ED - PRACTICAL EXAM TOPIC LIST - 2025/26 I. semester

1. Refractometry
    1/1. Definition of refractive index. Law of light refraction. Critical angle. Total internal reflection. Dispersion.
    1/2. Formation of Snell's window. Abbe’s refractometer. Concentration determination by refractometry.

2. Microscopy
    2/1. Image formation in microscope, magnification. Size determination of red blood cells by light microscope.
    2/2. Resolution of a microscope, Abbe’s principle and formula. Image formation by special microscopes.

3. Optics of the eye
    3/1. Focal accomodation of the eye. Refractive media and image formation of the eye. Refractive disorders of the eye and their corrections.
    3/2. The reduced eye. Limiting angle of vision. Visual acuity and its measurement. Factors influencing visual acuity. Estimation of receptor density.

4. Light emission
    4/1. Thermal emission and luminescence. Characterization of light emission spectra. Light sources.
    4/2. Parts of a spectrometer, monochromator types. Flame photometer and its diagnostic applications.

5. Light absorption
    5/1. Definition of absorbance and transmission. Beer-Lambert law. Concentration determination by light absorption.
    5/2. Absorption spectra, types, characteristics. Parts and function of absorption spectrometer.

6. Resonance
    6/1. Harmonic oscillation, undamped and damped free oscillation, critical damping. Driven oscillation, resonance.
    6/2. Elastic deformation, Hooke's law. The concept of resonance and the interpretation of the resonance curve.

7. Polarimetry
    7/1. Definition of polarized light. Relations between linearly and circularly polarized light. Optical activity. Parts of a polarimeter.
    7/2. Biot’s law. Definition of specific rotation. Factors influencing specific rotation. Parts of a polarimeter.

8. Nuclear medicine
    8/1. Parts and function of scintillation counter. Processes in the scintillation crystal.
    8/2. Parts and function of scintillation counter. Processes in the PM tube. Signal selection. Sources of noise. Signal-to-noise ratio.

9. Gamma absorption
    9/1. Attenuation of gamma radiation. Attenuation coefficient and half-value thickness. Mass attenuation coefficient, surface density, half-value mass.
    9/2. Atomic-level interactions determining the mass attenuation coefficient, their dependence on photon energy. Scintillation counter.

10. Dosimetry

10/1. Ionizing radiations, direct and indirect chemical effects, stochastic and deterministic effects. Scintillation counter, thermoluminescence dosimeter.

10/2. Definition of dose concepts (absorbed dose, exposure, equivalent and effective dose) and dose rate. Parts and function of ionization chambers.

11. Amplifier

11/1. Electric gain, linear transfer function, distortion. Power gain, voltage gain, gain level, transfer band.

11/2. Frequency response curve of the amplifier. Negative feedback. Advantage and disadvantage of negative feedback.

ED - PRACTICAL EXAM TOPIC LIST - 2025/26 II. semester

1. Coulter counter

1/1. The Coulter principle. Coulter counter. Size-discrimination of the corpuscular elements of blood. Frequency distribution of particle sizes.

1/2. Coulter Counter. Integral and differential discriminator. Optimal Ud-level determination for RBC setting.

2. Skin impedance

2/1. The electric model of the skin. Definition of impedance and its measurement.

2/2. Capacitive reactance. Determination of the specific resistance and capacitance of the skin.

3. X-ray

3/1. X-ray tube: parts, function. Bremsstrahlung and characteristic radiation, Duane-Hunt law. Power of X-ray radiation and efficiency of the X-ray tube.

3/2. Attenution of X-ray, attenuation coefficient, half-layer thickness. Mass-attenuation coefficient, and its dependence on the atomic number.

4. Gamma energy

4/1. Parts and function of scintillation counter. Pulse-amplitude spectrum of gamma-radiation determined by differential discriminator setting.

4/2. Photopeak and its characteristics. Determination of gamma energy based on photopeak measurements.

5. Flow

5/1. Stacionary flow, continuity equation. Hagen-Poiseuille law: pressure-dependence of the volumetric flow rate.

5/2. Laminar and turbulent flow. Hagen-Poiseuille law: dependence of the volumetric flow rate on the radius of the tube.

6. ECG

6/1. Origin of the ECG signal. Different and indifferent electrodes, bipolar and unipolar leads, Wilson`s central terminal. The mean eletric axis of the heart.

6/2. Einthoven`s standard leads. Determination of parameters of the ECG signal. Construction of the integral vector.

