IMaC-Okayama course catalogue

(2020 edition)

Lectures in IMaC-Okayama, 2020

Course No.	Course Title Sub-title of the Course	Lecturer(s)	Affiliation	Quarter	Day Period	Credit
1	Cosmology and Cosmic Microwave Background Exploration of the origin of the universe: The LiteBIRD project	ISHINO, Hirokazu	Phys	1Q, 2Q	Tue 1–3	3
2	Particle physics and Cosmology explored by using neutrinos	KOSHIO, Yusuke	Phys	1Q, 2Q	Mon 5–6	2
3	Physics of Materials under Extreme Condition Magnetism and Superconductivity at Low Temperatures: Quantum Critical Phenomena in Strongly Correlated Electron System	ARAKI, Shingo	Phys	1Q	Thu 3–4	1
4	Introduction to Material Science by using Synchrotron Facility	IKEDA, Naoshi	Phys	2Q	Tue 1–2	1
5	Solid-state Synchrotron Spectroscopy Photoemission spectroscopy - Photoelectron holography: in-depth understanding and direct observation of electronic/spin structure for new functionalities development	YOKOYA, Takayoshi	RIIS(Phys)	1Q	Tue 1–2	1
6	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	KOBAYASHI, Kaya	RIIS(Phys)	2Q	Wed 3–4	1
7	The Art of Materials Designing Physics and chemistry of iron-based superconductor	NOHARA, Minoru	RIIS(Phys)	1Q, 2Q	Tes 5–6	2
8	Solid-state physics and chemistry Electronic properties of graphene: from basic theory to application for FET	GOTO, Hidenori	RIIS(Chem)	1Q	Mon 1–2	1
9	Physical chemistry of interface Transport properties and electronic structures at oxide interfaces	EGUCHI, Ritsuko	RIIS(Chem)	2Q	Mon 1–2	1
10	Organometallic Catalysis	NISHIHARA, Yasushi IWASAKI, Masayuki	RIIS(Chem)	1Q, 2Q	Thur 1–2	2
11	Advanced Coordination Chemistry Fundamental aspect and recent advancement in Coordination Chemistry	SUZUKI, Takayoshi	RIIS(Chem)	1Q, 2Q	Fri 1–2	2
12	Chemistry of Complex Systems Complex phenomena in molecular sciecnce: molecular assembly, self-organization, etc. studied by using advanced Python analysis method	MATSUMOTO, Masakazu	RIIS(Chem)	1Q	Wed 5–6	1
13	Plasmonics: Fabrications and Applications Molecular sensing with plasmonic materials	TAKEYASU, Nobuyuki	Chem	2Q	Thu 3–4	1
14	Ferroelectricity and related phenomena Design of new and high-performance catalysts using ferroelectrics	KANO, Jun	Appled Chem	2Q	Wed 3–4	1
15	Energy Materials Phenomenology and energy applications in oxides and dielectrics	TERANISHI, Takashi	Applied Chem	2Q	Fri 3–4	1
16	Nanostructured Materials Structural and Transport properties in nanoscaled materials: applications to nano-carbon materials	HAYASHI, Yasuhiko	Elect. Comm. Eng.	2Q	Mon 3–4	1
17	Device Physics Overviews of fundamentals in advanced electronic/photonic/acoustic devices	TSURUTA, Kenji	Elect. Comm. Eng.	1Q **or** 2Q	Mon 7–8	1
18	Introduction to Genetics in Ecology and Evolution	MIMURA, Makiko	Bio	1Q, 2Q	Thu 5–6	2
19	Photosynthesis in plants and alga	TAKAHASHI, Yuichiro	Bio	1Q, 2Q	Mon 2	1
20	Molecular Mechanism of Animal Development Molecular genetic methods and developmental mechanism of Drosophila	UEDA, Hitoshi	Bio	1Q **or** 2Q	Mon 5–6	1
21	Neurogenetics Advanced neuroscience and genetics for understanding biological clocks	YOSHII, Taishi	Bio	2Q	Wed 1–2	1
22	Mechanisms of Plant Development Polyamines as pillars of cellular processes	TAKAHASHI, Taku	Bio	2Q	Thu 3–4	1
23	Neuroendocrinology Neuroendocrinology modulation underlying the expression of instinctive behaviour	SAKAMOTO, Hirotaka	Bio(UMI)	Spring **or** Summer breaks	Intensive	2
25	Mathematical modeling Kriging methods applied to Geostatistics	YAMAKAWA, Junji	Earth Sci	1Q	Tue 4–5	1
26	Superconductivity from basic concepts to today's advanced research topics	SACKS, William	Sorbonne	1Q, 2Q	Thu 1–2	1

