Subject Code	SD11010013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Seminar in Mathematical Structures		
Subject Number	SAMSM1701		
Credits	2Credits	Teaching Method	Seminar
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Latest research developments and results in the theory of mathematical structures.		
Goal of the Subject	To learn the latest research developments and results in some areas of mathematical structures.		
Contents of the Subject /Subject Plan	This course is given in the seminar format conducted by the faculty members.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SD11020013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Seminar in Mathematical Analysis		
Subject Number	SAMSM1702		
Credits	2Credits	Teaching Method	Seminar
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Latest research developments and results in mathematical analysis.		
Goal of the Subject	To learn the latest research developments and results in some areas of mathematical analysis.		
Contents of the Subject /Subject Plan	This course is given in the seminar format conducted by the faculty members.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SD12010013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Seminar in Fundamental Physics		
Subject Number	SAPS11701		
Credits	2Credits	Teaching Method	Special Seminar
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	In this seminar, the recent developments in fundamental physics are broadly studied.		
Goal of the Subject	In this lecture, every student is encouraged to set up voluntary research theme and plan.Proper academic advice leading to Doctoral thesis will be given.		
Contents of the Subject /Subject Plan	In this seminar, the recent developments in fundamental physics are broadly studied.		
Preparation and Review	It will be announced in the class.		
Evaluation Method	Evaluation is based on attendance, report and discussion in a class.		
Comments to Students	It will be announced in the class.		
Teaching Materials	It will be announced in the class.		
Remarks1			

Subject Code	SD12020013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Seminar in Astroparticle and High Energy Physics		
Subject Number	SAPS21701		
Credits	2Credits	Teaching Method	Special Seminar
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Learn a wide range of recent research results and development in the field of astrophysics and high energy physics from classes given by multiple faculty members.		
Goal of the Subject	Discuss research program leading to the writing of Doctoral thesis. Special emphasis will be placed on encouraging students to be independent in making research plans, and to think throughly on significance of the topic.		
Contents of the Subject /Subject Plan	Learn a wide range of recent research results and development in the field of astrophysics and high energy physics from classes given by multiple faculty members.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and the discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SD12030013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Seminar in Condensed Matter Physics		
Subject Number	SAPS31701		
Credits	2Credits	Teaching Method	Special Seminar
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Learn a wide range of recent research results and development in the field of condensed matter physics from classes given by multiple faculty members.		
Goal of the Subject	Discuss research program leading to the writing of Doctoral thesis. Special emphasis will be placed on encouraging students to be independent in making research plans, and to think throughly on significance of the topic.		
Contents of the Subject /Subject Plan	Learn a wide range of recent research results and development in the field of condensed matter physics from classes given by multiple faculty members.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and the discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SD13010013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Doctoral Thesis of Science (D1 Mathematics)		
Subject Number			
Credits	3Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Fundamental theory of each specialty.		
Goal of the Subject	To understand systematically fundamentals of the theory which is necessary to solve the research problem for the doctoral thesis.		
Contents of the Subject /Subject Plan	This is intended to gain a systematic understanding of fundamentals of the theory to solve the research problem for the doctoral thesis. For that purpose, each student is assigned reading materials and is expected to formulate and to solve the research problem for the doctoral thesis under the guidance of the thesis adviser. Also a guidance is given on how to give presentations at research conferences and on how to write a research paper and submit it to an academic journal.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is assigned based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SD13010023	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Doctoral Thesis of Science (D1 Physics)		
Subject Number			
Credits	3Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Acquiring the systematic knowledge and skills on the theories and experiments leading to the writing of the Doctoral thesis.		
Goal of the Subject	We aim to acquire the systematic knowledge and skills on the theories and experiments leading to the writing of Doctoral thesis.		
Contents of the Subject /Subject Plan	We aim to acquire the systematic knowledge and skills on the theories and experiments leading to the writing of Doctoral thesis. For this purpose, discuss research program leading to the writing of Doctoral thesis. Special emphasis will be placed on encouraging students to make research plans, to read textbooks and journal articles, and to acquire the experimental skills. It also provides guidance on the presentation of research results at academic conferences and the preparation and submission of manuscripts to academic journals.		
Preparation and Review	To be announced separately.		
Evaluation Method	Evaluation will be made totally on a basis of attendance, reports and discussions at the seminar.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SD13020013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Doctoral Thesis of Science (D2 Mathematics)		
Subject Number			
Credits	3Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Fundamental theory of each specialty.		
Goal of the Subject	To understand systematically fundamentals of the theory which is necessary to solve the research problem for the doctoral thesis.		
Contents of the Subject /Subject Plan	This is intended to gain the systematic understanding of the fundamentals of the theory to solve the research problem for the doctoral thesis. For that purpose, each student is assigned reading materials and is expected to formulate and to solve the research problem for the doctoral thesis under the guidance of the thesis adviser. Also a guidance is given on how to give presentations at research conferences and on how to write a research paper and submit it to an academic journal.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is assigned based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SD13020023	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Doctoral Thesis of Science (D2 Physics)		
Subject Number			
Credits	3Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Acquiring the systematic knowledge and skills on the theories and experiments leading to the writing of the Doctoral thesis.		
Goal of the Subject	We aim to acquire the systematic knowledge and skills on the theories and experiments leading to the writing of Doctoral thesis.		
Contents of the Subject /Subject Plan	We aim to acquire the systematic knowledge and skills on the theories and experiments leading to the writing of Doctoral thesis. For this purpose, discuss research program leading to the writing of Doctoral thesis. Special emphasis will be placed on encouraging students to make research plans, to read textbooks and journal articles, and to acquire the experimental skills. It also provides guidance on the presentation of research results at academic conferences and the preparation and submission of manuscripts to academic journals.		
Preparation and Review	To be announced separately.		
Evaluation Method	Evaluation will be made totally on a basis of attendance, reports and discussions at the seminar.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SD13030013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Doctoral Thesis of Science (D3 Mathematics)		
Subject Number			
Credits	2Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Fundamental theory of each specialty.		
Goal of the Subject	To understand systematically the fundamentals of the theory which are necessary to solve the research problem for the doctoral thesis.		
Contents of the Subject /Subject Plan	This is intended to gain a systematic understanding of the fundamentals of theory to solve the research problem for the doctoral thesis. For that purpose, each student is assigned reading materials and is expected to formulate and to solve the research problem for the doctoral thesis under the guidance of the thesis adviser. Also a guidance is given on how to give presentations at research conferences and on how to write a research paper and submit it to an academic journal.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is assigned based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SD13030023	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Doctoral Thesis of Science (D3 Physics)		
Subject Number			
Credits	2Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Acquiring the systematic knowledge and skills on the theories and experiments leading to the writing of the Doctoral thesis.		
Goal of the Subject	We aim to acquire the systematic knowledge and skills on the theories and experiments leading to the writing of Doctoral thesis.		
Contents of the Subject /Subject Plan	We aim to acquire the systematic knowledge and skills on the theories and experiments leading to the writing of Doctoral thesis. For this purpose, discuss research program leading to the writing of Doctoral thesis. Special emphasis will be placed on encouraging students to make research plans, to read textbooks and journal articles, and to acquire the experimental skills. It also provides guidance on the presentation of research results at academic conferences and the preparation and submission of manuscripts to academic journals.		
Preparation and Review	To be announced separately.		
Evaluation Method	Evaluation will be made totally on a basis of attendance, reports and discussions at the seminar.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SD40020013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	International Advanced Research Course for Doctoral Thesis of Science 2 (Mathmatics)		
Subject Number			
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	International research experience through research activities and scholarly exchanges abroad.		
Goal of the Subject	Each student is expected not only to make advancements in research towards the doctoral thesis, but also to participate in international scientific communities.		
Contents of the Subject /Subject Plan	Each student will be advised on where to go, what to do there, and also on how to give a research presentation in English, by his or her adviser. After returning to Japan, he or she is expected to present a research report.		
Preparation and Review	To be assigned individually. Also each student is expected to seek research problems actively.		
Evaluation Method	The grade is assigned based on the advancements in research and also on the improvements of the skill in research presentation and scientific communication in the international setting.		
Comments to Students	It is required to consult the adviser before registering this course.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SD40020023	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	International Advanced Research Course for Doctoral Thesis of Science 2 (Physics)		
Subject Number			
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Students are expected to experience research in international fields through research activities and academic exchanges outside Japan.		
Goal of the Subject	Through research activities outside Japan, we aim to make progress in research plans of the Doctoral thesis, to achieve research goals, and to participate in international scientific communities of students and researchers in each research field.		
Contents of the Subject /Subject Plan	The university or research institute to be dispatched and research plans will be determined through discussion with the supervisor. Encourage students to make research proposal and plan and to acquire the presentation of research (in English) or experimental skills. After returning to Japan, research results are to be reported.		
Preparation and Review	To be assigned by faculty. In addition, students are encouraged to make research subjects by oneself, and to study actively the subject before and after the project.		
Evaluation Method	Grading will be given based on research results and progress of research. Improvement of overseas presentation and communication skills is also confirmed and evaluated.		
Comments to Students	Regarding international research plans, etc., consult with the supervisor before registering for the course.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM11150012	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Algebraic Structures III		
Subject Number	SAMAL1507		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Mitsuyasu Hashimoto		
Main Theme of the Subject	Recent topics about Algebra are given by specialists in other universities as an intensive lecture.		
Goal of the Subject	To be assigned later.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the reports and the participation in the class.		
Comments to Students	To be assigned later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM11160012	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Algebraic Structures IV		
Subject Number	SAMAL1508		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Mitsuyasu Hashimoto		
Main Theme of the Subject	Recent topics about Algebra are given by specialists in other universities as an intensive lecture.		
Goal of the Subject	To be assigned later.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the reports and the participation in the class.		
Comments to Students	To be assigned later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM11190011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Geometric Structures III		
Subject Number	SAMGE1507		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Taizo Kanenobu		
Main Theme of the Subject	Recent topics about Geometry are given by specialists in other universities as an intensive lecture.		
Goal of the Subject	To be assigned later.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the reports and the participation in the class.		
Comments to Students	To be assigned later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM11200011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Geometric Structures IV		
Subject Number	SAMGE1508		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Taizo Kanenobu		
Main Theme of the Subject	Recent topics about Geometry are given by specialists in other universities as an intensive lecture.		
Goal of the Subject	To be assigned later.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the reports and the participation in the class.		
Comments to Students	To be assigned later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM11430011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Topics in Mathematical Structures 1		
Subject Number	SAMMS1501		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Hyohe Miyachi		
Main Theme of the Subject	Introduction to recent research topics and results in algebra by the faculty members in algebra.		
Goal of the Subject	This course is intended to learn recent research topics and results in algebra guided by the faculty members and by giving presentations. We hope to raise the level of the knowledge of the students to the research level.		
Contents of the Subject /Subject Plan	For example, in order to learn the theory of the category of modules using homological algebra, the following is a possibility. Lecture 1: Artinian rings Lecture 2: Modules over Artinian rings Lecture 3: Category of modules over Artinian rings Lecture 4: Injective objects Lecture 5: Differential complexes Lecture 6: Homology Lecture 7: Projective objects Lecture 8: Generators Lecture 9: Morita equivalence Lecture 10: Triangulated categories Lecture 11: Localization Lecture 12: Derived equivalence Lecture 13: Quasi-Frobenius rings Lecture 14: Derived equivalence concerning modules over groups		
Preparation and Review	To read and to understand the assigned materials.		
Evaluation Method	The grade is given based on the presentations and the attendance.		
Comments to Students	The format, the level and the contents of the course are subject to change according to the areas of specialty and the interests of the students and the faculty members.		
Teaching Materials	The materials and the references are assigned by the faculty members.		
Remarks1	Those who plan to register this course are required to contact the appropriate faculty member beforehand.		

