BACHELOR'S DEGREE IN PHYSICS STUDY PROGRAM CURRIRULUM

Study program	: Bachelor of Physics
University	: IPB University
Faculty	: Mathematics and Natural Sciences
Department	: Physics
Year of establishment	: 1997
Field of Science	: Natural Sciences
Degree	: S.Si
Head Study program	: Dr. Faozan,S.Si., M.Si.
National Accreditation	:
Accreditation institution	: LAMSAMA
Accreditation Status	: Superior
Validity Period	: 2026
International Accreditation	:
Accreditation institution	: ASIIN
Accreditation Status	: EQF LLL
Validity Period	: 2026
Referred curriculum standard	: PSI
Total Credit	: 147

Graduate Profile (GP)

Graduate Profile	Role in Professional Work	Description of Skills
GP 1	**Researcher**	Able to carry out experiments in physics and related fields, operate laboratory equipment, and support research activities independently or in a team.
GP 2	**Academics**	Able to develop and deliver physics material effectively, and have the potential and readiness to continue studies to a higher level.
GP 3	**Practitioner / Professional Industry**	Able to work professionally in companies or institutions that apply physics principles in operational activities or product development.
GP 4	**Entrepreneur**	Able to create and develop businesses based on physics applications, with an innovative spirit and managerial skills.
GP 5	**Civil Servant**	Able to formulate, implement, and evaluate public policies that are relevant to physics competencies and the needs of society.

GP 6	**Consultant**	Able to provide physics-based analysis and solutions in various professional contexts, as well as bridging technical and non-technical needs.

Program Learning Objectives (PLO)

PLO 1	Believe in and fear God Almighty and uphold norms academic and ethical
PLO 2	Able to solve basic physics problems with a classical physics approach using the principles of mechanics, thermodynamics, electromagnetics and waves.
PLO 3	Able to solve basic physics problems using a physics approach Modern physics uses the principles of quantum physics, relativistic physics, and statistical physics.
PLO 4	Able to carry out analysis using mathematical, statistical and computational methods in solving physics problems.
PLO 5	Able to carry out measurements based on the principles of instrumentation and experiments
PLO 6	Able to communicate the results of problem studies both in writing and orally, and able to lead and collaborate at various levels of roles in a team.
PLO 7	Able to describe and analyze physical phenomena through theoretical and experimental approaches.
PLO 8	Able to apply knowledge in the field of physics to broader fields such as life sciences.
PLO 9	Able to communicate both verbally and in writing in expressing ideas about problem solving and using the basic principles of classical physics and modern physics

Course Composition (According to IPB K2025 format)

Group Courses	Credit	Percentage
General Competencies*	31	21.09%
Fundamental Course (FC)**	7	4.76%
Core Courses of Study Program		0.00%
Foundational Literacies (FL)		0.00%
Academic Core Courses (ACC) + FL	38	25.85%
In-depth Courses (IDC)	21	22.45%
In-depth Courses (IDC) – Specialization (M)	12	
Final Year Project (FYP)	14	9.52%
Capstone (C)	5	3.40%
Enrichment Course (EC)	19	12.93%
Total	**147**	**100.00%**

* Engineering Science Cluster
** Di luar Courses GroupPKU Klaster Ilmu Keteknikan

Distribution of Courses by Semester

Course Group	Semester								Total Credits
	1	2	3	4	5	6	7	8	
General Competencies*	**18**	**13**							**31**
Foundational Course (FC)		**7**							**7**
Foundational Literacies (FL)									
Academic Core Course (ACC)			**20**	**12**	**6**				**38**
In-depth Courses (IDC)				**5**	**7**	**9**			**21**
In-depth Courses (IDC) – Specialization (M)					**4**	**4**	**4**		**12**
Final Year Project (FYP) + KKNT					**2**		**5**	**7**	**14**
Capstone (C)						**2**	**3**		**5**
Enrichment Course (EC)				**4**		**5**	**10**		**19**
Total	**18**	**20**	**20**	**21**	**19**	**20**	**22**	**7**	**147**

*** The General Competency Program courses consist of the following groups: Citizens (WN); Mandatory IPB (IPB), Quantitative Reasoning (QR), Science & Technology (ST); and Sociology/Humanities**

