BIOPHAM Master - Syllabus of the courses proposed in
Track 3: Molecular biophysics of pharmaceuticals (UNIPI-USK-USK)

TERM 1 – University of Pisa (UNIPI) – Italy				
Course name	**Classification**	**ECTS**	**Hours face-to-face in class**	**Compulsory/optional Recommendation**
Quantum physics of matter	Physcs	6	48	Compulsory for students with no strong “quantum mechanics” background
Solid state physics	Physics	6	48	compulsory for students with no strong “quantum mechanics” background
Disordered and off-equilibrium systems	Physics	6	48	Compulsory
Polymer science and engineering	Materials Science	6	48	Optional (6 ECTS must be chosen in this group)
Transport phenomena in materials	Materials Science	6	48	
Mechanical Behaviour of Materials	Materials Science	6	48	
Biofluids and Materials interactions	Materials Science	3	30	Compulsory
Computational materials science	Materials Science	6	48	Optional (6 ECTS must be chosen in this group);recommended for students with strong interest into scientific computation
Bioinformatics	Computer Science	6	48	Optional (6 ECTS must be chosen in this group); recommended for students with weak background in computing
English for scientific writing and communication	Soft Skills/Language knowledge	3	30	Compulsory
TOTAL		**30**	**252**	

BIOPHAM Master - Syllabus of the courses proposed in
Track 3: Molecular biophysics of pharmaceuticals (UNIPI-USK-USK)

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**QUANTUM PHYSICS OF MATTER**		
Credit Points (ECTS) 6	Hours (Face-to Face in class): Lectures:48 Practical works: 0 Total: 48	Duration 1 semester	Mode Compulsory for students with no strong "quantum mechanics" background
Instructors	Giuseppe Carlo La Rocca		
Contents	***Introduction to quantum mechanics:*** Waves and particles. Wave-particle duality and uncertainty principle. Wave function. Schroedinger equation and stationary states. Expectation values. ***Atomic Physics:*** First atomic models and their shortcomings. Hydrogen atom: energy spectrum, angular momentum and eigenfunctions. Electron spin. Pauli exclusion principle. Helium atom, singlet and triplet states. Many-electron atoms, periodic system of elements. Atomic spectroscopy. ***Molecular physics:*** Adiabatic approximation. The ionized hydrogen molecule. The hydrogen molecule. Homonuclear and heteronuclear diatomic molecules.Polyatomic molecules. Molecular vibrations. Molecular Spectroscopy. ***Condensed matter physics:*** Structure of liquids, amorphous solids and crystals. X-ray diffraction. Types of crystals: molecular, ionic, covalent and metallic. Boltzmann distribution, equipartition of energy. Quantum statistics: bosons and fermions. Phonons and specific heat of solids. Free electron model of metals: electrical conductivity and specific heat.		
Skills acquired	On successful completion of the course students will be familiar with the basic concepts and methods of nonrelativistic quantum mechanics which are at the base of the modern theory of atoms, molecules and condensed matter systems. He/she will also be able to peruse the literature on the quantum microscopic theory of matter that might be useful for his/her studies/research/work.		
Examination	Oral exam		
Classification	Physics		

BIOPHAM Master - Syllabus of the courses proposed in
Track 3: Molecular biophysics of pharmaceuticals (UNIPI-USK-USK)

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**Solid State Physics**		
Credit Points (ECTS) 6	Hours (Face-to Face in class): Lectures:48 Practical works: 0 Total: 48	Duration 1 semester	Mode Compulsory for students with strong "quantum mechanics" background
Instructors	Stefano Roddaro		
Contents	Electrons in a one-dimensional periodic potential. Electron tunneling through a periodic potential. Velocity, quasimomentum and effective mass of an electron in a band. Geometric description of crystals: direct and reciprocal lattices. Von Laue and Bragg scattering. The Drude electron gas. The theory of Sommerfeld. Energy and density of states of a two-and three-dimensional electron gas in a magnetic field. De Haas van Alphen effect. Landau diamagnetism and Pauli paramagnetism. Theory of harmonic crystal. Phonons. Optical properties of semiconductors and insulators. Charge transport in intrinsic and doped semiconductors. Fermi level in intrinsic semiconductors. Law of mass action. Donor and acceptor levels. Fermi level in doped semiconductors..		
Skills acquired	On successful completion of the course students will be able to interpret the main experimental phenomenology of condensed matter - will obtain a sound knowledge of structural, electronic, optical and vibrational properties of solids..		
Examination	Oral exam		
Classification	Physics		

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**Disordered and off-equilibrium systems**		
Credit Points (ECTS) 6	Hours (Face-to Face in class): Lectures:44 Practical works: 4 Total: 48	Duration 1 semester	Mode Compulsory
Instructors	Simone Capaccioli		
Contents	***1. From order to disorder*** Non-periodical Long range positional order: quasi-crystals. Disorder in long		

	range positional atomic systems (cellular disorder): Substitutional disorder: interstitial and substitutional impurities, vacancies; Orientational disorder: plastic crystals (e.g. fullerene). Disorder in atomic systems without long range positional order (topological disorder): Base elements in real crystals: Dislocations and Burger's vector, Interfacial defects. Liquid state and amorphous state: N-bodies distribution functions, particular case: pair distribution; static structure factor; Hard sphere atomic liquids: Percus-Yevick theory. ***2. From equilibrium to out of equilibrium*** Supercooled metastable states and glass transition in liquids: Van Hove function and its momenta; Collective and microscopic dynamics: cage effect and vibrational properties, local and structural relaxation, relaxation time distribution, diffusion. Rheology and visco-elasticity. Simple models of glass transition: Free volume, Configurational entropy. Elements of non-equilibrium thermodynamics: Zero Principle: fictive temperature in glasses, fluctuation-dissipation theorem violation. ***3. Experimental techniques: structure and dynamics of disordered systems*** Scattering from disordered systems: generalities: Scattering cross sections, coherent and incoherent scattering; Static and dynamic structure factor, elastic and inelastic scattering; Spatial, temporal and spatio-temporal correlation function. Structure of disordered systems: X-ray diffraction at wide and small angle; Dynamics in disordered systems: inelastic X-ray scattering, photocorrelation spectroscopy. Neutron scattering: neutron diffraction at wide and small angle. Comparison with X-ray; inelastic neutron scattering and spectroscopy
Skills acquired	On successful completion of the course students will be able to understand and analyse scientific reports concerning experimental, theoretical and computational studies concerning the physics of disordered and off-equilibrium systems.
Examination	Knowledge will be assessed via: ongoing assignments and final oral exam; the oral exam can be replaced by a seminar given at the joint winter school.
Classification	Physics

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**Polymer Science and Engineering**		
Credit Points (ECTS) 3	Hours (Face-to Face in class): Lectures:48 Practical works:0 Total: 48	Duration: 1 semester	Mode: Optional (6 ECTS must be chosen in the group of Materials Science list)
Instructors	Giuseppe Gallone		

