This course was designed to expose students to advanced topics in biomechanics and instrumentation. These topics have been chosen to represent areas where an understanding is necessary for performing biomechanics research and reading biomechanics literature. Students will be presented with lecture material and will be required to complete laboratory reports and assignments as well as a midterm and final exam.

**Instructors:**

Dr. Steve Brown          <shmbrown@uoguelph.ca>  ANNU 330B  ext. 53651  
Dr. Lori Ann Vallis      <lvallis@uoguelph.ca>   ANNU 343  ext. 54589  
Dr. Leah Bent            <lbent@uoguelph.ca>     ANNU 331  ext. 56442  
Mr. Shawn Beaudette      <sbeaudet@uoguelph.ca>  

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**Component:**  
**Schedule:**  
**Location:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Schedule</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>Friday 9:00AM – 12:00PM</td>
<td>SCIE 3317</td>
</tr>
<tr>
<td>Labs 1 and 2</td>
<td>Monday 9:00AM – 12:00PM</td>
<td>JTP 208B</td>
</tr>
<tr>
<td>Labs 3 and 4</td>
<td>Monday 9:00AM – 12:00PM</td>
<td>ANNU 373</td>
</tr>
<tr>
<td>Lab 5</td>
<td>Monday 9:00AM – 12:00PM</td>
<td>ANNU 273</td>
</tr>
<tr>
<td>JOURNAL CLUB</td>
<td>Wednesday noon</td>
<td>SCIE 2315</td>
</tr>
</tbody>
</table>

**Lecture Topics:**

**Bio-Instrumentation**
- Introduction to analog-to-digital recording
- Introduction to biological transducers and signal conditioning
- Electrical terminology
- Examples of transducers
- Critical instrumentation issues (input range, resolution, sampling rate, linearity etc)
- Nyquist Theorem (aliasing error)

**Numerical Methods in Biomechanics**
- Signal-to-noise ratio
- Differentiation methods
- Integration methods
- Frequency domain processing
- Fourier Analysis (the frequency spectrum)
- Frequency statistics applied to EMG (MnPF, MPF etc)
Joint Time-Frequency Analysis
- Smoothing techniques (analog and digital)
- Moving average, polynomial fits, cubic splines
- Filtering (bode plots, high and low-pass filters)
- Analog (RC circuit) and digital methods (eg. Butterworth)
- Auto and cross correlations
- Spike triggered averaging

Electromyography and Muscle Mechanics
- Force-length relationship
- Force-velocity relationship
- Force-EMG relationship
- Factors affecting EMG including electrode spacing, conduction velocity, tissue filtering, etc
- Indwelling EMG – sampling, filter issues

Analysis of Human Motion
- Imaging techniques
- 2D analysis
- Joint and segmental issues
- Defining instantaneous joint centres
- Rotation matrices
- 3D Analysis
- Issues beyond 2D

Dual Energy X-Ray absorptiometry
- Theory behind calculation of body anthropometrics specifically the measurement of bone mineral density and body fat composition
- Calibration procedures for data acquisition
- Limitations (e.g. radiation exposure) and caveats for the use of this imaging technology

Course Evaluation:

<table>
<thead>
<tr>
<th>Method of Assessment</th>
<th>Percent of final grade</th>
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</thead>
<tbody>
<tr>
<td>Assignments (2 x 5% each)</td>
<td>10%</td>
</tr>
<tr>
<td>Laboratory Reports (4 x 10 % each)</td>
<td>40%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>30%</td>
</tr>
</tbody>
</table>

Assignments:
The assignments are intended to reinforce material presented in lecture and will require you to apply equations and processing methods discussed in class to supplied data sets, interpret
processed data and finally writing about your findings in the context of literature. The written instructions and data sets for each assignment will be located on the D2L site for the course.

**Laboratory Reports:**
The laboratory reports are intended to reinforce material presented in lecture and provide hands-on experience with all aspects of bio-instrumentation, signal processing and data analysis. We will cover a different area of study for each of these five (5) laboratory seminar sessions. The laboratory experiences have been designed to encourage all biomechanics students to work together in laboratory to trouble shoot/comple the assigned lab with the goal of fostering a positive learning experience for all involved. Students enrolled in this course will be required to participate in all laboratory sessions and process the data collected. Following the lab, students will be asked to disseminate their findings in a brief laboratory report. An outline describing the expectations and format for each lab reports will be distributed in lecture; format may change depending on content and the different instructors for the course.

