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| Subject Code | SD11010013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Seminar in Mathematical Structures | | |
| Subject Name(English) | Seminar in Mathematical Structures | | |
| Subject Number | SAMSM1701 | | |
| Credits | 2 Credits | Teaching Method | Seminar |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD11020013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Seminar in Mathematical Analysis | | |
| Subject Name(English) | Seminar in Mathematical Analysis | | |
| Subject Number | SAMSM1702 | | |
| Credits | 2 Credits | Teaching Method | Seminar |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD12010013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Seminar in Fundamental Physics | | |
| Subject Name(English) | Seminar in Fundamental Physics | | |
| Subject Number | SAPS11701 | | |
| Credits | 2 Credits | Teaching Method | Special Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD12020013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Seminar in Astroparticle and High Energy Physics | | |
| Subject Name(English) | Seminar in Astroparticle and High Energy Physics | | |
| Subject Number | SAPS21701 | | |
| Credits | 2 Credits | Teaching Method | Special Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD12030013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Seminar in Condensed Matter Physics | | |
| Subject Name(English) | Seminar in Condensed Matter Physics | | |
| Subject Number | SAPS31701 | | |
| Credits | 2 Credits | Teaching Method | Special Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD13010023 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Number | | | |
| Credits | 3 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD13010013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Number | | | |
| Credits | 3 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD13020023 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Number | | | |
| Credits | 3 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD13020013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Number | | | |
| Credits | 3 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD13030023 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD13030013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Doctoral Thesis of Science | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Futoshi Takahashi | | |
| 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 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD40010023 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | International Advanced Research Course for Doctoral Thesis of Science 1 | | |
| Subject Name(English) | International Advanced Research Course for Doctoral Thesis of Science 1 | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SD40010013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | International Advanced Research Course for Doctoral Thesis of Science 1 | | |
| Subject Name(English) | International Advanced Research Course for Doctoral Thesis of Science 1 | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Seminar |
| Main Lecturer | Futoshi Takahashi | | |
| Main Theme of the Subject | International research experiences 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11130011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Algebraic Structures I | | |
| Subject Name(English) | Selected Topics in Algebraic Structures I | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Masato Okado | | |
| Main Theme of the Subject | A lecturer at another university gives intensive courses in one week on recent topics in structure and representation theory of algebraic systems. The theme is taken, by an expert, mainly from ring theory, algebraic number theory and representation theory of algebras, finite groups, algebraic groups, etc. | | |
| Goal of the Subject | Will be announced separately. | | |
| Contents of the Subject /Subject Plan | Will be announced separately. | | |
| Preparation and Review | Will be announced separately. | | |
| Evaluation Method | Report, etc. | | |
| Comments to Students | Will be announced separately. | | |
| Teaching Materials | Will be announced separately. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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| Subject Code | SM11140011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Algebraic Structures II | | |
| Subject Name(English) | Selected Topics in Algebraic Structures II | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Masato Okado | | |
| Main Theme of the Subject | A lecturer at another university gives intensive courses in one week on recent topics in structure and representation theory of algebraic systems. The theme is taken, by an expert, mainly from ring theory, algebraic number theory and representation theory of algebras, finite groups, algebraic groups, etc. | | |
| Goal of the Subject | Will be announced separately. | | |
| Contents of the Subject /Subject Plan | Will be announced separately. | | |
| Preparation and Review | Will be announced separately. | | |
| Evaluation Method | Report, etc. | | |
| Comments to Students | Will be announced separately. | | |
| Teaching Materials | Will be announced separately. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11170011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Selected Topics in Geometric Structures I | | |
| Subject Name(English) | Selected Topics in Geometric Structures I | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Mikiya Masuda | | |
| Main Theme of the Subject | Professor Megumi Harada (McMaster University, Canada) who is working on topology and algebraic geometry will introduce recent topics on the area. | | |
| Goal of the Subject | To be announced | | |
| Contents of the Subject /Subject Plan | To be announced | | |
| Preparation and Review | To be announced | | |
| Evaluation Method | Attendance and report. | | |
| Comments to Students | The lectures will be given in English, so that you can learn English as well. | | |
| Teaching Materials | None | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11180011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Selected Topics in Geometric Structures II | | |
| Subject Name(English) | Selected Topics in Geometric Structures II | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Mikiya Masuda | | |
| Main Theme of the Subject | Professor Megumi Harada (McMaster University, Canada) who is working on topology and algebraic geometry will introduce recent topics on the area. | | |
| Goal of the Subject | To be announced | | |
| Contents of the Subject /Subject Plan | To be announced | | |
| Preparation and Review | To be announced | | |
| Evaluation Method | Attendance and report, etc. | | |
| Comments to Students | To be announced | | |
| Teaching Materials | To be announced | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11430011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Topics in Mathematical Structures 1 | | |
| Subject Name(English) | Topics in Mathematical Structures 1 | | |
| Subject Number | SAMMS1501 | | |
| Credits | 2 Credits | Teaching Method | Lecture／Seminar |
| Main Lecturer | Masaaki Furusawa | | |
| 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.<br>Lecture 1: Artinian rings<br>Lecture 2: Modules over Artinian rings<br>Lecture 3: Category of modules over Artinian rings<br>Lecture 4: Injective objects<br>Lecture 5: Differential complexes<br>Lecture 6: Homology<br>Lecture 7: Projective objects<br>Lecture 8: Generators<br>Lecture 9: Morita equivalence<br>Lecture 10: Triangulated categories<br>Lecture 11: Localization<br>Lecture 12: Derived equivalence<br>Lecture 13: Quasi-Frobenius rings<br>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. | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11440011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Topics in Mathematical Structures 2 | | |
| Subject Name(English) | Topics in Mathematical Structures 2 | | |
| Subject Number | SAMMS1502 | | |
| Credits | 2 Credits | 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 wish to take this course should contact the supervisor in advance. | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11450011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Topics in Mathematical Structures 3 | | |
| Subject Name(English) | Topics in Mathematical Structures 3 | | |
| Subject Number | SAMMS1503 | | |
| Credits | 2 Credits | Teaching Method | Lecture／Seminar |
| Main Lecturer | Masaaki Furusawa | | |
| 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.<br>Lecture 1: Commutative rings<br>Lecture 2: Affine algebraic varieties<br>Lecture 3: Schemes<br>Lecture 4: Lie algebras<br>Lecture 5: Semisimple Lie algebras<br>Lecture 6: Representation theory of Lie algebras<br>Lecture 7: Lie groups<br>Lecture 8: Compact Lie groups<br>Lecture 9: Semisimple Lie groups<br>Lecture 10: Symmetric spaces<br>Lecture 11: Hermitian symmetric spaces<br>Lecture 12: Analysis on symmetric spaces<br>Lecture 13: Iwasawa theory<br>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. | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11460011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Topics in Mathematical Structures 4 | | |
