Program: Doctor of Philosophy Program in Physics
Degree: Doctor of Philosophy (Physics)
Study Plan:

1) Research Program (Scheme 1.1: for Master's Degree holder)

Year	First Trimester	Cr	Second Trimester	Cr	Third Trimester	Cr
Year 1	105999 Ph.D. Thesis	3	105999 Ph.D. Thesis	3	105999 Ph.D. Thesis	9
	Qualifying Examination				105897 Colloquium III	1
	Thesis Proposal Defense					
	Total	**3**	**Total**	**3**	**Total**	**10**
Year 2	105999 Thesis	9	105999 Ph.D. Thesis	9	105999 Ph.D. Thesis	9
					105997 Colloquium IV	1
	Total	**9**	**Total**	**9**	**Total**	**10**
Year 3	105999 Thesis	9	105999 Ph.D. Thesis	6	105999 Ph.D. Thesis	3
					Thesis Examination	
	Total	**9**	**Total**	**6**	**Total**	**3**

2) Regular Program (Scheme 2.1: for Master's Degree holder)

Year	First Trimester	Cr	Second Trimester	Cr	Third Trimester	Cr
Year 1	Elective Course	4	105999 Ph.D. Thesis	3	105999 Ph.D. Thesis	3
	Elective Course	4	105606 Research with Large collaboration	2	105896 Seminar III	1
			Elective Course	4	Elective Course	4
	Total	**8**	**Total**	**9**	**Total**	**8**
Year 2	105999 Ph.D. Thesis	3	105999 Ph.D. Thesis	9	105999 Ph.D. Thesis	12
	Elective Course	4			105996 Seminar IV	1
	Qualifying Examinatiobn					
	Thesis Proposal Defense					
	Total	**7**	**Total**	**9**	**Total**	**13**
Year 3	105999 Ph.D. Thesis	9	105999 Ph.D. Thesis	6	102991 Thesis	12
					Thesis Examination	
	Total	**9**	**Total**	**6**	**Total**	**12**

3) Regular Program (Scheme 2.2: for Bachelor's Degree holder)

Year	First Trimester	Cr	Second Trimester	Cr	Third Trimester	Cr
Year 1	105613 Mechanics	4	105621 Quantum Theory I	4	105617 Statistical Physics	4
	105614 Electrodynamics	4	105606 Research with large collaboration	2	105696 Seminar I	1
			Elective Course	4	Elective Course	4
	Total	**8**	**Total**	**10**	**Total**	**9**
Year 2	Elective Course	4	Elective Course	4	105799 Ph.D. Thesis	6
	105799 Ph.D. Thesis	3	105799 Ph.D. Thesis	3	105796 Seminar II	1
	Qualifying Examination					
	Thesis Proposal Defense					
	Total	**7**	**Total**	**7**	**Total**	**7**
Year 3	105799 Ph.D. Thesis	6	105799 Ph.D. Thesis	6	105799 Ph.D. Thesis	6
					105896 Seminar III	1
	Total	**6**	**Total**	**6**	**Total**	**7**
Year 4	105799 Ph.D. Thesis	6	105799 Ph.D. Thesis	6	105799 Ph.D. Thesis	6
					105996 Seminar IV	1
	Total	**6**	**Total**	**6**	**Total**	**7**
Year 5	105799 Ph.D. Thesis	6	105799 Ph.D. Thesis	6	105799 Thesis	3
					Thesis Examination	
	Total	**6**	**Total**	**6**	**Total**	**3**

Program: Doctor of Philosophy Program in Physics
Degree: Doctor of Philosophy (Physics)
Course Description:

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105503 Applied Mathematics for Physics	4(4-0-8)	Consent of the School	This course has been designed with the intention of training the student with the basic mathematical tools used in physics. The emphasis and the amount of coverage of the different mathematical techniques are: complex variables, second order ordinary and partial differential equations, boundary value problems, method of separation of variables, the Sturm-Liouville problem, detailed treatment of special functions often encountered in physics, Fourier Series and Fourier integrals, Laplace transforms, integral equation, Green functions, calculus of variations, and group theory.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105601	Mathematical and Numerical Methods for Applied Physics	4(4-0-8)	Consent of the School	This course aims to provide the essential mathematical backgrounds and numerical methods used in applied physics. The topics includes basics of vector calculus, ordinary differential equations, introduction to partial differential equations, Laplace's Equation, boundary value problems. The mathematical concepts will be used to study systems in physics. Numerical approach will be applied when analytical solutions do not exist.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105604	Modeling and Simulation in Physics	4(4-0-8)	Consent of the School	This course aims to provide students with essential concepts for problem solving in physics by making models based on mathematical functions, then utilize the models to simulate and solve for numerical solution or trend under different conditions. The topics include numerical data-analysis, optimization, curve fitting and method of least squares, functions and empirical models, rate of change, concepts of integral calculus, system dynamics models, growth and decay, force and motion, simulation techniques.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105605	Back-of-the-Envelope Physics	4(4-0-8)	Consent of the School	This course focuses on how to estimate the physical quantities in the following topics: mechanics, sound and light, heat, electricity, atoms and molecules, quantum mechanics, and astronomy	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105606	Research with large collaborations	2(2-0-4)	Consent of the School	This course is designed to provide basic understanding of working in large physics collaborations. Students will be prepared in working in collaboration among research groups/institutes/countries. Case studies may include Conseil Européen pour la Recherche Nucléaire (CERN), Jiangmen Underground Neutrino Observatory (JUNO), Five hundred meter Aperture Spherical Telescope (FAST), construction of synchrotron radiation facility, industrial-scale energy-storage project and/or solar-cell project.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. show responsibility and discipline 5. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 6. make use of research database 7. communicate, review and discuss physics knowledge 8. relate and apply physics knowledge related to this course 9. have research collaboration skills
105613	Mechanics	4(4-0-8)	Consent of the School	This course covers fundamentals of mechanics which include the following topics: review of basic mechanics, variational principles, Lagrangian, Hamiltonian, central force, rigid body, small oscillation, special theory of relativity, and canonical transformations	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105614 Electrodynamics	4(4-0-8)	Consent of the School	This course emphasizes on the following topics electrostatics including boundary- value problems, multipoles, electrostatics in dielectrics, magnetostatics, time-varying fields, Maxwell's equations, electromagnetic wave, propagation of wave, waveguides, polarization, reflection and electromagnetic radiation. Radiation by moving charges will be also studied, especially, Lienard-Wiechert's potential, and synchrotron radiation.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105615 Applied Electrodynamics	4(4-0-8)	Consent of the School	This course focuses on the following topics: electrostatic, magnetostatic, time-dependent field, Maxwell's equations, electromagnetic wave and the waveguide, polarization, refraction, electromagnetic radiation. The courses will also cover engineering applications such as wireless communications, the global positioning system or GPS system and the basic principles of synchrotron radiation.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105616 Thermodynamics	4(4-0-8)	Consent of the School	This course will cover the following contents: fundamental law and the first law of thermodynamics, kinetic theory of gases, internal energy, heat capacity, entropy and the second law, engine cycles, engine efficiency, free energies, Legendre transformation, phase equilibrium, the phase transition, the link between thermodynamics and statistical mechanics, and examples of engineering applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105617 Statistical Physics	4(4-0-8)	Consent of the School	This course introduces students to the very useful branch of statistical physics emphasizing the classical as well as the quantum aspects of the theory. Some of the topics to be covered are: the fundamental principles of statistical mechanics, ensembles and partition functions, foundations of quantum statistical methods, density matrix, Fermi and Bose systems. In addition, selection of special topics depending on current interest such as: superfluidity, superconductivity, critical phenomena and fluctuation may be covered.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105618 Fluid Mechanics	4(4-0-8)	Consent of the School	Basics of Fluid Mechanics describes the fundamentals of fluid static and fluid dynamic phenomena. Basic physics concepts (e.g. the conservation principles of mass, momentum, and energy for fluid) are used for exploring the following topics and their related applications: pressure in static liquid, forces on submerged surface and the center of pressure, viscosity, surface tension, capillarity, steady and turbulent flow, aerodynamics, and fluid measurements.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105619 Mechanics and Thermal Physics	4(4-0-8)	Consent of the School	This course covers two fundamentals of physics: mechanics and thermal physics. Mechanics part includes the following topics: review of basic mechanics, variational principles, Lagrangian, Hamiltonian, central force, rigid body, small oscillation, special theory of relativity, and canonical transformations. Thermal Physics part covers the following contents: fundamental law and the first law of thermodynamics, kinetic theory of gases, internal energy, heat capacity, entropy and the second law, engine cycles, engine efficiency, free energies, Legendre transformation, phase equilibrium, the phase transition, the link between thermodynamics and statistical mechanics, and examples of engineering applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105621 Quantum Theory I	4(4-0-8)	Consent of the School	This is the first of two courses on quantum physics. It is designed to introduce the student to the common probabilistic language of modern physics of the microscopic world. Topics to be covered are: historical review of experiments and theories in the development of quantum mechanics, mathematical tools, postulate of quantum mechanics, harmonic oscillator, spin and angular momentum, hydrogen atom and other three dimensional problems, perturbation theory, and path integral formulation of quantum mechanics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105622 Quantum Theory II	4(4-0-8)	105621 Quantum Theory I or consent of the School	This course is an extension of the course Quantum Theory I. Topics to be covered are: rotation and addition of angular momentum, approximation methods and variation principle, scattering and quantum collision theory, relativistic quantum mechanics, Klein-Gordon and Dirac equations, and field quantization.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. show responsibility and discipline 4. relate and apply physics knowledge to daily life phenomena

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105625 Applied Quantum Physics	4(4-0-8)	Consent of the School	This course introduces the weirdness of both the very small (quantum mechanics) and the very fast (Einstein's relativity). The principles and methods of quantum mechanics are covered in a practical context: students learn through applications to problems in modern electronics, material science and atomic physics. Similarly, the essentials of special relativity will be taught with reference to real applications in nuclear and astrophysics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105633 Astronomy	4(4-0-8)	Consent of the School	The course covers historical background, spherical astronomy, celestial dynamics, solar system, variable stars, galaxies and universe, optical telescope, radio astronomy, space exploration, observation techniques, and computation techniques	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105634 Cosmology	4(4-0-8)	Consent of the School	Course content includes the history of the universe, matter in the universe, galaxies and their evolution, cosmic background fluctuations, dark matter and dark energy, the cosmological constant, and the accelerating and expanding universe.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105637	Methods and Instrumentation for Astronomy	4(4-0-8)	105613 Mechanics or consent of the School	Topics include: astronomical radiation sources, observational limits, optics and telescope, atmospheric effects, detectors, photometry and imaging, spectroscopy, radio telescope, cosmic radiation observations, gravitational wave observation, space telescope.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105643	X-ray Scattering and Diffraction Techniques	4(4-0-8)	105615 Applied Electrodynamics or consent of the School	This course covers the following contents: the basic physics of X-ray scattering, small-angle X-ray scattering technique, and wide-angle X-ray scattering techniques, the basic physics of X-ray diffraction, and various X-ray diffraction techniques. Examples of research studies and applications are described.	1. describe concepts in complicated physics problems related to this course 2. describe knowledge in the frontier physics 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problemss 5. relate and apply physics knowledge related to this course
105644	X-ray Absorption Spectroscopy and its Applications	4(4-0-8)	Consent of the School	This course covers the following contents: the basic physics of absorption and reflection of X-rays, relating instrumentations, application of synchrotron light, electronic and atomic structure and spectral analysis at different energy ranges. Examples of research studies are described.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105653 Materials Physics	4(4-0-8)	105625 Applied Quantum Physics or consent of the School	This course covers the following topics: crystal structure, bonding types in solids, diffraction and the reciprocal lattice, crystal and disorder in a solid, phase diagram and phase transition, optical properties, magnetic and electrical properties, mechanical properties, thin film materials, surface and interface, and various methods of synthesis.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course
105654 Nanomaterials	4(4-0-8)	105625 Applied Quantum Physics or consent of the School	This course covers the following contents: the surface of nano materials, phase transition in nanomaterials, gas-phase synthesis, magnetic and electrical properties, optical properties, mechanical properties, various types of nanoparticles, and the characteristics of nanomaterials. Examples of research studies are described.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course
105655 Polymer Physics	4(4-0-8)	Consent of the School	This course covers the following topics: the origin of polymer science, types of polymers, model of the ideal polymer, model of the line (realistic) polymer, thermodynamics of mixing, polymer solution, coagulation of polymers, linked network of polymers and gels, and dynamics of free and tangled polymers.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105656 3D Printing Technology and Applications	4(4-0-8)	Consent of the School	The course covers a general understanding of additive manufacturing. This includes applications of 3D printing technology in Industry 4.0, physics of various 3D printing methods, design and construction, operation and maintenance. Development of advanced materials and characterizations of 3D printed parts are also included.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course
105661 Physical Optics I	4(4-0-8)	Consent of the School	The course covers principles of light wave propagation based on wave equation and Fourier transform theory. Topics include wave equations, Kirchhoff theory, Rayleigh-Sommerfeld theory, near- and far-field diffractions and angular spectrum.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics
105662 Physical Optics II	4(4-0-8)	105661 Physical Optics 1 or consent of the School	This course covers theory for analysis, design and set up of optical systems. The topics include properties of lenses, optical Fourier transform, optical filtering and computing, optical imaging system and optical transfer function.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105663 Low Temperature Physics	4(4-0-8)	105616 Thermodynamics or consent of the School	This course covers the following contents: properties of helium, liquid helium and superfluid, solids at low temperatures, behavior of phonons and electrons at low temperature, angular momentum and spin, superconductivity, cooling techniques and instrumentations for low-temperature research.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course
105664 Materials Characterization	4(4-0-8)	Consent of the School	This course covers the various techniques for characterization: optical microscopy, X-ray diffraction, transmission electron microscopy (TEM), scanning electron microscopy (SEM), scanning probe microscopy, X-ray spectroscopy for elemental analysis, electron spectroscopy for surface analysis, ion mass spectrometry, infrared spectroscopy and thermal analysis	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. relate and apply physics knowledge related to this course
105665 Fundamentals of Photonics	4(4-0-8)	Consent of the School	This course covers homogeneous and inhomogeneous laser medium, Gaussian beam, optical resonators, theory of laser oscillation, rate equation, 3 and 4-level laser system, general laser system, and laser applications.	1. describe concepts in complicated physics problems related to this course 2. describe knowledge in the frontier physics 3. make use of research database 4. relate and apply physics knowledge to daily life phenomena

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105666 Laser Technology and Applications	4(4-0-8)	Consent of the School	This course covers laser fundamentals, Q-switching, mode-locking, femtosecond laser, laser technologies in industries, interaction of laser and material, medical application, detect and measure laser signal, and laser safety.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. make use of research database 5. relate and apply physics knowledge to daily life phenomena 6. relate and apply physics knowledge related to this course
105667 Nonlinear Optics	4(4-0-8)	Consent of the School	Nonlinear optical interaction, properties of the nonlinear susceptibility, wave equation description of nonlinear optical interactions, the Manley-Row relations, second harmonic generation, phase matching, quantum mechanical theory of nonlinear optical susceptibility, , calculation of linear and higher order of susceptibilities, density matrix, intensity-dependent refractive indexes, nonlinear optics in the two-level approximation.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. make use of research database 4. relate and apply physics knowledge to daily life phenomena 5. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105668 Optical Systems Design	4(4-0-8)	Consent of the School	Concepts and principles of various basic optical components and accessories such as light sources, lenses, mirrors, prisms, beam splitter, fiber optics, polarizer, retarders, gratings, optical filters, beam steering devices, and Electro-Optics devices, working principles and implementation of each components, specification and selection guide, and examples of optical system design of basic optical systems for biomedical applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105669 Optical Tomography	4(4-0-8)	Consent of the School	Principle of optical tomograhy, focusing on Optical Coherence Tomography (OCT), OCT basic principle, time domain OCT, frequency domain OCT, swept-source OCT, resolution, sensitivity, dynamic range, techniques for dispersion compensation, a few examples of OCT applications in biomedical imaging.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105673 Nuclear and Particle Physics	4(4-0-8)	Consent of the School	After a brief introduction to the foundations of nuclear physics covering topics like properties of nuclei, nuclear models, nuclear forces, nuclear decays and nuclear reactions, the main part of the course is designed to treat at an advanced level the very rapidly developing branch of physics dealing with elementary particles. The course will emphasize the following: symmetry transformations and symmetry groups arising in particle physics, conservation laws and symmetry breaking, particles classification and the quark model, and introduction to unified theories of the fundamental interactions.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105674 Astrophysics	4(4-0-8)	105613 Mechanics and 105614 Electrodynamics or consent of the School	The course covers gravitation and mass, galaxy and interstellar matter, physical state of the stellar interiors, properties of stars, nucleosynthesis, stellar structure and evolution, astronomical spectroscopy, white dwarf, neutron star, pulsar, black holes, and models of the universe	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105681 Introduction to Biological and Medical Physics	4(4-0-8)	Consent of the School	This course aims at teaching the concepts and tools of physical chemistry and molecular physics to define and analyze the structures, energetics, dynamics, and interactions of biological molecules, leading to the applications in fields of genomics, proteomics, drug delivery, biosensors, clinical diagnostics, medicines and therapy.	1. describe knowledge in the frontier physics 2. make use of research database 3. communicate, review and discuss physics knowledge
105682 Nanobiotechnology	4(4-0-8)	Consent of the School	This course puts an emphasis on nanotechnology in biological applications, describing on various nanostructures and their applications in biosensors, biochips, drug delivery system, tissue engineering, cancer, dental care, agriculture, food and cosmetic dermatology. In addition, safety and environmental effects are discussed.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105683 Biomedical Optics	4(4-0-8)	Consent of the School	Basic principle of various optical techniques that have been developed for biomedical applications, such as light microscopy, dark field microscopy, polarization microscopy, confocal microscopy, two-photon and multi-photon microscopy, fluorescence imaging, photo-acoustic microscopy, diffuse tomography, optical coherence tomography, and photodynamic therapy. Optical design and engineering aspects of these selected techniques will be explained as well as their advantages and limitation in biomedical applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105684 Biotechnology for Physicists and Engineers	4(4-0-8)	Consent of the School	This course lectures on biological basis of cells, living organisms, biomolecules, genetic inheritance, gene expression, gene regulation, mutation, recombinant DNA technology, biotechnological principles and instruments for studying biomolecule interaction, DNA sequence analysis, DNA-, RNA-, protein- and cell-detection, and protein structure analysis	This course lectures on biological basis of cells, living organisms, biomolecules, genetic inheritance, gene expression, gene regulation, mutation, recombinant DNA technology, biotechnological principles and instruments for studying biomolecule interaction, DNA sequence analysis, DNA-, RNA-, protein- and cell-detection, and protein structure analysis

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105685 Introduction to Applied Physics	2(2-0-4)	Consent of the School	This course aims to introduce various fields of research in Applied Physics. The topics includes, for example, Electromagnetic wave and matters, Accelerator physics, Condensed matter physics, Astrophysics and Astrodynamics, High energy physics, Computational Physics, Optics, Photonics, and Laser technology, Electronics and Control theory, Nanotechnology, Engineering physics, and Biological and Medical physics. Contents should be limited to introduction, basic theorems, applications, technology progress.	1. describe concepts in complicated physics problems related to this course 2. describe knowledge in the frontier physics 3. make use of research database 4. relate and apply physics knowledge to daily life phenomena
105696 Seminar I	1(1-0-9)	Consent of the School	The series of four seminar courses aim to develop scientific communication skills of students. In this course, students will acquire the skills to deliver scientific presentations suitable in style and quality for a professional conference. More advanced writing skills for scientific articles will be emphasized. Joint seminars with other institutes will be organized (field trips required). Grade: A, B+, B, C+, C, and F	1. describe knowledge in the frontier physics 2. make use of research database 3. communicate, review and discuss physics knowledge

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105697 Colloquium I	4(4-0-8)	Consent of the School	The series of four colloquium courses aim to develop scientific communication skills of students. The class is designed to simulate the environment of an international academic conference: a student delivers a formal scientific presentation in English about a topic of interest and then entertains questions and discussion from an audience of peers. In this course, students acquire basic skills for giving effective scientific presentations and build self confidence as public speakers. Joint seminars with other institutes will be organized (field trips required). Grade: Satisfactory and Unsatisfactory.	1. describe knowledge in the frontier physics 2. make use of research database 3. communicate, review and discuss physics knowledge

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105699 M.Sc. Thesis in Physics		Consent of the Thesis Advisor	Individual research of a topic to be agreed upon with the thesis advisor.	1. describe concepts in complicated physics problems related to this course 2. describe knowledge in the frontier physics 3. show responsibility and discipline 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. analyze the research experimental data or simulation by appropriate means 6. make use of research database 7. relate and apply physics knowledge related to this course 8. design and conduct research 9. have research collaboration skills
105703 Computational Physics	4(4-0-8)	Consent of the School	This course provides an introduction to computational techniques for solving advanced physical problems. The course is divided into two parts. The basic part is a brief summary of basic numerical methods of solving general mathematical problems, e. g. differentiations, integrations, matrix manipulation, and solutions of differential equations. The application part demonstrates various examples of solving real physical problems by computation. Examples include both classical and quantum mechanical problems in various fields of Physics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105704 Group Theory	4(4-0-8)	105621 Quantum Theory I or consent of the School	The course is designed to systematically teach students the fundamental concepts of group theory and the applications of various groups in physics. It is emphasized time to time by examples in the course that group theory is a powerful method for modern physics. Knowledge, methods, and concepts developed in quantum mechanics are applied in the course to help students overcome understanding difficulties, which usually come in a course of group theory given in the viewpoint of mathematics. Important groups like permutation group, SU(N) group, SO(N) group, discrete group, and Lorentz group and their applications in physics are given in details.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105713 Continuum Mechanics	4(4-0-8)	105613 Mechanics or consent of the School	This course covers the topics in mechanics relating to continuous systems such as strings, membranes and fluids. The course will start with Lagrangian and Hamiltonian of continuous systems to explain about the vibration, sound wave, surface wave, heat transfer, and viscous fluids.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105714 Nonlinear Physics	4(4-0-8)	Consent of the School	When a physical system is disturbed slightly, using weak probes and fields, we can learn about the undisturbed system. Most standard physics courses focus on this linear (or weakly-disturbed) regime. This course introduces students to the strange new world outside this regime. Non-linear physics deals with systems that are strongly driven, far from equilibrium, and open to their environment--the disturbance is essential. Amazingly, from these chaotic conditions order arises: in sand drifts, fluid dynamics, chemical and biological reactions etc., unexpected patterns emerge due to non-linear effects. A broad overview of these phenomena will be given in the context of modern research.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105715 Advanced Electronics	4(4-0-8)	105615 Applied Electrodynamics or consent of the School	This course covers more advanced electronics topics with a variety of applications. The non-ideal effects in op-amps and various electronic devices will be discussed with applications emphasizing offset, gain and linearity. Sensors, pulse width modulations, SCRs, TRIACs and optoelectronics will be included. Interfacing and signal processing will also be discussed.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. communicate, review and discuss physics knowledge 4. relate and apply physics knowledge to daily life phenomena 5. relate and apply physics knowledge to industrial problems 6. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105716 Waves and Solitons	4(4-0-8)	Consent of the School	An introduction to linear and non-linear wave equations. Wave phenomena are ubiquitous in physics: appearing in classical mechanics, electromagnetism, quantum mechanics, quantum field theory, astrophysics and many other areas. A solid understanding of the mathematics of waves will thus benefit a student in any physics sub-discipline. While most physics undergraduates are familiar with elementary Fourier analysis, this course aims to lay a broader and deeper mathematical foundation. Students will learn the mathematical tools needed to understand and model physical waves, including non-linear methods required in the study of solitary wave pulses (or solitons).	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. show responsibility and discipline 5. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 6. make use of research database 7. communicate, review and discuss physics knowledge