Contents	Basic review of general concepts in polymer science. Generalities of step-growth polymerization and of chain-growth polymerizations. Thermodynamics of ideal solutions. Characterization of polymers at molecular level. Measurement of frictional properties of polymers in solutions. Molar mass distribution. Spectroscopic methods for characterization of chemical composition and molecular microstructure of polymers. The amorphous state of polymers. The crystalline state in polymers. Melting of crystalline polymers. Elasticity of rubbers. Electrical properties of polymers. Processing of polymers.
Skills acquired	The student who successfully completes the course: - will be aware of the specific characteristics of the materials included into the class of polymers, particularly with respect to structure and properties; - will acquire knowledge of both mechanisms for synthesizing polymeric materials and relevant industrial production and processing technologies; - will acquire basic knowledge of the principal experimental techniques for characterizing physical-chemical properties of polymeric materials
Examination	Oral Exam
Classification	Materials Science

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**Transport Phenomena in Materials**		
Credit Points (ECTS) 3	Hours (Face-to Face in class): Lectures:40 Practical works:8 Total: 48	Duration: 1 semester	Mode: Optional (6 ECTS must be chosen in the group of Materials Science list)
Instructors	Marco Lagnoni		
Contents	INTRODUCTION. Local equilibrium, definition of convective and diffusive fluxes, materials transport properties, dimensionless numbers (Reynolds, Prandtl, Schmidt, Peclet, etc), origin of diffusive equations & random walk. MICROSCOPIC GOVERNING EQUATIONS. Derivation of microscopic balance equations (general, mass, species, internal energy, momentum), Eulerian and Lagrangian approaches, tensor notation and operators. STATIONARY HEAT CONDUCTION. Governing equation and boundary conditions, Newton law of cooling, Biot and Nusselt numbers, unidirectional heat conduction (linear, cylindrical and spherical coordinates), effective thermal conductive of composite materials, heat conduction with heat source. TIME-DEPENDENT HEAT CONDUCTION. Step response in a semi-infinite slab, self-similar solutions,		

	response to heat pulse. FUNDAMENTALS OF MATERIAL TRANSPORT. Species fluxes and velocities, convection vs diffusion, mass vs molar basis, constitutive equations of diffusion (Fick law), balance equations and boundary conditions. STATIONARY MATERIAL TRANSPORT. Diffusion in a stagnant film, effective mass transport coefficient, Sherwood number, simplifications in the dilute limit, diffusion with heterogeneous reaction, diffusion with homogeneous reaction, Thiele modulus and effectiveness factor, scaling of regimes (kinetic, internal and external). TIME-DEPENDENT MATERIAL TRANSPORT. Unidirectional diffusion in semi-infinite slab with Robin-type boundary condition (Crank's solution). MOMENTUM TRANSPORT. Laminar and turbulent flows, velocity profiles in a pipe, non-Newtonian fluids, flow in porous media, Knudsen effects. TUTORIALS. Use of Microsoft Excel and codes in Comsol Multiphysics: basic use of the codes, isotope exchange.
Skills acquired	At the end of the class the student: • will have a deep knowledge of the fundamentals to transport phenomena (species, heat and momentum) according to a unified chemical engineering perspective • will be able to use quantitative balances (steady-state and dynamic) and to set up simple models, with or without analytical solution • will have a general understanding enabling her/him to apply the theory to more advanced applications • will have got some practical experience on numerical simulation of transport phenomena with commercial codes
Examination	During the final oral exam, the level of knowledge will be assessed through quantitative exercises to be set and solved by the candidate.
Classification	Materials Science

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**Mechanical Behaviour of Materials**		
Credit Points (ECTS) 3	Hours (Face-to Face in class): Lectures:40 Practical works:8 Total: 48	Duration: 1 semester	Mode: Optional (6 ECTS must be chosen in the group of Materials Science list)
Instructors	Andrea Lazzeri		
Contents	1. Introduction to deformation behaviour: Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications. 2. Tensile Test - stress-strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture.		

	3. Bonding and Material Behaviour, theoretical estimates of yield strength in metals and ceramics. 4. Elasticity (the State of Stress and strain, stress and strain tensor, tensor transformation, principal stress and strain, elastic stress-strain relation, anisotropy, elastic behaviour of metals, ceramics and polymers). 5. Viscoelasticity (Molecular foundations of polymer viscoelasticity. Rouse-Bueche theory, Boltzmann superposition principle, mechanical models, distribution of relaxation and retardation times, interrelationships between mechanical spectra, the glass transition, secondary relaxations, dielectric relaxations. 6. Plasticity (Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, flow rules, strain hardening, Ramberg-Osgood equation, stress -strain relation in plasticity, plastic deformation of metals and polymers). 7. Microscopic view of plastic deformation: crystals and defects, classification of defects, thermodynamics of defects, geometry of dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals, Hall-Petch and other hardening mechanisms, grain size effect - source limited plasticity, Hall-Petch breakdown, dislocations in ceramics and glasses. Effects of microstructure on the mechanics of polymeric media: deformation modes, yield, rubber toughening, alloys and blends. 8. Fracture mechanics (energetics of fracture growth, plasticity at the fracture tip, measurement of fracture toughness, - Linear fracture mechanics -KIC. Elasto-plastic fracture mechanics - JIC, Measurement and ASTM standards, Design based on fracture mechanics, effect of environment, effect of microstructure on KIC and JIC. Application of fracture mechanics in the design of metals, ceramics, polymers and composites, damage tolerance design, elements of fractography) 9. Fatigue (S-N curves, low- and high-cycle fatigue, laboratory testing in fatigue, residual stress, surface and environmental effects, fatigue of cracked components, designing out fatigue failure, Life cycle prediction, Fatigue in metals, ceramics, polymers and composites. 10. Creep. Creep in crystalline materials (stress-strain-time relationship, creep testing, different stages of creep, creep mechanisms and creep mechanism maps, diffusion, creep and stress rupture, creep under multi-axial loading, microstructural aspects of creep and design of creep resistant alloys, high temperature deformation of ceramics and polymers.
Skills acquired	After the completion of the course, the students will be able to: understand the mechanism of plastic deformation and origin of materials strength; suggest ways by which engineering materials may be intrinsically strengthened; derive ductile-brittle transition temperature and select materials accordingly; understand high temperature mechanical behavior of materials and be able to select the materials for high temperature applications; design and select

	engineering components based on the principles of fracture mechanics and fatigue; improve materials resistance to fracture and fatigue performance.
Examination	Oral Exam
Classification	Materials Science

