International Master Course (IMaC) Okayama

Overview

IMaC-Okayama is an educational program organized by the Graduate School of Natural Science and Technology, Okayama University. IMaC-Okayama provides a high-level education course to international and Japanese students enrolled together in specific master classes. Through this program, IMaC-Okayama encourages students to learn and understand interdisciplinary science. Lectures offered in English, start from generalities in fundamental natural science and technology, become gradually more specific and finally reach the level of research of the professors. This program provides international students with the ideal setting for studying abroad (in Japan): by enrolling in the program, students are not only given the opportunity to study at one of the most prominent universities in Japan, but they can also have benefits of personal experience and enrichment. Students will live and interact among Japanese people, and they will experience first-hand life style.

IMaC-Okayama has been structured to be highly flexible, specifically for students, as they can select their own education program and combine it or not with research periods.

Outline of the course

This course consists of (1) lectures, (2) tutorial-studies and (3) group-works. The lectures (1) are typically delivered with Japanese students. The tutorial-studies (2) are planned by each professor and performed as face-to-face seminar or group seminar at the professor's research group. The group-works (3) are task-solving seminars with several students (including Japanese ones) and contains literature searching, discussion and presentation.

Credit certification

Evaluation of the (1) lectures, (2) tutorial-studies and (3) group works are made by the corresponding professors. Typically, (1) lectures are evaluated by examinations, reports and contribution to the class, (2) tutorial-studies by activity, contribution and reports, (3) group-works by contribution, activity, and final presentation.

The certification is given by the Dean of the Graduate School of Natural Science and Technology, Okayama University. Okayama University will provide students with an official report of their academic records, listing course titles, grades and credits (under our scheme). Recognition of credits (in ECTS) earned at Okayama University is the responsibility of the students' home universities. On the basis of studying hours, our 1 credit by lecture corresponds to 15 studying hours in classes, and that by tutorial study or group work corresponds to 30 studying hours in classes.

Term of this course

The lectures of this course are provided either in the spring semester (the 1st and 2nd quarters) or in the autumn semester (the 3rd and 4th quarters), according to Okayama University academic calendar. The spring semester (the 1st quarter) usually starts 8th April to the early of August, and the autumn semester (the 3rd quarter) starts 1st October to the middle of February (each quarter consists of 8 weeks). The course students can add the studying weeks in a spring break (March) or a summer break (September) for their tutorial-studies and group works.

Expected enrolling students

This course is targeted to the inbound Master course students, who are registered as a regular student in the graduate school of the IMaC-Okayama partner universities*[1] having an international student exchange agreement with Okayama University.

Status of the IMaC-Okayama students

The students enrolling the IMaC-Okayama should apply for a special auditor student (for the other option: see below).

Combined study with research internship

If the exchange students have strong motivation to deepen research approaches and to acquire the knowledge from the lectures in IMaC-Okayama course, and if the designated research supervisor gives permission, they can perform both a research internship in a specific laboratory and attending lectures in IMaC-Okayama. In this case, the prospective students must designate your research supervisor (among professors/associate professors in Graduate School of Natural Science and Technology, Okayama University*[2]) and contact to him/her about your research project prior to the application. For students who wish to perform such a combined study, because the research internship program has a higher priority in our university system, you have to apply for a special research student to the graduate school via the expected supervisor. Please contact to the expected supervisor for the detailed procedures of this application. After approval of your status (as a special research student), you should apply to enroll the lectures in IMaC-Okayama course to the IMaC-Okayama committee.

*[1] If you find some difficulties whether your registered university is the IMaC-Okayama partner university or not, please contact to the IMaC-Okayama committee (imac-gnst@okayama-u.ac.jp).
*[2] In some cases, you can designate you supervisor from other graduate schools or research institutes in Okayama University, depending on the MoU agreement with your registered university.

Academic Curriculum

IMaC-Okayama provides students from partner universities with an excellent opportunity to study interdisciplinary science in Japan with comprehensive learning experiences at Okayama University.

The courses given by the IMaC-Okayama (2021 edition) are listed in the course catalogue.

Timeline for IMaC-Okayama	Spring Semester	Autumn Semester
• Application deadline (for a special auditor student):	**5th November, 2021**	**6th May, 2022**
• Acceptance notice to the applicants:	By 30th November, 2021	By 31th May, 2022
• CESR (for VISA) application:	Immediately after the acceptance*[3]	
• The date of the semester starts:	**8th April, 2022**	**1st October, 2022**

Application procedure

(*a*) Applicants who wish to apply as a special auditor student (without a research internship) must prepare

- Form 1 (Application),
- Form 2 (Statement of Purpose and Study Plan) and
- Form 3 (Letter of Recommendation).

In addition,

- a scanned copy of your passport (only the page showing your picture and name) and
- a Certificate of Enrollment from your institute (Form is attached)

are required.

(*b*) Applicants who wish to combine with a research internship must submit the following items, after approval of the application as a special research student by the expected graduate school,

- Form 1 (Application) and
- Form 2 (Statement of Purpose and Study Plan)

All application forms must be sent by e-mail (as attachments) to:

IMaC-GNST@okayama-u.ac.jp

Any question or inquire should also be sent to this e-mail address.

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*[3] The information about CESR application will be sent to the applicant from the International Affair Department (IAD), Okayama University.

IMaC-Okayama course catalogue

(2022 edition)

Lecutures in IMaC-Okayama, 2022

Course No.	Course Title Sub-title of the Course	Lecturer	Affiliation	Quarter	Day Period	Credit
L1	Introduction to Material Science by using Synchrotron Facility	Naoshi Ikeda	Phys	2Q	Tue 1-2	1
L2	Study of Cosmic Microwave Background Polarization Measurement	Hirokazu Ishino	Phys	2Q	Tue 1-2	1
L3	Carrier transport properties in materials -bulk and surface Transport properties in strong spin-orbit coupling systems: surface states and bulk electronic structure analysed in a newly developed topological approach	Kaya Kobayashi	RIIS(Phys)	3Q	Wed 3-4	1
L4	Advanced materials: metallic, superconducting and magnetic properties From basic concepts to advanced research topics	William Sacks	Sorbonne University	1Q, 2Q	Thur 1-2	1
L5	Solid-state physics and chemistry Electronic properties of graphene: from basic theory to application for FET	Hidenori Goto	RIIS(Chem)	1Q	Mon 1-2	1
L6	Organometallic Catalysis	Yasushi Nishihara	RIIS(Chem)	1Q, 2Q	Tue 1-2	2
L7	Advanced Coordination Chemistry Fundamental Aspect and Recent Advancement in Coordination Chemistry	Takayoshi Suzuki	RIIS(Chem)	1Q, 2Q	Fri 1-2	2
L8	Physical chemistry of interface Transport properties and electronic structures at oxide interfaces	Ritsuko Eguchi	RIIS(Chem)	2Q	Mon 1-2	1
L9	Advanced Analytical Chemistry	Takashi Kaneta	Chem	1Q, 2Q	Mon 1-2	2
L10	Solid State Chemistry Introduction to nuclear magnetic resonance	Kazuma Gotoh	Chem	1Q, 2Q	Wed 4	1
L11	Advanced Synthetic Chemistry Modern Organic Synthesis	Isao Kadota	Chem	1Q, 2Q	Fri 1-2	2
L12	Plasmonics Fabrications and Applications	Nobuyuki Takeyasu	Chem	2Q	Thur 3-4	1
L13	Reaction Mechanisms for Inorganic Compounds Fundamentals of Colloid and Surface Chemistry in Inorganic Synthesis	Takahiro Ohkubo	Chem	3Q	Tue 1-2	1
L14	Ferroelectric and related phenomena Design of new and high-performance catalysts using ferroelectrics	Jun Kano	Applied Chem	2Q	Wed 3-4	1
L15	Energy Materials Phenomenology and energy applications of oxides and dielectrics	Takashi Teranishi	Applied Chem	2Q	Fri 3-4	1
L16	Device Physics Overviews of fundamentals in advanced electronic/photonic/acoustic devices	Kenji Tsuruta	Elect Comm Eng	1Q or 2Q	Mon 7-8	1
L17	Terahertz science and technologies: from millimeter electronics to the mid-infrared	Jean-Louis Coutaz	Savoie Mont-Blanc University	TBA	*TBA	1
L18	Optical spectroscopies and technologies for advanced health and communication systems: from UV to the terahertz	Mircea Gabriel Modreanu	University College Cork-Cork-Ireland	TBA	*TBA	1
L19	Modern Information Retrieval	Manabu Ohta	Computer	1Q, 2Q	Fri 3-4	2
L20	Network Design	Yukinobu Fukushima	Computer	3Q, 4Q	Mon 3-4	2
L21	Advanced Linear Algebra	Zeynep Yucel	Computer	3Q, 4Q	Tue 3-4	2
L22	Media Information Processing Statistical machine learning approaches: neural networks and Bayesian modeling	Koichi Takeuchi	Computer	3Q, 4Q	Thur 1-2	2
L23	Molecular genetic methods and developmental mechanism of Drosophila Learning of animal development using fly	Hitoshi Ueda	Bio	1Q	Mon 5-6	1
L24	Ecological Genetics conservation genetics	Makiko Mimura	Bio	1Q	Tue 1-2	1
L25	Mechanisms of Plant Development Polyamines as pillars of cellular processes	Taku Takahashi	Bio	1Q	Fri 1-2	1
L26	Neurogenetics Advanced neuroscience and genetics for understanding biological clocks	Taishi Yoshii	Bio	3Q	Wed 1-2	1