Tutorial Studies in IMaC-Okayama, 2020

Course No.	Title of Tutorial Studies: Titorial Studies in ...	Lecturer(s)	Affiliation	E-mail	Day Period	Hours (total)	Credit
T1	Cosmology	ISHINO, Hirokazu	Phys	scishino@s.okayama-u.ac.jp	Tue 4–7	16 h	0.5
T2	Particle physics - Neutrino physics	KOSHIO, Yusuke	Phys	koshio@okayama-u.ac.jp	*DAC	31 h	1
T3	Physics of Materials under Extreme Condition	ARAKI, Shingo	Phys	araki-s@cc.okayama-u.ac.jp	*DAC	15 h	0.5
T4	Introduction for crystal structure analysis	IKEDA, Naoshi	Phys	ikedan@okayama-u.ac.jp	*DAC	15 h	0.5
T5	Solid-state Synchrotron Spectroscopy	YOKOYA, Takayoshi	RIIS(Phys)	yokoya@cc.okayama-u.ac.jp	Tue 4–7	15 h	0.5
T6	Carrier transport phenomena in materials	KOBAYASHI, Kaya	RIIS(Phys)	pmmy9z2d@okayama-u.ac.jp	*DAC	15 h	0.5
T7	The Art of Materials Designing	NOHARA, Minoru	RIIS(Phys)	nohara@science.okayama-u.ac.jp	*DAC	60 h	2
T8	Mesoscopic physics	GOTO, Hidenori	RIIS(Chem)	hgoto@okayama-u.ac.jp	*DAC	15 h	0.5
T9	Physical properties of oxide heterostructures	EGUCHI, Ritsuko	RIIS(Chem)	eguchi-r@okayama-u.ac.jp	*DAC	15 h	0.5
T10	Organometallic Chemistry	NISHIHARA, Yasushi IWASAKI, Masayuki	RIIS(Chem)	ynishiha@okayama-u.ac.jp iwasa-m@cc.okayama-u.ac.jp	Anytime	60 h	2
T11	Advanced Coordination Chemistry	SUZUKI, Takayoshi	RIIS(Chem)	suzuki@okayama-u.ac.jp	*DAC	60 h	2
T12	Molecular Data Science	MATSUMOTO, Masakazu	RIIS(Chem)	matsu-m3@cc.okayama-u.ac.jp	*DAC	30 h	1
T13	Plasmonics: Fabrications and Applications	TAKEYASU, Nobuyuki	Chem	takeyasu@okayama-u.ac.jp	*DAC	30 h	1
T14	Advanced Ferroelectric Science	KANO, Jun	Appled Chem	kano-j@cc.okayama-u.ac.jp	*DAC	30 h	1
T15	Energy Materials	TERANISHI, Takashi	Applied Chem	terani-t@cc.okayama-u.ac.jp	*DAC	30 h	1
T16	Nanostructured Materials	HAYASHI, Yasuhiko	Elect. Comm. Eng.	hayashi.yasuhiko@ec.okayama-u.ac.jp	*DAC	30 h	1
T17	Advanced Electronic/Photonic/Acoustic Devices	TSURUTA, Kenji	Elect. Comm. Eng.	tsuruta@okayama-u.ac.jp	*TBA	15 h	0.5
T18	Topics on Ecological Genetics and Genomics	MIMURA, Makiko	Bio	m.mimura@okayama-u.ac.jp	*DAC	15 h	0.5
T19	Molecular Biology, Biochemistry, and Biophysics of Photosynthesis	TAKAHASHI, Yuichiro	Bio	taka@cc.okayama-u.ac.jp	Fri 5–7	30 h	1
T20	Developmental Genetics and Molecular biology	UEDA, Hitoshi	Bio	hueda@cc.okayama-u.ac.jp	*DAC	15 h	0.5
T21	Chronobiology	YOSHII, Taishi	Bio	yoshii@cc.okayama-u.ac.jp	*DAC	15 h	0.5
T22	Plant Developmental Biology	TAKAHASHI, Taku	Bio	perfect@cc.okayama-u.ac.jp	*DAC	15 h	0.5
T23	Behavioral neuroscience	SAKAMOTO, Hirotaka	Bio(UMI)	hsakamo@okayama-u.ac.jp	*DAC	30 h	1
T24	Molecular Genetics / Molecular Biology	ABO, Tatsuhiko	Bio	tabo@okayama-u.ac.jp	*DAC	30 h	1
T26	Superconductivity	SACKS, William	Sorbonne	sacks.w@gmail.com	*DAC	15 h	0.5

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

Group Works in IMaC-Okayama, 2020

Course No.	Title of the Course	Lecturer(s)	Affiliation	E-mail	Day Period	Hours (total)	Credit
G1	Practice in Scientific Presentation 2	SUZUKI, Takayoshi	RIIS(Chem)	suzuki@okayama-u.ac.jp	Spring breaks	30 h	1

Lectures Schedule in IMaC-Okayama, 2020

Quarter 1 (from 8th April to 8th June*)

Period \ Day	Mon	Tue	Wed	Thur	Fri
Period 1 **8:40–9:40**	8: Goto	1: Ishino 5: Yokoya		10: Nishihara 26: Sacks	11. Suzuki
Period 2 **9:50–10:50**	8: Goto 19: Takahashi, Y.	1: Ishino 5: Yokoya		10: Nishihara 26: Sacks	11. Suzuki
Period 3 **11:00–12:00**		1: Ishino		3: Araki	
Period 4 **(12:10–13:10 or)** **12:50–13:50**	20: Ueda	25: Yamakawa		3: Araki	
Period 5 **14:00–15:00**	20: Ueda 2: Koshio	25: Yamakawa 7: Nohara	12: Matsumoto	18: Mimura	
Period 6 **15:10–16:10**	2: Koshio	7: Nohara	12: Matsumoto	18: Mimura	
Period 7 **16:20–17:20**	17: Tsuruta				
Period 8 **17:30–18:30**	17: Tsuruta				

Quarter 2 (from 11th June to 7th August*)

Period \ Day	Mon	Tue	Wed	Thur	Fri
Period 1 **8:40–9:40**	9: Eguchi	1: Ishino 4: Ikeda	21: Yoshii	10: Nishihara 26: Sacks	11. Suzuki
Period 2 **9:50–10:50**	9: Eguchi 19: Takahashi, Y.	1: Ishino 4: Ikeda	21: Yoshii	10: Nishihara 26: Sacks	11. Suzuki
Period 3 **11:00–12:00**	16: Hayashi	1: Ishino	14: Kano 6: Kobayashi	13: Takeyasu 22: Takahashi, T.	15: Teranishi
Period 4 **(12:10–13:10 or)** **12:50–13:50**	16: Hayashi 20: Ueda		14: Kano 6: Kobayashi	13: Takeyasu 22: Takahashi, T.	15: Teranishi
Period 5 **14:00–15:00**	20: Ueda 2: Koshio	7: Nohara		18: Mimura	
Period 6 **15:10–16:10**	2: Koshio	7: Nohara		18: Mimura	
Period 7 **16:20–17:20**	17: Tsuruta				
Period 8 **17:30–18:30**	17: Tsuruta				

***The schedules are subject to change.**

Spring Breaks	intensive
intensive	23: Sakamoto G1: Group work

Lecture title	**1:** Cosmology and Cosmic Microwave Background
Sub-title of the lecture	Exploration of the origin of the universe: The LiteBIRD project
Lecturer	Hirokazu Ishino
Contact E-mail	scishino@s.okayama-u.ac.jp
Affiliation, position	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	Quarter 1 & 2, Tuesday, Period 1–3
Credits	3 credits
Lecture plan	**I. Introduction to General Relativity** 8 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. **II. Theoretical basis of Cosmology** 8 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. **III. Physics in Cosmic Microwave Background** 8 Hours Students will learn the physics of the CMB radiation. We introduce the basic physics in the thermal equilibrium condition to derive the CMB spectrum. Thereafter, the anisotropy of the CMB temperature is introduced. Finally the polarization of the CMB is discussed, with a relation to the perturbations of scaler and tensor fields. The tensor field perturbation generated during the cosmic inflation before the Big Bang with quantum fluctuation resulted in the primordial gravitational waves. The CMB B mode polarization is a key observation object to search for the gravitational waves. The strength of the primordial gravitational waves is related with the energy scales that causes the accelerated space expansion. Therefore determining the strength would identify the mechanism of inflation which occurred in the energy scales of grand unification. **IV. Experimental techniques of the CMB measurements** 6 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.

Tutorial study title	**T1:** Tutorial Studies in Cosmology
Main topic of the study	
Lecturer	Hirokazu Ishino
Contact E-mail	scishino@s.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	Quarter 1 & 2, Tuesday, Period 4–7
Hours/Credits	16 hours / 0.5 credits
Lecture plan	Specific focus on a series of cosmology articles published in English in international journals will be made during those sessions. The sessions will include analysis of articles, interactive questions and discussions with lecturer.