Curriculum Structure

Code	Course	Credits	Credits (L)	Credits (P/R)	Sem.	Prerequisites**	Group**
General Comptenecies*							
IPB2100	Religion	3(2-1)	2	1	1		WN
FIS2101	Basic Physics 1	3(2-1)	2	1	1		T
STA2111	Statistics and Data Analysis	3(3-0)	3	0	1		QR
MAT2101	Mathematics 1	4(3-1)	3	1	1		QR
IPB2106	Indonesian	2(1-1)	1	1	1		WN
KIM2104	Chemistry	3(2-1)	2	1	1		ST
IPB2114	Citizenship Education	2(1-1)	1	1	2		WN
IPB2111	Pancasila Education	2(1-1)	1	1	2		WN
KPM2131	Sociology	2(2-0)	2	0	2		SH
BIO2102	Basic Biology	3(2-1)	2	1	2		ST
IPB2108	English	2(1-1)	1	1	2		IPB
IPB210C	Innovative Agriculture	2(2-0)	2	0	2		IPB
	Sub Total	31	24	7			
Basic Course (outside GC)							
FIS2102	Basic Physics 2	4(3-1)	3	1	2		FC
FIS2103	Mathematical Physics	3(2-1)	2	1	2		FC
	Sub Total	7	5	2			
Core Course of the Program							
FIS2211	Newtonian Mechanics	3(2-1)	2	1	3	FIS2101	ACC
FIS2213	Advanced Mathematical Physics	3(2-1)	2	1	3	FIS2103	ACC
FIS2215	Analog Electronics	3(2-1)	2	1	3		ACC
FIS2217	Thermodynamics	3(2-1)	2	1	3	FIS2101	ACC
FIS2219	Wave	3(2-1)	2	1	3	FIS2101	ACC
FIS221B	Electrostatics	3(2-1)	2	1	3	FIS2102	ACC
FIS221D	Computational Physics	2(1-1)	1	1	3		ACC

Code	Course	Credits	Credits (L)	Credits (P/R)	Sem.	Prerequisites**	Group**
FIS2212	Lagrange-Hamilton Mechanics	3(2-1)	2	1	4	FIS2211	ACC
FIS2216	Digital Electronics	2(1-1)	1	1	4	FIS2215	ACC
FIS221E	Advanced Computational Physics	2(1-1)	1	1	4	FIS221D	ACC
FIS221A	Modern Physics Experiments	2(1-1)	1	1	4		ACC
FIS2232	Biophysics	3(2-1)	2	1	4		IDC
FIS221C	Electrodynamics	3(2-1)	2	1	4	FIS221B	ACC
FIS2234	Materials Physics	2(2-0)	2	0	4		IDC
FIS2311	Quantum Physics	3(2-1)	2	1	5		ACC
FIS2313	Statistical Physics	3(2-1)	2	1	5		ACC
FIS2331	Optics and Photonics	3(2-1)	2	1	5		IDC
FIS2333	Theory of Relativity	2(2-0)	2	0	5		IDC
FIS2349	Physics Entrepreneurship	2(0-2)	0	2	5		IDC
FIS2332	Solid State Physics	3(2-1)	2	1	6	FIS2311	IDC
FIS2334	Advanced Quantum Physics	2(2-0)	2	0	6	FIS2311	IDC
FIS2338	Atomic and Molecular Physics	2(2-0)	2	0	6		IDC
FIS233A	Nuclear and Particle Physics	2(2-0)	2	0	6		IDC
	Sub Total	59	40	19			
Specialization Course							
Specialization in Theoretical and Computational Physics							
FIS2371	Nonlinear Physics and Complex Systems	2(2-0)	2	0	5		IDC
FIS2373	Machine Learning Based Physics	2(2-0)	2	0	5		IDC
FIS2374	Machine Learning Based Physics	2(2-0)	2	0	6		IDC
FIS2376	Astrophysics and Cosmology	2(2-0)	2	0	6		IDC
FIS2471	Physics of Materials Design	2(2-0)	2	0	7		IDC
FIS2473	Quantum Engineering Physics	2(2-0)	2	0	7		IDC
	Sub Total	12	12	0			

Code	Course	Credits	Credits (L)	Credits (P/R)	Sem.	Prerequisites**	Group**
Specialization in Applied Physics							
FIS2381	Material Characterization Methods	2(1-1)	1	1	5		IDC
FIS2383	Sensors and Transducers	2(1-1)	1	1	5		IDC
FIS2384	Biocomposite Physics	2(2-0)	2	0	6		IDC
FIS2386	Internet-based Instrumentation System	2(1-1)	1	1	6		IDC
FIS2493	Nanophysics	2(2-0)	2	0	7		IDC
FIS2481	Industrial Automation Physics	2(1-1)	1	1	7		IDC
	Sub Total	12	8	4			
Specialization in Biophysics							
FIS2393	Biomaterials	2(2-0)	2	0	5		IDC
FIS2381	Material Characterization Methods	2(1-1)	1	1	5		IDC
FIS2394	Membrane Physics	2(2-0)	2	0	6		IDC
FIS2396	Bioinstrumentations	2(2-0)	2	0	6		IDC
FIS2491	Radiation Physics	2(2-0)	2	0	7		IDC
FIS2493	Nanophysics	2(2-0)	2	0	7		IDC
	Sub Total	12	11	1			
KKNT, Capstone, Final Project, Seminar							
FIS2361	Physics Scientific Writing Methods	2(2-0)	2	0	5		FYP
FIS2351	Capstone Physics 1	2(0-2)	0	2	6		C
IPB2400	Thematic Community Service Program (KKN-T)	4(0-4)	0	4	7		KKNT
FIS2452	Capstone Physics 2	3(0-3)	0	3	7/8		C
FIS2461	Colloquium	1(0-1)	0	1	7/8		FYP
FIS2462	Seminar	1(0-1)	0	1	7/8		FYP
FIS2464	Final Project 1	4(0-4)	0	4	7/8		FYP
FIS2466	Final Project 2	2(0-2)	0	2	7/8		FYP
	Sub Total	19	2	17			