<table>
<tr><th colspan="4">TERM 1 – University of Pisa (UNIPI) – Italy</th></tr>
<tr><td>Course name</td><td colspan="3">Biofluids and Materials Interaction</td></tr>
<tr><td>Credit Points (ECTS) 3</td><td>Hours (Face-to Face in class):
Lectures: 24
Practical works: 6
Total: 30</td><td>Duration:
12 weeks</td><td>Mode:
Compulsory (Tracks 2 and 3)</td></tr>
<tr><td>Instructors</td><td colspan="3">Serena Danti</td></tr>
<tr><td>Contents</td><td colspan="3">1. Body Fluids and Biofluids
Fundamentals of fluids (Newtonian and non-Newtonian behavior, viscosity, density, surface tension). Overview of biofluids: intracellular and interstitial fluids, blood composition and rheology, plasma and cellular components, lymph, urine, cerebrospinal and other extracellular fluids, saliva, and gastrointestinal fluids. Artificial and simulated body fluids; cell culture media composition and functions.
2. Transport and Diffusion Phenomena
Flow and pressure in the human circulatory system (Hagen–Poiseuille law, shear-rate dependence, Fåhræus–Lindqvist effect). Osmosis, diffusion, and filtration across membranes; hypertonic, hypotonic, and isotonic conditions. Oncotic and hydrostatic pressures; Starling equation; renal filtration and glomerular transport mechanisms.
3. Biofluid–Material Interactions
Surface and interfacial phenomena: wettability, contact angle, capillary effects, biofouling, and biomimetic (Lotus effect) surfaces. Strategies for tuning surface hydrophilicity/hydrophobicity (chemical and physical modifications).
Hemocompatibility: Vroman effect, protein adsorption, thrombosis cascade, and design of blood-contacting materials.
Dialysis membranes: structure, fabrication (phase inversion), classification (RO, nano-, ultra-, microfiltration), and operation principles (diffusion and convection). Biomaterials for vascular grafts, prostheses, and biotextiles.
Degradation of biomaterials: mechanisms of hydrolysis and enzymatic attack; bulk vs. surface erosion; corrosion and metal degradation in vivo.
Absorbent materials: fluid–material interaction (Jurin's and Washburn equations), superabsorbent polymers (SAPs), swelling behavior, osmotic response, and applications in hygiene and biomedical products.</td></tr>
</table>

	Smart biomaterials: pH-responsive hydrogels (e.g., gellan gum, chitosan) for targeted drug delivery. **4. Biofluids for Diagnostics and Organ-on-Chip Systems** Protein electrophoresis and ELISA principles; colorimetric and fluorescence detection; clinical diagnostic applications. Introduction to microfluidics: laminar flow, diffusion, capillary effects, and surface energy at the microscale. Wettability and material design for microfluidic systems. Concepts and challenges of organs-on-a-chip: bioinspired and biomimetic approaches.
Skills acquired	On successful completion of the course, the students will acquire knowledge of biofluid composition, transport phenomena in the human body, and biomaterial interface chemistry; develop skills to design, characterize, and evaluate biomaterials and diagnostic systems interacting with biological fluids; and demonstrate attitudes/competences in applying critical thinking, ethical awareness, and interdisciplinary reasoning to biomedical and pharmaceutical challenges.
Examination	ORAL exam, laboratory reports Final Exam: 50% Laboratory reports 50%
Classification	Materials Science

<table>
<tr><th colspan="4">TERM 1 – University of Pisa (UNIPI) – Italy</th></tr>
<tr><td>Course name</td><td colspan="3">Computational Materials Science</td></tr>
<tr><td>Credit Points (ECTS) 6</td><td>Hours (Face-to Face in class):
Lectures:48
Practical works:0
Total: 48</td><td>Duration:
1 semester</td><td>Mode:
Optional (6 ECTS must be chosen in the computing group); recommended for students with strong interest into scientific computation</td></tr>
<tr><td>Instructors</td><td colspan="3">Giuseppe Brancato</td></tr>
<tr><td>Contents</td><td colspan="3">Intermolecular Forces: Hydrogen bonding, Electrostatic interactions, London forces. Molecular clusters, Supramolecular assemblies. Thermodynamics: Variational formulation. Free energy of a reaction, Equilibrium constants.</td></tr>
</table>

	Statistical Mechanics: Gibbs ensemble, Mechanical system, Generalized coordinates, Lagrangian formalism. Hamiltonian formalism, Hamilton's equation, Phase space. Properties of Hamiltonian systems, Conservation laws, Canonical transformation, Poisson brackets, Liouville's operator, Equation of motion of a dynamical variables. Liouville's equation and theorem, Probability density, Microcanonical ensemble, Canonical ensemble. Molecular Dynamics: Definition, Foundations of molecular simulations, Limits and approximations. Overview of the basic ingredients (Energy potential, Force fields, Numerical integrators). Energy potential, Force fields, Numerical integrators. Force field terms (bonding, bending, torsion, non-covalent interactions). Molecular Dynamics: Coordinate and Velocity inizialitation, Integrators. Numerial integrators (velocity Verlet, Leapfrog), Statstical mechanichal ensemble, Thermal and pressure coupling. Enhanced Sampling Methods. Simulation of the Kv ion channel. Simulation of a lipid bilayer. Fundamentals of enhanced sampling techniques. Implicit solvent and continuum electrostatic modeling. From collisional theory to stochastic dynamical systems. Stochastic differential equations and Statistical Mechanics. Structural properties: distribution functions, radial distribution functions. Monte Carlo methods: Numerical Integration, Importance samplig. Free Energy methods. Free Energy Methods: Thermodynamic Integration, Free energy perturbation, Umbrella Sampling Free Energy Methods: Metadynamics, Jarzinski method, Adiabatic free energy.
Skills acquired	On successful completion of the course students will be able to: - comprehend molecular modeling techniques currently used in the field of life and material sciences - develop competences on some of the most common computational methodologies used in molecular sciences - develop computational skills through tutorials and exercises
Examination	Oral Exam. In addition to questions related to the basic knowledge of the course, students will be asked to present a scientific problem of their interest suitable to be treated with molecular modelling methodologies
Classification	Materials Science

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**Bioinformatics**		
Credit Points (ECTS) 6	Hours (Face-to Face in class): Lectures: 37 Practical works: 11 Total: 48	Duration 1 semester	Mode: Mode: Optional (6 ECTS must be chosen in the computing group); recommended for students with weak

			background in computing
Instructors	Alessio Bechini		
Contents	The course aims to provide both conceptual and computational tools for data analysis in molecular biology, using Python, one of the most popular languages in bioinformatics and machine learning. The most prominent topics in bioinformatics are developed in the course: usage of data banks, algorithms for sequence analysis, alignments, creation and analysis of phylogenetic trees.		
Skills acquired	Upon completing the module, the student will successfully master the basic concepts in Bioinformatics and will be able to use the Python programming language to deal with related problems.		
Examination	Project, and subsequent oral exam		
Classification	Computer Science		

TERM 1 – University of Pisa (UNIPI) – Italy			
Course name	**English for scientific writing and communication**		
Credit Points (ECTS) 3	Hours (Face-to Face in class): Lectures: 30 Practical works: Total: 30	Duration 1 semester	Mode Compulsory
Instructors	Alessandra Meoni (professor still to be confirmed)		
Contents	Meaning and pronunciation of keywords in Mathematics Specific use of grammar in a scientific paper. Word order and conciseness. Basic information about the structure of a scientific paper “Good Writing Reflects Clear Thinking”: hints and tips to face the possible difficulties in writing a good paper		
Skills acquired	Students will acquire awareness of the basic linguistic skills for writing and publishing scientific articles in English, as well as the presentation skills necessary to ensure an interactive participation in international academic contexts (conferences, seminars, webinars, symposia, etc.). The course also prompts the students to practice their "soft skills" (transversal skills), such as		

	teamwork, cognitive skills-information skills, social skills-interpersonal communication, problem-solving, creativity, mental adaptability, and flexibility. All these skills are necessary for effective iteration in complex organizational contexts, both in the academic community and in future professional spheres.
Examination	Oral exam and project
Classification	Soft Skills/Language knowledge