Subject Code	SM11440011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Topics in Mathematical Structures 2		
Subject Number	SAMMS1502		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Taizo Kanenobu		
Main Theme of the Subject	Recent topics in geometric topology are introduced.		
Goal of the Subject	Researchers in the field of topology introduce recent research results and research subjects related to topological geometry. Students also present them under the direction of the supervisor.		
Contents of the Subject /Subject Plan	Basic notions in classical knot theory. Some topics in classical knot theory. Recent topics in classical knot theory. Basic notions in 4-dimensional knot theory. Some topics in 4-dimensional knot theory. Recent topics in 4-dimensional knot theory. Topological invariants in knot theory; basic notions related to (co)homology theory ;recent topics related to (co)homology. Basic notions in graph theory related to topology. Some topics in graph theory related to topology. Recent topics in graph theory related to topology. Basic notions in spatial graph theory. Some topics in spatial graph theory.		
Preparation and Review	Learning is expected to deepen the understanding of the topics and research results by reading the literature and its references.		
Evaluation Method	Comprehensively evaluated by presentations and/or reports.		
Comments to Students	The contents, progress and form of the course may be changed depending on the specialized field of the supervisor, the research field of the students, the research situation, etc.		
Teaching Materials	Will be introduced during the class		
Remarks1	Students who who wish to take this course should contact the supervisor in advance.		

Subject Code	SM11450011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Topics in Mathematical Structures 3		
Subject Number	SAMMS1503		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Takamichi Sano		
Main Theme of the Subject	Introduction to recent research topics and results in algebra by the faculty members in algebra.		
Goal of the Subject	This course is intended to learn recent research topics and results in algebra guided by the faculty members and by giving presentations. We hope to raise the level of the knowledge of the students to the research level.		
Contents of the Subject /Subject Plan	As an example, the following is a possibility. Lecture 1: Commutative rings Lecture 2: Affine algebraic varieties Lecture 3: Schemes Lecture 4: Lie algebras Lecture 5: Semisimple Lie algebras Lecture 6: Representation theory of Lie algebras Lecture 7: Lie groups Lecture 8: Compact Lie groups Lecture 9: Semisimple Lie groups Lecture 10: Symmetric spaces Lecture 11: Hermitian symmetric spaces Lecture 12: Analysis on symmetric spaces Lecture 13: Iwasawa theory Lecture 14: Non-commutative Iwasawa theory		
Preparation and Review	To read and to understand the assigned materials.		
Evaluation Method	The grade is given based on the presentations and the attendance.		
Comments to Students	The format, the level and the contents of the course are subject to change according to the areas of specialty and the interests of the students and the faculty members.		
Teaching Materials	The materials and the references are assigned by the faculty members.		
Remarks1	Those who plan to register this course are required to contact the appropriate faculty member beforehand.		

Subject Code	SM11460011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Topics in Mathematical Structures 4		
Subject Number	SAMMS1504		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Hirotaka Akiyoshi		
Main Theme of the Subject	This course deals with recent topics in topology.		
Goal of the Subject	At the end of the course, the participants are expected to acquire the necessary knowledge of topology needed to start their own study.		
Contents of the Subject /Subject Plan	Recent topics and results are introduced by researchers. Students also give oral presentations on the topics assigned. Lesson 1. Basics of Fuchsian groups Lesson 2. Topics in Fuchsian groups Lesson 3. Basics of the mapping class groups of surfaces Lesson 4. Topics in the mapping class groups of surfaces Lesson 5. Recent developments in the mapping class groups of surfaces Lesson 6. Basics of Heegaard splittings and Dehn surgeries of 3-manifolds Lesson 7. Topics in Heegaard splittings and Dehn surgeries of 3-manifolds Lesson 8. Recent developments in Heegaard splittings and Dehn surgeries of 3-manifolds Lesson 9. Basics of Kleinian groups Lesson 10. Topics in Kleinian groups Lesson 11. Recent developments in Kleinian groups Lesson 12. Basics of 3-dimensional geometric structures Lesson 13. Topics in 3-dimensional geometric structures Lesson 14. Recent developments in 3-dimensional geometric structures Course contents may change according to the attendants in the lectures.		
Preparation and Review	Carefully read through and understand the contents of the references.		
Evaluation Method	Evaluated based on class attendance and quality of oral presentations.		
Comments to Students	Course contents may change according to the attendants in the lectures.		
Teaching Materials	Will be introduced in the class.		
Remarks1			

Subject Code	SM11480011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Advanced Algebra II		
Subject Number	SAMAL1502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hyohe Miyachi		
Main Theme of the Subject	Homological Algebra has been used in a vast area in mathematics, not only algebra but also the other subject as a fundamental theory. As a prototype, we shall recall the (co)homology theory in module categories over rings. Starting from some basic properties on modules, we shall learn on the topics : Jacobson radicals, simple algebras, noetherian modules, artinian modules, injective modules and projective modules. These will be useful in more general abelian categores as the same kind of scheme works in those general categories.		
Goal of the Subject	The main theme is the ring theory and its representation theory. Recalling the quotient ring and the quotient modules, we shall learn semi simple modules, semi simple algebras, injective modules and projective modules. We shall learn as a protyotype of cohomology theory, which is supposed to be a basement of ring theory and representation theory.		
Contents of the Subject /Subject Plan	1. Modules over a ring and their properties. Read the section 4 of chapter 1 in the text book. Solve the exercises in the end of this section. 2. Modules over a ring and their homorphisms. Read the section 1 of chapter 2 in the text book. Solve the exercises in the end of this section. 3. Factor modules. Read the section 2 of chapter 2 in the text book. Solve the exercises in the end of this section. 4. Direct sum and product. Read the section 3 of chapter 2 in the text book. Solve the exercises in the end of this section. 5. Noetherian and artinian modules. Read the section 4 of chapter 2 in the text book. Solve the exercises in the end of this section. 6. Exact sequences. Read the section 5 and 6 of chapter 2 in the text book. Solve the exercises in the end of this section. 7. Direct sum revisited. Read the section 1 of chapter 3 in the text book. Solve the exercises in the end of this section. 8. Endomorphism rings and indecomposable modules. Read the section 2 and 3 of chapter 3 in the text book. Solve the exercises in the end of this section. 9. Characterizations of split exact sequences. Solve the exercises on topics of this section. 10. Semi simple modules and Jacobson radicals. Read the section 1 and 2 of chapter 7 in the text book. Solve the exercises in the end of this section. 11. Simple algebras. Read the section 3 of chapter 7 in the text book. Solve the exercises in the end of this section. 12. Semi simple algebras. Solve the exercises on topics of this section. 13. Injective modules and projective modules. Read the section 1 and 2 of chapter 4 in the text book. Solve the exercises in the end of this section. 14. The existence of injective hull. Read the section 3 and 4 of chapter 4 in the text book. Solve the exercises in the end of this section. 15. Homological algebra. Read the corresponding part of chapter 6 in the text book. Solve the exercises in the end of this section.		
Preparation and Review	Every time, abstract notion and definitions will appear. On the contrary keep concrete examples in mind and recreate exercise by your own. Especially, one should make the smallest non trivial example for each notion. The recalling and reviewing the nontion in lectures are supposed to be the most important. In Mathematics, the things are piled by basics, in other words, basements are the most important. Before going into the new topics, one should totally understand the past previous topics.		
Evaluation Method	Scored by the report.		
Comments to Students	Definitions themselves are perhaps very simple. But, to comprehend or to appreciate new (abstract) notion, one need some efforts finding a lot of applicable concrete examples. Applicants are supposed to have the credits on Algebra I, II and III.		
Teaching Materials	If one needs a text book written in English, ask the lecturer for this.		

Subject Code	SM11500011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Advanced Algebra IV		
Subject Number	SAMAL1504		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Shunsuke Yamana		
Main Theme of the Subject	I will give lectures on the basics of "algebraic number theory" which studies various properties of the field generated by algebraic numbers (numbers that are the roots of polynomials whose coefficients are rational numbers). Basic knowledge of algebra is assumed for the time being, but I would like to supplement it a little each time.		
Goal of the Subject	The goal of this lecture is to enable students to learn the following items and to proceed to more specialized study and research on algebraic number theory. (1) Explain the quadratic reciprocity law. (2) Explain the basic concepts of algebraic number fields such as integer rings, ideals, and discriminants. (3) Explain the fundamental theories, such as prime ideal decomposition, discriminants and ramifications, and Hilbert's theory on the splitting of prime ideals in Galois extensions. (4) Apply it to concrete examples such as quadratic and cyclotomic fields.		
Contents of the Subject /Subject Plan	(1): Euclidean algorithm and continued fraction (2): Primitive roots (3): Quadratic reciprocity law (4): review of the field theory (5): Algebraic numbers, algebraic fields and examples (6): Integer rings and ideals (7): Discriminants (8): Fundamental theorem of ideal theory (9): Residue rings (10): Decomposition of prime numbers in algebraic number fields (11): Ramification theory (12): Hilbert's Theory (13): Gauss sum and Jacobi sum (14): Cyclotomic fields (15): Quadratic fields		
Preparation and Review	(1): Read the corresponding part of Section 3 of the textbook. (2): Read the corresponding part of Section 10 of the textbook. (3): Read the corresponding part in Section 13 of the textbook. (4): Read the corresponding part of Chapter 2 of the textbook. After the lecture, solve the report problems imposed so far. (5): Read the corresponding part of Sections 14, 19 in the textbook. (6): Read the corresponding part of Section 22 of the textbook. (7): Read the corresponding part of Section 22 of the textbook. (8): Read the corresponding part of Section 23 of the textbook. (9): Read the corresponding part of Section 24 of the textbook. (10): Read the corresponding part of Section 25 of the textbook. (11): Read the corresponding part of Section 26 of the textbook. After the lecture, solve the report problem to be imposed in (5)-(11). (12): Read the corresponding part of Section 17 of the textbook. (13): Read the corresponding part of Section 27 of the textbook. (14): Read the corresponding part of Sections 28 and 29 of the textbook. (15): Read the corresponding part of Section 30 of the textbook. After the lecture, solve the report problem imposed in all areas.		

