**1. Optical coherence tomography (60%)**

a) Draw a diagram of a typical time-domain optical coherence tomography (OCT) system, label the major components, and briefly explain their functions.

b) OCT techniques were based on low time-coherence interferometry. Give one example of light sources used in OCT system. What is the center wavelength 0 and spectral bandwidth  of this light source? Explain how you will use 0 and  to calculate the axial resolution of the OCT system.

c) What are the major differences between Frequency-domain OCT (FD-OCT) and Time-domain OCT (TD-OCT)? What are the key advantages of FD-OCT over TD-OCT?

Ans:

**2. Photoacoustic tomography (20%)**

Describe the basic principle of the photoacoustic tomography.

Ans:

In a similar way to one-photon and two-photon microscopy where the radiative relaxation from a higher energy level to a lower energy level causes the system to have fluorescence , the photoacoustic effect causes a dissipation of heat from the system. Because photoacoustic takes into account the scattering of tissue, it can penetrate deeper than a confocal single or dual photon microscopy. The excitation of the tissue causes a volume expansion where the pressure of the wave propagation is mathematically proportional to an absorption coefficient and the local optical fluence.

Now, having briefly discussed the photoacoustic effect as a physical phenomenon the basic components of photoacoustic compute tomography(PAT) are a laser to illuminate, typically a short-pulse laser for a good wideband PA signal, a wideband ultrasonic transducer or transducer array for signal detection, and like many biomedical computational systems a DAC, and computer system for reconstruction. Of course for a PAT the transmitter and receiver should be tuned for the same ranges.

Finally, for PAT there are two strategies for computation, forward and reverse processing. In a forward system, one has a model of expected behavior and then takes measurements from the system. Here those measurements would consist of ultrasonic transducer measurements. The process is iterated until the difference from the forward is within some epsilon of the predicted. Now , for a reverse computational method, we do not have enough measurements to characterize all of the hidden values, so typically we run some optimization techniques that involve trying to determine how to extrapolate and underdetermined system. There are many such techniques in literature with a gradient descent and some regularization terms to help constrain the system as examples.

**3. Diffuse optical tomography (20%)**

Describe a potential clinical application of diffuse optical tomography.

Ans: