Detailed Enforcement Regulations for the Curriculum of the Department of Physics, General Graduate School

Implementation Date: March 1, 2026

Article 1 (Purpose)

① The purpose of these enforcement regulations is to establish detailed requirements for obtaining a degree in the aforementioned graduate department.

② Any person seeking to obtain a degree must satisfy all matters prescribed by the University Statutes, the Detailed Enforcement Regulations of the University Statutes, the Internal Regulations of the Graduate School, and the matters prescribed in these enforcement regulations regarding degree acquisition.

Article 2 (Educational Objectives)

The educational objectives of the department are as follows:

1. Acquisition of professional knowledge necessary to understand and explain the principles of natural phenomena.
2. Cultivation of international and creative human resources in the field of physics based on professional knowledge of the major.
3. Cultivation of professionals who can contribute to natural science and human life in general.
4. Strengthening industry-academic collaborative research capabilities through physics-based research and education.

Article 3 (Career and Employment Fields)

① The department's career and employment fields are as follows:

1. National research institutes
2. Domestic and international companies
3. Domestic and international higher education institutions
4. Start-ups in physics-based applied fields

Article 4 (Basic Structure of Curriculum)

① Any person wishing to graduate from (complete) the Department of Physics must earn the credits specified in **[Table 1] Basic Curriculum Structure Table** and **<Attachment 1> Curriculum Organization Table**.

② Graduate courses opened by other departments that are not included in **<Attachment 1> Curriculum Organization Table** shall be recognized as Major Electives within the limit of recognized credits from other departments specified in **[Table 1]**. However, if a student completes a major course related to quantum information opened by the same major in another department, it may be recognized as a major credit for the Quantum Information Science Major of this department.

③ Prerequisite credits are not included in graduation credits.

Department (Major)	Degree Program	Total Graduation (Completion) Credits				Recognized Credits from Other Depts.
		Major Required	Major Elective	Common Subjects	Total Credits	
Physics (Physics, Quantum Information Science)	Master's	-	24	-	24	6
	Ph.D.	-	36	-	36	6
	Integrated Master's-Ph.D.	-	60	-	60	6

Article 5 (Curriculum)

① The curriculum is as follows. **[Table 2] Major Course Organization Table**

Program	Completion Type	Subject Name		Count
Master's, Ph.D.	Major Elective	**Common** (Physics, Quantum Information Science)	Classical Mechanics(3), Classical Electromagnetism 1(3), Classical Electromagnetism 2(3), Quantum Mechanics(3), Statistical Mechanics 1(3), Statistical Mechanics 2(3), Solid State Physics(3), Elementary Quantum Field Theory(3), General Relativity(3), String Theory 1(3), String Theory 2(3), Advanced Topics in Particle Physics 1(3), Advanced Topics in Particle Physics 2(3), Special Topics in Particle Physics 1(3), Special Topics in Particle Physics 2(3), Advanced Statistical Physics(3), Statistical Thermodynamics(3), Quantum Information(3), Advanced data computing in physics(3), Computational Methodology for Electronic Structures 1(3), Computational Methodology for Electronic Structures 2(3), Advanced Solid State Physics 1(3), Advanced Solid State Physics 2(3), Advanced Solid State Physics 3(3), Advanced Solid State Physics 4(3), Magnetism and Magnetic Materials(3), Advanced Applied Physics 1(3), Advanced Applied Physics 2(3), Ellipsometry Data Analysis(3), Advanced Analysis of Ellipsometry(3), Electronics 1(3), Electronics 2(3), Nanomaterials(3), Semiconductor Physics(3)	34
		Quantum Information Science Major	Quantum Information Science 1(3), Quantum Information Science 2(3), Quantum Computers and Simulations 1, Quantum Computers and Simulations 2, Quantum Sensing and Measurement 1, Quantum Sensing and Measurement 2, Quantum Communication and Cryptography 1, Quantum Communication and Cryptography 2, Quantum Information Experiment 1, Quantum Information Experiment 2, Advanced Quantum Algorithms, Advanced Quantum Information Theory, Quantum Information Research Project 1, Quantum Information Research Project 2, Quantum Information Research Intern, Thesis Research 1, Thesis Research 2	17
Master's	Major Elective	**Common** (Physics, Quantum Information Science))	Master’s Thesis Research 1, Master’s Thesis Research 2	2
Ph.D.	Major Elective	**Common** (Physics, Quantum Information Science))	PhD Dissertation Research 1, PhD Dissertation Research 2, PhD Dissertation Research 3, PhD Dissertation Research 4	4

② The Curriculum Organization Table is as shown in **<Attachment 1>**.