Code	Course	Credits	Credits (L)	Credits (P/R)	Sem.	Prerequisites**	Group**
Enrichment Courses/MBKM****							
	Enrichment Course (EC)	**19**	**0**	**19**	**4/6/7**		**EC**
	Sub Total	**19**	**0**	**19**			
	Total	**147**					

*Engineering science cluster courses

**Write one prerequisite course code (if any)

***Write the course group code: GC, FC, FL, ACC, IDC, FYP, C, EC

**** Can refer to IPB enrichment course code

COURSE DESCRIPTION

General Competency Program Course Group (Engineering Cluster)

IPB2106 Indonesian Language, 2(1-1)
Increasing nationalism through the history of the Indonesian language. Material related to improving language skills includes effective sentence writing, including spelling, word choice, and structure. Material for reading and writing skills includes paragraph construction techniques, text composition, reading selection, critical thinking, and scientific writing. Material for oral language skills includes oral presentations. Student work includes paragraph outlines, paragraphs, text types, slides, videos, and simple research papers.

IPB2111 Pancasila Education, 2(1-1)
Encourages the development of national defense character in students, namely a love of the homeland, awareness of nation and state, loyalty to Pancasila, willingness to sacrifice, ability to defend the country, and a passion for realizing a sovereign, just, and prosperous nation. This course also encourages the application of science and technology towards realizing the nation's ideals as stated in the Preamble to the 1945 Constitution..

IPB2114 Citizenship Education, 2(1-1)
Providing students with an understanding of the importance of national defense awareness for the next generation of the nation in maintaining the integrity of the Republic of Indonesia through mastery and application of science and technology, which is based on 4 basic consensuses, namely the values of Pancasila, the 1945 Constitution of the Republic of Indonesia, Bhinneka Tunggal Ika and the Republic of Indonesia in order to realize sustainable national development based on the archipelagic outlook, national resilience and national vigilance that are in line with the principles of democracy, regional autonomy, good governance, and anti-corruption character.

IPB210C Innovative Agriculture, 2(2-0)
Providing knowledge, insight, experience, direct exposure, and stimulation to create and work in building innovative agriculture. The discussion includes: Agriculture in general: the development of agriculturelife- human civilization; Natural resources and the environment; Agromaritime, agrarian and policy; Agroecosystem services, climate and smart agriculture; Sustainable and integrated agriculture; Food, energy and health, biotechnology; Smart Agriculture, Smart Agriculture Extension; Agriculture Startup; Green and blue economy; Agriculture today and the future (challenges and solutions).

IPB2108 English, 2(1-1)
Encourage students to use English appropriately and in context. This includes introducing grammatical structures, rhetorical models of ideas, vocabulary development, and forms of speech appropriate to language functions in their respective contexts.

KPM2131 Sociology, 2(2-0)
Developing an inquiring mind based on sociological concepts and theories (knowledge aspect), training an anticipatory mindset towards the consequences of a change process due to human actions (social reality and problems) in society at various levels (understanding-attitude aspect), and training a proactive response full of interest towards social change in society 1.0 to society 5.0 (application aspect) as well as introducing skills regarding methods of approaching and solving social problems in society.

MAT2101 Mathematics 1, 4(3-1)
Provides essential mathematical fundamentals to support the understanding of advanced concepts in engineering. Topics include mathematical logic, basic trigonometric identities and equations, number systems and inequalities, functions and graphs, systems of linear and matrix equations, limits and continuity, the concept of derivatives, curve sketching and optimization, the fundamental theorem of calculus, and integration techniques.

KIM2104 Chemistry, 3(2-1)
Discusses fundamental concepts in chemistry, such as atomic structure, chemical bonding, stoichiometry, thermodynamics, and chemical kinetics. This course aims to help students understand the properties of matter and its changes, as well as to develop students' ability to solve chemical problems using chemical concepts and principles.

FIS2101 Basic Physics 1,3(2-1)
This course covers the basic principles of classical physics, covering topics from mechanics to thermodynamics. The material begins with an introduction to the scientific method, measurement, and vector analysis, then continues with kinematics and particle dynamics, Newton's laws, work and energy, the law of conservation of momentum, rotational motion, and torque and rigid body equilibrium. Students will also learn Newton's law of gravity, elasticity, harmonic oscillations, static and dynamic fluids, as well as the concepts of temperature, heat, and the laws of thermodynamics. This course aims to equip students with the conceptual understanding and analytical skills to solve various basic physics problems.

BIO2102 Basic Biology, 3(2-1)
Basic concepts of living systems, cell and molecular biology, mitosis and meiosis, principles of genetics, developmental biology (chemistry, biochemistry of macromolecules, cell structure and function, photosynthesis, respiration, evolution, diversity of life, DNA structure, and replication).

