MODULE HANDBOOK

Physics Undergraduate

Study Program

Curriculum 2018-2023

TABLE OF CONTENT

CURRICULUM DEPARTMENT OF PHYSICS 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,

Learning Outcome of Bachelor Program Graduates (S1)		
		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

Learning Outcome of Bachelor Program Graduates (S1)		
	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 / 6.4
2	SF184102	Mathematical Physics I	2 / 3.2
3	KM184101	Mathematics I	3 / 4.8
4	SK184101	Chemistry I	3 / 4.8
5	SB184161	Biology	2 / 3.2
6	UG184911	Pancasila	2 / 3.2
7	UG184914	English	2 / 3.2
		Total Credits (SKS / ECTS)	18 / 28.8
		SEMESTER II	
1	SF184202	Physics II	3 / 4.8
2	SF184203	Physics III	3 / 4.8
3	KM184201	Mathematics II	3 / 4.8
4	SK184202	Chemistry II	3 / 4.8
5	UG184913	Citizenship	2 / 3.2
6	UG184912	Bahasa Indonesia	2 / 3.2
7	UG1849XX	Religion	2 / 3.2
		Total Credits (SKS / ECTS)	18 / 28.8

		SEMESTER III	
1	SF184301	Mechanics I	3 / 4.8
2	SF184302	Waves	3 / 4.8
3	SF184303	Thermodynamics	3 / 4.8
4	SF184304	Mathematical Physics II	4 / 6.4
5	SF184305	Electronics	4 / 6.4

No.	Course Code	Name of Course	Credits (SKS / ECTS)
6	SF184306	Physical Measurement Methods	2 / 3.2
		Total Credits (SKS / ECTS)	19 / 30.4
		SEMESTER IV	
1	SF184401	Mechanics II	3 / 4.8
2	SF184402	Optics	3 / 4.8
3	SF184403	Modern Physics	4 / 6.4
4	SF184404	Mathematical Physics III	4 / 6.4
5	SF184405	Instrumentation	4 / 6.4
6	SF184406	Material Science	2 / 3.2
		Total Credits (SKS / ECTS)	20 / 32
		SEMESTER V	
1	SF184501	Quantum Physics	4 / 6.4
2	SF184502	Electromagnetic Fields I	3 / 4.8
3	SF184503	Laboratory Physics	2 / 3.2
4	SF184504	Computational Physics I	3 / 4.8
5	SF184505	Optoelectronics	2 / 3.2
6	SF184506	Digital Data Acquisition	2 / 3.2
		Total Credits (SKS / ECTS)	16 / 25.6

		SEMESTER VI	
1	SF184601	Statistical Physics	3 / 4.8
2	SF184602	Electromagnetic Fields II	3 / 4.8
3	SF184603	Laboratory Physics II	2 / 3.2
4	SF184604	Computational Physics II	3 / 4.8
5	SF184605	Geophysics Exploration Methods	2 / 3.2

No.	Course Code	Name of Course	Credits (SKS / ECTS)
6	UG184916	Insight and Application of Technology	3 / 4.8
		Total Credits (SKS / ECTS)	16 / 25.6
		SEMESTER VII	
1	SF184701	Nuclear Physics	4 / 6.4
2	SF184702	Solid State Physics	4 / 6.4
3	SF184703	Scientific Writing Methods	2 / 6.4☆
4	UG184915	Technopreneurship	2 / 3.2
5	SF184704	Physics of Radiology and Dosimetry	2 / 3.2
6	SF1847XX	Elective Coursses	6 / 9.6
		Total Credits (SKS / ECTS)	20 / 35.2
		SEMESTER VIII	
1	SF184801	Final Projact	6 / 16☆☆
2	SF184802	Laboratory Management	2 / 3.2
3	SF1848XX	Elective Courses	6 / 9.6
4	SF1848XX*	Enrichment courses (Physics of the Universe)	3 / 4.8
		Total Credits (SKS / ECTS)	17 / 33.6

No.	Course Code	Name of Course	Credits (SKS / ECTS)
		ADDITIONAL	
1	SF181101	Physics I	4 / 6.4
2	SF181201	Physics II	3 / 4.8
3	SF181103	Physics I	3 / 4.8
4	SF181104	Physics I	3 / 4.8
		Total Credits (SKS / ECTS)	13 / 20.8

ELECTIVE COURSES

No.	Course Code	Name of Course	Credits (SKS / ECTS)
		SEMESTER VII	
1	SF184702	Physics of Metal	3 / 4.8
2	SF184712	Physics of Ceramics	3 / 4.8
3	SF184713	Physics of Polymers	3 / 4.8
4	SF184721	Microcontrollers and Microprocessors	3 / 4.8
	SF184822	Electro-acoustics	3 / 4.8
5	SF184731	Fiber Optics	3 / 4.8
6	SF184732	Photonics	3 / 4.8
7	SF184741	Geology	3 / 4.8
8	SF184742	Seismology	3 / 4.8
9	SF184743	Earth Electricity Exploration	3 / 4.8
10	SF184751	Introduction to Particle Physics	2 / 3.2
11	SF184752	Advanced Mathematical Physics	2 / 3.2
	SF184753	Introduction to Relativity	3 / 4.8
12	SF184761	Anatomy and Physiology	2 / 3.2
13	SF184762	Medical Imaging Physics	2 / 3.2
14	SF184763	Medical Instrumentation	2 / 3.2
15	SF184764	Radiobiology	2 / 3.2
		Total Credits (SKS / ECTS)	45 / 72
		SEMESTER VIII	
1	SF184811	Physics of Composite	3 / 4.8
2	SF184812	Physics of Semiconductor	3 / 4.8
3	SF184813	Material Analysis Methods	3 / 4.8
4	SF184821	Physics of Building	3 / 4.8
5	SF184822	Intelligent Instrumentation and Control	3 / 4.8

No.	Course Code	Name of Course	Credits (SKS / ECTS)
6	SF184823	Heat Transfer	2 / 3.2
7	SF184824	Industrial Instrumentation	3 / 4.8
8	SF184831	Optical Computation	3 / 4.8
9	SF184832	Digital Imaging Processing	3 / 4.8
10	SF184833	Applied Electromagnetics	3 / 4.8
11	SF184841	Seismic Exploration	3 / 4.8
12	SF184842	Earth Potential Field Exploration	3 / 4.8
13	SF184843	Rock Physics and Well Log Analysis	3 / 4.8
14	SF184844	Inversion Model	3 / 4.8
15	SF184851	Group Theory	2 / 3.2
16	SF184852	Relativistic Quantum Theory	2 / 3.2
17	SF184853	Special Topics on Quantum Physics	3 / 4.8
18	SF184861	Biophysics	2 / 3.2
19	SF184862	Radiotherapy	3 / 4.8
20	SF184863	Health Physics and Radiation Protection	2 / 3.2
		Total Credits (SKS / ECTS)	45 / 72

ENRICHMENT COURSES

No.	Course Code	Name of Course	Credits (SKS / ECTS)
		ENRICHMENT COURSES	
1	SF184899*	Physics of the Universe	3 / 4.8
		Total Credits (SKS / ECTS)	3 / 4.8

1. SF184101 - Physics 1

Module Name	Physics 1
Module level, if applicable	Preparation Stage
Code, if applicable	SF184101
Subtitle, if applicable	-
Course, if applicable	Physics 1
Semester(s) in which the module is taught	1st Semester
Person responsible for the module	Susilo Indrawati
Lecturer	A teaching Team of all DoP Lecturers
Language	Indonesian (Regular Class) English (IUP Class)
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 2 time x 30 week per Semester Practicum : 170" per week X 6 time per Semester
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
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes	***Cognitive:*** 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]

<table>
<tr><td></td><td>Psychomotor:
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}

Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>
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
</td></tr>
<tr><td>Map of PLO and LO</td><td>
<table>
<tr><th></th><th>PLO-6</th><th>PLO-9</th></tr>
<tr><td>LO-1</td><td>✓</td><td></td></tr>
<tr><td>LO-2</td><td>✓</td><td></td></tr>
<tr><td>LO-3</td><td>✓</td><td></td></tr>
<tr><td>LO-4</td><td>✓</td><td></td></tr>
<tr><td>LO-5</td><td>✓</td><td></td></tr>
<tr><td>LO-6</td><td>✓</td><td></td></tr>
<tr><td>LO-7</td><td>✓</td><td></td></tr>
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	| **LO-8** | | ✓ |
Content	**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 dynamic**s: 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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice and Practicum ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	Main Refferences: 1. Halliday, Resnic, Jearl Walker ; 'Fundamental of Physics'. John Wiley and Sons, 10th ed, New York, 2014 2. Douglas C. Giancoli, 'Physics for Scientists and Engineers, Pearson Education, 4th 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 Refferences: 1. Sears & Zemanky,"University Physics", Pearson Education, 14thed, USA, 2016 2. Tipler, PA, 'Physics for Scientists and Engineers ',6th ed, W.H. Freeman and Co, New York, 2008

2. SF184102 - Mathematical Physics I

Module Name	Mathematical Physics I
Module level, if applicable	Preparation Stage
Code, if applicable	SF184102
Subtitle, if applicable	-
Course, if applicable	Mathematical Physics I
Semester(s) in which the module is taught	1st Semester
Person responsible for the module	Suminar Pratapa
Lecturer	Melania S. Muntini, Suminar Pratapa, Ali Yunus Rohedi
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2.5 hours x 16 weeks per Semester
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.
Credit points	2 SKS ~ 3.3 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor:*** PLO 8 - Able to apply the principles, characteristics,

	functions, and relevant and updated technological applications in the field of physics and software applications. [P] ***Affective***: Following the rules of the courses
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	(see table below)
Content	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.

Map of PLO and LO:

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

Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	Main Refferences: 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 Refferences: 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 I

3. SF184202 - Physics 2

Module Name	Physics 2
Module level, if applicable	Preparation Stage
Code, if applicable	SF184202
Subtitle, if applicable	-
Course, if applicable	Physics 2
Semester(s) in which the module is taught	2nd Semester
Person responsible for the module	Susilo Indrawati
Lecturer	All lecturers in a team teaching
Language	Indonesian (Regular class) English (IUP class)
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 2 time x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor*: -** ***Affective***: Following the rules of the courses

<table>
<tr><td>LO</td><td>

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.

</td></tr>
<tr><td>Map of PLO and LO</td><td>
<table>
<tr><th></th><th>PLO-6</th></tr>
<tr><td>LO-1</td><td>✓</td></tr>
<tr><td>LO-2</td><td>✓</td></tr>
<tr><td>LO-3</td><td>✓</td></tr>
<tr><td>LO-4</td><td>✓</td></tr>
<tr><td>LO-5</td><td>✓</td></tr>
<tr><td>LO-6</td><td>✓</td></tr>
<tr><td>LO-7</td><td>✓</td></tr>
<tr><td>LO-8</td><td>✓</td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>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</td></tr>
</table>

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element/variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	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 PrasetioR.W.Adi), "Fisika : untuk SainsTeknik, Jilid 2", Erlangga, Jakarta, 1998

4. SF184203 - Physics 3

Module Name	**Physics III**
Module level, if applicable	Preparation Stage
Code, if applicable	SF184203
Subtitle, if applicable	-
Course, if applicable	Physics III
Semester(s) in which the module is taught	2nd Semester
Person responsible for the module	Gatut Yudoyono
Lecturer	Gatut Yudoyono, Fahmi Astuti
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3x50"x 16 weeks per Semester
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
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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] ***Psychomotor*:** PLO 8 - able to apply the principles, characteristics,

	functions, and relevant and updated technological applications in the field of physics and software applications. [P] ***Affective***: Following the rules of the courses
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	(see table below)
Content	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,

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

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	Main Refferences: 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 Refferences: 1. Tipler, PA,(ted. L PrasetioR.W.Adi), "Fisika : untuk SainsTeknik, Jilid 2", Erlangga, Jakarta.

5. SF184301 - Mechanics I

Module Name	Mechanics I
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184301
Subtitle, if applicable	-
Course, if applicable	Mechanics I
Semester(s) in which the module is taught	3rd Semester
Person responsible for the module	Gontjang Prajitno
Lecturer	Mochamad Zainuri, Gontjang Prajitno
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3x50"x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics I (minimum grade D)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distance and levelling ***Affective***: Following the rules of the courses

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	<table><tr><td></td><td>**PLO-6**</td></tr><tr><td>**LO-1**</td><td>✓</td></tr><tr><td>**LO-2**</td><td>✓</td></tr><tr><td>**LO-3**</td><td>✓</td></tr><tr><td>**LO-4**</td><td>✓</td></tr><tr><td>**LO-5**</td><td>✓</td></tr><tr><td>**LO-6**</td><td>✓</td></tr><tr><td>**LO-7**</td><td>✓</td></tr></table>
Content	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)
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	Main Refferences: 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 Refferences: 1. R. Douglas Gregory, "Classical Mechanics", Cambridge University Press Uk, 2006

6. SF184302 - Waves

Module Name	Waves
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184302
Subtitle, if applicable	-
Course, if applicable	Waves
Semester(s) in which the module is taught	3rd Semester
Person responsible for the module	Gatut Yudoyono
Lecturer	Gatut Yudoyono, Sudarsono, Nurrisma Puspitasari
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics III
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** **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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling

	Affective: Following the rules of the courses
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	(see table below)
Content	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

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

	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.

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	Main Refferences: Pain, H.J., “The Physics of Vibrations and Waves”, John Wiley & Sons Ltd., 6-Ed., 2005 Supporting Refferences: Pedrotti, F.L. and Pedrotti, L.S., “Introduction to Optics”, Prentice-Hall, 1987

7. SF184303 - Thermodynamics

Module Name	**Thermodynamics**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184303**
Subtitle, if applicable	-
Course, if applicable	Thermodynamics
Semester(s) in which the module is taught	3rd Semester
Person responsible for the module	Malik Anjelh Baqiya
Lecturer	Suasmoro, Malik Anjelh Baqiya, Linda Silvia
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2.5 hours x 16 weeks per Semester
Workload	Class: 2.5 hours x 14 weeks = 35 hours Structured activities : 2.83 hours x 14 weeks = 40 hours Independent Study: 2.83 hours x 14 weeks = 40 hours Exam: 2 hours x 4 time = 8 hours Total = 123 hours 3 SKS -> 150 menit
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Contoh terkait dengan persyaratan exam Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics III
Module objectives/intendedlearning outcomes (PLO)	**Cognitive:** **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]

<table>
<tr><td></td><td>Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>• 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</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-6</th></tr><tr><td>LO-1</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>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</td></tr>
</table>

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.
Reading list	Main Refferences: 1. Zemansky, M.W, & R. H. Dittmann (terj: The Houw Liong, Ph.D)," KalorTermodinamika", penerbit ITB, 1986. 2. Sears. F.W., "An Introduction to Thermodynamics: the Kinetic Theory of Gases and Statistical Mechanics", Addison Wesley, 1963. Supporting Refferences: 1. Callen H.B. "Thermodynamics And An Introduction To Thermostatistics",2ed., Wiley, New York, 1985

8. SF184304 - Mathematical Physics II

Module Name	**Mathematical Physics II**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184304
Subtitle, if applicable	-
Course, if applicable	Mathematical Physics II
Semester(s) in which the module is taught	3rd Semester
Person responsible for the module	Heru Sukamto
Lecturer	Melania S. Muntini, Heru Sukamto, Fahmi Astuti, Diky Anggoro
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 4 x 50”x 16 week per Semester
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.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Mathematical Physics I (Minimum grade D)
Module objectives/intendedlearning outcomes (PLO)	**Cognitive:** **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] **Psychomotor:**

	PLO 8 - able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software applications. [P] ***Affective***: Following the rules of the courses
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	(see table below)

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

Content	• **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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom.

Reading list	Main Refferences: 1. Marry L Boas, . Mathematical Methods in the Physical Sciences 3rd Ed., John Wiley and Sons, 2006. Supporting Refferences: 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.