*TBA = to be announced

Tutorial Studies in IMaC-Okayama, 2022

Course No.	Title of Tutorial Studies: Tutorial Studies in …	Lecturer	Affiliation	E-mail	Day Period	Hours (total)	Credit
T1	Introduction for crystal structure analysis	Naoshi Ikeda	Phys	ikedan@okayama-u.ac.jp	*DAC	15h	0.5
T2	Carrier transport properties in materials -bulk and surface	Kaya Kobayashi	RIIS(Phys)	kayakobayashi77@okayama-u.ac.jp	*DAC	15h	0.5
T3	Magnetism and superconductivity	William Sacks	Sorbonne University	william.sacks@upmc.fr	*DAC	15h	0.5
T4	Mesoscopic physics	Hidenori Goto	RIIS(Chem)	hgoto@okayama-u.ac.jp	*DAC	15h	0.5
T5	Organometallic Chemistry	Yasushi Nishihara	RIIS(Chem)	ynishiha@okayama-u.ac.jp	Mon Anytime	60h	2
T6	Advanced Coordination Chemistry	Takayoshi Suzuki	RIIS(Chem)	suzuki@okayama-u.ac.jp	*DAC	30h	1
T7	Molecular Data Science	Masakazu Matsumoto	RIIS(Chem)	matsu-m3@okayama-u.ac.jp	Wed 5-6	20h	1
T8	Advanced Organic Chemistry	Isao Kadota	Chem	kadota-i@okayama-u.ac.jp	*DAC	30h	1
T9	Advanced Ferroelectric Science	Jun Kano	Applied Chem	kano-j@cc.okayama-u.ac.jp	*DAC	30h	1
T10	Advanced Device Physics	Kenji Tsuruta	Elect Comm Eng	tsuruta@okayama-u.ac.jp	*DAC	30h	1
T11	Terahertz science and technologies: from millimeter electronics to the mid-infrared	Jean-Louis Coutaz	Savoie Mont-Blanc University	jean-louis.coutaz@univ-savoie.fr	*TBA	16h	0.5
T12	Molecular Genetics/ Molecular Biology	Tatsuhiko Abo	Bio	tabo@okayama-u.ac.jp	*DAC	30h	1
T13	Behavioral Genetics	Hideki Nakagoshi	Bio	goshi@cc.okayama-u.ac.jp	*DAC	15h	0.5
T14	Plant Developmental Biology	Taku Takahashi	Bio	perfect@okayama-u.ac.jp	*DAC	15h	0.5

*DAC = decide after consultation with the students
*TBA = to be announced

Lecture Schedule in IMaC-Okayama, 2021

Quarter 1

Period / Day	Mon	Tue	Wed	Thur	Fri
Period 1 8:40-9:30	L5. Goto L9. Kaneta	L6. Nishihara L24. Mimura		L4. Sacks	L7. Suzuki L11. Kadota L25. Takahashi
Period 2 9:40-10:30	L5. Goto L9. Kaneta	L6. Nishihara L24. Mimura		L4. Sacks	L7. Suzuki L11. Kadota L25. Takahashi
Period 3 10:45-11:35					L19. Ohta
Period 4 11:45-12:35			L10. Gotoh		L19. Ohta
Period 5 13:25-14:15	L23. Ueda				
Period 6 14:25-15:15	L23. Ueda				
Period 7 15:25-16:15	L16. Tsuruta?				
Period 8 16:25-17:15	L16. Tsuruta?				

Quarter 2

Period / Day	Mon	Tue	Wed	Thur	Fri
Period 1 8:40-9:30	L8. Eguchi L9. Kaneta	L1. Ikeda L2. Ishino L6. Nishihara		L4. Sacks	L7. Suzuki L11. Kadota
Period 2 9:40-10:30	L8. Eguchi L9. Kaneta	L1. Ikeda L2. Ishino L6. Nishihara		L4. Sacks	L7. Suzuki L11. Kadota
Period 3 10:45-11:35			L14. Kano	L12. Takeyasu	L15. Teranishi L19. Ohta
Period 4 11:45-12:35			L10. Gotoh L14. Kano	L12. Takeyasu	L15. Teranishi L19. Ohta
Period 5 13:25-14:15					
Period 6 14:25-15:15					
Period 7 15:25-16:15	L16. Tsuruta?				
Period 8 16:25-17:15	L16. Tsuruta?				

Quarter 3

Period / Day	Mon	Tue	Wed	Thur	Fri
Period 1 8:40-9:30		L13. Ohkubo	L26. Yoshii	L22. Takeuchi	
Period 2 9:40-10:30		L13. Ohkubo	L26. Yoshii	L22. Takeuchi	
Period 3 10:45-11:35	L20. Fukushima	L21. Yucel	L3. Koboyashi		
Period 4 11:45-12:35	L20. Fukushima	L21. Yucel	L3. Kobayashi		
Period 5 13:25-14:15					
Period 6 14:25-15:15					
Period 7 15:25-16:15					
Period 8 16:25-17:15					

Quarter 4

Period / Day	Mon	Tue	Wed	Thur	Fri
Period 1 8:40-9:30				L22. Takeuchi	
Period 2 9:40-10:30				L22. Takeuchi	
Period 3 10:45-11:35	L20. Fukushima	L21. Yucel			
Period 4 11:45-12:35	L20. Fukushima	L21. Yucel			
Period 5 13:25-14:15					
Period 6 14:25-15:15					
Period 7 15:25-16:15					
Period 8 16:25-17:15					

IMaC-Okayama Syllabus (lectures)

No.	L1
Lecture title	Introduction to Material Science by using Synchrotron Facility
Sub-title of the lecture	
Lecturer	Naoshi Ikeda
Contact E-mail	ikedan@okayama-u.ac.jp
Affiliation	Department of Physics
position	professor
Specialty	
Quarter	Quarter 2
Day	Tuesday
Period	Period 1&2
Hours/Credits	20 hours / 1 credits
Lecture plan	I. Introduction: Character of Synchrotron Radiation X-ray ••• 2 Hours The lecture starts from the introduction of the character of synchrotron radiation X-ray. The explanation of how the synchrotron light is generated and why it has the excellent characters (blight, low divergence, extremely polarized, variable energy, having time structure) are given.
	II. EXAFS experiment and anomalous atomic scattering factor ••• 6 Hours This chapter provides the basics on the interaction of X-ray and atoms. The explanation on atomic X-ray scattering factor is given. The excitation state of atoms by X-ray appears in the anomalous X-ray scattering factor. The details of EXAFS experiment will be explained in order to understand such anomalous scattering effect and to get a good example on the synchrotron experiment utilizing for material science.
	III. Crystal Structure Analysis ••• 6 Hours This chapter provides the crystal structure analysis which has long history for the basis of the material science. The lecture explain the Fourier transformation, concept of reciprocal space, extinction rule in diffraction signals, the calculation of the structure factor and the fundamental calculation of the structure estimation.
	IV. Resonant X-ray Scattering ••• 6 Hours Using the energy dependence of the atomic scattering factor we can enhance the specific atomic signal in the diffraction data, which is called as an anomalous scattering method. The enhancement can be estimated through the calculation of the crystal structure factor. Such signal enhancement become strong near the energy absorption edge of the specific atom, which has similar origin with the EXAFS experiment, as called resonant X-ray scattering. This chapter describe the resonant and / or anomalous scattering on some interesting charge ordering materials.