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105733	Special Relativity and Symmetry	4(4-0-8)	105613 Mechanics and 105614 Electrodynamics or consent of the School	This course is designed to introduce the student the special theory of relativity and its applications from an advanced point of view. The lectures will cover foundations of the special relativity, Lorentz transformations and Lorentz group, covariance of Maxwell's equations, solutions of electrodynamics and kinetics of high energy collisions, and spin calculus and symmetry.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105734	Relativity and Space-Time	4(4-0-8)	105733 Special Relativity and Symmetry or consent of the School	This course is designed to introduce the student the general theory of relativity from an advanced point of view. The lectures will cover foundations of the general theory, mathematical tools (tensor and differential geometry), development of Einstein's field equations, gravitational collapse and black hole physics, fundamental cosmology, cosmic inflation, quantum description, and gravitational radiation.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105741	Accelerator Physics I	4(4-0-8)	105614 Electrodynamics or consent of the School	The course demonstrates basic physics of particle accelerators and storage rings. Principles of charged particle acceleration and theory of RF acceleration are introduced. Physics of linear accelerators, circular accelerators and storage rings are then explored. Linear dynamics of charge particle beam is investigated to give basic understanding of the physics of particle acceleration and behaviors of charged particles under influence of linear magnetic fields of accelerator elements.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course
105742	Accelerator Physics II	4(4-0-8)	105741 Accelerator Physics I or consent of the School	The course is a follow-up of Accelerator Physics I. This course aims to give thorough understanding of charged particle beam dynamics. The emphasis is placed on nonlinear beam dynamics. The Hamiltonian formalism of charged particle beam dynamics is investigated in details. Higher order perturbations, coupled motion of charged particles in accelerators, and theories of resonance in circular accelerator and storage rings are discussed.	1. describe concepts in complicated physics problems related to this course 2. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105743	Instrumentation Techniques for Physics Research	4(4-0-8)	Consent of the School	The course explores theories and applications of various instruments used in basic and advanced experimental physics research. The techniques include data acquisition and processing system, optical instruments, electron diffraction, X-ray diffraction, scanning probe instruments, surface analysis, surface preparation, epitaxial growth, low temperature techniques, magnet technology, radiation and particle detection, and novel techniques in experimental physics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course
105744	Applied Optics and Beam Line Technology	4(4-0-8)	Consent of the School	This course aims at teaching synchrotron light optics and beam line technology. The principles of measurement techniques using synchrotron light with different energy ranges for physical science research are also given. The practical training of students on the design and operation of beam line is carried out using the facilities of the Siam Photon Laboratory.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105745	Vacuum Science and Technology	4(4-0-8)	Consent of the School	The course describes, in details, physics and technologies of vacuum systems used in physics researches. This includes fundamental of pressure measurement, working principles of various vacuum pumps, measurement techniques of low and ultra low pressure, physics of out-gassing and materials, leak detection and vacuum control systems, and design and fabrication of vacuum systems. Applications of vacuum systems in various experimental physics research facilities are also explored.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course
105751	Condensed Matter Physics I	4(4-0-8)	Consent of the School	This course covers theory of metal, crystal lattices, symmetries and bindings, specific heat, electronics density of states, semiconductors and insulators, transport and scattering processes, introduction to electron band structure theory, and introduction to magnetism, superconductivity and liquid state.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105752 Condensed Matter Physics II	4(4-0-8)	105751 Condensed Matter Physics I or consent of the School	A continuation of Condensed Matter Physics I, this course covers theory of computing band structure, doping semiconductors, defect and dislocation, phonon in perfect crystal and phonon in crystal with defects, quantum structure, phase transitions, magnetism, superconductivity, superfluids, quantum Hall effect, disordered system, and metal-insulator transition.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105753 Crystal Growth	4(4-0-8)	Consent of the School	This course is intended to provide necessary background in the crystal growth area to postgraduate physics students. It covers nucleation, epitaxy, concepts of crystal growth phenomena, various theories, and details of the crystal growth techniques. Details of growth parameters of certain technologically important materials and their technical issues related to obtain device quality material are addressed. The instrumentation aspects of crystal growth are also included.	1. describe concepts in complicated physics problems related to this course 2. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105754 Electron Microscopy	4(4-0-8)	Consent of the School	This course covers the theory and practice of obtaining and interpreting techniques of transmission electron microscope (TEM) and scanning electron microscopy (SEM). Topics include specimen preparation, adjustment and calibration of the electron microscopes, and image formation. Special emphasis is placed on electron diffraction and obtaining useful images of crystal defects.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105755 Dislocation Theory	4(4-0-8)	Consent of the School	This course is account of the geometry, properties and behavior of dislocations in crystals. Basic features of the geometry, movement and elastic properties of dislocations are described along with an account of the methods of observing and studying dislocations. Lectures include the description of the more detailed features of dislocations in specific structures, basic properties of dislocation associated with movement, the description of geometry and properties of array of dislocation, and finally, the description of the interaction between dislocations and imperfections in crystals related to stress to move dislocations through a crystal containing imperfections.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