Evaluation Method	(1) Impose report problems to measure the achievements. (2) Evaluation is mainly based on reports, but also takes into account the attendance situation such as responses during lectures. (3) To be able to explain the basic concept of algebraic number field is the minimum criterion for passing.
Comments to Students	This course assumes basic knowledge of algebra, so be sure to prepare for the necessary materials according to the lecture schedule to be conveyed during the lecture. In addition, since the items explained during the lecture will be required in the next and subsequent lectures, review the definitions and theorems to ensure that one understands the contents.
Teaching Materials	Takashi Ono, An Introduction to Algebraic Number Theory, University Series in Mathematics.
Remarks1	

Subject Code	SM11520011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Advanced Geometry II		
Subject Number	SAMGE1502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Yoshihiro Ohnita		
Main Theme of the Subject	Harmonic map equations from Riemann surfaces to symmetric spaces is one of the fundamental objects in differential geomtetry. Starting from the beautiful fact that it can be formulated as the zero curvature equations with the spectral parameter, we will discuss the integrable system theoretic approach based on loop groups and infinite dimensional Grassmannians, their relations with Toda field equations and so on.		
Goal of the Subject	The aim of this lecture is to understand that the harmonic map equations from Riemann surfaces into symmetric spaces have various properties, structures and genralizations and infinite dimensional methods work well there.		
Contents of the Subject /Subject Plan	1. A short course of Riemannian geometry 2. Definition of harmonic maps between Riemannian manifolds 3. Harmonic maps from Riemann surfaces 4. Lie groups and symmetric spaces 5. Harmonic maps from Riemann surfaces to symmetric spaces 6. Zero curvature equations for harmonic map equations 7. Extended solutions into loop groups 8. Geometry of infinite dimensional Grassmann manifolds 9. Loop group actions on harmonic maps 10. Morse theoretic aspect of loop groups 11. Formula of Dorfmeister-Pedit-Wu 12. Uniton transforms for harmonic maps 13. Harmonic maps of finite uniton number 14. Finite type harmonic maps 15. Algebraically completely integrable systems		
Preparation and Review	In this lecture it is assumed that studentes have lerned mathematical basic subjects on calculus, linear algebra, set theory and general topology, algebras such as group theory and vector spaces, vector analysis, complex analysis, ODE, and geometry of curves and surfaces, elementary algebraic topology, basic theory of smooth manifolds etc.		
Evaluation Method	The evaluation to students will be done by the participation, exercises on lectures, mini-tests, reports etc.		
Comments to Students	Let us study one by one new mathematics for you. Do not forget to review even matematics which you have already learned.		
Teaching Materials	The notes and relevant literatures will be shown on the lectures.		
Remarks1			

Subject Code	SM11540011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Advanced Geometry IV		
Subject Number	SAMGE1504		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	We give an introductory course to symmetric spaces and quandles. Symmetric spaces are important concept in differential geometry, and quandles are originated in topology and knot theory. In general, symmetric spaces are quandles, and quandles can be regarded as discretization of symmetric spaces. In this course, we mention several studies from this viewpoint.		
Goal of the Subject	Study basic concepts of symmetric spaces and quandles through explicit examples.		
Contents of the Subject /Subject Plan	1-4: Basic concepts of symmetric spaces and quandles 5-9: Basic classes of symmetric spaces and quandles 10-14: Subsets in symmetric spaces and quandles		
Preparation and Review	Read the resume given in the class, and understand the story. Solve exercises. Construct examples which are not given in the lecture.		
Evaluation Method	Basically based on the reports. Possibly there are exams.		
Comments to Students	It is important to calculate and study explicit examples.		
Teaching Materials	Resume will be given.		
Remarks1			

Subject Code	SM11550011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Mathematical Analysis 1		
Subject Number	SAMMA1501		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Masaharu Nishio		
Main Theme of the Subject	We shall introduce some topics on the complex analysis, the probability theory, the potential theory, the partial differential equations, et al.		
Goal of the Subject	You should obtain the knowledge on the complex analysis, the probability theory, the potential theory, the partial differential equations, et al.		
Contents of the Subject /Subject Plan	The following is an example: 1st The Riemann surfaces 2nd The holomorphic differential 3rd The quasi-conformal mappings 4th The mathematical statistics 5th The 2 dimensional hyperbolic geometry 6th The Fuchsian groups 7th The probability theory 8th The stochastic processes 9th The dynamics on the circle 10th The asymptotic Teichmuller spaces 11th The partial differential equations 12th The variational methods 13th The harmonic functions 14th The potential theory		
Preparation and Review	You should read carefully and understand some papers.		
Evaluation Method	Wright reports.		
Comments to Students	Show those on the board.		
Teaching Materials	It will be suggested by each lerctures.		
Remarks1	You should contact us.		

Subject Code	SM11560011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Mathematical Analysis 2		
Subject Number	SAMMA1502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Several classical and modern topics selected from differential geometry and geometric analysis, especially geometric variational problems will be lectured.		
Goal of the Subject	This lecture aims to learn the foundations of differential geometry and related mathematics. Recent progress and research topics in differential geometry are presented by some lecturers.		
Contents of the Subject /Subject Plan	The lecture plan will be concretely shown in class. For example, Submanifolds in Euclidean spacesVector bundles and connectionsLie groups, classical groups and Lie algebrasRiemannian manifoldsGeodesics and variational formulasMorse theory over manifoldsIsometry groups and holonomy groupsCurvaturesRiemannian manifolds of constant curvaturesCurvatures and topology of manifoldsCurvatures and spectrum of Laplace operatorMinimal submanifoldsHarmonic mapsSymplectic manifoldsetc.		
Preparation and Review	Read and try to understand the books or papers suggested in advance or in class.		
Evaluation Method	Evaluated by the attendance, reports etc. to the lectures.		
Comments to Students	The contents, progress and style of the lectures are possible to be changed, depending on the speciality of lecturers and research field and interests of students.		
Teaching Materials	It will be suggested by each lerctures.		
Remarks1	A student who wants to attend this lecture must take contact to a main lecturer in advance.		

Subject Code	SM11570011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Analysis 3		
Subject Number	SAMMA1503		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Sachiko Hamano		
Main Theme of the Subject	The focus of this course is an introduction to mathematical analysis in general: complex analysis, probability theory, potential theory, partial differential equations, dynamical systems, harmonic analysis, mathematical statistics and so on.		
Goal of the Subject	Understand the basics of mathematical analysis in general: complex analysis, probability theory, potential theory, partial differential equations, dynamical systems, harmonic analysis, mathematical statistics and so on.		
Contents of the Subject /Subject Plan	Introduction to mathematical analysis in general: I. Complex analysis, II. Probability theory, III. Potential theory, IV. Partial differential equations, V. Dynamical systems, VI. Harmonic analysis, VII. Mathematical statistics, and so on.		
Preparation and Review	Students are expected to read a text book and references carefully.		
Evaluation Method	Attendance and report		
Comments to Students	It will be presented separately.		
Teaching Materials	Contents will be announced separately.		
Remarks1			

Subject Code	SM11580011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Analysis 4		
Subject Number	SAMMA1504		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Shin Kato		
Main Theme of the Subject	Introduction to recent topics on differential geometry.		
Goal of the Subject	To know recent topics and to understand recent results on differential geometry.		
Contents of the Subject /Subject Plan	Recent topics and recent results on differential geometry. [1] Basic facts on geometry of submanifolds [2] Topics on geometry of submanifolds [3] Recent results on geometry of submanifolds [4] Basic facts on symmetric spaces and Lie groups [5] Topics on symmetric spaces and Lie groups [6] Recent results on symmetric spaces and Lie groups [7] Basic facts on harmonic maps and minimal surfaces [8] Topics on harmonic maps and minimal surfaces [9] Recent results on harmonic maps and minimal surfaces [10] Basic facts on Riemannian geometry [11] Topics on Riemannian geometry [12] Recent results on Riemannian geometry [13] Basic facts on symplectic geometry and moment maps [14] Topics on symplectic geometry and moment maps [15] Recent results on symplectic geometry and moment maps		
Preparation and Review	Students attending this lecture are expected to read original papers on the topics introduced and to understand them deeply.		
Evaluation Method	Report etc..		
Comments to Students	Contact the lecturer before taking the registration for this lecture.		
Teaching Materials	Not specified.		
Remarks1			

Subject Code	SM11600011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Advanced Analysis II		
Subject Number	SAMAN1502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Takayuki Koike		
Main Theme of the Subject	We discuss on the fundamental theories on complex geometry, especially on compact Kahler manifolds.		
Goal of the Subject	Our goal is to understand the theories on harmonic itnegrations and Hodge theory, and as an application, the structure of the cohomology of a compact Kahler manifolds.		
Contents of the Subject /Subject Plan	1: Holomorphic functions and forms 2: Complex manifolds and vector bundles 3~6: Sheaf cohomology (Categories, Sheaves, Cohomology, Dolbeault's theorem) 7~9: Geometry of vector bundles (Metrics, Connections, Curvature tensors) 10~12: Kahler manifolds (Kahler-ness, Examples of Kahler manifolds, Vanishing theorems) 13~16: Harmonic integrals and its applications (Operators on Kahler manifolds, Harmonic forms, Hodge theory, Examples and applications)		
Preparation and Review	We strongly recommend the students to consider the example whenever we give a new definition or theorems.		
Evaluation Method	Based on the attendance and reports.		
Comments to Students	It is desirable that you have learned some fundamental theories on complex analysis and manifolds.		
Teaching Materials	Based on our lecture notes. The text book "Complex Geometry" by Shoshichi Kobayashi (in Japanese) will be a good reference.		
Remarks1			

Subject Code	SM11620011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Advanced Analysis IV		
Subject Number	SAMAN1504		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hideyuki Ishi		
Main Theme of the Subject	We discuss analytic problems related to the Heisenberg group. The Heisenberg group is a Lie group corresponding to the Lie algebra defined by the so-called canonical commutation relation, and it is named after a renowned physicist, Welner Karl Heisenberg.		
Goal of the Subject	Students will understand how the representation theory connects functional analysis, complex analysis, and mathematical physics.		
Contents of the Subject /Subject Plan	[1] The Heisenberg group [2] The Schroedinger representation [3] Twisted convolution [4] Harmonic Oscillator [5] The Fourier-Wigner transformations [6] Bijectivity of the Fourier-Wigner transformations [7] Examples of the Fourier-Wigner transformations [8] The Weyl quantizations [9] The Fock-Bargmann representaiton [10] The Forck-Bargmann representaiton and differential operators [11] Siegel domain and the Heisenberg group [12] A CR structure on the Heisenberg group [13] The CR Laplacian on the Heisenberg group [14] The Metaplectic group [15] Conclusion		
Preparation and Review	Students are expected to understand what is a problem, through reading references introduced in the lecture.		
Evaluation Method	Report etc.		
Comments to Students	Students are expected to have some knowledge about functional analysis and Lebesgue integrals		
Teaching Materials	G. B. Folland, "Harmonic Analysis in Phase Space", Pinceton University Press, 1989.E. M. Stein, "Haronic Analysis: Real-Variable Methods, Orthogonality, and Oscillatory Integrals", Princeton University Press, 1993. Other references are introduced in the l		
Remarks1			

Subject Code	SM11640011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Introduction to Mathematics II		
Subject Number	SAMIN1502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Masamichi Yoshida		
Main Theme of the Subject	This is an omnibus course of introductions on latest frontiers of mathematics. A half of the faculties introduce a topic of their research subjects by one or two lectures. The another half faculties are in charge of the introduction of mathematicsI.		
Goal of the Subject	The goal is to realize latest frontiers of mathematics and learn various mathematical perspectives through introductions on research subjects of faculties in an omnibus form.		
Contents of the Subject /Subject Plan	(1) An introduction on a topic of the representation theory (2) An introduction on a topic of the algebraic groups (3) An introduction on a topic of the number theory (4) An introduction on a topic of the ring theory (5) An introduction on a topic of the knot theory (6) An introduction on a topic of the 3- and 4-dimensional topology (7) An introduction on a topic of the geometry of transformation groups (8) An introduction on a topic of the differential geometry (9) An introduction on a topic of the variational methods (10) An introduction on a topic of the nonlinear partial differential equations (11) An introduction on a topic of the complex analysis (12) An introduction on a topic of the potential theory (13) An introduction on a topic of the ergodic theory (14) An introduction on a topic of the probability theory (15) An introduction on a topic of the statistics The above is one example. The order of the course contents may be different.		
Preparation and Review	To be assigned later.		
Evaluation Method	Attendance and reports		
Comments to Students	To be presented separately.		
Teaching Materials	A particular text book is not designated. A handout is freely given.		
Remarks1	The course starts biennially at an odd year.		

