Module Handbook

Physics Undergraduate Study Program

Organized by :

Faculty Curriculum Team
Physics Department Curriculum Team

Faculty Of Mathematics And Natural Sciences

Universitas Gadjah Mada

2021

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CURRICULUM OF THE PHYSICS STUDY PROGRAM, THE FACULTY OF MATHEMATICS AND NATURAL SCIENCES

1. STUDY PROGRAM IDENTITY

Study Program	Physics
Education Level	Bachelor Program (S1)
Department	Physics
Faculty	Faculty Of Mathematics and Natural Sciences
University	Universitas Gadjah Mada
Establishment Number	22/DIKTI/Kep/1985
Date of Establishment	May 1st, 1985
Month & Year Started	September 1st, 1956 as a Physics major or May 1st , 1985 as a Physics study program
Final Accreditation Rating (Score).	A
Decree Number BAN-PT	1226/SK/BAN-PT/Akred/S/IV/2019
Address	Department of Physics, FMIPA UGM, North Sekip, Bulaksumur BLS 21, Yogyakarta 55281
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2. VISION, MISSION, OBJECTIVES, STRATEGY AND UNIVERSITY VALUE

The vision of the BP-Phys is that by 2037 it will become an undergraduate Physics study program that excels nationally and is well known internationally in the fields of education and teaching for the glory and welfare of Indonesian people and mankind in general. This vision was later revealed to be the mission of the study program as follows:

1. Organizing education and teaching programs in Physics based on a quality management system that meets national and international standards which produce graduates with a bachelor's degree (S1) in Physics who are competent, active in community development efforts, creating prosperity and improving community civilization, and able to continue to education level higher (S2 and S3).

2. Organizing education and teaching of Physics that is oriented to the development of superior science and technology that is beneficial to human civilization.
3. Organizing integrated physics education and teaching in various community service activities to help achieve the nation's welfare.

The vision and mission of the undergraduate physics study program (S1) is in line with the vision and mission of FMIPA and the Physics Department, which is then carried out with the educational objectives of the physics undergraduate study program (PEO, Program Educational Objectives) as follows:

PEO-1 Produce Bachelors (S1) in the field of Physics who believe and fear God Almighty, have high integrity and personality, are open and responsive to changes, scientific advances and problems faced by society, especially those related to their fields of expertise, and international quality.

PEO-2 To produce undergraduates (S1) in Physics who have superior abilities to be able to study at an advanced level (S2 and S3) at national and international levels.

PEO-3 To produce knowledgeable and skilled personnel for centers of excellence in education, research and community service based on physics and its applications which are known and recognized at the national and international levels.

PEO-4 To produce graduates who are competent, qualified, with national and international insight, and able to work together, to encourage the growth of community welfare and the advancement of world civilization.

3. PROGRAM LEARNING OUTCOMES (PLOS)

To be able to form the expected graduate profile, it is necessary to have Learning Outcomes (PLO) based on general and specific descriptions of level 6 educational qualifications in the Indonesian National Qualifications Framework (IQF). In general, each level of qualification at the IQF includes the process of building the character and personality of Indonesian people, namely:

1. Fear God Almighty.
2. Have good morals, ethics, and personality in completing their duties.
3. To act as citizens who are proud and love their homeland and support world peace.
4. Able to work together and have high social sensitivity and concern for society and the environment.
5. Appreciate the diversity of cultures, views, beliefs, and religions as well as the original opinions/findings of others.
6. Uphold law enforcement and have the spirit to put the interests of the nation and the wider community first.

Meanwhile, specifically, the level 6 qualification level at the IQF includes the following graduate abilities:

1. Able to take advantage of science and technology in their field of expertise, and able to adapt to situations faced in solving problems.
2. Mastering the theoretical concepts of certain fields of knowledge in general and the theoretical concepts of specific sections in that field of knowledge in depth, and able to formulate procedural problem solving.
3. Able to make strategic decisions based on analysis of information and data, and provide guidance in choosing various alternative solutions.
4. Responsible for their own work and can be given responsibility for the achievement of the organization's work.

The description of the qualification level of the IQF level 6 above was later revealed to be more specific for Bachelor Program in Physics (BP-Phys) graduates by the Physical Society of Indonesia (PSI), as follows:

1. Ability in the field of work:
   a). Able to formulate physical symptoms and problems through analysis based on observations and experiments. (IQF 6.1)
   b). Able to produce mathematical or physical models following the hypothesis or forecast of the impact of the phenomenon that is the subject of discussion. (IQF 6.2)
   c). Able to analyze various alternative solutions to physical problems and conclude them for making the right decisions. (IQF 6.3)
   d). Able to predict the potential application of physical behavior in technology. (IQF 6.4)
   e). Able to disseminate the study results of problems and physical behavior from simple symptoms in reports or working papers according to standard scientific rules. (IQF 6.5)
2. Mastery of knowledge:
   a). Mastering the theoretical concepts and basic principles of classical and quantum physics. (IQF 6.6)
   b). Mastering the principles and applications of mathematical physics, computational physics, and instrumentation. (IQF 6.7)
   c). Mastering knowledge of physics-based technology and its application. (IQF 6.8)

With this profile outline, physics graduates can work in all sectors of work, especially those involving the abilities mentioned above. As for some general descriptions of fields that are usually entered by physics graduates, can be seen in the Graduate Profession table.

From the description of the profile of graduates of the previous BP-Phys, graduates of the BP-Phys have very wide opportunities in various fields which can be seen in Table 3.1.

Table 3.1. Professions of Graduates of the BP-Phys

Profession	Description
Educator	Educators in physics and related sciences, such as lecturers, teachers, instructors,

	trainers, etc.
Researcher	Researchers in physics and related fields, both in government institutions, as well as in industry, such as researchers in corporate R&D, data scientists, business and financial analysts, etc.
Consultant	Become a consultant both related to the application of physics or other fields related to adaptive skills acquired during the learning process in physics.
Community Leader	Leader at various managerial levels in various fields, both in government institutions, private, and social institutions.
Entrepreneur	Entrepreneurs whether in fields related to physics or not.

With the description of the qualification level of the IQF level 6 and its derivatives for the Physics Bachelor level by PSI above, the Program Learning Outcomes (PLO) of the BP-Phys are derived in 5 aspects and can be seen in Table 3.2 below.

Table 3.2. Description of Programme Learning Outcomes (PLOs) based on the IQF standards at Department of Physics – UGM Yogyakarta

PLO	Description
PLO-1	Have faith and fear of God Almighty, apply good morals, ethics, initiative, and responsibility in completing their duties.
PLO-2	Able to explain theoretical concepts and principles of classical and modern physics, and be able to apply the basic concepts of physics and related mathematical methods in finding a solution to a physical problem.
PLO-3	Able to communicate the results of research on problems and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team.
PLO-4	Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technology.
PLO-5	Able to analyze various existing alternative solutions to physical problems and conclude them for making the right decisions, both in familiar and new problems.

Bloom's Taxonomy, which is a categorization of expert levels for educational purposes, is used to determine the level of proficiency or expertise of each aspect of the PLO of the Physics Undergraduate Study Program. There are three categories of expert levels in Bloom's Taxonomy in determining educational goals, namely taxonomy based on:

1. Knowledge-based goals / Cognitive,
   - Knowledge (PLO-2)
   - Long life learning (PLO-5)
2. Skill-based goals / Psychomotor,
   - General skills (PLO-3)
   - Special skills (PLO-4)
3. Affective goals,
   - Attitude (PLO-1)

Based on the Indonesian National Qualifications Framework (IQF) for the Undergraduate level (level 6), the keywords that graduates of the undergraduate program must possess are being able to apply, study, make designs, utilize science and technology, and solve problems. Referring to these general keywords, the relationship of each PLO of the Physics Undergraduate Study Program with the expert level of each category in Bloom's Taxonomy can be seen in Table 3.3.

Table 3.3. Bloom's Taxonomy Expert Level

Knowledge/Cognitive		**Skills/Psychomotor**		**Attitude/Affective**	
P1	Remember: Remembering or recognizing ideas, procedures, and theories that have been studied.	**S1**	Perception (perception/awareness): Using sensory signals to guide action, from sensory stimulation and selection to translating these signals.	**A1**	Receiving: Showing a willingness to participate in an activity or a willingness to hear.
P2	Understand: Understand, explain, and interpret an instruction or problem in each language.	**S2**	Readiness (set): Readiness to take action in carrying out tasks or achieving goals. This readiness includes mental, physical, and emotional readiness, and all three will determine the response to different situations, also referred to as a mindset.	**A2**	Responding: Willing to participate actively, pay attention, and react to a phenomenon or activity. It is also characterized by a voluntary willingness to respond or satisfaction.
P3	Apply: Apply concepts, abstractions, and methods to concrete situations. Able to apply learned concepts to new situations.	**S3**	Integrated response (guided response): Knowing the steps needed to complete a task or achieve a goal. This stage is the initial phase in learning complex skills, which include imitation, trial, and error. Proficiency is achieved	**A3**	Internalizing values (valuing): Internalizing values, goals, phenomena, or activities, which can be characterized by an open attitude in appreciating a value.

			through practicing the required procedures.		
P4	Analysis (analyze): Be able to isolate the constituent parts of a complex concept and understand the relationships between the parts and how they relate to one another. Able to distinguish hypotheses and facts, also which variables are relevant and which are not.	**S4**	Mechanism/basic proficiency: This stage is an intermediate phase in mastering complex skills. Learned responses have become habitual and are performed with sufficient confidence and proficiency.	**A4**	Organization (organization): Organizing values and dividing them into priorities by comparing different values and resolving contradictions between these values to form a consistent internal value system.
P5	Evaluation: Able to assess ideas, methods, or materials using data or a criterion based on observation or rationalization.	**S5**	Expert (complex overt response/expert): Able to perform a task or achieve a goal, including competently performing complex procedures. Proficiency at this level is characterized by the ability to carry out procedures without hesitation and automatically.	**A5**	Characterization (characterization by a value or value complex): Having a value system that controls behavior so that this behavior is pervasive, consistent, and predictable. Alternatively, in other words, the value system has become a character.
P6	Creation (create): Being able to create or arrange a structure or pattern from various elements to produce something new.	**S6**	Adaptation: Skills mastered very well as described at the S5 level, and can modify procedures as needed in dealing with new situations.		
		S7	Original creation (origination): Create new procedures that suit a particular situation or problem. The resulting creativity is based on proficient skills in carrying out previously learned procedures.		

Table 3.4. Relation of Programme Learning Outcomes (PLO) of the Physics Undergraduate Study Program with Bloom's Taxonomy

Aspect	Expertist Level	PLO
Cognitive	P2-P4	PLO-2, PLO-5
Psychomotor	S4-S6	PLO-3, PLO-4
Affective	A3-A5	PLO-1

For each CPL category, whether cognitive, psychomotor, or affective, expert levels can be used in every lesson, whether through lectures or practicum/laboratory work, to the final project. Determining the extent of PLO achievement in each course can be considered by categorizing the year of study or whether a course is at an introductory level or has reached a higher expert level. Of course, in the Final Assignment, it is hoped that the expert level aimed at is the maximum level.

Tabel 3.5. PLO Curriculum 2021 Relation and Competencies of Graduates of the Physics Undergraduate Study Program

1. Attitude	**PLO-1.1**	Have a personality that is faithful, pious, and has a noble character.
	PLO-1.2	Have empathy, respect, and appreciation for fellow human beings.
	PLO-1.3	Have a supportive attitude towards the balance of the environment and the natural surroundings.
2. Knowledge	**PLO-2.1**	Understanding and knowing the concepts underlying Classical Physics, which includes understanding various aspects of mechanics, various aspects of multi-particle systems, and various aspects of fundamental interactions (Gravity and Electromagnetics).
	PLO-2.2	Understand and know the concepts underlying Modern Physics, which include the theory of relativity and the concepts of quantum physics.
	PLO-2.3	Understand and know the concepts of Classical Physics and Modern Physics at various levels of systems, starting from elementary particle systems, and complex material systems to the macroscopic systems of the universe.
	PLO-2.4	Understand and know various basic experiments and some advanced experiments in Physics.

	PLO-2.5	Understand and know the various branches of mathematics needed to master various branches of Physics, including the use of numerical methods and programming.
	PLO-2.6	Understand and know some of the latest concepts of Modern Physics and Physics applications in the latest technological fields.
3. General Skills	**PLO-3.1**	Can present, communicate, and provide arguments on a concept/idea related to the field of Physics in Indonesian and English.
	PLO-3.2	Can work independently or cooperate in a work team/research team.
	PLO-3.3	Can supervise and direct a practicum/experiment in the field of Physics.
4. Special Skills	**PLO-4.1**	Skilled in making observations of natural phenomena.
	PLO-4.2	Skilled in conducting physics experiments at basic and advanced levels along with their analysis.
	PLO-4.3	Skilled in using mathematics to describe various physical phenomena.
	PLO-4.4	Skilled in the use of Information and Communication Technology.
5. Long Life Learning	**PLO-5.1**	Skilled at identifying a Physics problem expressed in Physics concepts.
	PLO-5.2	Skilled in making conjectures/hypotheses on a physics problem.
	PLO-5.3	Skilled in planning and designing experiments in the field of physics and concluding the results of these experiments.
	PLO-5.4	Skilled in formulating the application of physics to solve natural problems and problems in human life both qualitatively and quantitatively.

4. LIST OF COURSES

The development of conceptual aspects can be carried out if the fields related to the theoretical concepts of physics and their supporting tools are mastered. Mastery of the theoretical concepts of physics includes mastery of the concepts and principles of the main branches of physics, namely classical mechanics, quantum mechanics, electromagnetics, statistical physics, atomic and molecular physics, nuclear and particle physics, incompressible matter physics, image physics, gravity and cosmology, and philosophy. Knowledge. Mastery of theoretical physics concepts can be achieved if the tools that support the mastery of theoretical physics concepts are also developed. These supporting tools are tools for obtaining information, measuring, modeling, and analyzing phenomena taught theoretically, computationally, experimentally, and observation (observation). These tools are the principles and applications of mathematical methods, measurement methods (instrumentation), and computational methods. Another tool that needs to be developed is mastering processing and analyzing data from observations and experiments. Efforts to master the fields of physics and its supporting tools are described in compulsory courses in the Physics Undergraduate Study Program, Department of Physics. (Source IQF Standard Curriculum Physics and Physics education).

In addition to fields related to the main branches of physics, the fields of study in the Physics Study Program at the Physics Department are areas of expertise based on the main branches of physics. This field of expertise seeks to understand natural phenomena from the point of view of specific skills. These areas of expertise are:

1. Field of theoretical physics and mathematics with fields of study: cosmology, particle physics, and mathematical formulas for natural phenomena.
2. Computational fields with study areas: complex systems, emergent quantum material spectroscopy, DFT computations, particle interactions in the matter, and computational physics for education and teaching.
3. Spectroscopy and acoustics with fields of study: photoacoustics for medicine, thermoacoustics, and acoustic energy harvesting.
4. Image and medical physics with study areas: Radiography and Computed Tomography (CT) Scans with gamma rays and X-Ray (ionizing radiation), Optical Coherence Tomography (OCT) with lasers (non-ionizing radiation), and magnetic interactions with organs or body tissues.
5. Field of functional materials with areas of study: development of biomaterial systems, development of multifunctional materials based on nanoscience and technology and their applications (sensors, supercapacitors, magnetic nanoparticles, nanofibers, photocatalysts, etc.), computational material design (CMD) for novel-functional predictions materials.
6. Field of instrumentation with fields of study: metrology and calibration, sensor systems, data acquisition, and artificial intelligence systems.

4.1 List of Compulsory Courses

Semester	Code	Course	Credits		Prerequisites
			SKS	ECTS	
1	UNU 100X	Religion	2	3.2	None
	MMM 1101	Calculus I	3	4.8	None
	MKK 1101	Fundamental of Chemistry I	3	4.8	None
	MII 1201	Programming	3	4.8	None
	MFF 1011	General Physics I	3	4.8	None

	MFF 1061	Measurement Technique in Physics	2	3.2	None
	MKK 1111	Basic Chemistry Experiment I	1	1.6	None
	MFF 1020	Mathematical Physics I	3	4.8	None
	MFF 1013	Laboratory for General Physics I	1	1.6	None
Credits total			21	33.6	
2	MFF 1012	General Physics II	3	4.8	None
	UNU 1010	Pancasila	2	3.2	None
	MFF 1024	Numerical Method	2	3.2	None
	MFF 1850	Electronics	3	4.8	None
	MFF 1014	Laboratory for General Physics II	1	1.6	None
	MFF 1401	Mechanics I	2	3.2	General Physics I (MFF1011), Calculus I (MMM1101)
	MFF 1053	Thermodynamics	3	4.8	General Physics I (MFF1011), Calculus I (MMM1101), Mathematical Physics II (MFF1021)
	MFF 1405	Waves	2	3.2	General Physics II (MFF1021*)
	MFF 1021	Mathematical Physics II	3	4.8	General Physics I (MFF1011), Mathematical Physics I (MFF1020)
Credits total			21	33.6	
3	MFF 2415	Electromagnetics I	2	3.2	General Physics II (MFF1012), Mathematical Physics I (MFF1020)
	MFF 2027	Computational Physics	2	3.2	Numerical Method (MFF1024), Calculus I (MMM1101)
	MFF 2851	Electronics Practicum**)	1	1.6	Electronics (MFF1850*)
	MFF 2028	Numerical Method Practicum**)	1	1.6	Numerical Method (MFF1024)
	MFF 2034	Quantum Physics I	3	4.8	Mechanics I (MFF1401)
	MFF 2024	Mathematical Physics III	3	4.8	Calculus I (MMM1101), Mathematical Physics I (MFF1020), Mathematical Physics II (MFF1021)
	MFF 2402	Mechanics II	2	3.2	Mechanics I (MFF1401)
	MFF 2031	Relaivity Theory	2	3.2	Mechanics I (MFF1401)
	MFF 2051	Statistical Physics	3	4.8	Thermodynamics (MFF1053), Quantum

					Physics I (MFF2034*)
	MFF 2062	Lab Assignments**)	1	1.6	Laboratory for General Physics II (MFF1014)
Credits total			20	32	
4	MFF 2310	Atomic and Molecular Physics	3	4.8	General Physics II (MFF1012), Quantum Physics I (MFF2034), Relativity Theory (MFF2031*), Statistical Physics (MFF2051)
	MFF 2410	Electromagnetics II	2	3.2	Mathematical Physics II (MFF1021), Electromagentics I (MFF2415)
	MFF 2033	Modern of Physics Practicum**)	1	1.6	Laboratory for General Physics II (MFF1014)
	MFF 2035	Quantum Physics II	3	4.8	Quantum Physics I (MFF2034)
	MFF 2601	Solid State Physics I	2	3.2	Quantum Physics I (MFF2034)
	MFF 2205	Nuclear and Particle Physics I	2	3.2	Quantum Physics I (MFF2034), Atomic and Molecular Physics (MFF2310), Relativity Theory (MFF2031*), Statistical Physics (MFF2051)
	MFF 2313	Atomic and Molecular Physics Experiments	1	1.6	Atomic and Molecular Physics (MFF2310)
	UNU 3000	Citizenship	2	3.2	None
	MFF 2060	Research Methodology and Scientific Communication**)	3	4.8	Minimum 50 Credits
Credits total			19	30.4	
5	MFF 3015	Philosophy of Physics	2	3.2	None
	MFF 3411	Modern of Optics	2	3.2	Waves (MFF1405), Quantum Physics I (MFF2034)
	MFF 3206	Nuclear and Particle Physics II	2	3.2	Nuclear and Particle Physics (MFF2205)
	MFF 3608	Solid of Physics II	2	3.2	Solid State Physics I (MFF2601)
	MFF 3204	Nuclear Physics Laboratory**)	1	1.6	Nuclear and Particle Physics (MFF2205)
	MFF 3602	Solid State Physics Laboratory**)	1	1.6	Solid State Physics I (MFF2601)
	UNU 4500	Community Service Program**)	3	4.8	Follow university rules
Credits total			13	20.8	
6					

7	MFF 4011	Final Project A**)	2	3.2	Research Methodology and Scientific Communication**) (MFF2060), Minimum 100 Credits
Credits total			2	3.2	
8	MFF 4013	Final Project B**)	4	6.4	Research Methodology and Scientific Communication**) (MFF2060), Final Project A (MFF4011*), Minimum 100 Credits
Credits total			4	6.4	

Sign description:
The * sign in the prerequisites states that the course can be taken together with the required courses.
The ** sign in the course name indicates that the course is offered in two semesters, odd and even.
UNU 100X Religion course, the letter X follows the following rules:
UNU 1000 = Religion of Islam
UNU 1001 = Catholic Religion
UNU 1002 = Christianity
UNU 1003 = Hindu Religion
UNU 1004 = Buddhism
UNU 1005 = Confucianism

4.2 List of Elective Courses

Semester	Code	Courses	Credits		Prerequisites
			SKS	ECTS	
ODD	MFG 1101	Introduction to Geophysics	2	3.2	None
	MFF 2061	Metrology and Calibration of Physics	3	4.8	Measurement Technique in Physics (MFF 1061)
	MFF 2071	Instrumentation System	2	3.2	Electronics (MFF 1850)
	MFF 2853	Sensor System	2	3.2	Electronics (MFF 1850)
	MFF 2873	Image of Physics	2	3.2	None
	MFF 2953	Celestial Mechanics	2	3.2	Mechanics I (MFF 1401)
	MFF 2029	Mathematics Theoretical of Physics I	2	3.2	None
	MFF 3053	Physics of Complex and Nonlinear Systems	2	3.2	Numerical Method (MFF 1024), Atomic and Molecular Physics (MFF 2310)
	MFF 3291	Nuclear and Particle Detection Method	2	3.2	Atomic and Molecular Detection Method (MFF 2322)
	MFF 3423	Introduction to Laser of	2	3.2	Electromagnetics I (MFF

		Physics			2415), Quantum Physics I (MFF 2034), Atomic and Molecular Physics (MFF 2310)
	MFF 3701	Medical of Physics	2	3.2	General Physics I (MFF 1011), General Physics II (MFF 1012)
	MFF 3843	Microwave	2	3.2	Electromagnetics I (MFF 2415), Mathematical Physics III (MFF 2024)I
	MFF 3871	Tomography of Physics	2	3.2	None
	MFF 3891	Environmental of Physics	2	3.2	None
	MFF 4033	Quantum Mechanics	2	3.2	Quantum Physics I (MFF 2034)
	MFF 4611	Liquid Crystal of Physics and Polymers	2	3.2	None
	MFF 4893	Introduction to Econophysics	2	3.2	None
	MFF 4043	Introduction to Astrophysics and Cosmology	3	4.8	Nuclear and Particle Physics I (MFF 2205)
		Internship	2	3.2	None
EVEN	MFF 1064	Graphical Methods in Physics	2	3.2	None
	MFF 1528	Simulation and Visualization in of Physics	2	3.2	None
	MFF 2070	Microcontroller and Interfacing	2	3.2	Electronics (MFF 1850)
	MFF 2322	Atomic and Molecular Detection Method	2	3.2	Atomic and Molecular Physics (MFF 2310)
	MFF 3002	Science and Religion	2	3.2	None
	MFF 3024	Capita Selecta Computational Physics	2	3.2	Computational Physics (MFF 2027)
	MFF 3030	Mathematics Theoretical of Physics II	2	3.2	None
	MFF 3114	Introduction to Particle of Physics	2	3.2	Nuclear and Particle Physics II (MFF 3206)
	MFF 3284	Reactor of Physics	2	3.2	Nuclear and Particle Physics I (MFF 2205)
	MFF 3288	Radiation Protection	2	3.2	Nuclear and Particle Physics I (MFF 2205)
	MFF 3436	Modern Acoustics	2	3.2	None
	MFF 3680	Introduction to Nanoscience	2	3.2	Atomic and Molecular Physics (MFF 2310)
	MFF 3810	Capita Selecta in Material Physics	2	3.2	Solid State Physics I (MFF 2601)
	MFF 3812	Materials Analysis	3	4.8	Solid State Physics I

		Method			(MFF 2601), Quantum Physics I (MFF 2034)
	MFF 3820	Computational Material of Physics	3	4.8	Computational Physics (MFF 2027), Solid State Physics I (MFF 2601)
	MFF 3872	Biophysics	2	3.2	Thermodynamics (MFF 1053), Waves (MFF 1405)
	MFF 3876	Radiographic of Physics	2	3.2	None
	MFF 3882	Energy	2	3.2	Thermodynamics (MFF 1053), Waves (MFF 1405)
	MFF 3892	Science and Technology Entrepreneurship	2	3.2	None
	MFF 4034	Advanced Quantum Mechanics	2	3.2	Quantum Physics I (MFF 2034)