1056763	Solid State Spectroscopy	4(4-0-8)	105614 Electrodynamics and 105621 Quantum Theory I or consent of the School	This course aims at teaching electronic energy states and electronic processes induced by high energy excitations and training on spectroscopic investigations of solid materials. Lectures includes the issues on (a) electronic structure of solids (b) excitations and excitonic processes, (c) electronic processes in correlated electron systems, (d) the electronic structure of low-dimensional system and (e) experimental probes of the solid state electronic structure. Students participate in research using the experimental stations at the Siam Photon Laboratory.	1. describe concepts in complicated physics problems related to this course 2. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105764	Electronic Structures of Solid Surface and Nanoscale Materials	4(4-0-8)	105614 Electrodynamics and 105621 Quantum Theory I or consent of the School	This course aims to provide students with information necessary for research in the field of atomic and electronic structure of solid surface and nano-scale materials. The fundamental knowledge necessary for understanding contemporary techniques of semiconductors, catalysis, and nano-technologies are presented. Lectures include various topics related to physical and chemical properties of solid surfaces and interfaces, and nano-scale materials.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105765	Atomic and Molecular Spectroscopy	4(4-0-8)	105614 Electrodynamics and 105621 Quantum Theory I or consent of the School	This course aims at teaching elementary physical processes brought about in atoms and molecules by high-energy photon and training on basic and applied spectroscopy of gaseous atoms and molecules. Students participate in research using the experimental stations at the Siam Photon Laboratory.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 4. relate and apply physics knowledge to industrial problems 5. relate and apply physics knowledge related to this course
105766	Quantum Electronics I	4(4-0-8)	105665 Fundamentals of Photonics or consent of the School	This course covers solutions of time-independent Schrödinger equation, matrix formulation of quantum mechanics, spontaneous and stimulated emissions, interaction of radiation with matter, propagation in anisotropic media and light modulation.	1. describe concepts in complicated physics problems related to this course 2. show responsibility and discipline 3. communicate, review and discuss physics knowledge
105767	Quantum Electronics II	4(4-0-8)	105767 Quantum Electronics I or consent of the School	This course covers nonlinear optical effects, tunable coherent light source, optical parameter oscillator, frequency conversion, stimulated Raman effects, ultrashort pulse generation and measurement, and applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105768	Laser in Industry	4(4-0-8)	Consent of the School	This course covers laser fundamentals, Q-switching, mode-locking, femtosecond laser, detected and measured laser signal, laser safety, and laser applications and technologies in industries; welding, cutting, drilling.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. describe knowledge in the frontier physics 4. relate and apply physics knowledge to industrial problems 5. design and conduct research
105771	Application of Grid and Cloud Computation in Particle Physics	4(4-0-8)	Consent of the School	This course provides students with the knowledge of grid and cloud computing used in particle physics. The details cover introduction to grid and cloud technology, the LHC computing grid, distributed computingmodel, software design and development, simulation, reconstruction and data analysis using ROOT, an object oriented program developed by CERN for large scale data analysis.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105773	Nuclear Reactor Physics	4(4-0-8)	105625 Applied Quantum Physics or consent of the School	This course introduces the student physical principles of nuclear reactors. Topics include nuclear reactions, nuclear fissions, neutron characteristics, neutron diffusion theory, criticality and multigroup theory, slowing down theory, heterogeneity effects, reactor kinetics and dynamics, and nuclear fuel cycle.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105774	Applied Nuclear Physics	4(4-0-8)	105625 Applied Quantum Physics or consent of the School	The course introduces the student both the basic knowledge and applications of nuclear physics, covering topics: nuclear properties, nuclear models, nuclear forces, nuclear radiations and applications, nuclear fission and fusion and their applications, and other nuclear reactions and applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105775	Physics of Synchrotron Radiation	4(4-0-8)	105614 Electrodynamics or consent of the School	The course is designed to explore physics and technologies of synchrotron radiation and its sources. Theory of synchrotron radiation from relativistic charged particles is discussed in details. Basic design principles and detailed discussion of synchrotron radiation sources are given. The course also explores theories and advanced technologies of insertion devices for high brightness synchrotron radiation sources. Properties of synchrotron radiation from these sources are studied to give pictures of advantages and disadvantages of synchrotron radiation for advanced research. Fundamental principle of free electron laser is also discussed.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105782	Selected Topics in Applied Physics	4(4-0-8)	Consent of the School	Selected topics of current interest in applied physics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105783	Selected Topics in Physics I	4(4-0-8)	Consent of the School	Selected topics of current interest in physics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105784	Selected Topics for Industrial Problem Solving	4(4-0-8)	Consent of the School	Selected topics of current interest in applied physics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105785 Biophysics	4(4-0-8)	Consent of the School	This course covers the following topics: physicists' solutions to biophysical problems, properties of water, nanoscale structure, structure of molecules and cells, quantum effects, light and life, photosynthesis, cell mechanism, thermodynamics and statistical physics which relate to bio-systems, and biological machines.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105786 Medical Physics	4(4-0-8)	Consent of the School	An introduction to key physical principles as applied to medical imaging and radiation therapy. Topics include: imaging metrics, ionizing radiation and radiation safety, radioactivity, radiation therapy, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105788 Selected Topics in Physics II	4(4-0-8)	Consent of the School	Selected topics of current interest in physics.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105791 Applied Optics Laboratory	2(0-6-8)	Consent of the School	The course emphasizes on experimental techniques for observing optical phenomena and quantitative data acquisitions.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105796 Seminar II	1(1-0-9)	105696 Seminar I	The series of four seminar courses aim to develop scientific communication skills of students. In this course, students will enhance their ability to give effective scientific presentations and will also learn basic skills for writing articles in scientific journals. Joint seminars with other institutes will be organized (field trips required). Grade: A, B+, B, C+, C, and F.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105797 Colloquium II	1(1-0-9)	105697 Colloquium I	The series of four colloquium courses aim to develop scientific communication skills of students. In this course, students will enhance their ability to give effective scientific presentations and will also learn basic skills for writing articles in scientific journals. Joint seminars with other institutes will be organized (field trips required). Grade: Satisfactory and Unsatisfactory.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105799	Ph.D. Thesis in Physics (for B.Sc. holder)		Consent on the Thesis Advisor	Individual research of a topic to be agreed upon with the thesis advisor.	1. describe concepts in complicated physics problems related to this course 2. describe knowledge in the frontier physics 3. show responsibility and discipline 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. analyze the research experimental data or simulation by appropriate means 6. make use of research database 7. relate and apply physics knowledge to this course 8. design and conduct research 9. have research collaboration skills
