BENG2015

Biomedical Engineering Fundamentals

Session 2, Special circumstance 2020

School of Engineering

Contents

Notice

As part of Phase 3 of our return to campus plan, most units will now run tutorials, seminars and ot her small group learning activities on campus for the second half-year, while keeping an online ver sion available for those students unable to return or those who choose to continue their studies onli ne.

To check the availability of face-to-face and onlin e activities for your unit, please go to timetable vi ewer. To check detailed information on unit asses sments visit your unit's iLearn space or consult yo ur unit convenor.

General Information

Unit convenor and teaching staff
Yves De Deene
yves.dedeene@mq.edu.au

Credit points
10

Prerequisites
(PHYS1520 or PHYS140) and (MATH1020 or MATH1025 or MATH136 or MATH133)

Corequisites
MATH235 or MATH2055

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:

ULO1: 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);
ULO2: Perform physiological measurements, process the acquired physiological signals and images, critically evaluate the processed results and present in a clearly written laboratory report.
ULO3: 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).
ULO4: 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;

General Assessment Information

Notifications

Formal notification of assessment tasks, grading rubrics and due dates will be posted on iLearn. Although all reasonable measures to ensure the information is accurate, the University reserves the right to make changes without notice. Each student is responsible for checking iLearn for changes and updates.

Weekly Plan

A weekly plan of lectures, assignments, tests, laboratory and workshop sessions will be posted on iLearn. Students are expected to be aware of possible minor variations.

Assignment Tasks

Assignment questions will be posted on iLearn.

All assignments must be submitted electronically through iLearn (in pdf format). Submissions are expected to be typed in a logical layout and sequence. Markers WILL NOT grade poorly organized or illegible scans or drafts. Illegible scans or drafts are assignments that are handwritten or digital photographed with for example a smartphone. The expected workload includes preparation of final copies and clear diagrams. Re-submissions will be permitted up to due date.

All assignments should be prepared individually. It is expected that students consult the unit convenor or other students while learning the concepts, but copying assignments from others is not accepted. Students are expected to have read and understood the academic honesty policy.

Late submissions and Re-submissions

Late submissions will attract a penalty of 30% marks per day. Extenuating circumstances will be considered upon lodgement of an application for special consideration.

Re-submissions of work are not allowed.

Absences

Late notices or absences from tests, workshops and laboratories will be considered under extenuating circumstances upon lodgement and approval of a formal notice of special considerations. You must attend and participate in at least 10 of the 12 weekly practical classes to pass this unit. This is a hurdle requirement.

Grading and passing requirement for unit

To obtain a passing grade (P/CR/D/HD) a total mark of 50% or more is required AND a mark of 50% or more is required for the final examination. For further details about grading, please refer below in the policies and procedures section.

If you receive special consideration for the final exam, a supplementary exam will be scheduled by the faculty during a supplementary exam period, typically about 3 to 4 weeks after the normal exam period. By making a special consideration application for the final exam you are declaring yourself available for a resit during the supplementary examination period and will not be eligible for a second special consideration approval based on pre-existing commitments. Please ensure you are familiar with the policy prior to submitting an application. Approved applicants will receive an individual notification one week prior to the exam with the exact date and time of their supplementary examination.

Hurdle Requirements

The final exam is a hurdle requirement because it is the only reliable assessment of individual performance for this unit. A passing grade of 50% or more in the final examination is a condition of passing this unit. Students who make a serious attempt but fail to meet the hurdle requirement will be given one further opportunity to pass.

If you are given a second opportunity to sit the final examination as a result of failing to meet the minimum mark required, you will be offered that chance during the supplementary examination period and will be notified of the exact day and time after the publication of final results for the unit. The second attempt at a hurdle assessment is graded as pass fail. **The maximum grade for a second attempt is the hurdle threshold grade.**

Assessment Tasks

Name	Weighting	Hurdle	Due
Hodgkin-Huxley model	10%	No	Week 7

Name	Weighting	Hurdle	Due
Quizzes	10%	No	Every second (even) week
Literature study	10%	No	Week 12
Formal exam	50%	Yes	Exam week
Physiological measurments	10%	No	Week 9
Physiological modeling	10%	No	Week 8

Hodgkin-Huxley model

Assessment Type [1]: Programming Task
Indicative Time on Task [2]: 9 hours
Due: **Week 7**
Weighting: **10%**

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

The Matlab-program will be demonstrated during an online practical session and a short report describing the results will be handed in.

