CHEMICAL ENG 4T03/6T03 AND IBEHS 4Y03: Applications of Chemical Engineering in Medicine

January – April 2027

INSTRUCTOR:	Dr. Boyang Zhang Email: zhangb97@mcmaster.ca	
TEACHING ASSISTANT:	Stephanie Skerrett	skerrets@mcmaster.ca
	Maddy Ludlow	ludlowm@mcmaster.ca
	Brenda Truong	truonb3@mcmaster.ca
	Rutika Shelar	shelarr@mcmaster.ca

LECTURE HOURS:	Wednesday 11:30-2:20pm
LOCATION:	T13-125

COURSE OBJECTIVE:
To impart some detailed knowledge and an overall appreciation of the contributions, actual and potential, of chemical engineering to medicine and biotechnology

SPECIAL INSTRUCTION FOR COURSE DELIVERY:
This course will be delivered in person. Students will form their own groups and are encouraged to collaborate in person on all group assignments. All major announcements, assignments, course materials, and grades will be posted on Avenue to Learn. In-class participation is not graded; however, students are expected to review all lecture material and work with their group members to complete in-class assignments. The Design Project presentation will take place in class. The midterm and final exams will be held in person during class time unless otherwise announced.

TOPICAL OUTLINE:
Unit 1: Biomaterials – Students will be introduced to the major classes of biomaterials — metals, ceramics, and polymers — and examine their physical and chemical properties, characterization methods, and biomedical applications. They will develop a framework for selecting appropriate biomaterials for specific clinical contexts.
Unit 2: Biological Responses to Biomaterials – Students will investigate how the body responds to implanted materials at the molecular and cellular level, tracing the sequence from protein adsorption and thrombosis through immune and inflammatory reactions, tissue repair, and resolution. They will understand how material properties shape these host responses.
Unit 3: Tissue Engineering and Biofabrication – Students will explore strategies for engineering functional tissues, covering scaffold design and fabrication, cell selection and culture, and the role of stem cells. The unit will address how cells communicate and self-organize within engineered constructs and how these principles translate to practical tissue substitutes.
Unit 4: Tissue Vascularization Strategy – Students will learn why vascularization is a critical bottleneck in tissue engineering and examine biological and engineering strategies to promote blood vessel formation. Topics include angiogenesis, vasculogenesis, and methods for creating perfusable vascular networks that sustain oxygen and nutrient transport.

Unit 5: Microphysiological Systems – Students will be introduced to organ-on-a-chip and other microphysiological platforms that recapitulate human physiology at small scale. The unit covers device design and fabrication principles, and applications in disease modeling and pharmacological and toxicological screening.
Unit 6: Drug Delivery – Students will examine the engineering principles behind controlled drug release, including polymer matrix and reservoir systems, transport phenomena governing release kinetics, and degradable carrier designs. They will connect these concepts to commercially available delivery systems and emerging applications in personalized medicine.

Course Schedule: Please note that this schedule is subject to change based on weather cancellations. Any changes to this schedule affecting evaluations will be announced at least one week in advance via on the Avenue to Learn site.

ChE 4T03/6T03 & IBEHS 4Y03 — Course Schedule | January – April 2027					
Week	**Date**	**Unit**	**Lecture**		**Workshop / Assessment**
Week 1	Jan 6	Unit 1	Introduction	Biomaterials – Metals and Ceramics	
Week 2	Jan 13	Unit 1	Biomaterials – Polymers (Part 1)	Biomaterials – Polymers (Part 2)	**Biomaterials Design Workshop (5%)**
Week 3	Jan 20	Unit 1	Biomaterials – Surface Modification	Biomaterials Characterization	**Biomaterials Characterization Workshop (5%)**
Week 4	Jan 27	Unit 2	Host Responses to Biomaterials (Part 1)	Host Responses to Biomaterials (Part 2)	**Biomaterials Paper Workshop (5%)**
Week 5	Feb 3	Unit 2	Host Responses to Biomaterials (Part 3)	Host Responses to Biomaterials (Part 4)	**Host Response Workshop (5%)**
Week 6	Feb 10	Unit 3	Tissue Engineering & Biofabrication (Part 1)	Tissue Engineering & Biofabrication (Part 2)	
Week 7	Feb 17	—	*MIDTERM RECESS – No Class*		
Week 8	Feb 24	—	**Midterm Exam (20% of grade)**		
Week 9	Mar 3	Unit 3	Tissue Engineering & Biofabrication (Part 3)	Tissue Engineering & Biofabrication (Part 4)	**Tissue Engineering Design Workshop (5%)**
Week 10	Mar 10	Unit 4	Tissue Vascularization Strategy (Part 1)	Tissue Vascularization Strategy (Part 2)	**Tissue Vascularization Workshop (5%)**
Week 11	Mar 17	Unit 5	Microphysiological Systems (Part 1)	Microphysiological Systems (Part 2)	**Microphysiological Systems Workshop (5%)**
Week 12	Mar 24	Unit 6	Drug Delivery (Part 1)	Drug Delivery (Part 2)	**Drug Delivery Design Workshop (5%)**
Week 13	Mar 31	—	Patents Lecture		**Patent Workshop (5%)**
Week 14	Apr 7	—	**Final Exam Review Session (Optional)**		
Week 15	Apr 9–22	—	**Final Exams (35% of grade)**		