7. Ultrasound

7/1. Ultrasound generation and detection, transducers. Acoustic impedance and reflectivity. The pulse-echo principle: sound velocity determination and distance measurement.

7/2. Medical imaging by ultrasound: A- and B-mode images. Investigating fantoms filled with different liquids in B-mode. Velocity measurements by Doppler method.

8. Sensor

8/1. Bases of sensory function. Compressive and expansive sensation. Psychophysical laws. Loudness sensation. The phon and son scales.

8/2. Receptor cells, receptor potential, amplitude- and frequency-coding. Psychophysical laws. Weight-sensation measurement.

9. Isotope diagnostics

9/1. Principles of isotope diagnostics: selection of proper isotopes, isotope accumulation curve, effective half-life. Technetium generator.

9/2. Medical imaging with isotopes: gamma camera, SPECT, PET. The role of collimators.

10. Diffusion

10/1. Mass-transport by diffusion. Fick`s first and second law. Determination of diffusion-coefficient by image-analysis.

10/2.The relation between diffusion and random-walk. The time-dependence of the average distance reached by diffusion.

11. Pulse generator

11/1. Two-state systems. Generation of pulses, time constant, trigger, types of pulse generators. Function codes of pacemakers.

11/2. Monostable and astable multivibrators in medical practice. Modeling of pacemaker signals. Energy and charge in a pulse.

12. Audiometry

12/1. Definition of sound, human hearing range, hearing threshold curve, audiogram, hearing loss.

12/2. Equal-loudness curves, phon and sone scales. Sound dose. Types of hearing loss and impaired hearing on audiograms.

13. CAT-scan

13/1. Medical imaging with X-ray. Summation image, density, elementary density, principles of 3D-reconstruction.

13/2. X-ray attenuation in bone and soft tissues. Contrast enhancements of X-ray images. HU-scale, windowing.

ED - THEORETICAL EXAM TOPIC LIST - 2025/26 I. semester

1. Radiation: definition, types, descriptive physical parameters of radiation, examples of radiation.

2. Law of attenuation of radiation: differential and integral forms, applications of the law in medical and laboratory practice.

3. Basic principles of optics I: geometric optics, Fermat's principle, refraction of light, Snell's law, applications: prism, optical fiber.

4. Basic principles of optics II : reflection, spectral reflectance, scattering: Rayleigh, Mie, Raman scattering.

5. Optics of the human eye: image formation, accomodation, reduced eye model, visual acuity, resolution of the eye.

6. Image formation by optical devices and their medical applications: optical lenses, microscope, resolution, Abbe’s principle.

7. Light as an electromagnetic wave: parameters of waves, electromagnetic spectrum.

8. Wave nature of light: Huygens' principle, diffraction, superposition principle, interference, optical grating, dispersion of white light.

9. Particle nature of light: photoelectric effect, the photon concept, application of photoelectric phenomenon.

10. Mechanism of light absorption, absorption spectra, Beer-Lambert law and its applications, light sources, monochromators, detectors.

11. Thermal radiation: its origin, absorption coefficient and radiant emittance, Kirchhoff's law, spectrum of blackbody radiation, Wien's displacement law.

12. Principles of thermography: Stefan-Boltzmann law, Wien's displacement law, thermal radiation of human body, applications.

13. Luminescence: Mechanisms of luminescence, Kasha's rule, emission spectra, Stokes shift, lifetimes and quantum yield.

14. Application fields of luminescence: Light sources based on luminescence, medical applications.

15. Concept of light amplification: Optical pumping and population inversion, induced emission, optical resonator.

16. Applications of LASER light: properties of LASER light, LASER types, medical applications of LASER light.

17. Light absorption in human body, biological effects of light, photodynamic therapy.

18. Generation of X-ray: X-ray tube, Duane-Hunt law, spectrum of Bremsstrahlung and characteristic radiation, efficiency of X-ray tube.

19. Absorption of X-ray: Linear and mass attenuation coefficients, absorption mechanisms, effective atomic number.

20. Medical application of X-ray: principles of X-ray diagnostics, image quality, application of contrast materials, DSA.

21. X-ray diagnostics: Summation image, concept of CT, CT generations, Hounsfield units, windowing, X-ray image amplifier.

22. Nuclear radiation: Composition and stability of nucleus, nuclear force, mass defect, radioactive decay, activity.

23. α, β, and γ radiations: mechanisms of decay, energy spectra, penetration depth.

24. Methods in isotope diagnostics I.: Selection of radioisotopes, radiopharmacons, metabolic labeling, isotope accumulation curve, effective and biological half-life, static and dynamic investigations.

