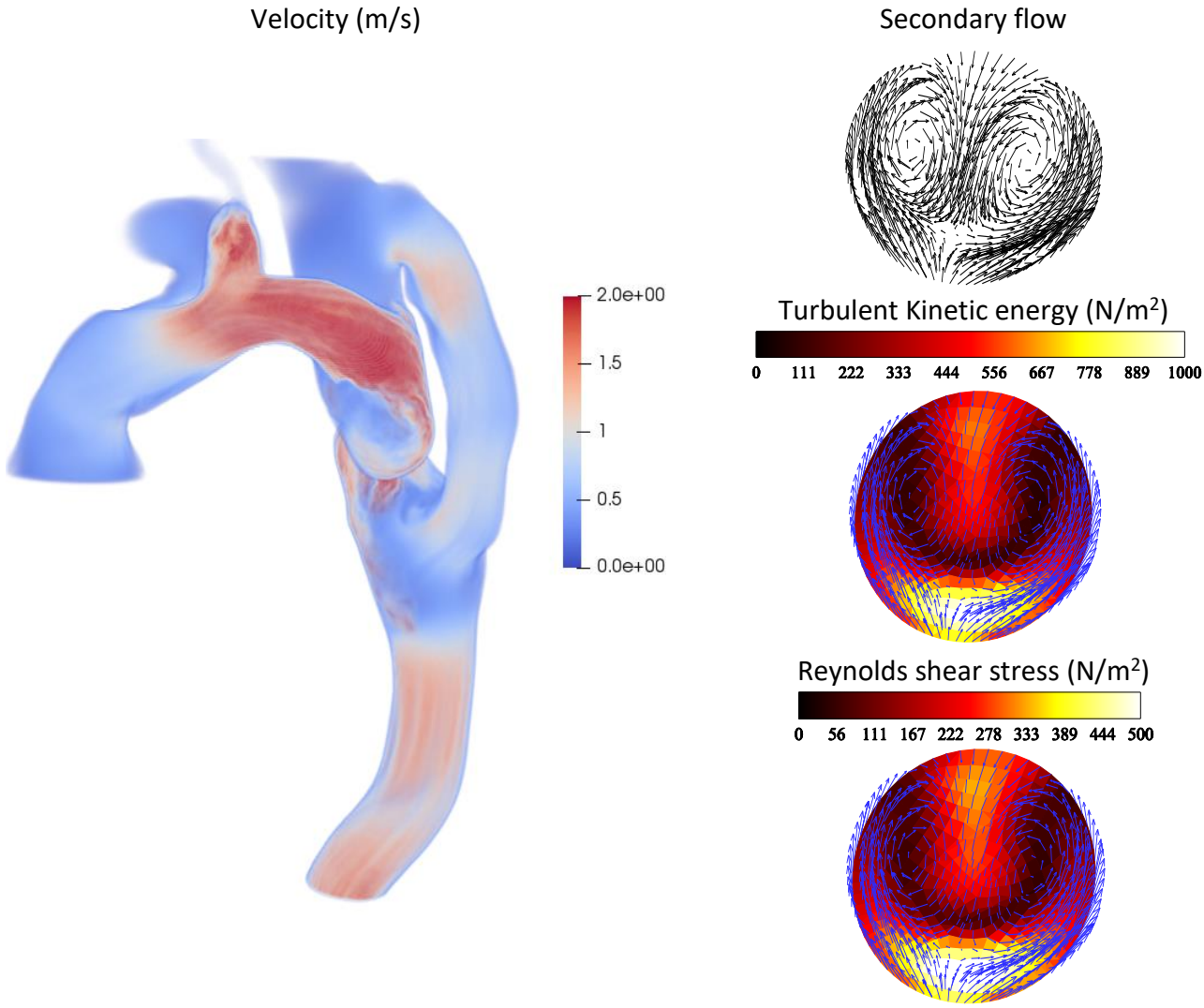
Department of Mechanical Engineering
McMaster University

MECHENG 4BF3 (Biofluid Mechanics)
Term 2 (January – April 2024)



https://www.eng.mcmaster.ca/mech/people/faculty/zahra-k-motamed

Instructor: Dr. Zahra Motamed
Office: *ABB-C* 307
Email: **motamedz@mcmaster.ca**
Office hours: Thursdays, 4 to 5 pm
Lectures: **Thursdays (7-10 pm) at ETB-119**
Tutorials: **Tuesdays (4:30 to 5:20 pm) at MDCL 1008**
(**Mr. MohammadAli Daeian; daeianm@mcmaster.ca**)
Course website: via *Avenue to Learn* (avenue.mcmaster.ca)

Course Description & Objectives

"The essence of our life is ultimately not blood but the fluidity of blood. It is remarkable how readily we miss this point." Mair Zamir

The circulatory system consists of the heart and a network of vessels that transport the blood. The heart consists of two pulsatile pumps in series and circulates blood through the vasculature. The vasculature consists of arteries, arterioles, capillaries, venules and veins. The circulatory system also includes local circulation subsystems such as cerebral, pulmonary and renal circulations.

Blood flow is the lifeline to each cell within our body. The main objective of the course is to learn basics of blood flow mechanics through the circulatory system and its subsystems. The field of Biofluid mechanics is broad and multidisciplinary covering motions of blood and vessel walls, complex biomechanics of the heart, a large network of the blood vessels with complicated geometries, persistent pulse-driven changes in flow and pressure and behavior of blood cells.

This course examines the physiology and mechanics of circulation, mechanobiology and the biomechanics of different components of the circulatory system, *in-vivo* and *in-vitro* techniques and their medical applications. This course covers normal circulatory system, diseases, and medical devices.

