**List of Erasmus classes - winter semesters**

| Semester | Org. unit. | Name of the subject | The content | Lecture | Class | Lab. | Project | ECTS | Coordinator |
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| 1 | FF | **Physics I** | Kinematics and principles of Newton dynamics. Elements of thermodynamics: expansibility of solid state, calorimetry. Gas transformations, ideal and real gases. 1st law of thermodynamics. Internal energy of ideal gas, work of changing the gas volume. 2nd and 3rd laws of thermodynamics. Reversible and nonreversible processes, Carnot's cycle. Entropy. Galileo and Lorentz transformations. Elements of the relativity theory. Gravitation field: universality of gravitation law. Kepler laws, field of gravitational forces. Electrostatic field: field of a point charge. Coulomb's law. Electric field intensity. Electric potential. Voltage, electromotive force. Field of the electric dipole. Motion of charges in electric field. Stationary electric current. Amperage. Magnetic field of electric current. Influence of magnetic field on the electric charges, Lorentz force. Conductor with electric current in magnetic field. Elements of geometric optics: image formation, reflection and refraction phenomena, lenses, optical instruments. Elements of wave optics: dispersion, interference, diffraction and polarization of light. | 45 | 45 | | | 7 | Prof. Vitalii Dugaev, DSc, PhD, Eng. |
| 1 | FF | **Introduction to Programming** | Health and safety at computer station. Basic configuration and user's interface in chosen development environments. Data types in programming languages. Formatted input/output. Operators, expressions, statements. Conditional statements. Input/output statements. Functions, tables, pointers, strings, elementary data structures. Files handling, classes, structures, modules. Bit manipulations, preprocessor, libraries. Advanced data representations and their use to create databases. | 30 | | 30 | | 5 | Czesław Jasiukiewicz, DSc, PhD |
| 3 | FF | **Physics of Continuous Media** | Energy and momentum conservation in physics of continuous media. Ideal liquid. Continuity equation. Euler's equation. Hydrostatics. Bernulli's equation. Energy and momentum flux. Incompressible liquid. Viscosity of liquid. Navier-Stokes equation. Laminar flow. Reynolds number R. Flow with small R. Turbulence. Transition to turbulence. Laminar boundary layer. Tensors of strain and stress in theory of elasticity. Homogeneous deformations. Equation of equilibrium for isotropic bodies. Elastic properties of crystals. Elastic waves. Deformations with change of temperature. Electrostatics of conductive media. Maxwell's equation for electric field. Energy of electrostatic field. Electrostatics of insulators. Dielectric function in insulators. Dielectric properties of crystals. Ferroelectrics. Constant electric current and conductance. Hall effect. Thermoelectric and | 15 | 15 | 15 | | 4 | Prof. Vitalii Dugaev, DSc, PhD, Eng. |

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| | | | thermomagnetoelectric effects. Constant magnetic field. Maxwell's equations in a continuous medium in magnetic field. Magnetic induction and magnetization. Magnetic susceptibility. Ferromagnetism and antiferromagnetism. Magnetic anisotropy. Mechanisms if magnetic ordering. Theory of phase transitions for magnetism. Spin wave and magnons. Superconductivity. Magnetic properties of superconductors. Meissner's effect. London's equations. Mechanism of superconductivity. Superconductive current. Superconductor in magnetic field. Electromagnetic waves in insulators. Equations of electromagnetic fields in crystals. Dielectric function. Energy of electromagnetic field. | | | | | | |
