



Attachment 1: Course Syllabus

Degree Program in Medicine and Surgery

Academic Year 2026 / 2027

INTEGRATED COURSE (I.C.): Physics, Statistics, Informatics, Information Processing System

NUMBER OF CFU (ECTS credits): 18

SSD (Academic Discipline Code): PHYS06/A, MEDS-24/A, INFO-01/A

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MODULE 1: PHYSICS

NUMBER OF CFU (ECTS credits): 6

SSD: PHYS06/A

LECTURER:

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MODULE 2: Statistics

NUMBER OF CFU (ECTS credits): 5

SSD: MEDS-24/A

LECTURER:

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Rutjes Anne Wilhelmina Saskia (2CFU)

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MODULE 3: Informatics

NUMBER OF CFU (ECTS credits): 3

SSD: INFO-01/A

LECTURER: Fagioli Alessio (3 CFU)

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MODULO 4: Informations Processing Systems

NUMERO DI CFU: 4

SSD: INF-05/A

DOCENTI:

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PREREQUISITE COURSES

None required

PREREQUISITES

Knowledge and skills in mathematics, statistics, and basic computer science at the secondary school level are required, including arithmetic, algebra, Euclidean geometry, trigonometry, and elements of differential and integral calculus.

LEARNING OBJECTIVES

The aim of the integrated course in Physics, Statistics, Computer Science, and Data Processing is to provide students with the foundational knowledge of applied physics, computer science, and statistics necessary for their future professional activities. In particular, the course will address the physical principles underlying medical physics and the operation of medical instrumentation.

By the end of the Physics module, students will understand the fundamental concepts of applying the scientific method to the study of biomedical phenomena (parameter selection and measurement, error assessment); they will be able to describe the physical phenomena of complex systems using appropriate mathematical tools; and they will be familiar with the scientific basis of medical procedures and the operating principles of equipment commonly used for diagnostics and therapy.

The objective of the Computer Science module is to provide students with a broad understanding of computer terminology, key hardware and software components, computer operations, and fields of application. It aims to enable students to independently use search engines and major application software—specifically spreadsheets—to conduct key statistical analyses and tests.

The purpose of the Medical Statistics module is to equip students with the foundational knowledge of medical statistics required for their future work, for the correct reading and interpretation of scientific articles and research, and for active participation in research protocols. A key objective of the Medical Statistics course is to master essential statistical elements, including: parameters for descriptive analysis (mean, median, mode, and frequency measures for categorical variable distributions); parameters for analyzing variability (variance, standard deviation, and confidence intervals); and elements of inferential statistics (use and interpretation of common statistical tests) and regression techniques. Students must be able to understand the importance of medical statistics within medical research methodology. read a basic biomedical scientific article, understanding its structure and critically evaluating its methods and results; work with a simple database, with particular reference to clinical medicine; and perform descriptive and inferential analyses.

The objective of the Data Processing Systems module is to acquire the skills necessary to understand the role of information systems and their main applications in the biomedical field. In particular, students will learn about various types of information systems, focusing on database management systems (DBMS) and statistical data analysis.

EXPECTED LEARNING OUTCOMES

By the end of the course, the student will be expected to know/be able to:

DD 1: Knowledge and understanding

Apply the principles of physics, computer science, and statistics to selected problems and a varied range of situations. Use the tools, methodologies, language, and conventions of physics, computer science, and statistics to test and communicate ideas and explanations.

DD 2: Applying knowledge and understanding

The overall objective of the integrated course in physics, statistics, and computer science is to learn the experimental method and its applications to the study of natural phenomena. Consequently, the aim is to encourage students to make accurate observations and develop critical analytical skills. By the end of the course, students will be able to apply statistical principles to selected problems and use statistical tools, methodologies, terminology, and conventions to test and communicate ideas and explanations.

DD3: Making judgements

Upon completion of the integrated course, the student will be able to recognize the importance of in-depth knowledge of the topics essential to a proper medical education, and to identify the fundamental role that sound theoretical knowledge of the subject plays in clinical practice.