9. SF184305 - Electronics

Module Name	Electronics
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184305
Subtitle, if applicable	-
Course, if applicable	Electronics
Semester(s) in which the module is taught	3rd Semester
Person responsible for the module	Suyatno
Lecturer	Diky Anggoro, Suyatno, Iim Fatimah, Bachtera Indarto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 4 x 50" x 16 week Per Semester
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
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics II (Minimum grade C)
Module objectives/intendedlearning outcomes (PLO)	**Cognitive:** 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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	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

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

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice and practicum ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.

Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Charles K. Alexander, Matthew N. O. Sadiku, Fundamentals of Electric Circuits, Fifth Edition, 2012. 2. J. W. NilsssonS. 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 Refferences: 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.

10. SF184306 - Physical Measurement Methods

Module Name	Physical Measurement Methods
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184306
Subtitle, if applicable	-
Course, if applicable	Physical Measurement Methods
Semester(s) in which the module is taught	3rd Semester
Person responsible for the module	Diky Anggoro
Lecturer	Diky Anggoro, Bachtera Indarto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Physics I 2. Physics II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	- 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)
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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

Map of PLO and LO:

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

	Supporting Refferences: Imron, A., "Diktat Analisa Pengukuran Fisis", Fisika, MIPA-ITS

11. SF184401 - Mechanics II

Module Name	Mechanics II
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184401
Subtitle, if applicable	-
Course, if applicable	Mechanics II
Semester(s) in which the module is taught	4th Semester
Person responsible for the module	Gontjang Prajitno
Lecturer	Gontjang Prajitno, Triwikantoro, Mashuri
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Mechanics I (minimum grade D)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses

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	<table><tr><th></th><th>PLO-6</th></tr><tr><td>**LO-1**</td><td>✓</td></tr><tr><td>**LO-2**</td><td>✓</td></tr><tr><td>**LO-3**</td><td>✓</td></tr><tr><td>**LO-4**</td><td>✓</td></tr><tr><td>**LO-5**</td><td>✓</td></tr></table>
Content	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 3. Frank M.White, "Fluid Mechanics", 8 th Ed, Mc Graw Hill, USA, 2016 Supporting Refferences: 1. R. Douglas Gregory, "Classical Mechanics", Cambridge University Press Uk, 2006

12. SF184402 - Optics

Module Name	Optics
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184402
Subtitle, if applicable	-
Course, if applicable	Optics
Semester(s) in which the module is taught	4th Semester
Person responsible for the module	Gatut Yudoyono
Lecturer	Gatut Yudoyono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Waves
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses

<table>
<tr><td>LO</td><td>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,</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-6</th></tr><tr><td>LO-1</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td></tr><tr><td>LO-7</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>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</td></tr>
</table>

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Hecht E., “Optics”, Pearson Education Limited, 5th-edition, 2017 2. Pedrotti, F.L.Pedrotti, L.S., “Introduction to Optics”, Prentice-Hall, 1987 Supporting Refferences: 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

13.SF184403 - Modern Physics

Module Name	**Modern Physics**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184403
Subtitle, if applicable	-
Course, if applicable	Modern Physics
Semester(s) in which the module is taught	4th Semester
Person responsible for the module	Mashuri
Lecturer	Mashuri, Zaenal Arifin, M. Zainuri, Retno Asih
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week pers Semester Private learning : 2 x 60" (2 hours) x 16 week per semester
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.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Physics I 2. Physics II 3. Physics III
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** **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]

	Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	see table below
Content	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Beiser, A., "Concepts of Modern Physics", McGraw Hill, Sixth Edition, New York, 2003. 2. Krane, S.K (terj: Hans J. Wospakrik), "Fisika Modern", UI Press, Jakarta, 1992. Supporting Refferences: 1. Eisberg, R. & Resnicks, R., "Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles", John Wiley & Sons, New York, 2nd Ed., 1985.

Map of PLO and LO:

	PLO-6
LO-1	✓
LO-2	✓
LO-3	✓
LO-4	✓

	2. Serway, R.A, Moses, C.J and Moyer, C.A, “Modern Physics”, third edition, 2005. (E-Book) 3. Singh, R.B, “Introduction to Modern Physics, New Age International Publishers, ” Volume 1, 2nd ed, 2009 (E-Book)

14. SF184404 - Mathematical Physics III

Module Name	**Mathematical Physics III**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184404
Subtitle, if applicable	-
Course, if applicable	**Mathematical Physics III**
Semester(s) in which the module is taught	4th Semester
Person responsible for the module	Bintoro A. Subagyo
Lecturer	Bintoro A. Subagyo, Heru Sukamto, Melania S. Muntini
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 1. Lectures : 3 x 50" x 16 week per Semster 2. Private learning : 2 x 60" (2 hours) x 16 week per Semester
Workload	3. Lectures : 3 x 50 = 150 minutes per week. 4. Exercises and Assignments : 2 x 60 = 120 minutes (2 hours) per week. 5. Private learning : 2 x 60 = 120 minutes (2 hours) per week.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Mathematical Physics II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	see table below
Content	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

Map of PLO and LO:

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

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Marry L Boas, . MathematicalMethods in thePhysicalSciences 3rd Ed., John Wileyand Sons, 2006 Supporting Refferences: 1. George B. Arfken& Hans J. Weber, Mathematica lMethods for Physicists, Sixth Edition: A Comprehensive Guide, Academic Press, 2005

15. SF184405 - Instrumentation

Module Name	Instrumentation
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184405**
Subtitle, if applicable	-
Course, if applicable	INSTRUMENTATION
Semester(s) in which the module is taught	4th Semester
Person responsible for the module	Diky Anggoro
Lecturer	Diky Anggoro, Susilo Indrawati
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester Practicum : 170" x 16 week per Semester
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.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	ELECTRONICS, MPF (minimum grade D)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	1 Op-Amp: Non-linear amplifier, Functional amplifier, Instrumentation Amplifier, and circuit amplifier application 2 Active filters, frequency response, Nyquist, bode diagram, Oscilator

Map of PLO and LO:

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

	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)
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice and practicum ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 YuwanaMelania Muntini S (2009), Laporan Hibah Pengajaran:“Pengajaran Elektronika Digital BerbasisLaboratorium”, Program Hibah Kompetisi PHKI Program B, ITS Surabaya. Supporting Refferences: 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

16. SF184406 - Material Science

Module Name	**Material Science**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184406**
Subtitle, if applicable	-
Course, if applicable	**Material Science**
Semester(s) in which the module is taught	4th Semester
Person responsible for the module	Darminto
Lecturer	Darminto, M. Zainuri, Triwikantoro, Suasmoro
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS

Requirements according to the examination regulations	Contoh terkait dengan persyaratan exam Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Physics I, II, and III 2. Chemistry 3. Mathematics I and II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor*****:** Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective*****:** Following the rules of the courses
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	✓	✓	✓

Content	• 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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 1. Smith, W.F., "Principles of Materials Science and Engineering", 3rd Edition, McGraw-Hill, Inc (International Edition), New York, 1996.

