COURSE DETAILS

Units of Credit 6
Contact hours 3 hours per week
Lecture Tuesday 15:00 – 18:00 Mathews 232
Tutorial/Laboratory Tuesday 15:00 – 18:00 or 18:00– 21:00 Samuels 518 (Design Lab)

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INFORMATION ABOUT THE COURSE

Background

Welcome to “Biomedical Instrumentation”. This course deals primarily with gaining an understanding of the physical principles which govern the measurement of a biological variable or system by a transducer which converts the variable into an electrical signal. By the end of the course you should understand various measurement devices and approaches including the underlying biological process that generates the quantity to be measured or controlled. You should also be qualified to advise on the choices available for a given measurement and the advantages and disadvantages of each alternative.

Concomitant with the development of modern medicine has been the increasing application of scientific methods and devices in the clinical setting. The central component of the scientific method is measurement and related to this biomedical instrumentation. It is therefore not surprising that biological instrumentation and physiological monitoring is an international, multi-billion dollar industry.

When one needs to understand or manage a system or process, one of the critical requirements is to be able to measure or sample various aspects of the system. From an engineering viewpoint, accurate measurement and acquisition of system observers is a fundamental necessity in order to model, understand and ultimately control a system. From a clinical viewpoint, the basis of a diagnosis is derived from observations and measurements. Biomedical instrumentation is an integral component of modern clinical medicine, bioscience discovery and medical research. The acquisition or transduction of physiological signs or variables is an essential component of the majority of diagnostic and therapeutic medical devices.

In this course we explore the complexity of physiological measurement. Initially a synthesis approach is taken, examining the fundamental principles of electrical engineering. This is followed by a systems approach to examine in a general way a computer-based, clinical recording instrument. A ‘black box’
representation of the instrument is presented – where we consider the instrument as a collection of functional units. This representation is broken down or reduced to functional units including transduction, amplification, filtering, digitisation and computer analysis.

The majority of the course however focuses on the very first unit in the instrument, namely that of biosensing or transduction. In a biosensor, a physical quantity that has a correspondence with a physiological variable is sensed and typically converted or ‘transduced’ to an electrical quantity for further processing by the instrument. In terms of terminology, a transducer is the general name for a sensor or actuator. In a broad definition, a sensor is a device that detects a change in physical stimulus and converts it into a signal, which can then be measured or recorded. An actuator does the converse in that it produces observable outputs in a system. The general concept of 'transduction' therefore is a device that transfers a signal from one energy system to another in the same or in a different form. In the majority of cases, a sensor converts a measured object quantity into an electrical signal. Once an object quantity is converted into an electrical signal, then standard instrumentation techniques can be applied.

The other term which needs definition is that of ‘signal’. The essential characteristic of a signal is that of being able to change as a function of space or time. In the case of a biological signal, it is a detectable unit of information that characterises the behaviour, structure or function of the biological system or process under study.

When performing physiological measurement, some signals are intrinsic to bodily function (for example voltages from biopotentials), whereas others are modulated when external energy sources are applied to the body (for example, blood flow in a vessel measured using an electromagnetic or ultrasonic flow meter).

Object quantities in biomedical measurements are typically chemical, mechanical or electric quantities that echo physiological functions in the living system. Specifically in this course we examine biosensing of electrical events – commonly called biopotentials. We also examine the process of neural stimulation of excitable tissue and temperature sensing.

BIOM9640 is a 6 UOC course and it is expected that you will devote a minimum of 9 hours per week to this course. In addition to the 3 hours in class, you should spend 6 hours per week reading lecture and reference materials and working on tutorial problems and assignments. This is particularly the case if you have not been exposed to the basic concepts underpinning electrical engineering.

**Presumed knowledge**

Some mathematics background is essential. It is helpful but not essential that you have some knowledge of electrical circuits and systems as well as complex number arithmetic. The essential material will be reviewed during the course.

**How this course relates to other courses**

BIOM9640 consists of integrated lecture, tutorial and practical work and includes a major revision of electrical engineering knowledge as well as a focus on instrumentation and measurement relating to bioelectric phenomena. BIOM9650 (Biosensors and Transducers) runs in semester 2 and focuses on other sensing and transduction mechanisms (displacement, force, volume, pressure, flow, etc.) used for clinical measurements. Some of the basic electrical engineering fundamentals introduced in BIOM9640 will be assumed knowledge in BIOM9650.

The course BIOM9660 (Implantable Bionics), expands on aspects of electrical engineering circuits, bioelectrodes, biopotentials and neural stimulation from the perspective of designing and manufacturing an implantable therapeutic device. The course BIOM9711 (Modelling Organs, Tissues and Devices) provides a practical overview of computational modelling in bioengineering, focusing on a range of applications including electrical stimulation of neural and cardiac tissues. The knowledge gained in BIOM9640 will assist in understanding these processes.

