Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Basic Physics 1</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">1st year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH601101</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">1st semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. sc. hum. Deni Hardiansyah</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. sc. hum. Deni Hardiansyah</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive learning</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Question-based learning</td><td>Interactive learning</td><td>56</td></tr>
<tr><td>Self-directed study</td><td>56</td></tr>
<tr><td>Assignments</td><td>56</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">168 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignment (15%), group assignment (15%), quizzes (20%), mid-term exam (25%), and final exam (25%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">None</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">None</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
Students are able to apply basic physics concepts to formulate a solution as well as its application in physics phenomenon in everyday life.

Skill & Knowledge:
1. Able to apply motion mechanics concepts to physics phenomenon in everyday life.
2. Able to apply fluid mechanics concepts to physics phenomenon in everyday life.
3. Able to apply vibrations and waves concepts to physics phenomenon in everyday life.
4. Able to apply heat physics concepts to physics phenomenon in everyday life.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Units, Dimension, and Measurements.
• Motion Kinematics
• Motion Dynamics
• Work and Energy
• Momentum and Impulse
• Rotating Motion
• Equilibrium
• Gravity
• Vibrations
• Waves
• Fluid Mechanics
• Calor and Kinetic Theory of Gas
• 1st and 2nd Law of Termodynamics</td></tr>
</table>

Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. Halliday, Resnick, dan Walker, Principles of Physics 10th Edition, Wiley, 2014. 2. Serway Jewett, Physics for Scientists and Engineers 9th Edition, Thomson Brooks/Cole, 2014. 3. Giancoli, Physics for Scientists and Engineers 7th Edition, Pearson, 2014

Physics Compulsory Courses 1st Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Laboratory Work of Basic Physics 1</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">1st year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH601142</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">2nd semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Djoko Triyono</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Djoko Triyono</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td>Practicum</td><td>50</td><td>3</td><td>Practicum</td><td>Practicum: 3 x 14</td><td>42</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">42 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">1 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on Practicum (70%), presentation (20%) and final exam (10%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">students in semester 2 are able to analyze basic physics concepts and operate measurement instruments in everyday life appropriately to solve existing problems in accordance with the laws of physics applies</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">This course is one of the compulsory subjects in the Undergraduate Physics Study Program. The subject matter includes: Measurement of Object Dimensions and Center of Mass and Moment of Inertia of Firms, Free Fall Motion, Density of the Liquid and Viscosity of the Liquid, Coefficient of Friction, The Law of Collision, Twist Swings and Mathematical Swings, Young's Modulus and Advance Tension Coefficient, Perforated Cylinder, Hardness Test, Linear expansion coefficient and thermal conductivity, Calorimetry and Ideal Gas Law, Joule Constants and Solar Collector, Newton cooling and Radiation Constants and Radiation Energy Absorption</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Individual assignments, quiz, mid-term exam, and final exam.</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">Practicum Equipment and Microsoft Excel</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] Basic Physics Practicum Guidebook, UPP IPD, 3rd edition, 2010.
[2] Giancoli, DC., Physics: Principle with Applications, 6th ed., Prentice Hall, 2005</td></tr>
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Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Basic Physics 2</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">1st year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH601201</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">2nd semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. sc. hum. Dwi Seno Kuncoro Sihono</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. sc. hum. Dwi Seno Kuncoro Sihono</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive learning</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Question-based learning</td><td>Interactive learning</td><td>56</td></tr>
<tr><td>Self-directed study</td><td>56</td></tr>
<tr><td>Assignments</td><td>56</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">168 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignment (30%), group assignment (10%), quizzes (20%), mid-term exam (20%), and final exam (20%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Basic Physics 1</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">Laboratory Works of Basic Physics 2</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
Students are able to apply basic physics principles and concepts to formulate a solution and their applications in physical phenomena in everyday life.

Skill & Knowledge:
1. Able to apply electricity concepts in physical phenomena in everyday life.
2. Able to apply magnetism concepts in physical phenomena in everyday life.
3. Able to apply vibrations and waves concepts in physical phenomena in everyday life.
4. Able to apply optics concepts in physical phenomena in everyday life.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Electric Charge and Electric Field
• Gauss's law
• Electric potential
• Capacitor and Dielectric
• Electric current
• Resistance and Direct Current
• Magnetic Field and Magnetic Force
• Magnetic Field Source
• Electromagnetic Induction
• Inductance
• Electromagnetic Oscillation
• Alternating Current
• Maxwell's equation
• Mechanical Wave</td></tr>
</table>

	• Sound Waves • Standing waves • The Nature and Propagation of Light • Light polarization • Light Wave Superposition & Interference • Light Wave Diffraction • Geometry optics • Optical tools and device
Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. Halliday, Resnick, dan Walker, Principles of Physics 10th Edition, Wiley, 2014. 2. Serway Jewett, Physics for Scientists and Engineers 9th Edition, Thomson Brooks/Cole, 2014. 3. Giancoli, Physics for Scientists and Engineers 7th Edition, Pearson, 2014

Physics Compulsory Courses 3rd Year

<table>
<tr><td>Module name</td><td colspan="5">Quantum Physics 2</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">3rd year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH602122</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">5th semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Prof. Dr. Drs. Terry Mart</td></tr>
<tr><td>Lecturer</td><td colspan="5">Prof. Dr. Drs. Terry Mart</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Compulsory course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lectures, discussions, and structured individual learning</td><td rowspan="3">50</td><td rowspan="3">3</td><td rowspan="3">Lectures and discussions</td><td>Lectures: 3 x 16</td><td>48</td></tr>
<tr><td>Assignments: 3 x 16</td><td>48</td></tr>
<tr><td>Independent study: 3 x 16</td><td>48</td></tr>
<tr><td>Total Workload</td><td colspan="5">144 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">3 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on weekly assignments (30%), mid-term exam (30%), and final exam (40%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">1. Quantum Physics 1 (prerequisite)</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">After the completion of this course, students will be able to apply advanced concepts and formulations in quantum mechanics on related problems in physics, such as the interaction between charged particles and an electromagnetic field, perturbation in quantum systems, and particle scattering due to electromagnetic interaction.</td></tr>
<tr><td>Content</td><td colspan="5">Interaction of charged particles and electromagnetic field, gauge transformations, minimal substitution, matrix mechanics, spin, base and representation, summation of angular momentum, the Clebsch-Gordan coefficient, spectroscopic notation, parity and orbital angular momentum, time-independent perturbation theory: non- degeneration and degeneration, realistic hydrogen atoms, helium atoms, atomic structures, molecules, time-dependent perturbation theory, scattering theory, density matrices: pure and mixed states.</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">Weekly assignments, mid-term exam, and final exam.</td></tr>
<tr><td>Media employed</td><td colspan="5">PowerPoint presentation</td></tr>
<tr><td>Reading list</td><td colspan="5">[1] S. Gasiorowicz, Quantum Physics 3rd Ed., John Wiley & Sons, Inc., 2003.
[2] A. Goswami, Quantum Mechanics 2nd Ed., Wm. C. Brown Publishers, 1997.</td></tr>
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Physics Compulsory Courses 2nd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Advanced Physics Laboratory Work 1</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">2nd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH602144</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">4th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Arief Sudarmaji, M.T.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Arief Sudarmaji, M.T.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Bahasa Indonesia</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td>Laboratory work, data processing, report writing, individual assignment, and written exam.</td><td>50</td><td>3</td><td>Laboratory work and presentation</td><td>Laboratory work: 3 x 14</td><td>42</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">42 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">1 credit</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on laboratory work (70%), presentation (20%), and the final exam (10%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Modern Physics</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students can analyze (C4) concepts in advanced physics and operate (P3) measuring instruments in daily life correctly to solve (A5) extant problems according to the applicable laws of Physics.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Torsional Oscillators, Magnetic Torque, Microwaves, Thomson Tube, Thermal Radiation, Zeeman Effect, Radioactive Decay and Half-life, the Franck-Hertz Effect, Nuclear Magnetic Resonance, Rutherford Scattering, Electron Spin Resonance, the Hall Effect (Metal), the Hall Effect (Semiconductor), and Hysteresis</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Laboratory work, presentation, and final exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">Laboratory equipment and Gnuplot</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] J.P Holman, Experimental Method for Engineers, 7th ed., McGraw-Hill Book, Inc, 2001.
[2] Ogawa Seiki, Instruction Manual: Franck-Hertz demonstration, OGAWA SEIKI, Tokyo Central PO Box No.1618 Tokyo, Japan, 1987.
[3] Ogawa Seiki, Instruction Manual: e/m Demonstration Apparatus, OGAWA SEIKI, Tokyo Central PO Box No.1618 Tokyo Japan, 1987
[4] Leybold-Heraeus, Physics Experiment, vol. 1,2 & 3, Leybold GmBH, 1986.</td></tr>
</table>

[5] Krane, Kenneth, Modern Physics, 2nd ed., Mc Graw Hill, 1996.
[6] H.D. Resnick dan J. Walker, Fundamental of Physics, 6th ed., John Wiley & Son, Inc, 2001.
[7] Pasco Heat conduction Apparatus, Instruction Manual 012-09189A, www.pasco.com, 2012.
[8] Teach Spin, Faraday Rotation, Guide to the experiment, Teach Spin.Inc., Tri-Main Centre-Suite 409, 2495 Main Street.Buffalo, NY 14214-2153, 2012

