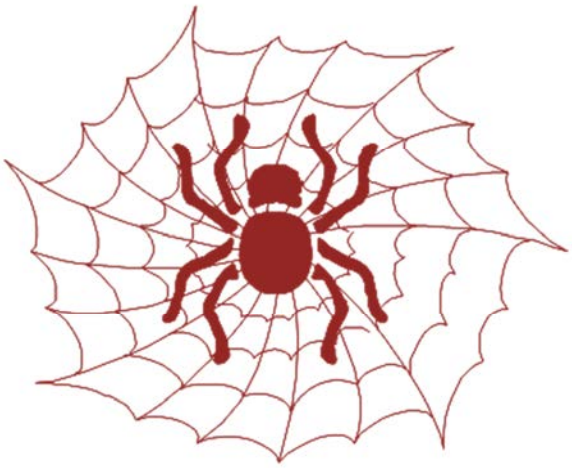
Medical Physics

in questions and answers



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CONTENT

1. ZÁKLADNÉ FYZIKÁLNE POJMY

1.1 MECHANICS

Mechanics is the branch of physics describing physical properties of bodies and rules of their mechanic motion.

Most important quantities and units in mechanics:

Statics – branch of physics describing bodies in quiet state and action of the force applied on them.

Volume [V] = 1 m^3

Mass [m] = 1 kg; m = F/a, where a – acceleration ($m.s^{-2}$), F – force (N)

Density [ρ] = 1 $kg.m^{-3}$; ρ = m/V, V – volume (m^3)

Specific density [γ] = 1 $N.m^{-3}$; γ = G/V, G – gravity (N)

Force [F] = 1 N = 1 $kg.m.s^{-2}$; F = m . a, vector quantity

Pressure [p] = 1 Pa = 1 $kg.m^{-1}.s^{-2}$; p = F/S, S – area

Kinematics – branch of physics describing mechanical movement without considering reasons of movement change.

Velocity [v] = 1 $m.s^{-1}$; v = ds / dt, vector quantity

Acceleration [a] = 1 $m.s^{-2}$; a = dv / dt, vector quantity

Uniform motion - motion, when a body passes equal trajectory in equal time intervals.

Trajectory of uniform motion $s = s_0 + v_0 . t$; [s] = 1 m

Velocity of uniform motion $v_0 = (s – s_0) / t$, constant

Uniformly accelerated motion – velocity of body increases with time

Velocity of uniformly accelerated motion $v = v_0 + a . t$

Acceleration of uniformly accelerated motion $a = (v – v_0) / t$, constant

Mean acceleration a_p – ratio of velocity vector change and Δv and change of corresponding time Δt.

Trajectory of uniformly accelerated motion $s = s_0 + v_0 . t + a . t^2 / 2$

Free fall – special example of uniformly accelerated motion, where $a = g = 9{,}81\ m.s^{-2}$; $v = g . t$; $s = g . t^2 /2$

Throw (vertical, horizontal, oblique) - motion composed uniform motion v0 = const. and free fall $v_y = - g / t$

Period *T* – time , in which a mass point during motion passes the trajectory $s = 2 . \pi . r$; [T] = 1 s

Frequency $f = 1 / T$ number of rounds of a mass point on the circle trajectory in 1 s; [f] = 1 s^{-1} = 1 Hz

Velocity of uniform motion on circle trajectory $v = 2. \pi .r /T = 2.\pi . r . f$

Angle trajectory φ - ratio trajectory *s*, passed by a point of rotating body and distance *r* of this point from the rotation axis $\varphi = s / r$; [φ] = 1 (radian) = 1

Angle velocity ω of a rotating body equals to ratio of angle trajectory φ and time *t*

$\omega = \varphi / t = 2.\pi /T = 2.\pi.f$ and contemporary $\omega = v / r$ vector quantity; [ω] = 1 rad . s^{-1} = s^{-1}

Angle acceleration α *of* a rotating body equals to ratio of angle velocity ω and time *t* $\alpha = \omega / t$ vector quantity; $[\alpha] = 1\ rad.s^{-2}$

Centripetal force F_d – force causing centripetal acceleration during motion on circle trajectory. It is equal to the product of mass *m* and centripetal acceleration a_d, i.e. $F_d = m . a = m . v^2 / r = m . \omega^2 . r$

Centripetal acceleration a_d - normal acceleration during motion on a circle trajectory caused by centripetal force F_d $a_d = v^2 / r$; $a_d = \omega^2 . r$

Centrifugal force – reaction force to centripetal force with equal magnitude. It causes the mass point to move on the circle trajectory and acts as inertial force in the rotating system. It equals to the ratio of mass *m*, angle velocity ω^2 and distance *r* of the centre of mass of a body from the rotation axis and is oriented out of the centre of rotation.

1.2 DYNAMICS

Dynamics – branch of physics describing changes of motion and its cause - forces.

Newton´s motion laws:

Inertial law – in conditions, that net external force acting on a body is zero, the body stays in quiet state or in direct uniform motion.

Force law - acceleration *a*, given to a body by force, is directly proportional to the force and indirectly proportional to mass of the body $a = F / m$, $F = m . a$.

Action and reaction law – if two bodies act mutually one to other by forces, these forces have equal magnitude and opposite direction.

Gravity force – force, by which a body acts on the contact point $G = m . g$; $g \cong 9{,}81\ m . s^{-2}$

Frictional force F_t – is directly proportional to the pressure force acting to the surface F_N , t.j. $F_t = f . F_N$, where f = friction coefficient

Moment of force M regarding the axis equals the effect of the force *F*, distance of the point of application from the axis *r* and SIN of the angle between them $M = r . F \sin$ (**r, F**)

Moment law – rotation effect on a body rotating around the axis is cancelled, if vector product of momentum of all forces related to the axis equals zero.

1.3 WORK AND ENERGY

Mechanical work *W* – force does work, if a body changes its position because of acting the force

$W = F. s . \cos \varphi$; φ - angle between direction of the force and motion $[W] = 1\ J = 1\ N . m = 1\ kg.m^2.s^{-2}$

Mechanical energy *E* - characterized state of a body or system of bodies, ability to perform work; [E] = 1 J

Law of conservation of mechanical energy – During mutual exchange of mechanic energy forms in an isolated system, their sum is constant. $E = E_p + E_k = m.g.h + m.v^2/2 = const.$ (E_p - potential energy, E_k - kinetic energy)

Power *P*– work performed per time unit $P = W / t$; $[P] = 1\ W = 1\ J . s^{-1} = kg . m^2 . s^{-3}$

Efficiency of machine η - ratio of performed and provided work, resp. ratio of provided and absorbed power (P_2 and $P_{1)}$ of the system $\eta = W_2 / W_1 = P_2 / P_1 < 1$

Momentum

Momentum [p] = 1 kg . m . s^{-1}; p = m . v, m – mass of a body, v – velocity of a body

Impulse of force – measure of the time effect of force I = F. t ; Impulse of force equals change of momentum p = m . v = F . t; vector quantity

Law of conservation of momentum - when no external forces acts on system of bodies (isolated system), its net momentum **p** is constant.

Angular momentum L – equals to the product of inertial momentum *I* of a body rotating around an axis and of its angle velocity ω. It is a state quantity.

1.4 MECHANICS OF LIQUIDS AND GASES

Pressure p caused by external force on liquid or gas p = F / S

Hydrostatic pressure – caused by gravity force of fluid p = h . ρ . g

Air pressure (aerostatic) - $p = p_0 \cdot e^{-(\rho_0/p_0)\cdot g\cdot h}$, where p_0 - pressure at the height h = 0, ρ_0 – density of air at 0°C at normal pressure, is caused by gravity force of air layer.

Normal atmospheric pressure p = 1,01325 . 10^5 Pa

Pascal law - pressure caused by external force acting on the surface of the liquid or gas is equal on each place.

Hydraulic press – a device composed of two connected containers and pistons with different cross sections S_1 *and* S_2 *,* which uses effect described by Pascal enable strong pressure force F_2 by acting lower force F_1. Mathematical relation: $p = F_1/ S_1 = F_2/ S_2$.

Hydrostatic paradox – force *F* acting to the bottom of a container does not depend amount of liquid, it is directly proportional to the area of container bottom *S* a and height of the liquid *h*, according to mathematic equation F = p . S = ρ . g . h .S

Connected containers – in connected containers liquids have equal levels, what does not depend on their volume, shape or number. If we put two liquids with different density in connected containers, mathematical relation applies: $\rho_1 . h_1 = \rho_2 . h_2$

Archimedes law – over flow force F acts on any body immersed in liquid (or gas), which equals to the gravity force of liquid with volume equal to the immersed part of body.

Continuity equation for liquids S . v = const.

Total pressure in flowing liquid (gas) $p_c = p_s + p_h + p_d$ (p_s – static, p_h – hydrostatic, p_d – dynamic pressure)

Bernoulli´s equation $p + h.\rho.g + \rho.v^2 / 2$ = const. Expresses the law of conservation of mechanical energy in flowing liquid. At stable flow of an ideal liquid the sum of kinetic and potential energy is constant.

Viscosity – dynamic property of liquids causing internal friction (dynamic, kinematical viscosity)

Stockes equation $F = 6 .\pi . \eta . r . v$ – expresses resistance of the environment during slow motion of a bal-shaped body in liquid (F – resistance of environment, η - dynamic viscosity, r – body radius, v – velocity of the body in the liquid).

Mechanic oscillation

Mechanic oscillation - periodic motion of a body characterized by change of mechanic quantities. It is described by physical quantities changed periodically – trajectory, amplitude, velocity, force, energy.

Harmonic oscillation – motion, in which the body returns to the equilibrium position due to force proportional to amplitude F = - k . y, can be described by function SIN or COS. (for example mathematical oscillator).

Equations of harmonic oscillation

- trajectory $y = y_m . \sin(\omega t + \varphi)$
- velocity $v = \omega . y_m . \cos(\omega t + \varphi) = - v_m . \cos(\omega t + \varphi)$
- acceleration $a = - \omega^2 . y_m . \sin(\omega t + \varphi) = - a_m . \sin(\omega t + \varphi)$; $a = - \omega^2 . y$

Mechanic undulation – effect, vhen energy propagates by bind of oscillators. It is described by physical quantities - amplitude, phase, period, frequency, angle frequency, wavelength, phase velocity.

Harmonic undulation – undulation, where binded oscillators oscillate harmonically. It can be described by mathematical relation: $y = f(s,t) = y_m . \sin[2\pi (t / T - s / \lambda) + \varphi]$

Phase velocity – velocity of undulation propagation, i.e.. phase, energy. Magnitude of phase velocity depends on the environment, in which the undulation propagates. It equals to the ratio of wavelength λ and period T, while $v = \lambda / T = \lambda . f$

Reflection of undulation – effect, when undulation after impinging to a boundary between two environments returns back, impinging angle α equals to reflection angle α' and is situated in the same plane.

Refraction of undulation – change of direction of undulation propagation, when undulation passes through boundary between two environments, where it propagates with different velocities. The refraction law applies: $\sin\alpha . v_2 = \sin\beta . v_1$, resp. $v_1 / v_2 = \sin\alpha / \sin\beta$.

Difraction of undulation - change of direction of undulation propagation on the aperture or edge.

Huygens´s principle – each point of environment, to which the propagation passed, becomes a new source of undulation. There is a ball-shape undulation sphere around each point-source of undulation.

Interference of undulation – superposition of more undulations, when amplitudes of oscillating particles are summed up. Interference causes amplification, when the trajectory difference $\Delta x = \pm k . \lambda$, and attenuation when the trajectory difference $\Delta x = \pm (2k + 1).\lambda/2$

Static undulation – originates by composition of two undulations with equal amplitude and frequency propagating in opposite directions.

Gravitation – mutual attraction of bodies. Force, acting between them is called gravitation force.

Gravitation force F_g between two bodies with mass m_1 and m_2 positioned in mutual distance r, can be expressed mathematically: $F_g = \kappa . m_1 . m_2 / r^2$ $\kappa = (6{,}6720 \pm 0{,}0041) . 10^{-11}$ $kg^{-1} .m^3 . s^{-2}$ - gravitation constant

Gravitation force F near the Earth (M – mass of the Earth): $G = m . g = F_g$, $F_g = \kappa . m_1 . M / r^2$ $g = \kappa . M / r^2$

Intensity of gravitation field $K_g = \kappa . M / r^2$

Circle velocity v_k – a body on circle trajectory near the Earth has the first cosmic velocity.

$v_k = \sqrt{\kappa \cdot M/R}$ = 7 912 $m.s^{-1}$

Parabolic velocity v_p – the second cosmic velocity is the smallest velocity which must be reached by a body to keep increasing distance from the Earth. $v_p \geq \sqrt{2 \cdot \kappa \cdot M/R}$ = 11 119 $m.s^{-1}$; $v_p = v_k . \sqrt{2}$

Hyperbolic velocity v_h – the third cosmic velocity is the smallest velocity which must be reached by a body to keep increasing distance from the Sun. v_h = 16 700 $m.s^{-1}$

1.5 THEORY OF RELATIVITY

Formulates rules for processes at velocities near to the velocity of light c. Laws of Newtonian mechanics are valid only when v « c.

Mechanical principles of relativity – rules of mechanics have the same form in all inertial coordinate systems. It is no possible to differ inertial systems by mechanical experiments.

Special principle of relativity – all physical laws have the same form in all inertial systems. Coordinate systems are equivalent. Velocity of light propagation in vacuum is the maximal possible velocity.

Velocity of light in vacuum in all inertial coordinate systems does not depend on direction of propagation and motion of the coordinate system. It is constant and its magnitude is $c = 299\,792\,458 \pm 1{,}0$ ($m.s^{-1}$).

Inertial coordinate system- system, regarding to which the body is in stationary state or uniform direct movement.

Time dilatation $dt = dt_o/k$; $k = \sqrt{1 - v^2/c^2}$. If there is a relative motion between the position of the observer and position of the observed phenomenon, the observer the time of the phenomenon prolonged by the time *1/k*.

Contraction of length $l = l_o.k$; $k = \sqrt{1 - v^2/c^2}$ If there is a relative motion between the position of the observer and position of the observed body, all lengths of the body, lying in the direction of the motion are expanded by *k*.

Relative mass *m* of a body depends on its velocity with regard to the coordinate system. It increases with increasing velocity, when v $\Rightarrow$ c it rises infinitely. $m = mo/k$; $k = \sqrt{1 - v^2/c^2}$

Energy of a body is proportional to its mass $E = m.c^2$

1.6 THERMICS AND MOLECULAR PHYSICS

Thermics and molecular physics is the branch of physics describing transport and change of heat and corresponding change of state.

Preview of most important terms, quantities and units of thermics and molecular physics:

Thermodynamic system – set of microscopic and macroscopic particles, which can exchange heat mutually or with their environment.

Isolated thermodynamic system – thermodynamic system, which does not exchange energy with environment.

Thermometry – concerns of temperature measurement methods.

Calorimetry - concerns of heat measurement and methods of heat amount measurement.

Thermodynamics – describes state exchanges in systems.

Kinetic theory of matter – explains properties of matters with regard to continual non-aligned motion of atoms and molecules.

Internal energy of a body U – is sum of all kinetic and mutual potential energies of system of particles (state quantity); [U] = 1 J

Heat *Q* – measure of energy transported by heat exchange by warmer body to colder body ; measure of change of internal energy of a system, when no work is performed during given action. [Q] = 1 J

Heat flow $\Phi = Q/\Delta T$

Density of heat flow $\varphi = \Phi/S$

Mechanisms of heat transport – conduction, convection, radiation. For heat transport the mathematical relation applies: $Q = \lambda . S . \Delta T . \Delta t / d$ (λ - coefficient of heat conductivity: $\lambda = \varphi . d / \Delta T$, Q – heat passing through area S in time Δt, d – distance where temperature change ΔT appears).

Temperature - state quantity describing heat state of a body (thermodynamic and Celsius temperature);
[T] = 1 K; 0°C = - 273,15 K

First thermodynamic law - heat given to a body ΔQ equals to the sum of exchange of internal energy ΔU of the body and mechanical work ΔW_m preformed by the body, resp. energy given to the system in form of heat and work performed by external forces results to increase of energy of the system. $\Delta Q = \Delta U + \Delta W_m$.

Second thermodynamic law – Spontaneous exchange of heat is possible only from the warmer body to the colder one.

Efficiency of a heat machine η - ratio of the work W_m performed by a machine and the heat Q, given to the machine $\eta = W_m / Q$. Efficiency of all heat machine is $0 < \eta < 1$.

Basic equation of thermics – heat ΔQ received or output by a body equals to the sum of specific heat of the matter c, of which the body is composed, its mass m and temperature increment ΔT, then mathematical relation $\Delta Q = c.m.\Delta T$ applies.

Heat capacity $C = \Delta Q / \Delta T$, where ΔQ – heat received by the body, ΔT – temperature change of the body.

Specific heat (specific heat capacity) - Physical quantity, which can be expressed mathematically as follows:
$c = \Delta Q/m.\Delta T = C / m$; $[c] = 1\ J . kg^{-1}. K^{-1}$

Heat exchange law - heat Q_1 received by the colder body equals to the heat Q_2, output by the warmer body, $Q_1 = Q_2$.

Calorimetric equation - $m_1.c_1.(T_1 - T) = m_2.c_2.(T - T_2) = const.$

Heat expansion- with changed temperature, dimensions of bodies and volume of liquids and gases change.

Heat longitudinal expansion - $l = l_0 (1 + \alpha.\Delta T)$, $l = l_0 .\alpha .\Delta T$, ($\alpha$ - coefficient of heat longitudinal dilatation $\alpha = \Delta l/l_0 \Delta T$)

Heat volume expansion - $V = V_0(1 + \beta. \Delta T)$, $V = V_0.\beta. \Delta T$, (β - coefficient of heat volume dilatation $\beta = \Delta V/V_0. \Delta T$). During heat volume change of solid and liquid, matters, they mass stays constant, but their density changes: $\rho \cong \rho_0 (1- \beta.\Delta T)$.

State quantities of gas - physical quantities, describing state of gas -thermodynamic temperature T, pressure p, volume V, mass m or amount of matter n.

Amount of matter n - quantity expressing the amount of matter using number of particles [n] = 1mol.

For amount of matter the relation $n = N / N_A = m / m_m$ applies, (n – amount of matter, N – number of molecules of gas, N_A – Avogadro constant $N_A = 6{,}023 . 10^{23}\ mol^{-1}$, m_m – molar mass).

Mol - basic unit of the international system SI. Amount of matter of a system with number of particles equal to number of atoms in 12 g of carbon $^{12}_{6}C$.

Molar mass is defined by mathematical relation $m_m = m / n$

Molar volume is defined by mathematic relation $V_m = V /n$

State equation of ideal gas – product of pressure p and volume V of gas equals to the product of its amount of matter n, gas constant R and temperature T: $p.V = n.R .T$;

For given amount of gas m = const., then p.V/T = const.= R_m

Molar gas constant (universal gas constant) R_m has the same value for all gases: R_m= 8,314 41 $J.K^{-1}.mol^{-1}$

Boltzmann constant k = R_m / N_A = 1,38.10 $J.K^{-1}$ is an universal nature constant.

Boyle-Mariot law - law expressing state change of given amount of ideal gas for isothermic process p.V = const.

Gay-Lussac law - law expressing state change of given amount of ideal gas for isobaric process V/T = const.

Heat expansion of gases $V = V_0(1 + \gamma.\Delta T)$, γ - coefficient of heat expansion of gas $\gamma = \Delta V / V_0 .\Delta T$

Charles law - law expressing state change of given amount of ideal gas for isochoric process p/T = const.

Heat expansion of gases $p = p_0(1 + \gamma'.\Delta T)$ γ'- coefficient of heat expansion of gas $\gamma' = \Delta p / p_0 .\Delta T$. Then relation $\gamma = \gamma' = (1/273{,}16)\ K^{-1}$ applies.

Adiabatic action - state change of given amount of gas in condition of thermal isolation of gas, $Q = 0$.

Van der Waals state equation - state equation for real gases considering the effect of the own molecules volume and forces acting between them: $(p + a/V^2)(V - b) = n.R.T$ (p - pressure of real gas, V - volume of real gas, T - thermodynamic temperature of real gas, n – amount of matter, R - molar gas constant, a,b - correction constants depending on the type of gas).

Change of state of a body is performed by input or output of energy, while the temperature of the body is not changed. To change state of 1 kg of matter it must receive latent heat $[Q] = 1\ J.kg^{-1}$

Triple point of water – equilibrium state of water, when water is in thermodynamic equilibrium in three states - solid (ice), liquid (water) and gas (vapour).

Water anomaly – one of 15 anomalies of water is that volume water in the temperature interval 273 – 277 K first decreases (density increases), and during further heating increases.

Kinetic theory of heat – instead of direct observation of (macroscopic) processes and properties, processes and properties in molecular (microscopic) area are observed.

Brown motion - motion of microscopically observable particles caused by collisions of molecules, which are in continual motion.

Diffusion - spontaneous transport of particles or molecules in order to reach equal distribution of concentrations.

Osmosis – penetration of molecules of solvent to the solution with higher concentration through semi permeable membrane.

Osmotic pressure π - hydrostatic pressure on the site of solution obstructing osmosis, thus compensates the tendency to decrease concentration. $\pi = i . c_i . R . T$ (c_i – concentration of dissolved matters, i – Van´t Hoff coefficient, indicating number of ions originated during dissociation of a salt, R – gas constant,

T – thermodynamic temperature)

Pressure of gas *p* is directly proportional to the number of particles N, mass m_k and square of mean velocity v_s of particles and indirectly proportional to the volume V of gas: $p = m_k.v_s^2 / 3V$

Work of gas W - mechanic work performed by pressure forces of the gas. It depends on the pressure of the gas and on the change of its volume: $W = p.\Delta V$, while the internal energy of the gas decreases.

Carnot´s cycle – reversible action (cycle) composed of two isothermic and two adiabatic actions.

Efficiency of a circle action (cycle) η - equals to the ratio of obtained work and heat delivered to the system:

$\eta = W'/Q_1 = Q_1 - Q_2/ Q_1 = T_1-T_2 / T_1$, (W´ - obtained work, Q_1 - received heat, Q_2 - output heat, T_1 - temperature of the heater, T_2 - temperature of the cooler).

Efficiency of reversible Carnot´s cycle depends only on the difference of temperatures of heater and cooler and does not depend on the working matter.

Deformation of a body – change of shape or volume of the body caused by effect of external forces (deformation by draw, pressure, bend, slide, rotation).

Elastic deformation –deformation of a solid body, which disappear when external forces are removed.

Plastic deformation – deformation of a solid body, which does not disappear when external forces are removed.

Mechanical tension σ - quantity defined as fraction of force and area, on which the force is acting, it is force acting to area unit: $\sigma = F/S$

Hook´s law – defines measure of deformation, which is proportional to tension. In case of deformation by draw the Hookov law for draw applies: $\varepsilon = \Delta l/l_o = (1/E)\sigma$, where ε is relative longitudinal deformation

Elasticity module in draw (Young elasticity module) E - material constant defined as fraction of normal tension σ_n and relative longitudinal deformation ε of a stick during draw deformation. $E = \sigma / \varepsilon$.

Surface energy - energy of the surface layer of the liquid [W] = 1 J. A liquid takes in an equilibrium state always such shape, that the surface energy has the smallest possible value.

Surface forces – attraction forces acting in the surface layer between molecules causing the effort of the liquid do decrease its surface.

Surface tension σ - quantity defined by the fraction of the force acting in the surface layer of a liquid perpendicularly to line of molecules and of its length: $\sigma = F/l$

Capillarity – effect of elevation or depression of of the liquid level in a capillary relative to level of the liquid, in which capillary is immersed.

State changes:

melting – change from solid to liquid state, freezing - change from liquid to solid state, evaporation - change from liquid to gas state, condensation - change from gas to liquid state, sublimation - change from solid to gas state.

Latent heat L - heat, which must be added or released during state changes.

Specific latent heat l - quantity defined as the ratio of latent heat L a mass of the matter m: $l = L/m$

Absolute air humidity - quantity defined as the ratio of mass of water vapour in given volume and of this volume. It expresses the amount of water vapour in 1 m^3 of air: $\Phi = m / V$

Relative air humidity - quantity defined as the ratio of the absolute air humidity and of the absolute humidity of air saturated by vapour at the same temperature. It is expressed in percents: $\varphi = \Phi / \Phi_m$.

1.7 ELECTRICITY AND MAGNETISM

Electricity and magnetism - is branch of physics describing properties of electric charges as well as their electric and magnetic fields, processes of electric conduction a electromagnetic oscillations and waves.

<u>Most important therms, quantities and units of electricity and magnetism:</u>

Electric field - force field caused by electric charge.

Electron - elementary particle with the nucleon number 1 and positive elementary charge.

Electric charge [Q] = 1 C = 1 A.s basic property of electrised objects.

Elementary electric charge e = 1,602.10^{-19} A.s

Conductor - electrically conductive matter enabling macroscopic transport of electric charges.

Semiconductor – solid or liquid matter with electric conductivity dependent on temperature and usually lower than conductivity of metals. Carriers of electric current in semiconductors are electrons, resp. holes.

Electric current [I] = 1 A - physical quantity, defined by fraction of charge Q passing through the section of conductor in time t: I = Q/t.

Electric potential defined as work necessary ti move the unit positive charge in electric field from the baseline to the place, where potential is being established.

Electric voltage [U] = 1 V = 1 W.s/C = W/A – between two points A and B of an electric field equals to fraction of work W performed by an electric field when transporting charge between these points and the charge: U = W/Q.

Directional electric circuit

Electric source - source of electric energy able to cause electric current in electric circuit.

Electric circuit – set of mutually connected resistors, capacitors, coils, appliances and sources.

Electromotoric voltage – magnitude of voltage on connectors of a non-loaded source, work of electric forces necessary to transport the charge ***Q:*** U_e = W/Q.

Connector voltage - voltage on connectors of a loaded source.

Voltage on a resistor - voltage of a part of an electric circuit defined as product of its resistance and electric current passing trough it.

Ohm´s law – electric current I passing through conductor is directly proportional to the voltage U on the ends of the conductor. The constant of proportionality is electric resistance [R] = Ω = 1 V.A^{-1}, where R = U/I..

Electric resistance [R] - 1 Ω - property of matter to resist the pass of electric current, equal to product of specific resistance ρ and length of the by the cross section area S of the conductor:

$R = \rho.l/S$. $R = R_o(1 + \alpha t)$.

Specific electric resistance (resistivity) [ρ] = Ω.m characterizes electric conductivity of matter

(G = 1/R), it depends on temperature.

Serial connection of resistors - total resistance equals to sum of resistances, voltage of final resistance equals to sum of voltages on individual resistors.

