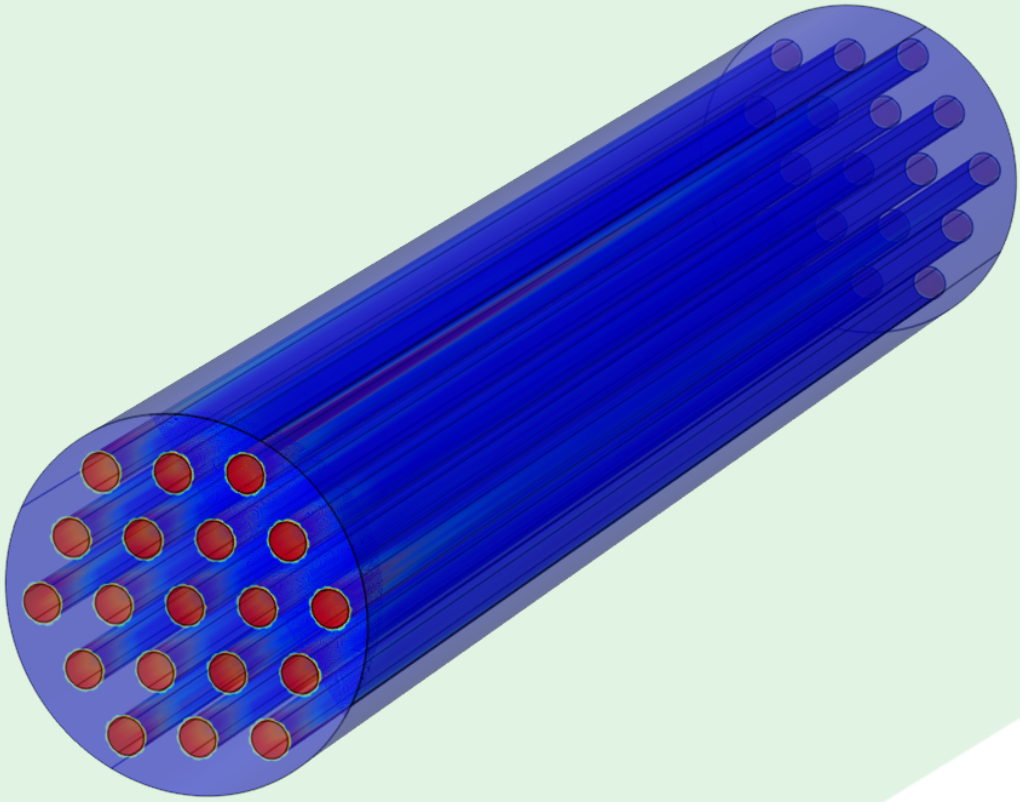
# BIOM9311

Mass Transfer in Medicine

Term 3, 2022



# Course Overview

## Staff Contact Details

### Convenors

| Name | Email | Availability | Location | Phone |
|---|---|---|---|---|
| Socrates Dokos | s.dokos@unsw.edu.au | By appointment (via e-mail) | Room 506, Samuels Bldg (F25) | 9385 9406 |

### Demonstrators

| Name | Email | Availability | Location | Phone |
|---|---|---|---|---|
| Keith Ly | keith.ly@unsw.edu.au | By appointment (via e-mail) | | |
| Dhyey Shah | dhyey.shah@student.unsw.edu.au | By appointment (via e-mail) | | |

## School Contact Information

Student Services can be contacted via unsw.to/webforms.

# Course Details

## Units of Credit 6

## Summary of the Course

This course is an introduction to mass transfer processes in medicine and biology, including the computational modelling of these. Topics covered include transfer of solutes across capillaries, mass transfer in haemodialysis, gas exchange in the lungs and in membrane oxygenators, transfer of drugs and toxins across the skin, slow release of drugs from implants, as well as mass transfer considerations in biosensors and in tissue engineering.

## Course Aims

The aim of this course is to introduce various mass transfer processes of medical or physiological importance, and the methods used to computationally model these.