**HANDBOOK DESCRIPTION**


**OBJECTIVES**

The objectives of this course are to:
• introduce students to the fundamentals of electrical engineering as it relates to understanding bioelectric phenomena and neural stimulation
• understand the physical principles which govern the measurement of a biological variable or system by a transducer which converts the variable into an electrical signal
• understand various measurement devices and approaches including the underlying biological process that generates the quantity to be measured or controlled

TEACHING STRATEGIES
This course consists of integrated lecture, tutorial and practical work. For the first half of the semester there will be a 3 hour period comprising a lecture and small group exercises/tutorials, group discussions and other methods to facilitate student learning. In the latter half of the semester a set of laboratory experiments will be conducted to reinforce practical aspects of biomedical instrumentation and bioelectric phenomena. Problem solving is an essential component of this subject. A Moodle courseware module has been established for this subject (http://moodle.telt.unsw.edu.au). Upcoming tutorial tasks, discussion groups and lecture notes and resource materials will be made available on this site during semester. Please look at announcements on Moodle for last minute changes. Assessments and feedback on tutorial work will be regularly provided to the students.

This course requires you to understand the lecture material and then apply the knowledge to basic bioinstrumentation applications. It is important to understand the fundamental concepts as soon as possible and to ask for help if you do not understand. Attend all the lectures and if something is unclear, please ask questions. Make sure you review all the lecture notes and read all material that is suggested or handed out. Class participation through attendance at lectures and participation in class exercises and group work is expected and will allow for alternative methods of absorbing the relevant information.

The material is diverse and not as tightly linked into an overall analytical structure as in some other subjects. You will need to be prepared to assimilate facts relating to a large number of different measuring instruments and measurement principles. If you treat this assimilation simply as an exercise in rote learning, the volume of material will make it hard. If you become sufficiently involved and interested in the material, you will find it easy to comprehend; very much less rote learning will be needed because you will understand the principles and be able to work out the consequences.

EXPECTED LEARNING OUTCOMES
On completion of this course, the student should:
• L1: have a broad understanding of the scope of biomedical instrumentation and its applications
• L2: understand the fundamental general transduction and biosensing principles used
• L3: be able to discuss, develop and apply electrical engineering concepts and principles to a range of problems and medical applications
• L4: critically review the literature in the area and apply knowledge gained from the course to analyse simple biosensing and transduction problems
• L5: clearly summarise and communicate findings from literature research using oral and written methods

For each hour of contact it is expected that you will put in at least 2 hours of private study.

ASSESSMENT
There will be a mid semester quiz, hand-in tutorial questions and a major laboratory report. There will also be a final examination consisting of both qualitative and quantitative long-answer questions. The following criteria will be applied in assessing your work:

• evidence of critical understanding of the concepts developed in the course
• ability to apply these concepts to a range of bioinstrumentation problems
• clarity of description, explanation and attention to the focus of the assessment task
• degree to which the material submitted for assessment addresses the specified requirements

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<tr>
<th>Assessment</th>
<th>Contribution</th>
<th>Comment</th>
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<tr>
<td>Tutorials/Hand in Questions</td>
<td>15%</td>
<td>A major aspect of this course is problem solving. This entails choosing the appropriate model, implementing it correctly and arriving at the correct answer. To complete the hand in questions,</td>
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students will use fundamental material from the lectures and tutorials. Assignments should be submitted on time. Marks may be deducted for late submission without prior approval. Related learning outcomes include L1, L2, L3. Related graduate capabilities include:
- understanding of the discipline in its interdisciplinary context
- rigorous in analysis, critique and reflection
- able to apply knowledge and skills to solving problems

Mid Semester Quiz 20%  A quiz is scheduled half way through the session. It comprises short answer questions and/or multiple choice questions in a format similar to the final exam. The aims of this assessment are to encourage student revision during the course and to allow students to gauge their progress in different topics and receive feedback on that progress. This assessment is a direct test of the degree to which the knowledge based learning outcomes listed above have been achieved. Related learning outcomes include L1, L2, L3. Related graduate capabilities include:
- understanding of the discipline in its interdisciplinary context
- rigorous in analysis, critique and reflection
- able to apply knowledge and skills to solving problems
- capable of independent, self-directed practice

Major Laboratory Report 15%  One laboratory will be chosen and the student will be expected to prepare a formal laboratory report that will include results, discussion, error sources and reference to relevant literature. The objectives of the major report are to consolidate information learned in class and to develop critical data analysis and literature research skills. Related learning outcomes include L2, L4, L5. Related graduate capabilities include:
- capable of independent and collaborative enquiry
- capable of effective communication
- information literate
- enterprising, innovative and creative
- collaborative and effective team workers
- understanding of the discipline in its interdisciplinary context
- rigorous in analysis, critique and reflection
- able to apply knowledge and skills to solving problems
- capable of independent, self-directed practice
- capable of lifelong learning

Laboratory Attendance 10%  It is expected that students will attend all laboratory classes and document results and discussion in a formal laboratory book. This book will be marked for completeness and consistency with a set of laboratory notebook guidelines that will be supplied to the student. The first laboratory involving using an oscilloscope is also assessable. Related learning outcomes include L2.