Parallel connection of resistors – inversed value of final resistance equals to sum of inversed values of individual resistances, resp. final conductivity equals to sum of all conductivity, total current equals to sum of currents in individual resistor, voltage on all resistors is the same.

Electric conductivity [G] = 1 S – characterizes ability of matter to conduct electric current, inversed value of resistance.

Specific electric conductivity [γ] = S.m^{-1} – inverse value of specific resistance, $\gamma = 1/\rho$.

1. ***Kerchoff´s law*** - algebraic sum of currents in a node of an electric circuit equals zero.
2. ***Kerchoff´s law*** – in all electric circuit the algebraic sum of electromotive voltages equals to algebraic sum of voltages on individual resistors.

Work performed by electric current [W] = 1 J - work, preformed during passing of electric current through a conductor $W = U.I.\Delta t = R.I^2.\Delta t$

Power of electric current [P] = 1 W - work performed by electric current per time unit

$P = W/\Delta t = U.I$

Ammeter - electric measuring device for measurement of electric current, it is connected in cascade with pertinent part of circuit.

Voltmeter electric measuring device for measurement of electric voltage, it is connected parallely with pertinent part of circuit.

Electric field - field, acting on the electrically charged body by a force F.

Intensity of electric field E - physical quantity, describing electric field. It equals to fraction of the force F acting in the electric field to the charge Q and of magnitude of their charge Q.

$E = F/Q$ - (vector quantity) $[E] = 1\ N.C^{-1} = 1\ N.A^{-1}.S^{-1} = 1\ V.m^{-1}$

Coulomb´s law – express magnitude of the force acting between two charges Q_1 and Q_2 positioned in the mutual distance r (ε - permittivity of the environment)

$F = (1/4\pi\varepsilon)\ Q_1.Q_2\ /r^2$

Work in electric field W- work of external forces during replacing of electric charge in electric field W = Q.E.l, Q - electric charge, E – intensity of electric field, l – distance of replacement of the charge.

Capacity of the conductor C - quantity characterizing property of the conductor to bound electric charge, which is given by the ratio of the charge on the conductor and of its own absolute potential $[C] = 1\ F = 1\ C.V^{-1} = 1\ A.s.V^{-1}$, $C = Q/U$

Capacity of a capacitor – ratio of charge on one of the two conductors of the capacitor and of the potential of this conductor regarding to the other one $C = Q/\Delta\varphi$

Capacity C of a plate capacitor - $C = \varepsilon.S/d$, where d is distance between plates of the capacitor.

Permittivity of environment $\varepsilon = \varepsilon_o.\varepsilon_r$ $\varepsilon_o = 8{,}854.10^{-12}\ F.m^{-1}$ - permittivity of vacuum, ε_r – relative permittivity

Parallel connection of capacitors – net capacity equals to sum of capacities of individual capacitors, voltage on all capacitors is the same.

Serial connection of capacitors – inverse value of the net capacity equals to sum of inverse values of capacities of individual capacitors, total voltage equals to the sum of voltages on individual capacitors

Energy of homogenous electric field of capacitor W_c - energy equal to work performed during charging the capacitor $W_c = Q.U/2 = Q^2/2C$

Electric current in electrolytes

Electrolyte – liquid or solid matter with ion conductivity.

Electrolytic voltage - voltage inside the electrolyte. After this voltage is reached, permanent current starts to flow through the electrolyte: $U_r = U - R.I$ (U - electric voltage on electrodes of the electrolyte, R – resistance of the electrolyte, I - electric current flowing through the electrolyte).

Electrolytic dissociation – process, during which the neutral molecules of the electrolyte disintegrate to positive and negative ions.

Electrolysis – physical and chemical process of chemical changes in the electrolyte when electric current is passing through the electrolyte. During electrolysis charge as well as matter are transported. On the cathode, hydrogen and metals are always separated, while the other elements are separated on the anode.

The following formula applies: $m = M_m.Q/F.v$ (m – mass of the matter separated on the cathode, M_m – molar mass, F - Faraday charge $F = 9{,}65.10^4 C.mol^{-1}$, v – valence of ion, Q – charge).

Galvanic battery – device creating electric current as result of chemical processes.

Magnetic field - physical field creating force effect on the moving charge or magnets. The necessary condition is the time change of electric field. Change of magnetic field causes electric field, thus we speak about electromagnetic field.

Magnetic induction $[B] = 1\ T = 1\ N.A^{-1}.m^{-1}$, $1\ T = 1\ Wb.m^{-2}$ - describes magnetic field.

To calculate the force F acting to an electric charge Q in an electromagnetic field the following relation must be applied:

F = Q.**v** x **B** (**v -** velocity of moving electric charge, **B** - magnetic induction of the field, vector quantity).

Magnetic induction B in given place of a field is $B = F/I.l.\sin\alpha$ (F is force acting to a conductor with the current I in the magnetic field, α - angle between conductor with the current, l – effective length of the conductor).

Magnetic induction B inside a coil equals $B = \mu.I.N/l$, where N – is number of spires of the coil.

Permeability of the environment $\mu = \mu_o.\mu_r$,

$\mu_o = 4\pi.10^{-7}.N.A^{-2}$ - permeability of vacuum μ_r – relative permeability

Intensity of magnetic field of a coil $[H] = 1\ A.m^{-1}$ equals $H = I.N/l$ - (vector quantity), $B = \mu.H$

Lorentz´s force $F = Q.v.B.\sin(\mathbf{v},\mathbf{B})$

Energy of homogenous magnetic field of a coil $W_m = L.I^2/2$

Force acting in magnetic field to parallel conductors with current

$F = (\mu/2\pi)\ I_1.I_2.l/d$, where l – length of conductors, d - mutual distance of conductors,

μ - permeability of environment.

Electromagnetic induction – physical process, at which permanently changing magnetic field causes voltage in a conductive loop.

Faraday´s law of electromagnetic induction – induced voltage $U_i = -d\Phi/dt$

Magnetic induction flow $[\Phi] = 1\ Wb = 1\ V.s$ equals $\Phi = B.S$

Lenz´s rule - induced current has always direction acting against the change, by which it was created; it follows from the energy conservation law.

Own induction of a coil $[L] = 1\ H = 1\ Wb.A^{-1} = 1\ V.s.A^{-1}$ - quantity characterizing the coil $L = \Phi/I$, which affects the U_i caused by the effect of the own induction. The coil has the own induction 1 H, when at change of current 1A per 1s $U_i = 1V$ originates. The relation $L = \mu.N^2.S/l$ applies.

Electromagnetic oscillation – phenomenon, at which quantities of electromagnetic field change periodically.

Immediate value of alternating voltage and current - $U = U_m.\sin\omega.t$, $I = I_m.\sin\omega.t$

Effective value of alternating voltage and current - $U_{ef} = U_m/\sqrt{2}$, $I_{ef} = I_m/\sqrt{2}$

Apparent power P_Z of alternating current - $P_Z = U.I$ (V.A)

Real power P_S of alternating current - $P_S = P_Z.\cos\varphi = U.I.\cos\varphi$ (W) (φ- phase shift between voltage and current, cos φ - power factor)

Impedance Z - complex quantity characterizing ability of electric net to conduct electric current

$Z = R + iX$ (R – resistance, X – reactance)

$Z = [R^2 + (\omega L - 1/\omega C)]^{1/2}$ (ω - angle frequency, L – own inductance of the circuit, C – capacity of the circuit).

Efficiency of a transformer $\mu = P_2/P_1$ – ratio of real power P_2 in the secondary coil and of the real power P_1 in the primary coil.

Oscillation circuit - circuit composed of a coil L and a capacitor C, which oscillates with the frequency $f = 1/ 2\pi (L.C)^{1/2}$, $T = 2\pi \sqrt{L.C}$ – Thomson's relation.

Electromagnetic undulation - periodic action of space and time change of the vector of intensity of electric field and contemporary of the vector of magnetic induction.

Electric conductivity – carriers of electric charge move due to effect of electric field (in solid, liquid and gas matter or in vacuum).

1.8 OPTICS

Optics - branch of physics exploring optical phenomena using three models:

1. Geometric model - geometric optics

2. Wave model - Wave optics

3. Quantum model - quantum properties of light

Most important terms, quantities and units of optics

Geometric optics – describes physical processes using a light beam. Particle and wave character of light is not considered.

Law of reflection – when a light beam is reflected on the border between two different optical environments, the reflected beam and the perpendicular axis to the plane of the border lies in the same plane. The impact angle equals to the reflection angle.

Law of refraction - when a light beam is passing through the border between two different optical environments with different refraction index N, it changes velocity and thus the direction as well. The impacting beam, axis perpendicular to the plane of the border and the refracted beam lies in the same plane.

Ratio of the impact angle α and the refraction angle β for two environments is a stable quantity and equals to refraction index n (Snell's phenomenon): $\sin\alpha / \sin\beta = v_1/v_2 = n_2/n_1 = n$

Optical system – set of refraction and reflection planes with identical axis, which serve to perform optical imaging.

Optical axis – axis, on which centres of all curvatures of all reflecting and refracting planes lie.

Main planes – optically associated planes perpendicular to the optical axis with unit cross magnification.

Focus – point on the optical axis, which is an optical image of a point positioned in infinity.

Focus distance f - distance of the focus from the main plane.

Optical power [φ] = 1 D – inverse value of the focus distance φ = 1/f

Lens - transparent optic environment bordered by two spherical refraction areas, or by one spherical and one plane area.

Mirror - reflection area reflecting the impinging light almost perfectly.

Imaging equation of a lens - $1/f = 1/a + 1/a'$,

where a - object distance, a´- image distance a f - focus distance

Imaging equation of a spherical mirror - $1/f = 1/a + 1/a'$,

where a - object distance, a´- image distance a f - focus distance

Important beams :

1/ beam perpendicular with the optical axis is reflected (resp. refracted) to the object's focus.

2/ beam passing through object's focus is reflected (resp. refracted) to perpendicularly to the optical axis.

3/ beam passing through the lens centre (the curvature centre) keeps its direction (or returns in opposite direction).

Wave optics is branch of physics describing optical phenomena using the wave model of light. The particle character of light is not considered.

Electromagnetic radiation - flow of quanta of electromagnetic field.

Light – it has character of electromagnetic waves with different frequencies, it propagates as undulation; particles of electromagnetic spectrum receipted by eyes.

Light energy – during light propagation only the energy and no matter is transported.

Velocity of light c - velocity of light propagation in given environment. Velocity of light in vacuum $c = 2{,}997\,924\,58 .10^8\ m.s^{-1} \approx 3.10^8\ m.s^{-1}$ is an universal constant.

It equals to the product of wavelength and frequency of the light f. It depends on the environment, in which it is propagating, $c = \lambda.f$

Wavelength of light λ - it depends on the environment, in which it is propagating (frequency does not depend on the environment).

Optical trajectory l equals l = n.s (n – refraction index , s - real trajectory)

Interference – superposition of two or more undulations. Interference can amplify or attenuate the undulation. Condition of comparable interference of light is that light beams are coherent. Magnitude of final illumination changes according to difference of optical trajectories l.

Amplification of light at interference on the thin layer occurs in places, for which $l = k.\lambda$

(l – trajectory change between beams reflected on the first and the second border, n – refraction index of the layer, λ - wavelength of the light, k = 0, 1, 2...).

Attenuation of light at interference on the thin layer occurs in places, for which $l = (2k + 1)\lambda/2$

Bending (diffraction) of light – aberration from the direct propagation in an homogenous environment following from wave properties of light.

Diffraction of light on a grid

- amplification occurs, when $l = b.\sin\alpha = k.\lambda$

- attenuation occurs, when $l = b.\sin\alpha = (2k - 1)\lambda/2$

(l – trajectory difference, b - grid constant - distance of aperture centres, α - diffraction angle, λ - wavelength of light, k = 0, 1, 2...).

Diffraction of light – natural white light is polychromatic, it contains more monochromatic components with different frequency. Diffraction of white light to monochromatic components occurs during dispersion and diffraction.

Spectrum:

- according to the type of diffraction - disperse, bend
- according to phase of bodies emitting light - continual, discrete
- according to effect of environment on light - emission, absorption

Polarization of light – rectifying of oscillations of electric vector of non-polarized light so that its end draws non-changing curve. Projection of this curve to the plane perpendicular to the direction of propagation of the light is an ellipse, but it can be also a circle or a segment (elliptic, circle, linear polarization).

Linearly polarized light – monochromatic light with electric vector oscillates in to the plane perpendicular to the direction of propagation of the light and with constant direction of the electric field.

Quantum optics

Photon - quantum of electromagnetic field, quantum of energy of monochromatic electromagnetic wave manifested as a particle.

Energy of photon E = h.f (h - Planck constant, f - frequency of electromagnetic wave).

Planck´s constant h = 6,625 176.10^{-34} J.s, basic physical constant.

External photoelectric effect - effect, when energy of impinging photons is used to release electrons from the matter (outgoing work) and excessive energy is changed to kinetic energy of the released electron. This effect is described in the Einstein's equation of photoelectric effect: $h.f = W_v + m_e.v^2/2$ (h – Planck´s constant, f – frequency of impinging radiation, W_v - outgoing work, m_e – mass of electron, v – velocity of electron).

Photocell – device creating photoelectromotive voltage when illuminated. Before illumination, there must be an electric field in the material.

Internal photoelectric effect - effect, when electrons emitted after impact of photons stay in the matter.

1.9 ATOMIC PHYSICS

Atomic physics - is branch of physics describing structure and properties of atoms and mutual actions among atoms.

Most important terms, quantities and units of atomic physics:

Structure of atom

Atoms – smallest particles of chemical elements, dat = 10^{-10} m dat – diameter of atom

Mass number A = Z + N (Z – number of protons, N - number of neutrons)

Relative atom mass A_r – expresses how many times is the mass of atom greater than the twelfth part of atom mass of carbon isotope $^{12}_{6}C$

$A_r = m_a/[m_a(^{12}_{6}C)/12]$

Atom mass constant u - is defined as 1/12 of atom mass of carbon isotope $^{12}{}_{6}C$

(1 u = 1,66.10^{-27}kg)

Atom shell – surrounds the atom nucleus and contains all electrons belonging to the atom, which compensate the charge of the nucleus. Electrons are distributed in the cover according to energetic level, electrons with nearly equal energetic levels are grouped to electron layers.

Wave properties of light

Wave model – interference of electrons when passing through a thin metal layer and bend on a crystal grid can be explained by the wave model.

Matter undulation (de Broglie) – to each current of moving particles a wave with wavelength λ is assigned.

De Broglie´s wavelength $\lambda = h/m.v$ (h – Planck´s constant)

Wavelength particles with charge e $\lambda = h/(2e.U.m)^{1/2}$

Quantum properties of light

External photoelectric effect (Einstein equation) $h.f = h.f_o + - m_e.v^2/2$

Photon model of light – each quantum of light has energy W = h.f

Planck's constant h = (6,6252 $\pm$ 0,0005).10^{-34} W.s^{-2}

Frequency of emitted light - f = W/h

Models of atom shell - Rutherford, Bohr, wave-mechanic

Corpuscular-wave dualism – explanation of different properties and forms of matter, which do not manifest at certain physical conditions. Micro objects at certain conditions appear as waves and at different conditions as particles.

Heisenberg´s principle of uncertainty $x \,.\, p_x \geq h/2\pi$

(x-uncertainty in position coordinates, p_x-uncertainty in momentum)

Atom nuclei:

Mass of nucleus $m_n = Z.m_p + N.m_n$

Mass defect (deficit) Δm_n - measured mass of nucleus is always lower than sum of masses of protons and neutrons in the nucleus $\Delta m_n = (Z.m_p + N.m_n) - m_n$

Charge of the nucleus Q = Z.e

Radius of the nucleus $R = R_o.A^{1/3}$ $R_o = 1{,}4.10^{-15}$ m

Bind energy of atom nucleus $W_j = c^2.\, m$

Nuclide – atom nucleus with given Z and A in certain energetic state.

Isotopes – atoms with equal chemical properties but different physical properties (nuclides with the same Z and different A).

Radionuclides – non-stable nuclei of atoms emitting radioactive radiation after disintegration, until a stable nucleus.

Radiation – emission of energy in form of emitted particles or radiation γ.

Law of radioactive transformation $N = N_o.e^{-\lambda.t}$, where N_0 – number of non decayed radioactive nuclei in time t = 0, N – number of non decayed radioactive nuclei in time t, λ – disintegration constant.

Halftime of decay (halftime of radioactive decay) $T = \ln 2/\lambda = 0{,}693/\lambda$

Basic particles – smallest particles of matter (except for particles originated during nuclear transformation and cosmic radiation –more than 200 basic particles)

Accelerators of particles – device, in which particles with electric charge (electrons, protons ions) are accelerated to very high velocities by means of electric fields. Accelerated particles with high energy hit other particles or atom nuclei stimulating nuclear transformations (linear accelerator, cyclotron, synchrocyclotron, synchrotron, betatron).

1.10 PHYSICAL QUANTITIES AND UNITS

Physical quantities describe properties of objects, processes or states, for which measurement methods exist. Physical quantity is given by product of numeric value and pertinent unit.

Division of physical quantities:

1. Basic and derived
2. Scalar and vector
3. State
4. Conservated

Quantity equation is mathematical record of relation between physical quantities or of definition of derived physical quantity.

Basic quantities – they cannot be established using other physical quantities and are mutually independent.

Derived quantities - are defined using previously defined physical quantities.

Scalar quantities – are unambiguously determined by numeric value and unit.

Vector quantities - unambiguously determined by numeric value, unit, direction in the plane or space and orientation.

State quantities describe equilibrium state of one or more mutually related systems. Their magnitude does not depend on the way, by which the state was established.

Consecrated quantities - law of conservation applies, they do not change in an closed system during the physical process.

Units SI

Basic units: m, kg, s, A, K, mol, cd

Derived units: ($m.s^{-1}$, $m.s^{-2}$, N, C, J, Pa ...)

Multiples and fractions of units:

T (tera-)	10^{12}	c (centi-)	10^{-2}
G (giga-)	10^{9}	m (mili-)	10^{-3}
M (mega-)	10^{6}	μ (mikro-)	10^{-6}
k (kilo-)	10^{3}	n (nano-)	10^{-9}
h (hekto-)	10^{2}	p (piko-)	10^{-12}
da (deka-)	10	f (femto-)	10^{-15}
d (deci-)	10^{-1}	a (atto-)	10^{-18}

Additional units: radian, steradian

Accessory units: beside SI units, resp. their multiples and fractions, it is allowed to use accessory units. For practical reasons. Accessory units are:

Quantity	**Name**	**Mark**
time	minute	min
	hour	h
day	d	
area	ar	ar
area	hectar	ha
volume	liter	ℓ
mass	tone	t
temperature	Celsius degree	°C
energy	electronvolt	eV

Some units used in biophysics, physiology and clinical practice

There are still many units in medical as well as technical practice, which had been used before the establishment of SI system. Here we introduce some of them, which are most often used. These were accepted temporarily for certain time, but we can see it even today in foreign literature.

For optical measurement the unit of length angstrőm (Å = 10^{-10} m = 0,1 nm) is used, which was defined from the wavelength of red line of cadmium (n = 6438,4696 Å).

To establish the temperature of bodies as well as organisms, the Celsius scale is used in (freezing point of water is 0 °C and boiling point 100 °C; 1 K = -273,15°C).

Unit of energy joule can be expressed also using unity of thermal energy, which was defined as heat necessary to warm 1 g of water from 14,5 °C to 15,5 °C – it is 1 calorie = (1 cal) = 4,184 joule.

In atomic physics the unit electronvolt (eV) is used to express energy. It is defined as energy, gained by particle with charge 1 coulomb when passing through potential difference of 1 volt (1 eV = 1,602.10^{-19} J).

Blood pressure as well as some other pressures in physiology are expressed often the height of the mercury column in mm Hg or in units Torr (1 mm Hg = 1 Torr = 133,32 Pa = 0,133 kPa). In technical practice, pressure is sometime expressed in atmospheres (1 atm = 101 325 Pa) or in bars (1 bar = 10^{5} Pa).

The amount of a radioactive substance is in old literature expressed in unit curie (Ci) and its parts (mCi a μCi); 1 curie = $3{,}7.10^{10}$ Bq = $3{,}7.10^{10}$ s^{-1}.

Also results of clinical examinations can be expressed differently. The concentration of substances is in SI system expressed in moles per cubic meter (mol/m^3 = mol.m^{-3}). In clinical practice it is often expressed in moles per liter (mol/l). Mass concentration can be expressed in grams per liter (we use g/ℓ - g% or mg/ℓ -mg%).

We introduce some non-SI units and their conversion to SI units in following table.

Quantity	Non SI unit	Factor	SI unit
length	micron (μ)	10^{-6}	meter (m)
	angstrőm	10^{-10}	meter (m)
energy	electronvolt (eV)	$1{,}602.10^{-19}$	joule (J)
	calorie (cal)	4,184	joule (J)
force	kilopond (kp)	9,807	newton (N)
pressure	mm Hg	133,32	pascal (Pa)
	atmosphere (atm)	101 325	pascal (Pa)
	bar (bar)	100 000	pascal (Pa)
mass	atom mass unit (m_u)	$1{,}660.10^{-27}$	kilogram (kg)
viscosity	centipoise (cP)	1	(mPa.s)
activity	curie (Ci)	$3{,}7.10^{10}$	becquerel(Bq)
absorbed dose dose equivalent exposition	rad	0,01	gray (Gy)
	rem	0,01	(J/kg)
	rőntgen (R)	$2{,}58.10^{-4}$	(C/kg)

2. Calculations

2.1 MEASUREMENT ERRORS, STATISTICS

1. The result of one measurement of an independent quantity is m = 350 g. The resolution of an observer on the measuring device is Δ = 1 d. Sensitivity of this device is c = 10 d.g^{-1}. Calculate the maximal error mm and write the correct result.
2. By repeated measurement of an independent quantity we got following set of 5 values of the quantity t [s]: 15, 17, 12, 16, 19. Calculate the arithmetic mean $\overline{t}$ and standard error of the mean $\overline{s_t}$ and write the correct result.

2.2 CONVERSION OF UNITS

1. Convert:

3 m	na	dm
5,8 kg	to	g
7 km	to	cm
450 mA	to	A
1 min	to	s
3 hod	to	min
5 hod 42 min	to	s

2. The winner of sprint ran with velocity of 10 m.s^{-1}. Calculate his velocity in km.hod^{-1}.
3. Density of water is 1 000 kg.m^{-3}. Calculate density of water in g.cm^{-3}.

2.3 GRAPHICAL PROCESSING OF MEASUREMENT, DRAWING OF GRAPHS

1. Draw a graph of given set of measured values on a millimeter-squared paper sheet, respectively to a semi-logarithmic paper.
2. Make a line graph from the scatter graph and make graphical interpolation.
3. Draw a graph of linear dependence of refraction index n on concentration of solution based on the sample of measured values on a millimeter-squared paper sheet.

c (%)	2,5	5	7,5	10	12,5	15	17,5
n (d)							

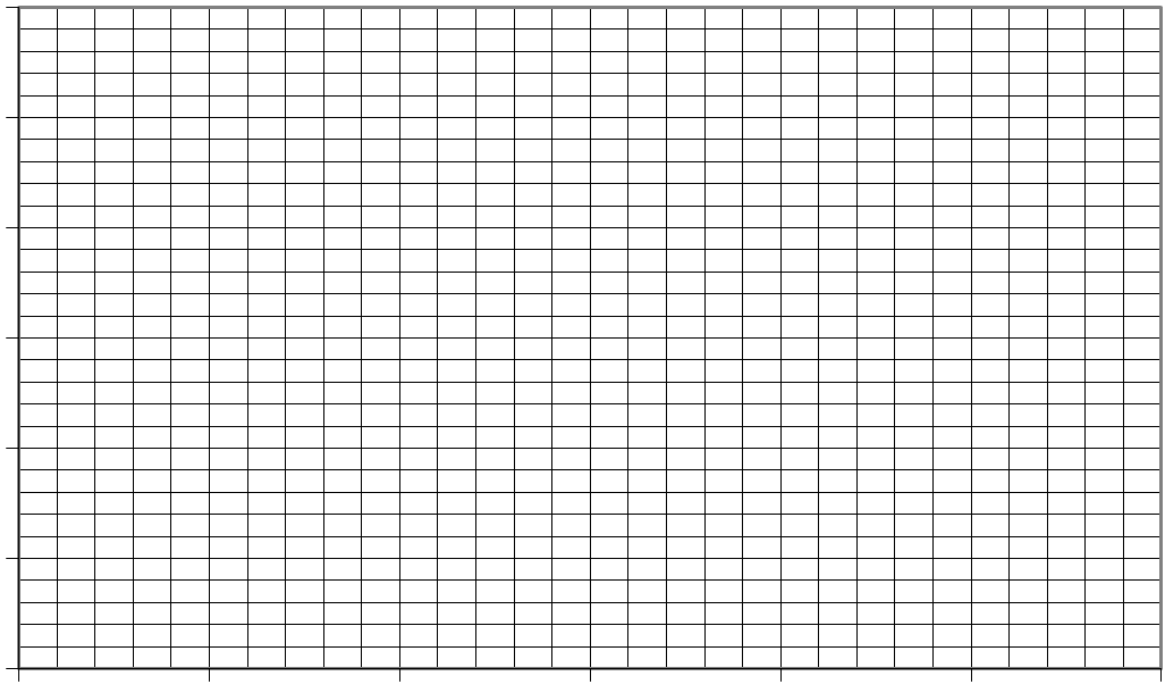
4. Draw a graph of linear dependence of specific resistance of water solutions on their mass concentration c_m based on the sample of measured values on a millimeter-squared paper sheet.

c_m (%)	5	10	15	20	25	30	35
$\rho(\Omega.m)$							

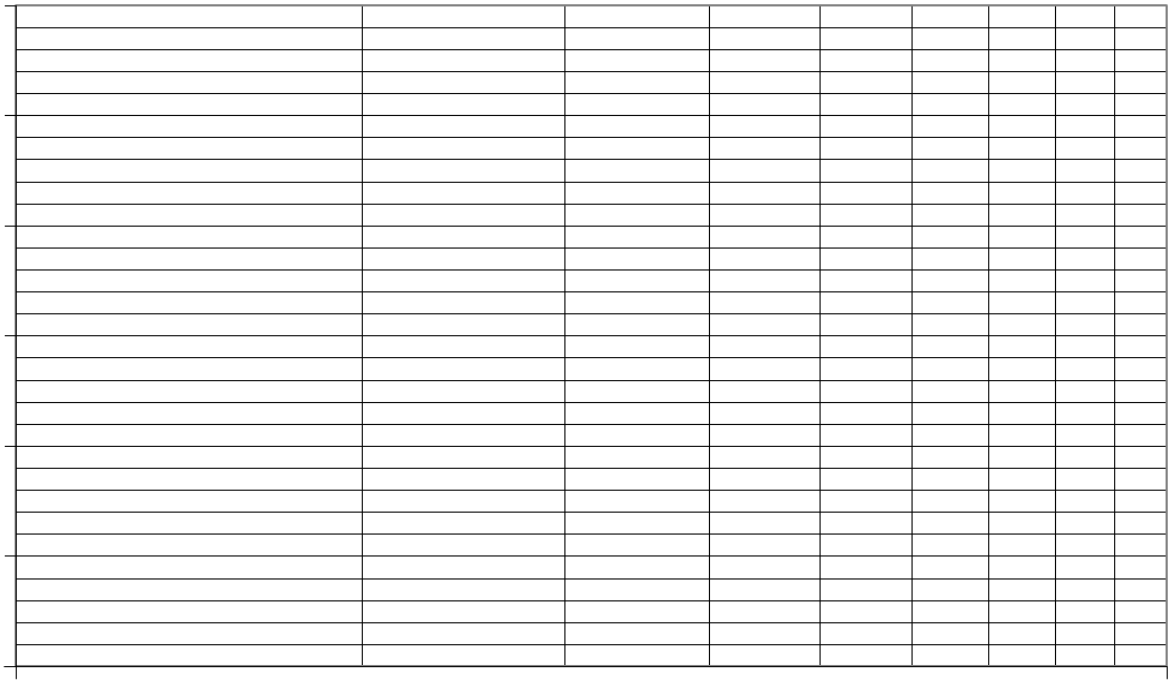
5. Draw a semi – logarithmic graph of dependence of whole-body impedance of man Z on frequency based on measured values:

f(Hz)	200	500	1 k	2 k	5 k	10 k	20 k
Z (Ω)							

Linear scale for construction of graph.