DD4: Communication skills

Present arguments in an organized and coherent manner. Use scientific language appropriately and in keeping with the topic of discussion.

DD5: Learning skills

By the end of the course, students will have acquired the learning methodologies and skills needed to delve deeper into the topics covered in class, thereby enhancing their expertise, including through the consultation of scientific literature and the critical use of web-based tools.

SYLLABUS

Syllabus MODULE 1: PHYSICS

Teaching Unit 1. Introduction to physics methods (workload valued at 0.2 CFU, with at least 20% dedicated to exercises)

Interpret basic elements of mathematics and physics (graphs and formulas). Perform vector operations; convert between units of measurement:

- Scientific notation.
- Physical quantities, dimensions and units of measurement, International System of Units (SI). Unit conversions and order-of-magnitude estimation. Extensive and intensive quantities. Scalar and vector quantities.
- Elementary trigonometric functions.
- Vectors: definition, components, operations (examples: sum, difference, scalar product, and vector product).

Teaching Unit 2. Mechanics (workload valued at 1.4 CFU, with at least 25% dedicated to exercises)

Describe and interpret elements of mechanics. Solve problems and numerical exercises related to mechanics:

- Kinematics of a point mass: definition of position and displacement over time. Concept of trajectory and equation of motion. Average and instantaneous velocity; average and instantaneous acceleration. Study of rectilinear and curvilinear motion, with significant examples: uniform rectilinear motion, uniformly accelerated motion, free fall. Uniform circular motion and centripetal acceleration.
- Dynamics of a point mass: analysis of interactions between bodies and formulation of the three laws of dynamics. Physical significance of the principle of inertia and conditions for static equilibrium (first law). Relationship between net force and acceleration (second law). Action and reaction between interacting bodies (third law). Application to concepts of translational equilibrium. Definition of force and main examples: weight, gravitational force, contact forces and friction (static and kinetic), tension, elastic forces, and Hooke's law for ideal springs. Elasticity, stress, tension, and fracture.
- Work and energy: concept of mechanical work as the effect of a force applied to a body. Definition of power and its relationship to work performed over a time interval. Work-energy theorem (kinetic energy). Work and comparison between conservative and non-conservative forces. Definition of potential energy. Examples: gravitational potential energy and elastic potential energy. Mechanical energy as the sum of kinetic and potential energy. Theorem of conservation of mechanical energy in ideal systems. Extended bodies: Characteristics of a rigid body. Torque and conditions for rotational equilibrium. Levers in the human body.

Teaching Unit 3. Fluid mechanics (teaching load valued at 1.2 ECTS credits, with at least 25% dedicated to practical exercises)

Describe and interpret elements of fluid mechanics. Relate fluid dynamics principles to physiological flows, resistances, and pressures in biological systems. Solve problems and numerical exercises related to fluid mechanics:

- States of matter: fundamental characteristics of fluids compared to solids. Definition of pressure and density and their role in the static and dynamic behavior of fluids.
- Laws of hydrostatics: Stevin's law for pressure in liquids as a function of depth; Pascal's principle for pressure transmission in incompressible fluids; Archimedes' principle regarding the buoyant force exerted by a fluid on an immersed body. Analysis of flotation conditions. Instruments and methods for measuring pressure (Torricelli's experiment, manometer).
- Fluids in motion (hydrodynamics): concepts of flow and flow rate; distinction between steady and turbulent flow, with particular attention to laminar flow. Continuity equation and conservation of mass in ideal fluids. Bernoulli's theorem and applications to blood circulation (stenosis and aneurysm).
- Real fluids and viscosity: analysis of laminar flow, parabolic velocity profile, concept of velocity gradient. Poiseuille's law and hydraulic resistances in series and in parallel.