TERM 2 – University of Silesia in Katowice (USK) – Poland				
Course name	**Classification**	**ECTS**	**Hours face-to-face in class**	**Compulsory/optional Recommendation**
Soft matter physics	PHYSICS	3	30h	**Compulsory**
Molecular biophysics with elements of computer modelling	BIOPHYSICS	5	60h	**Compulsory**
Pharmacology and drug discovery	PHARMACY	4	45h	**Compulsory**
Scattering techniques for structural investigation	PHYSICS MATERIAL SCIENCE	3	30h	**Compulsory**
Specialized laboratory - Microscopy of soft matter	BIOPHYSICS MATERIAL SCIENCE	4	45h	**Compulsory**
Stochastic dynamics of systems in molecular biology	PHYSICS	3	30h	**Compulsory**
Hot-melt extrusion: from theory to application in drug formulation	PHARMACY	3	30h	**Compulsory**
Short Internship	N/A	5	45h	**Compulsory**
TOTAL		**30**	**315h**	

<table>
<tr><th colspan="4">TERM 2 – University of Silesia in Katowice (USK) – Poland</th></tr>
<tr><td>Course name</td><td colspan="3">Soft matter physics</td></tr>
<tr><td>Credit Points (ECTS) 3</td><td>Hours (Face-to Face in class):
Lectures: 30h
Practical works: -
Total: 30h</td><td>Duration
1 semester</td><td>Mode
Compulsory</td></tr>
<tr><td>Instructors</td><td colspan="3">Prof. dr hab. Marian Paluch</td></tr>
<tr><td>Contents</td><td colspan="3">Soft matter encompasses a wide range of materials - such as polymers, colloids, liquid crystals, foams, gels, and surfactants - whose mechanical and thermodynamic behaviors are governed by weak interactions and thermal fluctuations. This course introduces the fundamental physical principles that determine the structure, dynamics, and mechanical properties of soft condensed matter. Emphasis will be placed on understanding how microscopic interactions and molecular organization lead to the macroscopic behavior observed in soft systems.
Course outline
1. Introduction: What is Soft Matter?
Overview of the main classes of soft materials - polymers, colloids, liquid crystals, and surfactants. Discussion of common features such as large and nonlinear responses and slow and non-equilibrium responses
2. Soft Matter Solutions
Review of key thermodynamic quantities: mixing free energy, osmotic pressure, and chemical potential. Examination of miscibility and the effects of molecular size on solution behavior.
3. Elastic Soft Matter
Elasticity of single polymer chains and polymer networks. Introduction to polymer gels and the statistical theory of rubber elasticity (Kuhn model).
4. Surfaces and Surfactants
Interfacial phenomena in soft matter. Concepts of surface tension and wetting. Roles of surfactants in stabilizing interfaces and mediating surface interactions.
5. Liquid Crystals
Molecular origins of orientational and positional order. Phase transitions from isotropic liquids to nematic and smectic phases. Introduction to order parameters and elastic continuum theory.
6. Brownian Motion and Thermal Fluctuations
Random motion of mesoscopic particles. Time evolution toward equilibrium, fluctuation - dissipation theorem, and response to external perturbations.
7. Diffusion and Permeation in Soft Matter
Transport processes in polymeric, colloidal, and porous soft systems. Relationship between microscopic structure and macroscopic diffusion coefficients.
8. Flow and Deformation of Soft Matter
Rheology of soft materials, including viscoelasticity, non-Newtonian flow, and</td></tr>
</table>

	relaxation processes. Emphasis on polymer solutions, melts, and cross-linked networks. 9. **Ionic Soft Matter** Soft systems with mobile charges: dissociation equilibria, ionic gels, ion distributions near interfaces, and electrokinetic phenomena.
Skills acquired	By the end of the course, students will be able to: 1. Describe the defining features and common characteristics of soft matter systems. 2. Apply thermodynamic and statistical-mechanical principles to analyze soft matter behavior. 3. Explain elasticity, flow, and deformation phenomena in polymeric and colloidal systems. 4. Understand interfacial and surface phenomena, including surface tension and wetting. 5. Interpret phase transitions and ordering in liquid crystals. 6. Analyze transport processes such as diffusion, permeation, and Brownian motion. 7. Discuss electrostatic effects and ionic behavior in soft materials. 8. Relate theoretical models to experimental observations in soft matter physics.
Examination	Written exam
Classification	PHYSICS

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Molecular biophysics with elements of computer modelling		
Credit Points (ECTS) 5	Hours (Face-to-Face in class): Lectures: 30h Practical works: 15h laboratory + 15h computer room Total: 60h	Duration 1 semester	Mode Compulsory
Instructors	dr hab. Marzena Rams-Baron, dr hab. Jarosław Paturej		
Contents	This course provides a comprehensive introduction to molecular biophysics, with a particular emphasis on biophysical methods relevant to the pharmaceutical and biomedical sciences. Students will become familiar with the fundamental physical principles underlying a range of experimental and computational methods, as well as their practical implementation in both academic research and industrial applications. Students will explore how physical techniques are applied to study proteins, nucleic acids, membranes, and molecular assemblies, systems that are central to drug discovery, delivery, and formulation. A		

	dedicated computational module will introduce students to molecular modelling tools, such as molecular dynamics and docking simulations, which are increasingly important in pharmaceutical research. This part introduces computational approaches for studying the structure, dynamics, and interactions of biomolecules. By the end of the course, through a combination of lectures, hands-on laboratory sessions, and computational exercises, students will have acquired a solid understanding of how biophysical methods contribute to the characterization of biological systems at the molecular level. Course outline: **1. Optical Spectroscopy in Molecular Biophysics** Introduction to UV-Vis, CD, and fluorescence spectroscopy for analyzing biomolecular structure, stability, and interactions. **2. Microscopy Techniques in Molecular Biophysics** Overview of advanced imaging methods such as AFM, fluorescence microscopy, and FRET for visualizing molecular processes. **3. Calorimetry and Thermodynamics of Molecular Interactions** Application of DSC and ITC to study thermal properties and binding energetics of biological and pharmaceutical systems. **4. Biophysical Insights into Molecular Transport** Investigation of diffusion, membrane transport, and molecular mobility using techniques like FRAP and FCS. **5. Magnetic and Electron Resonance Techniques** Use of NMR and EPR spectroscopy to probe the structure and dynamics of biomolecules and their complexes. **6. Introduction to Molecular Modelling in Biophysics.** Overview of molecular simulation techniques: molecular mechanics, MD, and docking. Applications to proteins, DNA, membranes, and pharmaceutical complexes. **7. Classical Molecular Dynamics: Principles and Algorithms.** Newton's equations of motion and integration algorithms. Force fields for biomolecules (AMBER, CHARMM, OPLS). Equilibration, production, and trajectory analysis. Visualization and interpretation with VMD. **8. Biopolymers and Structural Dynamics.** Structure and flexibility of proteins, peptides, and nucleic acids. Simulation of folding/unfolding events and conformational transitions. **9. Molecular Docking: From Principles to Applications.** Theoretical background of molecular docking and scoring functions. Protein–ligand docking workflow: structure preparation, grid setup, and docking runs (AutoDock Vina).
Skills acquired	After completion of the course:

