ELEC215

Biomedical Engineering Fundamentals

S2 Day 2019

School of Engineering

Contents

General Information

Unit convenor and teaching staff
Unit convenor
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Friday 3 pm - 7 pm

Lecturer, Tutor
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Credit points
3

Prerequisites
(MATH133 or MATH136) and (PHYS106 or PHYS140)

Corequisites
MATH235

Co-badged status

Unit description
The aim of this unit is to provide a basic understanding of human physiology with an emphasis on the human body that can be described as an ensemble of interacting systems. In a first module, an overview of physiological dynamics will be provided against a background of structural components from cells and tissues to organs. In a second module, major physiological systems will be explained: The cardiovascular (circulatory) system, the respiratory system, the nervous system, the endocrine, reproductive and lymphatic system, the gastrointestinal and urinary system, the sensory (auditory, visual, olfactory) and integumentary system, the skeletal and muscular system. The physiological systems will be discussed from an engineering point-of-view with an emphasis on numerical modeling. This involves quantitative mechanical analysis, flow dynamics, heat and mass transport and electrical analysis. The third module will focus on pharmacokinetic models, i.e. how the uptake, distribution and excretion of exogenous substances can be modeled using differential equations. Finally, it will be shown how a multiscale model can be used to model cancer progression. The theory of physiological systems will be tested in practice through practical sessions which involve measurements of physiological signals with an eHealth Arduino module and numerical modelling in Matlab.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);

Be able to perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.

Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders of magnitude of the outcomes which will enable them to interpret the simulated results critically;

Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

General Assessment Information

Grading and passing requirement for unit

In order to pass this unit a student must obtain a mark of 50 or more for the unit (i.e. obtain a passing grade P/ CR/ D/ HD).

Hurdle Requirements

The final examination is a hurdle requirement. A grade of 50% or more in the final examination is a condition of passing this unit.

Participation in tutorial/practical sessions is a hurdle requirement and students are required to attend at least 9/12 practical sessions to pass this unit.

Late submissions and Resubmissions

Late submissions will attract a penalty of 20% marks per day. Extenuating circumstances will be considered upon lodgment of an application for special consideration.

Resubmissions of work are not allowed.

Assessment Tasks

Name	Weighting	Hurdle	Due
Laboratory participation	10%	No	Weekly (starts on week 2)
Quizzes	5%	No	Week 3, 5, 7, 9, 11
Hodgkin-Huxley model	10%	No	week 6
Physiological modeling	10%	No	week 8
Physiological measurments	10%	No	week 9
Literature study	6%	No	week 10
Oral presentation	4%	No	week 11-12
Exam	45%	Yes	week 14-16

Laboratory participation

Due: **Weekly (starts on week 2)**
Weighting: **10%**

Practical sessions start in week 2 and are comprised of laboratory or problem-solving workshop sessions linked to the learning outcomes. Practical sessions are compulsory for all students. Students are expected to arrive on time and use the laboratory time efficiently. Students should enroll in one practical class at the beginning of the semester. Laboratory or workshop worksheets, required data and other necessary items will be posted on iLearn prior to the weekly sessions and it is compulsory for students to complete the preparatory work before coming to the session. It is strongly advisable to rehearse the lecture material before each practical session.

Practicals will be largely assessed in class but there may be some "take-home" assignments for the laboratory sections. More information will be available on iLearn.

On successful completion you will be able to:

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.
- Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders of magnitude of the outcomes which will enable them to interpret the simulated results critically;
- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Quizzes

Due: **Week 3, 5, 7, 9, 11**
Weighting: **5%**

Short in class tests on the content of previous 2 lectures

On successful completion you will be able to:

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders of magnitude of the outcomes which will enable them to interpret the simulated results critically;

Hodgkin-Huxley model

Due: **week 6**
Weighting: **10%**

Matlab numerical modelling of propagating action potentials in neurons (Hodgkin-Huxley model)

On successful completion you will be able to:

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders of magnitude of the outcomes which will enable them to interpret the simulated results critically;

Physiological modeling

Due: **week 8**
Weighting: **10%**

Matlab simulations of the cardiovascular system.

A good model to simulate blood flow in the aorta is the Windkessel function. For this assignment, you are asked to write a Matlab script that models the aortic blood flow by use of a 3-element Windkessel model.

On successful completion you will be able to:

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders of magnitude of the outcomes which will enable them to interpret the simulated results critically;

Physiological measurments

Due: **week 9**
Weighting: **10%**

In this assignment you will be asked to report on physiological measurements conducted during the practical sessions.

It involves **three major experiments**:

1. EEG

2. Blood pressure and pulse measurements

3. Ultrasound measurements

More details on the requirements for these exercises are provided on iLearn.

On successful completion you will be able to:

- Be able to perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.

