**1. Self-introduction (20%)** Are you an undergraduate or graduate student? Do you have any research project that related to optics or imaging? If yes, briefly describe it.

**2. Biomedical optics concept (20%).** Below is a list of biomedical optics methods that are currently used in biomedical research. Select one and do a quick research, then write a brief paragraph (10 sentences) about what it is and what is the advantages of this method.

* • Optical coherence tomography
* • Hyperspectral imaging
* • Photoacoustic microscopy
* • Photoacoustic tomography
* • Multiphoton microscopy
* • Diffuse optical tomography
* • Coherent anti-Stokes Raman spectroscopy
* • Diffuse optical spectroscopy
* • Differential interference contrast microscopy
* • Super-resolution microscopy
* • Optical tweezers
* • Photodynamic therapy

Ans:

The concept of two-photon microscopy (TPM) was first conceptualized by Maria Mayer in her 1931 doctoral dissertation, with the development of the laser in the 1960’s and second harmonic generation in the 1970’s, all laid the foundation for the modern-day invention of two-photon fluorescence microscopy by Denk et al. in 1990. The basic “trick” to two photon microscopy is that for a molecule to absorb both photons, an unlikely event, the actual fluorescence excitation is a very small focus area. This of course give very good resolution, but also has the effect of limiting light from other areas, the background excitation, which would contribute to the area of interest as noise and is suppressed because only our restricted molecule was able to absorb both photons. While a two-photon fluorescent microscope certainly gives good contrast and resolution its real value to biological study of tissues, which strongly scatter light, its depth penetration. Two large applications of TPM are for cancer research, and brain in-vivo imaging for neuroscience. Here TPM allows in brain imaging for less photobleaching which means less toxicity to tissue and therefore longer periods that the subject can be studied without any harm or side effects. The added technology of scanning allows a TPM to build up a 3-d reconstruction image like other modal imaging techniques. To summarize the benefits of two-photon microscopy are: 1. The ability to resolve deeper into the tissue. The suppression of background signal and finally since light is the modal signal, less damage to tissue and the ability for in vivo imaging.

**3. Photons (20%)**. How many photons per second are emitted from a 50 W yellow lightbulb (average wavelength, λ = 550 nm) if 2.5% of the applied energy is emitted as light? Assume that the remainder is just dissipated as heat. (Speed of light: 3×108 m/s)

Ans:

photon\_energy = (3e8)\*(6.62607015e-34)/(550e-9); % Joules- one photon

total\_energy\_photons = .025\*50; % This is watts or Joules/S

% We will assume that we are measuring energy over one second

number\_of\_photons = total\_energy\_photons/photon\_energy;

So photons per second = 3.4586e+18

**4. Snell’s law (20%).** Using Snell’s law, show analytically that a light beam impinging on a transparent planar glass plate exits that plate parallel to the incident direction. What is the parallel displacement (x) of the beam behind the glass plate as a function of glass thickness d, glass index n and the angle of index θi?

**5. Total internal reflection (20%).** A glass block (ng = 1.55) is covered with a water layer (nw = 1.33). What is the critical angle at the glass/water interface?

Ans:

% critical angle ni > nr

ni = 1.55; % index refraction of glass

nr = 1.33; % index refractiuon of water

critical\_angle = asin(nr/ni); % critical angle in radians

critical\_angle\_degrees = critical\_angle\* 360/(2\*pi)

critical angle = 59.1 degrees