	• After completion of the course: • The student can relate biological phenomena to their physical and chemical foundations • The student can find a proper biophysical method to solve a biological problem • The student understands the physical principles underlying the biophysical techniques introduced in the course • The student can characterize and analyze experimental data obtained from biological systems • The student acquires the skills necessary to operate advanced scientific instrumentation • Understand the theoretical principles underlying MD simulations and molecular docking. • Set up and perform molecular simulations of biopolymers and their complexes. • Visualize, analyze, and interpret simulation trajectories to extract thermodynamic and structural information. • Integrate computational modeling results with experimental biophysical data. • Use professional simulation software packages in molecular biophysics and pharmaceutical research contexts.
Examination	Lecture: written exam Laboratory classes: reports
Classification	BIOPHYSICS

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Pharmacology and drug discovery		
Credit Points (ECTS) 4	Hours (Face-to-Face in class): Lectures: 15h Practical works: 30h Total: 45h	Duration 1 semester	Mode Compulsory
Instructors	dr hab. Anna Mrozek-Wilczkiewicz, dr Robert Gawecki		
Contents	This course provides fundamental terms in pharmacology, including, in particular, pharmacokinetics and pharmacodynamics, along with elements of pharmacognosy. During the classes, students will be introduced to nomenclature and forms of drugs. In the following section, they will learn about drug properties and their types of action in the body. Side effects and toxicity of drugs will also be discussed, as will factors affecting the action of drugs. This course will address the absorption, distribution, redistribution, biotransformation, excretion, and transport of drugs. A large part of the course		

	will be devoted to the structure of molecules, as well as hydrophobicity vs. hydrophilicity, ionization of the drug, and Lipinski's rule. All these issues will be presented in the context of discovering new drugs and the importance of their molecular structure in interacting with targets in diseased cells. During the course, students will learn about solubility versus transport across cellular membranes. A significant part of the course will be devoted to cellular mechanisms occurring during drug therapy. During the course, students will learn about the practical aspects of using research techniques such as cell culture, cytotoxicity assays, cell cycle inhibition, and death study by flow cytometry, Western Blot – protein analysis, and PCR – gene analysis.
Skills acquired	On successful completion of the course, students will be able to: • Understand the principles of pharmacology, including the practical meaning of pharmacokinetics and pharmacodynamics of drugs. • Use the acquired knowledge in practical research on potential drugs. • Gain practical skills in methods of drug cytotoxicity determination, data acquisition, and analysis of the obtained results. • Relate the action of the drug, its side effects and toxicity to this molecular interaction in the cell. • Interpret and critically assess experimental data in pharmaceutical contexts.
Examination	Lecture: written final assesment Laboratory classes: reports
Classification	PHARMACY

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Scattering techniques for structural investigation		
Credit Points (ECTS) 3	Hours (Face-to-Face in class): Lectures: 15h Practical works: 15h Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	dr inż. Karolina Jurkiewicz		
Contents	The course introduces the current approaches used for characterizing the structure and related properties of soft matter, which are based on X-ray and neutron scattering. The aim of the course is to demonstrate how the properties of soft matter systems are strongly linked with the arrangement of the materials involved. The program obeys: 1) Basics of X-ray and neutron scattering.		

	2) X-ray and neutron sources, as well as large research facilities such as synchrotrons, free electron lasers, neutron reactors, and spallation sources. 3) Total X-ray and neutron scattering methods for the characterization of the local structure and non-crystalline systems. 4) Small X-ray and neutron scattering methods for probing the structural organization of matter. 5) Inelastic X-ray and neutron scattering for the investigation of the molecular dynamics. The students will have the capability to examine functional material systems on the nanoscale and learn about various structural and dynamic aspects of samples, including pharmaceuticals, proteins and amino acids, polymers, functional carbon materials, liquid and plastic crystals, solvents, and solutions.
Skills acquired	After the course, students should be able to: 1. Explain how X-rays and neutrons are scattered by soft matter. 2. Describe different X-ray and neutron sources and explain how they can be used to study the structural features of matter. 3. Know the differences between X-ray and neutron scattering by crystalline and non-crystalline systems. 4. Know the basics of techniques that can be used to characterize the structure on the nanoscale and be able to analyze the results collected for selected samples.
Examination	Lecture: oral exam Laboratory classes: reports
Classification	PHYSICS/MATERIAL SCIENCE

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Specialized laboratory – Microscopy of soft matter		
Credit Points (ECTS) 4	Hours (Face-to-Face in class): Lectures: - Practical works: 45h Total: 45h	Duration 1 semester	Mode Compulsory
Instructors	dr inż. Marcin Libera		
Contents	Microscopy is an essential tool for the characterization and understanding of materials at multiple length scales — from macroscopic to atomic. This course provides an introduction to advanced microscopy techniques and their applications in materials science, physics, chemistry, and biology. Emphasis will be placed on the principles of image formation, sample preparation, and data		

	interpretation for both structural and compositional analysis. Techniques covered include TEM, SEM-Raman, WDX, EDX, SEM-FIB, micro-CT, confocal microscopy, ultramicrotomy for TEM, and Cryo-TEM. **Objectives:** • Understand the basic physical principles underlying various microscopy techniques (Basics of scanning and transmission electron microscop; Applications of electron microscopy, Electron and ion optics [(Effect of geometric, chromatic and wave aberrations on the resulting electron microscope image; Effect of misalignment aberrations and their correction; Methods of correction of geometric and chromatic aberrations]; Sources of electrons and ions; Interaction of electrons and ions with solid state matter; Signal detection im electron microscopy; Vacuum system; Sample manipulation inside electron microscope • Learn appropriate sample preparation methods for different types of microscopy • Acquire the ability to interpret and correlate microscopy data from complementary techniques • Gain practical knowledge of the advantages, limitations, and typical applications of each method **Course outline:** • Fundamentals of image formation and resolution limits • Transmission Electron Microscopy (TEM): principles, contrast mechanisms, and sample preparation (including ultramicrotomy) • Cryo-TEM and its applications in soft matter and biological systems • Scanning Electron Microscopy (SEM): imaging modes, detectors, and analytical capabilities • Hybrid and correlative techniques: SEM-Raman, SEM-FIB • Elemental analysis using Wavelength Dispersive (WDX) and Energy Dispersive X-ray Spectroscopy (EDX) • Confocal microscopy: optical sectioning, 3D imaging, and fluorescence applications • Micro-Computed Tomography (micro-CT): 3D imaging and quantitative analysis of internal structures, including data processing and visualization using *Dragonfly* software, as well as automated feature recognition and segmentation with AI-assisted tools • Comparison of techniques: spatial resolution, depth of information, and suitable applications
Skills acquired	Upon completing the course, the student will be able to select appropriate microscopy techniques for specific research and engineering problems and prepare samples for TEM, SEM, and micro-CT analyses, including the use of ultramicrotomy and cryogenic methods. They will understand the operating principles, capabilities, and limitations of advanced microscopy instruments such as TEM, SEM, SEM-FIB, confocal microscopy and micro-CT. The student will acquire practical skills in structural and compositional analysis using WDX and EDX spectroscopy and will be able to integrate correlative techniques such as SEM-Raman and SEM-FIB for multidimensional investigations. They will learn to process, reconstruct, and visualize three-dimensional datasets using Dragonfly

	software and to apply AI-assisted tools for image segmentation, pattern recognition, and quantitative data analysis.
Examination	Written reports
Classification	BIOPHYSICS/MATERIAL SCIENCE

