Practical No 1
EMISSION SPECTRA OF ELEMENTS
Required theoretical knowledge:
1. Nature of light and quantum concept.
2. Types of spectra and the mechanism of their formation. Atomic and molecular (oscillation, vibration) spectra.
3. The behaviour of light while passing through a prism and diffraction grating.
4. Prism spectroscope, monochromator – principle of operation.
5. Analysis of a spectrum applying the spectroscope.
6. Application of spectral analysis in medical science.

Recommended literature:
1. R. K. Hobbie, "Intermediate Physics for Medicine and Biology", Springer, 1997.
2. P. Davidovits, "Physics in Biology and Medicine", Elsevier, 2001.

Practical No 2
NEPHELOMETRIC DETERMINATION OF COLLOID CONCENTRATION
Required theoretical knowledge:
1. Colloids. Optical properties of colloids.
2. Rayleigh theory of light scattering.
3. Interaction of light with matter – absorption and scattering
4. Raman scattering.
5. Principle of nephelometric measurement.

Recommended literature:
1. P.R. Bergethon "The Physical Basis of Biochemistry", Springer 1998
2. R. Cotterill "Biophysics An Introduction", Wiley 2003

Practical No 3
EXAMINATION OF OPTICAL ROTATION OF SOLUTIONS AND DETERMINATION OF CONCENTRATION USING A SACCHARIMETER
Required theoretical knowledge:
1. Light polarization and definition of a polarization plane.
2. Linear polarization phenomena:
   a) reflection from a dielectric surface (Brewster's angle),
   b) double refraction in some crystals.
3. Nicol prism, ordinary ray and extraordinary ray.
4. Optically active substances, specific rotation, dispersion of optical rotation.
5. Principle of operation of the Lippich saccharimeter.

Practical No 4
FLUORESCENCE ANALYSIS
Required theoretical knowledge:
1. Luminescence.
2. Mechanisms of fluorescence and phosphorescence.
3. The Stokes shift.
4. Quantum yield of fluorescence.
5. Fluorescence quenching.
6. Application of fluorescent measurements for qualitative and quantitative analysis.
7. Application of fluorescence markers in examination of membrane transport processes and intracellular processes.
8. Application of fluorescence in cancer diagnostics
9. Bioluminescence.

Practical No 5
DETERMINATION OF FOCAL LENGTH AND RADIUS OF CURVATURE OF THE EYE MODEL AND FOCAL LENGTH OF CORRECTING LENS
Required theoretical knowledge:
1. Structure of human eye and optical scheme of image creation.
2. Resolving power of the eye.
3. Eye accomodation.

4. Defects of vision and correction methods.
5. Elementary formulas for lenses.
6. Relationship between the refractive index and the angle of minimal refraction in the prism.
7. Scheme of an optical spectrometer.

Practical No 6
ESTIMATION OF FLICKER FUSION THRESHOLD OF PHOTORECEPTOR CELLS OF A HUMAN EYE
Required theoretical knowledge:
1. Distribution of photoreceptor cells in retina.
2. Photoreceptor cells: rods and cones. Structure and function.
3. Channel proteins in the cell membrane of the outer segment of a rod.
4. Ion currents flowing through the membrane of a rod „in darkness".
5. Mechanism of generation of electrical signals in rods.
6. Frequency of summation of electrical signals in cones and rods.
7. What is the "critical frequency" of a light stimulus ?
8. What is the "time resolution" of photoreceptor cells ?
9. Sensitivity of photoreceptor cells on different wavelengths of visible light.
10. Relationship between the „critical value of the frequency" and the angle of a position of a source of a flickering light.

Recommended literature:
1. L. Stryer „Biochemistry"

Practical No 11
IONIC MIGRATION VELOCITY
Required theoretical knowledge:
1. Constant straight line movement:
   a. Definition, parameters of this movement and their units of measure
   b. Plots of the displacement and velocity versus time
   c. Estimation of an average velocity based on a plot displacement versus time
   d. Conversion of units of average velocity, for example: $mm \cdot s^{-1}$ to $km \cdot h^{-1}$
2. Description of a movement of a spherical object in a liquid phase, with a constant velocity:
   a. Resistance force (internal friction force, viscosity force)
   b. The Stokes law
3. Intensity (E) and potential (U) of the electric field, definition and units of these physical quantities. Relationship between the intensity and the potential of the electric field.
4. Movement of ions in the electric field:
   a. Electric force acting on an ion in the electric field, the formula
   b. Explanation of a difference between the average velocity of ion migration and the ion mobility
   c. Derivation of the formula for mobility of ion (u)
   d. Definition of the ion mobility for infinite dilution (u_0)
   e. Method of estimation of the (u_0)
   f. Derivation of the formula for a hydrodynamic radius of the MnO_4^- ion

Recommended literature:
1. Glasser, „Biophysics", Springer, 2001.