IMaC-Okayama Syllabus (lectures)

No.	L2
Lecture title	Study of Cosmic Microwave Background Polarization Measurement
Sub-title of the lecture	
Lecturer	Hirokazu Ishino
Contact E-mail	scishino@s.okayama-u.ac.jp
Affiliation	Department of Physics
position	Professor
Specialty	
Quarter	Quarter 2
Day	Tuesday
Period	Period 1 and 2
Hours/Credits	16 hours / 1 credits
Lecture plan	Introduction to General Relativity — 4 Hours In this lecture we first introduce general relativity theory. Students will learn the basics of the derivation of Einstein's equation which associates space-time curvature with matter and radiation energy and momentum. We use the variational principle approach to derive the equation. Assuming a homogeneous isotropic universe of Einstein's equation, we derive the Friedmann equation to determine how the space expands.
	Theoretical basis of Cosmology — 6 Hours Following the previous chapter, students will learn the theoretical framework of the expansion of the universe based on Friedmann equations. The space expansion in the universe is governed by the contents contained in it. We discuss the thermal history of the universe, Big Bang nucleosynthesis and the production of the Cosmic Microwave Background (CMB) Radiation. Students will learn how the age of the universe is obtained based on the measurement values with the Lambda-CDM model which is one of the standard models of the universe.
	Experimental techniques of the CMB measurements — 4 Hours Finally students will learn the experimental techniques for the detection of the micro-wave radiation from the sky. We will introduce the basics of the radio astronomy experimental techniques. Students will learn the concept of the noise equivalent power with Fourier transformation and noise equivalent temperature which is used to identify the sensitivity of the experiments. We will introduce the experiments and future plans including a satellite project LiteBIRD to detect the CMB B mode polarization.
	Group discussion and presentation for CMB physics — 2 Hours Student groups will be formed to conduct group discussions on topics related to the CMB physics the group selects. Each group will give an oral presentations for 20 minutes and will discuss with other groups to deepen their understanding.
	••• bb Hours
	••• cc Hours

IMaC-Okayama Syllabus (lectures)

No.	L3
Lecture title	Carrier transport properties in materials -bulk and surface
Sub-title of the lecture	Transport properties in strong spin-orbit coupling systems: surface states and bulk electronic structure analysed in a newly developed topological approach
Lecturer	Kaya Kobayashi
Contact E-mail	kayakobayashi77@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	Associate Professor
Specialty	Condensed Matter Physics, Superconductivity
Quarter	Quarter 3
Day	Wednesday
Period	Period 3&4
Hours/Credits	20 hours / 1 credits
Lecture plan	I. Introduction to electrical and heat transport properties ••• 4 Hours The electronic transport properties in metals are briefly reviewed. They are understood in terms of electronic states analysis. Specific transport properties will be connected with singularities in electronic states structure The lecture starts from a quick overview of various effects reported, showing the similarities and differences in the materials. The well-known transport phenomena have been recently reviewed and categorized as a function of topological properties. The new breakthroughs obtained by using this innovative approach will be presented and examples will be given. The lecture will focus on the formalization of conduction in electrical and thermal transport. An understanding of longitudinal and off-diagonal transport differences will be provided.
	II. Principle of transport theory ••• 6 Hours Formal transport theory is discussed starting from continuum media. Deriving the Boltzmann equation and formalization of transport coefficients are given followed by some examples. In addition to electronic transport theory, the thermopower and the measurement techniques are also discussed.
	The transport properties in metals are presented in the perspective of the electronic states in the vicinity of Fermi energy. The formalism is treated by using a combination of semiclassical scheme and quantum treatment. Both treatments could be expanded when the spin-orbit interaction is strong, whereas usually the orbital information cannot be treated as independent eigen states. ••• 5 Hours
	IV. Transport in a magnetic field ••• 5 Hours The transport properties show even more rich physics in magnetic fields starting from the quantum oscillations and Hall effect that give us enormous electronic state information. Recent development of spin Hall effect and anomalous Hall effect triggered the establishment of topological aspect of existing materials. The lecture discusses these new effects proposed and detected in semiconductors/metals/semimetals/magnets. The lecture briefly touches the relation between various off-diagonal effects observed in those materials and how these exotic states are realized in the materials.

IMaC-Okayama Syllabus (lectures)

No.	L4
Lecture title	Advanced materials: metallic, superconducting and magnetic properties
Sub-title of the lecture	From basic concepts to advanced research topics
Lecturer	William Sacks
Contact E-mail	william.sacks@upmc.fr
Affiliation	IMPMC laboratory, Sorbonne University - Paris (France)
position	Professor
Specialty	Condensed matter theory, superconductivity, tunneling spectroscopy
Quarter	Quarter 1&2
Day	Thursday
Period	Period 1&2
Hours/Credits	24 hours / 1 credits
Lecture plan	*Prerequisites:* – A good working knowledge of solid state physics and quantum mechanics (Kittel level, or Shini-ichi Uchida). – Motivation to explore challenging states of matter and their theoretical concepts. **Outline:** The course is organized so that students will: • Gain knowledge of the physical properties of exotic materials and their theoretical base. • Investigate a number of challenging condensed phases such as superconductivity, charge density waves, vortex states, etc. • Gain a working knowledge of important experimental tools such as local (STM) and non-local (ARPES) electron spectroscopies. The most advanced research topics will be discussed: Majorana fermions, topological superconductivity, giant vortices, ultra-thin SC films. A wide variety of materials will be discussed: cuprates, pnictides, iridates, chalcogenides, etc.
	I. Introduction to solid state physics and novel materials ••• 4 Hours The course begins with an introductory review of materials having a wide range of electronic properties. We question why a given material is an insulator, semiconductor or superconductor. What are the essential parameters, and can new materials be tailored for specific physical properties? *Note: this chapter is a useful review of atomic structure, bonding, band theory of solids, and key features of a Fermi gas.*

	II. The metallic state and its instabilities The quantum theory of the metallic state is studied in more detail. Then, we consider important phase transitions to new 'ordered' states. The Landau model of higher-order phase transitions is a powerful tool, in which the free-energy and 'order parameter' play a central role. Collective phenomena such as charge density waves, magnetic states and superconductivity, are important examples. In each case, the phase transition is driven by a key microscopic electron-electron or electron-ion interaction.	••• 4 Hours
	III. Magnetism and magnetic materials This chapter introduces the concept of magnetism as a collective state formed by either ionic or electronic magnetic moments. Paramagnetism, ferromagnetism and anti-ferromagnetism will be illustrated by the Weiss molecular-field, Heisenberg and other models, emphasizing the important physical properties of the materials. Many applications will be presented.	••• 4 Hours
	IV. Conventional superconductivity: Ginzburg-Landau, London and BCS theories This chapter traces the historical challenge of understanding one of physics most exotic phenomena: superconductivity. The pre-BCS theoretical approaches will be studied in detail followed by the full microscopic BCS (Bardeen, Cooper, Schrieffer) model. A variety of key supporting experiments (thermodynamic, transport and electron spectroscopies), will be presented and discussed.	••• 4 Hours
	V. The high-Tc cuprate and iron-based superconductors An outstanding problem today is the unconventional high-Tc superconductivity of cuprates. In this chapter, the properties of both cuprates, and the related iron-based superconductors, will be discussed in detail. A selection of recent high-quality experiments will be presented accompanied by the insight of various important models.	••• 4 Hours
	VI. Phase sensitive and quantum effects: vortices, Josephson effects, SQUID, Shapiro steps This chapter reviews more advanced topics which strongly depend on the quantum nature of the order parameter, in particular the phase. Both fundamental aspects and device applications are important, in particular the SQUID magnetometer and high-frequency filters. Modern fundamental topics include Majorana fermions, giant vortices and topological superconductivity.	••• 4 Hours

IMaC-Okayama Syllabus (lectures)

No.	L5
Lecture title	Solid-state physics and chemistry
Sub-title of the lecture	Electronic properties of graphene: from basic theory to application for FET
Lecturer	Hidenori Goto
Contact E-mail	hgoto@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	associate professor
Specialty	Mesoscopic physics
Quarter	Quarter 1
Day	Monday
Period	Period 1&2
Hours/Credits	15 hours / 1 credits
Lecture plan	The aim of this lecture is to learn how to understand electronic states and quantum phenomena in solids based on a simple but profound two-dimensional material, graphene.
	I. Band theory in solids ••• 4 Hours The lecture starts by introducing basic band theories to describe electronic states in crystals.
	II. Crystal and band structures of graphene ••• 4 Hours The band structure of graphene is deduced on a tight-binding model. The linear dispersion relation between energy and momentum with a topological singularity is discussed.
	III. Transport and magnetic properties of graphene ••• 4 Hours The peculiar transport properties resulting from the topological singularity, such as the absence of back-scattering and the half-integer quantum Hall effect, are discussed.
	IV. Application for graphene FETs ••• 3 Hours Practical application of graphene for field-effect transistors (FETs) is mentioned. The characteristics of graphene FETs are compared with those of conventional inorganic FETs.

IMaC-Okayama Syllabus (lectures)

No.	L6
Lecture title	Organometallic Catalysis
Sub-title of the lecture	Organometallic Catalysis
Lecturer	Yasushi NISHIHARA
Contact E-mail	ynishiha@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	Professor
Specialty	Synthetic Organic Chemistry
Quarter	Quarter 1 & 2
Day	Tuesday
Period	Period 1&2
Hours/Credits	30 hours / 2 credits
Lecture plan	I. Organometallic Chemistry and Catalytic Reactions — 5 Hours The lecture starts by introducing some typical examples and recent topics in organometallic chemistry and catalytic reactions. An overview of this course will be provided.
	II. Organometallic Chemistry and Reaction Mechanism — 5 Hours This chapter provides the reaction mechanism of organometallic chemistry. Fundamental reactions in the catalytic cycles are discussed.
	III. Hydroformylation and Related Reactions — 4 Hours This chapter provides the hydroformylation and its related reactions. Four types of catalytic hydroformylation are discussed.
	IV. Acetic Acid and Acetyl Compounds — 6 Hours This chapter provides the synthetic routes of acetic acid and acetyl compounds. In particular, the Wacker oxidation, Monsanto process and their reaction mechanisms are discussed.
	V. Nylon Intermediate — 4 Hours This chapter provides the synthetic routes of Intermediates related to Nylon. In particular, the Hydrocyanation of 1,4-butadiene and its reaction mechanism are discussed.
	VI. Oligomerization and Polymerization of Olefins — 6 Hours This chapter provides transition-metal-catalyzed oligomerization and polymerization of olefins. In particular, SHOP (Shell Higher Order Process) and its reaction mechanism are discussed.