17. SF184501 - Quantum Physics

Module Name	**Quantum Physics**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184501**
Subtitle, if applicable	-
Course, if applicable	**Quantum Physics**
Semester(s) in which the module is taught	5th Semester
Person responsible for the module	Agus Purwanto
Lecturer	Agus Purwanto, Heru Sukamto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): Lectures : 3 x 50" x 16 week per Semester
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.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Modern Physics (Minimum grade D)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor*: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	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

Map of PLO and LO:

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

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. S. Gasiorowicz, “Quantum Physics”, 3rd Ed., Wiley Internat. Ed.,USA, 2003. Supporting Refferences: 1. A. Purwanto, “Fisika Kuantum”, Gava Media, Yogyakarta, 2006. 2. Libofs, R.L,“Introductory Quantum Mechanics” Wesley Publishing Company, 2nd.th, New York, 1992

18. SF184502 - Electromagnetic Fields I

Module Name	**Electromagnetic Fields I**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184502
Subtitle, if applicable	-
Course, if applicable	Electromagnetic Fields I
Semester(s) in which the module is taught	5th Semester
Person responsible for the module	Gontjang Prajitno
Lecturer	Gontjang Prajitno
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Physics II 2. Mathematical Physics III
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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;

	Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	see table below
Content	• 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

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

	• Inductance: Inductance, energy current system, Neumann formula • Electromagnetic Field: Maxwell's Postulate, Electromagnetic Waves in a Hollow
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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

19. SF184503 - Laboratory Physics I

Module Name	**Laboratory Physics I**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184503**
Subtitle, if applicable	-
Course, if applicable	**Laboratory Physics I**
Semester(s) in which the module is taught	5th Semester
Person responsible for the module	Faridawati
Lecturer	Faridawati
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester Practicum : 170” x 16 week per Semester
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
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Waves and Modern Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, Practicum-based learning
Reading list	Main Refferences: 1. Tim Asisten Fisika Madya. 2016. Modul praktikum Fisika Modern 2. Tim Asisten Fisika Madya. 2016. Modul praktikum Fisika Gelombang Supporting Refferences:

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

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20. SF184504 - Computational Physics I

Module Name	**Computational Physics I**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184504**
Subtitle, if applicable	-
Course, if applicable	Computational Physics I
Semester(s) in which the module is taught	5th Semester
Person responsible for the module	Sungkono
Lecturer	Sungkono, Ali Yunus Rohedi
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50” x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓

Content	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Erwin Kreyszig, 'Advanced Engineering Mathematics', Wiley International Edition, 9th 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 Refferences: 1. Bagus J.Santosa, 'Buku Ajar Fisika Komputasi', Jurusan Fisika FMIPA-ITS.

21. SF184505 - Optoelectronics

Module Name	Optoelectronics
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184505
Subtitle, if applicable	-
Course, if applicable	Optoelectronics
Semester(s) in which the module is taught	5th Semester
Person responsible for the module	Sudarsono
Lecturer	Sudarsono, Faridawati, Nurrisma P.
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] ***Psychomotor*: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective*: Following the rules of the courses
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	see table below
Content	● 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

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

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: John Wilson & Hawkes," Optoelctronics An Introduction' Third Edition, Prentice Hall, mexico, Paris 1998 Supporting Refferences: 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

22. SF184506 - Digital Data Acquisition

Module Name	DIGITAL DATA ACQUISITION
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184506
Subtitle, if applicable	-
Course, if applicable	DIGITAL DATA ACQUISITION
Semester(s) in which the module is taught	5th Semester
Person responsible for the module	Iim Fatimah
Lecturer	Iim Fatimah, Melania S. Muntini
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Electronics, minimum grade D
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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

<table>
<tr><td></td><td>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}
Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>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</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-2</th><th>PLO-7</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>Converter: analog to digital converter (ADC), digital to analog converter (DAC),
Signal processing: Quantization of signals and SNR
Digital data processor: Introduction Microprocessor, microcontroller, computer, digital filter, Fast Fourier Transform,)
Intelligent systems: Artificial neural networks, fuzzy logic, genetic algorithms</td></tr>
</table>

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation
Reading list	Main Refferences: 1. Bucha,D., "Applied Electronic Instrumentation & Measurement",Maxwell MacMillan Int, 1992 2. Simpson,C.D., " Industrial Electronics", Prentice Hall, 1996 Supporting Refferences: 1. Indarto, B., "Diktat Fisika Instrumentasi I", Fisika MIPA-ITS, Surabaya, 2003 2. Soetrisno, Elektroninka Dasar 1,2, Penerbit ITB, 1986

23. SF184601 - Statistical Physics

Module Name	STATISTICAL PHYSICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184601
Subtitle, if applicable	-
Course, if applicable	STATISTICAL PHYSICS
Semester(s) in which the module is taught	6th Semester
Person responsible for the module	Suasmoro
Lecturer	Suasmoro, Heru Sukamto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Thermodynamics (Minimum grade D)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distance and levelling ***Affective***: Following the rules of the courses
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	(see table below)

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

LO-7	✓	✓
LO-8	✓	✓

Content	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation
Reading list	Main Refferences: **1.** Pointon, A.J.,"An Introduction to Statistical Physics", Longman Grup Ltd., London, 1978 **2.** Yoshioka, D,''Statistical Physics : an introduction", Springer, 2007 Supporting Refferences: **1.** Purwanto, A.(2007).'Fisika Statistik', GavaMedia, Yogyakarta. **2.** Sontagg, R.E.van Wylen, G.J.(1991).'Introduction to Thermodynamics, Classical and Statistical', 3rd edition, John Wiley & Sons: New York.

24. SF184602 - Electromagnetic Fields II

Module Name	ELECTROMAGNETIC FIELDS II
Module level, if applicable	Undergraduate stage
Code, if applicable	SF184602
Subtitle, if applicable	-
Course, if applicable	ELECTROMAGNETIC FIELDS II
Semester(s) in which the module is taught	6^{th} Semester
Person responsible for the module	Gontjang Prajitno
Lecturer	Gontjang Prajitno
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Electromagnetic Fields I
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• Electrostatic Material: Polarization, Gaussian law, boundary, border state, E field energy • Magnetostatics Material: Magnetization, external and internal fields, boundary issues,

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	✓	✓	✓

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS classroom
Reading list	Main Refferences: 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 Refferences: 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

25. SF184603 - Laboratory Physics II

Module Name	LABORATORY PHYSICS II
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184603**
Subtitle, if applicable	-
Course, if applicable	**LABORATORY PHYSICS II**
Semester(s) in which the module is taught	6th Semester
Person responsible for the module	Sudarsono
Lecturer	Faridawati, Sungkono, Sudarsono, Susilo I., Suyatno, Saifuddin, Sri Yani Purwaningsih, M. Zainuri
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Laboratory Physics I
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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

Map of PLO and LO:

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

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practicum ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, practicum-based learning
Reading list	Main Refferences: Petunjuk Praktikum Fisika madya Supporting Refferences: -

26. SF184604 - Computational Physics II

Module Name	COMPUTATIONAL PHYSICS II
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184604
Subtitle, if applicable	-
Course, if applicable	COMPUTATIONAL PHYSICS II
Semester(s) in which the module is taught	6th Semester
Person responsible for the module	Sungkono
Lecturer	Sungkono, Ali Yunus Rohedi
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)

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

Content	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation
Reading list	Main Refferences: 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 Refferences:

27. SF184605 - Geophysics Exploration Methods

Module Name	GEOPHYSICS EXPLORATION METHODS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184605
Subtitle, if applicable	-
Course, if applicable	GEOPHYSICS EXPLORATION METHODS
Semester(s) in which the module is taught	6th Semester
Person responsible for the module	Saifuddin
Lecturer	Saifuddin
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	• Electromagnetic Fields I • Electronics • Waves
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓

Content	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation
Reading list	Main Refferences: 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 Refferences: -

28. SF184701 - Nuclear Physics

Module Name	**NUCLEAR PHYSICS**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184701
Subtitle, if applicable	-
Course, if applicable	NUCLEAR PHYSICS
Semester(s) in which the module is taught	7^{th} Semester
Person responsible for the module	Yanurita Dwi Hapsari
Lecturer	Yanurita Dwi Hapsari, Yoyok Cahyono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50” x 16 week per Semester Practicum : 170” x 16 week per Semester
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.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	• Mathematical Physics • Modern Physics • Quantum Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓	✓

Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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

29. SF184702 - Solid State Physics

Module Name	SOLID STATE PHYSICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184702
Subtitle, if applicable	-
Course, if applicable	SOLID STATE PHYSICS
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Mashuri
Lecturer	Mashuri, Zaenal Arifin, Malik A. Baqiya, M. Zainuri
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 4 x 50" x 16 week per Semester
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.
Credit points	4 SKS ~ 6.4 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Quantum Physics, Statistical Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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.