Semi-logarithmic scales for construction of graph.



2.4 MECHANICS (FORCE, GRAVITATION, CENTRE OF GRAVITY)

$$p = m.v = [kg.m.s^{-1}], \quad F = m.a = [kg].[m.s^{-2}] = [kg.m.\ s^{-2}] = [N]$$

1. A rocket with mass 10 000 kg flies by uniform direct motion with velocity 150 $m.s^{-1}$. What is the momentum of the rocket?
2. A tennis – ball with mass 0,05 kg hit by a rocket has acceleration 30 ms^{-2}. What force was applied to the ball by the rocket?

2.5 KINEMATICS

$$v = \frac{s}{t} = \left[\frac{m}{s}\right] = \left[m.s^{-1}\right], \qquad a = \frac{\Delta v}{\Delta t} = \frac{\left[m.s^{-1}\right]}{s} = \left[m.s^{-1}.s^{-1}\right] = \left[m.s^{-2}\right], \qquad a = \frac{v_1 - v_0}{t_1 - t_0} = \frac{\Delta v}{\Delta t}$$

1. A car crosses 360 km in 3 hours by uniform motion. What is its velocity?
2. Mean velocity of a running man is 12 $m.s^{-1}$. In what time does cross 50 m?
3. The distance between Bratislava and Prague is 346 km. A plane is flying with the velocity 300 $km.h^{-1}$. How long will the flight from Bratislava to Prague take?
4. A bus was accelerating for 2 s and it reached velocity 40 $km.h^{-1}$. What was the acceleration, when the motion was accelerated uniformly?
5. What time does the car need to accelerate from 0 $km.h^{-1}$ to 80 $km.h^{-1}$, when its with uniform acceleration is 2 $m.s^{-2}$?

2.6 WORK, POWER, ENERGY

$$W = F.s = [N.m] = \left[kg.m.s^{-2}.m\right] = \left[kg.m^2.s^{-2}\right] = [J]$$

$$P = \frac{W}{t} = \frac{[J]}{[s]} = \frac{\left[kg.m^2 s^{-2}\right]}{[s]} = \left[kg..m.^2 s^{-1}\right] = [W] \qquad E_k = \frac{1}{2} m \cdot v^2 = \left[kg \cdot m^2 \cdot s^{-2}\right] = [J] \qquad E_p = mg.h = \left[kg.m.s^{-2}.m\right] = [J]$$

1. What work will you perform when you bring a radiator weighing 50kg to the first floor (high 5m)?
2. You elevate a body with gravity force 50 N. Doing this you perform a work of 100 J. In what high is the body now?
3. What power does a man with gravity force 700 N perform when climbing to a 1000m hill in 6 hours?
4. One machine performs the work 30 000 J in 5 min. second one performs work 15 000 J in 10 min. Which machine does perform higher power?
5. A ball with mass 100 g is thrown perpendicularly to height 5 m. What potential energy does it have in the highest point?
6. A tennis ball with mass 0,05 kg has after hit by a rocket velocity 20 $m.s^{-1}$.What is its kinetic energy?

2.7 PHYSICAL PROPERTIES OF LIQUIDS

$$p = \frac{F}{S} = \frac{[N]}{[m^2]} = \frac{[kg \cdot m \cdot s^{-2}]}{[m^2]} = [kg \cdot m^{-1} \cdot s^{-2}] = [Pa]$$

$$p = h \cdot \rho \cdot g = [m \cdot kg \cdot m^{-3} \cdot m \cdot s^{-2}] = [kg \cdot m^{-1} \cdot s^{-2}] = [Pa]$$

1. A submarine dived to depth 50 m. What is the hydrostatic pressure in this depth?
2. In what depth is the diver, when the hydrostatic pressure is 98 Pa ?

2.8 HYDRODYNAMICS

$$S_1.v_1 = S_2.v_2 \qquad p + \frac{1}{2}\rho.v^2 = const.$$

1. Water flows through pipe with diameter 20 cm with velocity 1 m.s^{-1}. What is its velocity on the end with narrower diameter of 2 cm?
2. Water flows in a horizontal pipe with velocity 2 m.s^{-1} and the pressure is 300 kPa. What is its velocity on the end with narrower diameter, where the pressure is 200 kPa?

2.9 PHYSICAL PROPERTIES OF GASES

$$p.V = n.R.T \qquad p = \frac{F}{S} = \frac{[N]}{[m^2]} = \frac{[kg.m.s^{-2}]}{[m^2]} = [kg.m^{-1}.s^{-2}] = [Pa] \quad p.V = const.$$

$$R = 8{,}314\ J.K^{-1}.mol^{-1}$$

$$N_A = 6{,}023.10^{23}\ mol^{-1}$$

1. Calculate thermodynamic temperature of 10 moles of gas, which is in a container with the volume 1m^3 under pressure 101 000 Pa.
2. Gas is closed in a container with the volume 50 dm^3. What will be the pressure of the same gas in volume 100 dm^3?
3. How many molecules are in 4 moles of gas?

2.10 TEMPERATURE – MEASUREMENT OF TEMPERATURE

$$T = 0\ K = -237{,}15\ ^\circ C$$

$$T = 0\ ^\circ C = 237{,}15\ K$$

1. Convert to Celzius degrees :

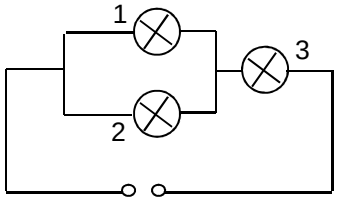
   312 K,485 K, 130 K,52 K
2. Convert to Kelvins:

   58,2 °C, 115 °C, -36 °C, 0 °C
3. In the night, the thermometer showed –10 °C. During the day it showed +3 °C. How many degrees did the temperature increase during the day?

2.11 ELECTRIC CIRCUIT

$$R=\frac{U}{I}=\frac{[V]}{[A]}=[\Omega] \quad I=I_1+I_2+...+I_n \ [A] \quad U_e=R_1.I+R_2.I+...+R_nI \ [V]$$

1. Calculate intensity of electric current passing through a lamp with resistance 30 kΩ at voltage 230 V.
2. Electric current 0,5 A is passing through the fibre of wolfram lamp at voltage 230 V. Calculate resistance of the fibre.
3. Lamps 1, 2, are connected parallelly, lamp 3 in series. They are connected to the network. How does the brightness of lamps 1, 2 change when we put the lamp 3 out? How wills the lamp 3 light when we put one of lamps 1, 2 out?
4. At the source voltage 12 V electric current 0,2 A passes through the lamp. What is the current passing through lamps 1 a 2 with equal resistance120 Ω?



2.12 ELECTRIC FIELD

$$Q=[A.s] \qquad F=\frac{1}{4\pi\varepsilon_0}\frac{Q_1.Q_2}{r^2}[N] \qquad E=\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}=\left[\frac{N}{C}\right]=[V.m^{-1}] \qquad \phi=\frac{1}{4\pi\varepsilon_0}.\frac{Q}{r}=[V]$$

1. Two small balls with negatiable mass hanging on cottons of the same length are charged by like charges Q. Calculate the repulsion F between them. (ε_0=8,854.10$^{/12}$ F.m^{-1})
2. Calculate the intensity of electrostatic field in area of charge 1 C in distance 1 m, 100 m and 1 km.
3. Calculate the difference of potentials of electrostatic field of charge 2 C in distance 10 m and 1000m (ε_0=8,854.10$^{/12}$ F.m^{-1})

2.13 LIGHT, ITS GEOMETRICAL AND WAVE PROPERTIES

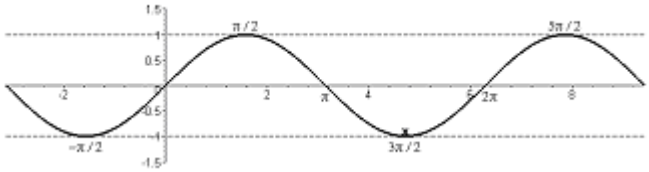
$$c = 300\ 000\ km.s^{-1} = 3.10^8\ m.s^{-1} \qquad v=\frac{c}{N}[m.s^{-1}] \qquad \lambda=\frac{c}{f}[m] \quad n=\frac{v_2}{v_1}\ \frac{n_1}{n_2}=\frac{\sin\beta}{\sin\alpha}$$

1. Calculate, in what time you receive answer from astronauts on the Moon, if distance between the Moon and the Earth is s = 370 000 km.
2. Calculate velocity of light propagation on an optical prism with refraction index N= 3,2 ($LiNb0_3$).
3. Light beam impings on an optical prism with refraction index n_2 = 2,7 immersed in a liquid with refraction index n_1 = 1,7 with angle α = 33°. Calculate the angle of propagation of the refracted beam in the prism.

2.14 OSCILLATION

$$f = \frac{v}{\lambda} = \frac{[m \cdot s^{-1}]}{[m]} = [s^{-1}] \quad T = \frac{1}{f} = \frac{1}{[s^{-1}]} = [s]$$

1. Calculate the time, in which a sound wave reflects form the wall in distance 1 500 m. Velocity of sound propagation in air is v = 344 $m.s^{-1}$.
2. After a lighting in tempest, the sound wave comes to the observer in 15 s. how far is the tempest?
3. What is the period of your heart cycle, when you measured pulse frequency 13 beats per 10 s ?
4. Show on given drawing of a sinus curve the maximal amplitude A, period T and parts of the period T/2 and 3/2T, and wavelength λ



2.15 SOUND

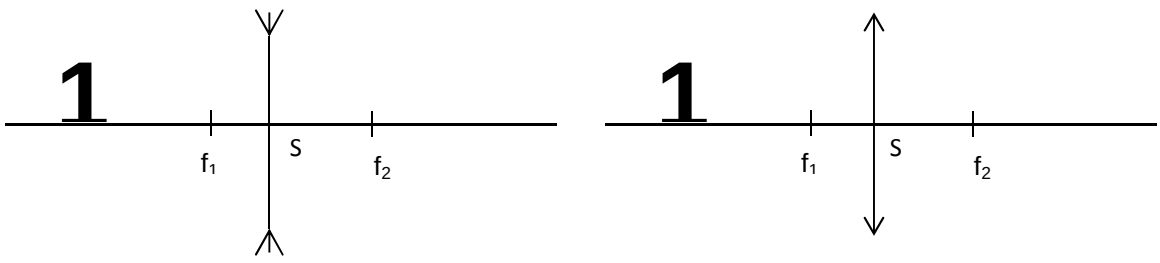
$$f = \frac{v}{\lambda} = \frac{[m.s^{-1}]}{[m]} = [s^{-1}] \qquad v_{vzduch} = 344 \ \ m.s^{-1} \qquad v_{voda} = 1.500 \ \ m.s^{-1}$$

1. Velocity of sound propagation in soft tissues is 1.500 $m.s^{-1}$. Calculate the time, in which the reflected sound wave returns to the ultrasound probe from an organ in distance 18 cm from the probe.
2. If you can hear the echo in mountains after 2,5 second, how far is the obstacle reflecting the sound?

2.16 OPTICAL IMAGING

$$\frac{\sin\alpha}{\sin\beta} = \frac{n_2}{n_1} \qquad \textit{Critical angle}: \ \sin\alpha_m = \frac{n_2}{n_1} \qquad \frac{1}{f} = \frac{1}{a} + \frac{1}{b}$$

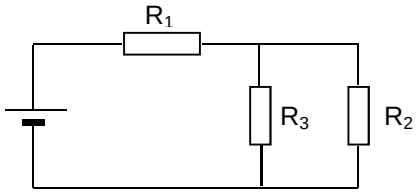
1. Calculate the refraction angle of a light beam when passing from air to water impinging to the water level at the angle 30°, if refraction index of water is N = 1,333 and refraction index of air is N = 1,0003.
2. Calculate critical angle for optical border of air and benzen C_6H_6, if refraction index of benzene is N = 1,5013 and refraction index of air is N = 1,0003.
3. How is the object on following schemes imaged? Construct the image of the object.



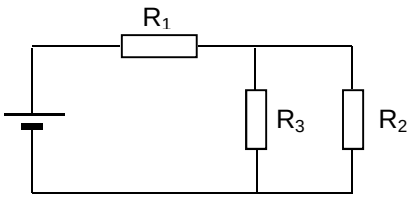
2.17 ELECTRIC MEASUREMENT DEVICES

1. Electric measurement device – voltmeter – has accuracy class 1,5. Calculate the measurement error at full-scale deflection 30 V and at deflection 5 V for the same measurement range.

2. Draw to the given scheme of the electric circuit, where you would connect an ammeter, when you want to measure electric current passing through the resistance R2.



3. Draw to the given scheme of the electric circuit, where you would connect an voltmeter, when you want to measure electric voltage on the resistance R_2.



2.18 RADIOACTIVITY

$$A = \frac{\Delta N}{\Delta t} = \left[s^{-1}\right] = \left[Bq\right] \quad T_{1/2} = \frac{\ln 2}{\lambda}$$

1. Calculate activity of a radioactive source, if during 10 seconds 400 decays occure.
2. The stroncium halftime of decay is 9 minutes. Calculate its disintegration constant.

3. QUESTIONS ON MEDICAL PHYSICS AND BIOPHYSICS TO VERIFY LEVELS OF MASTERY OF BASIC KNOWLEDGE

1. Write down the mathematical relationship for the number of interactions of neutrons with the target atom in 1 second and mark the respective symbols.
2. What physical principle expresses the number of interactions of neutrons with atomic nuclei. Mark the respective symbols
3. Write down mathematically and explain the basic law of radioactive decay.
4. What are the differences amongst ionization, excitation and luminescence of atoms.
5. Calculate the shortest wavelength of continuous spectrum from X-ray radiation for voltage U_a = 10 000 V.
6. What are the three constituents of linear coefficient of attenuation at interaction of radiation with matter.
7. State the elementary methods for radioactive radiation detection and measurement of radioactivity of the emitter according to the type of interaction of the radiation with the sensor of the detector.
8. Describe the algorithm of setting the working characteristics of Geiger-Müller detector.
9. In what way is the half–layer of radioactive radiation absorber defined.
10. Draw and explain the principle of Geiger-Müller detector.
11. Draw and explain the principle of scintillation detector.
12. Characterize the elementary types of nuclear radiation.
13. Explain the principle of tomography.
14. What are the advantages and disadvantages of X-ray examinations.
15. In what way does the X-ray radiation originate.
16. What causes the unsharpness of an X-ray image.
17. Explain the principle of computed tomography.
18. Name the elementary properties of the atomic core.
19. Characterize the Bohr model of the atom.
20. Define the basic division of elementary particles and name some examples.
21. Explain why are the absorption spectra of gases linear.
22. Explain the term ionizing energy.
23. Which physical quantities remain unchanged at the decay of a radioactive nucleus.
24. How does the core change at emission of an electron and a positron.
25. Explain the concept of primary and secondary ionization.
26. Explain the difference between the concepts „specific linear ionization“ and „linear energy transfer“.
27. Explain the concept of „compound nucleus“ and describe its properties.
28. Explain the difference amongst the concepts „potentional dispersion“, „flexible dispersion“ and „non-flexible dispersion“.
29. Explain the concept of „radiation capture“ and its difference from a fission reaction.
30. How do the α and β radiations differ in specific linear ionization and how does this difference influence the length of the α and β particles radius.
31. Which mechanisms take place at interaction of gamma radiation with matter.

32. What is the principle at storing pure gamma emitters and why.
33. What is the character of the energy spectrum of beta emitters, how does it influence the pathway length of beta particles in an absorber.
34. Explain the difference between direct and indirect biological effect of radioactive radiation on biological systems.
35. Explain the concept of „dose equivalent“ and state in what units it is expressed.
36. What are the basic mechanisms of biological effect of radioactive radiation.
37. Define the natural and artificial radiation.
38. Define the character of inner nucleus forces and name their properties.
39. Write down a scheme of nuclear transformation in minus beta particle emission.
40. How many decays occur in a minute, if the sample activity is 5 kBq.
41. Write down the relationship for binding energy of the nucleus and mark the respective symbols. Express the mass defect with the help of neutron proton mass.
42. What is the effective half-life of decay of $T_{ef,}$ if the biological half-life T_b = 10 days and the physical half-life T_p = 40 days.
43. Write down a scheme of nuclear transformation of nuclear particles at positron emission.
44. What is the half-layer thickness of a piece of material whose linear absorption coefficient is
45. $\mu = 0{,}693\ cm^{-1}$.
46. Derive the relationship betweeen the decay constant and the decay half-life. Define the decay constant.
47. Calculate the activity of a radioisotope after 5 half-lives have passed, if at the begining the activity was 6400 MBq.
48. Name the types of gamma radiation interactions with material environment and characterize the photoelectric phenomenon.
49. Define the radiation dose unit, write down the definition relationship.
50. Name the types of γ emission interactions with material environment and characterize the Compton effect.
51. Name the types of γ emission interactions with material environment and point the condition for the formation of an electron-positron pair.
52. Draw and characterize the difference between the ionization characteristics of the ionization chamber and the working characteristics of a Geiger-Műller detector.
53. Explain the principle of detection of nuclear emission and name the types of detectors which you know.
54. Draw a scheme of the scintillation detector, mark the main parts.
55. What is the function of the photomultiplier in a scintillation detector.
56. Express graphically the progress of changing the character of continuous spectrum of X-ray emission with the voltage increasing. Mark the respective axes of the rectangular coordinate system.
57. What function does the primary filter in an X-ray device have.
58. Specify examples of positive contrast materials and the reason why are they used in X-ray diagnostics.
59. How can we change the hardness and intensity of x-ray radiation.
60. Calculate the degree of homogeneity if the thickness PPV_1 = 5 mm and PPV_2 = 7 mm (PPV –half-layer thickness).
61. A 70 kg human body was exposed to radiation for 25 minutes of a constant dose rate. The total amount of absorbed energy is 2,1 J. Calculate the average dose to the body in mGy and the dose rate in mGy/s.

62. In radioisotope examination it was administered to the patient 37 MBq of isotope ^{86}Rb, whose biological half-life time is of 13,4 days and the transformation constant is 1,54 . 10^{-3} h^{-1} . Determine the effective half-life time T_{ef} and calculate in what time the applied energy in the body will decrease down to 3,7 kBq.
63. Absorption of soft x-ray radiation in a unit volume of matter is directly proportional to the third power of the proton number of respective atoms of the absorber and the number of atoms in it. Calculate how many times more the x-ray radiation will be absorbed in bone tissue in comparison with the absorption in water. Considerate the unit volume with the same number of atoms.
64. In sciascopic and sciagraphic examination of the digestive tract a positive contrast matter is used – a barium meal $BaSO_4$, which fills the respective organ in order to get a contrast image. Calculate how many times more the soft x-ray radiation will be absorbed in the barium meal than in the surrounding soft tissue, which is approximable to water.
65. Calculate the value of dose rate of a cobalt emmiter on the spot of irradiation of a patient placed in the distance of 1,5 m from the source, if the dose constant, i.e. the dose rate (Gy/s) 1 meter from the source (activity 1 Bq) is 7 . 10^{-17} Gy . m^{-2} . s^{-1} and the activity in the time of application is 150 GBq.
66. In the descent of an electron from the fourth quantum track to the second one a photon with the energy of 2,55 eV was emmitted. Calculate the wavelength of the emmitted light.
67. In total fission of 1 kg ^{235}U the released energy will be 8,2 . 10^{13} J. What amount of water (m^3), whose temperature is 293 K, can be evaporated using this released energy.
68. At the explosion of a neutron weapon with a power of 1 kt of TNT approximately 10^{24} neutrons will be released. Calculate how many neutrons will pass through an area of 1 m^2 in the distance of 1 000 m, assuming they will not be absorbed in the air.
69. At what speed will an electron and a proton move, which were formed by interaction of photon radiation of γ energy 3,02 MeV, and they will move in opposite directions.
70. In sciascopic screening hard x-ray radiation will be used, gained at anode voltage 150 kV. Calculate the maximum energy (keV) and the wavelength of spot radiation, which originated in the act.
71. Name the elementary components of a cell membrane, draw the elementary scheme (of molecular organization).
72. Explain the concept of „ion channels“. How do we sort them out according to their response to an stimulus?
73. Write down the Goldmann equation and mark the respective symbols.
74. Define the active transport through a membrane.
75. What values does the membrane potential reach. What do they depend on.
76. Define verbally and mathematically the Nernst equation.
77. Explain and describe mathematically Donnan equilibrium.
78. Name the types of passive and active transport through the cell membrane.
79. What is the difference between action and membrane potentials.
80. Name the basic functions of the cell membrane.
81. What is the lipid molecule structure like, what groups of membrane lipids do you know.
82. Name the groups of membrane lipids and mention what functions do they fulfil.
83. Draw an electric scheme of the cell membrane.
84. What is the function of a Na-K pump.
85. Describe the mechanisms which influence the passive transport.
86. Name the factors, which influence the velocity of spontaneous transport of molecules in diffusion.
87. What is the consequence of the existence of non-diffusable proteins in a cell for distribution the ions onto both sides of a membrane.

88. Explain why the membrane potential value equals approximately the value of potassium ions equilibrium potential.
89. How does the velocity of water transport through a membrane change in osmosis, if by unchanged area of membrane the permeability coefficient will rise 4,5 times.
90. Write down mathematically the volume of ion flow through a membrane considering the existence of concentration and electrical gradient. Explain the respective symbols.
91. Which two factors condition the active transport. Describe the transport mechanism.
92. Characterize the „sodium hypothesis of action potential origin".
93. Describe and graphically illustrate the course of action potential registered from a nerve fiber. Mark the respective axes.
94. Describe and graphically illustrate the changes in nerve fiber membrane permeability for K^+ and Na^+ ions. . Mark the respective axes.
95. Describe and graphically illustrate the dependence of rectangular current pulse threshold intensity on the time of its duration. Explain the concept of threshold intensity.
96. Explain the term membrane accomodation, illustrate graphically the accomodation dependence of threshold intensity of the stimulation current.
97. Describe the frequency dependence of threshold value of stimulation current.
98. Describe the principle of action potential propagation along the nerve fiber membrane, and in this relation its electrical properties.
99. Explain the mechanism of muscle contraction, draw a sarcomere.
100. Describe the properties of a nerve-muscle motor unit.
101. Describe and explain the difference between action potential of a nerve cell and that of a heart muscle cell. Illustrate grafically.
102. Explain the concept of the „electrical heart axis".
103. Explain the difference between bipolar and unipolar leads in electrocardiography.
104. Explain the conditions for formation of an electrocardiogram.
105. Describe the mechanism of direct current transmission through biological tissue.
106. Describe the mechanism of alternating current transmission through biological tissue.
107. Explain the concepts electrophoresis and electro-osmosis, describe their developments.
108. Describe the mechanisms and types of ion transport through a cell membrane.
109. Explain the concept of „diffusion" and state the elementary relationship for diffusive flow (mark the respective symbols).
110. Explain the concept of „osmosis" and state the elementary relationship for osmotic pressure (mark the respective symbols).
111. What is the physical-chemical mechanism of maintaining the isotonicity of organism inner environment.
112. Explain the difference between the concepts of „osmotic" and „oncotic" pressure.
113. Define the density of diffusion flow.
114. State the equilibrium condition for Na^+ ions, which concentration on both sides of a membrane is different.
115. Calculate the inner cell concentration of chlorine anions following the Donnan equilibrium, if

    $K_i = 120$ mmol . l^{-1}

    $K_e = 4$ mmol . l^{-1}

    $Cl_e = 150$ mmol . l^{-1}

Cl_i = ?

116. Explain the formation of action potential.
117. Calculate the equilibrium potential of potassium ions V_K if K_e = mmol.l^{-1} a K_i = 100 mmol.l^{-1} (log 2 = 0,3; log 100 = 2)
118. Describe the structure of a muscle fibre and draw it schematically.
119. Explain the „cable properties“ of a nerve fibre.
120. How is a signal transmitted from a nerve fibre into the contractile apparatus?
121. What does the term „chronaxy“ mean?
122. What does the term „rheobase“ mean?
123. Determine the electrical heart axis, if the resultant amplitude of the QRS complex in the second standard limb lead has double the amplitude than the QRS complex in the first standard limb lead.
124. Determine the final amplitude of the QRS complex in the third lead, if the final amplitude in the first lead is 0,4 mV and in the second lead is 0,8 mV. Then determine the electrical heart axis.
125. Draw, in a simplified form of one ECG oscillation, a record of standard limb leads for a case in which the electrical heart axis will be the following: a) -30°; b) + 120°.
126. Draw a scheme of connection for measuring unipolar leads VF and Goldberg lead aVR.
127. Describe the propagation of action potential through nerve fibres.
128. Explain the significance of electrical conductivity of tissue and name some examples.
129. Explain the concept of „lateral diffusion“.
130. Name and describe the basic mechanisms of transport of pharmaceuticals across cell membranes.
131. Explain the concept of „sodium electrogenesis“.
132. Explain the ion channels gating mechanisms.
133. Describe the method of creating the electrical heart axis.
134. Compare the process of development and duration of action potential on the skeletal and heart muscle membranes.
135. Characterize the role of chemical mediator in the transport of excitation between excitable cells.
136. Name the elementary electrical parameters which characterize the electrical properties of a cell membrane.
137. What is the nature of action potential synaptic transfer.
138. Characterize the phases across which the myocardial cells pass during action potential.
139. What is the distribution of water reserves in the human body.
140. Write down the state equation of gases and explain its importance in modelling of biological processes.
141. What is osmosis and what is its practical significance for living systems.
142. What is the biophysical significance of transport phenomena?
143. What is the biophysical principle (significance) of surface phenomena?
144. Which elementary laws of ideal gas have a direct relationship to biological processes.
145. Name the anomalous properties of water.
146. Define the concept of „dispersive system“. Write down a classification of dispersive systems.
147. What does the speed of diffusion depend on? Give some examples.
148. What is lyofilisation?
149. Name the colligative properties of dispersive systems and define each.