Lecture title	**2:** Particle physics and Cosmology explored by using neutrinos
Sub-title of the lecture	
Lecturer	Yusuke Koshio
Contact E-mail	koshio@okayama-u.ac.jp
Affiliation, position	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	Quarter 1 & 2, Monday, Period 5&6
Credits	2 credits
Lecture plan	**I. Relativistic quantum mechanics** 4 Hours The lecture starts from the expansion of the basic quantum equation, 'Schrodinger equation' to the relativistic particle, which is 'Klein-Gordon equation' and 'Dirac equation'. Especially, the Dirac equation is very simple and beautiful, and also naturally introduces new concepts like spin and anti-particle. You will find the power of physics that simply describes nature. **II. Quantum electrodynamics and Feynman diagram** 4 Hours Following the previous chapter, you will learn the quantum electrodynamics. It is the theory, which can quite precisely predict the electro-magnetic interaction probability among particles. The theory is based on the gauge invariant, and the brief introduction of the field theory will be given. The excellent method for the particle interaction calculation, Feynman diagram, will be introduced. You will be impressive that the method is quite simple for difficult calculations. **III. Neutrinos in weak interaction** 8 Hours This chapter provides the "strange" characteristics of weak interaction, like parity violation, CP asymmetry, etc. The weak interaction was unified to electro-magnetic interaction as electroweak interaction in 1967. At first, the history of the interaction model will be learned. Neutrino plays an important role in weak interaction, and also has unique characteristics. One of them is neutrino oscillation. It is based on the quantum mechanics, and naturally introduces the neutrino mass. The discovery of neutrino oscillation in Super-Kamiokande led the novel prize for Prof. Kajita in 2015, and the lecturer contributed this discovery. You can learn some interesting natures of neutrino. **IV. Neutrinos in cosmology** 8 Hours Since neutrino interacts only via weak interaction, it has special feature, such as very small interaction probability and penetrating almost everything. This feature can make neutrinos the research for the deep inside the star, e.g. the sun, supernovae. Neutrinos from the supernovae were first observed by Kamiokande in 1987, it led the novel prize for Prof. Koshiba in 2002. The observation of supernova neutrino is now very interesting topics to reveal the mystery of the universe. It is also related to the gravitational wave observation. You will find an importance of neutrino observation to research for cosmology. **V. Neutrino research frontiers** 8 Hours In Japan, world leading research for the neutrino physics and astrophysics are being conducted. Several most advanced experiments, such as

	Super-Kamiokande, T2K, KamLAND, are now operating, and they keep providing world class results. The next generation project, Hyper-Kamiokande is also proposed. The lecturer involves some of these experiments. In this chapter, the most updated results for ongoing experiments, state-of-art theories, and the future prospect for the neutrino physics will be presented.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T2:** Tutorial Studies in Particle physics - Neutrino physics
Main topic of the study	
Lecturer	Yusuke Koshio
Contact E-mail	koshio@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	31 hours / 1 credits
Lecture plan	Specific focus on a series of particle physics articles published in English in international journals will be made during those sessions. The sessions will include analysis of articles, interactive questions and discussions with lecturer.

IMaC-Okayama Syllabus (lectures)

Lecture title	**3:** Physics of Materials under Extreme Condition
Sub-title of the lecture	Magnetism and Superconductivity at Low Temperatures: Quantum Critical Phenomena in Strongly Correlated Electron System
Lecturer	Shingo Araki
Contact E-mail	araki@science.okayama-u.ac.jp
Affiliation, position	Graduate School of Natural Science and Technology, associate professor
Specialty	Condensed Matter Physics
Quarter, Day/Period	Quarter 1, Wednesday Period 3&4
Credits	1 credit
Lecture plan	I. Introduction: Overview of this course ··· 2 Hours The lecture starts by introducing some typical examples and recent topics in strongly correlated electron system. An overview of this course will be provided. II. Magnetism in Condensed Matter ··· 6 Hours This chapter provides the basics on the magnetism in the solid state. The various magnetic ordering and the magnetic interaction are discussed. The tuning of the magnetic interaction due to the external parameters, e.g. pressure, and the quantum critical phenomena are also discussed. III. Superconductivity ··· 4 Hours This chapter provides the basic theory to understand the superconductivity. The possible origin of the interaction for superconductivity are discussed. IV. Physical Properties Measurement at Low Temperatures ··· 3 Hours This chapter provides the basic knowledge for experimental technique to measure the physical properties of solid state at extreme conditions (low temperature and high pressure), e.g. how to generate low temperature and high pressure, measurement of the resistivity, specific heat, magnetic susceptibility and so on.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T3:** Tutorial Studies in Physics of Materials under Extreme Conditions
Main topic of the study	Solid State Physics
Lecturer	Shingo Araki
Contact E-mail	araki@science.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, associate professor
Specialty	Condensed Matter Physics
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	1 -- Title: Magnetism in strongly correlated electron system 2 -- Title: Quantum critical phenomena in heavy fermion compounds 3 -- Title: Pressure induced Superconductivity 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 (lectures)

Lecture title	**4:** 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, position	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	Quarter 1 & 2, Friday, Period 5&6
Credits	2 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 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 method is called as an anomalous scattering. 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 (tutorial studies)

Tutorial study title	**T4:** 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	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/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 (lectures)

Lecture title	**5:** Solid-state Synchrotron Spectroscopy
Sub-title of the lecture	Photoemission spectroscopy - Photoelectron holography: in-depth understanding and direct observation of electronic/spin structure for new functionalities development
Lecturer	Takayoshi Yokoya
Contact E-mail	yokoya@okayama-u.ac.jp
Affiliation, position	Research Institute for Interdisciplinary Science, professor
Specialty	Solid State Physics
Quarter, Day/Period	Quarter 1, Tuseday, Period 1&2
Credits	1 credit
Lecture plan	I Introduction to photoemission spectroscopy (2 Hours) Photoemission spectroscopy(PES) is a very powerful and one of the most widely used experimental techniques to get detailed analysis of chemical states. It also permits to perform electronic/spin structure analysis. The lecture starts from a quick overview of PES, explaining what is PES, how it works, and why it becomes one of popular experimental tools. II Principle of photoemission (6 Hours) Basics of photoemission spectroscopy are reviewed. A specific focus emphasizes the uniqueness this technique. The main features of PES principles and the crucial information that PES results contain (band structure, Fermi surface, formation of energy gap, and interaction with bosonic modes) will be presented. Details of PES instrumentation of PES enabling studies of energy, momentum, and spin of electrons will be given. III Electronic/spin structure analysis (8 Hours) This chapter provides detailed explanation of PES studies of various functional materials (semiconductors, thermoelectric materials, highly correlated materials, superconductors, Half metals etc.) in order to demonstrate importance of direct observation of electronic/spin structure to understand the mechanism/origin of functionalities. IV Local structure analysis (4 Hours) Last part of the lecture will be focused on photoelectron holography(PEH). Photoelectron holography is a method designed to directly detect the local structure of selected elements in different chemical states. This chapter explains the main principles of PEH and provides several examples to show the importance of the technique.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T5:** Tutorial Studies in Solid-state Synchrotron Spectroscopy
Main topic of the study	Electronic structure
Lecturer	Takayoshi Yokoya
Contact E-mail	yokoya@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science, professor
Specialty	Solid State Physics
Quarter, Day/Period	Tuesday Period 4-7
Hours/Credits	15 hours / 0.5 credit
Lecture plan	1 -- Title: Solid state physics 2 -- Title: Photoemission spectroscopy and photoelectron holography 3 -- Title: Electronic structure and local structure of solid 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.