<table>
<tr><td></td><td>{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}
Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>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</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-6</th><th>PLO-9</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>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)</td></tr>
</table>

	• 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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 1. S.W Winata, Z Arifin, "Fisika Zat Padat I" Diktat Kuliah Jurusan Fisika FMIPA-ITS, Surabaya, 2001 2. S.W Winata, Darminto,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

30. SF184703 - Scientific Writing Methods

Module Name	SCIENTIFIC WRITING METHODS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184703
Subtitle, if applicable	-
Course, if applicable	SCIENTIFIC WRITING METHODS
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Retno Asih
Lecturer	Suminar Pratapa, Susilo I, Nurrisma P., Eko Minarto, Retno Asih
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester
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.
Credit points	2 SKS ~ 6.4* ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physical Measurement Methods
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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

<table>
<tr><td></td><td>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}
Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>• 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</td></tr>
<tr><td>Map of PLO and LO</td><td>
<table>
<tr><th></th><th>PLO-2</th><th>PLO-8</th><th>PLO-11</th><th>PLO-12</th></tr>
<tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>• 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.</td></tr>
</table>

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: Mikrajuddin Abdullah, "Tuntunan Praktis Menulis Makalah Untuk Jurnal Ilmiah Internasional", ITB. 2011 Supporting Refferences: -

31. SF184704 - Physics of Radiology And Dosimetry

Module Name	PHYSICS OF RADIOLOGY AND DOSIMETRY
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184704
Subtitle, if applicable	-
Course, if applicable	PHYSICS OF RADIOLOGY AND DOSIMETRY
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Endarko
Lecturer	Endarko, Yanurita Dwi Hapsari, M. Haekal
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• Classification of radiation and quantities and units • Direct and indirect ionizing radiation • Interacting radiation with the material

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

	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: • 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*, 4^{th} ed. (Charles C. Thomas, Springfield, IL, 1983) • J. F. Knoll. *Radiation Detection and Measurement*. 3^{rd}. 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 Refferences: -

32. SF184801 - Final Project

Module Name	FINAL PROJECT
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184801
Subtitle, if applicable	-
Course, if applicable	FINAL PROJECT
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Secretary of Department
Lecturer	Supervisor of Final Project
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face supervising):
Workload	1.
Credit points	6 SKS ~ 16** ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Has taken courses with the number of credits ≥ 120 credits
Module objectives/intendedlearning outcomes (PLO)	PHYSICS OF RADIOLOGY AND DOSIMETRY
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

<table>
<tr><td></td><td>

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

</td></tr>
<tr><td>Map of PLO and LO</td><td>
<table>
<tr><th></th><th>PLO-1</th><th>PLO-2</th><th>PLO-3</th><th>PLO-4</th><th>PLO-5</th><th>PLO-6</th></tr>
<tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>PLO-7</td><td>PLO-8</td><td>PLO-9</td><td>PLO-10</td><td>PLO-11</td><td>PLO-12</td></tr>
<tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>

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

</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td>
Cognitive: Midterm exam, Final exam, Quizzes, Assignments
Psychomotor: Practice
Affective: Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
</td></tr>
</table>

Media employed	Classical teaching tools with white board and power point presentation, supervising for each student.
Reading list	Main Refferences: 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 Refferences: 1. Ketentuan penulisan ilmiah POMITS', ..., 2009

ELECTIVE COURSES OF CURRICULUM 2018-2023

SEMESTER VII

33. SF184702 - Physics of Metals

Module Name	PHYSICS OF METALS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184702
Subtitle, if applicable	-
Course, if applicable	PHYSICS OF METALS
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Triwikantoro
Lecturer	Triwikantoro, Zaenal Arifin, M. Zainuri
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Material Science 2. Modern Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***PLO 8 -*** able to apply the principles, characteristics, functions, and relevant and updated technological applications in the field of physics and software

	applications. [P] ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	▪ The types of metal structure, cell unit, crystal structure and crystallography, coordination number

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

	▪ 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom

Reading list	Main Refferences: 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 Refferences: 1. Sriati Djaprie (Terj: Lawrence H Van Vlack), "IlmuTeknologi 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

34. SF184712 – Physics of Ceramics

Module Name	PHYSICS OF CERAMICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184712
Subtitle, if applicable	-
Course, if applicable	PHYSICS OF CERAMICS
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Suasmoro
Lecturer	Suasmoro
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Material Science
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distance and levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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.

Map of PLO and LO:

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

	• Ceramic mechanical characteristics: fracture, Griffith criteria, Weibull distribution • Tomomechanical, thermal stress, thermal shock. • Electrical characteristics, conductivity, ferroelectricity. • Magnetic characteristics: paramagnetic, spinel, ferrite
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. C.B. Carter and M.G.Norton, Ceramic Materials: Science and Engineering, Springer, 2007. Supporting Refferences: 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

35. SF184713 - Physics of Polymer

Module Name	PHYSICS OF POLYMER
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184713
Subtitle, if applicable	-
Course, if applicable	PHYSICS OF POLYMER
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Mashuri
Lecturer	Mashuri, M. Zainul Asrori
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Material Science
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distance and levelling ***Affective***: Following the rules of the courses
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	<table><tr><th></th><th>PLO-8</th><th>PLO-9</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-7</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-8</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	• 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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences:

	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.

36. SF184753 - Introduction to Relativity

Module Name	INTRODUCTION TO RELATIVITY
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184753
Subtitle, if applicable	-
Course, if applicable	INTRODUCTION TO RELATIVITY
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Bintoro A. Subagyo
Lecturer	Bintoro A. Subagyo
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Mathematical Physics (minimum grade C)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	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,

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

	Einstein field equations, Schwarzchild solutions, gravitational radiation, and Cosmology.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: B. Schutz, "*A First Course in General Relativity*", 2nd Edition, Cambridge University Press, 2009 Supporting Refferences: W. Rindler, "*Relativity: Special, General and Cosmological*", 2. ed., reprinted., Oxford u.a. Oxford Univ. Press, 2009

37. SF184721 - Microcontrollers and Microprocessors

Module Name	MICROCONTROLLERS AND MICROPROCESSORS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184721
Subtitle, if applicable	-
Course, if applicable	MICROCONTROLLERS AND MICROPROCESSORS
Semester(s) in which the module is taught	7^{th} Semester
Person responsible for the module	Diky Anggoro
Lecturer	Diky Anggoro
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓

Content	**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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences:

38. SF184722 - Electro-Acoustics

Module Name	Electro-Acoustics
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184722
Subtitle, if applicable	-
Course, if applicable	Electro-Acoustics
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Suyatno
Lecturer	Suyatno
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics of Buildings
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)

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

	<table><tr><td>**LO-4**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-5**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-6**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	1. Introduction to: acoustic quantities and acoustic applications, addition and decibel measurements, 2. Hearing mechanisms with hearing disabilities, 3. Behaviour and noise and its impact and control, 4. Acoustic Component and Electro-mechanical Equivalent Circuit; Sound delays in free space and sound sources (speakers), 5. Response and speaker severity factor, 6. The basic concept of a microphone as the source of sound, 7. The basic concept of speakers in a confined space
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation
Reading list	Main Refferences: Beranek L.L., *Acoustics*, McGraw-Hill, New York, 1954 Supporting Refferences: 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

39. SF184731 - Fiber Optics

Module Name	FIBER OPTICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184709
Subtitle, if applicable	-
Course, if applicable	FIBER OPTICS
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Sudarsono
Lecturer	Sudarsono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Waves 2. Optics 3. Electromagnetic Fields I 4. Electromagnetic Fields II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	<table><tr><th></th><th>PLO-8</th><th>PLO-9</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-7</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-8</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	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.

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS classroom
Reading list	Main Refferences: 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 Refferences: 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.