Subject Code	SM11670011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Analysis III		
Subject Number	SAMAN1507		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Futoshi Takahashi		
Main Theme of the Subject	Recent topics about Analysis are given by specialists in other universities as an intensive lecture.		
Goal of the Subject	To be assigned later.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the reports and the participation in the class.		
Comments to Students	To be assigned later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM11680011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Analysis IV		
Subject Number	SAMAN1508		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Futoshi Takahashi		
Main Theme of the Subject	Recent topics about Analysis are given by specialists in other universities as an intensive lecture.		
Goal of the Subject	To be assigned later.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the reports and the participation in the class.		
Comments to Students	To be assigned later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM12010011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Quantum Field Theory		
Subject Number	SAPL11501		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Masaki Arima		
Main Theme of the Subject	Two instructors will give lectures. Prof. Arima will give a lecture on the basics of quantum field theory,whose final goal is the perturbation theory based on the canonical quantization for the scalar field and the electromagnetic field.Prof. Maru will give a lecture on the basics of quantum field theory, whose final goal is the perturbation theory and renormalization based on the path integral quantization.		
Goal of the Subject	Learning about the free field theory and interacting field theory through the canonical quantization and the path integral quantization.		
Contents of the Subject /Subject Plan	Arima 1 Review of classical field theory 2 Conservation law 3 On neutral scalar field: Hamiltonian 4 On neutral scalar field: Canonical quantization 5 On neutral scalar field: Examples of conservation law 6 On charged scalar field 7 On electromagnetic field: Differences between the scalar field and the electromagnetic field 8 On electromagnetic field: Difficulties in quantization 9 On electromagnetic field: Gauge fixing and quantization 10 On interactions of fields: Interaction representation 11 On interactions of fields: Wick's theorem 12 On interactions of fields: Application to the scalar field theory 13 On interactions of fields: Interaction with the gauge field 14 Introduction of renormalization: Higher order perturbations and divergence 15 Introduction of renormalization: Prescription for renormalization Maru 1 Path integral in quantum mechanics 2 Path integral of scalar field: Introduction 3 Path integral of scalar field: Green functions 4 Path integral of scalar field: Generating functional 5 Perturbation theory: Formulation 6 Perturbation theory: Feynman rules 7 Renormalization: Regularization 8 Renormalization: Φ4 theory 9 Renormalization: Φ3 theory, scalar QED, renormalizability 10 Effective action: Effective potential 11 Effective action: Dynamical symmetry breaking 12 Path integral of spinor field 13 Path integral of electromagnetic field 14 Renormalization group: Perturbative renormalization group 15 Renormalization group: Winsonian renormalization group		
Preparation and Review	It is desirable to confirm the content of the previous lecture before the lecture.It is required to check again the content of the lecture by yourself after the lecture.		

Evaluation Method	The grading is evaluated by attendance and a take-home exam.For those who take both lectures, the grading is evaluated by better scored one.
Comments to Students	Prof. Arima's lecture will be held in the second period on Tuesday at the science building B105.Prof. Maru's lecture will be held in the third period on Tuesday at the science building B105.Students can take either or both classes depending on the contents of the lecture. Attendance will be required. Questions about the lecture are welcome.
Teaching Materials	Greiner & Reinhardt, “Field Quantization”, Springer (Arima) Peskin & Schroeder, “An Introduction to Quantum Field Theory” (Maru)
Remarks1	

Subject Code	SM12020011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Theory of Elementary Particles		
Subject Number	SAPL11502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Nobuhito Maru		
Main Theme of the Subject	In this lecture, the basics and problems of the electroweak unified theory in particle physics are discussed.Grand unified theory as an example of physics beyond the Standard Model is also introduced.		
Goal of the Subject	In this lecture, the physics of the electroweak theory and the grand unified theory will be discussed.		
Contents of the Subject /Subject Plan	1 Spontaneous Symmetry Breaking: Discrete Symmetry 2 Spontaneous Symmetry Breaking: Abelian Symmetry, Goldstone Model 3 Spontaneous Symmetry Breaking: Non-Abelian Symmetry 4 Nambu-Goldstone's Theorem 5 Spontaneous Symmetry Breaking of Gauge Symmetry: Higgs Mechanism 6 Spontaneous Symmetry Breaking of Chiral Symmetry: Nambu-Jona-Lasino Model 7 Spontaneous Symmetry Breaking of Chiral Symmetry: Pion as a Nambu-Goldstone Particle 8 Weinberg-Salam model, Electroweak Symmetry Breaking 9 Lepton sector: Yukawa Coupling, Charged Current, Neutral Current 10 Quark sector: Yukawa Coupling, CKM Matrix 11 Quark sector:GIM Mechanism 12 Quark scetor: CP Violation 13 Neutrino Oscillation 14 Grand Unified Theory: SU(5) Model, Gauge Coupling Unification 15 Grand Unified Theory: Proton Decay, SO(10) Model		
Preparation and Review	Before attending a lecture, the content of the previous lecture should be checked.After the lecture, the calculations done in the lecture should be checked again by yourself.		
Evaluation Method	The grading is evaluated by a take-home exam.		
Comments to Students	Do not hesitate to ask if you have a question about the lectures.It is desirable to have knowledge of the basics of the special relativity and the quantum field theory.		
Teaching Materials	It will be announced in the lecture.		
Remarks1			

Subject Code	SM12030011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Methods of Physics		
Subject Number	SAPL11503		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hiromitsu Hamabata		
Main Theme of the Subject	The general methods of solutions of partial differential equations are explained systematically, and methods of solutions of several partial differential equations appearing in physics are also discussed.		
Goal of the Subject	We acquire the mathematical ability to understand the various solution methods of partial differential equations and to elucidate the physical phenomena that are often formulated in the form of partial differential equations.		
Contents of the Subject /Subject Plan	1. Linear Partial Differential Equations (1): Basic Concepts and Definitions. 2. Linear Partial Differential Equations (2): The Classification of Second-Order Linear Equations and The Method of Characteristics. 3. Linear Partial Differential Equations (3): The Method of Separation of Variables. 4. Linear Partial Differential Equations (4): Fourier Transforms and Initial-Boundary -Value Problems. 5. Linear Partial Differential Equations (5): Applications of Multiple Fourier Transforms to Partial Differential Equations. 6. Linear Partial Differential Equations (6): Laplace Transforms and Initial-Boundary-Value Problems. Green's Functions and Boundary-Value Problems. 7. First-Order, Quasi-Linear Equations and The Method of Characteristics (1): The Classification and Geometrical Interpretation of a First-Order Equation. 8. First-Order, Quasi-Linear Equations and The Method of Characteristics (2): The Method of Characteristics and General Solutions. 9. First-Order Nonlinear Equations: The Gerneralized Method of Characteristics and Complete Integrals of Certain Special Nonlinear Equations. 10. Conservation Laws and Shock Waves (1): Introduction and Conservation Laws. 11. Conservation Laws and Shock Waves (2): Discontinuous Solutions and Shock Waves. 12. Exact Solutions of Certain Nonlinear Partial Differential Equations (1): Burgers' and Thomos' Equations. 13. Exact Solutions of Certain Nonlinear Partial Differential Equations (2): KdV Equation. The Series Solution. 14. The Method of Solutions of Stochastic Differential Equations: Projection Operator Method.		
Preparation and Review	After the lecture, the students will have to attend the next lecture after confirming the contents of the lecture by using their own hands to calculate the contents of the lecture.		
Evaluation Method	Grading is given based on attendance attitude(40%) and end-of-term reports (60%).		
Comments to Students	To be specified separately.		
Teaching Materials	Distribute prints as appropriate. Reference: Ｌ．Ｄｅｂｎａｔｈ, Nonlinear Partial Differential Equations for Scientists and Engineers（Ｂｉｒｋｈａｕｓｅｒ）		
Remarks1			

Subject Code	SM12040011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Plasma Physics		
Subject Number	SAPL11504		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hiromitsu Hamabata		
Main Theme of the Subject	The basic equations are established based on kinetic and fluid theories of the plasma, which is an ensemble of a large number of charged particles that interact electromagnetically, and various plasma phenomena, especially plasma wave phenomena are explained. It also outlines the weak turbulence theory of the plasma.		
Goal of the Subject	Understand the basic principles of plasma physics and acquire the basic techniques of plasma physics.		
Contents of the Subject /Subject Plan	1. Introduction (1): Debye Shielding. Plasma Parameter. 2. Introduction (2): Plasma Frequency. Collisions. 3. Single Particle Motion (1): Various Drifts. 4. Single Particle Motion (2): Magnetic Moment. Adiabatic Invariant. Ponderomotive Force. 5. Plasma Kinetic Theory (1): Klimontovitch Equation. Plasma Kinetic Equation. 6. Plasma Kinetic Theory (2): Liouville Equation. BBGKY Hierarchy. 7. Plasma Kinetic Theory (3): Bogoliubov's Hypothesis. Leonard-Balescu Equation. 8. Vlasov Equation (1): Equilibrium Solutions. Electrostatic Waves. 9. Vlasov Equation (2): Landau Contour. Wave-Particle Interaction. Landau Damping. 10. Vlasov Equation (3): General Theory of Linear Vlasov Waves. 11. Vlasov Equation (4): Exact Solution of Nonlinear Waves (BGK Mode, etc.). 12. Fluid Equations (1): Derivation of the Fluid Equations From the Vlasov equation. Dielectric Function. 13. Fluid Equations (2): Fluid Theory of Various Linear Plasma Waves. Nonlinear Waves. 14. Weak Turbulence Theory (1): Quasi-Linear Theory. Induced Scattering. 15. Weak Turbulence Theory (2): Wave-Wave Interactions.		
Preparation and Review	After the lecture, the students will have to attend the next lecture after confirming the contents of the lecture by using their own hands to calculate the contents of the lecture.		
Evaluation Method	Evaluation is based on a total of 40 points of attendance and 60 points of end-of-term reports.		
Comments to Students	To be specified separately.		
Teaching Materials	Reference book: D. R. Nicholson, "Introduction to Plasma Theory"		
Remarks1			

