Imperial College London

Medical Imaging: Nuclear Diagnostics and MRI

Module Code	PHYS96025	FHEQ Level	Level 6
Pre-requisites	None	Co-requisites	None
Primary Department	Physics		
Module Leader	Prof. Kenneth Long		
Additional Teaching Departments	None		
Teaching Staff	Prof. Kenneth Long + Associate		
Programmes on which the Module is delivered			Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)			Elective
Learning Outcomes	On completing the Medical Imaging: Nuclear Diagnostics and MRI course, students will be able to: • Explain the main methods used for the production of radionucliotides; • Recall and apply the definitions of activity, half-life and decay constant; • Calculate the energies of the particles involved in radioactive decay in a given situation; • Explain the main radioactive decay pathways and discuss how the radiation produced can be used for medical imaging; • Calculate decay rates for radionuclides in a given situation; • Explain how a gamma camera operates and discuss the main parameters that affect its performance; • Calculate the resolution and efficiency of a gamma camera in a given situation; • Explain the different types of detection events (e.g. good, scatter in patient, septal penetration) that can be recorded by a gamma camera and discuss how these affect the final image; • Explain how Single Photon Emission Computed Tomography (SPECT) is performed; • Explain the assumptions typically made in the reconstruction of SPECT data and discuss some of the approaches used to correct for scatter and attenuation; • Explain how a positron emission tomography dataset is acquired and reconstructed and discuss the main factors that limit the performance of this technique; • Discuss the different types of detection events (e.g. true, random, scatter coincidences) that can be recorded by a PET system including how these affect the final image and propose ways that they can be reduced; • Calculate the following for a PET scanner in a given situation: resolution, radioactivity used/required, detection efficiency, detection rates and coincidence rates; • Explain how to compensate for attenuation and unwanted random and scatter events in PET; • Describe and discuss the main differences between 2D and 3D PET image acquisition;		

	• Describe quantitatively and qualitatively the basic principles behind nuclear magnetic resonance (NMR); • Discuss quantitatively and qualitatively how relaxation mechanisms contribute to the contrast in magnetic resonance imaging (MRI); • Describe the techniques required for spatial localisation of the NMR signals in MRI; • Distinguish between phase and frequency encoding and how they are implemented in MRI to enable the special localisation of the NMR signal; • Apply the concept of Fourier transform to the k-space and describe the relationship of MR images to this space; • Define the receiver bandwidth, acquisition time, sampling frequency and field of view, and illustrate how they are connected; • Identify the causes of the most common image artefacts; • Show how the signal to noise ratio is affected by the choice of acquisition parameters; • Recall the major hardware components necessary for MRI; • Interpret typical MRI pulse sequences from their diagram and draw their diagram from their description • Discuss the changes in image contrast arising from the use of different MRI sequences; and • Calculate the optimal TR and TE for maximising the image contrast for proton density, T1 and T2 weighting.
Description of Content	The aim of the course is to provide students with a general overview of how physical principles are used to generate contrast in modern medical imaging using “nuclear diagnostics” and Magnetic Resonance Imaging (MRI). Students should also gain an appreciation of the physical factors determining the resolution, speed and sensitivity of these two imaging modalities. The course is delivered in collaboration with the Department of Radiation Physics and Radiobiology Imperial College Healthcare NHS Trust by personnel from the Imperial Centre for the Clinical Application of Particles (the CCAP).

Assessment		Assessment Type	Weighting
Written exam		Exam	100%
Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
23.5	51.5	0	75
ECTS Credit	3	CATS Credit	6
Date of introduction	October 2016	Date of Last Revision	February 2020