STA2111 Statistics and Data Analysis, 3(3-0)
Basic concepts of statistics, understanding of several terms in statistics (sample, population, data, etc.); various techniques for understanding data (data understanding), which include data presentation and summarization, exploration of the existence of extreme values, exploration of distribution patterns, exploration of comparisons between groups, and exploration of relationships between variables; modeling, whichincludes association, correlation and introduction to linear regression models; understanding of several methods of data collection, data management and several techniques for presenting information in presentations of analysis results, which can be applied to various applied fields, such as Agriculture, Biology, Social, Business, and so on.

<u>Basic Course Group (non-General Competencies)</u>

FIS2102 Basic Physics 2, 4(3-1)
This course covers fundamental concepts in electromagnetism, electromagnetic waves, optics, and an introduction to modern physics. Topics include electric charge and field, Gauss's law, electric potential, capacitors and dielectrics, electric current and circuits, Kirchhoff's laws, magnetic fields and Ampère's law, electromagnetic induction, alternating current, and Maxwell's equations. Wave theory of light, interference, and diffraction are also discussed. As an introduction to modern physics, students will be introduced to special relativity, wave-particle dualism, basic quantum mechanics, and atomic structure.

FIS2103 Mathematical Physics, 3(2-1)

This course is a core physics course that equips students with an understanding of mathematical methods and techniques (mathematical analysis tools) needed to understand and solve problems related to physical phenomena in nature The analysis tools include solving series, complex numbers, linear algebra, matrices, eigen values and vectors, partial differentials, multiple integrals and vector analysis. Mastering this material is very important to support other core physics courses such as waves, thermodynamics, mechanics, electromagnetics and other advanced courses.

Core Courses of Study Program

FIS2211 Newtonian Mechanics, 3(2-1)
This course is a deepening of the Basic Physics 1 (PPKU) course which discusses vector algebra, Newtonian mechanics, oscillations, general motion in three dimensions, non-inertial frame systems, gravity and central fields, and the special theory of relativity.

FIS2213 Advanced Mathematical Physics, 3(2-1)
This course is a core physics course that equips students with an understanding of mathematical methods and techniques (mathematical analysis tools) needed to understand and solve problems related to physical phenomena in nature. The analytical tools include Fourier series and transforms, ordinary differential equations, calculus of variations, tensor analysis, special functions, series solutions of differential equations (Legendre, Bessel, Hermite, Laguerre), partial differential equations and analysis of complex functions.

FIS2215 Analog Electronics, 3(2-1)
This course is given with the aim of equipping students with basic analog instrumentation skills. Topics in this course include: Basic Principles of Electricity, Semiconductors, Semiconductor Diode Circuits, Power Supply Circuits, Bipolar Junction Transistors (BJT), BJT Amplifiers, Field Effect Transistors (FET), FET Amplifiers, Power Amplifiers, Signal Processing with Operational Amplifier ICs (Op-Amp), and Oscillators.

FIS2217 Thermodynamics, 3(2-1)
This course provides a foundation for the application of (classical) physics to various fields, and also serves as a bridge to studying Statistical Physics (Mechanics) related to the interactions of particle systems in the microscopic (quantum) realm. The material presented includes basic concepts of thermodynamics, the kinetic theory of gases, equations of state, the first law both thermodynamics, entropy, thermodynamic potentials, Maxwell's relations. Applications on simple systems.

FIS2219 Wave, 3(2-1)
This course is an in-depth understanding of the concept of waves with material coverage including free oscillations of simple systems; free oscillations of systems with many degrees of freedom; forced oscillations; traveling waves; reflection, impedance, modulation, Fourier analysis, two- and threedimensional wave motion, polarization, interference and diffraction, electromagnetic waves.

FIS221B Electrostatics, 3(2-1)
This course is a core physics course that provides knowledge, understanding, and analytical skills regarding fundamental concepts in nature related to electrostatic phenomena. The concepts of charge, Coulomb interactions, vector fields (electric fields), scalar fields (potential fields), continuous charge distributions in various geometric shapes, dipoles, and various

applications of electrostatic concepts are discussed in this course.

FIS221D Computational Physics, 2(1-1)

This course studies the basic and intermediate levels of the Python programming language. Python is a programming language widely used for big data, machine learning, the Internet of Things,and cybersecurity applications. In this course, students are trained to analyze a program created using Python. Students learn programming algorithms, libraries, and Python syntax, and can code programs using Python. Students use Google Colab and Jupiter Notebook, which can be used as a code editor and Integrated Development Environment (IDE). This course equips students with basic computing concepts and is equivalent to the Computational Thinking Course.

FIS2212 Lagrange-Hamilton Mechanics, 3(2-1)
This course is a compulsory advanced course with Newtonian Mechanics prerequisites that equips students with analytical tools and methods for solving more complex physical problems. In this course attention is focused on the representation of Newtonian mechanics in Lagrangian and Hamiltonian formulations. Topics in this course include the motion of particle systems, rigid body motion, gravitational forces and potentials, Hamiltonian and Lagrangian dynamic equations, inertia tensors and coordinate transformations, coupled oscillations, wire vibrations, fluid motion and relativistic mechanics.

