# General courses provided by the School

**Computational Science, Introduction**

It is the aim of this course that attendees obtain the basic knowledge and skills for computational science. For this purpose, we give lectures and exercises as described below. In lectures, we give the following topics: numerical algorithms, computer architecture, basics of high precision computation and high performance computing, parallel computing techniques, and applications of computational science in various fields. In exercises using the C language, students acquire optimization techniques for serial computing which is the most important technique to utilize computers, parallel computing techniques for computers with multi-core CPUs, and parallel computing techniques for distributed memory parallel computer.

**Computational Science, Exercise A**

Through statistical processing for large-scale data, it is the aim of this course that attendees obtain skills for computer science. For this purpose, we give lectures and exercises as described below. In lectures, we give the following topics: numerical algorithm, statistical processing, computer architecture, basics of high performance computing and parallel computing techniques. In exercises, students acquire optimization techniques for serial computing which is the most important technique to utilize computers and parallel computing techniques for computers with shared memory using OpenMP and for computers with distributed memory using MPI.

**Information and Intellectual Property**

This course introduces the copyright law and copyrights of digital contents, the patent law and patents related to IT area (software patent, business model patent etc.), information technology for management and creation of intellectual properties, the protection of personal data, information ethics and information security. Students are required to acquire the fundamental knowledge of the copyright law, the patent law, information technology for management and creation of intellectual properties, the protection of personal data, information ethics and information security.

**Innovation and Information**

This class overviews theories on research and development (R&D) in conjunction with information management. Any students, either humanities or science, either applying manufacturing companies or not, can take this class that lectures logic and background of innovations and value creation process. Topics are selected to foster in-depth understanding of how management theories and technology development interact; “Central Research Institute” today, definitions of R&D, product architecture

theory, innovation and marketing, innovation and knowledge management, innovation and management strategy, Japanese way of management and R&D ethics of engineers, and more.

**Information Analysis and Management**

Analyzing and managing huge data are essential techniques to leading-edge researches in any fields. Topics of this lecture are selected from techniques utilized in many fields, e.g. information mining and management, information analysis based on several kinds of algorithms and probabilistic models, and visualization of analytical results. More specifically, the topics include foundation of information science such as algorithms and modeling of problems using graphs, relations between alignment of array data and formal languages and the hidden Markov model, data mining, database, visualization of information, user interface and interaction techniques, and information publishing. The purpose of this lecture is that students understand fundamental ideas of these techniques and utilize them in their own fields by learning how to apply them to concrete problems.

**Information Analysis and Management, Exercise**

Analyzing and managing huge data are essential techniques to leading-edge researches in any fields. Topics of this exercise are selected from techniques utilized in many fields, e.g. information mining and management, information analysis based on several kinds of algorithms and probabilistic models, and visualization of analytical results. More specifically, the topics include foundation of information science such as algorithms and modeling of problems using graphs, relations between alignment of array data and formal languages and the hidden Markov model, data mining, database, visualization of information, user interface and interaction techniques, and information publishing. The purpose of this exercise is that students master how to apply these techniques to concrete problems and utilize them in their own fields.

**Social Contributions through Informatics**

This is a practical, hands-on course in order to support the social contributions of students through knowledge gained in the course of academic efforts in the informatics field, including social services and other activities based on knowledge derived from informatics.

The specifics regarding the implementation and credit approval processes of the course are as follows:

1) Students who wish to take the course shall prepare an implementation plan and submit it to the Dean of the School. The implementation plan shall include a specific plan stating i) what kind of knowledge related to informatics will be used in a social contribution activity, and how it will be used; ii) implementation schedule and location; iii) when the location is outside the University, information on preparation status, relevance to organizations (NPOs, etc.) outside the University, and student insurance coverage status; iv) whether the duration is long enough to cover 45 class hours required for credit approval; and v) observations by the student's supervisor.
2) When the implementation plan prescribed in paragraph 1 is submitted, the Dean of the School shall refer it to the Student Affairs Committee to deliberate on its appropriateness. When the Student Affairs Committee deems the implementation plan to be appropriate, the Dean of the School shall allow the course to be taken. The Student Affairs Committee shall conduct a comprehensive deliberation on such issues as whether or not the plan falls into the category of social contribution through informatics; relevance to other organizations; and, when the hands-on learning activity is implemented outside the University, the possible dangers of the location, the status of insurance coverage and preparations.
3) After finishing the activity, students shall submit a report to the Dean of the School, which shall include implementation records of the 45-hour activity, an evaluation regarding the degree of achievement of the implementation plan prescribed in paragraph 1, and an account of expenses incurred during the activity.
4) When the report prescribed in paragraph 3 is submitted, the Dean of the School shall refer it to the Student Affairs Committee to deliberate on its appropriateness and shall assign a grade using a pass/fail method based on the evaluation of the Student Affairs Committee.
5) Students who take the practical, hands-on course shall not be allowed to receive any compensation or reward (except actual travel and accommodation expenses) for the activity.