| Subject Name(English) | Topics in Mathematical Structures 4 | | |
| Subject Number | SAMMS1504 | | |
| Credits | 2 Credits | 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.<br>Lesson 1. Basics of Fuchsian groups<br>Lesson 2. Topics in Fuchsian groups<br>Lesson 3. Basics of the mapping class groups of surfaces<br>Lesson 4. Topics in the mapping class groups of surfaces<br>Lesson 5. Recent developments in the mapping class groups of surfaces<br>Lesson 6. Basics of Heegaard splittings and Dehn surgeries of 3-manifolds<br>Lesson 7. Topics in Heegaard splittings and Dehn surgeries of 3-manifolds<br>Lesson 8. Recent developments in Heegaard splittings and Dehn surgeries of 3-manifolds<br>Lesson 9. Basics of Kleinian groups<br>Lesson 10. Topics in Kleinian groups<br>Lesson 11. Recent developments in Kleinian groups<br>Lesson 12. Basics of 3-dimensional geometric structures<br>Lesson 13. Topics in 3-dimensional geometric structures<br>Lesson 14. Recent developments in 3-dimensional geometric structures<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11470011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Advanced Algebra I | | |
| Subject Name(English) | Advanced Algebra I | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Hyohe Miyachi | | |
| Main Theme of the Subject | Basics on algebraic geometry | | |
| Goal of the Subject | Learning basics on affine algebraic varieties, in particular, Hilbert's Nullstellensatz.By gluing affine algebraic varieties locally, we understand general algebraic varieties. Especially, we shall study projective varieties. | | |
| Contents of the Subject /Subject Plan | 1. Affine algebraic varieties<br>2. Noetherian rings<br>3. Hilbert's basis theorem<br>4. Modules over a commutative ring<br>5. Hilbert's Nullstellensatz.<br>6. Coordinate rings and morphisms<br>7. Affine algebraic varieties revisited<br>8. Zariski topology<br>9. Irreducible components<br>10. Ringed spaces<br>11. Algebraic varieties<br>12. Projective spaces<br>13. Projective varieties<br>14. Tangent spaces and dimensions<br>15. Application | | |
| Preparation and Review | Prereading is not necessary for the lecture. However, it is necessary for a participant to polish his or her understanding on the past lectures. | | |
| Evaluation Method | Scored by reports, exams, etc. | | |
| Comments to Students | Require basic knowledge: Algebra II, Algebra III, Algebra IV | | |
| Teaching Materials | No specified text book. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11490011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Advanced Algebra III | | |
| Subject Name(English) | Advanced Algebra III | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masaaki Furusawa | | |
| Main Theme of the Subject | Galois theory and the theory of finite fields | | |
| Goal of the Subject | After reviewing the theory of algebraic extensions of fields, we learn Galois theory and the fundamentals of finite fields. If time permits, we hope to treat the theory of exponential sums such as Gauss sums. | | |
| Contents of the Subject /Subject Plan | Lecture 1: Algebraic extensions and finite extensions<br>Lecture 2: Separable extensions<br>Lecture 3: Normal extensions<br>Lecture 4: Norm and trace<br>Lecture 5: Galois extensions<br>Lecture 6: Theorems on Galois extensions<br>Lecture 7: Main theorem of Galois theory<br>Lecture 8: Cyclotomic extensions<br>Lecture 9: Solvability of polynomial extensions by radicals<br>Lecture 10: Geometric constructions<br>Lecture 11: Finite fields<br>Lecture 12: Solutions of equations over finite fields<br>Lecture 13: Gauss sums and Jacobi sums<br>Lecture 14: Applications of exponential sums<br>The material to be treated in the course is subject to change according to the preparations and the interests of the students. | | |
| Preparation and Review | Before the first lecture, review the material of a standard undergraduate abstract algebra course, such as our Algebra I, II, III, IV sequence. Review your course notes and consult the references, if necessary, to understand well the material treated after each lecture. It is recommended to find problems related to the lectures in the references and to solve them by yourself. | | |
| Evaluation Method | It is planned to give grades according to the submitted solutions to the assigned problems. But this is subject to change depending on the circumstances. | | |
| Comments to Students | Prerequisites: understanding of the material of a standard undergraduate abstract algebra course, such as our Algebra I, II, III, IV sequence. | | |
| Teaching Materials | References:<br>John B. Fraleigh: A First Course in Abstract Algebra, Addison Wesley<br>Kenneth Ireland, Michael Rosen: A Classical Introduction to Modern Number Theory, Springer<br>More references might be mentioned during the lectures. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11510011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Advanced Geometry I | | |
| Subject Name(English) | Advanced Geometry I | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Mikiya Masuda | | |
| Main Theme of the Subject | Through concrete examples of manifolds, we become more familiar with manifolds and learn relation among the topology of manifolds, algebras, and combinatorics. | | |
| Goal of the Subject | Through the concrete examples of manifolds such as complex projective spaces, Grassmannians and flag manifolds, we will deepen our understanding about manifolds. It turns out that manifolds are not abstract objects and closely related to matrices. The goal of this lectures is to feel manifolds at hand. | | |
| Contents of the Subject /Subject Plan | 1. Complex projective spaces and cell decompositions<br>2-4. Grassmannians<br>5-8. Flag manifolds<br>9,10. Volume polynomials of manifolds<br>11,12. Gelfand-Zetlin polytopes<br>13,14. Related topics | | |
| Preparation and Review | One cannot understand mathematics just by attending lectures. It is necessary to make examples and computations by yourself. This course will provide many examples and you need to try to understand those examples from your own viewpoint at home. | | |
| Evaluation Method | Report | | |
| Comments to Students | It is desirable to have knowledge about manifolds and homology groups. | | |
| Teaching Materials | None | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11530011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Advanced Geometry III | | |
| Subject Name(English) | Advanced Geometry III | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Taizo Kanenobu | | |
| Main Theme of the Subject | This course provides mathematical theory of knots, which is a field of topology. One of the majour purposes of knot theory is classification of knots. Several knot invariants have been defined. In this course polynomial invariants such as Alexander and Jones polynomials are explained in detail. | | |
| Goal of the Subject | To understand knot theory through polynomial invariants of knots and links. | | |
| Contents of the Subject /Subject Plan | 1 Introduction to knot theory<br>2 Knot diagram and coloring number<br>3 Definition of the Conway polynomial and some examples<br>4 Properties of the Conway polynomial<br>5 Seifert surface for a knot and the genus of a knot<br>6 Alexander polynomial<br>7 Knot group and the Alexander polynomial<br>8 Covering spaces of a knot<br>9 Bracket polynomial<br>10 Definition of the Jones polynomial and some examples<br>11 Properties of the Jones polynomial<br>12 HOMFLYPT polynomial<br>13 Kauffman polynomial<br>14 Local moves of a knot | | |
| Preparation and Review | Students are required to solve exercises given in a handout. | | |
| Evaluation Method | Comprehensively evaluated by reports. | | |
| Comments to Students | Basic knowledge of topological space and algebraic topology (homology groups and fundamental group). | | |
| Teaching Materials | A handout will be distributed. | | |
| Remarks1 | References:R. H. Crowell and R. H. Fox, Introduction to Knot Theory, Dover.<br>K. Murasugi, Knot Theory and Its Applications, Springer Science & Business Media. | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11550011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Mathematical Analysis 1 | | |
| Subject Name(English) | Mathematical Analysis 1 | | |
| Subject Number | SAMMA1501 | | |
| Credits | 2 Credits | 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:<br>1st The Riemann surfaces<br>2nd The holomorphic differential<br>3rd The quasi-conformal mappings<br>4th The mathematical statistics<br>5th The 2 dimensional hyperbolic geometry<br>6th The Fuchsian groups<br>7th The probability theory<br>8th The stochastic processes<br>9th The dynamics on the circle<br>10th The asymptotic Teichmuller spaces<br>11th The partial differential equations<br>12th The variational methods<br>13th The harmonic functions<br>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 | | | |