ASSESSMENT:

In-class workshops	45%
Midterm exam	20%
Final exam	35%

NOTES ON ASSESSMENTS:

- **In-class workshops** are mandatory and are intended to give practical experience in understanding professional issues in biomedical engineering (patents, reading literature) as well as making design decisions (biomaterial choice and characterization, tissue engineering, drug delivery). Students may work in groups of up to four (Sign up here). Missed workshops will be evaluated upon presentation of a McMaster Student Absence Form (MSAF). The weighting for excused absences will be transferred to other workshops, not the final exam. A

maximum of one excused absence (of the eight workshops offered) will be accommodated via an MSAF except in exceptional circumstances; further missed workshops will receive a grade of zero. All in-class workshop assignments are **due on avenue at midnight on Wednesday of the following week.**

- **The midterm and final exams** will be open book (i.e., you may bring notes and any other reference material you wish to bring) but no internet access is allowed. This will be strictly enforced. The Midterm exams will be during class time as indicated on the course schedule.

RESOURCES:

No single textbook covers all aspects of this course. In addition to course notes (available online), the following sources may be found useful.

D. Williams, "Essential Biomaterials Science" (2014)

S. Ramakrishna, "Biomaterials: a nano approach" (2010)

J. Park, R.S. Lakes, "Biomaterials: an Introduction" (2007) – available as an e-book

J. Enderle, S. Blanchard, J. Bronzino "Introduction to Biomedical Engineering" (2005).

B.D. Ratner, "Biomaterials Science: An Introduction to Materials in Medicine", 2nd Ed. (2004) – particularly useful for biological response to materials section

L. Di Silvio (ed.), "Cellular Response to Biomaterials" (2009)

J.D. Bronzino (ed.), "The Biomedical Engineering Handbook" (1995)

R. Baker, "Controlled Release of Biologically Active Agents" (1987)

W. Mark Saltzmann, "Drug Delivery: Engineering Principles for Drug Therapy" (2001)

D.A. Lauffenburger and J.J. Linderman, "Receptors: Models for Binding, Trafficking and Signaling" (1993).

D.O. Cooney, "Biomedical Engineering Principles" (1976)

T.E. Creighton, "Proteins: Structure and Function" (1992)

A.L. Shrier and T.G. Kaufmann (eds.), "Mass Transfer in Biological Systems" CEP Symposium Series No. 99 (1970)

R.C. Seagrave, "Biomedical Applications of Heat and Mass Transfer" (1971)

C.W. Patrick, A.G. Mikos, L.V. McIntire (eds) "Frontiers in Tissue Engineering" (1998)

R.P. Lanza, R. Langer and W.L. Chick (eds) "Principles of Tissue Engineering" (1997)

INTENDED LEARNING OUTCOMES

Based on the Learning Outcomes (LOs) of the course, by the end of this course, the students should be able to:

1. Competence in Mathematics
2. Competence in Natural Sciences
3. Identifies and states reasonable assumptions and suitable engineering fundamentals, before proposing a solution path to a problem
4. Proposes problem solutions supported by substantiated reasoning, recognizing the limitations of the solutions
5. Defines the problem by identifying relevant context, constraints, and prior approaches before exploring potential design solutions.
6. Develops models/prototypes; tests, evaluates, and iterates as appropriate.
7. Demonstrates comprehension of technical and non-technical instructions and questions.
8. Composes an effective written document for the intended audience.

The P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.
Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries (oil/gas, financials, *etc*.) were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- **P**rofessionalism
- **R**esponsibility
- **O**wnership
- **C**uriosity
- **E**mpathy
- **S**elflessness
- **S**ervice

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.

The following Faculty of Engineering and University Senate policies will be followed in this course:

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-procedures-guidelines/

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

POLICIES ADDENDUM

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 either type of modification becomes 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.