Teaching Unit 4. Thermodynamics (teaching workload valued at 1 CFU, with at least 30% dedicated to exercises)

Describe and interpret elements of thermodynamics. Solve problems and numerical exercises related to thermodynamics:

- Fundamental concepts: definition of system and surroundings. Thermodynamic variables (pressure, volume, temperature) and thermodynamic state. State functions. Temperature and its measurement scales. Ideal gases and the equation of state.
- Heat and heat capacity: energy exchange in the form of heat. Definition of heat capacity and specific heat, with reference to ideal gases. Phase change phenomena (melting, evaporation, condensation), latent heat. Calorimetry.
- Heat transfer mechanisms: thermal conduction, convection, and radiation.
- First law of thermodynamics: definition and physical significance. Internal energy, heat, and work.
- Second law of thermodynamics: fundamental statements and the concept of irreversibility. Thermodynamic cycles: definition and operation.

Entropy as a state function, macroscopic implications, and statistical interpretation. Relationship between entropy change and the natural direction of thermodynamic processes.

Teaching Unit 5. Mechanical waves (academic workload valued at 0.4 ECTS credits, with at least 20% dedicated to practical exercises)

Describe and interpret the elements of mechanical waves. Relate wave phenomena to acoustics. Solve problems and numerical exercises regarding mechanical waves:

- Mechanical waves: introduction to the nature of mechanical waves as phenomena involving the propagation of energy and disturbance through a material medium. Definition of frequency, period, angular frequency, and wavelength. Wave propagation speed and the relationship between wave parameters.

Propagation equation for simple harmonic waves. Examples of one-dimensional waves: transverse waves on a string and longitudinal waves, such as sound waves in fluids.

- Principles of superposition and interference.
- Energy transported by waves: concept of energy associated with a mechanical wave. Power transported by a wave in an elastic medium. Wave intensity as a measurable physical quantity, related to the energy transported per unit area and time. Inverse-square law.
- Acoustic waves: sound propagation in various material media, with particular attention to the speed of sound. Relationship between sound intensity and sound perception. Definition of sound intensity level in decibels.
- Doppler effect: qualitative description.

Teaching Unit 6. Electricity and Magnetism (academic workload valued at 1.2 ECTS credits, with at least 30% dedicated to practical exercises)

Describe and interpret concepts of electricity and magnetism. Understand electrical and magnetic phenomena. Solve problems and numerical exercises related to electricity and magnetism:

- Electric charge and interactions: fundamental properties of electric charge, units of measurement, conservation of charge. Interaction between point charges and Coulomb's law. Definition of electric field and representation via field lines. Field generated by a point charge or a distribution of point charges. Motion of a charge in a uniform electric field.
- Electric energy and potential: potential energy associated with a charge distribution. Definition of electric potential and potential difference. Conservation of energy for a moving charge in an electric field.
- Conductors and dielectrics (insulators): qualitative description of electrostatic induction and polarization phenomena.
- Electric current: direct current, current intensity, ideal electric generator, and applied potential difference. Conduction in ohmic conductors. Ohm's laws, resistance, and material resistivity. Electric power dissipated via the Joule effect. Series and parallel combinations of resistors.
- Capacitance and capacitors: concept of electric capacitance. Capacitance of a parallel-plate capacitor; effect of a dielectric. Energy stored in a charged capacitor.
- Magnetic field: origin of the magnetic field from electric currents (Oersted's experiment). Lorentz force on a moving charge and on a current-carrying wire. Circular motion of an electric charge in a uniform magnetic field.
- Electromagnetic induction: variation of magnetic flux and generation of electromotive force. Faraday-Neumann-Lenz law. Induced currents and their direction.

