



## Diagnostic Devices at the Point of Care

BIEN 545, 3 credits (3-0-6)

Winter/2022

### COURSE SCHEDULE

	Day(s)	Time(s)	Location (Building & Room)
LECTURES	Wednesdays	2:05 -4:55 pm	Zoom
TUTORIALS			
LABS			

### INSTRUCTOR INFORMATION

**Name:** Sara Mahshid

**E-mail:** sara.mahshid@mcgill.ca

**Office hours:** Wednesdays 12- 1 pm

**Communication plan:**

Via zoom <https://mcgill.zoom.us/j/89765480647>

### TA INFORMATION

	Name	Email	Office hours/Communication Plan
Class	Hamed Shieh	hamed.shieh@mail.mcgill.ca	Fridays 3 – 4 pm via email



## COURSE DESCRIPTION

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This course overviews the fundamentals of diagnostic devices from design concepts to implementation in real-life applications. The students will be introduced with the topics required to develop point of care devices. The course will begin with a brief review of the gold standard diagnostic methods and their limitations. In the first chapter, the concepts of biomarkers and their applications in personalised medicine and early-stage diagnosis will be introduced. Then, the main groups of gold standard diagnostic methods, including image-based and chemical/cellular analysis will be discussed. In the following chapter, the main focus will be on different types of biomolecular detection assays, which are indispensable parts of any chemical/cellular diagnosis-based devices. In chapter 3, the applications of the assays, explained in chapter 2, in biosensing platforms and different types of biosensors for biomarkers detection purposes will be elaborated. After that in chapter 4 fundamentals of sample delivery systems and fluid flow based on microfluidic systems will be discussed. Additionally, micro-total analysis systems with healthcare applications and organ on chip principles will be introduced. Finally, in chapter 5 we discuss the technologies used in commercialized/near to be commercialized point of care devices, which are the combination of all the technologies discussed in the previous chapters.

## LEARNING OBJECTIVES

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**By the end of this course, you will be able to:**

**LO1:** Describe the working principle of gold standard diagnostic methods, and sensing mechanisms behind different types of molecular detection assays for detection of biomarkers. **KB.2**

**LO2:** Demonstrate competence in engineering fundamental of biosensing platforms including transducer and technical knowledge of bio recognition elements and sensing approaches. **KB.2**

**LO3:** Demonstrate ability to use knowledge and skills in microfluidic operation techniques and design of micro-total analysis systems with healthcare applications **PA.2 and DE.4**

**LO4:** Design a point of care device with focus on real-life applications and requirements to the process of commercialization. **DE.4**

**LO5:** Develop presentation and teamwork skills, and communicate concepts in a coherent manner **CS.3 and IT.4**

## INSTRUCTIONAL METHODS

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- Instructional approaches and Course format: Will be in the form of (1) lectures by the instructor and occasional tutorials by the TA, (2) class discussions, (3) individual/group presentations by students, and (4) group projects by students.

## EXPECTATIONS FOR STUDENT PARTICIPATION

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- The students should in person attend the course sessions and actively engage in class discussions on presented topics.
- The students should prepare presentations on relevant topics offered by the instructor.
- The students should prepare a mini review paper on relevant topics offered by the instructor.

Adapted from: Teaching and Learning Services. (2021). Course Outline Guide: 2021-2022 Academic Year. Retrieved from <https://www.mcgill.ca/tls/instructors/course-design/outline>



- The students should participate in taking one mid-term exam covering all the topics presented in the course.

## COURSE MATERIALS

- Lecture slides/notes and relevant publications, which will be introduced to the students during the semester.
- Optional course materials: Scholz, F. (2010). *Electroanalytical methods* (Vol. 1). Berlin: Springer., Meng, E., *Biomedical Microsystems*, CRC press, 2011, Gonsalves, K.(Ed.), *Biomedical Nanostructures*, John Wiley & Sons, Inc. , 2008

## COURSE SCHEDULE

Week/ Date	Lesson Topic & Learning Outcomes (LOs)	Reading/Materials	Assignments Due	Date
1	Course Introduction Chapter 1: Review on medical Diagnosis: Biomarkers, Image-based analysis, Cellular and chemical analysis	Lecture Slides/YouTube videos		01/05/2022
2	Chapter 1: Cellular and chemical analysis Chapter 2: Biomolecular detection assays: molecular biomarkers, body fluids, biocatalytic assays	Lecture slides/YouTube videos		01/12/2022
3	Chapter 2: Biomolecular detection assays: biocatalytic assays, Affinity-based assays, Nucleic acid hybridization-based assays	Lecture slides	Quiz#1 (Chapter 1)	01/19/2022
4	Chapter 3: Biosensing platforms: types of biosensors	Lecture slides	Assignment#1 out	01/26/2022
5	Chapter 3: Biosensing platforms: types of biosensors, selectivity, sensitivity	Lecture slides/relevant publications		02/02/2022
6	Chapter 3: Biosensing platforms: discussions on the assignments	Lecture slides/relevant publications	Assignment#1 due	02/09/2022
7	Chapter 4: Fundamentals of microfluidics and its healthcare applications: Introduction, fundamentals, microfluidic operation techniques	Lecture slides/relevant publications	Quiz#2 (Chapters 2 and 3)	02/16/2022
8	Chapter 4: Fundamentals of microfluidics and its healthcare applications: Microfluidic operation techniques, unit operations in miniaturized platforms/ description of the team project details	Lecture slides and relevant publications/textbooks	Team project out/ Assignment#2 out	02/23/2022