Note: If students knowingly provide incorrect information in the report prescribed in paragraph 3, such an act shall be deemed to constitute improper conduct provided for in Article 10 of the Graduate School of Informatics Academic Grading Regulations. The course shall not be subject to Article 11 of the same Regulations.

**Internship in the Field of Informatics**

The purpose of the course is to offer opportunities for graduate school students to deepen their understanding of social structures and carefully think about their future career paths through internship programs at private companies and other organizations.

The details regarding the implementation and credit approval processes of the course are as follows:

1) Students who wish to take the course shall, after detailed consultation with a host company, prepare an implementation plan and submit it to the Dean of the School. The implementation plan shall include a specific plan stating i) implementation schedule and location; ii) information on preparation status and student insurance coverage status; iii) whether the duration is long enough to cover at least 45 class hours required for credit approval; and iv) observations by the student's supervisor.
2) When the implementation plan prescribed in paragraph 1 is submitted, the Dean of the School shall refer it to the department to which the applicable student belongs for deliberation on its appropriateness. Following deliberation at a department meeting or other type of meeting, the chairperson of the applicable department shall report to the Dean of the School on whether or not the student is allowed to take the course.
3) When allowed to take the course, students shall, after finishing the activity, submit a report to the Dean of the School, which shall include implementation records of the 45-hour activity, and an account of expenses incurred during the activity.
4) When the report prescribed in paragraph 3 is submitted, the Dean of the School shall refer it to the Student Affairs Committee to deliberate on its appropriateness and shall assign a grade using a pass/fail method based on the evaluation of the Student Affairs Committee.
5) Students who take the practical, hands-on course shall not be allowed to receive any compensation or reward (except actual travel and accommodation expenses) for the activity.

Note: If students knowingly provide incorrect information in the report prescribed in paragraph 3, such an act shall be deemed to constitute improper conduct provided for in Article 10 of the Graduate School of Informatics Academic Grading Regulations. The course shall not be subject to Article 11 of the same Regulations.

# Department of Intelligence Science and Technology

(For the underlined courses, classes will be provided in English.)

**Introduction to Cognitive Science**

This course provides an introduction to the major properties of human sensation, perception, and cognition as well as their underlying neural mechanisms. It also introduces the principles of neural networks and the computational theory of human cognition.

**Introduction to Information Science**

This course provides students with a basic understanding of advanced research in Information Science. It explains the elements and structures of information as well as the theories of modeling and abstraction. It also explains methods of analyzing, understanding, and generating information in the areas of language processing media, speech media, and visual information media.

**Introduction to Bioinformatics**

This course introduces and discusses various information-scientific methods and findings for analyzing the information flow from genomic sequence, the blue print of life, to a variety of biological phenomena. The course provides an overview of the basics of bioinformatics through discussions of the foundations of life sciences, introduction of fundamental algorithms, statistical analyses, machine learning approaches, and probabilistic models.

**Seminar on Cognitive Science**

This seminar explores empirical and theoretical research in cognitive science. Seminar discussions will focus on recent topics and current problems.

**Computational Cognitive Neuroscience**

The wellspring of human intelligence is the brain, or more accurately, information processing (i.e., calculation) by the brain. This course explores acquisition of fundamental knowledge about information processing by the brain, which is required for purposes such as understanding human brain function and learning about human intelligence in order to develop novel intelligent systems. Starting with the importance of looking at things from the perspective of brain processing, this course explains how experiment and theory in cognitive neuroscience (i.e., experimental knowledge of the relationship between action and brain activity, and mathematical neuroscience models based on statistical information science and machine learning) work in tandem to advance our understanding of brain mechanisms and information processing by the brain. Specific topics to be covered include those related to a relatively microscopic level of understanding, such as the

encoding of external information by the activity of neuronal populations and the use of information geometry to conduct group interaction analysis; functions in brain areas such as basal ganglia circuits; as well as topics related to macroscopic understanding, such as higher-order cognitive functions in humans including caution, decision-making (enforced learning), and social decision-making (psychological theory). All of the above will be explained in terms of brain processing, and recent studies will be introduced as well.