40. SF184732 – Photonics

Module Name	PHOTONICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184732
Subtitle, if applicable	-
Course, if applicable	PHOTONICS
Semester(s) in which the module is taught	7^{th} Semester
Person responsible for the module	Gontjang Prajitno
Lecturer	Gontjang Prajitno
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. EM Fields II 2. Optics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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

<table>
<tr><td></td><td>potential application of physical behaviour in information technology in the context of scientific development and further implementation in the field of physics expertise. {KK}

Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>• 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.</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-8</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td></td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>Planar waveguide, coupling on two waveguides, acoustic-optic devices, electro optical devices, anisotropic media, nonlinear optical media</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td>Cognitive: Midterm exam, Final exam, Quizzes, Assignments
Psychomotor: Practice
Affective: Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.</td></tr>
<tr><td>Media employed</td><td>Classical teaching tools with white board and power point presentation, teaching through myITS Classroom</td></tr>
<tr><td>Reading list</td><td>Main Refferences:
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.</td></tr>
</table>

	Supporting Refferences: -

41. SF184741 - Geology

Module Name	GEOLOGY
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184711
Subtitle, if applicable	-
Course, if applicable	GEOLOGY
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Sungkono
Lecturer	Sungkono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.

Map of PLO and LO:

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

Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Christiansen. Eric H, Hamblin. Kenneth. 2008, *Earth's Dynamic Systems*. 2. Koesoemadinata, 1980, *Geologi MinyakGas Bumi Jilid 1*, Penerbit ITB Bandung. Supporting Refferences: 1. Setiagraha, Doddy, 1987, *MineralBatuan*, 2. Modul Ajar Batuan Sedimen 3. Modul Ajar Batuan Beku 4. Modul Ajar Batuan Metamorf 5. Modul Ajar TektonismeVulkanisme 6. Model Ajar Mineralogi

42. SF184742 - Seismology

Module Name	SEISMOLOGY
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184742
Subtitle, if applicable	-
Course, if applicable	SEISMOLOGY
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Saifuddin
Lecturer	Saifuddin, Sungkono, Bagus Jaya Santosa
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50” x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Waves
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences:

Map of PLO and LO:

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

	1. M. Gubbins, "Seismology", Blackwell Publication, 1987 Supporting Refferences: 1. Modul ajar Analisa Dasar Data Seismik

43. SF184743 - Earth Electrical Exploration

Module Name	**EARTH ELECTRICAL EXPLORATION**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184743
Subtitle, if applicable	-
Course, if applicable	EARTH ELECTRICAL EXPLORATION
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Sungkono
Lecturer	Sungkono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50” x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Mathematical Physcis I and II 2. Computational Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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

<table>
<tr><td></td><td>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}

Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>● LO-1: Ability in acquisition / acquisition of resistivity data.
● LO-2: Ability in resistivity data processing
● LO-3: Ability in interpretation of resistivity data.</td></tr>
<tr><td>Map of PLO and LO</td><td>
<table>
<tr><th></th><th>PLO-5</th><th>PLO-7</th><th>PLO-8</th><th>PLO-9</th></tr>
<tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>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</td></tr>
</table>

	ambiguity, VES application, Resistivity Mapping. Resistivity data processing and physical interpretation.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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.

44. SF184751 - Introduction To Particle Physics

Module Name	INTRODUCTION TO PARTICLE PHYSICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184751
Subtitle, if applicable	-
Course, if applicable	INTRODUCTION TO PARTICLE PHYSICS
Semester(s) in which the module is taught	7^{th} Semester
Person responsible for the module	Agus Purwanto
Lecturer	Agus Purwanto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	A brief history of elementary particles, dynamics and fundamental forces; lepton and quark; symmetry: group and law of conservation, CPT theorem; Feynman

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

	diagrams, introduction of quantum electrodynamics, introduction of quantum chromodynamics, weak interaction and unification
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: Grifftith, D., Introction to Elementary Particle, John Wiley and Sons, New York, 1987 Supporting Refferences: 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

45. SF184752 - Advanced Mathematical Physics

Module Name	ADVANCED MATHEMATICAL PHYSICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184752
Subtitle, if applicable	-
Course, if applicable	ADVANCED MATHEMATICAL PHYSICS
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Heru Sukamto
Lecturer	Heru Sukamto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	Integral Equations, Green Functions, Complex Analysis, Regulation Methods on Particle Physics, Introduction to Geometry and Topology
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: Kusse, B., Westwig, E."Mathematical Physics: Applied Mathematics for Scientists and Engineers", John Wiley & Sons, Canada, 1998

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

	Supporting Refferences: 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.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

46. SF184761 - Anatomy and Physiology

Module Name	ANATOMY AND PHYSIOLOGY
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184761
Subtitle, if applicable	-
Course, if applicable	ANATOMY AND PHYSIOLOGY
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Yanurita Dwi Hapsari
Lecturer	Yanurita Dwi Hapsari, Endarko
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)

	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	✓	✓	✓	✓	✓

Content	• The nomenclature of anatomy • Bones • Spinal column • Thorax • Abdomen • Respiratory system • Digestive system • Urinary system • Support system • Circulation system • Pathology
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: • R. PutzR. Pabst, *Atlas Anatomi Manusia Sobotta*. (EGC, 2010) • Serwood, *Fisologi Manusia: dari sel ke sistem*. (EGC, 2001) Supporting Refferences: -

47. SF184762 - Medical Imaging Physics

Module Name	MEDICAL IMAGING PHYSICS
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184762**
Subtitle, if applicable	-
Course, if applicable	**MEDICAL IMAGING PHYSICS**
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Endarko
Lecturer	Endarko
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics of Radiology and Dosimetry
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)

	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	✓	✓	✓	✓	✓

Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. 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). 2. P.P Dendy and B. Heaton. Physics of Diagnostic Radiology. (Institute of Physics Publishing, London, UK, 1999).

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

48. SF184763 - Medical Instrumentation

Module Name	MEDICAL INSTRUMENTATION
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184763
Subtitle, if applicable	-
Course, if applicable	MEDICAL INSTRUMENTATION
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Yanurita Dwi Hapsari
Lecturer	Yanurita Dwi Hapsari, Endarko
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics of Radiology and Dosimetry
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓	✓	✓

Content	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) 14. LINAC
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: J. G. Webster, *Medical Instrumentation: Application and Design*. John Wiley & Sons, New York, 1998. Supporting Refferences: -

49. SF184764 - Radiobiology

Module Name	RADIOBIOLOGY
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184764
Subtitle, if applicable	-
Course, if applicable	RADIOBIOLOGY
Semester(s) in which the module is taught	7th Semester
Person responsible for the module	Agus Rubiyanto
Lecturer	Agus Rubiyanto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics of Radiology and Dosimetry
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor*:** Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective*:** Following the rules of the courses
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	✓	✓	✓	✓	✓

Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: • 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 Refferences: -

50. SF184811 - Physics of Composites

Module Name	PHYSICS OF COMPOSITES
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184811
Subtitle, if applicable	-
Course, if applicable	PHYSICS OF COMPOSITES
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	M. Zainuri
Lecturer	M. Zainuri
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Physics of Metals 2. Physics of Polymers 3. Physics of Ceramics 4. Mathematical Physics II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor*:** Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective*:** Following the rules of the courses
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	see table below
Content	• 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

Map of PLO and LO

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

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 1. Zainuri, M & Asrori, M.Z., “Fisika Bahan Komposit”, Buku Ajar, Jurusan Fisika FMIPA ITS, 2009

51. SF184812 - Physics of Semiconductors

Module Name	Physics of Semiconductors
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184812
Subtitle, if applicable	-
Course, if applicable	Physics of Semiconductors
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Yoyok Cahyono
Lecturer	Yoyok Cahyono, Malik A. Baqiya
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Mathematical Physics II 2. Statistical Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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.

Map of PLO and LO:

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

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. S.M. SZe, Semikonductor Devices Physics and Technology 2nd ed, John Wiley & Sons, 2002. Supporting Refferences: 1. Andrew S. Grove ; Physics and Technology of Semiconductor Devices, John Wiley & Sons, New York 1967. 2. S. Reka RioM. Iida; FisikaTeknologi Semikonduktor, Association for International Technical Promotion, Tokyo, 1980

52. SF184813 - Material Analysis Method

Module Name	**Material Analysis Method**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184813
Subtitle, if applicable	-
Course, if applicable	Material Analysis Method
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Retno Asih
Lecturer	Suminar Pratapa, Retno Asih
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Modern Physics
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	<table><tr><td></td><td>**PLO-2**</td><td>**PLO-5**</td><td>**PLO-8**</td><td>**PLO-9**</td><td>**PLO-10**</td></tr><tr><td>**LO-1**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-2**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-3**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-4**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-5**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-6**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-7**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-8**</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Supporting Refferences: 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.