25. Methods in isotope diagnostics II.: gamma camera, SPECT, PET.

26. Modern microscopy techniques: fluorescence microscopy, confocal laser scanning microscopy, two-photon excitation.

27. Concept of electron microscopy, resolution, TEM, SEM.

28. Structure of matter: Development of atomic models, Bohr's model of hydrogen atom, energy levels of atoms, molecules, and solid-state materials.

ED - THEORETICAL EXAM TOPIC LIST - 2025/26 II. semester

1. Signals in medicine. Analog and digital signals. Fourier analysis of periodic and non-periodic signals.

2. Characteristics of amplifiers, bandwith. Negative feedback.

3. Analog-to-digital conversion, sampling. Shannon-Nyquist theorem.

4. Pulse generators in medicine: defibrillator, pacemaker. Time constant, duty cycle, pulse energy.

5. Sound as a mechanical wave: frequency ranges, velocity, acoustic impedance. Absorption and reflection of ultrasound, specific attenuation, reflectiivity.

6. Generation and detection of ultrasound. Pulse-echo principle. Distance measurement, sonography. Doppler-effect and its applications. Blood flow velocity measurement.

7. Ultrasound imaging: A, B, 2D-B and (T)M mode images, 3D-reconstruction. Axial and lateral resolution.

8. Dosimetry of ionizing radiations: types and effects of ionizing radiations. Dose concepts, dose-rate. Ionization chamber, scintillation counter, thermoluminescent dosimeter.

9. Radiation therapy: linear energy transfer, penetration depth, Bragg-peak. Devices for radiation therapy. ALARA principle, dose limits.

10. Volumetric flow rate, stationary flow, continuity equation. Newton`s law of friction, viscosity of fluids. Stokes law. Volumetric flow in tubes: laminar and turbulent flow, Reynolds number. Bernoulli`s law and blood flow.

11. Volumetric flow in tubes: Hagen-Poiseuille`s law, flow resistance. Characteristics of blood flow in the vascular system. Parameters affecting the viscosity of blood.

12. Material transfer by diffusion: Fick`s 1 and 2 laws. Einstein-Stokes equation. Diffusion and Brownian motion as random walk.

13. Van't Hoff`s law and the medical significance of osmotic pressure. Thermodiffusion, heat-transfer, general description of transport processes (Onsager`s linear relationships).

14. Transport across membranes: permeability coefficient and its dependence on material properties. Passive and active transport, facilitated diffusion.

15. Resting membrane potential: diffusion of ions through membranes, electrochemical potential. Donnan`s equilibrium, transport model of the resting potential, Goldman-Hodgkin-Katz equation. Role of the Na/K-exchanger pump.

16. Passive electric properties of the cell membrane: local potentials, time constant, space constant, electric model of the membrane. Spacial and temporal summation.

17. Development of action potentials: ion-currents, changes in conductivities. Refracter periods and the propagation of action potential. Conduction velocity, saltatory conduction.

18. Origin of ECG signal. Electric field as a multipole expansion. Characteristics of an ECG signal. Lead systems.

19. Stimulus threshold curve, rheobase, chronaxy. High frequency heat therapy, galvanotherapy, iontophoresis.

20. Principles of sensory function. Types of receptor cells. Receptor potential, adaptation. Signal propagation to CNS: action potential, frequency coding. Receptors with persistent action potentials.

21. Bases of psychophysics: how sensation depends on stimulus intensity. Threshold stimulus, just noticeable difference. Weber-Fechner and Stevens laws. Expansive and compressive sensing.

22. Biophysics of vision: structure and function of retina, characteristics of the different receptor cells. Molecular mechanism of light-sensing. Color vision.

23. Biophysics of hearing: roles of outer and middle ear in transferring sound into the inner ear. Deformations of basal membrane as a function of frequency. Signal generation by hair cells.

24. Basis of MRI: Spin, precession, Zeeman-splitting, FID signal, relaxation times, imaging by magnetic gradients, the role of the echo.

25. Types of dental wear and their causes: erosion, abrasion, attrition, and abfraction.

26. Biostatistics I: population and sample, probability distribution, normal distribution and its parameters. Estimations of expected value and standard deviation from samples.

27. Biostatistics II: t-distribution, confidence interval. Hypothesis testing: null-hypothesis, type-I and type-II errors. t-test for a single sample, for two samples, and for correlation.

28. Biostatistics III: correlation and regression analysis between statistical variables, linear regression.