**Computational Learning Theory**

This course provides machine learning based on theory of computation. We introduces on methods for learning formal languages, such as regular languages and context free languages, and sets of formulae in first-order logic, and then discuss on their properties in some appropriate learning models, including their justification. We also explain relationships of the learning with formal concept analysis, data mining, and computational algebra.

**Pattern Recognition (Advanced)**

The course introduces fundamentals of pattern recognition, clustering methods with several distance measures, and feature extraction methods. It gives a review of state-of-the-art classifiers such as Gaussian Mixture Models (GMM), Hidden Markov Models (HMM) and Neural Networks (NN) and also the learning theory which includes Maximum Likelihood Estimation (MLE), Bayesian learning and Deep learning. It also focuses on modeling and recognition of sequential patterns.

**Conversational Informatics**

Conversational communication is a durable method to exercise collective intelligence of interaction among the natural and artificial intelligence. In this lecture, we analyze linguistic and non-linguistic communication mechanism in terms of computational theory, then discuss the current topics of the interacting communicational system design based on this perception.

**Multimedia Communication**

In this lecture, we introduce and explain several protocols and algorithms that are used for multimedia communication on the Internet. Provided topics are as follows: end-to-end communication technology, technology for QoS (Quality of Service) guarantee, protocols and data formats for multimedia communications, graph algorithms for network communication, algorithms for secure communication, present situation of information security, and legal system for information security.

**Speech Processing (Advanced)**

This course covers fundamentals of speech, audio and music processing. After a brief review of human hearing mechanism, we introduce the source-filter model, which is the basis of speech analysis, synthesis, coding and recognition. Spoken dialogue systems are also reviewed. Next, we introduce music processing such as automatic transcription and source separation. Then, audio signal processing for robot audition is explained including source localization, separation and recognition.

**Language Information Processing (Advanced)**

This course focuses on morphological analysis, syntactic analysis, semantic analysis, and context analysis, which are necessary to process natural language texts. The course also explains their applications such as machine translation, information retrieval, and natural language man-machine interface.

**Computer Vision**

This course covers the basics and applications of visual information processing necessary for computational analysis and understanding of real-world images/videos of objects and scenes. Students will learn the theory and its applications of fundamental and applied computer vision topics, also through hands-on implementation experience, ranging from optical and geometric camera models, projective geometry, and image processing, to 3D reconstruction including photometric stereo and structure from motion, motion analysis and object recognition.

**Visual Interface**

This course focuses on the interface between humans and computers explored through visual media such as images. The course explains the basic concepts of human interface, virtualization of the real world, input and output devices for interface, and facial image processing.

**Statistical Learning Theory**

This course will cover in a broad sense the fundamental theoretical aspects and applicative possibilities of statistical machine learning, which is now a fundamental block of statistical data analysis and data mining. This course will focus first on the supervised and unsupervised learning problems, including a survey of probably approximately correct learning, Bayesian learning as well as other learning theory frameworks. Following this introduction, several probabilistic models and prediction algorithms, such as the support vector machine or conditional random fields will be introduced.

**Bioinformatics (Advanced)**

This course covers advanced topics in bioinformatics and biological sciences. In particular, the course will focus on discrete algorithms for bioinformatics and discrete mathematical models for biological networks. The Introduction of Bioinformatics course is a prerequisite for taking this course

**Advanced Study in Intelligence Science and Technology 1**

In this course, students obtain advanced knowledge related to their research themes in Intelligent Science and Technology from exercises that are based on a systematic teaching of basic material previously learned. The course consists of seminars, internships, and invited lectures.

**Advanced Study in Intelligence Science and Technology 2**

This course provides students with systematic exercises for studying various advanced research related to their research themes in Intelligent Science and Technology. The course consists of seminars in which students review recent research papers and discuss the methods and results published in the papers.

**Seminar on Intelligence Science and Technology I and II**

The goal of this course is to introduce students to the different aspects, methodological and applied, that form the field of Intelligence Science and Technology. Students following this course will be given opportunities that may include: visit other laboratories than that to which he/she is originally attached to, and possibly attend a course, a seminar or a practical training session; hear about the latest research carried out by members in other laboratories; carry out an internship within a relevant industrial partner or research institute. This course is intended for students of the IST department, but may accept, if conditions allow for it, students coming from outside the department.

