Curriculum Module Handbook

Physics Undergraduate Study Program

DEPARTMENT OF PHYSICS

Faculty of Science and Data Analytics

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

Jl. Arif Rahman Hakim, Surabaya, Indonesia, 60111

2021

FACULTY OF SCIENCE AND DATA ANALYTICS

Study Program	**DEPARTMENT OF PHYSICS**
Education Level	**Bachelor Program (S1)**

Learning Outcome of Bachelor Program Graduates (S1)		
1. ATTITUDE	1.a	Commits towards God Almighty and is able to show a religious attitude
	1.b	Uphold humanity during tasks based on religion, moral, and ethics
	1.c	Contribute in improving the quality of living in society, the nation, the country, and the improvement of civilization based on the Pancasila
	1.d	Partakes as a proud and country-loving citizen, has nationalism and a sense of responsibility towards the country and nation.
	1.e	Respects diversity of culture, views, religion, and beliefs, as well as opinions or original findings of others

	1.f	Cooperates and has social awareness and concern towards society and the environment
	1.g	Obeys the law and is disciplined in living in society and in the country
	1.h	I internalizes values, norms, and academic ethics
	Q	Shows responsibility towards work in their area of expertise independently
	1.j	Internalizes the spirit of independence, struggle, and entrepreneurship
	1.k	Tries maximally to achieve a perfect result
	1.l	Cooperates to utilize his/her potential maximally
2. GENERAL SKILLS	2.a	is able to apply logical, critical, systematic, and innovative thinking in the development or implementation of science and technology, paying attention and applying values of humanity according to their area of expertise
	2.b	Is able to show high-quality, independent, and measurable work
	2.c	Is able to examine the implication of development or implementation of science that concerns and implements values of humanities according to his/her area of expertise based on rules, procedures, and scientific ethics in order to produce solutions, ideas, design, or art criticism to prepare their scientific

		examination in the form of a thesis or final paper report and upload it on the university website.
	2.d	Is able to arrange a scientific description of that examination above in the form of a thesis or final paper report and upload it on the university website
	2.e	Is able to make decisions accurately in solving problems in their area of expertise, based on the results of information and data analysis
	2.f	Is able to maintain and develop networks with counselors, colleagues, both inside and outside the institution
	2.g	Is able to take responsibility for the achievements of group work and to supervise and evaluate the completion of work assigned to workers who are under their responsibility
	2.h	Is able to conduct self-evaluation towards work groups under their responsibility and is able to manage learning independently
	2.i	Is able to document, store, secure, and rediscover data to ensure validity and prevent plagiarism
	2.j	Is able to develop themselves and compete on a national and international level
	2.k	Is able to implement environmental insight in developing knowledge
	2.l	Is able to implement information technology and communication in executing their work
	2.m	Is able to implement entrepreneurship and understand technology-based entrepreneurship

3. KNOWLEDGE	3.a	Masters the theoretical concepts of classical physics and modern physics with great depth;
	3.b	Masters the principles and application of mathematical physics, computational physics, and instrumentation;
	3.c	Masters principles, characteristics, functions, and application of technology relevant to the field of physics;
	3.d	Masters complete operational knowledge of the functions, operation of common physical instruments, data analysis and information from such instruments; and
	3.e	Masters principles, characteristics, functions, and applications of software in the field of physics; and
	3.f	Understands and masters the concept of academic integrity in general and the concept of plagiarism in particular, in terms of the types of plagiarism, the consequences of offenses and prevention efforts
4. SPECIFIC SKILLS	4.a	Is able to formulate symptoms and physical problems through analysis based on obsevations and experiments;
	4.b	Is capable of producing mathematical models or physical models that correspond to hypotheses or forecasted impacts of phenomena subject to discussion;
	4.c	Is able to analyse various existing alternative solutions to physical problems and summarize them for proper decision making;
	4.d	Is able to predict the potential application of physical behaviour in technology;
	4.e	Is able to disseminate the results of the study of problems and physical behaviours of simple

		phenomena in the form of reports or working papers according to standard scientific guidelines
	4.f	Is able to publish academic work in the form of a thesis or final paper report which is uploaded to the university website;
	4.g	Is able to adapt, cooperate, create, contribute, and innovate in applying science to society life and have global insight in their role as global citizens;
	4.h	Is able to apply knowledge and skills of information technology in scientific development and implementation of their field of expertise;
	4.i	Is able to use at least one international language in listening, reading, speaking, and writing; and
	4.j	Is able to understand the concept of academic integrity, among others able to understand the meaning of plagiarism, its types, and its prevention efforts, as well as the consequences of plagiarism;

Description of Programme Learning Outcomes (PLOs) reformulated based on the KKNI standards at Department of Physics - ITS Surabaya

PLO	Description
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-3	able to perform management, leadership, and work together in a team in the capacity as a member or group leader and responsible for the achievement of teamwork. [KU]
PLO-4	able to communicate and apply information technology to document, store, and secure data. [KU]
PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be

	able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
PLO-11	able to disseminate the results of problem (case) studies and physical behaviours based on standard scientific principles in oral and written communication in the form of reports or scientific works according to correct writing rules by understanding the plagiarism mechanism and publishing them at the national or international level. {KK}
PLO-12	able to adapt, collaborate, create, contribute and innovate in applying science in social life and has a global insight in his role as a citizen of the world, as well as being able to use the international language. {KK}
Note: KKNI Criteria: S = Attitude; KU = General Skills; P = Knowledge; KK = Specific Skills	

LIST OF COURSES

No.	Course Code	Name of Course	Credits (SKS / ECTS)
		SEMESTER I	
1	SF184101	Physics I	4
2	SF184102	Mathematical Physics I	2
3	KM184101	Mathematics I	3
4	SK184101	Chemistry I	3
5	SB184161	Biology	2
6	UG184911	Pancasila	2
7	UG184914	English	2
		Total Credits (SKS / ECTS)	18
		SEMESTER II	
1	SF184202	Physics II	3
2	SF184203	Physics III	3
3	KM184201	Mathematics II	3
4	SK184202	Chemistry II	3
5	UG184913	Citizenship	2
6	UG184912	Bahasa Indonesia	2
7	UG1849XX	Religion	2
		Total Credits (SKS / ECTS)	18

SEMESTER III			
1	SF184301	Mechanics I	3
2	SF184302	Waves	3
3	SF184303	Thermodynamics	3
4	SF184304	Mathematical Physics II	4
5	SF184305	Electronics	4
6	SF184306	Methods of Measurements in Physics	2
		Total Credits (SKS / ECTS)	19
SEMESTER IV			
1	SF184401	Mechanics II	3
2	SF184402	Optics	3
3	SF184403	Modern Physics	4
4	SF184404	Mathematical Physics III	4
5	SF184405	Instrumentation	4
6	SF184406	Material Science	2
		Total Credits (SKS / ECTS)	20

SEMESTER V			
1	SF184501	Quantum Physics	4
2	SF184502	Electromagnetic Fields I	3
3	SF184503	Laboratory Physics	2
4	SF184504	Computational Physics I	3
5	SF184505	Optoelectronics	2
6	SF184506	Digital Data Acquisition	2
		Total Credits (SKS / ECTS)	16
SEMESTER VI			
1	SF184601	Statistical Physics	3
2	SF184602	Electromagnetic Fields II	3
3	SF184603	Laboratory Physics II	2
4	SF184604	Computational Physics II	3
5	SF184605	Methods of Exploration in Geophysics	2
6	UG184916	Insight and Application of Technology	3
		Total Credits (SKS / ECTS)	16

SEMESTER VII			
1	SF184701	Nuclear Physics	4
2	SF184702	Solid State Physics	4
3	SF184703	Methods of Scientifical Writing	2
4	UG184915	Technopreneurship	2
5	SF184704	Radiological Physics and Dosimetry	2
6	SF1847XX	Elective Coursses	6
		Total Credits (SKS / ECTS)	20
SEMESTER VIII SEMESTER VIII			
1	SF184801	Final Assignment	6
2	SF184802	Laboratory Management	2
3	SF1848XX	Elective Courses	6
4	SF1848XX*	Enrichment courses (Physics of the Universe)	3
		Total Credits (SKS / ECTS)	17

ADDITIONAL			
1	SF181101	Physics I	4
2	SF181201	Physics II	3
3	SF181103	Physics I	3
4	SF181104	Physics I	3
		Total Credits (SKS / ECTS)	6

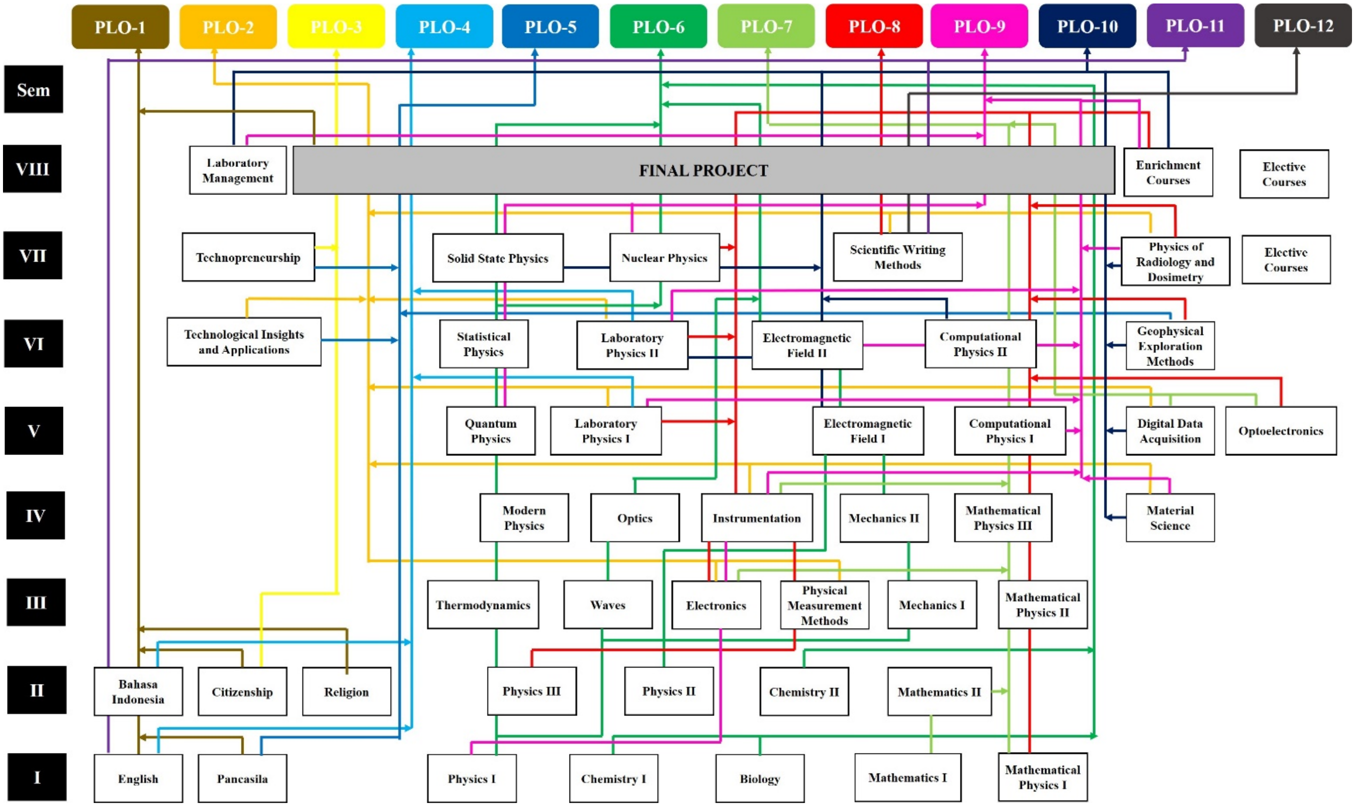
ELECTIVE COURSES

No.	Kode MK	Nama Mata Kuliah (MK)	SKS / ECTS
		SEMESTER VII	
1	SF184711	Metal Physics	3
2	SF184712	Ceramic Physics	3
3	SF184713	Polymer Physics	3
4	SF184721	Microcontrollers and Microprocessors	3
5	SF184722	Building Physics	3
6	SF184731	Fiber Optics	3
7	SF184732	Photonics	3
8	SF184741	Geology	3
9	SF184742	Seismology	3
10	SF184743	Earth Electricity Exploration	3
11	SF184751	Introduction to Particle Physics	2
12	SF184752	Advanced Mathematical Physics	2
13	SF184753	Introduction to Cosmology	3
14	SF184761	Anatomy and Physiology	2
15	SF184762	Medical Imaging Physics	2
16	SF184763	Medical Instrumentation	2

No.	Kode MK	Nama Mata Kuliah (MK)	SKS / ECTS
17	SF184764	Radiobiology	2
		Total Credits (SKS / ECTS)	45
		SEMESTER VIII	
1	SF184811	Composite Physics	3
2	SF184812	Semiconductor Physics	3
3	SF184813	Methods of Material Analysis	3
4	SF184821	Electro-acoustics	3
5	SF184822	Instrumentation and Intelligent Control	3
6	SF184823	Heat Transfer	2
7	SF184824	Industrial Instrumentation	3
8	SF184831	Optic Computation	3
9	SF184832	Digital Imaging Processing	3
10	SF184833	Applied Electromagnetics	3
11	SF184841	Seismic Exploration	3
12	SF184842	Earth Potential Field Exploration	3
13	SF184843	Rock Physics and Well Log Analysis	3
14	SF184844	Inversion Model	3
15	SF184851	Group Theory	2
16	SF184852	Relativistic Quantum Theory	2
17	SF184853	Special Topics in Quantum Physics	3
18	SF184861	Biophysics	2
19	SF184862	Radiotherapy	3
20	SF184863	Health Physics and Radiation Protection	2
		Total Credits (SKS / ECTS)	45

ENRICHMENT COURSES			
1	SF184899*	Physics of the Universe	3
		Total Credits (SKS / ECTS)	3

Mapping of the institutional and core courses that support the PLOs



Matrix correlation of the elective courses that support the PLOs

No	Elective Courses	Credits (SKS / ECTS)	PLO -1	PLO -2	PLO -3	PLO-4	PLO -5	PLO -6	PLO -7	PLO -8	PLO -9	PLO -10	PLO -11	PLO -12
	SEMESTER VII													
1	Metal Physics	3								X				
	Ceramic Physics	3						X		X		X		
	Polymer Physics	3								X	X	X		
2	Microcontroller and microprocessor	3								X	X	X		
	Building Physics	3	X							X	X	X		
3	Fibre Optics	3								X	X	X		
	Photonics	3								X		X		
4	Geology	3							X	X	X			
	Seismology	3							X	X	X			
	Earth Electrical Exploration						X		X	X	X			
5	Introduction to Particle Physics	2	X					X			X			
	Advanced Mathematical Physics	2	X					X			X			

	Introduction to Cosmology	3	X					X			X		
6	Anatomy and Physiology	2		X				X	X	X	X		
	Medical Imaging Physics	2		X				X	X	X	X		
	Medical Instrumentation	2		X				X	X	X	X		
	Radiobiology	2		X				X	X	X	X		
	SEMESTER VIII												
1	Composite Physics	3		X						X	X	X	
	Semiconductor Physics	3		X						X	X	X	
	Method of Material Analysis			X				X		X	X	X	
2	Electro-acoustic	3	X	X					X			X	
	Instrumentation and Intelligent Control	3								X	X	X	X
	Heat transfer	2		X				X			X		
	Industrial Instrumentation	3		X					X	X		X	X
3	Optical Computing	3								X	X	X	
	Digital Image Processing	3							X	X		X	

	Applied Electromagnetics	3								X	X	X	
4	Seismic Exploration	3							X	X	X	X	
	Earth Potential Field Exploration	3							X	X	X	X	
	Rock Physics and Well Log Analysis	3					X			X	X	X	X
	Inversion Model	3					X		X	X	X	X	
5	Group Theory	2	X	X				X			X		
	Relativistic Quantum Theory	2	X	X				X			X		
	Special Topics On Quantum Physics	3	X	X				X			X		
6	Biophysics	2		X				X	X	X	X	X	
	Radiotherapy	2		X				X	X	X	X	X	
	Health Physics and Radiation Protection	2		X				X	X	X	X	X	

Note: Course classification based on specialized fields and laboratory: 1. Advanced Materials; 2. Instrumentation Physics; 3. Optoelectronics and Applied Electromagnetics; 4. Geophysics; 5. Theoretical Physics; and 6. Biophysics and Medical Physics.

MANDATORY COURSES OF CURRICULUM 2018-2023

SEMESTER I

COURSE	**SF 184101**	:	**Physics I**
	Credits	:	4 SKS (3/0/1)
	Semester	:	I

COURSE DESCRIPTION	
In this course students will learn to understand the basic laws of physics, particle kinematics; Particle dynamics; Work and energy; Rotation motion; Vibration and fluid Mechanics, through simple mathematical descriptions and introducing examples of the use of concepts, and conducting material analysis in the form of practicum.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students understand physical units and unit systems, as well as the characteristics of scalar units and vector units
- Students understand the definition of rotational movement and straight movement visually and mathematically and are able to apply them to problem solving
- Students are able to understand two-dimensional parabolic movement formulas and are able to apply them to problem solving
- Students understand the basic principles of Newton’s laws and are able to apply Newton’s laws, and centripetal force in problem solving

- Students understand the principles of work and mechanical energy, the law of conservation of mechanical energy, and apply them to problem solving
- Students are able to apply impulse and momentum principles, conservation of momentum, elastic and inelastic collisions into problem solving
- Students understand the principle of moving a rigid body and rolling motion and are able to apply them in problem solving
- Students are able to understand and apply angular speed and acceleration, rotational motion, translation, and equilibrium of rigid bodies
- Students understand harmonic vibrations, Hooke's law on tensile and tensile elasticity
- Students understand the event of static fluid flow and the role of viscosity in fluid flow.

MAIN TOPICS

Units and vectors;
Particle kinematics: Position displacement, velocity, acceleration, straight motion, curved motion (parabolic and rotational); relative motion.
Particle dynamics: Newton's laws (I, II, and III), various forces (gravitational force, gravity, tension force, normal force, frictional force, and spring force), force equilibrium, application of Newton's laws (I, II, and III);
Work and Energy: Concepts of work, kinetic energy, potential energy (gravity and spring), energy work theorems, mechanical energy conservation laws,
Impulses and Momentum: impulses, momentum, collisions (elastic and non-elastic), center of mass;
Rotation dynamics: Angular displacement, angular velocity and acceleration, moment of force (torque), moment of force equilibrium, moment of inertia, rotational kinetic energy, rolling motion, energy conservation laws (translation and rotation)
Vibration: simple harmonic motion, simple harmonic motion energy, mathematical pendulum, physical pendulum, torsion pendulum, combined aligned vibration (parallel and perpendicular);
Fluid mechanics: Hydro-static pressure, Pascal's principle, Archimedes' principle, surface tension, continuity equation, Bernoulli's equation, viscosity.

PREREQUISITES

None

MAIN REFERENCES
1. Halliday, Resnic, Jearl Walker ; 'Fundamental of Physics'. John Wiley and Sons, 10^{th} ed, New York, 2014 2. Douglas C. Giancoli, 'Physics for Scientists and Engineers, Pearson Education, 4^{th} ed, London, 2014 3. Tim Dosen, "Diktat Fisika I", Fisika FMIPA-ITS 4. Tim Dosen, ”Soal-soal Fisika I", Fisika FMIPA-ITS 5. -, "Petunjuk Praktikum Fisika Dasar", Fisika, MIPA-ITS

SUPPORTING REFERENCES
1. Sears & Zemanky,"University Physics", Pearson Education, 14^{th}ed, USA, 2016 2. Tipler, PA, 'Physics for Scientists and Engineers ‘,6^{th} ed, W.H. Freeman and Co, New York, 2008

REFORMULATED COURSE LEARNING OUTCOME (LO)
• **LO-1:** Students understand physical units and unit systems, as well as the characteristics of scalar units and vector units • **LO-2:** Students understand the definition of straight movement, two-dimensional parabolic movement, and rotational movement visually and mathematically and are able to apply them to problem solving • **LO-3:** Students understand the basic principles of Newton’s laws and are able to apply Newton’s laws, and centripetal force in problem solving • **LO-4:** Students understand the principles of work and mechanical energy, the law of conservation of mechanical energy, impulse and momentum principles, conservation of momentum, elastic and inelastic collisions, and apply them to problem solving • **LO-5:** Students understand the principle of angular speed and acceleration, rotational and translation motion, equilibrium of rigid bodies, and rolling motion and are able to apply them in problem solving • **LO-6:** Students understand harmonic vibrations, Hooke’s law on tensile and tensile elasticity • **LO-7:** Students understand the event of static fluid flow and the role of viscosity in fluid flow. • **LO-8:** Students are able to formulate problems through analysis based on experimental results

MAP OF PLO AND LO

	PLO-6	PLO-9				
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					
LO-6	✓					
LO-7	✓					
LO-8		✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week

COURSE			
	SF 184102	:	**Mathematical Physics I**
	Credits	:	2 SKS (2/0/0)
	Semester	:	I

COURSE DESCRIPTION	
In this course, students will learn about various methods and techniques of mathematics as a basic science in studying physics. In this course, students are expected to correlate physical phenomena mathematically in a correct manner, and are able to solve problems in physics with analytical methods. In this course linear algebra will be discussed. Students will be given material about operating matrices and Cramer, linear function, so as to determine eigen values and eigen vectors. Students will also be introduced to diagonal, hermitian, orthogonal, and unitary matrices. In this course partial differentiation, chain rules and maximum concepts will be given, that can be used to solve physical problems.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to master the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]

LEARNING OUTCOME OF THE COURSE

- Ability to define matrices, perform mathematical operations on matrices and perform series reductions and calculate matrix determinants.
- Be able to define linear functions and understand linear operators.
- Be able to understand linear vector space, calculate eigenvalues and define eigenvectors
- Be able to know the properties and functions of the hermitian matrix and the unitary matrix
- Be able to know the nature of orthogonal matrices and be able to understand similar transformations.

- Be able to define partial differentiation notation, as well as total differentiation
- Be able to perform partial differentiation with chain rules, and know maximum and minimum concepts

MAIN TOPICS

Matrices, series reduction, determinants, Cramer's rule, vectors, lines and fields, linear combinations, linear functions, linear operators, dependence and linear dependence, specific matrices and its formulas, linear vector space, eigenvalues, eigenvectors, diagonal matrices and application of diagonal matrices, Hermitian matrix, unitary matrix, orthogonal matrix, similarity transformation, partial differentiation notation, total differentiation, advanced chain rule, maximum and minimum issues, Lagrange multiplier method, Jacobian.

PREREQUISITES

1. Calculus I (Minimum D)

MAIN REFERENCES

1. Marry L Boas, . Mathematical Methods in the Physical Sciences 3rd Ed., John Wiley and Sons, 2006
2. Howard Anton,. Elementary Linear Algebra 9th Ed., John Wiley and Son, 2005

SUPPORTING REFERENCES

3. George B. Arfken & Hans J. Weber, Mathematical Methods for Physicists, Sixth Edition: A Comprehensive Guide, Academic Press, 2005
4. K.F. RILEY, M.P. HOBSON and S. J. BENCE, Mathematical Methods for Physics and Engineering 3rd Ed., Cambride University Press, 2006
5. Modul ajar Fisika Matematika I

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: able to define matrices, perform mathematical operations on matrices and perform series reductions and calculate matrix determinants.
- LO-2: able to define linear functions and understand linear operators.
- LO-3: able to understand linear vector space, calculate eigenvalues and define eigenvectors
- LO-4: able to know the properties and functions of the Hermitian matrix and the unitary matrix
- LO-5: able to know the nature of orthogonal matrices and able to understand similar transformations.
- LO-6: able to define partial differentiation notation, as well as total differentiation

- LO-7: able to perform partial differentiation with chain rules, and know maximum and minimum concepts

MAP OF PLO AND LO

	PLO-7	PLO-8				
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓	✓				
LO-5	✓	✓				
LO-6	✓	✓				
LO-7	✓	✓				

WORKLOAD

1. Lectures : 2 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

SEMESTER II

COURSE			
	SF 184202	:	**Physics II**
	Credits	:	3 SKS (3/0/0)
	Semester	:	II

COURSE DESCRIPTION
In this course students will learn to understand the basic laws of physics, Electric Field; Potential Electricity; Electric current ; Magnetic field; Electrical Motion (EMF) Induction and Alternating Current, through simple mathematical descriptions and introducing examples of conceptual usage.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]

LEARNING OUTCOME OF THE COURSE

- Students understand the substances that construct the material, as well as the electrical properties, the nature of the conductor and the dielectric
- Students understand the electric field strength based on the style of coulomb and Gauss' law.
- Students understand various forms of electric potentials on charged conductors
- Students understand the capacitance principles of various capcitor forms in capacitor circuits, series, parallel, and mixed circuits.
- Students are able to use magnetic field force formulas with electric currents and moving charge
- Students can mention the role of magnetization in magnetic materials and hystensis loops
- Students understand the principles of electrostatic force, and current in resistors, capacitors, and inductors
- Students are able to determine the magnitude of impedance, the electric current, and the phase angle in series ciruits, parallel R-L, R-C, R-L-C.

MAIN TOPICS

Electric charge, Coulomb’s law;
Electric field: electric field strength, force lines, electric field strength calculation for point charge, line charge, ring, disc, cylinder;
Gauss’ law: flux, force lines, Gauss’ law and its application for cylindrical and sphere charges;
Electric potential: potential energy, electric potential difference, relationship between electric potential and electric fields, electrical potential calculation for point charges, line charge, ring, disc, cylinder, and sphere;
Capacitors: capacitance, capacitance calculations for parallel chip capacitors, series and parallel capacitor circuits, dielectric materials, capacitor energy;
Electric current: current and motion of charge, Ohm’s law, resistivity, resistance, electrical power;
Direct current circuit: series and parallel resistor circuit, Kirchoff’s laws;
Magnetic fields: flux and magnetic induction, Lorentz force, Biot Savard-Ampere law, calculation of magnetic field for straight wires, rings, solenoids, and toroids
EMF Induction: Faraday’s law, Lenz’s law, induced EMF< self inductance and inductance coupling; energy on the inductor;
Transient symptoms: calculation of current changes over time for series RC and Cl series
Alternating current: alternating currents in resistors, inductors, capacitors, impedance, R-L and R-C circuits for series and parallel, R-L-C series, power, resonance

PREREQUISITES

None

MAIN REFERENCES

1. Halliday & Resnic; 'Fundamental of Physics'. John Wiley and Sons, New York, 1987
2. Tim Dosen, "Diktat Fisika II", ”Soal-soal Fisika II", Fisika FMIPA-ITS
3. Giancoli, DC., (terj, Yuhilza H), 'Fisika, jilid 2', Ertangga, Jakarta, 2001

SUPPORTING REFERENCES

1. Alonso & Finn,"Fundamental University Physics", Addison Wesley Pub Comp Inc,$1^{3`}$.ed, Calf, 1990
2. Tipler, PA,(ted. L Prasetio dan R.W.Adi), "Fisika : untuk Sains dan Teknik, Jilid 2", Erlangga, Jakarta, 1998

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students understand the substances that construct the material, as well as the electrical properties, the nature of the conductor and the dielectric
- LO-2: Students understand the electric field strength based on the style of coulomb and Gauss' law.
- LO-3: Students understand various forms of electric potentials on charged conductors
- LO-4: Students understand the capacitance principles of various capcitor forms in capacitor circuits, series, parallel, and mixed circuits.
- LO-5: Students are able to use magnetic field force formulas with electric currents and moving charge
- LO-6: Students can mention the role of magnetization in magnetic materials and hysteresis loops
- LO-7: Students understand the principles of electrostatic force, and current in resistors, capacitors, and inductors
- LO-8: Students are able to determine the magnitude of impedance, the electric current, and the phase angle in series circuits, parallel R-L, R-C, R-L-C.

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					
LO-6	✓					
LO-7	✓					
LO-8	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184203	:	**Physics III**
	Credits	:	3 SKS (2/0/1)
	Semester	:	II

COURSE DESCRIPTION	
This course discusses the concepts of heat, heat gauges and units, calorimetry, thermodynamic laws and changes in form, mechanical waves and physical optics. Atomic theory, atomic spectrum and radioactivity. Experiments on the introduction of thermometers, heat generated by electric currents, the concept of Black's principle (calorimeter); length expansion coefficient, the resonance tube, lens radius, and the bias index of a material.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
LEARNING OUTCOME OF THE COURSE	
● Students are able to understand: a. Various kinds of thermometers and scales b. Phenomena of expansion c. Depth concept and phase change, Black's principle and calorimetry d. Conduction of heat in materials, ideal gas and the concept of thermodynamic laws e. Mechanical waves and magnitudes, doppler effects and their applications f. The concept of Snelius' law, optical instruments, as well as symptoms of reflection, interference, and polarization g. Basic concepts of waves as matter, atomic spectrum, atomic theory, and radioactivity	
MAIN TOPICS	
Thermometry and calorimetry: temperature scales, assorted thermometers, expansion (extended length, area and space); concept of	

heat, phase change and Black's principle, calorimetry (double-walled water calorimetry and continued)

Heat transfer: heat conduction in solids, liquids, and gases; thermodynamics: the kinetic theory of gases, heat capacity, ideal gas, heat-work, first and second law of thermodynamics;

Thermodynamics: the kinetic theory of gas, work, and heat; the first law of thermodynamics, the ideal gas calorific capacity, the second law of thermodynamics

Waves: wave functions, rapid propagation of waves, energy and wave intensity,

Optical geometry: reflection and refraction by flat and curved surfaces, thin and thick lenses, shadow formation in lenses and mirrors, deviations and dispersions on prisms, optical devices;

Modern physics: material waves, atom spectrum, atomic theory, X-ray spectrum, radioactivity, atomic nuclei

PREREQUISITES

None

MAIN REFERENCES

1. Halliday & Resnic; 'Fundamental of Physics'. John Wiley and Sons, New York, 1987
2. Tim Dosen, "Diktat Fisika I", "Soal-soal Fisika I", Fisika FMIPA-ITS
3. Tim Dosen, "Diktat Fisika II", "Soal-soal Fisika II", Fisika FMIPA-ITS
4. Giancoli, DC., (terj, Yuhilza H), 'Fisika, jilid 2', Ertangga, Jakarta, 2001

SUPPORTING REFERENCES

3. Tipler, PA,(ted. L Prasetio dan R.W.Adi), "Fisika : untuk Sains dan Teknik, Jilid 2", Erlangga, Jakarta, ...

REFORMULATED COURSE LEARNING OUTCOME (LO)

a. LO-1: Students are able to understand various kinds of thermometers and scales
b. LO-2: Students are able to understand phenomena of expansion
c. LO-3: Students are able to understand depth concept and phase change, Black's principle and calorimetry

d. LO-4: Students are able to understand conduction of heat in materials, ideal gas and the concept of thermodynamic laws
e. LO-5: Students are able to understand mechanical waves and magnitudes, doppler effects and their applications
f. LO-6: Students are able to understand the concept of Snelius' law, optical instruments, as well as symptoms of reflection, interference, and polarization
g. LO-7: Students are able to understand basic concepts of waves as matter, atomic spectrum, atomic theory, and radioactivity.