Physics Compulsory Courses 2nd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Quantum Physics 1</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">2nd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH602222</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">4th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Adam Badra Cahaya</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Adam Badra Cahaya</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lectures, discussions, and independent study</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Lectures and discussions</td><td>Lectures: 4 x 16</td><td>64</td></tr>
<tr><td>Assignments: 4 x 16</td><td>64</td></tr>
<tr><td>Independent study: 4 x 16</td><td>64</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">192 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (30%), group assignments (20%) mid-term exam (25%), and final exam (25%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">1. Elementary Linear Algebra (prerequisite)
2. Modern Physics (prerequisite)
3. Mathematical Methods in Physics 2 (prerequisite)
4. Mathematical Methods in Physics 3 (prerequisite)</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">After the completion of this course, students will be able to apply fundamental concepts in quantum mechanics to simple quantum systems and atoms such as hydrogen.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Black body radiation, the photoelectric effect, Compton scattering, wave-particle duality, the Bohr atom, de Broglie waves, the correspondence principle, wave packets, Heisenberg uncertainty principle, Schrödinger’s equation, wave functions, probability interpretation, normalization, expected value, operators, commutative property, stationary state, eigenvalue and eigenfunction, linear operator, hermiticity, expansion theorems, free wave normalization, parity, degeneration, Dirac notation, representation, problems with one-dimensional potential, simple harmonic oscillator and ladder operators, changes in expected value over time, time-dependence of operators, the Schrödinger picture and Heisenberg picture, N-particle systems, central force, Schrödinger’s equation in three dimensions, angular momentum, hydrogen-like atoms in simple quantum systems, and hydrogen-like atoms.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Individual assignments, group assignments, mid-term exam, and final exam.</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">PowerPoint presentation, EMAS UI Platform</td></tr>
</table>

Reading list	[1] S. Gasiorowicz, Quantum Physics 3rd Ed., John Wiley & Sons, Inc., 2003. [2] A. Goswami, Quantum Mechanics 2nd Ed., Wm. C. Brown Publishers, 1997.

Physics Compulsory Courses 1st Year

<table>
<tr><td>Module name</td><td colspan="5">Vibration and Waves</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">1st year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH602235</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">1st semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Dr. Djonaedi Saleh</td></tr>
<tr><td>Lecturer</td><td colspan="5">Dr. Djonaedi Saleh</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Compulsory courses</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Offline Lecture</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">In-class activeness</td><td>Lectures: 2 x 16</td><td>32</td></tr>
<tr><td>Assignments: 2 x 16</td><td>32</td></tr>
<tr><td>Independent study: 2 x 16</td><td>32</td></tr>
<tr><td>Total Workload</td><td colspan="5">96 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">2 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on group presentations (40%), mid-term exam (30%), and final exam (30%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">Basic Physics 1, Basic Physics 2, Basic Mathematics 1, Basic Mathematics 2, Mathematical Physics 1</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">After completing this lecture, physics students are expected to be able to analyze and explain properly and correctly about events that occur in the natural environment around them related to vibrations and waves.</td></tr>
<tr><td>Content</td><td colspan="5">Explain the Simple Harmonic Motion and Damped Harmonic Motion, Oscillator, Combination of various oscillators, Transverse Waves, Longitudinal Waves, Waves on the transmission line, Electromagnetic Waves, Many dimension waves, Fourier Method, Waves on an optical system, Non linear oscillation, Wave mechanics</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">individual assignments, group assignment, mid-term exam, and final exam.</td></tr>
<tr><td>Media employed</td><td colspan="5">PowerPoint presentation</td></tr>
<tr><td>Reading list</td><td colspan="5">• H.J. Pain, The Physics of Vibrations and waves, 3rd edition
• Bekefi and Barrett. Electromagnetic Vibrations, Waves and Radiation. Cambridge, MA: The MIT Press, ISBN: 9780262520478
• French, A. P. Vibrations and Waves. New York, N.Y.: W.W. Norton & Company, . ISBN: 9780393099362
• Iain G, Main, Vibrations and Waves in Physics, Cambridge Univesity Press, isbn: 9780521447010</td></tr>
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Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Physics of Measurement</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">2nd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH602258</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">3rd semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Santoso S.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Santoso S.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive learning</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Question-based learning</td><td>Interactive learning</td><td>28</td></tr>
<tr><td>Self-directed study</td><td>28</td></tr>
<tr><td>Assignments</td><td>28</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on attendance (10%), paper assignment (10%), presentation (20%), individual assignment (10%), group assignment (10%), mid-term exam (20%), and final exam (20%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Electronics 2</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">None</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
Students are able to design a good measurement instrument system that can measure physical quantities.

Skill & Knowledge:
1. Able to apply learning methods.
2. Able to explain basics of physics of measurement.
3. Able to explain measurement system.
4. Able to explain types of instrumentation and its characteristics.
5. Able to explain time dependent characteristics.
6. Able to explain standard units and dimension of measured quantities.
7. Able to explain measurement uncertainties.
8. Able to explain measurement reliability and security systems.
9. Able to solve mid-term exam problems.
10. Able to explain signal conditioning.
11. Able to explain digital measurement.
12. Able to calibrate sensor and measurement instrument.
13. Able to measure analog physical quantities.
14. Able to read and process data.
15. Able to design measurement instrument device.
16. Able to solve final exam problems.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Introduction to physics of measurement
• Measurement system
• Types of instruments and its characteristics
• Time-dependent characteristics
• Standard unit and dimension
• Measurement uncertainties</td></tr>
</table>

	• Measurement reliability and security system • Signal conditioning • Digital measurement • Sensor and measurement instrument calibration • Analog quantities measurement • Data reading and processing • Measurement instrument system
Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. Robert B. Northrop, Introduction to Instrumentation and Measurements, CRC Press, Taylor Francis Group, 2ed ,2005 2. Alan S Morsis, Measurement & Instrumentation Principles, Butterworth Heinemann, 3rd , 2001. 3. J. G Webster, The Measurement, Instrumentation and Sensors Handbook, A CRC Handbook Published in Cooperation with IEEE Press, 1999 4. T. G. Beckwith, R. D. Marangoni, dan J. H. Lienhard V, Mechanical Measurements (I. Fundamentals of Mechanical Measurement, II. Applied Mechanical Measurements), Addison-Wesley Publishing Company, 5ed , 1993.

Physics Compulsory Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Introduction to Solid State Physics</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603117</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">5th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Budhy Kurniawan</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Budhy Kurniawan</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive and collaborative learning</td><td rowspan="3">50</td><td rowspan="3">3</td><td rowspan="3">Lectures and discussions</td><td>Lectures: 3 x 16</td><td>48</td></tr>
<tr><td>Assignments: 3 x 16</td><td>48</td></tr>
<tr><td>Independent study: 3 x 16</td><td>48</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">144 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">3 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on weekly assignments (30%), homework (10%), online discussion (10%), final presentation (10%), mid-term exam (20%), and final exam (20%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">1. Modern Physics (prerequisite)</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">1. Statistical Physics</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">After taking this course, students are able to formulate well-defined solutions to simple modern physics problems related to solid matter and material physics.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Introduction, the crystal structure of solids, vibrational motion in solids, electronic structure of solids, superconductivity of solids, magnetic properties of solids, dielectric and ferroelectric properties of solids, and physical properties of solids other than crystals.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Weekly assignments, homework, online discussion, final presentation, mid-term exam, and final exam.</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">PowerPoint presentation, EMAS UI Platform</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] C. Kittle, Introduction to Solid State Physics 8th Ed., Wiley, 2005.</td></tr>
</table>

Physics Compulsory Courses 3rd Year

<table>
<tr><td>Module name</td><td colspan="5">Introduction to Nuclear Physics</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">3rd year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH603513</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">5th semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Dr. Imam Fachruddin</td></tr>
<tr><td>Lecturer</td><td colspan="5">1. Prof. Dr. Terry Mart
2. Prof. Dr. Anto Sulaksono
3. Dr. rer. nat. Agus Salam
4. Dr. Imam Fachruddin</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Specialization course in Theoretical Nuclear and Particle Physics</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lectures and discussions</td><td rowspan="3">50</td><td rowspan="3">3</td><td rowspan="3">Lectures and discussions</td><td>Lectures: 3 x 16</td><td>48</td></tr>
<tr><td>Assignments: 3 x 16</td><td>48</td></tr>
<tr><td>Independent study: 3 x 16</td><td>48</td></tr>
<tr><td>Total Workload</td><td colspan="5">144 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">3 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on group presentations (40%), mid-term exam (30%), and final exam (30%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">1. Modern Physics (prerequisite)</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">After completing this lecture, Physics students are expected to be able to describe the properties of the atomic nucleus, nuclear processes, and the benefits of nuclear physics.</td></tr>
<tr><td>Content</td><td colspan="5">Explain the properties of the atomic nucleus, nuclear processes, and the benefits of nuclear physics. Formation of matter includes Rutherford scattering, nuclear properties, binding energy, bonding fraction, surface effect, energy separation, nuclear radius, semiempirical mass formula, core spin, core electric moment, nuclear magnetic moment, nuclear instability, radioactivity, core models , nuclear force, particle physics, fundamental interactions, quark models, nuclear astrophysics, accelerators, detectors, nuclear reactors, the benefits of nuclear physics.</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">Group assignments, mid-term exam, and final exam.</td></tr>
<tr><td>Media employed</td><td colspan="5">PowerPoint presentation</td></tr>
<tr><td>Reading list</td><td colspan="5">[1] P. E. Hodgson, E. Gadioli, E. Gadioli Erba, Introductory Nuclear Physics, Oxford U. Press, 2000.
[2] W. E. Meyerhof, Elements of Nuclear Physics, McGraw-Hill Book Co., 1989.</td></tr>
</table>

Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Seminar</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603166</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">5th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Ariadne L. Juwono, M.Eng., Ph.D.
Prof. Terry Mart</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Thesis Advisors</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Compulsory Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="2">Discussion, Scientific Writing, and Presentation</td><td rowspan="2">-</td><td rowspan="2">2</td><td rowspan="2">Question-based learning</td><td>Discussion</td><td>28</td></tr>
<tr><td>Scientific Writing</td><td>56</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on papers (50%) and presentation (50%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">>64 Credits</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">Undergraduate Thesis</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
After completing this course, physics students will be able to write scientific paper and present their research findings.