IMaC-Okayama Syllabus (lectures)

No.	L7
Lecture title	Advanced Coordination Chemistry
Sub-title of the lecture	Fundamental Aspect and Recent Advancement in Coordination Chemistry
Lecturer	Takayoshi Suzuki
Contact E-mail	suzuki@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	professor
Specialty	Coordination Chemistry
Quarter	Quarter 1 & 2
Day	Friday
Period	Period 1&2
Hours/Credits	30 hours / 2 credits
Lecture plan	I. Introduction: Overview of this course ••• 2 Hours The lecture starts by introducing some typical examples and recent topics in coordination chemistry. An overview of this course will be provided.
	II. Structural Coordination Chemistry ••• 6 Hours This chapter provides the diversity and specificity of coordination compounds. Stereochemistry and isomerism of coordination compounds, syntheses and functionality of metal-organic frameworks and cluster compounds are discussed.
	III. The Angular Overlap Model ••• 4 Hours This chapter provides one of the basic and important theoretical approach, AOM, for understanding the structures and properties of coordination compounds.
	IV. Spectroscopic, Magnetic and Electrochemical Properties ••• 8 Hours This chapter provides the fundamental idea and basic theory to understand the characteristic properties of coordination compounds, e.g. ligand-field spectra, spin-cross over and magnetism, and multi-redox properties.
	V. Photochemistry and Photophysics ••• 4 Hours This chapter provides some recent examples and fundamental knowledge for photochemistry and photophysics of coordination compounds. The photo-functionality is one of the current topics in coordination chemistry.
	VI. Bioinorganic Chemistry ••• 6 Hours This chapter provides advanced idea how the coordination compounds act as catalysts for small molecule activation in organism. The reaction mechanism using an active metal centre is fascinating.

IMaC-Okayama Syllabus (lectures)

No.	L8
Lecture title	Physical chemistry of interface
Sub-title of the lecture	Transport properties and electronic structures at oxide interfaces
Lecturer	Ritsuko Eguchi
Contact E-mail	eguchi-r@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	Assistant professor
Specialty	Solid state physics
Quarter	Quarter 2
Day	Monday
Period	Period 1&2
Hours/Credits	1 credits
Lecture plan	I. Introduction: Overview of this course ••• 1 Hours An overview of this course is explained; interesting physical properties and recent topics in oxide heterostructures which has interfaces between different perovskite-type transition metal oxides.
	II. Fundamentals of Solid State Physics ••• 5 Hours This chapter provides an introduction to solid state physics, including the crystal and electronic structures of solids, for understanding the physics of transition metal oxides.
	III. Transport properties in transition metal oxides ••• 4 Hours This chapter provides electrical transport properties of transition metal oxides, e.g. metal-insulator transition and superconductivity.
	IV. Physical properties at oxide interfaces ••• 5 Hours This chapter provides experimental topics of emergent phenomena at oxide interfaces. Oxide heterostructures show extraordinary physical properties, e.g. interface superconductivity and magneto-electric coupling.
	••• bb Hours
	••• cc Hours

IMaC-Okayama Syllabus (lectures)

No.	L9	
Lecture title	Advanced Analytical Chemistry	
Sub-title of the lecture		
Lecturer	Takashi Kaneta	
Contact E-mail	kaneta@okayama-u.ac.jp	
Affiliation	Graduate School of Natural Science and Technology	
position	Professor	
Specialty	Analytical Chemistry	
Quarter	Quarter 1 & 2	
Day	Monday	
Period	Period 1&2	
Hours/Credits	30 hours / 2 credits	
Lecture plan	Types and characteristics of lasers: Fundamentals on the principle of laser oscillation, types, and characteristics will be described.	••• 4 Hours
	Safety consideration of lasers: General consideration of the safety in the use of lasers will be described.	••• 4 Hours
	Laser spectroscopy: The principles of several spectroscopies using lasers will be described.	••• 10 Hours
	Application of laser spectroscopy to bioanalysis: Recent applications of laser spectroscopies in the field of analytical chemistry will be	••• 12 Hours

IMaC-Okayama Syllabus (lectures)

No.	L10
Lecture title	Solid State Chemistry
Sub-title of the lecture	Introduction to nuclear magnetic resonance
Lecturer	Kazuma Gotoh
Contact E-mail	kgotoh@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Assosiate Professor
Specialty	Physical Chemistry
Quarter	Quarter 1 & 2
Day	Wednesday
Period	4
Hours/Credits	15 hours / 1 credits
Lecture plan	Basic Principles of Nuclear Magnetic Resonance (NMR) : ••• 4 Hours NMR spectroscopy is one of the most powerful techniques for determining molecular-level structure and dynamics, which is applicable not only to solution but also to solid samples. The basic principles for solid-state NMR are introduced.
	Shielding, Chemical Shift, and Dipole /Quadrupole Coupling : ••• 4 Hours Some interactions between nuclei and the surrounding environment are critical to the shape and the peak shift of NMR spectra.
	Essential Techniques for Solid-State NMR : ••• 4 Hours The basic and important technique to obtain solid-state NMR spectra are explained.
	Applications : ••• 3 Hours Solid-state NMR analysis is applied to several organic and inorganic materials. Some representative examples will be shown.

IMaC-Okayama Syllabus (lectures)

No.	L11	
Lecture title	Advanced Synthetic Chemistry	
Sub-title of the lecture	Modern Organic Synthesis	
Lecturer	Isao Kadota	
Contact E-mail	kadota-i@okayama-u.ac.jp	
Affiliation	Division of Molecular Sciences, Graduate School of Natural Science and Technology	
position	Professor	
Specialty	Organic Chemistry	
Quarter	Quarter 1 & 2	
Day	Friday	
Period	Period 1&2	
Hours/Credits	30 hours / 2 credits	
Lecture plan	I. Synthetic Design The lecture starts be intriducing the importance of synthetic design and the concept of retrosynthetic analysis for multi-step synthesis.	••• 4 Hours
	II. Stereochemical Considerations in Planning Syntheses This chapter describes the conformational analysis of cyclic and acyclic molecules, and the importance for the stereoselectivities.	••• 4 Hours
	III. The Concept of Protecting Functional Groups This chapter describes the variety of protective groups, and the methods for the intriduction and removal of the protective groups.	••• 4 Hours
	IV. Oxidation and Reduction This chapter describes the typical conditions and features of oxidation and reduction of organic molecule.	••• 8 Hours
	V. Reactions of Carbon-Carbon Double Bonds This chapter describes the characteristic reactions of carbon-carbon double bonds.	••• 4 Hours
	VI. Reactions of Carbon-Carbon Triple Bonds This chapter describes the characteristic reactions of carbon-carbon tirple bonds.	••• 4 Hours
	VII. Conclusion and Examination The chapter provides a conclusion and some examinations to understand the inpotance of synthetic design for the multi-step synthesis.	••• 4 Hours

IMaC-Okayama Syllabus (lectures)

No.	L12	
Lecture title	Plasmonics	
Sub-title of the lecture	Fabrications and Applications	
Lecturer	Nobuyuki Takeyasu	
Contact E-mail	takeyasu@okayama-u.ac.jp	
Affiliation	Chemistry	
position	Associate prof.	
Specialty	Plasmonic materials, Nanophotonics	
Quarter	Quarter 2	
Day	Thursday	
Period	Period 3&4	
Hours/Credits	16 hours / 1 credits	
Lecture plan	I. Introduction: Overview of this course The lecture starts by introducing history and recent topics in the research field of plasmonics. An overview of this course will be provided.	••• 1 Hours
	II. Fundamentals: This chapter provides the fundamentals of plasmonics. Surface plasmon polaritons, excitation of surface plasmon polaritons, localize surface plasmons etc. are discussed including electromagnetics.	••• 5 Hours
	III. Plasmonic materials/devices: This chapter provides plasmon waveguides and extraordinary transmission, metamaterials including the fabrication methods.	••• 5 Hours
	IV. Spectroscopy, Sensing and Imaging: This chapter provides enhancement of emissive processes, such as Raman and fluorescence, and the sensing/imaging applications including the fabrication methods.	••• 5 Hours

IMaC-Okayama Syllabus (lectures)

No.	L13
Lecture title	Reaction Mechanisms for Inorganic Compounds
Sub-title of the lecture	Fundamentals of Colloid and Surface Chemistry in Inorganic Synthesis
Lecturer	Takahiro Ohkubo
Contact E-mail	ohkubo@okayama-u.ac.jp
Affiliation	Department of Chemistry
position	Associate Professor
Specialty	Inorganic Chemistry
Quarter	Quarter 3
Day	Tuesday
Period	Period 1&2
Hours/Credits	16 hours / 1 credits
Lecture plan	I. Introduction: Colloidal state ••• 2 Hours The lecture starts by introducing some fundamental concepts and state-of-the-art topics in colloid and interface chemistry. Especially, the importance of fundamental concepts in colloid and interface chemistry in the synthesis of ordered nanoporous materials will be provided.
	II. Liquid-gas and liquid-liquid interfaces ••• 8 Hours This chapter provides fundamentals of some liquid interfaces. First, some important points of surface tension (or surface free energy) will be discussed. Then some practical examples related to surface tension will be provided. Finally, the concept of surface tension will be applied to liquid-liquid interfaces with a fundamental theorem in thermodynamics.
	III. Solid-gas interface ••• 4 Hours This chapter provides some basic concepts related to adsorption phenomena at solid interfaces.
	IV. Nanoporous materials from soft templates ••• 2 Hours This chapter summarizes the importance of colloid and surface chemistry by demonstrating some important method to synthesize ordered nanoporous materials including mesoporous metal oxides and silica-templated carbons.