MAP OF PLO AND LO

	PLO-6	PLO-8				
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓	✓				
LO-6	✓	✓				
LO-7	✓	✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week

SEMESTER III

COURSE	SF184301	:	**Mechanics I**
	Credits	:	3 SKS
	Semester	:	III

COURSE DESCRIPTION	
In this course, students will learn about one, two, and three dimensional particle motion. Vibrational motion, aligned vibration, damped vibration, forced vibration, resonance energy. Energy conservation, conservative forces, work of non-conservative forces. Motion of particle systems, centre of mass of systems, kinetic energy of particle systems, angular momentum of particle systems. Conservation of momentum, central collisions, particle collisions. Rotation of solid objects, rotation around the axis (moment of force, angular momentum, moment of inertia), parallel axis proximates and vertical axis proximates, moment of inertia of dimensionless objects, inertia tensors. Non-inertial reference structures: Accelerated reference structures and inertial force (fictive forces), rotational reference structures (centrifugal acceleration and Coriolis acceleration), particle dynamics in rotational reference structures (Foucault pendulum, windsets, climate change)	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
LEARNING OUTCOME OF THE COURSE	
MAIN TOPICS	
One, two, and three dimensional particle motion. Vibrational motion, aligned vibration, damped vibration, forced vibration, resonance energy. Energy conservation, conservative forces, work of non-conservative forces.	

Motion of particle systems, centre of mass of systems, kinetic energy of particle systems, angular momentum of particle systems.
Conservation of momentum, central collisions, particle collisions.
Rotation of solid objects, rotation around the axis (moment of force, angular momentum, moment of inertia), parallel axis proximates and vertical axis proximates, moment of inertia of dimensionless objects, inertia tensors.
Non-inertial reference structures:
Accelerated reference structures and inertial force (fictive forces), rotational reference structures (centrifugal acceleration and Coriolis acceleration), particle dynamics in rotational reference structures (Foucault pendulum, windsets, climate change)

PREREQUISITES

1. Physics I (minimum grade D)

MAIN REFERENCES

1. Arya, Atam Parkash, "Introduction to Classical Machanics", 2 nd Ed Allyn and Bacon, Boston, 1998
2. **Grant R. Fowles & George L. Cassiday, "Analytical Mechanics", 7 th Ed,Thomson brooks/cole, Belmort CA USA, 2005**

SUPPORTING REFERENCES

1. R. Douglas Gregory, "Classical Mechanics", Cambridge University Press Uk, 2006

REFORMULATED COURSE LEARNING OUTCOME (LO)

LO-1: able to understand one, two, and three dimensional particle motion.
LO-2: able to understand vibrational motion, aligned vibration, damped vibration, forced vibration, resonance energy. Energy conservation, conservative forces, work of non-conservative forces.
LO-3: able to understand motion of particle systems, centre of mass of systems, kinetic energy of particle systems, angular momentum of particle systems.
LO-4: able to understand conservation of momentum, central collisions, particle collisions.
LO-5: able to explain rotation of solid objects, rotation around the axis (moment of force, angular momentum, moment of inertia), parallel axis proximates and vertical axis proximates, moment of inertia of dimensionless objects, inertia tensors.
LO-6: able to explain non-inertial reference structures:
LO-7: able to apply accelerated reference structures and inertial force (fictive forces), rotational reference structures (centrifugal acceleration and Coriolis

acceleration), particle dynamics in rotational reference structures (Foucault pendulum, windsets, climate change)

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					
LO-6	✓					
LO-7	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184302	:	**Waves**
	Credits	:	3 SKS
	Semester	:	III

COURSE DESCRIPTION	
This course contains the concept and formulation of mechanical and optical waves as part of physics, among others: Simple Harmonic Waves, Transverse Wave Movements, Longitudinal Waves, Electromagnetic Waves, Waves on More Than One Dimension, Waves on Optical Systems, and their applications in various fields of physics and related engineering.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]

LEARNING OUTCOME OF THE COURSE

- Students are able to explain the phenomenon of Simple Harmonic Waves
- Students are able to explain the basic concept of Transverse Wave Movement
- Students are able to explain the basic concept of Longitudinal Waves
- Students are able to explain the basic concept of electromagnetic waves
- Students are able to explain the basic concept of Waves on More Than One Dimension
- Students are able to explain the basic concept of Waves on Optical Systems
- Students are able to apply the concept of mechanical and optical waves in various fields of physics and engineering

MAIN TOPICS

1. **Simple Harmonic Motion** [4-36]: Shift in simple harmonic motion, Speed and acceleration in simple harmonic motion, Simple harmonic oscillator energy, Superposition of two simple one-dimensional harmonic vibrations, Superposition of two simple harmonic vibrations perpendicular to each other, Superposition of *n* pieces simple harmonic vibration with the same amplitude and random phase.
2. **Transverse Wave Motion** [107-150]: Waves, Speed ff wave motion, Wave equation, Solution of wave equations, Characteristic of rope wave impedance (rope as damped oscillator), Reflection and transmission of

waves at the end of rope, reflective energy and transmission energy, Coefficient intensity reflected and transmitted, Impedance adjustment, Wave standing on a fixed length rope, Vibration energy strap, Energy of every normal mode of strand vibration, Wave standing ratio, Group wave and group velocity, Doppler Effect.

3. **Longitudinal Waves** [151-170]: Sound waves in gas, Distribution of energy in sound waves, Sound wave intensity, Longitudinal waves in solids, Reflections and transmissions of sound waves in the boundary plane, Intensity of reflected wave sound and transmission waves.
4. **Electromagnetic waves** [199-238]: Maxwell equations, electromagnetic waves in mediums with limited permeability and permittivity but have conductivity, electromagnetic wave equations, Poynting vector illustrations, dielectric impedance for electromagnetic waves, electromagnetic waves in the medium having, and (for), electromagnetic wave velocity in conductor and anomaly dispersion, Medium criterion is a conductor or dielectric, Why electromagnetic wave does not propagate in a conductor, Impedance of medium of electromagnetic wave, Reflection and transmission of electromagnetic waves in boundary field, Reflection of Conductor perpendicular), electromagnetic waves in the ionosphere.
5. **Waves in more than one dimension** [239-266]: Field waves expressed in two and three dimensions, Wave equations in two dimensions, Wave guides, Normal modes and variable separation methods, Two-dimensional Cases, Three-dimensional Cases, Reflection and transmission three-dimensional waves on the boundary plane, Total reflections in and evanescent waves.
6. **Waves on Optical Systems** [305-332]: Light Waves or rays, Fermat Principles, Reflection Law, Refraction Law, Rays and wave faces, Optical rays and optical systems, surface power of spheres, Power by spherical surface, Power of two optical bias surfaces, Power of thin lens in air, Main field and newton equations, Optical Helmholtz equations for conjugate plane at infinity, Method deviation for two lenses and thick lenses, Method matrix.

PREREQUISITES

1. Physics III

MAIN REFERENCES

1. Pain, H.J., “The Physics of Vibrations and Waves”, John Wiley & Sons Ltd., 6-Ed., 2005

SUPPORTING REFERENCES

1. Pedrotti, F.L. and Pedrotti, L.S., “Introduction to Optics”, Prentice-Hall, 1987

2. Crawford, F.S. ; “Waves”, Berkeley Physics Course, vol 3, Me Graw-Hill, 1968

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to explain the phenomenon of Simple Harmonic Waves
- LO-2: Students are able to explain the basic concept of Transverse Wave Movement
- LO-3: Students are able to explain the basic concept of Longitudinal Waves
- LO-4: Students are able to explain the basic concept of electromagnetic waves
- LO-5: Students are able to explain the basic concept of Waves on More Than One Dimension
- LO-6: Students are able to explain the basic concept of Waves on Optical Systems
- LO-7: Students are able to apply the concept of mechanical and optical waves in various fields of physics and engineering

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					
LO-6	✓					
LO-7	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week

COURSE	SF184303	:	**Thermodynamics**
	Credit	:	3 SKS (3/0/0)
	Semester	:	III

COURSE DESCRIPTION	
In this course, students will learn material about macroscopic and microscopic views, the scope of thermodynamics, thermal equilibrium, thermodynamic equilibrium, PV and PT diagrams, state equations, work, quasi-static processes, heat and the first law of thermodynamics, inverse and irreversible processes, entropy, Carnot cycle, enthalpy, Helmholtz and Gibbs function, heat capacity, phase change.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
LEARNING OUTCOME OF THE COURSE	
• Students are able to explain the basic description of thermodynamics, the state equations of thermodynamic laws I and II • Students are able to understand the concept of temperature, work and heat interconnection, and entropy • Students are able to understand the application of classic thermodynamic concepts	
MAIN TOPICS	
The Scope of Thermodynamics: Simple Thermodynamic Systems: equation of state, state units (temperature, pressure, volume), phase and phase change (solid, liquid, and gas), PV and PT diagrams The Zeroth Law of Thermodynamics: macroscopic and microscopic views Work: Quasi-static process, hydrostatic system work, PV diagram, work depends on process, work in quasi-static processes Heat and First Law of Thermodynamics: Work and heat, adiabatic work, internal energy functions (internal energy), mathematical formulation of the first law of thermodynamics, heat capacity, heat	

Ideal gas: ideal gas state equation, real gas state equation
Second Law of Thermodynamics: conversion of work to heat and vice-versa, Stirling machine, steam engine, combustion motor, refrigerant
Entropy: Entropy and energy as thermodynamic potential, Legendre transformation, ideal gas entropy, TS diagram, Carnot cycle, Entropy and inversion, Entropy and inverse
Enthalpy: Helmholtz and Gibbs functions, Maxwell relationship, heat capacity equation

PREREQUISITES

1. Physics III

MAIN REFERENCES

1. Zemansky, M.W, & R. H. Dittmann (terj: The Houw Liong, Ph.D)," Kalor dan Termodinamika", penerbit ITB, 1986.
2. Sears. F.W., "An Introduction to Thermodynamics: the Kinetic Theory of Gases and Statistical Mechanics", Addison Wesley, 1963.

SUPPORTING REFERENCES

1. Callen H.B. "Thermodynamics And An Introduction To Thermostatistics",2ed., Wiley, New York, 1985

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to explain the basic description of thermodynamics, the state equations of thermodynamic laws I and II
- LO-2: Students are able to understand the concept of temperature, work and heat interconnection, and entropy
- LO-3: Students are able to understand the application of classic thermodynamic concepts

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.

2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	**SF184304**	:	**Mathematical Physics II**
	Credits	:	4 SKS
	Semester	:	IV

COUSE DESCRIPTION

In this course the materials given are various methods and techniques of mathematics as a basic science in studying Physics. In this course, students are expected to be able to connect the physical phenomena with mathematical expressions that are appropriate and correct, and able to solve problems in physics with analytical methods.
It is expected that students are able to use special functions.
Students are able to explain the Legendre equation, Legendre polynomial and Legendre series on the Legendre polynomial generating function, Legendre polynomial orthogonality and Legendre reassociation polynomial. Determine the solution of partial differential equations by the method of variable separation on a Cartesian, cylinder, and sphere coordinate system. Perform a specific integrity evaluation using the residual theorem on complex variable functions. In this course students also understand the theory of probability.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE

PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]

LEARNING OUTCOME OF THE COURSE

- Be able to understand series, perform convergence tests on alternating series and conditional convergent series, perform a function approach using Taylor and Maclaurin series for one and two variables.
- Be able to understand complex numbers, complex algebra and complex series and able to understand and apply Euler's formula
- Be able to solve partial derivative problems and the determination of constrained optimization

- Be able to solve double and triple integral and develop them on repeated integral applications.
- Be able to solve general solutions for both homogeneous and not homogeneous first and second order ordinary linear differential equations
- Be able to solve problems related to repeated integration
- Be able to know the definition of scalar and vector fields and can define scalar field gradients and understand line integrals.
- Be able to solve physics problems using Fourier series and Fourier transform

MAIN TOPICS

- **Series**: infinite series, power series, convergence test and area of convergence, expansion of functions into power series;
- **Complex numbers**: complex numbers, conjugate complexes, complex number algebraes, Complex and Curve Equations in Complex Fields, Complex Power Ranks and Convergence Circles, Component Exponential Function, Complex and Root, Trigonometry, Hyperbolic and Complex Logarithms, Trigonometric Functions, complex function
- **Partial differentials**: approach to derivatives, chain and implicit rules, optimizations (issues of minimum and maximum values) functions with and without constraints (constrained)
- **Repeated integrals**: introduction, integrating technique, Variable Replacement Technique, Integral Technique per Section, Integral Differentiation and Leibniz Rule, Two Fold Integrals, Three Fold Integrals, Integral Variable Transformation
- **Vector analysis**: Terrain and Gradient operators, divergence and rotation, line integrals, conservative fields and potential models, divergence theorems, Stoke theorem
- **Fourier sequences and Fourier transform**s: Periodic series, Fourier series, Dirichlet conditions and Parseval theorem
- **Ordinary differential equations (ODE)**: ODE solutions (separation of variables, expansion of the series of DE Bessel and DE Legendre), nonhomogeneous DE

PREREQUISITES

1. Mathematical Physics I (Minimum grade D)

MAIN REFERENCES
1. Marry L Boas, . Mathematical Methods in the Physical Sciences 3rd Ed., John Wiley and Sons, 2006

SUPPORTING REFERENCES
1. George B. Arfken & Hans J. Weber, Mathematical Methods for Physicists, Sixth Edition: A Comprehensive Guide, Academic Press, 2005 2. K.F. RILEY, M.P. HOBSON and S. J. BENCE, Mathematical Methods for Physics and Engineering 3rd Ed., Cambride University Press, 2006 3. Modul ajar Fisika Matematika III

REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: able to understand series, perform convergence tests on alternating series and conditional convergent series, perform a function approach using Taylor and Maclaurin series for one and two variables. • LO-2: able to understand complex numbers, complex algebra and complex series and able to understand and apply Euler's formula • LO-3: able to solve partial derivative problems and the determination of constrained optimization • LO-4: able to solve double and triple integral and develop them on repeated integral applications. • LO-5: able to solve general solutions for both homogeneous and not homogeneous first and second order ordinary linear differential equations • LO-6: able to solve problems related to repeated integration • LO-7: able to know the definition of scalar and vector fields and can define scalar field gradients and understand line integrals. • LO-8: able to solve physics problems using Fourier series and Fourier transform

MAP OF PLO AND LO

	PLO-7	PLO-8				
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓	✓				
LO-5	✓	✓				

LO-6	✓	✓				
LO-7	✓	✓				
LO-8	✓	✓				

WORKLOAD

1. Lectures : 4 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184305	:	**Electronics**
	Credits	:	4 SKS (3/0/1)
	Semester	:	III

COURSE DESCRIPTION	
In this course students will learn about the basic concepts of DC circuits, Basic Laws, DC circuit analysis methods, circuit theorems, first order circuits, Steady state analysis, Introduction to Laplace transformations and their applications, Transient states, RLC circuits, Low pass filter, High pass filter, Transfer function, Amplitude response, Phase response, Bode plot approach, Diode, Transistor, Bipolar Junction Transistor (BJT), DC-biasing - BJT, BJT analysis in AC domain, Simple operational amplifier. The learning method is done in the classroom and the laboratory, so students have experience in theory and practice and are able to give the right decision about the use of electronics to solve physics problems and its application	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
LEARNING OUTCOME OF THE COURSE	
• Students are able to recognize, understand and solve problems related to the basic concept of circuits • Students are able to apply in practice the basic laws and methods of DC circuit analysis • Students are able to recognize, understand and analyse circuit theorems, first order circuits	

- Students are able to apply in practice the first order circuits and steady state analysis
- Students are able to understand about Laplace transform and its application
- Students are able to understand transient states, the RLC circuit and filter circuits
- Students are able to understand about diode, transistor, Bipolar junction transistor (BJT)
- Students are able to understand about simple operational amplifier

MAIN TOPICS

1. The basic concept of DC circuit: unit system, charge and current, voltage, power and energy, circuit elements
2. Basic laws: Ohm's law (point, branch, and loop), Kirchoff's laws, series-parallel resistor, voltage divider and current divider, wye-delta transformation DC circuit analysis method: point analysis, point analysis with voltage source, mesh analysis, analysis of mesh with current source Circuit Theorem: linearity, superposition, Thevenin Theorem, Norton's Theorem and maximum power transfer
3. First series of circuits: series and parallel, free source RC circuit, RL circuit with free source, singularity function, response step for RC and RL circuit, Sinusoids, Phasors, phasor connection for circuit element, impedance, instantaneous and average power, maximum power transfer, effective value and RMS, power factor
4. Steady state analysis: point analysis, mesh analysis, superposition theorem, source transformation, Thevenin and Norton equivalence circuit
5. Introduction to Laplace transform and its application
6. Transient state, RLC circuit, low pass filter, high pass filter, transfer function, amplitude response, phase response, Bode plot approach
7. Diodes: Semiconductor materials, *p* type semiconductors, *n* type semiconductors, *p-n* junctions, diodes, diode characteristics, diodes as rectifiers, Zener diodes, unregulated DC power supplies, diode application circuit
8. Transistor: bipolar transistor: *p-n-p* and *n-p-n* transistor, transistor characteristics, equivalent circuit of transistor, base powered amplifier (CB), emitter grounded emitter (CE), amplified collector amplifier (CC), voltage amplifier, transistor as small current amplifier, and dc. Field effect transistor: FET, JFET, MOSFET, FET as signal/voltage amplifier, equivalent circuit of FET amplifier, regulated power supply, switching power supply
9. Bipolar Junction Transistor (BJT), DC -biasing - BJT, BJT analysis in a domain

10. Simple operational amplifier: Ideal operational amplifier properties, inverting amplifier, non inverting amplifier, summing amplifier, differential amplifier

PREREQUISITES

1. Physics II (Minimum grade C)

MAIN REFERENCES

1. Charles K. Alexander, Matthew N. O. Sadiku, Fundamentals of Electric Circuits, Fifth Edition, 2012.
2. J. W. Nilssson dan S. A, Riedel, 2008, Electronic Circuit, Pearson Prentice Hall.
3. Boylestad, 2002, Introductory Circuit Analysis, 10th edition, Prentice Hall.
4. Dosen-dosen Instrumentasi, Modul praktikum Elektronika dasar 1

SUPPORTING REFERENCES

1. Millman and Halkias,2001, Integrated Electronics, Tata McGraw-Hill.
2. Robert L Boylestad and Louis Nashelsky, 2009, Electronics Devices and Theory, 10 edition, Pearson Education.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to recognize, understand and solve problems related to the basic concept of circuits
- LO-2: Students are able to apply in practice the basic laws and methods of DC circuit analysis
- LO-3: Students are able to recognize, understand and analyse circuit theorems, first order circuits
- LO-4: Students are able to apply in practice the first order circuits and steady state analysis
- LO-5: Students are able to understand about Laplace transform and its application
- LO-6: Students are able to understand transient states, the RLC circuit and filter circuits
- LO-7: Students are able to understand about diode, transistor, Bipolar junction transistor (BJT)
- LO-8: Students are able to understand about simple operational amplifier

MAP OF PLO AND LO

	PLO-2	PLO-7	PLO-8			
LO-1		✓				
LO-2		✓				
LO-3		✓				
LO-4		✓				

LO-5		✓				
LO-6		✓				
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 4 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week

COURSE	SF184306	:	**Physical Measurement Methods**
	Credits	:	2 sks
	Semester	:	III

COURSE DESCRIPTION	
In this course students will learn about physical quantities, measurement systems, measurement instruments, instrument characteristics, and measurement analysis methods.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
LEARNING OUTCOME OF THE COURSE	
• Be able to identify measurable physical quantities of a system and can explain how the measurement of the magnitude • Be able to use measuring instrument to measure a physical quantity • Be able to analyse measurement results with mathematical and statistical tools	
MAIN TOPICS	
- Observations and physical quantities, - Measurement systems, - Measurement instruments, - Characteristics of the instrument - Method of measurement analysis (important numbers, uncertainty, error, uncertainty analysis (variant, covariance, correction), regression and correlation, data processing, Poisson statistics, mathematical models, curve fitting)	
PREREQUISITES	
1. Physics I 2. Physics II	
MAIN REFERENCES	

1. Alan S. Moris “ Measurement and Instrumentation principles”Butterworth-heinemann, Xxford 2001
2. Ppl regtien, F vander heijden, M.J. Korsten, w. otthieis “ measurement science for engineer” Elsivier & technology, Books, 2004

SUPPORTING REFERENCES

1. Imron, A., "Diktat Analisa Pengukuran Fisis", Fisika, MIPA-ITS

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: able to identify measurable physical quantities of a system and can explain how the measurement of the magnitude
- LO-2: able to use measuring instrument to measure a physical quantity
- LO-3 able to analyse measurement results with mathematical and statistical tools

MAP OF PLO AND LO

	PLO-2	PLO-8				
LO-1	✓	✓				
LO-2	✓	✓				
LO-3	✓	✓				

WORKLOAD

1. Lectures : 2 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week.

SEMESTER IV

COURSE	**SF184401**	:	**Mechanics II**
	Credits	:	3 SKS
	Semester	:	IV

COURSE DESCRIPTION
In this course, students will learn about: Central-force motion, polar coordinate system, Kepler's Law, orbit differential equations, energy differential equations, orbit equations. The gravitational field, the definition of gravitational field, the definition of gravitational potential, gravitational field and potential due to mass, the gravitational field equation (Gauss' law). The Lagrange equation, the general coordinate system, the Lagrange function, the form of the Lagrange equation. Hamilton's equation, Hamilton function, form of Hamilton equation Ideal Fluid: Euler equation, Bernoulli equation, hydrostatic pressure, energy flow density, momentum flow density, circulation conservation law, potential flow, drag force, Viscous Fluid: Navier-Stokes equation, energy dissipation and uncompressed fluid, Stokes force, Flow of viscous fluid in pipes, Reynolds constant, Dynamics equations in various curved (curvilinear) coordinates.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]

LEARNING OUTCOME OF THE COURSE

MAIN TOPICS
Central-force motion, polar coordinate system, Kepler's Law, orbit differential equations, energy differential equations, orbit equations. The gravitational field, the definition of gravitational field, the definition of

gravitational potential, gravitational field and potential due to mass, the gravitational field equation (Gauss' law).
The Lagrange equation, the general coordinate system, the Lagrange function, the form of the Lagrange equation. Hamilton's equation, Hamilton function, form of Hamilton equation
Ideal Fluid: Euler equation, Bernoulli equation, hydrostatic pressure, energy flow density, momentum flow density, circulation conservation law, potential flow, drag force,
Viscous Fluid: Navier-Stokes equation, energy dissipation and uncompressed fluid, Stokes force, Flow of viscous fluid in pipes, Reynolds constant, Dynamics equations in various curved (curvilinear) coordinates.

PREREQUISITES

2. Mechanics I (minnimum grade D)

MAIN REFERENCES

3. Arya, Atam Parkash, "Introduction to Classical Machanics", 2 nd Ed, Allyn and Bacon, Boston, 1998
4. Grant R. Fowles & George L. Cassiday, "Analytical Mechanics", 7 th Ed,Thomson brooks/cole, Belmort CA USA, 2005
5. Frank M.White, "Fluid Mechanics", 8 th Ed, Mc Graw Hill, USA, 2016

SUPPORTING REFERENCES

1. R. Douglas Gregory, "Classical Mechanics", Cambridge University Press Uk, 2006

REFORMULATED COURSE LEARNING OUTCOME (LO)

LO-1: able to understand central-force motion, polar coordinate system, Kepler's Law, orbit differential equations, energy differential equations, orbit equations.
LO-2: able to understand the gravitational field, the definition of gravitational field, the definition of gravitational potential, gravitational field and potential due to mass, the gravitational field equation (Gauss' law).
LO-3: able to understand the Lagrange equation, the general coordinate system, the Lagrange function, the form of the Lagrange equation. Hamilton's equation, Hamilton function, form of Hamilton equation
LO-4: able to understand ideal Fluid: Euler equation, Bernoulli equation, hydrostatic pressure, energy flow density, momentum flow density, circulation conservation law, potential flow, drag force,
LO-5: able to understand viscous Fluid: Navier-Stokes equation, energy

dissipation and uncompressed fluid, Stokes force, Flow of viscous fluid in pipes, Reynolds constant, Dynamics equations in various curved (curvilinear) coordinates.

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184402	:	**Optics**
	Credits	:	3 SKS
	Semester	:	IV

COURSE DESCRIPTION	
This course contains the concept and formulation of: Motion of Waves: Electromagnetic theory, photon, and light; Light propagation; Geometric optics; Superposition of waves; Polarization; Interference; Diffraction; and the basic theory of coherence.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
LEARNING OUTCOME OF THE COURSE	

1. Students are able to understand wave motion which include: One-dimensional wave, harmonic wave, Phase and phase velocity, Principle of superposition, Complex shape, Phasor and wave summation, Field waves, Three-dimensional wave equation, Wave ball, Cylinder waves.
2. Students are able to understand Electromagnetic theory, photons, and light, which include: Electromagnetic waves, Energy and momentum, Radiation, Light in massive objects, Electromagnetic-photon spectrum.
3. Students are able to understand and apply Light propagation, which includes: Rayleigh Screening, Reflection, Refraction, Fermat Principle, Electromagnetic Approach, Reflection in total, Metal optical properties, Light and material interaction aspects, Treatment Stokes for Reflection and Refraction, Photon.
4. Students are able to understand and apply in the solution of geometric Optical problems, which include: Lens, Mirrors, Prisms, Optical Fiber, Optical System, Wave formation, Lenses and lens systems.
5. Students are able to understand the wave superposition, which includes: The addition of the same frequency wave, the addition of different frequency waves, anharmonic periodic waves, non-periodic waves
6. Students are able to understand and can solve Polarization problems, including: Polarization Light characteristics, Polarizer, Dichlorism,

Birefringence, Scattering and polarization, Polarization due to reflection, Retarder, Circular polarization, Polychromatic light polarization, Optical activity, Optical optical effect- Optical modulator, mathematical polarization.

7. Students are able to understand and apply in the solution of Interference problems, including: Conditions for Interference, Interferometer wave separation, Interferometer separation amplitude, Interference type framing and localization, Multi-plural interference, Application of single and plural layers, Interferometry application.

Students are able to understand Diffraction, which includes: Fraunhofer Diffraction, Fresnel Diffraction, Kirchhoff Diffraction Theory, Terms of wave diffraction limit,

Students are able to understand the basic theory of coherence, which includes: Fringe and coherence, Visibility, Coherence and mutual coherence, Coherence and Stellar interferometry

MAIN TOPICS

1. **Wave Motion [18-40]**: One-dimensional wave, harmonic wave, phase and phase velocity, Principle of superposition, Complex shape, Phasor and wave summation, Field waves, Three-dimensional wave equation, Wave ball, Cylindrical wave.
2. **Electromagnetic theory, photons, and light [54-88**]: Electromagnetic waves, Energy and momentum, Radiation, Light in mass objects, Electromagnetic-photon spectrum.
3. **Light propagation [96-150]**: Rayleigh Scattering, Reflection, Refraction, Fermat Principle, Electromagnetic Approach, Reflection in total, Metal optical properties, Light and material interaction aspects, Stokes treatment for Reflection and Refraction, Photons.
4. **Geometric Optics [159-239; 255-258]**: Lens, Mirrors, Prisms, Optical Fiber, Optical Systems, Wave forming, Lenses and lens systems.
5. **Wave superposition [291-330]**: Addition of same frequency wave, Added different frequency wave, Periodic anharmonic waves, non-periodic waves.
6. **Polarization [338-385**]: Light Polarization, Polarizer, Dichlorism, Birefringence, Scattering and Polarization, Polarization due to Reflection, Retarder, Polarization of circle, Polychromatic light polarization, Optical activity, Optical optical effect- Optical modulator, Mathematical description of polarization.
7. **Interference [402-450]**: Conditions for Interference, Interferometer wave separation, Interferometer separation amplitude, Interference

type framing and localization, Multiple plural interference, Single and multiple layer applications, Interferometry applications.