Teaching Unit 7. Radiation Physics (academic workload valued at 0.6 CFU, with at least 20% dedicated to practical exercises)

Describe and interpret the physics of radiation and understand its effects. Solve problems and numerical exercises related to radiation physics:

- Electromagnetic radiation: wave nature of electromagnetic waves as a combination of mutually perpendicular oscillating electric and magnetic fields; fundamental characteristics (wavelength, frequency, propagation speed, wave amplitude and intensity).
- Electromagnetic radiation spectrum: subdivision of the spectrum into regions (radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays), in order of increasing frequency and decreasing wavelength.
- Energy quantization: concept of the photon as a quantum of energy associated with radiation; relationship between photon energy and frequency.
- Absorption of electromagnetic radiation (Beer-Lambert law).
- Radioactivity and radioactive decay: definition of an unstable nucleus, concept of radioactive isotopes. Activity and the law of radioactive decay, half-life. Main types of decay (alpha, beta, gamma) and associated nuclear transformations.
- Ionizing and non-ionizing electromagnetic radiation: distinction based on the energy carried by the radiation relative to the ionization energy of atoms. Examples of non-ionizing radiation (radio waves, microwaves, infrared) and ionizing radiation (X-rays, gamma rays).
- Optics: laws of light reflection and refraction, concept of refractive index.

Syllabus MODULE 2: STATISTICS

Introduction to biomedical statistics (0.2 CFU)

- Basic concepts and definitions.
- Measurements and measurement scales
- Sampling and inferential statistics.
- Scientific method and experimental design.

Descriptive statistics (0.3 CFU)

- Ordered data series
- Frequency distribution
- Measures of central tendency
- Measures of dispersion

Fundamental probability concepts (0.5 CFU)

- Two views of probability: objective and subjective
- Basic probability properties
- Event probability
- Bayes' theorem, screening tests, sensitivity, specificity, and positive and negative predictive values

Probability distributions (0.5 CFU)

- Probability distributions for discrete variables
- The binomial distribution

- The Poisson distribution
- Continuous probability distributions
- The normal distribution
- Applications of the normal distribution

Fundamental concepts of sampling distributions (0.5 CFU)

- Distribution of the sample mean
- Distribution of the difference between two sample means
- Distribution of the sample proportion
- Distribution of the difference between two sample proportions

Estimation (0.5 CFU)

- Confidence interval for a population mean
- The t-distribution
- Confidence interval for the difference between two population means
- Confidence interval for a population proportion
- Confidence interval for the difference between two population proportions
- Sample size determination for estimating means
- Sample size determination for estimating proportions
- Confidence interval for the variance of a normally distributed population
- Confidence interval for the ratio of variances of two normally distributed populations

Hypothesis testing (0.5 CFU)

- Hypothesis testing: single population mean
- Hypothesis testing: difference between two population means
- Paired comparisons
- Hypothesis testing: single population proportion
- Hypothesis testing: difference between two population proportions
- Hypothesis testing: single population variance
- Hypothesis testing: ratio of two population variances
- Type II error and test power
- Sample size determination to control Type II errors

Simple linear regression and correlation (0.5 CFU)

- The regression model
- The sample regression equation
- Evaluating the regression equation

- Using the regression equation
- The correlation model
- The correlation coefficient
- Some precautions

Multiple regression and correlation (0.5 CFU)

- The multiple linear regression model
- Obtaining the multiple regression equation
- Evaluating the multiple regression equation
- Using the multiple regression equation
- The multiple correlation model

Regression analysis: additional techniques (0.5 CFU)

- Qualitative independent variables
- Variable selection procedures
- Logistic regression

The Chi-square distribution and frequency analysis (0.5 CFU)

- Mathematical properties of the Chi-square distribution
- Goodness-of-fit test
- Test of independence
- Test of homogeneity
- Fisher's exact test
- Relative risk, odds ratio, and Mantel–Haenszel statistic

Syllabus MODULE 3: INFORMATICS

Teaching Unit 1. Fundamentals of Computer Science (workload: 0.3 CFU)

Understand the fundamental principles of information representation and the operation of computer systems, and describe the main hardware and software components of a computer:

- Information representation and basic principles of computer systems.
- Computer architecture, hardware, and software.
- Operating systems and application software.

Teaching Unit 2. Computer networks, distributed systems, and connected systems (workload: 1.0 CFU)

Understand the fundamental principles of computer networks and distributed systems, and describe the main technologies for communication, distributed service delivery, and device interconnection:

- Fundamentals of computer networks and Internet technologies.