Literature study

Due: **week 10**
Weighting: **6%**

A specific healthcare problem will be discussed in the practical session. Aided by the scientific literature, your task will be to analyze the problem from a technological, societal, economical and ethical point-of-view and provide possible solutions to the problem.

On successful completion you will be able to:

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Oral presentation

Due: **week 11-12**
Weighting: **4%**

Oral presentation of the literature study by use of a powerpoint slide presentation.

On successful completion you will be able to:

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Exam

Due: **week 14-16**
Weighting: **45%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

Invigilated test of the learning outcomes.

On successful completion you will be able to:

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders

of magnitude of the outcomes which will enable them to interpret the simulated results critically;

Delivery and Resources

Delivery of this course is through a series of 13 theoretical lectures of 2 hours each and a series of practical sessions / tutorials.

The theoretical lecture series consist of 3 modules:

1. The Physiome: From cell to organism with a focus on biophysical concepts;
2. Physiological systems with a focus on modelling and measurement techniques;
3. Pharmacokinetic models where the uptake and excretion of exogenous substances will be discussed.

The practical sessions and tutorials involve hands-on experimentation using Arduino microcontrollers and sensors for physiological monitoring, an EEG system for measuring brain activity and an ultrasound scanner. Tutorial sessions will be provided to teach how to process signals and images in Matlab and to write Matlab scripts and functions. Matlab exercises on physiological monitoring will be conducted in the practical sessions.

Technology used and required

- Word processing (MS Word, Latex, ...)
- Arduino software (freeware)
- Matlab (can be downloaded from the university depositories)
- Powerpoint (or alternative presentation software (e.g. SliTex))
- Library and Internet search engines

Textbooks

The provided lecture material should be sufficient to obtain a profound understanding of the covered topics but some helpful textbooks for further reading will be recommended on iLearn and/or in the lecture notes.

Unit Schedule

Week	Lecture	Practical session / Tutorial	Assignments
The Physiome			
1	Biochemistry		
2	The Cell	Matlab Tutorial Session	
3	Cell Physiology	Matlab Exercices (DNA sequence analysis)	

4	Human tissues	Fluorescence microscopy + Matlab Exercises (Tumour Growth model)	
Physiological Systems			
5	Mathematical modelling physiological systems	Matlab: Electrophysiology	
6	The nervous system	Elecroencephalography (EEG)	Hodgkin Huxley model (Report + code)
7	The cardiovascular system	Arduino: Cardiac monitoring + Ultrasound	
8	The respiratory system	Matlab: Cardiovascular system + Experiment Windkessel function	Physiological modeling (Report + code)
9	The urinary system	Practical: Thermal imaging / Image processing in Matlab	Physiological measurements (Lab report)
10	The musculoskeletal system	Practical: Kidney dialysis filter experiment / Simulation (Matlab)	Literature study (report)
Pharmacokinetic models			
11	Drug delivery	Literature study presentations + Matlab: Simulation	Literature study (oral presentation)
12	Pharmacokinetic modeling	Literature study presentations + Matlab: Pharmacokinetic modeling	Literature study (oral presentation)
13	Cancer treatment	Round up, Research lab visit and Q&A	

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy (***Note:*** *The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

If you are a Global MBA student contact globalmba.support@mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcome

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Physiological measurments
- Literature study

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Literature study
- Oral presentation

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcome

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Literature study
- Oral presentation

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.
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- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Quizzes
- Hodgkin-Huxley model
- Physiological modeling
- Literature study
- Exam

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- Demonstrate an understanding of physiological systems on both the microscopic and macroscopic level: the nervous system, the cardiovascular system, the pulmonary system, the urinary system, the musculoskeletal and sensory systems (auditory, visual, olfactory);
- Be able to perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.
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- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Quizzes
- Hodgkin-Huxley model
- Physiological modeling
- Physiological measurments
- Literature study
- Oral presentation
- Exam

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- Be able to translate a physiological system into a mathematical concept: The steps involved in this process consist of (1) drawing a block schematic diagram (with feedback loops), (2) translating the block diagram into a differential equation and (3) being able to solve the differential equation (e.g. by using the Laplace transform and/or numerical computational methods). It is expected that students should also have a sense of orders of magnitude of the outcomes which will enable them to interpret the simulated results critically;
- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Hodgkin-Huxley model
- Physiological modeling
- Physiological measurments
- Literature study

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcomes

- Be able to perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.
- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Physiological measurments
- Oral presentation

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcome

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Literature study

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcome

- Analyse a healthcare problem from both an engineering, physiological and ethical perspective and be able to communicate and discuss possible solutions with healthcare stakeholders (patients and patient organisations, clinicians, government policy makers, healthcare industry).

Assessment tasks

- Laboratory participation
- Literature study

Changes from Previous Offering

A practical session on kidney dialysis will be organised.