5. SEMESTER LEARNING ACTIVITY PLANS (SLAP)

1. UNU 100X - Religion

Module Name	**Religion**
Code	UNU 100X
Semester(s) in which the module is taught	ODD semester
Module designation	Preparation stage
Person responsible for the module	Drs. Sunarta, MS.
Lecturer	Drs. Sunarta, MS.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 1** - Attitude. Have faith and fear of God Almighty, and apply good morals, ethics, initiative, and responsibility in completing their duties.
Course outcomes (CO)	**CO 1** : Students can manifest a good attitude (noble character) in studying the truth, including glorifying and glorifying the scientific council that teaches the Word of God and the words of the Prophet SAW as a source of truth. Students justify and believe in the Word of Allah SWT and the words of the Prophet SAW, which will be proven in their attitudes & actions as well as in preaching to others. **CO 2** : Students realize & can explain the purpose of their lives in this world, and as servants of Allah, they can carry out their obligations. In contrast, as the Ummah of the Prophet, SAW students can assume

	their responsibilities as preachers. Students can explain & distinguish between the purpose of life and the necessities of life. **CO 3** : Students can realize that life in this world is temporary & very short compared to the very long journey of life after death. However, this short life greatly determines their success, happiness, and safety from this world to the hereafter, which is eternal. That way, students can make the right decisions about what to live in this world. **CO 4** : Students believe in & use "Religion" as a fundamental cause to fulfill their life's needs and, solve their life problems in this world and fortify the dangers that may come in their lives without eliminating external causes, even trying to fulfill maximally the external causes that are understood by those who deserve it, man. **CO 5** : Students can explain that Islam is a mercy for Muslims and the whole world. Students understand how to realize Islam, that is, Rohmatan Lil 'Alamin. **CO 6** : Students realize that an essential part of a human being is his heart and believe that to shape personality, character & character as well as mental & morals, he must work on his heart. If the heart is good, it will produce good deeds (what is seen, heard, spoken about, thought about, decided on, and what is done is all good). Students can manage the heart (soul) to produce true faith and noble qualities. **CO 7** : Students can identify who a believer is, and students can believe that people who are successful & safe in driving digital-based science and technology advancements (numbers 0 and 1) are people who have digital-based IMTAQ, namely people whose lives believe in Laa ilaha illallah, which means there is no God (0) other than Allah (1). **CO 8** : Students can recognize ways to improve themselves, their families, and communities in villages, cities & countries, as well as the ummah throughout nature, which comes from the Creator of humans, who is All-knowledgeable and All-Wise, whose truth is guaranteed by the Truest Essence (Haq), namely Allah SWT. **CO 9** : Students are aware of & able to explain the concept that Hijroh & Nushroh is the basis for everything to progress and develop. This is the method Allah gave to the Prophet SAW to educate his Ummah to carry out the mission of religion so that it spreads to all human beings throughout nature and overcomes chaos & corruption, including erosion of faith, moral decadence, and extremities on earth. To achieve this, Hijroh & Nushroh activities must be carried out to

	propagate religion. **CO 10** : Students can distinguish between da'wah activities and ta'lim activities. Today, most are confused about understanding that da'wah requires much knowledge or must be 'alim,' a requirement for people who teach / study/teaching. **CO 11** : Students understand and practice that to know Allah requires ma'rifatullah effort, which is not enough with the effort of knowledge about Allah / knowing Allah's names in Asmaul Husna but must go through the mujahadah process in da'wah. **CO 12** : Students realize and believe that the victory of the Muslim ummah is only if there is the help of Allah (nushrotullah). Students can identify when Muslims win when Muslims lose.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Al-Qur'an and its commentary, free author, free publisher. 2. “Perjalanan Hidup Rasul yang Agung MUHAMMAD SAW” oleh Syaikh Shafiyur- Rahman al-Mubarokfury, Penerbit Darus Haq, 1427H / 2006M, Jakarta. 3. “Kembali kepada Al-Qur’an dan Sunnah” oleh K.H. Munawar Kholil, Penerbit PT Bulang Bintang, 1984M, Jakarta. 4. “Terjemah Riyadhus-Shalihin” oleh Drs. Muslich Shabir, penerbit CV Thoha Putra, 1981, semarang.

Content	1. The manners or order must be fulfilled to examine the truth; Formation of character/attitude of learning. 2. Purpose of life and necessity; Human obligations and responsibilities. 3. The long journey of human life and the purpose it was created in the world. 4. Fadhoil & the benefits of religion in the world. 5. The virtues & benefits of religion in the world. 6. The method of managing the soul so that it gives birth to noble qualities; humans are moral, character & character. 7. Metode pengelolaan jiwa agar melahirkan sifat-sifat mulia (Tazkiyatun nufus); Manusia bermoral, berwatak & berkarakter. 8. What is the definition of a believer? Faith digital taqwa is the principle of the success of the ummah. 9. What is the definition of a believer? Faith digital taqwa is the principle of the success of the ummah. 10. Islamic struggle to solve the problems of the ummah; prophetic mission 11. Hijrah and Nusroh the principle of everything to progress & develop. 12. Methods of overcoming the erosion of faith and moral decadence. 13. Do have to be pious first?; The difference between da'wah and ta'lim. 14. Efforts to know Allah (ma'rifatullah).
Examination forms	***Cognitive* :** Midterm Exam, Final Exam ***Psychomotor* :** Assistance ***Affective* :**

2. MFF 1011 - General Physics I

Module Name	**General Physics I**
Code	MFF 1011
Semester(s) in which the module is taught	ODD semester
Module designation	Preparation stage
Person responsible for the module	Dr. Mitrayana
Lecturer	Dr. Mitrayana., Dr. Moh. Ali Joko., Dr. Eko S., Dr. Mirza S.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions

	to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Explain concepts and solve cases in the motion of objects. **CO 2** : Explaining concepts and solving cases in fluids, waves, and heat.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Halliday, D. Resnick, R and Walker, J., 2018, Fundamentals of Physics: Extende, tenth edition, John Wiley & Sons, Inc. USA. 2. Tipler, P. A. Mosca, G., 2008, Physics for Scientists and Engineers, sixth edition, W. H. Freeman and Company, New York, USA. 3. Serway, R.S. dan Jewett, 2014, Physics for Scientists and Engineers, ninth edition, Brooks/Cole Cengage Learning, 4.

Content	1. Introduction: Explanation of RPKPS, physical quantities, dimensions, units, and vectors 2. Linear Motion: 1D Motion, GLB, GLBB, Free fall motion. 3. Newton's Laws and Forces: The concept of force, Newton's Laws. 4. Work, Power, and Energy 5. Linear momentum and angular momentum: collisions and moments of inertia. 6. Rotational Dynamics of Rigid Bodies. 7. Kesetimbangan dan Elastisitas. 8. Gravity. 9. fluid. 10. Vibration. 11. Wave. 12. Sound. 13. heat 1 14. heat 2
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam ***Psychomotor*** **:** ***Affective*** **:**

3. MFF 1061 - Measurement Technique in Physics

Module Name	Measurement Technique in Physics
Code	MFF 1061
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs., Sunarta, M.S.
Lecturer	Drs., Sunarta, M.S.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Having a "common sense" of measurement is high. **CO 2** : Mastering the process of analyzing measurement data and using measuring methods appropriately. So get accurate results. **CO 3** : Able to conduct rejection of measurement results data that is suspected of deviation from the expected data. **CO 4** : Able to analyze data with correct regression. **CO 5** : Able to compare the results of multiple methods, choose the best method, and produce a weighted value. **CO 6** : Able to appropriately develop measurement methodology and selecting instruments for object detection.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Taylor, J. R.1992. An Introduction to Error Analysis. University Science Book.California. 2. Bevington, P. R.1999. Data Reduction and Error Analysis for the Physical Science. Mc Graw-Hill Book Co. 3. Dulfer G, H & Fadeli., 1974. Metode Pengukuran & Analisa Data; FIPA-UGM. 4. Darmawan Djonoputro; 1984. “Teori Ketidakpastian Menggunakan satuan SI”; ITB.Bandung. 5. Staf Lab. Fisika Dasar, Jurusan Fisika-FMIPA UGM; 2012; “Petunjuk Praktikum Fisika Dasar Jurusan Fisika”; FMIPA-UGM Yogyakarta.

	6. Sunarta; Laporan LIT-2017 “Metode Jembatan Wheatstone untuk deteksi besaran Kelistrikan”; Dana Masyarakat UGM tahun 2017.
Content	1. Pengantar Metode Pengukuran Fisika (Pentingnya Eksperimen dalam ilmu fisika “Common sense” dalam pengukuran; Ralat pengukuran; Jenis ralat dan sumbernya). 2. Metode Penentuan Ralat Pengamatan (Pengukuran tunggal dan taksiran ralatnya; Pengukuran ber-ulang; Standar deviasi & Standar nilai rata-2; Program SD pada calculator). 3. Metode Perambatan Ralat (Teori perambatan ralat; Ralat gayut & tak-gayut; Rumus-rumus ralat perambatan; Rumus-rumus khusus perambatan). 4. Metode Penyajian Hasil Akhir (Metode penyajian mutlak(absolute); Metode penyajian relatif; Angka ber-arti dan metode pembulatan). 5. Grafik Pengamatan (Mengenal sumbu-sumbu grafik; Metode penarikan garis grafik; Besaran-besaran grafik linear; Ralat grafik; Metode max/min pada penentuan ralat gradient). 6. Metode Regresi (Linearitas persamaan; Rumus regresi linear; Ralat regresi; Contoh penggunaan metode regresi). 7. Kurva-kurva data pengamatan (Histogram dan fungsi distribusi; Fungsi distribusi gauss; Probabilitas pengukuran; Tabel Prosentase Probabilitas P(σ) dan Q(σ)). 8. Metode Penolakan data (Pengertian Penolakan Data Pengukuran; Kriteria Penolakan Data; Metode tσ; Metode “chauvenet”; Contoh Aplikasi penolakkan). Perbandingan metode Ukur (Syarat membandingkan metode ukur; Diskripansi hasil ukur; Nilai berbobot dari berbagai metode ukur; Ralat berbobot; Contoh aplikasi). Logbook dan Laporan Penelitian (Judul/topic eksperimen;

	Tujuan eksperimen; Dasar teori/Hypotesis; Peralatan dan metode pengamatan; Pengolahan data dan grafik pengamatan; Pembahasan dan kesimpulan; Saran-saran).
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor* :** ***Affective* :**

4. MFF 1020 - Mathematical Physics I

Module Name	**Mathematical Physics I**
Code	MFF 1020
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Agung B S Utomo, SU.
Lecturer	Prof. Dr. Agung B S Utomo, SU., Dr. Eko Sulistya, M. Si., Dr. Budi Eka Nurcahya, M. Si., Ikhsan Setiawan, S.Si., M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems.

	PLO 4 - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies.
Course outcomes (CO)	**CO 1** : Explain the concepts of Complex Algebra, Complex Roots, Powers of Complex Numbers, and Trigonometric Functions and their hyperbolic functions. **CO 2** : Explain Harmonic Series and Complex Series. **CO 3** : Explain Partial Derivative, Total Derivative, and Height/Extremum Value Derivation. **CO 4** : Explaining two-dimensional (parabola, ellipse, and hyperbola) and three-dimensional (paraboloid, ellipsoidal, and hyperboloidal) Geometry analytics. **CO 5** : Explains Vector algebra, dot product, and cross product. **CO 6** : Explains vector calculus, vector derivation, and integration. **CO 7** : Explaining vector, gradient, divergence, and rotation operators and cylindrical and spherical coordinates. **CO 8** : Explain the integration of lines, planes, and volumes. **CO 9** : Explain gradient integration, divergence, and rotation as well as Stokes' theorem and Gauss' theorem.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. K. F. Riley, M. P. Hobson and S. J. Bence, 2006, Mathematical methods for physics and engineering, edisi ketiga, Cambridge University Press, Cambridge. 2. Tom M. Apostol, Calculus, jilid I, edisi kedua, John Wiley & Sons, 1967. 3. Tom M. Apostol, Calculus, jilid II, edisi kedua, John Wiley & Sons, 1967. **Additional References :** 1. Boas, M.L., 1983, Mathematical Methods in the Physical Sciences, edisi 2, John Willey & Sons, NY. 2. Thomas G.B. dan Finney R.L., 1995, Calculus and Analytic Geometry, Addison Wesley.
Content	1. Introduction (Lecture rules, exams, and assessments). 2. Complex numbers (concept of complex numbers, complex number algebra, complex conjugates, polar representation de Moivre's theorem, complex roots, polynomial equations, logarithms, and powers of complex numbers 3. hyperbolic functions: definition, hyperbolic trigonometric functions, hyperbolic identities, hyperbolic equations, inverse hyperbolic functions, calculus of hyperbolic functions), 4. Series, harmonic or complex series. 5. Partial Derivatives (multivariable functions, definitions of partial derivatives, total and differential derivatives, exact and inexact differentials, essential theorems, chain rule, variable changes, Taylor series, extreme values), 6. Analytical Geometry (curves and surfaces, parametric, implicit, and explicit equations. 7. Conic sections (parabola, hyperbola, ellipse), three-dimensional shapes (parabola, hyperbola, ellipsoid, spheroid). 8. Vector Algebra (scalars and vectors, vector addition and subtraction, multiplication by scalars, basis vectors and vector components, magnitude of a vector, dot product, cross

	product, equation of line, equation of plane, surface of a sphere, determining distance to vector, reverse vector), 9. Vector calculus (vector derivative concerning a parameter, vector integration concerning a parameter, curves, and surfaces in space, vector fields and scalar fields, isoscalar surfaces, 10. Vector operators: gradient, divergence, rotation. important formulas, cylindrical coordinates and spherical coordinates, curved coordinate systems, 11. Line and surface integrals, connectivity of a region, Green's theorem on a plane, sustainable and potential fields, volume integral 12. Integral forms of gradient, divergence, and rotation 13. (continued) gradient, divergence, and integral rotation forms. 14. Stokes and Gauss theorem
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

5. MFF 1013 - Laboratory for General Physics I

Module Name	Laboratory for General Physics I
Code	MFF 1013
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.Sc. Ari Dwi Nugraheni, S.Si., M.Si.
Lecturer	Dr.Sc. Ari Dwi Nugraheni, S.Si., M.Si., Dr. Eko Sulistya, M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the

	results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain the concepts that underlie optical phenomena and relate them to the basic concepts [PLO 2 PLO 4 PLO 5]. **CO 2** : Students can explain the concepts of electrical phenomena and relate them to the basic concepts obtained. [PLO 2 PLO 4 PLO 5]. **CO 3** : Students can explain the concepts of mechanical phenomena and relate them to the basic concepts obtained [PLO 2 PLO 4 PLO 5]. **CO 4** : Students can convey their experiments' results in a written report [PLO 3]. **CO 5** : Students can work individually or in groups in experiments [PLO 3].
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Buku Panduan Praktikum Fisika Dasar II

Content	1. Gravity acceleration 2. Coefficient of long expansion 3. Boyle's Law 4. Water Cooling 5. Muffled vibration 6. Spring constant 7. The flow of water in the capillary tube 8. Stem oscillation 9. Equivalence of Heat-Electricity
Examination forms	***Cognitive*** **:** Pretest, Final test ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report**

6. MFF 1012 - General Physics II

Module Name	General Physics II
Code	MFF 1012
Semester(s) in which the module is taught	EVEN semester
Module designation	Preparation stage
Person responsible for the module	Dr. Rinto Anugraha NQZ
Lecturer	Dr. Rinto Anugraha NQZ
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can master the concepts, theories, and laws of physics, especially on electricity, magnetism, electromagnetic waves, optics, and modern physics, then formulate them in mathematical formulas, solving physics problems related to the topics above. [PLO 2, PLO 5]. **CO 2** : Students can explain various scientific phenomena in nature and in everyday life related to topics on electricity, magnetism, electromagnetic waves, optics, and modern physics based on the concepts, theories, and laws of physics that have been taught. [PLO 2, PLO 5]. **CO 3** : Students can study advanced fields of physics based on the fundamental physics knowledge that has been taught. [PLO 2, PLO 5].
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Halliday, D., Resnick, R and Walker, J., 2018, Fundamental of Physics, Fundamental of Physics Extended, Edisi 11, John Wiley & Sons, Inc, USA. 2. Tipler, P.A., 2008, Physics for Scientists and Engineers, sixth edition, W. H. Freeman and Company, New York, USA 3. Raymond A. Serway, dan John Jewett, 2014, Physics for Scientists and Engineers, Brooks/Cole Cengage Learning, Singapore.

Content	1. Electrostatics I (Electric Charge and Coulomb's Law, Electric Field, Gauss's Law, Conductors). 2. Electrostatics II (Electric Potential, Electric Potential Energy, Capacitance, and Dielectric). 3. Dynamic electricity (Electric current, Electrical Resistance, Electrical power, Electrical measuring instruments, Kirchhoff's Laws, RC Circuits). 4. Magnetism I (Magnetic Field, Magnetic Force, Biot-Savart Law, Ampere's Law, Gauss's Law in Magnets, Magnetism in Matter). 5. Magnetism II (Faraday's Law, Lenz's Law, Induction and Inductance, RL and RLC Circuits, Energy in a Magnetic Field, AC Current, Power in AC Circuits). 6. Maxwell's Equations (Shifting Currents, Maxwell's Equations in Vacuum and Matter). 7. Electromagnetic Waves (Field Electromagnetic Waves, Electromagnetic Wave Spectrum). 8. Light and Optical Rays (Properties of Light, Speed of Light, Huygens Principle, Dispersion). 9. Geometric Optics (Snell's Law, Formation of an image by reflection, Formation of an image by refraction, Optical Tools). 10. Physical Optics (Light as a wave, Light interference, Light diffraction). 11. Modern Physics I (Galileo's Relativity, Michelson-Morley Experiment, Einstein's Postulates, Lorentz Transformation, Relativistic Momentum and Energy, Mass and Energy). 12. Modern Physics II (Black Body Radiation, Planck's Quantum Theory, Photoelectric Effect, Compton Effect, Uncertainty Principles, Atomic Models, Lasers, Atomic Nuclei, Radioactivity, Nuclear Reactions). 13. Modern Physics III (Astrophysics and Cosmology). 14. Modern Physics IV (Electrical properties of solids, Semiconductors, Diodes and Transistors, Superconductors).

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

7. MFF 1024 - Numerical Method

Module Name	Numerical Method
Code	MFF 1024
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Pekik Nurwantoro, M.S., Ph.D
Lecturer	Drs. Pekik Nurwantoro, M.S., Ph.D., Dr. Fahrudin Nugroho., Dr. Iman Santoso., Dr. Eko Sulistyo
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out

	experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in these physics problems through various tricks or specific mathematical procedures and utilize various approximations. **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. J. Kiusalaas, 2013, Numerical Methods in Engineering with Python 3, Cambridge University Press, ISBN 978-1-107-03385-6 2. Curtis F. Gerald dan Patrick O Wheatley, 2004, Applied Numerical Analysis, 7th Eddition, Addison Wesley 4. A. B. Setio Utomo, 2016, Pengantar Metode Komputasi untuk Sains dan Teknik, UGM Press, ISBN: 978-602-386-091-3 5. Sholihun dan Zohan Syah Fatomi, 2021, Pemrograman dan Komputasi Numerik Menggunakan Python, UGM Press, ISBN: 978-602-386-957-2
Content	1. An introduction to numerical methods, some of the necessary tools, and a brief review of programming languages 2. Explanation regarding number representation, discretization, and an overview of approximation steps (approach or approximation). 3. An understanding of the accuracy of numerical calculations and their relation to computer performance. 4. Explanation of various methods for evaluating function values based on the series method. 5. Explanation of various methods for evaluating function values based on recurrence links. 6. The bisection method is the explanation for calculating the zero point or finding the roots of any function without involving the derivative of the function. 7. Explanation of calculating the zero point or finding the roots of any function by involving the derivative of the function, namely the Newton-Raphson method 8. Explanation of the method of calculating integral values in a numerical discretization with various integral forms and integral limits 9. Explanation of the method of calculating integral values in numerical quadrature with various integral forms and integral limits

	10. Explanation of the matrix evaluation method for solving a set of simultaneous equations 11. Explanation of the matrix evaluation method for solving eigenvalue problems 12. Explanation of the finite difference approach for approximating the derivative of any function 13. Explanation of the finite difference approach for approximating the solution of the differential equation in the initial condition problem 14. Explanation of the finite difference approach for approximating the solution of the equation
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

8. MFF 1850 - Electronics

Module Name	Electronics
Code	MFF 1850
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eng. Ahmad Kusumaatmja, S.Si., M.Sc.
Lecturer	Dr. Eng. Ahmad Kusumaatmja, S.Si., M.Sc.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can apply the fundamental laws of circuits and their analysis methods to direct current (DC) electric circuits. **CO 2** : Students can analyze the use of capacitors and inductors. **CO 3** : Students can analyze the use of diodes and transistors. **CO 4** : Students can use operational amplifiers according to their characteristics and functions. **CO 5** : Students can apply the concept of digits, number systems (codes), and converters. **CO 6** : Students can apply digital electronics concepts to operational amplifiers and logic gates (truth tables). **CO 7** : Students can understand various combinations of logic.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Horowitz, Paul, and Winfield Hill. 2015. The Art of Electronics. 3rd ed. Cambridge, TAS, Australia: Cambridge University Press. 2. Sadiku, M.N.O., dan Alexander, C.K., 2016, Fundamentals of Electric Circuits, 5th edition, The McGrawHill Companies, Inc. 3. Wang, M., 2010, Understandable Electric Circuits, The Institution of Engineering and Technology, London, United Kingdom. 4. Tokheim, R.L., 1995, Elektronika Digital, edisi kedua, Erlangga, Jakarta.

Content	1. Basic Concepts 2. Basic Laws 3. Circuit Analysis Methods and circuit simulation software 4. Theorem on circuits 5. Diodes and Transistors 6. O.P. Amps 7. RLC circuit 8. AC circuit Circuit Analysis Method on AC Current 9. Digital Electronics Number System 10. Multivibrator Basic logic gate circuit 11. Flip-flop Counter multiplexer PLD (Programmable Logic Devices)
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor* :** Project Results ***Affective* : Attendance**

9. MFF 1014 - Laboratory for General Physics II

Module Name	Laboratory for General Physics II
Code	MFF 1014
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.Sc. Ari Dwi Nugraheni, S.Si., M.Si.
Lecturer	Dr.Sc. Ari Dwi Nugraheni, S.Si., M.Si., Drs. Yosef Robertus Utomo, S.U.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out

	experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain concepts based on optical phenomena and relate them to the basic concepts [PLO 2 PLO 4 PLO 5]. **CO 2** : Students can explain the concepts of electrical phenomena and relate them to the basic concepts obtained. [PLO 2 PLO 4 PLO 5] **CO 3** : Students can convey the results of their experiments in the form of a written report [PLO 3] **CO 4** : Students can work either individually or in groups in carrying out experiments [PLO 3]
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 6. Buku Panduan Praktikum Fisika Dasar II 7. Wilson, J.D.,& Hernandez, C.A.,2014, Physics Laboratory Experiments, 7th ed, BROOKS/COLE Cengage Learning, USA. 8. Kraftmakher, Y., 2015, Experiments and Demonstrations in Physics, 2nd ed., World Scientific Publishing Co. Pte. Ltd..