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9	<b>Winter Reading Break</b>			
<b>10</b>	Chapter 4: Fundamentals of microfluidics and its healthcare applications: Micro-total analysis system ( $\mu$ -TAS), Organ-on-chip	Lecture slides and relevant publications/textbooks		03/09/2022
<b>11</b>	Chapter 4: Fundamentals of microfluidics and its healthcare applications: discussions on the assignments	Lecture slides and relevant publications/textbooks	Assignment#2 due	03/16/2022
<b>12</b>	Chapter 5: Point-of-care testing: Market, Commonly employed technologies in POC devices	Lecture slides/Publications		03/23/2022
<b>13</b>	Chapter 5: Point-of-care testing: commercialized devices	Lecture slides/publications	Team project due 04/1/2022	03/30/2022
<b>14</b>	A Brief review on the chapters and discussions	Lecture slides/notes	Quiz#3 (chapter 4 and 5)	04/06/2022
				04/12/2022

## EVALUATION METHODS

The students' grade will be determined based on table below:

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Assessment	LO(s)	Due Date
<p><b><u>Assignment #1:</u></b></p> <p>It will be in the form of a presentation, where the structure and sensing mechanism of a developed biosensor in the literature will be explained. The students should get approval for the papers they are going to work on.</p> <p style="text-align: right;"><b>Weight %:20</b></p>	<p>LO1 LO2 LO5</p>	<p>TBA</p>
<p><b><u>Assignment #2:</u></b></p> <p>It will be in the form of a presentation, where a micro-total analysis system will be explained in terms of operation and detection mechanism. The students should get approval for the papers they are going to work on.</p> <p style="text-align: right;"><b>Weight %20</b></p>	<p>LO1 LO3 LO5</p>	<p>TBA</p>
<p><b><u>Team Project:</u></b></p> <p>It involves preparation of a mini review paper in the field of point of care devices with diagnostic applications. The students will be given a list of relevant titles for their papers. Then, each group will select one of the given titles and prepare the paper by the deadline.</p> <p style="text-align: right;"><b>Weight %30</b></p>	<p>LO1 LO2 LO3 LO4 LO5</p>	<p>TBA</p>
<p><b><u>Quizzes:</u></b> It will cover chapters 1,2,3.</p> <p><b>Format:</b> TBA</p> <p><b>Duration:</b> TBA</p> <p style="text-align: right;"><b>Weight %30</b></p>	<p>LO1 LO2 LO3 LO4</p>	<p>TBA</p>
<p><b><u>Class activity (bonus):</u></b></p> <p style="text-align: right;"><b>Weight %5</b></p>		

**Submission Policies:**

- The mini review prepared by the students will be checked for plagiarism.

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## Canadian Engineering Accreditation Board (CEAB) Curriculum Content

CEAB curriculum category content	Number of AU's	Description
<b>Math</b>	0	Mathematics include appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis, and discrete mathematics.
<b>Natural science</b>	10	Natural science includes elements of physics and chemistry, as well as life sciences and earth sciences. The subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and/or experimental techniques.
<b>Complementary studies</b>	0	Complementary studies include the following areas of study to complement the technical content of the curriculum: engineering economics; the impact of technology on society; subject matter that deals with central issues, methodologies, and thought processes of the arts, humanities and social sciences; management; oral and written communications; healthy and safety; professional ethics, equity and law; and sustainable development and environmental stewardship.
<b>Engineering science</b>	14	Engineering science involves the application of mathematics and natural science to practical problems. They may involve the development of mathematical or numerical techniques, modeling, simulation, and experimental procedures. Such subjects include, among others, applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena, elements of materials science, geoscience, computer science, and environmental science.
<b>Engineering design</b>	15	Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.

### Graduating Student Attributes:

This course contributes to the development of the following attributes:

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Graduating Attributes	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
Level	D	A	n/a	D	n/a	A	D	n/a	n/a	n/a	n/a	n/a

n/a = Not applicable; I = Introduced; D = Developed; A = Applied

**KB - Knowledge Base for Engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

**PA - Problem Analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

**IN - Investigation:** An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

**DE - Design:** An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.

**ET - Use of Engineering Tools:** An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

**IT - Individual and Team Work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

**CS - Communication Skills:** An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

**PR - Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

**IE - Impact of Engineering on Society and the Environment:** An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

**EE - Ethics and Equity:** An ability to apply professional ethics, accountability, and equity

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**EP - Economics and Project Management:** An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.