Subject Code	SM12070011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Relativistic Astrophysics		
Subject Number	SAPL11507		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Hideki Ishihara		
Main Theme of the Subject	Physical phenomena in relativistic cosmology		
Goal of the Subject	We aim to understand physical phenomena in the universe where general relativity plays important roles.		
Contents of the Subject /Subject Plan	1. Review of Fuluid Mechanics 2. Fundamental Aspects of General Relativity; Riemannian Geometry 3. Fundamental Aspects of General Relativity; Einstein's Equation 4. Big-bang Cosmology; Homogeneous and Isotropic Cosmological Models 5. Big-bang Cosmology; Red Shift and Hubble's Law 6. Big-bang Cosmology; Themal History of the Universe 1; Relativistic Statistical Mechanics 7. Big-bang Cosmology; Themal History of the Universe 2; Recombination, Primordial Neutrinos 8. Big-bang Cosmology; Themal History of the Universe 3; Nucleosynthesis 9. Big-bang Cosmology; Cosmic Microwave Background 10. Big-bang Cosmology; Inflationary Universe 11. Black Holes; Schwarzschild Solution 12. Black Holes; Kuruskal Coordinates and Event Horizon 13. Black Holes; Geodesics, Apsidal precession, Gravitational Lensing 14. Gravitational Collapse; Chandrasekhar Mass, Dust Collapse		
Preparation and Review	To be announced in the lecture.		
Evaluation Method	To be announced in the lecture.		
Comments to Students	Active discussion is encouraged.		
Teaching Materials	To be announced in the lecture.		

Subject Code	SM12080011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Nuclear Physics I		
Subject Number	SAPL11508		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Koichi Sato		
Main Theme of the Subject	This course deals with basic properties of atomic nuclei as quantum many-body systems and introductory nuclear structure and reaction theories. Through the course, students understand the role and importance of nuclear physics in modern physics.		
Goal of the Subject	The goal is to understand the concepts of models of nuclear structure and reaction. The following topics are covered in this course;* Nuclear structure: basic properties (nuclear size, shape, binding energy...), single-particle picture and nuclear shell m		
Contents of the Subject /Subject Plan	1. Discovery of atomic nucleus, measurement of nuclear size and binding energy 2. Electron scattering and nuclear charge density 3. Properties of nuclear force and effective interaction 4. Mean field and single-particle picture, shell model 5. Nuclear collective motion (vibration, rotation and giant resonance) 6. Microscopic models on nuclear collective motion I (Hartree-Fock method, Time-dependent Hartree-Fock method and RPA) 7. Microscopic models on nuclear collective motion II (quasi-particles, Hartree-Fock-Bogoliubov theory, density functional theory) 8. Basics of nuclear reaction 9. Quantum scattering theory and scattering states 10. Elastic scattering and Optical model 11. Multiple scattering and effective interaction, optical potential 12. Models of direct reaction I (DWBA) 13. Models of direct reaction II (Coupled channel method) 14. Unstable nuclei and break-up process, many-body scattering problem		
Preparation and Review	Students are expected to review each class for roughly one hour, look over references introduced in the class, and submit some reports if necessary.		
Evaluation Method	Grading will be based on submitted reports, attendance, questions, and contribution to discussion in classes.		
Comments to Students	Depending the number of students, the course may be given in a seminar style.		
Teaching Materials	Textbooks and materials relevant to the lecture will be introduced in the class. Some examples are as follows: "Nuclear Structure", K. Takada and K. Ikeda (Asakura Shoten) [原子核構造論（高田健次郎、池田清美、朝倉書店）],"The Nuclear Many-body Problems", P, Ring and P. Schuck (Springer), "Introduction to quantum scattering theory", K. Oagata (Kyoritsu Shuppan) [量子散乱理論への招待（緒方一介、共立出版）], Nuclear Reactions for Astrophysics (Thompson, Nunes, Cambridge).		
Remarks1			

Subject Code	SM12090011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Nuclear Physics II		
Subject Number	SAPL11509		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Masaki Arima		
Main Theme of the Subject	The "Hadron" is the name for the smallest 'visible' particles. The nucleon, which composes the nucleus, is a member of the hadrons.This lecture will explore the hadronic phenomena in terms of the field theory with reference to their properties of internal symmetry.		
Goal of the Subject	This lecture aims to give an overview of the hadron world, and to understand the roll of the internal symmetry in the hadron physics		
Contents of the Subject /Subject Plan	1. Review of the field theory; Basic process of quantization 2. Review of the field theory; Internal degree of freedom 3. Review of the field theory; Conservation law 4. Examples of the symmetry; Gauge symmetry 5. Examples of the symmetry; Chiral symmetry 6. Hadrons and the symmetry; Nuclear phenomena 7. Hadrons and the symmetry; Isospin symmetry 8. Hadrons and the symmetry; Weak interaction 9. SU(3) symmetry; "Strange" phenomena 10. SU(3) symmetry; Strangeness 11. SU(3)XSU(3) symmetry; Weak interaction and Parity violation 12. SU(3)XSU(3) symmetry; Chiral symmetry 13. Phenomenological model of Hadrons; Quark model I 14. Phenomenological model of Hadrons; Quark model II 15. Phenomenological model of Hadrons; Skyrme model		
Preparation and Review	It is desirable to check the contents of the last lecture every time. Take the contents of every lesson in a notebook.Check each formulas, and/or equations shown in the lecture by yourself so as to understand their meanings correctly.		
Evaluation Method	The grade is evaluated by the attendance and the reports.		
Comments to Students	Attend every lesson seriously.		
Teaching Materials	G. Reinhardt, “Field quantization”, SpringerI.J.R. Aitchison, “An informal introduction to gauge field theories”		
Remarks1			

Subject Code	SM12110013	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Fundamental Physics IB		
Subject Number	SAPI11502		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Masaki Arima		
Main Theme of the Subject	Lectures on recent topics of fundamental physics are given by experts in other Universities.To acquire basic knowledge and basic skill about fundamental physics.		
Goal of the Subject	To acquire basic knowledge and basic skill about various fields of fundamental physics.		
Contents of the Subject /Subject Plan	To be announced separately.		
Preparation and Review	To be announced separately.		
Evaluation Method	Class participation.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM12150011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	High Energy Physics I		
Subject Number	SAPL21501		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Kazuhiro Yamamoto		
Main Theme of the Subject	We review the particle physics, and aim to obtain the basic and advanced knowleges which are necessary to study the particle phisics.		
Goal of the Subject	We aim to obtain the clear understandings of vearious sort of quantum numbers and behavior of particles, while comparing between the accumulated experimental results for far and the theory which explains them in order to understand the particle physics.		
Contents of the Subject /Subject Plan	The 1st lecture: Review of elementary earticles The 2nd lecrure: Review of four tyes of forces The 3rd lecture: Interactions and fields The 4th lecture: Behavior of particles in the field The 5th lecture: Invariant principle and conservation low The 6th lecture: Spin and parity The 7th lecture: Charge conjugation and time reversal The 8th lecture: Isospin The 9th lecture: Hadrons containing heavy quarks The 10th lecture: Classification of baryons The 11th lecture: Classification od of mesons The 12th lecture: Electron-positron pair annihilation process The 13th lecture: Deep inelastic scattering The 14th lecture: Interactions between quark The 15th lecture: Quantum Chromodynamics		
Preparation and Review	The prior leanings are not necessarily required, but the review of the lecture note after the lectures are required.		
Evaluation Method	The score is evaluated the attendance to lectures and the term paper.		
Comments to Students	To be announced separately.		
Teaching Materials	Reference: “Introduction to High Energy Physics; 4th edition”, D. H. Perkins, Cambridge		
Remarks1			

Subject Code	SM12160011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	High Energy Physics II		
Subject Number	SAPL21502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Yoshihiro Seiya		
Main Theme of the Subject	Reviews on how the weak interactions were understood based on experimental and theoretical developments and were combined with the electromagnetic interactions to form the Weinberg-Salam theory.Also, the standard model of the elementary particle physics including the strong interactions and beyond are briefly introduced.		
Goal of the Subject	Understanding weak interaction phenomenology and basics of the standard model of the elementary particle physics.		
Contents of the Subject /Subject Plan	1. Brief history of the elementary particle physics and review of the four forces. 2. Dirac equation. Helicity and spin polarization of Dirac particles. 3. Basics of the quantum field theory. Gauge symmetry. 4. Calculation of cross sections. 5. Weak interactions and quarks. GIM mechanism. Kobayashi-Maskawa mass matrix. 6. Weinberg-Salam theory. Charged, Neutral, electromagnetic current. 7. Higgs particle and spontaneous symmetry breaking. 8. Masses of gauge bosons. 9. Masses of fermions and Kobayashi-Maskawa mass matrix. 10. Production of Higgs particles and detection. 11. Strong interactions. Structure functions of hadrons. 12. QCD corrections of the tructure functions of hadrons. 13. Beyond the standard model of the elementary particle physics. 14. Uncertainty, probability, statistics. 15. Current status of the experimental elementary particle physics.		
Preparation and Review	To be announced separately.		
Evaluation Method	Attendance status, reports, and other overall performance.		
Comments to Students	Announced when necessary.		
Teaching Materials	・”Introduction to High Energy Physics; 4th edition”, D. H. Perkins, Cambridge. ・”Quarks and Leptons: An Introductory Course in Modern Particle Physics”, F. Halzen and A. D. Martin, Wiley		
Remarks1			

Subject Code	SM12170011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Cosmic Ray Physics I		
Subject Number	SAPL21503		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Yoshiki Tsunesada		
Main Theme of the Subject	To be announced separately.		
Goal of the Subject	To be announced separately.		
Contents of the Subject /Subject Plan	To be announced separately.		
Preparation and Review	To be announced separately.		
Evaluation Method	To be announced separately.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM12200011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Experimental Physics of Gravitational Waves		
Subject Number	SAPL21507		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Nobuyuki Kanda		
Main Theme of the Subject	This lecture focus on basic knowledge and technical explanation required for the gravitational wave detection experiment. The lecture also explain physics and scientific prospect with observations of gravitational waves that radiate from various astronomical objects, e.g. neutron star, black hole, supernova etc. Students will understand the principle of the detection experiment and the outline of the event search data analysis.		
Goal of the Subject	In the introduction, the theoretical background of gravitational waves, potential gravitational wave sources, and the history of experiments on gravitational and gravitational waves will be explained. Next, the fundamental principles of laser interferometer type detectors and the fundamental noise sources will be understood. Advanced explanation of data analysis methods and statistical treatment of the gravitational wave events are focus of last half of the lectures.		
Contents of the Subject /Subject Plan	1. History of gravitational waves and detection experiments, latest observations 2. Gravitational waves and their sources 3. Principle of a detector (1) Resonant antenna 4. Principle of a detector (2) Laser interferometer (free point-mass type) 5. Principle of a detector (3) Response of a laser interferometer, reconstruction of the strain 6. Detector noise (1) Thermal noise 7. Detector noise (2) Seismic noise, laser, electronics 8. Basics of spectrum analysis 9. Signal Detection by the Matched Filter Method (1) Principle and signal to noise ratio 10. Signal Detection by the Matched Filter Method (2) Template bank 11. Hands-on session using open data (1) Event data 12. Hands on session using open data (2) LIGO Algorithmic Library Suite 13. Error propagation and parameter estimation 14. Electromagnetic and neutrino follow-up on gravitational wave events. Other gravitational wave experiments (pulsar timing and space-borne detectors)		
Preparation and Review	Students are expected to prepare for each topic that will be explained in the class using the references introduced there. They are also expected to review the class by submitting reports on a couple of topics explained in the class.		
Evaluation Method	By Reports		
Comments to Students	Students have to learn wider topics, i.e. general relativity, astrophysics, detector instruments, signal processing.		
Teaching Materials	Blackboard, viewgraphs and printed materials		
Remarks1			