Skill & Knowledge:
1. Able to write a thesis in accordance with University of Indonesia guideline.
2. Able to write a scientific paper applicable to publication.
3. Able to make a presentation from research results.
4. Able to present the research results well.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Thesis writing according to UI guideline (chapter 1 & 2)
• Thesis writing according to UI guideline (chapter 3, 4, 5, abstract, references, and attachment)
• Writing scientific paper that is applicable to publication
• Make presentation from research results
• Present research results</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Online Exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">PowerPoint</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">1. Surat Keputusan Rektor UI nomor 628/SK/R/UI/2008, tentang Pedoman Teknis Penulisan Tugas Akhir Mahasiswa Universitas Indonesia, 16 June 2008.</td></tr>
</table>

	2. Format dokumen Naskah Ringkas Tugas Akhir, Perpustakaan Universitas Indonesia, Desember 2012 3. R. Weissberg dan S. Buker, Writing Up Research; Experimental Research, Report Writing for Students of English, Prentice-Hall, Inc, 1990. 4. R. A. Day, How to Write and Publish a Scientific Paper, 3rd ed., Cambridge Univeristy Press, 1991. 5. Examples of scientific paper and the procedures 6. Various source from internet about scientific presentation technique.

Physics Elective Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Materials Characterization Methods</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603515</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Azwar Manaf, M.Met.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Azwar Manaf, M.Met.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lectures, question-based learning, self-directed study, and discussions</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Lectures and discussions</td><td>Lectures: 4 x 16</td><td>64</td></tr>
<tr><td>Assignments: 4 x 16</td><td>64</td></tr>
<tr><td>Independent study: 4 x 16</td><td>64</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">192 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (20%), mid-term exam (40%), and final exam (40%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">1. Modern Physics (prerequisite)
2. Advanced Physics Laboratory Work 1 (prerequisite)
3. Advanced Physics Laboratory Work 2 (prerequisite)
4. Introduction to Solid State Physics (prerequisite)</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">After completing this lecture, students are able to apply physics principles to test instruments and evaluate standard methods for testing and characterizing materials in processing material properties data appropriately</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">The basic principles of X-Ray, XRD, XRF, TEM, SEM, EDS, DTA, TGA, DSC, UTM, Impact Test, LPSA, AAS, ESR. Permeameter, VSM. Various test standards (including ASTM E 975-95), material phase identification, heat capacity, thermal conductivity, APD program, Match and GSAS, mechanical properties testing and standardization, ultrasonic and its applications, radiography and its applications, Eddy Current technique and its applications, optical diffraction and its applications, magnetic properties and their standardization.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Individual assignments, mid-term exam, and final exam.</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">PowerPoint presentation, EMAS UI Platform</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] B.D. Cullity, Introduction to X-Ray Diffraction, Addition Wesley, 1978
[2] P.J. Goodhew and F.J. Humphreys, Electron Microscopy and Analysis, Taylor & Francis, 1988</td></tr>
</table>

	[3] ASM Handbook Volume 10, Materials Characterization, ASM International, 1992 [4] Scientific publications related to material methods and characterizations.

Physics Specialization Courses 4th Year

Module name	**Relativistic Quantum Mechanics**				
Module level, if applicable	4th year				
Code, if applicable	SCPH603700				
Semester(s) in which the module is taught	7th semester				
Person responsible for the module	Dr. Agus Salam				
Lecturer	Dr. Agus Salam				
Language	Bahasa Indonesia				
Relation to curriculum	Elective course				
Types of teaching and learning	Class Size	Attendance time (hours per week per semester)	Forms of active participation	Workload	
Interactive lecture and independent learning	50	4	Lectures	Lectures: 4 x 14	56
				Assignments: 4 x 14	56
				Independent study: 4 x 14	56
Total Workload	168 hours				
Credit points	4 credits				
Requirement according to examination regulations	Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (40%), the midterm exam (30%), and the final exam (30%)				
Recommended prerequisites	Quantum Physics 1				
Related Course	-				
Module objectives/intended learning outcome	Students can apply the concepts and principles in time-dependent electromagnetic fields to solve problems in physics involving electromagnetic interactions.				
Content	String quantization, electromagnetic field quantization, interaction between radiation and matter, the Klein-Gordon equation, the Dirac equation and its applications, second quantization, symmetry, interacting field theory, quantum electrodynamics, renormalization, bound states, and unitarity.				
Study and examination requirements and forms of examination	Individual assignments, midterm exam, and final exam				
Media employed	Whiteboard				
Reading list	[1] [Gross] F. Gross, Relativistic Quantum Mechanics and Field Theory, John Wiley & Sons, 1993. [2] [Maiani] L. Maiani and O. Benhar, Relativistic Quantum Mechanics and An Introduction to Relativistic Quantum Field, Taylor and Francis Group, 2016.				

Physics Specialization Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Classical Field Theory</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603701</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">5th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Handhika Satrio Ramadhan, Ph.D</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Handhika Satrio Ramadhan, Ph.D</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Bahasa Indonesia</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lecture and independent learning</td><td rowspan="3">50</td><td rowspan="3">3</td><td rowspan="3">Lectures</td><td>Lectures: 3 x 14</td><td>42</td></tr>
<tr><td>Assignments: 3 x 14</td><td>42</td></tr>
<tr><td>Independent study: 3 x 14</td><td>42</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">126 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">3 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (40%), the midterm exam (30%), and the final exam (30%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Electromagnetic Field 1, Classical Mechanics</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students can analyze fundamental fields and their symmetry in the framework of Lagrangian formalism, understand the unification of fundamental forces in physics in the framework of gauge theory, and analyze gravitational fields as a consequence of curvature in spacetime and apply them to problems within astrophysics</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Lorentz transformation, tensor algebra and calculus, covariant formulation of Maxwell’s electromagnetic field, Lagrangian formulation and least action principle for continuous systems (fields), Euler-Lagrange equation for Maxwell fields and scalar fields (Klein-Gordon), Noether’s theorem and the energy-momentum tensor, gauge transformation for Abelian and non-Abelian symmetry, equivalence between inertial mass and gravitational mass, tensor fields and tensor calculus in curved manifolds, metric tensor, the Christoffel symbol, covariant derivatives, and geodesic equations, Riemann curvature tensor, Ricci tensor, Einstein’s equation for gravitational fields, several exact solutions to Einstein’s equation: the Schwarzschild solution, the Reissner-Nordstrom solution, the de Sitter and anti-de Sitter solution, black holes</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Individual assignments, midterm exam, and final exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">Whiteboard</td></tr>
</table>

Reading list	[1] L. Ryder, Introduction to General Relativity, Cambridge University Press, 2012. [2] S. Carroll, Spacetime and Geometry: an Introduction to General Relativity, Pearson Education, 2014. [3] M. Carmeli, Classical Fields: General Relativity and Gauge Theories, John Wiley and Sons, 1982. [4] M. P. Hobson, G.P. Efstathiou, dan A.N. Lasenby, General Relativity: An Introduction for Physicists, Cambridge University Press, 2006.

Physics Specialization Courses 3rd Year

Module name	**Advanced Computational Physics**				
Module level, if applicable	3rd year				
Code, if applicable	SCPH603702				
Semester(s) in which the module is taught	6th semester				
Person responsible for the module	Muhammad Aziz Majidi and Imam Fachruddin				
Lecturer	Muhammad Aziz Majidi and Imam Fachruddin				
Language	Bahasa Indonesia				
Relation to curriculum	Elective course				
Types of teaching and learning	Class Size	Attendance time (hours per week per semester)	Forms of active participation	Workload	
Lecturing	20	3	Lectures	Lectures: 3 x 14	42
				Assignments: 3 x 14	42
				Independent study: 3 x 14	42
Total Workload	126 hours				
Credit points	3 credits				
Requirement according to examination regulations	Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (40%), the midterm exam (30%), and the final exam (30%)				
Recommended prerequisites	Computational Physics				
Related Course	Computational Physics				
Module objectives/intended learning outcome	Students can apply numerical methods in calculations to solve problems in Physics and use the Fortran programming language or its equivalent to do calculations using numerical methods.				
Content	Finding the roots of functions, solving systems of linear equations, fitting using the least-square method, interpolation, numerical integration, solving ordinary and partial differential equations with boundary conditions, solving eigenvalue problems using the power method, solving secular equations or characteristic polynomial matrices.				
Study and examination requirements and forms of examination	Individual assignments, midterm exam, and final exam				
Media employed	PowerPoint presentation				
Reading list	[1] . L. DeVries, A First Course in Computational Physics (John Wiley & Sons, Inc., New York, 1994)				

Physics Compulsory Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Introduction to Material Scoence</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603703</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Anawati, PhD</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">1. Anawati, PhD
2. Ariadne L Juwono, PhD</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Specialization course for material physics</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lecture, Cooperative learning, Presentation, Structured learning, Independent study</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Group discussion</td><td>Lectures: 4 x 16</td><td>64</td></tr>
<tr><td>Assignments: 4 x 16</td><td>64</td></tr>
<tr><td>Independent study: 4 x 16</td><td>64</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">192 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on group presentations (40%), mid-term exam (30%), and final exam (30%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Modern Physics, Introduction to Solid State Physics</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students are expected to have a knowledge about fundamentals, types of materials, process-properties-material structure relationships, material structures (structure: macro, micro, sub, crystal and atomic electronic structures); atomic bonds in crystals, binding energy; unit cell; allotropy; crystal direction and plane; defects in crystals; materials: metals and alloys, ceramics, polymers, composites, electronic and magnetic materials</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Explain Atomic structures and bonds, Crystal structure, Crystal defects, Dislocation and reinforcement mechanisms, Mechanical properties of metals, Structure and properties of ceramics, The structure and properties of the polymer, Metal forming process, The process of forming ceramics, The polymer formation process</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Discussion, presentation, sub-CLO problem test, homework, mid term exam, final term exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">PowerPoint presentation</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">1. W.D. Callister, Jr. Materials Science and Engineering: An Introduction, 7th Ed, John Wiley & Sons, Inc., 2007.
2. Related articles and journals.</td></tr>
</table>