Content	1. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 2. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 3. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 4. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 5. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 6. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 7. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 8. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 9. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 10. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 11. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law

	12. Newton's ring, Measurement of electric power, Photometry, Measurement of Refractive Index, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 13. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law 14. Newton's Rings, Electrical power measurement, Photometry, Refractive Index Measurement, Earth's Magnetic Field, Oscilloscope, Stefan's Law, Ohm's Law
Examination forms	***Cognitive*** **:** Pretest, Final test ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report**

10. MFF 1401 - Mechanics I

Module Name	Mechanics I
Code	MFF 1401
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Mitrayana
Lecturer	Dr. Mitrayana., Drs. Imam Suyanto, M. Si., Dr. Yosef Robertus Utomo, S. U., Ibnu Jihad, S. Si., M. Sc.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics I (MFF1011), Calculus I (MMM1101)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Explain and solve cases of dynamics of single-body motion **CO 2** : Explain and solve cases of dynamics of motion of many bodies and rigid bodies .
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Fowles & Cassiday (1993), Edisi 7; Analytical Mechanics. 2. David Morin (2004); Introductory Classical Mechanics, with Problems and Solutions. 3. Qiang Yuan-qi dkk. (!994); Problems and Solutions on Mechanics; Major American University Ph. D. Qualifying Questions and Solution.
Content	1. Basic Concepts and Vectors: measures of space and time: units and dimensions, vectors, multiplication of scalars, multiplication of vectors, Examples of Multiplication of vectors: Moment of Force, Multiplication of Three vector quantities, 2. Changes in Coordinate Systems: Transformation Matrices, Vector Derivatives, Particle Position Vectors: Velocity and Acceleration in Perpendicular Coordinates, Velocity, and Acceleration in Plane Polar Coordinates, Velocity and Acceleration in Cylindrical and Spherical Coordinates. 3. Newton's Mechanics and Reciprocal Motion of Particles: Newton's Laws of Motion: An Introduction to History, Straight Motion: Uniform

	Acceleration Under Constant Force, 4. Position-dependent force is kinetic and potential energy; velocity-dependent force is fluid resistance and terminal velocity. 5. Oscillation: Linear Reverse Force: Harmonic Motion, Overview of Energy in Harmonic Motion, Damped Harmonic Motion, Forced Harmonic Motion: Resonance. 6. The general motion of particles in three dimensions: Introduction: General Principles, Potential Energy Functions in Three Dimensional Motion: Del operator, Force of Separable Types: Projectile Motion, Harmonic Oscillators in Two and Three Dimensions, Motion of Charged Particles in Electric and Magnetic Fields, Constrained Particle Motion 7. Noninertial Reference Systems: Accelerated Coordinate Systems and Inertial Forces, Rotating Coordinate Systems, Particle Dynamics in Rotating Coordinate Systems, Effects of Earth's Rotation, Foucault's Pendulum. 8. Gravity and Central Force: Gravity Force between Uniform Spheres and Particles, Kepler's Laws of Planetary Motion, Kepler's Second Law: Equal Areas, Kepler's First Law: Ellipses, Kepler's Third Law: 9. Harmonic Law, Potential Energy in a Gravitational Field: Gravitational Potential, Potential Energy in the Central General Field, Orbital Energy Equation in the Central Field, Orbital Energy in the Inverse-Square Field, Limits of Radial Movement: Effective Potential, Near-Circular Orbit in the Central Field: Stability. 10. Particle system dynamics: Introduction: Center of Mass and Linear Momentum of the System, Angular Momentum and Kinetic Energy of the System, Motion of Two Interacting Objects: Reduced Mass, Collision, Oblique Collision, and Scattering: Comparison of Laboratory Coordinates and Center of Mass. 11. Rigid Body Mechanics: Planar Motion: Center of Mass of Rigid Bodies, Rotation of Rigid Bodies on Fixed Axis: Moment of Inertia, Calculation of

	Moment of Inertia, Physical Pendulum, Angular Momentum of Rigid Bodies in Laminar Motion, Examples of Laminar Motion of Rigid Bodies, Impulses and Collisions Involving Rigid Bodies 12. Calculation of Moment of Inertia, Physical Pendulum, Angular Momentum of Rigid Bodies in Laminar Motion, Examples of Laminar Motion of Rigid Bodies, Impulses, and Collisions Involving Rigid Bodies 13. The motion of Rigid Bodies in Three Dimensions: Rotation of Rigid Bodies about Any Axes: Moments and Products of Inertia—Angular Momentum and Kinetic Energy, Principal Axis of Rigids, Euler's Equations of Motion of Rigid Bodies, Free Rotations of Rigid Bodies: Geometric Description of Motion, Free Rotation of Rigid Bodies with Axis of Symmetry: Analytical Treatment, Description of Rigid Bodies Rotation Relative to a Fixed Coordinate System: Euler Angles, Movement from Above, Energy and Nutation Equations, Gyrocompass 14. Principal Axes of Rigid Bodies, Euler's Equation of Motion of Rigid Bodies, Free Rotation of Rigid Bodies: Geometric Description of Motion, Free Rotation of Rigid Bodies with Axis of Symmetry: Analytical Treatment, Description of Rotation of Rigid Bodies Relative to a Fixed Coordinate System: Euler's Angles.
Examination forms	***Cognitive* :** Midterm Exam, Final Exam ***Psychomotor* :** ***Affective* :**

11. MFF 1053 - Thermodynamics

Module Name	**Thermodynamics**
Code	MFF 1053
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Harsojo, SU., M.Sc.
Lecturer	Prof. Dr. Harsojo, SU., M.Sc., Mirza Satriawan, S.Si., M.Si., Ph.D.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics I (MFF1011), Calculus I (MMM1101), Mathematical Physics II (MFF1021)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems.

	PLO 5 - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can describe the state of balance of a system and the dynamics of its changes to changes in related variables. **CO 2** : Students can describe typical processes in changing the state of a system (forms: solid, liquid, and gas) in 2D diagrams. **CO 3** : Students can use exact and inexact differential equations to solve the problem of changing the system's state. **CO 4** : Students can apply the Laws of Thermodynamics I in reversible and non-reversible processes and their use in thermodynamic machines. **CO 5** : Students can apply the Laws of Thermodynamics II and the TDS Equation in calculating the entropy change of the universe and its use in thermodynamic machines. **CO 6** : Students can apply the concept of Thermodynamic Potential (including free energy and enthalpy) and its role in thermodynamic systems.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Greiner, W., dkk. 1997, Thermodynamic and Statistical Mechanics, Springer, New York. 2. Sears, F.W.,and Salinger, G.L, 1982, Thermodynamics, Kinetic Theory, and Statistical Thermodynamics, Addison-Wesley, Reading, massachussetts. 3. Zemansky,M.W., dan Ditman, 1984, Heat and Thermodynamics, McGraw-Hill, New York. 4. Dimsiki Hadi, Termodinamika, Diktat LPTK
Content	1. Basic Concepts: (1). System, environment, boundary. Definitions: Thermodynamic equilibrium: Macroscopic quantities. (2). State of a thermodynamic system Processes and cycles Basic principles of temperature, scale, and temperature measurement, Hk. 0th thermodynamics. (3). Pressure, Energy 2. Basic Concepts: (1). System, environment, boundaries. Definitions: Thermodynamic equilibrium: Macroscopic quantities. (2). The state of a thermodynamic system Processes and cycles Basic principles of temperature, scale, and temperature measurement, Hk. 0th thermodynamics. (3). Pressure,Energy 3. Equation of State 4. Situation Equation 5. (1). Partial Derivative. (2). Application of Partial Derivatives to Thermodynamic Systems: Coefficients of Cubic Expansion and Condensation. (3). Exact differential 6. (1). Work or Effort (2). Internal Power (Dakhil Power) (3). Heat / Heat Flow (4). Heat capacity, specific heat (5). First Law of Thermodynamics (6). Adiabatic Process (7). Carnot cycle. 7. (1). Work or Effort (2). Internal Energy (Dakhil Energy)

	(3). Heat Flow / Heat (4). Heat capacity, specific heat (5). First Law of Thermodynamics (6). Adiabatic Process (7). Carnot Cycle. 8. 2nd Law of Thermodynamics 9. Entropy 10. Statements about the 2nd Law of Thermodynamics 11. Thermodynamic machines 12. Helmholtz function and Gibbs function 13. balance and terms 14. 3rd Law of Thermodynamics
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** Project Results ***Affective*** **: Attendance**

12. MFF 1405 - Waves

Module Name	Waves
Code	MFF 1405
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Juliasih Partini
Lecturer	Dr. Juliasih Partini., Dr. Wiwit Suryanto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics II (MFF1021*)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can understand the basic phenomenological understanding of oscillations as the concept that underlies waves, both in mechanical and electromagnetic oscillations. (PLO 2, PLO 5). **CO 2** : Students can use wave differential equations to explain wave propagation. (PLO 2, PLO 5). **CO 3** : Students can describe and explain mechanical wave propagation in kinematics, wave dynamics, and wave energetics. (PLO 2, PLO 5). **CO 4** : Students can identify and explain the propagation of electromagnetic waves in a vacuum or medium and electromagnetic radiation. (PLO 2, PLO 5).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Hirose, A., dan K.E. Longren, 2010: Fundamental of wave phenomena, Edisi ke 2, John Wiley & Sons. 2. Pain., H.J., 2005: The physics of vibrations and waves, J. Wiley & Sons. 3. Zahara M., 1994: Gelombang dan optika, Proyek Pembinaan Tenaga Kependidikan PT, Ditjen DIKTI, Depdikbud.

Content	1. Oscillation 2. Wave Motion 3. Wave Motion 4. Mechanical Wave 5. Mechanical Wave 6. Sound waves travel through solids, liquids, and gases 7. Sound waves travel through solids, liquids, and gases 8. Wave Reflection and Standing Wave 9. Spherical Waves and Standing Waves 10. Doppler Effect on Sound Waves and Shock Waves 11. The Doppler Effect on Sound Waves and Shock Waves 12. Electromagnetic wave 13. Electromagnetic wave 14. Electromagnetic Wave Radiation
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

13. MFF 1021 - Mathematical Physics II

Module Name	**Mathematical Physics II**
Code	MFF 1021
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Prof. Agung B S Utomo, SU.
Lecturer	Dr. Prof. Agung B S Utomo, SU., Dr. Ing. Ari Setiawan, M.Si., Dr. Rinto Anugroho, NQZ, M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics I (MFF1011), Mathematical Physics I (MFF1020)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out

	experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies.
Course outcomes (CO)	**CO 1** : Can explain the concepts of matrices, determinants, special matrices, swavectors and self-values of a matrix, changes in basis, diagonals of matrices, systems of linear equations, and vector spaces. **CO 2** : Can explain the Fourier Series and Complex Fourier Series, the Fourier transform and its properties, the uncertainty principle, and the Dirac delta. **CO 3** : Can explain the Fourier series for odd and even functions, convolution, and deconvolution. **CO 4** : Can explain the Fourier transform for high dimensions. **CO 5** : Be able to explain the Laplace transform. Inversion of the Laplace transform and methods of solving differential equations with the Laplace transform. **CO 6** : Can explain ordinary differential equations (equations of the first degree, equations of the second degree, answers with sequences: ordinary and singular points, series around ordinary points, rows around singular points), **CO 7** : Can explain the press. Legendre, press. Hermite, press. Bessel, Etc. **CO 8** : Can explain partial differential equations (boundary conditions, variable separation, Fourier analysis, diffusion equations, heat propagation, and waves. **CO 9** : Can explain Integral Equations.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google

	Classroom)
Reading list	**Main References :** 1. K. F. Riley, M. P. Hobson and S. J. Bence, 2006, Mathematical methods for physics and engineering, edisi ketiga, Cambridge Press. 2. Tom M. Apostol, Calculus, jilid I, edisi II, John Wiley & Sons, 1967 3. Tom M. Apostol, Calculus, jilid II, edisi II, John Wiley & Sons, 1967. **Additional References :** 1. Boas, M.L., 1983, Mathematical Methods in the Physical Sciences, edisi 2, John Willey & Sons, NY. 2. Thomas G.B. dan Finney R.L., 1995, Calculus and Analytic Geometry, Addison Wesley.
Content	1. Matrix, determinant, special matrices, swavector and self-value of a matrix, the transformation of bases, diagonalization of a matrix, systems of linear equations, and vector spaces. 2. Matrices, determinants, special matrices, swavectors and self-values of a matrix, changes in basis, matrix diagonals, systems of linear equations, and vector spaces. 3. Fourier Series and Complex Fourier Series, Fourier transforms and their properties, uncertainty principle, Dirac delta. 4. Fourier and Complex Fourier series, the Fourier transform and its properties, the uncertainty principle, and the Dirac delta. 5. Series of Functions for Functions odd and even, convolution and deconvolution 6. Fourier transform for high dimensions. 7. Laplace transform (Laplace transform for derivatives and integrals, properties of Laplace transform). 8. Laplace transform (Laplace transform for derivatives and integrals, properties of Laplace

	transform). 9. Ordinary differential equations (equations of degree one, equations of degree two, answers with sequences: ordinary and singular points, series around ordinary points, series around singular points. 10. Ordinary differential equations (equations of degree one, equations of degree two, answers with sequences: ordinary and singular points, series around ordinary points, series around singular points. 11. press. Legendre, press. Hermite, pers. Bessel, etc. 12. Introduction to partial differential equations (boundary conditions, separation of variables, Fourier analysis, equations of diffusion and heat propagation, wave equations, 13. Introduction to partial differential equations (boundary conditions, separation of variables, Fourier analysis, equations of diffusion and heat propagation, wave equations, 14. Integral Equation
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

14. MFF 2415 - Electromagnetics I

Module Name	Electromagnetics I
Code	MFF 2415
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Wagini R., M.S.
Lecturer	Drs. Wagini R., M.S., Idham Syah Alam, S.Si., M.Sc.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics II (MFF1012), Mathematical Physics I (MFF1020)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Able to represent vectors and vector algebra in various coordinate systems. **CO 2** : Able to display nabla, divergence, curl, and laplacian operators in various coordinate systems, and be able to identify and apply various coordinate systems to various geometries (shapes) of the physical system under review and be able to apply operations and physical meanings of nabla, divergence, curl and laplacian to electric and magnetic fields. **CO 3** : Able to understand the physical meaning of Stoke's theorem and Gaus's theorem and able to apply Gauss's theorem and Stoke's theorem to display Maxwell's equations in Differential form. **CO 4** : Be able to distinguish the properties of electric field lines and magnetic fields about the concept of electric and magnetic monopoles and see the relationship between fields and field sources in Coulomb's law and Ampère's law. **CO 5** : Identify the fundamental laws of electrostatics and magnetostatics and display Maxwell's equations about electric and magnetic monopoles. **CO 6** : Able to review electric and magnetic fields in materials through electric polarization and magnetization of materials. **CO 7** : Able to review the electrical aspects of materials made up of atoms and chemical bonds through the concepts of free and bound charges and magnetic moments. **CO 8** : Able to apply boundary conditions for electrostatic and magnetostatic fields. **CO 9** : Be able to distinguish the meaning of electric field, electric flux density, and magnetic field and magnetic flux density.

	CO 10 : Be able to identify the properties of electric and magnetic forces as well as the Lorentz force law. **CO 11** : Be able to express the magnetic force acting on particles and conductors that conduct current and the interaction between two conductors that conduct current. **CO 12** : Able to understand the integration of electrical and magnetic phenomena through Maxwell's equations. **CO 13** : Be able to display Maxwell's equations for time-dependent fields.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Griffiths, D. J., 1999, Introduction to Electrodynamics, Prentice Hall, Upper Saddle River, New Jersey. 2. Wangness, R. K. 1979, Electromagnetic Fields, John Wiley & Sons, USA. 3. Reitz, J. R., F. J. Milford, dan R. W. Christy, 1992 : Foundations of Electromagnetic Theory, edisi 3, Addison-Wesley.
Content	1. Vector concepts, orthogonal curvilinear coordinates, and transformation rules between coordinate systems 2. Scale factor, general equation of nabla, divergence, curl in orthogonal curvilinear coordinate System, properties of electric and magnetic vector fields, and applying spherical and cylindrical coordinates in two cases. 3. Stokes' theorem and Gauss's theorem, Application of Gauss's theorem to Quolomb's law

	and the sum of magnetic flux on closed surfaces, and applying Stokes' theorem to Ampere's law and electric emf. 4. Properties of continuity of electric field lines and magnetic field lines, nature of divergence and curl of electric and magnetic fields from static sources, Coulomb's Law, and Ampère's Law 5. Maxwell's four equations for sources of static electric and magnetic fields. 6. Electric and magnetic fields in materials (polarization and magnetization). 7. Bonded and free charges, orbital magnetic moments, and spin intrinsic orbital moments. 8. Ampere's and Gauss's laws for the interface between two mediums with different permittivity and permeability. 9. Sources of electric and magnetic fields measured electric and magnetic fields. 10. Electric force, magnetic force and their conservative and non-conservative properties, Lorents force and equations of motion (trajectory) of particles in electric and magnetic fields 11. Charges and conductors that conduct electric current in a magnetic field, as well as interactions between two conductors 12. The relationship between the electric field and the magnetic field 13. Maxwell's equations with sources change with time. 14. Electromagnetic waves, the properties of electromagnetic waves in a vacuum, and the properties of electromagnetic waves in materials are the boundary conditions of electric and magnetic fields for the interaction between electromagnetic waves and materials.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

15. MFF 2027 - Computational Physics

Module Name	**Computational Physics**
Code	MFF 2027
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Pekik Nurwantoro, M.S., Ph.D
Lecturer	Drs. Pekik Nurwantoro, M.S., Ph.D., Prof.,Agung Bambang Setio Utomo, S.U., Ph.D.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Numerical Method (MFF1024), Calculus I (MMM1101)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out

	experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilizing various approaches (approximations). **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references for research gain insight into an important piece of information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. R. H. Landau, M. J. Páez, C. C. Bordeianu, 2008, A Survey of Computational Physics, Introductory Computational Science, Princeton University Press, ISBN: 978-0-691-13137-5 2. DeVries, P. L., & Hasbun, J. E., 2011, A first Course in Computational Physics, Jones & Bartlett Learning, Sudbury, MA. 3. Koonin, S. E., & Meredith, D. G., 1990, Computational Physics, second edition, Perseus Book.
Content	1. Explanation of some of the software and hardware that is potentially useful in carrying out the computing process, 2. Applying the numerical integration method for the study of physical problems, which cannot be expressed in a feasible integral, and, therefore, in the form of an improper integral, uses several numerical quadrature methods. 3. Applying numerical integration methods for the study of physical problems, which can be expressed in proper integral form using the Trapezoidal method, Simpson's method, or similar numerical integration methods. 4. Computation for evaluating functions in the form of series, recurrence relations, and asymptotic forms, which are often involved in solving various physics problems 5. Computation for evaluating matrices and sets of simultaneous linear equations in linear algebra is often involved in solving various physics problems. 6. Application of the problem of finding the roots (roots finding) of non-linear functions based on the Bisection or Newton-Raphson method to solve physics problems: solving the eigenvalue problem in quantum mechanics, namely the search for energy levels of finite potential wells 7. Applying the finite difference discretization method to solve physical problems: solving the

	eigenvalue problem in quantum mechanics, namely the search for the energy levels of a bound system with an arbitrary potential. 8. The simple iteration or the Relaxation method for solving systems of simultaneous equations in several physical problems, such as electrical circuits. 9. Continued use of the Gauss-Seidel iteration method for solving simultaneous systems of equations in several physics problems, such as in electric circuits. 10. Applying a system of simultaneous linear equations with matrix representation in the initial conditions problem to solve some physics problems: solving the equations of motion of a pendulum or oscillation using the Euler method or the low-order Runge-Kutta method. 11. Applying a simultaneous linear equation system with matrix representation in the initial conditions problem to solve some physics problems: solving the equations of motion of a pendulum or oscillation using the high-order Runge-Kutta method. 12. Simultaneous application of a system of linear equations with matrix representation on boundary condition problems to solve several physics problems: solving Poisson and Laplace equations in 1 Dimension (1D) magnetic, an electric system for computing force, field, and electric potential as well as heat or heat propagation. 13. Simultaneous application of systems of linear equations with matrix representation on boundary condition problems to solve several physics problems: solving Poisson and Laplace equations in 2 Dimensions or 3 Dimensions (2D or 3D) magnetic electric systems for computing force, field, and electric potential as well as heat or heat propagation. 14. Simultaneous application of systems of linear equations with matrix representation on boundary condition problems to solve several physics problems: solving Poisson and Laplace equations in 2 Dimensions or 3 Dimensions (2D

	or 3D) magnetic electric systems for computing force, field, and electric potential as well as heat or heat propagation.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

16. MFF 2851 - Electronics Practicum**)

Module Name	Electronics Practicum**)
Code	MFF 2851
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eng. Ahmad Kusumaatmaja, S.Si, M.Sc.
Lecturer	Dr. Eng. Ahmad Kusumaatmaja, S.Si, M.Sc., Muhammad Arifin, S.Si, M.Sc., Ph.D.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Electronics (MFF1850*)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the

	results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can identify and explain the function of various electrical components. **CO 2** : Students can understand and compile electrical circuits on a breadboard. **CO 3** : Students can practice the fundamental laws of electric circuits. **CO 4** : Students can apply digital electronics concepts. **CO 5** : Students can analyze experimental results, compare them with theory and provide conclusions from experiments. **CO 6** : Students can explain experimental results orally and in writing.
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Buku panduan Praktikum Elektronika, Laboratorium Fisika Material dan Instrumentasi. **Additional References :** 1. Sadiku, M.N.O., dan Alexander, C.K., 2016, Fundamentals of Electric Circuits, 5th edition, The McGrawHill Companies, Inc. 2. Wang, M., 2010, Understandable Electric Circuits, The Institution of Engineering and Technology, London, United Kingdom.
Content	1. ELK-1 Practical Transistor as a switch and multivibrator 2. ELK-2 Practicum Operational Amplifier (Op-Amp) 3. ELK-3 Practical Integrated Circuit (IC) 4. ELK-4 Seven-Segment Practicum 5. ELK-5 Practical Direct Current (DC) Circuits 6. ELK-6 Arduino Practicum as a proximity and temperature sensor.
Examination forms	***Cognitive*** **:** Pretest, Final test ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report, Attendance**

17. MFF 2028 - Numerical Method Practicum**)

Module Name	Numerical Method Practicum**)
Code	MFF 2028
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Pekik Nurwantoro
Lecturer	Dr. Pekik Nurwantoro., Dr. Fahrudin Nugroho., Dr. Iman Santoso., Dr. Sholihun
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Numerical Method (MFF1024)
Module objectives/intended learning outcomes PLO	**PLO 1** - Attitude. Have faith and fear of God Almighty, and apply good morals, ethics, initiative, and responsibility in completing their duties. **PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics

	and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilize various approaches (approximations). **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (Experimental tool) and Online (Zoom Meeting,

	Google Meet, Google Classroom)
Reading list	**Main References :** 1. J. Kiusalaas, 2013, Numerical Methods in Engineering with Python 3, Cambridge University Press, ISBN 978-1-107-03385-6 2. Curtis F. Gerald dan Patrick O Wheatley, 2004, Applied Numerical Analysis, 7th Eddition, Addison Wesley 3. A.B. Setio Utomo, 2016, Pengantar Metode Komputasi untuk Sains dan Teknik, UGM Press, ISBN: 978-602-386-091-3.
Content	1. Introduction to the Numerical Method Practicum and an explanation regarding the implementation of the practicum 2. Practical activities for Module 1: Introduction to the latest programming languages that support scientific computing, Python or Julia, and their ecosystems. 3. Module 2 practicum activities: Utilization of series and recurrence links to evaluate some typical functions. 4. Practical activities for Module 3: Calculation of root values of any function 5. Practical activities Module 4: Calculation of integral values with various forms of integrals and integral limits. 6. Module 5 practicum activities: Finite difference approach for approximating the derivative value of any function 7. Practical activity Module 6: Finite difference approach for solving differential equations (Euler method). 8. Practical activities Module 7: Evaluation of matrices for solving a set of simultaneous equations (Poisson's equations).

Examination forms	***Cognitive*** **:** ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report**

18. MFF 2034 - Quantum Physics I

Module Name	**Quantum Physics I**
Code	MFF 2034
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Pekik Nurwantoro, M.S., Ph.D
Lecturer	Drs. Pekik Nurwantoro, M.S., Ph.D., Prof.,Agung Bambang Setio Utomo, S.U., Ph.D
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Mechanics I (MFF1401)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilize various approaches (approximations). **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. D. J. Griffiths, 2018, Introduction to Quantum Mechanics 3rd Edition, Cambridge University Press, ISBN-10 : 1107189632, ISBN-13 : 978-1107189638 2. Schwabl, F., 2007, Quantum Mechanics, 4th ed. Springer-Verlag, Berlin.

