Department of Mechanical and Aerospace Engineering
EGM 4853 (Section: 4E04) / EGM 6855 (Section: 21D7): Bio-Fluid Mechanics and Bio-Mass Transfer

Catalog Description: Credits: 3; A study of biotransport-fluid sciences. Emphasis on physiological processes occurring in human blood circulation and underlying mechanisms from an engineering prospective.

Textbook: Applied Biofluid Mechanics, McGraw Hill 2nd Ed., 2017, by Lee Waite and Jerry Fine, ISBN: 978-1-25-964416-0

Course Objectives: The objective of this course is to provide students with the necessary background in bio-transport/fluid sciences in order to allow them to better understand the physiological processes that occur in the human body and analyze the physical mechanisms that underline them. It stresses fundamental engineering science principles applied to physiological processes. Students will learn to apply the conservation equations to control volumes and express them through mathematical formulations, with emphasis on biological systems. Upon completion of this course, students are expected to understand basic fluid mechanic and mass transfer solution techniques, coupled with a strong foundation and appreciation for the underlying biology and physics of physiological processes.

Lecture Times and Days: M, W, F: 3th Period (9:35am - 10:25 am); MCCB 1108

Office Hours: M, W, F: 4th Period (10:40pm - 11:30 am); MAE-A 216

Assessment Methods: Your grade for this course will be determined based on your performance on homework and exams as follows:

Homework, quizzes, and Research paper review	20%
Exam #1	15%
Exam #2	15%
Exam #3	15%
Exam #4	15%
Term paper & Presentation/Final Exam	20%

NOTES

Holidays

January 20: Martin Luther King Jr. Day
February 29 - March 8: Spring Break

Examination Schedule:

1. Exam 1 on Friday, January 24
2. Exam 2 on Friday, February 14
3. Exam 3 on Friday, March 20
4. Exam 4 on Friday, April 10

Term Paper Presentation: April 13 - 22

Class ends April 22, 2020

Commitment to a safe and inclusive learning environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination.

It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@ufl.edu

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Course Topics

Part 1 – Background/Fundamentals (Lectures 1-19)

1. **Introduction - Scope of Course (1)**
2. **Physical Properties of Biofluids (2)**
    a. Systems of Units
    b. Intrinsic Fluid Properties
    c. Surface Tension
    d. Cortical Tension
    e. Fluid Classification
3. **Basics of Biofluid Mechanics (3-8)**
    a. System and Control Volume
    b. Integral Analysis
        * Conservation of Mass - Continuity Equation
        * Conservation of Momentum – Newton's Second Law of Motion
        * Conservation of Energy
    c. Differential Analysis / Eulerian & Lagrangian Frameworks
        * Fluid Element Kinematics
        * Conservation of Mass - Continuity Equation
        * Conservation of Momentum – Newton's Second Law of Motion

Lecture 9 - Exam 1

4. **Basics of Biomass Transport (10-13)**
    4.1 Mass Transfer Across a Cell Membrane - Overview
    4.2 Cell Membrane
    4.3 Tissue and Body Membranes
    4.5 Active Transport
    4.6 Mass Transfer Across a Cell Membrane - Summary
    4.7 Theory of Diffusion
    4.8 Diffusion Coefficient Method – Fick's Laws of Diffusion
    4.9 Mass Transfer Coefficient Method
    4.10 Limitation of Diffusion
    4.11 Membrane Transport Disorders

Lecture 14 - Exam 2

5. **Rheology of Biofluids (15-17)**
    a. Time Independent Behavior
    b. Time Dependent Behavior
    c. Viscoelastic Materials
    d. Dynamic and Steady State Measurements Relationship
    e. Flow Regimes of Viscoelastic Fluids
6. **Methods for Measuring Rheological Properties (18-19)**
    a. Biological Fluid Measurements
    b. Blood Cell and Tissue Measurements

Part 2 – Blood Circulation (Lectures 20-31)

7. **Rheological Properties of Blood**
    a. Physical Properties of Blood
    b. Mechanical Properties of Blood
    c. Mechanical Properties of Blood Cells

8. Heart and Systemic Circulation
- a. Heart Structure and Function
- b. Vessel Structure and Function
- c. Vasa Vasorum

9. Pulmonary Circulation
- a. Structure and Function
- b. Blood Flow through the Lungs
- c. Flows through airways

10. Flow Properties of the Circulation
- a. Blood Pressure, Blood Flow, and Resistance
- b. Regulation of Blood Pressure
- c. Regulation of Blood Volume
- d. Velocity of Blood Flow
- e. Physical Properties of Circulation

11. Mechanisms of Fluid and Mass Exchanges
- a. Lymphatic System
- b. Structure and Function of Exchange Micro-vessels
- c. Transcapillary Exchange
- d. Drug Delivery

Lecture 31 - Exam 3

Part 3 – Modeling (Lectures 32-39)

12. Modeling of the Circulation
- a. Blood Flow in Arteries
- b. Blood Flow in Veins
- c. Microcirculation

13. Multiscale Modeling and Validation
- a. Overview of the Multiscale Issues in Hemodynamics
- b. Computational Techniques
- c. Examples of Multiscale Processes
- d. Solution Verification
- e. Model Validation

Lecture 39 - Exam 4

Part 4 – Student Presentations/ Student Projects (Lectures 40-44)

14. Presentations of Individual Term Papers in Chosen Areas of Biofluids, Biomass Transfer