# Course Outline (W2019)

**BME809: Biomedical Systems Modelling**

## Instructor(s)
Adel Alhalawani [Coordinator]  
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Phone: TBA  
Email: adel.alhalawani@ryerson.ca  
Office Hours: TBA

## Calendar Description
Mathematical modeling of biomedical systems. Lumped and distributed models of electrical, mechanical, and chemical processes applied to cells, tissues, and organ systems.

## Prerequisites
BLG 601 and BME 229 and BME 639 and BLG 701

## Antirequisites
None

## Corequisites
None

## Compulsory Text(s):

## Reference Text(s):
2. Cardiac Electrophysiology Methods and Models, Daniel C. Sigg, Paul A. Laizzo, Yong-Fu Xiao and Bin He (Editors), Springer, 2010

## Learning Objectives (Indicators)
At the end of this course, the successful student will be able to:

1. Apply numerical and analytical methods to generate computational models of physiological systems and simulate physiological signals (using Simulink and Matlab) to address biomedical problems (e.g. effect of pathologies or drugs on a system). (1b)
2. Understand the underlying physiological, electrical, mechanical and chemical processes of human cells, tissues and organ systems that result in physiological signal generation and their role in generating biophysical models. (1c), (12b)
3. Apply and evaluate the suitability of various signal processing techniques to different types of physiological measurements (e.g. action potentials, ECG, EMG) for analysing signal characteristics and improving signal quality using Matlab. (2b), (3b), (5a)
4. Apply numerical and analytical methods to generate computational models of physiological systems and simulate physiological signals (using Simulink and Matlab) to address biomedical problems (e.g. effect of pathologies or drugs on a system). (4b)
5. Learn to identify and evaluate the implications of different approaches to addressing/modelling a biomedical problem and develop decision making criteria to determine the optimal solution under different conditions. (8b)

**NOTE:** Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).

## Course Organization
3.0 hours of lecture per week for 13 weeks  
2.0 hours of lab/tutorial per week for 12 weeks

## Teaching Assistants
Justin DiGregorio, Email: justin.digregorio@ryerson.ca  
Philips Lai, Email: phillips.lai@ryerson.ca
# Course Evaluation

<table>
<thead>
<tr>
<th>Theory</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Midterm Exam</td>
<td>25 %</td>
</tr>
<tr>
<td>Quizzes (2 x 10%)</td>
<td>20 %</td>
</tr>
<tr>
<td>Final Exam</td>
<td>35 %</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Laboratory</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Labs (4 x 5%)</td>
<td>20 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100 %</td>
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</tbody>
</table>

# Examinations

- Midterm exam in week 9 of the course will be 2 hours, closed book and will cover material from weeks 1-6.
- 2 Quizzes in weeks 5 and 12 of the course will be 30 minutes at the start of class, closed book.
- Final exam will be during exam period, and will be 3 hours, closed book, and will cover all material from weeks 1-13.

# Other Evaluation Information

- Labs and tutorial will be held in room ENG 408. Laboratory manuals will be posted on the course shell on D2L.
- Labs will run every week beginning week 2 (Week of Jan 14). All labs will involve simulating and/or processing physiological signals and systems using Matlab and/or Simulink software.
- Each lab is worth 5%, and will be marked based on completion of the lab report. A lab report must be submitted for each of the four labs, one lab report per group, submitted within 1 week of completing the lab (to the TA at the start of the next lab).

# Other Information

- Lectures - Wednesdays 12-3pm, TRS3149
- Labs and tutorials - ENG408

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## Course Content

<table>
<thead>
<tr>
<th>Week</th>
<th>Hours</th>
<th>Chapters / Section</th>
<th>Topic, description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>2.1 2.2 3.1 3.2 3.3</td>
<td>Lecture topics: Introduction to systems and modelling and physiological signals and noise Review of signals and systems basics statistical description of random process continuous and discrete signals and digitization</td>
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<tr>
<td></td>
<td></td>
<td>5.1 5.2 5.3 5.4</td>
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<tr>
<td>2</td>
<td>3</td>
<td>3.3 4.1 4.2 4.3 4.4</td>
<td>Lecture topics: Review of frequency decomposition of signals Fourier series Fourier Transform (discrete-time discrete fast short-time) wavelet transform Laplace transform filtering</td>
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<tr>
<td></td>
<td></td>
<td>6.1 6.2 6.3 6.4</td>
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<tr>
<td>3</td>
<td>3</td>
<td>1.2 15.1-1.5.3</td>
<td>Lecture topics: Differential equations and numerical methods State space models Modelling of the cardiovascular system</td>
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<tr>
<td>4</td>
<td>3</td>
<td>3.3 6.1 6.3 6.5</td>
<td>Lecture topics: Time series modelling system identification model validation</td>
</tr>
<tr>
<td>Week</td>
<td>Lab</td>
<td>Description</td>
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<tr>
<td>2-3</td>
<td>1</td>
<td>Lab 1: Wavelet transformation applied to EEG</td>
<td></td>
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<tr>
<td>4</td>
<td>T1</td>
<td>Tutorial 1: Introduction to Simulink</td>
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<tr>
<td>5-6</td>
<td>3</td>
<td>Lab 2: Windkessel model of blood circulation</td>
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<tr>
<td>7</td>
<td>T2</td>
<td>Tutorial 2: Review of course concepts problem solving</td>
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</tr>
<tr>
<td>8-9</td>
<td>T1</td>
<td>Lab 3: System Identification</td>
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Academic Integrity

Missed Classes and/or Evaluations

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. Health certificates - If a student misses the deadline for submitting an assignment, or the date of an exam or other evaluation component for health reasons, they should notify their instructor as soon as possible, and submit a Ryerson Student Health Certificate AND an Academic Consideration Request form within 3 working days of the missed date. Both documents are available at https://www.ryerson.ca/senate/forms/medical.pdf. If you are a full-time or part-time degree student, then you submit your forms to your own program department or school;

2. Religious, Aboriginal and Spiritual observance - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at www.ryerson.ca/senate/forms/relobservforminsrr.pdf. If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;

3. Academic Accommodation Support - Before the first graded work is due, students registered with the Academic Accommodation Support office (AAS - www.ryerson.ca/student/learningsupport/academic-accommodation-support) should provide their instructors with an Academic Accommodation letter that describes their academic accommodation plan.

Academic Integrity

Ryerson's Policy 60 (the Academic Integrity policy) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspicion of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to an including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams
For more detailed information on these issues, please refer to the Academic Integrity policy (https://www.ryerson.ca/senate/policies/pol60.pdf) and to the Academic Integrity Office website (https://www.ryerson.ca/academicintegrity/).

Important Resources Available at Ryerson

1. The Library (https://library.ryerson.ca/) provides research workshops and individual assistance. Inquire at the Reference Desk on the second floor of the library, or go to library.ryerson.ca/guides/workshops.
2. Student Learning Support (https://www.ryerson.ca/studentlearningsupport) offers group-based and individual help with writing, math, study skills and transition support, and other issues.