③ The Course Descriptions are as shown in **<Attachment 2>**.

Article 6 (Prerequisite Courses)

① Persons falling under the following categories must complete prerequisite courses as follows:

1. **Target**: Persons who entered a department (major) different from that of their lower degree program.
2. **Required Prerequisite Credits**: 9 credits for Master's program, 12 credits for Ph.D. and Integrated Master's-Ph.D. programs.
3. **List of Prerequisite Courses**: Refer to **[Table 3] Prerequisite Course List**.

[Table 3] Prerequisite Course List

No.	Course Name	Offering Dept.	Credits	Recognition Type	Target Degree Program
1	Physics and Laboratory 1	Physics	3	Prerequisite	Master's, Ph.D.
2	Physics and Laboratory 2	Physics	3	Prerequisite	Master's, Ph.D.
3	Mathematical Physics 1	Physics	3	Prerequisite	Master's, Ph.D.
4	Mathematical Physics 2	Physics	3	Prerequisite	Ph.D.

✻ Courses not designated above may be recognized as prerequisite courses through a department meeting.

② If a student applies for credit recognition for subjects taken in a lower degree program before admission and receives approval from the head of the relevant department after confirmation by the academic advisor and the department chair, those credits may be recognized as prerequisite credits.

Article 7 (Recognition of Courses from Other Departments and Graduate Schools)

① With the approval of the academic advisor and the department chair, students may take major courses from other departments within this Graduate School, and these may be recognized as Major Electives within the limit of recognized credits from other departments in **[Table 1]**. However, for **KHU/Ecole Polytechnique dual degree students**, as an exception, all credits obtained from the Department of Information Display may be recognized as necessary credits for completion and graduation.

② In cases where the department and major are changed due to a transfer, credits may be recognized as Major Electives within the limit of recognized credits from other departments in **[Table 1]** through the approval of the department chair.

③ Cases exceeding the limit of recognized credits from other departments may be recognized through a department meeting.

Article 8 (Completion of Graduate Common Courses)

① If a student takes "Common Subjects" (Convergence Education Courses) targeting all graduate students in the Graduate School, they may be recognized as completion (graduation) credits through the approval of the advisor and the department chair.

Article 9 (Completion)

① Completion is recognized only for those who have completed the courses corresponding to Article 4 and satisfied all requirements presented in higher regulations such as the University Statutes and Internal Regulations.

② Students subject to prerequisite credit requirements must acquire the prescribed prerequisite credits. However, prerequisite credits are not included in completion credits.

③ For credits recognized as other department courses and common courses, only the credits prescribed in each of the above articles are recognized as completion credits.

④ Students wishing to complete the **Quantum Information Science Major** must satisfy the following requirements:

- Master's Program: Must take 2 or more subjects in the Quantum Information Science field.
- Ph.D. Program: Must take 3 or more subjects in the Quantum Information Science field.
- Integrated Program: Must take 5 or more subjects in the Quantum Information Science field.

Quantum Information Science related subjects taken as credit exchange at other domestic or international graduate schools may be recognized as taking Quantum Information Science field subjects with the approval of the advisor and the department chair.

Article 10 (Graduation)

Graduation is recognized only for those who satisfy Article 9 and all graduation requirements such as the degree qualification examination, degree thesis, and paper publication requirements.

Article 11 (Degree Qualification Examination)

① To apply for the submission of a degree thesis, one must pass the degree qualification examination.

② The degree qualification examination consists of two subjects: Open Presentation and Comprehensive Examination, and one must pass all subjects.

③ Degree Qualification Examination (Open Presentation) is a research plan presentation.