| Remarks1 | You should contact us. | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11560011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Mathematical Analysis 2 | | |
| Subject Name(English) | Mathematical Analysis 2 | | |
| Subject Number | SAMMA1502 | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Yoshihiro Ohnita | | |
| 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,<br>1. Submanifolds in Euclidean spaces<br>2. Vector bundles and connections<br>3. Lie groups, classical groups and Lie algebras<br>4. Riemannian manifolds<br>5. Geodesics and variational formulas<br>6. Morse theory over manifolds<br>7. Isometry groups and holonomy groups<br>8. Curvatures<br>9. Riemannian manifolds of constant curvatures<br>10. Curvatures and topology of manifolds<br>11. Curvatures and spectrum of Laplace operator<br>12. Minimal submanifolds<br>13. Harmonic maps<br>14. Symplectic manifolds<br>etc. | | |
| 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. | | |
| Remarks2 | | | |

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| Subject Code | SM11570011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Analysis 3 | | |
| Subject Name(English) | Mathematical Analysis 3 | | |
| Subject Number | SAMMA1503 | | |
| Credits | 2 Credits | 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:<br>I. Complex analysis,<br>II. Probability theory,<br>III. Potential theory,<br>IV. Partial differential equations,<br>V. Dynamical systems,<br>VI. Harmonic analysis,<br>VII. Mathematical statistics,<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11580011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Analysis 4 | | |
| Subject Name(English) | Mathematical Analysis 4 | | |
| Subject Number | SAMMA1504 | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masato Okado | | |
| 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.<br>[1] Basic facts on geometry of submanifolds<br>[2] Topics on geometry of submanifolds<br>[3] Recent results on geometry of submanifolds<br>[4] Basic facts on symmetric spaces and Lie groups<br>[5] Topics on symmetric spaces and Lie groups<br>[6] Recent results on symmetric spaces and Lie groups<br>[7] Basic facts on harmonic maps and minimal surfaces<br>[8] Topics on harmonic maps and minimal surfaces<br>[9] Recent results on harmonic maps and minimal surfaces<br>[10] Basic facts on Riemannian geometry<br>[11] Topics on Riemannian geometry<br>[12] Recent results on Riemannian geometry<br>[13] Basic facts on symplectic geometry and moment maps<br>[14] Topics on symplectic geometry and moment maps<br>[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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11590011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Advanced Analysis I | | |
| Subject Name(English) | Advanced Analysis I | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masamichi Yoshida | | |
| Main Theme of the Subject | Introduction to the theory of dynamical systems | | |
| Goal of the Subject | Understanding of basic concepts of dynamical systems | | |
| Contents of the Subject /Subject Plan | 1st：Orbit<br>2nd：Minimal set<br>3rd：Nonwandering set<br>4th：Invariant measure<br>5th：Ergodicity<br>6th：Rotation number<br>7th：Poincare's rotation number theorem<br>8th：Supplementary remark on Poincare's theorem<br>9th：Factor map<br>10th：Classification of dynamical systems on the circle<br>11th：Denjoy's theorem<br>12th：Supplementary remark on Denjoy's theorem<br>13th：Basic properties of Denjoy dynamical system<br>14th：Supplementary remark on Denjoy dynamical system | | |
| Preparation and Review | Review of each lecture | | |
| Evaluation Method | Report : subject of report is to be announced | | |
| Comments to Students | Understanding of naive ideas in dynamical systems | | |
| Teaching Materials | To be annouced in each lecture | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11610011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Advanced Analysis III | | |
| Subject Name(English) | Advanced Analysis III | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masaharu Nishio | | |
| Main Theme of the Subject | We consider holomorphic functions and harmonic functions. After recalling the fundamental properties of those functions, I shall explain some topics with relation to Fourier analysis and partial differential equations. | | |
| Goal of the Subject | You should recall fundamental properties of holomorphic and harmonic functions, and understand some relations with Fourier series and partial differential equations. | | |
| Contents of the Subject /Subject Plan | 1st Holomorphic functions<br>2nd Cauchy-Riemann equation<br>3rd The Taylor expansion<br>4th Harmonic functions<br>5th Power series expansion<br>6th The Laplace equation<br>7th The wave equation<br>8th The heat equation<br>9th Fundamental solutions<br>10th Hypo-ellipticity<br>11th Analytic hypo-ellipticity<br>12th The Fourier series<br>13th The Hardy spaces<br>14th The Bergman space | | |
| Preparation and Review | You should possibly recall fundamental properties on the complex analysis, the functional analysis, and the Lebesgue integral. | | |
| Evaluation Method | You should write some reports. | | |
| Comments to Students | You should ask some questions. | | |
| Teaching Materials | I shall show some bibliography in the class. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11630011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Introduction to Mathematics I | | |
| Subject Name(English) | Introduction to Mathematics I | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Ken Abe | | |
| 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 mathematics II. | | |
| 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<br>(2) An introduction on a topic of the algebraic groups<br>(3) An introduction on a topic of the number theory<br>(4) An introduction on a topic of the ring theory<br>(5) An introduction on a topic of the knot theory<br>(6) An introduction on a topic of the 3- and 4-dimensional topology<br>(7) An introduction on a topic of the geometry of transformation groups<br>(8) An introduction on a topic of the differential geometry<br>(9) An introduction on a topic of the variational methods<br>(10) An introduction on a topic of the nonlinear partial differential equations<br>(11) An introduction on a topic of the complex analysis<br>(12) An introduction on a topic of the potential theory<br>(13) An introduction on a topic of the ergodic theory<br>(14) An introduction on a topic of the probability theory<br>(15) An introduction on a topic of the statistics<br>The above is one example. The order of the course contents may be different. | | |
| Preparation and Review | Closely read and understand indicated literatures and their references. | | |
| Evaluation Method | Attendance and reports | | |
| Comments to Students | Faculties in charge and schedules are announced at the beginning of April. | | |
| Teaching Materials | A particular text book is not designated. A handout is freely given. | | |
| Remarks1 | The course starts biennially at an odd year. | | |
| Remarks2 | | | |

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| Subject Code | SM11650011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Analysis I | | |
| Subject Name(English) | Selected Topics in Analysis I | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Takayuki Koike | | |
| Main Theme of the Subject | Recent topics on global analysis and differential geometry, including boundary areas such as partial differential equation, geometric measure theory and the theory on metric measure spaces, will be lectured by an expert from another university. | | |
| Goal of the Subject | To be announced. | | |
| Contents of the Subject /Subject Plan | To be announced. | | |
| Preparation and Review | To be announced. | | |
| Evaluation Method | Based on attendance record, reports, and so on. | | |
| Comments to Students | To be announced. | | |
| Teaching Materials | To be announced. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM11660011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Analysis II | | |
| Subject Name(English) | Selected Topics in Analysis II | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Takayuki Koike | | |
| Main Theme of the Subject | Recent topics on global analysis and differential geometry, including boundary areas such as partial differential equation, geometric measure theory and the theory on metric measure spaces, will be lectured by an expert from another university. | | |
| Goal of the Subject | To be announced. | | |
| Contents of the Subject /Subject Plan | To be announced. | | |
| Preparation and Review | To be announced. | | |
| Evaluation Method | Based on attendance record, reports, and so on. | | |
| Comments to Students | To be announced. | | |
| Teaching Materials | To be announced. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12010011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Quantum Field Theory | | |
| Subject Name(English) | Quantum Field Theory | | |
| Subject Number | SAPL11501 | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masaki Arima | | |