Physics Compulsory Courses 3rd Year

<table>
<tr><td>Module name</td><td colspan="5">Applied Material Physics</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">3rd year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH603704</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">5th semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Ariadne L. Juwono</td></tr>
<tr><td>Lecturer</td><td colspan="5">Ariadne L. Juwono</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Specialization course for material physics</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lecture, Cooperative learning, Presentation, Structured learning, Independent study</td><td rowspan="3">50</td><td rowspan="3">3</td><td rowspan="3">Group discussion</td><td>Lectures: 3 x 16</td><td>48</td></tr>
<tr><td>Assignments: 3 x 16</td><td>48</td></tr>
<tr><td>Independent study: 3 x 16</td><td>48</td></tr>
<tr><td>Total Workload</td><td colspan="5">144 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">3 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on group presentations (40%), mid-term exam (30%), and final exam (30%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">Modern Physics, Advanced Physics Practicum 1 & 2, and Introduction to Solid Physics</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">Students are expected to be able to apply physics to polymer, ceramic, metal and composite-based materials, both conventional and advanced materials. In addition, students are able to analyze the synthesis process, physical properties, chemical properties and mechanical properties of materials and are able to characterize materials based on the principles of physics. Topics covered include polymer-based materials, ceramics, metals, and composites, and their properties. This lecture is delivered face-to-face and online (EMAS); with the flipped class room method, cooperative learning and collaborative writing Wiki in EMAS.</td></tr>
<tr><td>Content</td><td colspan="5">Explain the principle of mass conservation in the preparation of metal alloys; Induction melting technology, arc melting, mechanical alloying¸powder metallurgy for the preparation of metal alloys and blast furnace technology for metal reduction; Thermodynamics overview of the process of forming metal alloys (entropy and free energy); Solidification process; homogeneous, heterogeneous nucleation; nucleation rate, alloy system, solubility limit, Hume-Rothery rules; microstructure; Alloy system binary phase diagram (miscibility gap, eutectic, eutectoid, pretectic, pretectoid, intermediate phase, intermetallic phase, lever rule); Ternary system phase diagram (introduction); Alloy</td></tr>
</table>

	system Fe-C (steel, hypo and hyper eutectoid steel, cast iron); Heat treatment process in the system; microstructure evolution; grain growth kinetics; recrystallization kinetics, mechanical and magnetic properties of alloy systems. The use of x-rays for phase identification, determination of the volume fraction of the phase in alloy systems, Basic concepts of polymer science (differences in polymer physics and polymer chemistry). Describe the mechanism and kinetics of polymerization reactions (initiation, propagation, termination). Classification of polymers based on their properties: Thermoplastic, thermoset and elastomer. Polymer material synthesis techniques. Synthetic polymers: PVC, PS, PE (LDPE and HDPE), PP, PTFE, PMMA, PET, Nylon. Polymer morphology and characterization using SEM / TEM. The rheology and mechanical properties of polymers. Physical properties of polymer materials. Analysis of polymer thermal properties (DTA, TGA, DSC). Characterization of polymer mechanical properties (tensile strength, compressive strength, flexural strength, impact resistance, fatigue / fatigue, hardness, flexibility, Young's Modulus), Effects of chemical bonds on physical properties, diffusion and electrical conductivity, formation, structure and properties of glass, sintering of solids, sintering of liquids and grain growth, mechanical properties, thermal properties, dielectric properties, magnetic properties and optical properties., Introduction, various types of composites and their applications, various types of matrices and reinforcements, selection of matrix and reinforcing materials, matrix-reinforcing interfaces, mechanical properties of isotropic composites and Rule of Mixtures, as well as introduction of anisotropic models on uninterrupted fiber reinforcement.
Study and examination requirements and forms of examination	Homework, presentation, discussion, wiki writing, mid term exam, final exam
Media employed	PowerPoint presentation
Reading list	1. Callister, Introduction of Materials Science, edisi ke-7, 2007 2. Peter Hassen, Physical Metallutgy, Cambridege University Press, London (ISBN: 0-521-29183-6) 3. Suryanarayana, Grant Norton, X-Ray Diffraction: Practical Approach, Plenum Press, New York and London (ISBN: 0-306-45744-X) 4. M. W. Barsoum, Fundamentals of Ceramics, Inst. of Publishing, 2003. 5. Stevens, M.P., 1975 : Polimer Chemistry and Introduction, Addison Wesley, N.Y. 6. F.W. Billmeyer, JR. (1998) Textbook of Polymer Science, Amerika : John Wiley & Sons, Inc. 7. Various articles from selected journals

Physics Elective Courses 3rd / 4th Year

<table>
<tr><td>Module name</td><td colspan="5">Transport and Optical Properties of Materials</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">3rd / 4th year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH603706</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">6th / 8th semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Efta Yudiarsah, Ph.D.</td></tr>
<tr><td>Lecturer</td><td colspan="5">Efta Yudiarsah, Ph.D.</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Elective course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive and collaborative learning</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Lectures and discussions</td><td>Lectures: 4 x 16</td><td>64</td></tr>
<tr><td>Assignments: 4 x 16</td><td>64</td></tr>
<tr><td>Independent study: 4 x 16</td><td>64</td></tr>
<tr><td>Total Workload</td><td colspan="5">192 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">4 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and homework (30%), quizzes (15%), class involvement (5%), mid-term exam (25%), and final exam (25%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">-</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">Students are able to explain the concept of the emergence of transport properties of charge and heat, as well as the optical properties of solids from a simple view of a free electron system to a more complex one with respect to the potential effects of crystals, phonons, etc.</td></tr>
<tr><td>Content</td><td colspan="5">Energy band structure, electric charge transport phenomena, heat transport, electron beam by phonons, defects and impurities, magneto-transport phenomena, two-dimensional electron gas, quantum wells and semiconductor superlattices, transport in low dimension system, fundamental relationships in optical phenomena, Drude's theory, transitions between bands, joint density of states, absorption of light in solids.</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">Individual assignments/homework, quizzes, mid-term exam, and final exam.</td></tr>
<tr><td>Media employed</td><td colspan="5">-</td></tr>
<tr><td>Reading list</td><td colspan="5">[1] C. Kittle, Introduction to Solid State Physics 8th Ed., Wiley, 2005.
[2] J. R. Hook and H. E. Hall, Solid State Physics 2nd Ed, Wiley, 1991.
[3] N. W. Ashcroft and N. D. Mermin, Solid State Physics, Saunders College Publishing, 1976.
[4] H. Ibach and H. Luth, Solid-State Physics 4th Ed., Springer, 2009.</td></tr>
</table>

Specialization Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Sensors and Actuators</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">Undergraduate</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603710</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6th Semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Santoso</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Santoso</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Concentration Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lectures and discussions</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Lectures and Discussions</td><td>Lectures: 4 x 7</td><td>28</td></tr>
<tr><td>Assignments: 4 x 7</td><td>28</td></tr>
<tr><td>Independent Study: 4 x 7</td><td>28</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments andForms (20%), Student Assignment Sheets (20%), Papers and presentation (First Home Group and Second Home Group) (10%), Presentation (10%), Mid-Term Exam (20%) and Final Exam (20%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Electronics 2 (prerequisite)</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students are able to explain the technology behind sensors and actuators, precisely select and chose sensors and actuators needed for certain conditions, and apply it for monitoring and measuring physical units</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Explaining the basic principles of Sensors and Actuators which include Temperature Sensors (Thermistors, Resistance Temperature Sensors, Silicon Resistive Sensors, Thermoelectric Sensors, PN Junction Temperature Sensors, and Optical Temperature Sensors), Mechanical Sensors (Pressure Sensors, Flow Sensors, and Level Sensors), Definitions, Classification and Characteristics of Actuators, Electric Actuators, Stepper Motors, Hydraulic Actuators, and Continuous Drive Actuators.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Forms, Student Assignment Sheet, Papers and Presentation (HG1 and HG2), Presentation, Mid-Term Exam and Final Exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">Books, PowerPoint Presentation, Microsoft Teams</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] https://scele.ui.ac.id/course/view.php?id=7081
enrollment key:</td></tr>
</table>

[2] J. G Webster, *The Measurement, Instrumentation and Sensors Handbook*, A CRC Handbook Published in Cooperation with IEEE Press, 1999

[3] Fraden, J. , GAIP Handbook of Modern Sensors, Physics, Designs and Applications, J American Institute of Physics, 2004.

[4] Sensors, Volume 5, Magnetic Sensor, W. Gospel, J. Hesse, JN. Zemel, VCH, 1989.

[5] Sensors, Volume 6, Optical Sensor, W. Gospel, J. Hesse, JN. Zemel, VCH, 1992.

[6] Instrumentation Reference Book, Walt Boyes, Butterwort - Heinemann, 2003

[7] William C. Dunn, Introduction to Instrumentation, Sensors, and Process Control, Artech House, 2006.

