1. Briefly explain the meaning and significance of the following terms (in the medical imaging context). Each term is 1p; total 6p

a) PET-FDG
b) Modified Beer-Lambert Law
c) K edge
d) Minimum norm estimate
e) Figure-of-eight coil
f) Echo-Planar Imaging

2. a) Explain the operating principle of 2D and 3D X-ray imagingsystems; illustrate main parts of the instruments with structural figures. (3p)
b) How does 3D image reconstruction in computed tomography work? Explain either an iterative reconstruction algorithm of your choice, or filtered backprojection in detail. What are the advantages of iterative vs. backprojection methods? (3p)

online   *offline*

3. What are the advantages and technical challenges in combining PET with a) CT or b) MRI? What applications do the combined systems (and the combination of information from the two modalities) have? (6p)

4. An MRI device with a B_0 field of 3 T can generate gradient fields with strengths of 40 mT/m. You intend to acquire an image slice with 256 x 256 in-plane pixel resolution with frequency and phase encodings. Let the field of view (FOV) be 25 x 25 cm^2. The detector is a copper coil that has been tuned to enhance the MR signal. What should the bandwidth (BW) of the receiver be to image the FOV? What happens if the BW is too small and why? The gyromagentic ratio of a proton $\gamma = 42.58$ MHz/T. (6p)

5. a) Which kind of instrumentation is typically used to record MEG signals? Describe briefly the main components of an MEG system (3p)

b) An external sensory stimulus activates a small patch of cortex. The activation can be represented by a current dipole with peak Q = 10 nAm and the response comprises frequencies 1–17 Hz. From the MEG forward operator we can see that the gain at this source location to a MEG sensor is 2.0 x 10^{-5} T/Am. That same sensor sees total noise (background brain activity, intrinsic sensor noise and environmental noise) spectral density of 40 fT Hz$^{-1/2}$. The noise can be assumed to be uncorrelated. When optimally filtering the signal, how many responses to that sensory stimulus need to be averaged to achieve signal-to-noise ratio (SNR) of 10? SNR is defined as the ratio of the peak signal amplitude to the RMS amplitude of the noise. (3p)

Good luck with the exam!