| Main Theme of the Subject | Two instructors will give lectures.<br>Prof. Arima will give a lecture on the basics of quantum field theory,<br>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,<br>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<br>1 Review of classical field theory<br>2 Conservation law<br>3 On neutral scalar field: Hamiltonian<br>4 On neutral scalar field: Canonical quantization<br>5 On neutral scalar field: Examples of conservation law<br>6 On charged scalar field<br>7 On electromagnetic field: Differences between the scalar field and the electromagnetic field<br>8 On electromagnetic field: Difficulties in quantization<br>9 On electromagnetic field: Gauge fixing and quantization<br>10 On interactions of fields: Interaction representation<br>11 On interactions of fields: Wick's theorem<br>12 On interactions of fields: Application to the scalar field theory<br>13 On interactions of fields: Interaction with the gauge field<br>14 Introduction of renormalization: Higher order perturbations and divergence<br>15 Introduction of renormalization: Prescription for renormalization<br>Maru<br>1 Path integral in quantum mechanics<br>2 Path integral of scalar field: Introduction<br>3 Path integral of scalar field: Green functions<br>4 Path integral of scalar field: Generating functional<br>5 Perturbation theory: Formulation<br>6 Perturbation theory: Feynman rules<br>7 Renormalization: Regularization<br>8 Renormalization: Φ4 theory<br>9 Renormalization: Φ3 theory, scalar QED, renormalizability<br>10 Effective action: Effective potential<br>11 Effective action: Dynamical symmetry breaking<br>12 Path integral of spinor field<br>13 Path integral of electromagnetic field<br>14 Renormalization group: Perturbative renormalization group<br>15 Renormalization group: Winsonian renormalization group | | |

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| 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.<br>Attendance will be required. Questions about the lecture are welcome. |
| Teaching Materials | Greiner & Reinhardt, “Field Quantization”, Springer (Arima)<br>Peskin & Schroeder, “An Introduction to Quantum Field Theory” (Maru) |
| Remarks1 | |
| Remarks2 | |

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|---|---|---|---|
| Subject Code | SM12020011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Theory of Elementary Particles | | |
| Subject Name(English) | Theory of Elementary Particles | | |
| Subject Number | SAPL11502 | | |
| Credits | 2 Credits | 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<br>２ Spontaneous Symmetry Breaking: Abelian Symmetry, Goldstone Model<br>３ Spontaneous Symmetry Breaking: Non-Abelian Symmetry<br>４ Nambu-Goldstone's Theorem<br>５ Spontaneous Symmetry Breaking of Gauge Symmetry: Higgs Mechanism<br>６ Spontaneous Symmetry Breaking of Chiral Symmetry: Nambu-Jona-Lasino Model<br>７ Spontaneous Symmetry Breaking of Chiral Symmetry: Pion as a Nambu-Goldstone Particle<br>８ Weinberg-Salam model, Electroweak Symmetry Breaking<br>９ Lepton sector: Yukawa Coupling, Charged Current, Neutral Current<br>１０ Quark sector: Yukawa Coupling, CKM Matrix<br>１１ Quark sector:GIM Mechanism<br>１２ Quark scetor: CP Violation<br>１３ Neutrino Oscillation<br>１４ Grand Unified Theory: SU(5) Model, Gauge Coupling Unification<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12030011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Methods of Physics | | |
| Subject Name(English) | Mathematical Methods of Physics | | |
| Subject Number | SAPL11503 | | |
| Credits | 2 Credits | 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 | Linear Partial Differential Equations (1): Basic Concepts and Definitions. Linear Partial Differential Equations (2): The Classification of Second-Order Linear Equations and The Method of Characteristics. Linear Partial Differential Equations (3): The Method of Separation of Variables. Linear Partial Differential Equations (4): Fourier Transforms and Initial-Boundary -Value Problems. Linear Partial Differential Equations (5): Applications of Multiple Fourier Transforms to Partial Differential Equations. Linear Partial Differential Equations (6): Laplace Transforms and Initial-Boundary-Value Problems. Green's Functions and Boundary-Value Problems. First-Order, Quasi-Linear Equations and The Method of Characteristics (1): The Classification and Geometrical Interpretation of a First-Order Equation. First-Order, Quasi-Linear Equations and The Method of Characteristics (2): The Method of Characteristics and General Solutions. First-Order Nonlinear Equations: The Gerneralized Method of Characteristics and Complete Integrals of Certain Special Nonlinear Equations. Conservation Laws and Shock Waves (1): Introduction and Conservation Laws. Conservation Laws and Shock Waves (2): Discontinuous Solutions and Shock Waves. Exact Solutions of Certain Nonlinear Partial Differential Equations (1): Burgers' and Thomos' Equations. Exact Solutions of Certain Nonlinear Partial Differential Equations (2): KdV Equation. The Series Solution. 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 (40%) and end-of-term reports (60%). | | |
| Comments to Students | To be specified separately. | | |
| Teaching Materials | Distribute prints as appropriate.<br>Reference: L Debnath, Nonlinear Partial Differential Equations for Scientists and Engineers （Birkhauser） | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12050011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Fluid Mechanics | | |
| Subject Name(English) | Fluid Mechanics | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture／Seminar |
| Main Lecturer | Hiromitsu Hamabata | | |
| Main Theme of the Subject | After explaining the basic concepts of fluids, the basic equations of fluids are established, and the fundamental concepts for analyzing the flow are explained and the laminar flow of the non-viscous and viscous fluids is outlined. In addition, we outline the mathematical method or the physical consideration method which is useful in understanding turbulent flow phenomena. | | |
| Goal of the Subject | In addition to laminar flow, students acquire the ability to analyze fluid phenomena by understanding the fundamental issues of turbulence and understanding different thinking methods in laminar and turbulent flows. | | |
| Contents of the Subject /Subject Plan | Introduction: Various phenomena of fluid flows.Basic equations: Continuum approximation and concept of fields. Mass conservation law. Momentum equation. Energy conservation law. Basic concepts of analysing flows.Non-viscous fluid motion (1): The properties of vorticity. Belnoulli's theorem.Non-viscous fluid motion (2): Two dimentional irrotational flows. Water waves.Non-viscous fluid motion (3): Three dimensional irrotational incompressible flows. Compressible flows.Viscous fluid motion (1): Mathematical method necessary for analysis.Viscous fluid motion (2): Flows represented by exact solutions.Viscous fluid motion (3): Low Reynolds number flows. High Reynolds number flows.Turbulence (1): The occurrence of turbulence. Average operation. Ensemble-mean system of equationsSta.Turbulence (2): Homogeneous turbulence. Generation of turbulence in inhomogeneous turbulence, characteristics of diffusion.Turbulence modeling (1): Mode number of turbulence. Reynolds-averaged model.Turbulence modeling (2): Subgrid-scale modeling.Statistical theory of turbulence (1): Mathematical method necessary for analysis. The theory of inhomogeneous turbulence.Statistical theory of turbulence (2): Theoretical derivation of turbulence modeling. | | |
| Preparation and Review | After the lecture, the students will have to attend hardships 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 (40%) and end-of-term reports (60%). | | |
| Comments to Students | To be specified separately. | | |
| Teaching Materials | Reference: Yoshizawa, A,Fluid Mechanics (Tokyo Univ. Press). | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12060011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Relativistic Theory of Gravitation | | |
| Subject Name(English) | Relativistic Theory of Gravitation | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture／Seminar |
| Main Lecturer | Hideki Ishihara | | |
| Main Theme of the Subject | Basic knowledge about general relativity as a theory of gravity and its application. | | |
| Goal of the Subject | To acquire basic knowledge about general relativity as a theory of gravity and to understand typical physical processes in our universe through general relativity. | | |
| Contents of the Subject /Subject Plan | 1. Geometrical quantities 1: vectors and tensors<br>2. Geometrical quantities 2: metric tensor and curvature<br>3. Parallel transport and connection<br>4. Geodesics in curved spacetime<br>5. Geodesic deviation equation<br>6. Equation for gravity: the Einstein equations<br>7. Newtonian limit of gravity<br>8. Asymptotically flat spacetime<br>9. Gravitational collapse<br>10. Black holes<br>11. Massive and massless particles in a black hole spacetime<br>12. Relativistic model of the universe<br>13. Time evolution of the universe<br>14. Gravitational waves | | |