Specialization Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="5">Sensors and Actuators Laboratory</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="5">Undergraduate</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="5">SCPH603711</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="5">6th Semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="5">Surya Darma, M.Si.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="5">Surya Darma, M.Si.</td></tr>
<tr><td colspan="2">Language</td><td colspan="5">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="5">Concentration Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="3">Workload</td></tr>
<tr><td>Lectures and discussions</td><td>50</td><td>3</td><td>Lectures and Discussions</td><td colspan="2">Laboratory Work: 3 x 14</td><td>42</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="5">42 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="5">1 credit</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and Discussions (20%), Presentations and QnA (10%), Sub-CLO Evaluation Assignments (20%), Laboratory Work (30%), Mid Term Exam (10%) and Final Exam (10%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="5">Electronics 2</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="5">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="5">After finishing this course, students are able to precisely explain the concepts of how sensors and actuators work, select and choose sensors and actuators for certain tasks and apply it for monitoring and measuring physical units.</td></tr>
<tr><td colspan="2">Content</td><td colspan="5">Explaining the basic principles of Sensors and Actuators which include Temperature Sensors, Pressure and Weight Sensors, Light Sensors, Flow Sensors, Level Sensors, Magnet Sensors, Proximity Sensors, Chemical Sensors, Electric Actuators, Hydraulic Actuators and Pneumatic Actuators.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="5">Discussions, Presentations and QnA, Sub-CLO Evaluation Assignments, Laboratory Work, Mid-Term Exam and Final Exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="5">Direct Practice, Power Point, Ms Teams, Ms Word (for reports)</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="5">[1] Departemen Fisika FMIPA UI, Buku Panduan Praktikum Sensor dan Aktuator
[2] Beckwith, T. G. , Marangoni, R. D. dan J. H. Lienhard V, Mechanical Measurements (I. Fundamentals of Mechanical Measurement, II. Applied Mechanical</td></tr>
</table>

	Measurements), Addison-Wesley Publishing Company, 6ed , 2006

Specialization Courses 3rd Year

<table>
<tr><td>Module name</td><td colspan="5">Embedded System</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">Undergraduate</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH603712</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">5th Semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Dr. Prawito Prajitno</td></tr>
<tr><td>Lecturer</td><td colspan="5">Dr. Prawito Prajitno</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Concentration Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lectures and discussions</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Lectures and Discussions</td><td>Lectures: 4 x 7</td><td>28</td></tr>
<tr><td>Assignments: 4 x 7</td><td>28</td></tr>
<tr><td>Independent Study: 4 x 7</td><td>28</td></tr>
<tr><td>Total Workload</td><td colspan="5">84 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">2 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and In-class quiz (10%), homework and simulations (10%), group project (20%), mid-term exam (30% and final exam (30%).</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">Electronics 1 and Electronics 2</td></tr>
<tr><td>Related Course</td><td colspan="5">Laboratory Work of Embedded Systems</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">Students are able to apply a range of basic techniques needed in making an embedded system while being thought 2 types of programming language (Assembly language and C language) and is able to create a simple project for embedded systems using a microcontroller.</td></tr>
<tr><td>Content</td><td colspan="5">Basic concepts about embedded systems, examples of embedded systems, microprocessors and microcontrollers, microcontroller architecture, memory organization, minimum systems based on microcontrollers, instruction sets, parallel inputs and outputs, interrupts, Counters and Timers, Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC), interfacing external memory, interfacing external peripherals and devices, serial data communication such as : USART, SPI, I2C, 1-Wire, and Real-time Operating Systems (RTOS)</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">Individual assignments, in-class quizzes, group project, mid-term, and final exam.</td></tr>
<tr><td>Media employed</td><td colspan="5">Books, PowerPoint Presentation, Microsoft Teams</td></tr>
</table>

Reading list	[1] Mazidi, M.A, Naimi, S., *The AVR Microcontroller and Embedded Systems Using Assembly and C*, Prentice Hall, 2011. [2] Barnett, R.H, Cox, S, O'Cull, L, *Embedded C Programming and The Atmel AVR, 2nd edition*, Thomson Delmar Learning, 2007 [3] Maxim Integrated, *DS-1820 High-Precision 1-Wire Digital Thermometer*, Maxim Integrated Product, 2015. [4] Barrr, R, *Mastering the Free RTOS Real Time Kernel, A Hands-On Tutorial Guide*, Real Time Engineers Ltd. 2016

Specialization Courses 3rd Year

Module name	**Control System Laboratory**				
Module level, if applicable	Undergraduate				
Code, if applicable	SCPH603713				
Semester(s) in which the module is taught	6th Semester				
Person responsible for the module	Surya Darma, M.Si.				
Lecturer	Surya Darma, M.Si.				
Language	Indonesian				
Relation to curriculum	Concentration Course				
Types of teaching and learning	Class Size	Attendance time (hours per week per semester)	Forms of active participation	Workload	
Lectures and discussions	50	3	Lectures and Discussions	Laboratory Work: 3 x 14	42
Total Workload	42 hours				
Credit points	1 credit				
Requirement according to examination regulations	Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and answering the pre-test before the course starts every week (5%), Laboratory Work (70%) and the Final Project (25%)				
Recommended prerequisites	Electronics 2				
Related Course	-				
Module objectives/intended learning outcome	After finishing this course, students are ably to apply the basic principles of control systems for identifying and designing a continuous linear process that is continuous and simple that has a fast and slow response towards time				
Content	After finishing this course, students taking the concentration of Instrumentational Physics in the 7th term is able to explain the principals of a control system, select and chose the transfer function and the control system for specific applications, and is able to design a control system for a certain proces. The instructional language used in this course will be the Indonesian language.				
Study and examination requirements and forms of examination	Discussions, Presentations and QnA, Sub-CLO Evaluation Assignments, Laboratory Work, Mid-Term Exam and Final Exam				
Media employed	Direct Practice, Power Point, Ms Teams, Ms Word (for reports)				
Reading list	[1] National Instruments Corporation, LabVIEW Fundamentals, ni.com, 2005				

	[2] Sulaymon Eshkabilov, Beginning MATLAB and Simulink: From Novice to Professional, Apress, Fargo, USA, 2019 [3] Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017. [4] Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017. [5] Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics and Control, 4th ed., John Wiley & Son., 2017. [6] Quanser, QNET DC Motor Trainer, QNET Rotary Pendulum Trainer, QNET Heating and Ventilation Trainer, 2011.

Specialization Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Control System</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">Undergraduate</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603714</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6th Semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Arief Sudarmaji</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Arief Sudarmaji</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Concentration Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lectures and discussions</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Lectures and Discussions</td><td>Lectures: 4 x 7</td><td>28</td></tr>
<tr><td>Assignments: 4 x 7</td><td>28</td></tr>
<tr><td>Independent Study: 5 x 7</td><td>28</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and In-class Quizzes (10%), Homework and Simulations (10%), Group Project (20%), Mid-Term Exam (30%) and Final Exam (30%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">1. Electronics 1 (prerequisite)
2. Electronics 2 (prerequisite)</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">Laboratory Work of Control System</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students are able to understand problems and apply interfacing and programming methods in embedded systems effectively and efficiently</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Giving the basic concepts about control systems such as feedback and control systems, Laplace transformation, linear transfer function systems, linearization of unilinear systems, modelling mathematical systems, mechanical and electrical systems, block diagram modelling, graphical signal flow modelling, state variable models, error signal analysis, sensitivity of feedback control system towards the variety of parameters in the control system, signal disturbance in a feedback control system, controlling the transient response of a system, steady state errors, second order system, effects of third pole and zero's in a second order system, work index of control systems, simplification of linear systems, analyzation of loop systems (open and closed loop), testing the stability of control systems using characteristic functions and the Ruth Hurwitz method, control system design: root locus concept, parameter design of control system using the root locus, determining the parameters of PID using trial and error methods, identifying the process of a stable open loop system, determining the parameters of a PID with the Direct Synthesis, Inter Model Control, System Index, Ziegler Nichols, Cohen Coon and Reactive Curve methods, analyzing the frequency response using the Bode</td></tr>
</table>

	and Nyquist plot, designing PI, PID, Lead, Lag, and Lead Lag systems, and finally, designing feedback systems with state variables.
Study and examination requirements and forms of examination	In-Class Quizzes, Homework and Simulations, Group Project, Mid-Term, and Final Exam.
Media employed	Books, PowerPoint Presentation, Microsoft Teams
Reading list	[1] N.S. Nise, M.A, *Control Systems Engineering*, 7^{th} edition, Wiley, 2015. [2] R. C. Dorf and R.H. Bishop, *Modern Control System*, 12^{th} edition, Prentice Hall, 2011 [3] D.E. Seborg, T.F. Edgar, D.A. Mellichamp, and F.J. Doyle, *Process Dynamics and Control*, 4^{th} edition, Wiley, 2017.

Specialization Courses 3rd Year

Module name	**Control System Laboratory**				
Module level, if applicable	Undergraduate				
Code, if applicable	SCPH603715				
Semester(s) in which the module is taught	6th Semester				
Person responsible for the module	Surya Darma, M.Si.				
Lecturer	Surya Darma, M.Si.				
Language	Indonesian				
Relation to curriculum	Concentration Course				
Types of teaching and learning	Class Size	Attendance time (hours per week per semester)	Forms of active participation	Workload	
Lectures and discussions	50	3	Lectures and Discussions	Laboratory Work: 3 x 14	42
Total Workload	42 hours				
Credit points	1 credit				
Requirement according to examination regulations	Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and Discussions (20%), Presentations and QnA (10%), Sub-CLO Evaluation Assignments (20%), Laboratory Work (30%), Mid Term Exam (10%) and Final Exam (10%)				
Recommended prerequisites	Electronics 2				
Related Course	-				
Module objectives/intended learning outcome	After finishing this course, students are ably to apply the basic principles of control systems for identifying and designing a continuous linear process that is continuous and simple that has a fast and slow response towards time				
Content	After finishing this course, students taking the concentration of Instrumentational Physics in the 7th term is able to explain the principals of a control system, select and chose the transfer function and the control system for specific applications, and is able to design a control system for a certain proces. The instructional language used in this course will be the Indonesian language.				
Study and examination requirements and forms of examination	Discussions, Presentations and QnA, Sub-CLO Evaluation Assignments, Laboratory Work, Mid-Term Exam and Final Exam				
Media employed	Direct Practice, Power Point, Ms Teams, Ms Word (for reports)				
Reading list	[1] National Instruments Corporation, LabVIEW Fundamentals, ni.com, 2005				

[2] Sulaymon Eshkabilov, Beginning MATLAB and Simulink: From Novice to Professional, Apress, Fargo, USA, 2019

[3] Dorf, Richard C., and Bishop, Robert H., Modern Control System, 13th ed., Prentice Hall, 2017.

