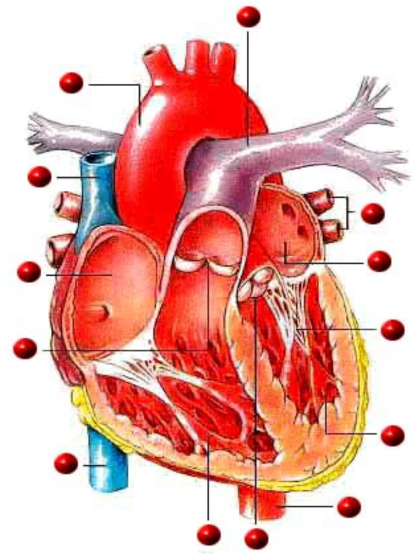
BIOFLUID DYNAMICS

MECH 433



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Class Format

Two 1.5-hour classes each week (Tuesdays and Thursdays – 17:00-18.30) HDP 101

Course Description

The need for engineers with integrated multidisciplinary knowledge is expected to grow along with the rapid advances in biomedical science and technology. 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.

Learning Objectives

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

- Understand the physiology and anatomy of 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,
- Have the capability to carry out a biofluid dynamics design project..

Prerequisites

MECH 380.

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. Goyal , Megh R, Biofluid Dynamics of Human body systems, CRC Press, 2013.
3. David Rubenstein, Wei Yin, Mary Frame, Biofluid Mechanics: An introduction to Fluid Mechanics, Macrocirculation and Microcirculation , 2nd edition, Academic press series in biomedical engineering, 2015.
4. C. Kleinstreuer, Biofluid Dynamics: Principles and Applications, CRC Press, Taylor&Francis Group, 2006
5. Ali Ostadfar, Biofluid Mechanics: Principles and Applications , Elsevier, 2016
6. M. Zamir, The Physics of pulsatile flow, Springer-Verlag NY, 2000.
7. J. N. Mazumdar, Biofluid Mechanics, World Scientific, 2004.
8. Y.C. Fung, Biodynamics: Circulation, Springer-Verlag NY, 1997.
9. L. Waite, Applied Biofluid Mechanics, McGraw Hill, 2007
10. L. Waite, Biofluid Mechanics in Cardiovascular Systems, McGraw-Hill , 2006.

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

Assessment Strategies

Midterms

Two midterms of 1.5 hour duration will be given during the term. They will represent 50 % of the final grade. You must pass the midterms in order to pass the course.

Quiz

One quiz will be given at the end of the term. It will represent 15 % of the final grade.

Problem sets

After each major topic (5), an assignment based on a problem set will be distributed. It will represent 12 % of the final grade.

Term Projects

Students will individually perform a biofluid dynamics design project from a list of possibilities provided by the instructor. Examples include: redesign of ventricular assisted device, design of a graft, redesign of an artificial heart valve. The design or redesign will be done using approaches presented in the lectures. It will represent 22 % of the final grade.

Graduate Seminars

Times and dates have to be decided. Attendance and participation are required.

Grading System

Midterms (2) and Quiz (1)	65 %
Assignments (5)	12 %
Term project	22 %
Seminar	1 %

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. Flow in specific vessels and arteries. Heart-valve hemodynamics. Diseases related to obstruction of blood flow. Artificial heart valves and stents.

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. **Respiratory biofluid mechanics**

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

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

Week	Topic
1	Review of basic fluid mechanics
2	Biorheology
3	Biorheology
4	Circulatory biofluid mechanics
5	Circulatory biofluid mechanics
6	Circulatory biofluid mechanics
7	Circulatory biofluid mechanics
8	Circulatory biofluid mechanics
9	Synovial fluid in joints
10	Synovial fluid in joints
11	Respiratory biofluid mechanics
12	Respiratory biofluid mechanics
13	Flow and pressure measurement techniques in human body.

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community.

UBC provides appropriate accommodation for students with disabilities and for religious and cultural observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available at https://senate.ubc.ca/policies-resources-support-student-success. Mechanical Engineering also has a Student Services Office (students@mech.ubc.ca), located in CEME 2205, where there are staff who can provide support and refer students to the appropriate resources.

Inclusive Environment

The Department of Mechanical Engineering is committed to providing an inclusive learning experience, and affirms the UBC Statement on Respectful Environment (https://www.hr.ubc.ca/respectful-environment/files/UBC-Statement-on-Respectful-Environment-2014.pdf). You are encouraged to contact the instructor if situations arise that are not consistent with this expectation. You are also invited to advise the instructor if you wish to be addressed by or referred to with particular pronouns.