FIS2216 Digital Electronics, 2(1-1)
This course is given with the aim of equipping students with basic digital instrumentation skills. This course discusses the basic concepts of digital systems such as number systems, Boolean algebra, combinational circuits, Karnaugh maps, characteristics of TTL and CMOS ICs, decoders - encoders, multiplexers and demultiplexers, sequential circuits such as flip-flops, registers and counters, memory, and an introduction to microcomputer systems.

FIS221E Advanced Computational Physics, 2(1-1)
This course discusses programming and numerical methods for solving various problems in the field of physics, including solving the roots of a linear and nonlinear equation to obtain the eigenvalues of a wave function, solving ordinary differential equations using the Euler and Runge-Kutta methods to explain simple and damped harmonic motion, solving partial differential equations using finite difference and finite element methods to explain heat propagation, solving linear and nonlinear regressions from experimental data sets to obtain interpolation and extrapolation equations.

FIS221A Modern Physics Experiments, 2(1-1)
This course covers several fundamental experimental topics that build quantum theory and advanced physics, which underpin advanced technology. The experimental topics in this course include atomic spectra, blackbody radiation, oil droplets, the e/m ratio, the photoelectric effect, the Frank-Hertz experiment, radioactive counting, the laws of thermal radiation, electron spin resonance, the Hall effect, the speed of light, and laser characteristics.

FIS2232 Biophysics, 3(2-1)
This course is designed to equip all students with general graduate competencies related to their chosen program of study. Specifically, it provides an understanding of physics concepts and methods in discussing biological phenomena and phenomena. The course covers cell biophysics, forces at the nanometer scale, the structure and physical properties of biomolecules, biological thermodynamics, photobiophysics, radiation biophysics, and the electrical and magnetic properties of cells. The course does not require a strong mathematical background, so it is expected to be easily understood and digested by all students..

FIS221C Electrodynamics, 3(2-1)
This course is a core physics course that equips students with an understanding of classical electrodynamic phenomena based on Maxwell's four equations. It extends the concept of electrostatics to accelerated charges, describes Maxwell's Equations in differential and integral forms, conservation laws, electromagnetic waves and their propagation in materials, the concept of potential and field, electromagnetic wave radiation, the relationship between electrodynamics and relativity, vector calculus and curved coordinates, and Helmholtz's theorem.

FIS2234 Materials Physics, 2(2-0)
This course explains the types, properties, and characteristics of materials in general and their applications. Students will be able to understand and plan the selection of materials according to their use and function, including techniques for selecting metals, non-metals, ceramics, polymers, composites, and advanced materials.

FIS2311 Quantum Physics, 3(2-1)
This course provides an adequate foundation for development towards Theoretical Physics, Biophysics and Applied Physics. The material presented will be particle-wave dualism, wave functions, one-dimensional potentials and the SchrÖdinger equation for determining eigenvalues, operator methods in quantum mechanics, the general structure of quantum mechanics, angular momentum, the SchrÖdinger equation for the hydrogen atom, perturbation theory, and many-particle systems.

FIS2313 Statistical Physics, 3(2-1)
This course equips students with statistical principles for both general and specific cases in physics, such as the behavior of phonon gases and electron gases. For cases with a very large number of components, such as the behavior of molecules in a gas, it is certainly impossible to apply them exactly. Statistical physics is formulated to describe the macroscopic properties of a gas of particles without having to calculate the detailed motion of individual gas molecules. Three particle distribution models are studied: Maxwell-Boltzmann statistics, Bose-Einstein statistics, and Fermi-Dirac statistics. Statistical concepts for temperature, entropy, canonical ensembles, microcanonical and grand canonical ensembles and their applications are studied in this course.

FIS2331 Optics and Photonics, 3(2-1)
This course is an advanced physics course that equips students to understand the characteristics of light and the interaction of light with matter along with the latest applications. Understanding that light is an electromagnetic wave, the formation of dipoles and dipole radiation in materials as a result of interaction with light, Huygens' Principle and Fermat's Principle, geometric derivation of Snell's Law, Fresnel's equation, photonic crystals, waveguides, wave propagation in optical fibers, plasmon propagation on surfaces, virus detection using plasmons, metamaterials, introduction to nonlinear optics, quantum theory of light, photoelectric effect, interferometry/gravity wave detection by LIGO, and the state of the art of photovoltaic cells (Perovskite solar cells).

FIS2373 Theory of Relativity, 2(2-0)
This course covers the special and general theories of relativity. The discussion of special relativity includes a review of Galileo's principle of relativity and Newtonian dynamics, the postulates of special relativity, Lorentz transformations, the principle of space-time equivalence, space-time diagrams, the physical consequences of the postulates of special relativity, relativistic mechanics, and the covariant formulation of Maxwell's theory. The discussion of general relativity includes the formulation of space manifolds, non-Euclidean geometry, Riemannian geometry, tensor calculus, covariant derivatives, parallel transport,

Einstein's field equations, Schwarzschild geometry, static black holes, Friedman- Robertson-Walker geometry, and an introduction to cosmology.