[4] Golnaraghi, Farid., and Kuo, Benjamin C., Automatic Control System, 10th ed. McGraw Hill Education., 2017.

[5] Seborg, Dale E., Edgar, Thomas F., and Mellichamp, Duncan A., Process Dynamics and Control, 4th ed., John Wiley & Son., 2017.

[6] Quanser, QNET DC Motor Trainer, QNET Rotary Pendulum Trainer, QNET Heating and Ventilation Trainer, 2011.

Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Introduction to Radiology Physics and Dosimetry</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603716</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6/7th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Akbar Azzi, M.Si.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Akbar Azzi, M.Si.
Lukmanda Evan Lubis, M.Si.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="2">Interactive Learning & Lecture Video</td><td rowspan="2">50</td><td rowspan="2">2</td><td rowspan="2">Discussion</td><td>Asynchronous</td><td>56</td></tr>
<tr><td>Synchronous</td><td>28</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on module exam (40%), summary (15%), video (15%), mid-term exam (15%), and final exam (15%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Modern Physics</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">None</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
Students able to identify basic physics principle related to radiology and appropriate dosimeter according to international protocol.

Skill & Knowledge:
1. Able to explain characteristics of radiation according to basic physics principle
2. Able to apply basic modern physics principle to interaction of radiation with matter problems.
3. Able to identify characteristics of radiation measurement in dosimetry
4. Able to illustrate and differentiate various dosimeter used for clinical situation.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Classification of radiation
• Radiation units and quantities
• Interaction coefficients
• Ionizing and non-ionizing radiation
• Interaction of radiation with matter (photon)
• Interaction of radiation with matter (electron)
• Radioactive decay
• Charged Particle Equilibrium
• Radiation dosimetry
• Cavity Theory
• Ionization chamber
• Photon and electron calibration with ionization chamber
• Clinical dosimetry protocol: radiotherapy
• Clinical dosimetry protocol: radiology diagnostic and interventional
• Absolute and relative dosimetry technique</td></tr>
</table>

Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. Podgorsak, Radiation Oncology Physics: Handbook for Teacher and Student. (IAEA, 2005) 2. F. H. Attix. Introduction of Radiological Physics and Radiation Dosimetry (John Willey and Sons, New York, NY, 1986) 3. Dance, Diagnostic Radiology Physics: A Handbook for Teachers and Students. (IAEA, 2010) 4. Metcalfe, et al, The Physics of Radiotherapy X-rays and Electron. (Medical Physics Publishing, 2007) 5. H. E. Johns and J. R. Cunningham. The Physics of Radiology, 4th ed. (Charles C. Thomas, Springfield, IL, 1983) 6. J. F. Knoll. Radiation Detection and Measurement. 3rd. ed. (John Willey and Sons, New York, NY, 2000). 7. AAPM TG-21, AAPM TG-51, IAEA TRS 277, IAEA TRS 398, IAEA TRS 457, and ICRU Report 74

Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Anatomy and Physiology</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603717</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6/7th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. sc. hum. Deni Hardiansyah</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">dr. Nurhadi Ibrahim, Ph.D.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive Learning</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Discussion & question-based learning</td><td>Self-directed study</td><td>28</td></tr>
<tr><td>Assignments</td><td>28</td></tr>
<tr><td>Interactive learning</td><td>28</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on papers (30%), presentation (20%), mid-term exam (25%), and final exam (25%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">General Biology</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">None</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
Students can describe the anatomical structure and physiological mechanisms of homeostasis in the human’s body in daily lives to solve existing problems.

Skill & Knowledge:
1. To identify anatomical structure in daily lives to solve existing problems.
2. To describe physiological mechanisms of homeostasis in the human’s body in daily lives to solve existing problems.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Anatomical nomenclature
• Human bone
• Human brain
• Spinal column
• Thorax
• Abdomen
• Nerve system
• Respiratory system
• Digestive system
• Urinary system
• Reproduction system
• Circulation system
• Pathology Absolute and relative dosimetry technique</td></tr>
</table>

Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. R. Putz dan R. Pabst, Atlas Anatomi Manusia Sobotta, EGC, 2010. 2. Serwood, Fisologi Manusia: dari sel ke sistem, EGC, 2001

Module Handbook

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Introduction to Biophysics</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH603718</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6/7th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Nurlely, M.Si.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Nurlely, M.Si.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive Learning & Lecture Video</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Discussion & interactive learning</td><td>Synchronous</td><td>28</td></tr>
<tr><td>Assignments</td><td>28</td></tr>
<tr><td>Self-directed study</td><td>28</td></tr>
<tr><td colspan="2">Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 Credits</td></tr>
<tr><td colspan="2">Requirements according to the examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (30%), group assignments (30%), mid-term exam (20%), and final exam (20%).</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">General Biology</td></tr>
<tr><td colspan="2">Related course</td><td colspan="4">None</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcomes</td><td colspan="4">Intended Learning Outcomes:
After completing this course, medical physics and biophysics student are able to know and understand biophysics phenomenon that happen in biology and medicine or other live sciences.

Skill & Knowledge:
1. Able to explain and apply basic biophysics concepts to classify structure, characteristic, and function of macromolecule.
2. Able to explain and apply thermodynamics concepts on biological process and system.
3. Able to explain and apply electromagnetism concepts on cell membrane.
4. Able to explain and apply biophotonic and bioacoustics concepts to vision and hearing sense.
5. Able to explain and apply biophysics concepts on muscle contraction, biomechanics of hard and soft structure as well as the biophysics of radiation.
6. Able to explain and apply biophysics concepts and its application in determining characteristics of macromolecule.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">• Introduction to cell biophysics
• Molecular structure and interaction
• Bioenergy 1
• Bioenergy 2
• Membrane Transport
• Electrical characteristics of cell membrane
• Bioelectromagnetic
• Biophotonic
• Bioacoustics
• Biomechanics
• Biophysics of radiation
• Biophysics technique and application 1</td></tr>
</table>

	• Biophysics technique and application 2
Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. W. Hoppe, W. Lohmann, H. Markl, H. Ziegler, Biophysics, Publisher : Springer; 1st Edition (September 21, 1983). 2. Patrick F. Dillon, Biophysics, Published in the United States of America by Cambridge University Press, New York, 2012. 3. Rodney M J Cotteril, Introduction to Biophysics, Published by John Wiley & Sons Ltd, 2002. 4. Thomas Heimburg, Thermal Biophysics of Membrane , WILEY-VCH Verlag GmbH & Co. KGaA, 5. Weinheim, 2007. 6. MUDr. Elena Kukurová, CSc, Eva Kráľová, Michal Trnka, Basics of Medical Physics and Biophysics for electronic education of health professionals, Publisher: Asklepios, Bratislava 2013.

Module Handbook

<table>
<tr><td>Module name</td><td colspan="5">Health Physics and Radiation Protection</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">3rd year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH603719</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">6/7th semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Lukmanda Evan Lubis, M.Si.</td></tr>
<tr><td>Lecturer</td><td colspan="5">Lukmanda Evan Lubis, M.Si.</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Elective Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class size</td><td>Attendance time (hour per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive Learning & Lecture Video</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Discussion & interactive learning</td><td>Synchronous</td><td>28</td></tr>
<tr><td>Assignments</td><td>28</td></tr>
<tr><td>Self-directed study</td><td>28</td></tr>
<tr><td>Workload</td><td colspan="5">84 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">2 Credits</td></tr>
<tr><td>Requirements according to the examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on essay (20%), scientific paper (20%), exercises (20%), mid-term exam (20%), and final exam (20%).</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">Introduction to Nuclear Physics</td></tr>
<tr><td>Related course</td><td colspan="5">None</td></tr>
<tr><td>Module objectives/intended learning outcomes</td><td colspan="5">Intended Learning Outcomes:
After completing this course, medical physics and biophysics students are able to apply radiation protection principles to the use of ionizing and non-ionizing radiation in healthcare services according to the standards of the medical physicist profession.

