IBEHS 4DO3

Introduction to Medical Imaging

COURSE OUTLINE

Please refer to course website for updated information.

COURSE DESCRIPTION

Through this introductory course, students will learn methods of how medical images are formed, and will gain knowledge of the Fourier transform and its applications in medical imaging. Basic understanding of the sources of noise and artifacts in the different modalities will also be attained, along with an understanding of the limits to the achievable resolution. Imaging modalities that will be covered include ultrasound, x-rays, computed tomography and magnetic resonance imaging.

PRE-REQUISITES AND ANTI-REQUISITES

Pre-requisite(s): IBEHS 3A03 and registration in the Integrated Biomedical Engineering and Health Sciences (IBEHS) program or registration in Level IV Electrical and Biomedical Engineering.
Anti-requisite(s): ElecEng 4BF4

COURSE SCHEDULE

Lectures: Tuesdays and Fridays 12:30-1:20pm, MDCL-1105
Tutorials: Tutorials will be held every other week.

- For students in labs 2,4,6,8,10, tutorials will start the week of January 16th:
  T02 Mon 1:30-2:20, JHE-326H
  T04 Tues 11:30-12:20, JHE-326H
- For students in labs 1,3,5,7,9, tutorials will start the week of January 23rd:
  T01 Mon 1:30-2:20, JHE-326H
  T03 Mon 9:30-10:20, BSB-B156

Labs: There are 6 labs to do over the course (one every other week). There are 5 lab slots: Mondays, Tuesdays, Wednesdays, Thursdays and Fridays, 2:30-5:30pm in ETB-533.

For students in labs 2,4,6,8,10, labs will start the week of January 16th in ETB-533
For students in labs 1,3,5,7,9, labs will start the week of January 23rd in ETB-533

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Michael Noseworthy, PhD PEng
Office: MUMC 3N26-E
Radiology Administration
nosewor@mcmaster.ca

Office Hours:
Thursdays 12:30-1:30pm,
Fridays 1:30-2:30pm
or by appointment

INSTRUCTIONAL TEAM

Leela Pilli (LAB COORDINATOR)
pillil@mcmaster.ca

Mitra Tavakkoli
tavakkm@mcmaster.ca

Alex Amador
amadorta@mcmaster.ca

Konrad Grala
gralak@mcmaster.ca

Ethan Samson
samsone@mcmaster.ca

Zexi Wang
wangz418@mcmaster.ca

COURSE DELIVERY

All lectures, tutorials and labs will be in person. The Instructor and TAs will not be posting audio or video recordings of any in-class materials. Avenue-to-Learn will be the online management system for the course. Through Avenue, you will be able to:

- Find all course materials (lecture slides, lab materials, linked videos, etc.)
- View course-related announcements
- Submit course work (assignment, project deliverables) for grading
- View your gradebook

NOTE: Regular important announcements will be made on the Avenue course website. It is the student's responsibility to regularly check these notices.

COURSE OBJECTIVES

This course is designed to allow students to become familiar with medical imaging technologies- both from a physics and engineering perspective through to a practical perspective. The course will focus primarily on X-ray techniques (including mammography and CT), nuclear medicine (PET, SPECT) and magnetic resonance imaging (e.g. MRI, in vivo NMR, etc.). However, comparative applications with other imaging modalities will be made where appropriate. Practical applications and clinical usage of the technologies, outlining advantages and disadvantages of techniques, will be thoroughly demonstrated in most lectures. In addition, throughout the course, students will learn the most frequent artefacts and their causes.

ASSUMED KNOWLEDGE

You should have a solid knowledge of linear algebra and vector calculus. Also, a thorough mastering of Matlab is critical. Lastly, thorough working knowledge of anatomy and physiology is assumed.

COURSE MATERIALS

All course material will be regularly posted to Avenue. It is the student's responsibility to check regularly for updates.

Text Book

A number of key review papers that fully complement the course material will be suggested to students throughout the term. There is no required textbook for the course. If you are interested in buying added reading materials to supplement the course I recommended: Prince JL, and Links J (2014) Medical Imaging Signals and Systems, 2nd Edition, Prentice Hall. Other excellent books (none are required) include:

1) A. Oppelt (2005) Imaging Systems for Medical Diagnostics, Publicis Corporate Publishing. ISBN: 3-89578-226-2.

2) Bushberg JT, et al. (2011) The Essential Physics of Medical Imaging. Lippincott Williams & Wilkins; 3rd Ed. ISBN: 078-178-0578.