Content	1. Background and early development of Quantum Mechanics and the potential role of quantum mechanics in the latest technological developments. 2. Introduction of several new concepts that can explain the experimental results of several physical phenomena regarding aspects of matter and waves 3. Introduction to the formal aspects of mathematics and the interpretation of several expressions in the formulation of quantum mechanics from the description of differential equations and the correspondence of their matrix expressions through linear algebra. 4. The introduction of several operators representing physical quantities, the Hermitian property, the probability density of finding a particle, the expected value of a physical quantity, the measurement uncertainty of a physical quantity, and the Heisenberg uncertainty concept. A brief introduction to the postulates of quantum theory. 5. Infinite well potential system. The description of the one-dimensional bound model for a potential is in the form of a well of infinite depth. 6. Finite well potential system. An explanation of the one-dimensional model for a potential in the form of a well of finite depth. 7. Interpretation of quantum mechanical results. An explanation of the solution of a finite linear well potential system. 8. The linkage of the potential embankment system with reflection and transmission events. Explanation of the analogy of reflection and transmission events in optics with reflection and breakthrough phenomena of particles in quantum mechanics. 9. (continued) Introduction and completion of the Harmonic Oscillator system. Explanation of the one-dimensional model for a parabolic potential with the solution of differential equations. 10. Introduction and completion of Harmonic Oscillator system. Explanation of the one-dimensional model for potential in the form of

	parabolic with differential equation solution. 11. Introduction to the algebraic solution of the harmonic oscillator and compare it to the results obtained through differential equations. Explanation of the emergence of energy quantization and quantum breakthrough 12. Introduction and completion of the Atomic Hydrogen system. Explanation of the three-dimensional model for the Hydrogen Atom Explanation for reducing the reduction from a two-body system to a one-body system. 13. Details the steps for solving the Schrodinger equation for Hydrogen atoms in the radial variable section. An explanation of the steps needed to simplify the solution of partial differential equations. 14. Understanding orbital angular momentum and its relation to the completion of the Hydrogen atom in the variable angular section. An explanation of the emergence of orbital angular momentum operators in the Hydrogen atom problem and matters related to the conservation of orbital angular momentum and its quantization.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

19. MFF 2024 - Mathematical Physics III

Module Name	Mathematical Physics III
Code	MFF 2024
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Lecturer	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Calculus I (MMM1101), Mathematical Physics I (MFF1020), Mathematical Physics II (MFF1021)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a

	physical problem based on the results of observations and experiments, and able to operate related technologies.
Course outcomes (CO)	**CO 1** : Mastering and applying the basic concepts of typical functions. **CO 2** : Mastering and applying special functions in solving simple math and physics problems. **CO 3** : Understanding and skilled in using typical functions in solving math and physics problems. **CO 4** : Mastering and applying the basic concepts of complex variable calculus **CO 5** : Mastering and applying complex variable calculus in solving simple math and physics problems. **CO 6** : Understanding and skill in using complex variable calculus to solve math and physics problems. **CO 7** : Mastering and applying the basic concepts of complex variable calculus. **CO 8** : Mastering and applying the calculus of variations in solving simple math and physics problems. **CO 9** : Understand and be skilled in using the calculus of variations in solving math and physics problems.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. M.L. Boas, Mathematical Methods in The Physical Sciences 2nd ed, John Wiley & Sons, 1983. 2. G.B. Arfken and H.J. Weber, Mathematical Methods for Physicists, Academic Press, 1995. 3. K.F. Rilley, M.P. Hobson, and S.J. Bence, Mathematical Methods for Physics and Engineering, 3rd ed. Cambridge University Press, 2006.

Content	1. Introduction and introduction to the particular function, the Gamma function 2. Explanation of the Beta function 3. Explanation of the Error function 4. Practice questions for typical functions (Gamma, Beta, and Error functions) 5. Explanation of Legendre and Bessel functions 6. Explanation of Hermite functions 7. Practice questions for special functions (Legendre, Bessel, and Hermite Functions 8. Introduction and introduction to complex variable functions, analytical functions 9. Explanation of the Laurent series 10. Introduction and introduction about residue 11. Practice questions for complex variable functions (Analytical functions, Laurent series, and Residues) 12. Explanation of the application of residues and 3D Taylor series 13. An explanation of the calculus of variations 14. Practice questions for typical functions of complex variables and calculus of variations
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

20. MFF 2402 - Mechanics II

Module Name	Mechanics II
Code	MFF 2402
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Muh. Farchani Rosyid, M.Sc.
Lecturer	Dr. Muh. Farchani Rosyid, M.Sc., Dr. Bambang Murdaka Eka Jati, M.S.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Mechanics I (MFF1401)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Can solve problems and cases of classical mechanics related to Euler-Lagrange Equation, Calculus of Variations, Hamilton's Principle, and Phase Spaces [PLO 2 and PLO 5]. . **CO 2** : Can solve problems and cases of classical mechanics related to Motion in a Centralized Field, Dynamics of Motion of Rigid Bodies about Any Axis, and Fluid Flow Dynamics [PLO 2 and PLO 5].
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Fowles, G.R. & Cassidy, G.L., 2006: Analytical Mechanics, 6th edition, Thomson Brooks & Cole 2. Douglas, G., 2006: Classical Mechanics, 2nd edition, Cambridge University Press, Cambridge.

Content	1. Euler Lagrange's equations 2. Constraints and Forces of Constraint 3. Lagrange Function and Energy 4. Calculus of Variation 5. Hamilton's equation 6. Phase Space 7. Lionville Theorem and Recurrence 8. Centered Field Motion: Kepler's Laws and Ellips Equations 9. Motion in General and Special Central Forces 10. Orbit Stability and Particle Scatter 11. Rigid Body Dynamics and Euler's Equation, 12. Principal Axis and Free Rotation in Rigid Bodies 13. Fluid Flow and Heat Flow in Fluids 14. Bernoulli's Law of Dynamics
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** Project Results ***Affective*** **: Attendance**

21. MFF 2031 - Relativity Theory

Module Name	**Relaivity Theory**
Code	MFF 2031
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Juliasih Partini
Lecturer	Dr. Juliasih Partini., Dr. Romy Hanang Setya Budhi , ,
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Mechanics I (MFF1401)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a

	physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can understand the background knowledge of several natural phenomena that Classical Mechanics failed to explain, namely through solutions based on Newton's Laws which led to the introduction of the concepts of special relativity and general relativity. **CO 2** : Students can identify several procedures for solving physics problems that require handling the concept of special relativity and general relativity and understanding the actual results of solving these problems. **CO 3** : Students are skilled in problem-solving by presenting some simple examples of the application of special and general relativity in physics and the procedures for solving these problems.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Lawden, D. F., 1982: An Introduction to Tensor Calculus, Relativity and Cosmology, edisi 3, John Wiley. 2. Ta-Pei Cheng, 2015, A college course on relativity and cosmology, Oxford Univ press. 3. Bernard Schutz, 2009, A First Course in General Relativity, Second Eds, Cambridge Univ Press.
Content	1. Basic postulates of the particular theory of relativity, definition of inertial frames of reference, covariance of the laws of motion, in variation 2. Lorentz transform, length contraction, time dilation, twin paradox 3. Orthogonal Transformation, Cartesian Tensor 4. Mechanics Special relativity: velocity, mass, and momentum vectors, Lorentz transformations for force 5. Lagrange and Hamiltonian equations, Momentum energy tensor 6. Relativistic electrodynamics: current-density-4, potential vector4 7. Lorentz transforms for electric and magnetic fields, Lorentz force, energy tensor of electromagnetic field momentum 8. Introduction to general relativity, noninertial frames, equivalence principles, and spacetime geometry 9. Spacetime geometry: Riemannian spaces and general tensor calculus 10. General Theory of Relativity: equivalence principle, Einstein's law of gravity, the motion of free particles in a gravitational field, weak gravitational field, correspondence of Newton's law of gravity and General Relativity 11. General Theory of Relativity: Metric spherical symmetry, Schwarzschild solution, planetary orbits, gravitational deflection of light beams 12.

	General Theory of Relativity: a gravitational shift in spectral lines, black holes, gravitational waves 12. Cosmology: cosmological principle, spaces of constant curvature, metric Robenson-Walker, Hubble constant and deceleration parameter, the redshift of galaxies 13. Cosmology: cosmic dynamics, Einstein and de Sitter universe models, Friedmann universe, radiation model, particle and event horizon.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

22. MFF 2051 - Statistical Physics

Module Name	Statistical Physics
Code	MFF 2051
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Moh. Adhib Ulil Absor, M.Sc.
Lecturer	Dr. Moh. Adhib Ulil Absor, M.Sc., Dr. Harsojo, SU.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Thermodynamics (MFF1053), Quantum Physics I (MFF2034*)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can understand and explain the basic concepts of statistical physics. **CO 2** : Students can apply the basic concepts obtained in some instances. **CO 3** : Students can identify a problem involving statistical physics and be able to solve the problem through the use of the methods and fundamental concepts that have been given previously. **CO 4** : Students are skilled in solving physics cases through theoretical-mathematical or phenomenological approaches. **CO 5** : Students can present, communicate and provide arguments on a concept/idea about statistical physics. **CO 6** : Students can work in solving cases both independently and in groups.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Greiner W. Dkk., 1997, Thermodynamic and statistical mechanics, Springer, New York. 2. Sears, F. W. dan G. L. Salinger, 1982, Thermodynamics, kinetic theory, and statistical thermodynamics, Addison-Wesley, Reading, Massachussetts.

Content	1. a. Basic concepts of statistical physics: Micro and macro states of many particle systems, the concept of phase divisions, equipartition theory, virial theorem, Gibbs' paradox, and examples of problems., 2. b. Ensembles in statistical mechanics: Microcanonical and canonical ensembles 3. b. Ensembles in statistical mechanics: Canonical macro ensembles. 4. b. Ensemble in statistical mechanics: The concept of the partition function, the relationship between entropy, and the phase space density. 5. b. Ensembles in statistical mechanics: Observables as ensemble means, Relation of partition functions and thermodynamic quantities. 6. c. Quantum Statistics: Pure state and mixed state, density operator, 3rd law of thermodynamics. 7. c. Quantum Statistics: Symmetry of the multi-particle wave function, Explanation of the mid-semester exam (UTS) grid. 8. d. Types of statistics: Maxwell-Boltzmann 9. d. Types of statistics: Bose-Einstein 10. d. Statistical types: Fermi-Dirac 11. e. Applications of Statistical Physics: Plank Radiation 12. e. Applications of Statistical Physics: Condensation of Bosons 13. e. Applications of Statistical Physics: Fermi Gases 14. e. Applications of Statistical Physics: Landau Diamagnetics and Pauli Paramagnetic
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Assignments ***Psychomotor* :** ***Affective* :**

23. MFF 2062 - Lab Assignments**)

Module Name	Lab Assignments**)
Code	MFF 2062
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Sc. Ari Dwi Nugraheni
Lecturer	Dr. Sc. Ari Dwi Nugraheni, Tim Laboratorium Fisika Dasar
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Laboratory for General Physics II (MFF1014)
Module objectives/intended learning outcomes PLO	**PLO 1** - Attitude. Have faith and fear of God Almighty, and apply good morals, ethics, initiative, and responsibility in completing their duties. **PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics

	and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain the concepts of mechanical phenomena and relate them to the basic concepts that have been obtained [PLO 1, PLO 2, PLO 4, PLO 5] **CO 2** : Students can explain the concepts of heat phenomena and relate them to the basic concepts that have been obtained [PLO 1, PLO 2, PLO 4, PLO 5] **CO 3** : Students can explain the concepts of electrical phenomena and relate them to the basic concepts obtained. [PLO 1, PLO 2, PLO 4, PLO 5] **CO 4** : Students can explain the concepts that underlie optical phenomena and relate them to the basic concepts [PLO 1, PLO 2, PLO 4, PLO 5] **CO 5** : Students can convey the results of their experiments in the form of written reports [PLO 3]. **CO 6** : Students can work individually or in groups in experiments [PLO 3].
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Buku Panduan Praktikum Fisika Dasar Layanan
Content	1. Measurement of the thermometer, air humidity, heat-electric equivalence, surface tension, the specific gravity of solids, Laplace constant, multimeter, OSK, incandescent lamp, earth magnet, transformer, Wheatstone bridge, mathematical swing, spring constant, modulus of elasticity of wire and rod, speed earth in air, physical swing, positive lens power, refractive index, microscope, light dispersion, positive and negative lens, photometer. 2. Measurement of the thermometer, air humidity, heat-electric equivalence, surface tension, the density of solids, Laplace constant, multimeter, OSK, incandescent lamp, earth magnet, transformer, Wheatstone bridge, mathematical swing, spring constant, modulus of elasticity of wire and rod, velocity earth in the air, physical swing, positive lens power, refractive index, microscope, light dispersion, positive fan negative lens, photometer.
Examination forms	***Cognitive*** **:** ***Psychomotor*** **:** Presentation, Assitance assemement ***Affective*** **: Practicum Report, Attendance**

24. MFF 2310 - Atomic and Molecular Physics

Module Name	Atomic and Molecular Physics
Code	MFF 2310
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D
Lecturer	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D , Dr. Yosef R. Utomo, SU.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics II (MFF1012), Quantum Physics I (MFF2034), Relativity Theory (MFF2031*), Statistical Physics (MFF2051)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilize various approaches (approximations). **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Krane, K., 1992, Modern Physics, John Willey and Sons. 2. Haken, H. and Wolf, H. C., 1984, Atomic and Quantum Physics, Springer-Verlag, Berlin. 3. Robert L. Carter, Molecular Symmetry and Group Theory, 1998, John Wiley & Sons, USA. 4. Svanberg, 1992, Atomic and Molecular Spectroscopy, edisi 2, Springer-Verlag, New York. 5. David J. Willock, Molecular Symmetry, 2009, John Wiley & Sons, UK.
Content	1. Black Body Radiation, Photoelectric Effect 2. Franck-Hertz experiment, Thomson Atomic Model 3. Rutherford's Experiment, Bohr's Atomic Theory, and Weaknesses of the Old Quantum Theory 4. Hydrogen Atom: Schrödinger equation, quantum numbers n,l,m 5. Wavefunction interpretation, hope value, spin quantum number, coupling 6. Complex Atoms: central field approximation and Pauli exclusion, electron configuration, coupling 7. Fine structure, the sum of MJ values in one configuration, Zeeman effect, hyperfine structure 8. Molecular Introduction: covalent bond and ionic bond 9. HOMO and LUMO 10. Symmetry and Chemical Bonds: orbital symmetries and overlap, valence-bond theory and hybrid orbitals 11. Localized and delocalized molecular orbitals, -bonding, - bonding in aromatic ring systems 12. Molecular Geometry: Stability of molecular configurations 13. Molecular Symmetry: symmetry operations and elements 14. Symmetry operation merging, point group of molecular crystal system, point group classification

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

25. MFF 2410 - Electromagnetics II

Module Name	Electromagnetics II
Code	MFF 2410
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D
Lecturer	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D , Dr. Juliasih Partini, M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Mathematical Physics II (MFF1021), Electromagentics I (MFF2415)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills to formulate and describe (to describe) electromagnetic phenomena and reveal important information contained in these physics problems through various tricks or specific mathematical procedures and utilize various approximations. **CO 2** : Students have the ability in Analytical Skills to pay attention to the problems of electromagnetic phenomena in detail (detail), analyze problems, and build arguments logically and carefully. **CO 3** : Students have the ability in Problem-Solving Skills to solve a problem related to electromagnetic phenomena with well-defined solutions, formulating a problem carefully.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Ronald K. Wangsness, 1986, Electromagnetic Fields, Edisi ke-2, Penerbit: John Wiley & Sons. 2. Griffiths, D. J., 1989, Introduction to Electrodynamics, Edisi ke-2, Penerbit: Prentice Hall. 3. Reitz, J.R., Milford, F. J. dan Christy, R. W., 1992, Foundations of Electromagnetic Theory, Edisi ke-3, Penerbit: Addition-Wesley.

Content	1. Unique methods in electromagnetics: Reflection method 2. Solving Laplace's equation using the variable separation method in Cartesian coordinate systems and spherical coordinates 3. Shift flow meeting. General Maxwell's equations in differential and integral form. Boundary condition equations 4. Material (medium) isotropic linear, homogeneous. Poynting's theorem. Electromagnetic momentum. 5. Scalar potential and general vector potential. Scalar potential and vector potential for homogeneous isotropic linear substances. Terra transformation 6. Electromagnetic wave fields in non-conducting and conducting materials 7. Electromagnetic waves are fields within an electrically charged substance. Electromagnetic wave polarization 8. The law of reflection and refraction. Reflection and refraction in normal incident cases. Reflection and refraction in oblique incidents. Snell's Law. Total bounce 9. The relationship between reflection, refraction, and electromagnetic energy. Reflection on the surface of the conductor. Propagation in the waveguide. Fields in the waveguide. Rectangular waveguide 10. The fields in the resonant cavity (resonator). Kirchhoff's law. Series RLC circuit 11. Transmission lines (transmission lines). Potentially delayed. Multipole expansion for an oscillating harmonic source. 12. Electric dipole radiation. Magnetic dipole radiation. Linear electric quadrupole radiation. Antenna 13. Introduction to the particular theory of relativity. Lorentz transformation. Lorentz transforms -4 Vectors and general Tensors. 14. Lorentz Transforms, Vector-4, and General Tensor. Vector formulation - 4 for electromagnetics in vacuum

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

26. MFF 2033 - Modern of Physics Practicum**)

Module Name	Modern of Physics Practicum**)
Code	MFF 2033
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dra. Eko T. Sulistyani, M.Sc.
Lecturer	Dra. Eko T. Sulistyani, M.Sc., Dr. Fahrudin Nugroho , Tim dosen Lab Atom & Inti
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Laboratory for General Physics II (MFF1014)
Module objectives/intended learning outcomes PLO	**PLO 1** - Attitude. Have faith and fear of God Almighty, and apply good morals, ethics, initiative, and responsibility in completing their duties. **PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics

	and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can understand the nature of existing microwave generators, namely klystrons, and can use them to measure the length of microwaves in a waveguide. **CO 2** : Students can develop a mindset and explain how to understand the photoelectric effect/symptom experimentally and determine the work function of the photocell, the Planck constant value, and the maximum kinetic energy of the photoelectron. **CO 3** : Students have the competence and ability to understand the working principle of the Michelson Interferometer. Students can use an interferometer to measure the wavelength of light in the spectrum of Cadmium/Sodium atoms. Students can also determine the effect of pressure on the refractive index of air/gas. **CO 4** : Students understand the X-ray spectrum from an X-ray tube. Students can determine the distance between a crystal's Bragg planes and a material's absorption coefficient against X-rays. **CO 5** : Students can explain Millikan's experiment, demonstrate the discrete nature of electric and elemental charges, and determine Avogadro's number by observing Brownian motion.
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Panduan Praktikum Eksperimen Fisika Modern, Lab. Fisika Atom & Inti, FMIPA UGM, Yogyakarta, 2012. 2. Melissinos, A.C., Experiments in Modern Physics, Acad. Press, New York, 1966, hal 18-27. 3. Weidner, R.T., Elementary Modern Physics, Edisi ke-3, Allyn and Bacon Inc., 1980, hal 89-99. 4. Harnwell, G.P. dan Livingood, J.J., Experiment Atomic Physics, Mc Graw Hill, 1933, hal. 214-223. 5. Portis, A.M., Berkeley Physics Lab MO1, MO2, MO3, Mc Graw Hill. 6. Weast, R.C., Handbook of Chemistry and Physics, Edisi ke-57, CRC Press, 1976. **Additional References :** 1. Millikan, R.A., Electrons (+ and -), proptons, photons, neutrons, mesotrons and Cosmic Rays, 1974. 2. Semat, H., Introduction to Atomic and Nuclear Physics, Holt, Rinehart & Winston, 1962, hal 146-186. 3. Eisberg, R.M., Fundamentals of Modern Physics, John Wiley & Sons, Japan, 1961. 4. Jenkins, F.A. & White, H.E., Fundamentals of Optics, Edisi ke-4, International Student Ed, Mc Graw Hill, Japan, 1981, hal 416 – 418.

Content	1. Microwave Experiments, Photoelectric Effect Experiments, Michelson Interferometer Experiments, X-Ray Experiments, and Minster's Experiments 2. "Microwave Experiments, Photoelectric Effect Experiments, Michelson Interferometer Experiments, X-Ray Experiments, and Minster's Experiments 3. Microwave Experiments, Photoelectric Effect Experiments, Michelson Interferometer Experiments, X-Ray Experiments, and Own Experiments 4. Microwave Experiments, Photoelectric Effect Experiments, Michelson Interferometer Experiments, X-Ray Experiments, and Minster's Experiments 5. Microwave Experiments, Photoelectric Effect Experiments, Michelson Interferometer Experiments, X-Ray Experiments, and Minster's Experiments
Examination forms	***Cognitive* :** Pretest, Final test ***Psychomotor* :** Practicum ***Affective* : Practicum Report, Attendance**

27. MFF 2035 - Quantum Physics II

Module Name	Quantum Physics II
Code	MFF 2035
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Pekik Nurwantoro, M.S., Ph.D
Lecturer	Drs. Pekik Nurwantoro, M.S., Ph.D , Dr. M. F. Rosyid , ,
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Quantum Physics I (MFF2034)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilizing various approaches (approximations). **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), to formulate a problem carefully, and try other approaches (approaches) to improve the solution to a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. J. J. Sakurai, J. Napolitano, 2018, Modern Quantum Mechanics, Cambridge University Press, ISBN 9781108499996 2. Griffiths, D. J., 2018, Introduction to Quantum Mechanics, 3 ed, Cambridge University Press,ISBN-10: 11071896632, ISBN-13: 978-1107189638

Content	1. An explanation of the dynamics of quantum systems and the time-dependent Schrodinger equation 2. " 3. An explanation of the dynamics of quantum systems and the time-dependent Schrodinger equation 4. An explanation of the dynamics of quantum systems and the time-dependent Schrodinger equation 5. Introduction to the concept of orbital and spin angular momentum and the operator properties that represent them, as well as solving eigenvalue problems related to quantum systems 6. Introduction to the concept of sum or coupling of angular momentum and spin along with the Clebsch-Gordan coefficient 7. Some examples of solving physical systems of N-body or identical particles involving angular momentum coupling (L -S and J -J coupling) 8. The Introduction of several approach methods (approximations), namely the Variational method 9. Introduction of several approximations, namely the time-independent Perturbation method 10. Introduction of several approximations, namely the time-independent Perturbation method 11. Introduction of several approximation methods, namely the WKB method and its application to the solution of molecular systems 12. Introduction of the Suzuki -Trotter matrix decomposition method for solving some dynamics problems in quantum systems 13. The use of the Suzuki - Trotter matrix decomposition method for solving some problems in quantum 14. Introduction to quantum scattering and Born approximation
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

28. MFF 2601 - Solid State Physics I

Module Name	**Solid State Physics I**
Code	MFF 2601
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D
Lecturer	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D , Dr.. Ari Dwi Nugraheni, M.Sc.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Quantum Physics I (MFF2034)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and reveal important information in the physics problem through various tricks or specific mathematical procedures and utilizing various approaches (approximations). **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. C..Kittel, Solid State Physic, Edisi 8, 2005. 2. R.K. Puri , V.K. Babbar, 1997, Solid State Physic, S. Chand & Company LTD, New Delhi.

Content	1. Crystal Structure: (i) Type and crystal lattice. (ii) Crystal directions and planes 2. An explanation of the dynamics of quantum systems and the time-dependent Schrodinger equation 3. X-Ray Diffraction: (i) Bragg's law (ii) Back lattice (iii) Brillouin zone 4. X-Ray Diffraction: (iii) Brillouin zone (iv) Factor of geometric structure 5. Bonds in crystals: (i) Interaction Forces and Bond types (ii) Bonding energies in ionic and noble gas bonds 6. Lattice Vibrations: (i) One and two-dimensional lattice vibrations, (ii) Phonons 7. Lattice Vibration: (iii) Phonons (iv) Heat capacity, classical theory, Einstein model, Debye model. 8. The theory of free electrons in metals: (i) Summerfields. quantum theory 9. Energy band theory: (i) Bloch's theorem (ii) Kronig - Penney model 10. Energy band theory: (iii) Speed and effective mass of electrons (iv) Classification of materials: metals, insulators, and semiconductors 11. Energy band theory: (iii) Speed and effective mass of electrons (iv) Classification of materials: metals, insulators, and semiconductors 12. Energy band theory: (iii) Speed and effective mass of electrons (iv) Classification of materials: metals, insulators, and semiconductors 13. Semiconductors :(i) Intrinsic Semiconductors 14. Semiconductors:(i) Extrinsic Semiconductors.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

29. MFF 2205 - Nuclear and Particle Physics I

Module Name	**Nuclear and Particle Physics I**
Code	MFF 2205
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dra. Eko T. Sulistyani, M.Sc.
Lecturer	Dra. Eko T. Sulistyani, M.Sc., Dr. Dwi Satya Palupi, S.Si, M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Quantum Physics I (MFF2034), Atomic and Molecular Physics (MFF2310), Relativity Theory (MFF2031*), Statistical Physics (MFF2051)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Explain the core properties, static and dynamic properties, and the basics of core detection methods. **CO 2** : Explain the static properties of the nucleus: intrinsic angular momentum, magnetic moment, nuclear states, nuclear states **CO 3** : Provides an understanding of the binding energy of the nucleus that causes the particles that make up the nucleus to bind to each other, the energy separating the particles. **CO 4** : Explaining the binding energy of the Core: Semi-empirical mass formula: semi-empirical formula terms, mass parabola. **CO 5** : Explaining the Nucleus Model: the electron proton model and its implications, the proton-neutron model, the Fermi Gas model. **CO 6** : Explaining about Core Model: Shell model: core state based on shell model with well potential, oscillator potential, L.S coupling. **CO 7** : Mention the particles that make up the universe and can classify the particles that make up the universe (Fermions: Leptons and Quarks; Tera Bosons: Photons, W and Z, Gluons). **CO 8** : Describes the Particles that make up the Universe and Fundamental Interactions (Scalar Bosons: Higgs, Composite Particles/bonded states: Hadrons (Mesons and Baryons), Nuclei, Atoms). **CO 9** : Explaining the Phenomenology of Nuclear and Particles: Low energy reactions, Scattering Reactions, Decay Reactions, and Bonded States. **CO 10** : Explain the concepts of reaction latitude, decay rate, and transition energy. **CO 11** : Explain Hadronization: plasma quarks – gluons become in a strongly interacting bound state.