- Master's and Ph.D. students can take it after acquiring 12 credits, and Integrated students after acquiring 36 credits. For Ph.D. and Integrated students, the degree thesis cannot be submitted until **2 semesters** (including the semester passed) have passed after passing the Open Presentation.
- Examination committee members are appointed by the advisor, consisting of 2 members for Master's and 3 or more for Ph.D. and Integrated courses.
- For KHU/Ecole Polytechnique dual degree students, the Open Presentation exam is exempted.

④ **Degree Qualification Examination (Comprehensive Examination)** is a major competency test.

- Detailed subjects of the Comprehensive Examination are **Classical Mechanics, Electromagnetism, Quantum Mechanics, and Statistical Mechanics**, and all subjects must be passed.
- The Comprehensive Examination is conducted by a committee consisting of 4 or more full-time professors of the department.

- If a grade of **A- or higher** is received in **<Classical Mechanics>**, it is considered a pass for the detailed subject Classical Mechanics.
- If a grade of **A- or higher** is received in **<Classical Electromagnetism 1>** or **<Classical Electromagnetism 2>**, it is considered a pass for the detailed subject Electromagnetism.
- If a grade of **A- or higher** is received in **<Quantum Mechanics>**, it is considered a pass for the detailed subject Quantum Mechanics.
- If a grade of **A- or higher** is received in **<Statistical Mechanics 1>** or **<Statistical Mechanics 2>**, it is considered a pass for the detailed subject Statistical Mechanics.
- For Ph.D. students, if they obtained a Master's degree from the Department of Physics at this Graduate School, the Degree Qualification Examination (Comprehensive Examination) is exempted.

Article 12 (Publication Requirements)

① To obtain a degree, one must submit **paper publication results** separately from the degree thesis, and must conduct an **open presentation within the department** after passing the degree thesis defense.

② Paper publication requirements follow the Graduate School's internal regulations.

Addenda

- **Addendum 1**: Implemented from March 1, 2014.
- **Addendum 2**: Implemented from March 1, 2016. (Changes to other dept course completion, deletion of common course completion, correction of Attachment 1 & 2). Students entered before implementation follow the old curriculum but may apply the new one if necessary.
- **Addendum 3**: Implemented from March 1, 2017. (Changes to other dept course completion).
- **Addendum 4**: Implemented from March 1, 2018.
- **Addendum 5**: Implemented from March 1, 2021 (Applied from 2020 freshmen).
- **Addendum 6**: Implemented from March 1, 2022.
  - The degree qualification examination can also be applied to students who entered before 2022.
  - The degree qualification examination can replace the open presentation or thesis submission qualification exam.
  - Those who replace with the degree qualification examination are not recognized for previously acquired open presentation or thesis submission qualification exams.
- **Addendum 7**: Implemented from September 1, 2023.
- **Addendum 8**: Implemented from March 1, 2024.
- **Addendum 9**: Implemented from March 1, 2025.
- **Addendum 10**:
  - Article 1 (Enforcement Date): Implemented from March 1, 2026.
  - Article 2 (Transitional Measures): Students who entered before the enforcement date follow the old curriculum but may apply the new curriculum with the approval of the department chair through a department meeting if necessary.

<Attachment 1> Curriculum Organization Table

No.	Completion Type	Course Code	Course Title	Credits	Target Students	Course Type	Semester	Remarks

					Master's	Ph.D.	Theory	Practice	Practical	Design	1st	2nd	
1	Major Elective	PHYS7009	고전전자기학1 Classical Electromagnetism 1	3	○	○	○				○		Substitute subject for Comprehensive Exam
2	Major Elective	PHYS7008	고전역학 Classical Mechanics	3	○	○	○					○	Substitute subject for Comprehensive Exam
3	Major Elective	PHYS7119	양자역학 Quantum Mechanics	3	○	○	○					○	Substitute subject for Comprehensive Exam
4	Major Elective	PHYS7020	통계역학1 Statistical Mechanics 1	3	○	○	○				○		Substitute subject for Comprehensive Exam
5	Major Elective	PHYS7117	고체물리 Solid State Physics	3	○	○	○				○		
6	Major Elective	PHYS7031	기초양자장론 Elementary quantum field theory	3	○	○	○				○		
7	Major Elective	PHYS7037	고급통계물리학 Advanced Statistical Physics	3	○	○	○					○	
8	Major Elective	PHYS7110	양자정보 Quantum Information	3	○	○	○					○	
9	Major Elective	PHYS7111	첨단데이터컴퓨팅물리학 Advanced data computing in physics	3	○	○	○					○	
10	Major Elective	PHYS7001	고전전자기학2 Classical Electromagnetism 2	3	○	○	○					○	Substitute subject for Comprehensive Exam
11	Major Elective	PHYS7018	일반상대론 General Relativity	3	○	○	○					○	
12	Major Elective	PHYS7068	끈이론1 String Theory 1	3	○	○	○				○		
13	Major Elective	PHYS7069	끈이론2 String Theory 2	3	○	○	○					○	