| Preparation and Review | Reading the introduced textbook before and after each lecture. | | |
| Evaluation Method | A grade for class participation. | | |
| Comments to Students | Active discussions are desirable. | | |
| Teaching Materials | Useful articles will be introduced in lectures. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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| Subject Code | SM12080011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Nuclear Physics I | | |
| Subject Name(English) | Nuclear Physics I | | |
| Subject Number | SAPL11508 | | |
| Credits | 2 Credits | 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;<br>* Nuclear structure: basic properties (nuclear size, shape, binding energy...), single-particle picture and nuclear shell model, collective model, and mean-field theory<br>* Nuclear reaction: quantum scattering theory, elastic scattering and optical model, and reaction models on direct reaction process (DWBA, channel-coupling method...) | | |
| Contents of the Subject /Subject Plan | 1. Discovery of atomic nucleus, measurement of nuclear size and binding energy<br>2. Electron scattering and nuclear charge density<br>3. Properties of nuclear force and effective interaction<br>4. Mean field and single-particle picture, shell model<br>5. Nuclear collective motion (vibration, rotation and giant resonance)<br>6. Microscopic models on nuclear collective motion I (Hartree-Fock method, Time-dependent Hartree-Fock method and RPA)<br>7. Microscopic models on nuclear collective motion II (quasi-particles, Hartree-Fock-Bogoliubov theory, density functional theory)<br>8. Basics of nuclear reaction<br>9. Quantum scattering theory and scattering states<br>10. Elastic scattering and Optical model<br>11. Multiple scattering and effective interaction, optical potential<br>12. Models of direct reaction I (DWBA)<br>13. Models of direct reaction II (Coupled channel method)<br>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）],<br>"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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12090011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Nuclear Physics II | | |
| Subject Name(English) | Nuclear Physics II | | |
| Subject Number | SAPL11509 | | |
| Credits | 2 Credits | 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.<br>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<br>2. Review of the field theory; Internal degree of freedom<br>3. Review of the field theory; Conservation law<br>4. Examples of the symmetry; Gauge symmetry<br>5. Examples of the symmetry; Chiral symmetry<br>6. Hadrons and the symmetry; Nuclear phenomena<br>7. Hadrons and the symmetry; Isospin symmetry<br>8. Hadrons and the symmetry; Weak interaction<br>9. SU(3) symmetry; "Strange" phenomena<br>10. SU(3) symmetry; Strangeness<br>11. SU(3)XSU(3) symmetry; Weak interaction and Parity violation<br>12. SU(3)XSU(3) symmetry; Chiral symmetry<br>13. Phenomenological model of Hadrons; Quark model<br>14. 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.<br>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”, Springer<br>I.J.R. Aitchison, “An informal introduction to gauge field theories” | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12100011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Fundamental Physics IA | | |
| Subject Name(English) | Selected Topics in Fundamental Physics IA | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Hideki Ishihara | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12150011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | High Energy Physics I | | |
| Subject Name(English) | High Energy Physics I | | |
| Subject Number | SAPL21501 | | |
| Credits | 2 Credits | 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<br>The 2nd lecrure: Review of four tyes of forces<br>The 3rd lecture: Interactions and fields<br>The 4th lecture: Behavior of particles in the field<br>The 5th lecture: Invariant principle and conservation low<br>The 6th lecture: Spin and parity<br>The 7th lecture: Charge conjugation and time reversal<br>The 8th lecture: Isospin<br>The 9th lecture: Hadrons containing heavy quarks<br>The 10th lecture: Classification of baryons<br>The 11th lecture: Classification od of mesons<br>The 12th lecture: Electron-positron pair annihilation process<br>The 13th lecture: Deep inelastic scattering<br>The 14th lecture: Interactions between quark<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12160011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | High Energy Physics II | | |
| Subject Name(English) | High Energy Physics II | | |
| Subject Number | SAPL21502 | | |
| Credits | 2 Credits | 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<br>2. Dirac equation. Helicity and spin polarization of Dirac particles.<br>3. Basics of the quantum field theory. Gauge symmetry.<br>4. Calculation of cross sections.<br>5. Weak interactions and quarks. GIM mechanism. Kobayashi-Maskawa mass matrix.<br>6. Weinberg-Salam theory. Charged, Neutral, electromagnetic current.<br>7. Higgs particle and spontaneous symmetry breaking.<br>8. Masses of gauge bosons.<br>9. Masses of fermions and Kobayashi-Maskawa mass matrix.<br>10. Production of Higgs particles and detection.<br>11. Strong interactions. Structure functions of hadrons.<br>12. QCD corrections of the tructure functions of hadrons.<br>13. Beyond the standard model of the elementary particle physics.<br>14. Uncertainty, probability, statistics.<br>15. Current status of the experimental elementary particle physics. | | |
| Preparation and Review | | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12180011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Cosmic Ray Physics II | | |
| Subject Name(English) | Cosmic Ray Physics II | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Shoichi Ogio | | |
| Main Theme of the Subject | Review of the theoretical and the experimental studies of the cosmic ray physics covering very wide energy range, from low energies measured with satellite-borne detectors to ultra high energies. Particularly, this lecture is specially focused on the standard theories, basic experimental techniques, recent results and unsettled questions. | | |
| Goal of the Subject | The first goal is to learn the theoretically and experimentally established "standards". The second goal is to deepen your knowledge of recent results and to develop your ability to study current and unsolved problems on the firm foundation for the standards, | | |
| Contents of the Subject /Subject Plan | Day 1. Cosmic rays<br>Day 2. Energy spectrum and chemical composition of low energy cosmic rays<br>Day 3. Transport equation for the cosmic ray propagation<br>Day 4. Leaky box model<br>Day 5. Acceleration of cosmic rays<br>Day 6. Fermi acceleration<br>Day 7. Air shower phenomenon<br>Day 8. Several methods for air shower observations<br>Day 9. On going projects and recent results for the studies of cosmic rays below 10 PeV<br>Day 10. Future plans for studies on cosmic rays below 10 PeV<br>Day 11. Observations of TeV gamma rays<br>Day 12. Propagation of ultra high energy cosmic rays<br>Day 13. Possible sources of ultra high energy cosmic rays<br>Day 14. On going projects and recent results for the studies of ultra high energy cosmic rays<br>Day 15. Future plans for the studies of ultra high energy cosmic rays | | |
| Preparation and Review | To be announced separately. | | |
| Evaluation Method | Grading will be given based on discussions in the classes and reports. | | |
| Comments to Students | It is recommended to complete "Cosmic ray physics I". | | |
| Teaching Materials | T. K. Gaisse, "Cosmic Rays and Particle Physics", Cambridge University Press | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12210011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Astrophysics | | |
| Subject Name(English) | Astrophysics | | |
| Subject Number | SAPL21508 | | |
| Credits | 2 Credits | 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 hierarchy of the universe such as stars, galaxies and the large-scale structure of the cosmos. In the lecture, we will explain the latest observations and experimental results of not only the theory but also various astronomical phenomenon, e.g., high-energy astronomical objects, cosmic rays, gravitational waves, accelerators, and explain how they contribute to the understanding of the universe. | | |
| Contents of the Subject /Subject Plan | 1. General Relativity and Expanding Universe<br>2. Big Bang and Cosmic Microwave Background<br>3. Cosmological Parameters<br>4. Cosmological Constant and Dark Energy<br>5. Large-scale Structure of the Cosmos<br>6. Galaxy<br>7. Evolution of Stars<br>8. Death of Stars (Blackhole, Neutron Star, Supernova)<br>9. High-Energy Astronomical Phenomenon<br>10. Dark matter (Astronomical)<br>11. Dark matter (CDM)<br>12. Early Universe and Particle Physics<br>13. Nucleosynthesis<br>14. Dark Matter<br>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 | | | |