**Seminar on Intelligence Science and Technology III and IV**

The goal of this course is to introduce students to the different aspects, methodological and applied, that form the field of Intelligence Science and Technology. Students following this course will be given opportunities that may include: hear about the latest research carried out by members in other laboratories in the department; attend lectures provided by a lecturer from a different research institute or in the industry; carry out an internship within the industry or in another research institute. This course is intended for students of the IST department, but may accept, if conditions allow for it, students coming from outside the department.

# Department of Social Informatics

Courses whose name is underlined will be provided in English in principle. For courses provided in both Japanese and in English, the credits can be earned from either of them.

**Information and Society** (Class given both in English and Japanese, at the same time, in separate classrooms)

This course introduces social issues dealing with the impact of information technology on society: information policy, information and law, information and economics, information ethics, and information and education. Students will learn the social aspects of information technology from multi-disciplinary viewpoints: the history and trends of information technology; problematic issues regarding an information society; social revolution brought on by information technology, privacy, and security issues; policies concerning information, intellectual properties, and the way IT experts think and the responsibilities they bear.

**Information System Design** (Class taught in English with Japanese language support in the classroom)

This course introduces fundamental concepts, methodologies and underlying technologies for analyzing, designing and implementing social information systems. In particular, the course presents fundamental concepts and methodologies regarding the basics of set data representation, design considering security and privacy protection, and incentive design. Students will examine design methodology and implementing/operation technologies to learn how information systems are designed, implemented and operated.

**Information System Analysis** (Class taught in Japanese with English language support in the classroom)

This course introduces fundamental theories and technologies for analyzing and evaluating information and information systems. Students will learn several statistical processing methods: experimental design, systems analysis, data analysis, and data mining. In conjunction with lectures, students of the department of social informatics will complete exercises on information system analysis so that they may understand information system analysis theory and technology through the practice of applying them to real data.

**Practice of Information Systems** (Japanese and English lectures will be held in the same classroom)

Training exercises on the theory and techniques of information systems analysis and information systems design theory will provide users with basic knowledge of analyzing and designing

information systems.

**Distributed Information Systems** (Class taught in English with Japanese language support in the classroom)
This course introduces technical issues related to the Web and databases. We will pick out topics from the areas of Web databases, distributed databases, information retrieval, and information extraction.

**Human-Robot Interaction**
Intelligent robots are becoming more and more common in people's everyday lives. An increasing number of robots are designed with a variety of interactions as its primary function; for example, human-like robots capable of social interaction with humans, robots performing duties and activities alongside humans without getting in the way, and robots controlled by humans such as telepresence robots or drones. To build robots with a capacity for interactions requires not only information processing technology and artificial intelligence robotics technology but also an academic thought process for understanding the characteristics of human recognition and psychology. In this lecture, objective views of human-robot interactions in a variety of forms are presented and students will learn to acquire an academic thought process so that they can design and build new forms of interactions.

**Biosphere Informatics** (Class taught in Japanese with English language support in the classroom)
In this course, students will learn about basic methods for analyzing data obtained in the biosphere, primarily using R. In addition, students will give a presentation on the results of their data analyses related to biological and environmental problems.

**Disaster Information**
This course presents an outline of disaster prevention and reduction countermeasures both inside and outside Japan, with special reference made to disaster-information-related topics. The course introduces concrete examples of disaster information systems to show that the psychological aspect of information users under critical social conditions is carefully taken into account in such current disaster information systems.

**Emergency Management**
Damage from disasters is defined by two factors: scale of hazard and social resiliency. Two strategies and losses exist to reduce damage and losses from disasters—namely, crisis management as a post-event countermeasure and risk management as a pre-event measure. This course introduces

an integrated research for disaster reduction, consisting of response, recovery, mitigation, and preparedness.

**Medical Informatics**

This course covers the applications of information science and technology in the field of medicine as well as recent topics. Additionally, the course covers what information science and technology provided for the field of medicine.

**Informatics of E-business**

This course introduces the theory, practice and state-of-the-art solutions regarding various phenomena related to a ubiquitous network society, as viewed from the perspective of ICT businesses. Topics include, for example, e-businesses, ubiquitous networks, communication policies, corporate information systems, knowledge management, community IT, etc.

