DDS - SEMINAR TOPICS 2019/2020

1. PHYSICAL PROPERTIES OF BODY TISSUES AND DENTAL MATERIALS

1. Stress and strain. The Hooke law. Stress-strain diagrams for different materials and their description and interpretation (the concepts of resilience and toughness). Types of stress: tensile stress, compressive stress, shear stress. The Young modulus, bulk modulus of elasticity and shear modulus of elasticity. Necking.

2. Stress and deflection in bending beams. Cantilever bending vs. three-point bending.

3. Rheological properties of materials. Viscous, elastic and viscoelastic materials. Newtonian and non-Newtonian fluids (dilatant, pseudoplastic).
   Rheological models of viscoelastic materials:
   - the Maxwell model: the stress relaxation process and the process of creep, determination of the relaxation time and velocity of creep,
   - the Kelvin-Voigt model: the elongation retardation process - determination of the retardation time.
   Viscoelastic properties of the muscle tissue. The passive and active component of a muscle force.

4. Hardness of material – definition and selected test methods: Brinell test, Vickers test, Knopp test, Rockwell test.

5. Fundamental modes of heat transfer: conduction (Fourier's law), convection (Newton's law), radiation (Stefan-Boltzmann law) concerning dentistry and dental materials.

6. Thermal properties of (dental) materials. Specific heat and thermal capacity. Process of thermal expansion. Thermal expansion vs. compressive stress in dentistry. Thermal conductivity and thermal diffusivity. Discussion of thermal mismatch.

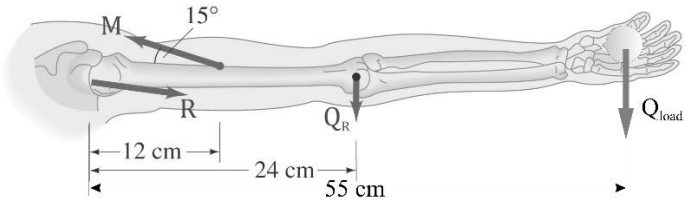
2. BIOMECHANICS OF THE MUSCULOSKELETAL SYSTEM

1. Types of muscle contraction with examples. Definition of the torque with illustrations and some numerical examples. The lever equation.

2. Lever – the structure of the lever. Classification of levers. Mechanical advantage - please be ready to present exemplary calculations.

3. Statics. Conditions for the static equilibrium - please be ready to present exemplary calculations.

4. Levers: Calculate the magnitude of the force M required of the deltoid muscle to hold the outstretched arm and the force R exerted by the shoulder joint on the upper arm if there is:
   - no load in the hand (the arm weight equals Q_R = 30 N)
   - load in the hand of value from 50 through 100 N.



5. The mandible as an example of a lever system – analysis of the forces acting on tooth. The Hooke law, the internal stress, Young's modulus, compressive strength of enamel and dentine.

6. Structure of dental braces. Analysis of forces created by the arc wire used to align the teeth.

3. BIOPHYSICS OF THE VISUAL SYSTEM

1. Index of refraction. Law of refraction (Snell's law): passage of light through a border of two media; flat and curved surfaces. Thin lenses (types: converging, diverging) focal point, focal length, optical power and their unit. Examples.

2. Finding the image position formed by a thin lens. The thin Lens Equation. The sign convention. Examples. The lensmaker's equation. Examples. Combination of lenses. Please be ready to present exemplary calculations.

3. Aberrations: spherical and chromatic. Astigmatism. Spectral sensitivity of the eye: the photonic and scotopic vision.

4. Optical system of the eye. The reduced eye. Accommodation. The near and the far point of accommodation. The amplitude of accommodation.

5. Resolving power of the Human eye (angular and spatial resolution). Limits of resolution (Rayleigh criterion) Circular aperture.

6. Visual defects of the eye. Principles of correction. The error of refraction. Principles of corrections of visual defects for farsighted and near sighted eye. Examples.

4. BIOPHYSICS OF THE AUDITORY SYSTEM

1. The mechanism of sound perception - functions of the outer ear (resonance in the outer ear); resonance in pipes, differences in resonances for infants and adults

2. The mechanism of sound perception - functions of the middle ear (the middle ear as an impedance matching system); mechanical impedance, role of middle ear

3. The mechanism of sound perception - functions of the inner ear (the place principle of frequency discrimination); hearing range of frequencies that can be heard by humans

4. Pure tone audiometry. Bone and air conduction. Procedure of examination, preparation of test subjects, format for audiogram forms

5. Localization of sound sources: interaural intensity difference and interaural time difference

6. Localization of sound sources: the effects of the pinna, the head-related transfer function, motion and environmental cues.