Significance

The extracorporeal systems, such as medical devices, should be tested to satisfy government regulations and biofluid is often essential in these tests. Thus, in the development of medical devices, biofluid mechanics plays important roles at all stages from design to evaluation of the hemodynamic effects of medical devices after implantation in the patient body. Moreover, biofluid mechanics plays major roles in uncovering causes of pathologies, in enabling prediction of effectiveness of interventions, in allowing systematic testing of possible clinical solutions, and in enabling personalization of interventions.

Course Topics:

Major topics to be covered include:

- Anatomy and pathophysiology of cardiovascular and respiratory system
- Flow- pressure relationship in circulatory system
- Pulse wave velocity and wave reflections
- Analysis of composite cardiac waveforms
- Dynamics of pulsatile flow
- Principles underlying blood flow
- Biorheology
- Blood flow visualization techniques in research and clinic
- Mechanical forces on cardiovascular tissue (blood vessels, the heart)
- Mechanical forces on cardiovascular cells (endothelial cells, platelets, red and white blood cells)
- Clinical diagnostic metrics

Audience

This course *has* been designed for 4th and 5th year undergraduate students in engineering interested in learning about biofluid mechanic and its applications. The course will be of interest of students in the following departments and schools:
Mechanical Engineering, Chemical Engineering, Computing and Software, Electrical and Computer Engineering, Engineering Physics, School of Biomedical Engineering and School of Computational Science & Engineering.

Email Policy

All emails directed to the *instructor* should include a subject prefix of "ME [course number]-[subject]".

Course Materials

Lecture Notes:

The lectures notes will be made available on *Avenue*. The lectures notes do not always repeat materials from *supplementary* references.

Textbooks:

There is no specific textbook for this course. The instructor will provide reading material including course notes, articles, videos and schematics. Following are some useful references for the course:

- Zamir M (2016) Hemo-Dynamics, Springer.
- Nichols W, O'Rourke M, Vlachopoulos C (2011) McDonald's Blood Flow in Arteries, Sixth Edition, CRC Press, Taylor & Francis Group.
- Waite L, Fine JM (2017) Applied Biofluid Mechanics, Second Edition, McGraw Hill.
- Kleinstreuer C (2006) Biofluid Dynamics: Principles and Applications, CRC Press, Taylor & Francis Group.

Evaluation

The final grade will be calculated by combining presentations, term project report and the final exam as follows. The percentage marks will be converted to a final letter grade using the standard conversion scale shown in the McMaster Graduate Calendar.

First presentation **(February 15h & 27th** & Abstract **(February 14th)**	**20%** (10 minutes **presentation** of project definition and one-page **abstract** defining the project)
Second presentation **(March 21st & 28th)**	**25%** (15 minutes **presentation** of project update)
Term project paper	**45%** (Deadline for submission: **April 25th**)
*Contributing to class discussions during lecture sessions	**10%**

* In this course, class discussion about the subject matter helps better understanding of the material. 10% mark is considered for contributing to class discussions during the lecture sessions.

Term Project: **All students will be required to work on a research project individually or in a group of 2 to 3 students. The final deliverable will be a written research report.** Each group will select a topic relevant to **cardiovascular engineering** and will prepare a report. **Potential topics will be presented to the students during the first lecture.** Each group will submit two project reports and each group will give two presentations. Although students will do a team project, evaluation will be done for each individual student. Every student equally presents parts of the project and should mention his or her detailed contribution to the group project in both reports. **The teams should be formed and be informed to the instructor by the end of the third week of the term.**

Guidelines: Guidelines for the project reports, presentations and rubrics for evaluating them will be presented to students at the beginning of semester.

Attendance: *Class attendance is strongly recommended*.

Class Website: All registered students will have access to the class website via *Avenue* (avenue.mcmaster.ca). Class announcements, course information and course documents are contained on this website. This website will be continuously updated with related information throughout the semester.

Learning Outcomes

Upon successful completion of the course, it is expected that the students will be able to:

- Understand the governing physics of solid and fluid mechanics applied to the circulatory system
- Know specific circulatory diseases and how they are related to biofluid mechanics
- Understand fluid mechanics models currently used for circulatory research problems
- Understand the effect of mechanical forces on various circulatory cells
- Understand biomechanical issues in selected circulatory medical devices
- Have the understanding to develop simple models of circulatory function under varying preload, afterload, and contractility
- Have the understanding to develop simple models of blood flow in devices and circulatory system
- Have the understanding to develop simple models of stress and strain in blood vessels and heart tissue
- Be familiar with the current state of the art computational modeling tools, experimental in vitro, in vivo and multi-scale methodologies
- Develop critical thinking regarding the current research challenges in biofluid mechanics
- Have the understanding to carry out a circulatory-mechanics research project

Notice Regarding Possible Course Modification

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If any modifications become necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the

student to check their McMaster email and course websites weekly during the term and to note any changes

Equity, Diversity, and Inclusion

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you. The Department of Mechanical Engineering is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office.

Physical and Mental Health

For a list of McMaster University's resources, please refer to the Student Wellness Centre. There is also a list of resources appended to this document.

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty. Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage.**

This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-roceduresguidelines/

The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

Authenticity / Plagiarism Detection

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty. Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line

search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

Courses with an On-Line Element

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle,ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Online Proctoring

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

Conduct Expectations

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online.**

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

Academic Accommodation of Students with Disabilities

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Requests for Relief for Missed Academic Term Work

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

Academic Accommodation for Religious, Indigenous or Spiritual Observances (Riso)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office *normally within 10 working days* of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.