8. **Diffraction [457-535]**: Fraunhofer Diffraction, Fresnel Diffraction, Kirchhoff Diffraction Theory, Terms of wave diffraction limit,
9. **The basic theory of coherence [590-608]**: Fringe and coherence, Visibility, Coherence and mutual coherence, Coherence and Stellar interferometry

PREREQUISITES

1. Waves

MAIN REFERENCES

1. Hecht E., “Optics”, Pearson Education Limited, 5th-edition, 2017
2. Pedrotti, F.L. dan Pedrotti, L.S., “Introduction to Optics”, Prentice-Hall, 1987

SUPPORTING REFERENCES

1. Pain, J.G., “Vibration and Wave in Physics”, Cambrindge University Press, 1987
2. Crawford, F.S. ; “Waves”, Berkeley Physics Course, vol 3, Me Graw-Hill, 1968

REFORMULATED COURSE LEARNING OUTCOME (LO)

1. LO-1: Students are able to understand wave motion.
2. LO-2: Students are able to understand Electromagnetic theory, photons, and light.
3. LO-3: Students are able to understand and apply Light propagation.
4. LO-4: Students are able to understand and apply in the solution of geometric Optical problems.
5. LO-5: Students are able to understand the wave superposition.
6. LO-6: Students are able to understand and can solve Polarization problems.
7. LO-7: Students are able to understand and apply in the solution of Interference problems, diffraction, and the basic theory of coherence,

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					

LO-6	✓					
LO-7	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184403	:	**Modern Physics**
	Credits	:	4 SKS (4/0/0)
	Semester	:	IV

COURSE DESCRIPTION	
In this course, students will learn about modern physics concepts so that students have the basic knowledge to take the course of quantum physics and to prepare a framework for understanding nuclear physics and physics of solids.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
LEARNING OUTCOME OF THE COURSE	
• Students are able to understand the special theory of relativity • Students are able to understand the nature of wave-particle dualism • Students are able to understand the theory of atoms and molecules • Students are able to understand the introduction of quantum physics, statistical physics, solid-state physics theory, core physics, and elementary particles.	
MAIN TOPICS	
Special Theory of Relativity, Particle Natures of Waves, Atomic Structures, Introduction to Quantum Physics, Quantum Atomic Theory of Hydrogen and Many-electron atoms, Molecular Theory, Statistical Physics, Solid Physics, Atomic Core and Nuclear Transformation, and Elementary Particles.	
PREREQUISITES	
1. Physics I 2. Physics II 3. Physics III	
MAIN REFERENCES	
3. Beiser, A., "Concepts of Modern Physics", McGraw Hill, Sixth Edition, New York, 2003.	

4. Krane, S.K (terj: Hans J. Wospakrik), "Fisika Modern", UI Press, Jakarta, 1992.

SUPPORTING REFERENCES

2. Eisberg, R. & Resnicks, R., "Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles", John Wiley & Sons, New York, 2nd Ed., 1985.
3. Serway, R.A, Moses, C.J and Moyer, C.A, "Modern Physics", third edition, 2005. (E-Book)
4. Singh, R.B, "Introduction to Modern Physics, New Age International Publishers, " Volume 1, 2nd ed, 2009 (E-Book)

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand the special theory of relativity
- LO-2: Students are able to understand the nature of wave-particle dualism
- LO-3: Students are able to understand the theory of atoms and molecules
- LO-4: Students are able to understand the introduction of quantum physics, statistical physics, solid-state physics theory, core physics, and elementary particles.

MAP OF PLO AND LO

	PLO-6					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF18xxxx	:	**Mathematical Physics III**
	Credits	:	4 SKS
	Semester	:	IV

COURSE DESCRIPTION
In this course the materials given are various methods and techniques of mathematics as a basic science in studying Physics. In this lecture, students are expected to be able to connect physical and mathematical phenomena that is appropriate and correct, and are able to solve the problems in physics with analytical methods. Gamma functions, beta functions, error functions, ellogonal function, orthogonal function, Bessel function, Legendre function, recursion relation, Legendre series, Hermitte function, Laguerre function; Partial differential equations (PDE): wave equations, Laplace and Poisson equations, equations of heat and diffusion propagation, solutions using variable separation methods Integral transformations: Laplace transform, Fourier transform, convolution, Green Function, PD solution with transformation; integral equations. The function of complex variables.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]

LEARNING OUTCOME OF THE COURSE
• Able to understand and use Gamma function, beta function, error function, ellogonal integrity, orthogonal function, Bessel function,

Legendre function, recursion relation, Legendre series, Hermitte function, Songerre function; in the relevant course
- Able to resolve partial differential equations (PDE) which include wave equations, Laplace and Poisson equations, equations of heat and diffusion propagation, solutions using variable separation methods
- Able to understand and use integral transformation which includes Laplace transform, Fourier transform, convolution, Green Function, PD solution with transformation; integral equations.
- Able to understand and apply complex variable functions.

MAIN TOPICS

Definitions and applications: factorial function, Stirling formulation, gamma function, beta function and its relation to gamma function, error function, ellogonal integrity, orthogonal function, Bessel function, Legendre function, recursion relation, Legendre series, Hermitte function, Laguerre function; Understanding and notation of partial differential equations (PDP), solutions of wave equations, solutions of Laplace and Poisson equations, solutions of equations of heat and diffusion propagation, and examples of their applications.
Laplace transform: the definition and use of Laplace transform, Laplace transformer equation, solution of differential equation using Laplace transform; Fourier transform: The concept and application of Fourier transformation, Fourier Sinus Transformation, Fourier Cosinus Transformation. Convolution: understanding, concepts and application of convolution. Complex variable functions: analytic function definition, Cauchy condition, Cauchy theorem, Cauchy integral formula, expansion of complex functions into Laurent series, singular points of complex functions, residual theorems and their applications, conformal mappings and applications

PREREQUISITES

1. Mathematical Physics II

MAIN REFERENCES

1. Marry L Boas, . MathematicalMethods in thePhysicalSciences 3rd Ed., John Wileyand Sons, 2006

SUPPORTING REFERENCES

1. George B. Arfken& Hans J. Weber, MathematicalMethodsforPhysicists, SixthEdition: A ComprehensiveGuide, AcademicPress, 2005

2. K.F. RILEY, M.P. HOBSON and S. J. BENCE, MathematicalMethodsforPhysicsand Engineering 3rd Ed., CambrideUniversityPress, 2006
3. Modul ajar Fisika Matematika III

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand and use Gamma function, beta function, error function, ellogonal integrity, orthogonal function, Bessel function, Legendre function, recursion relation, Legendre series, Hermitte function, Songerre function; in the relevant course
- LO-2: Able to resolve partial differential equations (PDE) which include wave equations, Laplace and Poisson equations, equations of heat and diffusion propagation, solutions using variable separation methods
- LO-3: Able to understand and use integral transformation which includes Laplace transform, Fourier transform, convolution, Green Function, PD solution with transformation; integral equations.
- LO-4: Able to understand and apply complex variable functions.

MAP OF PLO AND LO

	PLO-7	PLO-8				
LO-1	✓					
LO-2	✓	✓				
LO-3	✓	✓				
LO-4	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	**SF184405**	:	**INSTRUMENTATION**
	Credits	:	4 SKS (3/0/1)
	Semester	:	IV

COURSE DESCRIPTION	
In this course students will learn about operational-amplifiers, digital electronics, input devices, analog signals and displays. The learning method is done in the classroom and in the laboratory, so students have experience in theory and practice and are able to provide the right decisions about the use of electronics to solve the physics problem and its application.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students are able to understand about Op-Amp: Non-linear amplifier, Functional amplifier, Instrumentation Amplifier, and circuit amplifier application
- Students are able to understand about Active Filter, frequency response, Nyquist, bode diagram, Oscilator
- Students are able to understand about Digital electronics
- Students are able to understand about Input tools: sensor characterization, Sensors, and other types of sensors
- Students are able to understand about analog signals
- Students are able to understand about display: analog display (CRT), digital display (LCD, LED)

MAIN TOPICS
1 Op-Amp: Non-linear amplifier, Functional amplifier, Instrumentation Amplifier, and circuit amplifier application 2 Active filters, frequency response, Nyquist, bode diagram, Oscilator 3 Digital electronics: basics of a digital system, basic circuit, OR, NOT, Karnaugh map, flip-flop: RS flip-flop, JK flip-flop, T flip-flop, D flip-flop, counter, multiplexer 4 The input software: sensor characterization, sensor, sensor types: temperature sensor, mechanical sensors sensor: proximity sensor, force sensor, speed sensor, acceleration sensor, optical sensor, magnetic sensor, biosensor, chemical sensor 5 Analog signal: signal conditioner, signal amplifier, filter: low pass filter, band pass filter, high pass filter, bandpass, stop pass, 1st order filter, 2nd order filter, lock-in amplifier, phase-lock-loop (PLL), filter design 6 Display: analog display (CRT), digital display (LCD, LED), printer)
PREREQUISITES
ELECTRONICS, MPF (minimum grade D)
MAIN REFERENCES
1. Bucha,D., "Applied Electronic Instrumentation & Measurement",Maxwell MacMillan Int, 1992 2. Simpson,C.D., " Industrial Electronics", Prentice Hall, 1996 3. Walt Jung, Analog Device, Op-Amp Applications Handbook, 2005 4. Roger L. Tokheim, (2008), Digital Electronics - Principles & Applications,7th edition, The McGraw-Hill Companies, Inc. 5. Lila Yuwana dan Melania Muntini S (2009), Laporan Hibah Pengajaran:"Pengajaran Elektronika Digital BerbasisLaboratorium", Program Hibah Kompetisi PHKI Program B, ITS Surabaya.
SUPPORTING REFERENCES
1. Jacob,J.M., "Industrial Control Electronics, Amplification & Design",Prentice Hall, 1995 2. Indarto, B., "Diktat Fisika Instrumentasi I", Fisika MIPA-ITS, Surabaya, 2003 3. David Terrel, Op-Amp,: Design, Application, and Trouble Shooting, 2005
REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand about Op-Amp: Non-linear amplifier, Functional amplifier, Instrumentation Amplifier, and circuit amplifier application
- LO-2: Students are able to understand about Active Filter, frequency response, Nyquist, bode diagram, Oscilator
- LO-3: Students are able to understand about Digital electronics
- LO-4: Students are able to understand about Input tools: sensor characterization, Sensors, and other types of sensors
- LO-5: Students are able to understand about analog signals
- LO-6: Students are able to understand about display: analog display (CRT), digital display (LCD, LED)

MAP OF PLO AND LO

	PLO-2	PLO-7	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week.

COURSE	SF184406	:	**MATERIAL SCIENCE**
	Credits	:	2 SKS (2/0/0)
	Semester	:	IV

COURSE DESCRIPTION
In this course students will study and understand the classification of materials, structures and bonds of atoms, solid structures, solids deformities, metal structures, ceramics, polymers, composites, Phase diagrams, some material properties: mechanical properties; electrical properties, magnetic, thermal properties, electrochemical properties.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand the classification of materials
- Students understand the structure and types of atomic bonds
- Students understand the structure of crystal and amorphous solids
- Students understand the defects in solids
- Students understand metal, ceramic, polymer and composite structures
- Students understands the phase diagram and heat treatment of the material
- Students understand some of the properties of materials: mechanical properties, electrical properties, magnetic properties, thermal properties, electrochemical properties

MAIN TOPICS
• Classification of Materials: Metals, Ceramics, Polymers, Composites. • Atomic structure : atomic theory (J.J.J. Thomson, E. Rutherford, N. Bohr), electron configuration, periodic nature of the usur. • Atomic bonds: primary (covalent, ionic, metallic) eartings, secondary bonds (van der Walls, hydrogen). • Solid structure: amorphous, crystalline, crystal systems and structures, fields and direction of crystals, metal crystals, ceramics and polymers. • Solid defects: interstitial, substitution, Frenkel, Schotky, slip and slip systems, dislocations and dislocation movements, diffusion. • Chase diagram: single system, binary system, ternary, material heat treatment system. • Properties of Materials: Mechanical, Electrical properties (Insulators, Semiconductors, Conductors, Superonductors), Magnet Properties (Ferro-, Ferrimagnetic, Paramagnetic, Diamagnetic), Electrochemical properties of materials.
PREREQUISITES
1. Physics I, II, and III 2. Chemistry 3. Mathematics I and II
MAIN REFERENCES
1. Callister Jr,W.D.,"Fundamental of Materials Science & Engineering", John Wiley and Son, 5th Edition, New York, 2001. 2. Askeland, D.R.,"Science and Engineering of Materials", ….1996.
SUPPORTING REFERENCES
1. Smith, W.F., "Principles of Materials Science and Engineering", 3rd Edition, McGraw-Hill, Inc (International Edition), New York, 1996.
REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: Students understand the classification of materials • LO-2: Students understand the structure and types of atomic bonds • LO-3: Students understand the structure of crystal and amorphous solids • LO-4: Students understand the defects in solids • LO-5: Students understand metal, ceramic, polymer and composite structures • LO-6: Students understands the phase diagram and heat treatment of the material

- LO-7: Students understand some of the properties of materials: mechanical properties, electrical properties, magnetic properties, thermal properties, electrochemical properties

MAP OF PLO AND LO

	PLO-2	PLO-9	PLO-10			
LO-1		✓	✓			
LO-2		✓	✓			
LO-3		✓	✓			
LO-4		✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			

WORKLOAD

1. Lectures : 2 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week.

SEMESTER V

COURSE	SF184501	:	QUANTUM PHYSICS
	Credits	:	4 SKS
	Semester	:	V

COURSE DESCRIPTION	
This course discusses quantum principles, an understanding of simple quantum systems, methods of formulation and solutions for solving atomic and molecular problems.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to understand wave mechanics: Schrodinger equation, wave function interpretation, wave normalization, eigenvalues, eigen function, degeneration, operator and expectation value
- Students are able to derive and solve Schrodinger equation solutions: free particles, ladder potential, potential wells, breakthrough effects, simple harmonic oscillators, hydrogen atoms, angular momentum
- Students are able to explain the theory of time-free disorder: non-degeneration cases, degeneration cases, fine structure of H atoms, Zeeman effects
- Students are able to use the approach method: the theory of disorder (time dependent: two state system, emission and absorption), WKB approach
- Students are able to understand about relativistic quantum mechanics: Klein-Gordon equation, Dirac equation, second quantization)

MAIN TOPICS
wave model, principle of indetermination, Schroedinger equation, eigen function and value, particle motion in one dimensional potential, operator method, particle motion in three dimensional space, hydrogen atom, radial, polar and azimuthal equation, angular momentum, matrix method of operator and spin, the sum of angular momentum, the theory of time-free disorder, the stark effect, the real hydrogen atom, the theory of time-dependent disorder, the WKB approach, the introduction of relativistic quantum theory
PREREQUISITES
2. Modern Physics (Minimum grade D)
MAIN REFERENCES
1. S. Gasiorowicz, "Quantum Physics", 3rd Ed., Wiley Internat. Ed.,USA, 2003.
SUPPORTING REFERENCES
1. A. Purwanto, "Fisika Kuantum", Gava Media, Yogyakarta, 2006. 2. Libofs, R.L,"Introductory Quantum Mechanics" Wesley Publishing Company, 2nd.th, New York, 1992
REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: Students are able to understand wave mechanics: Schrodinger equation, wave function interpretation, wave normalization, eigenvalues, eigen function, degeneration, operator and expectation value • LO-2: Students are able to derive and solve Schrodinger equation solutions: free particles, ladder potential, potential wells, breakthrough effects, simple harmonic oscillators, hydrogen atoms, angular momentum • LO-3: Students are able to explain the theory of time-free disorder: non-degeneration cases, degeneration cases, fine structure of H atoms, Zeeman effects • LO-4: Students are able to use the approach method: the theory of disorder (time dependent: two state system, emission and absorption), WKB approach • LO-5: Students are able to understand about relativistic quantum mechanics: Klein-Gordon equation, Dirac equation, second quantization)

MAP OF PLO AND LO

	PLO-6	PLO-9				
LO-1	✓	✓				
LO-2	✓	✓				
LO-3	✓	✓				
LO-4	✓	✓				
LO-5	✓	✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184502	:	**ELECTROMAGNETIC FIELDS I**
	Credits	:	3 sks
	Semester	:	V

COURSE DESCRIPTION	
In this course students will learn to understand the formulation of the basic laws of electromagnetic field in a vacuum and able to apply it to various fields of physics and related engineering	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	Master the theoretical concepts of classical and modern physics in depth
PLO-10	Be able to analyse the various alternative solutions available to the physical problem and summarize it for proper decision making;
LEARNING OUTCOME OF THE COURSE	
• Students are able to understand vector fields, gradient, divergence, rotation, Gauss & Stokes theorem • Students are able to explain and calculate problems regarding the gravitational, electrical and magnetic fields of divergence and curl of electric fields and magnetic fields • Students are able to understand and explain the nature of the electrostatic field in a vacuum • Students are able to understand and explain about the problem of simple boundary conditions, iteration methods & mapping and shadow methods • Students are able to understand and explain the nature of the magnetostatic field in a vacuum • The student is able to understand and calculate the inductance and energy of the current system • Students are able to explain Maxwell's postulate and electromagnetic waves in a vacuum	
MAIN TOPICS	
• Vector Analysis: Vector field, gradient, divergence, rotation, Gauss & Stokes's theorem • Basic Concepts of EM Fields: Fields of gravity, electric, magnetic	

- Properties of Electrostatic Fields: E-field rotation, electric potential, divergence E, Laplace equations, boundary, multipoles, conductor, and energy
- Special Methods: Iteration & mapping methods, shadow methods, capacitances, transmission lines and methods of group variables
- Magnetostatic Field Properties: Divergences B, B rotation, vector potential and magnetic scalar
- Inductance: Inductance, energy current system, Neumann formula
- Electromagnetic Field: Maxwell's Postulate, Electromagnetic Waves in a Hollow

PREREQUISITES

1. Physics II
2. Mathematical Physics III

MAIN REFERENCES

1. Zaki, M., "Medan Elektromagnetik", Bagian pertama, Jurusan Fisika FMIPA ITS, 2014
2. Reitz, J.R., F.J Milford, & R.W. Christy, "Foundations of Electromagnetic Theory", 2nd, Addison Wesley, 1993
3. Griffith, D.J., "Introduction to Electrodynamics", 4th, Prentice Hall, 2013

SUPPORTING REFERENCES

1. Nayfeh, M.H. & M.K Brussel, "Electricity and Magnetis'm, John Wiley & Sons, 1983
2. Wangsness, R.K.,"Electromagnetic Fields", John Wiley & Sons, 1986

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand vector fields, gradient, divergence, rotation, Gauss & Stokes theorem
- LO-2: Students are able to explain and calculate problems regarding the gravitational, electrical and magnetic fields of divergence and curl of electric fields and magnetic fields
- LO-3: Students are able to understand and explain the nature of the electrostatic field in a vacuum
- LO-4: Students are able to understand and explain about the problem of simple boundary conditions, iteration methods & mapping and shadow methods
- LO-5: Students are able to understand and explain the nature of the magnetostatic field in a vacuum
- LO-6: The student is able to understand and calculate the inductance and energy of the current system

- LO-7: Students are able to explain Maxwell's postulate and electromagnetic waves in a vacuum

MAP OF PLO AND LO

	PLO-6	CPL-10				
LO-1	✓	✓				
LO-2	✓	✓				
LO-3	✓	✓				
LO-4	✓	✓				
LO-5	✓	✓				
LO-6	✓	✓				
LO-7	✓	✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184503	:	LABORATORY PHYSICS I
	Credits	:	2 SKS
	Semester	:	V

COURSE DESCRIPTION	
In this course students are expected to understand the properties and characteristics of modern physics and waves in the form of practicum.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-4	able to communicate and apply information technology to document, store, and secure data. [KU]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand the model of Bohr atoms and excitation phenomena, able to determine atomic excitation voltages and determine the possible spectrum of neon atoms from the energy levels obtained.
- The student is able to determine the size of the oil droplets and is able to determine the oil grain charge;
- Students are able to understand the process of plasma occurrence of gas lamps, able to determine and compare the wavelength spectrum of neon and helium gas lights, and determine the refractive index of glass prism;
- Students are able to understand the photoelectric effect, determine the value of planck constant and work function of a material, and to know the effect of light intensity on the current;
- Students are able to understand how solar cells work, the characteristics of I-V and P-V solar cells before and after being given a slope angle, and know the effect of the angle on the solar cell on the output power

- The student is able to understand the stationary wavelength, to understand the relationship between the fast wave propagation (V) with the strain voltage (F), and to analyse the factors affecting the wave velocity on the rope;
- Students are able to understand the type of attenuation, know the factors that affect the damping, and can determine the damping system spring constant;
- Students are able to understand the symptoms of diffraction, can detect the wavelength of the laser, and to know the effect of the lattice distance to the screen against the resulting dark light pattern;
- The student is able to understand the interference event in the Newton Ring experiment, knowing the tool functions of the Newton Ring, capable of measuring the Wavelength of the Halogen lamp using Newton's ring method, as well as knowing the accuracy of the measured wavelength with the actual wavelength;
- Students understand the polarimeter principle, can measure the rotation angle type of sugar solution as a function of concentration, and able to determine the concentration of sugar solution with polarimeter;

MAIN TOPICS

- Frank Hertz's experiment
- Milikan’s Oil Tank
- Spectrometer
- The Planck Constant
- Influence of Tilt Angle on Solar Cells
- Melde experiments
- Supressed vibration
- Diffraction Arm
- Newton's ring
- Polarimeter

PREREQUISITES

Waves and Modern Physics

MAIN REFERENCES

Tim Asisten Fisika Madya. 2016. Modul praktikum Fisika Modern
Tim Asisten Fisika Madya. 2016. Modul praktikum Fisika Gelombang

SUPPORTING REFERENCES

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students understand the model of Bohr atoms and excitation phenomena, able to determine atomic excitation voltages and determine the possible spectrum of neon atoms from the energy levels obtained.
- LO-2: The student is able to determine the size of the oil droplets and is able to determine the oil grain charge;
- LO-3: Students are able to understand the process of plasma occurrence of gas lamps, able to determine and compare the wavelength spectrum of neon and helium gas lights, and determine the refractive index of glass prism;
- LO-4: Students are able to understand the photoelectric effect, determine the value of planck constant and work function of a material, and to understand how solar cells work, the characteristics of I-V and P-V solar cells;
- LO-5: The student is able to understand the stationary wavelength, to understand the relationship between the fast wave propagation (V) with the strain voltage (F), and able to understand the type of attenuation, know the factors that affect the damping, and can determine the damping system spring constant;
- LO-6: Students are able to understand the symptoms of diffraction, can detect the wavelength of the laser, and to know the effect of the lattice distance to the screen against the resulting dark light pattern;
- LO-7: The student is able to understand the interference event in the Newton Ring experiment, knowing the tool functions of the Newton Ring, capable of measuring the Wavelength of the Halogen lamp using Newton's ring method, as well as knowing the accuracy of the measured wavelength with the actual wavelength;
- LO-8: Students understand the polarimeter principle, can measure the rotation angle type of sugar solution as a function of concentration, and able to determine the concentration of sugar solution with polarimeter;

MAP OF PLO AND LO

	PLO-2	PLO-4	PLO=8	PLO-9		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		
LO-6	✓	✓	✓	✓		

LO-7	✓	✓	✓	✓		
LO-8	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week

COURSE	SF 184504	:	COMPUTATIONAL PHYSICS I
	Credits	:	3 sks
	Semester	:	V

COURSE DESCRIPTION	
In this course, students will learn how to solve physics problems by implementing numerical methods programmed in computer. Through the various methods given in this recovery, students are expected to master the solution of algebra and transcendent equations that are often present in the dynamics and other branches of physics, interpolate the results of experimental physics to obtain measurable quantities, solve matrix problems (determinants, inverses, the eigenvalue) and the system of linear equations, can curve the fittings that is the release of the function of the physiological model to the experimental data, can differentiate and integrate the function of the physiological model of the physiology programmatically, and can solve the ordinary differential equations (ODE) initial values of degree one and high degree, ODE with two boundary values.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to understand the basics of programming Computer
- Ability to solve algebraic equations in mathematics and computation
- Students are able to understand and study the types of root value search methods by numerical methods and analyse the best methods.

- Students are able to understand the concept of interpolation and the types of interpolation and its application in computing
- Able to master and understand the concept of linear equation solution in computing.
- Able to master and understand the process of matrix operation that is often used in computing
- Able to understand methods and operating systems of matrix eigenvalues.
- Able to understand Householder tridiagonalization methods and QR factorization methods
- Able to understand and master the curve optimization method by using Curve Fitting using least square method
- Able to understand the straight line model, the model of the nonlinear curve and the linearization method.
- Students are able to understand and master the method of differentiation and numerical integration in computing
- Capable of mastering and mastering the usual differential equations and types - the type with the initial value in the set and its application in computing.

MAIN TOPICS

Computer Programming; Completion of the algebra and transcendent equations of free converts: bisection method, Newton-Raphson, Secant, solving of simultaneous equations by Newton method; Interpolation: linear interpolation, Lagrange interpolation, Newton interpolation, Spline interpolation; Systems of Linear Equations: methods of elimination of Gauss, Gauss-Jordan, Cholesky, LU factorization, Gauss Seidel method; Matrix eigenvalues: Householder tridiagonalization method, QR factorization method; Fitting curve uses least square method: straight line model, nonlinear curve model (rank function, exponential function, high degree polynomial function), linierization method; Numerical Differentials: differential schemes with a combination of Taylor series and Lagrange interpolation; Numerical integral: trapezoidal rule, Simpson rule, Newton-Cotes formula, Gauss-Legendre formula, Gauss-Hermite formula, Gauss-Laguerre formula; Ordinary differential equations (ODE) Initial Value: Euler method, Heun method, Runge-Kutta-Fehlberg method, high-order ODE and ODE system; ODE with two values of boundary conditions: different methods up to.

PREREQUISITES

None

MAIN REFERENCES

1. Erwin Kreyszig, ’Advanced Engineering Mathematics’, Wiley International Edition, 9^{th} ed, 2006.

2. Jaan Kiusalas,'Numerical Method in Engineering with Matlab', Cambridge University Press,2005.
3. Y.C.Pao,'Engineering Analysis', Interactive Methods and Programs with Fortran, Quick Basic, Matlab, and Mathematica, CRC Press, 2001.

SUPPORTING REFERENCES

5. Bagus J.Santosa, 'Buku Ajar Fisika Komputasi', Jurusan Fisika FMIPA-ITS.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the basics of programming computer to solve algebraic equations in mathematics and computation
- LO-2: Able to understand and study the types of root value search methods by numerical methods and analyse the best methods.
- LO-3: Able to understand the concept of interpolation and the types of interpolation and its application in computing and able to understand the concept of linear equation solution in computing.
- LO-4: Able to master and understand the process of matrix operation that is often used in computing and able to understand methods and operating systems of matrix eigenvalues.
- LO-5: Able to understand Householder tridiagonalization methods and QR factorization methods
- LO-6: Able to understand and master the curve optimization method by using Curve Fitting using least square method
- LO-7: Able to understand the straight line model, the model of the nonlinear curve and the linearization method.
- LO-8: Able to understand and master the method of differentiation and numerical integration in computing and able to master the usual differential equations and types - the type with the initial value in the set and its application in computing.

MAP OF PLO AND LO

	PLO-7	PLO-8	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD
1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week. 3. Private learning : 2 x 60 = 120 minutes (2 hours) per week. 4. Practicum : 170 minutes per week.

COURSE	SF184505	:	OPTOELECTRONICS
	Credits	:	2 SKS
	Semester	:	V

COURSE DESCRIPTION	
In this course will be discussed about the interaction of light with the material in the gas, liquid or solid phase, and devices that depend on the interaction. Study materials include Light source, Light modulation, Waveguide, photodetector, and display device	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
LEARNING OUTCOME OF THE COURSE	
• Ability to explain about Semiconductors and Light sources • Ability to explain and use formulation in the phenomenon of light modulation • Ability to explain the principle of light guidance in optical waveguides • Ability to explain Parameter detector, Temperature Detector and Photon Device • Capable of explaining luminescence events, cathode tubes, LEDs, plasma displays and liquid crystal displays	
MAIN TOPICS	
● Semiconductors and Light Source: Energy Tapes on Conductor, Semiconductor and Isolator. Electrical conductivity, Semiconductor type, emission and radiation absorption, laser mode, Laser classification, Laser application ● Modulation of Light: Light polarization, double bias, optical activity, electro optical effect, Magneto optical, acoustic optical effect,	

- Optical Waveguide: Reflection in total, Optical waveguide, Fiber optic, fiber optic connector, fiber optic characteristic measurement, Fiber optic material and its manufacture
- Photodetector: Parameter detector, Temperature detector, Photon device
- Display Devices: luminescence, cathode tube, LED, plasma display, liquid crystal display

PREREQUISITES

None

MAIN REFERENCES

1. John Wilson & Hawkes,” Optoelctronics An Introduction’ Third Edition, Prentice Hall, mexico, Paris 1998

SUPPORTING REFERENCES

1. Shun Lien Chuang,”physics of Optoelctronic Devices”, John Wiley & Sons, New York, 1995
2. K.Zhang D.Li,’Electromagnetic Theory for microwaves and Optoelectronics”, Springer, Beijing, 1998
3. G yudoyono,”Diktat Optoelektronika”, Jurusan Fisika ITS, 2001

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: able to explain about Semiconductors and Light sources
- LO-2: able to explain and use formulation in the phenomenon of light modulation
- LO-3: able to explain the principle of light guidance in optical waveguides
- LO-4: able to explain Parameter detector, Temperature Detector and Photon Device
- LO-5: able to explain luminescence events, cathode tubes, LEDs, plasma displays and liquid crystal displays

MAP OF PLO AND LO

	PLO-7	PLO-8				
LO-1	✓	✓				
LO-2	✓	✓				
LO-3	✓	✓				
LO-4	✓	✓				
LO-5	✓	✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.