150. Explain the nature of polar character of water and its biological significance.
151. Draw a simple scheme of blood circulation and mark in it the resistance and capacity systems, as well as pressure conditions.
152. Write down the Hagen-Poiseuille equation, mark and describe the respective symbols and give an example of its application in describing the biological processes in human organism.
153. Express the vascular resistance by using the Hagen-Poiseuille law, explain its significance.
154. Write down the expression for critical velocity at which in a capillary the laminar flow changes into turbulent flow and mark the respective symbols.
155. Which blood-vessel components make it possible for them to change their volume (capacity)?
156. Write down the relationship for total mechanical work of heart during one systole and mark the respective symbols.
157. Applying the law of conservation of energy explain the elastic vessel mechanism.
158. Express mathematically the mechanical work of heart during one cardiac cycle.
159. What is oncotic pressure? Explain its significance for tissue circulation.
160. Which physical quantities express the filter pressure in capillaries? Explain its significance.
161. Calculate the overall resting cardiac output exercised in one systole, when the systolic pressure value is 13,2 kPa, diastolic pressure 9 000 Pa in the aorta, the mean blood velocity in it is 280 mm/s and the stroke volume of the left ventricle is 60 ml.
162. Calculate the work excercised by the right heart ventricle of a sportsman in 10 minutes, if the systolic blood pressure in the aorta was 19 kPa, the diastolic blood pressure in the aorta 10 000 Pa, the mean blood velocity in the aorta 150 cm/s, the stroke volume 120 ml, the heart rate 160 beats/min.
163. Systolic blood pressure is 20 kPa, diastolic blood pressure is 14 kPa, the mean blood velocity in the aorta is 140 cm/s, the heart rate 150 beats/min, the overall heart work in one systole is 3,2 J. Calculate the cardiac output in one minute.
164. By what percentage will increase in performance the left ventricle in one systole, if the mean blood pressure value in the aorta increases by 20 % and the heart rate also increases by 20 % (the rest of the parameters remains unchanged).
165. By what percentage and by how many liters the *cardiac output will change*, when originally it was 10 l at the stroke volume of 100 ml, if the stroke volume *decreases* to 80 ml and the heart rate *increases* by 40%?
166. The mean pressure in the aorta is 12.8 k Pa, the vein blood pressure in front of the right ventricle is 1,2 kPa, the stroke volume is 0.07 l, heart rate is 90 beats/min. Calculate the peripheral resistance, which imposes the arterial section of vascular blood circulatory system, if its value corresponds to 60 % of the total periferal resistance.
167. The currently used unit of peripheral vascular resistance (PVR – resistance offered to the flow of blood in the blood vascular system) is kPa/(l.min^{-1}). Derive the basic unit of this quantity in the SI system.
168. Calculate the magnitude of the system and pulmonary PVR of a healthy adult in rest in kPa/(l.min^{-1}) units and in the basic units of the SI system.
169. Calculate the value of PVR, if at the heart rate of 100 beats/min and the stroke volume of 40 ml you know, that the difference between mean arterial pressure and venous pressure is 15 kPa.
170. By what percentage has to rise the blood value pressure at increasing PVR by 50 %, if the cardiac output of the heart should stay constant?
171. How does the PVR value change in increasing the total vascular diameter by 50 % ?
172. Decide whether the blood flow in a vessel is turbulent or laminar at mean velocity of blood 0,3 m.s^{-1} and the vessel diameter 2 cm with dynamic viscosity 3.10^{-3} Pa.s.

173. Calculate what is the smallest value of blood dynamic viscosity, so the blood flow in the vessel be laminar, if the blood velocity is 0,5 $m.s^{-1}$ and the vessel diameter is 1,2 cm.
174. By what percentage has to be changed the pressure fall in an artery, in which the cross–section has changed by 25 %, if the blood flow has to remain unchanged?
175. At certain place in the abdominal aorta with the diameter of 2,2 cm an aneurysm (a bulging, weak area in the wall of an artery) has been formed with a diameter of 5 cm. The blood velocity at pressure of 15 kPa in the artery equals 30 cm/s. Determine the difference in blood pressure at the place of arterial aneurysm.
176. Calculate the value of osmotic pressure in 5,5 % glucose solution at 20 °C.
177. Calculate the value of osmotic pressure in plasma proteins, if their relative molecular mass is $6,6 . 10^5$ and the mass concentration is 4 % at 37 °C.
178. Calculate the osmotic pressure of physiological solution at 0 °C and 37 °C.
179. Calculate what concentration must have a glucose solution, if it has to have the same osmotic effects as a physiological solution.
180. How will the value of osmotic pressure change in a solution, if its temperature rises from 4 °C to 41 °C?
181. Determine the final concentration of a solution prepared by diluting 200 ml of physiological solution with 0,1 l of distilled water. Express the result as a percentage.
182. Which are the basic mechanical properties of bones and articulations?
183. Write down the expression for critical speed at which occurs a changeover from laminar flow into turbulent and mark the respective symbols.
184. By what mechanism can a human change the pitch, timbre and strength of their voice?
185. How does the human voice originate and what are the characteristic acoustic curves of human speech?
186. What is the significance of the negative inner chest pressure in a human, when does it reach the largest value?
187. What is the vital lung capacity?
188. Which lung volumes cannot be measured directly with a spirometer?
189. Define the vital and total lung capacity.
190. Explain the concept of biological respiratory work.
191. Define the respiratory work.
192. What is the principle of body plethysmography?
193. Describe the principle of artificial lung ventilation.
194. Draw a scheme of the relationship amongst the functional units of the respiratory system.
195. Describe the mechanisms of exchange of gases in the respiratory system.
196. Which components does the lung resistance include?
197. How do the pressure and speed parameters in respiratory canals change at cough?
198. Describe the principle of ultrafiltration.
199. Describe the principle of hemodialysis.
200. Name the basic principles of measurement of hydroxonium (hydronium) cations concentration.
201. What is the function superficially active substances?
202. What is the contents of pharmacokinetics?
203. How does the negative pleural pressure work in the breathing process?

204. Explain the principle of experimental setting of molecular mass of a soluble substance with help of measuring of osmotic pressure.
205. Name the most important physical and chemical properties of biological liquids which have to be taken into account at inducting pharmaceuticals into an organism.
206. Name and explain the basic methods of expressing the concentration.
207. Explain the concepts of „substance (mole)“ and „mass“ concentration.
208. Characterize the colligative properties of solutions.
209. Explain the concept of „homeostasis“ of organism.
210. Name and describe the elementary parts of a sense organ.
211. Describe the biophysical function of a receptor.
212. Draw the course of spectral sensibility at photopic and scotopic vision. Mark the respective receptors.
213. What malfunctions of the optical system do you know and what are their possible corrections?
214. Illustrate and explain graphically the concept of „hearing field“ (sphere of hearing).
215. Write down the mathematical relation and explain the meaning of Weber-Fechner and Stevens´ laws. Give an example when describing the physiological actions in human a organism.
216. Describe the function of the middle ear.
217. What is the level of intensity in dB, if the level of acoustic stimulus is 10^{-7} W.m^{-2}?
218. Draw a scheme of the biophysical function of the outer ear and middle ear.
219. Describe the function and explain the nature of a cochlear microphonic potential formation.
220. Describe the function of the organ of Corti (or spiral organ).
221. Describe the most frequent types of hearing malfunctions and explain their biophysical nature.
222. What is the accomodation width of the human eye? Explain.
223. Explain how does the decrease of accomodation ability of a human eye depend on the biological age of an individual and explain it graphically.
224. Explain the physical substance of astigmatism and the way of its correction.
225. Explain the biophysical effect of sound on organism.
226. Explain the biophysical effect of ultrasound on organism.
227. What are the isophones?
228. Describe the Doppler effect and give examples of its utilisation in medicine.
229. The sound volume of a normal talk is 50 dB. What will be the level of sound in an auditorium during a break when two hundred students will talk at the same time, if the sound absorption is 50 % and the level of surrounding noise is 20 %?
230. At the sound level of 150 dB occurs rupture of the tympanic membrane. Calculate the corresponding pressure amplitude and deviation of gas molecules for a tone with frequency of 100 Hz.
231. How big is an object in the distance of 10 m if it is seen under the visual angle of 1´ ?
232. What is the smallest distance between two points observed from conventional visual distance (25 cm), which the eye perceives separately, at differentiating between 1´ ?
233. What is the smallest dimension of an object which can be glimpsed by the human eye on the Moon surface if the distance is 380 000 km?
234. Calculate the optical corneal thickness if there was air on its both sides. Compare the result with data for cornea in the text book.

235. Calculate the optical thickness of non-accommodated eye lens where there would be air on both sides and the same value for lens of an inviolated eye.
236. At a maximum accommodation the curve diameters of both the lens surfaces are 5,3 mm and the refractive index increases up to 1,424. Calculate the optical lens thickness at maximum accommodation.
237. Calculate the size of an object which we can discern from a 5 m distance.
238. If the distance of pupils of the eye is 70 mm, in what distance ends the ability of stereoscopic seeing as a result of binocular vision?
239. By what distance closer to the observer, whose distance of pupils of the eye is 70 mm, has to be an object for him to recognize that it does not lie in the same plain as another object in the distance of 120 m?
240. Draw the dependence graph of frequency change from the observer velocity at a stable source in Doppler effect.
241. What is the function of the eye´s refraction of light system?
242. What is the function of the retina from the biophysical point view?
243. How is physically the transport of information from the eye to the brain brought into effect?
244. What does the range of binocular visual field depend on?
245. Explain the reason of chromatic aberration of an emmetropic eye and specify by what means does the eye rectify it.
246. Explain the reason of spherical aberration of an emmetropic eye and specify by what means does the eye rectify it.
247. How big is the axial myopia of an eye which optical axis will be by 2 mm longer than normal. The total eye refraction corresponds to the refraction of an emmetropic eye (?).
248. How does the eye optical system refraction have to change, if the image is not created by the imaging system on the retina?
249. By which optical elements can a sharp image of an object be obtained, located in front of the retina?
250. What is presbyopi? How do the physical conditions change in it? How are they being rectified?
251. How does the refraction of an emmetropic eye change considering the prevailing colour constituent during the day?
252. How does the seeing change at diving? Explain.
253. How does the seeing change at surgical removal of the lens? Explain.
254. How does the corneal refraction change after a surgical incision by radial microcuts on the cornea along the whole of its peripheral circumference? Explain.
255. How can the function of the rod and cone cells of the retina be explained in term of the formation of a biosignal?
256. What is the essential nature of stereoscopic vision?
257. Name in pairs the changes in the structure of the eye which excercise influence on its functions.
258. Where and how is the action potential generated, when the eye is illuminated?
259. Describe the principle of an excimer laser.
260. What is presbyacusis? How do the physical conditions change in it? How can it be rectified?
261. In what does the biophysical nature of transmissive hearing impairment reside? How can it be rectified?
262. In what does the biophysical nature of perceptive hearing impairment reside? How can it be rectified?
263. Describe the physical nature of the outer ear function.
264. Describe the function of mechanical receptors the inner ear.

265. Where and how is the action potential generated when sound is applied?
266. How does the hearing change with a scarred ear drum?
267. What is the reason of „tinnitus auris“? How can it be rectified? Explain the physical nature.
268. Name in pairs the change in structure of respective parts of the hearing analyser, which influence its functions.
269. Describe how and by what means hearing impairments can be rectified.
270. What is the physical principle of checking up the corneal curvature with the help of a keratoscope (Placido´s disc).
271. Name and characterize the objective checking-up methods for the eye refraction.
272. What is the physical principle of corneal astigmatism check-up with the help of Javal ophthalmometer
273. What is the result of a perimetric eye exam?
274. What physical phenomenon is used in measuring illumination?
275. Explain the concept of „hearing loss“.
276. Explain the difference between the quantities of „sound intensity level“ and „pressure intensity level“.
277. Name and physically characterize the acoustic diagnostic methods.
278. Illustrate graphically a normal audiogram.
279. What is the difference between transmission of sound by aerial conduction and bone conduction in the hearing system?
280. Write down and explain the physical importance of Bernoulli´s equation. Mention examples of usage in describing the physiological processes in the human body.
281. Write down and explain the physical importance of the relationship of potential and kinetic energy taking into account the law of conservation of energy. Mention an example of utilization in describing the physiological processes in the human body.
282. Write down and explain the physical importance of Ohm´s Law. Mention an example of utilization in describing the physiological processes in the human body.
283. Write down and explain the physical principle of operation and effectiveness of a hydraulic press . Mention an example of utilization in describing the physiological processes in the human body.
284. Write down and explain the physical principle of a lever. Mention an example of utilization in describing the physiological processes in the human body.
285. Write down and explain the physical importance of Snell´s Law. Mention an example of utilization in describing the physiological processes in the human body.
286. Explain the physical principle of piezoelectric effect and write down an example of utilization in describing the physiological processes in the human body.
287. Write down the definition relationship for Hooke´s Law. Mention along with explanation an example of utilization in describing the physiological processes in the human body.
288. Write down and explain the physical importance of Weber-Fechner and Stevenson laws. Mention an example of utilization in describing the physiological processes in the human body.
289. Write down and explain the Hagen-Poiseuille´s law. Mention an example of utilization in describing the physiological processes in the human body.
290. Write down and explain Stefan-Boltzmann law. Mention an example of utilization in describing the physiological processes in the human body.
291. Write down and explain the First and the Second Fick´s Law. Mention an example of utilization in describing the physiological processes in the human body.

292. Write down and explain the physical relationship for surface tension. Mention an example of utilization in describing the physiological processes in the human body.
293. Write down and explain the physical relationship for the calculation of the Reynolds number. Mention an example of utilization in describing the physiological processes in the human body.
294. Write down and explain the physical nature of the Nernst equation. Mention an example of utilization in describing the physiological processes in the human body.
295. Write down and explain the physical nature of the Goldman equation. Mention an example of utilization in describing the physiological processes in the human body.
296. Write down the equation for the Donnan equilibrium. Explain the physical nature. Mention an example along with an explanation of utilization in describing the physiological processes in the human body.
297. Write down and explain the physical relationship for heat transfer (conduction). Mention an example of utilization in describing the physiological processes in the human body.
298. Write down and explain vant´ Hoff law. Mention an example.
299. Write down and explain Stockes´ law. Mention an example.
300. Name the types of mechanical forces effects on human body.
301. Name the basic bioclimatic factors and mention their basic units.
302. Explain the principle of source and generation of laser radiation and name the possibilities of utilization in medicine.
303. Explain the principle of monitoring the surface temperature by means of disk tomography.
304. Draw or verbally describe the scheme of regulation of the human body temperature.
305. Characterize the forms by which the heat is dissipated from the human body.
306. Characterize the types of interactions between the human body and the outer physical factors of the environment.
307. Shortly describe the biophysical principle of galvanotherapy.
308. How does the human body react to the effects of centrifugal (compressive) force and weightlessness?
309. What is diathermy and how do we divide it?
310. What is ionophoresis?
311. What is in principle the difference in measurement of temperature by contact and non-contact methods?
312. Explain what does the term „ecological biophysics“ mean. Write down its division.
313. Explain the effects of alternating current on the human body.
314. Explain the effects of direct current on the human body.
315. Name the basic principles of protection against ionizing radiation.
316. Name the thermoregulating mechanisms by which a human individual keeps their core body temperature at 37° C.
317. In what does the mechanism of biological effect of high frequency current rest?
318. Explain the principle of measuring the surface temperature by means of a non-contact method. Give an example.
319. Explain the basic principle of audiometry.
320. Name and describe the methods of measuring the solution concentration of optically active substances.
321. Explain the principle of an electric model of vasoconstriction compensation mechanism at the beginning of a circular shock.

322. Explain the principle of measuring the viscosity of liquids by means of a capillar viscometer.
323. What is the difference between terminal and electromotoric cell voltage?
324. Name the basic dosimetric quantities and mention their units.
325. Explain the function of a photocell and a monochromator in spectrophotometry.
326. Describe the psychrometric method of measuring the relative humidity of air.
327. What are the „Korotkoff´s phenomena“ and how do they originate?
328. Calculate the concentration of a glucose solution (specific rotation = +52,5), which has rotated the plane of polarized light by 2°. Mention the complete progress in calculation.
329. What are the Snellen´s optotypes? Describe the principle of their construction.
330. Describe the method/steps to be taken in an audiometric check-up and the basic type of an audiogram.
331. Describe the basic principle of electric measurement devices of magnetoelectric types.
332. Describe the concentration cell.
333. Draw a schematic diagram and describe a pen dosimeter. On what principle does it function?
334. What is the difference between the innere and outer temperature fall? Mention the importance for heat transfer in the human body.
335. Write down and explain the mathematical relationship of the Beer-Lambert law. Give an example of utilization.
336. What does the transmission bandwidth of an electrical amplifier inform us about?
337. Name the basic parts of an immersion refractometer and explain their functions.
338. Explain the principle of the refractometric method.
339. Name the optical methods of measurement of pure solutions concentration. Mention their basic principle.
340. On what principle do the thermistor thermometers function?
341. What does the record „BP: 110/70“ express? Transfer this value into the SI system.
342. Mention the principal difference between Ampere Meter and Voltmeter. Draw a schematic diagram of their connection into electric circuits.
343. What is the difference beween polarized and non-polarized light? Mention an example of utilization in laboratory techniques.
344. Explain the biophysical principle in measuring the blood pressure (BP) by means of Riva-Rocci method.
345. Schematically illustrate and describe the principle of a spectrophotometer.
346. What kinds of electrodes for pH measurements do you know?
347. Name and explain types of methods for pH measurement.
348. Explain the principle of „current clamp“ method.
349. Explain the principle of „voltage clamp“ method.
350. Explain the principle of „patch clamp“ method.
351. Explain the principle of electrical model of action potential generation on the muscle cell surface membrane.
352. Explain the principle of electrical model of stimulus summing generation on the input neuron.
353. What is a tomogram?
354. What is the principle of the whole body gamagraphy?
355. Draw a general block diagram of a measurement device (apparatus).

356. Mention the elementary principle of measuring the integral and differential spectrum of a radioactive preparation.
357. Explain the mechanism of the effects of overpressure to the human body.
358. Explain the mechanism of the effects of underpressure to the human body.
359. Explain the concept of „dysbarism“.
360. Explain the nature of harmful effects of mechanical energy to the human body.
361. What effects of ultrasound are put to use in diagnostic and therapeutic procedures?
362. What is the primary object of study in biometeorology?
363. What is the significance and mechanism if thermoregulation?
364. In what does the physical significance of lithotripsy rest?
365. What basic physical principles are put to use in ultrasound imaging systems?
366. What is the principle of echotomography? What information does a echotomogram provide?
367. How do we classify systems from the point of view of control and information processes?
368. Which systems are called „static“?
369. Characterize a dynamic system.
370. Organize the dynamic systems.
371. How is the system transformation expresssed:
372. What kind of links in a system do you know? Explain the difference between direct and indirect (links), give an example.
373. Explain the negative feed-back and its effects.
374. Explain the positive feed-back and its effects.
375. Explain the difference between direct and indirect feed-back in information systems.
376. What significance does the memory have in a personal computer? What types do you know?
377. Classify the systems according to the relatioships amongst their constituents.
378. Characterize information and determine its information contents.
379. What is the purpose of biocybernetics?
380. What is an algorithm?
381. What are the possibilities of utilization of microcomputers in medicine?
382. What is a programming language? Name the most commonly used.
383. How is in an organism a piece of information processed and propagated?
384. What is the difference between a bit and a byte“?
385. What is an infromation system?
386. Explain the concept of „program“. Give a simple example.
387. Explain the concept „computer memory“.
388. Draw and explain the simpliest schematical block diagram of a personal computer.
389. What is a system? According to which criteria do we classify systems?
390. In what way do the information processes in the human body take place?
391. What is the essence of control and regulation?
392. Describe the principle of modeling in medicine.

393. What are the regulation models? Give an example.
394. Explain an example of a direct analogy model.
395. What is the principle of a nervous system model?
396. Describe the principle of a compartment model.
397. Draw a general schematic diagram of a regulated system.
398. Describe the function of an information channel.
399. What is a biosignal. Give some examples.
400. How do we classify signals according to general properties?
401. How can we scan/read biosignals?
402. How can we modify biosignals?
403. How can we register biosignals? Mention some examples.
404. What is the object of interest of medical informatics?
405. What does the Gauss´ distribution law say about error distribution? Draw and explain graphically.
406. What is Gaussian distribution?
407. Explain the concept of „representative part of a set“ and mention its properties.
408. How do we divide selected properties of a statistical set of elements?
409. Name the basic statistical characteristics.
410. Mention the relationship for the calculation of the weighted arithmetic mean.
411. What are the „mean values“? What kinds of correlations among them do exist?
412. Write down the mathematical relationships for expressing the measure of variability.
413. What does the coefficient of variation express?
414. Mention the mathematical relationship for the calculation of a mean error with the diameter $\overline{s}$ of an independent value.
415. Mention the definition relationship for the calculation of the mean error of arithmetical average of the value $\overline{A}$ expressed by the relationship: $\overline{A} = \frac{\overline{x}.\overline{y}}{z_t}$; $A = x^m$
416. Mention the definition relationship for the calculation of the mean error of arithmetical average of the value A expressed by the relationship : $\overline{A} = k . \overline{x}$ a $\overline{A} = x + y$.
417. Determine the arithmetical average, selective standard deviation and the mean error of the arithmetical average from the following set of data: 50,0; 48,0; 53,5; 52,0; 46,5.
418. Determine the interval in which lies 67 % of measured values from the following set of measurements: 0,080; 1,120; 0,095; 0,085; 0,105; 0,090; 0,115; 0,110.
419. Students A and B obtained two sets of data from the measuremetns of the same physical value. Compare the coefficients of variation of both the sets: A: 2,8; 3,0; 3,2; 2,9; 3,1 B: 2,8; 3,1; 3,1; 2,9; 3,2; 2,9
420. What is the coefficient of variation in measurement of the red corpuscules, if the following values were measured: 6,7; 6,6; 7,1; 7,3; 6,8; 7,2; 7,4; 6 ,9; 7,1. Decide whether the final result is satisfactory enough (the terminal value for V_k is 30 %).
421. Whcih elementary parts has to contain the protocol of measurements?
422. Whcih elementary parts has to contain in the working protocol the table? Mention an example.
423. Which elementary conditions has to accomplish a graphical record?

424. Which are the most important types of measurement errors and how do they originate?
425. How do the information processes function in a living organism?
426. Name the three elementary regulation models of physiological functions of the human body.
427. Describe the fundamentals of the thermoregulation model, draw its block schematic diagram and explain it.
428. Describe the fundamentals of the cardiovascular system model, draw its block schematic diagram and explain it.
429. Describe the fundamentals of the glycemic regulation model, draw its block schematic diagram and explain it.
430. Name the possible analogies between hydrodynamic and electrical models of cardiovascular system.
431. If a projectile has kinetic energy of 1 kJ it tears tissue and crashes bones. Calculate the velocity of such a projectile with weight 5.10^{-3} kg.
432. An adult has approximately 5,5 l of blood with mass of 5 500 g. Calculate the blood density.
433. The concetration of lactic acid in blood of a human after maximal exercise is 12 nmol/l. Calculate the substance volume of lactic acid in blood of a woman after maximal exercise, supposing she has 4,5 l of blood.
434. Vital lung capacity (VC) of a human is 4,2 l. Calculate the one-second-capacity of lungs (FEV_1) if you know that FEV represents 70 % VC.
435. In a human 50 ml of blood is restored daily. In what time all the blood will be changed in a man who has 5,5 l of blood?
436. Normal value of mercury concentration in urine is up to 0,75 μmol/l. The patient had in 170 ml of urine 5.10^{-7} μmol/l of mercury. Is the amount of mercury in the patient´s urine within the norm?
437. During a bite between the upper and lower incisive teeth a force of 10 N is generated. What force is exerted on each side of the temporo-mandibular joint? (TMJ = joint connecting the lower jaw and the skull.)
438. What force is exerted on the wall of a cell membrane, if on an area of 0,01 mm^2 acts a solution of chloride salts with pressure of 20 Pa?
439. What hydrostatic pressure is exerted on the diver´s body 30 m underwater?
440. The volume of mercury in a medical thermometer at temperature of 36,5 ^{0}C is 1 cm^3. Calculate the temperature of the human body if at the measurement the volume of mercury has changed by 10^{-4} cm^3.
441. Convert into basic units of the SI system: 46 MHz, 3,2 kHz.
442. The heart-rate is 0,25. Calculate the amplitude of cardiac systole in time t = 0,5 s, if you know that the maxium systolic amplitude is 0,5 cm.
443. Calculate the intensity of sound which is transferred in the form of waves to the eardrum at a rock concert. The output of the sound waves in this scene is 5.10^{-6} W. Suppose the eardrum area is 0,5 cm^2.
444. The deepest perceptible sound in human hearing has frequency of 16 Hz. What is its wavelength in the air?
445. How big a force was generated at combing between the comb and hair supposing that on each of the 200 hairs, which undergo friction, there is a charge of 4.10^{-6} C. The comb has a charge of 10^{-7} C, the distance of the comb and the hair is 15 cm.
446. Calculate the areal density of a charge on the cell membrane with surface 10^{-8} m^2, which charge is 10^{-9} C.
447. In what extent does the conductivity of the human body change if the resistance changes from 1 to 100 kΩ?
448. What resistance have wires used for the connection of electrodes with a registration apparatus, if their length is 2 m, diameter 0,3 mm and specific resistance is of $3,92.10^6$ Ω?
449. Calculate the total energy of lightning, if the magnitude of charge at its flashover between the earth and the sky is 20 C, current which flows through such a channel is 10^4 A. Between the earth and the sky originates a potential difference of 10^9 V.

450. The magnetic bracelet used for therapy in the seventies of the last century had magnetic induction B = 50 mT. Its thickness (the width of magnets) was 1 cm. Suppose that by movement of an erythrocyte with certain charge in the vessel a current of 1 μA will originate. Calculate the force exerted by the magnet to the erythrocyte (disregard the absorbtion of magnetic field by tissue).