**Information Education (Not provided for this academic year)**

Modern society depends more on information and communication technologies (ICT) and knowledge. Hence, we need to not only train ICT specialists, but also help all people acquire adequate knowledge about information and ICT as well as the skills necessary for dealing with them. This course introduces information and information technology education, focusing mainly on general education at the higher educational level.

**Cryptography and Information Society**

This course covers basic security technologies, including encryption and authentication as well as their applications in our information society. In particular, the course introduces various issues that arise in the operation of public-key cryptography used in PKI, which is the infrastructure for authentication and digital signatures on the Internet. The course also presents new applications of cryptography such as e-cash and e-voting as well as the current situation in e-trading and operation in actual networking infrastructures.

**Theories of Service Modeling**

This course examines theories about service modeling for the purpose of valuing, analyzing and applying services. The scope of the course is not limited to the tertiary industry as represented by consumer services, but also covers the overall industry, including the industrial shift from manufacturing companies to ones that create service-related value. This service methodology fosters human resources that help improve productivity in the tertiary industry and/or tackle

commoditization in the IT industry. Thus, lectures are interdisciplinary, involving the areas of business administration and informatics.

**Advanced Study in Social Informatics 1**

Students propose research topics dealing with the social applications of information and network technologies. Moreover, they conduct research on their topics, which includes systematic surveys, exercises, and experiments.

**Advanced Study in Social Informatics 2**

Students will select their research themes and then conduct research (including technology development, survey work, and a research discussion) dealing with the social applications of information and network technologies. Finally, they will present their research results in the form of a research paper. Through their research, students will learn ways of evaluating and critiquing research.

# Department of Applied Mathematics and Physics

(The underlined courses will be provided in English.)

**Operations Research, Advanced**

This course examines optimization methods for various mathematical models that arise in engineering, the social sciences, and the natural sciences, with particular emphasis given to the theory of nonlinear optimization and the design of discrete optimization algorithms.

**Mathematical Physics, Advanced**

This course deals with various problems that appear in mathematical physics by focusing on mathematical aspects. In particular, the topics include applications of perturbation theory, calculus of variations, singularity analysis to some physical models including forced pendulum, billiard mapping, and celestial mechanics.

**Systems Analysis, Advanced**

This course deals with fundamentally important issues related to dynamical systems modeling, and systems analysis.. The first half of the course covers system identification schemes such as prediction error methods and subspace methods. The second half of this course is concerned with the generalized inverse matrix, pseudo-inverse matrix and singular value decomposition for constructing the least square approximation solution of linear systems.

**Mathematical Analysis, Advanced**

The aim of this course is to provide students with knowledge of advanced mathematical analysis methods used with nonlinear models. In this course, integrable systems are introduced as precisely solvable nonlinear models and discussed from various points of view. The course also shows how a typical numerical algorithm is constructed from an integrable system.

**Discrete Mathematics, Advanced**

This course focuses on the fundamental techniques for designing algorithms such as dynamic programming, divide-and-conquer, the greedy method and min-max property (duality) in discrete optimization. The course also introduces some new topics from the areas of graph network theory, approximation algorithms, and randomized algorithms.

**Control Systems Theory, Advanced**

This course covers fundamental issues on control systems analysis and synthesis including recent trends. The importance of system model uncertainty is discussed after reviewing subjects taught in

standard undergraduate control courses. Topics include: robust control theory, application of convex optimization and polynomial methods, distributed control for multi-agent systems, and the effects of stochastic noises in control systems.

**Optimization Theory, Advanced**

The course focuses on basic optimization theory and algorithm design for solving convex optimization problems. Topics include duality in nonlinear optimization, interior point methods for linear and convex programming problems, and convex optimization approaches to real-world problems.

**Physical Statistics, Advanced**

This course focuses on basic spectral theory of stochastic processes based on ergodic theory, statistical mechanics of deterministic chaos, and physical statistics with special attention given to the application of stochastic processes and stochastic physics to communications systems, energy-information integrated networks, physical, biological and sociological model systems.

**Dynamical Systems, Advanced**

The knowledge of dynamical systems is extremely important in mathematical sciences and applied mathematics. This course provides an outline of dynamical systems theory, which is a tool to analyze nonlinear phenomena such as bifurcations and chaos, and enables you to gain better understandings of these phenomena and applications by using a numerical bifurcation analysis software.

**Introduction to Mathematical Finance (Not provided for this year)**

This course introduces the topic of mathematical finance with asset-price processes modeled by stochastic processes.

**Financial Engineering**

Researchers familiar with the real world of finance teach this course on financial engineering, with particular emphasis given to the understanding and solution of financial problems in economics and management from the viewpoint of mathematical science.