Lecture title	**6:** 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, position	Research Institute for Interdisciplinary Science, Associate Professor
Specialty	Condensed Matter Physics, Superconductivity
Quarter, Day/Period	Quarter 2, Wednesday, Period 3&4
Credits	1 credit
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. III. Electronic/heat conductions in metals ··· 5 Hours 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. 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 (tutorial studies)

Tutorial study title	**T6:** 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, Associate Professor
Specialty	Condensed Matter Physics, Superconductivity
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	1 -- Title: Transport properties in magnetic materials 2 -- Title: Transport properties in superconducting materials at higher temperatures 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.

Lecture title	**7:** The Art of Materials Designing
Sub-title of the lecture	Physics and Chemistry of Iron-based Superconductor
Lecturer	Minoru Nohara
Contact E-mail	nohara@science.okayama-u.ac.jp
Affiliation, position	Research Institute for Interdisciplinary Science, professor
Specialty	Solid State Physics and Chemistry
Quarter, Day/Period	Quarter 1 & 2, Tuesday, Period 5&6
Credits	2 credits
Lecture plan	I. Atomic Orbitals ··· 4 Hours Periodic table of the elements is introduced with emphasis on the orbital energy of the elements. The physical/chemical properties of the elements/compounds are explained in terms of the orbital energy of valence electrons. II. Molecular Orbitals ··· 4 Hours The perturbation theory is introduced to determine the molecular orbital (MO) energy of diatomic molecules. Inorganic compounds that consist of molecule-like C_2 are introduced as examples, in which the degeneracy of MO plays a crucial role in enhancing superconducting transition temperature. III. sp Network and Extended Chemical Bonds ··· 5 Hours Graphite and MgB_2 are introduced as typical examples of honeycomb network of sp^2 hybridized orbital. Superconducting transition temperature is very high for MgB_2, while it is very low for graphite-intercalated compounds. The reason of this difference is clarified in terms of π and σ bonds. IV. Chemistry meets Physics: From Bonds to Bands ··· 5 Hours Band theory is introduced. Chemical bonds in the real space are converted into bands in the momentum space by using a tight-binding model. The difference between metal and band insulator is clarified in terms of bands. V. Materials with d orbitals: Between Bonds and Bands ··· 6 Hours Effect of electron correlation is introduced. Examples include 3d transition metal oxides in which electrons are localized because of the strong Coulomb repulsions between them, and a Mott insulating state results. On the other hand, when the correlations are weak electrons are delocalized and a metallic state results. Exotic electronic states that emerge between them are overviewed. High-T_c superconductivity in copper oxides is introduced as a typical example. VI. Iron-based Superconductors ··· 6 Hours Recent progress of physics and chemistry of iron-based superconductors is overviewed. The relation between the crystal structure, valence states, and superconductivity is discussed.

Tutorial study title	**T7:** Tutorial Studies in The Art of Materials Designing
Main topic of the study	Physics and Chemistry of Thermoelectric Materials
Lecturer	Minoru Nohara
Contact E-mail	nohara@science.okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science, professor
Specialty	Solid State Physics and Chemistry
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	60 hours / 2 credits
Lecture plan	1 – Thermoelectricity for Harvesting Waste Heat 2 – New Materials for Thermoelectric Application 3 – Crystal and Electronic Structures of Thermoelectric Materials 4 – Quest for Ultra-High-Efficiency Thermoelectric Materials 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.

Lecture title	**8:** 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, position	Research Institute for Interdisciplinary Science, associate professor
Specialty	Mesoscopic physics
Quarter, Day/Period	Quarter 1, Monday, Period 1&2
Credits	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 ··· 3 Hours The lecture starts by introducing basic band theories to describe electronic states in crystals. II. Crystal and band structures of graphene ··· 4 Hours This chapter provides the band structure of graphene in 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 This chapter provides the peculiar transport properties resulting from the topological singularity. The absence of back-scattering and the half-integer quantum Hall effect are discussed. IV. Application for graphene FETs · 4 Hours This chapter provides practical applications of graphene to field-effect transistors (FETs). The characteristics of graphene FETs are compared with those of conventional inorganic FETs to clarify the advantages and problems.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T8:** 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, associate professor
Specialty	Mesoscopic physics
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	1 -- Title: Coherent transport properties in mesoscopic systems. 2 -- Title: The wave-particle duality of an electron. 3 -- Title: Size effects on ordered states. 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 above. The tutorial lessons include interactive questions, discussion, and presentation about the topics.

Lecture title	**9:** 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, position	Research Institute for Interdisciplinary Science, Assistant professor
Specialty	Solid state physics
Quarter, Day/Period	Quarter 2, Monday, Period 1&2
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.

Tutorial study title	**T9:** Tutorial Studies in Physical chemistry of interface
Main topic of the study	Physical properties of oxide heterostructures
Lecturer	Ritsuko Eguchi
Contact E-mail	eguchi-r@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science, Assistant professor
Specialty	Solid state physics
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	Students study the several topics about the studies of oxide heterostructures with the aid of suitable textbooks and recent literatures. In addition, the tutorial study demonstrates analysis of electrical transport data and experimental results about electronic structures. Students analyze the data practically e.g. resistivity, Hall effect, depth profiling of electronic structure, and so on.

IMaC-Okayama Syllabus (lectures)

Lecture title	**10:** Organometallic Catalysis
Sub-title of the lecture	Organometallic Catalysis
Lecturer	Yasushi Nishihara
Contact E-mail	ynishiha@okayama-u.ac.jp
Affiliation, position	Research Institute for Interdisciplinary Science, professor
Specialty	Synthetic Organic Chemistry
Quarter, Day/Period	Quarter 1 & 2, Thursday, Period 1&2
Credits	2 credits
Lecture plan	I. Organometallic Chemistry and Catalytic Reactions 5 Hours The lecture starts by introducing fundermental reactions in catalytic organic chemistry. An overview of this course will be provided. II. Organometallic Chemistry and Reaction Mechanism 5 Hours This chapter provides the diversity and specificity of reaction mechanism of catalytic reactions. A catalytic cycle and kinetics are discussed. III. Hydroformylation and Related Reactions 4 Hours This chapter provides the examples of hydroformylation and related reactions. IV. Acetic Acid and Acetyl Compounds 6 Hours This chapter provides the synthetic methods for acetic acids and related acetyl compounds. V. Nylon Intermediate 4 Hours This chapter provides a fundamental aspect of the synthetic route of nylon derivatives. VI. Oligomerization and Polymerization of Olefins 6 Hours This chapter provides the polymerization of terminal olefins and some recent examples.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T10:** Tutorial Studies in Advanced Organometallic Chemistry
Main topic of the study	Organometallic Chemistry
Lecturer	Yasushi Nishihara
Contact E-mail	ynishiha@okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science, professor
Specialty	Synthetic Organic Chemistry
Quarter, Day/Period	Any time
Hours/Credits	60 hours / 2 credits
Lecture plan	1 -- Title: Stereochemistry of Olefins 2 -- Title: Carbon-Hydrogen Activation 3 -- Title: Cross-Coupling Reactions 4 -- Title: Organic Semiconductors 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.