2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week

COURSE	**SF184506**	:	**DIGITAL DATA ACQUISITION**
	Credits	:	2 SKS
	Semester	:	V

COURSE DESCRIPTION	
In this course will be given material how to do data acquisition digitally and how to do data processing. The materials include how to convert analog signal to digital converter (ADC), digital to analog signal converter (DAC). Signal processing: Quantization of signals and SNR. For such processing students need to be given an introduction about: microprocessor, microcontroller, computer, digital filter, Fast Fourier Transform. In the present era, data acquisition and processing are also performed with methods approach that imitates human intelligence (intelligent system), namely: artificial neural network, fuzzy logic, genetic algorithm.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
• Students are able to perform data acquisition by utilizing some converter method • Student are able to quantify the signal and calculate the ratio between amplitude and signal ratio,	

- Students are able to do digital alter design, Fast Fourier Transform,
- Students understand the simple operation of microprocessors, microcontrollers, computers.
  Students understand the performance of computational method by using artificial neural network approach, fuzzy logic, genetic algorithm

MAIN TOPICS

1. Converter: analog to digital converter (ADC), digital to analog converter (DAC),
2. Signal processing: Quantization of signals and SNR
3. Digital data processor: Introduction Microprocessor, microcontroller, computer, digital filter, Fast Fourier Transform,)
4. Intelligent systems: Artificial neural networks, fuzzy logic, genetic algorithms

PREREQUISITES

Electronics, minimum grade D

MAIN REFERENCES

1. Bucha,D., "Applied Electronic Instrumentation & Measurement",Maxwell MacMillan Int, 1992
2. Simpson,C.D., " Industrial Electronics", Prentice Hall, 1996

SUPPORTING REFERENCES

1. Indarto, B., "Diktat Fisika Instrumentasi I", Fisika MIPA-ITS, Surabaya, 2003
2. Soetrisno, Elektroninka Dasar 1,2, Penerbit ITB, 1986

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to perform data acquisition by utilizing some converter method
- LO-2: Student are able to quantify the signal and calculate the ratio between amplitude and signal ratio,
- LO-3: Students are able to do digital alter design, Fast Fourier Transform,
- LO-4: Students are able to understand the simple operation of microprocessors, microcontrollers, computers,
- LO-5: Students are able to understand the performance of computational method by using artificial neural network approach, fuzzy logic, genetic algorithm

MAP OF PLO AND LO

	PLO-2	PLO-7	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week.

SEMESTER VI

COURSE	**SF184601**	:	**STATISTICAL PHYSICS**
	Credits	:	3 SKS
	Semester	:	VI

COURSE DESCRIPTION	
In this course students will study the microscopic aspects of thermodynamic phenomena (macroscopic) through the statistical distribution models of Maxwell-Boltzmann (MB), Bose-Einstein (BE) and Fermi-Dirac (FD). Students study the differences in the basic characteristics of particles to derive the statistical and quantum particle statistical distribution equations. Students study the reduction of thermodynamic quantities through the partition function and distribution equations, then examine some of the applications described using those models.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	
• Able to understand probability theory (average price value and mean square root) and the context of statistical physics (scope of statistical physics discussion) • Able to understand the configuration of the preparation of particles on the system include state degeneration, microstate, macrostate • Able to understand the concept of thermodynamic equilibrium in the statistical physics review • Able to understand the concept of phase space includes the definition of phase space, phase volume volume elements, along with applications to calculate the number of states	

- Able to understand and reduce the partition function in statistical physics along with the concept of β and Boltzmann parameters
- Able to understand and derive Maxwell-Bolzmann's statistical distribution along with probable distribution along with a review of thermodynamic state equations according to statistical physics concepts
- Able to apply the Maxwell-Bolzmann distribution concept to the ideal gas system to obtain physical information related to average speed, maximum speed, and rms speed
- Able to understand and decrease the distribution of Bose-Einstein statistics
- Able to understand and decrease the distribution of Fermi-Dirac statistics
- Able to understand the concept of Fermi-Dirac distribution on electron gas to get the value of heat capacity in metal
- Able to understand the concept of Bose-Einstein distribution on phonon gas
- Able to understand the concept of Pauli paramagmetism
- Able to understand the concept of Bose-Einstein distribution on black body radiation
- Able to understand the concept of microcanonic ensemble
- Able to understand the concept of a canonical ensemble

MAIN TOPICS

Probability theory, statistical physics context, system compilation configuration (degeneration, microstate and macrostate), thermodynamic equilibrium, phase space, partition function (parameter β, Boltzmann factor) decreasing MB, BE and FD distributions, probable distribution,, electron gas and phonon gas, Pauli paramagmetism, heat capacity and black body radiation, microenonic ensemble, canonical ensemble

PREREQUISITES

1. Thermodynamics (Minimum grade D)

MAIN REFERENCES

1. Pointon, A.J.,"An Introduction to Statistical Physics", Longman Grup Ltd., London, 1978

2. Yoshioka, D,''Statistical Physics : an introduction", Springer, 2007

SUPPORTING REFERENCES

1. Purwanto, A.(2007).'Fisika Statistik', GavaMedia, Yogyakarta.

2. Sontagg, R.E. dan van Wylen, G.J.(1991).'Introduction to Thermodynamics, Classical and Statistical', 3rd edition, John Wiley & Sons: New York.

3. Alonso, M. dan Finn, E.J.(1979).'Fundamental University Physics. III, Quantum and Statistical Physics', Addison Wesley: Reading.
4. Greiner, W., Neise, L. dan Stocker H..(1997).'Thermodynamics and Statistical Mechanics', Springer, Berlin.
5. Huang, K.(2001).'Introduction to Statistical Physics', Taylor and Francis: London & New York.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand probability theory (average price value and mean square root) and the context of statistical physics (scope of statistical physics discussion)
- LO-2: Able to understand the configuration of the preparation of particles on the system include state degeneration, microstate, macrostate
- LO-3: Able to understand the concept of thermodynamic equilibrium in the statistical physics review, the concept of phase space includes the definition of phase space, phase volume volume elements, along with applications to calculate the number of states, and able to understand and explain the partition function in statistical physics along with the concept of β and Boltzmann parameters
- LO-4: Able to understand and apply Maxwell-Bolzmann's statistical distribution along with probable distribution along with a review of thermodynamic state equations according to statistical physics concepts
- LO-5: Able to understand and explain the distribution of Bose-Einstein statistics and Bose-Einstein distribution on phonon gas and distribution on black body radiation
- LO-6: Able to understand the distribution of Fermi-Dirac statistics and distribution on electron gas to get the value of heat capacity in metal
- LO-7: Able to understand the concept of Pauli paramagmetism
- LO-8: Able to understand the concept of microcanonic ensemble and the concept of a canonical ensemble

MAP OF PLO AND LO

	PLO-6	PLO-9				
LO-1	✓	✓				
LO-2	✓	✓				
LO-3	✓	✓				
LO-4	✓	✓				
LO-5	✓	✓				
LO-6	✓	✓				

LO-7	✓	✓				
LO-8	✓	✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	**SF184602**	:	**ELECTROMAGNETIC FIELDS II**
	Credits	:	3 SKS
	Semester	:	VI

COURSE DESCRIPTION	
In this course students will learn to understand the concepts, properties and formulation of the terrain and electromagnetic waves in dielectric and magnetic materials as well as microscopic theory of electromagnetic fields in materials and their applications in various fields of physics and related engineering	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students are able to understand and explain about electrostatics in materials, polarization, Gauss law in dielectric, problem of boundary conditions with dielectric and electric field energy
- Students are able to understand and explain about magnetostatics in materials, external & internal magnetic fields, magnetic fields in magnetic materials,
- Students are able to explain the state of the magnetic field border, the issue of boundary conditions with magnetic materials, ferromagnetism and magnetic field energy

- Students are able to understand and explain the theory of microscopic diamagnetic-paramagnetic-ferromagnetic and dielectric microscopic theory
- Students are able to understand and apply the EM wave equations in dielectrics and conductors
- Students are able to understand and calculate the energy and momentum of electromagnetic waves
- Students are able to understand and apply the concept of electromagnetic fields on specific special topics (waveguide, transmission line, antenna)

MAIN TOPICS

- Electrostatic Material: Polarization, Gaussian law, boundary, border state, E field energy
- Magnetostatics Material: Magnetization, external and internal fields, boundary issues, ferromagnetism, magnetic circuit, magnetic field energy
- Microscopic Theory: Microscopic theory of diamagnetic, paramagnetic and ferromagnetic; dielectric microscopic theory
- Electromagnetic Waves: Equations of EM Waves inside dielectrics and conductors, energy & wave momentum, reflection & habituation, potential waves, radiation,
- Special Topics: Short dipole antenna, transmission line, square wave guide

PREREQUISITES

1. Electromagnetic Fields I

MAIN REFERENCES

1. Zaki, M., "Medan Elektromagnetik", Bagian pertama, Jurusan Fisika FMIPA ITS, 2014
2. Reitz, J.R., F.J Milford, & R.W. Christy, "Foundations of Electromagnetic Theory", 2nd, Addison Wesley, 1993
3. Griffith, D.J., "Introduction to Electrodynamics", 4th, Prentice Hall, 2013

SUPPORTING REFERENCES

1. Nayfeh, M.H. & M.K Brussel, "Electricity and Magnetis'm, John Wiley & Sons, 1983
2. Wangsness, R.K.,"Electromagnetic Fields", John Wiley & Sons, 1986

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand and explain about electrostatics in materials, polarization, Gauss law in dielectric, problem of boundary conditions with dielectric and electric field energy

- LO-2: Students are able to understand and explain about magnetostatics in materials, external & internal magnetic fields, magnetic fields in magnetic materials,
- LO-3: Students are able to explain the state of the magnetic field border, the issue of boundary conditions with magnetic materials, ferromagnetism and magnetic field energy
- LO-4: Students are able to understand and explain the theory of microscopic diamagnetic-paramagnetic-ferromagnetik and dielectric microscopic theory
- LO-5: Students are able to understand and apply the EM wave equations in dielectrics and conductors
- LO-6: Students are able to understand and calculate the energy and momentum of electromagnetic waves
- LO-7: Students are able to understand and apply the concept of electromagnetic fields on specific special topics (waveguide, transmission line, antenna)

MAP OF PLO AND LO

	PLO-6	PL0-9	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184603	:	**LABORATORY PHYSICS II**
	Credits	:	2 SKS
	Semester	:	VI

COURSE DESCRIPTION	
In this course students will do practicum that covers the fields of instrumentation, optics, materials, and earth physics as well as designing and preparing practical activities and presenting the results. So students are expected to have the ability to experiment with the use of laboratory equipment that support the final project, as well as to know the various methods and approaches in various types of experiments.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-4	able to communicate and apply information technology to document, store, and secure data. [KU]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
Able to perform various experiments by utilizing laboratory equipment that exist in laboratory instrumentation, optics, materials, and earth physics. Able to make presentations to report on experimental results.	

MAIN TOPICS
• Conducting practicum activities at the Materials Physics Laboratory, to study the mechanical, electrical, physical, optical, and heat transfer properties of materials • Conducting practicum activities at the Optical Physics Laboratory to determine the thickness of the thin film, analyzing the roughness of the plate by observing the pattern of the speckles, and to find out the antenna radiation pattern • Conducting practicum activities at the Instrumentation Physics Laboratory to create a RLC circuit by observing transient symptoms at a DC source and observing the phase voltage and current at the AC source, to make the OP Amp Inverting and Non Inverting circuit and measuring its gain, and to measure the spreading of the sound pressure level in the room and calculate the absorption coefficient of a material • Conducting practicum activities at the Earth Physics Laboratory, to measure the value of resistivity beneath the soil surface and for the identification of conductive materials
PREREQUISITES
1. Laboratory Physics I
MAIN REFERENCES
Petunjuk Praktikum Fisika madya
SUPPORTING REFERENCES
None
REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: Able to perform various experiments by utilizing laboratory equipment that exist in laboratory of instrumentation, optics, materials, earth physics, and biophysics and medical physics. • LO-2: Able to make presentations to report on experimental results.
MAP OF PLO AND LO

	PLO-2	PLO-4	PLO-8	PLO-9	PLO-10	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	

WORKLOAD
1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week. 3. Private learning : 2 x 60 = 120 minutes (2 hours) per week. 4. Practicum : 170 minutes per week.

COURSE	SF184604	:	**COMPUTATIONAL PHYSICS II**
	Credits	:	3 SKS
	Semester	:	VI

COURSE DESCRIPTION	
In this course, students will learn to implement numerical methods in solving the physics problems that are modeled in the Partial Differential Equations (PDE) type of "boundary conditions", and optimizing the function of physical symptom models in computer programs. Students are expected to master the application of different methods up to and Fourier transform methods to solving Laplace equations and Poisson equations commonly present in heat and temperature conduction problems, solving mechanical and electromagnetic propagation equations, and finite element methods on solving various vibration and structural deflection problems. Students are expected to be also reliable in maximizing and / or minimizing functionality programmed in order to get the optimum variable.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE
• Able to understand Different Methods Up to Elliptical PDP on settling Laplace and Poisson equations • Able to master and understand the Parabolic PDP on the solution of heat conduction equation (temperature) • Able to understand the Hiperbolic PDP at the completion of the wave equation • Able to understand methods Finite Analytical Elements • Able to understand the finite element method Numerics • Able to master and understand Fourier transform • Able to understand the optimization without constraints and linear programming
MAIN TOPICS
Different-end method for Elliptical PDE on the settlement of Laplace and Poisson equations: mesh method, ADI method, mixed boundary condition method; PDE Parabolic on completion of heat conduction equation (temperature): Crank-Nicolson method; Hiperbolic PDE on solving wave equations: explicit method, implicit method; Analytical Finite Element Method: Galerkin method, Rayleigh-Ritz method; Finite element method Numerics: one dimension (linear element, quadratic element), dimension two (triangle element, box element); Fourier transform: discrete Fourier transform, fast Fourier transform; Unlimited optimization and linear programming: steepest descent method, conjugate gradient method.
PREREQUISITES
None
MAIN REFERENCES
1. Erwin Kreyszig, ’Advanced Engineering Mathematics’, Wiley International Edition, 9th ed, 2006. 2. Y.C.Pao,‘Engineering Analysis’, Interactive Methods and Programs with Fortran, Quick Basic, Matlab, and Mathematica, CRC Press, 2001. 3. J.N. Reddy,’An Introduction to The Finite Element Method’, 3rd, Department of Mechanical Engineering, Texas A & M University.
SUPPORTING REFERENCES
-
REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: Able to understand Different Methods Up to Elliptical PDP on settling Laplace and Poisson equations • LO-2: Able to master and understand the Parabolic PDP on the solution of heat conduction equation (temperature) • LO-3: Able to understand the Hiperbolic PDP at the completion of the wave equation

- LO-4: Able to understand methods Finite Analytical Elements
- LO-5: Able to understand the finite element method Numerics
- LO-6: Able to master and understand Fourier transform
- LO-7: Able to understand the optimization without constraints and linear programming

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week.

COURSE	SF184605	:	**GEOPHYSICS EXPLORATION METHODS**
	Credits	:	2 SKS
	Semester	:	VI

COURSE DESCRIPTION	
In this course students will learn to understand the parameters of physics to study natural phenomena or for exploration which includes the subject: Earth Physics; The formation and structure of the earth, Earth's temperature; Earthquakes and observations; Genesis, Strength scale, and seismology study; Seismic exploration, Heavy and Geomagnet; Earth's electricity; electromagnetic earth	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to understand about the concepts of earth physics
- Students are able to understand the physical parameters of rocks and the physical principles used in earth physics
- Students understand the formation and structure of the earth
- Students understands the temperature of the earth on the earth layer along with its propagation
- Students are able to understand earthquake mechanism and understand earthquake observation system
- Students are able to understand the mechanical wave propagation used to determine the subsurface model

- Students are able to understand the steps of modelling the subsurface through rock density parameters through gravity method and rock susceptibility using Geomagnet
- Students are able to understand the subsurface depiction through electrical properties
- Students are able to understand the subsurface depiction through the characteristic of electromagnetic wave propagation in rocks

MAIN TOPICS

1. Earth Physics: Understanding, Rock Physics, Earth Physics Parameters, Earth Physical Applications
2. Information and structure in the earth: Earth formation, Earth structures, geological time division, Age determination by active radio method, erosion rate and sedimentology
3. Earth temperature: Temperature gradient and heat flow, heat source,
4. Earthquakes and their observations: Seismographs and seismograms, types of earthquakes, earthquakes, earthquake intensities
5. Incident, Strength scale, and seismology study: Earthquake events, Strength scale, Seismological studies for structure, hypocenter relocation, focus mechanism
6. Seismic exploration: introduction, hydrocarbon trap, environmental problems, refraction seismic, seismic reflection, dispersion curve
7. Heavy force and Geomagnet: anomaly bouguer, insulation, gravity exploration, geomagnetic exploration
8. Electrical earth: self-potential method, type resistance method, Induced polarization method, electric seismo method,
9. Electromagnetic methods: Ground penetrating radar, magnetotelluric, VLF-EM

PREREQUISITES

- Electromagnetic Fields I
- Electronics
- Waves

MAIN REFERENCES

1. Everet, M.E., 2013. Near-Surface Applied Geophysics, Cambridge university press
2. Sharma, P.V., 1997. Environmental and engineering Geophysics, Cambridge University press
3. Santoso, J., 2002.Pengantar Teknik Geofisika, Penerbit ITB

SUPPORTING REFERENCES

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand about the concepts of earth physics
- LO-2: Students are able to understand the physical parameters of rocks and the physical principles used in earth physics, the formation, and structure of the earth
- LO-3: Students are able to understand the temperature of the earth on the earth layer along with its propagation
- LO-4: Students are able to understand earthquake mechanism and understand earthquake observation system
- LO-5: Students are able to understand the mechanical wave propagation used to determine the subsurface model
- LO-6: Students are able to understand the steps of modelling the subsurface through rock density parameters through gravity method and rock susceptibility using Geomagnet
- LO-7: Students are able to understand the subsurface depiction through electrical properties
- LO-8: Students are able to understand the subsurface depiction through the characteristic of electromagnetic wave propagation in rocks

MAP OF PLO AND LO

	PLO-5	PLO-8	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
4. Practicum : 170 minutes per week.

SEMESTER VII

COURSE	SF184701	:	NUCLEAR PHYSICS
	Credits	:	4 SKS (4/0/0)
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn and understand the basic properties of core, core model, radioactivity, radioactive decay theory, radiation detection system, Core reaction, reactor base, some application of radioisotope in everyday life.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
• Students understand the structure and properties of the nucleus • Students understands the calculation of core binding energy and is able to apply it to problem solving • Students understands the symptoms of radioactivity	

- Students understands the calculations in radioactivity and is able to apply them to problem solving
- Students understand the types of nuclear radiation and its application in life
- Students understands the basic nuclear reaction and its application in life
- Students understands the basics and interactions of elementary particles

MAIN TOPICS

- The structure and properties of the atomic nucleus: the core arrangement, the size and shape of the atomic nucleus, the angular momentum and the nuclear magnetic moment, the nuclear force (interaction between nucleons in atomic nuclei), atomic nuclear stability, nuclear energy, semi-empirical Weiszacker
- Model of core: Liquid drop model, Fermi model, Leather Model (potential well model, harmonic oscillator model), L.S coupling
- Radioactivity: the fundamental quantities of radioactivity, successive decay, radioactive balance, artificial radioactivity.
- Type of nuclear radiation: alpha decay, beta decay, gamma decay, radiation detector.
- Nuclear reactions: classification of nuclear reactions, nuclear reaction mechanisms, kinematics of nuclear reactions, nuclear reaction parameters.
- Radiactive Applications:
  Elementary particles: interactions muon, hadron, lapton, quark

PREREQUISITES

- Mathematical Physics
- Modern Physics
- Quantum Physics

MAIN REFERENCES

1. Das, A. & Ferbel, T, "Introduction to Nuclear and Particle Physics", World Scientific, 2nd Ed., 2003.
2. Arya, A.P., “Fundamental Nuclear Physics”, John Wiley and Sons, New York, 1983.

SUPPORTING REFERENCES

1. Eisberg, R., & R. Resnick, “Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles”, John Wiley & Sons, New York, 2nd Ed., 1985.

2. Wong,S.S.M., “Introductory Nuclear Physics”, PTR Prentice Hall, Englewood, New Jersey, 1990.
3. Krane, K.S., “Introductory Nuclear Physics”, John Wiley & Sons, New York, 1988.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: able to understand the structure and properties of the nucleus
- LO-2: able to understand the calculation of core binding energy and is able to apply it to problem solving
- LO-3: able to understand the symptoms of radioactivity
- LO-4: able to understand the calculations in radioactivity and is able to apply them to problem solving
- LO-5: able to understand the types of nuclear radiation and its application in life
- LO-6: able to understand the basic nuclear reaction and its application in life
- LO-7: able to understand the basics and interactions of elementary particles

MAP OF PLO AND LO

	PLO-6	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		
LO-6	✓	✓	✓	✓		
LO-7	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184702	:	**SOLID STATE PHYSICS**
	Credits	:	4 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In the subject of Solid State Physics students study the physical properties (heat, electricity, semiconductivity, dielectric, optical, magnetic, superconductivity) of solid material. In studying the physical properties of solids begins by examining the crystal structure and characterization equipment used. Physical properties studied are also observed from the contemporary particle size mater (nanomaterial). At the end of the lecture students are able to explain and apply the principles of physics in understanding the structure and properties of solids and their application.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students can understand the crystal structure, diffraction in crystal, crystal lattice vibration
- Students can understand the electro in metal and electronic structure of solids
- Students can understand thermal conduction, semiconductivity and other devices
- Students can understand the optical and magnetic properties of solids

- Students can understand superconductivity and nanomaterials.

MAIN TOPICS

- Crystal structure (crystalline state, Bravais lattice, direction and crystal plane) and Inter atomic force; X-ray diffraction (Hk bragg, atomic and crystalline rearing, reverse grid, x-ray application) neutron and electron diffraction; Vibration lattice (heat capacity of Einstein and debye models, heat capacity, thermal conductivity, x-ray scattering, neutrons, and light by phonons).
- Electrons in metals (conduction electrons, electrical conductivity and resistivity, Fermi surfaces, heat conductivity in metals); electronic structure of solids (solid band structure, Brillouin zone, energy band and its application)
- Semiconductivity (semiconductor materials, intrinsic and extrinsic semiconductors, p-type and n-type semiconductors, diffusion phenomena), semiconductor devices (p-n connections, transistor connectors, diode types, integrated circuits)
- Dielectric and optical properties of solids (formulation of dielectics and dielectric constant, polarization and polarizability, pizoelectric, ferroelectric), Magnetism and magnetic Resonance (magnetism, magnetic susceptibility, magnetic material classification, paramagnetical resonance and nuclear magnetic resonance)
- Superconductivity (symptoms of superconductivity and superconductivity, ionic conduction, semiconductor amorphous, liquid crystals), nanomaterials.

PREREQUISITES

Quantum Physics, Statistical Physics

MAIN REFERENCES

1. M.A Omar, “Elementary Solid State Physics”, Addison Wesley, New York, 1975
2. Kittel, “Introduction Solid State Physics” John Willey and Sons, New York, 1991
3. J.R Christman, “Fundamentals of Solid State Physics” John Wiley and Sons, New York, 1988

SUPPORTING REFERENCES

1. S.W Winata, Z Arifin, “Fisika Zat Padat I” Diktat Kuliah Jurusan Fisika FMIPA-ITS, Surabaya, 2001
2. S.W Winata, Darminto, dan Z Arifin, “Fisika Zat Padat II” Diktat Kuliah Jurusan Fisika FMIPA-ITS, Surabaya, 2002

3. F Blackmore, “Solid State Physics” John Willey and Sons, New York, 1976

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students can understand the crystal structure, diffraction in crystal, crystal lattice vibration
- LO-2: Students can understand the electrons in metal and electronic structure of solids
- LO-3: Students can understand thermal conduction, semiconductivity and other devices
- LO-4: Students can understand the optical
- LO-5: Students can magnetic properties of solids
- LO-6: Students can understand superconductivity and nanomaterials

MAP OF PLO AND LO

	PLO-6	**PLO-9**	**PLO-10**			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184703	:	SCIENTIFIC WRITING METHODS
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In the seminar course students are able to understand and make background, objectives, problem formulation and the benefits of research / experimental activities. Students are able to read and summarize a few articles of scientific journals in Indonesian and English, then compile summaries and critiques of certain articles and present them in front of the class. Students are able to make presentations, submit research results, and give opinions in a limited forum (classroom).	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-11	able to disseminate the results of problem (case) studies and physical behaviours based on standard scientific principles in oral and written communication in the form of reports or scientific works according to correct writing rules by understanding the plagiarism mechanism and publishing them at the national or international level. {KK}
PLO-12	able to adapt, collaborate, create, contribute and innovate in applying science in social life and has a global insight in his role as a citizen of the world, as well as being able to use the international language. {KK}
LEARNING OUTCOME OF THE COURSE	
• Ability to convey the behaviour or character of self as a religious person according to beliefs and religion adopted • Able to be polite in being scientific in other academic and social environments	

- Be able to recognize and have social sensitivity, respect diversity of opinions and be honest in the world of scholarship
- Ability to actualize the observance of scientific procedures
- Able to read and browse scientific studies based on reading libraries and other social media
- Able to read, search and find a background, problems, goals and benefits of a physical study in the scientific writing of others
- Capable of utilizing scientific social media via internet and library to get the latest information
- Able to make scientific writing and present the results of simple physics studies in limited forums
- Ability to prepare, coordinate and carry out simple scientific discussions and report in limited forums
- Able to initiate networks, communicate actively or passively well, responsibly and evaluate work together in a limited organization
-

MAIN TOPICS

- Terms of scientific writing and publication (oration, posters, papers, journals),
- Read and summarize articles of English-language scientific journals
- Compile summaries and criticisms of two scientific articles (Indonesian and English)
- Presenting the work in front of the class using multimedia in the form of presentation.

