Practice questions on the final exam 2019/20 II. semester (EM)

I. Semester

1. Microscopy I.
   Theoretical background:
   - types of optical lenses, parameters of them
   - image formation of convex lenses
   - lens laws
   - image formation and magnification of microscope
   - resolving power of microscope (Abbe's principle)
   Quantities to be determined based on the given data:
   calibration value of eyepiece scale and size of the object.

2. Refractometry
   Theoretical background:
   - law of light refraction, definition of index of refraction
   - critical angle, total reflection
   - formation of Snell circle
   - factors influencing the value of index of refraction
   - parts and function of Abbe-refractometer
   Quantities to be determined based on the given data after proper graphical representation:
   the unknown concentrations.

3. Light absorption
   Theoretical background:
   - derivation of Lambert-Beer law from the absorption law
   - absorbance, transmittance and the relation of them
   - absorption spectrum and the information available from it
   - parts of absorption spectrometer
   - application of absorbance measurement in laboratory diagnostics
   Quantities to be determined based on the given data after proper graphical representation:
   photon energy belonging to electron transition (in eV units)

4. Polarimetry
   Theoretical background:
   - linearly polarized, circularly polarized light and the connection between them
   - definition and interpretation of optical activity
   - Biot-law, specific rotation
   - parts and function of polarimeter
   Quantities to be determined based on the given data:
   the type of given sugar and the unknown concentration.

5. Optics of the eye
   Theoretical background:
   - refractive media and image formation of the eye
   - accommodation
   - refractive disorders of eye and the way for correction of them
   - limiting angle of vision, visual acuity (visus), factors influencing the visual acuity
   - distribution of photoreceptors on the retina
   Quantities to be determined based on the given data:
   accommodation power and visual acuity.

6. Nuclear medicine
   Theoretical background:
   - parts of scintillation counter
   - possible processes happening in the scintillation crystal
   - processes happening in the photomultiplier
   - signal selection, function of the discriminator, sources of noise pulses
   - optimal setting of scintillation counter
   Quantities to be determined based on the given data after proper graphical representation:
   the optimal discrimination level.

7. Gamma-absorption
   Theoretical background:
   - attenuation law of radiation, attenuation coefficient, mass attenuation coefficient
   - processes of attenuation on the atomic scale (photoeffect, Compton-scattering, pair production, elastic scattering)
   - the dependence of mass attenuation coefficients due to different processes on the photon energy
   - viewpoints of radiation protection
   Quantities to be determined based on the given data after proper graphical representation:
   D, μ, $\mu_{m,}$ for all the absorbents and ε, τ_{mPb}, σ_{mPb}.

8. Resonance
   Theoretical background:
   - elastic deformation, Hooke's law
   - harmonic oscillation
   - undamped and damped free oscillation
   - driven oscillation, resonance
   - effect of external force (depending on the distance) on the driven oscillation (working principle of AFM)
   Quantities to be determined based on the given data after proper graphical representation:
   the spring constant.

9. Skin impedance
   Theoretical background:
   - definition and components of impedance
   - electric model of the skin and the possible simplifications on the model
   - frequency dependence of capacitive reactance, approximation of skin impedance in case of low and high frequencies
   - practical applications of impedance measurement
   Quantities to be determined based on the given data:
   specific resistance and specific capacity of the skin.

10. Dosimetry
    Theoretical background:
    - the most important basic concepts in dosimetry
    - function of thermoluminescent dosimeter
    - application of the ionization chamber as dose rate measuring device
    Quantities to be determined based on the given data after proper graphical representation:
    Voltage – current diagram of the ionization chamber. Name the ranges of the diagram and determine the exposure rate and absorbed dose rate in air.

11. Amplifier
    Theoretical background:
    - gain, gain level

- frequency response curve of the amplifier
- negative feedback
- advantages and disadvantages of feedback

Quantities to be determined based on the given data after proper graphical representation: The maximum gain level, cut-off frequencies of the transfer band. Can it be used for the amplification of ECG signal?

II. semester

1. Coulter-counter

   Theoretical background:
   - parts and function of the equipment
   - function of ID, DD and multichannel analyzer
   - additional methods for counting different types of blood cells

   Quantities to be determined based on the given data after proper graphical representation: Calibration value, unknown blood cell concentration, RBC discrimination level

2. Diffusion

   Theoretical background:
   - phenomenon of diffusion and its mathematical description: Fick's I. and II. law.
   - solution of Fick's II. law in case of concrete experimental conditions (to be listed)
   - dependence of average distance covered by a particle on the time

   Quantities to be determined based on the given data after proper graphical representation: The diffusion coefficient .

3. X-ray I.

   Theoretical background:
   - parts and function of the X-ray tube
   - production, spectrum and diagnostic energy range of X-radiation
   - power of Bremsstrahlung and efficiency of X-ray tube

   Based on the given spectra make a graph, which proves Duane–Hunt-law.

4. X-ray II.

   Theoretical background:
   - attenuation of X-ray intensity
   - application of filters in X-ray diagnostics
   - atomic processes of attenuation, dependence of their mass attenuation coefficients on the photon energy
   - explain which photonenergies are the best for X-ray diagnostics

   Based on the given data make a graph that shows the relationship between the mass attenuation coefficient of photoeffect and the atomic number of the absorbent.

5. Gamma energy

   Theoretical background:
   - energy transformations in the scintillation counter, energy selectivity
   - possible applications of discriminators
   - spectrum of gamma radiation and the pulse amplitude spectrum
   - give an example for dual isotope labeling, and explain its advantage

   Quantity to be determined based on the given data after proper graphical representation: The unknown photon energy

6. Audiometry
   Theoretical background:
   - physical characteristics of sound
   - the human hearing range, threshold of hearing, threshold of pain
   - loudness, loudness level and the connection between them
   - interpretation of the audiogram
   Based on the given data construct the hearing threshold curve and the audiogram

7. Pulse generator
   Theoretical background:
   - characteristic parameters of square pulses
   - types of multivibrators, practical application of them
   - parameters of pacemakers
   Determine the parameters of the pulse series shown on the attached graph (amplitude, pulse duration time, period time, frequency, duty cycle, and the energy of one pulse)

8. ECG
   Theoretical background:
   - explain the formation of the ECG curve, and its components
   - types of ECG leads
   - Einthoven-triangle, integral vector
   - parts of the ECG equipment, differential amplifier
   Based on the attached ECG curves construct the integral vector and determine the heart rate

9. Flow
   Theoretical background:
   - stationary and pulsed, laminar and turbulent flow
   - Hagen–Poiseuille-law and the conditions of its validity
   - changes of pressure, cross section and flow velocity in the circulatory system
   Based on the given data determine the function describing the connection between tube radius and flow intensity and the viscosity.

10. Sensor
    Theoretical background:
    - model of the sensory system
    - stimulus, receptor potential, action potential, sensation
    - interpretation of amplitude and frequency coding
    - psychophysical laws
    Based on the given data after proper graphical representation whether the model supports the Weber–Fechner or the Stevens-law.

11. CAT-scan
    Theoretical background:
    - X-ray density and the Hounsfield scale
    - comparison of summation image and CAT-scan image
    - theoretical background of the CAT-scan image formation
    Based on the given data determine the position of absorbents in the model.

12. Ultrasound
    Theoretical background:
    - characteristics of ultrasound
    - production of ultrasound
    - reflection of ultrasound, basis of image formation
    - A, B and M (TM) images

- Doppler principle and its application
Quantities to be determined based on the given data after proper graphical representation: velocity of ultrasound and the unknown distance