Engineering Tripos Part IIB, 4G2: Biosensors, 2017-18

Leader

Prof A Seshia [1]

Lecturers

Prof A Seshia and Professor E A Hall

Timing and Structure

Lent term. Lectures and coursework. Assessment: 100% coursework.

Aims

The aims of the course are to:

- link engineering principles to understanding of biosystems in sensors and bioelectronics

Objectives

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

- extend principles of engineering to the development of bioanalytical devices and the design of biosensors.
- understand the principles of linking cell components and biological pathways with energy transduction, sensing and detection
- appreciate the basic configuration and distinction among biosensor systems.
- demonstrate appreciation for the technical limits of performance.
- make design and selection decisions in response to measurement problems amenable to the use of biosensors.

Content

This course covers the principles, technologies, methods and applications of biosensors and bioinstrumentation. The objective of this course is to link engineering principles to understanding of biosystems in sensors and bioelectronics. It will provide the student with detail of methods and procedures used in the design, fabrication and application of biosensors and bioelectronic devices. The fundamentals of measurement science are applied to optical, electrochemical, mass, and pressure signal transduction. Upon successful completion of this course, students are expected to be able to explain biosensing and transduction techniques, as well as design and construct biosensor instrumentation.

Introduction

- Overview of Biosensors
- Fundamental elements of biosensor devices
- Engineering sensor proteins

Electrochemical Biosensors

- Electrochemical principles
- Amperometric biosensors and charge transfer pathways in enzymes
- Glucose biosensors
- Engineering electrochemical biosensors

Optical Biosensors

- Optics for biosensors
- Attenuated total reflection systems

Acoustic Biosensors

- Analytical models
- Acoustic sensor formats
- Quartz crystal microbalance

Micro- and Nano-technologies for biosensors

- Microfluidic interfaces for biosensors
- DNA and protein microarrays
- Microfabricated PCR technology

Diagnostics for the real world

- Communication and tracking in health monitoring
- Detection in resource limited settings

Coursework

The coursework will be assessed on two marked assignments. The first assignment will involve a laboratory session illustrating the functional demonstration of glucose sensor technology. The second assignment will involve a laboratory session illustrating the principle of a quartz crystal microbalance and related acoustic sensor technologies.

Coursework	Format	Due date & marks
Coursework activity #1 Glucose biosensors Learning objectives: • To introduce students to electrochemical sensors employed for the measurement of glucose; • To quantitatively analyse measurements conducted using test strip glucose biosensors on a range of samples; • To extend the principles to the design of a biosensor for the measurement of lactate.	Individual Report anonymously marked	Mon week 5 [30/60]
[Coursework activity #2 Quartz crystal microbalance] Learning objectives: • To introduce experimental techniques associated with employing the quartz crystal microbalance as a sensor; • To assess the validity of analytical models associated with the operation of a quartz crystal microbalance and comment on discrepancies between theory and experiment;	Individual Report anonymously marked	Wed week 9 [30/60]

Coursework	Format	Due date & marks
• To extend concepts covered in the lectures and the laboratory to the conceptual design of an integrated acoustic sensor platform for the rapid screening and detection of infectious agents.		

Booklists

Please see the Booklist for Group G Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] 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.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

D4

Ability to generate an innovative design for products, systems, components or processes to fulfil new needs.

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.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

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.

US4

An awareness of developing technologies related to own specialisation.

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