**Topics in Applied Mathematics and Physics A**

The purpose of this program is to understand how scientific achievements in mathematical engineering are transferred into real world applications in relation to an information society. Requirements for practical applications of mathematical engineering are explained by primarily

focusing on OSs, networks, body area networks (BANs) as well as optical blood analysis technologies and mathematical designs in related fields. As examples, we delve into contemporary issues such as next generation mobile networks and energy efficient and security-related BAN technologies, mainly in the medical and health care application fields.

**Topics in Applied Mathematics and Physics B**

Based on their experiences pursuing actual corporate research, corporate researchers present lectures on construction theory for mathematical models, which is indispensable for planning, evaluating, and operating systems. As an application example, they teach modeling theory for IT systems, especially manufacturing systems, and also explain in concrete terms the use trend of the modeling technique used in the social infrastructure field (particularly, so-called lifelines such as railways, electric power, communication, and water service).

**Seminar in Mathematical Analysis**

The goal of this course is to understand and acquire basic mathematical methods and techniques for advanced study on mathematical analysis. In particular, taking the students' request, basic academic ability and research experience into consideration, we will choose textbooks and hold seminars.

**Seminar in Discrete Mathematics**

In this course, we study how algorithm design techniques such as branch-and-bound method, dynamic programming, and integer program are used to solve actual problem instances of discrete optimization. For this, we use solver tools such as CPLEX and MATLAB and write program codes in C language to conduct computational experiments.

**Seminar in System Optimization**

In this course, we study mathematical optimization models, optimization theories and algorithms such as robust optimization, conic optimization, dual theory, and the first- and second-order methods. Moreover, we learn to write program codes in Python/Matlab/C language to conduct numerical experiments for mathematical optimization.

**Seminar in Control Systems Theory**

This seminar focuses on the design of control systems using up-to-date research as well as fundamental theories. The seminar content includes optimal control, robust control, stochastic control, networked control, estimation, and system identification. Applications to industrial as well as social systems are also discussed.

**Seminar in Physical Statistics**

The Central Limit Theorem (CLT) is deeply related to statistics of various kinds of data. In this seminar, we study the fundamental theory of CLT, the Generalized Central Limit Theorem (GCLT) and its applications to data analysis in Finance, Engineering, and Physics.

**Seminar in Dynamical Systems**

The goal of this course is to understand and acquire several theories and techniques required for advanced level studies related to dynamical systems by reading textbooks and discussing various topics treated there. The textbooks will be chosen by taking students' requests into account.

**Advanced Study in Applied Mathematics and Physics 1**

In the fields of applied mathematics and physics, recent topics are addressed in each seminar along with computer simulations or exercises according to the themes covered.

**Advanced Study in Applied Mathematics and Physics 2**

Each seminar deals with topics from the above-mentioned Advanced Study I course or with advanced topics connected to those addressed in Advance Study I, with computer simulation if necessary.

# Department of Systems Science

(For the underlined courses, classes will be provided in English.)

**Systems Sciences, Advanced I**

This course covers a wide range of research topics in systems science including the topics such as synthesis and evaluation of various systems, analysis of system stability and reliability, and the relation of systems to humans and society. In this lecture, we will describe most-advanced research topics in each field of the department with its methodology.

**Systems Sciences, Advanced II**

This course covers a wide range of current research topics and future directions in systems science. This course covers synthesis and evaluation of various systems, their stability and reliability, and the relation of systems to humans and society. Student presentations are required during this course.

**Control Theory for Mechanical Systems**

The basic theory of advanced control for mechanical systems is lectured. The topics covered include algebraic control theory which includes coprime factorization and two-degree-of-freedom control, and H-infinity control theory.

**Theory of Human-Machine Systems**

Various interactions observed in human-machine systems, especially interactions involving human behavior and roles are discussed with respect to human recognition ability, their actions, errors, inferences, feelings of affection, and biological characteristics. Theories and methodologies for constructing reliable human-machine systems are taught. Lectures that discuss the application methods involving these systems are held with practical examples.

**Theory of Integrated Dynamical Systems**

In this course, we will study optimal control theory of nonlinear systems and distributed control theory of multi-agent systems as a general methodology for modeling, analysis, design, and control of various kinds of systems integrating humans, machines, societies, and environments. In the first half of the course, after an overview of fundamentals of optimization, we will discuss various settings of problems, numerical solution techniques, applications, and recent research trends of optimal control problems. In the latter half of the course, we will discuss the basics and applications of distributed control theory centered on consensus control of multi-agent systems.