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Stochastic dynamics of systems in molecular biology		
Credit Points (ECTS) 3	Hours (Face-to-Face in class): Lectures: 30h Practical works: - Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	dr hab. Jakub Spiechowicz		
Contents	The course will give an introduction to a comprehensive theoretical framework for a description of dynamics and thermodynamics of systems in molecular biophysics in terms of both equilibrium and non-equilibrium statistical mechanics. Outline: • Elements of the probability theory • Physics of the Langevin equation • Stochastic calculus • Fokker-Planck equation • Principles of the stochastic thermodynamics • Fluctuation relations and beyond		
Skills acquired	Students will be able to describe dynamics and thermodynamics of systems in molecular biophysics using the framework of stochastic (thermo)dynamics and investigate theoretically their properties.		
Examination	Oral final assesment		
Classification	PHYSICS		

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Hot-melt extrusion: from theory to application in drug formulation		
Credit Points	Hours (Face-to-Face in class):	Duration	Mode

(ECTS) 3	Lectures: 15h Practical works: 15h Total: 30h	1 semester	Compulsory
Instructors	prof. dr hab. Żaneta Wojnarowska, dr hab. Justyna Knapik Kowalczuk		
Contents	The course offers an introduction to the principles and applications of hot-melt extrusion in pharmaceutical technology. Objectives This comprehensive course provides an in-depth exploration of hot-melt extrusion (HME) as an advanced manufacturing technology in pharmaceutical development. It is designed to deliver a robust understanding of the fundamental principles while equipping students with practical, hands-on skills for formulating and processing solid dispersions. The curriculum seamlessly integrates theoretical knowledge with laboratory application to address the challenges of enhancing the solubility and bioavailability of poorly water-soluble drugs. Course outline During the lecture (15 hours), students will gain insight into: - The physicochemical principles underlying hot-melt extrusion and the viscoelastic characteristics of polymers and drugs; - Material selection and formulation design (drug - polymer interactions, thermal behavior, miscibility); - Equipment design and processing parameters (temperature profiles, screw configuration, torque, residence time). The laboratory sessions (15 hours) will offer hands-on experience with the process. Students will: - Measure the viscoelastic properties of amorphous drug - polymer systems using a rheometer; - Determine the optimal polymer concentration and temperature for successful hot-melt extrusion; - Perform extrusion using a twin-screw laboratory extruder; - Evaluate the physical characteristics of the extruded materials and discuss formulation performance.		
Skills acquired	On successful completion of the course students will be able to: • Explain the theoretical principles of hot-melt extrusion and describe its role in modern drug formulation and manufacturing; • Analyze the physicochemical behavior of drug - polymer systems and evaluate their suitability for hot-melt extrusion based on rheological data; • Design and perform a laboratory-scale hot-melt extrusion process using a twin-screw extruder, selecting appropriate processing parameters and polymer concentrations; • Interpret and discuss the results of extrusion experiments, linking formulation composition, processing conditions, and the resulting material properties.		

Examination	Lecture: 1 final oral assessment Laboratory: 1 report based on the lab practical session
Classification	PHARMACY

TERM 2 – University of Silesia in Katowice (USK) – Poland			
Course name	Short Internship		
Credit Points (ECTS) 5	Hours (Face-to-Face in class): Lectures: - Practical works: 45h Total: 45h	Duration 1 semester	Mode Compulsory
Instructors	Supervisor from the Institute/Company + Tutor from USK		
Contents	Research/industrial internship		
Skills acquired	After completing the internship, students will have hands-on, operational knowledge of a research project carried out at a university, research institute, facility, or private company. They will actively participate in a line of research or the development of a product and become acquainted with the work environment that is the target of the Erasmus Mundus programme.		
Examination	Evaluation by Supervisor. Written report evaluated by the Tutor.		
Classification	dependent on the project		

TERM 3 – University of Silesia in Katowice (USK) – Poland				
Course name	**Classification**	**ECTS**	**Hours face-to-face in class**	**Compulsory/optional Recommendation**
Animal models in contemporary pharmacy	PHARMACY	3	30h	**Compulsory**
Polymers and biopolymers for pharmaceutical applications	MATERIAL SCIENCE	3	30h	**Compulsory**
Specialized laboratory	BIOPHYSICS MATERIAL SCIENCE	4	45h	**Compulsory**
Dielectric spectroscopy in the study of dynamics of biological systems	PHYSICS	3	30h	**Compulsory**
Application of vibrational spectroscopy in therapeutic substance studies	PHYSICS	4	30h	**Compulsory**
Machine learning and data-driven techniques with applications in bioscience	PHYSICS	4	30h	**Compulsory**
General academic module (Humanities)	TRANSFERABLE SKILLS	3	30h	**Compulsory**
General academic module (Social Sciences)	TRANSFERABLE SKILLS	3	30h	**Compulsory**
Joint advanced winter course	N/A	3	24h	**Compulsory**
TOTAL		**30**	**309**	

<table>
<tr><th colspan="4">TERM 3 – University of Silesia in Katowice (USK) – Poland</th></tr>
<tr><td>Course name</td><td colspan="3">Animal models in contemporary pharmacy</td></tr>
<tr><td>Credit Points (ECTS) 3</td><td>Hours (Face-to-Face in class):
Lectures: 20h
Practical works: 10h
Total: 30h</td><td>Duration
1 semester</td><td>Mode
Compulsory</td></tr>
<tr><td>Instructors</td><td colspan="3">Dr Witold Nowak</td></tr>
<tr><td>Contents</td><td colspan="3">This course provides an overview of the use of animal models in modern pharmaceutical research, focusing on their role in understanding disease mechanisms, drug development, and preclinical testing. Students will gain insight into how experimental animals contribute to pharmacology, toxicology, and translational medicine, as well as the ethical, regulatory, and methodological considerations involved in their use.

Course Objectives
• To present the principles and applications of animal models in pharmaceutical and biomedical sciences.
• To discuss major types of animal models used for studying human diseases and evaluating novel therapeutic strategies.
• To provide practical experience in the design, execution, and analysis of basic preclinical experiments.
• To promote ethical awareness and understanding of 3R principles (Replacement, Reduction, Refinement) in animal research.
•

Lecture Topics (20 h)
1. Introduction to laboratory animal science and ethics.
2. Legal and regulatory framework for animal experimentation in pharmacy.
3. Rodent models of metabolic, cardiovascular, and neurological diseases.
4. Generation of transgenic mouse models.
5. Non solum mures: fruitfly and C. elegans in research.
6. Pharmacokinetics, pharmacodynamics, and toxicological assessments.
7. Translational value and limitations of animal studies.
8. Alternatives to animal testing and emerging in vitro/in silico models.