IMaC-Okayama Syllabus (lectures)

No.	L14
Lecture title	Ferroelectric and related phenomena
Sub-title of the lecture	Design of new and high-performance catalysts using ferroelectrics
Lecturer	KANO Jun
Contact E-mail	kano-j@cc.okayama-u.ac.jp
Affiliation	Division of Applied Chemistry, Graduate School of Natural Science and Technology
position	Associate professor
Specialty	Solid-state physics, Catalytic chemistry
Quarter	Quarter 2
Day	Wednesday
Period	Period 3&4
Hours/Credits	16 hours / 1 credit
Lecture plan	I. Introduction: Overview of this course ••• 2 Hours The lecture starts by introducing essential background and recent topics in ferroelectric materials. An overview of this course will be provided.
	II. Dielectric Property and phonon dynamics ••• 7 Hours This chapter provides the fundamental ferroelectric properties observed dielectric measurement and inelastic scattering such as Raman, Brillouin and terahertz spectroscopies.
	III. Semiconducting property of ferroelectrics ••• 7 Hours We can treat ferroelectric materials as semiconductor with wide band gap. This chapter provides firstly the fundamental knowledge of semiconductor, and then try to understand a characteristic behavior of ferroelectric semiconducting property. Finally, the application will be introduced such as electron tunneling, photo volatile, photocatalysis, and oxidation-reduction catalysis.

IMaC-Okayama Syllabus (lectures)

No.	L15	
Lecture title	Energy Materials	
Sub-title of the lecture	Phenomenology and energy applications of oxides and dielectrics	
Lecturer	Takashi Teranishi	
Contact E-mail	terani-t@cc.okayama-u.ac.jp	
Affiliation	Applied Chemistry	
position	Associate professor	
Specialty	Functional Ceramics, Dielectrics, Ferroelectrics	
Quarter	Quarter 2	
Day	Friday	
Period	Period 3&4	
Hours/Credits	16 hours / 1 credits	
Lecture plan	I. Introduction: Overview of this course The lecture provides introduction of energy applications and functional materials utilized to those energy devices.	2 Hours
	II. Functional electro-ceramics This chapter provides basics of dielectrics, semi-conductor, and ion-conductor ceramics. Polarization mechanism in dielectrics, valence control in semi-conductors, and ion conduction mechanism in oxides are explained.	2 Hours
	III. Phenomenology of dielectric and ferroelectric ceramics The lecture provides basic idea of dielectrics, piezoelectrics and ferroelectrics. The origin of dielectric polarization and role of ferroelectric domains are explained. The lecture also explains dielectric dispersion phenomenon as well as thermodynamics in ferroelectrics linked to Landau theory.	4 Hours
	IV. Applications of electro-ceramics: From capacitors to batteries This chapter introduces the various applications of functional electro-ceramics; from conventional ceramic capacitors and ferroelectric memories to next generation secondary batteries.	4 Hours
	V. Group work/debate related to energy materials	4 Hours

IMaC-Okayama Syllabus (lectures)

No.	L16
Lecture title	Device Physics
Sub-title of the lecture	Overviews of fundamentals in advanced electronic/photonic/acoustic devices
Lecturer	Kenji TSURUTA
Contact E-mail	tsuruta@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Professor
Specialty	Materials Science, Device Physics
Quarter	Quarter 1 OR 2
Day	Monday
Period	7&8
Hours/Credits	16 hours / 1 credits
Lecture plan	**** Students can choose any two topics from II-V listed below. ****
	I Introduction: Overview of the course ••• 2 Hours The lecture starts by introducing recent topics in novel electronic/photonic/acoustic devices. An overview of this course will be provided.
	II Semiconductor Devices ••• 7 Hours This chapter deals with essential contents in solid-state and semiconductor physics.
	III Photonic Devices ••• 7 Hours This chapter provides fundamental theories for solar cell, optical fiber, laser, photonic crystal, and plasmonic devices. Methodologies of numerical simulations for those topics will also be covered.
	IV Acoustic Devices ••• 7 Hours Beginning with fundamental theories of elasticity, this chapter provides the essence acoustic /elastic devices including piezoelectric device, surface-acoustic device, and phononic crystal. Methodologies of numerical simulations for those topics will also be covered.
	V Electronic Theories for Nanostructure Devices ••• 7 Hours This chapter provides outline of contemporary methodologies of materials simulations for nanostructured devices, based mainly on the density-functional theory (DFT). Applications of the method include semiconductor nanodevices (quantum wire/dot), metallic nanoparticles.

IMaC-Okayama Syllabus (lectures)

No.	L17
Lecture title	Terahertz science and technologies: from millimeter electronics to the mid-infrared
Sub-title of the lecture	
Lecturer	Jean-Louis COUTAZ
Contact E-mail	jean-louis.coutaz@univ-savoie.fr
Affiliation	IMEP-LAHC laboratory, Savoie Mont-Blanc University – Chambéry - France
Position at origin University	Emeritus Professor
Specialty	Terahertz spectroscopy and technology, Ultrafast optoelectronics
Quarter	TBA
Day	TBA
Period	TBA
Hours/Credits	20 hours / 1 credits
Lecture plan	*Prerequisites:* – A good working knowledge of photonics (Saleh and Teich) and solid state physics (Kittel), – Optics, electromagnetism and solid state physics (master level). – Motivations to explore one of the most active research and development domain of modern science and technology. **Outline:** The course is organized so that students will: • Embrace the whole amazing modern topic of THz science and technologies, from fundamental principles to present academic and applied researches and industrial developments. • Understand the whole intellectual process from the physical basics of a given phenomenon to the conception, realization, characterization and use of components, devices and instruments. • Get more insight in the physical and technological notions through illustration by recent published results.
	I An introduction to THz science and technology This lecture will introduce the domain of electromagnetic waves at THz frequencies, with some basic principles and orders of magnitude, an historical overview, and a synthesized description of present researches and developments, as well as a list of foreseen applications.
	II Physics at THz frequencies This chapter describes the main interaction phenomena between THz waves and matter in the solid, liquid and gaseous states. A special emphasis will be given regarding dielectric, conducting, semiconducting and magnetic materials, and collective excitations (phonons, plasmons, etc.) in such materials.

	III Sources, detectors and components This chapter addresses the main emitting and receiving devices that are not driven by a pulsed laser. Sources include thermal radiators, lasers, tubes and large instruments (FEL, synchrotrons). Basic principles and definitions of detection will be explained, like sensitivity, NEP, heterodyne scheme and so on, and then energy detectors (bolometers, micro-bolometers, Golay cells…) will be presented. Electronics emitting and receiving devices, for example Schottky and RTD diodes or nano-transistors, will be described. Finally, this lecture will end up with a presentation of passive and active optical components for the THz.
	IV THz time-domain techniques and studies This topic still constitutes a large part of present research and development activities. The lecture starts with an explanation of the time-frequency conversion, a description of photo-conducting and electrooptic antennas, and of the newly opticaly-induced air-plasma technique. The widely spread THz time-domain spectroscopy technique will be treated, including the extraction of material properties, pump-and-probe studies, polarimetric studies, etc. Comparison with CW optoelectronics techniques will be done.
	V Applications THz researches are strongly driven by numerous applications that will be presented in this chapter. The first part is devoted to sensing (principles and industrial applications), then we will focus on imaging (basics, imaging for the industry, security and defense, biology and medicine). Telecoms at THz frequencies and remote sensing of the Earth will be described. Finally, THz technology for astrophysical observations will be introduced.
	VI High power THz physics Since a couple of years, one can produce very high power THz pulses. Their availability opens the road to a new domain research, namely the highly nonlinear regime, well beyond the classical Bloembergen perturbation model. This chapter will be illustrated with the main techniques to generate such pulses and the main results achieved so far.