Lecture title	**11:** 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, position	Research Institute for Interdisciplinary Science, professor
Specialty	Coordination Chemistry
Quarter, Day/Period	Quarter 1 & 2, Friday, Period 1&2
Credits	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.

Tutorial study title	**T11:** 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, professor
Specialty	Coordination Chemistry
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	60 hours / 2 credits
Lecture plan	1 -- Title: Stereochemistry of Coordination Compounds 2 -- Title: Ligand Field Theory and Its Application 3 -- Title: Physical Inorganic Chemistry 4 -- Title: Bioinorganic Chemistry 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 (lectures)

Lecture title	**12:** Chemistry of Complex Systems
Sub-title of the lecture	Complex phenomena in molecular sciecnce: molecular assembly, self-organization, etc. studied by using advanced Python analysis method
Lecturer	Masakazu Matsumoto
Contact E-mail	matsu-m3@cc.okayama-u.ac.jp
Affiliation, position	Research Institute for Interdisciplinary Science, associate professor
Specialty	Theoretical Chemistry
Quarter, Day/Period	Quarter 1, Wednesday, Period 5&6
Credits	1 credits
Lecture plan	**Outline**: In traditional molecular sciences, computation is used mainly for solving several equations such as Schrodinger equation, partition functions, equation of motion, etc. They are called computer simulations. On the other hand, there is another trend in modern science in which computers are used for storing, classifying, searching, characterizing data to find some "rules" hidden in big data. In this use, computer is used not to solve a problem but to pinpoint the problems inherent in the big data. In this lecture, the typical usage of computers in modern science will be introduced and practical methods to "crunch" the big data with Python programming language will be presented. I **Introduction: Overview of this course** 2 Hours The lecture starts by introducing some typical examples and recent topics of computation in modern chemistry. An overview of this course will be provided. Where do you introduce PYTHON ? II **Inverse Problems** 2/4 Hours Introduction of the inverse problem and analysis of some examples that lead to big scientific discoveries. Inverse problem is a source of hints to find a new problem to solve. III **Informatics** 2/3 Hours Basic ideas of informatics. IV **Automation in Chemistry** 2/3 Hours This chapter introduces the recent advances in automation and robotics in chemistry. V **Neural Network** 2/3 Hours History, mechanisms recent breakthroughs, and limitation of the neural networks. Their influence to the scientific researches is also discussed.

Tutorial study title	**T12:** Tutorial Studies in Molecular Data Science
Main topic of the study	Practical programming in Python language
Lecturer	Masakazu Matsumoto
Contact E-mail	matsu-m3@cc.okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science, associate professor
Specialty	Theoretical Chemistry
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	1. **Introduction to Python language (6 hours)** 2. **Use of external libraries (2 hours)** 3. **Making your own functions (2 hours)** 4. **Use of advanced libraries for data analyses (10 hours)** 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.

Lecture title	**13:** Plasmonics
Sub-title of the lecture	Fabrications and Applications
Lecturer	Nobuyuki Takeyasu
Contact E-mail	takeyasu@okayama-u.ac.jp
Affiliation, position	Chemistry, associate professor
Specialty	Plasmonic materials, Nanophotonics
Quarter, Day/Period	Quarter 2, Thursday, Period 3&4
Credits	1 credit
Lecture plan	I. Introduction: Overview of this course ··· 1 Hours The lecture starts by introducing history and recent topics in the research field of plasmonics. An overview of this course will be provided. II. Fundamentals ··· 5 Hours This chapter provides the fundamentals of plasmonics. Surface plasmon polaritons, excitation of surface plasmon polaritons, localize surface plasmons etc. are discussed including electromagnetics. III. Plasmonic materials/devices ··· 5 Hours This chapter provides plasmon waveguides and extraordinary transmission, metamaterials including the fabrication methods. IV. Spectroscopy, Sensing and Imaging ··· 5 Hours This chapter provides enhancement of emissive processes, such as Raman and fluorescence, and the sensing/imaging applications including the fabrication methods.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T13:** Tutorial Studies in Plasmonics
Main topic of the study	Fabrications and applications on plasmonics
Lecturer	Nobuyuki Takeyasu
Contact E-mail	takeyasu@okayama-u.ac.jp
Affiliation	Chemistry, associate professor
Specialty	Plasmonic materials, Nanophotonics
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	1 credit
Lecture plan	1 -- Title: Surface-enhanced spectroscopy 2 -- Title: Electromagnetic metamaterials 3 -- Title: Bottom-up approach for plasmonic materials/devices 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/report about the studied subject is mandatory.

Lecture title	**14:** Ferroelectricity and Related Phenomena
Sub-title of the lecture	Design of New and High-performance Catalysts using Ferroelectrics
Lecturer	Jun Kano
Contact E-mail	kano-j@cc.okayama-u.ac.jp
Affiliation, position	Division of Applied Chemistry, associate professor
Specialty	Ferroelectrics, Solid state physics, Catalytic chemistry
Quarter, Day/Period	Quarter 2, Wednesday, Period 3&4
Credits	1 credits
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. Theory of electric polarization: Landou phenomenological theory ··· 6 Hours This chapter provides the discussion of the homogeneous Landau theory for bulk ferroelectrics with spatially uniform polarizations, reviewing first- and second-order phase transitions and the dielectric and specific heat responses. III. Theory of electric polarization: Berry phase formulation ··· 10 Hours This chapter provides the modern theory of electric polarization, focusing how the polarization can be defined in terms of the accumulated adiabatic flow of current occurring as a crystal is modified or deformed. We try to explain how the polarization is closely related to a Berry phase of the Bloch wave functions. IV. Dielectric Property and phonon dynamics ··· 5 Hours This chapter provides the fundamental ferroelectric properties observed dielectric measurement and inelastic scattering such as Raman, Brillouin and terahertz spectroscopies. V. 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 (tutorial studies)

