Biofluid Mechanics

EGM 4853 Class# 18833, Section# 4E04
Class Periods: MWF, 3rd period, 9:35-10:25am
Locations: MAEB 229 (3rd)
Academic Term: Spring-2022

It may become necessary to modify this syllabus during the semester.
In this event, students will be notified and the revised syllabus will be posted on the course web site.

Instructor:
Name: Dr. Roger Tran-Son-Tay
Email Address: rtst@ufl.edu
Office Phone Number: 352-392-6229
Office Location: MAEA-216
Office Hours: MWF: 10:30 to 11:30am (other times on arrangement).

Teaching Assistant/Peer Mentor/Supervised Teaching Student:
Please contact through the Canvas website

Course Description
Credits: 3; A study of bio transport-fluid sciences. Emphasis on physiological processes occurring in human blood circulation and underlying mechanisms from an engineering perspective.

Course Pre-Requisites / Co-Requisites
EGN 3353C

Course Objectives
The objective of this course is to provide students with the necessary background in bio-transport/fluid sciences 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.

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	Medium
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Medium
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software
None

Course Schedule
See course outline below

Examination Schedule:
1. Exam 1 on Thursday, January 27 (7:30pm-9:30pm)
2. Exam 2 on Thursday, February 17 (7:30pm-9:30pm)
3. Exam 3 on Thursday, March 17 (7:30pm-9:30pm)
4. Exam 4 on Thursday, April 7 (7:30pm-9:30pm)

Term Paper Presentation: April 11-20

Class ends April 20, 2022

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%

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

NOTES
Holidays
January 17: Martin Luther King Jr. Day
March 5-12: Spring Break

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Honorlock:
Consistent with University of Florida policy, Honorlock will be used for the mid-term exams and the final. Please see the following link: https://distance.ufl.edu/proctoring/ for more information.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

Use of Live Zoom (HyFlex)
In light of the challenge of the pandemic, the instructor may live stream to those who are sick or just quarantining. Associated recordings may be made. Regarding associated details, the instructor will update the class throughout the semester.

University Honesty Policy
In this class, use of unauthorized aid, copying of homework, sharing of files (Solidworks or reports), dishonest attendance logging (in-class Webgems) are considered honor code violations. (If you are leaving class early or leaving our Zoom meeting, fine. Do not log attendance. Logging and leaving is an honor code violation.)

Honor code violation can result in "E" for the course, even if it's your first offense. UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and

our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel (e.g. the instructor). A violation of the honor code will result in academic sanctions (typically a failing grade "E" assigned for the course) and further disciplinary action. If you have any questions or concerns, please consult with the instructor in this class.

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 Undergraduate Program Coordinator: advising@mae.ufl.edu
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@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@eng.ufl.edu

Software Use and Copyrighted Material

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use and the use of copyrighted material. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Online Course Recording

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Office hour sessions may likewise be audio visually recorded.

Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. Students who are in class likewise agree to have their voices recorded.

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

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

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

COVID-19
- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.
- Consistent with UF policy: "If a student is absent from classes or examinations because of illness, they should contact their instructors."
- If you contract Covid-19 during the semester, the instructor pledges to help you to the extent possible, to help you learn and manage your assignments. Letting the instructor know is step one.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

Course Outline

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 (3-9)**
    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 10 - Exam 1

4. **Basics of Biomass Transport (11-14)**
    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
5. **Rheology of Biofluids (15-16)**
    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 (17-18)**
    a. Biological Fluid Measurements
    b. Blood Cell and Tissue Measurements

Lecture 19 - Exam 2

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 32-37)

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 37 - Exam 4

Part 4 – Student Presentations/ Student Projects (Lectures 38-42)

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