FIS2349 Physics Entrepreneurship 2(0-2)
This course is designed to equip Physics students with the knowledge, skills, and mindset of entrepreneurship. The primary focus is on how to identify, evaluate, and develop innovative ideas rooted in physics concepts (such as instrumentation, optics, materials, energy, and computing) into commercially valuable products or services. Students will learn about basic economic concepts, business models, market validation, intellectual property, financial planning, and marketing strategies for deep-tech products. Learning will emphasize case studies, analysis, and the development of physicsbased business proposals in groups. This course equips Physics students with economic and entrepreneurial concepts.

FIS2332 Solid State Physics, 3(2-1)
This course is an advanced physics course that equips students to understand the physics phenomena related to solids as a basis for studying advanced materials. Studying lattices + bases as forming crystal systems, symmetry, crystals, x-ray diffraction, miller indices, dispersion relations, thermal and electric conductivity of phonons and electrons (metals), Dulong Petit heat capacity, Einstein, Debye, phonon scattering, dc and ac drude models, Hall Effect, Quantum Hall Effect, Franz Wiedeman Law, phonon DOS, electron DOS, Fermi level, k sphere, Fermi-Dirac distribution, thermoelectric effects of solids, fermi surface, dipole/vd waals bond, Lenard-Jones potential, ionic bonding, Madelung constant, covalent bonding, molecular orbital theory, bonding and antibonding, orbital hybridization, orbital mixing, homo lumo, electronic band structure, direct and indirect transition, fg bloch, bloch waves, Kronig-Penney model, nearly free electron model..

FIS2334 Advanced Quantum Physics, 2(1-1)
This course covers advanced quantum mechanics, focusing on theoretical approaches to atomic and molecular systems and their interactions with external fields. The material includes time-independent and time-dependent perturbation theory, atomic interactions with external fields, and the theory of time-dependent and time-independent perturbations electromagnetics, real atomic structure, molecular physics, atomic radiation, and radiation absorption in materials. Students are equipped with a deep understanding and analytical skills in applying quantum principles to explain physical phenomena in real systems.

FIS2338 Atomic and Molecular Physics, 2(2-0)

This course will introduce quantum physics to the fundamentals of atoms and molecules). The material will be divided into three parts: the first part provides a historical perspective leading to the contemporary view of atomic and molecular physics, and outlines the principles of non-relativistic quantum mechanics. The second part covers a description of atomic physics and its interaction with radiation, while the third part deals with molecular physics and its interaction with radiation. The molecular energy spectrum includes rotational, vibrational, and electronic modes. An introduction to quantum orbital theory (LCAO), molecular bond hybridization, and various types of molecular bonds (pi and sigma bonding) are presented.

FIS233A Nuclear and Particle Physics, 2(2-0)
This course is a basic physics course that provides students with an understanding of the basic structures that form matter, including nuclear and subatomic particles, as well as the basic interactions responsible for its stability (standard model). Discusses the static and dynamic quantities of nuclear, nuclear models, such as the liquid drop model (Bethe-Weizsäcker), the Fermi model, and the Shell model. Discusses fission, fusion, and nuclear decay reactions. Basic principles and technology of nuclear detection, nuclear astrophysics. Various applications of nuclear and particle physics in everyday life such as energy problems, health, agriculture, determining the age of objects (carbon dating), physics research and others.

Specialization Courses

FIS2371 Nonlinear Physics and Complex Systems, 2(2-0)
This course examines nonlinear phenomena and complex systems, as well as the complexity paradigms that emerge in various natural and social systems. Students will learn the definition of nonlinear systems, the system dynamics approach, and analytical techniques such as agent-based modeling, network analysis, and fractal geometry. Principles of thermodynamics and statistical physics are also used to understand collective behavior in complex systems. This course equips students with theoretical and practical skills for analyzing and modeling systems that cannot be described linearly.

FIS2373 Machine Learning Based Physics, 2(2-0)
This course introduces a data -driven approach to physics through the application of machine learning. Students will learn how statistical models and machine learning algorithms are used to analyze physics data, discover hidden patterns, predict the behavior of physical systems, and accelerate modeling and simulation processes. Topics include regression, classification, clustering, dimensionality reduction, and the application of neural networks and deep learning to experimental and simulated data. Students are also introduced to the integration of physics principles and physics-informed machine learning models to improve model interpretability and accuracy.

FIS2374 Nuclear Engineering and Radiation Physics, 2(2-0)
This course provides students with a theoretical foundation and in-depth insight into the applications of nuclear, particle, and radiation physics in various fields. Topics covered include nuclear stability and the phenomena of particle radiation and electromagnetic waves (EM) in various isotopes. The course examines the theoretical basis of nuclear reactions, both fission and fusion, and their applications in various types of nuclear reactors from generation 1 to 4.
In addition, students will learn the theoretical basis of interactions between heavy and light particles and GEMs with matter, particle detectors, muon imaging, and the use of Monte Carlo simulations in applications such as radiotherapy, radiodiagnostics, external beam radiation therapy (EBRT), brachytherapy, and radiation protection. Aspects of radiation protection will also be discussed comprehensively, covering its application in hospitals, nuclear reactors, and cosmic radiation mitigation for space satellites. To complement the insight, the latest information on nuclear and particle research conducted at world-class facilities such as CERN, Jefferson Lab, and Super-Kamiokande will be presented.