Tutorial study title	**T14:** 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, associate professor
Specialty	Ferroelectrics, Solid state physics, Catalytic chemistry
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	1 -- Title: Inversion symmetry breaking and structural phase transition of ferroelectrics 2 -- Title: Application of ferroelectrics and its future perspective 3 -- Title: Ferroelectric semiconductor 4 -- Title: Ferroelectric catalyst 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 (lectures)

Lecture title	**15:** Energy Materials
Sub-title of the lecture	Phenomenology and energy applications in oxides and dielectrics
Lecturer	Takashi Teranishi
Contact E-mail	terani-t@cc.okayama-u.ac.jp
Affiliation, position	Applied Chemistry, Associate professor
Specialty	Functional Ceramics, Dielectrics, Ferroelectrics
Quarter, Day/Period	Quarter 2, Friday, Period 3&4
Credits	1 credits
Lecture plan	I. Introduction: Overview of this course --- 2 hours The lecture provides introduction of energy applications and functional materials utilized to those energy devices. II. Functional electro-ceramics --- 4 hours 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. III. Phenomenology of dielectric and ferroelectric ceramics --- 5 hours 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. IV. Applications of electro-ceramics: From capacitors to batteries --- 5 hours This chapter introduces the various applications of functional electro-ceramics; from conventional ceramic capacitors and ferroelectric memories to next generation secondary batteries.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T15:** Tutorial Studies in Energy Materials
Main topic of the study	Phenomenology and energy applications in oxides and dielectrics
Lecturer	Takashi Teranishi
Contact E-mail	terani-t@cc.okayama-u.ac.jp
Affiliation	Applied Chemistry, Associate professor
Specialty	Functional Ceramics, Dielectrics, Ferroelectrics
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	1 – Energy applications of functional electro-ceramics 2 – Materials science in dielectrics and ferroelectrics 3 – Materials science in semi-conductor and ion-conductor ceramics Several aspects of the topics listed in the above titles are studied by independent self-study (by student) with the aid of suitable textbooks and recent literatures (suggested by professor). The tutorial lessons include interactive questions and discussion about the topics with professor. A final presentation about the studied subject is mandatory.

IMaC-Okayama Syllabus (lectures)

Lecture title	**16:** Nanostructured Materials
Sub-title of the lecture	Structural and Transport properties in nanoscaled materials: applications to nano-carbon materials
Lecturer	Yasuhiko HAYASHI
Contact E-mail	hayashi.yasuhiko@ec.okayama-u.ac.jp
Affiliation, position	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	Quarter 2, Monday, Period 3&4
Credits	1 credits
Lecture plan	I **Introduction to nanocarbon materials** 3 Hours A carbon nanotube is one of the desirable materials potentially used for broad applications like automobiles, aircraft, spacecraft and space elevators. The lecture starts with a quick overview of nanocarbon materials, explaining why they have attracted such the attention in the future devices. II **Characterization methods** 6 Hours The nanocarbon exhibit extremely high electric conductivity, thermal diffusivity, and tensile strength. However, these structure and transport properties are valid only on the nanometer-scale, and they decrease by several orders of magnitude when the nanocarbons are assembled as bulk-scaled devices. This lecture describes the methodologies to measure such the structure and transport properties of bulk nanocarbon. III **Nanoscaled measurements for nanocarbon** 6 Hours The conventional methods for the structure and transport properties of materials are aimed for bulk-scaled materials. In our laboratory, we developed several methodologies, e.g., time-resolved measurements, to understand the properties of materials on the nanometer scale. In this lecture, some of the topics about the methodologies to understand the properties of materials on the nanometer scale.

Tutorial study title	**T16:** Tutorial Studies in Nanostructured Materials
Main topic of the study	Application of nanocarbons
Lecturer	Yasuhiko HAYASHI
Contact E-mail	hayashi.yasuhiko@ec.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, professor
Specialty	
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	All group members look for a research topic on the on nanocarbon materials. The students explore it through the database or journal papers. The idea is in the range of synthesis, characterization, and application of nanocarbon materials.

Lecture title	**17:** 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, position	Graduate School of Natural Science and Technology, professor
Specialty	Materials Science, Device Physics
Quarter, Day/Period	Quarter 1 **OR** 2, Monday, Period 7&8
Credits	1 credits
Lecture plan	****** Students can choose any two topics from II-V listed below. ****** I **Introduction: Overview of the course** ... 1 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** ... 4 Hours This chapter deals with essential contents in solid-state and semiconductor physics. III **Photonic Devices ...** 3 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** ... 3 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** ... 4 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 (tutorial studies)

Tutorial study title	**T17:** 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, professor
Specialty	Materials Science, Device Physics
Quarter, Day/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.

Lecture title	**18:** Ecological Genetics in Conservation
Main topic of the study	Introduction to Genetics in Ecology and Evolution
Lecturer	Makiko Mimura
Contact E-mail	m.mimura@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, associate professor
Specialty	Plant Ecology and Evolution
Quarter, Day/Period	Quarter 1 & 2, Thursday, Period 5 & 6
Credits	2 credits
Lecture plan	Introduction to ecology and evolution within and among populations. This includes population genetics to understand how genetic variations in wild populations are structured under mutation, gene flow, genetic drift and natural selection. This course consists of three sections; (1) lectures: basic knowledge of ecological genetics, (2) lab practices: genetic parameter estimations in computer lab, and (3) group/individual presentation based on selected papers. Lecture (10 hours) I. Introduction to Ecological Genetics 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. II. Population History in Changing Environments Species' distribution changes over time and space in response to environmental changes, e.g. climate changes. This chapter introduces past and current environmental factors involving current genetic diversity within/among populations. III. Consequences of being Small Population When population size is decreasing, the population may face various consequences; for instance, inbreeding depression. This chapter introduces how inbreeding and genetic drift further reduce genetic diversity. IV. Gene flow and Hybridization Migration/gene flow have crucial effects on population sustainability We review how migration shapes population structure and effective population sizes, as well as slow down natural selection. The lecture also introduce hybridization and its consequences in changing environments. V. Introduction to Bioinformatics in Ecology This chapter starts with introducing genomic analysis and evolution in response to natural selection in changing environments. It also introduce several basic statistical tests for natural selection and to detect genomic regions that is responsible to natural selection. Computer Lab Exercises (10 hours) Title: Estimating Population Parameters Outline: Some parameters are traditional and still essential to describe and summarize population status. In the computer lab, we will estimate Ho, He, π, θ, and test Hardy-Weinberg equilibrium as within-population parameters, as well as F-statistics as among-population parameters, using computer programs or R packages. Title: Estimating Gene Flow Outline: In this computer lab, we will estimate gene flow among populations,

	based on maximum likelihood or Bayesian inference, using computer programs. Presentation (10 hours) Outline: After taking lectures and computer labs, you will be expected to have some basic knowledge to understand ecological and evolutionary analyses in scientific papers. In this part, you or a group of you will pick one of the selected papers in ecological managements and evolutionary applications, and make an oral presentation based on the paper.