Additional Materials

Lecture Information: All lecture notes will be posted on the course web page by noon on the day before lecture.

Lab Information: There will be lab talks and handouts in each lab, all of which will be posted on avenue (lab section).

NOTE 1: You will acquire imaging data in all of the labs. It is your responsibility to get the data before leaving the lab. The TAs will assist during the lab time but after that will not be responsible for finding your data. Lab data will not be posted on Avenue.

NOTE 2: Both Dr. Noseworthy and the TAs will often use a white board or chalk board in lectures / lab talks. Students will also be responsible for understanding any such materials detailed on this medium.

COURSE OBJECTIVES AND LEARNING OUTCOMES

Upon successful completion of this course, the student should be able to understand:	
1	General concepts and history of medical imaging. Interactions of radiation with matter. Types of images and simple concepts of medical image formation. Image quality, point spread function (PSF), modulation transfer function (MTF).
2	X-ray systems, mammography, DXA and Computed Tomography (CT).
3	Basics of CT image reconstruction. Basics of nuclear medicine
4	Molecular imaging and imaging metabolism: In vivo NMR (magnetic resonance spectroscopy) vs. positron emission tomography (PET) vs. single photon emission computed tomography (SPECT).
5	Basics of Ultrasound (US) imaging.
6	Physics and chemistry of contrast agents. Imaging Flow and Perfusion: MRI vs. PET/SPECT vs. Ultrasound techniques
7	Basics of nuclear magnetic resonance (NMR). Going from NMR to magnetic resonance imaging (MRI): Application of magnetic field gradients, signal sampling, k-space, 2D Fourier transformations.
8	Basic MRI pulse sequences
9	Advanced MRI pulse sequences: diffusion weighted imaging (DWI), diffusion tensor imaging (DTI), fat/water imaging
10	Functional Imaging: fMRI
11	Biomedical engineering of multimodal imaging

LABORATORY OVERVIEW

The goal of the labs are: 1) Medical imaging equipment will be demonstrated on a wide range of objects; and 2) labs will be used to acquire data for analysis in assignments. You are required to attend your lab each week.

LAB #1- Weeks of January 16th & 23th : PSF, LSF, MTF, X-ray systems. CT scanning
LAB #2- Weeks of January 30th and February 6th : Optical "SPECT/CT".
LAB #3- Weeks of February 13th and 27th : Ultrasound imaging. Ultrasound elastography.
LAB #4- Weeks of March 6th and March 13th : MRI Part1: Basics of calibration, T1 and T2, shimming
LAB #5- March 20th and 27th : MRI Part2 – Imaging Sequences, gradient echo, spin echo, RARE
LAB #6- April 3rd MRI Part3 – Advanced Human MRI lab. Diffusion MRI, fMRI.

LABORATORY OPERATION

All labs will begin with a brief 'chalk talk' concerning the lab. Labs 1 and 2 will be performed using teaching 'SPECT/CT' scanners that use visible light (instead of high energy Xrays) and a CCD to acquire data. There are no high energy photons. Lab 3 will be done with students performing US scanning on each other using handheld US systems that connect via Bluetooth to iPads. Labs 4, 5 and 6 focus on Magnetic Resonance Imaging (MRI). We have two 0.33Tesla 'Flowerpot MRI' systems for students to use for experiments in labs 4 and 5. The last lab (#6) will involve asynchronous video content of human MRI scanning done by Dr. Noseworthy. It will be necessary to watch the videos prior to attending Lab #6 (in person). ***NOTE: Lab attendance will be taken. Failure to attend your lab will result in a 0% for that lab assignment grade***.

ASSESSMENTS

There will be a combination of exams[1] and group lab reports over the course of the semester. Students will hand in a lab report for every 2 labs. These will be based on data acquired in each lab and also material learned in lectures and tutorials. Lab reports will require programming in Matlab (or Python). Students are encouraged to work in groups (up to a maximum of 4 per group). *Groups hand in only one assignment* with all names on the first page. All group members will receive the same grade. However, if anyone feels other group member(s) haven't provided equal input they can also submit group member evaluations (form, with instructions, will be available upon request from lab TAs).