	CO 12 : Explaining the I-Hadron Bound State: Baryon, baryon wave function, magnetic moment, baryon mass.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Arya, Atam H.,1966,Fundamental of Nuclear Physics,Allen and Bacon Inc. 2. Martin,R Brian, 2006, Nuclear and particle Physics, An Introduction, John Wiley & Sons, Ltd, England. 3. Krane.KS, 1988, Introductory Nuclear Physics, John Wiley & Sons. 4. Meyerhoff,W.E.,1967, Elemen of Nuclear Physics, McGraw Hill Book Co. 5. David Griffiths, 2004: Introduction to elementary particles, Wiley-VCH.
Content	1. Nuclear mass, nuclear radius, angular momentum Model of the proton-electron, proton neutron, nomenclature 2. Crystal Structure: (ii) Crystal direction and plane (iii) Crystal structure of SC, BCC, FCC, diamond, and HPC 3. Nuclear binding energy, Average binding energy, stability of the nucleus, Proton splitting energy, Neutron splitting energy 4. Semi-empirical mass formula: semi-empirical formula terms, mass parabola. 5. The proton-electron model and its implications, the proton-neutron model, and the Fermi Gas model. 6. Shell model: core state based on petal model with well potential, oscillator potential, and L.S. coupling. 7. 8. Fermions: Leptons and Quarks; Tera bosons: Photons, W and Z, Gluon 9. Scalar Bosons: Higgs, Composite/bonded state particles: Hadrons (Mesons and Baryons),

	Nuclei, Atoms. 10. Low energy reactions, Scattering Reactions, Decay Reactions, and Bound States 11. Concept of reaction latitude, decay rate, and transition energy. Experiments and detection in Core and particles. 12. Hadronization: plasma quarks – gluons into a strongly bonded state of interaction, Analogy with the hydrogen atom: a review of the Schrodinger equation of hydrogen atoms, positronium, quarkonium, light mesons. 13. Baryon, baryon wave function, magnetic moment, baryon mass.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **: Attendance**

30. MFF 2313 - Atomic and Molecular Physics Experiments

Module Name	**Atomic and Molecular Physics Experiments**
Code	MFF 2313
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Iman Santoso
Lecturer	Dr. Iman Santoso, Dr.Eng. Fahrudin Nugroho., Ikhsan Setiawan, M. Si., Elida Istiqomah, M. Sc.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Atomic and Molecular Physics (MFF2310)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the

	results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can carry out experiments on the e/m ratio using an electro-magnet setup, analyze data, and provide conclusions from this experiment. **CO 2** : Students can conduct experiments with Franck-Hertz to show the discrete nature of charge e and can analyze data and provide conclusions from this experiment. **CO 3** : Students can conduct experiments on Atomic Spectroscopy using the Hilger spectrometer and can analyze data and provide conclusions from this experiment. **CO 4** : Students can carry out electron spin resonance (ESR) experiments using electromagnetic setups and are also able to determine the value of the gyromagnetic factor of organic materials. Students are also able to analyze data and provide conclusions from this experiment. **CO 5** : Students can carry out the Zeeman Effect experiment to show the influence of magnetic fields on atomic emission spectra. They can analyze data and provide conclusions from this experiment based on the coupling of angular, angular momentum, and spin of an atom.
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Melissinos, A. C., 2003: Experiments in Modern Physics, Academic Press. 2. Tim Pengampu, 2016, Petunjuk Praktikum Fisika Atom dan Molekul, Lab. Fisika Atom-Inti. 3. Sayer, M dan A Mansingh, 2000. Measurement Instrumentation and Experiment Design in Physics and Engineering, Prentice Hall, New Delhi.
Content	1. (1). An e/m experiment determines an electron's charge-to-mass ratio using electric and magnetic fields. (2). The Franck-Hertz experiment demonstrated the discrete nature of electrons using high voltages. (3). Atomic Spectroscopy Experiment, showing the emission and absorption of an atomic gas using a Hilger spectrometer. (4). Electron spin resonance (ESR) experiments using an electromagnet setup are also capable 2. Intrinsic angular momentum, magnetic moment, core states, core states 3. (1). Experiment e/m, determine the ratio of charge and mass of electrons using electric and magnetic fields. (2). The Franck-Hertz experiment demonstrated the discrete nature of electrons using high voltages. (3). Atomic Spectroscopy Experiment, showing the emission and absorption of an atomic gas using a Hilger spectrometer. (4). Electron spin resonance (ESR) experiments using an electromagnet setup are also able to 4. (1). An e/m experiment determines an electron's charge-to-mass ratio using electric and magnetic fields. (2). The Franck-Hertz experiment demonstrated the discrete nature of electrons using high voltages. (3). Atomic Spectroscopy Experiment, showing the emission and absorption of an atomic gas using a Hilger spectrometer. (4). Electron spin resonance (ESR) experiments using an electromagnet setup are also capable 5. Response

Examination forms	***Cognitive*** **:** Pretest, Final test ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report, Attendance**

31. MFF 2060 - Research Methodology and Scientific Communication**)

Module Name	Research Methodology and Scientific Communication**)
Code	MFF 2060
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Fahrudin Nugroho
Lecturer	Dr. Fahrudin Nugroho., Prof. Dr. Eng. Kuwat Triyana, M.Si.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Minimum 50 Credits
Module objectives/intended learning outcomes PLO	**PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can understand and apply standard research procedures. **CO 2** : Students can produce valid data and communicate their research results in oral and written forms, free from scientific and ethical issues.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google

	Classroom)
Reading list	**Main References :** 1. Jean-Luc Lebrun, 2007, Scientific Writing, World Scientific Publishing. 2. Blackwell J & Martin, J., 2011, A scientific approach to scientific writing, Springer.
Content	1. Introduction 2. Collective work in Science : (1). Science Character: Generality (2). How to Learn Science (3). How to Develop Science 3. Introduction to Scientific Research Concepts: The Role of Students in Research 4. Topic research and literature search: Log Book, Techniques for reading and selecting literature. 5. Introduction of the stages of scientific research: (1). Background interests and fields mastered, (2). Advisory Lecturer according to the topic of work planning, (3). Literature Search, (4). Information Gathering, (5). Scientific Formulation. 6. Preparing Research Proposals: Introduction, Background, Problems, Objectives, Benefits, Research Methods. 7. Introduction to scientific research concepts: Observation, Problem Definition, Hypothesis Generation, Testing, Theory Results, Confirmation. 8. Level of quality and trust in scientific articles: Identifying the place of publication 9. Scientific Writing: Saves reader's memory, Keeps reader's attention, saves speaker's time. 10. Scientific Writing: Save the reader's memory, Keep the reader's attention, and save the speaker's time. 11. Scientific Writing: Keeping readers motivated, Bridging gaps with readers, Creating storylines, Creating reading momentum, saving reader energy 12. Structure of scientific articles: Introduction, Methods, Results and Discussion, Conclusions, References / Bibliography. 13. Ethics in writing: Plagiarism, Avoiding Fabrication

	and Falsification, Manipulation, Procedures for referring and paraphrasing 14. Ethics in writing: Plagiarism, Avoiding Fabrication and Falsification, Manipulation, Procedures for referring and paraphrasing
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

32. MFF 3015 - Philosophy of Physics

Module Name	Philosophy of Physics
Code	MFF 3015
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Arief Hermanto
Lecturer	Dr. Arief Hermanto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 1** - Attitude. Have faith and fear of God Almighty, and apply good morals, ethics, initiative, and responsibility in completing their duties. **PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.

Course outcomes (CO)	**CO 1** : Students can express both orally and in writing various topics quite deep in the theory of relativity, quantum theory, and the fundamental differences between the two based on literature studies, not with mathematical equations but with the qualitative power of logical-analytic verbal expressions.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. R B Angel, 1980, Relativity : the theory and its philosophy Pergamon. 2. S Cannavo, 2009, Quantum theory : a philosopher's overview, SUNY. 3. A Hermanto, 2012, Bahan ajar Filsafat Fisika, FMIPA-UGM.
Content	1. Logic 2. Logic 3. Logic 4. Relativity 5. relativity 6. Relativity 7. Logic and Relativity 8. Quantum 9. Quantum Comparison and Relativity 10. Comparison of Quantum and Relativity 11. Quantum Comparison and Relativity 12. Quantum Comparison and Relativity 13. Comparison of Quantum and Relativity 14. Quantum and Quantum-Relativity Comparison
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

33. MFF 3411 - Modern of Optics

Module Name	Modern of Optics
Code	MFF 3411
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Iman Santoso
Lecturer	Dr. Iman Santoso., Dr. Mitrayana
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Waves (MFF1405), Quantum Physics I (MFF2034)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain and solve cases in geometric optics. **CO 2** : Students can explain and solve cases in physical optics.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Eugene Hecht (and Alfred Zajac), Optics, fourth (fifth) ed., Addison-Wesley.California, 2001. 2. Peatross and Ware, Physics of light and optics, Brighram Young University, 2013. 3. M.P. Vaughan, Lecture Notes on Optics PY3101, University College Cork, 2014.
Content	1. INTRODUCTION: History of the Development of Optics, Electromagnetic Fields. 2. Review material from Mathematical Physics: Vector Algebra (inner product, cross product, integral divergence theorem, Stokes integral theorem, divergence, rotation, complex algebra, Euler notation, Phasor, differential wave equations. 3. BASICS OF GEOMETRY OPTICS: Introduction, Branches of Optics, The Nature of Light, Light Rays (B.C), Reflection and Refraction (Snell's Law), Total Internal Reflection, Characteristics of a Clear Medium, Minimum Deviation, Minimum Deviation and Type of Material, Light Dispersion, Refraction In Plan-Parallel Glass, Huygens' Principle on Reflection and Refraction, Fermat's Principle on Reflection, Fermat's Principle on Refraction, Optical Path Length (PLO). 4. 4. FRESNEL EQUATION: Electric Field Perpendicular to the Incident Plane, Electric Field Parallel to the Incident Plane, Interpretation of the Fresnel Equation, Reflectance, and Transmittance. 5. 5. GEOMETRY OPTICS (Paraxial Optical): Spherical Reflector Surface (R.S), Single Spherical Reflector Surface. 6. THIN LENSES: Introduction, Types of Lenses, Geometry, Characteristics, Focal Planes, Shadow Formation Equations, Image Formation, Properties and Magnification of Shadows, Lateral Magnification, Magnification of Three Dimensional Objects, Sign Conventions, Position of Convex Lens Shadows, Three-dimensional Image Orientation, Lens combination. 7. A. THICK LENSES: Geometry, Characteristics, Beam State, Nodal Points and Optical Centers, Light Propagation in Thick Lenses. B.

	ABERRATION: Introduction, Types of Monochromatic Aberration 8. Wave superposition: Algebraic method, Complex method, Phasor sum, Standing wave, Beats, Group velocity, Fourier analysis, Fourier integral, Pulse and wave packets, Optical bandwidth. 9. Polarization of Light: Properties of polarized light, Polarisator, Dichroism, Birefringence, Scattering and polarization, Polarization by reflection, Retarders, Circular Polarization, Light Polarization, Polychromatic, Optical Activity, Optical Modulator, Mathematical description of polarization. 10. Interference: Overview, Interference Terms, Wavefront-splitting Interferometer. Amplitude splitter interferometer, Double-beam dielectric film interference, Multiple-beam interference, Fabry-Perot interferometer, Interferometer application. 11. Diffraction: Preliminary review, Fraunhofer Diffraction, Fresnel Diffraction, Kirchoff's Scalar Diffraction Theory, Limited Wave Diffraction 12. Fourier Optics: Introduction, Fourier Transform, Optical Applications 13. Fundamentals of Coherence Theory: Introduction, Visibility, Common coherence functions and degrees of coherence, Steller's coherence and interferometer, Lasers and Laser light. 14. Fundamentals of Coherence Theory: Introduction, Visibility, Common coherence functions and degrees of coherence, Steller's coherence and interferometer, Lasers and Laser light.
Examination forms	***Cognitive* :** Midterm Exam, Final Exam ***Psychomotor* :** ***Affective* :**

34. MFF 3206 - Nuclear and Particle Physics II

Module Name	**Nuclear and Particle Physics II**
Code	MFF 3206
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dra. Eko Tri Sulistyani, M. Sc.
Lecturer	Dra. Eko Tri Sulistyani, M. Sc., Mirza Satriawan, S. Si., M. Sc., Ph. D.
Language	Indonesian
Relation to curiculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Nuclear and Particle Physics (MFF2205)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Describes the interaction of radiation with matter and uses it as a method for detecting nuclei. **CO 2** : Describe radioactivity **CO 3** : Explain the general properties of decay and alpha, beta and gamma decay. **CO 4** : Explain the mechanism of weak and strong interaction based on old models: Yukawa's meson model for solid interactions and Fermi's weak interaction model.

	CO 5 : Explain the mechanism of weak and strong interactions based on new models: the quark and QCD models for solid interactions and the Weinberg-Salam electroweak model for interactions. **CO 6** : Explaining Lagrangan's formalism in elementary particle physics. **CO 7** : Describe the various continuous symmetries in Lagrangian and their relationship to the continuous flow (Noether's theorem). **CO 8** : Qualitatively explain discrete symmetry in elementary particle physics, parity symmetry, charge conjugation, and time reversal (PCT). **CO 9** : Using Feynman diagrams qualitatively to analyze various kinds of elementary particle reactions. **CO 10** : Explain in outline the content of the particles and the properties of the particles in the standard model. **CO 11** : Describe the process of mass formation in the Higgs mechanism qualitatively.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Arya, Atam H.,1966, Fundamental of Nuclear Physics, Allen and Bacon Inc. 2. Martin, R Brian, 2006, Nuclear and particle Physics, An Introduction, John Wiley & Sons, Ltd, England. 3. Krane, KS, 1988, Introductory Nuclear Physics, John Wiley & Sons. 4. Meyerhoff,W.E.,1989, Elemen of Nuclear Physics,McGraw Hill Book Co. 5. David Griffiths, 2004: Introduction to elementary particles, Wiley-VCH.

Content	1. Interaction of Radiation with matter 2. Radioactivity 3. Alpha decay 4. Gamma decay 5. Beta decay 6. Weak Interaction and strong interaction according to old theory 7. Weak interaction and strong interaction according to the strong theory 8. Lagrangian formalization for elementary particle physics 9. Discrete Symmetry in Elementary Particle physics 10. Standard Models 11. Feynmann diagrams
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **: Attendance**

35. MFF 3608 - Solid of Physics II

Module Name	Solid of Physics II
Code	MFF 3608
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D
Lecturer	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D , Prof., Dr. Harsojo, SU, M.Sc. , ,
Language	Indonesian
Relation to curiculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Solid State Physics I (MFF2601)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.

Course cutcomes (CO)	**CO 1** : Students have the ability in Physics Skills, namely how to formulate and describe (to describe) the physical phenomena being studied and uncover important information contained in the physics problem through various tricks or certain mathematical procedures and utilizing various approximations. **CO 2** : Students have the ability in Analytical Skills, namely how to pay attention to physics problems in detail, analyze problems and build arguments logically and carefully. **CO 3** : Students have the ability in Investigative Skills, namely how to search for physics problems from various sources and references to understand important information. **CO 4** : Students have the ability in Problem-Solving Skills, namely how to solve a problem with a structured solution (well-defined solutions), formulate a problem carefully, and try other approaches (approaches) to improve solving a challenging problem (challenging problems).
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. C..Kittel, Solid State Physic, Edisi 8, 2005. 2. R.K. Puri , V.K. Babbar, 1997, Solid State Physic, S. Chand & Company LTD, New Delhi.

Content	1. Magnetic properties of materials: Diamagnets, Paramagnets, ferromagnets, antiferromagnets, and ferrimagnets 2. Magnetic properties of materials: Diamagnets, Paramagnets, ferromagnets, antiferromagnets, and ferrimagnets 3. Magnetic properties of materials: Diamagnets, Paramagnets, ferromagnets, antiferromagnets, and ferrimagnets 4. Dielectric Properties: polarizability, dielectric constant, ferroelectricity, piezo-electricity. 5. Dielectric Characteristics: polarizability, dielectric constant, ferroelectricity, piezo-electricity. 6. Elementary excitation: Plasmon, polariton, polaron 7. Elementary excitation: Plasmon, polariton, polaron 8. Superconductivity: perfect diamagnetism, super current and penetration depth, required field and temperature, type I and typed II superconductors, thermodynamic and optical properties. 9. Superconductivity: perfect diamagnetism, super current and depth of penetration, critical field and temperature, type I and type II superconductors, thermodynamic and optical properties. 10. Superconductivity: perfect diamagnetism, super current and penetration depth, required field and temperature, type I and typed II superconductors, thermodynamic and optical properties. 11. The Phenomenon of Magnetic Resonance 12. The Phenomenon of Magnetic Resonance 13. Physical phenomena in surface systems, interfaces, and nanostructures. 14. Physical phenomena in surface systems, interfaces, and nanostructures.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

36. MFF 3204 - Nuclear Physics Laboratory**)

Module Name	**Nuclear Physics Laboratory**)**
Code	MFF 3204
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Iman Santoso
Lecturer	Dr. Iman Santoso., Dr.Eng. Fahrudin Nugroho., Ikhsan Setiawan, M. Si, Eko Tri Sulistyani, M. Sc.
Language	Indonesian
Relation to curiculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Nuclear and Particle Physics (MFF2205)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Students can carry out nuclear detection using a gas detector (Geiger-Mueller Counter), analyze data, and provide conclusions from this experiment. **CO 2** : Students can carry out alpha spectroscopy experiments to detect alpha particles decaying from radioactive sources using Solid State (NaI Tl) detectors and can analyze data and provide conclusions from this experiment. **CO 3** : Students can conduct beta-ray spectroscopy experiments in terms of detecting beta particles decaying from radioactive sources using a semiconductor (silicon) detector or an organic antransine scintillator detector and can analyze data and provide conclusions from this experiment. **CO 4** : Students can perform alpha-ray spectroscopy experiments in detecting Gamma particles decaying from radioactive sources using Solid State (NaI Tl) detectors. They can analyze data and provide conclusions from this experiment. **CO 5** : Students can perform X-ray spectroscopy experiments to detect discrete X-ray series emitted from radioactive sources using Solid State (NaI Tl) detectors. They can analyze data and provide conclusions from this experiment.
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Melissinos, A. C., 2003: Experiments in Modern Physics, Academic Press 2. Tim Pengampu, 2016: Petunjuk Praktikum Fisika Inti, Lab. Fisika Atom-Inti 3. Tsoulfanidis, N., 2015: Measurement and Detection of Radiation, McGraw-Hill. 4. ORTEC AN34 Laboratory Manual, 2020: Experiment in Nuclear Science Laboratory, 4th ed.

Content	A. 1. Experiment with Nuclear detection methods using GM counters, understand how GM counters work, and determine the absorption of materials against beta and gamma nuclear radiation. 2. Alpha Spectroscopy Experiment, detecting alpha particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 3. Beta Spectroscopy Experiment, detecting beta particles decaying from a radioactive source using a semiconductor (silicon) detector or anthracin organic scintillator detector. 4. Gamma-ray spectroscopy experiment, detecting Gamma particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 5. X-ray spectroscopy experiment, detecting discrete X-ray series emitted from a radioactive source using a Solid State (NaI Tl) detector. B. 1. Experiment with Nuclear detection methods using GM counters, understand how GM counters work, and determine the absorption of materials against beta and gamma nuclear radiation. 2. Alpha Spectroscopy Experiment, detecting alpha particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 3. Beta Spectroscopy Experiment, detecting beta particles decaying from a radioactive source using a semiconductor (silicon) detector or anthracin organic scintillator detector. 4. Gamma-ray spectroscopy experiment, detecting Gamma particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 5. X-ray spectroscopy experiment, detecting discrete X-ray series emitted from a radioactive source using a Solid State (NaI Tl) detector. C. 1. Experiment with Nuclear detection methods using GM counters, understand how GM counters work, and determine the absorption of materials against beta and gamma nuclear radiation. 2. Alpha Spectroscopy Experiment, detecting

	alpha particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 3. Beta Spectroscopy Experiment, detecting beta particles decaying from a radioactive source using a semiconductor (silicon) detector or anthracin organic scintillator detector. 4. Gamma-ray spectroscopy experiment, detecting Gamma particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 5. X-ray spectroscopy experiment, detecting discrete X-ray series emitted from a radioactive source using a Solid State (NaI Tl) detector. D. 1. Experiment with Nuclear detection methods using GM counters, understand how GM counters work and determine the absorption of materials against beta and gamma nuclear radiation. 2. Alpha Spectroscopy Experiment, detecting alpha particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 3. Beta Spectroscopy Experiment, detecting beta particles decaying from a radioactive source using a semiconductor (silicon) detector or anthracin organic scintillator detector. 4. Gamma ray spectroscopy experiment, detecting Gamma particles decaying from a radioactive source using a Solid State (NaI Tl) detector. 5. X-ray spectroscopy experiment, detecting discrete X-ray series emitted from a radioactive source using a Solid State (NaI Tl) detector. E. "1. Experiment with nuclear detection methods using GM counters, understand how GM counters work, and determine material absorption of beta and gamma nuclear radiation. F. Response
Examination forms	***Cognitive*** **:** Pretest, Final test ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report, Attendance**

37. MFF 3602 - Solid State Physics Laboratory)**

Module Name	**Solid State Physics Laboratory**)**
Code	MFF 3602
Semester(s) in which the module is taught	ODD/EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Chotimah
Lecturer	Dr. Chotimah., Devy Pramudyah Wardani, M.Sc.
Language	Indonesian
Relation to curiculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Teaching methods	CBL (Case Based Learning): Pretest, Presentation of material and some display material, Hands-on experiments using available set-ups, Making reports
Workload	1. **Lectures :** 1 x 50 = 50 minutes per week. 2. **Exercises and Assignments** : 1 x 60 = 60 minutes per week. 3. **Private Learning :** 1 x 60 = 60 minutes per week.
Credits points	1 SKS ~ 1.6 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Solid State Physics I (MFF2601)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Students can explain the concepts underlying physical phenomena in solid materials and their applications in related technologies. **CO 2** : Students can explain the experimental design to observe a physical phenomenon and relate it to the basic concept. **CO 3** : Students can carry out experiments on a phenomenon in solid materials and analyze their

	experiments' results. **CO 4** : Students can convey the results of their experiments both in the form of written and oral communication. **CO 5** : Students can work individually and in groups in experiments and present the results obtained.
Media employed	Offline (Experimental tool) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Buku Panduan Praktikum Fisika Zat Padat
Content	1. Determination of the Diffusion Rate of Salt Molecules by Laser Deflection Measurement 2. Power Diode/LED Gap Measurement 3. The response I : Practical Topic in Weeks 1 - 2 4. Hall Assignment Measurement and Load Carrier Meeting 5. Measurement of Magnetic Susceptibility with the Gouy Method 6. 2. Alpha Spectroscopy Experiment, detecting alpha particles that decay from radioactive sources using a Solid State (NaI Tl) detector. 7. Test Current-Voltage Characteristics of Silicon Solar Cells 8. Response II Practicum Topics in Weeks 4-6
Examination forms	***Cognitive*** **:** Pretest, Final test ***Psychomotor*** **:** Practicum ***Affective*** **: Practicum Report, Attendance**

38. MFG 1101 - Introduction to Geophysics

Module Name	**Introduction to Geophysics**
Code	MFG 1101
Semester(s) in which the module is taught	ODD semester
Module designation	
Person responsible for the module	Dr. Eddy Hartantyo, M.Si.
Lecturer	Dr. Eddy Hartantyo, M.Si., Dr. Wahyudi, MS., Drs. Imam Suyanto, M.Si., Dr.rer.nat. Ade Anggraini,S.Si, MT.
Language	Indonesian
Relation to curiculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team.
Course cutcomes (CO)	**CO 1** : Students can explain the position of the earth in the context of the universe to th internal structure of the earth and the contribution of geophysics in understanding the position and structure **CO 2** : Students can explain the role of geophysics in natural resource exploration

Media employed	
Reading list	**Main References :** 1. Field Geophysics, Malcolm 2012 2. Fundamentals of Geophysics, Author: William Lowrie; Andreas Fichtner, Cambridge University Press, 3rd edition, 2020.
Content	1. Geophysical science and its role in general 2. Earth and Solar System. The shape, size, and composition of the Earth. Earth's revolution and rotation. Parts of the Earth: exosphere, atmosphere, hydrosphere, lithosphere, upper mantle or asthenosphere, lower matle, outer core, and inner core. 3. Erath's Gravitational Field: pendulum and gravitymeter, geoid, isostasy and tides. 4. Seismoloy: Seismographs and seismometers, the mechanism of earthquake occurrence (focal mechanism) and its propagation, the internal structure of the Earth, micro-earthquakes, tsunamis. 5. Geomagnetism and rock magneticsm: compass and magnetometer, main and external fields, daily variations and westward drift, rock magnetization, Paleomagnetism, and ocean floor spreading. 6. Georadioactivity: absolute dating (absolute dating), the age of the Earth. 7. Earth's internal heat: temperature, temperature gradient and surface heat flux, variations in temperature with depth.