**Adaptive Systems Theory**

It discusses theories necessary for artificially realizing abilities of adaptation and learning, which are ubiquitously observed in animals and human. The main focus will be on mathematical approaches to problems of inference and learning on the basis of probability theory and statistics.

**Statistical Systems Theory**

This course explains statistical methods for inferences, predictions, and decisions from data on the basis of probability models, with an emphasis on the mathematical aspect of model selection using information criteria and resampling methods.

**Theory of Information Systems**

Mathematical modeling and performance methodologies for proper design and evaluation of information service systems will be covered in the lecture. In particular, the basic theory of Markov chains, generating random numbers by Markov chain, and ranking and rating based on matrix analysis will be described.

**Integrated Systems Biology**

This course aims to present information processing models of biological phenomena and human intelligence systems. Particular topics include the mathematical models of sensory information processing in neural systems, computational basis of optimal decision making in non-deterministic environment, theoretical basis of reinforcement learning to achieve optimal action policy, and statistical approaches to bioinformatics data analysis.

**Medical Information Systems**

Various information systems are used in the fields of medicine and health care from blood analysis system to electric medical record system or telemedicine system. Special accuracy and exclusive security for personal information are required to medical information system. Essential design and the uniqueness of such medical information systems are lectured. Principles of biophysical measurement methods from physiological test to medical imaging are also addressed in connection with the fundamentals of physiology and related technology.

**Supercomputing, Advanced**

This lecture is for learning architectural and software issues in supercomputing focusing on parallel high-performance scientific computing. The students will use the supercomputer in ACCMS to learn how a real supercomputer works. The lecture is open to students from any graduate schools whose convenience to attend the lecture is regarded by assigning the fifth period for the lecture.

**Industrial Mathematics and Design**

Methodologies of mathematical modeling, statistical data analysis, and mathematical optimization are discussed as mathematical common languages supporting inter-disciplinary viewpoints and design thinking for resolving complex problems in today's societies. Various concepts in industrial mathematics used in modeling objects are reviewed to develop high-angle viewpoints for modeling, and data analysis and optimization are lectured as systematic problem-solving methodologies utilizing mathematical modeling. Tools and solvers useful for dealing with practical problems are also reviewed.

**Modeling and Problem-Solving of Complex Systems**

This class aims to provide frameworks for solving various problems of complex systems. The methodologies consist of modeling target systems, feedback control to achieve our objectives, and formulation of optimization problems by taking account of constraints.

**Computational Neuroscience**

The brain and neural systems are special in that they are information processing systems build from natural components. Computational neuroscience, as a research discipline, studies the brain from an information processing viewpoint. This course addresses the brain's ability to operate in uncertain environments and its capacity to learn (adapting to the environment) by discussing various models of the brain and their applications to engineering tasks.

**Computational Intelligence**

Thanks to advances in information technology we are able to accumulate vast amounts of real-world data, making data mining, the task of efficiently extracting meaningful information from such data, increasingly important. This course presents computational intelligence methods based on statistical science (such as statistical learning theory), and describes their applications to various information extraction problems.

**Systems Biology (Not provided for this year)**

This course will introduce interdisciplinary knowledge, techniques, and concepts covering a wide range of areas related to developmental, cellular, and mathematical biology, as well as information science. Students will deepen their understanding of the structure, function, and dynamics of cells, as well as their molecular actions, and learn systems biology that considers cells as systems.

**Advanced Study in Systems Science 1**

Seminars and workshops on various current research themes in systems science are held. Also, experimental practices and exercise on respective research themes are carried out.

**Advanced Study in Systems Science 2**

Seminars, workshops, experimental practices and exercise on further and advanced research themes are carried out.

# Department of Communications and Computer Engineering

(For the underlined courses, classes will be provided in English.)

**Theory of Discrete Algorithms**

This course covers recent topics within the field of discrete algorithms. It describes the basic concepts of computational theory, outlines of the basic algorithmic techniques for the divide-and-conquer method and dynamic programming, and covers practical techniques for approximating algorithms and online algorithms. Furthermore, the course introduces advanced algorithmic techniques for efficiently manipulating large-scale discrete structural data such as logics, sets, sequences, and permutations.
Required background: algorithms and data structure, logic systems, graph theory

**Introduction to Algorithms and Informatics**

This is an introductory course on algorithms and informatics for students with no prior knowledge of the subject matter. Undergraduate students are allowed to take the course depending on the capacity limited.