IMaC-Okayama Syllabus (lectures)

No.	L18
Lecture title	Optical spectroscopies and technologies for advanced health and communication systems: from UV to the terahertz
Sub-title of the lecture	
Lecturer	Mircea Gabriel MODREANU
Contact E-mail	mircea.modreanu@tyndall.ie
Affiliation	Tyndall National Institute - University College Cork-Cork-Ireland
Position at origin University	Principal Investigator
Specialty	Optical spectroscopies enabling technologies and digital solutions for personalized medicine of the future
Quarter	TBA
Day	TBA
Period	TBA
Hours/Credits	18 hours / 1 credits
Lecture plan	*Prerequisites:* *– Optics, electromagnetism and solid state physics (master level).* *– A good working knowledge of photonics (Saleh and Teich) and solid state physics (Kittel)* *– Motivations to explore one of the most active research and development domains of modern science and technology:* *** Next Generation of modern communication: 5G and 6G* *** Energy autonomous Internet of Things for the 4th Industrial revolution* *** Personalized Medicine of the future* *** Tools, technologies and digital solutions for health*
	Outline: The Course is organized so that students will: • Embrace the whole amazing modern topic of optical spectroscopies and technologies, from fundamental principles to present academic and applied researches and industrial developments. • Understand the rational process from the physical basics of a given phenomenon to the conception, realization, characterization and use of components, devices and instruments. • Understand the principles and practical applications of most popular optical spectroscopies: spectroscopic ellipsometry, optical spectrophotometry, infrared spectroscopy and Raman spectroscopy for biochemistry and medical applications. • Get more insight in the physical and technological notions through illustration by recent published results.
	I An introduction to Optical spectroscopies and technologies This lecture will introduce the domain of electromagnetic waves at optical frequencies, with some basic principles and orders of magnitude, an historical overview, and a synthesized description of present researches and developments, as well as a list of foreseen applications.

	II Physics at optical frequencies This chapter describes the main interaction phenomena between photons and matter in the solid, liquid and gaseous states. A special emphasis will be given regarding polarized light interaction with dielectric, metal and semiconducting materials.
	III Sources, detectors and components This chapter addresses the main components used for spectroscopic ellipsometry, optical spectrophotometry, infrared spectroscopy and Raman spectroscopy: light sources, polarizing components, energy detectors (photodiodes, CCD, infrared and THz detectors…). Basic principles and definitions of detection over various spectral ranges (e.g. UV, Visible, Infrared and THz) will be explained. Finally, this lecture will end up with a presentation of passive and active optical components for the optical spectroscopies.
	IV Applications I: Spectroscopic ellipsometry and Optical spectrophotometry This topic still constitutes a large part of present research and development activities. The first part is devoted to the main application for optical spectrophotometry in several fields of material science for industrial application. The second part will review the main applications of spectroscopic ellipsometry for health oriented systems, photonics, microelectronics, modern communication technologies
	V Applications II: Infrared Spectroscopy and Raman spectroscopy This topic currently constitutes hot topic for present research and development activities. First the lecture will introduce the application of infrared spectroscopy for several industrial applications such as microelectronics, biochemistry and medical studies. Since last two decades' significant advances in the development of lasers sources (from UV to Near-IR) and of the highly sensitive detectors (CCD) allowed the significant development of Raman spectroscopy. Their availability opens the road to the emerging domain research for one and two-dimensional nanomaterials such as carbon nanotubes and graphene. This chapter will be illustrated with the examples of application of Raman spectroscopy for the studies of material for emerging nanoelectronics devices and as well with example of applications of Raman spectroscopy for biochemistry and medical applications.

IMaC-Okayama Syllabus (lectures)

No.	L19
Lecture title	Modern Information Retrieval
Sub-title of the lecture	None
Lecturer	Manabu Ohta
Contact E-mail	ohta-m@cc.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Professor
Specialty	Data Engineering
Quarter	Quarters 1 & 2
Day	Friday
Period	Periods 3 & 4
Hours/Credits	30 hours / 2 credits
Lecture plan	I. Introduction to Information Retrieval (IR) 8 Hours In this lecture, I first explain overview of information retrieval (IR). Students will learn the components of IR systems including indexing methods and queries. They also learn some basic IR models such as Boolean and vector space models. I also introduce some existent IR systems.
	II. Evaluation of IR 4 Hours Following the previous chapter, students will learn evaluation of IR systems, which include important evaluation metrics such as recall and precision for IR. They will also learn prominent IR evaluation frameworks such as the Text REtrieval Conference (TREC) in the US and the NII (National Institute of Informatics) Test Collection for Information Resources (NTCIR) in Japan.
	III. Full-text Search 4 Hours In this chapter, students will learn some famous full-text search techniques such as the signature file and the inverted index.
	IV. Search Engines 4 Hours Search engines are one of the practical IR systems most people use every day. In this chapter, I will introduce the basics of search engines including their crawlers, indexing, and search process. Students will also learn the concept and algorithm of PageRank used by Google search engine to rank Web pages in their search results.
	V. Data Mining and Review 10 Hours Finally students will learn some data mining techniques because data mining is closely related to IR and especially important in this big data era. They will learn association rule mining for discovering interesting rules or patterns in databases by Apriori algorithm and also learn Apriori-based sequential pattern mining.

IMaC-Okayama Syllabus (lectures)

No.	L20
Lecture title	Network Design
Sub-title of the lecture	
Lecturer	Yukinobu Fukushima
Contact E-mail	fukusima@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	associate professor
Specialty	Communication Network Engineering
Quarter	Quarter 3 & 4
Day	Monday
Period	Period 3 & 4
Hours/Credits	30 hours / 2 credits
Lecture plan	I. Introduction: Overview of this course ••• 1 Hours The lecture starts from the introduction of network design. An overview of this course will be provided.
	II. Basics of linear programming ••• 2 Hours This chapter explains basics of linear programming, which is useful in optimally designing and controlling communication networks.
	III. Usage of GLPK (GNU Linear Programming Kit) ••• 1 Hours This chapter introduces the software called GLPK for solving linear programming problems.
	IV. Basic problems for communication networks ••• 6 Hours This chapter explains basic problems for communication networks, which can be tackled by linear programming. This chapter presents formulations and solutions by GLPK for 1) shortest path problem, 2) max flow problem, and 3) minimum-cost flow problem.
	V. Cutting-edge researches on communication networks ••• 20 Hours In this chapter, students survey the cutting-edge researches on communication networks, and solve the problems tackled in them by themselves using GLPK.

IMaC-Okayama Syllabus (lectures)

No.	L21	
Lecture title	Advanced Linear Algebra	
Sub-title of the lecture		
Lecturer	Zeynep Yucel	
Contact E-mail	zeynep@okayama-u.ac.jp	
Affiliation	Graduate School of Natural Science and Technology	
position	Assistant Professor	
Specialty		
Quarter	Quarter 3 & 4	
Day	Tuesday	
Period	3 & 4	
Hours, Credits	30 hours, 2 credits	
Lecture plan	1. Basic matrix definitions and operations, Properties of matrix operations	••• 2 Hours
	2. Systems of linear equations, Geometric interpretation, Elementary row operations, Elimination and Substitution, Equivalent systems	••• 2 Hours
	3. Gaussian elimination, Gauss-Jordan method, Consistency, Linear Combination	••• 2 Hours
	4. Row echelon form and row rank, Solutions of homogeneous systems, Null space, Nonsingular matrices	••• 2 Hours
	5.General form: Particular and complementary solutions, Column space Vectors in R^{nx1}, Linear independence	••• 2 Hours
	6. Vector space, Definitions and properties, Subspaces	••• 2 Hours
	7. Span, Further discussion on linear independence, Basis of a vector space	••• 2 Hours
	8. Dimension of a vector space, Finding a basis, Coordinates and ordered Bases	••• 2 Hours
	9. Change of basis, Linear Transformations	••• 2 Hours
	10. Isomorphisim, Inverse transformation, Matrix representation of linear Transformation	••• 2 Hours
	11. Matrix inverse, Determinants and Laplace (cofactor) expansion, Cramer's rule, LU factorization	••• 2 Hours
	12. Inner product spaces, Cauchy-Schwarz inequality, Orthogonal sets and orthogonal projections, Gram-Schmidt orthogonalization	••• 2 Hours
	13. Eigenvalue and eigenvectors, Eigenspaces, Cayley-Hamilton theorem, Diagonalization	••• 2 Hours
	14. Applications of eigenvalue and eigenvector concept, Markov chains, Singular value decomposition	••• 2 Hours
	15. Brushup review, Final exercise	••• 2 Hours

IMaC-Okayama Syllabus (lectures)

No.	L22
Lecture title	Media Information Processing
Sub-title of the lecture	Statistical machine learning approaches: neural networks and Bayesian modeling
Lecturer	Koichi Takeuchi
Contact E-mail	takeuc-k@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Senior research assistant
Specialty	Natural language processing
Quarter	Quarter 3 & 4
Day	Thursday
Period	Period 1&2
Hours/Credits	30 hours / 2 credits
Lecture plan	I. Introduction: Basic learning models of neural networks ••• 8 Hours The lecture starts by introducing some typical learning approaches for neural networks. Backpropagation, 3-layer neural networks and design of the non-linear functions at the final layer are discussed.
	II. Recent techniques of neural networks ••• 2 Hours This chapter provides recent techniques to make neural networks learn latent information of the target task. Pre-training and auto encoder are discussed.
	III. Well-known network structures ••• 12 Hours This chapter provides efficient neural network structures especially for categrizing sequential inputs such as texts. Convolutional neural networks, recurrent neural networks, LSTM, neural-attention models, transformers are discussed.
	IV. Bayesian modeling ••• 8 Hours This chapter provides Bayesian modeling that is a generative model to assume prior functions focusing on Topic modeling. The basic three types of estimation approaches, maximum likelihood estimation, maximum a posteriori estimation and basian inference eare discussed.