Skill & Knowledge:
1. Students are able to explain the use of ionizing and non-ionizing radiation in health services and their regulations.
2. Students are able to explain the principles of protection against ionizing radiation in health services.
3. Students are able to explain the principles of protection against non-ionizing radiation in health services.
4. Students are able to apply the principle of protection against ionizing radiation in health services.
5. Students are able to apply the principle of protection against non-ionizing radiation in health services.</td></tr>
<tr><td>Content</td><td colspan="5">• Introduction and historical perspective (discovery and early application of ionizing radiation, observation of radiation injury, recommended radiation protection practices of pre-regulated radiation protection initiatives).
• Operational dosimetry (unit, kerma and absorbed dose, equivalent dose, recent ICRU recommendations on neutron quality factors).
• Radiation detection instrumentation (ionometry including proportional counters and Geiger-Mueller, scintillation detectors and TLD devices, equivalent dose instrumentation).
• Radiation shielding: properties and design (direct ionizing particles, indirect ionized particles, build-up parameterization, stochastic sampling: Monte Carlo, particle accelerator, NCRP recommendation on radiation shielding calculation.</td></tr>
</table>

	• Statistics (statistical interpretation of instrument responses, experimental design, stochastic and non-stochastic error analysis, interpretation of experimental results). • Personnel radiation monitoring (instrumentation and engineering, internal and active devices, dynamic range and response sensitivity, film, TLD, Lexan, OSL, and CR-39, ionization booths and GM counters, pregnant workers and fetal dose limits). • Internal exposure (ICRP 26, ICRP 2A recommendation, internal medical radiation dose dosimetry, MIRD), radiation monitoring and control, biological testing, spread in the work environment, permissible intake limits and concentrations of air (or water). • Biological effects (basic radiation biology, non-stochastic and stochastic responses, biological experimental database of radiation injury, BEIR (Biological Effects of Ionizing Radiation) and UNSCEAR (United Nations, Scientific Committee on the Effects of Atomic Radiation), • Patient and fetal dosage. • Regulations. • Non-ionizing Radiation.
Study and examination requirements and forms of examination	Online Exam
Media employed	PowerPoint
Reading list	1. ICRP No. 60. 1990 Recommendations of International Commission on Radiological Protection, Elsevier Science, 1990. 2. Herman Cember, Introduction to Health Physics. 2nd ed., Pergamon Press Inc. New York, NY. 1983. 3. RL. Kathren, Radiation Protection, Adam Hilger LTD., Bristol, 1985. 4. D. A. Gollnick. Basic Radiation Protection Technology. 2nd ed., Pacific Radiation Corporation, Altadena, CA, 1993. 5. C. J. Martin and D. G. Sutton, Practical Radiation Protection in Healthcare, Oxford: Oxford University Press, 2015 6. EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, Vienna: IAEA, 2014 7. ICRP, The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP 37 (2-4), 2007. 8. Undang-Undang No.10 Tahun 1997 tentang Ketenaganukliran 9. Peraturan Pemerintah No.33 Tahun 2007 tentang Keselamatan Radiasi Pengion dan Keamanan Sumber Radioaktif

	10. Peraturan Pemerintah No.29 Tahun 2008 tentang Perizinan Pemanfaatan Sumber Radiasi Pengion Dan Bahan Nuklir 11. Peraturan Presiden RI No.80 Tahun 1993 tentang Pengesahan Amendment of Article VI of The Statute of The International Atomic Energy Agency 12. D. G. Sutton et al., Radiation Shielding for Diagnostic Radiology, London: The British Institute of Radiology, 2012 13. NCRP, Report No. 147 - Structural Shielding Design for Medical X-Ray Imaging Facilities, Bethesda: NCRP, 2004 14. NCRP, Report No. 151 - Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities, Bethesda: NCRP, 2005 15. P. H. McGinley, Shielding Techniques for Radiation Oncology Facilities, Madison: Medical Physics Publishing, 2002

Physics Specialization Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Scattering Theory</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH604700</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Imam Fachruddin</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Imam Fachruddin</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Bahasa Indonesia</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lecturing</td><td rowspan="3">20</td><td rowspan="3">2</td><td rowspan="3">Lectures</td><td>Lectures: 2 x 14</td><td>28</td></tr>
<tr><td>Assignments: 2 x 14</td><td>28</td></tr>
<tr><td>Independent study: 2 x 14</td><td>28</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (20%), group assignments (20%), the midterm exam (30%), and the final exam (30%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Quantum Physics 1, Introduction to Nuclear Physics</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students can apply (C3) quantum mechanics to formulate the scattering process of two particles, both for neither particle having spin and for particles having spin of ½ each, up to the point where the equations for the scattering cross-section and spin magnitudes are derived.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Scattering kinematics, scattering wave function, scattering amplitude, scattering cross-section, Born approximation, Lipmann-Schwinger equation, propagators, scattering matrix, partial wave analysis, phase shift, density matrix, spin magnitude, the numerical calculation to solve the Lippmann-Schwinger equation for scattering matrix T.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Individual and group assignments, midterm exam, and final exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">Whiteboard</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] Liboff, R.L., Introductory Quantum Mechanics, 2nd Ed., Addison-Wesley, Reading, Massachusetts (1992).
[2] Davydov, A.S., Quantum Mechanics, 2nd Ed., Pergamon Press, Oxford (1965).
[3] Glöckle, W., The Quantum Mechanical Few-Body Problem, Springer Verlag, Berlin (1983).
[4] Rose, M.E., Elementary Theory of Angular Momentum, Wiley, New York (1957).
[5] Okubo, S. dan R.E. Marshak, Ann. Phys. 4, 166 (1958).</td></tr>
</table>

[6] Malfliet, R.A. dan J.A. Tjon, Nucl. Phys. A127, 161 (1969).
[7] Machleidt, R., Adv. Nucl. Phys. 19, 189 (1989).
[8] Wiringa, R.B., V.G.J. Stoks, R. Schiavilla, Phys. Rev. C51, 38 (1995).

Physics Specialization Courses 3rd Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Nuclear and Particle Physics</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">3rd year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH604701</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Prof. Dr. Anto Sulaksono and Dr. Agus Salam</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Prof. Dr. Anto Sulaksono and Dr. Agus Salam</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Bahasa Indonesia</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lecture and independent learning</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">Lectures</td><td>Lectures: 4 x 14</td><td>56</td></tr>
<tr><td>Assignments: 4 x 14</td><td>56</td></tr>
<tr><td>Independent study: 4 x 14</td><td>56</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">168 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments (30%), quizzes (10), the midterm exam (30%), and the final exam (30%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Quantum Physics 1,
Introduction to Nuclear Physics</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students can apply three of the most essential concepts in low energy nuclear physics such as electromagnetic transition rates, the collective nuclear model, and the microscopic nuclear model correctly in problems that might arise related to their undergraduate thesis (C3) and apply relativistic concepts on the kinematics of a particle reaction, rotation transformations, isospin, parity, charge conjugation, and time reversal in particle reactions; can explain the bound state spectrum of a system of particles; apply Feynman's rule and diagram in particle scattering and decay; explain the origin of particle mass well in problems that might arise related to their undergraduate thesis (C3).</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Lorentz transformation, Lorentz invariance, 4-vector momentum and position, collision of two particles, the laboratory frame and the center of mass frame, symmetry and the conservation law, group theory, spin, isospin, parity, charge conjugation, time reversal, the CPT theorem, Schrödinger's equation, the Hydrogen atom, Lamb shift, fine structure, positronium, quarkonium, light mesons, baryons, scattering cross-section, decay rate, the Klein-Gordon equation, the Dirac equation, Maxwell's equation, electron-electron interactions, electron-quark interactions, parton model, Bjorken scaling, quark-quark interaction, asymptotic freedom, weak interaction of leptons, weak interaction of quarks, muon, pion and neutron decay,</td></tr>
</table>

	electroweak unification, the Yang-Mills theory, spontaneous symmetry breaking, Higgs mechanism
Study and examination requirements and forms of examination	Individual assignments, Quizzes , mid-term exam, and final exam
Media employed	Whiteboard
Reading list	[1] [Greiner] W. Greiner and J. A. Maruhn, Nuclear Models, Springer, 1989 [2] [Griffiths] David Griffiths, Introduction to Elementary Particles, John Wiley & Sons, 1987.

Physics Specialization Courses 4^{th} Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Angular Momentum Theory</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">4^{th} year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH604702</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">7^{th} semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Prof. Dr. Drs. Terry Mart</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Prof. Dr. Drs. Terry Mart</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Bahasa Indonesia</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Elective course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lecturing</td><td rowspan="3">20</td><td rowspan="3">4</td><td rowspan="3">Lectures</td><td>Lectures: 4 x 14</td><td>56</td></tr>
<tr><td>Assignments: 4 x 14</td><td>56</td></tr>
<tr><td>Independent study: 4 x 14</td><td>56</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">168 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on presentation and discussion (50%) and weekly assignments (50%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Quantum Physics 2</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students can derive relations in angular momentum theory and apply them in problem within physics that includes quantum mechanics, nuclear physics, particle physics, and few-body physics.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Introduction, Hermite operators, unitary transformation, diagonalization of operators, unitary operators in exponential form, definition of angular momentum operators, orbital angular momentum, commutative properties of angular momentum operators, eigenvalue of angular momentum operators, physical interpretation of angular momentum, definition of the Clebsch-Gordan coefficient, symmetry relation for the Clebsch-Gordan coefficient, calculation of the Clebsch-Gordan coefficient, matrix representation of rotation operators, Clebsch-Gordan coefficient series, determining rotation matrices, orthogonality and rotation matrix normalization, definition of irreducible tensor operators, Racah coefficients, Wigner-Eckart theorem, projection theorem, coupling of three angular momenta, characteristics of Racah coefficients, basic applications of Racah coefficients, applications in electromagnetic fields, applications in static interactions, applications for particles with spin-½, applications in polarized nuclei, applications in nuclear reactions, and applications in systems with identical particles</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Presentation, discussion, and weekly assignments</td></tr>
</table>

Media employed	Whiteboard
Reading list	[1] M. E. Rose, Elementary Theory of Angular Momentum, Dover Books on Physics, 2011. [2] R. Edmonds, Angular Momentum in Quantum Mechanics, Princeton University Press, 1996. [3] A. de-Shalit and I. Talmi, Nuclear Shell Theory, Dover Publications, 2004

