ME5BIO7 Advanced Medical Imaging [5 credits]

Coordinator: Ussher Assistant Professor Michael Monaghan, School of Engineering
(monaghmi@tcd.ie)

Semester: 1

Module Organisation
This module runs during semester 1 and comprises of lectures and corresponding laboratory
demonstrations and hands-on experience. (excluding study week). Total contact time is 33
hours. One laboratory practical is mandatory as part of this course.

Module Description
This objective of this module is to equip students with an understanding of engineering
approaches to advance biomedical imaging. A strong focus is placed on understanding the
physical processes that occur between a particular imaging modality and the biological
material being investigated. This module introduces the physical concepts of advanced
medical imaginig followed by lectures focused on specific imaging modalities. Modules will
cover various imaging techniques to provide an advanced understanding of the physics of the
signal and its interaction with biological tissue; image formation or reconstruction; modality-
specific issues for image quality; clinical applications; and biological effects and safety. State-
of-the-art emerging imaging modalities in research will be studied in detail and engineering
approaches to advance such techniques to the clinic. Finally, the importance of advanced
medical imaging in the quality control of medical devices and tissue engineered constructs
will be covered along with their implantation and monitoring in vivo.

Learning Outcomes
At the end of this module it is anticipated that students will have obtained:
1. A theoretical understanding of the fundamental physical and mathematical principles
   underlying major modern medical imaging technologies in both clinical and research
   settings.
2. An appreciation of the pre-requisites of imaging modalities in clinical and research
   settings and the safety
3. The ability to function on multidisciplinary teams
4. Understand how the structure and composition of tissues and cells influences and
determines the application and/or combination of imaging modalities
5. Awareness of current “state of the art”, emerging technologies and advances in the field.
6. An understanding of the application of medical imaging in the quality control of implants
   and tissue engineered constructs
7. A theoretical understanding of the concepts involved in the generation of
8. Ability to identify, formulate and adapt advance medical imaging solutions to unmet
   biological needs
9. Ability to perform a quantitative analysis of in vitro multiphoton imaging data, and
   interpretation thereof.
10. The ability to extract, through comprehensive analysis of the literature, information
    pertinent to the design of an imaging solution to an unfamiliar problem
Module Content
- Overview of medical imaging
- Basic principles of physics applied to medical imaging
- Instrumentation in medical imaging
- Principles of X-Ray imaging modalities
- Applied X-Ray Imaging Modalities
- Computed tomography
- Applications and principles of echocardiography
- Magnetic Resonance Imaging
- Histology and immunohistology
- Principles of microscopy
- Biomedical optics
- Non-invasive microscopy
- Fluorescent Lifetime Imaging Microscopy (FLIM)
- Fluorescence Recovery After Photobleaching (FRAP)
- Forster Resonance Energy Transfer (FRET)
- Principles and application of magnetic resonance imaging
- Modalities of electron microscopy
- Advanced biomedical imaging in the evaluation and characterization of biomedical and tissue engineered implants

Module Notes
Provided via Blackboard. At the end of each lecture students will receive more specific learning outcomes for the lecture and be expected to undertake self-directed further reading and research.

Teaching Strategies
The module is taught using a combination of lectures, laboratories, and study assignments. Each student is given a learning assignment, which introduces the student to research skills necessary for life-long learning. At the end of each lecture students will receive more specific learning outcomes for the lecture and be expected to undertake self-directed further reading and research.

Assessment Modes

<table>
<thead>
<tr>
<th>Type of assessment</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written Examination</td>
<td>55%</td>
</tr>
<tr>
<td>Data analysis exercise and report</td>
<td>10%</td>
</tr>
<tr>
<td>Group Assignment</td>
<td>25%</td>
</tr>
<tr>
<td>Emerging Technology Report</td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>10%</td>
</tr>
</tbody>
</table>

Recommended Texts
- Medical Imaging: Principles and Practices Analoui (Ed)
- Fluorescence Microscopy: from Principles to Biological Applications Kubitscheck (Ed)

A wide range of introductory and advanced reading materials will also be provided via blackboard.