- Network architectures and communication protocols.
- World Wide Web and Internet services.
- Fundamentals of cloud computing and distributed services.
- Fundamentals of Big Data and data-intensive systems.
- Internet of Things and connected devices.
- Applications of network, distributed, and connected technologies.

Teaching Unit 3. Cybersecurity, privacy, and cryptography (workload: 0.8 CFU)

Understand the fundamental principles of cybersecurity, privacy, and cryptography, and describe the main mechanisms for protecting systems, communications, and data:

- Fundamentals of cybersecurity.
- Cyber threats and protection mechanisms.
- Fundamentals of cryptography and secure communications.
- Authentication, authorization, and access control.
- Privacy and data protection.
- Security issues in sensitive data management. Unit 4. Scientific information, data management, and digital applications (academic workload: 0.9 ECTS credits)

Understanding key digital methods and tools for researching, organizing, and processing scientific information, and describing specific applications of digital technologies in the healthcare sector:

- Academic databases, scientific search engines, and information retrieval.
- Spreadsheets for data organization, analysis, and visualization.
- Healthcare information systems and electronic health records.
- Digital health and telemedicine.
- Applications of digital and connected technologies in healthcare.
- Applications for remote monitoring and clinical decision support.

Syllabus MODULE 4: INFORMATION PROCESSING SYSTEMS

Unit 1. Introduction to data processing systems (academic workload: 0.8 CFU)

Understand the fundamental principles of information representation and processing, and describe the main hardware and software components of a processing system:

- Definitions of algorithm and information; information processing.
- Basic hardware and software concepts.
- Overview of programming languages.
- Information representation: bits and multiples; memory allocation and estimation.
- Binary encoding of numerical data.

- Memory structure and computer architecture; memory hierarchy: primary memory, cache, and secondary memory.
- General principles of memory and processor implementation.

Unit 2. Databases (academic workload: 1.2 CFU)

Understand the fundamental principles of data organization, modeling, and management. Represent simple information structures and use basic tools for querying databases:

- Data and information: definitions and differences.
- Types of databases: relational, non-relational, cloud-based, and hybrid.
- Fundamental database concepts: tables, records, fields, and keys.
- Database Management Systems (DBMS): data creation and manipulation functions, security, and access control; examples of common DBMS and cloud-based DBMS.
- Conceptual data modeling: entities, attributes, and one-to-one, one-to-many, and many-to-many relationships.
- Entity-Relationship (ER) diagrams and the relational model.
- Primary keys, foreign keys, and referential integrity.
- Introduction to SQL: basic commands, conditional queries, and joins.

Teaching Unit 3. Digital images and medical images (academic workload: 1.2 CFU)

Understand the principles of digital image formation and representation, and describe the main techniques for image processing, compression, and management in the medical field:

- Overview of the electromagnetic spectrum.
- Digital images and color representation.
- Key quality parameters for digital images.
- Digital image processing techniques: filtering, equalization, and point transformations.
- Image compression methods.
- The DICOM standard for medical image representation, management, and exchange.

Teaching Unit 4. Artificial Intelligence (academic workload: 0.8 CFU)

Understand the fundamental principles of Artificial Intelligence and machine learning. Interpret the key elements used for model evaluation and recognize the characteristics, applications, limitations, and risks of modern Artificial Intelligence systems:

- Definition and historical overview of Artificial Intelligence (AI).
- The role of data in Artificial Intelligence systems.
- Supervised, unsupervised, and reinforcement learning: fundamental principles and main task types.
- Ground truth, confusion matrix, and key performance evaluation metrics.
- Machine Learning and Deep Learning: characteristics and differences.
- Neural networks: artificial neuron, layers, weights, and biases; main applications.

- Explainability and limitations of Deep Learning models.
- Generative Artificial Intelligence: Large Language Models and the generation of images, audio, and video.
- Concepts of creativity and data distribution.
- Chatbots and prompting principles for interacting with generative AI systems.
- Ethical aspects and main risks associated with Artificial Intelligence: hallucinations, bias, privacy, and responsible AI use.