451. Calculate the amplification in an amplifier which is used for scanning muscle action potentials. The monitored muscle had a potential value 20 mV, while voltage on the output was 2 V.

452. Electrotherapy utilizes currents of approximately $2{,}5.10^{-6}$ A. The apparatuses are supplied from standard electricity distribution network with current I = 0,25 A. Determine the transformation ratio of the used transformer.

453. Calculate the refractive index of a human lens, if the light in it propagates at velocity 212 314,22 km/s.

454. Determine the refractive index of eye chamber water if the ray angle of draw is 45^0.

455. Calculate the lens optical thickness in a human eye if the focal distance is 0,0461 m.

456. Calculate the angle of vision if two points, observed from the distance of 25 cm, are perceptible and the distance between them is 0,072 mm.

457. What optical thickness must have glasses for a far-sighted eye with the near point in the distance of 25 cm from it?

458. Determine the distance of the near point for a short-sighted eye, if the glasses optical thickness for this eye is – 7 D.

459. Calculate the decay constant of iodine $^{131}_{53}I$ used in diagnostics of thyroid gland disease, if its decay half-life is T = 8 days.

460. The blood vessels help the flow of blood with regular contractions. What work is done by a vessel if with the blood pressure of 9 kPa its volume changes by 3 cm^3?

461. What gravitational acceleration is exerted on a 75 kg living thing in free fall in vaccum?

462. How does the weight of an astronaut change in a space ship, if before the start it was 70 kg and the ship is moving with speed 0,5 c? (c = speed of light in vacuume)

463. How does the heart rate frequency of future astronauts change, if the centrifuge moves at 0,3 c? Their average hear rate before training is 70 min^{-1}.

464. A human received from the environment 300 kJ of heat by which his body temperature raised by 2 ^{0}C. What is the heat capacity of the human body?

465. Calculate the quantum of heat which a person received from bath in 50 l of 40 ^{0}C warm water, if you know that in fact they received only 50 % of heat contained in the bath (suppose the body temperature 36,5 ^{0}C).

466. Calculate the heat flow for the human body surface, if in 1 hour it radiates 420 kJ of heat (disregard the heat conductivty coefficient and thickness of the layer).

467. After stopping inhalation the pressure in the lungs is 1 kPa and the temperature 30 ^{0}C. What amount of air molecules gets into the lungs at inhalation of 3,5 l of air?

468. At maximum inhalation the pressure in lungs is 1 kPa. Calculate the oxygen partial pressure in lungs after maximum inhalation (air contains approximately 18 % O_2).

469. The head of coxal articulation (hip-joint) has a surface of 9 cm^2, when walking a force of 600 N is exerted to it. What is the normal tension exerted on the join head?

4. EXAMINATION QUESTIONS ON SUBJECTS: MEDICAL PHYSICS, BIOPHYSICS, MEDICAL PHYSICS AND PRINCIPLES OF eHEALTH

4.1 EXAMINATION QUESTIONS – THEORETICAL PART

1. Position and significance of medical physics, biophysics and medical biophysics in the study curriculum of medical branches. As an example use the study program: general medicine, dentistry.
2. Human organism as an integrated biological system (IBS) in healthy and ill condition. Regulation of organism functions and coupling types.
3. Interactions of IBS with physical factors (PhF) of living environment generally and in healthcare institutions.
4. Controlled interactions of IBS with PhF as a part of diagnostic methods in healthcare.
5. Controlled interaction of IBS with PhF as a part of therapeutic methods and procedures in healthcare.
6. Analysis of physical properties of water with regard to its biological function. Regulation of hydratation of an organism during its life.
7. Transport phenomena in dispersion systems (heat transfer, viscosity, diffusion), surface phenomena generally.
8. Transport phenomena in biological systems (heat transfer in tissues, viscosity of body liquids, diffusion through semi permeable membranes), surface tension of pulmonal alveoli.
9. Categorisation of disperse systems and their properties.
10. Colligative properties of liquids in biological systems (osmosis, osmotic pressure , regulation of isoosmosis in an organism) application of infusions etc.
11. Physical principle of diffusion in biological systems. Internal breathing and its application.
12. Physical principle of osmosis in biological systems. Basic laws of gases.
13. Basic physical principle of rest membrane potential in vivo.
14. Basic physical principles of generation, propagation and registration of action potential in vivo.
15. Passive electrical properties of biological tissues, their significance for diagnostic and therapeutic processes in healthcare.
16. Active electrical properties of biological tissues and their significance in evidence based medicine, diagnostic and therapeutic processes in healthcare.
17. Biological signals and their sources in a human organism in vivo, division, ways of registration as a condition for use of auxiliary examination methods in evidence based medicine.
18. Physical analysis of graphical processing or image processing of biological signals.
19. Biophysical analysis of a physical model of structure of sensual organs (eye, ear, skin).
20. Physical analysis of function of sensual organs model (eye, ear, skin).
21. Biological rhythms and their significance for synchronisation of regulated systems in an organism.
22. Physical analysis of a simplified model of regulated IBS systems (cardiovascular, respiration and thermoregulation system).
23. Biomechanics of the human locomotion apparatus.

24. Physical principles and general rules of safe use of physiotherapeutic procedures.
25. Physical principles of mechanotherapeutical procedures (basic physical relations and laws).
26. Physical principles of hydrotherapeutical procedures (basic physical relations and laws).
27. Physical principles of phototherapeutical procedures (basic physical relations and laws).
28. Physical principles of electrotherapeutical and magnetotherapeutical procedures (basic physical relations and laws).
29. Physical principles of loading functional diagnostics (basic physical relations and laws).
30. Physical principles of auxiliary methods, their forms and means of regeneration of an organism in medical and veterinary practice.
31. Meaning of the term „electronised healthcare“ (eHealth).
32. The most important electronical sources of medical information and medical knowledge.
33. Significance of change of the patient's record form paper to electronic form for eHealth.
34. Information system generally versus hospital information system.
35. Benefits, negatives and safety risks of an outpatient and hospital information system.

4.2 EXAMINATION QUESTIONS – PRACTICAL PART

1. Physical experiment versus medical practice.
2. Protocol from physical measurement versus patient's documentation.
3. Numerical evaluation of physical measurements versus results of biochemical and other auxiliary diagnostic methods and their comparison to adequate physiological values.
4. Basic statistical characteristics necessary for numeric processing of examinations in diagnostic practice and their calculation.
5. Graphical evaluation of physical measurements versus graphical evaluation of results in medical practice.
6. Image processing of results of signal measurement from technical sources versus image processing of results obtained from biological signals by auxiliary examination methods in medical practice.
7. Basic technical parameters of electric measurement devices and equipments in healthcare institutes in diagnostics and therapy and conditions for their connection to an electric circuit. Related physical laws.
8. Basic block diagrams of diagnostic and application technical elements of devices used in healthcare institutions.
9. Using of PC for on-line evaluation of auxiliary laboratory measurement results (give an example).
10. Safety rules for experimental and practical use of technical devices in medical experiment and practice.
11. Basic safety and hygienic norms and importance of their application in prevention of population sicknesses.
12. Basic principles of detectors of physical factors in laboratory conditions.
13. Detection of values of physical factors (PhF) in living and working environment in healthcare institutes and their comparison with hygienic norms.
14. Monitoring of physical factors of living and working environment in healthcare institutes.

15. Implementation of physical and physical-chemical methods and procedures into diagnostic and therapeutic process in healthcare as a way to obtain exact data for evidence based medicine.
16. General scheme of a diagnostic process using basic physical knowledge.
17. Medical technique in internal medicine and surgical disciplines (example).
18. Algorithm of contextual management of a concrete physical problem in regular as well as distance form of practical teaching of physics in medical study (e-learning).
19. Forms and means of a semester project creation as a base for diploma work.
20. Algorithm of schemes for solving of basic problem areas of diagnostic and therapeutic auxiliary methods with regard to contextual practical teaching of medical physics, biophysics and medical biophysics.
21. Analysis of the chosen thematic area of diagnostics and therapy in medicine from point of view of contextual practical teaching of medical physics, biophysics and medical biophysics.
22. Basics of work in laboratory in practice of general and dental medicine.
23. Microclimatic factors of living environment.
24. Thermometry in working environment of medical institutes and during continual monitoring of health state of a patient.
25. Biophysical properties of fluids (algorithm of solution). Related physical laws.
26. Biophysical analysis of the functional model of visual analyzer (algorithm of solution). Related physical laws.
27. Biophysical analysis of the model of hearing and speech (algorithm of solution). Related physical laws.
28. Electric models of physical and physiological phenomena (algorithm of solution). Related physical laws.
29. Biomedical monitoring (algorithm of solution). Related physical laws.
30. Using of virtual laboratory, outpatient departments and hospitals for widening of possibilities to obtain practical knowledge and skills.

4.3 EXAMINATION QUESTIONS – PRINCIPLES OF eHEALTH

1. Define the concept of electronic healthcare – eHealth.
2. What do you understand under the concept of „authentication“ of a person?
3. What do you understand under the concept of „authorization“ of a person?
4. What do you understand under the concept of „identification“ of a person?
5. Name at least five segments comprising eHealth.
6. What data should contain electronic health record?
7. Describe the role of ISO – International Organisation for Standardisation.
8. Describe the role of CEN – European Committee for Standardisation.
9. Describe the role of IHTSDO – International Health Terminology SDO.
10. Describe the role of HL7 – Health Level 7.
11. Describe the role of DICOM – Digital Imaging and Communications in Medicine.
12. What is „OpenEHR“ about?

13. What is the role of IHE initiative – Integrating the Healthcare Enterprise?
14. Briefly describe GMD´s e-Health Method.
15. Why are, according to some healthcare professionals, EHRs (Electronic Health Records) not meaningful to doctors and hospitals?
16. How does a digital or *electronic signature* work?
17. Describe the role of EHIC.
18. Desctibe the principles of functioning of GPS (the Satelite Navigation System).
19. Which organization is the owner of GPS (the Satelite Navigation System)?
20. What is the role of European Public Health Alliance?
21. What is e-prescribing and what are the benefits?
22. Define the overall goal of the epSOS project in Europe.
23. What cross-border services does include the epSOS project in Europe?
24. Define the concept of „telemedicine“.
25. Define the principle of „ePrescription“.
26. Define the acronym „SNOMED CT“.
27. What are the goals of NANDA International organisation?
28. Define the role of „EHR archetypes“.
29. What are the goals of IHTSDO?
30. What are the goals of IHE initiative?

5. MONITOR QUESTIONS ON BIOPHYSICS

5.1 MONITOR QUESTIONS ON BIOPHYSICS – GENERAL MEDICINE

1. The flow velocity of an infusion solution in a solution set is:
   a) the higher, the higher the infusion bottle is hung
   b) the higher, the lower the infusion bottle is hung
   c) the higher, the higher the viscosity of the solution is
   d) the lower, the higher the temperature of the solution is

2. Osmosis is an action in which:
   a) the solvent spontaneously passes through a semi-permeable membrane into a solution with higher concentration of the dissolved matter until reaching osmotic balance
   b) the solvent spontaneously passes through a semi-permeable membrane into a solution with lower concentration of the dissolved matter
   c) particles of the dissolved matter spontaneously pass through a semi-permeable membrane into the solution
   d) a total separation between the solution and the solvent takes place

3. Frequency is:
   a) time, during which one vibration occurs
   b) number of vibrations of a periodical event per unit time
   c) non dimensional physical quantity
   d) a quantity stated in Hz^{-1} units

4. Sound is:
   a) electromagnetic wave motion with low frequency
   b) electromagnetic wave motion with high energy
   c) mechanical wave motion
   d) best audible in a vacuum

5. Absorption is a physical action in which dissolution of a gas takes place in a liquid (gaseous embolus in Keson disease). It depends on:
   a) physical properties of a gas and a liquid, on the pressure „p“ and temerature „T“
   b) physical properties of a liquid and doesn´t depend on gas pressure „p“
   c) physical properties of a liquid and on gas pressure „p“, doesn´t depend on temperature „T“
   d) physical properties of a liquid and the gas temperature „T“

6. What is the activity of an radionuclide?
   a) it is a statistical activity which velocity describes the half-life of decay
   b) it is a statistical activity which velocity describes the temperature „T“, pressure „p“, volume „V“
   c) it is the absolute number of radioactive decays within one year
   d) it is expressed as a relative number of decays in a given emitter in 1 second

7. An algorithm is an unambiguos set of rules or definitions that must be followed when solving a particular operation in a given sequence:
   a) in medicine it is used as a sequence of clinical procedures, collection of medical data, decision making activities
   b) in medicine the algorithms are not used in clinical procedures
   c) in medicine the algorithms of clinical procedures are used only in the laboratory practice
   d) in medicine the algorithms of clinical procedures are used only in collection of medical data

8. What is the amplitude of biological rhythm?
   a) half the value of the difference between limit values of biological function
   b) value of the difference between limit values of periodical biological function
   c) half the value of period τ
   d) the amplitude depends on the length of period of the given biological rhythm

9. Time is a basic quantity which:
   a) expresses a continuos sequence of physical actions, where we distinguish the intensity and interval
   b) expresses a continuos sequence of physical actions, where we do not distinguish the intensity and interval
   c) expresses a continuos sequence of physical actions, where we distinguish only the intensity
   d) expresses a continuos sequence of physical actions, where we distinguish only the interval

10. The work of heart conditions:
   a) the value of blood pressure, which creates and maintains the necessary pressure gradient needed for unidirectional flow of blood in the blood vessel system
   b) the value of blood pressure, which creates and maintains the necessary pressure gradient needed for bi-directional blood flow in the blood vessel system
   c) the value of blood pressure, which creates and maintains the necessary pressure gradient needed for unidirectional flow of blood in an open blood vessel system
   d) the value of blood pressure, which creates and maintains the pressure gradient at bilateral blood flow in the whole of blood vessel system

11. Edema develops from the biophysical point of view as a result of:
   a) a failure of balance between the permeability of blood capillaries and the value both of oncotic and blood pressure inside them
   b) a failure of balance between the diameter of blood capillaries and the value of blood pressure
   c) a failure of balance between the diameter of blood capillaries and arteries and the value of blood pressure inside them
   d) a failure of balance between permeability of blood capillary walls and arteries and the value of both oncotic and blood pressure in them

12. Personal film dosimeter represents a sensor of radioactive or X-ray radiation on the principle of a sensitive film exposure. The level of exposure is evaluated:
   a) densitometrically
   b) by a scintillator
   c) by gamagraphy
   d) by radiometry

13. Gamagraphy – scintigraphy is an imaging examination method of nuclear medicine in vivo, which is based on the principle of:
    a) selective recapturing of target by applied radiopharmaceuticals (sources of γ radiation) in tissues and organs
    b) selective recapturing of target by applied radiopharmaceuticals which are sources of α radiation in tissues and organs
    c) selective recapturing of target by applied radiopharmaceuticals which are sources of β radiation in tissues and organs
    d) selective recapturing of target by applied radiopharmaceuticals which are sources of X-ray (röntgen) radiation in tissues and organs

14. What pressure acts an 80 kg person on their foot surface, by standing on one foot and the area considered is a 100 cm^2 ?
    a) 0,8 kg/m^2
    b) 8 kg
    c) 80kg
    d) 0,08 kg/m^2

15. What force must the muscles develop in order to keep holding in an arm raising forward a load of 0,5 kg?
    a) 0,5 N
    b) 5 N
    c) 50 N
    d) 500 N

16. What multiple or part of a basic unit describes the prefix nano?
    a) 10^{-3}
    b) 10^{+3}
    c) 10^{-9}
    d) 10^{+6}

17. Calculate how many minutes and seconds is 1 217 s.
    a) 17 min 0 s
    b) 20 min 17 s
    c) 12 min 17 s
    d) 20 min 20 s

18. In one cm^3 there are $2,7 . 10^{22}$ molecules. How many molecules are there in 1 mm^3 ?
    a) $2,7 . 10^{19}$
    b) $2,7 . 10^{25}$
    c) $2,7 . 10^{20}$
    d) $2,7 . 10^{3}$

19. From the hydrodynamic point of view blood circulation represents:
    a) an open system made up from the heart, vessels and blood which are in mutual dynamic relations
    b) a closed system made up from the heart and vessels, in which blood flows constantly and they are in mutual dynamic relations
    c) an open system made up from the heart and blood, which are not in mutual dynamic relations

d) a closed system made up from the heart and blood, which are in mutual dynamic relations

20. To examine the illumination of a working area serves the illuminometer, which sensor uses the photoelectric effect. This sensor is called:
    a) photocell
    b) monochromator
    c) analyser
    d) photographic film

21. Nuclear magnetic resonance use for activation a mediated biosignal:
    a) activation of atomic nuclei of the measured object by strong magnetic fields
    b) activation of atoms with the help of strong electromagnetic fields
    c) activation of atoms with the help of weak electromagnetic fields
    d) activation of atoms with the help of light radiation

22. The blood and plasma are fluids:
    a) really Newtonian
    b) non-Newtonian
    c) ideal
    d) compressible

23. The lens in the human eye is:
    a) plano-convex
    b) concave–convex
    c) biconcave
    d) biconvex

24. Accomodation of the human eye is:
    a) the ability of the lens to change the index of refraction
    b) the ability of the eye lens to change its optical thickness in dependence of the change of curvature diameter
    c) the ability of the eye lens to transmit better some wave lengths
    d) the ability of the eye lens to change the diameter of curvature

25. The current–voltage characteristics of biological tissue is the graphic record of functional dependence I = f (U). It expresses the actual ability to conduct direct electric current, which amount is in inverse proportion:
    a) to its electric resistance
    b) to the activity of electrical properties of the biological tissue
    c) to functional dependence of active and passive electrical properties of tissue
    d) to functional dependence of the amount of tension/voltage in relation to the applied current

26. At the transmission of radiation through an absorbent environment occurs an attenuation of its intensity:
    a) in general exponentionally with the thickness of the absorbent envirnoment
    b) nonlinearly with the thickness of the environment, if the case is a thin layer
    c) exponentionally with the size of the surface of the envirnoment
    d) linearly with the size of the surface of the envirnoment

27. Ultrasound is a mechanic undulation with a frequency:
    a) above 20 kHz
    b) under 16 Hz
    c) from 16 Hz to 20 kHz
    d) from 16 kHz to 20 kHz

28. The velocity of the sound in liquids is:
    a) bigger than in the air
    b) lower than in the air
    c) equal as in the air
    d) bigger than in solid materials

29. Ultrasound spreads itself in a material environment with a speed which is:
    a) approximately the same as the speed of sound in the same material environment
    b) lower as the speed of sound in the given environment
    c) higher as the speed of sound in the given environment
    d) different as the speed of sound in the given environment

30. The law of radioactive decay is valid:
    a) only for natural radionuclides
    b) only for artificial radionuclides
    c) for natural and artificial radionuclides
    d) for fission of cores ^{235}U in a nuclear reactor

31. Heat transfer is a physical process at which:
    a) the arranged moving mass particles of different temperature exchange their energy
    b) the non-arranged moving mass particles of different temperature exchange their energy
    c) the non arranged moving mass particles of different temperature exchange their electric and temperature charge
    d) the arranged moving mass particles of different temperature exchange the electrical and temperature charge

32. Photoreceptors in the human eye represent biological detectors for approximately the wavelengths of electromagnetic radiation in the band of:
    a) 460 – 760 nm
    b) 260 – 760 nm
    c) 460 – 960 nm
    d) 300 – 800 nm

33. Infrasound is a mechanical undulation with a frequency:
    a) under 16 Hz
    b) above 20 kHz
    c) from 16 Hz to 20 kHz
    d) above 16 Hz

34. Protective glasses in alpinism serve as an absorber of light radiation. Their task is to:
    a) absorb mainly the UV (ultraviolet) light

b) absorb mainly the polarized light
c) prevent from snow blindness
d) they in fact have no preventive importance

35. The velocity of blood flow in particular parts of cardiovascular system in vivo differs, where it is valid that:
    a) it is higher in the aorta than in the capillary
    b) it is subjected to atmospheric pressure
    c) in the aorta it is lower than in the capillary
    d) the equation of continuity has only a limited validity

36. Each sense organ can be divided into three basic segments: peripheral, proper receptor and the central segment. From the biophysical point of view it represents in the following order the function of:
    a) selectively permeable protective layer for energetic signal; sensor; control center
    b) non-selectively permeable layer for sensor; control center; signal
    c) non-selectively permeable layer for control center; signal; sensor
    d) selectively permeable protective layer for sensor; control center; signal

37. Ionizing radiation, which is used for the welfare of a patient in diagnostics and treatment has also undesirable side effects. As one of the means of prevention the following is used:
    a) higher income of proteins
    b) against alfa radiation there are no effective personal protective devices
    c) minimalization of the number of examinations using ionizing radiation
    d) wearing of personal dosimeters by patients

38. The human eye can differentiate two comparable points as autonomous in case their image falls into the macula of the retina:
    a) of two cones, between which there is at least one not excited cone
    b) on two neighbourig cones
    c) on two neighbourig rods
    d) on two rods, between which there is at least one not excited rod

39. Fibrescopes are optical devices with its own halogene source of light. They make it possible to monitor the body ventricles on the principle of:
    a) refraction of light rays
    b) a set of electromagnetic lenses in optical fibres
    c) a set of optical fibres
    d) total reflexion of light rays from the observed tissue

40. Infrared radiation (IRR) is used in physiotherapy. For its application Stefan–Boltzman law says that:
    a) longtime exposure to it does not cause any danger to the subcutaneous organs
    b) thermal influence is caused only by the highest wavelengths of IRR
    c) the majority of radiation is absorbed in the skin, where the thermal effect takes place
    d) the radiation penetrates deeper layers to the inner organs

41. Ultraviolet radiation has bactericidal effects thanks to the fact that:
    a) the high energy of its photons destroys the chemical bonds in the bacteria cells
    b) the energy of its photons does not influence the molecular bonds
    c) it does not have a high level of intensity

d) it can not be applied in doses

42. The imaging method which using the properties of ionizing radiation of radionuclides from positrone emitters is called:

a) magnetic resonance tomography
b) computerized tomography of the fourth and fifth generation
c) positrone emission tomography
d) panoramic skiagraphy (mostly in stomatology)

43. For therapeutical irradiation of oral cavity cancer the best is to treat it using:

a) alpha emitter placed on the outer side of the face
b) beta emitter placed inside the oral cavity for pre-calculated period of exposure
c) beta emitter placed on the outer side of the face
d) gamma emitter placed inside the oral cavity

44. Between two electrodes connected to a power supply of direct current occurs rectified motion of ions moving in the following direction:

a) cations towards the anode (+)
b) cations towards the cathode (-)
c) all ions towards the anode (+)
d) all ions towards the cathode (-)

45. In therapeutical application of direct current to biological tissue:

a) irritant effects always occur
b) irritant effects never occur
c) irritant effects occur only in case of a sudden rapid change of setting the intensity of the applied current
d) irritant effects occur in case the treatment is of a long time nature with the same intensity

46. In spirometry testing the volume of air which can be exspired maximally after a maximum inspiration is:

a) vital capacity
b) total capacity
c) expiratory reserve volume
d) sum of inspiration capacity and of exspiratory reserve volume

47. The relative humidity of air expresses:

a) the ratio of maximum humidity to actual humidity at a given temperature
b) the volume quantity of water vapour in 1 m^3
c) the ratio of absolute humidity of air at a given temperature and absolute humidity of air saturated with water vapour at the same temperature
d) the product of the absolute and maximum humidity of air

48. The absolute humidity of air is a value given by:

a) the maximum humidity of air at a given temperature
b) the ratio of the relative and maximum humidity of air
c) the product of the relative humidity of air and the atmospheric pressure
d) the mass of water vapour in a volume unit of air

49. Electrocardiography is a medical method which makes it possible to scan and graphically record:
    a) electrical activity of an individual myocardial cell
    b) electrical activity of the heart
    c) electrical activity of a nerve fibre
    d) mediated biosignal

50. Mediated biosignal originates:
    a) as a response of a biological object to outer stimuli of a physical or chemical factor
    b) as an answer of heart listened by a stethoscope
    c) only as an expression of a biological system activity
    d) as a result of intrinsic activity of the biological system

51. Acoustic phenomenon of Korotkoff´s is:
    a) tapping sound, synchronous with the heartbeat, which can be heard by a stethoscope placed on the brachial artery
    b) atypical sound accompanying heart murmur
    c) a rare phenomenon in laminar flow in a blood vessel
    d) asynchronous with the heartbeat

52. Sound phenomena, which originate in the flow of blood in blood vessels:
    a) have to do with the turbulent flow of blood
    b) have nothing to do with the way of flow
    c) have to do with the laminar flow
    d) are called Reynolds phenomena

53. The velocity of blood flow, according to the equation of continuity, is:
    a) inversely proportional to cross-sectional area of blood vessels
    b) directly proportional to cross-sectional area of blood vessels
    c) independent from cross-sectional area of blood vessels
    d) directly proportional to blood viscosity

54. Unit for volume 1 liter has dimension:
    a) 1000 dm^3
    b) 10 dm^3
    c) 1 dm^3
    d) 100 dm^3

55. Thermal difference between the temperature of boiling and the temperature of freezing of water is:
    a) 0^o C
    b) 100^o C
    c) 273 K
    d) 100 K

56. Optical thickness of lens (D) has dimension
    a) m^{-1}
    b) m
    c) cm^{-1}
    d) dm^{-1}

57. A vibrating system is called:
    a) oscillator
    b) tuning-fork
    c) sinusoid
    d) flexible body

58. Heat propagates in biological environment by convection (flow):
    a) from metabolically active organs by flow of blood through blood vessels only to the surface of the human body
    b) evaporating water from the body surface in the air
    c) as infrared radiation from the body in the air
    d) as infrared radiation from metabolically active organs through blood into the skin

59. A clinical thermometer is a measuring device to determine:
    a) the height and the extent of body temperature of human organism
    b) the size and the extent of body heat of human organism
    c) the size and the extent of surface temperature of human organism
    d) the height and the extent of surface heat of human organism

60. Density (specific density) of mass is a quantity determined by:
    a) the ratio of weight **m** and coresponding volume **V** of the given matter with defined pressure **p** and temperature **T**
    b) the ratio of volume **V** and corresponding weight **m** of the given matter with defined temperature **T** and absolute humidity
    c) the ratio of weight **m** of the corresponding volume **V** of the given matter with defined relative pressure and relative temperature
    d) the multiplication of volume **V** and the corresponding matter **m** with defined relative humidity, pressure and temperature

61. Whole-body impedance is a physical quantity, which characterizes organism from the point of view of its ability:
    a) to conduct alternating electrical current
    b) to conduct direct electrical current
    c) to conduct both types of electrical current
    d) to conduct electrical, magnetic and heat flow

62. Refractive index is a physical quantity which characterizes optical environment. Its value is:
    a) inversely proportional to the environment temperature
    b) directly proportional to the environment temperature
    c) directly proportional to the the temperature and inversely proportional to the pressure
    d) depends on atmospheric pressure