Subject Code	SM12210011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Astrophysics		
Subject Number	SAPL21508		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Nobuyuki Kanda		
Main Theme of the Subject	Astrophysics and cosmology are described by general relativity in its macroscopic aspects, and by particle physics in its microscopic aspects. Astronomical observations in multi-wavelengths since the 20th century revealed various phenomena in the universe, and our general pictures and understandings about the universe have been continuously updated with improved observational techniques and refined theoretical models. This course deals with the basics of astrophysics, and discusses the frontier of astrophysics and cosmology, i.e. the recent discoveries, perspectives, long-standing mysteries, and newly recognized puzzles.		
Goal of the Subject	We learn about the foundation of cosmology, interactions of elementary particles and gravity in the early universe, the big bang and inflation model. We explain the modern topics such as dark matter and dark energy. In addition, we will review the hierarc		
Contents of the Subject /Subject Plan	1. General Relativity and Expanding Universe 2. Big Bang and Cosmic Microwave Background 3. Cosmological Parameters 4. Cosmological Constant and Dark Energy 5. Large-scale Structure of the Cosmos 6. Galaxy 7. Evolution of Stars 8. Death of Stars (Blackhole, Neutron Star, Supernova) 9. High-Energy Astronomical Phenomenon 10. Dark matter (Astronomical) 11. Dark matter (CDM) 12. Early Universe and Particle Physics 13. Nucleosynthesis 14. Dark Matter 15. Neutrino Astronomy		
Preparation and Review	Students have to study the references and prepare for each item.We pick up some of lecture contents for a report.		
Evaluation Method	We evaluate using a report on the term-end and attendance, questions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM12220013	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Astro and High Energy Physics I		
Subject Number	SAPI21501		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Nobuyuki Kanda		
Main Theme of the Subject	Topics on astrophysics and/or high energy physics are given as an intensive course by an expert from other institution.		
Goal of the Subject	Announced when the course is given.		
Contents of the Subject /Subject Plan	Announced when the course is given.		
Preparation and Review	Announced when the course is given.		
Evaluation Method	Attendance status and reports.		
Comments to Students	Announced when the course is given.		
Teaching Materials	Announced when the course is given.		
Remarks1			

Subject Code	SM12250013	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Particle Physics I		
Subject Number	SAPI21504		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Eiichi Nakano		
Main Theme of the Subject	In this intensive course, recent topics on particle physics will be lectured by an expert from another university.		
Goal of the Subject	To be announced separately.		
Contents of the Subject /Subject Plan	To be announced separately.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance and reports.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM12280011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Condensed Matter Physics I		
Subject Number	SAPL31501		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Osamu Ishikawa		
Main Theme of the Subject	This course provides the understandings of the electron's behavior of metal, in which atoms are arranged periodically, on the basis of quantum mechanics, statistical mechanics and electromagnetism which are principal subjects in modern physics.And by introducing the Fermi liquid theory, it also provides the understandings of the behavior of many particle's interacting with each other.We will study the outlines of superconductivity in metal and superfluidity in liquid He.		
Goal of the Subject	The goals to be accomplished are to understand the electronic physical properties, like the electric resistance, as electron motions in the lattice which consists of atoms to be arranged periodically and to understand macroscopic properties of many partic		
Contents of the Subject /Subject Plan	Part 1 Basic properties of conduction electrons (waves in lattice, classical electric conduction and scattering time) Part 2 (free electron model, periodic boundary condition) Part 3 (Fermi energy level, Fermi degenerate) Part 4 (electronic conduction as free electrons, specific heat of electrons, and Pauli susceptibility) Part 5 Interacting Fermi particles system (Fermi liquid theory and quantum statistical mechanics) Part 6 (quasiparticle distribution function and energy change of the system) Part 7 (spin of electron and Landau parameters) Part 8 (some properties in an equilibrium state; specific heat, magnetic susceptibility, effective mass, compressibility) Part 9 Motion of electrons and transport property (viscosity, thermal conductivity, spin diffusion in Fermi liquid theory) Part 10 (Landau quantization) Part 11 (Hall effect, Quantum Hall effect) Part 12 (other transport phenomena) Part 13 Coherent state Part 14 Superconductivity and superfluidity Part 15 Review		
Preparation and Review	In advance you should review some relating subjects which you studied in statistical mechanics and quantum mechanics as an undergraduate.After the class, you should review the contents of a lecture and reflect them on your homework.		
Evaluation Method	We will evaluate the score totally by an evaluation of several homework and a student's attendance record.		
Comments to Students	It will be good for a student to master an basic approach of thinking, when considering the motion of electrons of metal.		
Teaching Materials	Reference bookC. Kittel "Introduction of Solid State Physics"		
Remarks1			

Subject Code	SM12290011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Condensed Matter Physics II		
Subject Number	SAPL31502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Mitsuru Sugisaki		
Main Theme of the Subject	This course is intended to coherently understand various physical processes in materials. In general, condensed matter physics deals with the large collections of atoms that compose both ordinary and exotic materials. Following Condensed Matter Physics I, this course provides a survey of electrical, optical, and magnetic properties of matter.		
Goal of the Subject	This course is aimed at understanding the origin of magnetism based upon the relativistic electron theory. Themes also include: ferromagnetism and antiferromagnetism where the electron-electron interaction is important, while paramagnetism can be understo		
Contents of the Subject /Subject Plan	1. Electron in a magnetic field; Paramagnetism and diamagnetism 2. Dirac equation 3. Spin–orbit interaction 4. Exchange interaction and Hund's rules 5. Ferromagnetism and antiferromagnetism 6. Magnetic anisotropy and domains 7. Magnon 8. X-ray crystallography 9. Lattice vibration and phonon 1: acoustic and optical modes 10. Lattice vibration and phonon 2: second quantization 11. Density of states; Lattice heat capacity; Anharmonic potential 12. Drude model; Reflection and refraction 13. Plasmon, exciton, polaron, and polariton 14. Nonlinear optical response		
Preparation and Review	Prerequisite: fundamentals of quantum mechanics, statistical mechanics, and electromagnetism.Students are expected to pursue extended projects provided at the class.		
Evaluation Method	Grading scheme:Class participation + Assignments + Research Paper Report		
Comments to Students	Preferred prerequisite: Condensed Matter Physics I		
Teaching Materials	J.R. Hook and H.E. Hall, "Solid State Physics, 2nd Edition", Chichester, 1995, John Wiley & Sons.		
Remarks1	Exclusion: students who have the credits of Condensed Matter Physics 2 for undergraduate students, offered from Faculty of Science, OCU.		

Subject Code	SM12310011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Quantum Statistical Physics II		
Subject Number	SAPL31504		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Akira Oguri,		
Main Theme of the Subject	This course introcues the theory for quantum statistical physics of many-particle systems.		
Goal of the Subject	The aim of this course is to help students ascquire the basic notions of condensed matter physics, especially electronic properties at low energies.		
Contents of the Subject /Subject Plan	1. Introduction 2. Density matrix in the quantum statistical physics 3. Perturbation expansion for thermal averages 4. Linear response theory 5. Thermal properties of a Fermi gas 6. Magnetic properties of a Fermi gas 7. Second quantization and Green's function 8. Many-effects and Landau Fermi liquid theory 9. Strongly correlated Fermion systems 10. Mott-Hubbard transition 11. Heisenberg model and related phase transitions 12. Transport properties 13. Superconductivity 14. Kondo effect		
Preparation and Review	To be announced in the class.		
Evaluation Method	Grading will be based on submitted reports and attendance.		
Comments to Students	To be announced in the class.		
Teaching Materials	To be announced in the class.		
Remarks1			

Subject Code	SM12320011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Low Temperature Physics		
Subject Number	SAPL31505		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Osamu Ishikawa		
Main Theme of the Subject	In modern physics, the condensed matter system at lower temperatures becomes more important. The condensed matter system is the condensing state that contains many particles. In this lecture, several quantum mechanical phenomena that are observed in superconducting state and in superfluid state are explained		
Goal of the Subject	Recognizing necessity of quantum mechanics to understand both superconducting state and superfluid state through studying these remarkable characteristic phenomena. Understanding that superconducting state and superfluid state are macroscopic quantum phenomena, behind which there exists coherent state. Understanding what order parameter is. Understanding of anisotropic superfluid and anisotropic superconductor.		
Contents of the Subject /Subject Plan	1. Discovery of superconductivity and of superfluid: Some characteristic phenomena. 2. Basic property of superconducting state: Theory by London. 3. Coherence length 4. Macroscopic quantum phenomena 5. BCS theory 6. G-L equations describing ordered state: Theory by Ginzburg and Landau 7. Type 1 and Type 2 superconductors 8. Liquid helium: zero point motion and quantum liquid 9. Bose gas and BEC (Bose-Einstein condensation) 10. Lambda transition (Phase transition between normal liquid state and superfluid state) 11. Phonon and roton (Elementary excitation in quantum liquid) 12. Vortex in superfluid 13. Two fluid model 14. Counter flow and critical velocity 15. Anisotropic superfluid and anisotropic superconducting state		
Preparation and Review	Check some key words before the class. Review the contents learning in the class.		
Evaluation Method	Evaluate the reports at the end of the course.		
Comments to Students	To be announced separately.		
Teaching Materials	Ref. 「Introduction to superconductivity」; Michael Tinkham		
Remarks1			

Subject Code	SM12380013	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Solid State PhysicsIIA		
Subject Number	SAPI31503		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Mitsuru Sugisaki		
Main Theme of the Subject	In this intensive course, recent topics on solid sate physics will be lectured by experts from other universities.		
Goal of the Subject	Understand the concept of state-of-the-art research on solid state physics.		
Contents of the Subject /Subject Plan	To be announced separately.		
Preparation and Review	After the lecture, prepare a report related to the content of the class.		
Evaluation Method	Grading will be given based on attendance and reports.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM12420013	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Condensed MatterPhysics IIA		
Subject Number	SAPI31507		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Osamu Ishikawa		
Main Theme of the Subject	In this intensive course, recent topics on condensed matter physics will be lectured by lecturers from other universities.		
Goal of the Subject	Understand the concept of state-of-the-art research on condensed matter physics.		
Contents of the Subject /Subject Plan	To be announced separately.		
Preparation and Review	After the lecture, prepare a report related to the content of the class.		
Evaluation Method	Grading will be given based on attendence and reports.		
Comments to Students	To be annouced separately.		
Teaching Materials	To be annouced separately.		
Remarks1			

