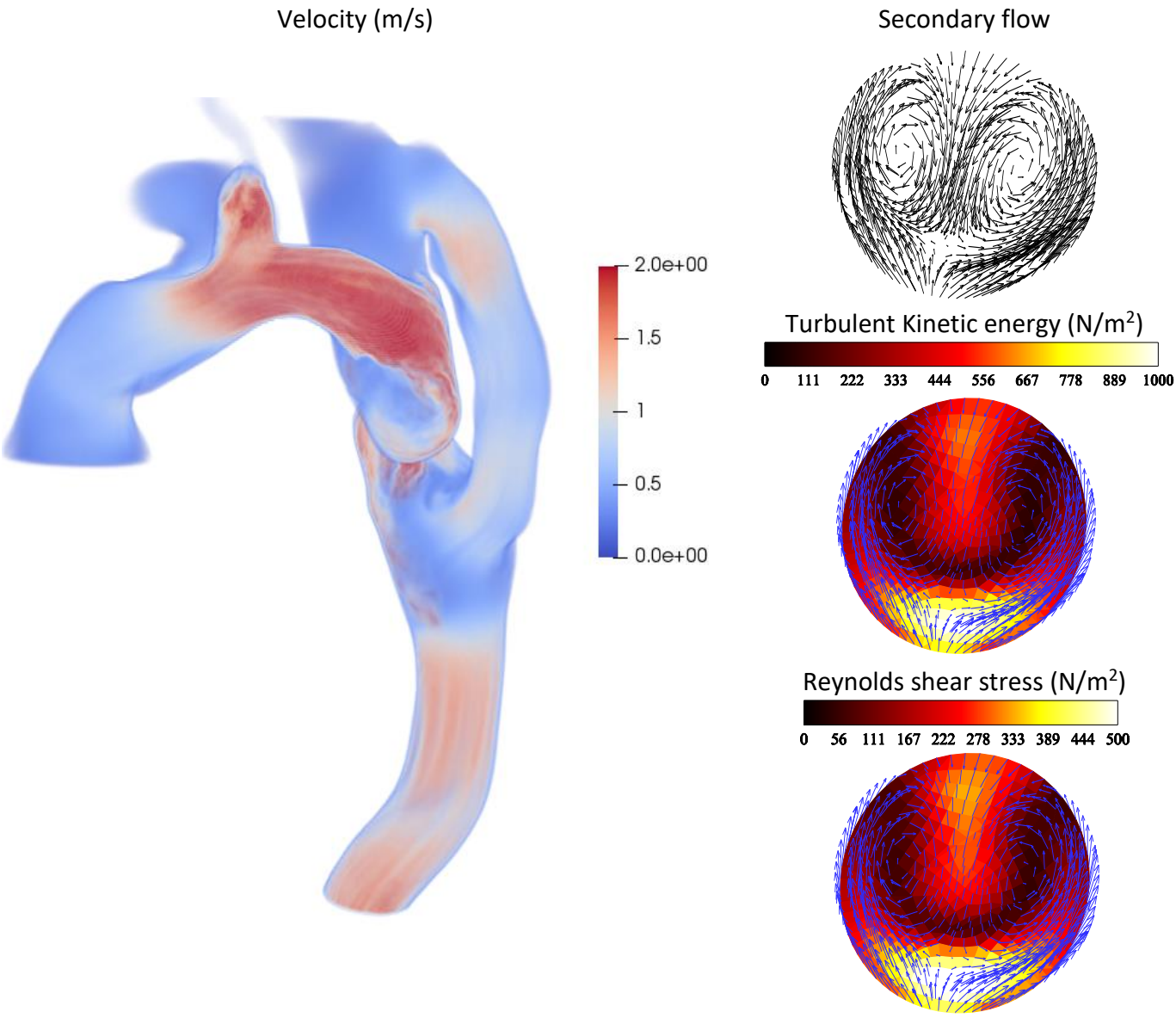
Faculty of Engineering
McMaster University

MECHENG 4BF3
Biofluid Mechanics

Term 1 (September - December 2019)



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

Instructor:	Dr. Zahra K. Motamed
Office / Email:	JHE A416 / motamedz@mcmaster.ca
Office hours:	TBD
Lectures:	Mondays and Wednesdays (11:30 am to 12:20 pm) and Fridays (1:30 to 2:20 pm)
Tutorials:	TBD
Laboratories:	none
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, project reports, quizzes etc. 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 project presentation & abstract *Date: TBD*	**25%** (20 minutes presentation of project definition and two-page abstract defining the project)
Quizzes *Date: TBD*	**15%** (3 quizzes, one each month and each one 10% of the final mark, closed book tests)
Final project presentation *Date: TBD*	**20%** (30 minutes presentation of project)
Final project report *Date: TBD*	**40%**

Term Project: All students will be required to work on a research project in a group of 2 students. The final deliverable will be a written research report. Each group will select a topic and will prepare a

report. Some 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.**

Exams: There will be three closed book quizzes. For that, the instructor will provide the students with a sheet containing related formulas and unit conversions.

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 highly 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 physiology and anatomy of the circulatory system
- 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

Policy Reminders: Students are reminded of the following Policies, which could be relevant to activities in this course.

ADVERSE DISCRIMINATION

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

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.
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.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at www.mcmaster.ca/academicintegrity.

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

In this course we will be using a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. Students will be expected to submit their work electronically either directly to Turnitin.com or via Avenue to Learn (A2L) plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish to submit their work through A2L and/or Turnitin.com must still submit an electronic and/or hardcopy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com or A2L. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). To see the Turnitin.com Policy, please go to www.mcmaster.ca/academicintegrity.

COURSE COMMUNICATIONS

In this course we will be using *Avenue*. Students should be aware that, when they access the electronic components of this course, 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 this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Student Accessibility Services can be contacted by phone

905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca. 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 requiring a RISO accommodation 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.

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.