## Course Learning Outcomes

After successfully completing this course, you should be able to:

| Learning Outcome | EA Stage 1 Competencies |
|---|---|
| 1. Explain the principles of diffusion and diffusive mass transport across synthetic and biological membranes. | PE1.1, PE3.2 |
| 2. Solve biomedical problems in mass transport by analytical and/or numerical means. | PE1.2 |
| 3. Analyse the relative importance of convection and diffusion in a given system. | PE1.3 |
| 4. Formulate and use mathematical models of mass transfer in medical applications such as haemodialysis, drug release and biosensors. | PE2.1, PE2.2 |
| 5. Explain the concepts of flow limitation and membrane limitation, distinguishing whether one or the other, or neither, is limiting in a particular medical application. | PE1.3 |

## Teaching Strategies

This course will be taught via weekly online lectures (pre-recorded) and weekly computer laboratories (face-face and fully online classes are available). Students will be expected to apply theory covered in the lectures to the weekly team-based learning activities in class. You will need to come to each class prepared by watching the lecture and revising material from the previous week's laboratory.

During the computer laboratory class itself, you will be given an individual test under exam conditions (30 minutes), followed by an opportunity to confer with members of your allotted class group and post a revised answer to the same exercises (another 15 minutes). Some of these problems will involve computational simulations using COMSOL mathematical software. Your team-based learning

mark for that week will consist of the averaged marks between your individual submission and your submission following group discussion. The remainder of the laboratory class will consist of further group submissions and following through with worked problems. This latter class work is not assessable.

## Additional Course Information

For each hour of contact, it is expected that you will put in at least 1.5 hours of private study. You will need to spend substantial time implementing computer-based assignments in COMSOL. The following describes the learning approaches recommended for this course:

### *Private Study*

- Watch the pre-recorded lecture and review the lecture notes each week (Moodle).
- Revise the previous week's laboratory exercises (Intedashboard and Moodle)
- Make a list of things you do not understand. Ask questions.
- Join/start Moodle discussions of problems.
- Learn COMSOL by working through example problems.

### *Computer Laboratory Sessions*

- Work through the weekly team-based learning activities, both the individual and group-based assessments.
- Work through remaining exercises in class.
- Ask questions.

### *Laboratory Report and Major Assignment*

- Carefully read the detailed laboratory and assignment instructions.
- Process, present and interpret any experimental data.
- Perform any necessary simulations in COMSOL.

# Assessment

The assessment tasks for BIOM9311 Mass Transfer in Medicine have been designed to measure your achievement of the learning outcomes. The final grade for this course will normally be based on the sum of the scores from each of the assessment tasks.
**Quizzes** will consist of online multiple choice questions and are designed to encourage learning throughout the semester and prepare students for the types of questions in the final exam. Quizzes must be attempted during the laboratory class, and will consist of an individual-based test (known as an individual readiness assurance test, or IRAT) and a team-based test (referred to as a team readiness assurance test, or TRAT). Both quizzes are worth 7.5% each, comprising 15% of the course assessment.
The **major assignment** is worth 20% of the total course assessment. A substantial problem of some complexity will be defined. The conceptual material required to solve it will have been covered in lectures but applying that material to this problem will not be trivial. It will not be a matter of simply finding the right equation. Clear thinking and working up from the basics will be required. In addition, values of some required material properties will have to be found from the literature. This will not be trivial either. It is expected that the report will clearly detail the method of solution, including all simplifying assumptions.
The **laboratory report** will be an opportunity for students to analyse experimental data and present findings in the form of a laboratory report. The laboratory report is worth 20% of the total course assessment.
The **final exam** will be held during the formal exam period and is worth 45% of the total course assessment.

| Assessment task | Weight | Due Date | Course Learning Outcomes Assessed |
|---|---|---|---|
| 1. Online Quizes | 15% | Weekly in class | 2, 3, 4 |
| 2. Laboratory Report | 20% | 07/11/2022 05:00 PM | 1, 2, 4 |
| 3. Major Assignment | 20% | 21/11/2022 05:00 PM | 2, 3, 4, 5 |
| 4. Final Examination | 45% | TBA | 1, 2, 3, 4, 5 |

## Assessment 1: Online Quizes

**Start date:** Weekly in class
**Due date:** Weekly in class

This assessment consists of a series of online weekly quizzes, given during the weekly laboratory class. It consists of individual and group-based quizzes.