Laboratory Classes (10 h)
During laboratory sessions, students will:
• Observe basic techniques used in handling and monitoring laboratory animals.
• Learn principles of experimental design, anesthesia, and sample collection.
• Conduct a simple experiment ex vivo under supervision (white blood cell count, sutures).</td></tr>
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	• Analyze and interpret obtained data in the context of preclinical research.
Skills acquired	Upon completion of the course, students will: • Understand the scientific rationale and ethical considerations for using animal models in pharmacy. • Be able to identify and critically assess appropriate models for specific research objectives. • Acquire basic practical skills relevant to preclinical experimentation. • Demonstrate awareness of alternatives and modern trends in reducing animal use in research.
Examination	• Quiz (theoretical part) • Laboratory report and participation evaluation
Classification	PHARMACY

TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	Polymers and biopolymers for pharmaceutical applications		
Credit Points (ECTS) 3	Hours (Face-to-Face in class): Lectures: 15h Practical works: 15h Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	Prof. dr hab. Kamil Kamiński, dr inż. Roksana Bernat		
Contents	This course provides theoretical and practical training in the design, synthesis, and application of polymeric and biopolymeric materials for pharmaceutical use. It focuses on the use of polymers as excipients and drug carriers aimed at improving the solubility, stability, and bioavailability of poorly soluble active pharmaceutical ingredients (APIs). Since many currently available formulations fail to overcome solubility limitations, particular emphasis is placed on the design of new, tailor-made polymer-based drug delivery systems. The lecture component introduces students to the fundamental concepts of polymer science relevant to pharmaceutical technology. Topics include polymer structure and properties, polymer-drug interactions, mechanisms of drug release, biodegradation, and biocompatibility. Students will learn about the most important classes of polymers used in pharmaceutical and biomedical applications. The course also explores how polymer composition, molecular weight, and architecture influence drug release profiles and formulation performance. The students will be introduced to the principles of polymer chemistry, including both conventional polymerization methods used commonly in the industry and advanced controlled/'*pseudoliving*' polymerization techniques that allow precise control over molecular weight, architecture, and		

	functionality. The course also discusses current trends in polymer-based drug delivery systems, such as micelles, nanoparticles, hydrogels, and implants, as well as regulatory and safety aspects related to the use of polymeric materials in medicine. Through laboratory exercises, students will learn how to synthesize, purify, and characterize polymeric materials using modern analytical techniques such as Nuclear Magnetic Resonance (NMR), Gel Permeation Chromatography (GPC), and Differential Scanning Calorimetry (DSC). They will also gain hands-on experience in working with air- and moisture-sensitive systems using Schlenk line, as well as in preparing and analyzing binary mixtures and polymer-based pharmaceutical formulations. In addition, the course introduces principles of Good Laboratory Practice (GLP) to ensure safe, reproducible, and well-documented experimental work. Students will develop practical and teamwork skills essential for research and industrial environments related to polymer chemistry, materials science, and pharmaceutical technology. By the end of the course, students will be able to design and evaluate polymeric materials for specific pharmaceutical applications, understand their role in modern drug delivery strategies, and apply this knowledge to the development of innovative formulations that enhance drug performance.
Skills acquired	On successful completion of the course, students will: • Have knowledge of the main classes of polymeric materials used in biomedical and pharmaceutical applications, understanding their structure-property relationships and functional roles. • Gain knowledge of the main methods for polymer synthesis, including controlled/'*pseudoliving*' polymerization techniques. • Develop practical skills in the synthesis of polymeric materials designed for pharmaceutical use, in particular excipients and drug delivery systems. • Acquire the basic laboratory skills required for polymer chemistry, including the use of Schlenk line techniques for handling air- and moisture-sensitive reactions. • Know methods for purification of polymeric materials. • Be familiar with the main analytical techniques for polymer characterization, such as: 1. Nuclear Magnetic Resonance (NMR) spectroscopy for structural analysis, 2. Gel Permeation Chromatography (GPC) for determination of molecular weight and dispersity, 3. Differential Scanning Calorimetry (DSC) for studying thermal properties and transitions. • Prepare and analyze binary mixtures for pharmaceutical applications based on polymeric and biopolymeric materials. • Develop teamwork skills and the ability to collaborate effectively in a research and laboratory environment.

	• Apply the principles of Good Laboratory Practice (GLP) in laboratory work and documentation.
Examination	Lecture: oral exam Laboratory: 3 reports based on the lab practical session
Classification	MATERIAL SCIENCE

TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	Specialized laboratory		
Credit Points (ECTS) 4	Hours (Face-to-Face in class): Lectures: - Practical works: 45h Total: 45h	Duration 1 semester	Mode Compulsory
Instructors	dr hab. Magdalena Tarnacka, dr hab. Marzena Rams-Baron, dr Katarzyna Balin		
Contents	The aim of this course is to introduce students to advanced research techniques that are useful for understanding the stability, compatibility, and performance of active pharmaceutical ingredients (APIs) and formulation additives. The laboratory is divided into three sections, each conducted by a different instructor. Students will complete 1–2 laboratory exercises with each instructor, covering a specific research technique or scientific problem. The course will take place in the following laboratories: • Differential Scanning Calorimetry (DSC) • Thermogravimetric Analysis (TGA) • Dielectric Spectroscopy Laboratory (BDS) • High-pressure BDS Laboratory • Electron Spectroscopy Laboratory Each laboratory exercise includes the following components: 1. Preparation for the laboratory (pre-lab quiz or participation in a discussion on topics indicated by the instructor) 2. Execution of the experiment (including independent sample preparation and performing measurements together with the instructor) 3. Data analysis carried out according to the instructor's guidelines 4. Preparation of a report summarizing the completed research (student's individual work)		

Skills acquired	• Explain the principles of these experimental methods • Gain practical skills in sample preparation, data acquisition, and analysis for each technique. • Interpret thermal and dielectric data to assess phase transitions, thermal stability, polymorphism, and molecular mobility in pharmaceutical materials. • Evaluate the physicochemical properties of active pharmaceutical ingredients (APIs) and formulation additives based on thermal and dielectric measurements. • Apply thermal and dielectric techniques to investigate the compatibility and stability of drug-excipient systems. • Utilize X-ray Photoelectron Spectroscopy (XPS) to characterize the surface chemical composition and elemental states of APIs. • Critically analyze experimental results and draw conclusions relevant to pharmaceutical formulation and quality control. • Operate laboratory instruments (e.g, DSC, TGA, dielectric spectrometer, XPS) and follow standard procedures for sample preparation and data acquisition.
Examination	3 Reports based on the lab practical session
Classification	BIOPHYSICS/MATERIAL SCIENCE

TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	Dielectric spectroscopy in the study of dynamics of biological systems		
Credit Points (ECTS) 3	Hours (Face-to Face in class): Lectures: 30h Practical works: - Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	Prof. dr hab. Marian Paluch		
Contents	The content of the lecture includes: 1. Dielectric in a constant field (macroscopic and microscopic dielectric parameters, mechanisms of dielectric polarization, local field models, and records of phase transformations in dielectric measurements). 2. Dielectric in an alternating field (the phenomenon of dielectric relaxation: dipole and electrical conductivity). 3. Theoretical foundations of the phenomenon of polarization of heterogeneous media (two-, three-, and multiphase systems, membranes). 4. The phenomenon of dielectrophoresis.		

