Engineering Tripos Part IIB, 4G6: Cellular & Molecular Biomechanics, 2019-20

Module Leader

Prof V Deshpande [1]

Lecturers

Prof V Deshpande and Prof N Fleck [2]

Timing and Structure

Michaelmas term. 14 lectures + 2 examples classes. Assessment: 100% exam

Prerequisites

3C7 useful.

Aims

The aims of the course are to:

- deal with the relation between microstructure of and properties such as strength, stiffness and actuation capability of natural materials such as cells and tissues and their properties, including stiffness.

Objectives

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

- understand the relation between micro-structure of soft biological materials and their mechanical properties.
- have a working understanding of the various components within plant and animal cells with a more detailed knowledge of the cytoskeletal components.
- understand the origins of the mechanical forces generated due to the polymerization of cytoskeletal proteins and derive the key equations.
- develop an understanding of muscles as actuators at the tissue, cell and protein length scales.

Content

Overview Lecture (Prof N. A. Fleck 1L)

The microstructure of the cell – animal cells, plant cells and the sub-cell building materials.

Mechanical Properties of Soft Solids (4L) (Prof. N A Fleck)

- The mechanical properties of natural materials – property maps
- Bending versus stretching micro-structures and entropic networks
- The notion of persistence length
- Models of stiffness and strength

- Mechanics of skin: stress v. strain responses, toughness and skin injection

The cytoskeleton (4L) (Prof.V. Deshpande)

- Review of basic thermodynamics and kinetics
- Introduction to cytoskeletal components and basics mechanics of the filaments
- Re-organization of the cytoskeletal filaments: polymerization, force generation and an introduction to motility

Muscle Mechanics (5L) (Prof.V. Deshpande)

- Twitch and tetanus and the Hill model
- Structure of the muscle: fibers, fibrils and contractile proteins
- Sources of energy in the muscle- Lohmann reaction
- Huxley Sliding filament model
- Models of myosin

Further notes

Further details and online resources:-

http://www-g.eng.cam.ac.uk/lifesciences/courses.html [3]

Booklists

Please see the Booklist for Group G Courses [4] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [5].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [6] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

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Links
[1] mailto:vsd20@cam.ac.uk
[2] mailto:vsd20@cam.ac.uk, naf1@cam.ac.uk
[3] http://www-g.eng.cam.ac.uk/lifesciences/courses.html
[4] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=56111
[5] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[6] https://teaching.eng.cam.ac.uk/content/uk-spec