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

39. MFF 2061 - Metrology and Calibration of Physics

Module Name	**Metrology and Calibration of Physics**
Code	MFF 2061
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Eng. Kuwat Triyana, M.Si.
Lecturer	Prof. Dr. Eng. Kuwat Triyana, M.Si.
Language	Indonesian
Relation to curiculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Measurement Technique in Physics (MFF 1061)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Know and understand quality infrastructure, national standard systems, and international standard systems **CO 2** : Knowledge of metrology and metrology organization, units and traceability, scientific and industrial metrology, and nanometrology. **CO 3** : Know and understand measurement uncertainty and basic principles of calibration

	CO 4 : Know and understand about calibration of dimensional measuring instruments, calibration of temperature measuring instruments, calibration of time measuring instruments, and calibration of analytical instruments
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Anonim, 2010, Evaluation of measurement data: Guide to the expression of uncertainty in measurement, BPIM 2. Drijarkara, A.P. dan Zaid, G. 2005, Metrologi: Sebuah Pengantar, Puslit KIM-LIPI 3. Hebra, A.J., 2010, The Physics of Metrology, Springer-Verlag, Morlenbach, Germany 4. Janne Kivilaakso, J., Pitkäkoski, A., Valli, J., Johnson, M., Inamoto, N., Aukia, A., dan Saito, M., 2006, Calibration Book, Vaisala Oyj, Helsinki Finland 5. Leach, R.K., 2010, Fundamental Principles of Engineering Nanometrology, Elsevier Inc., Burlington
Content	1. Quality infrastructure 2. National Standard System 3. International standard system 4. Metrology and metrology organization 5. Metrological units and traceability 6. Scientific and industrial metrology 7. Nano-Metrology 8. Measurement Uncertainty 9. Basic principles of calibration 10. Mass measuring instrument calibration 11. Dimension measuring instrument calibration 12. temperature measuring instrument calibration 13. time gauge calibration 14. Calibration of analytical instruments
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

40. MFF 2071 - Instrumentation System

Module Name	Instrumentation System
Code	MFF 2071
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Eng. Kuwat Triyana, M.Si.
Lecturer	Prof. Dr. Eng. Kuwat Triyana, M.Si., Prof. Dr. Harsojo, SU., M.Sc.
Language	Indonesian
Relation to curiculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Electronics (MFF 1850)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Knowing and understanding instrumentation systems, types of measuring instruments, and statistical and dynamic characteristics of measuring instruments **CO 2** : Know and understand errors during measurements, how to calibrate and measure quality assurance, and first and second-order instruments.

	CO 3 : Know and understand noise measurement and noise reduction methods **CO 4** : Know and understand signal processing, variable conversion elements **CO 5** : Know and understand non-destructive testing
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Alan S. Morris, 2001, Measurement and Instrumentation Principles, Butterworth-Heinemann, Oxford 2. Hebra, A.J., 2010, The Physics of Metrology, Springer-Verlag, Morlenbach, Germany.
Content	1. Introduction to instrumentation systems 2. Types of measuring instruments 3. Statistical characteristics of measuring instruments 4. Dynamic characteristics of measuring instruments 5. Error during measurement 6. Calibration and measurement quality assurance 7. Measuring instruments of order one and two 8. First and second-order measuring instruments 9. Noise Measurement 10. Noise Reduction Method 11. Signal processing 12. Variable Conversion Element 13. Introduction to non-destructive testing
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **: Attendance**

41 . MFF 2853 - Sensor System

Module Name	**Sensor System**
Code	MFF 2853
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Eng. Kuwat Triyana, M.Si
Lecturer	Prof. Dr. Eng. Kuwat Triyana, M.Si., Dr.Eng. Edi Suharyadi, S.Si., M.Eng.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Electronics (MFF 1850)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and Understanding the Basics of Sensors and their applications **CO 2** : Know and understand sensor systems and signal conditioning **CO 3** : Know and understand the types of sensors
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google

	Classroom)
Reading list	**Main References :** 1. Alan S. Morris, 2001, Measurement and Instrumentation Principles, Butterworth-Heinemann, Oxford 2. Hebra, A.J., 2010, The Physics of Metrology, Springer-Verlag, Morlenbach, Germany 3. Wilson, J.S., 2005, Sensor Technology Handbok, Elsevier Inc., Burlington, USA.
Content	1. Sensor basics and their application 2. Sensor System 3. Signal Conditioning 4. Acceleration and Vibration Sensor 5. Chemical sensors and biosensors 6. Inductive and capacitive-based displacement sensors 7. Electromagnetism Sensor 8. Flow and level sensor 9. Force and weight sensors 10. Temperature and humidity sensors 11. Optical sensor 12. Position sensor 13. Pressure sensor 14. Strain sensor
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

42. MFF 2873 - Image of Physics

Module Name	**Image of Physics**
Code	MFF 2873
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Gede Bayu Suparta, M.S., Ph.D.
Lecturer	Drs. Gede Bayu Suparta, M.S., Ph.D.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and Understanding the basic concepts of Image Physics **CO 2** : Knowing and understanding Instruments in Image physics **CO 3** : Know and understand imaging methods **CO 4** : Know and understand the Application of Image Physics in the industry

Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Allison, W., 2006, Fundamental Physics for Probe and Imaging, Oxford University Press, New York. 2. National Academic of Science, 1996, Mathematics and Physics of Emerging Biomedical Imaging, National Academic Press, Washington, Ch. 7-14. **Additional References :** 1. Relevant scientific journals and patents
Content	1. Basic Concept: Digital image 2. Digital image acquisition system 3. digital image formats 4. digital image quality 5. Digital image processing 6. Instruments: Digital photography, digital microscope, 7. Thermal camera, Inspection Camera 8. Imaging methods: photo images, panoramic images, 9. video image, time-lapsed image (cinema), 10. incognito image, 3D image 11. Industrial Application: Visual inspection, 12. surveillance, biometrics 13. iridology, palmistry 14. borescope, ultrasound.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

43. MFF 2953 - Celestial Mechanics

Module Name	**Celestial Mechanics**
Code	MFF 2953
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eng. Rinto Anugraha NQZ, S.Si., M.Si
Lecturer	Dr. Eng. Rinto Anugraha NQZ, S.Si., M.Si
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Mechanics I (MFF 1401)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and Understanding Plane and Spherical Trigonometry **CO 2** : Know and understand the Coordinates of the Earth and Heavenly Bodies **CO 3** : Know and understand Julian Day and the Calendar System **CO 4** : Know and understand two and three object problems

	CO 5 : Knowing and understanding the motion of the sun, planets, and moon, phases of the moon, solar and lunar eclipses.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Jean Meeus, 1991, Astronomical Algorithm, Willmann-Bell, Virginia, USA. 2. Y. Ryabov, 2006, An Elementary Survey of Celestial Mechanics, Dover Publication, USA.
Content	1. Plane and Spherical Trigonometry 2. Coordinates of Earth and Celestial Bodies 3. Julian Day 4. Calendar System 5. Problems two and three things 6. The motion of the Sun, Planets, and Moon 7. Moon phases 8. Solar and Moon Eclipse
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

44. MFF 2029 - Mathematics Theoretical of Physics I

Module Name	Mathematics Theoretical of Physics I
Code	MFF 2029
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Lecturer	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Mastering and applying the concepts and properties of semigroups, groups, subgroups, homomorphisms, kernels, co-sets, factor groups, direct products, group actions, types of action, orbits, and

	rigid points. **CO 2** : Mastering and applying the concepts and properties of arenas, sub-fields, fields, vector spaces, vector subspaces, freedom, linear coherence, bases, **CO 3** : Mastering the concepts and properties of linear mapping, isomorphism, matrix representation for vector spaces and linear mapping, systems of linear equations, and self-value equations. **CO 4** : Mastering and applying the concepts and properties of metric spaces, open and closed spheres, metric topology, long spaces, scalar product spaces, Hilbert spaces, orthogonality, Gramm-Schmidt orthonormalization, Pythagorean theorem, Schwartz inequality, orthonormal basis, Fourier series **CO 5** : Mastering and applying the concepts and properties of operators in Hilbert spaces, companion operators, self-accompanied operators, isometric mapping, and self-assessment problems for operators in Hilbert spaces .
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Erwin Kreyszig, 1989, Introductory to Functional Analysis wit Applications, John Wiley & Sons., Inc. 2. M. F. Rosyid, 2015, Aljabar Abstrak dalam Fisika, Gama Press.
Content	1. Concepts and properties of semigroups, groups, subgroups, examples 2. Concepts and properties of group homomorphisms, kernels, co-sets, factor groups, direct products, examples 3. Concept and properties of group action, types of action, orbits, rigid points, examples 4. The concept and properties of the arena, sub-rink, field, and examples 5. Concepts and properties of vector spaces, vector subspaces, linear independence, dependence, bases, examples 6. Concept and properties of linear mapping, isomorphism, matrix representation for vector spaces and linear mapping, examples 7. Systems of linear equations, self-valued

	equations, examples 8. Concepts and properties of metric spaces, open and closed spheres, examples 9. Topological concepts and properties of metrics, long spaces, examples 10. The concept and properties of scalar product spaces, Hilbert spaces, orthogonality, Gramm-Schmidt orthonormalization, examples 11. Pythagorean theorem, Schwartz inequalities, orthonormal basis, Fourier series, examples 12. Concepts and properties of operators in Hilbert space, co-operators, self-accompanied operators, examples 13. Concept and properties of isometric mapping, the self-value problem for operators in Hilbert spaces, examples
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

45. MFF 3053 - Physics of Complex and Nonlinear Systems

Module Name	Physics of Complex and Nonlinear Systems
Code	MFF 3053
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eng. Rinto Anugraha NQZ, S.Si., M.Si.
Lecturer	Dr. Eng. Rinto Anugraha NQZ, S.Si., M.Si., Dr.Eng. Fahrudin Nugroho, S.Si., M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Numerical Method (MFF 1024), Atomic and Molecular Physics (MFF 2310)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Provide examples of systems that can demonstrate complex phenomena **CO 2** : Explain the physical mechanism of the occurrence of complex phenomena in several systems. Included in this is how to direct by setting a specific physical parameter so that the system goes to a complex state

	CO 3 : Explain what is meant by turbulence and chaos with a physical definition. **CO 4** : Conduct qualitative and quantitative analysis of the dynamics of a system (time evolution). With this analysis, students can distinguish whether a dynamic is categorized as a chaotic dynamic or not. Furthermore, students can determine how high the level of nonlinearity is.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Mori, H., Kuramoto, Y., 1998, Dissipative Structure and chaos, Springer, Berlin. 2. Zwanzig, R, 2001, Nonequilibrium statistical mechanics, Oxford Univ Press, UK. **Additional References :** 1.
Content	1. Explanation and agreement of lectures, Brief review of the primary keys in linear systems 2. Rayleigh-Bernard Convection 3. Electrohydrodynamic System: Nematic liquid crystal 4. Turbulence 5. Review of Phase Spaces and Paths in phase space; Definition of Chaos 6. Attractors and Strange attractors 7. Logistics Map 8. Random dynamics (data plotting) 9. Leap Unov Exponent and Spectral Analysis 10. Gizburg Landau equation type: Korteweg-DeVries 11. Gizburg Landau equation type: Swift Hohenberg 12. The Ginzburg-Landau equation type: Nikolaevskiy 13. Ginzburg-Landau equation type: Nikolaevskiy damped and Linear stability analysis

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

46. MFF 3291 - Nuclear and Particle Detection Method

Module Name	**Nuclear and Particle Detection Method**
Code	MFF 3291
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Agung Bambang Setio Utomo, S.U.
Lecturer	Prof. Dr. Agung Bambang Setio Utomo, S.U.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Atomic and Molecular Detection Method (MFF 2322)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Understand the mechanism of nuclear radiation interaction with matter (especially detectors) so that students can use nuclear detection equipment, electronic auxiliary equipment, and their use **CO 2** : Having an adequate understanding of the manufacture and design of nuclear radiation detection systems for applications and analysis involving nuclear radiation

	CO 3 : Increase cooperation in groups and the ability to convey ideas or thoughts, as well as improve the ability to think logically and creatively, which will indirectly foster leadership through group work. **CO 4** : Have skills in obtaining lecture materials both from materials provided by lecturers and other materials by searching through books and the internet
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Tsoulfanidis N, 1983, Measurement and detection of radiation, Mc Graw Hill
Content	1. Introduction: Lecture game rules, assessment rules, Material (Syllabus) 2. Fundamentals of radiation-matter interactions in general 3. Mechanism of a reaction in gas cylinder detectors, scintillators, semiconductors, and high-energy radiation detection 4. Mechanisms and functions of nuclear electronic auxiliary equipment 5. Nuclear detection circuit/system 6. Dosimetry 7. Nuclear Spectroscopy: Gamma, X-ray, NMR. 8. Spectrum analysis. 9. Radiation application nuclear: Activation neutrons.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

47. MFF 3423 - Introduction to Laser of Physics

Module Name	**Introduction to Laser of Physics**
Code	MFF 3423
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Moh. Ali Joko Wasono, M.S.
Lecturer	Dr. Moh. Ali Joko Wasono, M.S., Prof. Dr. Agung Bambang Setio Utomo, S.U.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Electromagnetics I (MFF 2415), Quantum Physics I (MFF 2034), Atomic and Molecular Physics (MFF 2310)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Understand the mechanism of electron interaction in atoms so that students can use lasers, electronic assistive devices, and their uses. **CO 2** : Have an adequate understanding of the use of lasers for applications and analysis involving laser light radiation. **CO 3** : Increase cooperation in groups and the ability to

	convey ideas or thoughts, as well as improve the ability to think logically and creatively, which will indirectly foster leadership through group work. **CO 4** : Have skills in obtaining lecture materials from lectures provided by lecturers and other materials by searching through library books and the internet.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Svelto O, 1989, Principles of Lasers, Plenum Press. 2. Milonni PW dan Eberly H, 1991, Lasers, John Wiley. 3
Content	1. Introduction: Lecture game rules, assessment rules, Material (Syllabus) 2. Light quantization 3. Properties of gas atoms 4. The interaction of electromagnetic radiation with matter 5. Atomic transition processes: absorption, spontaneous emission, and forced emission of radiation 6. Laser working principle 7. Optical pumping mechanism as a condition for the welding process 8. Optical resonator mechanism and function 9. Types, properties, and characteristics of lasers and laser beams made from active gases, solids, liquids, and semiconductors 10. Laser app
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

48. MFF 3701 - Medical of Physics

Module Name	Medical of Physics
Code	MFF 3701
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Bambang Murdaka Eka Jati, MS.
Lecturer	Dr. Bambang Murdaka Eka Jati, MS.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	General Physics I (MFF 1011), General Physics II (MFF 1012)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Understand the form of applying Basic Physics I to problems related to human health and medical devices **CO 2** : Understand the form of applying Basic Physics II to problems related to human health and medical devices
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and

	Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Jati, BME, 2021: Pengantar Fisika Kedokteran (Mekanika, Gelombang Kalor), edisi-1, UGM Press, Yogyakarta 2. Jati, BME, 2022: Pengantar Fisika Kedokteran (Listrik, Magnit, Optika, Radiasi Nuklir, dan Teknologi Medis), edisi-2, UGM Press, Yogyakarta 3. Maqbool, M., 2018: An Introduction to Medical Physics, Springer, 1st edition, Birmingham 4. Gabriel, J.F., 1996: Fisika Kedokteran, edisi-7, Penerbit Buku Kedokteran EGC, Denpasar. **Additional References :** 1. Fosbinder, R.A. & Kelsey, C.A., 2002: Essentials of Radiologic Science, 1st edition, Mc Graw Hill, Medical Publishing Edition, New York 2. Cember, H. & Johnson, T.E., 2009: Introduction to Health Physics, 4th edition, Graw Hill, Medical Publishing Edition, New York 3. Hendee, W.R. & Ritenour, E.R., 2002: Medical Imaging Physics, 4th edition, Wiley Liss Inc.
Content	1. Metrology in Medical Physics 2. biomechanics 3. Biofluids 4. Vibration and Resonance 5. Sound and sense of hearing 6. Ultrasound in medicine 7. Heat and Sense of Taste 8. Bioelectric 9. biomagnetic 10. Electromagnetic wave 11. Biooptics and the Sense of Sight 12. Atoms and Nuclear Radiation 13. X-rays and Tomography 14. MRI
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** Project Results ***Affective*** **: Attendance**

49. MFF 3843 - Microwave

Module Name	Microwave
Code	MFF 3843
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Mitrayana, S.Si., M.Si.
Lecturer	Dr. Mitrayana, S.Si., M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Electromagnetics I (MFF 2415), Mathematical Physics III (MFF 2024)I
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain microwave propagation in various waveguide models. **CO 2** : Students can understand the working principles of control components and microwave generator sources. **CO 3** : Students can explain the application of microwaves in ESR, Radar, Communication Systems, and Tomographic Thermoacoustic Systems.

Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Allan W. Scott, 1993, Understanding Microwaves, John Wiley & Sons. 2. Mike Golio, 2008, RF and Microwave Applications and Systems. 3. Mitrayana, 2016, Gelombang Mikro Teori dan Aplikasi, Gadjah Mada Press.
Content	1. Introduction: Lecture Contract, Survey of Microwave (GM) equipment and systems, the relationship of gm WITH OTHER ELECTRONIC EQUIPMENT, gm SYSTEM, gm spectrum, why GM equipment is needed, the basic design of GM system 2. GM transmission forms, signal control components, semiconductor amplifiers and insulators, GM tubes, GM weak sound receivers, GM antennas 3. Microwave Field 4. Wave Guide 5. Insertion Loss, Gain, and Return Loss 6. Adjustment to the Smith Chart 7. Microwave Transmission Line 8. Microwave Signal Control Components 9. Microwave Equipment 10. Microwave Application 1: Electron Spin Resonance 11. Microwave App 2: Radar 12. Microwave App 3: Communication with Microwaves 13. Microwave Application 4: Thermoacoustic Tomography (TAT)
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Group Assignments ***Psychomotor*** **:** ***Affective*** **:**

50. MFF 3871 - Tomography of Physics

Module Name	**Tomography of Physics**
Code	MFF 3871
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Gede Bayu Suparta, M.S., Ph.D.
Lecturer	Drs. Gede Bayu Suparta, M.S., Ph.D.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and Understanding the History of CT, application trends, and R&D trends **CO 2** : Know and understand the basic theory of Hough, Radon, Fourier, Matrix, and Matrix equations and iteration transformations **CO 3** : Knowledge and understanding of the CT system **CO 4** : Knowing and understanding the Sampling Process

	CO 5 : Know and understand reconstruction methods **CO 6** : Know and understand CT Software
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Buzug, T.M., 2008. Computed Tomography: From Photon Statistics to Modern Cone-Beam CT, SpringerVerlag Berlin Heidelberg. 2. Kak, A.C. and M. Slaney, 1988, Principles of Computed Tomography Imaging, IEEE Press, Piscataway, NJ.
Content	1. Introduction: CT history, application trends, R&D trends 2. Basic Theory of Hough Transformation, Radon Transformation, 3. Fourier transform, Matrix transform, 4. Matrix Equation and Iteration. 5. CT System: Design, Components 6. CT system: set-up, working principle 7. CT system: Parameters 8. Sampling Process: data acquisition, interpolation, 9. Process Sampling: pre-processing data 10. Reconstruction Method: interpolation process, 11. , reverse project process, and image display process 12. CT software: sampling, 13. CT software: image processing 14. CT software: image analysis.
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Assignments ***Psychomotor* :** ***Affective* :**

51. MFF 3891 - Environmental of Physics

Module Name	**Environmental of Physics**
Code	MFF 3891
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Sunarta, MS.
Lecturer	Drs. Sunarta, MS., Drs. Wagini, MSc.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and understanding the history of life on Earth, the thermodynamic state of the Earth, changes in environmental conditions, as well as humans and their activities **CO 2** : Know and understand environmental problems; take the role of protecting and managing the environment from a physical and analytical approach. **CO 3** : Get to know the sources and characteristics of

	environmental pollution in general. **CO 4** : Recognize the types of pollution in the soil and water environment caused by heavy metals **CO 5** : Analyze physically, especially the type of pollution from liquid waste and industrial waste **CO 6** : Identify, analyze and conclude ways of handling pollution in the field.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Smith C., 2011, Environmental Physics; 2. Monteith J., 2007, Principles of Environmental Physics, Univ. of Nottingham 3. Wagini, 2009, Fisika Lingkungan, Jurusan Fisika FMIPA UGM..
Content	1. The history of life on earth, a thermodynamic review of the state of the earth, changes in environmental conditions, the environment (natural resources, living natural resources, and environmental conditions), humans and their activities 2. Environmental problems, the role of science (physics) as a contribution to maintaining and managing the environment 3. Sources and nature of environmental pollution 4. Environmental Radiation 5. Pollution of soil and water 6. Metal type pollutant 7. Handling and treatment of liquid waste 8. Identification of the home industry 9. Field survey
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor* :** Project Results ***Affective* :**

52. MFF 4033 - Quantum Mechanics

Module Name	Quantum Mechanics
Code	MFF 4033
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Lecturer	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Quantum Physics I (MFF 2034)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Understand the general description of mechanics: state space, Observables, expected values, standard deviations, dynamics **CO 2** : Mastering and applying the concept of Hilbert space as a physical space: complex vector space, scalar product, norm, orthogonality and orthonormality, orthonormal basis and Fourier series, completeness of scalar product space.

	CO 3 : Mastering and applying the concepts of linear operators in Hilbert space: adjoint operators, self-adjoint operators, unitary operators, exponential operators, self-value equations, degeneration, self-adjoint and self-adjoint operators, and unitary operators. **CO 4** : Mastering and applying the postulations of quantum mechanics: quantum state space, quantum observables, quantum probability, expected value and standard deviation, Heisenberg uncertainty, and quantum dynamics. **CO 5** : Mastering and applying quantum dynamics: time shift operators, derivation of the Schroedinger equation for time shift operators, and state vectors. **CO 6** : Master and apply position representation and momentum representation: external basis, position basis, and momentum basis, Fourier transform, position operator and momentum operator in position and momentum basis, and Schroedinger equation in position and momentum basis. **CO 7** : Mastering and applying Schroedinger Drawing and Heisenberg Drawing.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Cohen-Tannoudji, C. dkk., 2003, Quantum Mechanics, John Wiley 2. Bowman, G. E., 2008, Essential Quantum Mechanics, Oxford University Press, Oxford.