IMaC-Okayama Syllabus (lectures)

No.	L23
Lecture title	Molecular genetic methods and developmental mechanism of Drosophila
Sub-title of the lecture	Learning of animal development using fly
Lecturer	Hitoshi Ueda
Contact E-mail	hueda@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Professor
Specialty	Developmental Genetics/ Molecular Biology
Quarter	Quarter 1
Day	Monday
Period	Period 5& 6
Hours/Credits	15 hours / 1 credits
Lecture plan	I Introduction: Overview of this course ••• 1 Hours Introduction of basic concepts and importance of developmental biology and molecular genetics.
	II Drosophila as a model organism ••• 1 Hours Basic information upon the Drosophila exceptional technical advantages to understand a diverse range of biological processes from genetics and inheritance.
	III Molecular genetic method using Drosophila3 Hours ••• 3 Hours Molecular genetic methods used to understand the function of genes in Drosophila.
	IV How fly embryo develop from single embryonic cell (determination of anterior- posterior axis) ••• 3 Hours Determination mechanism of anterior-posterior axis using information derived from oocyte.
	V How fly embryo develop from single embryonic cell (determination of dorsal- ventral axis) ••• 2 Hours Determination mechanism of dorsal-ventral axis using information derived from oocyte
	Time determination mechanism in post-embryonic development ••• 5 Hours Various mechanisms of time determination systems during post-embryonic development of insects.

IMaC-Okayama Syllabus (lectures)

No.	L24
Lecture title	Ecological Genetics
Sub-title of the lecture	conservation genetics
Lecturer	Makiko Mimura
Contact E-mail	m.mimura@okayama-u.ac.jp
Affiliation	Department of Biology
position	Associate Professor
Specialty	Plant Ecology
Quarter	Quarter 1
Day	Tuesday
Period	Period 1&2
Hours/Credits	14 hours / 1 credit
Lecture plan	I. Introduction to Ecological Genetics ••• 4 Hours The lecture starts by introducing how population genetics have contributed to understand ecological and evolutionary processes. You will learn how genetic diversity takes a role in ecology and evolution as well as how we can estimate and evaluate it. This class comes with a workshop to estimate summary statistics for a population (i.e. gene diversity).
	II. Population History in Changing Environments ••• 4 Hours Species' distribution and its range change over time and space in response to environmental changes, e.g. climate changes. This shapes current popualtion structure. This chapter introduces such consequeces of environmental chanegs. This class comes with a workshop to estimate population structure using STRUCTURE or ADMIXTURE.
	III. Natural Selection in Wild Populations ••• 4 Hours This chapter starts with introducing some analyses and evolution in response to natural selection in. It also introduce several basic statistical tests for natural selection. This class come with a workshop to perform neturality tests (e.g. MK test).
	IV. Topics in Ecological Genetics ••• 2 Hours We will self-introduce topics in ecological genetics; evolution of invasive speices, adaptation to environmental changes, consequences of being small populations.

IMaC-Okayama Syllabus (lectures)

No.	L25
Lecture title	Mechanisms of Plant Development
Sub-title of the lecture	Polyamines as pillars of cellular processes
Lecturer	Taku Takahashi
Contact E-mail	perfect@okayama-u.ac.jp
Affiliation	Division of Biological Sciences
position	Professor
Specialty	Plant developmental biology
Quarter	Quarter 1
Day	Friday
Period	Period 1&2
Hours/Credits	15 hours / 1 credits
Lecture plan	I. Introduction: Overview of this course ••• 3 Hours Introduction of biogenic polyamines/ An overview is given, including a brief history of polyamine biology.
	II. Distribution and diversity of polyamines in living organisms ••• 3 Hours Distribution, structural diversity, and biosynthetic pathways of polyamines in bacteria, plants and animals.
	III. Physiological function of polyamines ••• 3 Hours Important roles of polyamines in various aspects of cellular processes are comprehensively reviewed.
	IV. The mode of action of polyamines in mRNA translation ••• 3 Hours Specific regulatory roles of polyamines in mRNA translation are presented.
	V. State-of-the-art research on plant polyamines ••• 3 Hours New findings on the function of plant polyamines, especially achieved using genetic mutants of a model plant Arabidopsis are shown. The power of molecular genetics in studying polyamine functions will be discussed.

IMaC-Okayama Syllabus (lectures)

No.	L26
Lecture title	Neurogenetics
Sub-title of the lecture	Advanced neuroscience and genetics for understanding biological clocks
Lecturer	Taishi Yoshii
Contact E-mail	yoshii@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	associate professor
Specialty	Chronobiology/Genetics and Neurobiology
Quarter	Quarter 3
Day	Wednesday
Period	Period 1&2
Hours/Credits	15 hours / 1 credits
Lecture plan	I. Introduction: Overview of this course ••• 1 Hours The history of researches about biological clocks. An overview.
	II. Basic of Chronobiology ••• 3 Hours Understanding the biological significance of biological clocks
	III. The most advanced genetics for manipulating neuron ••• 3 Hours Introduction of the powerful genetics in fruit fly, Drosophila melanogaster.
	IV. Application of the Drosophila genetics ••• 3 Hours Introduction of how the Drosophila genetics can be used in animal behavior researches
	V. What we know about biological clocks now ••• 3 Hours The molecular and neuronal mechanisms of animal clocks.
	VI. Biological clocks across species in the field ••• 2 Hours Introduction of researches to link between lab data and field observations about rhythmic behaviors in different animal species.

IMaC-Okayama Syllabus (tutorial studies)

No.	T1
Tutorial study title	Tutorial Studies in Introduction for crystal structure analysis
Main topic of the study	
Lecturer	Naoshi Ikeda
Contact E-mail	ikedan@okayama-u.ac.jp
Affiliation	Department of Physics
position	professor
Specialty	
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	Prof. provide the crystal structure of some typical material, and the students analyze and calculate the X-ray energy dependence of some diffraction point of each material.

IMaC-Okayama Syllabus (tutorial studies)

No.	T2
Tutorial study title	Tutorial Studies in Carrier transport properties in materials -bulk and surface
Main topic of the study	Solid State Physics
Lecturer	Kaya Kobayashi
Contact E-mail	kayakobayashi77@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	Associate Professor
Specialty	Condensed Matter Physics, Superconductivity
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	Based on the personal work, a series of presentations are given by each member followed by a short discussion on the topics (examples are listed above). They are requested to submit research papers on the personal work and the report including the discussion session.
	1 -- Title: Transport properties in magnetic materials ••• 7 Hours
	2 -- Title: Transport properties in superconducting materials at higher temperatures ••• 8 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T3
Tutorial study title	Tutorial studies in magnetism and superconductivity
Main topic of the study	Advanced materials: metallic, superconducting and magnetic properties
Lecturer	William Sacks
Contact E-mail	william.sacks@upmc.fr
Affiliation	IMPMC laboratory, Sorbonne University - Paris (France)
position	Professor
Specialty	Condensed matter theory, superconductivity, tunneling spectroscopy
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	Outline: About 6 tutorials will be proposed in which the students, working in pairs and guided by the professor, will study and present a recent high-level 'hot topic' scientific paper in the field.

IMaC-Okayama Syllabus (tutorial studies)

No.	T4
Tutorial study title	Tutorial Studies in Mesoscopic physics
Main topic of the study	Coherent transport properties in mesoscopic systems
Lecturer	Hidenori Goto
Contact E-mail	hgoto@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	associate professor
Specialty	Mesoscopic physics
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	The aim of this lecture is to study several topics in mesoscopic physics. Through textbooks and recent papers, students learn the universal electronic properties which are described by quantum physics. The examples of topics are listed below. The tutorial lessons include interactive questions, discussion, and presentation about the topics. 1 -- Coherent transport in mesoscopic systems. 2 -- The wave-particle duality of an electron. 3 -- Size effects on ordered states.