5. APPLICATION OF ELECTROMAGNETIC RADIATION FROM ULTRAVIOLET, VISUAL AND INFRA-RED RANGE IN MEDICINE.

PROPERTIES AND SOME APPLICATIONS OF LASER LIGHT

1. Spectrum of electromagnetic radiation. Localisation of the ultraviolet, visual and infrared radiation wavebands within the electromagnetic spectrum, corresponding wavelengths and energies of photons. Effects of optical radiation on the human body. Action spectra. Light hardening (curing).

2. Absorption and emission of energy. The linear and continuous spectra: atomic vs. molecular spectrum. Jabłoński diagram. Transitions between electronic, vibrational and rotational energy levels - corresponding spectra. Radiative and non-radiative transitions. Luminescence, phosphorescence, fluorescence and energy transfer.

3. Fundamentals of spectrophotometry. The Beer-Lambert law: absorbance, transmittance and the coefficient of absorption; related depth of penetration in tissues. Absorption spectra of water and some natural dyes: hemoglobin, oxyhemoglobin and melanin. Pulse oximetry.

4. Photodynamic methods in diagnostics(PDD) and therapy (PDT) – principles, mechanism, clinical applications.

5. Fundamentals of thermography. Thermal radiation, black-body radiation, Stefan-Boltzmann law, Wien's displacement law. Body temperature and its measurement methods. Structure and function of a thermal imaging camera. Applications of thermography in medicine.

6. Laser in medicine**.** Structure and function of a laser. Properties of the laser light. Power density and fluence. Thermal and nonthermal effects of the laser light. Photocoagulation and photovaporisation (selective absorption). Classification of lasers and their practical applications in medicine (especially in dentistry).

6. IONIZING RADIATION IN MEDICAL SCIENCES

1. Meaning of the term *ionizing radiation*. Energies related to ionizing radiation. Definition of the electronvolt (eV) unit of energy. Ionization of atom and ionization energy. Classification of the ionizing radiation: direct and indirect ionization:
   - mechanisms of indirect ionization, penetration depth (γ and X-rays)
   - mechanisms of indirect ionization, penetration depth (neutrons)
   - mechanisms of direct ionization, penetration depth (charged particles)
2. Quantitative evaluation of interaction of ionizing radiation with mater:
   - definition of the linear energy transfer(LET)
   - LET for different types of radiation (γ, X, β, α and beam of protons)
   - the absorbed dose and the exposure dose and their interrelation
   - the exposure dose vs. absorbed dose - measurement problems
3. Quantitative evaluation of the interaction of the ionizing radiation with living matter: the dose equivalent and the effective dose:
   - Types of ionizing radiation and their influence on irradiation of living forms.
   - definition and the interpretation of the equivalent dose
   - sensitivity of tissues to irradiation – global measure: the effective dose.
4. Long and short time effects of irradiation – the deterministic (somatic) and stochastic effect:
   - tissue radio-sensitivity
   - <u>deterministic</u> (immediate) somatic effects: their relationship to the absorbed dose
   - <u>stochastic</u> (delayed) effects and its relationship to the irradiation equivalent dose
   - cells survival from irradiation; the surviving fraction vs. absorbed dose relationship; differences between diploid and haploid cell populations; cell recovery from irradiation
5. The idea of medical examination based on radio-nuclear markers. Nature and types of spontaneous nuclear disintegration. Probabilistic nature of disintegration in case of low disintegration rates:
   - α, β and γ disintegration – nuclear reactions
   - law of spontaneous radioactive decay
   - nuclear activity and the specific activity: meaning and units
   - mean life-time of nuclei
   - accuracy of measurement and imaging quality in the context of medical diagnostics
6. Gamma (Anger) camera and the single-photon emission computed tomography (SPECT):
   - functional components
   - γ rays collimation
   - ambiguous localization of the γ photon source
   - SPECT method as an extension of the gamma camera imaging
   - basic problems in SPECT: spatial and temporal resolution of imaging system in context of the nuclear disintegration side effects
7. Principles of the positron-emission tomography (PET) technique:
   - β^+ disintegration, the annihilation products and their properties
   - components of the PET device
   - comparison PET and SPECT: imaging quality and the irradiation load of the human body