Content	1. 1. Overview of mechanics in general: state space, Observables, expected values, standard deviations, dynamics. 2. Examples 2. Hilbert space as a state space: a complex vector space, 3. Scalar product, norm, orthogonality and orthonormality, orthonormal basis and Fourier series, and space completeness have a scalar product. 4. Mastering and applying the concept of linear operators in Hilbert space: adjoint operators, self-adjoint operators, unitary operators, exponential operators, 5. Self-assessment, degeneracy, self-assessment, and self-adjoint operators and unitary operators. 6. Postulations of quantum mechanics: quantum state space, quantum observables, quantum probability, expected value, and standard deviation, 7. Heisenberg uncertainty, quantum dynamics. Examples 8. Quantum dynamics: time shift operators, derivation of the Schroedinger equation for time shift operators and state vectors, 9. Quantum dynamics examples 10. Position and momentum representatives: external basis, position and momentum basis, Fourier transform, position operator and momentum operator in position and momentum basis, Schroedinger equation in position and momentum basis 11. Examples of Position Representative and Momentum Representative 12. Mastering and applying Schroedinger Drawing and Heisenberg Drawing. Examples.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

53. MFF 4611 - Liquid Crystal of Physics and Polymers

Module Name	**Liquid Crystal of Physics and Polymers**
Code	MFF 4611
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Yusril Yusuf, S.Si., M.Si., M.Eng., D.Eng., Ph.D.
Lecturer	Prof. Yusril Yusuf, S.Si., M.Si., M.Eng., D.Eng., Ph.D.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and Understanding Liquid Crystal **CO 2** : Know and understand the optical properties of Liquid Crystals **CO 3** : Know and understand the effects of electricity on liquid crystals and Freedericksz. transitions **CO 4** : Know and understand Polymer Physics **CO 5** : Know and understand the properties of polymer molecules

	CO 6 : Knowing and understanding Polymer Liquid Crystals
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Deng-Ke Yang and Shin-Tson Wu, Fundamental of Liquid Crystal Devices, John Wiley & Sons Ltd., 2006. 2. Masao Doi, Introduction to Polymer Physics, Oxford Science Publication, Oxford University Press, 2001
Content	1. Introduction to Liquid Crystal 2. Liquid Crystal Physics (Orientational order, elastic properties of liquid crystals, response of liquid crystals to electric and magnetic fields) 3. Optical properties of liquid crystals 4. Electrical Effects on the liquid crystal 5. Frederick. Transition 6. Introduction to Polymer physics 7. The properties of polymer molecules (ideal chains, distribution of segments in polymer chains, and non-ideal chains) 8. Polymer Liquid Crystal
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

54. MFF 4893 - Introduction to Econophysics

Module Name	Introduction to Econophysics
Code	MFF 4893
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Dwi Satya Palupi
Lecturer	Dr. Dwi Satya Palupi
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Able to explain the scope of the field of econophysics, mention the basic similarities and differences between physics and economics **CO 2** : Able to explain complex systems in physics and economics, mention analogies between physics and economics **CO 3** : Able to explain several applications of thermodynamics in economics, analyze wealth

	distribution, money distribution, and income distribution using statistical physics concepts **CO 4** : Able to formulate market price dynamics by applying the concepts of classical mechanics and quantum mechanics **CO 5** : Able to analyze the state of a financial market using stochastic processes, statistical physics concepts, and quantum mechanics concepts
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Montegna, RN dan Stanley, E.H., 2000, An Introduction to Econophysics, Correlations and Complexity in Finance, Cambridge University Press, Cambridge, UK ISBN 0 521 62008 2. 2. Michael Schulz, 2003, Statistical Physics and Economic, concepts, tools, and Application, Spinger Verlag New York. **Additional References :** 1. Rickles,Dean, 2007, Econophysics for philosophers.,Studies in History and Philosopy of Modern Physics, , 948 -947., doi: 10.1016/jshpsb.2007.01.0003., www.elsevier.com/locate/sh 2. Dragulescu, A dan Yakovenko,VM., 2000, Statistical Mechanic of money, Eur.Phys.J.B.17.723-729.
Content	1. 1. Explanation of the RPKPS, 2. Scope of the field of econophysics: branches of physics and the similarities of physics with economics related to objects, methods, amount of data, applications, PACS, the definition of econophysics, differences and 2. Economics is a complex system of many objects and interactions, microeconomics and macroeconomics in mathematical equations. 3. Analogies in the fields of physics and economics: system analogies, data patterns, quantities 4. Applied thermodynamics in economics: applied equations of state for ideal gases and quantities that express the state of the system, applied statistical physics to obtain distributions of wealth, money, income 5. The dynamics of commodity prices in the market: describing price dynamics with classical mechanics and prices with quantum mechanics. 6. Financial markets: definition of financial markets,

	stock price movements, options, and currency exchange rates, 7. Stochastic processes applied statistical physics in financial markets: entropy, stock, and option price movements, 8. application of quantum mechanics in financial markets: stock and option price movements, probability analogy and operator analogy, calculation methods, the Schrodinger equation, and the Black-School model of trajectory.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** Presentation, Project Results ***Affective*** **:**

55. MFF 4043 - Introduction to Astrophysics and Cosmology

Module Name	Introduction to Astrophysics and Cosmology
Code	MFF 4043
Semester(s) in which the module is taught	ODD semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eng. Rinto Anugraha NQZ, S.Si., M.Si.
Lecturer	Dr. Eng. Rinto Anugraha NQZ, S.Si., M.Si., Romy Hanang Setya Budhi, S.Si., M,Sc., Ph.D.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Nuclear and Particle Physics I (MFF 2205)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Knowing and Understanding Stellar Astrophysics

	CO 2 : Knowing and understanding the Galaxy **CO 3** : Knowing and understanding Cosmology
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Arnab Rai Choudhuri, Astrophysics for Physicists, 2010, Cambridge University Press 2. Francis Leblanc, An Introduction to Stellar Astrophysics, 2010, John Wiley and Sons, Ltd 3. David Lyth, Cosmology For Physicists, 2017, Taylor & Francis Group, LLC 4. Ryden, B. Introduction of Cosmology, 2016, Department of Astronomy, The Ohio State University 5. Raine, D.J & Thomas, E.G, An Introduction To The Science Of Cosmology, 2001, IOP Publishing. 6. M. Kachelrieß, A Concise Introduction to Astrophysics, 2011, Institutt for fysikk NTNU, Trondheim Norway.
Content	1. Stellar Astrophysics: Continuous radiation from the stars (star brightness, star color, black body radiation, stellar distance, luminosity, and absolute magnitude) 2. Stellar Astrophysics: b. Line spectrum and its formation (Bohr-Summerfield atomic model, line spectrum formation, Hertzsprung-Russel diagram), Telescopes and other detectors (optical telescopes, other wavelength regions, neutrinos, and gravitational waves 3. Stellar Astrophysics: d. Binary stars and star parameters (Kepler's Laws, mass-luminosity relation, star radius) 4. Stellar Astrophysics: e. Star atmosphere and radiation transport, main sequence stars and stellar structure (stellar structure equations, Eddington luminosity and convective instability, Eddington standard model, stellar stability, stellar variables). 5. Stellar Astrophysics: Nuclear Processes in stars (Sources of energy in stars, fundamental interactions, thermonuclear reactions, significant nuclear combustion reactions, solar neutrinos) 6. Stellar Astrophysics: Endpoints of stellar evolution (Sirius B observations, degenerative

	Fermi gas pressure, Chandrasekar white dwarfs and limits, supernovae, pulsars, and Neutron stars) 7. Stellar Astrophysics: Black Holes (Schwarzschild metric, gravitational radiation from pulsars, thermodynamics, and evaporation of Black Holes). 8. Galaxies: Star formation and interstellar medium (interstellar dust, interstellar gas, star formation) 9. Galaxies: Star clusters (evolved globular clusters, virial masses, Hetzsprung-Russel masses in clusters) 10. Galaxy: Galaxy (Milky Way, regular and active galaxies, non-thermal radiation) 11. Cosmology: a. An introduction to the universe on a large scale (problems on the static Newtonian universe, cosmological principles, expansion of the universe and Hubble's laws). 12. Cosmology: b. Cosmological model (Friedmann's equations, scale dependencies on various forms of energy, cosmological model with one energy component, ACDM model) 13. Cosmology: c. Young universe (thermal history of the universe, Big Bang Nucleosynthesis, structure formation, CMB, inflation)
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

56. - Internship

Module Name	Internship
Code	MFF 4891
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.Eng. Ahmad Kusumaatmaja, S.Si., M.Sc.
Lecturer	Dr.Eng. Ahmad Kusumaatmaja, S.Si., M.Sc.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : **CO 2** : **CO 3** : **CO 4** :

	CO 5 : **CO 6** : **CO 7** : **CO 8** : **CO 9** : **CO 10** : **CO 11** : **CO 12** : **CO 13** :
Media employed	
Reading list	**Main References :** 1. 2. 3. 4. 5. 6. **Additional References :** 1. 2. 3. 4.
Content	1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14.
Examination forms	***Cognitive*** **:** ***Psychomotor*** **:** ***Affective*** **:**

57. MFF 1064 - Graphical Methods in Physics

Module Name	**Graphical Methods in Physics**
Code	MFF 1064
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Sunarta, MS.
Lecturer	Drs. Sunarta, MS.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Get an overview of the Analysis model graphically. **CO 2** : Making graphs as a basis for analyzing observational data **CO 3** : Draw the Analysis chart correctly. **CO 4** : Calculate the values of the magnitudes and the

	values of the uncertainty of the graph quantities. Analyze accurately **CO 5** : Analyze data with linear and quadratic graph models **CO 6** : Analyze data with exponential graph models, calibrations, and hypotheses **CO 7** : Converting non-linear data models to linear analysis **CO 8** : Analyzing real data obtained from observations in the lab
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop, unit mikrokontoler) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Buku : Modul Kuliah “Metode Analisa Grafik”-Sunarta, 2013 2. Taylor, J. R.1992.An Introduction toError Analysis. University Science Book.California 3. Bevington, P. R.1999.Data Reduction and Error Analysis for the Physical Science. Mc Graw-Hill Book Co 4. Dulfer G, H & Fadeli., 1974. Metode Pengukuran & Analisa Data; FIPA-UGM.
Content	1. The importance/benefit of graphs in processing research data 2. Method of Plotting Graph Analysis 3. Calculating the values of graphical quantities (in general) 4. Graph Error Analysis (in general) 5. Linear Graph Analysis 6. Quadratic Graph Analysis 7. Exponential Graph Model Analysis 8. Analysis of the Calibration chart model 9. Analysis of the Hypothesis Graph Model 10. Graph Linear Method 11. Testing Linear data analysis 12. Exponential Analysis data testing 13. Data testing Hypothesis analysis and calibration

Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor* :** ***Affective* :**

58. MFF 1528 - Simulation and Visualization in of Physics

Module Name	Simulation and Visualization in of Physics
Code	MFF 1528
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eko Sulistya, M.Si.
Lecturer	Dr. Eko Sulistya, M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 4** - Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Create animation and visualization of 1-dimensional and 2-dimensional object motion to explain the concepts of

	speed, acceleration and distance traveled by objects. **CO 2** : Simulate the phenomenon of object motion and relate it to direct measurements, for example the free fall of objects and measure the time it reaches the ground using a stopwatch. **CO 3** : Using simulation and visualization methods to solve physics problems, and verify the results with the results of manual calculations. **CO 4** : Using software that applies computational methods as a basis for calculating physics simulations, which are related to the application of physics in various fields of people's lives.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop, unit mikrokontoler) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Halliday, D., Resnick, R., & Walker, J. (2018). Fundamentals of physics. 11ed. New York: Wiley. 2. Ziegler, J.F., Biersack, J.P., & Ziegler, M.D., (2008). SRIM The Stopping and Range of Ions in Matter. Chester, Maryland, U.S.A: SRIM Co. 3. Ramtal, D. and Dobre, A., (2011), Physics for Flash Games, Animation, and Simulations, Apress Berkeley, CA 4. http://www.srim.org/ 5. https://www.design-simulation.com/ip/ **Additional References :** 1. Briggs, A., (2012), Hello!Python, Manning Publication Co., Shelter Island, NY. 2. Langtangen, H.P.,(2009), A Primer on Scientific Programming with Python, Springer-Verlag, Berlin 3. Shaw, Z.A., (2011), Learn Python The Hard Way, http://learnpythonthehardway.org/ 4. Sulistya, E., (2011), Pemrograman Python-Analisis Data Eksperimen Fisika, Dep. Fisika, FMIPA, UGM
Content	1. Use Microsoft Excel to create visualizations and physics simulations. 2. Calculation of physics formulas with VBA (Visual Basic for Application). 3. Give examples of cases of 2-dimensional motion with the Excel program. 4. Introducing and using programming languages to create physics simulations and visualizations, including Adobe Flash, Python, and Pygame. 5. Create class objects with action scripts to visualize with Adobe Flash. 6. Create motion visualizations with the Interactive physics program

	7. Make an experimental mechanical simulation (2-dimensional motion) by measuring real-time time with a stopwatch. 8. Doing physics problems from textbooks by applying physics visualization. 9. Comparing the results of problem-solving between simulations and analytical calculations 10. Simulate the interaction between ions and the medium. 11. Creating a radiotherapy simulation design with the SRIM program.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** Project Results ***Affective*** **: Attendance**

59. MFF 2070 - Microcontroller and Interfacing

Module Name	**Microcontroller and Interfacing**
Code	MFF 2070
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Eko Sulistya, M.Si
Lecturer	Dr. Eko Sulistya, M.Si
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Electronics (MFF 1850)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Create animations and visualizations of the motion of 1-dimensional and 2-dimensional objects to explain the concepts of speed, acceleration, and distance traveled by objects. **CO 2** : Simulate the phenomenon of object motion and relate it to direct measurements, such as the free fall motion of objects, and measure the time to the ground using a stopwatch.

	CO 3 : Use simulation and visualization methods to solve physics problems, verify the physics problems, and verify the results with the results of manual calculations. **CO 4** : Use software that applies computational methods as the basis for physics simulation calculations, which are related to the application of physics in various fields of community life.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop, unit mikrokontoler) and Online (Zoom Meeting, Google Meet, Google Classroom, tinkercad, wokwi)
Reading list	**Main References :** 1. Halliday, D., Resnick, R., & Walker, J. (2018). Fundamentals of physics. 11ed. New York: Wiley. 2. Ziegler, J.F., Biersack, J.P., & Ziegler, M.D., (2008). SRIM The Stopping and Range of Ions in Matter. Chester, Maryland, U.S.A: SRIM Co. 3. Ramtal, D. and Dobre, A., (2011), Physics for Flash Games, Animation, and Simulations, Apress Berkeley, CA 4. http://www.srim.org/ 5. https://www.design-simulation.com/ip
Content	1. An introduction to the tinkercad.com site. as a medium and means of design with a microcontroller. 2. Calculation of physics formulas with VBA (Visual Basic for Application). 3. Give examples of cases of 2-dimensional motion with the Excel program. 4. Introducing and using programming languages to create physics simulations and visualizations, including Adobe Flash, Python, and Pygame. 5. Create class objects with action scripts to visualize with Adobe Flash. 6. Make motion visualizations with the Interactive Physics program 7. Make an experimental mechanical simulation (2-dimensional motion) by measuring real-time time with a stopwatch. 8. Do physics problems from textbooks by applying physics visualization

	9. Comparing the results of problem-solving between simulations and analytical calculations 10. Simulate the interaction between ions and the medium. 11. Create a radiotherapy simulation design with the SRIM program.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** Project Results ***Affective*** **:**

60. MFF 2322 - Atomic and Molecular Detection Method

Module Name	**Atomic and Molecular Detection Method**
Code	MFF 2322
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Agung Bambang Setio Utomo, S.U.
Lecturer	Prof. Dr. Agung Bambang Setio Utomo, S.U.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Atomic and Molecular Physics (MFF 2310)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Know and understand the atomic structure and atomic processes **CO 2** : Know and understand the various types of optical radiation sources **CO 3** : Knowledge and understanding of optical radiation detection **CO 4** : Knowledge and understanding of optical and electronic support devices

	CO 5 : Knowledge and understanding of atomic spectroscopy **CO 6** : Know and understand spectrum analysis and its application
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Svanberg, S., 1992. Atomic and Molecular Spec-trocopy, edisi 2, Springer-Verlag, New York. 2. Boyd, R. W., 1983 : Radiometry and the Detection of Optical Radiation, John Wiley & Sons, New York.
Content	1. Atomic Spectroscopy 2. Fine and hyperfine structure 3. Atomic emission, line width, and life time 4. Isotropic shift, atomic scattering, absorption, and fluorescence 5. Optical radiation source 6. Optical radiation detection: Electromagnetic radiation and its interaction with matter 7. Radiation, photoconductive and photovoltaic detectors 8. optical and electronic support tools 9. Atomic spectroscopy 10. spectrum analysis and its applications
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz ***Psychomotor*** **:** ***Affective*** **:**

61. MFF 3002 - Science and Religion

Module Name	Science and Religion
Code	MFF 3002
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Sunarta, MS.
Lecturer	Drs. Sunarta, MS., Dr. Moh. Ali Joko
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 1** - Attitude. Have faith and fear of God Almighty, and apply good morals, ethics, initiative, and responsibility in completing their duties.
Course outcomes (CO)	**CO 1** : Knowing and Understanding the position and role of Science in Religion and Religion as a source of inspiration for Science.

	CO 2 : Knowing and Understanding the science of Inheritance **CO 3** : Knowing and understanding the separation between religion and science **CO 4** : Knowing and understanding the formation of human characters with spiritual-based science Religion Scientific miracles in humans, animals, plants, and the universe. **CO 5** : Knowing and understanding the concurrency of science with Divine knowledge (Religion) to obtain happiness, salvation, and human glory. **CO 6** : Knowing and understanding the contribution of science and technology to the solution of human problems, concepts, and recipes for human success and glory
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Teologi Filsafat sains, Purwadi, A., UMM-Press, Malang, 2002. 2. Lima Masalah Terbesar SAINS yang belum terpecahkan, Wiggins, A.W., & Wynn, C. M., PT Intan Sejati, 2004., 3. AL-Qur'an Ilmu pengetahuan & Teknologi, Baiquni A., PT Dana Bhakti Prima Jasa, 1994. BO71 4. Sains dalam Alqur'an, mengerti mukjizat ilmiah Firman Allah, Thayyarah N., ZAMAN, 2013., 5. Ayat ayat Kosmos dalam Alqur'an, ElNaggar Z., Shorouk International Bookshop, 2010., 6. Ayat ayat Semesta, Purwanto A., Mizan, 2008., **Additional References :** 1. Keajaiban tubuh manusia, Tilong A. D., DIVA Press,

	2012.
Content	1. The position and role of science in religion 2. Inheritance mathematical analysis 3. Muslim family Property Management 4. Calculating inheritance with heir chart 5. The method of dividing the inheritance if the number of inheritances is reduced 6. The method of dividing inheritance when the amount of inheritance is excessive 7. Calculating the wealth of a Muslim family 8. Misunderstanding, the dichotomy between RELIGION and science and technology 9. Efforts to know the pattern of creation of the Creator of all things 10. Human nature wants to be successful, happy, and safe forever, and how to get it. 11. Al-Qur'an is the absolute truth as a source of scientific inspiration. 12. Digital IMTAQ-based Saintek. 13. Hijrah, movement is the principle of everything to progress and develop. 14.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

62. MFF 3024 - Capita Selecta Computational Physics

Module Name	**Capita Selecta Computational Physics**
Code	MFF 3024
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.Eng. Fahrudin Nugroho, S.Si., M.Si.
Lecturer	Dr.Eng. Fahrudin Nugroho, S.Si., M.Si., Dr. Eko Sulistya, M.Si.
Language	Indonesian
Relation to curiculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Computational Physics (MFF 2027)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Know and understand advanced computational methods in solving various current physics problems **CO 2** : Applying advanced computational methods in solving various physics problems
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Robin H. landau, Manual J. Paez dan Critian C. Bordelanu, 2008, A Survey of Computational Physics, Princeton University Press, New Jersey.
Content	1. The basic principles and implementation of high-performance computing with parallel computing strategies or quantum computers 2. Solving N-body system problems with the Monte-Carlo. method 3. Density Functional Method Theory (DFT) 4. Density Matrix Renormalization Group (DMRG) Method 5. The Suzuki-Trotter decomposition method or another approximation method, 6. Simulation of Random Walk and Traveling Salesman Problem 7. Radioactive Decay Simulation 8. Solution of Partial Differential Equations 9. Fast Fourier Transform and Signal Filtering problems
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

63. MFF 3030 - Mathematics Theoretical of Physics II

Module Name	**Mathematics Theoretical of Physics II**
Code	MFF 3030
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Lecturer	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in

	writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Mastering and applying the concepts and properties of general topology, the concept of open sets and their properties, the concept of closed sets, the natural topology on lines, planes, and real spaces **CO 2** : Mastering and applying the concepts and properties of interior and closure, density sets, continuous mapping, and homeomorphism **CO 3** : Mastering and applying the concepts and properties of maps and atlases, diversity, differentiable mapping, differentiable functions and curves, tangent vectors, tangent spaces, and companion tangents. **CO 4** : Mastering and applying the concepts and properties of tensor, vector field, tensor field integral curve, and Lie derivative. **CO 5** : Mastering and applying the concepts and properties of metric tensors and semi-Riemannan diversity, connections, geodesic, covariance derivatives, curvature, and torsion.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. J M. Lee, 2011, Introcduction to Topological Manifolds, Springer, Berlin.

Content	1. Examples are general topological concepts and properties, open and closed-set concepts and their properties. 2. Natural topology on lines, planes, and real spaces. 3. 4. Mastering and applying the concepts and properties of interior and closing, density sets, continuous mapping, and homeomorphism examples. 5. 6. Mastering and applying the concepts and properties of maps and atlases, diversity, and examples. 7. Mastering and applying differential mapping, differential functions and curves, tangent vectors, tangent spaces, companion tangent spaces, and examples. 8. Mastering and applying the concepts and properties of tensor, vector field, integral curve, Lie derivative, examples. 9. Mastering and applying the concepts and properties of tensor fields, examples. 10. 11. 12. Examples include mastering and applying the concepts and properties of semi-Riemananan metric and multiplicity tensors. 13. Examples include mastering and applying the concepts and properties of the connection, geodesic, covariance derivative, curvature, and torsion. 14.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

64. MFF 3114 - Introduction to Particle of Physics

Module Name	**Introduction to Particle of Physics**
Code	MFF 3114
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Mirza Satriawan, S.Si., M.Si., Ph.D.
Lecturer	Mirza Satriawan, S.Si., M.Si., Ph.D.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Nuclear and Particle Physics II (MFF 3206)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain concepts and solve cases in elementary particles in standard models. Elementary particle dynamics: electromagnetic interactions, weak interactions, and strong interactions., Relativistic kinematics. Group symmetry and conservation law, flavor symmetry, C, P, and T symmetry, Bond states Positronium, quarkonium, meson, and baryon. **CO 2** : Students can explain concepts and solve cases in cross-section and half-life, calculate Feynmann diagrams, Feynmann rules for quantum electrodynamics, Quantum electrodynamics for hadrons and quarks, Parton Model, and Bjorken Scaling. **CO 3** : Students can explain concepts and solve cases in Feynmann's Rules for Quantum Chromodynamics and Asymptotic Freedom. Weak interactions: weakly charged and neutral interactions for leptons and quarks. **CO 4** : Students can explain concepts and solve cases in electroweak unification, Lagrangian formulations, local Tera field theory, Mass terms, and the Higgs mechanism.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. David J. Griffiths, 2008, Introduction to Elementary Particles, 2nd edition, John Wiley and Sons. 2. Donald H. Perkins, 2000, Introduction to High Energy Physics, 4th edition Cambridge Univ. Press.