PREREQUISITES

Physical Measurement Methods

MAIN REFERENCES

1. Mikrajuddin Abdullah, "Tuntunan Praktis Menulis Makalah Untuk Jurnal Ilmiah Internasional", ITB. 2011

SUPPORTING REFERENCES

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REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to have competence in reading, looking for and finding a background, problems, goals and benefits of a physical study in a scientific article
- LO-2: Able to compile summaries and criticisms of two scientific journal articles

- LO-3: Able to write scientific papers in POMITS scientific article templates based on reading results, summarize and critique scientific articles
- LO-4: Able to compile scientific presentations from scientific writings made
- LO-5: Able to present, convey research results, and express opinions in limited forums

MAP OF PLO AND LO

	PLO-2	PLO-8	PLO-11	PLO-12		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184704	:	**PHYSICS OF RADIOLOGY AND DOSIMETRY**
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn about the physics of radiation and dosimetry	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE
• Students understands the classification of radiation as well as its magnitude and unit of radiation • Students understands the direct and indirect ionizing radiation • Students understands the interaction of radiation with the material • Students understands the exponential attenuation • Students are able to understand radioactive decay • Students are able to understand charged particles and radiation balance

- Students able to understand the radiation dosimetry
- Students are able to understand the theory of cavity and ionization chamber
- Students are able to understand the calibration of photons and electrons with the ionization chamber
- Students are able to understand relative dosimetry and absolute dosimetry techniques

MAIN TOPICS

- Classification of radiation and quantities and units
- Direct and indirect ionizing radiation
- Interacting radiation with the material
- Exponential attenuation
- Radioactive decay
- Particles charged and radiation balance
- Dosimetry of radiation
- The cavity theory and ionization chamber
- Calibrate the photons and electrons with the ionization chamber
- Relative and absolute dosimetry techniques

PREREQUISITES

MAIN REFERENCES

- F. H. Attix. *Introduction of Radiological Physics and Radiation Dosimetry* (John Willey and Sons, New York, NY, 1986)
- H. E. Johns and J. R. Cunningham. *The Physics of Radiology*, 4th ed. (Charles C. Thomas, Springfield, IL, 1983)
- J. F. Knoll. *Radiation Detection and Measurement*. 3rd. ed. (John Willey and Sons, New York, NY, 2000).
- Podgorsak, *Radiation Oncology Physics: Handbook for Teacher and Student*. (IAEA, 2005)
- Metcalfe, et al, *The Physics of Radiotherapy X-rays and Electron*. (Medical Physics Publishing, 2007)

SUPPORTING REFERENCES

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students understands the classification of radiation as well as its magnitude and unit of radiation, understands the direct and indirect ionizing radiation, the interaction of radiation with the material
- LO-2: Students understands the exponential attenuation
- LO-3: Students are able to understand radioactive decay
- LO-4: Students are able to understand charged particles and radiation balance

- LO-5: Students are able to understand the radiation dosimetry
- LO-6: Students are able to understand the theory of cavity and ionization chamber
- LO-7: Students are able to understand the calibration of photons and electrons with the ionization chamber
- LO-8: Students are able to understand relative dosimetry and absolute dosimetry techniques

MAP OF PLO AND LO

	PLO-2	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		
LO-6	✓	✓	✓	✓		
LO-7	✓	✓	✓	✓		
LO-8	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

SEMESTER VIII

COURSE	SF184801	:	FINAL PROJECT
	Credits	:	6 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
In the final course, students will learn how to do research with themes in the field of physics interest (material physics, instrumentation physics, earth physics, optical physics and theoretical physics), the weight of the material determined by the supervisor, the implementation under the guidance of a the team of supervisors as a form of research exercise is correct. The final project lectures include proposal-making activities, conducting research in accordance with the approved theme of the lecturer, making the final report booklet, presenting in front of the limited forum (examiner and student team), closed examination by the examining lecturer team and publishing on the scientific publication media. Students are expected to be able to understand and learn how to do physics research, start taking the theme, doing research, making reports and presenting and publish the results of his research on scientific publications POMITS publications (online publications ITS students).	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-3	able to perform management, leadership, and work together in a team in the capacity as a member or group leader and responsible for the achievement of teamwork. [KU]
PLO-4	able to communicate and apply information technology to document, store, and secure data. [KU]

PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
PLO-11	able to disseminate the results of problem (case) studies and physical behaviours based on standard scientific principles in oral and written communication in the form of reports or scientific works according to correct writing rules by understanding the plagiarism mechanism and publishing them at the national or international level. {KK}
PLO-12	able to adapt, collaborate, create, contribute and innovate in applying science in social life and has a global insight in his role as a citizen of the world, as well as being able to use the international language. {KK}

LEARNING OUTCOME OF THE COURSE

- Able to convey the behaviour or character of self as a religious person according to beliefs and religion adopted
- Able to be polite in being scientific in other academic and social environments
- Be able to recognize and have social sensitivity, respect diversity of opinions and be honest in the world of scholarship
- Ability to actualize the observance of scientific procedures

- Able to read and browse scientific studies based on reading libraries and other social media
- Able to read, search and find a background, problems, goals and benefits of a physical study in the scientific writing of others
- Capable of utilizing scientific social media via internet and library to get the latest information
- Able to make scientific writing and present the results of simple physics studies in limited forums
- Able to prepare, coordinate and carry out simple scientific discussions and report in limited forums

MAIN TOPICS

- Strategy of theme selection, background, problem formulation, objectives and research benefits
- Assessment of material weighting, implementation procedures, how to analyse data and affordability research time for the final project
- Provisions of scientific writing and publication (oration, posters, papers, journals)
- Communicative and informative scientific presentation techniques

PREREQUISITES

1. Has taken courses with the number of credits ≥ 120 credits

MAIN REFERENCES

1. Panduan penulisan Tugas Akhir ITS
2. Academic writing and publishing, J. Hartley, Taylor and Francis e-Library, 2008.
3. Writing for science and engineering, H. Sylin-Roberts, Butterworth-Heinemann 2002.
4. www.sciencedirect.com

SUPPORTING REFERENCES

1. 'Ketentuan penulisan ilmiah POMITS', ..., 2009

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to actualize the observance of scientific procedures
- LO-2: Able to read and browse scientific studies based on reading libraries and other social media
- LO-3: Able to read, search and find a background, problems, goals and benefits of a physical study in the scientific writing of others

- LO-4: Able to utilize scientific social media via internet and library to get the latest information
- LO-5: Able to make scientific writing and present the results of simple physics studies in limited forums
- LO-6: Able to prepare, coordinate and carry out simple scientific discussions and report in limited forums

MAP OF PLO AND LO

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6
LO-1	✓	✓	✓	✓	✓	✓
LO-2	✓	✓	✓	✓	✓	✓
LO-3	✓	✓	✓	✓	✓	✓
LO-4	✓	✓	✓	✓	✓	✓
LO-5	✓	✓	✓	✓	✓	✓
LO-6	✓	✓	✓	✓	✓	✓
	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11	PLO-12
LO-1	✓	✓	✓	✓	✓	✓
LO-2	✓	✓	✓	✓	✓	✓
LO-3	✓	✓	✓	✓	✓	✓
LO-4	✓	✓	✓	✓	✓	✓
LO-5	✓	✓	✓	✓	✓	✓
LO-6	✓	✓	✓	✓	✓	✓

WORKLOAD

1.

ELECTIVE COURSES OF CURRICULUM 2018-2023

SEMESTER VII

COURSE	**SF184704**	:	**PHYSICS OF METALS**
	Credits	:	3
	Semester	:	VII

COURSE DESCRIPTION	
Students study and understand the basic properties and structures of metals, structures and solids, diagrams and transformations of phases, solid solutions, metal compaction, structural identification and properties of metals, ferrous and non ferrous metals, heat treatment, metal and alloy failure, corrosion and material degradation. Through this course students are able to explain and understand the superior properties of the metal and its alloys and able to explain the test method in identifying the structure and properties of metals and alloys.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
LEARNING OUTCOME OF THE COURSE	

- Able to understand the crystal bond, Energy in the crystal
- Students are able to understand the types of metal solid structures
- Students are able to understand and explain the techniques of metal characterization and its alloys
- Students are able to understand about defects in crystals and plastic deformation
- Students are able to understand about diffusion of vacancies and interstitials
- Students are able to understand and explain about solid dissolution.

- Students are able to understand and explain methods of metal compaction, nucleation and grain growth kinetics.
- Students are able to understand the failure of the metal and its alloys.
- Students are able to understand and explain the phase diagram
- Students are able to understand and explain the iron-carbon alloy system
- Students are able to understand and explain the phase transformation
- Students are able to explain the mechanical properties and microstructure of metals and alloys.
- Students are able to understand methods of metal reinforcement through heat treatment.
- Students are able to understand and explain the selection of nonferrous alloy systems.
- Students are able to explain corrosion behaviour and metal degradation

MAIN TOPICS

- The types of metal structure, cell unit, crystal structure and crystallography, coordination number
- Bonding of crystals, energy in crystals
- First crystal defects, interstesy defects, stress and strain fields, slip systems, dislocation meetings, cross slip and plastic deformation
  Diffusion, intrinsic diffusion, self-diffusion, diffusion coefficient, isomofi diffusion in alloy system, interstitial measurement of diffusion.
- Grain boundary items, dislocation models, grain boundary field, grain boundary energy, surface tension, grain boundary effect on mechanical properties, grain size effects, meeting points.
- Vacuum on metal crystals, metal thermal sakak, internal energy, entrophy, spontaneous reaction, free energy, movement of the crystal void.
- Methods of metal reinforcement, annealing, hardening, precipitation hardening, normalizing.
- Solid solids, Intermediate phase, solid dissolving interstitial.
- Phase diagram on metal, Equilibrium between two phases, Two component systems contain two phases, two component systems contain three phases.
- Transformation phase, isomorphous alloy system, heating and cooling, eutectic system and its microstructure, peritectic, monotectic, intermediate-phase transformation.
- Methods of metal compaction, nucleation and growth kinetics of grains.
- Iron-carbon alloy system, TTT diagram, twinning deformation method and martensite reaction.
- Technical techniques, XRD, XRF, STEM, SEM, AES, Optical metallography, Topography

- The properties of metals and alloys: mechanical properties and physical properties
- Electrochemical properties, Corrosion and degradation of materials

PREREQUISITES

1. Material Science
2. Modern Physics

MAIN REFERENCES

1. W.D Callister,Jr "Materials Science and Enggineering An Introduction" John Willey and Sons, Inc. New York, 2007 (Ebook)
2. R. E. Smallman, and R. J. Bishop, "Modern Physical Metallurgy and Materials Engineering" Butterworth-Heinemann Linacre House, Jordan Hill, Oxford, 1999 (Ebook)

SUPPORTING REFERENCES

1. Sriati Djaprie (Terj: Lawrence H Van Vlack), "Ilmu dan Teknologi Bahan" Edisi ke lima, Erlangga, Jakarta, 1989
2. F.T Sisco, "Engineering Metallurgy" A Collaboration Writing Group of Metallurgy Professors, Pitman Publishing Corporation, New York, 1967

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand the crystal bond, energy in the crystal, able to understand the types of metal solid structures
- LO-2: Students are able to understand and explain the techniques of metal characterization and its alloys, able to understand about defects in crystals and plastic deformation, and able to understand about diffusion of vacancies and interstitials
- LO-3: Students are able to understand and explain about solid dissolution, able to understand and explain methods of metal compaction, nucleation and grain growth kinetics.
- LO-4: Students are able to understand the failure of the metal and its alloys.
- LO-5: Students are able to understand and explain the phase diagram, able to understand and explain the iron-carbon alloy system, and able to understand and explain the phase transformation
- LO-6: Students are able to explain the mechanical properties and microstructure of metals and alloys, able to understand methods of metal reinforcement through heat treatment.
- LO-7: Students are able to understand and explain the selection of nonferrous alloy systems
- LO-8: Students are able to explain corrosion behaviour and metal degradation

MAP OF PLO AND LO

	PLO-8					
LO-1	✓					
LO-2	✓					
LO-3	✓					
LO-4	✓					
LO-5	✓					
LO-6	✓					
LO-7	✓					
LO-8	✓					

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	**SF184705**	:	**CERAMIC OF PHYSICS**
	Credits	:	3 SKS
	Semester	:	VII

COURSE DESCRIPTION	
Introduction, Molecular bonding in crystalline, Closed packing, Structure AX, Ax2, Structure A2X3, ABX3, Phase diagram, Composition forming reaction, Sintering study, Microstructural review, Mechanical properties assessment, Thermal shock study, Electrical properties, Magnetic properties.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to understand and explain the structures and characteristics associated with the structure of ceramic materials.
- Students are able to understand and explain various methods of synthesis of ceramic materials and mechanisms that occur during the process of making ceramic materials and their analysis.
- Students are able to understand and explain the functional characteristics of ceramic materials.

MAIN TOPICS

- Introduction, understanding of ceramic material, virtue and usage.
- Crystalline: driving force, molecular bond in crystalline, structure.
- Packing of ions, CCP, HCP, Pauling rules in the formation of structures.
- AX structures (CsCl, rock salt), AX2 / A2X (fluorite, zirconia).
- Structure A2X3 (alumina, ilmenite), ABX3 (perovskite), spinel structure and complex structure, silicate structure.
- Defect, Kroger diagram, oxidation reduction.

- Balance of phase, phase diagram, binary and ternary.
- Synthesis of ceramics: thermal analysis, chemical reactions.
- Solid state reaction, wet reaction route.
- Sintering, shrinkage analysis.
- Microstructure, density, grain-growth.
- Ceramic mechanical characteristics: fracture, Griffith criteria, Weibull distribution
- Tomomechanical, thermal stress, thermal shock.
- Electrical characteristics, conductivity, ferroelectricity.
- Magnetic characteristics: paramagnetic, spinel, ferrite

PREREQUISITES

1. Introduction to Material Physics

MAIN REFERENCES

1. C.B. Carter and M.G.Norton, Ceramic Materials: Science and Engineering, Springer, 2007.

SUPPORTING REFERENCES

1. W.D. Kingery, Introduction to Ceramics 2^{nd} ed Willey.
2. M. W. Barsoum, Fundamentals of Ceramics, The McGraw-Hill, International Edition, 1997.
3. M.N. Rahaman, Ceramic Processing and Sintering, Second Edition, Taylor & Francis Group, 2003

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand and explain the structures and characteristics associated with the structure of ceramic materials.
- LO-2: Students are able to understand and explain various methods of synthesis of ceramic materials and mechanisms that occur during the process of making ceramic materials and their analysis.
- LO-3: Students are able to understand and explain the functional characteristics of ceramic materials.

MAP OF PLO AND LO

	PLO-6	PLO-8	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.

2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
1. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184706	:	**POLYMER PHYSICS**
	Credits	:	3 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In the course of Polymer Physics students study the basics of polymers, synthesis, characterization of physical properties and the introduction of characterization tools. In studying the physical properties of the polymer corresponds to the crystallinity structure and the thermal properties of the polymer. Students also study the development and contemporary physical properties (heat, electricity) are poured in the form of making paper with a simple theme according to the application of polymer in everyday life. At the end of the lecture students are able to explain and apply the principles of physics in understanding the structure and properties of polymer and its application in everyday life.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
● Be able to recognize and understand polymer science in everyday life ● Able to track the development of polymer physics from materials knowledge to renewable materials ● Able to understand chain structure and polymer synthesis	

- Able to understand the provision of chemical reactions in polymer synthesis
- Read, trace the polymer physics logging including methods of synthesis, physical properties, polymer testing
- Able to understand and understand the type of bonding, polymer chemical reactions, molecular structures and polymer crystals
- Able to understand polymer synthesis based on pre-experimental mathematical calculations
- Able to understand the mechanical, thermal, electrical properties of polymers based on theoretical studies and experimental results
- Able to understand the types of natural and synthetic polymers as well as physical characterization (mechanical, thermal, electrical)
- Able to understand the mathematical theoretical studies of mechanical properties of polymeric materials
- Able to work on theoretical problems and experimental studies of polymer physical properties
- Able to follow the development of polymer science applications in the industrial world, the environment and contemporary properties of polymeric properties through book libraries and other social media
- Ability to create essay based on positive and negative impact studies of polymers independently or in groups
- Able to plan, execute and evaluate group studies in the field of study of the polymer physical properties

MAIN TOPICS

- Type and type of Polymer.
- Bonds in polymers, bonding distance and bond strength.
- Structure of polymer chains, polymer molecules, molecular weight of polymers.
- Synthesis of polymeric materials, adduct polymerization, condensation polymerization.
- Crystallinity of the polymer, polymer crystallinity model, semicrystal structure, glass transition.
- Characteristics of polymer materials, thermoplastics and thermosets, polymer properties (mechanical, thermal, optical, electrical).
- Introduction of conductive polymers and current polymers.

PREREQUISITES

Material Science

MAIN REFERENCES

1. Rosen, S. L., “Fundamental Principles of Polymeric Materials”, A Wiley-Interscience Publication, John Wiley & Sons, New York, 1986.

2. Billmeyer, F.W., “Texbook of Polymer Science”, Wiley Interscience, New York, 1990.

SUPPORTING REFERENCES

1. William M Alvino, Plastics For Electronic, Materilas, Properties, and Design Applications, McGraw-Hill, Inc, New York, 1994
2. Iwao Teraoka, Polymer Solutions, An Introduction to Physicals Properties, John Wiley & Sons, Inc, 2002.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to recognize and understand polymer science in everyday life, the development of polymer physics from materials knowledge to renewable materials
- LO-2: Able to understand chain structure and polymer synthesis, the provision of chemical reactions in polymer synthesis, the polymer physics logging including methods of synthesis, physical properties, polymer testing
- LO-3: Able to understand and understand the type of bonding, polymer chemical reactions, molecular structures and polymer crystals
- LO-4: Able to understand polymer synthesis based on pre-experimental mathematical calculations
- LO-5: Able to understand the mechanical, thermal, electrical properties of polymers based on theoretical studies and experimental results
- LO-6: Able to understand the types of natural and synthetic polymers as well as physical characterization (mechanical, thermal, electrical)
- LO-7: Able to understand the mathematical theoretical studies of mechanical properties of polymeric materials, and to work on theoretical problems and experimental studies of polymer physical properties
- LO-8: Able to follow the development of polymer science applications in the industrial world, the environment and contemporary properties of polymeric properties through book libraries and other social media, to create essay based on positive and negative impact studies of polymers independently or in groups, and to plan, execute and evaluate group studies in the field of study of the polymer physical properties

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			

LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184707	:	**MICROCONTROLLERS AND MICROPROCESSORS**
	Credits	:	3 SKS (3/0/0)
	Semester	:	VII

COURSE DESCRIPTION	
This course discusses the architecture of microcontroller, instructional device, addressing model, interface system (interfacing microcontroller), basic programming and simple application of microcontroller system. Students will learn about the principles and mechanisms of microprocessor system work, how microprocessors perform operations, translation of program code, and program line execution. You will also learn about control signals and microprocessor interfaces with memory and I / O systems in data exchange. Also provided comparisons between processors used in x86-based computers / PCs with an ARM-based embedded system. In addition, materials on the interface of the device between the microprocessor and the peripherals of the computer system and their signals, such as memory, basic I / O, communications, DMA, and Interruptions	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
• Be able to understand the understanding of microcontrollers and its difference with microprocessor	

- Understand the basic architecture of the microprocessor, process mechanism, and its constituent logic components
- Understand the various forms of addressing, instruction set and standard opcode microprocessor, and able to analyse work processes that occur
- Compile and evaluate basic microprocessor programs
- Setting up a microprocessor interface with supporting peripherals to form a computer system
- Understand and be able to develop new knowledge on computer technology Be able to express their ideas or ideas verbally and in writing
- Able to understand the AVR microcontroller architecture and Arduino platform.
- Able to understand memory maps, register status, and I / O port of AVR microcontroller.
- Able to understand the instruction set of interrupt, timer and counter on the AVR microcontroller
- Able to understand Arduino platform-based microcontroller system.
- Ability to create basic Arduino programming for input and output applications.
- Ability to design and create a series of simple applications (simple project) based on microcontroller system.
- Ability to analyse the working principle of microcontroller based application system

MAIN TOPICS

Introduction to microcontroller technology, AVR and AVR microcontroller Architecture, Set of instructions on AVR microcontroller, Arduino Board and Interface Concepts, Arduino Interrupt Programming, Timer and Counter AVR microcontroller, Simple project based circuit Arduino; Students will learn about the principles and working mechanisms of microprocessor systems, how microprocessors perform operations,
translation of program code, and program line execution. Will also learn about control signals and microprocessor interface with
memory and I / O systems in data exchange. Also provided comparisons between processors used in x86-based computers / PCs
with an ARM-based embedded system. In addition, materials on the interface of the device between the microprocessor and the peripherals of the computer system and their signals, such as memory, basic I / O, communications, DMA, and Interruptions

PREREQUISITES

1. (Minimum grade D)

MAIN REFERENCES

1. 1.Barry B. Brey. The Intel Microprocessor: Architecture, Programming, and Interfacing. Prentice Hall. 2009.
2. William Stallings. Computer Organization and Architecture: Designing for Performance. Pearson. 2010.
3. Douglas V Hall. Microprocessor and Interfacing. Prentice Hall

SUPPORTING REFERENCES

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REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the understanding of microcontrollers and its difference with microprocessor
- LO-2: Able to understand the basic architecture of the microprocessor, process mechanism, and its constituent logic components
- LO-3: Able to understand the various forms of addressing, instruction set and standard opcode microprocessor, and able to analyse work processes that occur
- LO-4: Able to Compile and evaluate basic microprocessor programs, able to Setting up a microprocessor interface with supporting peripherals to form a computer system
- LO-5: Able to understand and be able to develop new knowledge on computer technology, able to express their ideas or ideas verbally and in writing
- LO-6: Able to understand the AVR microcontroller architecture and Arduino platform, able to understand memory maps, register status, and I / O port of AVR microcontroller, and able to understand the instruction set of interrupt, timer and counter on the AVR microcontroller
- LO-7: Able to understand Arduino platform-based microcontroller system, and able to create basic Arduino programming for input and output applications.
- LO-8: Able to design and create a series of simple applications (simple project) based on microcontroller system, and able to analyse the working principle of microcontroller based application system

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			

LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184708	:	PHYSICS OF BUILDINGS
	Credits	:	3 SKS (3/0/0)
	Semester	:	VII

COURSE DESCRIPTION	
Physical aspects of buildings include acoustics, indoor and outdoor lighting, electrical in buildings, fire protection and lightning rods.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Explain about room acoustics, sound propagation in space
- Describes the hum room, the humming and the buzzing
- Explaining sound isolation and transmission loss
- Explain about natural and artificial lighting
- Ability to calculate and design lighting in space
- A strong count of artificial lighting
- Explain about the variety and use of energy saving cables
- Explain about the principle of lightning
- Explain the kinds of lightning-rod according to its purpose and history of the formation of lightning rods
- Explain about fire protection

MAIN TOPICS

- Space Acoustics, indoor sound projection, sound reflection and absorption, buzzing time, sound insulation.
- Lighting, electrical room, ventilation, fire protection.

PREREQUISITES

MAIN REFERENCES

1. Rosing, "*Handbook of Acoustics*", Springer, 2007:.
2. Long Marshall, "*Architectural Acoustics*", Elsevier Academic Press, 2006

SUPPORTING REFERENCES

1. **............, Building Physics, www.arup.com**
2. **Prasasto Satwiko, "Fisika Bangunan 2", Andi Ofset, Jogjakarta, 2004**

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to explain about room acoustics, sound propagation in space
- LO-2: Able to describes the hum room, the humming and the buzzing
- LO-3: Able to explain sound isolation and transmission loss
- LO-4: Able to explain about natural and artificial lighting, able to calculate and design lighting in space, and able to explain a strong count of artificial lighting
- LO-5: Able to explain about the variety and use of energy saving cables
- LO-6: Able to explain about the principle of lightning
- LO-7: Able to explain the kinds of lightning-rod according to its purpose and history of the formation of lightning rods
- LO-8: Able to explain about fire protection

MAP OF PLO AND LO

	PLO-1	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		
LO-6	✓	✓	✓	✓		

LO-7	✓	✓	✓	✓		
LO-8	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184709	:	FIBER OPTICS
	Credits	:	3 SKS (3/0/0)
	Semester	:	VII

COURSE DESCRIPTION	
Discusses light traces in optical systems, light matrices for tracking of rays in optical systems: the formulation of light matrices for basic optical components, cavity stability analysis, Gaussian bundles in optical cavities. A description of the guiding pattern of light waves, the boundary condition of the moda is cut off. Description of optical fiber properties: optical attenuation, dispersion of optical fibers, spectral distribution for power loss on optical fibers. Power loss due to material uptake. Loss due to scattering power. Power loss due to fiber optic curvature: macrobending and microbending on multimode and single-mode optical fibers. Also discussed about the basic concepts of optical communication systems.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
1.	Students are able to understand and apply electromagnetic theory in Maxwell Equations analysis, Widening of Gaussian file, wave

propagation in Anisotropic medium, and Coherent Electromagnetic Radiation.

2. Students are able to understand the method of light matrices for tracking of rays in optical systems: light matrices, cavity stability analysis, and Gaussian files in optical cavities,
3. Students understand the notion of gaussian beam in relation to TEM Wave, lowest order TEM Mode, Longitudinal and radial phase factor, High order mode, and ABCD law for Gaussian files.
4. Ability to apply in the solution of the problem
5. Students are able to understand and apply optical fiber in connection with Optical Communication System (SKO), Advantages and Disadvantages, SKO Components, Geometric Optics fiber step-index and graded-index fiber.
6. Students are able to understand the meaning of dispersion in single-mode fiber in terms of group velocity Dispersion, material dispersion, dispersion of waveguide, high mode dispersion, and polarization mode Dispersion.
7. Students are able to understand the loss of power in optical fiber in terms of weakening coefficient, material absorption, Rayleigh Scattering, Waveguide Defect, power loss due to macrobending and microbending.
8. Students are able to understand multi-modal step-index fibers in terms of number of modes, Power distribution at core and cladding, Numerical Aperture on Step-index fibers, Modal loss, single mode, and Wavelength of pancung.
9. Students are able to understand multilayered graded-index fiber in terms of Optical fiber characteristics, Optical fiber loss.

MAIN TOPICS

1. Electromagnetic theory: Maxwell's equation, Widening of Gaussian file, wave propagation in anisotropic medium, Coherent electromagnetic radiation.
2. Matric rays for ray tracking in optical systems: light matrices,
Analysis of cavity stability, Gaussian beam in optical cavities,
3. Gaussian libraries: TEM waves, lowest order TEM Mode, Longitudinal and radial phase factors, ABCD law for Gaussian files.
4. Optical fiber: Optical Communication System (SKO), Advantages and Disadvantages, SKO Components, Geometric Optics fiber step-index and graded-index fiber.
5.Dispersion in single mode fiber: Group speed dispersion, material dispersion, waveguide dispersion, high mode dispersion, polarization mode dispersion.
6.Rose Power on Optical Fiber: Coefficient of attenuation, Material absorption, Rayleigh Scattering, Waveguide defect, power loss due to macrobending and

microbending.
7.Virtual step-index Multiple Mode: number of modes, Power distribution at core and cladding, Numerical Aperture: Step-index fiber, Modal loss, single mode, Wavelength of beam.
8. Multilayered graded-index fiber: Optical fiber characteristics, Optical fiber loss.

PREREQUISITES

1. Waves
2. Optics
3. Electromagnetic Fields I
4. Electromagnetic Fields II

MAIN REFERENCES

1. Verdeyen, J.T.,"Laser Electronics", 3ed., Prentice-Hall, Inc., New Jersey, 1995.
2. Agrawal, G.P. "Fiber-Optic Communication Systems", Wiley-Interscience, 4-Ed, 2010
3. Powers, J.P.,_"An_Introduction_to_Fiber_Optic_Systems", 2-Ed, McGraw Hill
4. Keiser, Gerd,"Optical Fiber Communications", McGraw-Hill, 2nd-Ed,1991.

SUPPORTING REFERENCES

1. Crisp J., Elliott B., "Introduction to Fiber Optics", 3rd-Ed, Elsevier, 2005.
2. Gowar, J., "Optical Communication Systems", Prentice-Hall,International, Inc., 1984.
3. Cherin, A.H., "An Introduction to Optical Fibers", McGraw-Hill, 1987.
4. Suematsu,Y.& K.Iga, "Introduction to Optical Fiber Communication Systems", John Wiley & Sons, 1982.

REFORMULATED COURSE LEARNING OUTCOME (LO)

1. LO-1: Students are able to understand and apply electromagnetic theory in Maxwell Equations analysis, Widening of Gaussian file, wave propagation in Anisotropic medium, and Coherent Electromagnetic Radiation.
2. LO-2: Students are able to understand the method of light matrices for tracking of rays in optical systems: light matrices, cavity stability analysis, and Gaussian files in optical cavities,

3. LO-3: Students understand the notion of gaussian beam in relation to TEM Wave, lowest order TEM Mode, Longitudinal and radial phase factor, High order mode, and ABCD law for Gaussian files.
4. LO-4: Students are able to understand and apply optical fiber in connection with Optical Communication System (SKO), Advantages and Disadvantages, SKO Components, Geometric Optics fiber step-index and graded-index fiber.
5. LO-5: Students are able to understand the meaning of dispersion in single-mode fiber in terms of group velocity Dispersion, material dispersion, dispersion of waveguide, high mode dispersion, and polarization mode Dispersion.
6. LO-6: Students are able to understand the loss of power in optical fiber in terms of weakening coefficient, material absorption, Rayleigh Scattering, Waveguide Defect, power loss due to macrobending and microbending.
7. LO-7: Students are able to understand multi-modal step-index fibers in terms of number of modes, Power distribution at core and cladding, Numerical Aperture on Step-index fibers, Modal loss, single mode, and Wavelength of pancung.
8. LO-8: Students are able to understand multilayered graded-index fiber in terms of Optical fiber characteristics, Optical fiber loss.

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.

2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	**SF184710**	:	**PHOTONICS**
	Credits	:	3 SKS
	Semester	:	VII

COURSE DESCRIPTION

In this course, students will learn about the reflection and refraction of light, anisotropic media, liquid crystals, single, two and three-dimensional photonic crystals. Planar waveguide, two-dimensional waveguide, photonic crystal waveguide, optical coupling in waveguide; The interaction of light with sound, acousto-optical device, anisotropic acoustic-optic media. Besides, students will learn electro-optical principles, electro-optical anisotropic media, liquid crystal electro-optics, photo-refractivity, electro-absorption; Nonlinear media, nonlinear optics second order Optical interconnect, passive optical route, photonic switching, optical logic gate

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE

PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

Students are able to think critically about the basic concept of optical wave in photonic devices.
Students have knowledge on how to solve photonic problems and can follow the development of photonic device technology.

MAIN TOPICS

Planar waveguide, coupling on two waveguides, acoustic-optic devices, electro optical devices, anisotropic media, nonlinear optical media.

PREREQUISITES

1. **EM Fields II**
2. **Optics**

MAIN REFERENCES

1. Bahaa E.A. Saleh and Malvin Carl Teich, "Fundamentals of Photonics", 2nd Ed., A John Wiley & Sons, Inc Publication, New Jersey, 2007.
2. Keico iizuka, "Elements of Photonics", Vol. I & II, A John Wiley & Sons, Inc Publication, New York, 2002.
3. Hunspenger,R.G., "Integrated Optics: Theory and Technology", Springger-Verlag Berlin, 1995.
4. Amnon Yariv, "Optical Electronics", 4th Ed.,Harcourt Brace Jovanoviel College Publishers, New York, 1991.
5. Tamir,T.,"Guided-wave Optoelectronics", Springer-Verlag, Berlin, 1990.

SUPPORTING REFERENCES

None

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to think critically about the basic concept of optical wave in photonic devices.
- LO-2: Students have knowledge on how to solve photonic problems and can follow the development of photonic device technology.

MAP OF PLO AND LO

	PLO-8	PLO-10				
LO-1	✓					
LO-2	✓	✓				

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184711	:	**GEOLOGY**
	Credits	:	3 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn about Geological theories and phenomena that exist on Earth. ranging from rock geology, minerals to tectonism and volcanism. This course is a basic course that is given to students of the Department of Physics ITS for the basis of Geophysics. In this lecture, students are expected to be able to analyse the existing geological phenomena, able to describe the type of rock and its formation process, able to explain about the existing minerals on earth and to know the properties of rocks against the properties of Physics. In this lecture discussed about basic knowledge about earth science, that is about earth structure, process of volcanism and tectonism as base of earth dynamics and formation of rock, types of rock, magnetic properties, gravity, frequency or electricity.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	
• Able to understand about the process of volcanism and tectonism • Able to understand the formation of minerals and rocks • Ability to describe mineral content in rocks.	

- Able to understand the types of mineral rocks.
- Able to understand the role of Geology in Energy exploration
- Able to identify rocks in either the laboratory or the Field.