| 3 | FF | **Fluid Mechanics** | Biological fluids and their role in the functioning of the human body. Basic properties of fluids: viscosity, pressure, temperature, fluid compressibility. Influence of microstructure of biological fluid on its viscosity. Composition of the blood. Factors influencing its viscosity. Measurement of fluid viscosity. Rheological models of biological fluids. Basic human fluid systems. Cell and body fluids. Fluid transport in the human body: diffusion, convection, momentum transport. Characterization of the type of transport of bio liquids in the human body. Basic laws of physics describing the transport of bio liquids: Fick's law (flows in the respiratory system), convection and diffusion equations, the principle of conservation of momentum (flow in the circulatory and urinary systems). Fluid kinematics. Flow rate (mass and volume flow). Conservation principle - equation of continuity. Mass forces, surface forces, stress tensor acting on a fluid element. The principle of conservation of momentum and its simplified form: the Bernoulli equation. Relationship between speed and pressure. Influence of pipe cross-section on velocity and pressure. Analysis of velocity and pressure changes during blood flow in the human circulatory system depending on the cross-section of the flow vessel. Influence of hydrostatic pressure on blood flow. Laminar and turbulent flows of fluid. Fluid pressure losses due to friction and swirling. Poiseuille flow. Laminar and turbulent flows of bio liquids in the human body. Laminar and turbulent flows through pipelines, determination of pressure losses. Human circulatory system resistance. Ways of designating. Measurement of pressure in the human body. The heart and its structure. Efficiency and power of the heart. Operation of a flow pump in a flow system. The heart as a pump in the circulatory system. Pump characteristics. Pulsating flows in pipelines. Pulsating flow in the circulatory system. Wall stresses. Pulse wave. Operation of the heart rate monitor. The principle of operation of the "artificial heart" Robin. Structure of veins and arteries. Flow abnormalities in the circulatory system | 15 | 15 | 15 | | 4 | Prof. Vitalii Dugaev, DSc, PhD, Eng. Prof. Anna Kucaba-Piętal, DSc, PhD |

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| | | | caused by a defect in the walls: aneurysms, constrictions caused by atherosclerotic plaques. The human respiratory system - structure. Lung function. The role of water vapor and air compressibility in gas exchange in the respiratory system. Lung capacity. Spirometry. Operation of respirators and artificial lung. Methods of improving pulmonary function. Basics of filtration - kidney function. Dialyzer. Principle of operation. Basics of filtration - kidney function. Dialyzer - principle of operation. Basics of lubrication in bio-yields - joints on the example of the hip joint. Construction of the hip joint. Composition of the synovial fluid. The influence of the microstructure of the synovial fluid (hyaluronic acid) and rheumatological diseases on lubrication. The role of cartilage. The effect of cartilage damage on lubrication. | | | | | | |
| 3 | FF | **Electromagnetism and optics laboratory** | Determination of measurement uncertainty. Activation energies determination of semiconductors. Determination condenser capacity and RC circuit time constant from the discharge curve of the capacitor. Thermocouple calibration. Determination of inductance of a coil and capacity a condenser in an AC circuit. Determination of transistor characteristics. Characteristics of a semiconductor diode. Study of the magnetic field of a solenoid. The internal photoelectric phenomenon. Determination of photo resistor characteristics. Determination of the unknown light source intensity using a photometer. Determination of the relative refractive index for a transparent medium by a microscope. Checking Malus' law. Determination of the polarized light intensity distribution. Determination of the diffraction grating constant. Study of the gases emission spectrum. Determination of unknown wavelengths. Light absorption in liquids. Determination of lens radius by Newton's ring method. | | | 30 | | 2 | Tomasz Szczepański, PhD |
| 3 | FF | **Computer Aided Engineering Calculations II** | Possibilities of the Matlab environment in engineering applications. Division of project tasks - division of group work into individual project teams. Presentation of the main concept of solving a design problem. Working with the project - the descriptive part related to the recognition of a medical issue. Presentation of the state of knowledge, preparation of the algorithm to solve the problem, and description of the code and its operation. Working with a project - practical part related to writing scripts and functions that allow you to achieve the intended goal. Code verification, checking the correctness of component functions, error analysis. Preparation of the final version of the algorithm. Presentation of the final version of the project, i.e. the descriptive part and the algorithm written in MATLAB. | | | | 30 | 2 | Michał Inglot, PhD, Eng. |