63. Basic units of SI are:
    a) m, kg, s, A, K, mol, cd
    b) m, kg, s, V, °C, mmol, rad
    c) cm, g, s, N, R, mmol, sr
    d) mm, kg, s, °C, °K, mol, rad

64. Coefficient is a physical quantity in physical relations:
    a) usually a constant of proportionality
    b) usually a constant which does not have any dimension
    c) usually it is not a constant
    d) usually it is not a constant, more often it is used as an exponent

65. Period in undulation expresses:
    a) time interval during which undulation passes the wavepath of one wavelength
    b) time interval of two positive amplitudes of undulation
    c) time interval of two negative amplitudes of undulation
    d) time interval during which undulation passes the wavepath of two positive amplitudes

66. Medicine in the form of a solution can be administered to the patient intravenously if it complies with the condition of safety. The solution has to be prepared towards the tonicity of the blood plasma as:
    a) hypertonic
    b) hypotonic
    c) isotonic
    d) any of the above mentioned, but it has to have the temperature of 37 °C

67. A nurse measures the heartbeat by pressuring softly three fingers on the inner side of the left arm wrist and afterwards she repeats the measurement using her thumb instead. The results of both measurements (we consider a regular and well palpable heartbeat):
    a) have to be always equal
    b) can be equal
    c) they do not depend on the way the measurement was done
    d) with the second method there has to be lower pressure

68. What represents physically absolutely dark matter?
    a) absorption standard of electromagnetic radiation independently from its wavelength λ and temperature T
    b) absorption standard of electromagnetic radiation independently from its wavelength λ
    c) absorption standard of electromagnetic radiation independently from its temperature T
    d) absorption standard of electromagnetic radiation dependent from its wavelength λ and temperature T

69. In therapeutical application of direct electric current in dentistry:
    a) the gels applied onto the gums/gingiva under electrodes have only a minimal effect
    b) only its irritative effect is used
    c) the electrical resisitance of mucous tissue cannot influence the magnitude of its penetration
    d) the electrical resisitance of mucous tissue can influence the magnitude of its penetration, and thus its efficacy

70. Water anomaly is given by:
    a) extraordinary structural and physical properties of water, different from other hydrogen (H) compounds
    b) extraordinary structural and physical properties of water, different from other oxygen (O) compounds
    c) extraordinary structural and physical properties of water, different from other tritium ($H_{3)}$ compounds
    d) extraordinary properties of hydrogen, which do not differ from other basic elelements

71. A nurse has measured a patient with sinusoidal rhythm on jugular vein 11 heartbeats in 10 seconds. What is their heartbeat frequency?
    a) 66
    b) 64
    c) 60
    d) 70

72. In what relation are the following quantities – pressure, force and area?
    a) pressure is directly proportional to force and inversely proportional to area on which the force acts
    b) they have no relation
    c) pressure is inversely proportional to force and directly proportional to area on which the force acts
    d) pressure is directly proportional to force and area on which the force acts

73. A group of cells with the ability of endogenous oscillation is called:
    a) pacemaker
    b) flexible biological tissue
    c) sinusoid
    d) desynchronizer

74. Bioelectric potentials are:
    a) complex electric phenomena which can be detected above anatomic structures in dependence of their physiological activity and overall functional state of organism
    b) simple electric phenomena which can be detected above anatomic structures in dependence of their physiological activity and overall functional state of organism
    c) complex electric phenomena which can not be detected above anatomic structures in dependence of their physiological activity and overall functional state of organism
    d) complex electric phenomena which can be detected above anatomic structures and are independent from their physiological activity and overall functional state of organism

75. Osmotic pressure:
    a) impedes at osmosis penetration of molecules of the solvent into solution through semipermeable membrane at osmosis
    b) supports at osmosis penetration of molecules of the solvent into solution through semipermeable membrane at osmosis
    c) supports at osmosis penetration of molecules of the solution into solvent through semipermeable membrane at osmosis
    d) impedes penetration of molecules of the solution through semipermeable membrane of the solvent at osmosis

76. For a correct indirect measurement of blood pressure by conventional method of Riva-Rocci the following rule is applied:
    a) the bigger the patient´s arm circumference is, the wider and longer the inflatable rubber cuff has to be used
    b) the bigger the patient´s arm circumference is, the narrower and longer the inflatable rubber cuff has to be used
    c) the result of the the measurement doesn´t depend on the the inflatable rubber cuff´s length
    d) the result of the the measurement doesn´t depend on the the inflatable rubber cuff´s width

77. A person´s center of gravity, when in an upright position, lies:
    a) outside their body
    b) in the area of chest
    c) in the area of hip and stomach
    d) in the area of hip and stomach or ouside the body, depending on the actual position

78. Astigmatism, from the physical point of view, is:
    a) a state of the eye´s optical system, in which the cracking planes perpendicular to each other don´t have symmetrical spheric shape
    b) a state of the eye´s optical system, in which the cracking planes perpendicular to each other have symmetrical spheric shape
    c) a state of the eye´s optical system, in which the cracking planes perpendicular to each other don´t have symmetrical aspheric shape
    d) a state of the eye´s optical system, in which the cracking planes perpendicular to each other have symmetrical aspheric shape

79. The barrier function of skin, from the physical point of view, represents:
    a) a barrier to transmission of electric current, transfer of liquid substances, influence of physical and chemical factors
    b) a barrier only to transfer of liquid substances, influence of physical and chemical factors
    c) a barrier to transmission of electric current and doesn´t represent a barrier to transfer of liquid substances, influence of physical and chemical factors
    d) a barrier only to transfer of electromagnetic radiation

80. Magnitude of the force of gravity **G** and accelaration **g** influence in mammals:
    a) the blood pressure in arteries, veins, the cardiac output of the heart
    b) only the cardiac output of the heart of an individual person
    c) only the venous pressure of an individual person
    d) doesn´t influence the cardiac output

81. Hearing organ, from the physical point of view, is formed by parts with functions in the following order:
    a) resonator, amplifier and transformer, detector
    b) detector, resonator, transformer
    c) resonator, detector, amplifier
    d) transformer, amplifier, detector, resonator

82. How do we have to connect a pair of 4,5 V batteries so the final voltage will be 9 V?
    a) in parallel connection
    b) series connection
    c) series-parallel connection
    d) side by side connection

83. Visual receptors, cones and rods, represent from the physical point of view a receptor system in which, after sufficient impact of light quantum, starts an action which is:
    a) mechano-electrical
    b) piezoelectric
    c) photochemical
    d) mechanical

84. A patient suspicios of having a rib fracture underwent an X-ray check-up. However, the ribs in the picture are shadowed by the soft organs as a result of anterodorsal projection. In repeated check-up it is necessary to:
    a) expose the picture from a different angle
    b) use X-radiation with higher frequency
    c) expose the picture for longer time
    d) use contrast medium

85. Alternating electric current is applied in physiotherapeutical procedures in the treatment of less severe lesions in the motion system. Thereby it is valid that its thermic effects:
    a) do not depend on the frequency or the amplitude
    b) with the lowering frequency they always get stronger
    c) with the raising frequency they always get stronger
    d) do not depend on the frequency

86. When suspicious about the obstruction of air passages you would indicate examination:
    a) excercise test
    b) determination of the vital capacity
    c) measuring of the air flow at exspiration
    d) X-ray of the upper part of air the passages

87. In selective sense perception the intensity of sensation according to physical laws:
    a) depends on the incentive intensity linearly
    b) depends on the incentive intensity logarithmically or exponentially
    c) is coded by the magnitude of action potentials
    d) is coded exclusively by the shape of action potentials

88. In measurements in vivo of the transmembrane potential of a human exciting cell the following values of tension were measured in the interval from -90 mV up to -70 mV, which corresponds to:
    a) values of plateau action potential of cardiomyocyte
    b) non-polarized axon membrane
    c) the pertinent value of its resting membrane potentional
    d) the peak of action potential of most of the cells

89. If in a particular place of an excitable cell after excitation originates an action potential, there can simultaneously originate a new action potential on the re-polarized section of the membrane:
    a) only during the depolarization phase of the first action potential
    b) only during the refractory phase of the first action potential
    c) only at repeated or very high above threshold impulse
    d) at any indifferent above threshold excitation

90. If on the wall of a vein originates an atherosclerotic plaque, thus its cross-section area becomes smaller. An equal flow of blood through the tapered cross-section will be secured by:
    a) longer time of blood flow
    b) longer vein
    c) higher blood pressure
    d) higher heartbeat frequency

91. In order a person can take a breath, the air pressure in the lungs has to be:
    a) lower than the atmospheric pressure
    b) lower than in the intratoracal cavity
    c) the same as the atmospheric pressure
    d) higher than the atmospheric pressure

92. Oxygen diffuses through alveolocapillary membrane from pulmonary alveoli into pulmonary capillaries because of:
    a) the fact that its partial pressure in alveoli is higher than in the capillary blood
    b) the fact that higher partial pressure is in the capillaries
    c) the fact that higher partial pressure of carbon monoxide is present in alveoli
    d) the fact that higher partial pressure of carbon monoxide is present in capillaries

93. Light coming from the surrounding environment has to pass through several optical media of the eye with different refractive index before it impacts the retina. Mostly it refracts at the bounder:
    a) of the cornea and the lens
    b) of the cornea and the retina
    c) of the outer environment and the lens
    d) of the outer environment and the cornea

94. The limit of resolution of a light microscope:
    a) depends directly propotionally on the wavelength of the used light and inversely propotionally on the environmental refractive index between the microscope preparation and the objective lens
    b) depends only on the light wavelength
    c) depends on the light wavelength and the light intensity
    d) depends directly propotionally on the light intensity and inversely propotionally on the wavelength

95. „Murmuring“ sound when breathing through the nose in a person with a cold (edema of the mucous membrane) originates as a consequence of:
    a) laminar air flow
    b) slowed-down air flow
    c) turbulent air flow
    d) accelerated air flow

96. Generated ultrasound undulation in ultrasonic diagnostic devices when set on the highest possible frequency will allow for:
    a) the best elimination of differences among acoustic properties of various tissues
    b) a better penetration of undulation into tissues and organs
    c) the highest capacity for resolution, by which the quality of the image raises
    d) getting the required image of tissues and organs in the quickiest way

97. In an ultrasound examination, between the transducer and the skin, we apply jelly which:
    a) improves the reflection of ultrasound from particular tissues
    b) lowers the friction and the probe (transducer) slides more easily down the skin
    c) eliminates the differences between acoustic impedancies of air, the transducer and the skin. Otherwise the majority of ultrasound would be knocked off the epidermis
    d) increases the difference between acoustic impedancies of air and the transducer, otherwise the majority of ultrasound would be absorbed by the skin

98. Extracorporeal lithotripsy is a method for breaking up kidney or gallblader stones by:
    a) electromagnetic field
    b) shock waves
    c) laser
    d) piezoelectric principle

99. Analogy of light from a light source in an optical microscope is in an electrone microscope
    a) an array of electrones from a so called electron canon concentrated into a parallel beam in the force field of the electrode system
    b) an array of neutrones from a so called electron canon concentrated into a parallel beam in the force field of the electrode system
    c) an array of photones from a so called electron canon concentrated into a parallel beam in the force field of the electrode system
    d) an array of positrones from a so called electron canon concentrated into a parallel beam in the force field of the electrode system

100. Impedance Z characterizes electric propertiers of biological tissue to the transition of alternating current. It is formed by:
    a) resistance and induction of the cell
    b) ohmic resistance and cell membrane capacitance
    c) sum of capacitancies of cell membranes
    d) ohmic, capacitance and inductive component of cells

101. Transport phenomena, which present dispersed systems (including biological) are the folowing:
    a) osmosis, viscosity, heat conduction
    b) viscosity, diffusion, heat conduction, filtration
    c) diffusion, filtration, osmosis, conduction of ions
    d) osmosis and filtration

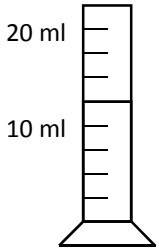
102. The shape of an action potential which originates after stimulation of an excitable cell:
    a) depends on the magnitude of stimuli until it crosses the threshold intensity
    b) changes according to duration of stimuli
    c) does´t depend on the magnitude of stimuli with overthreshold intensity
    d) is the same for different types of cells

103. An action potential:
    a) is a biophysical event in which the membrane polarity of an excitable cell temporarily changes in the place of stimulus
    b) originates at a change of permeability of a membrane for chloride anions
    c) originates at a change of permeability of a membrane for potassium ions, but not for sodium ions
    d) is time-unlimited

104. Diffusion is a transport event at which the dispersive part of the dispersive system moves into solvent until reaching diffusion balance:
    a) in the direction of a concentration gradient
    b) against the direction of a concentration gradient
    c) with supplying energy from the outside
    d) contrary to the direction of electrochemical gradient

105. Blood flow volume in arteries, veins and capillaries is according to Hagen-Poisseuill equation:
    a) inversely proportional to pressure drop
    b) directly proportional to pressure drop in the circulatory blood system
    c) dependent on pulse frequency
    d) directly proportional to the viscosity of the flowing blood

106. What is the volume of liquid in the graduated cylinder in dm^3?



    a) 0,125 dm^3
    b) 0,0120 dm^3
    c) 0,0125 dm^3
    d) 0,125 dm^2

107. In two equal flasks there is 100 ml of medical product soluion. In the flask no. 1 the solvent is water and in the flask no. 2 it is alcohol. For the dosage of drops it is valid that the medicine is measured out:
    a) equal number of drops
    b) different number of drops
    c) depending on the type of the dropper
    d) depending on the residual amount of solution in the flask

108. After having been operated on the abdominal cavity it is easier for the patient to get out of bed if the starting point position is the position:
    a) prone
    b) on back
    c) on hip
    d) of any kind

109. The water surface in a completely filled glass has a convex shape. How come it doesn´t spill out?
    a) the air pressure acts, holding the water together
    b) water has stronger surface tension than glass
    c) it isn´t true. Water leaks out so to reach exactly to the edge of the glass.
    d) water has a high viscosity

110. We dropped two balls with equal diameter, one of steel and one of paper, from the same height and in the same time on the floor. Greater gravitational force will be exerted:
    a) on the steel ball
    b) on the paper ball
    c) the same gravitational force is exerted on both the balls
    d) in dependance on the atmospheric pressure

111. Minimum separabile of the human eye can be enlarged:
    a) using optical system of converging lenses
    b) can not be changed
    c) using optical system of converging and diverging lenses
    d) using optical system of diverging lenses

112. Myopia, from the physical point of view, is an optical aberration usually caused by:
    a) disproportion between eye geometry and the optical thickness of the human eye as an optical system caused by enlargement of the eyeball
    b) unequal curvature of the cornea and enlargement of the eyeball
    c) disproportion in the number of retinal cones to the number of retinal rods
    d) disproportion between eye geometry and the size of the retina

113. Chromatic aberration (error) of the human eye is biophysically conditioned by:
    a) different optical depth and optical thickness of respective individual parts of the lens
    b) different optical absorption in individual parts of the lens and the vitreous humour
    c) different thickness of optical parts of the human eye
    d) different fine colouring of the liquid parts of the eye front and rear chamber

114. Intensity of the ultrasound undulation (USU) is defined as:
    a) the USU energy which passes during a time unit through a unit area perpendicular to the direction of its propagation
    b) the exponential function dependence of the area density on the distance from source
    c) the linear dependence of the area density of USU on the distance from source
    d) the mechanical work, which exerts the force of ultrasound undulation during a time unit

115. Compartment is a functional element of idealized biological system:
    a) defined only for one examined property
    b) morpho-topologically defined for transparent phenomena in an organism
    c) can not be defined
    d) defining at least two of its examined properties

116. Provided that the blood viscosity won´t change, the peripheral mechanical resistance of blood vessels against the blood flow, according the Poisseuill Law, depends mostly on:
    a) their geometric dimensiones
    b) the atmospheric pressure
    c) the number of capillar branches which fall onto one artery
    d) the pressure in vein walls

117. The origin of receptor potential in mechanoreceptors of the organ of Corti in the inner ear can be physically explained on the principle of:
    a) piezoelectric phenomenom
    b) hydraulic press
    c) single-arm lever
    d) action and reaction

118. From the physical point of view the electric field of the heart creates a dipole (the heart as a generator) which is:
    a) changing in time its size and direction
    b) stable in time
    c) changing in time its size at constant direction
    d) stable in time during one heartbeat

119. Spectrophotometry is an optical-analytical method based on the principal of:
    a) absorption spectrum analysis
    b) adsorption spectrum analysis
    c) turning the plane of linearly polarized light
    d) spectrum analysis of light refraction

120. Viscosity as a physical quantity represents:
    a) qualitative expression of inner friction of the flowing fluid
    b) quantitative expression of outer friction of the flowing fluid
    c) qualitative expression of outer friction of the flowing fluid
    d) quantitative expression of inner friction of the flowing fluid

121. The internal energy expresses the total energy of a system. It is a state function of molecules:
    a) independent from the form in which it has been reached
    b) dependent from the form in which it has been reached
    c) dependent from the temperature and pressure
    d) dependent from the relative humidity of the surroundings and temperature

122. The relative biological effectiveness (RBE) is a factor:
    a) by which we have to multiply the dose of ionizing radiation in order to determine its estimated biological effect
    b) by which we have to raise the dose of ionizing radiation in order to determine its estimated biological effect
    c) a physical phenomenon expressing biological effect of ionizing radiation
    d) by which the physical phenomenon of biological interpretation in tissues is expressed in vivo

123. A solution, from the physical point of view, is:
    a) a dispersed system composed of two or more different elements, phases or substances, which dispersive ratio is equally diffused
    b) a nonhomogeneous dispersive system
    c) a nonhomogeneous system, which dispersive propotion is equally diffused in the dispersive environment
    d) a homogeneous system, which dispersive propotion is unequally diffused in the dispersive environment

124. The physical principle of X-ray diagnostic technology is based on:
    a) interaction of X-ray radiation with structural units of the observed object, the result of which is different attenuation of the intensity of X-ray radiation
    b) interaction of X-ray radiation with structural units of the observed object, the result of which is attenuation of the intensity of X-ray radiation
    c) interaction of X-ray radiation with structural units of the observed object, the result of which is different reinforcement of the intensity of X-ray radiation
    d) interaction of X-ray radiation with structural units of the observed object, the result of which is reinforcement of the intensity of X-ray radiation

125. The rate of diffusion velocity of the diffunding substance in biological dispersive environment is determined by:
    a) diffusion coefficient D, which magnitude is [$m^2.s^{-1}$]
    b) diffusion coefficient D, which magnitude is [$m^2.s$]
    c) diffusion coefficient D, which magnitude is [$kg.m.s^2$]
    d) diffusion coefficient D, which magnitude is [$kg.m.s^{-2}$]

126. The speed of sound in air with a degree increase of temperature:
    a) increases
    b) decreases
    c) doesn´t change
    d) increases with temperatures lower than 0 ºC

127. A sensor is:
    a) every device which either receives or creates a signal, mostly electric one, representing a physical phenomenon or process for further electronic processing
    b) every device which creates mostly an electric signal, representing a physical phenomenon or process for further electronic processing
    c) every device which receives mostly an electric signal, representing a physical phenomenon or process for further electronic processing
    d) every device which electronically processes a biosignal, mostly electrical one, representing a physical phenomenon or process for further electronic processing

128. Basic characteristcs of technical parameters of a sensor are its:
    a) sensitivity, measurable extent, reproducibility of the measured values of a given quantity, discriminating capacity, accuracy
    b) only sensitivity and amplification of a signal
    c) amplification, dynamic extent, accuracy, digitalization of a signal
    d) amplification, sensitivity, digitalization of a signal

129. The relative air humidity of the environment is an important physical factor from the point of view of thermoregulation of the human body. It influences particulary:
    a) heat release by evaporation
    b) heat release by emanation
    c) heat release by conduction
    d) heat release by convection

130. The relative index of refraction $n_{1,2}$ between two optical media determines the quotient of their absolute refraction indexes in the ratio:
    a) $n_{1,2} = \frac{N_2}{N_1}$
    b) $n_{1,2} = \frac{N_1}{N_2}$
    c) $n_{1,2} = N_1.N_2$
    d) $n_{1,2} = v_1.v_2$

5.2 ANSWERS TO QUESTIONS ON BIOPHYSICS – GENERAL MEDICINE

1. a)
2. a)
3. b)
4. c)
5. a)
6. a)
7. a)
8. a)
9. a)
10. a)
11. a)
12. a)
13. a)
14. a)
15. b)
16. c)
17. b)
18. a)
19. b)
20. a)
21. a)
22. b)
23. d)
24. b)
25. a)
26. a)
27. a)
28. a)
29. a)
30. c)
31. b)
32. a)
33. a)
34. a)
35. a)
36. a)
37. c)
38. a)
39. d)
40. c)
41. a)
42. c)
43. b)
44. b)
45. c)
46. a)
47. c)
48. d)
49. b)
50. a)
51. a)
52. a)
53. a)
54. c)
55. b)
56. a)
57. a)
58. a)
59. a)
60. a)
61. a)
62. a)
63. a)
64. a)
65. a)
66. c)
67. b)
68. a)
69. d)
70. a)
71. a)
72. a)
73. a)
74. a)
75. a)
76. a)
77. c)
78. a)
79. a)
80. a)
81. a)
82. b)
83. c)
84. b)
85. c)
86. c)
87. b)
88. c)
89. d)
90. c)
91. a)
92. a)
93. d)
94. a)
95. c)
96. c)
97. c)
98. b)
99. a)
100. b)
101. b)
102. c)
103. a)
104. a)
105. b)
106. c)
107. b)
108. c)
109. b)
110. a)
111. a)
112. a)
113. a)
114. a)
115. a)
116. a)
117. a)
118. a)
119. a)
120. a)
121. a)
122. a)
123. a)
124. a)
125. a)
126. a)
127. a)
128. a)
129. a)
130. a)

5.3 MONITOR QUESTIONS ON BIOPHYSICS – DENTISTRY

1. The flow velocity of an infusion solution in a solution set is:
   a) the higher, the higher the infusion bottle is hung
   b) the higher, the lower the infusion bottle is hung
   c) the higher, the higher the viscosity of the solution is
   d) the lower, the higher the temperature of the solution is

2. Osmosis is an action in which:
   a) the solvent spontaneously passes through a semi-permeable membrane into a solution with higher concentration of the dissolved matter until reaching osmotic balance
   b) the solvent spontaneously passes through a semi-permeable membrane into a solution with lower concentration of the dissolved matter
   c) particles of the dissolved matter spontaneously pass through a semi-permeable membrane into the solution
   d) a total separation between the solution and the solvent takes place

3. Frequency is:
   a) time, during which one vibration occurs
   b) number of vibrations of a periodical event per unit time
   c) non dimensional physical quantity
   d) a quantity stated in Hz^{-1} units

4. Sound is:
   a) electromagnetic wave motion with low frequency
   b) electromagnetic wave motion with high energy
   c) mechanical wave motion
   d) best audible in a vacuum

5. Absorption is a physical action in which dissolution of a gas takes place in a liquid (gaseous embolus in Keson disease). It depends on:
   a) physical properties of a gas and a liquid, on the pressure „p“ and temerature „T“
   b) physical properties of a liquid and doesn´t depend on gas pressure „p“
   c) physical properties of a liquid and on gas pressure „p“, doesn´t depend on temperature „T“
   d) physical properties of a liquid and the gas temperature „T“

6. What is the activity of an radionuclide?
   a) it is a statistical activity which velocity describes the half-life of decay
   b) it is a statistical activity which velocity describes the temperature „T“, pressure „p“, volume „V“
   c) it is the absolute number of radioactive decays within one year
   d) it is expressed as a relative number of decays in a given emitter in 1 second

7. An algorithm is an unambiguos set of rules or definitions that must be followed when solving a particular operation in a given sequence:
   a) in medicine it is used as a sequence of clinical procedures, collection of medical data, decision making activities
   b) in medicine the algorithms are not used in clinical procedures
   c) in medicine the algorithms of clinical procedures are used only in the laboratory practice
   d) in medicine the algorithms of clinical procedures are used only in collection of medical data

8. What is the amplitude of biological rhythm?
   a) half the value of the difference between limit values of biological function
   b) value of the difference between limit values of periodical biological function
   c) half the value of period τ
   d) the amplitude depends on the length of period of the given biological rhythm

9. Time is a basic quantity which:
   a) expresses a continuos sequence of physical actions, where we distinguish the intensity and interval
   b) expresses a continuos sequence of physical actions, where we do not distinguish the intensity and interval
   c) expresses a continuos sequence of physical actions, where we distinguish only the intensity
   d) expresses a continuos sequence of physical actions, where we distinguish only the interval

10. The work of heart conditions:
   a) the value of blood pressure, which creates and maintains the necessary pressure gradient needed for unidirectional flow of blood in the blood vessel system
   b) the value of blood pressure, which creates and maintains the necessary pressure gradient needed for bi-directional blood flow in the blood vessel system
   c) the value of blood pressure, which creates and maintains the necessary pressure gradient needed for unidirectional flow of blood in an open blood vessel system
   d) the value of blood pressure, which creates and maintains the pressure gradient at bilateral blood flow in the whole of blood vessel system

11. Edema develops from the biophysical point of view as a result of:
   a) a failure of balance between the permeability of blood capillaries and the value both of oncotic and blood pressure inside them
   b) a failure of balance between the diameter of blood capillaries and the value of blood pressure
   c) a failure of balance between the diameter of blood capillaries and arteries and the value of blood pressure inside them
   d) a failure of balance between permeability of blood capillary walls and arteries and the value of both oncotic and blood pressure in them

12. Personal film dosimeter represents a sensor of radioactive or X-ray radiation on the principle of a sensitive film exposure. The level of exposure is evaluated:
   a) densitometrically
   b) by a scintillator
   c) by gamagraphy
   d) by radiometry

13. Gamagraphy – scintigraphy is an imaging examination method of nuclear medicine in vivo, which is based on the principle of:
    a) selective recapturing of target by applied radiopharmaceuticals (sources of γ radiation) in tissues and organs
    b) selective recapturing of target by applied radiopharmaceuticals which are sources of α radiation in tissues and organs
    c) selective recapturing of target by applied radiopharmaceuticals which are sources of β radiation in tissues and organs
    d) selective recapturing of target by applied radiopharmaceuticals which are sources of X-ray (röntgen) radiation in tissues and organs

14. What pressure acts an 80 kg person on their foot surface, by standing on one foot and the area considered is a 100 cm^2 ?
    a) 0,8 kg/m^2
    b) 8 kg
    c) 80kg
    d) 0,08 kg/m^2

15. What force must the muscles develop in order to keep holding in an arm raising forward a load of 0,5 kg?
    a) 0,5 N
    b) 5 N
    c) 50 N
    d) 500 N

