



# ENGG\*4040 Medical Imaging Modalities

01

Fall 2022

Section(s): C01

School of Engineering

Credit Weight: 0.50

Version 2.00 - September 07, 2022

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## 1 Course Details

### 1.1 Calendar Description

The course will cover the basic knowledge of medical imaging systems, how they operate and to what uses they can be applied. Systems covered will include x-ray radiography, computed tomography, magnetic resonance imaging, positron emission tomography, gama cameras, and ultrasound imaging. Emphasis will be on the underlying physics and computation, highlighting factors affecting image quality, patient safety, and clinical use.

**Pre-Requisites:** ENGG\*3390 or PHYS\*3130

**Restrictions:** PHYS\*4070

### 1.2 Timetable

The timetable is subject to change. Please see WebAdvisor/CourseLink for the latest information.

#### Lectures

Monday	Most Sections	ROZH, 105	2:30PM-3:50PM
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#### Lectures/Tutorials

Wednesday	Most Sections	ROZH, 105	2:30PM-3:50PM
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#### Labs

Monday		THRN, Room 2307	4:00PM-6:00PM
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Friday		THRN, Room 2307	8:30AM-10:20AM
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##Look on CourseLink for updates.

## 1.3 Final Exam

Date: December 10, 2022. Time: 8.30 am to 10.30 am (2 hours).

Exam time is subject to change. Please see WebAdvisor/CourseLink for the latest information.

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## 2 Instructional Support

### 2.1 Instructional Support Team

<b>Instructor:</b>	Eran Ukwatta PhD, PEng
<b>Email:</b>	eukwatta@uoguelph.ca
<b>Telephone:</b>	519-824-4120 x53404
<b>Office:</b>	Richards 1507
<b>Office Hours:</b>	Wednesdays from 4 pm to 5 pm. If this time does not work for you, please email to schedule individual appointments.

<b>Lab Co-ordinator:</b>	Ahmed Mezil
<b>Email:</b>	amezil@uoguelph.ca
<b>Telephone:</b>	+1-519-824-4120 x53729
<b>Office:</b>	THRN 2308
<b>Office Hours:</b>	TBA

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## 3 Learning Resources

### 3.1 Required Resources

#### Course Website (Website)

<http://courselink.uoguelph.ca>

Course material, news, announcements, and grades will be regularly posted to the ENGG\*4040

CourseLink site. You are responsible for checking the site regularly.

#### **J. L. Prince & J. M. Links, Medical Imaging Signals and Systems (2nd Edition), Pearson Prentice Hall, 2014. ISBN: 0-13-214518-9. (Textbook)**

In my opinion, there is no single book which covers all the material for this course in its entirety.

Therefore supplementary material will be suggested to students as the course proceeds.

### 3.2 Reference Book

Digital Image Processing for Medical Applications by Geoff Dougherty, Cambridge University Press, ISBN: 9780521860857

### 3.2 Lecture Information

All the lecture notes are posted on the web page usually a day before the lecture (week #1-#13).

### 3.2 Lab Information

Labs will take place every other week for each group of students. Students are expected to acquire the required data to complete the lab during the lab session. The handouts and/or supplementary data for all the lab sessions are within the lab section of the website. Lab reports will be due in two weeks after the completion of the lab and should be submitted using CourseLink.

The lab coordinator will be available during the off weeks to respond to any questions on the labs.

### 3.2 Exams

All the exams in this course (i.e, midterm and final exam) are open book. You are allowed to have your course notes, the course textbook (Medical Imaging Signals and Systems) and calculator. Browsing of any other material on the Internet on cell phones, computers, and other electronic devices are not allowed.

### 3.2 Miscellaneous Information

Any other relevant information will also be posted on the web page in Courselink.

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## 4 Learning Outcomes

This course aims to familiarize students with existing imaging modalities from both an engineering and clinical/practical perspective. Students are exposed to the underlying physics and engineering to understand their implications in the clinical settings. Numerous applications of the various imaging modalities will be explored.

### 4.1 Course Learning Outcomes

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

1. Describe the physics and engineering design of various medical imaging modalities (ultrasound, x-ray, CT, PET, SPECT, MRI & NMR, digital histopathology)
2. Apply knowledge of fundamental engineering principles in implementing concepts of medical imaging systems and solving problems
3. Examine artifacts and defects in imaging systems and challenges in in-vivo imaging of

- humans
4. Operate several model hardware to acquire imaging data
  5. Write programming code in Matlab to process medical imaging data
  6. Utilize analysis methods and models to extract clinically relevant information from medical images
  7. Compare the technical strengths and limitations of imaging modalities for a given clinical application

## 4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1, 2
1.3	Recall, describe and apply fundamental engineering principles and concepts	1
1.4	Recall, describe and apply program-specific engineering principles and concepts	2
3	Investigation	2, 3, 4, 6
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	2, 6
3.3	Analyze and interpret experimental data	4
3.4	Assess validity of conclusions within limitations of data and methodologies	3, 6
5	Use of Engineering Tools	3, 5, 7
5.2	Demonstrate proficiency in the application of selected engineering tools	5, 7
5.3	Recognize limitations of selected engineering tools	3, 7

## 5 Teaching and Learning Activities

The following is a tentative list of topics covered in the class. As the course progress, the order in which the topics are covered is subject to change.