105813	High-Pressure Physics	4(4-0-8)	105616 Thermodynamics or consent of the School	This course covers the following contents: static compression, dynamic compression, the basic physics of high pressure, techniques for creating high pressure, unique properties of materials at high pressure, high-pressure physics and geology, synthesis of new materials at high pressure and analysis of physical properties at high pressure.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105814 Geophysics	4(4-0-8)	105613 Mechanics or consent of the School	The course introduces the formation of planets, structure and composition of the earth, interactions between crust, mantle, and core, earth dynamics, heat flow and mantle convection, and applications of physics to geology.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105815 Atmospheric Physics	4(4-0-8)	Consent of the School	This course covers the following contents: the big picture of the atmosphere, thermodynamics laws, systems of mixed gases, humidity, radiation effect on the atmosphere, clouds, dynamics of the atmosphere, atmospheric waves, energy and heat transfer in the atmosphere.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to daily life phenomena 4. relate and apply physics knowledge related to this course
105823 Quantum Field Theory	4(4-0-8)	105622 Quantum Theory II or consent of the School	This course covers the following topics: Lagrangian field theory, quantum fields and propagators, interacting quantum fields, perturbation theory, simple applications (scattering processes to the lowest order), renormalization theory and renormalization group, bound states, and the functional method.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105825 Quantum Computation	4(4-0-8)	105625 Applied Quantum Physics or consent of the School	The course is designed to introduce the student the principles of quantum computation. Topics to be covered are: overview of quantum mechanics, mixed states and open quantum systems, quantum entanglement and Bell's theorem, basic linear algebra for quantum computing, classical teleportation and quantum teleportation, quantum circuit model and universal quantum computation, quantum Fourier transformation, various algorithms, quantum error corrections, possible implications of quantum computation.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105853 Superconductivity	4(4-0-8)	105621 Quantum Theory I and 105751 Condensed Matter Physics I or consent of the School	A survey of superconducting materials and mechanisms: this course provides students with the tools needed to understand conventional superconductors and to approach the (unsolved) problem of modern unconventional superconductors. After a brief review of the Bardeen-Cooper-Shrieffer (BCS) theory of conventional weak coupling superconductors and the Ginzburg-Landau theory of superconducting phases, discussion will move on to strongly-coupled superconductors, unconventional high-temperature superconductors and other systems of modern interest. General methods to study strongly-correlated electron systems will be introduced	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105854 Computational Methods for Real Materials	4(4-0-8)	105752 Condensed Matter Physics II or consent of the School	First principles simulations, using density functional theory, have proved to be reliable and computationally manageable tool in condensed matter physics with increasing impact on virtually every area. In this course, the introduction to basic concepts, commonly used algorithms, widely accepted approximations, as well as the potential and successful applications of the tool will be covered. Students will have hand-on experience in first principles calculations using modern computational codes.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105855 Surface Physics	4(4-0-8)	Consent of the School	The course discusses various physical properties and dynamics of thin films and the surface of bulk materials. The topics are historical review, thermodynamics, chemical bonding, crystal structure, electronic structure, phase transitions, optical properties, physisorption, chemisorption, energy transfer, kinetics and dynamics of surfaces, and epitaxy and quantum structures based on surface.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105864 Fundamentals of Holography	4(4-0-8)	105661 Physical Optics I or consent of the School	This course covers principles of optical and digital holography. Topics include light source and recording materials for holograms, type of holograms, wavefront reconstructions, holographic interferometry and computer-generated holograms.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105865 Information Optics	4(4-0-8)	105662 Physical Optics II or consent of the School	This course covers principles of optical processing, detection and recording of information based on optical Fourier transform. Topics include phase contrast imaging, optical correlations, scale and rotation invariant optical systems, optical pulse conversion, wavefront recording and reconstruction.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105896 Seminar III	1(1-0-9)	105796 Seminar II or consent of the School	The series of four seminar courses aim to develop scientific communication skills of students. In this course, students will acquire the skills to deliver scientific presentations suitable in style and quality for a professional conference. More advanced writing skills for scientific articles will be emphasized. Joint seminars with other institutes will be organized (field trips required). Grade: A, B+, B, C+, C, and F.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105897	Colloquium III	1(1-0-9)	105797 Colloquium II or consent of the School	The series of four colloquium courses aim to develop scientific communication skills of students. In this course, students will acquire the skills to deliver scientific presentations suitable in style and quality for a professional conference. More advanced writing skills for scientific articles will be emphasized. Joint seminars with other institutes will be organized (field trips required). Grade: Satisfactory and Unsatisfactory.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105903	Geometrical Methods in Physics	4(4-0-8)	105704 Group Theory or consent of the School	This course aims to introduce a wide range of geometrical methods, which have their origin in differential geometry and which have used in theoretical physics. The topics include manifolds, fiber bundles, differential manifolds and tensors, Lie derivatives and Lie groups, differential forms, applications in physics, and connection for Riemanian manifolds and gauge theories.