 lecture)
Laminar and turbulent flows in pipes, entrance effects, bifurcations

5. Blood flow in elastic vessels (1 lecture)
Pulsatile blood flow, wave speed and flow limitation

6. Design principles and allometric scaling of airway and vascular trees

7. Morphology of the lung parenchymal tissues (1 lecture)
Composition and histopathology of the connective tissue matrix

8. Measurements of mechanical properties (2-3 lectures)
Mechanical impedance at low, medium and high frequencies

9. Distributed parameter models of the airways (high frequencies) (1 lecture)
wave propagation, high frequency impedance

10. Lumped parameter and structural models of the respiratory system (1-2 lectures)
Mead and Otis models, Low-frequency Horsfield-like models, parameter estimation

11. Low-frequency models of lung mechanics (2 lectures)
Molecular interpretation of linear and nonlinear viscoelastic models of lung tissues

12. Cellular basis of lung function (1-2 lectures)
Introduction to cell mechanics, smooth muscle plasticity, cellular injury

13. Surfactant properties and function, airway opening phenomena (2 lectures)
chemical composition, surface tension, airway opening, avalanches, crackle sound

14. Major diseases (2-3 lectures)
Structure-function in emphysema, pathophysiology of asthma, and ARDS and mechanical ventilation

15. Respiratory control (1 lecture)
Anatomy and function of respiratory rhythm generator, neural network models of the oscillator

16. Student presentation (1 lecture)
Graduate students present a research paper

Laboratory:
A comprehensive set of laboratory exercises will be given including the following topics:
- probability essentials
- development of computer models of the branching airway networks
- calculating function such as resistance of the branching network
- lung impedance at low and medium frequencies
- simulations of diseases in the impedance models
- developing an elastic network model of lung parenchyma
(- developing a neural network model of the respiratory oscillator)

Students are encouraged to discuss laboratory assignments with classmates. However, directly copying a classmate's work or allowing a classmate to knowingly copy your work is not allowed. A good rule to follow is, never share written versions of lab reports or computer code.

Homework:
Homework will be given from several topics.

Grading:
- Laboratory 30%, Homework 10%, Midterm exam 20%, Student presentation 15%, Final exam 25%.
- Students must earn at least 50% of the grade in order to obtain a passing grade (D).

Incomplete & withdrawal:
Incomplete will be given to students demonstrating good progress (C or better) with acceptable reason for being unable to complete the course. Students may withdraw from course prior to the University deadline. Having taken the final exam, students will not be able to receive an incomplete or withdraw.