ED – PRACTICAL EXAM TOPIC LIST – 2020/2021 FINAL EXAM

FIRST SEMESTER

Optics of the eye

1 Focal accomodation of the eye. Refractive media and image formation of the eye. Refractive disorders of the eye and their corrections.

2 The reduced eye. Limiting angle of vision. Visual acuity and its measurement. Factors influencing visual acuity. Estimation of receptor density.

Light emission

1 Thermal emission and luminescence. Characterization of light emission spectra. Light sources.

2 Parts of a spectrometer, monochromator types. Flame photometer and its diagnostic applications.

Refractometry

1 Definition of refractive indices. Law of light refraction. Critical angle. Total internal reflection. Dispersion.

2 Formation of Snell's window. Abbe refractometer. Concentration determination by refractometry.

Resonance

1 Oscillation, harmonic oscillation, damped and undamped free oscillation. Definition of driven oscillation. Critical damping, resonance.

2 Elastic deformation. Hooke's law. The concept of resonance and the interpretation of the resonance curve.

Light absorption

1 Definition of absorbance and transmission. Beer-Lambert law. Concentration determination by light absorption.

2 Absorption spectra, types, characteristics. Parts and function of absorption spectrometer.

Nuclear medicine

1 Parts and function of scintillation counter. Processes in the scintillation crystal.

2 Parts and function of scintillation counter. Processes in the PM tube. Signal selection. Sources of noise. Signal-to-noise ratio.

Amplfier

1 Amplification of electric signals, linear transfer function, distortion. Power gain, voltage gain, calculating gain levels, transfer band.

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

Polarimetry

1 Definition of polarized light. Relations between linearly and circularly polarized light. Optical activity. Parts and function of polarimeter.

2 Definition of specific rotation. Factors influencing specific rotation. Biot law. Parts and function of polarimeter.

Dosimetry

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

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

Gamma absorption

1 Attenuation of gamma radiation. Attenuation coefficient and half-value thickness. Mass attenuation coefficient, surface density, half-value mass.

2 Atomic-level interactions determining the mass attenuation coefficient, their dependence on photon energy. Parts of scintillation counter.

SECOND SEMESTER

Coulter counter

1 The Coulter principle. Coulter counter. Amplitude-frequency spectrum. Size-discrimination of the corpuscular elements of blood.

2 Integral and differential discriminator. Optimal Ud-level determination for RBC setting.

Skin Impedance

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

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

X-ray

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.

2 Attenution of X-ray, attenuation coefficient, half-layer thickness. Mass-attenuation coefficient, and its dependence on the anode material.

Gamma energy

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

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

Diffusion

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

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

Sensor

1 Bases of sensory function. Compressive and expansive sensation. Psychophysical laws for loudness sensation. The phon and son scales.

2 Receptor cells, receptor potential, amplitude- and frequency-coding. Psychophysical laws for weight-sensation measurement.

Flow

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

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

Isotope diagnostics

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

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

ECG

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.

2 Einthoven's standard leads. Determination of parameters of the ECG signal. Construction of the integral vector.

Pulse generator

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

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

Audiometry

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

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

Ultrasound

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

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

CAT scan

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

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

ED – THEORETICAL EXAM TOPIC LIST – 2020/2021 FINAL EXAM

FIRST SEMESTER

1 Radiation: Properties and types of radiation; Physical parameters of radiation

2 Law of attenuation of radiation: Experimental interpretation, forms and validity of the law; Application of the law in medical and laboratory practice

3 Basic principles of optics I: 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, reduced eye model, visual acuity, resolution of the eye

6 Image formation by optical devices and their medical application: Optical lenses, microscope; Resolution; Abbe’s principle

7 Light as electromagnetic wave: parameters of electromagnetic waves; electromagnetic spectrum

8 Wave nature of light: Huygens' principle, diffraction, superposition, 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 spectrum; Beer-Lambert law and its applications; Measuring techniques: 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 telethermography: Stefan-Boltzmann law, Wien's displacement law; Thermal radiation of human body, application fields of thermal radiation

13 Luminescence: Mechanisms of luminescence, Kasha's rule, Emission spectrum, Stokes shift, Lifetime of fluorescence and phosphorescence, quantum yield