MAIN TOPICS

- Volcanism and Tectonism
- The Earth Dynamics
- The types of rocks
- Geological Oil and Gas
- Nature of Rocks on Physical Properties (Electricity, Magnetism, Heavyweight, frequency)
- Mineralogy of rocks

PREREQUISITES

None

MAIN REFERENCES

1. Christiansen. Eric H, Hamblin. Kenneth. 2008, *Earth's Dynamic Systems*.
2. Koesoemadinata, 1980, *Geologi Minyak dan Gas Bumi Jilid 1*, Penerbit ITB Bandung.

SUPPORTING REFERENCES

1. Setiagraha, Doddy, 1987, *Mineral dan Batuan*,
2. Modul Ajar Batuan Sedimen
3. Modul Ajar Batuan Beku
4. Modul Ajar Batuan Metamorf
5. Modul Ajar Tektonisme dan Vulkanisme
6. Model Ajar Mineralogi

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand about the process of volcanism and tectonism
- LO-2: Able to understand the formation of minerals and rocks
- LO-3: Able to describe mineral content in rocks.
- LO-4: Able to understand the types of mineral rocks.
- LO-5: Able to understand the role of Geology in Energy exploration
- LO-6: Able to identify rocks in either the laboratory or the Field.

MAP OF PLO AND LO

	PLO-7	PLO-8	PLO-9			
LO-1	✓	✓	✓			

LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184712 : **SEISMOLOGY**
	Credits : 3 SKS
	Semester : VII

COURSE DESCRIPTION
In this course, students will learn about the development of global seismology history, learn about tensor strain, stress, stress and strain relationship, P and S wave equations, travel time and wave paths in solid earth model, and constitutive equations, and Rayleigh and Love waves, and dispersion curve. In this lecture students are expected to be able to analyse the seismic travel time, inverting data travel time to get a new hypocenter position. In this lecture discussed about stress and strain, Navier equation of motion, equation of wave vector and scalar equation of wave potential, gradient and rotation derivative for wave P and S. Students will be given material about measuring the travel time of P and S waves, processing of travel time data.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE
● Able to understand the propagation of P and S waves. ● Able to measure the travel time of P and S waves. ● Ability to calculate wave beam parameters. ● Ability to calculate the travel time of wave phase. ● Ability to convert hypocenter relocation.
MAIN TOPICS

- Phases of P and S waves, the process of P and S waves.
- The split wave energy at the horizontal interface
- Transmission of P and S waves.
- The parameter of light, travel time and wave trajectory.
- Inversion of hypocenter position.

PREREQUISITES

1. Waves

MAIN REFERENCES

1. M. Gubbins, "Seismology", Blackwell Publication, 1987

SUPPORTING REFERENCES

1. Modul ajar Analisa Dasar Data Seismik

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the propagation of P and S waves.
- LO-2: Able to measure the travel time of P and S waves.
- LO-3: Able to calculate wave beam parameters.
- LO-4: Able to calculate the travel time of wave phase.
- LO-5: Able to convert hypocenter relocation.

MAP OF PLO AND LO

	PLO-7	PLO-8	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	**SF184713**	:	**EARTH ELECTRICAL EXPLORATION**
	Credits	:	3 SKS
	Semester	:	VII

COURSE DESCRIPTION
In the Earth Electrical Exploration Course, students will learn about the advantages and disadvantages of resistivity methods, the basic concepts of Self-potential and Induced Polarity, understanding Resistance and Resistivity, Archie's Law, the concept of current propagation in homogeneous and non-homogeneous mediums, quasi Resistivity and electrode configurations, Electrical Electrical Sounding (VES), apparent resistivity with linear filter, VES data analysis, VES measurement and data analysis, VES ambiguity, VES application, Resistivity Mapping. Measurement Procedure, Data Analysis and Utility Resistivity Tomography, understanding, analyzing and planning measurement, data processing and Interpretation of Earth resistivity data.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE
● Ability in acquisition / acquisition of resistivity data.

- Ability in resistivity data processing
- Ability in interpretation of resistivity data.

MAIN TOPICS

The concept of earth electricity, Self-potential and Induced Polarity, understands Resistance and Resistivity, Archie's Law, the concept of current propagation in homogeneous and non homogeneous mediums, False Resistivity and electrode configurations, Electrode configuration characteristics, field procedures and electrode selection, Vertical Electrical Sounding (VES), apparent resistivity calculation with linear filter, VES data analysis, VES measurement and data analysis, VES ambiguity, VES application, Resistivity Mapping. Resistivity data processing and physical interpretation. The concept of earth electricity, Self-potential and Induced Polarity, understanding Resistance and Resistivity, Archie's Law, the concept of propagation of currents in homogeny and non homogeneous medium, False resistivity and electrode configuration, Electrode configuration characteristics, field procedures and elections electrode, Vertical Electrical Sounding (VES), apparent resistivity calculation with linear filter, VES data analysis, VES measurement and data analysis, VES ambiguity, VES application, Resistivity Mapping. Resistivity data processing and physical interpretation.

PREREQUISITES

1. Mathematical Physcis I and II
2. Computational Physics

MAIN REFERENCES

1. Costain, John K. and Cahit Çoruh, 2004, Basic Theory Of Exploration Seismology, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, U.S.A.
2. Gubbins, M., 2001., Geophysical Data Measurement and Analysis. , 2nd Edition, Cambridge University Press
3. M.S. Zhdanov, G.V. Keller, The Geoelectrical Methods in Geophysical Exploration, Elsevier, 1994
4. Philip Kearey, Michael Brooks, Ian Hill, An Introduction to Geophysical Exploration, THIRD EDITION
5. Sheriff, R. E. and Geldart, L. P., Exploration Seismology, Vol. I, Cambridge University Press, 1982.
6. W.M. Telford, L.P. Geldart, R.E. Sheriff, Applied Geophysics (2nd edition), Cambridge, 1990.

SUPPORTING REFERENCES

1. M. Nabigian (ed.), Electromagnetic methods in Applied Geophysics, vol. 1 Theory, vol. 2 Application, Society of Exploration Geophysicists, 1989.
2. Menke, W., 2012., Geophysical Data Analysis: Discrete Inverse Theory, 3rd Edition, Matlab Edition, Academic Press
3. Miller, R., Bradford, J.H. and Holliger, K. Advances in near surface Seismology and Ground-penetration Radar. American Geophysical Union, 2010.
4. J.M. Reynolds, An Introduction to Applied and Environmental Geophysics, Wiley, 1998.
5. Yilmaz, Öz, Seismic Data Analysis, Vol. I, Society of Exploration Geophysicists, 2001.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Ability in acquisition / acquisition of resistivity data.
- LO-2: Ability in resistivity data processing
- LO-3: Ability in interpretation of resistivity data.

MAP OF PLO AND LO

	PLO-5	PLO-7	PLO-8	PLO-9		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184714	:	INTRODUCTION TO PARTICLE PHYSICS
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
This course deals with the introductory materials of elementary particle physics and their interactions. The discussion includes the characteristics of elementary particles (fermions, bosons) and explanations of electro-magnet interactions, weak interactions, and strong interactions. In addition, we also discussed the process of calculating the cross sections by applying Feynman rules to describe the interaction of a scattering process.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students are able to understand and explain the short history of elementary particles, dynamics, and fundamental forces
- Students are able to understand and explain Lepton and Quark: quantum numbers of lepton and quark (spin, flavor, isospin, color,), positronium, meson, baryon, eight-fold way
- Students are able to understand and explain the concept of symmetry: group and law of conservation, the CPT theorem
- Students are able to understand and explain Feynman diagram: Feynman rules, propagators, clutch constants, cross sections

- Students are able to understand and explain Introduction to quantum electrodynamics: Klein-Gordon and Dirac equations
- Students are able to understand and explain Introduction to quantum chromodynamics: Quark-quark interaction, asymptotic freedom
- Students are able to understand and explain weak interaction and unification

MAIN TOPICS

A brief history of elementary particles, dynamics and fundamental forces; lepton and quark; symmetry: group and law of conservation, CPT theorem; Feynman diagrams, introduction of quantum electrodynamics, introduction of quantum chromodynamics, weak interaction and unification

PREREQUISITES

MAIN REFERENCES

1. Grifftith, D., Introction to Elementary Particle, John Wiley and Sons, New York, 1987

SUPPORTING REFERENCES

1. Fayyazuddin and Riazuddin, “A Modern Introduction to Particle Physics”, World Scientific, Singapore, 1992
2. Halzen, F. and Martin, A.D., Quarks and Leptons, an Introductory Course in Modern Particle Physics, John Wiley and Sons, New York, 1984

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand and explain the short history of elementary particles, dynamics, and fundamental forces
- LO-2: Students are able to understand and explain Lepton and Quark: quantum numbers of lepton and quark (spin, flavor, isospin, color,), positronium, meson, baryon, eight-fold way
- LO-3: Students are able to understand and explain the concept of symmetry: group and law of conservation, the CPT theorem
- LO-4: Students are able to understand and explain Feynman diagram: Feynman rules, propagators, clutch constants, cross sections
- LO-5: Students are able to understand and explain Introduction to quantum electrodynamics: Klein-Gordon and Dirac equations
- LO-6: Students are able to understand and explain Introduction to quantum chromodynamics: Quark-quark interaction, asymptotic freedom

- LO-7: Students are able to understand and explain weak interaction and unification

MAP OF PLO AND LO

	PLO-1	PLO-6	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184715	:	ADVANCED MATHEMATICAL PHYSICS
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
This course discusses topics of mathematical physics including integral equations, green functions, complex analysis, introduction of geometry and topology as methods for solving advanced physics problems	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to understand and apply Integral Equations
- Students are able to understand and apply the Green Function
- Students are able to understand and apply Advanced Complex Analysis
- Students are able to understand the Regulation Method on particle physics
- Students are able to understand the basic concepts of Geometry and Topology

MAIN TOPICS

Integral Equations, Green Functions, Complex Analysis, Regulation Methods on Particle Physics, Introduction to Geometry and Topology

PREREQUISITES

MAIN REFERENCES

1. Kusse, B., Westwig, E."Mathematical Physics: Applied Mathematics for Scientists and Engineers", John Wiley & Sons, Canada, 1998

SUPPORTING REFERENCES

1. Wyld, H.W., "Mathematical Method for Physics", Benyamin/Cumming, Massachusset, 1976
2. Arfken, G., "Mathematical Method for Physicists", Academic Press, London, 1985
3. Riley, K.F., Hobson, M.P. dan Bence, S.J.,"Mathematical Methods for Physics and Engineering", Edisi 3, Cambridge University Press, 2006
4. Barton, G. "Elements of Green's Functions and Propagation", Oxford Science publications, 1991
5. Boas, M.L.,"Mathematical Methods in the Physical Science", Edisi 3, John Wiley Sons, New York, 2006.
6. Nash, C. and S. Sen, "Topology and Geometry for Physicist", Academic Press, London, 1983

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand and apply Integral Equations
- LO-2: Students are able to understand and apply the Green Function
- LO-3: Students are able to understand and apply Advanced Complex Analysis
- LO-4: Students are able to understand the Regulation Method on particle physics
- LO-5: Students are able to understand the basic concepts of Geometry and Topology

MAP OF PLO AND LO

	PLO-1	PLO-6	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			

WORKLOAD
1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week. 3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184716	:	INTRODUCTION TO COSMOLOGY
	Credits	:	3 SKS
	Semester	:	VII

COURSE DESCRIPTION	
This course equips students to understand Einstein's theory of special relativity to general relativity. Next will be discussed also the application of both in cosmology based on the theory of general relativity Einstein	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to understand Einstein's special theory of Einstein's postulate and electromagnetism as a consequence of special relativity
- Student are able to understand the Lorentz transformation along with relativistic kinematics, the sum of velocity
- Students are able to understand tensor in special and general relativity
- Students are able to understand the curved space-time and redefine Einstein's equations
- Students are able to understand Einstein's field equations
- Students are able to understand the Schwarzchild solution and the black hole
- Students know about the gravitational waves
  Students understand the basic principles of cosmology.

MAIN TOPICS
Special relativity postulates, electromagnetism, Lorentz transformation, relativistic kinematics, summation of velocity and transformation, relativistic energy and momentum, principle of equivalence, general relativity principles, global and local metrics, Einstein field equations, Schwarzchild solutions, gravitational radiation, and Cosmology.
PREREQUISITES
1. Mathematical Physics (minimum grade C)
MAIN REFERENCES
1. B. Schutz, "*A First Course in General Relativity*", 2nd Edition, Cambridge University Press, 2009
SUPPORTING REFERENCES
1. W. Rindler, "*Relativity: Special, General and Cosmological*", 2. ed., reprinted., Oxford u.a. Oxford Univ. Press, 2009
REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: Students are able to understand Einstein's special theory of Einstein's postulate and electromagnetism as a consequence of special relativity • LO-2: Student are able to understand the Lorentz transformation along with relativistic kinematics, the sum of velocity • LO-3: Students are able to understand tensor in special and general relativity • LO-4: Students are able to understand the curved space-time and redefine Einstein's equations • LO-5: Students are able to understand Einstein's field equations • LO-6: Students are able to understand the Schwarzchild solution and the black hole • LO-7: Students know about the gravitational waves • LO-8: Students understand the basic principles of cosmology.
MAP OF PLO AND LO

	PLO-1	PLO-6	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			

LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184717	:	**ANATOMY AND PHYSIOLOGY**
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn about medical terminology, identify anatomical structures, organ systems, and describe physiological mechanisms for improvement, maintenance, and growth	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand the nomenclature of anatomy
- Students are able to understand Bones
- Students understand the spinal column
- Students understand the thorax
- Students understand the abdomen
- Students are able to understand the Respiratory System

- Students are able to understand the digestive system
- Students are able to understand the urinary system
- Students are able to understand the reproduction
- Students are able to understand the circulation system
- Students are able to understand Pathology

MAIN TOPICS

- The nomenclature of anatomy
- Bones
- Spinal column
- Thorax
- Abdomen
- Respiratory system
- Digestive system
- Urinary system
- Support system
- Circulation system
- Pathology

PREREQUISITES

MAIN REFERENCES

- R. Putz dan R. Pabst, *Atlas Anatomi Manusia Sobotta*. (EGC, 2010)
- Serwood, *Fisologi Manusia: dari sel ke sistem*. (EGC, 2001)

SUPPORTING REFERENCES

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand the nomenclature of anatomy
- LO-2: Students are able to understand Bones and the spinal column
- LO-3: Students are able to understand the thorax and the abdomen
- LO-4: Students are able to understand the Respiratory System
- LO-5: Students are able to understand the digestive system
- LO-6: Students are able to understand the urinary system and the reproduction
- LO-7: Students are able to understand the circulation system
- LO-8: Students are able to understand Pathology

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	

LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	
LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184718	:	MEDICAL IMAGING PHYSICS
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn to understand the concept of medical imaging techniques, image quality, and image reconstruction, as well as understand the basic principles of Computed Tomography, Ultrasound, Magnetic Resonance (MRI) as well as nuclear medicine.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand the basic computational basis for medical image processing
- Students understand 2 Dimension and 3 Dimensional image reconstruction techniques
- Students are able to understand Image formation and contrast

- Students understand the basic principles of radiographic receptors
- Students understand the principles of screen-film and fluoroscopy Radiography and Radiography and digital fluoroscopy
- Students are able to understand the principles of Mammography and Dental Radiology
- Students are able to understand the principles of image formation and CT quality
- Students are able to understand the principles of Magnetic Physics Resonance Imaging and MRI image formation
- Students are able to understand the principles of Ultrasound Physics and Ultrasound image formation
- Students are able to understand the working principles of Gamma Cameras
- Students are able to understand Radiopharmaceutical and pharmacokenetis
- Students are able to understand the Internal Dosimetry
- Students are able to understand SPECT-CT, PET and Cyclotron as well as QA Nuclear Medicine Equipment

MAIN TOPICS

- Computer Introduction
- 2 Dimensional and 3 Dimensional Image reconstruction techniques
- Creation of image and contrast
- Radiographic receptors
- Radiographic screen-film and fluoroscopy as well as Radiography and digital fluoroscopy
- Mammography and Dental Radiology
- Establishment of CT image and quality
- Physical Principles of Magnetic Resonance Imaging and MRI image formation
- Principles of Ultrasound Physics and Ultrasound Image Formation
- The working principle of Gamma Camera
- Radiopharmaceutical and pharmacokenetis
- Internal Dosimetry
- SPECT-CT, PET and Cyclotron and QA Nuclear Medicine Equipment

PREREQUISITES

Physics of Radiology and Dosimetry

MAIN REFERENCES

2. J. T. Bushberg, J. A. Seibert, E. M. Leidhodt, Jr., J. M. Boone. The Essential Physics of Medical Imaging. 2nd ed., (Williams and Wilkins, Baltimore, MD, 2002).
3. P.P Dendy and B. Heaton. Physics of Diagnostic Radiology. (Institute of Physics Publishing, London, UK, 1999).

4. P. Sprawl. Physical Principles of Medical Imaging. (Aspen Publishers,. Gaithersburg, Maryland, 1987).
5. Adrienne Finch (Editor). Assurance of Quality in the Diagnostic Imaging Department. (The British Institute of Radiology, London, 2001)
6. G. ter Haar and F. A. Duck (Editor). The Safe Use of Ultrasound in Medical Diagnostic. (The British Institute of Radiology, London, 2001)
7. AAPM Report No. 39. Specification and Acceptance Testing of Computed Tomography Scanners. (American Institute of Physics, New York,1993)
8. AAPM Report no. 76. Quality Control in Diagnostic Radiology. (American Institute of Physics, New York, 2002).

SUPPORTING REFERENCES

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students understand the basic computational basis for medical image processing, 2 Dimension and 3 Dimensional image reconstruction techniques, and are able to understand Image formation and contrast
- LO-2: Students understand the basic principles of radiographic receptors
- LO-3: Students understand the principles of screen-film and fluoroscopy Radiography and Radiography and digital fluoroscopy, Mammography and Dental Radiology
- LO-4: Students are able to understand the principles of image formation and CT quality
- LO-5: Students are able to understand the principles of Magnetic Physics Resonance Imaging and MRI image formation, Ultrasound Physics and Ultrasound image formation
- LO-6: Students are able to understand the working principles of Gamma Cameras
- LO-7: Students are able to understand Radiopharmaceutical and pharmacokenetis
- LO-8: Students are able to understand the Internal Dosimetry, SPECT-CT, PET and Cyclotron as well as QA Nuclear Medicine Equipment

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	

LO-6	✓	✓	✓	✓	✓	
LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184719	:	MEDICAL INSTRUMENTATION
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn to understand the concept of Understanding the basics of instrumentation and electronics specially on medical equipment	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	

- The student understands the basic of instrumentation
- Students understand the basics of sensors, principles and applications
- Students are able to understand amplifiers and signal processing
- Students understand biopotential
- The student understands the principles of blood pressure and sound
- Students are able to understand blood flow and volume measurements

- The student is able to understand the principle of the respiratory signal
- The students are able to understand the principles of chemical biosensors
- Students are able to understand the principles of clinical laboratory instrumentation
- Students are able to understand the prosthetic equipment and (physio) therapy
- Students are able to understand electrical safety
- The student is able to understand the radiation detector
- Students are able to understand the radiation planes (Co 60 and kv x-ray) and LINAC

MAIN TOPICS

1. Basic electronic instrumentation
2. Basic sensors, principles and applications
3.Amplifiers and Signal Processing
4.Biopotensial
5. Blood pressure and sound
6. Flow Measurement and Blood Volume
7.Pengukuran respiratory system
8.Biosensor chemistry
9.Instrumentation of Clinical Laboratory
10. Prosthetic Equipment and (Physio) Therapy
11. Electrical Safety
12.Detector of radiation
13. Radiotherapy plane (Co 60 and kV X ray)
LINAC

PREREQUISITES

Physics of Radiology and Dosimetry

MAIN REFERENCES

- J. G. Webster, *Medical Instrumentation: Application and Design*. John Wiley & Sons, New York, 1998.

SUPPORTING REFERENCES

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Student are able to understands the basic of instrumentation, able to understand the basics of sensors, principles and applications, able to understand amplifiers and signal processing
- LO-2: Students are able to understand biopotential
- LO-3: Student are able to understands the principles of blood pressure and sound, able to understand blood flow and volume measurements, able to understand the principle of the respiratory signal, able to understand the principles of chemical biosensors

- LO-4: Students are able to understand the principles of clinical laboratory instrumentation
- LO-5: Students are able to understand the prosthetic equipment and (physio) therapy
- LO-6: Students are able to understand electrical safety
- LO-7: Student are able to understand the radiation detector
- LO-8: Students are able to understand the radiation planes (Co 60 and kv x-ray) and LINAC

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	
LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184720	:	RADIOBIOLOGY
	Credits	:	2 SKS
	Semester	:	VII

COURSE DESCRIPTION	
In this course students will learn to understand the concept of understanding the basics of instrumentation and electronics especially on medical equipment	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand the interaction of radiation with the material
- Students understand the radiation wound in DNA
- Students are able to understand the repair of DNA damage
- Students understand the damage and chromosome repair due to radiation induction
- Students understands the survival curve theory

• Students are able to understand cell death: the concept of cell death (apoptosis and cell death reproduction) • Students are able to understand the cellular healing process • Students are able to understand the principles of chemical biosensors • Students are able to understand the principle of cell cycle • Students are able to understand the radiation-sensitizer and protector response modifiers • Students are able to understand RBE, OER, and LET • Students are able to understand the Kinetic Cells • Students are able to understand the radiation wound on the tissue
MAIN TOPICS
• Review the interaction of radiation with the material • Radiation wound on DNA • Repair of DNA damage • Damage and chromosome repair due to radiation induction • The survival curve theory • The death of cells: the concept of cell death (apoptosis and cell death reproduction) • The cellular healing process • Cycle cells • Conversors of radiation-sensitizer and protector responses • RBE, OER, and LET • Kinetic cells • Radiation wound on the tissues • Radiation radiation- acute and advanced effects • Histopathology
PREREQUISITES
Physics of Radiology and Dosimetry
MAIN REFERENCES
• G. Gordon Steel (Editor). *Basic Clinical Radiobiology*. (Edward Arnold,London, UK, 1993) • Eric J. Hall . *Radiobiology for the Radiologist*. 5th ed. (Lippincott Williams and Wilkins,Philadelphia, PA, 2000).
SUPPORTING REFERENCES
REFORMULATED COURSE LEARNING OUTCOME (LO)
• LO-1: Students are able to understand the interaction of radiation with the material, the radiation wound in DNA, and the repair of DNA damage and chromosome repair due to radiation induction

- LO-2: Students are able to understands the survival curve theory, the cell death, the concept of cell death (apoptosis and cell death reproduction) and the cellular healing process
- LO-3: Students are able to understand the principles of chemical biosensors
- LO-4: Students are able to understand the principle of cell cycle
- LO-5: Students are able to understand the radiation-sensitizer and protector response modifiers
- LO-6: Students are able to understand RBE, OER, and LET
- LO-7: Students are able to understand the Kinetic Cells
- LO-8: Students are able to understand the radiation wound on the tissue

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	
LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

SEMESTER VIII

COURSE	SF184802	:	PHYSICS OF COMPOSITES
	Credits	:	3 sks
	Semester	:	VIII

COURSE DESCRIPTION	
This course describes the concept of composite materials as substitutes of conventional materials such as metals, ceramics, and polymers with micromechanical analytic reviews as well as qualitative analysis in terms of microstructures. In the analytic mechanics of composites described the concept of orientation of the amplifier to the matrix in the unidirectional, anisotropic and isotropic directions.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
• Students are able to understand the concept of composite materials and differentiate them from monolithic materials • Student are able to analyse the micromechanical aspect by using tensor analysis	

- Students are able to analyse qualitative microstructures of destructive composite materials

MAIN TOPICS

- Definition of composite materials
- Material matrix and filler / filler
- Composite: unidireksional, isotropic, lamina and ply structures
- Micromechanical analysis of composite materials
- Fabrication of composite materials
- Microstructures, defects, cracks and tears
- Application of composite materials
- Introduction to composite nano materials

PREREQUISITES

1.Physics of Metals
2.Physics of Polymers
3.Physics of Ceramics
4.Mathematical Physics II

MAIN REFERENCES

1. Chawla, A.K., "Mechanics of Composite Materials", CRC Press, New York, 1997
2. Lauge Fulgsang Nielsen," Composite materials", Springer-Verlag Berlin Heilderberg 2005
3. Bhagwan D. Agarwal," ANALYSIS AND PERFORMANCE OF FIBER COMPOSITES", ISBN: 978-81-265-3636-8, WILEY, Printed at: Sai Printo Pack Pvt. Ltd. Delhi 2015

SUPPORTING REFERENCES

2. Zainuri, M & Asrori, M.Z., "Fisika Bahan Komposit", Buku Ajar, Jurusan Fisika FMIPA ITS, 2009

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand the concept of composite materials and differentiate them from monolithic materials
- LO-2: Student are able to analyse the micromechanical aspect by using tensor analysis
- LO-3: Students are able to analyse qualitative microstructures of destructive composite materials

MAP OF PLO AND LO

	PLO-2	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE			
	SF184803	:	**Physics of Semiconductors**
	Credits	:	3 SKS (3/0)
	Semester	:	VII

COURSE DESCRIPTION	
This lecture is given to equip students about the foundations of semiconductor science and technology. Semiconductor science teaches about the semiconductor material knowledge and engineering the semiconductor material into electronic equipment such as p - n (diode), transistor and so on. While semiconductor technology talks about the basics of engineering or fabrication of semiconductor raw materials and electronic equipment.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
Able to understand the fundamentals of semiconductor science and technology and can apply it in the world of semiconductor industry	

MAIN TOPICS

- Semiconductor theory: The basic understanding of the energy band and the concentration of the load carrier in thermal equilibrium, the transport phenomenon of the load carrier.
- Semiconductor Equipment: Relationship p - n transistor, field transistor effect, metal-semiconductor contact.
- Photonic equipment: Radiative transition, optical absorption, LEDs (Light Emitted Devides), semiconductor lasers, solar cells.
- Semiconductor technology: Growth of crystals and epitaxy, thermal oxidation, semiconductor deposition, plasma enhanced chemical deposition system.

PREREQUISITES

1. Mathematical Physics II
2. Statistical Physics

MAIN REFERENCES

1. S.M. SZe, Semikonductor Devices Physics and Technology 2nd ed, John Wiley & Sons, 2002.

SUPPORTING REFERENCES

1. Andrew S. Grove ; Physics and Technology of Semiconductor Devices, John Wiley & Sons, New York 1967.
2. S. Reka Rio dan M. Iida; Fisika dan Teknologi Semikonduktor, Association for International Technical Promotion, Tokyo, 1980

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the fundamentals of semiconductor science and technology
- LO-2: Able to apply it in the world of semiconductor industry

MAP OF PLO AND LO

	PLO-2	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184804	:	**Material Analysis Method**
	Credits	:	3 SKS
	Semester	:	VIII

COURSE DESCRIPTION
In this course students will learn the material about the theory of crystallography, namely symmetry, group point, group space and crystal material. Students study the theory of x-ray generation, x-ray interaction and matter and the occurrence of X-ray diffraction by crystals. Students perform sample preparation and measurement of diffraction data using difractometer. Students use software-software for the conversion and manipulation of diffraction data, then analyse it for phase identification. Students recognize the use of software for quantitative analysis of diffraction data. Students study the interaction between radiation and matter, the experimental picture of various spectroscopic and its application in the industry.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE
• Students explain the principles of crystallography which includes symmetry, group of spots and groups of spaces, as well as know some characteristics of crystal material • The students explain the process of x-ray generation and its utilization for crystalline diffraction Students explain the occurrence of crystal diffraction • The students are able to prepare samples and perform the measurement of diffraction data • Students are able to perform phase identification through measured diffraction data • Students can follow the basic steps of quantitative phase analysis • Students can understand the electromagnetic radiation and its interactions with atoms and molecules, as well as general experimental images • Students can understand the basic principles of rotational spectroscopy, vibration, electronics, magnetic resonance, lasers • Students can understand the principles of micrography: MO, SEM, EPMA, EDX and its application. • Students are able to choose the type of characterization, evaluate, perform analysis and interpretation of data from • various characterization techniques.
MAIN TOPICS
● Introduction to Crystallography: types of symmetry, dot group, Bravais lattice and space group, Crystal structure ● X-ray generation: x-ray interaction and material, x-ray diffraction by crystals, Bragg's Law ● Sample preparation and measurement of diffraction data ● Phase identification: Quantitative analysis by Rietveld method. ● Interaction of radiation with matter (electromagnetic radiation, absorption and radiation emission, line widening). The experimental method (electromagnetic spectrum, dispersion element, absorption experimental component in various spectral regions, other experimental techniques, recording spectrophotometer type), Practicum (Emission Spectroscopy) ● rotation spectroscopy (symmetry rotor and asymmetry, infrared rotation, millimeter wave, microwave spectra, rotational Raman spectroscopy), vibration spectroscopy (diatomic molecule: infrared spectra, raman spectra, anharmonization, rotational-vibration spectroscopy; polyatomic molecule: vibration group, vibration-vibration, rotational-vibration spectroscopy, anharmonization), Electronic spectroscopy (atomic

spectroscopy, electronic spectroscopy for diatomic molecules, electronic spectroscopy for polyatomic molecules), nuclear magnetic resonance and electrons (nuclear magnetic and electron properties, resonance process, chemical shift, coupling hyperfine), Laser Spectroscopy (Laser in General, Types of lasers, usability of lasers in spectroscopy)

- Micrographic analysis with OM (optal microscope), SEM (electron microscope), EPMA (electron probe micro analysis), EDX (energy dispersive X-ray), experimental methods with OM, SEM, EPMA, and EDX. Micrographic Practicum

PREREQUISITES

Modern Physics

PUSTAKA UTAMA

1. Tilley, R. D. J., (2006), Crystal and Crystal Structure, John Wiley & Sons, LTD, England.
2. Cullity, B. D., Stock, S. R., (2001), Elements of X-Ray Diffraction, Prentice Hall, New Jersey.
3. Sands, D. E., (1968), Introduction to Crystallography, DOVER PUBLICATIONS, INC., New York.
4. J.M Hollas, “Modern Spectroscopy”, John Wiley & Sons, New York, 1987
5. Oliver Howarth, “Theory of Spectroscopy An Elementary Introduction” Thomas Nelson and Sons Ltd, London, 1973

PUSTAKA PENDUKUNG

1. Dinnebier, R. E.dan Billinge, S. J. L., (2008), Powder Diffraction Theory and Practice, RSC Publisher, UK.
2. Young, R. A. (ed.) 1993, The Rietveld method, International Union of Crystallograhy; Oxford University Press, Oxford; New York.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students explain the principles of crystallography which includes symmetry, group of spots and groups of spaces, as well as know some characteristics of crystal material
- LO-2: The students explain the process of x-ray generation and its utilization for crystalline diffraction and the occurrence of crystal diffraction
- LO-3: The students are able to prepare samples and perform the measurement of diffraction data
- LO-4: Students are able to perform phase identification through measured diffraction data and follow the basic steps of quantitative phase analysis

- LO-5: Students can understand the electromagnetic radiation and its interactions with atoms and molecules, as well as general experimental images
- LO-6: Students can understand the basic principles of rotational spectroscopy, vibration, electronics, magnetic resonance, lasers
- LO-7: Students can understand the principles of micrography: MO, SEM, EPMA, EDX and its application.
- LO-8: Students are able to choose the type of characterization, evaluate, perform analysis and interpretation of data from various characterization techniques.