	5. Dielectric properties of selected biological materials (cells, tissues, proteins, blood, biopolymers)
Skills acquired	• student knows the elementary theory of the interaction of the electric field with dielectric materials, • student knows the basics of broadband dielectric spectroscopy measurements, how to apply it for the study of biological systems, and how to analyse obtained dielectric measurements, • student knows the theory of suspensions of particles in homogeneous fields, • student knows the applications of the phenomenon of dielectrophoresis for the study of small biological organisms.
Examination	Written/oral assesment
Classification	PHYSICS

TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	Application of vibrational spectroscopy in therapeutic substance studies		
Credit Points (ECTS) 4	Hours (Face-to-Face in class): Lectures: 15h Practical works: 15h Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	prof. dr hab. Marian Paluch, dr hab. Barbara Hachuła		
Contents	The entire course consists of lectures and laboratory exercises that introduce students to the theory and practice of applying two complementary research techniques: infrared absorption (IR) spectroscopy and Raman scattering (RS). This will give them the knowledge to solve many significant problems in pharmacy: 1. drug identity, 2. test purity, 3. crystal structures of drugs, 4. characteristics of polymorphism, 5. tautomerization, 6. interactions between active drugs and excipients. In the first part of the lecture, students will be introduced to the basic principles of vibration spectroscopy. In the second part, the possibilities of using spectroscopic methods in pharmacy will be presented in detail. During the laboratory work, they learn the practical aspects of various vibration spectroscopy measuring techniques.		

Skills acquired	The student has acquired knowledge and practical skills: • the laws of physical chemistry underlying vibration spectroscopy methods, • gathered extensive information on the usefulness of vibration spectroscopy in the analysis of pharmaceutical materials, • knows how to perform basic measurements using IR and Raman spectrometers, • can analyse the results of measurements obtained from these two techniques.
Examination	Lecture: Oral/written exam Laboratory: report based on the lab practical session
Classification	PHYSICS

TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	Machine learning and data-driven techniques with applications in bioscience		
Credit Points (ECTS) 4	Hours (Face-to-Face in class): Lectures: 15h Practical works: 15h Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	Prof. dr hab. Jerzy Dajka, dr Paulina Trybek		
Contents	This course provides a comprehensive introduction to the fundamental principles of machine learning (ML) and data-driven methodologies, with a focus on practical applications in the biosciences. Students will gain hands-on experience in data analysis, model development, and the exploration of case studies in bioinformatics, as well as broader applications in the exact and natural sciences. Key topics include: • Data Preprocessing and Feature Engineering Techniques • Building Predictive Models Using Machine Learning Algorithms • Evaluating Model Performance: Metrics and Techniques • Exploring Clustering and Classification Methods Applying Supervised and Unsupervised Models in: 1. Bioinformatic 2. Biochemical engineering 3. Biomaterials evolution 4. Polymeric Biomaterials 5. Biomechanics and Mechanobiology		
Skills acquired	Understand key ML concepts and algorithms. Apply ML and data-driven techniques to analyze bioscience data.		

	Build and evaluate predictive models for real-world biological problems.		
Examination	Lecture: Written Test Laboratory classes: Project-Based Assessment The final assessment will involve a project in which students address a real-world problem, using data science techniques to interpret data and develop analytical models.		
Classification	PHYSICS		
TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	General academic module (Humanities)		
Credit Points (ECTS) 3	Hours (Face-to-Face in class): Lectures: 30h Practical works: - Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	depending on the choice		
Contents	The humanistic general academic module allows the student to get acquainted with selected areas of the subject-related specificity of humanities. The student has a chance to compare different methodological and interpretative approaches, and gains knowledge about the benefits of adopting a humanistic perspective of the view of reality. The student learns to implement recognized paradigms of humanistic thinking into their scientific activity, creatively solving the problems posed during the classes. Based on specific cases, the student trains the ability to integrate views appropriate for humanities with the points of view that belong to the fields of science and scientific disciplines appropriate for the studied programme. During the meetings, the student identifies manners of participation in present and future cultural formations, recognizing the paths of individual participation in the life of adequate human communities in the presented and experienced activities.		
Skills acquired	• The student knows selected issues related to the subject-related specificity of the humanities, understands their nature, place and importance in the system of sciences, as well as their connections with fields of science and scientific disciplines specific to the studied programme, allowing for the integration of perspectives appropriate for different scientific disciplines. • The student is able to select, interpret and evaluate knowledge from selected disciplines in the field of humanities and integrate and apply it in scientific activity and professional practice in a manner that allows for original and creative solutions to problems that they experience as participants in cultural life.		

	• The student is able to creatively undertake, analyse and become involved in current sociocultural discourses, using knowledge of the studied problems of contemporary humanities and acquired communication skills as well as subject-related argumentation that considers various scientific approaches and types of scientific reflection. • The student, who is a participant in cultural life in its various manifestations, shows the need for continuous learning and improvement of those dispositions that allow to appreciate humanistic reflection and integrate it with issues and experiences resulting from choosing one's own path of scientific and professional activities and related to individual cultural activity.
Examination	course work
Classification	TRANSFERABLE SKILLS

TERM 3 – University of Silesia in Katowice (USK) – Poland			
Course name	General academic module (Social Sciences)		
Credit Points (ECTS) 3	Hours (Face-to-Face in class): Lectures: 30h Practical works: - Total: 30h	Duration 1 semester	Mode Compulsory
Instructors	depending on the choice		
Contents	The social general academic module allows the student to get acquainted with selected areas of the subject-related specificity of social sciences. The student has a chance to compare different methodological and interpretative approaches, gains knowledge about the benefits of adopting a perspective of reality appropriate for social sciences. Based on specific cases, the student trains the ability to integrate views appropriate for social sciences with points of view that belong to fields of science and scientific disciplines appropriate for the studied programme.		
Skills acquired	• The student knows selected issues related to the subject-related specificity of social sciences, understands their nature, place and importance in the system of sciences, as well as their connections with fields of science and scientific disciplines specific to the studied programme, allowing for the integration of perspectives appropriate for different scientific disciplines. • The student is able to select, interpret and evaluate knowledge from selected disciplines in the field of social sciences and integrate and		

	apply it in scientific activity and professional practice in a manner that allows for original and creative solutions to problems that they experience as participants in social life. • The student is able to creatively undertake, analyse and become involved in current sociocultural discourses, using knowledge of the studied content, acquired communication skills and subject-related argumentation taking into account various scientific approaches and types of scientific reflection. • The student, who is a participant in social life in its various manifestations, shows the need for continuous learning and improvement of those dispositions that result from choosing their own path of scientific and professional activities and related to individual social activity.
Examination	course work
Classification	TRANSFERABLE SKILLS