FIS237 Astrophysics and Cosmology, 2(2-0)
This course examines the structure and evolution of the universe, from the scale of stars to the cosmos as a whole. Topics include fundamentals of astrophysics, such as the formation and evolution of stars, galaxies, and other celestial objects, as well as modern cosmological concepts such as the Big Bang theory, the expansion of the universe, dark matter, and dark energy. Students are also introduced to the principle of general relativity, the foundation of cosmological theory, as well as observations and theoretical models used to understand the dynamics of the universe.

FIS2471 Physics of Materials Design
This course examines the physical principles underlying the design and engineering of functional materials through theoretical and computational approaches. Students will learn how material properties can be predicted, modified, and optimized using theoretical physics methods and numerical simulations. Topics include a review of quantum mechanics, electronic structure theory, quantum approximation methods, ab-initio methods, density functional theory (DFT), and the application of machine learning in materials discovery. This course also includes case studies of cutting-edge materials such as 2D materials, battery electrodes, catalysts, solar cell materials, sensor materials, and superconductors. Students are expected to be able to integrate knowledge of physics and computational engineering to design innovative materials in the fields of energy, electronics, and nanotechnology.

FIS2374 Quantum Engineering Physics, 2(2-0)
This course examines the basic principles of quantum physics, which serve as the foundation for the development of quantum information technology and quantum computing. The material covers quantum information concepts such as qubits, superposition, and entanglement , as well as their implementation in quantum communication, such as quantum teleportation and quantum cryptography. Students also learn the fundamental logic of quantum computing and quantum algorithms. Emphasis is placed on theoretical and applied understanding as the basis for engineering quantum-based systems.

FIS2323 Material Characterization Methods, 3(2-1)
This course is given in semester 7 with the aim of equipping final year students with knowledge and understanding of measurement instrumentation, characterization, and analysis of test results. The main topics of this course include: basics of measurement, calibration techniques of measuring instruments, radiation testing of biomedical materials, atomic spectroscopy (AAS, AES, and XRD), molecular spectroscopy (UV-Vis, FTIR, fluorescence, andthermoluminescence), material characterization using microscopes (optical and electron microscopes), chemical electroanalytical (potentiometry, voltammetry), thermal measurement methods (DTA, DSC), and nanomaterial analysis (PSA)

FIS2381 Sensors and Transducers, 2(1-1)
This course is given to equip students to be able to explain the concept of the working mechanism of sensors related to the material response to the detected physical/chemical parameters. The topics that will be presented in this course include Terminology, Classification and characteristics of sensors, temperature sensors, optical sensors, fiber optic sensors, resistive, capacitive and magnetic sensors, mechanical sensors, acoustic sensors, radiation sensors, chemical sensors and biosensors.

FIS2384 Biocomposite Physics, 2(2-0)
The Composite Physics course discusses the basics of physics and engineering principles of composite materials, namely materials formed from two or more different phases (matrix and reinforcement) to produce superior mechanical and physical properties. The material includes the classification of composite materials (fiber composites, particles, laminates), the physical and mechanical properties of each component, interactions between phases, fabrication processes, and applications of composites in various industries (automotive, aerospace, construction, etc.), the relationship between microstructure and macro properties of composites, and composite failure analysis. In the practicum/response, visits to industry and/or manufacturing, testing of simple composite samples are carried out.

FIS2384 Internet-based Instrumentation Systems, 2(1-1)
This course discusses the basic principles and implementation of instrumentation systems integrated with Internet of Things (IoT) technology. Students will learn the concepts of sensors, data acquisition, the fundamentals of TCP/IP networks, wireless data communications, and the integration of hardware and software in distributed systems. Focus is given to the design and development of IoT-based remote monitoring and control systems, including the use of microcontrollers, communication protocols (such as MQTT and HTTP), as well as cloud platforms and data visualization dashboards. This course emphasizes practical skills in building modern internet-based instrumentation solutions.

FIS2481 Industrial Automation Physics, 2(1-1)
Industrial automation is the use of automated systems, such as computers and robots, to control and operate machines and processes in industry. The goal is to increase efficiency, productivity, and reduce human error in production processes. This course discusses the principles, systems, and applications of automation in industrial environments. The material

covered includes sensors and actuators, logic controllers (PLC), pneumatic and hydraulic systems, SCADA, HMI, and the concept of automated system integration based on Industry 4.0. Students will also practice designing and simulating automation systems using software and hardware.

FIS2393 Biomaterials, 2(2-0)
Biomaterials course provides students with insight into the definition of biomaterials, the types and characteristics of biomaterials, biomaterial research trends, and the body's response to foreign substances for health applications. This course covers material biocompatibility, biocompatibility testing, preclinical testing both in vitro and in vivo, metallic biomaterials, polymer biomaterials, ceramic biomaterials, and composite biomaterials.