14	Major Elective	PHYS7072	통계역학2 Statistical Mechanics 2	3	○	○	○					○	Substitute subject for Comprehensive Exam
15	Major Elective	PHYS7030	통계열역학특론 Statistical Thermodynamics	3	○	○	○					○	
16	Major Elective	PHYS7033	전자구조계산방법론1 Computational Methodology for Electronic Structures 1	3	○	○	○					○	
17	Major Elective	PHYS7028	전자구조계산방법론2 Computational Methodology for Electronic Structures 2	3	○	○	○					○	
18	Major Elective	PHYS7046	고체물리특론1 Advanced Solid State Physics 1	3	○	○	○				○		
19	Major Elective	PHYS7049	고체물리특론2 Advanced Solid State Physics 2	3	○	○	○					○	
20	Major Elective	PHYS7047	고체물리특론3 Advanced Solid State Physics 3	3	○	○	○				○		
21	Major Elective	PHYS7050	고체물리특론4 Advanced Solid State Physics 4	3	○	○	○					○	
22	Major Elective	PHYS7042	자성체물리학 Magnetism and Magnetic Materials	3	○	○	○					○	
23	Major Elective	PHYS7032	응용물리특론1 Advanced Applied Physics 1	3	○	○	○				○		
24	Major Elective	PHYS7015	응용물리특론2 Advanced Applied Physics 2	3	○	○	○					○	
25	Major Elective	PHYS7038	타원편광해석법 Ellipsometry Data Analysis	3	○	○	○				○		

26	Major Elective	PHYS7044	타원해석법응용 Advanced Analysis of Ellipsometry	3	○	○	○					○	
27	Major Elective	PHYS7087	전자물리학1 Electronics 1	3	○	○	○				○		
28	Major Elective	PHYS7088	전자물리학2 Electronics 2	3	○	○	○					○	
29	Major Elective	PHYS7039	나노물성학 Nanomaterials	3	○	○	○				○		
30	Major Elective	PHYS7045	반도체물리학 Semiconductor Physics	3	○	○	○					○	
31	Major Elective	PHYS7064	입자물리특론1 Advanced Topics in Particle Physics 1	3	○	○	○				○		
32	Major Elective	PHYS7065	입자물리특론2 Advanced Topics in Particle Physics 2	3	○	○	○					○	
33	Major Elective	PHYS7019	입자물리특수연구1 Special Topics in Particle Physics 1	3	○	○	○				○		
34	Major Elective	PHYS7052	입자물리특수연구2 Special Topics in Particle Physics 2	3	○	○	○					○	
35	Major Elective	PHYS7120	양자정보과학1 Quantum Information Science 1	3	○	○	○				○		
36	Major Elective	PHYS7121	양자정보과학2 Quantum Information Science 2	3	○	○	○					○	
37	Major Elective	PHYS7122	양자컴퓨터및시뮬레이션1 Quantum Computers and Simulations 1	3	○	○	○				○		
38	Major Elective	PHYS7123	양자컴퓨터및시뮬레이션2 Quantum Computers and Simulations 2	3	○	○	○					○	
39	Major Elective	PHYS7124	양자센싱및측정1 Quantum sensing and measurement 1	3	○	○	○				○		