**LL - Life-Long Learning:** An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge

## MCGILL POLICY STATEMENTS

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[The following two statements are included on the Engineering Faculty Standard Course Outline. Select any statements of your choice to include on your course outline]

### Language of Submission

“In accord with McGill University’s [Charter of Students’ Rights](#), students in this course have the right to submit in English or in French any written work that is to be graded. This does not apply to courses in which acquiring proficiency in a language is one of the objectives.” (Approved by Senate on 21 January 2009)

« Conformément à [la Charte des droits de l’étudiant](#) de l’Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté, sauf dans le cas des cours dont l’un des objets est la maîtrise d’une langue. »

### Academic Integrity

“McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the [Code of Student Conduct and Disciplinary Procedures](#)” (Approved by Senate on 29 January 2003)

« L’université McGill attache une haute importance à l’honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l’on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l’étudiant et des procédures disciplinaires (pour de plus amples renseignements, veuillez consulter le [guide pour l’honnêteté académique de McGill](#)).»

### ADDITIONAL STATEMENTS [optional, can adapt phrasing as desired]

**University Assessment Policy:** “The [University Student Assessment Policy](#) exists to ensure fair and equitable academic assessment for all students and to protect students from excessive workloads. All students and instructors are encouraged to review this Policy, which addresses multiple aspects and methods of student assessment, e.g. the timing of evaluation due dates and weighting of final examinations.”

**Text Matching Software:** “Work submitted for evaluation as part of this course may be checked with text matching software within myCourses.”

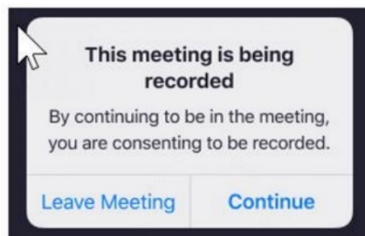
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**Course Materials:** “© Instructor-generated course materials (e.g., handouts, notes, summaries, exam questions) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of [copyright](#) can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.”

**Zoom Recordings:** “Please read the [Guidelines for Instructors and Students on Teaching, Learning, and Assessment](#) and this course outline. You will be notified through a “pop-up” box in Zoom if part of a class is being recorded (see image below). By remaining in sessions that are recorded, you agree to the recording, and you understand that your image, voice, and name may be disclosed to classmates. You also understand that recordings will be made available in myCourses to students registered in the course.”



**Respectful Communication:** “The University is committed to maintaining teaching and learning spaces that are respectful and inclusive for all. To this end, offensive, violent, or harmful language arising in contexts such as the following may be cause for disciplinary action:

1. Zoom sessions, including Username (use only your legal or preferred name), virtual backgrounds, “chat” boxes, whiteboard annotations, breakout rooms
2. myCourses discussion fora”

**Learning Environment:** “As the instructor of this course I endeavor to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and the [Office for Students with Disabilities](#), 514-398-6009.”

**Mental Health Support:** “Many students may face mental health challenges that can impact not only their academic success but also their ability to thrive in our campus community. Please reach out for support when you need it; many [resources](#) are available on-campus, off-campus and online.”

**Land Acknowledgment:** [If you wish to include a land acknowledgement, we encourage you to consult the Indigenous Initiatives [The Land and Peoples](#) webpage for guidance.]

**Content Warning:** [In some courses, a content warning may be appropriate to inform students of content that may cause a strong emotional or physiological response. Such a warning can be communicated in the course outline. In addition, it can be provided via myCourses, lecture notes/slides (if applicable), or verbally.]

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“Content warning: Please be aware that some of the course content may be disturbing for some students. It has been included in the course because it directly relates to the learning outcomes. Please contact the instructor if you have specific concerns about this.”

**Support Services:** “If you have difficulty affording food or if you lack a safe and stable place to live and believe that this may affect your performance in this course, I encourage you to contact the [Dean of Students](#) who can connect you with support services. If you feel comfortable doing so, please let me know as well, so we can discuss how I can best support your learning.” [adapted from [Goldrick-Rab, 2017](#)]

**End-of-Course Evaluations:** “[End-of-course evaluations](#) are one of the ways that McGill works towards maintaining and improving the quality of courses and the student’s learning experience. You will be notified by e-mail when the evaluations are available. Please note that a minimum number of responses must be received for results to be available to students.”

**Extraordinary Circumstances:** [In keeping with McGill’s preparedness planning strategies with respect to potential pandemic or other concerns, the Administration suggests that all course outlines contain the statement]:

“In the event of extraordinary circumstances beyond the University’s control, the content and/or evaluation scheme in this course is subject to change.”

**Academic Issues:** Additional policies governing academic issues which affect students can be found in the [McGill Charter of Students’ Rights](#).

**Sustainability:** McGill has policies on sustainability, paper use, and other initiatives to promote a culture of sustainability at McGill. (See the [Office of Sustainability](#).)

**MC2:** [Guidelines for the use of mobile computing and communications (MC2) devices in classes at McGill have been approved by the APC. Consult the [Guidelines](#) for a range of sample wording that may be used or adapted by instructors on their course outlines.]