Subject Code	SM12440011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Experimental Physics of Cosmic-rays and Elementary ParticlesI		
Subject Number	SAPL21505		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Eiichi Nakano		
Main Theme of the Subject	The measurement technologies which are necessary for cosmic rays observation and elementary particle experiment are explained.		
Goal of the Subject	The aim of this class is to understand foundations and techniques of measuring devices for cosmic rays observation and an elementary particle experiment.		
Contents of the Subject /Subject Plan	The interaction between particle and materials, principles of particle detectors, history of detector developments, making and usage of detectors and electronics circuits for signal readout are explained. And accelerators and beam optics are mentioned. 1. interaction between particle and material 2. energy loss (dE/dx) 3. proportional chamber 4. drift chamber 5. Multi Wire Proportional/Drift Chamber (MWPC/MWDC) 6. Micro Pattern Gaseous Detector（MPGD） 7. resistive plate chamber, Geiger-Muler counter 8. semi-conductor detector 9. Cherenkov detector, transition radiation detector 10. scintillation counter 11. calorimeter, neutron detector 12. muon detector, neutrino detector 13. electronics circuit I (analogue) 14. electronics circuit II (transfer circuit, digital) 15. accelerator		
Preparation and Review	The term paper is necessary		
Evaluation Method	The grade is evaluated based on lecturing reply and term paper.		
Comments to Students	It is desirable that electromagnetism and special theory of relativity are understood.		
Teaching Materials	Reference : Introduction to experimental particle physics, R.C. Fernow, Cambridge university press (1986)		
Remarks1			

Subject Code	SM12460011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Atomic Physics		
Subject Number	SAPL31507		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Shin Inouye		
Main Theme of the Subject	Can you explain the behavior of two-level atom illuminated by light using a spin and an oscillating magnetic field? Is it true that the absorption cross section of two-level atom is on the order of wavelength squared? The main theme of this lecture is to understand the interaction of light and atoms fully so that one can answer such important questions.		
Goal of the Subject	Using the behavior of a spin, understand the precession, Rabi oscillation, and adiabatic transfer. Following the discussion of Einstein, review the concept of spontaneous and stimulated emissions. Understand the origin of large absorption cross section on resonance. Introduce the density matrix for describing the time evolution of a two-level atom. Watch the edX program on the same subject, and obtain skills for discussing such scientific topics.		
Contents of the Subject /Subject Plan	1. The hydrogen atom 2. Fine Structure 3. The Lamb shift 4. Q-value of a resonance 5. Linewidth 6. Rabi oscillation 7. Adiabatic transfer 8. The interaction of atoms with light 9. Einstein's A and B coefficients 10. Spontaneous emission 11. The optical absorption cross section 12. The saturation intensity 13. The selection rules 14. Three-level system 15. Laser cooling and Bose-Einstein condensation		
Preparation and Review	Review of lecture contents. Instructions for video materials will be given during the class.		
Evaluation Method	Evaluations will be given based on exams, reports, and contributions to discussions during the class.		
Comments to Students	"Atomic and Optical Physics" offered at edX web site will be used during the lecture. Discussions will be conducted in Japanese.		
Teaching Materials	C.J.Foot, "Atomic Physics" (ISBN: 0198506961), edX "Atomic and Optical Physics"		
Remarks1	Please refer to the web page <http://www.sci.osaka-cu.ac.jp/phys/laser/> for updates.		

Subject Code	SM13060011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Mathematical Physics I		
Subject Number	SAMPL1504		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Hiroshi Itoyama		
Main Theme of the Subject	To be announced separately.		
Goal of the Subject	To be announced separately.		
Contents of the Subject /Subject Plan	To be announced separately.		
Preparation and Review	To be announced separately.		
Evaluation Method	To be announced separately.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM13070011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Physics II		
Subject Number	SAMPL1505		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Sanefumi Moriyama		
Main Theme of the Subject	This class aims to study non-abelian gauge theory, which is utilized to describe modern particle physics.		
Goal of the Subject	After recapitulating path integral quantization and renormalization group, we study gauge fixing in quantization and asymptotic freedom.		
Contents of the Subject /Subject Plan	1. gauge principle 2. non-abelian gauge symmetry 3. Yang-Mills theory 4. path integral quantization 5. gauge fixing 6. BRST symmetry 7. Faddeev-Popov gauge fixing 8. renormalization group 9. beta function 10. asymptotic freedom 11. conformal symmetry 12. quantum anomaly 13. anomalous dimension 14. Wess-Zumino condition		
Preparation and Review	Students are expected to read the textbook carefully in advance and lead or join actively the discussions.		
Evaluation Method	The evaluation is based on the activity in the study.		
Comments to Students	This class aims to deepen the contents introduced in Mathematical Physics I. The contents are subject to change depending on the study progress of students. Students should contact in advance.		
Teaching Materials	Michael E. Peskin, Daniel V. Schroeder, An Introduction to Quantum Field Theory, Perseus Books		
Remarks1			

Subject Code	SM13080011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Mathematical Physics III		
Subject Number	SAMPL1506		
Credits	2Credits	Teaching Method	Lecture／Seminar
Main Lecturer	Hideki Ishihara		
Main Theme of the Subject	Invariance and covariance in physics.		
Goal of the Subject	To understand that invariance and covariance are most fundamental concepts for costruction of theories in physics.		
Contents of the Subject /Subject Plan	1. Spacetime and manifold 2. Vectors and 1-forms; basis of general relativity 3. Metric space 4. Parallel transport and covariant derivative 5. Geodesic equations 6. Lie derivative 7. Isometry and Killing vector 8. Symmetry of spacetime and conservation law 9. Canonical formalism of relativistic particles 10. Mechanics of Nambu-Goto string 11. Mechanical system with constraint conditions 12. Constraint and symmetry 13. First and second class of constraint 14. Symmetry of general relativity		
Preparation and Review	To be announced in the lecture.		
Evaluation Method	A grade for class participation.		
Comments to Students	To be announced in the lecture.		
Teaching Materials	To be announced in the lecture.		
Remarks1			

Subject Code	SM13090011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Physics IV		
Subject Number	SAMPL1507		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Sanefumi Moriyama		
Main Theme of the Subject	This class aims to study supersymmetry which is a major attempt beyond the standard model.		
Goal of the Subject	After studying four-dimensional supersymmetry algebra and its representation, we study supersymmetric multiplets and supersymmetric theories from the viewpoint of superspace.		
Contents of the Subject /Subject Plan	1. bosons and fermions 2. Poincare symmetry 3. Coleman-Mandula theorem 4. four-dimensional supersymmetry algebra 5. supersymmetry transformation 6. chiral multiplet 7. vector multiplet 8. superspace, superfield 9. chiral superfield 10. vector superfield 11. extended supersymmetry 12. supersymmetric algebra in other dimensions 13. maximally supersymmetric theories 14. supergravity		
Preparation and Review	Students are expected to read the textbook carefully in advance and lead or join actively the discussions.		
Evaluation Method	The evaluation is based on the activity in the study.		
Comments to Students	This class aims to deepen the contents introduced in Mathematical Physics I. The contents are subject to change depending on the study progress of students. Students should contact in advance.		
Teaching Materials	This class aims to deepen the contents introduced in Mathematical Physics I. The contents are subject to change depending on the study progress of students. Students should contact in advance.		
Remarks1			

Subject Code	SM13120013	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Selected Topics in Mathematical Physics II		
Subject Number	SAMPI1506		
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Experts from other universities explain recent hot topics in mathematical physics.		
Goal of the Subject	This class aims to help students to acquire knowledge and methods in various areas of mathematical physics.		
Contents of the Subject /Subject Plan	It will be announced separately. Contact for more information.		
Preparation and Review	It will be announced separately.		
Evaluation Method	Based on attendance record and homework.		
Comments to Students	It will be announced separately.		
Teaching Materials	It will be announced separately.		
Remarks1			

Subject Code	SM13140011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Sciences A		
Subject Number	SAMPL1501		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Mitsuyasu Hashimoto		
Main Theme of the Subject	Recent topics on representation theory of quantum groups are discussed.		
Goal of the Subject	Study recent topics on representation theory of quantum groups and understand research results.		
Contents of the Subject /Subject Plan	Recent topics and research results on representation theory of quantum groups are introduced. 1. Introduction 2. Definition of the quantized enveloping algebra 3. Structure as a Hopf algebra 4. Representation theory of Uq(sl2) 5. Representation theory of the quantized enveloping algebra (1): Highest weight module 6. Representation theory of the quantized enveloping algebra (2): Complete reducibility 7. Definition of the crystal basis 8. Existence of a crystal basis 9. Finite-dimensional modules of quantum affine algebras 10. Definition of the Kirillov-Reshetikhin module 11. Properties of Kirillov-Reshetikhin modules 12. Crystal bases of Kirillov-Reshetikhin modules (1): Existence 13. Crystal bases of Kirillov-Reshetikhin modules (2): Structure 14. Introduction of the Kerov-Kirillov-Reshetikhin type bijection 15. Summary and unsolved problems		
Preparation and Review	Further studies are expected to read original papers and understand them on introduced topics and research results.		
Evaluation Method	Report, etc.		
Comments to Students	Will be announced separately.		
Teaching Materials	Resumes will be delivered.		
Remarks1			

Subject Code	SM13150011	Offering Academic Year/Semester	2020Year First Semester
Subject Name(English)	Mathematical Sciences B		
Subject Number	SAMPL1502		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Hideyuki Ishi		
Main Theme of the Subject	The Lie group SU(1,1) acts on the unit disk in the complex plane transitively as linear fractional transformations. Because of this group action,we can develop rich geometry and analysis over the unit disk. Bounded symmetric domains and bounded homogeneou		
Goal of the Subject	Through observations of geometry over homogeneous spaces, students will learn how to make use of Lie groups and Lie algebras as tools to study mathematical objects.		
Contents of the Subject /Subject Plan	[1] Introduction and overview [2] Geometry of classical domains (type I) [3] Geometry of classical domains (type II and III) [4] Geometry of classical domains (type IV) [5] Borel embeddings of bounded symmetric domains [6] Harish-Chandra realizations of bounded symmetric domains [7] Siegel domains and Cayley transforms [8] Examples of symmetric Siegel domains [9] Bounded homogeneous domains [10] Normal j-algebras [11] Examples of homogeneous Siegel domains [12] Bergman mappings and representative domains [13] Equivariant imbeddings of homogeneous Siegel domains [14] Matrix realizations of homogeneous Siegel domains [15] Toward a classification of bounded homogeneous domains		
Preparation and Review	Students attending this lecture are expected to read original papers on the topics introduced and to understand them deeply.		
Evaluation Method	Report etc..		
Comments to Students	Contact the lecturer before taking the registration for this lecture.		
Teaching Materials	Related literatures are introduced in the lecture.		
Remarks1			