40	Major Elective	PHYS7125	양자센싱및측정2 Quantum sensing and measurement 2	3	○	○	○					○	
41	Major Elective	PHYS7126	양자통신및암호1 Quantum Communication and Cryptography 1	3	○	○	○				○		
42	Major Elective	PHYS7127	양자통신및암호2 Quantum Communication and Cryptography 2	3	○	○	○					○	
43	Major Elective	PHYS7128	양자정보실험1 Quantum Information Experiment 1	3	○	○	○				○		
44	Major Elective	PHYS7129	양자정보실험2 Quantum Information Experiment 2	3	○	○	○					○	
45	Major Elective	PHYS7130	고급양자알고리즘 Advanced Quantum Algorithms	3	○	○	○				○		
46	Major Elective	PHYS7131	고급양자정보이론 Advanced Quantum Information Theory	3	○	○	○					○	
47	Major Elective	PHYS7132	양자정보연구과제설계1 Quantum Information Research Project 1	3	○	○				○		○	
48	Major Elective	PHYS7133	양자정보연구과제설계2 Quantum Information Research Project 2	3	○	○				○	○		
49	Major Elective	PHYS7134	양자정보연구인턴 Quantum Information Research Intern	3	○	○	○				○		
50	Major Elective	PHYS7135	논문지도1 Thesis Research 1	3	○	○	○				○		
51	Major Elective	PHYS7136	논문지도2 Thesis Research 2	3	○	○	○					○	
52	Major Elective	PHYS0000	석사논문연구1 Master's Thesis Research I	3	○		○				○		
53	Major Elective	PHYS0000	석사논문연구2 Master's Thesis Research II	3	○		○					○	
		PHYS000	박사논문연구1										

54	Major Elective	0	PhD Dissertation Research I	3		○	○				○		
55	Major Elective	PHYS0000	박사논문연구2 PhD Dissertation Research II	3		○	○					○	
56	Major Elective	PHYS0000	박사논문연구3 PhD Dissertation Research III	3		○	○				○		
57	Major Elective	PHYS0000	박사논문연구4 PhD Dissertation Research IV	3		○	○					○	

<Attachment 2> Course Descriptions

1. Classical Electromagnetism 1 Topics include boundary-value problems of potential, electric and magnetic properties of matter, Maxwell's and Jefimenko's equations, gauge transformation.

2. Classical Mechanics Topics include the Newtonian mechanics, Lagrangian and Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi theory, motion of rigid bodies and small oscillations.

3. Quantum Mechanics Topics include fundamental concepts, Hilbert spaces and Dirac notations, general theory of quantum mechanics, including the Schrödinger, Heisenberg, and interaction pictures, the path integral formulation, nature of quantum measurement, addition of angular momenta.

4. Statistical Mechanics 1 In this course, we will introduce the fundamental concepts and hypotheses in equilibrium statistical physics, such as Ergodic theory and ensemble theory. Numerous examples including the classical gas system will be discussed. We will also introduce some basic ideas and concepts in quantum statistical mechanics and study the physical properties of photon-photon gas, Bose gas, Fermi gas, etc.

5. Solid State Physics The course provides an introduction to solid state physics, including the lattice structure, basic experimental methods, thermal properties, and basic band theory.

6. Elementary Quantum Field Theory Topics include relativistic wave equations for spin-0, spin-1/2, and spin-1 particles, Noether's theorem, canonical quantizations, S-matrix, reduction formulas, perturbation theory and Feynman diagrams, introduction to renormalization.

7. Advanced Statistical Physics Based on the fundamental concepts in statistical physics such as scaling theory, renormalization group theory, we will introduce various methods to study the physical properties in equilibrium and non-equilibrium systems.

8. Quantum Information This course provides students with an opportunity to learn quantum information theory and its application. It covers quantum bits, quantum algorithms, quantum computers, quantum thermodynamics and so on, and the recent trend of cutting edge research.

9. Advanced Data Computing in Physics This course covers various topics in physics using computer programs. Numerical methods for the computer simulation of physics systems and analysis techniques to understand data are introduced. For the data analysis techniques, ideas from artificial intelligence will be used to select data and extract useful information. Hypothesis testing on the data based on statistics will be applied. Students can have exercises to write their own computer programs based on parallel and distributed computing environments such as GPUs.