| Teaching Materials | | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12240011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Astro and High EnergyPhysics III | | |
| Subject Name(English) | Selected Topics in Astro and High EnergyPhysics III | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Yoshihiro Seiya | | |
| 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 | | | |
| Remarks2 | | | |

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| Subject Code | SM12270011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Particle Physics III | | |
| Subject Name(English) | Selected Topics in Particle Physics III | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Shoichi Ogio | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12280011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Condensed Matter Physics I | | |
| Subject Name(English) | Condensed Matter Physics I | | |
| Subject Number | SAPL31501 | | |
| Credits | 2 Credits | 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 particles with or without interaction and to understand the coherent state in superconducting state and superfluid state. | | |
| Contents of the Subject /Subject Plan | Part 1 Basic properties of conduction electrons (waves in lattice, classical electric conduction and scattering time)<br>Part 2 (free electron model, periodic boundary condition)<br>Part 3 (Fermi energy level, Fermi degenerate)<br>Part 4 (electronic conduction as free electrons, specific heat of electrons, and Pauli susceptibility)<br>Part 5 Interacting Fermi particles system (Fermi liquid theory and quantum statistical mechanics)<br>Part 6 (quasiparticle distribution function and energy change of the system)<br>Part 7 (spin of electron and Landau parameters)<br>Part 8 (some properties in an equilibrium state; specific heat, magnetic susceptibility, effective mass, compressibility)<br>Part 9 Motion of electrons and transport property (viscosity, thermal conductivity, spin diffusion in Fermi liquid theory)<br>Part 10 (Landau quantization)<br>Part 11 (Hall effect, Quantum Hall effect)<br>Part 12 (other transport phenomena)<br>Part 13 Coherent state<br>Part 14 Superconductivity and superfluidity<br>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 book<br>C. Kittel "Introduction of Solid State Physics" | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12290011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Condensed Matter Physics II | | |
| Subject Name(English) | Condensed Matter Physics II | | |
| Subject Number | SAPL31502 | | |
| Credits | 2 Credits | 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 understood simply by introducing the interaction with an external magnetic field; the concept of elementary excitations, such as magnon, plasmon, phonon, exciton, etc. Students are expected to gain an understanding of physical properties of elementary excitations in external fields. | | |
| Contents of the Subject /Subject Plan | 1. Electron in a magnetic field; Paramagnetism and diamagnetism<br>2. Dirac equation<br>3. Spinorbit interaction<br>4. Exchange interaction and Hund's rules<br>5. Ferromagnetism and antiferromagnetism<br>6. Magnetic anisotropy and domains<br>7. Magnon<br>8. X-ray crystallography<br>9. Lattice vibration and phonon 1: acoustic and optical modes<br>10. Lattice vibration and phonon 2: second quantization<br>11. Density of states; Lattice heat capacity; Anharmonic potential<br>12. Drude model; Reflection and refraction<br>13. Plasmon, exciton, polaron, and polariton<br>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:<br>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. | | |
| Remarks2 | | | |

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| Subject Code | SM12300011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Quantum Statistical Physics I | | |
| Subject Name(English) | Quantum Statistical Physics I | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Makoto Tsubota | | |
| Main Theme of the Subject | We will learn the basics of theory of condensed matter physics, low temperature physics. In particular, we will learn the basics of quantum hydrodynamics. | | |
| Goal of the Subject | Students will be able to read the papers by themselves and make some simple analytical and numerical calculations on this topics. | | |
| Contents of the Subject /Subject Plan | | | |
| Preparation and Review | Students should read papers and solve problems proposed in classes. | | |
| Evaluation Method | | | |
| Comments to Students | Students can learn from basics to advanced contents of low temperature physics. | | |
| Teaching Materials | M. Tsubota, M. Kobayashi, H. Takeuchi, Physics Reports 522, 191 (2013) | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12330011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Optical Properties of Condensed Matter | | |
| Subject Name(English) | Optical Properties of Condensed Matter | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Katsuichi Kanemoto | | |
| Main Theme of the Subject | The course concentrates on optical properties of condensed matters, especially functional materials, and their underlying physics.Main topics to be covered: Bacterial photoreceptors, Optical functional materials, and Opto-electronic devices.Recent progresses in the field of optical condensed matter physics will be also surveyed. | | |
| Goal of the Subject | The goals of this lecture are to deeply understand the optical physics of condensed matter and modern laser spectroscopy. The course especially focuses upon photophysics of organic solids and photoreceptor proteins.Topics to be covered include: exciton, motional narrowing, exciton-phonon interaction, self-trapping, photo-induced nucleation, photoinduced electron transfer, dephasing, optically forbidden transition and energy transfer, and atomic spin of transition metals. | | |
| Contents of the Subject /Subject Plan | 1. Fundamentals of optical processes in materials: absorption and fluorescence.2. Introduction to group theory and its relationship with linear optical responses.3. Time evolution operator in Hilbert space; introduction to density operator.4. Nonlinear polarizability in Liouville space.5. Relationship between double-sided Feynman diagrams and nonlinear optical responses.6. Ultra-fast phenomena in biological organelles.7. Examples of nonlinear optical response in photosynthetic systems 1: photon echo and vibronic interaction.8. Examples of nonlinear optical response in photosynthetic systems 2: 2-dimensional spectroscopy and electronic coherence.9. Spectral evaluation of electron-phonon interaction.10. Nonlinear susceptibility of one-dimensional materials.11. Dynamics of photoexcitations in organic semiconductors.12. Photo-induced spin dynamics in semiconductors.13. Physics of solar cells.14. Physics and operating principles of optoelectronic devices.15. Semiconductor lasers and pseudo laser phenomena. | | |
| Preparation and Review | Prerequisite: studying fundamentals of optics and solid state physics. | | |
| Evaluation Method | Grading scheme:<br>Class participation + Assignments + Research Paper Report | | |
| Comments to Students | Original text booklets and supplemental materials should be read in advance. | | |
| Teaching Materials | References: S. Mukamel, Nonlinear Optical Spectroscopy, New York, 1999, Oxford Univesity Press; W. W. Parson, Modern Optical Spectroscopy, Berlin, 2015, Springer. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12350011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Low Temperature Solid State Physics | | |
| Subject Name(English) | Low Temperature Solid State Physics | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Hideo Yano | | |
| Main Theme of the Subject | The course will deepen your understanding of quantum solid systems appearing at low temperature, such as exchange interaction due to the zero point motion of an atom, quantum statistics of bosonic helium 4 or fermionic helium 3, and nuclear magnetism of solid helium 3. | | |
| Goal of the Subject | The course aims at giving students the fundamentals of low temperature physics starting from a microscopic quantum statistics approach. The primary goal of the course is to prepare students for research in low temperature physics and materials science. | | |
| Contents of the Subject /Subject Plan | 1. Physical properties and magnetism at very low temperature<br>2. Nuclear spin ordering at very low temperature<br>3. Characteristics of helium<br>4. Quantum statistics of solid helium<br>5. Phase diagram of helium<br>6. Cooling techniques and experimental methods<br>7. Exchange interaction in solid helium 4 (Boson system)<br>8. Exchange interaction in solid helium 3 (Fermion system)<br>9. Solid helium 3: Nuclear spin interaction<br>10. Solid helium 3: Crystal structure and effective Hamiltonian<br>11. Solid helium 3: Magnetic properties at high temperatures and nuclear magnetic transition<br>12. Solid helium 3: Nuclear spin resonance and spin structure<br>13. Vacancies in solid helium<br>14. Quantum statistics and superfluidity of liquid helium 4<br>15. Exchange interaction and momentum distribution in superfluid helium 4 | | |