Practical No 12
COMPUTER SIMULATION OF ACTION POTENTIAL GENERATION
Required theoretical knowledge:
1. Nernst equilibrium; equilibrium potentials for sodium, potassium and chloride ions. Definition of electric driving force.
2. Basic concepts of electrodiffusion (migration - Ohm's law, diffusion - Fick's law, electric potential, electrochemical potential).
3. The origin of resting potential. Goldman-Hodgkin-Katz equation.
4. Voltage-gated ion channels: molecular structure, classification, biophysical properties. Voltage sensor, activation gate, inactivation gate.
5. Threshold potential and its dependence on membrane conductance for sodium, potassium and chloride ions.
6. Explanation of the time course of action potential on the basis of kinetic properties of voltage-gated ion channels.

7. Mechanism of action potential propagation in myelinated and non-myelinated axons; the role of inactivation of voltage-gated sodium channels.
8. Ion channel toxins (TTX and TEA) and their influence on action potential. Application in medicine.

Recommended literature:
1. R. Cotterill, Biophysics. An Introduction, Wiley 2004.
2. R. Glaser, Biophysics, Springer 2001.
3. http://butler.cc.tut.fi/~malmivuo/bem/bembook/
4. http://www.st-andrews.ac.uk/~wjh/neurotut/mempot.swf

Practical No 13
MEMBRANE POTENTIAL MEASUREMENT AT NERNST EQUILIBRIUM
Required theoretical knowledge:
1. Passive membrane transport – electrodiffusion.
2. Nernst equilibrium.
3. Nernst equilibrium potential.
4. Membrane voltages in living cells.
5. Goldman equation.

Practical No 14
MICROCALORIMETRIC SIMULATION STUDIES ON PHASE TRANSITIONS IN LIPIDS
Required theoretical knowledge:
1. Structure of biological membranes.
2. Phase transitions in lipids and their significance in biological systems.
3. Structural parameters of lipid molecules affecting their transition temperatures.
4. Calorimetry. Principles of work of a differential scanning microcalorimeter. Parameters of the thermogram (transition temperature, transition enthalpy change, haf-width height).

Practical No 15
ANALOG MODEL OF SYNAPTIC TRANSMISSION
Required theoretical knowledge:
1. Passive electrical properties of cell membranes: electrical capacitance, electrical resistance, membrane time constant.
2. Action potential – basic properties and the mechanism of generation.
3. Structure of synapses between neurons.
4. Mechanism of conversion of electrical signal to chemical signal (neurotransmitter release) in the presynaptic ending.
5. Mechanism of conversion of chemical signal to electrical signal in the postsynaptic ending. Excitatory and inhibitory synapses.
6. Model of electric properties of a cell membrane and relationship between changes of a membrane potential and intensity of electric current flowing through a membrane.

Recommended literature:
1. Cotterill R. “Biophysics. An introduction”. J. Wiley & Sons, 2004.
2. Alberts, B., Bray,D., Lewis,J., Raff.M., Roberts,K., Watson,J.D., “Molecular Biology of the cell”, Garland Publishing, Inc., New York, 1994.
3. Glaser, R., „Biophysics“. Springer-Verlag, 2004.

Practical No 16
PROPAGATION OF ACTION POTENTIAL ALONG UNMYELINATED AND MYELINATED AXONS
Required theoretical knowledge:
1. Passive electrical properties of cell membranes: electrical resistance and capacitance of membrane, membrane time and space constant, equivalent electrical circuit of a membrane.
2. Mechanism of action potential generation in a neuron (explain the phenomenon of threshold)
3. Propagation of action potential along unmyelinated and myelinated axons.

Recommended literature:
1. Principles of Neural Science, Kandel E., McGraw-Hill Education, 5th edition 2012
2. Cotterill R. Biophysics. An introduction. J. Wiley & Sons, 2004.
3. Glaser R. Biophysics an introduction. 2-nd ed. – Berlin: Springer, 2012.