IMaC-Okayama Syllabus (tutorial studies)

Lecture title	**T18:** Tutorial Study in Ecological Genetics in Conservation
Main topic of the study	Topics on Ecological Genetics and Genomics
Lecturer	Makiko Mimura
Contact E-mail	m.mimura@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, associate professor
Specialty	Plant Ecology and Evolution
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	・Landscape Genetics ・Ecological Applications ・Evolutionary Applications Outline: 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 of the studied subject is mandatory.

Lecture title	**19:** Photosynthesis in plants and algae
Sub-title of the lecture	
Lecturer	Yuichiro Takahashi
Contact E-mail	taka@cc.okayama-u.ac.jp
Affiliation, position	Research Institute for Interdisciplinary Science, professor
Specialty	Biochemistry and molecular biology of Photosynthesis
Quarter, Day/Period	Quarter 1 & 2, Monday, Period 2
Credits	1 credit
Lecture plan	I. **Introduction: Overview of this course** 1 Hours The lecture starts by introducing basic concepts and importance of photosynthesis in plants and algae. An overview of this course will be provided. **II. Basic of Photosynthesis Reactions** 3 Hours This chapter provides the basic of photosynthesis reactions from light collection, phtotochemical reaction, electron transfer reactions, ATP synthesis, and CO_2 fixation. Characteristics of photosynthesis reactions are discussed in detail. **III. Biochemistry of photosynthetic proteins** 3 Hours This chapter provides biochemistry of proteins involved in photosynthesis reactiions. In particular, multi-protein complexes located in the thylakoid membranes are focused. **IV. Functional and structural dynamics of photosynthesis** 3 Hours This chapter provides the dynamic features of photosynthetic reactions that are essentila for photosynthetic apparatus to cope with changing environments. **V. Engineering of photosynthetic proteins** 3 Hours This chapter provides genetic engineering of photosynthetic proteins. The methods of chloroplast and nuclear transformation are discussed. **VI. Application of photosynthesis** 2 Hours This chapter provides potentials of photosynthesis for application to increase productivity of agriculture, renewable energy, and phytoremediation.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T19:** Tutorial Studies in Plant Biochemistry and Molecular Biology
Main topic of the study	
Lecturer	Yuichiro Takahashi
Contact E-mail	taka@cc.okayama-u.ac.jp
Affiliation	Research Institute for Interdisciplinary Science, professor
Specialty	Plant Biochemistry and Molecular Biology
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credit
Lecture plan	1 -- Title: Overview of photosynthesis 2 -- Title: Oxygenic photosynthetic electron transfer reactions 3 -- Title: Biochemsitry of chlorophyll protein complexes 4 -- Title: Engineering of photosynthetic proteins 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.

Lecture title	**20:** Molecular Mechanism of Animal Development
Main topic of the study	Molecular genetic methods and developmental mechanism of Drosophila
Lecturer	Hitoshi Ueda
Contact E-mail	hueda@cc.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, professor
Specialty	Developmental Genetics / Molecular biology
Quarter, Day/Period	1Q or 2Q, Mon 4&5
Credits	1 credits
Lecture plan	1-- **Introduction: Overview of this course:** 1 Hours Introduction of basic concepts and importance of developmental biology and molecular genetics. 2 -- **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 to embryonic development, learning, behavior, and aging. 3 -- **Molecular genetic method using Drosophila**: 3 Hours Molecular genetic methods used to understand Drosophila social brain. 4 -- **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. 5 -- **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 6 -- **Time determination mechanism in post-embryonic development:** 5 Hours Various mechanisms of time determination systems during post-embryonic development of insects.

Lecture title	**T20:** Tutorial Study in Developmental Genetics and Molecular biology
Main topic of the study	
Lecturer	Hitoshi Ueda
Contact E-mail	hueda@cc.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, professor
Specialty	Developmental Genetics / Molecular biology
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	1 -- Title: Mechanism of time determination systems during development. 2 -- Title: Effect of nutrition for post-embryonic development. 3 -- Title: Regulation mechanisms of gene expression. Outline: 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.

IMaC-Okayama Syllabus (lectures)

Lecture title	**21:** 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, position	Graduate School of Natural Science and Technology, associate professor
Specialty	Chronobiology/Genetics and Neurobiology
Quarter, Day/Period	Quarter 2, Wednesday, Period 1&2
Credits	1 credits
Lecture plan	I. Introduction: Overview of this course ··· 1 Hour 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)

Tutorial study title	**T21:** Tutorial Studies in Chronobiology
Main topic of the study	Chronobiology
Lecturer	Taishi Yoshii
Contact E-mail	yoshii@okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, associate professor
Specialty	Chronobiology/Genetics and Neurobiology
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credits
Lecture plan	1 -- Title: Jet-lag and social jet-lag 2 -- Title: Human disorders related to circadian clocks 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.

Lecture title	**22:** Mechanisms of Plant Development
Sub-title of the lecture	Polyamines as pillars of cellular processes
Lecturer	Taku Takahashi
Contact E-mail	perfect@cc.okayama-u.ac.jp
Affiliation, position	Graduate School of Natural Science and Technology, Professor
Specialty	Plant Molecular Genetics
Quarter, Day/Period	Quarter 2, Thursday, Period 3&4
Credits	1 credit
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 (tutorial studies)

Tutorial study title	**T22:** Tutorial Studies in Plant Developmental Biology
Main topic of the study	Plant Developmental Biology
Lecturer	Taku Takahashi
Contact E-mail	perfect@cc.okayama-u.ac.jp
Affiliation	Graduate School of Natural Science and Technology, Professor
Specialty	Plant Molecular Genetics
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	15 hours / 0.5 credit
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.

Lecture title	**23:** Neuroendocrinology
Sub-title of the lecture	Neuroendocrinology modulation underlying the expression of instinctive behaviour
Lecturer	Hirotaka SAKAMOTO
Contact E-mail	hsakamo@okayama-u.ac.jp
Affiliation, position	Ushimado Marine Institute, Graduate School of Natural Science and Technology, associate professor
Specialty	Behavioural Neuroendocrinology
Quarter, Day/Period	Spring or Summer breaks, Intensive
Credits	2 credits
Lecture plan	I **Introduction: Overview of this course** 1 Hour The lecture starts by introducing basic concepts and importance of hormonal regulation of behaviour in vertebrates. An overview of this course will be provided. II **Basic of hormonal behaviour regulation** 3 Hours Basic of hormonal behaviour regulation. Specific focus on the effects of sex steroids and neuropeptides will be made. Differences in their molecular dynamics properties are discussed in detail. III **The sexual dimorphism of the vertebrate central nervous system** 3 Hours Sexual dimorphism in the vertebrate central nervous system. Specific focus will be made on sexual dimorphism regulation of a range of sexual behaviours in males and females. IV **Organizing actions by sex steroids in the developing brain** 3 Hours Sex steroids organization of sexually dimorphic nuclei in the brain during embryonic and neonatal life in vertebrates. V **The molecular basis underlying neuropeptide release** 3 Hours Recent topics on the molecular mechanism underlying neuropeptide release in some model animals like ??? VI **Reorganization of neural circuits induced by sexual experience and its behavioural modulation** 2 Hours Sexual experience modulation of the reorganization of neural circuits/molecular expressions in the brain underlying sexual behaviour in rodents. We will discuss whether these phenomena can apply to human case.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T23:** Tutorial Studies in Behavioral neuroscience
Main topic of the study	Behavioral neuroscience
Lecturer	Hirotaka SAKAMOTO
Contact E-mail	hsakamo@okayama-u.ac.jp
Affiliation	Ushimado Marine Institute, Graduate School of Natural Science and Technology, associate professor
Specialty	Behavioural Neuroendocrinology
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	1 -- Title: Newly developed neurophysiological methods: optogenetics, chemogenetics, and fibre photometry and its application. 2 -- Title: Comparative studies to investigate evolutional origin of neuroendocrinology. Outline: 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 a suitable textbook and recent literatures (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.