FIS2394 Membrane Physics, 2(2-0)
This course examines the physical aspects of membrane systems, both natural and artificial, which play a crucial role in various biological, chemical, and technological phenomena. The material covers membrane structure and mechanical properties, elasticity, thermal fluctuations, membrane dynamics, and molecular transport across membranes. Students also study theoretical models such as the lipid bilayer model, continuous models, and numerical simulations of membranes. Applications in biological systems (such as cell membranes) and technology (such as sensors, filtration, and thin materials) are also discussed to provide a strong interdisciplinary understanding.

FIS2396 Bioinstrumentation, 2(2-0)
This course discusses the principles and application of instrumentation systems for measuring biological signals and physiological processes. Students will learn the basics of biosensors, transducers, signal amplification, acquisition, and processing of biological signals such as ECG, EEG, and EMG, as well as the application of vision technology to biological systems. Interfacing techniques, digital data processing, and integration with microcontroller- and computer-based systems are also discussed. This course emphasizes the design, testing, and evaluation of biomedical measuring instruments, with attention to safety and accuracy aspects in clinical and research applications.

FIS2491 Radiation Physics, 2(2-0)
This course discusses the basic principles of radiation physics and its various applications in science and technology. The material covers the types of radiation (such as electromagnetic radiation, alpha, beta, and gamma particles), the mechanisms of radiation interaction with matter, the laws of radioactive decay, and the concepts of radiation dose and protection. Students also learn radiation detection and measurement techniques using various types of detectors, as well as radiation applications in the medical field (radiotherapy and imaging), industry (material testing, irradiation), the environment, and nuclear energy. Emphasis is placed on a strong theoretical understanding as well as analytical skills and practical applications in real-world contexts.

FIS2386 Nanophysics, 2(2-0)
This course is an advanced physics course that equips students with an understanding of physics at the nanoscale, which can have different characteristics than physics at the macroscale. It covers quantum theory of nanomaterials, the particle-in-a-potential-box analogy, subwavelength optics, and the dependence of absorption and emission on nanoparticle size. Nanomaterial synthesis methods, top down vs bottom up, nanostructures (gratings, meta-structures), nanoparticles, Kubo levels, nanomaterial characterization, carbon quantum dots and carbon nanotubes, conventional and green synthesis carbon quantum dots fabrication, nanoparticle synthesis via laser ablation, the role of nanotechnology in medicine, advanced materials, sensors, biosensors, biology, ecology, and renewable energy.

KKNT Course Group, Internship, Capstone, Final Project, Seminar

FIS2361 Physics Scientific Writing Methods, 2(1-1)
This course provides students with guidance on how to write scientific papers in the form of publications, reports, theses, etc., by following/complying with all matters related to technical writing, literature searches, and plagiarism prevention. The ethics and rules of scientific writing, paraphrasing techniques, the use of reference managers (Endnote, Mendeley, Bibtex, etc.), as well as language checking software (Grammarly) and plagiarism checkers, both paid and free, will also be explained in this lecture.

FIS2351 Physics Capstone 1, 2(0-2)
This course is organized in the form of project-based learning (PBL), which is the culmination of the application of knowledge and skills from various courses studied from the first to third year. Physics Capstone 1 focuses on the exploration of research problems and ideas as well as mastery of the tools or methods needed in research activities. The output of Physics Capstone 1 is a scientific document containing the results of literature studies, the state of the art of a research topic, research methods, and research design. This document can be part of the Final Project proposal to be presented in the Colloquium course activities. Recording activities related to this course in the form of a log book is mandatory as proof of achievement of study hours.

FIS2452 Physics Capstone 2, 2(0-2)
This course is delivered in the form of project-based learning (PBL), which is the culmination of the application of knowledge and skills from various courses studied from the first to the third year of the undergraduate program. The output of this activity can be in the form of research results, model development, prototype tools/devices/ materials, and so on as solutions to real problems in society, industry, and/or science. The output of this Capstone Project can be part of the Final Project document (Thesis/Final Project) which will be presented in the Final Project Seminar activity.

FIS2461 Colloquium, 1(0-1)
In this course, students create a research proposal for their final assignment and present it to their supervisor, examiners, and fellow students. The examiners' reviews and feedback from the ongoing discussions will be used to refine the students' research activity plans and final assignments.

FIS2462 Seminar, 1(0-1)
In this lecture, students present the results of their research to test their scientific validity and feasibility, as well as their compliance with the KKNI level 6 and the Learning Outcomes Program of the IPB Physics Undergraduate Program, in front of their supervisors, examiners, and fellow students. The examiners' feedback is used to refine their final assignment.

FIS2464 Final Project 1, 4(0-4)
This course provides an assessment of the quality of research activities/final project assignments which has been done by students with output in the form of a thesis/scientific work documents. Assessment is based on the sustainability of the process and output with the KKNI level 6 standards and the learning outcomes program of the IPB Physics Undergraduate Study Program.

FIS2466 Final Project 2, 2(0-2)
This course is a final evaluation to assess students' mastery of fundamental concepts in physics as a requirement for graduation from the undergraduate program. The comprehensive exam covers the core material that has been studied during the study period, including classical mechanics, waves and optics, thermodynamics and statistical physics, electricity and magnetism, and modern physics (including quantum mechanics and special relativity).