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);
- 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;

Quizzes

Assessment Type [1]: Quiz/Test
Indicative Time on Task [2]: 0 hours
Due: **Every second (even) week**

Weighting: **10%**

Short in class tests on the content of previous 2 lectures. Note time spent on preparation in this assessment is assumed to take place as a regular non-scheduled teaching activity.

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);
- 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;

Literature study

Assessment Type [1]: Literature review
Indicative Time on Task [2]: 20 hours
Due: **Week 12**
Weighting: **10%**

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.

You will present the literature review by use of a powerpoint presentation in one of the online practical sessions.

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).

Formal exam

Assessment Type [1]: Examination
Indicative Time on Task [2]: 12 hours
Due: **Exam week**
Weighting: **50%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

Formal exam on the material covered during the lectures and practical sessions. A minimum mark of 50% on the exam AND in total is needed to pass the unit.

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);
- 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

Assessment Type [1]: Project
Indicative Time on Task [2]: 20 hours
Due: **Week 9**
Weighting: **10%**

In this assignment you will be asked to report on physiological measurements conducted during either practical sessions on campus or at home using lab equipment (Arduino, Raspberry Pi and eHealth shield) that you can borrow. (*)

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

(*) The exact nature of the assignment is susceptible to the COVID-19 situation at that moment.

On successful completion you will 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.

Physiological modeling

Assessment Type [1]: Programming Task
Indicative Time on Task [2]: 9 hours
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);
- 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;

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[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the Writing Centre for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

Course material

- In this course, we will take you on a journey from molecules to physiological systems. Rather than following a medical approach, an engineering approach will be followed whereby physiological systems are broken down in interacting systems. It will be demonstrated how physiological systems can be modeled mathematically.
- The course consists of three modules:
    1. The Physiome: From elementary biochemistry to cell biology and tissues
    2. Physiological Systems
    3. Pharmacokinetic models
- No required handbooks are necessary but the following textbooks provide a comprehensive overview of cell biology to physiology and on physiological modeling:
    - Tortora G J, Derrickson B, Introduction to the Human Body, 11th Edition, Australia and New Zealand Edition, Wiley, 2018. ISBN 978-1119-39273-6
    - Wood A W, Physiology, Biophysics and Biomedical Engineering, Series in Medical Physics and Biomedical Engineering, CRC Press, Taylor and Francis, 2012. ISBN 978-1-4200-6513-8
    - Khoo, M C K, Physiological Control Systems: Analysis, Simulation and Estimation, IEEE Press Series in Biomedical Engineering, IEEE Press, ISBN 0-7803-3408-6
    - Bronzino J D, Biomedical Engineering Fundamentals, CRC Press, Taylor and Francis, ISBN 0-8493-2121-2

Practical sessions:

- Practical sessions involve usage and coding of Matlab software. Matlab is available on the desktop computers in the laboratory but students are strongly encouraged to install Matlab on their own laptops. Some coding is required for the assignments.
- Tutorials and free online handbooks on Matlab are provided on the iLearn-page.
- Laboratory experiments will be conducted using Arduino and Health shields with sensors. In the case of a Covid-19 lockdown where you are unable to attend on campus practical sessions, you will be provided with an Arduino microcontroller and Health-shield with sensors. You will have to install the Arduino and Matlab software on your computer. Arduino software can be downloaded from the Arduino website (https://www.arduino.cc/en/main/software) and a student license of Matlab is available at https://au.mathworks.com/academia/tah-portal/macquarie-university-916052.html#get

Unit Schedule

Refer to iLearn and lecture notes for the unit schedule.

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.)*

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 help you improve your marks and take control of your study.

- Getting help with your assignment
- Workshops
- StudyWise
- Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides
- Ask a Librarian

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.

Changes from Previous Offering

One assignment has been replaced with a literature study where you will critically read a review paper on a healthcare subject and present a summary in the form of a Powerpoint presentation in week 12 to your peers.

More details on the literature study will be posted on iLearn.

Changes in response to student feedback

No significant changes are made as previous student feedback was praising the unit.