Final Exam 40%  The final exam may be made up of any of the following: true/false, multiple choice, matching, short answer and essay questions. The aims of this assessment are to encourage students to review the entire course including laboratory work and to allow students to apply all the knowledge disseminated to solve problems. This assessment is a direct test of the degree to which the knowledge based learning outcomes listed above have been achieved. Related learning outcomes include L1, L2, L3, L4. Related graduate capabilities include:
- understanding of the discipline in its interdisciplinary context
- rigorous in analysis, critique and reflection
- able to apply knowledge and skills to solving problems
- capable of independent, self-directed practice
RELEVANT RESOURCES

Moodle is the main resource for this course and can be found at http://moodle.telt.unsw.edu.au. Two useful reference books that are held in the UNSW Library are:

Biomedical Transducers and Instruments, by T. Togawa, T. Tamura and P.Å. Öberg (CRC Press).

An excerpt from a chapter in a book titled 'Physiological Measurement' will also be supplied.

COURSE EVALUATION AND DEVELOPMENT

Anonymous student feedback on the course and the lecturers in the course is gathered periodically using the university's Course and Teaching Evaluation and Improvement (CATEI) Process. Your feedback is much appreciated and taken very seriously. Continual improvements are made to the course based in part on such feedback and this helps us to improve the course for future students. For 2016, more sessions dedicated to problem solving will be included as well as video tutorials for Matlab and lab work.

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:
https://my.unsw.edu.au/student/resources/KeyDates.html

PLAGIARISM

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise will have their names entered on plagiarism register and will be liable to disciplinary action, including exclusion from enrolment.

It is expected that all students must at all times submit their own work for assessment. Submitting the work or ideas of someone else without clearly acknowledging the source of borrowed material or ideas, is plagiarism.

All assessments which you hand in must have a Non Plagiarism Declaration Cover Sheet. This is for both individual and group work. Attach it to your assignment before submitting it to the Course Coordinator or at the School Office.

Plagiarism is the use of another person’s work or ideas as if they were your own. When it is necessary or desirable to use other people’s material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:
https://student.unsw.edu.au/plagiarism

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism,
- Special Considerations,
- School Student Ethics Officer, and
- BESS

Refer to the School website available at:
http://www.engineering.unsw.edu.au/biomedical-engineering/
<table>
<thead>
<tr>
<th>Wk</th>
<th>Date</th>
<th>Lectures</th>
<th>Tutorials (after lecture as part of 3-6pm slot)</th>
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<tbody>
<tr>
<td>1</td>
<td>1 Mar</td>
<td>Overview of instrumentation, signal conditioning and processing. Basic DC</td>
<td>NL Tute 1: DC Circuits</td>
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<td>circuit theory - passive components, voltage and current sources, Ohm's</td>
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<td>law, Thevenin's theorem, Kirchoff's law, complex numbers, voltage</td>
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<td>divider principle.</td>
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<td>2</td>
<td>8 Mar</td>
<td>Simple DC and AC circuit analysis, low and high pass filters.</td>
<td>NL Tute 2: AC Circuits</td>
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<tr>
<td>3</td>
<td>15 Mar</td>
<td>Bode plots, operational amplifiers, active filters, instrumentation</td>
<td>SR Tute 3: Opamps and filters</td>
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<td></td>
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<td>amplifiers.</td>
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<td>4</td>
<td>22 Mar</td>
<td>Electrodes and biopotentials.</td>
<td>RG Tute 4: Biopotentials and electrodes</td>
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<td>5</td>
<td>29 Mar</td>
<td>Mid Session Break</td>
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<td>6</td>
<td>5 Apr</td>
<td>Cells and excitable tissue, action potentials and propagation, modelling.</td>
<td>SR Tute 5: Excitable tissue</td>
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<td>7</td>
<td>12 Apr</td>
<td>Instrumentation for measurements from excitable tissue. Sources of</td>
<td>SR Tute 6: Amplification and noise</td>
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<td>noise and noise reduction techniques. Temperature measurement.</td>
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<td>8</td>
<td>19 Apr</td>
<td>Quiz</td>
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<td>9</td>
<td>26 Apr</td>
<td>Physics: 1 Measurement</td>
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<td>Lab 2: Matlab</td>
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<td>10</td>
<td>3 May</td>
<td>Labs 3 – Lab 8</td>
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<td>11</td>
<td>10 May</td>
<td>Labs 3 – Lab 8</td>
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<tr>
<td>12</td>
<td>17 May</td>
<td>Labs 3 – Lab 8</td>
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<tr>
<td>13</td>
<td>24 May</td>
<td>Labs 3 – Lab 8</td>
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<td>14</td>
<td>31 May</td>
<td>Revision</td>
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Laboratories 3-8 (weeks 9-12) comprise one of the following depending on which group you are assigned:
3. Bioelectrodes
4. Electrocardiograms
5. Functional Electrical Stimulation
6. Visual Evoked Response
7. Temperature
8. Excitable tissue model in Matlab

Group A will do their laboratories on Tuesdays 3pm – 6pm in weeks 8-12. Group B will do their laboratories on Tuesday 6pm – 9pm in weeks 8-12. A laboratory schedule will be provided on Moodle later in the semester.