North Dakota State University
Department of Mechanical Engineering
ME 480/680 Biofluid Mechanics (3 credits)
Syllabus
2023 Spring Semester
MWF 2:00pm-2:50pm, Dolve 215

Instructor: Dr. Y. Bora Suzen
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Assistance Hours: M&F 12:00pm-1:00pm or by appointment via Zoom

Learning Assistant:
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Assistance Hours: TBD and by appointment via Zoom

Course Prerequisites: ME 352 and admission to professional program or graduate standing.

Course Catalog Description: Overview of fluid dynamical phenomena in biological systems; flow behavior of fluids in living organisms; application of fluid mechanics to the cardiovascular system and blood circulation.

Course Objectives:
Biofluid mechanics, the study of the fundamentals of biological fluid flow, has been recognized to be extremely important for the understanding of how changes in the flow behavior within living tissue may affect both the fluid and the tissue. Fluids in living tissue include blood, water, air and bodily fluids of animals, as well as the fluids in plants. Biofluid mechanics is a field whose importance to the field of biomedical engineering has increased over the last few decades as pharmaceuticals, biomaterials and non-invasive diagnostic and surgical technologies create new challenges. This course will provide students with an understanding of unique features of biological flows, and the application of fluid mechanics to cardiovascular system and blood circulation. The course is intended to prepare students for work in the health care device industry and others for graduate work in mechanical and biomedical engineering.

Text:
"Biofluid Mechanics: The Human Circulation" 2nd edition, by Krishnan B. Chandran, Stanley, E. Rittgers and Ajit P. Yoganathan., CRC Press, 2012. *(Inclusive Access is available on Blackboard)*

Reference:
"Biofluid Dynamics: Principles and Selected Applications" by Clement Kleinstreuer, CRC Press, 2006.

Materials out of the scope of the textbook may be used and students will be provided with handouts if necessary.

Anticipated Course Outcomes and Affected Program Outcomes

The anticipated course outcomes are listed below and a list of NDSU ME program objectives and outcomes are listed at the end of the syllabus.

Upon completion of this course:

1. Students will understand the physiology of cardiovascular system and blood circulation.
2. Students will understand blood structure and rheology.
3. Students will learn how to model and characterize fluid flow in biological systems.
4. Students will learn how to model and characterize transport phenomena in biological systems.

Communication:

- The primary method by which course-related information will be communicated is during class session. Reminders, notification of any assignments or schedule changes will be communicated through NDSU email and posted on Blackboard course page.
- Your NDSU email address is the official route for information.
- You may meet with me or the Learning Assistant virtually using Zoom during help hours or by appointment.

Copyright of Course Materials:

In accordance with NDSU Policy 190 on Intellectual Property in this course recording the lectures is prohibited with your own personal devices (without prior approval from the instructor).

Assessment:

- Your level of success in attaining the anticipated course outcomes will be assessed during the semester by homework assignments, quizzes, a midterm exam, and a final exam. ***The format of your solutions in homework assignments and exams should be in acceptable engineering form including labeled drawings of the system considered.***
- In this course Blackboard will be used for assignment submission (and grading) for all students.

(a) Homework Assignments:

- Homework assignments may consist of both "hand-solution" of problems and computer assignments. Assignments will typically be assigned on a weekly basis. There will be a 30% grade deduction if the homework is submitted after the due time and before the solution is posted, unless arrangements are made in advance (at least 24 hours prior to the beginning of the class when the homework is due). After the solution is posted on NDSU blackboard or discussed in class, no homework will be accepted. Copying homework solutions is forbidden. Students involved in copying homework or projects will be penalized.

(b) Quizzes/Class Participation:

- During the semester quizzes will be given regularly. Quizzes are typically in forms of multiple choices and short questions covering topics that have been covered in previous classes and included in study/reading assignments.
- Students are expected to actively participate in class through online group activities.

(c) Exams

All examinations will be comprehensive of covered materials. Students who fall ill, or who know they will be missing an exam for a valid reason (e.g. Family emergency) are encouraged to notify the instructor by email prior to the exam, if at all possible, and then make arrangements for making up the exam. Students missing an exam without prior notification and a valid excuse will receive a grade of zero for that exam.

(d) Topic Presentations

By consultation with the instructor, each student project group (2 students/group) will determine a special topic within the scope of Biofluid Mechanics before the end of the fourth week of classes. Students will present topics orally during the semester. Format requirements of the presentations will be discussed in class.

(e) Course Project (Graduate students only)

A list of course project options and instructions will be provided for students before the end of the first four weeks of classes. Each student will select a single project to work on and inform the instructor by the fifth week. Each student will submit a project paper and deliver a presentation on or before the project deadline, which will be near the end of the semester. Format requirements of the presentations and reports will be discussed in class.

