# BME772: Biomedical Signal Analysis

**Instructor(s)**
Sridhar Krishnan [Coordinator]
Office: ENG 367  
Phone: (416) 979-5000 x 4931 / 7548  
Email: krishnan@ryerson.ca  
Office Hours: Mondays 1pm to 3pm

**Calendar Description**
This course will cover the different biomedical signals and the related signal modeling and analysis techniques. The topics covered in the course include an introduction to various physiological/biomedical signals such as the action potential, the electro-neurogram (ENG), the electromyogram (EMG), the electrocardiogram (ECG), the electroencephalogram (EEG), event-related potentials (ERPs), the electro gastrogram (EGG), the phonocardiogram (PCG), the carotid pulse (CP), signals from catheter-tip sensors, speech and oto-acoustic emission signals. The biomedical signal analysis portion of the course will deal with the analysis of concurrent, coupled and correlated processes, filtering for removal of artifact from biomedical signals, event detection techniques, analysis of wave-shape and waveform complexity associated with biomedical signals, mathematical modeling of biomedical systems, and medical decision support systems.

**Prerequisites**
BLG 601 and BME 632 and BLG 701 and BME 639

**Antirequisites**
ELE 772

**Corequisites**
None

**Compulsory Text(s):**  
TBA

**Reference Text(s):**
1. BME 772 Lecture Notes of Prof. Sri Krishnan  
4. Technical articles and other material [Print-outs to be provided/posted if required]

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

1. Solve design problems (4b)  
2. Analyse data to make decisions. (5b)  
3. Contribute to teamwork in an equitable and timely manner. (6a)  
4. Use Technical vocabulary related to Biomedical Engineering accurately. (7a)  
5. Make concise technical presentations to a peer group. (7b)  
6. Use graphics to analyse and display data. (7c)  
7. Understand how technological innovations can affect the well-being of those that use them. (8b)  
8. Gains a working knowledge of the literature of biomedical engineering and how it effects the day to day life (12b)

**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**
Giordanno Arezza, garezza@ryerson.ca  
Syem Ishaque, sishaque@ryerson.ca
## Course Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Theory</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm Exam</td>
<td>25 %</td>
<td>Lab Reports</td>
</tr>
<tr>
<td>Final Exam</td>
<td>40 %</td>
<td>Project</td>
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<tr>
<td>TOTAL:</td>
<td>100 %</td>
<td>TOTAL:</td>
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**Note:** In order for a student to pass a course with **Theory and Laboratory** components, in addition to earning a minimum overall course mark of 50%, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the “Course Evaluation” section for details on the Theory and Laboratory components.

## Examinations

- Midterm exam in Week 8, two hours, closed book (covers Weeks 1-7).
- Final exam, during exam period, three hours, closed-book (covers Weeks 1-13).

## Other Evaluation Information

### Course Project

- Project on state-of-the-art biomedical analysis systems that may include implementation as well as a written report and presentation. The details will be discussed in class. The project will have to be done in groups of three students.
- A report including the problem statement, methodology, and results for each must be submitted by the date which will be provided later.
- The report should be in IEEE double column format, and should not be more than 6 double-column, single-spaced pages (IEEE templates for Word and Latex may be downloaded from the IEEE website). The presentation of the report will also be required, and a presentation schedule will be provided later in the course.

## Other Information

- None

## Course Content

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<thead>
<tr>
<th>Week</th>
<th>Hours</th>
<th>Chapters / Section</th>
<th>Topic, description</th>
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<tr>
<td>1-2</td>
<td>4</td>
<td>SK Module 1</td>
<td>Biomedical signal analysis: Opportunities and Challenges</td>
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<tr>
<td>2-3</td>
<td>3</td>
<td>SK Module 1</td>
<td>Sensing and acquisition of biomedical signals</td>
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<td>3-5</td>
<td>8</td>
<td>SK Module 2</td>
<td>Filtering of biomedical signals</td>
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<tr>
<td>6-7</td>
<td>6</td>
<td>SK Module 2</td>
<td>Time-domain analysis of biomedical signals</td>
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<tr>
<td>8</td>
<td>2</td>
<td></td>
<td>Midterm</td>
</tr>
<tr>
<td>Week</td>
<td>Lab</td>
<td>Description</td>
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<tr>
<td>2</td>
<td>ENG409</td>
<td>Lab 0: Foundational aspects of biomedical signal analysis</td>
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</tr>
<tr>
<td>3 and 4</td>
<td>ENG409</td>
<td>Lab 1: Synchronized averaging</td>
<td></td>
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<tr>
<td>5 and 6</td>
<td>ENG409</td>
<td>Lab 2: Filtering of the ECG for 60Hz removal</td>
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<tr>
<td>7 and 8</td>
<td>ENG409</td>
<td>Lab 3: QRS Detection and ECG Rhythm Analysis</td>
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<tr>
<td>9 and 10</td>
<td>ENG409</td>
<td>Lab 4: Frequency Domain Analysis</td>
<td></td>
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<tr>
<td>11 and 12</td>
<td>ENG409</td>
<td>Open Lab for projects</td>
<td></td>
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### Policies & Important Information:

1. Students are required to obtain and maintain a Ryerson e-mail account for timely communications between the instructor and the students;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Refer to our Departmental FAQ page for information on common questions and issues at the following link: [https://www.ee.ryerson.ca/studentstruction/Student.Academic.FAQ.html](https://www.ee.ryerson.ca/studentstruction/Student.Academic.FAQ.html).

### 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 Certificate** - 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](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/relobservforminstr.pdf](http://www.ryerson.ca/senate/forms/relobservforminstr.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/studentlearningsupport/academic-accommodation-support](http://www.ryerson.ca/studentlearningsupport/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.

Suspicions 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.