53. SF184821 - PHYSICS OF BUILDINGS

Module Name	PHYSICS OF BUILDINGS
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184708
Subtitle, if applicable	-
Course, if applicable	PHYSICS OF BUILDINGS
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Suyatno, Susilo I.
Lecturer	Suyatno
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distance and levelling ***Affective***: Following the rules of the courses
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	(see table below)

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

Content	• Space Acoustics, indoor sound projection, sound reflection and absorption, buzzing time, sound insulation. • Lighting, electrical room, ventilation, fire protection.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Rosing, "*Handbook of Acoustics*", Springer, 2007. 2. Long Marshall, "*Architectural Acoustics*", Elsevier Academic Press, 2006 Supporting Refferences: 1. ...., Building Physics, www.arup.com 2. Prasasto Satwiko, "Fisika Bangunan 2", Andi Ofset, Jogjakarta, 2004

54. SF184822 - INTELLIGENT INSTRUMENTATION AND CONTROL

Module Name	**INTELLIGENT INSTRUMENTATION AND CONTROL**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184806
Subtitle, if applicable	-
Course, if applicable	INTELLIGENT INSTRUMENTATION AND CONTROL
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Melania S. Muntini
Lecturer	Melania S. Muntini
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	

	<table><tr><th></th><th>PLO-8</th><th>PLO-9</th><th>PLO-10</th><th>PLO-11</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-7</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-8</td><td></td><td></td><td></td><td>✓</td></tr></table>
Content	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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. Supporting Refferences:

	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

55.SF184823 - HEAT TRANSFER

Module Name	**HEAT TRANSFER**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184807
Subtitle, if applicable	-
Course, if applicable	HEAT TRANSFER
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Lila Yuwana
Lecturer	Susilo Indrawati, Lila Yuwana, Bachtera Indarto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50” x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics III
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)

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

Content	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. 4. Heat Radiation, Radiation Quantities, Black and No Black Radiation, Radiation Form Factor, Heat Exchange Non-Black Material
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: J. P. Holman, “Heat Transfer” Mc Grow-Hill, Ltd 2002 Supporting Refferences: F. P. Incropera & D. P. De Witt, *Fundamentals of Heat Transfer*, John Wiley & Sons, New York 1981

56. SF184824 - Industrial Instrumentation

Module Name	Industrial Instrumentation
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184824
Subtitle, if applicable	-
Course, if applicable	Industrial Instrumentation
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Bachtera Indarto
Lecturer	Bachtera Indarto, Melania S. Muntini
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	• Electronics • Instrumentation
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓	✓	✓

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<tr><td></td><td>
<table>
<tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-7</td><td></td><td></td><td></td><td></td><td>✓</td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>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</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td>Cognitive: Midterm exam, Final exam, Quizzes, Assignments
Psychomotor: Practice
Affective: Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.</td></tr>
<tr><td>Media employed</td><td>Classical teaching tools with white board and power point presentation</td></tr>
<tr><td>Reading list</td><td>Main Refferences:
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. NilsssonS. A, Riedel, 2008, Electronic Circuit, Pearson Prentice Hall.
4. Boylestad, 2002, Introductory Circuit Analysis, 10th edition, Prentice Hall.

Supporting Refferences:
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.</td></tr>
</table>

57. SF184831 - Optical Computation

Module Name	**Optical Computation**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184831
Subtitle, if applicable	-
Course, if applicable	Optical Computation
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Yono Hadi Pramono
Lecturer	Yono Hadi Pramono, Ali Yunus Rohedi
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50” x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Computational Physics I and II 2. Electromagnetic Field II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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

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

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 1. Modul ajar " Metode beda hingga optikFDBPM", Fisika ITS 2014 2. Modul ajar " Metode beda hingga antenna FDTD", Fisika ITS 2014

58. SF184832 - Digital Image Processing

Module Name	**Digital Image Processing**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184832
Subtitle, if applicable	-
Course, if applicable	Digital Image Processing
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Sudarsono
Lecturer	Sudarsono, M. Arif Bustomi
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50” x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Computational Physics I Computational Physics II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)

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

	<table><tr><td>**LO-5**</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-6**</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-7**</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>**LO-8**</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	**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

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Solomon, C.Breckon, T., " **Fundamentals of Digital Image Processing** : A Practical Approach with Examples in Matlab ", John Willey and Son 2012 2. Gonzalez, R.C.Woods, R.E., " **Digital Image Processing** ", Second Edition, Prentice Hall. Supporting Refferences: 1. Jain, A.K., " Fundamentals of Digital Image Processing ", Prentice Hall. 2. Pengolahan Citra DigitalAplikasinya Menggunakan Matlab, Eko Prastyo

59. SF184833- Applied Electromagnetics

Module Name	**Applied Electromagnetics**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184833**
Subtitle, if applicable	-
Course, if applicable	**Applied Electromagnetics**
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Yono Hadi Pramono
Lecturer	Yono Hadi Pramono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Electromagnetic Field I 2. Electromagnetic Field II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	• 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.

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

	• Microwave devices and circuits and their applications
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 1. Hund.E,"Microwave Communications,Component and Circuit", Mc.Graw-Hill, New York 1989

60. SF184841 - Seismic Exploration

Module Name	**Seismic Exploration**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184842
Subtitle, if applicable	-
Course, if applicable	Seismic Exploration
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Eko Minarto
Lecturer	Eko Minarto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Mathematical Physics I and II 2. Computational Physics 3. Seismology
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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,

<table>
<tr><td></td><td>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}

Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>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.</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-7</th><th>PLO-8</th><th>PLO-9</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>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-</td></tr>
</table>

	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.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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.

61. SF184842 - Earth Potential Field Exploration

Module Name	**Earth Potential Field Exploration**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184842
Subtitle, if applicable	-
Course, if applicable	Earth Potential Field Exploration
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Eko Minarto
Lecturer	Eko Minarto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	1. Mathematical Physics I and II 2. Computational Physics 3. Seismology
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	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

Map of PLO and LO:

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

	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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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.

62. SF184843 - Rock Physics and Well-log Analysis

Module Name	Rock Physics and Well-log Analysis
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184814
Subtitle, if applicable	-
Course, if applicable	Rock Physics and Well-log Analysis
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Sungkono
Lecturer	Sungkono
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Electromagnetic Field I, Electronics, and Waves (minimal D)
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	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;

	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	✓	✓	✓	✓	✓

	11. **Quantitative analysis**: calculation of shale volume, porosity, resistivity, water saturation, and rock pore pressure based on well-log data.
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation
Reading list	Main Refferences: 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 Refferences: 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.

63. SF184844 - Inversion Model

Module Name	Inversion Model
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184844
Subtitle, if applicable	-
Course, if applicable	Inversion Model
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Saifuddin
Lecturer	Sungkono, Saifuddin
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Computational Physics I, Mathematical Physics I and II
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***PLO 5 -*** able to develop themselves, long-life learning, and implement environmental insight and technology-based entrepreneurship. {KU} 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓	✓	✓

	<table><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-7</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-8</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	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.

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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

64. SF184851 - Group Theory

Module Name	Group Theory
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184818**
Subtitle, if applicable	-
Course, if applicable	**Group Theory**
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Bintoro A. Subagyo
Lecturer	Bintoro A. Subagyo, Heru Sukamto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	Symmetry and group definition; Finite group; Group representation theory; continuous group; Applications in quantum mechanics, and crystallography
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. Jones, H.F., Groups, Representations and Physics, Institute of Physics, Bristol, 1998 Supporting Refferences: 1. Joshi, A.W.,' Element of Group Theory for Physicists", Wiley Eastern, New Delhi, 1973

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	✓	✓	✓	✓

	2. Tung, W.K., "Group Theory in Physics", World Scientific, Singapore, 1985.

65. SF184852 - Relativistic Quantum Theory

Module Name	**Relativistic Quantum Theory**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184852
Subtitle, if applicable	-
Course, if applicable	Relativistic Quantum Theory
Semester(s) in which the module is taught	8^{th} Semester
Person responsible for the module	Bintoro A. Subagyo
Lecturer	Bintoro A. Subagyo, Heru Sukamto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	(see table below)
Content	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.