16. What multiple or part of a basic unit describes the prefix nano?
    a) 10^{-3}
    b) 10^{+3}
    c) 10^{-9}
    d) 10^{+6}

17. Calculate how many minutes and seconds is 1 217 s.
    a) 17 min 0 s
    b) 20 min 17 s
    c) 12 min 17 s
    d) 20 min 20 s

18. In one cm^3 there are $2,7 . 10^{22}$ molecules. How many molecules are there in 1 mm^3 ?
    a) $2,7 . 10^{19}$
    b) $2,7 . 10^{25}$
    c) $2,7 . 10^{20}$
    d) $2,7 . 10^{3}$

19. From the hydrodynamic point of view blood circulation represents:
    a) an open system made up from the heart, vessels and blood which are in mutual dynamic relations
    b) a closed system made up from the heart and vessels, in which blood flows constantly and they are in mutual dynamic relations

c) an open system made up from the heart and blood, which are not in mutual dynamic relations
d) a closed system made up from the heart and blood, which are in mutual dynamic relations

20. To examine the illumination of a working area serves the illuminometer, which sensor uses the photoelectric effect. This sensor is called:
    a) photocell
    b) monochromator
    c) analyser
    d) photographic film

21. Nuclear magnetic resonance use for activation a mediated biosignal:
    a) activation of atomic nuclei of the measured object by strong magnetic fields
    b) activation of atoms with the help of strong electromagnetic fields
    c) activation of atoms with the help of weak electromagnetic fields
    d) activation of atoms with the help of light radiation

22. The blood and plasma are fluids:
    a) really Newtonian
    b) non-Newtonian
    c) ideal
    d) compressible

23. The lens in the human eye is:
    a) plano-convex
    b) concave–convex
    c) biconcave
    d) biconvex

24. Accomodation of the human eye is:
    a) the ability of the lens to change the index of refraction
    b) the ability of the eye lens to change its optical thickness in dependence of the change of curvature diameter
    c) the ability of the eye lens to transmit better some wave lengths
    d) the ability of the eye lens to change the diameter of curvature

25. The current–voltage characteristics of biological tissue is the graphic record of functional dependence I = f (U). It expresses the actual ability to conduct direct electric current, which amount is in inverse proportion:
    a) to its electric resistance
    b) to the activity of electrical properties of the biological tissue
    c) to functional dependence of active and passive electrical properties of tissue
    d) to functional dependence of the amount of tension/voltage in relation to the applied current

26. At the transmission of radiation through an absorbent environment occurs an attenuation of its intensity:
    a) in general exponentionally with the thickness of the absorbent envirnoment
    b) nonlinearly with the thickness of the environment, if the case is a thin layer

c) exponentionally with the size of the surface of the envirnoment
d) linearly with the size of the surface of the envirnoment

27. Ultrasound is a mechanic undulation with a frequency:
    a) above 20 kHz
    b) under 16 Hz
    c) from 16 Hz to 20 kHz
    d) from 16 kHz to 20 kHz

28. The velocity of the sound in liquids is:
    a) bigger than in the air
    b) lower than in the air
    c) equal as in the air
    d) bigger than in solid materials

29. Ultrasound spreads itself in a material environment with a speed which is:
    a) approximately the same as the speed of sound in the same material environment
    b) lower as the speed of sound in the given environment
    c) higher as the speed of sound in the given environment
    d) different as the speed of sound in the given environment

30. The law of radioactive decay is valid:
    a) only for natural radionuclides
    b) only for artificial radionuclides
    c) for natural and artificial radionuclides
    d) for fission of cores ^{235}U in a nuclear reactor

31. Heat transfer is a physical process at which:
    a) the arranged moving mass particles of different temperature exchange their energy
    b) the non-arranged moving mass particles of different temperature exchange their energy
    c) the non arranged moving mass particles of different temperature exchange their electric and temperature charge
    d) the arranged moving mass particles of different temperature exchange the electrical and temperature charge

32. Photoreceptors in the human eye represent biological detectors for approximately the wavelengths of electromagnetic radiation in the band of:
    a) 460 – 760 nm
    b) 260 – 760 nm
    c) 460 – 960 nm
    d) 300 – 800 nm

33. Infrasound is a mechanical undulation with a frequency:
    a) under 16 Hz
    b) above 20 kHz
    c) from 16 Hz to 20 kHz

d) above 16 Hz

34. Protective glasses in alpinism serve as an absorber of light radiation. Their task is to:
    a) absorb mainly the UV (ultraviolet) light
    b) absorb mainly the polarized light
    c) prevent from snow blindness
    d) they in fact have no preventive importance

35. The velocity of blood flow in particular parts of cardiovascular system in vivo differs, where it is valid that:
    a) it is higher in the aorta than in the capillary
    b) it is subjected to atmospheric pressure
    c) in the aorta it is lower than in the capillary
    d) the equation of continuity has only a limited validity

36. Each sense organ can be divided into three basic segments: peripheral, proper receptor and the central segment. From the biophysical point of view it represents in the following order the function of:
    a) selectively permeable protective layer for energetic signal; sensor; control center
    b) non-selectively permeable layer for sensor; control center; signal
    c) non-selectively permeable layer for control center; signal; sensor
    d) selectively permeable protective layer for sensor; control center; signal

37. Ionizing radiation, which is used for the welfare of a patient in diagnostics and treatment has also undesirable side effects. As one of the means of prevention the following is used:
    a) higher income of proteins
    b) against alfa radiation there are no effective personal protective devices
    c) minimalization of the number of examinations using ionizing radiation
    d) wearing of personal dosimeters by patients

38. The human eye can differentiate two comparable points as autonomous in case their image falls into the macula of the retina:
    a) of two cones, between which there is at least one not excited cone
    b) on two neighbourig cones
    c) on two neighbourig rods
    d) on two rods, between which there is at least one not excited rod

39. Fibrescopes are optical devices with its own halogene source of light. They make it possible to monitor the body ventricles on the principle of:
    a) refraction of light rays
    b) a set of electromagnetic lenses in optical fibres
    c) a set of optical fibres
    d) total reflexion of light rays from the observed tissue

40. Infrared radiation (IRR) is used in physiotherapy. For its application Stefan–Boltzman law says that:
    a) longtime exposure to it does not cause any danger to the subcutaneous organs
    b) thermal influence is caused only by the highest wavelengths of IRR
    c) the majority of radiation is absorbed in the skin, where the thermal effect takes place

d) the radiation penetrates deeper layers to the inner organs

41. Ultraviolet radiation has bactericidal effects thanks to the fact that:
    a) the high energy of its photons destroys the chemical bonds in the bacteria cells
    b) the energy of its photons does not influence the molecular bonds
    c) it does not have a high level of intensity
    d) it can not be applied in doses

42. The imaging method which using the properties of ionizing radiation of radionuclides from positrone emitters is called:
    a) magnetic resonance tomography
    b) computerized tomography of the fourth and fifth generation
    c) positrone emission tomography
    d) panoramic skiagraphy (mostly in stomatology)

43. For therapeutical irradiation of oral cavity cancer the best is to treat it using:
    a) alpha emitter placed on the outer side of the face
    b) beta emitter placed inside the oral cavity for pre-calculated period of exposure
    c) beta emitter placed on the outer side of the face
    d) gamma emitter placed inside the oral cavity

44. Between two electrodes connected to a power supply of direct current occurs rectified motion of ions moving in the following direction:
    a) cations towards the anode (+)
    b) cations towards the cathode (-)
    c) all ions towards the anode (+)
    d) all ions towards the cathode (-)

45. In therapeutical application of direct current to biological tissue:
    a) irritant effects always occur
    b) irritant effects never occur
    c) irritant effects occur only in case of a sudden rapid change of setting the intensity of the applied current
    d) irritant effects occur in case the treatment is of a long time nature with the same intensity

46. In spirometry testing the volume of air which can be exspired maximally after a maximum inspiration is:
    a) vital capacity
    b) total capacity
    c) expiratory reserve volume
    d) sum of inspiration capacity and of exspiratory reserve volume

47. The relative humidity of air expresses:
    a) the ratio of maximum humidity to actual humidity at a given temperature
    b) the volume quantity of water vapour in 1 m^3
    c) the ratio of absolute humidity of air at a given temperature and absolute humidity of air saturated with water vapour at the same temperature
    d) the product of the absolute and maximum humidity of air

48. The absolute humidity of air is a value given by:
    a) the maximum humidity of air at a given temperature
    b) the ratio of the relative and maximum humidity of air
    c) the product of the relative humidity of air and the atmospheric pressure
    d) the mass of water vapour in a volume unit of air

49. Electrocardiography is a medical method which makes it possible to scan and graphically record:
    a) electrical activity of an individual myocardial cell
    b) electrical activity of the heart
    c) electrical activity of a nerve fibre
    d) mediated biosignal

50. Mediated biosignal originates:
    a) as a response of a biological object to outer stimuli of a physical or chemical factor
    b) as an answer of heart listened by a stethoscope
    c) only as an expression of a biological system activity
    d) as a result of intrinsic activity of the biological system

51. Acoustic phenomenon of Korotkoff´s is:
    a) tapping sound, synchronous with the heartbeat, which can be heard by a stethoscope placed on the brachial artery
    b) atypical sound accompanying heart murmur
    c) a rare phenomenon in laminar flow in a blood vessel
    d) asynchronous with the heartbeat

52. Sound phenomena, which originate in the flow of blood in blood vessels:
    a) have to do with the turbulent flow of blood
    b) have nothing to do with the way of flow
    c) have to do with the laminar flow
    d) are called Reynolds phenomena

53. The velocity of blood flow, according to the equation of continuity, is:
    a) inversely proportional to cross-sectional area of blood vessels
    b) directly proportional to cross-sectional area of blood vessels
    c) independent from cross-sectional area of blood vessels
    d) directly proportional to blood viscosity

54. Unit for volume 1 liter has dimension:
    a) 1000 dm^3
    b) 10 dm^3
    c) 1 dm^3
    d) 100 dm^3

55. Thermal difference between the temperature of boiling and the temperature of freezing of water is:
    a) 0^{o} C
    b) 100^{o} C
    c) 273 K
    d) 100 K

56. Optical thickness of lens (D) has dimension
    a) m^{-1}
    b) m
    c) cm^{-1}
    d) dm^{-1}

57. A vibrating system is called:
    a) oscillator
    b) tuning-fork
    c) sinusoid
    d) flexible body

58. Heat propagates in biological environment by convection (flow):
    a) from metabolically active organs by flow of blood through blood vessels only to the surface of the human body
    b) evaporating water from the body surface in the air
    c) as infrared radiation from the body in the air
    d) as infrared radiation from metabolically active organs through blood into the skin

59. A clinical thermometer is a measuring device to determine:
    a) the height and the extent of body temperature of human organism
    b) the size and the extent of body heat of human organism
    c) the size and the extent of surface temperature of human organism
    d) the height and the extent of surface heat of human organism

60. Density (specific density) of mass is a quantity determined by:
    a) the ratio of weight **m** and coresponding volume **V** of the given matter with defined pressure **p** and temperature **T**
    b) the ratio of volume **V** and corresponding weight **m** of the given matter with defined temperature **T** and absolute humidity
    c) the ratio of weight **m** of the corresponding volume **V** of the given matter with defined relative pressure and relative temperature
    d) the multiplication of volume **V** and the corresponding matter **m** with defined relative humidity, pressure and temperature

61. Whole-body impedance is a physical quantity, which characterizes organism from the point of view of its ability:
    a) to conduct alternating electrical current
    b) to conduct direct electrical current
    c) to conduct both types of electrical current

d) to conduct electrical, magnetic and heat flow

62. Refractive index is a physical quantity which characterizes optical environment. Its value is:
    a) inversely proportional to the environment temperature
    b) directly proportional to the environment temperature
    c) directly proportional to the the temperature and inversely proportional to the pressure
    d) depends on atmospheric pressure

63. Basic units of SI are:
    a) m, kg, s, A, K, mol, cd
    b) m, kg, s, V, °C, mmol, rad
    c) cm, g, s, N, R, mmol, sr
    d) mm, kg, s, °C, °K, mol, rad

64. Coefficient is a physical quantity in physical relations:
    a) usually a constant of proportionality
    b) usually a constant which does not have any dimension
    c) usually it is not a constant
    d) usually it is not a constant, more often it is used as an exponent

65. Period in undulation expresses:
    a) time interval during which undulation passes the wavepath of one wavelength
    b) time interval of two positive amplitudes of undulation
    c) time interval of two negative amplitudes of undulation
    d) time interval during which undulation passes the wavepath of two positive amplitudes

66. Medicine in the form of a solution can be administered to the patient intravenously if it complies with the condition of safety. The solution has to be prepared towards the tonicity of the blood plasma as:
    a) hypertonic
    b) hypotonic
    c) isotonic
    d) any of the above mentioned, but it has to have the temperature of 37 °C

67. A nurse measures the heartbeat by pressuring softly three fingers on the inner side of the left arm wrist and afterwards she repeats the measurement using her thumb instead. The results of both measurements (we consider a regular and well palpable heartbeat):
    a) have to be always equal
    b) can be equal
    c) they do not depend on the way the measurement was done
    d) with the second method there has to be lower pressure

68. What represents physically absolutely dark matter?
    a) absorption standard of electromagnetic radiation independently from its wavelength λ and temperature T
    b) absorption standard of electromagnetic radiation independently from its wavelength λ
    c) absorption standard of electromagnetic radiation independently from its temperature T

d) absorption standard of electromagnetic radiation dependent from its wavelength λ and temperature T

69. In therapeutical application of direct electric current in dentistry:
    a) the gels applied onto the gums/gingiva under electrodes have only a minimal effect
    b) only its irritative effect is used
    c) the electrical resisitance of mucous tissue cannot influence the magnitude of its penetration
    d) the electrical resisitance of mucous tissue can influence the magnitude of its penetration, and thus its efficacy

70. Water anomaly is given by:
    a) extraordinary structural and physical properties of water, different from other hydrogen (H) compounds
    b) extraordinary structural and physical properties of water, different from other oxygen (O) compounds
    c) extraordinary structural and physical properties of water, different from other tritium ($H_{3)}$ compounds
    d) extraordinary properties of hydrogen, which do not differ from other basic elelements

71. A nurse has measured a patient with sinusoidal rhythm on jugular vein 11 heartbeats in 10 seconds. What is their heartbeat frequency?
    a) 66
    b) 64
    c) 60
    d) 70

72. In what relation are the following quantities – pressure, force and area?
    a) pressure is directly proportional to force and inversely proportional to area on which the force acts
    b) they have no relation
    c) pressure is inversely proportional to force and directly proportional to area on which the force acts
    d) pressure is directly proportional to force and area on which the force acts

73. A group of cells with the ability of endogenous oscillation is called:
    a) pacemaker
    b) flexible biological tissue
    c) sinusoid
    d) desynchronizer

74. Bioelectric potentials are:
    a) complex electric phenomena which can be detected above anatomic structures in dependence of their physiological activity and overall functional state of organism
    b) simple electric phenomena which can be detected above anatomic structures in dependence of their physiological activity and overall functional state of organism
    c) complex electric phenomena which can not be detected above anatomic structures in dependence of their physiological activity and overall functional state of organism
    d) complex electric phenomena which can be detected above anatomic structures and are independent from their physiological activity and overall functional state of organism

75. Osmotic pressure:
    a) impedes at osmosis penetration of molecules of the solvent into solution through semipermeable membrane at osmosis
    b) supports at osmosis penetration of molecules of the solvent into solution through semipermeable membrane at osmosis
    c) supports at osmosis penetration of molecules of the solution into solvent through semipermeable membrane at osmosis
    d) impedes penetration of molecules of the solution through semipermeable membrane of the solvent at osmosis

5.4 ANSWERS TO QUESTIONS ON BIOPHYSICS – DENTISTRY

1. a)
2. a)
3. b)
4. c)
5. a)
6. a)
7. a)
8. a)
9. a)
10. a)
11. a)
12. a)
13. a)
14. a)
15. b)
16. c)
17. b)
18. a)
19. b)
20. a)
21. a)
22. b)
23. d)
24. b)
25. a)
26. a)
27. a)
28. a)
29. a)
30. c)
31. b)
32. a)
33. a)
34. a)
35. a)
36. a)
37. c)
38. a)
39. d)
40. c)
41. a)
42. c)
43. b)
44. b)
45. c)
46. a)
47. c)
48. d)
49. b)
50. a)
51. a)
52. a)
53. a)
54. c)
55. b)
56. a)
57. a)
58. a)
59. a)
60. a)
61. a)
62. a)
63. a)
64. a)
65. a)
66. c)
67. b)
68. a)
69. d)
70. a)
71. a)
72. a)
73. a)
74. a)
75. a)

6. OPUS SAPIENTIÆ

Medical e-learning and testing system powered by crowdsourcing and based on social networks designs

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Abstract

Three years of development of on-line e-learning and testing system adapted on medical students' and teachers' needs, resulted into current on-line project called Opus Sapientiæ. It represents a smart on-line examination system, which takes advantage of crowdsourcing. Crowdsourcing is an answer for many other good on-line projects gaping with emptiness in a desperate need for further content. Opus Sapientiæ does not concentrate on the education but rather verification of the knowledge although it represents a complex tool for building, editing and application of its content. It allows wider freedom to students in choosing the form and way of learning. The basic premise is that complex knowledge of a particular topic could be divided into finite number of facts. Facts those acquaintances could be uniquely determined. System with a few simple features avoids some negative effects in medical education: mechanical memorizing, learning "to pass the exam", distinction of importance of various facts, non-evidence-based dogmas. It is designed to be intuitive with intentional similarities to some of the most popular social networks.

Keywords: e-learning, medical education, crowdsourcing, on-line examination, test

Introduction

Current e-learning efforts of most of the academic institutions concentrate on innovation of teaching methods, transfer of old non-digital content to cyber-world. Old papers, pictures, photos, analog x-ray and lectures are converted into digital format. The creators of the project Opus Sapientiæ were formerly frustrated from enormous *and* uncompetable funding of foreign universities in creating of eContent. Teams of animators, coders, graphics, flash-creators and other developers were truly uncompetable in the amount and quality of the output. The role of mere translators of foreign eContent was also boring. Realization of the fact that university students are everyday more and more aware of the on-line educational content, able to speak foreign languages and able to search and choose the most understandable source explaining the desired information, the production of eContent started to seem obsolete. With a true respect to teachers - who struggle and create eLearning content, the creators of Opus Sapientiæ chose a different path. To accept all worldwide sources and let the students to chose their way. The student still has a list of recommended literature and also lectures at the university. The knowledge covered with them is compulsory; however nobody is forced to learn in a particular way. To accept the change of paradigm shift in education and accept the position of the lecturer as leader who guides and recommends, who helps to understand and see the connections between facts and the one who encourage to think. Not the one who is supposed to support students with the background papers that they are supposed to learn, the one who is supposed to create the content by himself. These are the things he could do, but where the difference is often forgotten is that we don't want the student to learn the facts the way we want, but we want student to know and understand the facts no matter the way he gains them. If it is not our boring 2D

PowerPoint that made him understand the differences between LeFort fractures but a YouTube animation somewhere from North Carolina university, does it matter? But what if he learns it wrong? What if the students use the unreliable Wikipedia? Why they even Google for knowledge? It is because we will be never able to make complete coverage for a topic as the research goes on. Also do the web sources improve and advance. We will never be able to make our lecture or text so universal that suits everybody. And of course student instinctively search for the easiest way to learn the problem. Even if it is so simplified that it is actually wrong.

So what if students get it wrong? These are the real risks of letting students use complementary web resources. And here comes role of this project. The position of mere translators of foreign eLearning content was boring and humiliating. The perspectives and volume of the eContent resembled a supernova however there was still one narrowing left. The stream of pre-exam and further post-exam education was due to the web too massive to be reasonably controlled, widening every day. The sorting and filtration of the web sources would be an infinite and difficult task with a questionable effect. The only narrowing of the stream, where everybody must go through, was the exam itself. Here was identified the opportunity to implement the variables with power to indirectly affect what and how students learn. To clean up and balance the pre-exam process of learning. Common criteria, defined by the examiner, act as reliable filter able to distinguish student's awareness of facts in any desired topic. The way of use and the role in the examination process of this "filter" is completely up to the examiner. However the knowledge of particular facts could be uniquely determined. Different features of the smart on-line system fight with some of current negatives in medical education: mechanical memorizing, learning "to pass the exam", distinction of importance of various facts or non-evidence-based dogmas.

Opus Sapientiæ has many features. If it should be described by one sentence from aspect of use, its closest definition would be: "web application able to test, teach and create its contents as you desire by who you want". If should be described simply from a rather technical aspect it could be called as "PHP application on autonomous server with web 2.0 features". Except for many possible uses it was designed for testing the knowledge with multiple-choice tests. Not necessarily the way you imagine multiple-choice test. The questions and answers could contain or be substituted with pictures, videos, animations or sounds. Most of its unique properties rely on vast amount of questions in the database. Because of this, one of the most important features are the tools for creating these questions. How to create huge numbers of non-repeating questions covering every fact in particular topic is explained by crowdsourcing. The crowdsourcing is described later in the text and for the project is crucial. The project allows creation of its content in various language mutations.

OPUS SAPIENTIÆ

Academic network versus social network

Internet was a new opportunity for education maybe 10 years ago. Now, it is just a must. Young people "living" on social networks like Facebook or MySpace is a current reality with an intensively growing trend. Research published in 2009 by Nielsen [4] shows time spent on Facebook increased up by 700%. Growing tendency is well known however this number from the last year is kind of staggering. The numbers increase not only in the number of users but also increases the time spent in these networks for each user. The amounts of content users create or upload also increases. The Opus Sapientiæ has many similarities with social networks although not for the same motives. As the social network designers every day develop more and more sophisticated designs to draw their users to the network more often and for a longer time, the networks slowly became a huge "time-spender". The academic e-learning networks will be the opposite. Trying to support requested information as quickly as possible concentrated on its aim (teaching, testing etc..). However the ways of building a crowdsourcing army of students, teachers, alumni, specialists and others, will by similar to common social networks. If we call such an army for example an "academic social network" it has poor chances in

competition with giant projects like MySpace or Facebook. The best way is adaptation. Avoiding creating barriers between mostly entertaining networks and academic networks, there is a chance to create dedicated social network ready to make a “big things”. Implemented features common in current social networks are necessary for easy orientation and crowdsourcing activities of its users.

Basic blocks of the system

The system has upper and right side menu. The system was recently moved to a new server and two redirections will be ready to enter the system. www.opus.sapienti.ae and www.sapienti.ae The first redirection will lead you to an info page about the project and all the articles written about it, manuals and instruction videos. The second links directly to Opus Sapientiæ login site. Both redirections are based on Arabic domain with strict policy against pornographic or religiously offensive content. The reason of this is the project later ambition to spread and become multilingual with no affinity a particular country. Server is placed in Bratislava with sufficient up/down bandwidth.

Before login there is an intro page with a brief info what is currently going on in the system. There is the upper menu allowing you to log-on, register or go directly to official tests. If you go directly to official tests section you will have to log-on or identify with an ISIC/ITIC card number. After entering the user sees only the part of Opus Sapientiæ with official tests without any other distraction by other system features. This is suitable for official student testing.

Registration is necessary when you wish to create your account. If you wish just to test yourself you could go directly to official test section and identify yourself with ISIC/ITIC card with no other harassment. Otherwise the registration process requires your personal data. In the registration form you select your role in the system (student/teacher etc..), these could be accepted automatically if you choose student or teacher role that is confirmed by university servers according you ISIC/ITIC card number. Automatic acceptance depends on the system settings adjusted by admins. Other roles with higher rights like power-user or administrator could be arranged only by other administrator. Registration ends with an activation email sent to your address and is automatic. Immediately you can start using the system.