10. Classical Electromagnetism 2 Topics include electromagnetic waves, reflection and refraction, scattering and diffraction, electromagnetic radiation from oscillating dipoles, covariant formulation of Maxwell equations.

11. General Relativity We first review special relativity and discuss the equivalence principle. Topics covered are basics of differential geometry, derivation of Einstein equation, Schwarzschild black hole solution, and introductory cosmology.

12. String Theory 1 We study string theory, especially superstring theory. We start from classical string theory and through quantization note that string theory contains gravity. We also note that there exist five anomaly-free string theories. We also study various topics in theoretical and mathematical physics needed in the study of string theory.

13. String Theory 2 We study non-perturbative properties of string theory and understand that the string dualities are systematically explained in terms of eleven dimensional M-theory. We also study supergravity, D-branes and Yang-Mills theory, Matrix models, and AdS/CFT correspondence.

14. Statistical Mechanics 2 In this course we will introduce the general theory on phase transitions, scaling theory, and renormalization group theory. As specific examples, phase transition in Ising model and special topics in statistical physics, such as superfluid He, will be discussed. We also cover the non-equilibrium statistical mechanics such as Boltzmann equation.

15. Statistical Thermodynamics Based on the understanding of the equilibrium and non-equilibrium systems, we study the contemporary topics in statistical physics including self-organization, diffusion-reaction dynamics, etc.

16. Computational Methodology for Electronic Structures 1 This course introduces fundamental methodology of calculating the electronic structures of materials. It provides the relation between experimentally-observed quantities and electronic structures in ground-state or excitations to make a connection from theoretical study to experimental observations.

17. Computational Methodology for Electronic Structures 2 This course introduces fundamental methodology of calculating the electronic structures of materials. It provides a basic idea of pseudopotential method, which is applied into empirical pseudopotential method and into density functional theory. Students will also learn various basis sets for the matrix representation of Hamiltonian.

18. Advanced Solid State Physics 1 Topics such as group theory, phase transition, glass transition, superlattice, X-ray scattering, Raman scattering, photoluminescence will be presented. Research articles of current hot topics will be selected for discussion.

19. Advanced Solid State Physics 2 Characteristics of amorphous materials such as chemical bonding, atomic structure, disorder, electrical transport will be presented.

20. Advanced Solid State Physics 3 Carrier mobility, diffusion, percolation in 2D and 3D of disordered materials will be covered.

21. Advanced Solid State Physics 4 Devices of amorphous semiconductors such as solar cell, drum in a copy machine, image sensors, thin film transistors will be discussed.

22. Magnetism and Magnetic Materials The course provides an introduction to the magnetism research, including basic classical and quantum physics on magnetism, the origin of magnetism phenomena, and basic theories on the interactions of spins.

23. Advanced Applied Physics 1 In order to build his/her own foundation of spectroscopic analysis research in advanced applied physics, students acquire the knowledge of the optical properties of materials and characteristics of light and learn deeply about operational principles of equipment.

24. Advanced Applied Physics 2 Based on the principles of the spectroscopic-analysis research in advanced applied physics, this course is designed to raise the ability to obtain results from analyzed data and to make competent researchers who are able to handle various samples through multilateral point of views.

25. Ellipsometry Data Analysis This course is mainly for the graduate students of ellipsometry major. It covers basic concepts of polarized light and optical parameters and combines simple experimental examples, which increase the capability of ellipsometric analysis.

26. Advanced Analysis of Ellipsometry This course is intensive course of ellipsometry to develop operating skills of ellipsometer and analyzing optical properties of the obtained data. It covers Mueller matrix, anisotropic material, and inhomogeneous layer et cetera. Students will be able to have enhanced abilities on ellipsometric analysis of complex materials.

27. Electronics 1 In this lecture, students learn knowledges of electronic engineering, particularly on the theory of circuits. As understanding those, they also learn fundamental concepts of analog electronic engineering, needed to accomplish physical experiments.

28. Electronics 2 In this lecture, students learn the fundamental principles of digital electronic engineering. As understanding those, they treat applied physics and operation principles of many measuring devices.

29. Nanomaterials This lecture introduces multiple physical properties on nano materials. Correlations of those physical properties are also introduced.