| Preparation and Review | Students are encouraged to discuss the lectures and homework material. | | |
| Evaluation Method | The grade will be determined by the attendance rate and the homework. | | |
| Comments to Students | | | |
| Teaching Materials | "The Frontia of Physics 3: Solid Helium at Very Low Temperature (Japanese)", Y. Nagaoka, Kyoritsu Shuppan<br>"Superconductivity, Superfluids and Condensates", J. F. Annett, Oxford University Press | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12360011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Solid State Physics IA | | |
| Subject Name(English) | Selected Topics in Solid State Physics IA | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12400011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Condensed Matter Physics IA | | |
| Subject Name(English) | Selected Topics in Condensed Matter Physics IA | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Akira Oguri | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12440011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Experimental Physics of Cosmic-rays and Elementary Particles I | | |
| Subject Name(English) | Experimental Physics of Cosmic-rays and Elementary Particles I | | |
| Subject Number | SAPL21505 | | |
| Credits | 2 Credits | 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.<br>1. interaction between particle and material<br>2. energy loss (dE/dx)<br>3. proportional chamber<br>4. drift chamber<br>5. Multi Wire Proportional/Drift Chamber (MWPC/MWDC)<br>6. Micro Pattern Gaseous Detector（MPGD）<br>7. resistive plate chamber, Geiger-Muler counter<br>8. semi-conductor detector<br>9. Cherenkov detector, transition radiation detector<br>10. scintillation counter<br>11. calorimeter, neutron detector<br>12. muon detector, neutrino detector<br>13. electronics circuit I (analogue)<br>14. electronics circuit II (transfer circuit, digital)<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM12450011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Experimental Physics of Cosmic-rays and Elementary Particles II | | |
| Subject Name(English) | Experimental Physics of Cosmic-rays and Elementary Particles II | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masako Iwasaki | | |
| Main Theme of the Subject | This course deals with the basic concepts of the data analysis, and data acquisition for the cosmic-rays and elementary particle experiments. It also enhances the development of students' skill in the programming. | | |
| Goal of the Subject | The goals of this course are to<br>- understand the data analysis and data acquisition for the cosmic-rays and elementary particle experiments<br>- be able to use C++ and Python for programming. | | |
| Contents of the Subject /Subject Plan | 1. Introduction: LINUX and Xwindow<br>2. Introduction: Data analysis in cosmic-rays and elementary particle experiments<br>3. C++ programming: Introduction<br>4. C++ programming: Class<br>5. C++ programming: Inheritance<br>6. ROOT programming: Introduction, histogram<br>7. ROOT programming: Random number generation, fitting<br>8. ROOT programming: Event generation with PYTHIA<br>9. ROOT programming: Physics analysis<br>10. Python programming introduction (1)<br>11. Python programming introduction (2)<br>12. Introduction: Data acquisition in cosmic-rays and elementary particle experiments<br>13. DAQ programming: Introduction<br>14. DAQ programming: Distributed detector control system<br>15. DAQ programming: User Interface | | |
| Preparation and Review | There will be home work in the class, and it should be solved by the next class. | | |
| Evaluation Method | Your overall grade in the class will be decided based on class attendance, usual performance, programming performance, and homework. | | |
| Comments to Students | There will be programming excises using PC in the class. | | |
| Teaching Materials | Text will be distributed in the class. | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13060011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Mathematical Physics I | | |
| Subject Name(English) | Mathematical Physics I | | |
| Subject Number | SAMPL1504 | | |
| Credits | 2 Credits | Teaching Method | Lecture／Seminar |
| Main Lecturer | Hiroshi Itoyama | | |
| Main Theme of the Subject | | | |
| Goal of the Subject | | | |
| Contents of the Subject /Subject Plan | | | |
| Preparation and Review | | | |
| Evaluation Method | | | |
| Comments to Students | | | |
| Teaching Materials | | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13070011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Physics II | | |
| Subject Name(English) | Mathematical Physics II | | |
| Subject Number | SAMPL1505 | | |
| Credits | 2 Credits | 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<br>2. non-abelian gauge symmetry<br>3. Yang-Mills theory<br>4. path integral quantization<br>5. gauge fixing<br>6. BRST symmetry<br>7. Faddeev-Popov gauge fixing<br>8. renormalization group<br>9. beta function<br>10. asymptotic freedom<br>11. conformal symmetry<br>12. quantum anomaly<br>13. anomalous dimension<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13080011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Mathematical Physics III | | |
| Subject Name(English) | Mathematical Physics III | | |
| Subject Number | SAMPL1506 | | |
| Credits | 2 Credits | 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<br>2. Vectors and 1-forms; basis of general relativity<br>3. Metric space<br>4. Parallel transport and covariant derivative<br>5. Geodesic equations<br>6. Lie derivative<br>7. Isometry and Killing vector<br>8. Symmetry of spacetime and conservation law<br>9. Canonical formalism of relativistic particles<br>10. Mechanics of Nambu-Goto string<br>11. Mechanical system with constraint conditions<br>12. Constraint and symmetry<br>13. First and second class of constraint<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13090011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Physics IV | | |
| Subject Name(English) | Mathematical Physics IV | | |
| Subject Number | SAMPL1507 | | |
| Credits | 2 Credits | 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<br>2. Poincare symmetry<br>3. Coleman-Mandula theorem<br>4. four-dimensional supersymmetry algebra<br>5. supersymmetry transformation<br>6. chiral multiplet<br>7. vector multiplet<br>8. superspace, superfield<br>9. chiral superfield<br>10. vector superfield<br>11. extended supersymmetry<br>12. supersymmetric algebra in other dimensions<br>13. maximally supersymmetric theories<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13100011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Computational Science | | |
| Subject Name(English) | Computational Science | | |
| Subject Number | | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Yousuke Itoh | | |
| Main Theme of the Subject | In this lecture, we study basics of information theory and logic. Structure and history of computers are briefly reviewed. We learn a few but useful numerical methods using computers. In the latter half, we learn probability and statistics, and how to properly handle data in natural science. | | |
| Goal of the Subject | The aim of the first part of this lectures is to understand boolean algebra and its usage, basics of information, numerical representations of data on a computer, and basics of operation circuits. Students are also expected to gain a sense on history of development of computers.They are supposed to master basics of probability theory and statistics. They are expected to get familiar with numerical algorithms such as Fast Fourier Transform and Markov-Chain Monte-Carlo using or developing simple programs on their own computers. | | |
| Contents of the Subject /Subject Plan | 1. Computer science and information theory, boolean algebra<br>2. Computers and their history<br>3. Numerical figures on a computer<br>4. Basics of operation circuits<br>5. Numerical calculation and programming language<br>6. Random number<br>7. Monte-Carlo method: definition and applications<br>8. Monte-Carlo: Markov-Chain<br>9. Numerical integration, solution of an equation.10. Fast Fourier Transform<br>11. Probability theory, Bayes theorem<br>12. Basics of statistics, error propagation<br>13. Chi-square and regression<br>14. Maximum likelihood<br>15. Goodness of fit | | |
| Preparation and Review | Using standard textbooks, students are expected to be familiar with basics of a computer (how to use one), probability theory and statistics in advance. Homework will be given after lectures, to complete which students need to use their own computers. | | |
| Evaluation Method | Weighted average of results of reports, attendances, and quizzes. | | |
| Comments to Students | For writing reports and programming hands-on session, students are requested to prepare computers by themselves or to obtain ones from their laboratories, or to have rights to use ones in the Osaka-City University Media Center. An editor software or a graph plotter of preference should be installed in the computers. | | |