### 5.1 Lecture

#### Week 1

**Topics:** Introduction of the Course

**Week 2**

**Topics:** Overview of Medical Imaging Modalities & Signal Processing

**Week 3**

**Topics:** Signals and Systems (specific focus on Fourier Transform)

**Week 4**

**Topics:** Image Quality

**Week 5**

**Topics:** Projection Radiography

**Weeks 6 & 7**

**Topics:** Computed Tomography

**Week 8**

**Topics:** Physics of Ultrasound Imaging

**Week 9**

**Topics:** Ultrasound Imaging Systems and Applications

**Weeks 10 & 11**

**Topics:** Nuclear Medicine: PET and SPECT

**Weeks 11 & 12**

**Topics:** Magnetic Resonance Imaging (MRI)

**Week 12**

**Topics:** Postprocessing of Medical Images

## 5.2 Lab

**Mon, Sep 26 - Fri, Sep 30**

**Topics:** Evaluation of Image Quality (Based on DeskCAT system)

**Learning Outcome:** 3, 4

**Mon, Oct 3 - Fri, Oct 7**

**Topics:** Lab 1 Follow-up Hour(s)

**Mon, Oct 17 - Fri, Oct 21**

**Topics:** CT Reconstruction (Based on DeskCAT system)

**Learning Outcome:** 1, 2

**Mon, Oct 24 - Fri, Oct 28**

**Topics:** Lab 2 Follow-up Hour(s)

**Mon, Oct 31 - Fri, Nov 4**

**Topics:** SPECT Reconstruction (Based on DeskCAT system)

**Learning Outcome:** 4

**Mon, Nov 7 - Fri, Nov 11**

**Topics:** Lab 3 Follow-up Hour(s)

**Mon, Nov 14 - Fri, Nov 18**

**Topics:** Postprocessing of Imaging Data (Based on 3DSlicer and/or Matlab)

**Learning Outcome:** 6

**Mon, Nov 21 - Fri, Nov 25**

**Topics:** Lab 4 Follow-up Hour(s)

**Learning Outcome:** 4

## 5.3 Other Important Dates

**Monday, October 10, 2022:** Holiday -- **No Classes Scheduled** -- Classes rescheduled to

Friday, December 2

**Tuesday, October 11 2022:** Fall Study Break Day -- **No Classes Scheduled** -- classes rescheduled to Thursday, December 1

**Thursday, December 1, 2022:** Make up for Study Day (Tuesday Schedule)

**Friday, December 2, 2022:** Make up for Holiday (Monday Schedule), Last day to drop F22 one semester courses

## 6 Assessments

### 6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Assignment	5
Lab experiments & Reports (5 marks each)	20
Midterm	25
Final Exam	50
Total	100

### 6.2 Assessment Details

#### Assignment (5%)

**Due:** Mon, Oct 17, 11:59 PM

**Learning Outcome:** 1, 2

This assignment will be released on September 26<sup>th</sup> and it will be group-based.

#### Lab Reports (20%)

**Learning Outcome:** 3, 4, 5, 6

Each lab is weighted equally.

A report must be submitted for each lab where it is due in **two weeks** after the scheduled lab date. The lab report should be brief and must contain information on acquired data and relevant comments along with answers to the corresponding lab questions. Labs are to be completed in groups of 1-3. You are responsible to ensure that you/or your group submit the report.

#### Midterm Test (25%)

**Date:** Wed, Oct 19, 02:30 PM, Virtual

**Learning Outcome:** 1, 3, 7

The midterm will be held virtually during the class time. The exam will be invigilated using

the Zoom tool. The students are expected to keep their cameras on during the exam time.

### **Final Exam (50%)**

**Date:** Sat, Dec 10, 8:30 AM, Virtual

**Learning Outcome:** 1, 3, 6

The final exam will be held virtually. The exam will be invigilated using the Zoom tool. The students are expected to keep their cameras on during the exam time.

## **7 Course Statements**

### **7.1 Course Grading Policies**

**Missed Assessments:** If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:

<http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

**Accommodation of Religious Obligations:** If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:

<http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml>

**Passing grade:** In order to pass the course, you must pass the overall course and exam portions (midterm and final exam). Students must obtain a grade of 50% or higher on the combined exam and midterm portions (with above weights, i.e.  $[0.5 \times \text{Exam Mark (in \%)} + 0.25 \times \text{Midterm Mark (in \%)}] > 37.5\%$ ) of the course in order to pass the course.

**Missed midterm tests:** If you miss a test due to grounds for granting academic consideration or religious accommodation, the weight of the missed test will be added to the final exam.

**Lab Work:** You should participate in all laboratories. If you miss a laboratory, arrangements must be made with the instructor.

**Late Assignments & Projects:** Late submissions of assignments will be subject to a penalty (20%/day). Assignment and lab reports more than one day late will not be accepted.



## 8 School of Engineering Statements

### 8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

### 8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

### 8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

## 9 University Statements

### 9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

### 9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

Graduate Calendar - Grounds for Academic Consideration

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions  
<https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml>

### 9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic Calendars.

Undergraduate Calendar - Dropping Courses  
<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

Graduate Calendar - Registration Changes  
<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml>

Associate Diploma Calendar - Dropping Courses  
<https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml>

### 9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

### 9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website  
<https://www.uoguelph.ca/sas>

For Ridgetown students, information can be found on the Ridgetown SAS website

<https://www.ridgetownc.com/services/accessibilityservices.cfm>

## 9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

Graduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

## 9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

## 9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars

<https://www.uoguelph.ca/academics/calendars>

## 9.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (<https://news.uoguelph.ca/2019-novel-coronavirus-information/>) and circulated by email.

## 9.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).

## 9.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- <https://news.uoguelph.ca/return-to-campus/how-u-of-g-is-preparing-for-your-safe-return/>
- <https://news.uoguelph.ca/return-to-campus/spaces/#ClassroomSpaces>

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.

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