Nuclear diagnostics and Magnetic Resonance Imaging

Aims, objectives, and recommended books

Aims

With the course I aim to:

- Provide students with a general overview of the physical principles that underlie nuclear diagnostics (ND) and magnetic resonance imaging (MRI);
- Allow students to appreciate the factors that influence the development of contrast in ND and MRI; and
- Give students the means to estimate the resolution, speed, and sensitivity of ND and MRI imaging modalities.

Objectives

At the end of the course students will be able to:

- Explain the principal methods used for the production of radionuclides;
- Explain 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 principal radioactive decay pathways and the application of the radiation produced to medical imaging;
- 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 particular situation; and
- Explain the different types of event that can be recorded by using a gamma camera and discuss how these affect the image.

Objectives 2: SPECT and PET

At the end of the course students will be able to:

- Explain how Single Photon Emission Computed Tomography (SPECT) is performed;
- Explain the methods typically used in the reconstruction of a SPECT images;
- Explain how a Positron Emission Tomography (PET) image is produced and discuss the principal limitations of PET;
- Discuss the different types of detection events recorded by a PET system and how they affect the image;
- Calculate the resolution, detection efficiency, detection rate, and coincidence rate for a particular PET scanner;
- Explain how to compensate for attenuation and unwanted random and scatter events in PET; and
- Describe and discuss the main differences between 2D and 3D PET image acquisition.

Objectives 3: Magnetic resonance imaging

At the end of the course students will be able to:

- Describe the principles of nuclear magnetic resonance (NMR);

- Discuss how relaxation mechanisms contribute to the generation of contrast in magnetic resonance imaging (MRI);
- Describe techniques for spatial localisation of the NMR signals in MRI;
- Distinguish between phase and frequency encoding is used in MRI to enable the spatial localisation of the NMR signal;
- Use the Fourier-transform technique to exploit 'k-space' to describe MRI images in this space;
- Connect the receiver bandwidth, acquisition time, and sampling frequency to the field of view and resolution;
- Identify the causes of the most common image artefacts;
- Show how the signal-to-noise ratio (SNR) is affected by the choice of data acquisition parameters;
- Recall the major hardware components necessary for MRI;
- Recall, devise, and interpret typical MRI pulse sequences and discuss the changes in image contrast induced by changes in the pulse sequences; and
- Calculate the optimal 'TR' and 'TE' to maximise image contrast for 'proton density', 'T1', and 'T2' weighted imaging.

Recommended books

Physics in Nuclear Medicine
S. Cherry, J.A. Sorenson, M.E. Phelps
Central Library: 616.075 CHE

The Essential Physics of Medical Imaging
J. Bushberg, J. Seibert, E. Leidholdt, J. Boone
Central Library: 616.075 BUS

MRI: the basics
R. Hasgemi, W. Bradley, C. Lisanti
Central Library: 616.075 HAS
