

Engineering Tripos Part IIA, 3G2: Mathematical Physiology, 2018-19

Module Leader

[Prof M Lengyel](#) [1]

Lecturers

Prof M Lengyel, Prof G Csanyi, Dr T Savin, Dr A Agarwal

Lab Leader

[Dr A Agarwal](#) [2]

Timing and Structure

Lent term. 16 lectures.

Aims

The aims of the course are to:

- Provide a basic understanding of what functions are necessary for a living organism, and how they are achieved.
- Provide an overview of the modelling techniques that are used to understand those functions.

Objectives

As specific objectives, by the end of the course students should be able to:

- Express physical, mechanical and chemical principles in the context of physiological processes
- Understand underlying assumptions and check their validity
- Use mathematical and computational tools to identify and discuss solutions

Content

A wide variety of topics are touched upon, from biochemistry and cellular function to neural activity and respiration. In all cases, the emphasis is on finding the simplest mathematical model that describes the observations and allows us to identify the relevant physiological parameters. The models often take the form of a simple functional relationship between two variables, or a set of coupled differential equations. The course tries to show where the equations come from and lead to: what assumptions are needed and what simple and robust conclusions can be drawn.

Physical and chemical principles (4L A Kabla)

- Molecular transport, diffusion, osmotic pressure
- Chemical reactions, law of mass action, kinetics
- Enzyme catalysis, Michaelis-Menten model, cooperativity.
- Gases, partial pressures and solubility

Electrophysiology (5L T OLeary)

- Biophysical bases of cellular electrogenesis and basic ingredients of the equivalent circuit model.
- Action potential generation in neurons: Hodgkin-Huxley model.
- Phase plane analysis; reduced models, extension to bursting and pacemaking activity
- Signal propagation along dendritic and axonal projections, and across chemical and electrical synapses. .

Blood Physiology (3L A Kabla)

- Blood physiology, composition
- Gas storage in red blood cells
- Blood rheology, Cason equation, flow in capilleries

Physiological transport systems (4L A Kabla)

- Circulatory system, heart, cardiac output, arterial pulse
- Vessel compliance, pulsatile flow profile
- flow in capillary beds, filtration
- Respiratory system, gas exchange in the lungs, ventilation-perfusion

Coursework

Physiology of speech production.

Learning objectives:

- Learn about how vocal folds generate sound
- Understand the process of modeling a complex physiological process, from hypothesis to numerical solutions.
- Learn how to solve numerically non-linear differential equations.
- Develop Python/Matlab skills

Practical information:

- Sessions will take place in the EIETL, around week 3.
- This activity involves preliminary work (about 1h).

Full Technical Report:

Students will have the option to produce a Full Technical Report (FTR).

Booklists

Please see the [Booklist for Part IIA Courses](#) [3] for module references.

Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [4].

UK-SPEC

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [5] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has

been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the '[Accreditation of Higher Education Programmes](#)' (AHEP) document [6] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [7] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links

[1] <mailto:ml468@cam.ac.uk>

[2] <mailto:aa406>

[3] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=49001>

[4] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[5] <http://www.engc.org.uk/ukspec.aspx>

[6] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[7] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>