14 Application fields of luminescence: Light sources based on luminescence, medical and laboratory use of luminescence
15 Concept of light amplification: Optical pumping and population inversion, induced emission
16 Production of LASER light: conditions for LASER operation, properties of LASER light
17 Medical application of LASER: characteristics of LASER light; Biological effects and medical application of LASER light
18 Generation of X-ray: Structure and operation of 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
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, X-ray image amplifier
22 Nuclear radiation: Composition and stability of nuclei, nuclear force, mass defect, radioactive decay and its characzerization, activity
23 α, β, and $\gamma$ 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: fluorescent microscopy, confocal laser scanning microscopy; two-photon excitation
27 Concept of electron microscopy: resolution of the electron microscope; TEM, SEM
28 Biostatistics I: stochastic variable and probability distribution; Normal distribution and its parameters
29 Biostatistics II: Sample and its characteristics; Estimations of expected value and standard deviation
30 Biostatistics III: linear regression; correlation
31 Hypothesis testing I: t-distribution, confidence interval, null-hypothesis, type-I and type-II errors
32 Hypothesis testing II: t-test for a single sample, t-test for two samples, t-test for correlation

SECOND SEMESTER
1 Signals in medicine. Analog and digital signals. Fourier analysis of periodic and non-periodic signals.
2 Characteristics of amplifiers, bandwith. Negative feedback. Analog-to-digital conversion, sampling. Shannon-Nyquist theorem.
3 Stimulus threshold curve, rheobase, chronaxy. High frequency heat therapy, galvanotherapy, iontophoresis.
4 Pulse generators in medicine: defibrillator, pacemaker. Time constant, duty cycle, pulse energy.
5 Sound as a mechanical wave: frequency ranges, velocity, acoustic impedance. Generation and detection of ultrasound.
6 Absorption and reflection of ultrasound, specific attenuation, reflectiivity. Pulse-echo principle. Distance measurement, sonography.
7 Ultrasound imaging: A, B, 2D-B and (T)M mode images, 3D-rekonstruction. Axial and lateral resolution.
8 Doppler-effect and its applications. Blood flow velocity measurement. Pulsed-Doppler, color coding. Ultrasound therapy.
9 Dosimetry of ionizing radiations: types and effects of ionizing radiations. Dose concepts, dose-rate.
10 Radiation therapy. Linear energy transfer, penetration depth, Bragg-peak. Devices for radiation therapy.

11 Radiation protection. Exposure due to natural backgrounds and medical interventions. ALARA principle, occupational dose limits and dose limits for the population.
12 Measuring dose and dose-rate. Ionizing chamber and its regimes. Solid phase dosimeters: scintillation counter, thermoluminescent dosimeter.
13 Principles of sensory function. Types of receptor cells. Receptor potential, adaptation. Signal propagation to CNS: action potential, frequency coding. Receptors with persistent action potentials.
14 Bases of psychophysics: how sensation depends on stimulus intensity. Threshold stimulus, just noticeable difference. Weber-Fechner and Stevens laws. Expansive and compressive sensing.
15 Volumetric flow rate, streamlines, stationary flow, continuity equation. Newton's law of friction, viscosity of fluids. Stokes law.
16 Volumetric flow in tubes: laminar and turbulent flow, Reynolds number. Bernoulli's law and blood flow.
17 Volumetric flow in tubes: Hagen-Poiseuille's law, resistance to flow, comparison with Ohm's law.
18 Charateristics of blood flow in the vascular system. Parameters affecting the viscosity of blood.
19 Material transfer via diffusion: Fick's 1 and 2 law. Einstein-Stokes equation. Diffsion and Brownian motion as random walk.
20 Van’t Hoff's law and the medical significance of osmotic pressure. Thermodiffusion, heat-transfer, general description of transport processes (Onsager's linear relationships).
21 Transport across membranes: permeability coefficient and its dependence on material properties. Passive and active transport, facilitated diffusion.
22 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.
23 Passive electric properties of the cell membrane: local potentials, time constant, space constant, electric model of the membrane. Spacial and temporal summation.
24 Development of action potential: ion-currents, changes in conductivities. Refracter periods and the propagation of action potential. Conduction velocity, saltatory conduction.
25 Biophysics of vision: structure and function of retina, characteristics of the different receptor cells. Molecular mechanism of light-sensing. Color vision.
26 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.
27 Primary and secondary interactions in proteins, their roles in 3D-structure stabilization. Cooperativity, folding, dynamics in protein function.
28 Bases of MRI: spins in magnetic field, Zeeman's effect, Larmor frequency. Spin-ordering by 90° pulse, spin-spin (T2) and spin-lattice (T1) relaxations.
29 Pixel, voxel: physical properties of image elements in different medical imaging methods. Computed tomography.