**Midterm and Final Exams:**
The midterm exam will cover material presented in lectures will test all material taught in the first half of the course. The final exam will focus on remaining material, however, as the first part of the course contains important fundamental concepts, some overlap may be present.

*To give you an idea of the expectations and potential examination questions, copies of exams from previous years will be made available to you prior to the mid-term and final examination.*

**Readings:**
Selected references and readings will be required for lectures. A list of required reading is attached. These reading will help in understanding the course material and it is advised that they are read prior to the assigned lecture. While the papers will not formally be taken up in class, you are responsible for their content.

**Advice:** ☺
The assignments and laboratory seminar preparation can consume a very large amount of time depending on your background and how well you have synthesized the course material and supplementary readings. You should prepare for the laboratory sessions prior to arriving to collect the data. This will insure that the data you collect will address the lab questions and limit the number of times you have to recollect the data. Make sure to start the assignments and seminar preparation early, as there will be a new assignment or seminar almost every week. **There will be no extensions and late material will receive a maximum of half marks.**

**Ethics**
Ethical approval has been obtained from the Research Ethics Board at the University of Guelph for subject participation. Please refer to the [University of Guelph ethics website](http://example.com) for further information.

If you have any concerns about the ethics of this research, please contact the University of Guelph ethics officer, Sandy Auld, Telephone: (519) 824-4120, ext. 56606, E-mail: sauld@uoguelph.ca, Fax: (519) 821-5236.
HK*6200 Fall 2015

Course Outline

LECTURE TIMES: Friday 9 am - noon (Science Complex 3317)
LAB TIMES: Mon 9 am to noon: for Labs 1,2; ANNU 373 for Labs 3,4; ANNU 273 for Lab 5
JOURNAL CLUB: Wednesday noon (SCI 2315)

<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture Topic (Fri)</th>
<th>Date</th>
<th>Assignment/Lab (Mon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept 11 (Steve)</td>
<td>Overview of Course Signal Analysis (Properties of signals; time, amplitude domains; frequency domain)</td>
<td>Sept 14 10 AM (Lori)</td>
<td>Assignment 1: Annu 338 COP &amp; COM calculations</td>
</tr>
<tr>
<td>Sept 18 (Steve)</td>
<td>Numerical Methods (Differentiation, integration smoothing, filters; transducers)</td>
<td>Sept 21 (Dan)</td>
<td><strong>Lab 1:</strong> JTP 208B A/D Conversion &amp; Frequency response: Analogue &amp; digital filter</td>
</tr>
<tr>
<td>Sept 25 (Steve)</td>
<td>Biinstrumentation (Transducers)</td>
<td>Sept 28 (Dan)</td>
<td><strong>Lab 2:</strong> JTP 208B Using an oscilloscope &amp; DAQ to acquire data from Transducer (spring damper system)</td>
</tr>
<tr>
<td>Oct 2 (Steve)</td>
<td>Bioinstrumentation &amp; Numerical Methods: Summary</td>
<td>Oct 5 (Steve)</td>
<td>Assignment 2: JTP 208B Filtering, differentiation, interpolation, extrapolation; re-sampling</td>
</tr>
<tr>
<td>Oct 9 (Lori)</td>
<td>Kinematics 1 (Goniometer, electromagnetic, accelerometers, optical recordings; DEXA)</td>
<td>Oct 12</td>
<td><strong>Lab 2 due</strong></td>
</tr>
<tr>
<td>Oct 16 (Steve &amp; Lori)</td>
<td>Review Session</td>
<td>Oct 19</td>
<td>Midterm Exam (SCIE 2315)</td>
</tr>
<tr>
<td>Oct 23 (Leah)</td>
<td>Numerical Methods 2 (Correlations; spike triggered avg)</td>
<td>Oct 26 (Leah)</td>
<td><strong>Lab 3 Group A:</strong> ANNU 373 Surface &amp; Indwelling EMG of FDI muscle</td>
</tr>
<tr>
<td>Oct 30 (Leah)</td>
<td>EMG 1 (X-bridge theory; recruitment; instrumentation; vel-force relationships)</td>
<td>Nov 2 (Leah)</td>
<td><strong>Lab 3 Group B:</strong> ANNU 373 Surface &amp; Indwelling EMG of FDI muscle</td>
</tr>
<tr>
<td>Nov 6 (Leah)</td>
<td>EMG 2 (Force &amp; fatigue relationship; EMG analysis techniques)</td>
<td>Nov 9</td>
<td>No Lab</td>
</tr>
<tr>
<td>Nov 13 (Shawn)</td>
<td>Kinematics 2 (Marker systems; DLT theory)</td>
<td>Nov 16 (Lori)</td>
<td><strong>Lab 4:</strong> ANNU 273/272 Kinematics: Comparison of data from different marker systems</td>
</tr>
<tr>
<td>Nov 20 (Shawn)</td>
<td>Kinematics 3 (reference frames; coordinate systems);</td>
<td>Nov 23</td>
<td>No Lab</td>
</tr>
<tr>
<td>Nov 27 (Shawn)</td>
<td>Kinematics 4 Wrapping it all up!</td>
<td>Nov 30</td>
<td>Review class (Shawn &amp; Leah)</td>
</tr>
</tbody>
</table>

