I part – Electronics for the processing of biological signals

1) Origin of the biological signals. Electrodes and sensors employed for the signal acquisition.

2) Analog circuits for the amplification and filtering of biological potentials. Application in the electrocardiograph. Amplifier for bio-potentials: basic parameters and design issues (noise, insulation and protection techniques, common-mode and interferences rejection). Application of the Instrumentation amplifier to the measurement of bio-signals.

3) The electronics of the pacemaker: basic functionalities, batteries, amplification circuits, pulses generators, telemetry. Integrated circuits used in the pacemaker, example of time-invariant architectures and switched-capacitor topologies. Integrated charge pumps for the increase of the power supply. Examples of amplifiers and filters. Low-power and low-voltage designs based on the use of transistors operating in sub-threshold regime.

4) Special topic on application of integrated technologies in the biomedical field: microelectronics systems for artificial vision.

II part – Electronics for medical imaging systems

1) Basics on diagnostic medical systems based on the use of radiation. Digital radiography, computed tomography, SPECT and PET. Figures of merit: efficiency, resolution, signal/noise ratio. Examples of application in the medical field. The PET time-of-flight.

2) The Anger Camera. Architecture and components. Scintillators coupled to photodetectors (photomultiplier tubes, PiN photodiodes, avalanche photodiodes). Basic on collimation systems for the radiation (parallel holes, pinholes). Estimation methods for the determination of the ionizing event in the detector (centroid, maximum likelihood, neural networks). Effect of the electronics noise of the photodetector-amplifier in the spatial and energy resolution.

3) Integrated circuits employed in the medical imaging systems. Examples of design of the integrated front-end. Recall of the electronics noise and its representation by means of the equivalent noise charge. The charge preamplifier and the optimization of the input transistor. The integrated filter. The peak stretcher (Kruiskamp and Leenaerts type). The baseline holder. Examples of design of integrated circuits by means of Cadence (optional laboratory drills).

4) Basic timing techniques: leading edge, constant fraction discriminator, zero-crossing discriminator. Application in PET.