MAP OF PLO AND LO

	PLO-2	PLO-5	PLO-8	PLO-9	PLO-10	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	
LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184805	:	**Electro-Acoustics**
	Credits	:	3 SKS (3/0/0)
	Semester	:	VIII

COURSE DESCRIPTION	
In this course students will learn: The basics of electro-acoustic components, the workings of typical acoustic measuring devices, and the corresponding understandings of electro-mechanical circuits. Acoustic base quantities as well as sound behaviour in space so that students can experiment with acoustic instruments and present their results and apply equivalence to electromechanical circuits and analyse sound behaviour in space by using acoustic quantities that support student end-tasks	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
1.Students are able to explain about the phenomenon of acoustics / sounds 2.Students able to explain about the various acoustic quantities	

3. Ability to calculate the sum of sounds 4.Students able to Explain about the sound of noise 5.Students are able to explain about hearing, noise and hearing threshold that can be heard 6. Students are able to explain about loudness 7. Students are able to perform accuracy in measurement 8. Students are able to explain and analyse measurement results 9. Students are able to explain about electric, mechanical and acoustic circuits 10. Students are able to connect / analog of acoustic-mechanic-electric circuit in facilitating calculation 11. Students are able to explain the principles and work of speakers. 12. Students are able to determine the characteristics of speakers 13. Students are able to explain the working principle of microphones 14. Students are able to formulate speaker parts 15. Student Able to explain about acoustic / sound phenomenon 16. Students are able to explain about the various acoustic quantities 17. Can count the sum of sounds 18. Students are able to Explain about sound distribution 19. Students are able to explain about hearing, noise and hearing threshold 20. Students are able to explain about loudness 21. Students are able to make accurate measurements 22. Students are able to explain and analyse measurement results
MAIN TOPICS
1. Introduction to: acoustic quantities and acoustic applications, addition and decibel measurements, 3. Hearing mechanisms with hearing disabilities, 4. Behaviour and noise and its impact and control, 5.Acoustic Component and Electro-mechanical Equivalent Circuit; 6. Sound delays in free space and sound sources (speakers), 7.Response and speaker severity factor, 8. The basic concept of a microphone as the source of sound, 9. The basic concept of speakers in a confined space
PREREQUISITES
Physics of Buildings
MAIN REFERENCES
1. Beranek L.L., *Acoustics*, McGraw-Hill, New York, 1954
SUPPORTING REFERENCES
1. Prasetio L., *Akustik*, Jurusan Fisika – FMIPA, 2003 2. Smith B.J., Peters R.J., Owen S., *Acoustics and Noise Control*, Addison Wesley Longman Ltd, England, 1996

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to explain about the phenomenon of acoustics / sounds, the various acoustic quantities, and able to calculate the sum of sounds and sound distribution
- LO-2: Students able to Explain about the sound of noise, hearing, noise and hearing threshold that can be heard, and loudness
- LO-3: Students are able to perform accuracy in measurement and able to explain and analyse measurement results
- LO-4: Students are able to explain about electric, mechanical and acoustic circuits
- LO-5: Students are able to connect / analog of acoustic-mechanic-electric circuit in facilitating calculation
- LO-6: Students are able to explain the principles and work of speakers, determine the characteristics of speakers, the working principle of microphones, formulate speaker parts

MAP OF PLO AND LO

	PLO-1	PLO-2	PLO-7	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		
LO-6	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184806	:	INTELLIGENT INSTRUMENTATION AND CONTROL
	Credits	:	3 SKS (3/0/0)
	Semester	:	VIII

COURSE DESCRIPTION	
In this course students will learn about the basic concepts and application of artificial intelligence in instrumentation. Artificial neural networks, fuzzy logic (Fuzzy Logic) and genetic algorithms are discussed in lectures in the class and in the laboratory, so students have experience using one of the artificial intelligence methods in instrumentation. In this lecture will also present a case study of artificial intelligence systems related to the application of physics, so that students will have experience learning and critical thinking about the use of intelligent instrumentation in physics and its application. In this course students will learn about introduction of control systems, mathematical modelling for mechanical, electrical, fluid and thermal systems, transient response analysis, root locating methods, stability analysis, frequency response analysis, spatial analysis, control system design method of root position and frequency response method. In this lecture will present a case study of a simple control system that deals with the application of physics, so that students will have experience learning and critical thinking about the use of physical system analysis in physics and its application. The learning method is done in class and laboratory, so students have experience in theory and practice	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in

	information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
PLO-11	able to disseminate the results of problem (case) studies and physical behaviours based on standard scientific principles in oral and written communication in the form of reports or scientific works according to correct writing rules by understanding the plagiarism mechanism and publishing them at the national or international level. {KK}

CAPAIAN PEMBELAJARAN MATA KULIAH

- Be able to recognize and understand models of artificial intelligence and can use artificial intelligence for physics and application
- Able to solve problems associated with intelligent instrumentation developed with artificial neural networks, fuzzy logic (Fuzzy Logic) and genetic algorithms
- Able to have experience in the practice of intelligent instrumentation
- Be able to express their ideas or ideas verbally and in writing
- Able to recognize, understand and analyse the types of control systems both conventional and modern
- Able to solve problems related to mathematical modelling of control systems, mathematical modelling for mechanical, electrical, fluid and thermal systems, as well as transient response analysis, root locality method, stability analysis, frequency response analysis, spatial analysis, root position and control system design with frequency response method.
- Able to have experience in the practice of control systems
- Be able to express their ideas or ideas verbally and in writing

POKOK BAHASAN

Introduction to artificial neural networks, the basic models of neural network computing, guided and unwounded learning, examples of neural network learning: preptron, back-propagation, radial basis
function and self organizing map (SOM), hopfield network, cryptic logic, fuzzy inference system, fuzzy clustering, fuzzy associate memory (FAM), and genetic algorithm; Introduction to control systems, mathematical backgrounds: Laplace matrix and transformations, mathematical modelling of control systems, modelling
mathematics for mechanical, electrical, fluid and thermal systems, transient response analysis, rootstab method, stability analysis, frequency-response analysis, space-state analysis, control system design

with root positioning method and control system design with frequency response method.

PRASYARAT

1. (Minimum D)

PUSTAKA UTAMA

1. Ogata, K., "Modern Control Engineering, 4th edition", Prentice Hall, 2010.
2. R. C. Dorf and R.H. Bishop., "Modern Control System, 12th editiom", Prentice Hall, 2010.

PUSTAKA PENDUKUNG

3. Min, F.L., "Neural Network in Computer Intelligence", McGraw-Hill. Inc, Singapore, 1994.
4. Rao,B., Hayagriva, V.Rao, and Valluru, "C++ Neural Network and Fuzzy Logic", MIS PRESS, New York, 1993.
5. J.-S.R.Jang, C-T. Sun, E. Mizutani, Neuro-Fuzzy and Soft Computing, Prentice Hall International, Inc, 1997
6. Satish Kumar, Neural Networks: A Classroom Approach, Mc.Graw Hill, 2005
7. George F.I., William A.S., "Artificial Intelligence and Design of Expert system", 1989

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to recognize and understand models of artificial intelligence and can use artificial intelligence for physics and application
- LO-2: Able to solve problems associated with intelligent instrumentation developed with artificial neural networks, fuzzy logic (Fuzzy Logic) and genetic algorithms
- LO-3: Able to have experience in the practice of intelligent instrumentation
- LO-4: Able to express their ideas or ideas verbally and in writing
- LO-5: Able to recognize, understand and analyse the types of control systems both conventional and modern
- LO-6: Able to solve problems related to mathematical modelling of control systems, mathematical modelling for mechanical, electrical, fluid and thermal systems, as well as transient response analysis, root locality method, stability analysis, frequency response analysis, spatial analysis, root position and control system design with frequency response method.
- LO-7: Able to have experience in the practice of control systems
- LO-8: Able to express their ideas or ideas verbally and in writing

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10	PLO-11		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		
LO-6	✓	✓	✓	✓		
LO-7	✓	✓	✓	✓		
LO-8				✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184807	:	HEAT TRANSFER
	Credits	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION
Discusses the mode of heat conduction by focusing on the use of mathematics to obtain the formulation of conductivity, convection and radiation mode and the network method on the electric analogy

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to explain steady conduction heating rate in the area of flat, cylinder and ball.
- Students are able to explain the decrease of conduction differential equation and able to formulate conduction conduction with heat source.
- Students are able to explain the types of cooling system in the form of fin and efficiency
- Students are able to explain two-dimensional steady conduction heating rates on rectangular and other shaped surfaces.
- The student is able to explain the type of fluid flow in the boundary layer in the conduction of forced convection.
- The student is able to forecast the coefficient value of the mean forced convection of a surface

- The student is able to explain the type of fluid flow within the boundary layer in the conduction of free convection
- The student is able to predict the average free convection coefficient value of a surface
- The student is able to calculate the average free convection coefficient value by using empirical formula
- Students are able to explain the magnitudes associated with conducting radiation heat
- The student is able to explain the radiation heat rate in black and non-black objects
- Students are able to read the radiation form factor graph from the interaction of the two surfaces
- Students can explain the relationship between radiation form factor
- Students are able to explain the exchange of heat between non-black objects

MAIN TOPICS

1. Heat Conduction, One Dimensional Conduction, Differential Conduction Density, Cooling System Fin, Two Dimensional Steady Conduction.
2. Forced Convection, Boundary Thickness, Mean Coefficient of Convection Convection.
3. Free Convection, Boundary Thickness, Coefficient of Free-Mean Convection, Empirical Formula Free Convection.

Heat Radiation, Radiation Quantities, Black and No Black Radiation, Radiation Form Factor, Heat Exchange Non-Black Material

PREREQUISITES

Physics III

MAIN REFERENCES

J. P. Holman, "Heat Transfer" Mc Grow-Hill, Ltd 2002

SUPPORTING REFERENCES

F. P. Incropera & D. P. De Witt, *Fundamentals of Heat Transfer*, John Wiley & Sons, New York 1981

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to explain steady conduction heating rate in the area of flat, cylinder and ball, able to explain the decrease of conduction differential equation, and able to formulate conduction with heat source.
- LO-2: Students are able to explain the types of cooling system in the form of fin and efficiency

- LO-3: Students are able to explain two-dimensional steady conduction heating rates on rectangular and other shaped surfaces.
- LO-4: Student is able to explain the type of fluid flow in the boundary layer in the conduction of forced convection, able to forecast the coefficient value of the mean forced convection of a surface, able to explain the type of fluid flow within the boundary layer in the conduction of free convection, able to predict the average free convection coefficient value of a surface, and able to calculate the average free convection coefficient value by using empirical formula
- LO-5: Students are able to explain the magnitudes associated with conducting radiation heat, able to explain the radiation heat rate in black and non-black objects, able to read the radiation form factor graph from the interaction of the two surfaces, able to explain the relationship between radiation form factor
- LO-6: Students are able to explain the exchange of heat between non-black objects

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-9			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE			
	SF184808	:	**Industrial Instrumentation**
	Credit	:	3 sks
	Semester	:	VIII

COURSE DESCRIPTION
Industrial Instrumentation is a subject which contains the basics of DCS (distributed control system), system sorting, subsystem controller design, integrated controller. The design of the converter and how to do the conversion will also be given in this course. In addition, students will also be given basic knowledge about thermoelectrics, an explanation of thermoelectric producing devices, and thermoelectric applications. One of the applications of thermoelectric is in heating systems. In heating systems students will also learn about the instruments that will be used for heating systems both in laboratories and industrial equipment. At the end of the semester students will be given training on the design and development of instrumentation based on industrial instruments and research needs

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
PLO-11	able to disseminate the results of problem (case) studies and physical behaviours based on standard scientific principles in

	oral and written communication in the form of reports or scientific works according to correct writing rules by understanding the plagiarism mechanism and publishing them at the national or international level. {KK}

LEARNING OUTCOME OF THE COURSE

- Students are able to recognize, understand and analyse models of systems and subsystems
- Students are able to solve problems related to the model and control subsystem
- Students are able to have experience in practice about types of converters
- Students are able to recognize, understand the basics of thermoelectrics
- Students are able to have practical experience in making thermoelectric generators
- Students are able to recognize, understand and design heating systems and their PID controls.
- Students are able to express their ideas or ideas orally and in writing

MAIN TOPICS

Basic basics and applications of DCS, Design of various types of converters, basic and thermoelectric applications, basic and heating system applications, as well as designing and developing instrumentation based on industrial instruments and research needs

PREREQUISITES

- Electronics
- Instrumentation

MAIN REFERENCES

1. Obe, D.M.Rowe, Material, Preparation, and Characterization in Thermoelectric, Taylor and Francis Group LLC, 2012
2. Charles K. Alexander, Matthew N. O. Sadiku, Fundamentals of Electric Circuits, Fifth Edition, 2012.
3. J. W. Nilssson dan S. A, Riedel, 2008, Electronic Circuit, Pearson Prentice Hall.
4. Boylestad, 2002, Introductory Circuit Analysis, 10th edition, Prentice Hall.

SUPPORTING REFERENCES

1. Millman and Halkias,2001, Integrated Electronics, Tata McGraw-Hill.
2. Robert L Boylestad and Louis Nashelsky, 2009, Electronics Devices and Theory, 10 edition, Pearson Education.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to recognize, understand and analyse models of systems and subsystems
- LO-2: Students are able to solve problems related to the model and control subsystem
- LO-3: Students are able to have experience in practice about types of converters
- LO-4: Students are able to recognize, understand the basics of thermoelectrics
- LO-5: Students are able to have practical experience in making thermoelectric generators
- LO-6: Students are able to recognize, understand and design heating systems and their PID controls.
- LO-7: Students are able to express their ideas or ideas orally and in writing

MAP OF PLO AND LO

	PLO-2	PLO-7	PLO-8	PLO-10	PLO-11	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	
LO-7					✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184809	:	**Optical Computation**
	Credit	:	3 SKS
	Semester	:	VIII

COURSE DESCRIPTION
In this course, students will learn about numerical methods and computational Difference Finite to apply Maxwell's equations in the phenomenon of propagation of electromagnetic waves in free space and in wave guides. Students will learn to analyse and calculate the coefficient of reflection and transmission of electromagnetic waves in various medium structures, both one- and two-dimensional space. Students will learn to program boundary conditions issues in most cases of transmission mediums, both the PML and MURR methods. Students will learn Fourier transform programming which is integrated in finite difference methods to obtain reflection and transmission coefficients in the frequency domain. Students learn to calculate parameters such as the characteristic impedance of a material, the power radiation pattern. In addition, students will also learn visual programming and animation of the propagation of electromagnetic waves in linear and nonlinear optical waveguides by combining the Crank Nicholson method, the Tridiagonal matrix and Gauss Jordan.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE
• Able to apply a programming language which is a translation of the mathematical language of the electromagnetic wave equation

- Able to understand and analyse the phenomenon of interaction between Opto-Electromagnetic waves with a guide medium
- Able to provide visual opto-electromagnetic symptoms from programming results
- Able to quickly calculate the radiation power pattern, reflection coefficient, vswr, characteristic impedance of various waveguide and antenna design structures.
- Able to apply interactive software for various waveguide and antenna structures

MAIN TOPICS

- Review of Maxwell's Equations and their writing in programming languages:
- Issues of boundary conditions, electric and magnetic fields in medium, lossy medium, lossless, dielectric materials and conducting materials
- Writing programming languages with numerical method capabilities: differential and integral equations, ordinary and partial differential equations, Crank Nicholson method, Tridiagonal matrix, Gauss Jordan, FFT schemes, and finite difference approach.
- Writing Opto-Electromagnetic programming: TE, TM, and TEM waves in linear and nonlinear materials, reflection, refraction, and optical wave forwarding in planar wave guides
- Programming the antenna structure: Microwave guides, transmission lines, characteristic impedance, reflection coefficient, transmission coefficient, VSWR and radiation patterns
- Programming of optical waveguide structures

PREREQUISITES

1. Computational Physics I and II
2. Electromagnetic Field II

MAIN REFERENCES

1. Richard H.Enns and George C.Mc Guire, “Nonlinear Physics with Mathematica for sicientists and Engineers”, Birkhauser, Boston,2001.
2. William Mc.Donald et al, “Wave and Optics Simulations”, The Consorcium for Upper-
3. Level Physics Software, John Wiley & Sons INC,1993.
4. Introduction to the Finite-Difference Time-Domain (FDTD) Method for Electromagnetics, S. D. Gedney, Morgan and Claypool Publishing, 2011.

SUPPORTING REFERENCES

1. Modul ajar “ Metode beda hingga optikFDBPM”, Fisika ITS 2014
2. Modul ajar “ Metode beda hingga antenna FDTD”, Fisika ITS 2014

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to apply a programming language which is a translation of the mathematical language of the electromagnetic wave equation
- LO-2: Able to understand and analyse the phenomenon of interaction between Opto-Electromagnetic waves with a guide medium
- LO-3: Able to provide visual opto-electromagnetic symptoms from programming results
- LO-4: Able to quickly calculate the radiation power pattern, reflection coefficient, vswr, characteristic impedance of various waveguide and antenna design structures.
- LO-5: Able to apply interactive software for various waveguide and antenna structures

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184810 : **Digital Image Processing**
	Credit : 3 SKS
	Semester : VIII

COURSE DESCRIPTION

In this course, students will learn to understand digital image processing through study materials which include the introduction of digital image processing, the basics of image processing, histogram and convolution, image transformation, image quality improvement, image segmentation, edge detection, morphology and feature extraction.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE

PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand the process of getting an image, the difference between digital and analog images, being able to calculate the memory needed to store an image
- Students understand digital image representation, image quantization, image quality, how to read images with software, how to get image size and display images
- Students are able to understand the type of image, RGB Image, Grayscale Image, Binary Image
- Students are able to convert RGB images to gray degree images, RGB images to binary images

- Students understand displaying a histogram from an image, are able to calculate and display a histogram from an image, be able to understand the types of histograms
- Students are able to understand convolution in an image, calculate image convolution manually and be able to convolute an image using software
- Able to understand about image transformation and transform an image
- Students are able to understand about improving image quality and improving the quality of an image
- Students know and understand about image segmentation
- Students are able to understand about edge detection in an image and create a program to detect the edges of an image
- Students are able to understand the principles of morphology in an image
- Students are able to understand about feature extraction in an image

MAIN TOPICS

Introduction to Digital Image Processing;
Understanding Image, Analog Image and Digital Image, Process of getting an image, Converting an analog image into a digital image, Calculating the amount of memory needed to store an image,

Digital Image Processing Basics:
Digital Image Representation in a matrix, RGB Image, Gray Degree Image, Binary Image, Convert RGB Image to Gray Image, Convert RGB Image to Binary Image

Histogram and Convolution:
Definition of a histogram, types of histograms, how to calculate a histogram from an image, how to display a histogram from a Convolution theory, the application of convolution to an image manually and by using software, displays the results of the convulsion from an image

Image Quality Improvement:
Point Operation (Image quality change), Gamma Correction, Image Histogram Change, Filtering (Linear filter, Non linear filter) Geometry Operations (Translation, Rotation, Scaling)

Image Segmentation:
Definition of image segmentation, image segmentation techniques (Thresholding (global thresholding and local adaptive thresholding), Connected Component labeling, Clustering-Based Segmentation

Edge Detection:
Definition of image edges, Techniques for Detecting Edges: Sobel Operators, Prewitt Operators, Roberts Operators

Image Morphology:
Morphological image processing, Operation Morphology: Dilation, Erosion, Opening, Closing Thinning, thickening, skeletonizing
Feature Extraction:
Feature extraction method: Geometry, Histogram, Gradient, Fourier Spectrum, Wavelet, Color based Features, Gabor Filter, Fractal

PREREQUISITES

Computational Physics I
Computational Physics II

MAIN REFERENCES

1. Solomon, C. dan Breckon, T., " **Fundamentals of Digital Image Processing** : A Practical Approach with Examples in Matlab ", John Willey and Son 2012
2. Gonzalez, R.C. dan Woods, R.E., " **Digital Image Processing** ", Second Edition, Prentice Hall.

SUPPORTING REFERENCES

1. Jain, A.K., " **Fundamentals of Digital Image Processing** ", Prentice Hall.
2. Pengolahan Citra Digital dan Aplikasinya Menggunakan Matlab, Eko Prastyo

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the process of getting an image, the difference between digital and analogue images, able to calculate the memory needed to store an image, digital image representation, image quantization, image quality, how to read images with software, how to get image size and display images
- LO-2: Able to understand the type of image, RGB Image, Grayscale Image, Binary Image, able to convert RGB images to gray degree images, RGB images to binary images
- LO-3: Able to understand displaying a histogram from an image, are able to calculate and display a histogram from an image, be able to understand the types of histograms
- LO-4: Able to understand convolution in an image, calculate image convolution manually and be able to convolute an image using software
- LO-5: Able to understand about image transformation and transform an image
- LO-6: Able to understand about improving image quality and improving the quality of an image

- LO-7: Able to know and understand about image segmentation, edge detection in an image and create a program to detect the edges of an image, and the principles of morphology in an image
- LO-8: Able to understand about feature extraction in an image

MAP OF PLO AND LO

	PLO-7	PLO-8	PLO-10			
LO-1	✓	✓	✓			
LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			
LO-6	✓	✓	✓			
LO-7	✓	✓	✓			
LO-8	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE			
	SF184811	:	**Applied Electromagnetics**
	Credit	:	3 SKS
	Semester	:	VIII

COURSE DESCRIPTION

In this course, students will learn about the application of electromagnetic field theory in engineering, especially telecommunications engineering and be able to solve simple problems in that field. Students will learn about Maxwell's theory in more detail in calculating the characteristic impedance of several transmission lines, wave guides, antennas, microwaves, and radio wave propagation.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE

PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Able to solve electromagnetic field problems with Maxwell's equations
- Able to solve electromagnetic waveguide problems
- Able to calculate and measure the parameters of electromagnetic propagation in any free space medium, atmosphere or waveguide.
- Keep up with the development of science and technology in optical telecommunications, radio waves in antennas, radar and satellites
- Able to apply the fundamentals of electromagnetic fields to other fields

MAIN TOPICS

- Transmission lines: propagation & reflection, VSWR, impedance matching, Smith charts, striplines; Wave guide
- Rectangular waveguides, TE-TM-TEM mode, transmission losses, circular wave guides, cavity resonators, planar wave guides.
- Antenna: antenna parameters, dipole and slot antennas, array antennas, antenna measurements.
- Radio wave propagation: influence of the earth's surface, attenuation factors, tropospheric propagation, ionosphere propagation.
- Microwave devices and circuits and their applications

PREREQUISITES

1. Electromagnetic Field I
2. Electromagnetic Field II

MAIN REFERENCES

1. Liao,S.Y., "Engeneering Applications of Electromagnetic Theory", Info Acces Dist, 1992.
2. Kraus, J.D., "Electromagnetics", Mc.Graw-Hil, 4th.ed, 1992.
3. Collins,R.E.,"Antenuas and Radio Wave Propagation", Mc.Graw-Hill Int, 1985

SUPPORTING REFERENCES

1. Hund.E,"Microwave Communications,Component and Circuit", Mc.Graw-Hill, New York 1989

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to solve electromagnetic field problems with Maxwell's equations
- LO-2: Able to solve electromagnetic waveguide problems
- LO-3: Able to calculate and measure the parameters of electromagnetic propagation in any free space medium, atmosphere or waveguide.
- LO-4: Able to keep up with the development of science and technology in optical telecommunications, radio waves in antennas, radar and satellites
- LO-5: Able to apply the fundamentals of electromagnetic fields to other fields

MAP OF PLO AND LO

	PLO-8	PLO-9	PLO-10			
LO-1	✓	✓	✓			

LO-2	✓	✓	✓			
LO-3	✓	✓	✓			
LO-4	✓	✓	✓			
LO-5	✓	✓	✓			

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184812	:	**Seismic Exploration**
	Credit	:	3 SKS
	Semester	:	VIII

COURSE DESCRIPTION
In this Seismic Exploration course, students will learn about the principles of seismic wave propagation, types of seismic acquisition, advantages, disadvantages of each seismic method, and so on. Students are familiar with the theory and application of wave propagation in seismic surveys. Students understand the procedures and stages in the acquisition of reflected seismic data and the initial steps for processing it. Students are able to use reflected seismic data processing techniques to track, analyse and make interpretations of rock bed structures and their physical characteristics.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE
• Able to design and conduct surveys using seismic methods, as well as carry out modelling and interpretation according to the survey objectives. • Able to write seismic data simulation program.

- Able to acquire / obtain reflection seismic data.
- Capable of processing enormous seismic data.
- Able to interpret seismic sections.

MAIN TOPICS

- Introduction to the reflection seismic method,
- Instrumentation and measurement equipment for reflected seismic data, the theory of propagation of reflected seismic waves,
- Rock physics: seismic velocity, influencing factors and measurement methods; filter theory and noise elimination, deconvolution, normal-moveout, velocity analysis and static correction, dip-moveout, migration (pre-stack and post-stack in the time domain and depth), the method of interpretation and introduction to reservoir geophysics.

PREREQUISITES

1. Mathematical Physics I and II
2. Computational Physics
3. Seismology

MAIN REFERENCES

1. Gubbins, M., 2001., Geophysical Data Measurement and Analysis. , 2nd Edition, Cambridge University Press
2. Philip Kearey, Michael Brooks, Ian Hill, An Introduction to Geophysical Exploration, THIRD EDITION
3. Sheriff, R. E. and Geldart, L. P., Exploration Seismology, Vol. I, Cambridge University Press, 1982.
4. W.M. Telford, L.P. Geldart, R.E. Sheriff, Applied Geophysics (2nd edition), Cambridge, 1990.
5. Yilmaz, Öz, Seismic Data Analysis, Vol. I, Society of Exploration Geophysicists, 2001.

SUPPORTING REFERENCES

1. Costain , John K. and Cahit Çoruh, 2004, Basic Theory Of Exploration Seismology, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, U.S.A.
2. J.M. Reynolds, An Introduction to Applied and Environmental Geophysics, Wiley, 1998.
3. M. Nabigian (ed.), Electromagnetic methods in Applied Geophysics, vol. 1 Theory, vol. 2 Application, Society of Exploration Geophysicists, 1989.
4. M.S. Zhdanov, G.V. Keller, The Geoelectrical Methods in Geophysical Exploration, Elsevier, 1994

5. Menke, W., 2012., Geophysical Data Analysis: Discrete Inverse Theory, 3rd Edition, Matlab Edition, Academic Press
6. Miller, R., Bradford, J.H. and Holliger, K. Advances in near surface Seismology and Ground-penetration Radar. American Geophysical Union, 2010.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to design and conduct surveys using seismic methods, as well as carry out modelling and interpretation according to the survey objectives.
- LO-2: Able to write seismic data simulation program.
- LO-3: Able to acquire / obtain reflection seismic data.
- LO-4: Able to apply processing enormous seismic data.
- LO-5: Able to interpret seismic sections.

MAP OF PLO AND LO

	PLO-7	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184813	:	**Earth Potential Field Exploration**
	Credit	:	3 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
In this Earth Potential Field Exploration course, students will learn about the various variations in density and susceptibility variations in rocks, the basic concepts of the gravity method, measurement systems and management of gravity data, corrections to gravity data, and basic concepts of magnetic methods, measurement system methods. magnetic, corrections to magnetic data, graphical separation of local and regional anomalies, reduction in plane, Second vertical derivative, conceptual upward and downward continuation, synthetic data methods and inversion of gravitational and magnetic data. In this Earth Potential Field Exploration lecture, students are expected to be able to measure magnetic data, and be able to apply data reduction processes and interpret the earth's structure with simple magnetic and gravitational data.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	

- Able to design and conduct surveys using gravity and magnetic methods, as well as carry out modelling and interpretation according to the survey objectives.
- Able to write gravity and magnetic data simulation programs.
- Able to calculate the frequency spatial transformation of measured gravitational and magnetic data.
- Able to invert synthetic data to get initial parameters.
- Able to invert very plural gravitational and magnetic data.