Grading Module	Due date	Weight
Lab reports	**(due 1 week after your assigned lab at 11:59pm)**	**36% TOTAL**
Labs #1 and 2	Week of January 30th	12%
Labs #3 and 4	Week of February 27th	12%
Labs #5 and 6	Week of April 10th	12%
Midterm Exam (7-10pm) Thurs. Feb. 16th		24%
Final Exam (2.5hrs, date/time = TBA)		40%
Total		100%

[1] NOTE that both the midterm and final exams will be closed book exams. Relevant equations will be provided as needed.

In terms of lab reports, students need to learn how to be concise and also to follow instructions (more text does not equate to a higher grade). In the real world scientific publications that are wordy and/or do not follow publisher instructions are automatically rejected. As such, there will be a hard page limit of 25 pages/report (Arial 12pt font, single spaced, 1" for all margins), including figures (not including appended code and references). Each extra page will result in a 25% penalty per page. Code must always be appended to assignments.

The midterm exam will cover all materials up to the end of lecture on Tuesday February 14th. The midterm will also cover materials covered in labs #1 and #2. The Final exam will cover materials from February 17th to the end of the course and include materials from labs 3 to 6, inclusive. Note, both the midterm and final exam will be closed book.

COMPLETION AND SUBMISSION OF WORK

It is the student's responsibility to ensure assessments are correctly submitted to the correct location, on time, and in the specified format. Failure to correctly submit an assignment will result in a mark deduction (see below).
Submission Penalties

NOTE 1: lab reports are due digitally (i.e. upload to Avenue) at 11:59pm on the due date. *Late reports will be deducted 20% per day*.
NOTE 2: No make-up labs will be granted. A missed lab report will constitute a grade of 0.
NOTE 3: Lab reports are to be PDF format and legible (i.e. avoid lossy compression). An illegible lab report due to lossy compression will be given a grade of 0. It is the student's responsibility to verify the PDF quality before uploading.
NOTE 4: Attendance in labs will be taken. Missing a lab will result in a grade of 0% on the report associated with that lab.
NOTE 5: In the case where a student submits a MSAF the value of the missed material will be transferred completely to the final exam

IMPORTANT DATES

Winter Term	
Monday January 9	Winter Classes Begin!
Thursday February 16th	Midterm (7-10pm)
February 20 – 24	Winter Reading Week
Friday April 7	Good Friday (no classes)
Wednesday April 12	Winter Classes End
Thursday April 13	No classes
April 14 – 29	Winter Term Examinations (the date of the End-of-Year Exam is TBD)

COMMUNICATION POLICY

All communication to the class will be done via Avenue. Important notices will be done with the mail tool in Avenue. All students are encouraged to routinely check whether they have an announcement there. Communication to the

professor or a TA should be addressed with the subject line "4DO3". Only emails from McMaster email addresses will be responded to. If a required response is more than a few sentences they will not be replied to and the student is encouraged to come to office hours or to email the professor (or TA) to make an appointment.

INCLUSIVE ENVIRONMENT STATEMENT

We consider this classroom to be a place where you will be treated with respect, and we welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. We will gladly honour your request to address you by an alternate name or gender pronoun. Please advise of this preference early in the semester so that we may make appropriate changes to our records.

ACCREDITATION LEARNING OUTCOMES

The Graduate Attributes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's actual grade in the course. For more information on Accreditation, please visit: https://www.engineerscanada.ca. Mapping of the course Learning Outcomes (LO) to the Canadian Engineering Accreditation Board (CEAB) Graduate Attributes (GA) are outlined in the table below:

Graduate Attribute (GA)	Learning Outcome (LO)
GA1. Knowledge Base: **1.4. Competence in Specialized Engineering knowledge**	To be able to understand an array of common medical problems, their aetiology and the associated ideal imaging modality for assessment. Shows understanding of how medical problems can be resolved using engineering principles
GA2. Problem Analysis: 2.1. Identifies and states reasonable assumptions and suitable engineering fundamentals, before proposing a solution path to a problem.	To understand how imaging hardware is constructed, including materials, design and operation. Students must know how the device is optimized for ideal function
GA2. Problem Analysis: 2.2. Proposes problem solutions supported by substantiated reasoning, recognizing the limitations of the solutions.	Students have an understanding of existing techniques or are able to formulate new approaches for image reconstruction, quality assurance and image analysis. Students should analyze the benefits of each method and the artifacts or errors generated by the methods.
GA4. Design: 4.2. Explores a breadth of potential solutions, considering their benefits and trade-offs as they relate to the project requirements.	Students are fully aware of life cycle analysis of medical imaging equipment, understand sources of raw materials, energy requirements, environmental impact device manufacture and their disposal.
GA4. Design: 4.3. Develops models/prototypes; tests, evaluates, and iterates as appropriate.	Students are able to take a medical imaging problem and be able to solve it using any of an array of analysis pathways/methods.