Subject Code	SM13160011	Offering Academic Year/Semester	2020Year Second Semester
Subject Name(English)	Mathematical Sciences C		
Subject Number	SAMPL1503		
Credits	2Credits	Teaching Method	Lecture
Main Lecturer	Masamichi Yoshida		
Main Theme of the Subject	This course serves advanced complex analysis such as the uniformization theorem.		
Goal of the Subject	Students will be accustomed to dealing with basic complex analysis.		
Contents of the Subject /Subject Plan	I. Introduction for basic complex analysis II. Harmonic functions III. Analytic continuation and Riemann surfaces IV. Conformal mappings		
Preparation and Review	Students are expected to review after every lecture for understanding technical terms and theorems in each lecture.		
Evaluation Method	Reports mainly. Fulfill the omitted discussion and computations in the lecture.		
Comments to Students	Required knowledge is the courses Complex Analysis I and Complex Analysis II or corresponding knowledge.		
Teaching Materials	Elias M. Stein & Rami Shakarchi: Complex Analysis (Princeton Lectures in Analysis), Princeton University Press, 2003. L. V. Ahlfors: Complex Analysis, McGraw-Hill, 1966.		
Remarks1			

Subject Code	SM14030013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Mathematical Structures（M1）		
Subject Number	SAMEX1501		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Masaaki Furusawa		
Main Theme of the Subject	To present and to discuss some selected recent research papers in the theory of mathematical structures in the seminar and to report progress on own research.		
Goal of the Subject	To deepen and to broaden the understanding of some areas in the theory of mathematical structures.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM14040013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Mathematical Structures（M2）		
Subject Number	SAMEX1601		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Masaaki Furusawa		
Main Theme of the Subject	To present and to discuss some selected recent research papers in the theory of mathematical structures in the seminar and to report progress on own research.		
Goal of the Subject	To deepen and to broaden the understanding of some areas in the theory of mathematical structures.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM14050013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Mathematical Analysis（M1）		
Subject Number	SAMEX1502		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Futoshi Takahashi		
Main Theme of the Subject	To present and to discuss some selected recent research papers in mathematical analysis in the seminar and to report progress on own research.		
Goal of the Subject	To deepen and to broaden the understanding of some areas in mathematical analysis.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM14060013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Mathematical Analysis（M2）		
Subject Number	SAMEX1602		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Futoshi Takahashi		
Main Theme of the Subject	To present and to discuss some selected recent research papers in mathematical analysis in the seminar and to report progress on own research.		
Goal of the Subject	To deepen and to broaden the understanding of some areas in mathematical analysis.		
Contents of the Subject /Subject Plan	To be assigned later.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and the participations in the seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM14070013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Fundamental Physics（M1）		
Subject Number	SAPE11501		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Nobuhito Maru		
Main Theme of the Subject	Review and discuss journal articles on recent research results on fundamental physics.Report on progress of ones own research projects and have a group discussion.		
Goal of the Subject	In addition to developing the understanding of each specialized topic in the field of fundamental physics,we aim to acquire a wide range of knowledge applicable to entire fieldof physics. If necessary, read research papers and solve problem sets.		
Contents of the Subject /Subject Plan	The plan of class will be announced by each instructor.		
Preparation and Review	It will be announced in the class.		
Evaluation Method	The grade evaluation is based on attendance, report and discussion in a seminar.		
Comments to Students	It will be announced in the class.		
Teaching Materials	It will be announced in the class.		
Remarks1			

Subject Code	SM14080013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Fundamental Physics（M2）		
Subject Number	SAPE11601		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Nobuhito Maru		
Main Theme of the Subject	Review and discuss journal articles on recent research results on fundamental physics.Report on progress of ones own research projects and have a group discussion.		
Goal of the Subject	In addition to developing the understanding of each specialized topic in the field of fundamental physics,we aim to acquire a wide range of knowledge applicable to entire fieldof physics. If necessary, read research papers and solve problem sets.		
Contents of the Subject /Subject Plan	The plan of class will be announced by each instructor.		
Preparation and Review	It will be announced in the class.		
Evaluation Method	The grade evaluation is based on attendance, report and discussion in a seminar.		
Comments to Students	It will be announced in the class.		
Teaching Materials	It will be announced in the class.		
Remarks1			

Subject Code	SM14090013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Astro and High Energy Physics（M1）		
Subject Number	SAPE21501		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Yoshiki Tsunesada		
Main Theme of the Subject	Review and discuss journal articles on recent research results on astrophysics and high energy physics. Report on progress of ones own research projects and have a group discussion.		
Goal of the Subject	In addition to developing the understanding of each specialized topic in the field of astrophysics and high energy physics, we aim to acquire a wide range of knowledge applicable to entire field of physics.		
Contents of the Subject /Subject Plan	Read research papers and solve problem sets.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM14100013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Astro and High Energy Physics（M2）		
Subject Number	SAPE21601		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Yoshiki Tsunesada		
Main Theme of the Subject	Review and discuss journal articles on recent research results on astrophysics and high energy physics. Report on progress of ones own research projects and have a group discussion.		
Goal of the Subject	In addition to developing the understanding of each specialized topic in the field of astrophysics and high energy physics, we aim to acquire a wide range of knowledge applicable to entire field of physics.		
Contents of the Subject /Subject Plan	Read research papers and solve problem sets.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM14110013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Condensed Matter Physics（M1）		
Subject Number	SAPE31501		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Mitsuru Sugisaki		
Main Theme of the Subject	Review and discuss journal articles on recent research results on condensed matter physics. Report on progress of ones own research projects and have a group discussion.		
Goal of the Subject	In addition to developing the understanding of each specialized topic in the field of condensed matter physics, we aim to acquire a wide range of knowledge applicable to entire field of physics. If necessary, read research papers and solve problem sets.		
Contents of the Subject /Subject Plan	To be assigned by faculty.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM14120013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Exercises in Condensed Matter Physics（M2）		
Subject Number	SAPE31601		
Credits	4Credits	Teaching Method	Seminar
Main Lecturer	Mitsuru Sugisaki		
Main Theme of the Subject	Review and discuss journal articles on recent research results on condensed matter physics. Report on progress of ones own research projects and have a group discussion.		
Goal of the Subject	In addition to developing the understanding of each specialized topic in the field of condensed matter physics,we aim to acquire a wide range of knowledge applicable to entire field of physics. If necessary, read research papers and solve problem sets.		
Contents of the Subject /Subject Plan	To be assigned by faculty.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM14130013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Master's Thesis of Mathematics I		
Subject Number	SAARC1501		
Credits	6Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Fundamental theory of each specialty.		
Goal of the Subject	To understand systematically fundamentals of the theory which is necessary to solve the research problem for the master thesis.		
Contents of the Subject /Subject Plan	Each student is expected to gain the systematic understanding of fundamentals of the theory to solve the research problem for the master thesis. For that purpose, each student is assigned reading materials and is expected to formulate and to solve the research problem for the master thesis under the guidance of his or her adviser.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and participations in his or her seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM14140013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Master's Thesis of Mathematics II		
Subject Number	SAARC1601		
Credits	6Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	Fundamental theory of each specialty.		
Goal of the Subject	To understand systematically fundamentals of the theory which is necessary to solve the research problem for the master thesis.		
Contents of the Subject /Subject Plan	Each student is expected to gain the systematic understanding of fundamentals of the theory to solve the research problem for the master thesis. For that purpose, each student is assigned reading materials and is expected to formulate and to solve the research problem for the master thesis under the guidance of his or her adviser.		
Preparation and Review	To be assigned later.		
Evaluation Method	The grade is given based on the presentations and participations in his or her seminar.		
Comments to Students	To be communicated later.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM14150013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Master's Thesis of Physics I		
Subject Number	SAARC1501		
Credits	6Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Acquiring the systematic knowledge and techniques about theories and experiments leading to the writing of the Master's thesis.		
Goal of the Subject	We aim to acquire systematic knowledge and techniques about theories and experiments leading to the writing of the Master's thesis.		
Contents of the Subject /Subject Plan	Discuss research program leading to the writing of the Master's thesis. Special emphasis will be placed on encouraging students to make research plans, to read textbooks and journal articles, and to acquire the experimental skills.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM14160013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	Advanced Research Course for Master's Thesis of Physics II		
Subject Number	SAARC1601		
Credits	6Credits	Teaching Method	Seminar／Laboratory
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Acquiring the systematic knowledge and techniques about theories and experiments leading to the writing of the Master's thesis.		
Goal of the Subject	We aim to acquire systematic knowledge and techniques about theories and experiments leading to the writing of the Master's thesis.		
Contents of the Subject /Subject Plan	Discuss research program leading to the writing of the Master's thesis. Special emphasis will be placed on encouraging students to make research plans, to read textbooks and journal articles, and to acquire the experimental skills.		
Preparation and Review	To be announced separately.		
Evaluation Method	Grading will be given based on attendance, reports, and discussions in the class.		
Comments to Students	To be announced separately.		
Teaching Materials	To be announced separately.		
Remarks1			

Subject Code	SM40020013	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	International Advanced Research Coursefor Master's Thesis of Science 2(Mathmatics)		
Subject Number			
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Hiroshi Tamaru		
Main Theme of the Subject	International research experience through research activities and scholarly exchanges abroad.		
Goal of the Subject	Each student is expected not only to make advancements in research towards the master thesis, but also to participate in the international scientific community.		
Contents of the Subject /Subject Plan	Each student will be advised on where to go and what to do there and also on how to give a research presentation in English, by the adviser. After returning to Japan, it is expected to present a research report.		
Preparation and Review	To be assigned individually. Also each student is expected to seek research problems actively.		
Evaluation Method	The grade is assigned based on the advancements in research and also on the improvements of the skill in research presentation and scientific communication in the international setting.		
Comments to Students	It is required to consult the adviser before registering this course.		
Teaching Materials	To be assigned later.		
Remarks1			

Subject Code	SM40020023	Offering Academic Year/Semester	2020Year First Semester, 2020Year Second Semester
Subject Name(English)	International Advanced Research Coursefor Master's Thesis of Science 2(Physics)		
Subject Number			
Credits	1Credit	Teaching Method	Lecture
Main Lecturer	Ken-ichi Nakao		
Main Theme of the Subject	Students are expected to experience research in international fields through research activities and academic exchanges outside Japan.		
Goal of the Subject	Through research activities outside Japan, we aim to make progress in research plans of the Master's thesis, to achieve research goals, and to participate in international scientific communities of students and researchers in each research field.		
Contents of the Subject /Subject Plan	The university or research institute to be dispatched and research plans will be determined through discussion with the supervisor. Encourage students to make research proposal and plan, and to acquire the presentation of research (in English) or experimental skills. After returning to Japan, research results are to be reported.		
Preparation and Review	To be assigned by faculty. In addition, students are encouraged to make research subjects by oneself and to study actively the subject before and after the project.		
Evaluation Method	Grading will be given based on research results and progress of research. Improvement of overseas presentation and communication skills is also confirmed.		
Comments to Students	Regarding international research plans, etc., consult with the supervisor before registering for the course.		
Teaching Materials	To be announced separately.		
Remarks1			