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

Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: W. Greiner, Relativistic Quantum Mechanics - Wave Equations, Springer (2000) Supporting Refferences: 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

66. SF184853 - Special Topics on Quantum Physics

Module Name	**Special Topics on Quantum Physics**
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184853**
Subtitle, if applicable	-
Course, if applicable	**Special Topics On Quantum Physics**
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Heru Sukamto
Lecturer	Heru Sukamto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	-
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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

<table>
<tr><td></td><td>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}

Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>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</td></tr>
<tr><td>Map of PLO and LO</td><td><table><tr><th></th><th>PLO-1</th><th>PLO-2</th><th>PLO-6</th><th>PLO-9</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table></td></tr>
<tr><td>Content</td><td>Quantum Computing (Quantum Bits, Quantum Gates, Quantum Algorithm), Quantum Teleportation, Quantum Thermodynamics</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td>Cognitive: Midterm exam, Final exam, Quizzes, Assignments
Psychomotor: Practice
Affective: Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.</td></tr>
<tr><td>Media employed</td><td>Classical teaching tools with white board and power point presentation, teaching through myITS Classroom</td></tr>
<tr><td>Reading list</td><td>Main Refferences:
M. Nakahara, Quantum Computing, CRC Press(2008)

Supporting Refferences:
M.A. Neilson, I.L. Chuang, Quantum Computation and</td></tr>
</table>

	Quantum Information, Cambridge Press(2000)

67. SF184861 - Biophysics

Module Name	Biophysics
Module level, if applicable	Undergraduate Stage
Code, if applicable	**SF184861**
Subtitle, if applicable	-
Course, if applicable	**Biophysics**
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Nasori
Lecturer	Nasori, Agus Rubiyanto
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Physics of Radiology and Dosimetry
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	✓	✓	✓	✓	✓	✓

Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences:

68. SF184862 - Radiotherapy

Module Name	**Radiotherapy**
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184862
Subtitle, if applicable	-
Course, if applicable	Radiotherapy
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	Endarko
Lecturer	Endarko, Yanurita Dwi Hapsari
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 3 x 50" x 16 week per Semester
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.
Credit points	3 SKS ~ 4.8 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Fisika RadiologiDosimetri
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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 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] 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} ***Psychomotor***: Students are able to perform positioning, determining the position, angle, distanceand levelling ***Affective***: Following the rules of the courses
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	<table><tr><th></th><th>PLO-2</th><th>PLO-6</th><th>PLO-7</th><th>PLO-8</th><th>PLO-9</th><th>PLO-10</th></tr><tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-3</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-4</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-5</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-6</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-7</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr><tr><td>LO-8</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table>
Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 1. AAPM Report No. 46. Comprehensive QA for Radiation Oncology. (American Institute of Physics, New York, 1994)

	2. AAPM Report No. 47. AAPM Code of Practice for Radiotherapy Accelerator. (American Institute of Physics, New York, 1994) 3. AAPM Report No. 67. Protocol for Clinical Reference Dosimetry of High Energy Photon and Electron Beams. (American Institute of Physics, New York, 1999). 4. IAEA Report No. 23. Absorbed Dose Determination in Photon and Electron Beams. An International Code of Practice. (International Atomic Energy Agency, Vienna, Austria, 1987). 5. ICRU Report No. 38. Dose and Volume Specifications for Reporting Intracavitary Therapy in Ginecology. (International Commission on Radiation Unit and Measurements, Bethesda, MD, 1985). 6. ICRU Report No. 50. Prescribing, Recording and Reporting Photon Beam Therapy. (International Commission on Radiation Unit and Measurements, Bethesda, MD, 1993). 7. H. E. Johns and J. R. Cunningham. The Physics of Radiology, 4th ed. (Charles C. Thomas, Springfield, IL, 1983) 8. S. C. Klevenhagen, Physics and Dosimetry of Therapy Electron Beams. (Medical Physics Publishing, Madison, WI, 1993) 9. W. J. Meredith and J. B. Massey. Fundamental Physics of Radiology. 3rd ed. (J. Wright, Bristol, UK, 1977) 10. J. Van Dyk (Editor). The Modern Technology of Radiation Oncology (Medical Physics Publishing, Philadephia, PA, 1999) 11. J. R. Williams and D. I. Thwaites. Radiotherapy Physics in Practice. (Oxford University Press, New York, 1994) 12. Siamak Shahabi (Editor). Blackburn's Introduction to Clinical Radiation Therapy Physics. (Medical Physics Publishing Corporation, Madison, Wisconsin, 1989) 13. P. M. K. Leung. The Physical Basis of Radiotherapy. (The Ontario Cancer Institute incorporating The Princess Margaret Hospital, 1990). 14. G. C. Bentel, C. E. Nelson, and K.T. Noell. Treatment Planning Dose Calculation in Radiation Oncology. McGraw Hill, New York, NY, 1989)

	15. Metcalfe, et al, The Physics of Radiotherapy X-rays and Electron. (Medical Physics Publishing, 2007) 16. G. C. Bentel, C. E. Nelson, and K.T. Noell. Treatment Planning Dose Calculation in Radiation Oncology. McGraw Hill, New York, NY, 1989) 17. Podgorsak, Radiation Oncology Physics: Handbook for Teacher and Student. (IAEA, 2005) 18. Khan, Gerbi. Treatment Planning in Radiation Oncology. Lippincott Williams & Wilkins, Philadelphia: 2012 19. J. R. Williams and D. I. Thwaites. Radiotherapy Physics in Practice. (Oxford University Press, New York, 1994) Supporting Refferences: -

69. SF184863 - Health Physics and Radiation Protection

Module Name	Health Physics and Radiation Protection
Module level, if applicable	Undergraduate Stage
Code, if applicable	SF184863
Subtitle, if applicable	-
Course, if applicable	Health Physics and Radiation Protection
Semester(s) in which the module is taught	8th Semester
Person responsible for the module	M. Haekal
Lecturer	Endarko, M. Haekal, Yanurita Dwi Hapsari
Language	Indonesian
Relation to curriculum	Compulsory Courses for undergraduate program in Bachelor of Physics
Type of teaching, contact hours	Lecture (Face to face lecture): 2 x 50" x 16 week per Semester
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.
Credit points	2 SKS ~ 3.2 ECTS
Requirements according to the examination regulations	Registered in this course Minimum 80% attendance in this course
Recommended prerequisites	Modern Physics, Radiology
Module objectives/intendedlearning outcomes (PLO)	***Cognitive:*** ***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

<table>
<tr><td></td><td>system. [P]
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]
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}
Psychomotor: Students are able to perform positioning, determining the position, angle, distanceand levelling
Affective: Following the rules of the courses</td></tr>
<tr><td>LO</td><td>• 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</td></tr>
<tr><td>Map of PLO and LO</td><td>
<table>
<tr><th></th><th>PLO-2</th><th>PLO-6</th><th>PLO-7</th><th>PLO-8</th><th>PLO-9</th><th>PLO-10</th></tr>
<tr><td>LO-1</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>LO-2</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
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LO-3	✓	✓	✓	✓	✓	✓
LO-4	✓	✓	✓	✓	✓	✓
LO-5	✓	✓	✓	✓	✓	✓
LO-6	✓	✓	✓	✓	✓	✓
LO-7	✓	✓	✓	✓	✓	✓
LO-8	✓	✓	✓	✓	✓	✓

Content	• 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
Study and examination requirements and forms of examination	***Cognitive:*** Midterm exam, Final exam, Quizzes, Assignments ***Psychomotor:*** Practice ***Affective:*** Assessed from the element /variables achievement, namely (a) Contributions (attendance, active, role, initiative, language), (b) Being on time, (c) Effort.
Media employed	Classical teaching tools with white board and power point presentation, teaching through myITS Classroom
Reading list	Main Refferences: 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 Refferences: 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).