Tutorial study title	**T24:** 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, professor
Specialty	Molecular Genetics / Molecular Biology
Quarter, Day/Period	(decide after consultation with the students)
Hours/Credits	30 hours / 1 credits
Lecture plan	1 -- Title: The power of bacterial genetics revisited 2 -- Title: Ribosome rescue, how the cells maintain their gene expression system in shape? Outline: 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.

Lecture title	**25:** Mathematical modeling
Sub-title of the lecture	Kriging methods applied to Geostatistics
Lecturer	Junji Yamakawa
Contact E-mail	ufeq0285@cc.okayama-u.ac.jp
Affiliation, position	Graduate School of Natural Science and Technology, assistant professor
Specialty	Geostatistics
Quarter, Day/Period	Quarter 1
Credits	1 credits (16 Hours)
Lecture plan	**Foreword** This course addresses Kriging methods applied in Geostatistics. A focus will be also done in the last course developments on other fields like biology and materials sciences where Kriging recently got renewed interest. In statistics, originally in geostatistics, kriging or Gaussian process regression is a method of interpolation for which the interpolated values are modeled by a Gaussian process governed by prior covariance. Under suitable assumptions on the priors, kriging gives the best linear unbiased prediction of the intermediate values. Interpolating methods based on other criteria such as smoothness (e.g., smoothing spline) need not yield the most likely intermediate values. The method is widely used in the domain of spatial analysis and computer experiments. The technique is also known as Wiener–Kolmogorov prediction, after Norbert Wiener and Andrey Kolmogorov. The theoretical basis for the method was developed by the French mathematician Georges Matheron in 1960, he based on the Master's thesis of Danie G. Krige, the pioneering plotter of distance-weighted average gold grades at the Witwatersrand reef complex in South Africa. Krige sought to estimate the most likely distribution of gold based on samples from a few boreholes. The English verb is "to krige" and the most common noun is kriging. The word is sometimes capitalized as Kriging in the literature. **Lecture Breakdown** I. Introduction to Geostatistics ··· 4 Hours In this section, an overview of the Geostatisics analysis for the environment will be given. Some results of Geostatistics analysis will be represented by using the Geographical Information Software (GIS) such as QGIS and Google Earth. Through the representations, the importance of the mathematical modeling of the environment will be introduced. II. Theoretical basis of Geostatistics ··· 4 Hours Theoretical basis element of Geostatistics will be given. Geostatistics is primary based on spatial interpolation methods frequently used in the oil industry such as Contouring, Trend surfaces, Inverse Distance Weighting (IDW) and Kriging methods. Additional statistics methods used in Geostatistics will be also introduced. III. Kriging methods ··· 4 Hours Originally Krige developed the methods for mining technological. The

	explanation of the method will be divided into two sections. The former is Mathematical modeling of the Environment by using Variogram functions. The latter is Predictions of spatial distributions by using the Modeled function. Various weighting schemes used in the "Prediction" approach will also be shown in this section. IV. Practical knowledge required in Geostatistics ··· 4 Hours Details of the cartographic projection method and data format using in data exchange between the Geostatistics softwares will be presented. In each hours, students will be put into small groups to perform various analyses related to Geostatistics using computer softwares. After the analysis, each group will take 10-15 minutes short oral presentations. Then all groups will share their experience and understandings.

Lecture title	**26:** Superconductivity
Sub-title of the lecture	from basic concepts to today's advanced research topics
Lecturer	William Sacks
Contact E-mail	sacks.w@gmail.com
Affiliation, position	IMPMC laboratory, Sorbonne University - Paris (France) Professor
Specialty	Theoretical Solid State Physics
Quarter, Day/Period	Quarter 1& 2, Thursday, Period 1&2
Credits	1 credits (20 hours)
Lecture plan	*Prerequisites:* – *A good working knowledge of solid state physics (Ashcroft & Mermin or Kittel level).* – *Quantum mechanics at the Masters 1 level.* – *Motivation to explore the most challenging states of matter and their theoretical concepts.* **Outline:** The course is organized so that students will: • Gain knowledge of advanced physical properties of exotic materials and their theoretical base. • Study the particular electronic degrees of freedom going beyond the independent electron concept, i.e. electron correlations. • Investigate in detail 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 advanced solid state physics and novel materials** The course begins with an introductory review of materials displaying a wide range of electronic properties. Fundamental questions arise such as why a given material is an insulator, semiconductor or superconductor. What are the essential parameters driving such systems and can new materials be tailored for specific physical properties? II. **The metallic state and its instabilities** Once the quantum theory of the metallic state is well understood, this chapter explores important phase transitions to new 'ordered' states. The Landau theory of second order phase transitions is a powerful tool in

which the concepts of a free-energy functional and ‘order parameter’ play a central role. Collective phenomena such as charge density waves, magnetic states and, of course, superconductivity, will be discussed. In each case the phase transition is driven by a key microscopic electron-electron or electron-ion interaction.

III. **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 phenomenological 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 various spectroscopies), will be presented and discussed.

IV. **The high-Tc cuprate and iron-based superconductors**
An outstanding problem in solid state physics today is the unconventional high-Tc superconductivity of cuprates. In this chapter the properties of both cuprates, and the possibly related iron-based superconductors, will be treated in detail. A selection of recent high-quality experiments will be presented and the insight of various proposed models will be discussed.

V. **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.

IMaC-Okayama Syllabus (tutorial studies)

Tutorial study title	**T26:** Tutorial Studies in Superconductivity
Main topic of the study	Superconductivity: from basic concepts to today's advanced research topics
Lecturer	William Sacks
Contact E-mail	sacks.w@gmail.com
Affiliation	IMPMC laboratory, Sorbonne University - Paris (France) Professor
Specialty	Theoretical Solid State Physics
Quarter, Day/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.