Physics Compulsory Courses 4th Year

<table>
<tr><td>Module name</td><td colspan="5">Artificial Intelligence</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">4th year</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH604707</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">7th semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Adhi Harmoko Saputro</td></tr>
<tr><td>Lecturer</td><td colspan="5">Adhi Harmoko Saputro</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Specialization course for system and instrumentation physics</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Discussion</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Group discussion</td><td>Lectures: 2 x 16</td><td>32</td></tr>
<tr><td>Assignments: 2 x 16</td><td>32</td></tr>
<tr><td>Independent study: 2 x 16</td><td>32</td></tr>
<tr><td>Total Workload</td><td colspan="5">96 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">2 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on group presentations (40%), mid-term exam (30%), and final exam (30%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">Calculus 1 & 2, Elementary Linear Algebra, Computational Physics</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">This course explains the basic concepts of artificial intelligence and applies them to analyzing and designing an intelligent instrumentation system and willing the student to be able to describe the latest instruments that supports its work and using IT in lectures</td></tr>
<tr><td>Content</td><td colspan="5">Introduction to artificial intelligence; problem representation & heuristic search techniques: hill climbing, simulated annealing, depth, breadth, best first search, genetic algorithm and A-star algorithm; knowledge representation; reasoning: rule-based, fuzzy logic, diagnosis reasoning; machine learning & learning algorithms: supervised learning: regression, support vector machines, artificial neural networks, unsupervised learning: partitional-based clustering, hierarchical clustering, self-organizing maps; reinforcement learning; statistical learning; deep learning.</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">Designing a Final Project Proposal, Present the Final Project, Mid term exam and final exam</td></tr>
<tr><td>Media employed</td><td colspan="5">PowerPoint presentation and tools for the final project</td></tr>
<tr><td>Reading list</td><td colspan="5">Compulsory:
1. S.J.Russel and P.Norvig, Artificial Intelligence: A Modern Approach, 3rd edition, Pearson, 2016.
2. V.Chandra and A.Hareendran, Artificial Intelligence and Machine Learning, PHI Learning, 2014.</td></tr>
</table>

	Additional: 1. G.James, D.Witten, T.Hastie and R.Tibshirani, An Introduction to Statistical Learning, Springer, 2017. 2. E.Alpaydin, Introduction to Machine Learning, 4th edition, MIT Press, 2020

Physics Specialization Courses 4th Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Digital Signal Processing</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">4th year</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH604708</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">7th semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Adhi Harmoko Saputro, Ph.D.</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Adhi Harmoko Saputro, Ph.D.</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Specialization course in System and Instrumentation Physics</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Interactive lectures, question-based learning, self-directed study, discussion</td><td rowspan="3">50</td><td rowspan="3">4</td><td rowspan="3">question-based learning, self-directed study, discussion</td><td>Lectures: 4 x 16</td><td>64</td></tr>
<tr><td>Assignments: 4 x 16</td><td>64</td></tr>
<tr><td>Independent study: 4 x 16</td><td>64</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">192 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">4 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on group presentations (40%), mid-term exam (30%), and final exam (30%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Modern Physics, Mathematical Physics 2, Electronics 2</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">After completing this lecture, physics students with a special interest in systems and physics instrumentation in semester 7 are able to analyze digital signals in the discrete time domain and discrete frequency and apply the concept of transformation for digital filter applications appropriately.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Explain the Signal and system recognition, ADC and DAC signal conversion, Discrete time systems and signals, Z transformation, Continuous time signal sampling, Application of the Z transformation for time-invariant linear (LTI) systems, Continuous time signal frequency analysis, Discrete time signal frequency analysis, Fourier transform for discrete time signals, Fourier analysis for discrete time signals, Filter concept, Finite Impulse Response (FIR) digital filter, Infinite Impulse Response (IIR) digital filter.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">individual assignments, mid-term exam, and final exam.</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">PowerPoint presentation</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">• Kehtarnavas, N., Digital Signal Processing System Design: LabVIEW-Based Hybrid Programming, Academic Press, 2008.
• Ingle, V.K., and Proakis, J.G., Digital Signal Processing using Matlab, Cengage Learning, 4th Ed., 2012.</td></tr>
</table>

	• Oppenheim, A.V. and Schafer, R.W., Discrete-Time Signal Processing (3rd Ed), Prentice Hall, 2009.

Specialization Courses 3rd Year

<table>
<tr><td>Module name</td><td colspan="5">Computer-Based Data Acquisition</td></tr>
<tr><td>Module level, if applicable</td><td colspan="5">Undergraduate</td></tr>
<tr><td>Code, if applicable</td><td colspan="5">SCPH604709</td></tr>
<tr><td>Semester(s) in which the module is taught</td><td colspan="5">5th Semester</td></tr>
<tr><td>Person responsible for the module</td><td colspan="5">Dr. Prawito Prajitno</td></tr>
<tr><td>Lecturer</td><td colspan="5">Dr. Prawito Prajitno</td></tr>
<tr><td>Language</td><td colspan="5">Indonesian</td></tr>
<tr><td>Relation to curriculum</td><td colspan="5">Concentration Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Lectures and discussions</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Lectures and Discussions</td><td>Lectures: 2 x 14</td><td>28</td></tr>
<tr><td>Assignments: 2 x 14</td><td>28</td></tr>
<tr><td>Independent Study: 2 x 14</td><td>28</td></tr>
<tr><td>Total Workload</td><td colspan="5">84 hours</td></tr>
<tr><td>Credit points</td><td colspan="5">2 credits</td></tr>
<tr><td>Requirement according to examination regulations</td><td colspan="5">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and Individual Assignments (30%), Mid-Term Exam (35%), and Final Exam (35%)</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="5">Electronics 2 (prerequisite)</td></tr>
<tr><td>Related Course</td><td colspan="5">-</td></tr>
<tr><td>Module objectives/intended learning outcome</td><td colspan="5">Students are able to apply a range of basic instrumentation techniques for data acquisition using computers through the software of LabView or other programming languages.</td></tr>
<tr><td>Content</td><td colspan="5">Basic instrumentation techniques, LabVIEW programming techniques, computer inputs and outputs, instrumentation concepts for signal conditioning, communication mechanics of computer systems and designing techniques in data acquisition.</td></tr>
<tr><td>Study and examination requirements and forms of examination</td><td colspan="5">Individual assignments, mid-term, and final exam.</td></tr>
<tr><td>Media employed</td><td colspan="5">Books, PowerPoint Presentation, Microsoft Teams</td></tr>
<tr><td>Reading list</td><td colspan="5">[1] Cotfas, P.A., Cotfas, D.T., Ursutiu, D. and Samoila, C., NI ELVIS Computer-Based Instrumentation, NTS, 2012.
[2] Travis, J., and Kring, J. LabVIEW for Everyone, 3rd Ed., Prentice Hall, 2006
[3] Sumathi, S. and Surekha, P., LabVIEW based Advanced Instrumentation Systems, Springer, 2007.</td></tr>
</table>

Specialization Courses 3^{rd} Year

<table>
<tr><td colspan="2">Module name</td><td colspan="4">Instrumentational Systems</td></tr>
<tr><td colspan="2">Module level, if applicable</td><td colspan="4">Undergraduate</td></tr>
<tr><td colspan="2">Code, if applicable</td><td colspan="4">SCPH604710</td></tr>
<tr><td colspan="2">Semester(s) in which the module is taught</td><td colspan="4">6^{th} Semester</td></tr>
<tr><td colspan="2">Person responsible for the module</td><td colspan="4">Dr. Adhi Harmoko S</td></tr>
<tr><td colspan="2">Lecturer</td><td colspan="4">Dr. Adhi Harmoko S</td></tr>
<tr><td colspan="2">Language</td><td colspan="4">Indonesian</td></tr>
<tr><td colspan="2">Relation to curriculum</td><td colspan="4">Concentration Course</td></tr>
<tr><td>Types of teaching and learning</td><td>Class Size</td><td>Attendance time (hours per week per semester)</td><td>Forms of active participation</td><td colspan="2">Workload</td></tr>
<tr><td rowspan="3">Collaborative Learning</td><td rowspan="3">50</td><td rowspan="3">2</td><td rowspan="3">Lectures and Discussions</td><td>Lectures: 2 x 14</td><td>28</td></tr>
<tr><td>Assignments: 2 x 14</td><td>28</td></tr>
<tr><td>Independent Study: 2 x 14</td><td>28</td></tr>
<tr><td colspan="2">Total Workload</td><td colspan="4">84 hours</td></tr>
<tr><td colspan="2">Credit points</td><td colspan="4">2 credits</td></tr>
<tr><td colspan="2">Requirement according to examination regulations</td><td colspan="4">Minimum attendance of 75% (according to UI regulation). Final score is evaluated based on individual assignments and Online Activity (10%), Final Presentation / Paper (10%), Home Group Presentation (20%), Individual Assignments (10%), Group Assignments (10%), Mid-Term Exam (20%), Final Exam (20%)</td></tr>
<tr><td colspan="2">Recommended prerequisites</td><td colspan="4">Electronics 2</td></tr>
<tr><td colspan="2">Related Course</td><td colspan="4">-</td></tr>
<tr><td colspan="2">Module objectives/intended learning outcome</td><td colspan="4">Students are able to explain the basic concepts of instrumentation based on scientific and physical properties.</td></tr>
<tr><td colspan="2">Content</td><td colspan="4">Basic principles of instrumentational systems which will discuss about types of instrumentation, models instrumentational systems, instrument characters, calibration principals, noise measurement and signal processing, indicators, and instruments for testing electrical signals, methods on converting electrical units, protocols in transmitting digital signals, digital computation and smart devices, and also the reliabilities and safety protocols of instrumentational systems.</td></tr>
<tr><td colspan="2">Study and examination requirements and forms of examination</td><td colspan="4">Online Activity, Final Presentation / Paper, Home Group Presentation, Individual Assignments, Group Assignments, Mid-Term Exam, and Final Exam</td></tr>
<tr><td colspan="2">Media employed</td><td colspan="4">Books, PowerPoint Presentation, Microsoft Teams</td></tr>
<tr><td colspan="2">Reading list</td><td colspan="4">[1] Moris, Alan S, Measurement and Instrumentation Principles, 3^{rd} Ed, Butterworth – Heinemann, 2001
[2] Boyes, Walt, Instrumentation Reference Book, 3^{rd} Ed, Butterworth – Heinemann, 2003.</td></tr>
</table>

	[3]	Webster, John G., *Measurement Instrumentation and Sensor Handbook,* CRC Press, 1999.