After login to the system in a normal way the menus are depending on the rights your role has. There is an upper and right-side menu. The upper menu is the main menu and allows you to access 5 main sections:

1. My profile
2. Users
3. Database of questions
4. Tests
5. System

There are 4 different designs of the system: modern, retro, classic and non-graphic. The systems’ content is represented mostly by pre-questions, questions and tests. The pre-question is more than simple text with question mark at the end. It contains:

1. expression of the question (text or media = pic/foto/anim/movie/flash/sound)
2. expression of the question in English mutation (text or media)
3. optional // source of the multimedia (copyright if any)
4. optional // explanation is an author comment invisible during testing (text)
5. optional // language mutation of the explanation (text)
6. regular literature reference (text)

7. proposer – is filled automatically, although can be changed
8. Keywords (text separated by commas)
9. English mutation keywords (text separated by commas)
10. Type of the pre-question – pregradual/postgradual (dropdown box)
11. Importance 1-5 (probability of system choosing this question in random choice, where 3 is normal, 1,2 should be used for rather rare and not crucial knowledge, 4&5 for essential facts)
12. Categorisation (module/study-program/subject/topic/subcategory)

If the prequestion has a language mutation the corresponding fields should be filled. The prequestion is the product of the student and could have arbitrary number of answers. These also could be as a text or media including its language mutations. The limit of answers per question is currently set to 12 but could be changed. The system recognizes also different roles of users. The roles are:

1. Superuser (*absolute rights in the system, his right can't be restricted*)
2. Administrator (nearly all rights in the system, *his rights could be restricted*)
3. No role user *(guest – has no rights)*
4. Teacher *(rights of questions and tests management)*
5. Student – proposer *(could run the tests, propose pre-questions)*
6. Student *(could run the tests)*
7. *Official tester (could run the official tests)*

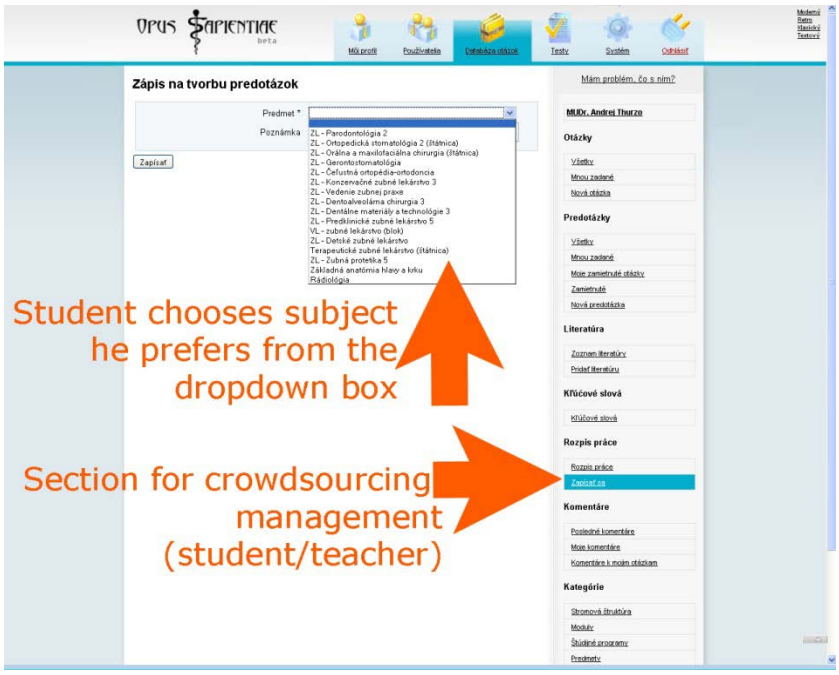
The basic workflow in the system is following:

1. Creating the pre-question
2. Creating/Accepting the question
3. Official testing
4. Non-official testing
5. System management

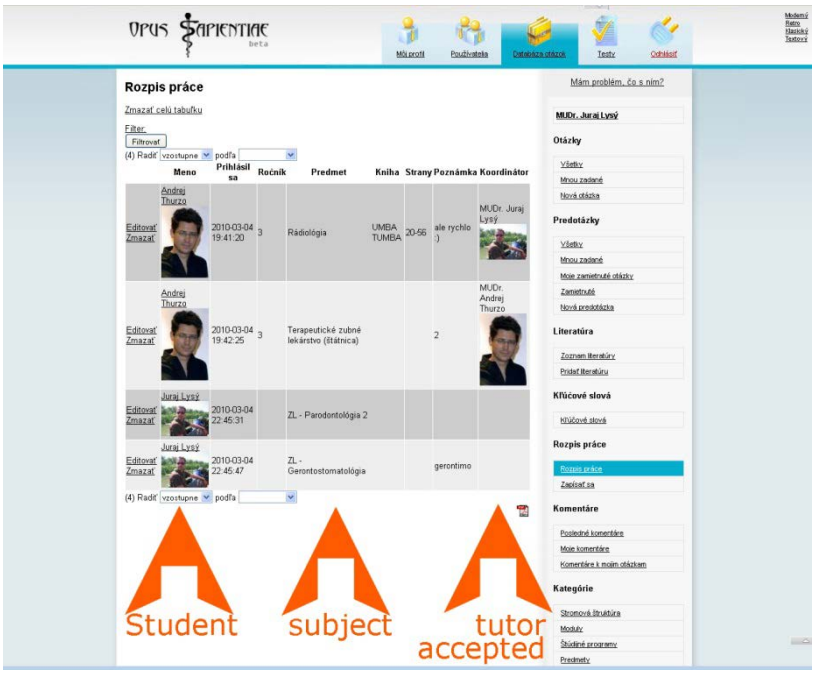
Creating a question

For example the process of creation a question looks like this. Imagine a medical student has an exam from internal medicine, surgery and radiology at the end of winter semester. Before he starts this semester he knows he should choose (on-line) one of these subjects and that he will be required to make for example 20 questions from this subject. Either way he will study this subject during this semester very intensively. In the Opus Sapientiæ there is a section for task administration – where students choose and teachers distribute ranges of recommended literature to be processed. This means that student goes through the text and each particular fact captures in the question or one of the answers. After choosing his preference for a subject for example radiology (picture 1) the teacher is on the move. Teacher sees the list of students enrolled on his subject and distributes the page ranges from recommended literature for each student. He could do it on the fly or from time to time. He distributes the ranges as he wish or he could respect the preference of the student as there is a place for short message for student when he is enrolling to a subject. All that is necessary to remember for a teacher is that the range should be reasonable for desired amount of questions. Rather smaller than bigger while it is important to avoid text processed with skipped facts. The list of enrolled students could be filtered and organized as desired. For example only students for particular subject could be displayed. Teacher sees the list on the picture 2 with student official photos. The comment field is shared with both student and teacher and could be previously filled

with student request for a particular topic and teacher could rewrite it with his own comment to student. After teacher fills the resource and the range to be processed (*for example book XY pages 12-15 or PowerPoint XY slides 4-10*) and optionally write any comment, all is done. This process usually does not take more than 5-10 seconds. By entering the data he accepts the student and becomes his tutor.



Picture 1 – "Student-crowd" (crowdsourcing) task management – student enrolment.



Picture 2 – "Student-crowd" task management – tutor defines the book, page range and all else writes as comment if necessary.

After student creates a prequestion it is available for teacher edits. Teacher could reject question with or without writing a reason or request to the proposing student or just do nothing. He could also accept it directly without any changes or do any desired changes and accept it. After teacher's acceptation the prequestion changes to question with the teacher as a tutor of the question and student as proposer. The question could be

elected for a test. The system's improving quality of its questions is very important and to support this, Opus Sapientiæ allows comments, feedbacks, and discussion for each question in the system. Even more during testing the user can make notice about any question or answer by one click directly in the test. This alerts any suspected incorrectness, incoherency, typing error or duplicity that is immediately announced to author of that question. Also if the user has proper rights he could edit any feature of the question/answer on the fly during testing (*for immediate correction*).

Each question in the system has its own life. This means it has a log of every change made to the question since its birth. Recording who and what changed to the question. After a significant change the system also changes the tutor of the question to teacher who made the change.

Creating a test

Test can be created with a teacher. The non-official tests are meant to serve as a remote practise for students. The internet access is not crucial to keep the Opus Sapientiæ working. The server allows access through LAN within the whole hospital, where the department of dentistry and maxillofacial surgery is situated. The non-official tests are example tests that are useful for students who wish to test their level of knowledge mostly from home. If student decides to "learn directly from tests" there are few principles that render this choice extremely ineffective. Even if there is a non-official test designed with the same or similar parameters like the official one, the questions used in the test and even the answers are random so the student cannot reliably learn by heart the answers. If he repeats the tests again and again, he gets random questions with random answers and after few repetitions he gets the tests with more and more questions he already got through. If the test is set up to pick 20 questions out of 3 folders with totally 500 questions and each question as approximately 10 answers and 5 of them are also chosen randomly... there is no reasonable way to learn from the tests. There is another principle that learning from the test makes ineffective. The huge ballast of basic facts the student already knows hinder the student in progress – in learning the new facts. Another important principle is that these new fact could student absorb from the test without any context. The retention of such information without understanding is very poor and obviously the advantage is on the side of students who study directly from books or other sources that support understanding and context. The coffin nail in demotivation of students avoiding the context and understanding of the facts is that most of the answers are or should be formulated in a way that concerns negative of the fact. Here is the example:

The question "When the patient collapses after local anaesthesia:" could have answers be like this:

1. We administer vitamin B and C
2. We administer estrogens with noradrenalin
3. We administer oxytocine
4. We administer epinephrine with testosterone
5. We must disinfect oral cavity with hydrogen peroxide

All answers are wrong. If the question would be more sophisticated the tester needs to have a proper knowledge to identify the wrong answers. It is very hard and frustrating to memorize negative invaluable information. To learn by heart 10 things you would not do in some situation versus 1 procedure you should do. The number of correct answers is of course up to the creators of the question.

On the picture 3, there is a list of non-official tests created in the system. The flag represents language of the test. There is information about number of questions and answers. When creating a test (picture 4), teacher could define over 20 parameters of the test. Here are just the most important of them:

1. Name of the test and its specification + their language mutations

2. Optionally the targeted study year and study program
3. Time of test availability (time & date)
4. The way of testing (by one question or all together)
5. Number of questions
6. Number of answers in the test
7. Time for testing (this is optional, if teacher decides for on-line testing, rather than to print out the test for paper versions)
8. Random order of questions or answers
9. Preferred keywords – system with higher probability elects the questions with the preferred keyword (optional)
10. Proffered authors of the questions – the same like above
11. Language of the test
12. Allowing flash/sound/video (must be disabled for "paper testing")
13. Difficulty index (explained later in the text)
14. Showing answers (immediately after each answered question OR after finishing the whole test OR don't show)
15. Evaluate test yes/no
16. % criteria for passing the test (optional)
17. Method of test evaluation (standard, double, university, whole answers or inverse)
    a. standard = one answer - one point
    b. double = each answer – two points
    c. university = the interval <0,100>points is projected to <minus 50points, plus 50points> the same for percents..
    d. whole answers = maximum points is the number of questions
    e. inverse = it is more like "sudden death" where system counts your wrong answers – you could set limit for wrong answers
18. Record high score from this test to "hall of fame"? yes/no
19. Choosing folders/categories from which the questions are randomly picked up.

Here it is very important to emphasize that one of the first motives for creating the Opus Sapientiæ was fact that medical students were not often repeating their knowledge. And as everybody knows "Repetitio Est Mater Studiorum" the project pushes to repetition of pre-requisite subjects. During creating the test is encourages you, in fact it requests, to choose 30% of the total test questions from other subjects which you find concerning the main subject of the test. This rule could be bypassed. It often happened that students after passing for example the biochemistry exam stated that they doubt that they will ever use 90% of their biochemistry knowledge later in their medical studies. This is the main reason of "*studying for the exam*" habit. And if students are aware of this rule they would benefit from their studies and will appreciate to learn with long term retention aspects. Otherwise they will not see the point to keep the Krebs cycle in their heads for longer time.

Choosing the folders (module, study-program, subject, topic and subtopic) allows structuralizing your test very precisely. The Opus Sapientiæ has an internal structure of folders. The "module" represents a friendly medical faculty / university cooperating in the project, study-program is for example dentistry or general medicine, subject is mostly understood as official subject in curriculum like radiology, restorative dentistry or

orthodontics. Topic within a subject could be for example “caries” in restorative dentistry. You could create a question even without moving it to a particular folder and do it later. The subtopic is optional and helps you to make a better order within your topic or later to pick up from smaller sets of questions. Reordering of questions is easy. The questions are supposed NOT to repeat. So when creating a test for example from orthodontics you could take:

5% from MODULE (OUSA-*St.Elisabeth oncology institute*) /// STUDY-PROGRAM (general medicine) /// SUBJECT (radiology)

15% from MODULE (LFMU- *Masaryk University*) /// STUDY-PROGRAM (general medicine) /// SUBJECT (histology) /// TOPIC (embryology) /// SUBTOPIC (teeth)

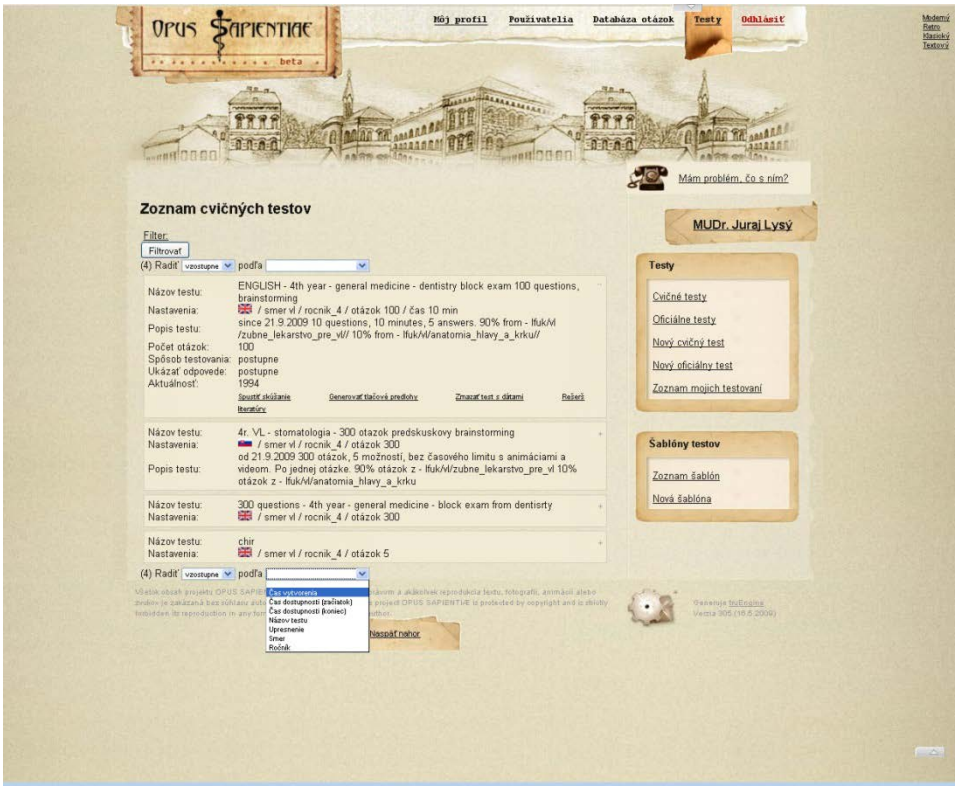
10% from MODULE (LFUK-*Comenius University*) /// STUDY-PROGRAM (dentistry) /// SUBJECT (paediatric dentistry) /// TOPIC (teeth eruption) ///

Here we have filled the 30% for repetition from 3 different universities (we like their questions, we made our language mutation for them, they use the literature we also recommend etc..)

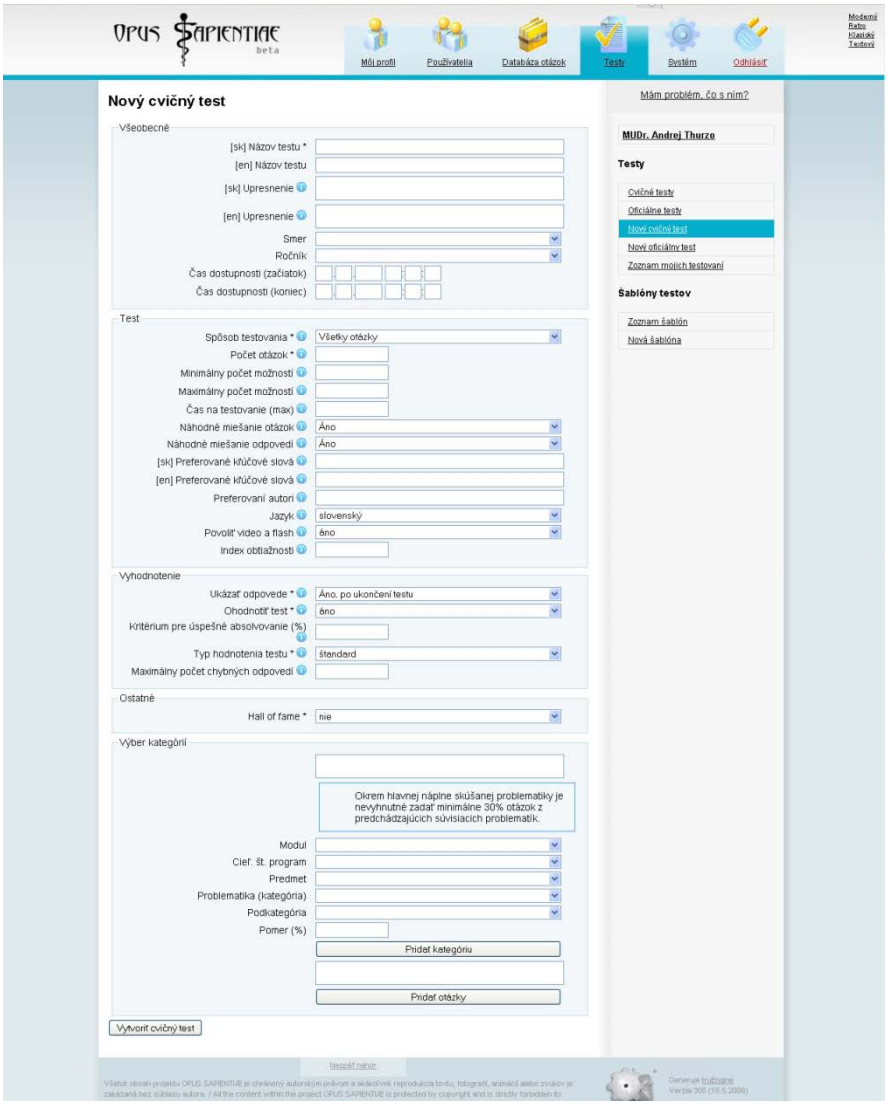
65% from MODULE (LFUK- *Comenius University*) /// STUDY-PROGRAM (dentistry) /// SUBJECT (orthodontics)

5% from MODULE (JLFUK- *Comenius University-Martin*) /// STUDY-PROGRAM (general medicine) /// SUBJECT (surgery) /// TOPIC (maxillofacial surgery) /// SUBTOPIC (orthognatic surgery)

This puzzle makes together 100% where 30% is repetition, it is not necessary to use other university modules, but it is probable the use of questions from cooperating medical faculties will grow in an effort to have as many as possible questions in the pool.



Picture 3 - The sortable list of non-official tests with first test expanded by upper right “+“, showing flag of the test language, number of questions, the way of testing and average age of the test’s source literature.



Picture 4 – screen for creating a new test showed in modern design

System indexes

To improve the system over time by analysis of student behaviour in the system, many background processes are set up. One of the most important quality sentinel flags is the index of difficulty. The teacher might want to generate a difficult test or opposite. To do so, it must be possible to identify more difficult questions/answers. Only objective way is to make statistics for each answer. Index of difficulty is of course evaluated only from official testing to avoid intentional mistakes made by students in non-official tests to make easy answers look difficult. Index of difficulty is the ratio of correctly answered questions to number of totally answered questions. The smaller it is - more difficult is that particular answer. When creating the test this parameter could be entered. From other background evaluations alerting on incorrect or unclear questions and answers, is one another index necessary to mention. It is the “age of the test”. This is the average year of the literature used as reference for the questions. This means, the higher the year is - the test is more up to date. This makes a pressure on authors and proposers to look for as fresh resources as possible. Even the “old truths” in the questions referring to on old research could be updated with a new publications dealing with that particular fact. This could be done only with updating the literature reference in older questions. The test with the age 1980 would be for example a test with 4 questions referring to articles from 1950, 2010, 1978 and 1982.

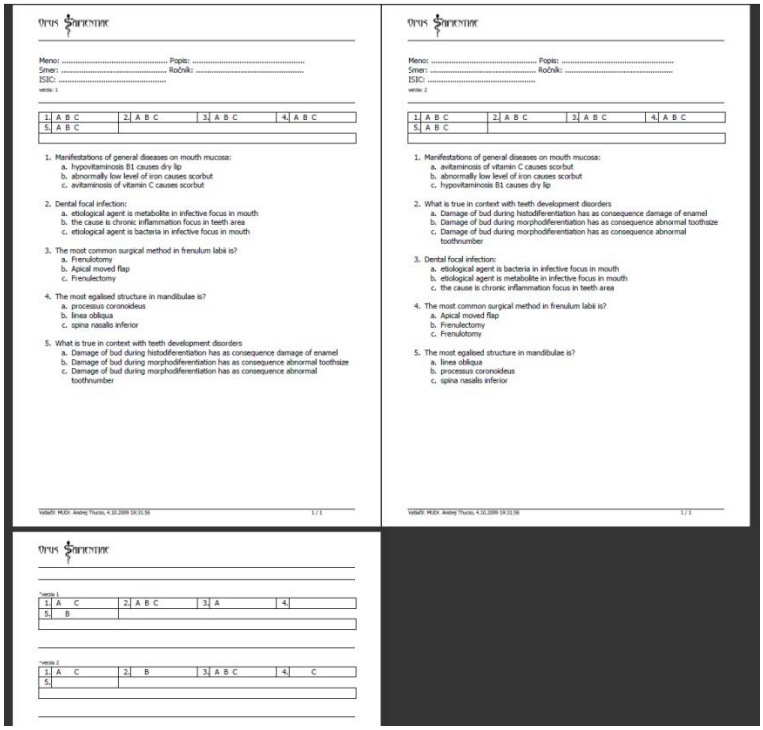
Testing

There are two main concepts how to test with the Opus Sapientiæ. First is “paper testing” and the second “on-line testing”. The paper testing allows generating test from official test in desired amount and type. By type are understood various groups/mutations of the same test. For example you could generate 10 tests for your 10 students however if they sit too close to each other so you prefer to have different test versions. The difference of the test you could be defined as:

1. Everybody has a different test (different questions and different answers)
2. Everybody has the same questions but different answers
3. Everybody has the same questions and the same answers but in random order that makes the cheating nearly impossible.

Of course you could print 1000 copies of the same test if you wish. All paths above are done through direct PDF export from the system. The PDFs could be stored or archived, this works also for the PDF exported from on-line student testing. If you dot trust archiving the student test result on-line you could print them out and store in the safe. To generate the same test with random order of the questions and answers is one of the most popular while the students cannot complain somebody has more difficult test. The results are then truly comparable.

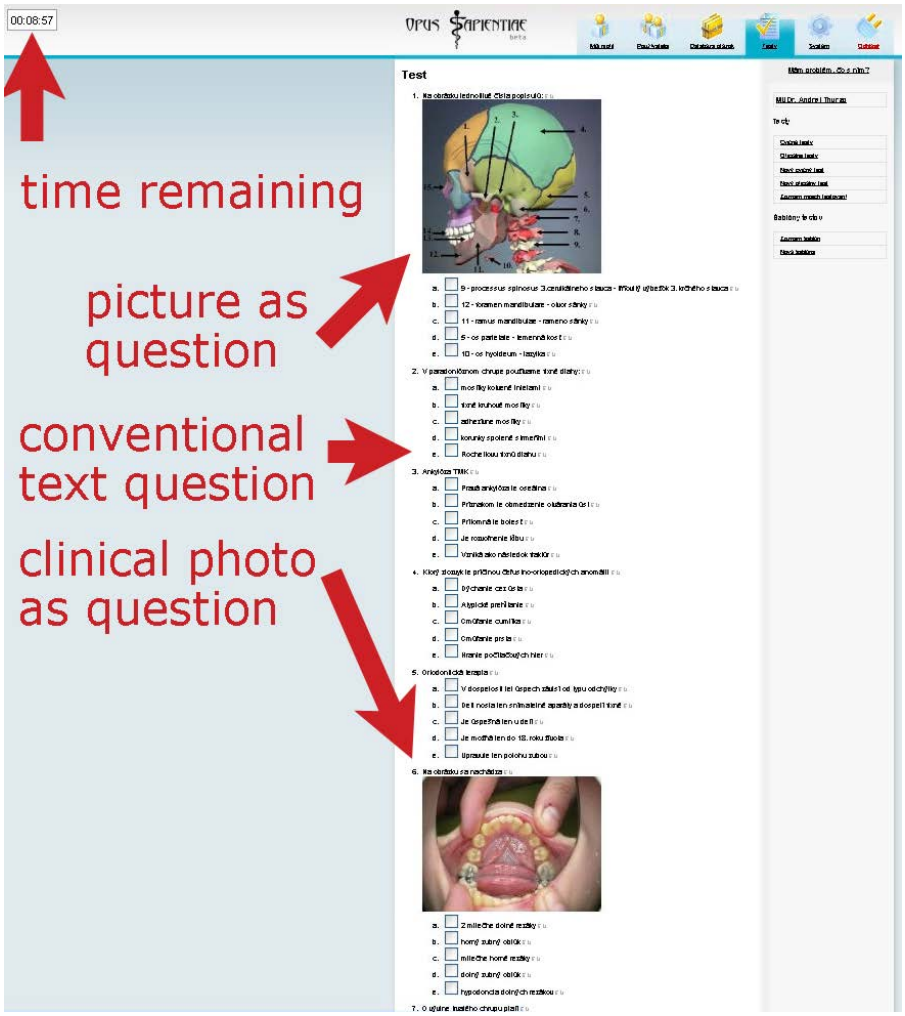
The most interesting feature in paper testing is the “correcting template/table” which is printed as last page after the test and is a very useful tool for the teacher. It shows a table with correct answers that could be used by a teacher correcting the test after students. This will significantly speed up the way of correcting the tests and make it more comfortable for the teacher. On the picture 5 is the example of two tests with five questions each. The questions are the same but not the answers. At the beginning of each test there is the header which the student is supposed to fill. The answer sheet after this header is the most important. It is always on the first page of the test. If the test has more pages it would be chaotic and difficult for teacher to search for answers. All the teacher needs to do now is to compare his correcting table with the answer sheet of the first page (they look the same).



Picture 5 Example of paper test /PDF, answer sheet at the top, correcting table at the end.

On-line testing (picture 6) is more fun with immediate evaluation, ready to be archived as PDF, stored automatically; allowing use of multimedia and many other advantages. Only requirement for successful on-line testing is a set of desktops with web/LAN access. The ideal change the system induces in students learning is:

1. Student studies from books, lectures, on-line sources according to defined topic.
2. Student uses the Opus Sapientiæ only for continuous checking the level of his knowledge. Especially for checking his retention knowledge of previous subjects.
3. The Opus Sapientiæ is used by teacher as complementary tool and saves time in verification of basic facts that student should know. And so oral examination could be used only to check student skill to think, combine and interlink acquired facts.
4. Opus Sapientiæ serves as filter for "exam gamblers" trying to slip through exam with minimal knowledge, only with luck - if met with particular topic he knows.



Picture 6 On-line testing, example of timed multimedia 5-answer-test showed at once.

Technical background

Former developing location was at www.elcoms.sk/demo/kega/sk/

Current redirections to 172.22.3.22 are www.sapienti.ae and www.opus.sapienti.ae

Logo of the project is:

Since February 2010 the system has been moved to an autonomous server to improve the security and performance. Opus Sapientiæ does not require its own server. The current server parameters are:

Processor: x3550 M2, Xeon 4C E5520 2.26GHz/1066MHz/8MB L3, RAM: 8GB RAM PC3-10600 CL9 ECC DDR3 1333MHz Chipkill LP RDIMM, Hard-drive: 3x IBM 73 GB, 6Gbps SAS HDD +ServeRAID-MR10i SAS/SATA

Project in numbers

1.1.2010 Opus Sapientiæ contained 391 questions in total. All were created during development phase, directly by doctors/teachers with more than 3100 answers in the subject „dentistry" in general medicine study program (English and Slovak mutation). Students have been already officially tested by paper-testing in 2009. There are 2.464 pre-questions waiting for acceptance with more than 20.000 answers. This is a result of 3-month crowdsourcing. Further development of the project will aim to successful launch on the new server, dealing with minor bugs and creation of further language mutations for questions and system menus. Improve the cooperation within Mefanet network, especially to deal with identification issue that is currently done with Comenius University student database. The goal is to adopt a wider and secure student identification system and support friendly medical faculties with this useful tool.

Acknowledgement

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Literature

- Thurzo A. et al., Projekt Opus Sapientiæ. [Online]. Available: www.opus.sapienti.ae
- Mesko D, DIGITAL M-EDUCATION ERA, Mefanet report 02, page 19
- Dušek L, Schwarz D, Stipek S, Stuka C, Project MEFANET– a New Kind of Collaborative Space for Electronic Support of Medical and HealthCare Education, Mefanet report 02, page 25
- The Nielsen Company, Time Spent on Facebook up 700%, but MySpace Still Tops for Video. [Online]. Available: http://blog.nielsen.com/nielsenwire/online_mobile/time-spent-on-facebook-up-700-but-myspace-still-tops-for-video/

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