Practical No 21

DETERMINATION OF THE DEAD TIME OF GEIGER-MÜLLER COUNTER BY THE TWO-SOURCE METHOD

Required theoretical knowledge:

1. Natural radioactivity: alpha (α), beta (β), gamma (γ) radiation.
2. Ionising radiation decay law.
3. Principles of work of the Geiger-Müller counter and the semiconductor detector of ionising radiation
4. Explain definition of the dead time of ionising radiation detectors
5. Units of ionising radiation activity
6. Radioactive series.

Recommended literature:

1. P.R. Bergethon "The Physical Basis of Biochemistry", Springer 1998
2. R. Cotterill "Biophysics An Introduction", Wiley 2003

Practical No 22

INTERACTION OF β RADIATION WITH MATTER

Required theoretical knowledge

1. Radioactive series
2. Radioactive decays α, β^-, β^+
3. The principle of working the G-M counter
    a. gaseous
    b. semiconductor
4. Describe the law of absorption of ionizing radiation
5. The ability to transform the equation of attenuation of ionizing radiation to the form of a linear function
6. Interpretation of the linear and mass attenuation coefficient
7. The ability to derive the formula for the half-value thickness from the equation of attenuation ionizing radiation
8. Definition of the half-value thickness
9. Method of determining the range of electrons in an absorbent
10. Interaction of ionizing radiation with matter: Compton effect, photoelectric effect, creation of pairs: positron-electron.

Practical No 23

ESTIMATION OF THE DIFFERENCE IN VISUAL LATENCY IN THE PULFRICH EFFECT

Required theoretical knowledge:

1. Binocular vision: fixation, retinal correspondence, retinal disparity. Horopter. Sensor fusion, Panum's fusional area.
2. Idea of the Pulfrich effect (see introduction).
3. Experimental methods applied in the practical (see introduction).

Practical No 24

DIPOLE MODEL OF A HEART

Required theoretical knowledge:

1. Knowledge of basic definitions applied in electricity: electric potential, intensity of electric field, dipole moment, electromotive force.
2. Dipole model as physical model of an electric activity of the heart.
3. Ideas of electrocardiography, Einthoven's triangle, bipolar Einthoven's leads (V_I, V_{II} and V_{III}) and geometric estimation of a projection of the "electric vector of the heart" on the front vertical plane.

Practical No 25

AUDIOMETRY

Required theoretical knowledge:

1. Physical description of waves, acoustic waves. Audible, infra- and ultra- sounds.
2. Hearing and pain thresholds, equal-loudness contour
3. Acoustic pressure, sound intensity, sound intensity level, pitch and timbre of sound.
4. Weber-Fechner law (the decibel scale and phonon scale, level of loudness and loudness).
5. Mechanism of sound recognition by human ear. Transformation of mechanical vibrations in electrical signals in the

organ of Corti.
6. Air and bone conductance of sound.
7. Audiometry

Recommended literature:
1. Roland Glaser, "Biophysics, an introduction", Springer 2012. (chapter 4.3)
2. P. Davidovits, "Physics in Biology and Medicine", Elsevier, 2001. (chapter 12)

Practical No 26
MAGNETIC MOMENT IN THE MAGNETIC FIELD
Required theoretical knowledge
1. Uniform magnetic field, induction of a magnetic field. Units of measure of the strength and induction of a magnetic field. Magnetic force acting on an electric charge moving in a uniform magnetic field. Magnetic force acting on a wire placed in a uniform magnetic field.
2. Pair of forces acting on a current-carrying rectangular frame placed in a uniform magnetic field.
3. Definition of a torque (moment of force) and of a magnetic moment (units of measure).
4. Calculation of a value of a magnetic moment for a circuit with a circular shape.
5. Calculation of a torque exerted by the magnetic force on a current-carrying circuit placed in a uniform magnetic field.
6. Structure of the setup (Helmholtz coils) used to measure forces acting on a current-carrying circuit placed in a uniform magnetic field.
7. Absorption of electromagnetic waves - transitions between energy levels of paramagnetic nuclei in a constant magnetic field with the induction of B. The phenomenon of a nuclear magnetic resonance (NMR). Resonance frequency.
8. The NMR spectroscopy and its application in chemistry, biology and medicine. Functional NMR and its application in a medical diagnostics.

