Topics of Biophysics lectures 2012-2013 first semester

**Geometrical optics**
Fermat principle, application of the Fermat principle for curved surfaces
Optical imaging, refractive strength
Imaging law of thin lenses (with spherical surfaces)
**Fundamentals of physical or wave optics**
Huygens-Fresnel principle, characterization of a wave
Coherent light waves, connection between amplitude and intensity
Interference of light, Young's double slit experiment. Diffraction through an optical lattice
Fundamentals of diffraction methods Light as electromagnetic wave
Optical anisotropy and polarization of light, Doubly refractive materials
Light as photon radiation of light particles, Photoelectric effect
**Basics of radiometry**
Emitted power, intensity, (flux density)
Source, radiation, irradiated target
Spherical (point-like isotropic radiator), cylindrical and planar symmetry
Decrease in radiation intensity while passing through matter
Dependency of outgoing intensity on both the type and depth of the traversed medium, validity of the law
Attenuation coefficient, layer thickness for half-intensity
**Structure of atoms**
Atoms, electrons, nuclei, Rutherford's scattering experiment
Franck-Hertz experiment, Bohr's model
Electron as a wave, state function
Propagation law of free electrons, Heisenberg uncertainty relation
Bound state electron and atomic states
Discrete atomic energy levels, quantum numbers
Spin and associated magnetic momentum of an electron
Structure of the nucleus, mass deficiency and binding energy
**Atomic interactions**
Binding distance, binding energy
Classification of bond types, intramolecular, intermolecular
Van der Waals interactions, radii
Atomic Force Microscopy (AFM)
**Many atom systems**
Boltzmann distribution; Barometric formula; thermal emission of metals; Nernst equation
Equilibrium and rates of chemical reactions, Arrhenius-plot
Gases, Ideal gases; temperature, pressure of the gas
Real gases; Van der Waals state equation
Solid state materials; Crystalline substances, lattice, elementary cells
Energy bands; valence band, forbidden band, conduction band
Properties determined by the width of the forbidden band
Insulators, semiconductors, conductors
Creating 'semiconductor properties' by doping
Donor level, acceptor level
Lattice defects, hole or vacancy, interstitium

**Light emission, scattering, absorption**
Thermal radiation
Kirchhoff's law, absolute black body
Emission spectrum of thermal radiation at various temperatures
Stefan – Boltzmann law, Wien's displacement law
Application in medical diagnostics: Telethermography
**Luminescence**
Fluorescence, phosphorescence
Lifetime of excited states, metastable excited state
Light sources; Sun, incandescent lamps, halogen lamp, metal vapour (e.g. Hg) lamps
Lasers; Light amplification, conditions for LASER operation
Properties of laser light
**Liquids, liquid crystals: anisotropic liquids**
Translational order, orientational order
Smectic, nematic, cholesteric or twisted nematic states
Thermotropic, lyotropic
Thermo-optical effects, electro-optical effects
**Sructural organization of living systems;**
Water; Structure of water molecules
H-bridge bond system of water molecules
Nucleic acids
Building blocks and primary structure of nucleic acids
Secondary structure of nucleic acids
Tertiary structure of DNA: Superhelix
Proteins
Primary structure of proteins: amino acids
Secondary, tertiary and quaternary structure of proteins
**Radioactive isotopes, nuclear radiation**
$\alpha$, $\beta$ decay; $\alpha$, $\beta$, $\gamma$ radiation; spectra
Law of radioactive decay
Decay speed, decay constant, average life-time, half-life, activity
Application of radioactive isotopes
Physical aspects of selecting an isotope for in vivo studies
Interaction of nuclear radiations with atomic systems
linear energy transfer (LET), effective range
pair production PET
**X-ray**
X-ray tube, Bremsstrahlung, characteristic X-ray
Spectrum, total power, efficiency
Photo effect, Compton-effect, contrast materials
Particle accelerators in medicine; Linear accelerator, cyclotron