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| 3 | FF | **Fundamentals of Electric and Electronic Engineering** | Physical parameters and its dimensions, electric charge, electric field, electric current, electric voltage, energy in electric field, electric power. Physical rules regarding conduction, elements of electric circuits - ideal and real, active and passive, current and voltage sources. Basic principles of electric circuits - analysis of simple direct current circuits. Analysis of simple and ramified circuits, voltage and current divider, power balance, different methods of analysis of electric circuits - Kirchhoff method. Electric circuits solving methods - loop currents and nodal method. Superposition rule, statement of Thevenin and Norton. Statement of compensation and reciprocity (mutuality), reduction of source junctions, power and efficiency, electric circuit state, measuring devices, electric current in human body. Sine waves, synchro phasors, relations between current and voltage on the resistor, inductor and capacitor, impedance, admittance, phase angle. Analysis of simple ac circuits, power in the circuits, the classic method of circuit analysis, resonance, reactive power compensation. The method of symbolic analysis of AC circuits - complex numbers, synchro phasor acquisition, Ohm and Kirchhoff law in complex form, complex impedance, complex apparent power. Balance of power, the real voltage and current source, state of energy matching, measuring equipment, safety rules. Electronic components, semiconductors, diodes, Zener diode. Transistors, operational amplifiers, other semiconductor components. Operational amplifiers, opto-electronic components, photovoltaic elements. Resistive circuits, circuit transformations, star-delta and reverse transformation. Analysis of DC circuits - use of Ohm's law and Kirchhoff equations.<br>The method of loop currents - DC circuit analysis, the matrix method of solving. Nodal method - analysis of DC circuits. The analysis of electrical circuits in transient state. AC circuits - phasor method. AC circuits - symbolic method. 1. DC circuits studies, Ohm's and Kirchhoff's laws, resistance measurements 2. AC circuits studies, impedance measurements. 3. Study on rectifiers - diodes, current-voltage characteristics. 4. Bipolar transistor - characteristics, polarization systems. 5. Unipolar transistor - characteristics in various agreements of polarization. 6. Study on switching elements: thyristor, triac. 7. Study on optoelectronic components. | 15 | 15 | 15 | | 3 | Mariusz Trybus, PhD, Eng. |
| 5 | FF | **Artificial Intelligence in Biomedical** | Introduction to machine learning and artificial intelligence Other types of machine learning algorithms, decision trees and clustering algorithms applied to medical data Analysis of chosen medical datasets using modern machine learning methods like Convolutional Neural Networks. Future state of the art methods in machine learning and data analysis fields | 15 | | 30 | | 3 | Marcin Kowalik, PhD, Eng. |

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| | | **Applications** | | | | | | | |
| 5 | FF | **Computer Graphics** | Graphic Library Utility Toolkit (GLUT); Geometry and Projection in OpenGl Lights and lighting; Program code optimization. Color blending. Bitmaps and images; Textures and texturing methods. OpenGl buffers and their application; Interactive graphics - selection and picking. Curves and surfaces in parametric representation. Other visualization techniques. | 15 | | 30 | | 3 | Czesław Jasiukiewicz, DSc, PhD |
| 5 | FF | **Physical Methods in Technology and Medicine** | Introduction - physical methods in technology and medicine. Review of non-destructive testing techniques in technology and medical diagnostics. Resonance methods: nuclear magnetic resonance (NMR), electron magnetic resonance (EPR / FMR), Mossbauer spectroscopy; and complementary techniques: dielectric spectroscopy and vibrating sample magnetometer (VSM). The use of X-rays in material science research technic. X-ray diffraction (XRD) and X-ray fluorescence (XRF). Imaging techniques used in medicine: MRI, USG, CT, PET. Selected methods of structure and composition research: electron microscope (SEM and TEM), optical spectroscopy, Raman spectroscopy, and mass spectrometry. Elements of nuclear physics used in medical therapy and technology. | 15 | | 30 | | 3 | Łukasz Dubiel, PhD, Eng. |