MAIN TOPICS

Density and susceptibility variations in rocks, basic concepts of the gravity method, gravity data measurement and management systems, corrections to gravity data, and basic concepts of magnetic methods, magnetic method measurement systems, corrections to magnetic data, separation of local and regional anomalies , reduction in the plane, Second vertical derivative, Continuation up and down, synthetic data methods and inversion of gravity and magnetic data and 4 D Gravity

PREREQUISITES

1. Mathematical Physics I and II
2. Computational Physics
3. Seismology

MAIN REFERENCES

1. Costain , John K. and Cahit Çoruh, 2004, Basic Theory Of Exploration Seismology, Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, U.S.A.
2. Gubbins, M., 2001.Geophysical Data Measurement and Analysis. , 2nd Edition, Cambridge University Press
3. J.M. Reynolds, An Introduction to Applied and Environmental Geophysics, Wiley, 1998.
4. M. Nabigian (ed.), Electromagnetic methods in Applied Geophysics, vol. 1 Theory, vol. 2 Application, Society of Exploration Geophysicists, 1989.
5. Philip Kearey, Michael Brooks, Ian Hill, An Introduction to Geophysical Exploration, THIRD EDITION
6. Sheriff, R. E. and Geldart, L. P., Exploration Seismology, Vol. I, Cambridge University Press, 1982.
7. W.M. Telford, L.P. Geldart, R.E. Sheriff, Applied Geophysics (2nd edition), Cambridge, 1990.

SUPPORTING REFERENCES

1. M.S. Zhdanov, G.V. Keller, The Geoelectrical Methods in Geophysical Exploration, Elsevier, 1994
2. Menke, W., 2012., Geophysical Data Analysis: Discrete Inverse Theory, 3rd Edition, Matlab Edition, Academic Press
3. Miller, R., Bradford, J.H. and Holliger, K. Advances in near surface Seismology and Ground-penetration Radar. American Geophysical Union, 2010.
4. Yilmaz, Öz, Seismic Data Analysis, Vol. I, Society of Exploration Geophysicists, 2001.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to design and conduct surveys using gravity and magnetic methods, as well as carry out modelling and interpretation according to the survey objectives.
- LO-2: Able to write gravity and magnetic data simulation programs.
- LO-3: Able to calculate the frequency spatial transformation of measured gravitational and magnetic data.
- LO-4: Able to invert synthetic data to get initial parameters.
- LO-5: Able to invert very plural gravitational and magnetic data.

MAP OF PLO AND LO

	PLO-7	PLO-8	PLO-9	PLO-10		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184814 : **Rock Physics and Well-log Analysis**
	Credit : 2 SKS
	Semester : VIII

COURSE DESCRIPTION	
This course describes the physical characteristics of rocks and several methods for measuring well-log data. The combination of the two is expected to identify permeable and impermeable rocks, as well as identify the position and type of hydrocarbons from the well-log data. In addition, this course also describes quantitative analysis to determine shale volume, porosity, resistivity, water saturation, and rock pore pressure based on well-log data.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
PLO-11	able to disseminate the results of problem (case) studies and physical behaviours based on standard scientific principles in oral and written communication in the form of reports or scientific works according to correct writing rules by understanding the plagiarism mechanism and publishing them at the national or international level. {KK}
LEARNING OUTCOME OF THE COURSE	
• Students understand and are able to apply the properties of rock physics	

- Students understand the logging environment related to the hydrocarbon trapping system, sludge characteristics, the logging system and the measurement system.
- Students are able to describe the Caliper log measurement system along with the interpretation of the measurement results
- Students are able to describe and apply measurement systems and Gamma Ray log responses on rocks, along with their applications
- Students are able to describe the causes of potential difference (SP) on log data, along with their application to characterize subsurface.
- Students are able to describe resistivity log measurements with the law, be able to interpret the resistivity logs, and be able to calculate water saturation in log data.
- Students are able to describe the Neutron Log measurement system, the factors that affect physics Neutron log values, and are able to apply.
- Students are able to describe the log density measurement system, the geological factors that affect the density log measurement, as well as being able to apply them.
- Students are able to describe the Sonic log measurement system, the geological effect on sonic log measurements, and be able to interpret sonic log data.
- Students are able to apply rock physics and well-log parameters

MAIN TOPICS

1. **Physical properties of rocks**: porosity, density, resistivity, wave velocity, fluid saturation;
2. **Logging Environment**: Hydrocarbon traps, sludge characteristics, well-log measurement systems
3. **Log Caliper**: impermeable and permeable rock on calliper logs, washout, cave, swelling, mud cake;
4. **Gamma Ray logs**: Gamma ray log measurements, advantages and disadvantages of Gamma ray logs, Gamma Ray log characteristics, shale volume;
5. **Self-potential log**: potential source, SP log measurement, SP log properties;
6. **Resistivity logs**: pseudo resistivity theory, Archie's law, Sonic log measuring system, resistivity log advantages and disadvantages, resistivity log applications;
7. **Neutron Log**: Neutron log measurement system, neutron log advantages and disadvantages, Neutron log application;
8. **Log Density**: density-based rock characteristics, density log concepts and measurement systems, density log applications;

9. **Sonic logs**: sonic log measurement system, sonic log advantages and disadvantages, Sonic logs application;
10. **Qualiatative analysis**: identification of permeable and impermeable rocks, and identification of the position and type of hydrocarbons from well-log data;
11. **Quantitative analysis**: calculation of shale volume, porosity, resistivity, water saturation, and rock pore pressure based on well-log data.

PREREQUISITES

Electromagnetic Field I, Electronics, and Waves (minimal D)

MAIN REFERENCES

1. Schön, J.H. 2011. Physical Properties of Rocks, Elsevier.
2. Serra, L. & Serra, O. 2004.Well Logging Data Acquisition and Applications, Serralog. Calvados, France
3. Serra, O., & Serra, L. (2003). *Well Logging and Geology.* SerraLog, Calvados, France
4. Darling, T. 2005. Well Logging and Formation Evaluation, Elsevier.

SUPPORTING REFERENCES

1. Asquith, G., and Krygosky, D., 2004. Basic Well log Analysis 2nd Edition, AAPG methods in exploration Series, No. 16.
2. Rider, M. 2000. The Geological Interpretation of Well Logs 2nd edition, Rider-Frenc Consulting.
3. Ellis, D.V., and Singer , J.M. 2008. Well Logging for Earth Scientists 2nd edition, Elsevier.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students understand and are able to apply the properties of rock physics, the logging environment related to the hydrocarbon trapping system, sludge characteristics, the logging system and the measurement system.
- LO-2: Students are able to describe the Caliper log measurement system along with the interpretation of the measurement results, able to describe and apply measurement systems and Gamma Ray log responses on rocks, along with their applications
- LO-3: Students are able to describe the causes of potential difference (SP) on log data, along with their application to characterize subsurface.
- LO-4: Students are able to describe resistivity log measurements with the law, be able to interpret the resistivity logs, and be able to calculate water saturation in log data.

- LO-5: Students are able to describe the Neutron Log measurement system, the factors that affect physics Neutron log values, and are able to apply.
- LO-6: Students are able to describe the log density measurement system, the geological factors that affect the density log measurement, as well as being able to apply them.
- LO-7: Students are able to describe the Sonic log measurement system, the geological effect on sonic log measurements, and be able to interpret sonic log data.
- LO-8: Students are able to apply rock physics and well-log parameters

MAP OF PLO AND LO

	PLO-5	PLO-8	PLO-9	PLO-10	PLO-11	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	
LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE			
	SF184815	:	**Inversion Model**
	Credit	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
In this course, students are presented with the differences between inversion modelling and future modelling as well as explaining inversion methods to produce models along with the advantages and disadvantages of each of these methods.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-5	able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU}
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students are able to distinguish between forward modelling and backward modelling (inversion)
- Students are able to understand and apply L2- and L1-norm for linear regression
- Students understand the character of noise in measurement data

- Students are able to understand linear inversion for under- and over-determined cases
- Students are able to understand the uncertainty of model solutions on the inversion results
- Students are able to understand and apply linear inversion a priori for under- and over-determined cases
- Students are able to apply several linear inversion methods to solve non-liner problems
- Students are able to understand and apply the concept of global optimization and apply it to the inversion process

MAIN TOPICS

1. **Forward modelling and inversion modelling**: basic concepts in geophysics (data measurement and analysis), forward and inversion modelling, modelling aspects, and application of the inversion method
2. **Linear Regression**: introduction to linear regression, statistical aspects of the Least Squares (L2-norm) method, unknown standard deviation measures, L1-norm based regression;
3. **Probability Theory**: noise measurement, Gaussian Probability Density function, Gaussian statistics, interfal Confidence;
4. **Linear inversion problem (simple approach)**: linear inversion problem formulation, model parameter estimation, density probability function, application;
5. **Linear inversion problems**: maximum likelihood, resolution and covariance models for inversion models (under and over determined), means of non-uniqueness models, statistics on Gaussian inversion problems and Non-Gaussian Statistics, applications;
6. **Linear inversion problems use priori**: advantages and disadvantages of linear inversion problems, under-determined problems, mixed-determined problems, inversion using multiple a priori, reference models, model refinement, general form of a priori models, applications;
7. **Nonlinear inversion uses a linear approach**: model parameterization, nonlinear problem inversion using a linear approach, Gauss-Newton method, Lavemberg-Marquardt method, Occam method, nonlinear inversion using iterative method, nonlinear inversion using Singular value decomposition, applications;
8. **Global optimization**: lack of nonlinear inversion using linear approaches, Monte Carlo, Genetic Algorithm, Simulated Annealing, applications.

PREREQUISITES

Computational Physics I, Mathematical Physics I and II

MAIN REFERENCES

1. Menke, W., 2012. Geophysical data analysis : discrete inverse theory, 3rd Editions, Elsevier Academic Press, Palisades, New York.
2. Grandis, H., 2009. Pengantar Pemodelan Inversi Geofisika, Himpunan Ahli Geofisika

SUPPORTING REFERENCES

1. Sen, M. K., Stoffa, P.L., 2013. Global Optimization Methods in Geophysical Inversion, 2nd Edition, Cambridge university press.
2. Michael Zhdanov, 2002. Geophysical Inverse Theory and Regularization Problems, Elsevier Academic Press

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to distinguish between forward modelling and backward modelling (inversion)
- LO-2: Students are able to understand and apply L2- and L1-norm for linear regression
- LO-3: Students understand the character of noise in measurement data
- LO-4: Students are able to understand linear inversion for under- and over-determined cases
- LO-5: Students are able to understand the uncertainty of model solutions on the inversion results
- LO-6: Students are able to understand and apply linear inversion a priori for under- and over-determined cases
- LO-7: Students are able to apply several linear inversion methods to solve non-liner problems
- LO-8: Students are able to understand and apply the concept of global optimization and apply it to the inversion process

MAP OF PLO AND LO

	PLO-5	PLO-7	PLO-8	PLO-9	PLO-10	
LO-1	✓	✓	✓	✓	✓	
LO-2	✓	✓	✓	✓	✓	
LO-3	✓	✓	✓	✓	✓	
LO-4	✓	✓	✓	✓	✓	
LO-5	✓	✓	✓	✓	✓	
LO-6	✓	✓	✓	✓	✓	

LO-7	✓	✓	✓	✓	✓	
LO-8	✓	✓	✓	✓	✓	

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184818	:	**Group Theory**
	Credit	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION

This course discusses the principles of symmetry in group theory as a method of simplification, classification and solving of physics problems. Broadly speaking, the discussion of the material is divided into 2, namely the finite group and the continuous group.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE

PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Understand the concept of symmetry in physics and group definitions with simple examples of groups (kinds of numbers, cyclic groups Sn, dehydral groups Dn)
- Understand the concept of Permutation groups and Cayley's Theorem
- Understand the concept of finite groups, properties (class conjugation, subgroups, homomorphism, isomorphism, automorphism), and examples of finite groups
- Calculate and recognize the properties of several finite group examples

- Understand the concept of representation theory and its properties (representation equivalence, character, reducibility), along with vector spaces, scalar products, and unitary representations.
- Understand the concept of irreducible representations (Schur Lemma, fundamental orthogonality theorem, character orthogonality)
- Understand and calculate Character Tables, product representation direc, and their decomposition
- Understand the concept of the continue group and some examples (SO (2), SO (3), SU (2))
- Understand the nature of the continue group (commutation relationship, irreducible representation, character, Clebsch-Gordan coefficient)
- Understand the application of finite groups to the macroscopic properties of crystals and H2O molecules
- Understand the application of finite groups and continue groups at the atomic energy level
- Understand the concept of the SU (N) group and its application to particle physics
- Calculating and applying the concept of SU (N) and SO (N) groups in the model building unified theory

MAIN TOPICS

Symmetry and group definition; Finite group; Group representation theory; continuous group; Applications in quantum mechanics, and crystallography

PREREQUISITES

MAIN REFERENCES

1. Jones, H.F., Groups, Representations and Physics, Institute of Physics, Bristol, 1998

SUPPORTING REFERENCES

1. Joshi, A.W.,' Element of Group Theory for Physicists", Wiley Eastern, New Delhi, 1973
2. Tung, W.K., "Group Theory in Physics", World Scientific, Singapore, 1985.

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the concept of symmetry in physics and group definitions with simple examples of groups (kinds of numbers, cyclic groups Sn, dehydral groups Dn)
- LO-2: Able to understand the concept of Permutation groups and Cayley's Theorem, the concept of finite groups, properties (class conjugation, subgroups, homomorphism, isomorphism, automorphism), and examples of finite groups, and able to calculate and recognize the properties of several finite group examples
- LO-3: Able to understand the concept of representation theory and its properties (representation equivalence, character, reducibility), along with vector spaces, scalar products, and unitary representations.,the concept of irreducible representations (Schur Lemma, fundamental orthogonality theorem, character orthogonality)
- LO-4: Able to understand and calculate Character Tables, product representation direc, and their decomposition
- LO-5: Able to understand the concept of the continue group and some examples (SO (2), SO (3), SU (2))
- LO-6: Able to understand the nature of the continue group (commutation relationship, irreducible representation, character, Clebsch-Gordan coefficient)
- LO-7: Able to understand the application of finite groups to the macroscopic properties of crystals and H2O molecules and the application of finite groups and continue groups at the atomic energy level
- LO-8: Able to understand the concept of the SU (N) group and its application to particle physics and able to calculate and apply the concept of SU (N) and SO (N) groups in the model building unified theory

MAP OF PLO AND LO

	PLO-1	PLO-2	PLO-6	PLO-9		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		
LO-5	✓	✓	✓	✓		

LO-6	✓	✓	✓	✓		
LO-7	✓	✓	✓	✓		
LO-8	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE			
	SF184817	:	**Relativistic Quantum Theory**
	Credit	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
This course discusses material on quantum mechanics in relativistic cases. Discussions of matter ranging from derivation of the Klein-Gordon equation, Dirac, to an introduction to quantum field theory.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}

LEARNING OUTCOME OF THE COURSE

- Able to understand the formulation of the Klein-Gordon, Dirac equation and the solution of the Weyl equation
- Able to understand Maxwell's equation formulation in relativistic notation and Yang-Mills theory
- Be able to understand the second quantization process of the Klein-Gordon, Dirac, EM, and Majorana fields

- Able to understand the mechanism of disturbance theory and its application in simple quantum field systems

MAIN TOPICS

The Klein-Gordon equation, the Dirac equation, the Weyl equation solution, the Maxwell equation, the classical Yang-Mills theory, the Klein-Gordon, Dirac and Majorana quantization of the field, the disturbance theory for simple quantum field systems.

PREREQUISITES

MAIN REFERENCES

1. W. Greiner, Relativistic Quantum Mechanics - Wave Equations, Springer (2000)

SUPPORTING REFERENCES

1. F. Gross, Relativistic Quantum Mechanics and Field Theory, Wiley (1993)
2. F. Mandl and G. Shaw, Quantum Field Theory, rev. ed., Wiley (1994)
3. Halzen, F. and Martin, A.D., Quarks and Leptons, an Introductory Course in Modern Particle Physics, John Wiley and Sons, New York, 1984

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1 Able to understand the formulation of the Klein-Gordon, Dirac equation and the solution of the Weyl equation
- LO-2: Able to understand Maxwell's equation formulation in relativistic notation and Yang-Mills theory
- LO-3: Able to understand the second quantization process of the Klein-Gordon, Dirac, EM, and Majorana fields
- LO-4: Able to understand the mechanism of disturbance theory and its application in simple quantum field systems

MAP OF PLO AND LO

	PLO-1	PLO-2	PLO-6	PLO-9		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		
LO-4	✓	✓	✓	✓		

WORKLOAD
1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week. 3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

MATA KULIAH			
	SF184818	:	**Special Topics On Quantum Physics**
	Kredit	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
This course discusses the popular topics of current quantum physics, including quantum teleportation, quantum computing, and quantum thermodynamics.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-1	able to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that takes into account the norms of religion, society, nation and state as well as scientific ethics in accordance with their field of expertise. [S]
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
LEARNING OUTCOME OF THE COURSE	
• Able to understand about Quantum Computing (Quantum Bits, Quantum Gates, and Quantum Algorithm) • Able to understand Quantum Teleportation • Able to understand the concept of quantum thermodynamics	
MAIN TOPICS	
Quantum Computing (Quantum Bits, Quantum Gates, Quantum Algorithm), Quantum Teleportation, Quantum Thermodynamics	
PREREQUISITES	
-	
MAIN REFERENCES	

M. Nakahara, Quantum Computing, CRC Press(2008)

SUPPORTING REFERENCES

1. M.A. Neilson, I.L. Chuang, Quantum Computation and Quantum Information, Cambridge Press(2000)

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand about Quantum Computing (Quantum Bits, Quantum Gates, and Quantum Algorithm)
- LO-2: Able to understand Quantum Teleportation
- LO-3: Able to understand the concept of quantum thermodynamics

MAP OF PLO AND LO

	PLO-1	PLO-2	PLO-6	PLO-9		
LO-1	✓	✓	✓	✓		
LO-2	✓	✓	✓	✓		
LO-3	✓	✓	✓	✓		

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

MATA KULIAH	**SF 184819**	:	**Biophysics**
	Credit	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
In this course students will learn to understand the concept of biophysics, especially the process of physics in living things and the application of physics in research on living things.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	

- Students understand the basics of biophysics
- Students understand the basic cell
- Students are able to understand DNA and gene material structure

- Students understand physics in the human body
- Students understand the application of physics methods in research on living things
- Students are able to understand biomaterials and the fabrication process

MAIN TOPICS

- Introduction to biophysics
- Cells
- DNA and gene material structure
- Physics in the human body
- The application of physical methods in research on living things
- Biomaterials and fabrication processes

PREREQUISITES

Physics of Radiology and Dosimetry

MAIN REFERENCES

1. Wolter Hoppe, Wolfgang Lohmann, Hubert Marki, and Hubert Ziegler, Springer-Verlag, Biophysics, Berlin, 1983.
2. Roland Glaser, Biophysics. (Springer, 2001)
3. Albert Lehninger, Biochemistry, 2nd Ed., Worth Publisher Inc., New York, 1975

SUPPORTING REFERENCES

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REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Able to understand the basics of biophysics
- LO-2: Able to understand the basic cell
- LO-3: Able to understand DNA and gene material structure
- LO-4: Able to understand physics in the human body
- LO-5: Able to understand the application of physics methods in research on living things
- LO-6: Able to understand biomaterials and the fabrication process

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
LO-1	✓	✓	✓	✓	✓	✓
LO-2	✓	✓	✓	✓	✓	✓
LO-3	✓	✓	✓	✓	✓	✓
LO-4	✓	✓	✓	✓	✓	✓
LO-5	✓	✓	✓	✓	✓	✓

LO-6	✓	✓	✓	✓	✓	✓

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF 184820	:	**Radiotherapy**
	Credit	:	3 SKS
	Semester	:	VIII

COURSE DESCRIPTION
In this course, students will learn to understand the application of external and internal radiation beams produced by therapeutic aircraft as well as external, brachytherapy, and internal radiotherapy planning.

PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE

PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

LEARNING OUTCOME OF THE COURSE

- Students understand an introduction to radiation oncology
- Students understand the basics of radiobiology in radiotherapy

- Students are able to understand clinical photon file description, dose calculation
- Students understand the basic principles of clinical dosimetry
- Students understand the principles of clinical electron beam
- Students are able to understand single field and multi-field radiotherapy planning
- Students are able to understand the principles of planning with various techniques (2D, 3D, conformal, IMRT, IGRT)
- Students are able to understand the working principles of simulators and introduction to various radiotherapy accessories
- Students are able to understand the working principles of simulators and introduction to various radiotherapy accessories
- Students are able to understand the principles of intracavital brachytherapy, implantation, intraluminal
- Students are able to understand brachytherapy dose calculations
- Students are able to understand internal radiotherapy and internal dosimetry

MAIN TOPICS

- Introduction to radiation oncology
- Radiobiological basis in radiotherapy
- Clinical photon beam description, point dose calculation, Clinical dosimetry basics
- Clinical electron file
- Single-field and multi-field radiotherapy planning.
- Planning with various techniques (2D, 3D, conformal, IMRT, IGRT)
- The working principle of the simulator and the introduction of various radiotherapy accessories
- Principles of dose calculation and calibration of external radiotherapy
- Introduction of intracavital brachytherapy, implantation, intraluminal
- Brachytherapy dose calculation
- Introduction of internal radiotherapy and internal dosimetry

PREREQUISITES

Fisika Radiologi dan Dosimetri

MAIN REFERENCES

4. AAPM Report No. 46. Comprehensive QA for Radiation Oncology. (American Institute of Physics, New York, 1994)
5. AAPM Report No. 47. AAPM Code of Practice for Radiotherapy Accelerator. (American Institute of Physics, New York, 1994)

6. AAPM Report No. 67. Protocol for Clinical Reference Dosimetry of High Energy Photon and Electron Beams. (American Institute of Physics, New York, 1999).
7. IAEA Report No. 23. Absorbed Dose Determination in Photon and Electron Beams. An International Code of Practice. (International Atomic Energy Agency, Vienna, Austria, 1987).
8. ICRU Report No. 38. Dose and Volume Specifications for Reporting Intracavitary Therapy in Ginecology. (International Commission on Radiation Unit and Measurements, Bethesda, MD, 1985).
9. ICRU Report No. 50. Prescribing, Recording and Reporting Photon Beam Therapy. (International Commission on Radiation Unit and Measurements, Bethesda, MD, 1993).
10. H. E. Johns and J. R. Cunningham. The Physics of Radiology, 4th ed. (Charles C. Thomas, Springfield, IL, 1983)
11. S. C. Klevenhagen, Physics and Dosimetry of Therapy Electron Beams. (Medical Physics Publishing, Madison, WI, 1993)
12. W. J. Meredith and J. B. Massey. Fundamental Physics of Radiology. 3rd ed. (J. Wright, Bristol, UK, 1977)
13. J. Van Dyk (Editor). The Modern Technology of Radiation Oncology (Medical Physics Publishing, Philadephia, PA, 1999)
14. J. R. Williams and D. I. Thwaites. Radiotherapy Physics in Practice. (Oxford University Press, New York, 1994)
15. Siamak Shahabi (Editor). Blackburn's Introduction to Clinical Radiation Therapy Physics. (Medical Physics Publishing Corporation, Madison, Wisconsin, 1989)
16. P. M. K. Leung. The Physical Basis of Radiotherapy. (The Ontario Cancer Institute incorporating The Princess Margaret Hospital, 1990).
17. G. C. Bentel, C. E. Nelson, and K.T. Noell. Treatment Planning Dose Calculation in Radiation Oncology. McGraw Hill, New York, NY, 1989)
18. Metcalfe, et al, The Physics of Radiotherapy X-rays and Electron. (Medical Physics Publishing, 2007)
19. G. C. Bentel, C. E. Nelson, and K.T. Noell. Treatment Planning Dose Calculation in Radiation Oncology. McGraw Hill, New York, NY, 1989)
20. Podgorsak, Radiation Oncology Physics: Handbook for Teacher and Student. (IAEA, 2005)
21. Khan, Gerbi. Treatment Planning in Radiation Oncology. Lippincott Williams & Wilkins, Philadelphia: 2012
22. J. R. Williams and D. I. Thwaites. Radiotherapy Physics in Practice. (Oxford University Press, New York, 1994)

SUPPORTING REFERENCES

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REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students are able to understand an introduction to radiation oncology and the basics of radiobiology in radiotherapy
- LO-2: Students are able to understand clinical photon file description, dose calculation, the basic principles of clinical dosimetry, and the principles of clinical electron beam
- LO-3: Students are able to understand single field and multi-field radiotherapy planning
- LO-4: Students are able to understand the principles of planning with various techniques (2D, 3D, conformal, IMRT, IGRT)
- LO-5: Students are able to understand the working principles of simulators and introduction to various radiotherapy accessories
- LO-6: Students are able to understand the principles of intracavital brachytherapy, implantation, intraluminal
- LO-7: Students are able to understand brachytherapy dose calculations
- LO-8: Students are able to understand internal radiotherapy and internal dosimetry

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
LO-1	✓	✓	✓	✓	✓	✓
LO-2	✓	✓	✓	✓	✓	✓
LO-3	✓	✓	✓	✓	✓	✓
LO-4	✓	✓	✓	✓	✓	✓
LO-5	✓	✓	✓	✓	✓	✓
LO-6	✓	✓	✓	✓	✓	✓
LO-7	✓	✓	✓	✓	✓	✓
LO-8	✓	✓	✓	✓	✓	✓

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.

COURSE	SF184821	:	**Health Physics and Radiation Protection**
	Credit	:	2 SKS
	Semester	:	VIII

COURSE DESCRIPTION	
In this course students will learn to understand the basic principles and concepts of health physics and radiation protection as well as several techniques in radiation protection and be able to apply them in medical physics applications.	
PROGRAMME LEARNING OUTCOME (PLO) OF THE COURSE	
PLO-2	able to demonstrate independent and responsible performance in the application of science and technology in the analysis of information and data compiled for problem solving in the field of physics expertise. [S]
PLO-6	able to apply the theoretical concepts of classical physics and modern physics in depth through identification of the physical properties of a physical system. [P]
PLO-7	able to apply the principles and applications of mathematical physics, computational physics, and instrumentation in both how to operate physical instruments in general and analyse data and information from these instruments. [P]
PLO-8	able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P]
PLO-9	able to formulate physical phenomena and problems and be able to make mathematical or physical modelling / simulations that fit the hypothesis based on the results of observations and experiments carried out. {KK}
PLO-10	able to comprehensively solve physical problems with various alternative solutions and analyse existing physical systems and predict the potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}
LEARNING OUTCOME OF THE COURSE	
• Students understand the basics of radiation in medical physics	

- Students understand the basic principles of shielding, its properties and design
- Students understand the basic principles of nuclear enumeration statistics
- Students understand the basic principles of radiation monitoring for personnel
- Students understand the basic principles of internal exposure
- Students understand the basic principles of environmental dispersion
- Students understand the biological effects of radiation
- Students understand the regulations regarding radiation protection
- Students understand the basic principles of low and high degree waste disposal
- Students understand the basic principles of non-ionizing radiation

MAIN TOPICS

- preliminary
- Shielding: Nature and design
- Nuclear enumeration statistics
- Radiation monitoring for personnel
- Internal exposure
- Environmental dispersion
- Biological effects
- Regulations regarding radiation protection
- Low and high grade waste disposal
- Non-ionizing radiation

PREREQUISITES

Modern Physics, Radiology

MAIN REFERENCES

1. ICRP No. 60. 1990 Recommendations of International Commission on Radiological Protection. (Elsevier Science, 1990).
2. Herman Cember and Thomas E. Jhonson, Introduction to Health Physics. 4th ed., (McGraw Hill. New York, NY. 2009).

SUPPORTING REFERENCES

1. RL. Kathren, Radiation Protection. (Adam Hilger LTD., Bristol, 1985).
2. D. A. Gollnick. Basic Radiation Protection Technology. 2nd ed. (Pacific Radiation Corporation, Altadena, CA, 1993).

REFORMULATED COURSE LEARNING OUTCOME (LO)

- LO-1: Students understand the basics of radiation in medical physics, the basic principles of shielding, its properties and design

- LO-2: Students understand the basic principles of nuclear enumeration statistics
- LO-3: Students understand the basic principles of radiation monitoring for personnel
- LO-4: Students understand the basic principles of internal exposure
- LO-5: Students understand the basic principles of environmental dispersion
- LO-6: Students understand the biological effects of radiation and the regulations regarding radiation protection
- LO-7: Students understand the basic principles of low and high degree waste disposal
- LO-8: Students understand the basic principles of non-ionizing radiation

MAP OF PLO AND LO

	PLO-2	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10
LO-1	✓	✓	✓	✓	✓	✓
LO-2	✓	✓	✓	✓	✓	✓
LO-3	✓	✓	✓	✓	✓	✓
LO-4	✓	✓	✓	✓	✓	✓
LO-5	✓	✓	✓	✓	✓	✓
LO-6	✓	✓	✓	✓	✓	✓
LO-7	✓	✓	✓	✓	✓	✓
LO-8	✓	✓	✓	✓	✓	✓

WORKLOAD

1. Lectures : 3 x 50 = 150 minutes per week.
2. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week.
3. Private learning : 2 x 60 = 120 minutes (2 hours) per week.