| Teaching Materials | References: The Review of Particle Physics, W.-M. Yao et al., Journal of Physics, G 33, 1 (2006),<br>Numerical Recipes in C, http://numerical.recipes | | |
| Remarks1 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13110011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Selected Topics in Mathematical Physics I | | |
| Subject Name(English) | Selected Topics in Mathematical Physics I | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Lecture |
| Main Lecturer | Sanefumi Moriyama | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13140011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Sciences A | | |
| Subject Name(English) | Mathematical Sciences A | | |
| Subject Number | SAMPL1501 | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Masato Okado | | |
| 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.<br>1. Introduction<br>2. Definition of the quantized enveloping algebra<br>3. Structure as a Hopf algebra<br>4. Representation theory of Uq(sl2)<br>5. Representation theory of the quantized enveloping algebra (1): Highest weight module<br>6. Representation theory of the quantized enveloping algebra (2): Complete reducibility<br>7. Definition of the crystal basis<br>8. Existence of a crystal basis<br>9. Finite-dimensional modules of quantum affine algebras<br>10. Definition of the Kirillov-Reshetikhin module<br>11. Properties of Kirillov-Reshetikhin modules<br>12. Crystal bases of Kirillov-Reshetikhin modules (1): Existence<br>13. Crystal bases of Kirillov-Reshetikhin modules (2): Structure<br>14. Introduction of the Kerov-Kirillov-Reshetikhin type bijection<br>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 | | | |
| Remarks2 | | | |

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| Subject Code | SM13150011 | Offering Academic Year/Semester | 2019 First Semester |
| Subject Name | Mathematical Sciences B | | |
| Subject Name(English) | Mathematical Sciences B | | |
| Subject Number | SAMPL1502 | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Shin Kato | | |
| Main Theme of the Subject | Minimal surface in the Euclidean 3-space is one of the main objects of study in geometry since early times, and many new significant results are discoverd also in these days. In this lecture, we study basic facts on minimal surfaces, and also surfaces in the Lorentzian 3-space, which are related with physics. In the latter part of the lecture, recent topics are introduced. | | |
| Goal of the Subject | To acquire skills for study of geometry by understanding the theory of minimal surfaces and related topics. | | |
| Contents of the Subject /Subject Plan | [1-3] Curvature of surfaces in the Euclidean 3-space<br>[4-6] Minimal surfaces and variational problems<br>[7-9] Minimal surfaces and flux<br>[10-12] Spacelike maximal surfaces and timelike minimal surfaces in the Lorentzian 3-space<br>[13-15] Recent topics | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM13160011 | Offering Academic Year/Semester | 2019 Second Semester |
| Subject Name | Mathematical Sciences C | | |
| Subject Name(English) | Mathematical Sciences C | | |
| Subject Number | SAMPL1503 | | |
| Credits | 2 Credits | Teaching Method | Lecture |
| Main Lecturer | Sachiko Hamano | | |
| 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<br>II. Harmonic functions<br>III. Analytic continuation and Riemann surfaces<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14020023 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Master's Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Master's Thesis of Science | | |
| Subject Number | SAARC1601 | | |
| Credits | 6 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14020013 | Offering Academic Year/Semester | 2019 First Semester, 2019 Second Semester |
| Subject Name | Advanced Research Course for Master's Thesis of Science | | |
| Subject Name(English) | Advanced Research Course for Master's Thesis of Science | | |
| Subject Number | SAARC1601 | | |
| Credits | 6 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Futoshi Takahashi | | |
| Main Theme of the Subject | Fundamental theory of each specialty. | | |
| Goal of the Subject | To understand systematically the 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 the 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 the adviser. | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14030013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Mathematical Structures | | |
| Subject Name(English) | Exercises in Mathematical Structures | | |
| Subject Number | SAMEX1501 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14040013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Mathematical Structures | | |
| Subject Name(English) | Exercises in Mathematical Structures | | |
| Subject Number | SAMEX1601 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14050013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Mathematical Analysis | | |
| Subject Name(English) | Exercises in Mathematical Analysis | | |
| Subject Number | SAMEX1502 | | |
| Credits | 4 Credits | 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14060013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Mathematical Analysis | | |
| Subject Name(English) | Exercises in Mathematical Analysis | | |
| Subject Number | SAMEX1602 | | |
| Credits | 4 Credits | 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14070013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Fundamental Physics | | |
| Subject Name(English) | Exercises in Fundamental Physics | | |
| Subject Number | SAPE11501 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 field<br>of 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14080013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Fundamental Physics | | |
| Subject Name(English) | Exercises in Fundamental Physics | | |
| Subject Number | SAPE11601 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 field<br>of 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14090013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Astro and High Energy Physics | | |
| Subject Name(English) | Exercises in Astro and High Energy Physics | | |
| Subject Number | SAPE21501 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14100013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Astro and High Energy Physics | | |
| Subject Name(English) | Exercises in Astro and High Energy Physics | | |
| Subject Number | SAPE21601 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14110013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Condensed Matter Physics | | |
| Subject Name(English) | Exercises in Condensed Matter Physics | | |
| Subject Number | SAPE31501 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14120013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Exercises in Condensed Matter Physics | | |
| Subject Name(English) | Exercises in Condensed Matter Physics | | |
| Subject Number | SAPE31601 | | |
| Credits | 4 Credits | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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,<br>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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14130013 | Offering Academic Year/Semester | 2019 First Semester, 2019 Second Semester |
| Subject Name | Advanced Research Course for Master's Thesis of Mathematics I | | |
| Subject Name(English) | Advanced Research Course for Master's Thesis of Mathematics I | | |
| Subject Number | SAARC1501 | | |
| Credits | 6 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Futoshi Takahashi | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM14150013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | Advanced Research Course for Master's Thesis of Physics I | | |
| Subject Name(English) | Advanced Research Course for Master's Thesis of Physics I | | |
| Subject Number | SAARC1501 | | |
| Credits | 6 Credits | Teaching Method | Seminar／Laboratory |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM40010023 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | International Advanced Research Course for Master's Thesis of Science 1 | | |
| Subject Name(English) | International Advanced Research Coursefor Master's Thesis of Science 1 | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Seminar |
| Main Lecturer | Shin Inouye | | |
| 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 | | | |
| Remarks2 | | | |

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|---|---|---|---|
| Subject Code | SM40010013 | Offering Academic Year/Semester | 2019 First Semester,<br>2019 Second Semester |
| Subject Name | International Advanced Research Course for Master's Thesis of Science 1 | | |
| Subject Name(English) | International Advanced Research Coursefor Master's Thesis of Science 1 | | |
| Subject Number | | | |
| Credits | 1 Credit | Teaching Method | Seminar |
| Main Lecturer | Futoshi Takahashi | | |
| 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, 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 a 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 | | | |
| Remarks2 | | | |