| 5 | FF | **Fundamentals of Technical Diagnostics** | The essence and purpose of technical diagnostics. Forms of technical diagnostics: diagnosing, forecasting and generating. Diagnostic parameters - division and characteristics Models of technical diagnostic objects. Objectives and principles of creating diagnostic models, practical usefulness of diagnostic models. Classification and characteristics of diagnosis processes. Diagnostic states of machine components. Organizational and economic aspects of diagnostics. Modern techniques in technical diagnostics: the X-ray computed tomography (CT) method. Modern techniques in technical diagnostics: the digital radiology (DR) method. Modern techniques in technical diagnostics: the method of micro tomography (uCT). Modern techniques in technical diagnostics: optical methods. Modern techniques in technical diagnostics: tactile methods. Defectoscopy: electromagnetic, radiological and ultrasonic methods. Digital data processing. Creation of vector models, Cad models on the basis of data obtained in the acquisition process. Analysis of image data obtained from acquisition by computed micro tomography. Processing of digital data. Creation of vector models on the basis of tomographic data. Creation of CAD models of a selected machine component. Making a model of a machine component using the chosen RP technique. Study and analysis of thermal imaging camera image, analysis of machine component image. | 15 | | 30 | | 3 | Sławomir Wolski, PhD Tomasz Kudasik, PhD, Eng. Wiktoria Wojnarowska, MSc, Eng. |

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| 5 | FF | **Fundamentals of Imaging Diagnostics** | Introduction to medical diagnostics. Recognition and processing of medical image data. Selected issues of medical modeling. Imaging diagnostics: radiography (x-ray). Imaging diagnostics: x-ray computed tomography (CT). Imaging diagnostics: magnetic resonance imaging (MRI) tomography. Imaging diagnostics: positron emission tomography (PET). Imaging diagnostics: radioisotope imaging-nuclear medicine. Imaging diagnostics: thermography. Imaging diagnostics: ultrasonography. Processing of electrodiagnostic signals. Diagnostic model - experimental research in medicine (elasto-optical methods). Analysis of medical image data in DICOM format. Processing of medical data. Creation of vector models based on medical data. Processing vector data of selected anatomical structures. Making a medical model with the chosen RP technique. | 15 | | 30 | | 3 | Sławomir Wolski, PhD Tomasz Kudasik, PhD, Eng. Wiktoria Wojnarowska, MSc, Eng. |
| 5 | FF | **Measurement and Control Systems II** | Practical aspects of LabVIEW application programming, prototype measurement and control systems, based on an embedded real-time system that works with analog and digital measurement devices, measuring different physical quantities. | | | | 15 | 1 | Wiesław Szaj, MSc, Eng. |
| 7 | FF | **Cryogenics** | Introduction to the subject, discussion of the basic issues related to the topics covered during the lectures in the semester. Thermodynamic basics of obtaining low temperatures. Techniques and devices allowing obtaining low temperatures and measuring it, the safety rules for working with cryogenic liquids. Basics of using low temperatures in medicine. Description of the impact of low temperatures on living organisms Cryotherapy. Other medical uses of low temperatures. | 15 | | 15 | 15 | 3 | Jacek Fal, PhD, Eng. Gaweł Żyła, DSc, PhD, Eng. |
| 7 | FF | Biophysics | Introduction to the lecture, discussion of the basic issues related to the topics covered during the lectures, projects and laboratories in the semester. Overview of the structure of atoms (description of the atomic nucleus, electron shells) and the hierarchical structure of living organisms. Elements of molecular biophysics Introduction to cell biophysics. Tissue and organ biophysics. The influence of physical factors on a living organism (electric and magnetic fields, ionizing and non-ionizing radiation). Imaging of tissues and organs using physical methods. | 15 | | 15 | 15 | 3 | Jacek Fal, PhD, Eng. Gaweł Żyła, DSc, PhD, Eng. |