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105913	Industrial Instrumentations and Automations	4(4-0-8)	105613 Mechanics or consent of the School	This course covers the following contents: introduction to equipment and industrial automation, principles and usage of controls, process variables, dimension and motion sensors, communication, interface, valves, servo motors, robots, and control improvement.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105914	Sensor and Transducer Technology	4(4-0-8)	Consent of the School	This course covers the following contents: pressure and tension measurement, position detection, distance and movement measurement, light and radiation measurement, temperature sensor and heat transducer, sensors for gas, liquid and solid, sensors for environmental applications, various switches, and related tools.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105915	Data Storage Technology	4(4-0-8)	105615 Applied Electrodynamics or consent of the School	This course describes about data storage unit, magnetic data storages, optical data storage, and nano-scale data storage.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105923	Advanced Quantum Field Theory I	4(4-0-8)	105823 Quantum Field Theory or consent of the School	This course is designed to introduce the student mainly the standard models for weak and strong interactions, and briefly the non-standard models. The lectures will cover Higgs mechanism and Goldstone theorem, electroweak interaction and its applications, quantum chromodynamics (QCD) and its applications, effective Lagrangian methods, and non-standard models.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105924	Chiral Perturbation Theory	4(4-0-8)	105673 Nuclear and Particle Physics and 105823 Quantum Field Theory or consent of the School	The course summarizes the main elements and methods of the effective field theory of the standard model, the chiral perturbation theory, and reviews the applications of the chiral perturbation theory to the interactions of mesons and baryons at low energies with special emphasis on developments of the latest years. Among the topics covered are the strong, electromagnetic, and weak interactions of mesons at and beyond next-to-leading order in the chiral expansion, nonleptonic weak interactions of mesons, virtual photon corrections, and meson-baryon systems.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses		Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105925	Advanced Quantum Field Theory II	4(4-0-8)	105903 Geometrical Methods in Physics and 105923 Advanced Quantum Field Theory I or consent of the School	This course introduces supersymmetry, supergravity, superstring theory, Calabi-Yau Compactification, duality, D-Branes, and M-Theory and others.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105953	Semiconductors Technology	4(4-0-8)	105625 Applied Quantum Physics or consent of the School	This course covers the following topics: semiconductor materials, p-n junction, metal-insulator-semiconductor capacitors, transistors, power devices, photonics devices and sensors.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105954	Nanoscience and Nanotechnology	4(4-0-8)	Consent of the School	This course covers the following contents: role and importance of nanoparticles around us, different types of carbon nanostructures, synthesis of various nanoparticles, technical analysis of various nanoparticles, applications of nanoparticle technology in electronics, medical applications, Casimir forces in nano machines.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105955 Thin-film Technology and Applications	4(4-0-8)	Consent of the School	This course covers the following contents: introduction to thin-film technology, an overview of the materials used for this technology, processes in creating different types of thin-films, plasma and the interaction between charged particles and surfaces, methods for surface cleaning, chemical vapor deposition (CVD) technique, substrate surface and molecular deposition, pulsed laser deposition (PLD) technique, thin film properties and their applications.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course
105973 Heavy Ion Reactions	4(4-0-8)	105673 Nuclear and Particle Physics or consent of the School	The course gives an overview of heavy ion collisions at intermediate and high energies, with emphasis on the properties of hot and dense nuclear matter, the medium dependence of hadron properties in this environment, and the phase transition from hadronic matter (nuclear matter) to the quark gluon plasma (quark matter). Topics to be covered are: models for heavy ion collisions, kinematics, correlations, the equation of state for nuclear matter, production of entropy in nuclear collisions, sub-threshold production of particles, phase transitions, and quark gluon plasma	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge to industrial problems 4. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105974 Multi-Quark Systems	4(4-0-8)	Consent of the School	The course aims to systematically teach students advanced applications of group theory to various multi-quark systems, both the normal and exotic states. The course cover followings: Review of various quark models and basic knowledge of group theory, advanced knowledge of SU(N) group and permutation group, constructions of state functions of normal hadrons and exotic multi-quark states like glueballs, hybrid mesons, hybrid baryons, pentaquarks and six-quark states, productions and annihilation of exotic multi-quark systems.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105996 Seminar IV	4(4-0-8)	105896 Seminar III	The series of four seminar courses aim to develop scientific communication skills of students. In this course, students will fine-tune their techniques for giving highly effective oral scientific presentations and will further advance their skills for scientific-journal writing. Joint seminars with other institutes will be organized (field trips required). Grade: A, B+, B, C+, C, and F	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course

Courses	Credit (Lect.-Lab-Self stud.)	Prerequisite	Course Description	Expected Learning Outcomes
105997 Colloquium IV	4(4-0-8)	105897 Colloquium III	The series of four colloquium courses aim to develop scientific communication skills of students. In this course, students will fine-tune their techniques for giving highly effective oral scientific presentations and will further advance their skills for scientific-journal writing. Joint seminars with other institutes will be organized (field trips required). Grade: Satisfactory and Unsatisfactory.	1. describe concepts in complicated physics problems related to this course 2. execute basic problem-solving strategies for problems related to this course 3. relate and apply physics knowledge related to this course
105999 Ph.D. Thesis in Physics (for M.Sc. holder)		Consent of the Thesis Advisor	Individual research of a topic to be agreed upon with the thesis advisor.	1. describe concepts in complicated physics problems related to this course 2. describe knowledge in the frontier physics 3. show responsibility and discipline 4. use the advanced scientific equipment to properly carry out experiments and analyze data related to this course with safety 5. analyze the research experimental data or simulation by appropriate means 6. make use of research database 7. relate and apply physics knowledge to this course 8. design and conduct research 9. have research collaboration skills