IMaC-Okayama Syllabus (tutorial studies)

No.	T5
Tutorial study title	Organometallic Chemistry
Main topic of the study	
Lecturer	Yasushi NISHIHARA
Contact E-mail	ynishiha@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	Professor
Specialty	Synthetic Organic Chemistry
Quarter	Quarter 1 and 2
Day	Monday
Period	Any time
Hours/Credits	60 hours / 2 credits
Lecture plan	Several aspects of the topics listed in the above titles are studied by personal tutorial lessons (by professor and tutors) together with independent self-study (by student) with the aid of a suitable textbook and recent literatures (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with professor (or tutors). A final presentation/examination about the studied subject is mandatory.
	Title: Stereochemistry of Olefins 15 Hours
	Title: Carbon-Hydrogen Activation 15 Hours
	Title: Cross-Coupling Reactions 15 Hours
	Title: Organic Semiconductors 15 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T6
Tutorial study title	Tutorial Studies in Advanced Coordination Chemistry
Main topic of the study	Coordination Chemistry
Lecturer	Takayoshi Suzuki
Contact E-mail	suzuki@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science
position	professor
Specialty	Coordination Chemistry
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	Several aspects of the topics listed below are studied by personal tutorial lessons (by professor and tutors) together with independent self-study (by student) with the aid of a suitable textbook and recent literatures (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with professor (or tutors). A final presentation/examination about the studied subject is mandatory.
	1 -- Stereochemistry of Coordination Compounds ••• 6 Hours
	2 -- Ligand Field Theory and Its Application ••• 8 Hours
	3 -- Physical Inorganic Chemistry ••• 8 Hours
	4 -- Bioinorganic Chemistry ••• 8 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T7	
Tutorial study title	Tutorial Studies in Molecular Data Science	
Main topic of the study	Practical Programming in Python language	
Lecturer	Masakazu Matsumoto	
Contact E-mail	matsu-m3@okayama-u.ac.jp	
Affiliation	Research Institute for Interdisciplinary Science	
position	associate professor	
Specialty	Theoretical Chemistry	
Quarter	1Q	
Day	Wed	
Period	5,6 (online)	
Hours/Credits	20 hours / 1 credits	
Lecture plan	Outline: Python language has been getting more and more popular over these last 10 years. Nowadays, demonstrational implementations of the newest researches in artificial intelligence are often available in and only in Python. Python is favoured due to its simple and clear syntax, easy data treatment, full extensibility, etc. In this course, Python programming is practiced from the beginning to the advanced stage. Bring your own PC.	
	Introduction to Python	2 Hours
	Basic features	4 Hours
	Advanced features for scientific calculations	8 Hours
	Machine learning and beyond.	6 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T8
Tutorial study title	Tutorial Studies in Advanced Organic Chemistry
Main topic of the study	Modern Organic Synthesis
Lecturer	Isao Kadota
Contact E-mail	kadota-i@okayama-u.ac.jp
Affiliation	Division of Molecular Sciences, Graduate School of Natural Science and Technology
position	Professor
Specialty	Organic Chemistry
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	Various synthetic methods and reactions in modern organic chemistry will be discussed with some examples.
	I. Synthetic Design ••• 4 Hours
	II. Stereochemical Considerations in Planning Syntheses ••• 4 Hours
	III. The Concept of Protecting Functional Groups ••• 4 Hours
	IV. Oxidation and Reduction ••• 8 Hours
	V. Reactions of Carbon-Carbon Double Bonds ••• 4 Hours
	VI. Reactions of Carbon-Carbon Triple Bonds ••• 4 Hours
	VII. Conclusion and Examination ••• 4 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T9
Tutorial study title	Tutorial Studies in Advanced Ferroelectric Science
Main topic of the study	Ferroelectrics
Lecturer	Jun Kano
Contact E-mail	kano-j@cc.okayama-u.ac.jp
Affiliation	Division of Applied Chemistry, Graduate School of Natural Science and Technology
position	Associate professor
Specialty	Solid state physics, Catalytic chemistry
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	Period 1&2 or 3&4
Hours/Credits	30 hours / 1 credits
Lecture plan	Several aspects of the topics listed in the above titles are studied by personal tutorial lessons (by professor and tutors) together with independent self-study (by student) with the aid of a suitable textbook and recent literatures (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with professor (or tutors). A final presentation/examination about the studied subject is mandatory.
	1: Inversion symmetry breaking and structural phase transition of ferroelectrics ••• 7 Hours
	2: Application of ferroelectrics and its future perspective ••• 7 Hours
	3: Ferroelectric semiconductor ••• 8 Hours
	4: Ferroelectric catalyst ••• 8 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T10
Tutorial study title	Tutorial Studies in Advanced Device Physics
Main topic of the study	Advanced Electronic/Photonic/Plasmonic/Acoustic Device Physics
Lecturer	Kenji TSURUTA
Contact E-mail	tsuruta@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Professor
Specialty	Materials Science, Device Physics
Quarter	(decide after consultation with the students)
Day	(decide after consultation with the students)
Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	1 -- Title: Advanced Electronic Devices 2 -- Title: Advanced Photonic/Plasmonic Devices 3 -- Title: Advanced Acoustic/Elastic Devices 4 -- Title: Advanced Materials Simulation Outline: Several aspects of the topics listed in the above titles are studied by personal tutorial lessons (by professor and tutors) together with independent self-study (by student) with the aid of a suitable textbook and recent literatures (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with professor (or tutors). A final presentation/examination about the studied subject is mandatory.

IMaC-Okayama Syllabus (tutorial studies)

No.	T11
Tutorial study title	Terahertz science and technologies: from millimeter electronics to the mid-infrared
Main topic of the study	
Lecturer	Jean-Louis COUTAZ
Contact E-mail	jean-louis.coutaz@univ-savoie.fr
Affiliation	IMEP-LAHC laboratory, Savoie Mont-Blanc University – Chambéry - France
Position at origin University	Emeritus Professor
Specialty	Terahertz spectroscopy and technology, Ultrafast optoelectronics
Quarter	TBA
Day	TBA
Period	TBA
Hours/Credits	16 hours or project / 0.5 credits
Lecture plan	About 6 tutorials will be proposed in which the students, working in pairs and guided by their professors, will study and present a recent high-level ‘hot topic’ scientific paper in the field.

IMaC-Okayama Syllabus (tutorial studies)

No.	T12
Tutorial study title	Tutorial Studies in Molecular Genetics/ Molecular Biology
Main topic of the study	Innovative Molecular biology approaches to gene expression
Lecturer	Tatsuhiko ABO
Contact E-mail	tabo@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology
position	Professor
Specialty	Molecular Genetics / Molecular Biology
Quarter	decide after consultation with the students
Day	decide after consultation with the students
Period	decide after consultation with the students
Hours/Credits	30 hours / 1 credits
Lecture plan	Several aspects of the topics listed in the above titles are studied by personal tutorial lessons (by a professor and tutors) together with independent self-study (by the student) with the aid of suitable papers (suggested by professor). Up-to-date papers will be provided for both of two titles. The 1st title should include genetic point of view such as how the topics were identified or solved. The latter should summarize comprehensive view of the specific topic. The tutorial lessons include interactive questions and discussion about the topics with the professor (or the tutors). A final presentation/examination of the studied subject is mandatory.
	The power of bacterial genetics revisited 10 Hours
	Ribosome rescue, how the cells maintain their gene expression system in shape? 20 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T13	
Tutorial study title	Tutorial Studies in Behavioral Genetics	
Main topic of the study	Sexual Behavior in *Drosophila*	
Lecturer	Hideki Nakagoshi	
Contact E-mail	goshi@cc.okayama-u.ac.jp	
Affiliation	Department of Biology	
position	professor	
Specialty	Molecular Genetics	
Quarter	(decide after consultation with the students)	
Day	(decide after consultation with the students)	
Period	(decide after consultation with the students)	
Hours/Credits	15 hours / 0.5 credits	
Lecture plan	Several aspects of the topics listed in the above titles are studied by personal tutorial lessons (by a professor and tutors) together with independent self-study (by the student) with the aid of suitable papers (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with the professor (or the tutors). A final presentation/examination of the studied subject is mandatory	
	1 -- Molecular genetic techniques to explore functions of neuronal circuitry	••• 3 Hours
	2 -- Neuronal circuitry of sexual behaviour	••• 6 Hours
	3 -- Physiological significance of nutrient-sensing pathways	••• 3 Hours
	4 -- Regulation of fecundity by seminal fluid	••• 3 Hours

IMaC-Okayama Syllabus (tutorial studies)

No.	T14	
Tutorial study title	Tutorial Studies in Plant Developmental Biology	
Main topic of the study	Plant Developmental Biology	
Lecturer	Taku Takahashi	
Contact E-mail	perfect@okayama-u.ac.jp	
Affiliation	Division of Biological Sciences	
position	Professor	
Specialty	Plant developmental biology	
Quarter	(decide after consultation with the students)	
Day	(decide after consultation with the students)	
Period	(decide after consultation with the students)	
Hours/Credits	15 hours / 0.5 credits	
Lecture plan	1 -- Title: Molecular evolution of polyamine biosynthetic genes. 2 -- Title: Diversity of regulatory mechanisms of mRNA translation. 3 -- Title: Principles of detection of polyamines.	
	Several aspects of the topics listed in the above titles are studied by personal tutorial lessons (by professor and tutors) together with independent self-study (by student) with the aid of a suitable textbook and recent literatures (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with professor (or tutors). A final presentation/examination about the studied subject is mandatory.	•••15 Hours