## Assessment 2: Laboratory Report

**Start date:** 17/10/2022 05:00 PM
**Due date:** 07/11/2022 05:00 PM

This assessment involves completion of an at-home experiment, subsequent simulation and analysis of data generated, and presentation of findings in the form of a laboratory report.

## Assessment 3: Major Assignment

**Start date:** 17/10/2022 05:00 PM
**Due date:** 21/11/2022 05:00 PM

Students are required to simulate a mass transfer system in medicine or biology, submitting a detailed report describing methods, assumptions, results and significance of findings.

## Assessment 4: Final Examination

**Start date:** TBA
**Due date:** TBA

This assessment constitutes the final exam for the course. It will be an online exam consisting of multiple-choice and calculation-type questions.

## Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

## Course Schedule

Online lectures will be released every week in Moodle by Monday 11 am. These will be pre-recorded and can be viewed at any time, but please ensure you have done so prior to the computer laboratory class each week.

For the weekly computer laboratory class, please come to the class you have been enrolled in (i.e. face-face or online class), otherwise you will not be able to access the in-class online materials required. The face-face class will be held in the Computer Laboratory, Samuels building room 518. The online class can be accessed in Moodle near the top of the course page under Online Lab Sessions --> Weekly Tutorial Sessions). In each weekly lab class, we will be working together through a set of tutorial problems (online quizzes), for which you are required to submit answers by the end of each class session. There will be eight such quizzes in total, forming 7.5% of the overall course assessment.

Each week after the lab class, you will be required to complete an online quiz, due 5 pm the following Monday. There will be eight such quizzes in total, forming another 7.5% go the overall course assessment.

View class timetable

### Timetable

| Date | Type | Content |
|---|---|---|
| Week 1: 12 September - 16 September | Lecture | Fundamentals of Mass Transfer & Introduction to COMSOL |
| | Assessment | In-Class Quiz 1 (IRAT & TRAT) |
| Week 2: 19 September - 23 September | Lecture | Mass Transfer Across Membranes |
| | Assessment | In-Class Quiz 2 (IRAT & TRAT) |
| Week 3: 26 September - 30 September | Lecture | Biosensors |
| | Assessment | In-Class Quiz 3 (IRAT & TRAT) |
| Week 4: 3 October - 7 October | Lecture | Haemodialysis |
| | Assessment | In-Class Quiz 4 (IRAT & TRAT) |
| Week 5: 10 October - 14 October | Lecture | Drug Delivery |
| | Assessment | In-Class Quiz 5 (IRAT & TRAT) |
| Week 7: 24 October - 28 October | Lecture | Fluid Dynamics and Convection |
| Week 8: 31 October - 4 | Lecture | Mass Transfer in the Cardiovascular System |

| | | |
|---|---|---|
| November | Assessment | In-Class Quiz 6 (IRAT & TRAT) |
| Week 9: 7 November - 11 November | Lecture | Tissue Engineering and Bioreactors |
| | Assessment | In-Class Quiz 7 (IRAT & TRAT) |
| | Assessment | Laboratory Report (due Monday Week 9) |
| | Assessment | Laboratory Report |
| Week 10: 14 November - 18 November | Lecture | Artificial Lung and Blood Gas Exchange |
| | Assessment | In-Class Quiz 8 (IRAT & TRAT) |
| Study Week: 21 November - 24 November | Assessment | Major Assignment (due Monday Week 11) |
| | Assessment | Major Assignment |

# Resources

## Prescribed Resources

- Basic Transport Phenomena in Biomedical Engineering (3rd Edition) by Fournier, Ronald A. L. CRC Press 2012. (Available from the Library: 571.64/3A, 571.64/3B, plus one copy of an earlier edition).