COURSE STRUCTURE

In-person instruction comprises 60 hours of Medical Physics, 50 hours of Medical Statistics, 30 hours of Computer Science, and 40 hours of Information Processing Systems. Instructors utilize teaching aids such as PowerPoint presentations featuring explanatory diagrams, illustrations, and images. Interactive lessons involving in-class exercises are included. Ongoing assessments may be scheduled for all modules. Attendance is mandatory; students must attend at least 67% of the total scheduled hours for the courses within the integrated teaching unit. 2.5 hours of practical activities are provided for each ECTS credit.

COURSE GRADE DETERMINATION

Student proficiency will be assessed via a written exam. Questions may be multiple-choice or open-ended, or may require the solution to a problem or exercise. Some questions may carry different weights (scores) based on their complexity.

The exam is evaluated as a whole for the entire integrated course, and the grade will be expressed on a scale of thirty. If a student fails the integrated exam at a given sitting, they must retake the entire exam at a subsequent sitting or session.

The exam will be evaluated overall according to the following criteria:

Fail	Significant gaps and/or inaccuracies in knowledge and understanding of the topics; limited analytical and synthesis skills; argumentation absent or frequently incorrect.
18–20	Barely sufficient knowledge and understanding of the topics, with possible imperfections; sufficient analytical, synthesis, and judgement skills.
21–23	Routine knowledge of the topics; correct analytical and synthesis skills with coherent logical argumentation.
24–26	Fair knowledge and understanding of the topics; good analytical and synthesis skills; rigorously expressed argumentation.

27–29	Complete knowledge of the topics; considerable analytical and synthesis skills; good independent judgement.
30–30L	Excellent level of knowledge and understanding. Considerable analytical, synthesis, and independent judgement skills. Original argumentation expressed with full command of specialized terminology.

During the written exam, the use or possession of handouts, manuals, notes, charts, electronic devices (tablets, earphones, mobile phones, smartwatches, smart glasses, or pens), or other reference materials at one's workstation is strictly prohibited. Should a student be found in possession of or using such devices or materials, or fail to comply with the exam regulations, the exam will be immediately annulled, and no result will be recorded.

Students with disabilities and Specific Learning Disorders (SLD): in accordance with current regulations and guidelines from the University's inclusion services, students with certified disabilities or specific learning disorders are entitled to compensatory tools and established measures (e.g., extra time, concept maps, equivalent assessment methods). Exam accommodations are agreed upon by the lecturer, the student, and the relevant office, provided that the equivalence of the assessed learning outcomes is maintained.

OPTIONAL ACTIVITIES

In addition to the scheduled coursework, students will have the opportunity to delve deeper into the topics covered through seminars and practical exercises, as well as suggested supplementary readings—such as articles and book chapters. Instructors are available via email or remote calls to provide clarifications and further insights.

READING MATERIALS

Texts MODULE PHYSICS

- Introduction to Medical Physics; Bacchetta, Scannicchio; Ambrosiana Publishing House.

Students can adopt a textbook of their choice.

Texts MODULE STATISTICS

- Daniel, W. W., Cross, C.L., Biostatistics: a foundation for analysis in the health sciences, 11th edition, Hoboken (NY): John Wiley & Sons; 2018. ISBN: 978-1-119-28237-2, chapter 1-7, 9-12.

The textbook serves as the reference for study. Other editions of the text are also accepted. Additionally, the professors will provide the slides shown during lectures via the WebApp.

Texts MODULE INFORMATICS

The lecture slides serve as the primary reference for study and will be provided by the instructors via the WebApp. Additional supplementary materials for further study will be provided by the instructors where necessary.

Texts MODULE INFORMATIONS PROCESSING SYSTEMS

The lecture slides serve as the primary reference for study and will be provided by the instructors via the WebApp. Additional supplementary materials for further study will be provided by the instructors where necessary.