Content	1. Elementary particles in the standard model. Elementary particle dynamics: electromagnetic interactions, weak interactions, and strong interactions. 2. Relativistic Kinematics. Symmetry, group and conservation law, flavor symmetry, C, P, and T symmetry. 3. Bound states: Positronium, quarkonium, meson and baryon. 4. Cross-section and half-life, Feynmann diagram calculations. 5. Feynmann's rules for quantum electrodynamics, 6. Quantum electrodynamics for hadrons and quarks. 7. The Parton Model and Bjorken Scaling. 8. Feynmann's rules for quantum chromodynamics, 9. Asymptotic freedom. 10. Weak interactions: weakly charged and neutral interactions for leptons and quarks. 11. Electroweak bonding. 12. The formulation of the ban 13. Local Tera field theory 14. The mass term and the Higgs mechanism.
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

65. MFF 3284 - Reactor of Physics

Module Name	Reactor of Physics
Code	MFF 3284
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Dwi Satya Palupi
Lecturer	Dr. Dwi Satya Palupi., Dr. Sholihun, Tim dari PRTA BRIN Yogyakarta.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Nuclear and Particle Physics I (MFF 2205)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions

	to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Able to explain the working principle of power reactors, then classify reactor types and explain the advantages and disadvantages of reactor types **CO 2** : Able to explain the branches of science that play a role in reactor physics, the core reactions that occur in power reactors, and the effect of these reactions on power reactors. **CO 3** : Be able to mention the essential parts and components of the power reactor and their functions. **CO 4** : Able to explain the neutron cycle in the reactor core, the processes that occur in the reactor core at critical, sub-critical, and supercritical conditions, **CO 5** : Able to explain and solve neutron transport equations in various cases and analyze the relationship between power and the factors that affect changes in power as a function of time.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. J.J. Duderstat dan L.J. Hamilton, 1976, Nuclear Reactor Analysis, John Wiley & Sons,Inc,New York USA. 2. website url batan: http://irlkartini.batan.go.id

Content	1. The basic principles of power reactors with a fission reaction power source: comparison of fission reactors with other power plants, branches of science related to fission reactors, types of fission reactors 2. The nuclear reactions that occur in the fission reactor core and their effect on reactor power: neutron capture and neutron reactions, fission reactions. 3. Nuclear reactions that occur in the fission reactor core and their effects on reactor power: alpha, gamma, beta decay, microscopic cross-sections, macroscopic cross-sections, and scattering. 4. Components of a fission reactor: reactor core, coolant, moderator, NSSS system. 5. Components of a fission reactor: reactor core, coolant, moderator, NSSS system. 6. Neutron cycle: formula factor -4, factor 6, reactor size, multiplication factor and its effect on the reactor, critical reactor, subcritical, supercritical 7. Triga-Mark Reactor Experiment with Kartini Reactor 8. Triga Reactor Experiment - Mark with Kartini Reactor 9. Triga - Mark Reactor Experiment with Kartini Reactor 10. Triga-Mark Reactor Experiment with Kartini Reactor 11. Triga-Mark Reactor Experiment with Kartini Reactor 12. Neutron transport equation: factors affecting the neutron flux in the reactor core and its boundary conditions, diffusion approach, and boundary conditions 13. Solving the neutron diffusion equation in various cases, the balance between fuel and reactor size. 14. Reactor kinetic equations affect reactor power, hourly equations, and reactor reactivity.
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Assignments ***Psychomotor* :** Project Results ***Affective* : Attendance**

66. MFF 3288 - Radiation Protection

Module Name	**Radiation Protection**
Code	MFF 3288
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Dwi Satya Palupi
Lecturer	Dr. Dwi Satya Palupi., Dr. Mitrayana
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Nuclear and Particle Physics I (MFF 2205)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Able to name the types of ionizing radiation, explain the radiation's interaction with matter, explain the radiation's penetrating power in a material, and then arrange the order of matter in a material so that radiation does not penetrate the material. **CO 2** : Able to name units of radiation used in radiation protection and explain the biological effects of radiation at the cellular, tissue, and organ level, the difference between stochastic and deterministic effects, as well as explain radiation sources and the principles of radiation protection. **CO 3** : Able to explain the principles of radiation detection for various types of radiation and the working principles of radiation detection devices. **CO 4** : Able to mention the dangers of radiation from outside and inside the body, then explain and arrange radiation protection procedures for radiation hazards from outside and inside the body. **CO 5** : Able to explain the use of radiation in industry and its radiation protection and able to explain the use of radiation in the medical field and its radiation protection.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Martin, Alan, Sam Harbison, Karen Beach, dan Peter Cole, (2012), An Introduction to Radiation Protection, 6th ed., Hodder Arnold, Hodder Education, UK. 2. Ahmed, Syed Naeem, (2015), Physics and Enginering of Radiation Detection, 2nd ed., Elsevier Inc., USA.

Content	1. Types of ionizing radiation: radiation from charged particles such as alpha and beta, photon radiation such as gamma and x-rays, and neutron radiation. 2. The interaction of radiation of photons (gamma and x-rays), charged particles (alpha and beta), and neutrons and the radiation range of photons (gamma and x-rays), charged particles (alpha and beta), and neutrons in a material. 3. Radiation units are used in radiation protection. 4. Radiation biological effects, stochastic effects, and deterministic effects 5. Radiation sources and the principle of radiation protection. (according to ICRP). 6. Radiation hazards from outside the body, controlling and monitoring radiation for radiation hazards from outside the body. 7. Radiation hazards from outside the body, controlling and monitoring radiation for radiation hazards from outside the body. 8. Radiation hazards from within the body, radiation control, and monitoring for radiation hazards from within the body. 9. Principles of radiation detection for various types of radiation, and radiation detection devices and their working principles. 10. Radiation detection principles for various types of radiation, and radiation detection tools and their working principles. 11. The use of radiation in industry and radiation protection in the industry, as well as the use of radiation in the medical field and its radiation protection. 12. The use of radiation in industry and radiation protection in the industry, as well as the use of radiation in the medical field and its radiation protection. 13. The use of radiation in industry and radiation protection in the industrial sector, as well as the use of radiation in the medical field and its radiation protection. 14. Emergency radiology

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **: Attendance**

67. MFF 3436 - Modern Acoustics

Module Name	Modern Acoustics
Code	MFF 3436
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Mitrayana
Lecturer	Dr. Mitrayana., Dr. A. Ali Joko Wasono
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude

	them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain concepts and solve cases of Acoustic wave propagation in various mediums (gas, liquid, and liquid). **CO 2** : Students can explain concepts and solve cases of the working principle of acoustic transducers. **CO 3** : Students can work in groups to study the development of the latest (Modern) Acoustic Theories and Applications.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Kinsler, Frey, Copper, Sanders, 2000, Fundamentals of Acoustics, Fourth Edition, John Wiley and Sons New York. 2. Rossing, 2007, Hand Book of Acoustic, Springer Science+Business Media, LLC New York. 3. Morse. P, dan K.U. Ingard 1968. Theoretical Acoustic, Mc Graw Hill.
Content	1. Introduction: Acoustics: The Science of Sound, Sounds We Hear, Sounds We Cannot Hear: Ultrasound and Infrasound, Sounds We Should not Hear. 2. Environmental Noise Control, Sound Aesthetics: Music, Human Voices: Speech and Singing, How We Hear: Physiological and Psychological Acoustics, Acoustics, Architecture, Harnessing Sound: Physical and Engineering Acoustics, Medical Acoustics, Sounds from the Sea. 3. Basic linear acoustics: Continuum Mechanics Equations, Linear Acoustic Equations, Variation Formulations, Constant Frequency Waves, Plane Waves, 4. Sound Attenuation, Acoustic Intensity and Power, Impedance, Reflection and Transmission, Spherical Waves, Cylindrical Waves, Simple

	Sound Sources, Integral Equations in Acoustics, Waveguides, Channels, and Resonators, Ray Acoustics, Diffraction, Parabolic Equation Methods 5. Atmospheric Sound Propagation: A Brief History of Outdoor Acoustics, Applications of Outdoor Acoustics, Diffusion Loss, Atmospheric Absorption, Diffraction and Resistance, Soil Effects, Attenuation Through Trees and Foliage, Effects of Wind and Temperature Gradients on Outdoor Sound 6. Underwater Acoustics: Marine Acoustic Environment, Physical Mechanisms, SONAR and SONAR Equations, Sound Propagation Models, Quantitative Description of Propagation, ONAR Array Processing, Acoustics, and Marine Animals 7. Physical Acoustics: Theoretical Overview, Physical Acoustic Applications, Equipment, Surface Acoustic Waves, Nonlinear Acoustics 8. Thermoacoustics/Photoacoustics: History, Concepts, experimental methods, and their applications 9. Acoustic- Mechanical- Electrical Analogy 10. Microphone 11. Loudspeaker 12. Sound Storage Media 13. Recording Technique 14. Audio signal processing
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

68. MFF 3680 - Introduction to Nanoscience

Module Name	Introduction to Nanoscience
Code	MFF 3680
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.Eng. Edi Suharyadi, S.Si., M.Eng.
Lecturer	Dr.Eng. Edi Suharyadi, S.Si., M.Eng., Prof. Dr. Eng. Kuwat Triyana, M.Si.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Atomic and Molecular Physics (MFF 2310)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems.

Course outcomes (CO)	**CO 1** : Know and understand the concept of nanoscience and technology **CO 2** : Knowing and understanding the concept of physics of compressed matter in nanosystems **CO 3** : Knowledge and understanding of nanostructures and their characteristics
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Douglas Natelson, Nanostructures and Nanotechnology, Cambridge University Press, 2015. (e-book is available). 2. Vladimir V. Mitin, Dimitry I. Sementsov, Nizami D. Vagidov, Quantum Mechanics of Nanostructures, Cambridge University Press, Cambridge UK, 2010 (e-book is available).
Content	1. Introduction to the concept of nanoscience and nanotechnology 2. The concept of size-dependent (Bulk Material and Film) 3. Summary of the concept of physics of incompressible substances in nanosystems (Meeting of states, electronic structure, phonons, Joint Density of States) 4. Study of nanostructures (quantum dot, quantum well and quantum wires) 5. Physics of nanostructures 6. Summary Fabrication of nanostructures (PLD/Pulse Laser Deposition 7. MBE/Molecular Beam Epitaxy 8. SAM/Self-Assembly Material) 9. Summary of Nanostructure Characterization (AFM/Atomic Force Microscopy 10. STM/Scanning Tunneling Microscopy

	11. SE/Spectroscopy Ellipsometry).
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor* :** ***Affective* :**

69. MFF 3810 - Capita Selecta in Material Physics

Module Name	Capita Selecta in Material Physics
Code	MFF 3810
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Prof. Dr. Yusril Yusuf
Lecturer	Prof. Dr. Yusril Yusuf., Dr. Juliasih Partini., Dr. Ari Dwi Nugraheni., Dr. Ahmad Kusumaatmaja.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Solid State Physics I (MFF 2601)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various

	alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain about Biomaterials and Liquid Crystals **CO 2** : Students can explain the fabrication and characterization of metamaterials. **CO 3** : Students can explain about protein physics and its characterization **CO 4** : Students can explain polymers and their applications in physics.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Related international journals (accessed from http://lib.ugm.ac.id, as well as international journal sources other)
Content	1. Biomaterial Physics 2. Biomaterials and Bioplastics 3. Research in Liquid Crystals 4. Introduction to Metamaterial 5. Metamaterial Fabrication 6. Characterization of Metamaterials 7. Protein Physics 8. Characterization in protein physics 9. polymer introduction 10. Polymer applications in materials physics
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam ***Psychomotor*** **:** ***Affective*** **:**

70. MFF 3812 - Materials Analysis Method

Module Name	**Materials Analysis Method**
Code	MFF 3812
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Chotimah, M.Si.
Lecturer	Dr. Chotimah, M.Si., Dr.Eng. Edi Suharyadi, S.Si., M.Eng.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Solid State Physics I (MFF 2601), Quantum Physics I (MFF 2034)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems.

	PLO 5 - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can determine the characteristics that must be known about research materials and the research process results. **CO 2** : Students can choose the method needed to find out detailed information about the character of a material **CO 3** : Students can anticipate the condition of the material whose properties will be known. **CO 4** : Students can analyze the results shown by supporting tools
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. McMohan, G., 2007: Analytical Instrumentation: A Guide to Laboratory, Portable and Miniaturized Instruments, ohn Wiley & Sons Ltd, England. 2. Skoog, D.A. dan West, D.M., 1980: Principles of Instrumental Analysis, Sounders College, Philadelphia.

Content	1. Introduction: Basics of Spectroscopy, GEM interaction with matter, UV-Vis Spectroscopy. 2. UV-Vis spectroscopy, and calculating the Energy Gap from the UV-Vis curve, Assignment review paper using UV-Vis characterization 3. FT-IR spectroscopy, Raman spectroscopy 4. Atomic Absorption Spectroscopy (AAS) and Atomic Fluorescence Spectrometry (AFS) 5. Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), mass Spectroscopy (MS) 6. Nuclear Magnetic Resonance (NMR), Exposure group assignment 7. Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC) 8. Optical Microscopy, confocal Microscopy 9. Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) 10. Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM). 11. Electrochemical Instruments, Potentiometry, voltammetry, conductimetry 12. X-ray Diffraction (XRD) 13. Electronic Impedance Analyzer 14. Student assignments (Group and Independent)
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

71. MFF 3820 - Computational Material of Physics

Module Name	**Computational Material of Physics**
Code	MFF 3820
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr. Iman Santoso
Lecturer	Dr. Iman Santoso., Dr. Sholihun
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 3 x 50 = 150 minutes per week. 2. **Exercises and Assignments** : 3 x 60 = 180 minutes per week. 3. **Private Learning :** 3 x 60 = 180 minutes per week.
Credits points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Computational Physics (MFF 2027), Solid State Physics I (MFF 2601)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can apply computational methods of numerical derivatives, numerical integration, and root search in extracting dielectric constant values from reflections and equilibrium positions of diatomic molecules. **CO 2** : Students can apply computational methods of numerical derivatives, numerical integration, Discrete Fourier Transform, and Fast Fourier Transform in

	calculating linear response functions (e.g., optical constant, dielectric constant) of a material as well as the Kramers-Kronig relation that connects the real and imaginary parts of the linear response function. **CO 3** : Students can apply computational methods of numerical derivatives, numerical integration, Numerov methods, factorization, iteration, and matrix diagonalization (similarity transformation, Householder, and Jacobi Rotation) in solving the time-independent Schrodinger equation, which will produce band diagrams of 1D material systems and 2d. **CO 4** : Students can apply computational optimization methods like Gauss-Newton, Gradient descent, Levenberg-Marquardt, and BFGS (Broyden–Fletcher–Goldfarb–Shanno) to optimize the geometry of a material.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Richard Martins, 2004, Electronic Structure, Cambridge University Press 2. J.M., Thijssen, 1999, Computational Physics, Cambridge University Press 3. Tao Pang, An introduction to computational physics, Cambridge press (2006)
Content	1. INTRODUCTION: the role of computing in explaining fundamental and applied problems in material physics, namely linear response functions, optical constants, dielectric constants, Kramers-Kronig relations), band diagrams of 1D and 2D systems, equilibrium positions, and optimization of the geometry of materials. 2. SUMMARY OF NUMERIC METHODS: Numerical derivative (finite difference method), numerical integration (trapezium and Simpson1/3), Discrete Fourier Transform, and Fast Fourier Transform 3. TIME DEPENDENT SCHRODINGER EQUATION: Numerical solution using the second-order Numerov method 4. Timeless SCHRODINGER EQUATION: Numerical solution using matrix diagonalization method (similarity transformation, Householder transformation, Jacobi rotation)

	5. POWER LEVEL DIAGRAM FOR 1D and 2D SYSTEM PARTICLES: Bloch's Theorem, Application of the diagonalization method in obtaining the band structure of 1D and 2D systems 6. Introduction to the tight-binding method: Numerical methods for solving band structures use tight-binding, integral transfer, integral overlap, and orbital overlap methods. 7. Geometry Optimization 8. Geometry Optimization 9. Geometry Optimization 10. DFT
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Assignments ***Psychomotor* :** ***Affective* :**

72. MFF 3872 - Biophysics

Module Name	**Biophysics**
Code	MFF 3872
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Wagini, S.U.
Lecturer	Drs. Wagini, S.U., Dr. Sc. Ari Dwi Nugraheni
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Thermodynamics (MFF 1053), Waves (MFF 1405)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain the concepts of physics in biology **CO 2** : Students can explain concepts and relate cases in biology from a physics perspective.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Reading list	**Main References :** 1. Philip Nelson, Biological Physics, W. H. Freeman, 1st Edition, 2007 2. Roland Glaser, Biophysics, Springer, 2nd edition, 2012.
Content	1. RPKPS explanation, introduction 2. Components in biological systems 3. Approach to Statistical Physics in biological systems 4. Diffusion physics in biology and surface phenomena 5. Life in the study of Reynolds Numbers 6. Entropy and Energy in Biology 7. The environment and its effects on humans 8. Mechanics in cell biology 9. Sequences in cell biology 10. Photobiophysics 11. Radiation and its effects on humans 12. Effects of magnetic fields on humans
Examination forms	***Cognitive* :** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor* :** Project Results ***Affective* :**

73. MFF 38776 - Radiographic of Physics

Module Name	**Radiographic of Physics**
Code	MFF 38776
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Gede Bayu Suparta, M.S., Ph.D.
Lecturer	Drs. Gede Bayu Suparta, M.S., Ph.D.
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Know and understand the history of radiography and the application of radiography in the industrial, medical, and laboratory fields **CO 2** : Know and understand the fundamental theories in Radiography Physics **CO 3** : Know and understand how the radiographic system **CO 4** : Knowledge and understanding of digital

	radiography **CO 5** : Knowing and understanding the application of Radiography
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Buzug, T.M., 2008. Computed Tomography: From Photon Statistics to Modern Cone-Beam CT, SpringerVerlag Berlin Heidelberg. 2. National Academic of Science, 1996, Mathematics and Physics of Emerging Biomedical Imaging, National Academic Press, Washington, Ch. 1-6.
Content	1. History of Radiography, Applications of radiography (laboratory, medical and industrial) 2. Basic Theory: Atoms and Atomic Structure 3. Basic Theory: Electricity and Magnetism 4. Basic Theory: Electromagnetic radiation and the interaction of radiation with matter 5. Radiographic System: X-ray/gamma generator 6. Radiography System: Detector and detection system 7. Fluorescent radiography and film radiography 8. Digital radiography: Digital images and digital scanners 9. Digital radiography: Image capture and computer radiography 10. Digital radiography: Live digital radiography 11. Digital radiography: Teleradiology 12. Radiographic Applications: NDT 13. Radiographic applications: Inspection of goods, Inspection of micro materials/objects 14. radiology (medical)
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

74. MFF 3882 - Energy

Module Name	Energy
Code	MFF 3882
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Wagini, S.U
Lecturer	Drs. Wagini, S.U , Dr. Sc. Ari Dwi Nugraheni , ,
Language	Indonesian
Relation to curriculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Thermodynamics (MFF 1053), Waves (MFF 1405)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course outcomes (CO)	**CO 1** : Students can explain the concept of physics in the context of energy use and its consequences for the environment **CO 2** : Students can explain some examples of energy sources available in the surrounding environment

	CO 3 : Students can explain the concept of energy conservation techniques by focusing on a physics approach.
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Robert L Jaffe dan Wangshington Taylor, The physics of energy, Cambridge university press, 2018 2. Functional Material for Sustainable energy applications, Woodhead publishing, 2012
Content	1. Explanation of RPKPS, introduction to energy in general, and units and scales in energy 2. Thermal energy, energy in chemical systems, and CO2. flow processes 3. Entropy and temperature and their application to machines 4. Natural style; weak interaction and beta decay 5. Nuclear energy sources: fission and fusion 6. Energy in the universe; sunlight 7. Photovoltaic solar cells 8. Biological energy: energy from moving water 9. Energy and Climate 10. Earth's climate; past, present, and future 11. Energy efficiency, conservation, and source of energy change 12. Energy storage and conservation
Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Assignments ***Psychomotor*** **:** ***Affective*** **:**

75. MFF 3892 - Science and Technology Entrepreneurship

Module Name	Science and Technology Entrepreneurship
Code	MFF 3892
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Drs. Gede Bayu Suparta, M.S., Ph.D.
Lecturer	Drs. Gede Bayu Suparta, M.S., Ph.D. , Prof. Dr. Harsojo, SU., M.Sc.
Language	Indonesian
Relation to curiculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	None
Module objectives/intended learning outcomes PLO	**PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Knowing and Understanding the Philosophy of Entrepreneurship and the development of an entrepreneurial spirit **CO 2** : Know and understand Education oriented to job creators and leaders with an entrepreneurial spirit **CO 3** : Know and understand Intellectual Property Rights and Contract Law **CO 4** : Knowing and understanding Entrepreneurship and how to build good relations and selling techniques **CO 5** : Knowing and understanding how to set up a small business and how to manage a small and medium business

	CO 6 : Knowing and understanding about Ethics in entrepreneurship
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Jati, B.M.E; Priyambodo, T.K. , 2011: Kewirausahaan (Technopreneurship) untuk Mahasiswa Sains dan Teknologi, edisi 1, Penerbi Andi, Yogyakarta 2. Meridith, G.G., dkk., 2000: Kewirausahaan Teori dan Praktek, PT Pustaka Binaman Pressindo, Jakarta Suryana, 2001: Kewirausahaan, Penerbit Salemba 4, Jakarta 3. Waldiono, dkk., 1999: Entrepreneurship (EPS) di Perguruan Tinggi, Proyek Pemandu EPS di Perguruan Tinggi, LP3 – UGM, Yogyakarta 4. Wibowo, dkk., 2000: Petunjuk Mendirikan Perusahaan Kecil, Penerbit Swadaya, Jakarta 5. Wibowo, dkk., 2000: Pedoman Mengelola Perusahaan Kecil, Penerbit Swadaya, Jakarta 6. Wijandi,S., 2000: Pengantar Kewiraswastaan, Sinar Baru, Algensindo, Bandung **Additional References :** 1. Junus, E., 1999: Undang-Undang dan Informasi Umum Perlindungan Hak Atas Kekayaan Intelektual, Jurnal P & PT, Vol.1, No.9, 1999, Jakarta 2. Sutomo, B.P.G., 1997: Hukum Perjanjian pada Jual Beli Pesawat Terbang Produksi IPTN, Skripsi S1 Ilmu Hukum Perdata UGM, Yogyakarta.
Content	1. Entrepreneurship Philosophy 2. Entrepreneurial Spirit Development 3. Job Creation-Oriented Education 4. Entrepreneurial leader 5. Intellectual property rights 6. Legal Agreement 7. Entrepreneurship 8. Good relations and selling techniques 9. Setting up a small business 10. Managing Small and Medium Enterprises 11. Ethics in entrepreneurship

Examination forms	***Cognitive*** **:** Midterm Exam, Final Exam, Quiz, Assignments ***Psychomotor*** **:** ***Affective*** **:**

76. MFF 4034 - Advanced Quantum Mechanics

Module Name	**Advanced Quantum Mechanics**
Code	MFF 4034
Semester(s) in which the module is taught	EVEN semester
Module designation	Undergraduate stage
Person responsible for the module	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si.
Lecturer	Dr.rer.nat. Muhammad Farchani Rosyid, M.Si. , , ,
Language	Indonesian
Relation to curiculum	Elective Courses for undergraduate program in Bachelor of Physics
Teaching methods	SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods
Workload	1. **Lectures :** 2 x 50 = 100 minutes per week. 2. **Exercises and Assignments** : 2 x 60 = 120 minutes per week. 3. **Private Learning :** 2 x 60 = 120 minutes per week.
Credits points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 75% attendance in this course
Required and recommended prerequisites for joining the module	Quantum Physics I (MFF 2034)
Module objectives/intended learning outcomes PLO	**PLO 2** - Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems. **PLO 3** - General Skills. Able to communicate the results of problem studies and physical behavior both in writing and verbally, as well as being able to lead and collaborate at various levels of roles in a team. **PLO 5** - Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course cutcomes (CO)	**CO 1** : Understand symmetry in quantum mechanics and master the concepts of groups that describe this symmetry: spatial translational symmetry, rotational

	symmetry, time shift symmetry, space translation group, rotation group, dynamic group, space translation generator, rotation generator, and time shift generator. **CO 2** : Mastering and applying path integral formulations for quantum mechanics: path integrals, propagators, formulations for free particles, and harmonized vibrations. **CO 3** : Mastering and applying relativistic quantum mechanics: Klein Gordon equation, Dirac equation, probability density and probability current density problems, antiparticle interpretation, Dirac equation covariance, symmetry generator in relativistic quantum mechanics .
Media employed	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)
Reading list	**Main References :** 1. Mueller-Kirsten, H.W, 2006, Introduction to Quantum Mechanics: SchroedingerEquation and Path Integral, World Scientific, Singapore. 2. Greiner, W. dan Mueller, B., 1994, Quantum Mechanics: Symmetries, Springer-Verlag, Berlin. 3. Greiner, W., 1994, Relativistic Quantum Mechanics: Wave Equations, Springer-Verlag, Berlin.
Content	1. spatial translational symmetry, rotational symmetry, time shift symmetry, 2. Space translation group, rotation group, dynamic group, 3. Space translation generator, rotation generator, and time shift generator. 4. The path integral, propagator, 5. the formulation for free particles and harmonized vibrations. 6. Klein-Gordon equation, Dirac equation, 7. the problem of opportunity density and opportunity flow density, antiparticle interpretation, 8. covariance of the Dirac equation, a symmetry generator in relativistic quantum mechanics

Examination forms	***Cognitive* :** Midterm Exam, Final Exam ***Psychomotor* :** ***Affective* :**