Engineering Tripos Part IIB, 4G2: Biosensors, 2018-19

Leader
Prof A Seshia

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.

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

- 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.

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**Booklists**


**Examination Guidelines**

Please refer to [Form & conduct of the examinations](http://teaching.eng.cam.ac.uk/content/form-conduct-examinations) [3].

**UK-SPEC**

The [UK Standard for Professional Engineering Competence (UK-SPEC)](http://www.engc.org.uk/ukspec.aspx) [4] 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 [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](http://teaching.eng.cam.ac.uk/content/output-standards-matrices) [6] 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:aas41@cam.ac.uk