**Final Exam Period is Dec 1-12; Exam Tentatively scheduled for Friday Dec 4, 2015 (SCIE 2315)**
Guidelines to Help Focus Reading of Scientific Papers

The following are some guidelines to keep in mind while reading scientific publications.

1. What was the reason for doing the work in the first place?
2. Was the question posed in a researchable way?
3. What was being measured?
4. Was the measure appropriate to answer #1?
5. How was it measured?
6. Was the measurement technique suitable?
7. Were there any assumptions or errors (implicit or explicit) that might nullify any conclusions drawn?
8. What were the main useful facts and findings?
9. What did the author(s) conclude?
10. Were the finding/data unequivocal? Were/are there other equally valid interpretations?
11. How would you have approached the research problem?

Suggested General Readings


Bio-instrumentation Section:


**Numerical Methods Section:**


This is an informative and detailed text. The material is intended to reinforce the concepts that are covered in class. Accordingly, only certain sections are pertinent. For example:

- **Chapter 1**: pages 1-3 DSP intro
- **Chapter 2**: pseudocode representation of algorithms, Σ, time domain, pdf, cumulative pdf, precision/accuracy.
- **Chapter 3**: quantization and sampling theorem apply to Bioinstrumentation section.
- **Chapter 4**: general concepts from pages 67-76.
- **Chapter 5**: to page 100 & Fourier decomposition pg. 104.
- **Chapter 8**: Discrete Fourier Transform
- **Chapter 14**: Digital Filters etc.


**Electromyography Section**


**Analysis of Motion Section:**


41. S. H. Wei, K. J. McQuade, and G. L. Smidt. Three-Dimensional Joint Range of Motion


**Dual-energy X-ray absorptiometry (DEXA) Section:**


Course and University Policies

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 and be prepared to provide supporting documentation. See the Graduate Calendar for information on regulations and procedures for Academic Consideration on page 11 in pdf version.

Accessibility
The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact Student Accessibility Services as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca. Also, see the website: Student Accessibility Services and Academic Accommodation the Graduate Calendar.

Academic Misconduct
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 discourages misconduct. 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.

The Academic Misconduct Policy is detailed in the Graduate Calendar: Academic Misconduct

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

Drop Date
The last date to drop one-semester courses, without academic penalty, is the 40th class day. To confirm the actual date please see the schedule of dates in the Graduate Calendar.
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.

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

Grading
Indicate all course policies regarding in-semester tests and assignment submissions, including time and place for submission of assignments and explicit penalties for late submissions.

Campus Resources
The Academic Calendar is the source of information about the University of Guelph’s procedures, policies and regulations which apply to undergraduate, graduate and diploma programs: Academic Calendars

If you are concerned about any aspect of your academic program:

● Make an appointment with your corresponding Graduate Coordinator or Research Supervisor or Department Chair.

If you are struggling with personal or health issues:

● Counselling services offers individualized appointments to help students work through personal struggles that may be impacting their academic performance. Counselling Services
● Student Health Services is located on campus and is available to provide medical attention. Student Health Services
● For support related to stress and anxiety, besides Health Services and Counselling Services, Kathy Somers runs training workshops and one-on-one sessions related to stress management and high performance situations. Stress Management & High Performance Clinic

If you have a documented disability or think you may have a disability:

● Student Accessibility Services (formerly Centre for Students with Disabilities) can provide services and support for students with a documented learning or physical disability. They can also provide information about how to be tested for a learning disability. For more information, including how to register with the centre please see: Student Accessibility Services