Recommended literature:
D. Halliday, R. Resnick, J. Walker: „Fundamentals of physics"

Practical No 31
MEASUREMENT OF LIQUID FLOW VELOCITY WITH THE USE OF DOPPLER EFFECT

Required theoretical knowledge:
1. Waves. Physical parameters describing waves. Wave equation.
2. Acoustic waves. Audible sounds, infra- and ultrasounds.
3. Ultrasound and its basic properties. Ultrasound sources (piezoelectric effect), the near and the far field.
4. Doppler effect and its application for velocity measurements.

Recommended literature:
1. Glaser, "Biophysics", Springer, 2001.
2. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Practical No 32
STUDY OF PROPERTIES OF ELECTROMAGNETIC WAVES
Required theoretical knowledge:
1. Nature of light.
2. Generation of laser's light (population inversion, optical pumping, parameters of semiconductor laser, spontaneous and stimulated emission).
3. Characteristics of laser work
4. Light polarization.
5. Properties of laser's light.
6. Malus's law.
7. Phenomenon of the total internal reflection.
8. Principle of operation of a waveguide.
9. Basic photometric quantities and their units.
10. Lambert's cosine law.

Suggested sources:
1. Wikipedia
2. http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

Practical No 33
HARMONIC ANALYSIS OF ACOUSTIC WAVES
Required theoretical knowledge:
1. The speech organ, the ear and their structure.
2. Acoustic waves, objective (physical) and subjective properties of sound. Loudness, loudness level.
3. Spectrogram and sound spectrum.
4. Fourier theorem. Fourier analysis. Sound timbre.
5. Helmholtz and Bekesy theory of hearing.
6. Spectrogram and spectrum of a sound

Practical No 34
ULTRASOUND PROBE
Required theoretical knowledge:
1. Ultrasound as a mechanic wave. Wavelength, frequency and propagation rate of ultrasound.
2. Impulse echolocation as a method of a spatial localization of organs inside a body in an ultrasound image. The axial resolution of an ultrasound beam and its dependence on the frequency of ultrasound.
3. Ultrasound echo presentation modes A and B.
4. Artifacts in an ultrasound image.

Practical No 35
ESTIMATION OF VOLUME AND RADIUS OF A SINGLE MOLECULE APLYING THE VISCOMETRIC METHOD
Required theoretical knowledge:
1. Types of liquid flow: laminar flow, turbulent flow.
2. Internal friction during transportation of liquids.
3. Viscosity of liquids – Newton law – viscosity coefficient, viscosity units.
4. Which liquids are newtonian and which are non-newtonian ?
5. Poisseuille law for liquid transportation in a vessel
6. Einstein formula describing viscosity of a solution in relation to viscosity of a solvent, in which spherical molecules are dissolved..
7. Define a relative viscosity, specific viscosity and limiting viscosity number.
8. Method of determination of limiting viscosity number.
9. Describe the method of determination of volume and radius of a single molecule using Ostwald viscometer and Poisseuille law.

Recommended literature:
1. Glaser, “Biophysics”, Springer, 2001.

Practical No 36
WAVE ABSORPTION IN SOLUTIONS OF ORGANIC DYES. ANALYSIS OF SOLUTION COMPOSITION
Required theoretical knowledge:
1. What is spectroscopic analytical method ?
2. Types of chemical bonds in organic compounds and names of molecular orbitals.
3. What is a chromophore in a structure of organic molecule.
4. Ground and excited state of a molecule, mechanism of excitation.
5. Types of electronic transitions in molecules.
6. What is UV-VIS spectroscopy ?
7. Light absorption laws:
   a) Lambert Law (I absorption law)
   b) Lambert-Beer law (II absorption law)
   c) absorption addition law (III absorption law)
8. What is electronic absorption spectrum and what are its parameters ?
9. What is a monomer and what is an aggregate of organic dye in a water solution.
10. Condition, at which molecules of organic dye in a solution exist in a monomeric phase.
11. Main reasons of deviations from Lambert-Beer law.
12. Spectral analysis of mixture of two dyes:
   a) interpretation of equation about additivity of absorption of two organic dyes
   b) describe the method of determination of unknown concentration of fluorescein (FL) and bengali rose (RB) in a mixture