Grading Policy:

The grade distribution is:

	Undergraduate	***Graduate***
Homework/Quizzes/Participation	30%	30%
Midterm Exam	20%	15%
Final Exam	30%	25%
Topic Presentation	20%	20%
Project	0%	10%

Final course grades will be assigned according to the following scale:

A	90-100
B	80-89
C	70-79
D	60-69
F	below 60

The final grades will NOT be curved.

Additional Information:

- Unless specifically stated otherwise, **all assigned work is assumed to be performed individually.**
- You are expected to work on all assignments.
- You are expected to read, study, and work on the study materials before class.

Attendance/Participation Policy:

- According to NDSU Policy 333 (www.ndsu.edu/fileadmin/policy/333.pdf), attendance and participation in classes are required.
- Please do not come to class if
    - you are feeling ill, particularly if you are experiencing COVID-19 symptoms, or
    - you are infected during your five-day isolation period.
    - You will still need to complete the assignments, exams, reading, etc. necessary to meet class learning objectives. You can complete missed work by contacting the

instructor for alternate arrangements for accommodations (synchronous online attendance or recording of the classes) and extensions as needed.
    - If you were exposed to COVID-19, please follow CDC guidance available here.
    - If you tested positive for COVID-19, please follow CDC guidance available here.
    - Free testing kits can be picked up at the NDSU Bookstore, Library or Student Health Service. Rapid and PCR testing is available at the Student Health Service by appointment Monday through Friday during regular business hours for both symptomatic and asymptomatic students.
- Veterans and student service members with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

Academic Honesty Statement

The academic community is operated on the basis of honesty, integrity, and fair play. All work in this course must be completed in a manner consistent with Code of Academic Responsibility and Conduct, NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at www.ndsu.edu/academichonesty.

Americans with Disabilities Act for Students with Special Needs

Any students with disabilities or other special needs, who need special accommodations in this course, are invited to share these concerns or requests with the instructor and contact the Disability Services Office (www.ndsu.edu/disabilityservices) as soon as possible.

Tentative Course Outline

#	Topics	Chapter
1	Review of Basic Fluid Mechanics Concepts	T1, R1
2	Cardiovascular Structure and Function	T3, R2.2
3	Anatomy, Physiology and Diseases of Blood Vessels	R2.2, R3.1, R3.2
4	Mechanics of Native Heart Valves	T7, R2.2
5	Hematology and Blood Rheology	T4
6	Static and Steady Flow Models	T5, R1.4
	Midterm	
7	Unsteady Flow and Non-uniform Geometric Models	T6
8	Transport Phenomena	R2.1
9	Measurement Techniques	T10
10	CFD Analysis of the Human Circulation	T11, R5
11	Special Topics	R4, *etc.*
	Final Exam – Monday, May 8, 2023, 8:00 am – 10:00 am	

T – Text book, R – Reference book

Department of Mechanical Engineering
North Dakota State University

Vision

To become nationally recognized and respected for excellence in engineering education, research, and service to local and regional industries.

Mission

The Department of Mechanical Engineering at NDSU will contribute to the aspirations of a land-grant university in the three primary components of education, research, and service. In support of these endeavors, the mission of the department is to:

- Educate undergraduate and graduate students in the fundamentals of the discipline, prepare graduates (BS, MS, or PhD) to effectively function in society in the field of their choice, and provide the learning skills to adapt to evolving personal and professional goals.
- Develop and maintain high quality research programs in traditional and emerging areas that build on the diverse strengths of the faculty, foster interdisciplinary collaborations, and address national and global needs.
- Serve the needs of the profession, the state of North Dakota, and regional industries to promote and enhance economic development opportunities.

Educational Objectives

In support of the mission of the ME Department, the educational objectives of the program are to produce engineering graduates who:

1) Are well educated in the fundamentals of the discipline, and possess the ability and willingness to adapt to emerging technologies through continued professional development.
2) Will contribute in a competent manner to the engineering profession in the field of their choice.
3) Demonstrate a commitment to uphold high ethical and professional standards in the practice of engineering.
4) Can effectively function in a team environment and interact with people of diverse backgrounds.
5) Understand the context in which their designs will be implemented and the corresponding impact of their activities on society.

Program Outcomes

To foster attainment of the program educational objectives, the ME Department has developed a curriculum that insures students will achieve the following outcomes (1) through (7). Attainment of these outcomes prepares graduates to enter the professional practice of engineering.

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

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

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 an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.