## Recommended Resources

The lecture notes given along with information posted on Moodle will be the primary source of information. Additional optional resources are given below:

A text which provides useful case studies in biomedical engineering mass transfer phenomena, as well as a useful resource in COMSOL modelling is:

- Datta A, Rakesh V: An Introduction to Modeling of Transport Processes: Applications to Biomedical Systems,Cambridge University Press (2010).

A text which is organised quite differently from the course but which might be helpful on selected topics:

- Trusky GA, Yuan Fan, Katz DF: Transport Phenomena in Biological Systems,Pearson Prentice Hall (2004). GSBME library. [Level 7, Main Library (571.64/26)]

A basic mass transfer reference:

- Cussler EL: Diffusion: Mass transfer in fluid systems. Cambridge, Cambridge University Press (1984). [Level 9, Main Library (P 660.28423/23)]

A reference that gives a simple discussion of diffusion as well as the problem of diffusion to a receptor (as on a cell):

- Berg HC: Random walks in Biology. Princeton, Princeton University Press (1993). [Library Level 7 MB 574.01519282/1]

A relatively simple reference on fluid flow and dialysis:

- Keller KH: Fluid mechanics and mass transfer in artificial organs. (1973). A simple introduction to fluid flow and dialysis, but a bit limited.

## Course Evaluation and Development

Student feedback has helped to shape and develop this course, including feedback obtained from on-line evaluations as part of UNSW's myExperience process. You are highly encouraged to complete such an on-line evaluation toward the end of Term. Feedback and suggestions provided will be important in improving the course for future students.

## Submission of Assessment Tasks

Laboratory reports and major assignments will require a Non Plagiarism Declaration Cover Sheet.

Assignments should be submitted on time. A daily penalty of 5% of the marks available for that assignment will apply for work received after the due date. Any assignment more than 5 days late will not be accepted. The only exemption will be when prior permission for late submission has been granted by the Course coordinator. Extensions will be granted only on medical or compassionate grounds under extreme circumstances.

# Academic Honesty and Plagiarism

**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 a 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 Information

**COURSE EVALUATION AND DEVELOPMENT**
Student feedback has helped to shape and develop this course, including feedback obtained from on-line evaluations as part of UNSW's as part of UNSW's myExperience process. You are highly encouraged to complete such an on-line evaluation toward the end of Term. Feedback and suggestions provided will be important in improving the course for future students.

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

**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/

**Supplementary Examinations:**

Supplementary Examinations for Term 1 2022 will be held on (TBC) should you be required to sit one.

This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

## Image Credit

Hollow fibre dialyser simulation using COMSOL Multiphysics

## CRICOS

CRICOS Provider Code: 00098G

## Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW

Kensington campus is located.

## Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

| **Program Intended Learning Outcomes** | |
|---|---|
| Knowledge and skill base | |
| PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline | ✓ |
| PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline | ✓ |
| PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline | ✓ |
| PE1.4 Discernment of knowledge development and research directions within the engineering discipline | |
| PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline | |
| PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline | |
| Engineering application ability | |
| PE2.1 Application of established engineering methods to complex engineering problem solving | ✓ |
| PE2.2 Fluent application of engineering techniques, tools and resources | ✓ |
| PE2.3 Application of systematic engineering synthesis and design processes | |
| PE2.4 Application of systematic approaches to the conduct and management of engineering projects | |
| Professional and personal attributes | |
| PE3.1 Ethical conduct and professional accountability | |
| PE3.2 Effective oral and written communication in professional and lay domains | ✓ |
| PE3.3 Creative, innovative and pro-active demeanour | |
| PE3.4 Professional use and management of information | |
| PE3.5 Orderly management of self, and professional conduct | |
| PE3.6 Effective team membership and team leadership | |