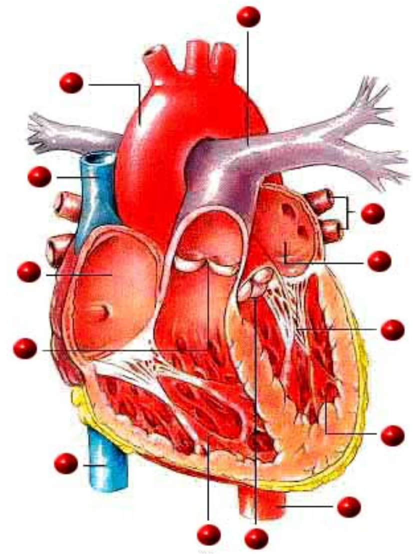
BIOFLUID DYNAMICS

MECH 533



Contact information

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Class Format

Three 1-hour classes each week (M,W,F – 10.00-11.00)

CEME 1206

Guest lectures (2)

- Dr. John Webb - Cardiology, Faculty of Medicine - heart diseases and heart valve replacement
- Dr. Jerome Fryer, Chiropractor – synovial joints mechanics (confirmed)

Course Description

This course elaborates on the application of fluid mechanics principles to major human organ systems. The course is an introduction to physiologically relevant fluid flow phenomena, underlying physical mechanisms from an engineering perspective. The focus of the course is on the integration of various fluid mechanics concepts to address relevant problems of the human body's systems. An important objective of the course is to develop a broad knowledge and a critical thinking regarding the current research challenges in biological fluid dynamics.

Learning Objectives

By the end of the course it is expected that students will be able to:

- Understand the physiology and anatomy of the studied systems,
- Analyze fluid mechanics models currently used for clinical research problems,

- Integrate fluid dynamics engineering concepts to examine and to model the biological flow in human body,
- Identify specific diseases and how they are related to fluid dynamics,
- Develop a critical thinking regarding the current research challenges in biological fluid dynamics,
- Have the capability to carry out a biofluid dynamics research project..

Prerequisites

MECH 222 or equivalent.

Textbook

There is no required textbook for the course. Lecture notes will be provided on the course website. Informational sources could be found via the following textbooks:

1. C.Ross Ethier and Craigg A. Simmons, Introductory Biomechanics, Cambridge texts in Biomedical Engineering, 2007.
2. C. Kleinstreuer, Biofluid Dynamics: Principles and Applications, CRC Press, Taylor&Francis Group, 2006.
3. M. Zamir, The Physics of pulsatile flow, Springer-Verlag NY, 2000.
4. J. N. Mazumdar, Biofluid Mechanics, World Scientific, 2004.
5. Y.C. Fung, Biodynamics: Circulation, Springer-Verlag NY, 1997.
6. L. Waite, Applied Biofluid Mechanics, McGraw Hill, 2007
7. L. Waite, Biofluid Mechanics in Cardiovascular Systems, McGraw-Hill , 2006.

A general fluid mechanics textbook will be useful (White, Cimbala)

Assessment Strategies

Quizzes

Three quizzes of 1 hour duration will be given during the term. It will represent 45% of the final grade.

Assignments

After each major topic (5), an assignment based on a problem set will be distributed. It will represent 5% of the final grade.

Research paper and Presentations

Each graduate student will conduct a technical literature review in an area that was either poorly covered in the course or a new evolving area that they believe should be included. The review should highlight the advancements and the critical questions remaining unanswered. A presentation during the seminar will be done. It will represent 15% of the final grade.

Term project

Graduate students will be required to work on a biofluid dynamics research project, individually or in groups. A list of potential topics will be provided by the instructor. Examples include: 1) Modeling of lubrication mechanism in a hip joint or 2) Modeling of particle transport in lungs. Students are asked to provide the current state of art, followed by an original approach of the specific research problem. The students will identify an experimental approach that one could use to verify the suggested model.

The term project will represent 35% of the final grade.

Grading System

Three Quizzes	45% (3x15%)
Assignments (5)	5%
Research paper and presentation	15%
Term project	35%

Detailed Course Outline

1. **Review of basic fluid mechanics**

2. **Biorheology**

Constitutive equations. Non-Newtonian fluid models.

3. **Circulatory biofluid mechanics**

Circulatory system physiology. Function of circulatory system, circulation in heart, blood and lymphatic vessels. Blood properties. Hemorheology.

Models for blood flow: Steady flow in tubes. Pulsatile flow in a rigid tube. Pulsatile flow in an elastic tube. Wave propagation in elastic tubes.

Applications in circulatory system: Blood flow dynamics in arteries and veins. Microcirculation. Flow in specific vessels and arteries. The Heart. Heart-valve hemodynamics. Diseases related to obstruction of blood flow. Stroke. Heart injury.

4. **Synovial fluid in joints**

Synovial joints physiology. Function of synovial fluid. Diseases. Synovial fluid properties and rheology. Lubrication theory. Application for synovial fluid flow. Arthritis. Knee and Hip injury.

5. **Biofluid dynamics of the human brain.**

Cerebrospinal fluid. Cerebral blood flow. Blood brain barrier. Brain diseases.

6. **Respiratory biofluid mechanics**

Respiratory system physiology. Alveolar ventilation. Air flow in the lungs. Mechanics of breathing. Gas exchange and transport.

7. **Flow and pressure measurement techniques in human body.**

Week	Topic
1	Review of basic fluid mechanics
2	Biorheology

3	Biorheology, Circulatory biofluid mechanics
4	Circulatory biofluid mechanics
5	Circulatory biofluid mechanics
6	Circulatory biofluid mechanics
7	Circulatory biofluid mechanics
8	Synovial fluid in joints
9	Synovial fluid in joints
10	Biofluid dynamics of the human brain.
11	Respiratory biofluid mechanics
12	Respiratory biofluid mechanics
13	Flow and pressure measurement techniques in human body.