30. Semiconductor Physics Learn the basic information about the atomic structure of the semiconductor, the band structure, manufacturing method, and physical properties, and then study about semiconductor fabrication methods for pn junction, Schottky junction, MOS, MOSFET, and a field effect transistor, as well as acquire the basic knowledge of a research of relating to these semiconductors.

31. Advanced Topics in Particle Physics 1 We study from basics to advanced topics in theoretical particle physics. We study flavor physics and Yang-Mills theory. We also study topological solutions in quantum field theory, and Weinberg-Salam model.

32. Advanced Topics in Particle Physics 2 We study quantization of gauge theories using path integral. We also discuss instantons, and study renormalization group and effective action. We also cover topics such as axial anomaly, asymptotic freedom and infrared problem in QCD.

33. Special Topics in Particle Physics 1 Topics include advanced materials of particle physics such as conformal field theory and supersymmetric field theory.

34. Special Topics in Particle Physics 2 Topics include advanced materials of particle physics such as quantum field theory in curved spacetime and AdS/CFT correspondence.

35, 36. Quantum Information Science 1, 2 Introduction to quantum algorithms and information theory, Quantum algorithms including Shor's factoring algorithm and Grover's search algorithm, Quantum error correction.

37, 38. Quantum Computers and Simulations 1, 2 Experience comprehensive research on the principles and applications of quantum computers and simulations.

39, 40. Quantum Sensing and Measurement 1, 2 Understand advanced technology exploration for precision sensing and measurement using quantum systems.

41, 42. Quantum Communication and Cryptography 1, 2 Introduction to quantum communication and quantum cryptography including the state of the art of quantum networks, techniques for building quantum repeaters that promise to deliver qubits over long distances, and one of the most famous applications of quantum cryptography, quantum key distribution.

43, 44. Quantum Information Experiment 1, 2 Experience designing and performing experiments to investigate quantum information phenomena.

45. Advanced Quantum Algorithms Quantum algorithms for simulating quantum mechanics, Limitations on the power of quantum computers, Selected recent developments in quantum algorithms.

46. Advanced Quantum Information Theory Purifications and fidelity, Naimark's theorem: characterizations of channels, Semidefinite programming, Semidefinite programs for fidelity and optimal measurements, Entropy, Continuity of von Neumann entropy: quantum relative entropy, Holevo's theorem and Nayak's bound, Separable mappings and the LOCC paradigm.

47, 48. Quantum Information Research Project 1, 2 Conducting research projects related to quantum information science and deriving the research results.

49. Quantum Information Research Intern Participate in research projects to contribute to the development of quantum information science under the supervision of experts.

50, 51. Thesis Research 1, 2 Developing academic writing skill through logical thinking.

52. Master's Thesis Research I This course provides the foundation for master's-level research in physics. Students work with their advisor to define a physics-related research topic, review relevant physical theories and prior studies, and acquire fundamental skills in experimental, theoretical, or computational physics. A physics-oriented research plan is developed as part of the course.

53. Master's Thesis Research II This course focuses on the full execution of the master's thesis research in physics. Students collect and analyze physical data through experimental, theoretical, or computational methods and organize their findings within a physics framework. The course includes developing a thesis draft and strengthening scientific presentation skills.

54. PhD Dissertation Research 1 This course covers the initial stage of doctoral-level physics research. Students conduct an in-depth review of relevant physical theories and current developments, identify key physics problems, and establish an original research topic that contributes meaningfully to the field. A long-term research plan is formulated.

55. PhD Dissertation Research II This course focuses on building the research framework required for physics dissertation work, including experimental setup, physical modeling, and computational physics code development. Students conduct preliminary experiments or simulations to validate the physical soundness of their research approach.

56. PhD Dissertation Research III This course represents the central phase of the physics dissertation research. Students carry out full-scale experimental, theoretical, or computational studies to generate and analyze significant physical data. The objective is to produce research results suitable for international conferences or peer-reviewed physics journals.

57. PhD Dissertation Research IV This course constitutes the final stage of doctoral research in physics. Students Integrate all research findings within a physics framework to complete the dissertation, prepare manuscripts for submission to International physics journals, and complete the requirements for the dissertation defense.