GA5. Use of Engineering Tools: 5.2. Successfully uses engineering tools	Students understand the functioning and use of modern medical imaging systems. They are aware how to acquire data, assess quality and perform quality assurance measures.

For more information on Accreditation, please visit: https://www.engineerscanada.ca

McMaster Approved Policy Statements

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 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., submission of work not one's own or which other credit 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 the following website: www.mcmaster.ca/academicintegrity.

ACADEMIC ACCOMMODATIONS FOR 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.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS, OR SPIRITUAL OBSERVATIONS (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 examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

ACADEMIC ACCOMMODATIONS FOR RELIEF FOR MISSED ACADEMIC WORK: (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".

- All McMaster Student Absence forms (MSAFs) are to be directed to nosewor@mcmaster.ca. Sending to another email address will delay processing.
- It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.

COURSES WITH AN ON-LINE ELEMENT

In this course, we will be using Avenue-to-Learn, and if necessary (or in extreme circumstances), Zoom. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, usernames 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.

COPYWRITE 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.

REFERENCE TO RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to https://reo.mcmaster.ca/.

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.

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 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.

Integrated Biomedical Engineering & Health Sciences (IBEHS) Labs/Design Studio Safety

Information for Laboratory Safety and Important Contacts

This document is for users of IBEHS instructional laboratories at the following locations:

- ABB C104 (Design Studio)
- ETB 533 (Medical Imaging/Biomaterials Lab)
- ETB 534 (Medical Instrumentation/Robotics Lab)
- HSC 4N72 (Genetic Engineering Lab)

This document provides essential information for the healthy and safe operation of IBEHS instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in IBEHS. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

Details on Standard Operating Procedures (SOPs), Health and Safety videos and other resources can be found online at the iBioMed Health and Safety webpage.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

- Food and beverages are not permitted in the instructional laboratories.
- A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
- Laboratory equipment should only be used for its designed purpose.
- Proper and safe use of lab equipment should be known before using it.
- The lab tech or course TA leading the lab should be informed of any unsafe conditions.
- The location and correct use of all available safety equipment should be known.
- Potential hazards and appropriate safety precautions should be determined, and the sufficiency of existing safety equipment should be confirmed before beginning new operations.
- Proper waste disposal procedures should be followed.
- Personal ergonomics should be practiced when conducting lab work.
- Current University health and safety issues and protocols should be known.

Location of Safety Equipment

Fire Extinguisher: on walls in halls outside of labs or within labs

First Aid Kit: ABB C104, ETB 533, ETB 534, HSC 4N72 or dial “88” after 4:30 p.m.

Telephone: on the wall of every lab near the door

Fire Alarm Pulls: Near all building exit doors on all floors

Who to Contact?

Emergency Medical / Security:

On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.

Hospital Emergency Medical / Security:

For McMaster HSC, call Security at extension **5555** or **905-521-2100** from a cell phone.

Non-Emergency Accident or Incident: Immediately inform the Lab Tech, TA on duty or Course Instructor.

University Security (Enquiries / Non-Emergency):

Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.

See Lab Tech, TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs.

Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.

IBEHS Specific Instructional Laboratory Concerns: For non-emergency questions specific to the IBEHS laboratories, please contact appropriate personnel below from a McMaster phone:

- Leela Pilli, Laboratory Technician – 26888
- Parmveer Bola, Instructional Assistant – 23521
- Andrej Rusin, Wet Laboratory Technician – 28347
- Alexa Behar-Bannelier, Program Manager – 24548

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people.

1. Douse with water from safety shower immediately or
2. Roll on the floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if a blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents. Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press the wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you are not sure, ask!

Defined Roles

IBEHS Lab Technician	Leela Pilli, pillil@mcmaster.ca
IBEHS Instructional Assistant	Parmveer Bola, bolap1@mcmaster.ca
IBEHS Wet Lab Technician	Andrej Rusin, rusina@mcmaster.ca
IBEHS Co-Directors	Dr. Colin McDonald, cmcdona@mcmaster.ca Dr. Michelle MacDonald, macdonml@mcmaster.ca
IBEHS Program Manager	Alexa Behar-Bannelier, alexa.behar@mcmaster.ca
IBEHS Course Instructor	Please contact your specific course instructor directly