**Digital Communications Engineering**

This course explains fundamental technologies in digital communications engineering such as matched filter theory, modulation and demodulation schemes, convolutional coding, and maximum-likelihood decoding. It also discusses how these techniques will be applied to actual wireless communication systems. It moreover introduces representative anti-multipath fading techniques and the recent technical trend of broadband wireless communications.

**Information Networks**

This course introduces information network architectures, protocols, and traffic theory. It also discusses standardizations of information network, services, and business issues.
Required background: fundamentals of digital communications, fundamentals of probability and statistics

**Integrated Circuits Engineering, Adv.**

An integrated circuit is a key device that enables functionality enhancement, performance increase, and cost reduction of an electronic system. Steady progress in fabrication technology leads to exponential increase in integration scale. This course focuses on the design methodology of a large-scale integrated circuit (LSI), with particular emphasis on logical and physical design process. Topics covered by the course include the current status and future directions regarding LSI design technology, CMOS process technology, CMOS layout design, CMOS device characteristics, CMOS

static gates, CMOS dynamic gates, and LSI design methodology.
Required background: electronic circuits, digital circuits, logic circuits

**Design in ICT**

Computers and communication networks are representative complex technical artifacts, but it is not an easy task to perceive their construction principles because their design processes are invisible for us. In this course, we study design principles for information and computer technology (ICT) in terms of (1) hierarchical abstraction, (2) tradeoff, and (3) human and social analogy, being the computers and the communication networks as specific examples. Recent advances and directions for the design of future ICT will be also discussed using the above design principles.

**Theory of Computational Complexity**

The main purpose of Theory of Computational Complexity is to categorize the issues with its complexity. In this course, the first half covers the basics of complexity theory, especially NP-completeness. The second half is comprised of the advanced current topics on the theory.
Required background: design and analysis of algorithms

**Parallel Computer Architecture**

In this lecture, we first learn instruction-level parallelism in a single processor and its limitations, and then, learn data-level parallelism, thread-level parallelism etc., as well as various parallel computer architectures.
Required background: computer architecture, compiler

**Hardware Algorithm**

Various dedicated circuits are equipped in VLSI systems for high-speed and low-power processing. In development of such circuits, design of their underlying hardware algorithms, i.e., procedures suitable for hardware implementation, is crucial.
In this lecture, we learn hardware algorithms and their design methods mainly for arithmetic operations. We also learn theory of logic functions and logic circuits which are basis of hardware algorithm design.
Required background: computer architecture, logic circuit, algorithm

**Parallel and Distributed Systems**

The course discusses process calculi, formal frameworks to specify parallel and distributed systems, such as CCS, the pi-calculus, the ambient-calculus. It also covers notions of equivalence of two systems and techniques to verify safety properties of parallel and distributed systems described in process calculi.

Required background: formal semantics of computer programs

**Formal Semantics of Computer Programs**

The course discusses formal semantics of computer programs including that of advanced constructs (such as pattern matching and exceptions) found in high-level programming languages and theoretical frameworks to ensure safety of program execution, such as type systems, and type inference.
Required background: programming languages

**Transmission Media Engineering, Adv**,

This course introduces the following: (1) the technical foundations of wireless and wired transmission technologies such as synchronization; (2) communications link analysis; (3) multiple access and medium access control schemes; and (4) radio resource management based on optimization and game theory.
Required background: information theory, modulation theory, and basic knowledge of communication networks.

**Integrated System Architecture and Synthesis**

This course first introduces algorithms for application-specific domains such as image and video processing. Students then study integration methodologies for multi-media systems. Considering the different levels of parallelism, this course covers basic algorithms, VLSI architectures, taxonomy of system integration, and evaluation.
Required background: computer system, logic circuits, image processing

**System-Level Design Methodology for SoCs**

This course introduces state-of-the-art design methodologies for system-on-a-chip (SoC). The course covers high-level synthesis, verification technologies, low-power design, design for testability, and other design technologies used in computer-aided design of SoC.
Required background: computer system, logic circuits, programming languages

**Atmospheric Measurement Techniques**

Various interactions between electromagnetic waves and the Earth's atmosphere, such as scattering, delay, refraction, and radiation, are applied to design novel atmospheric measurement techniques. This lecture explains the fundamental processes occurring in the Earth's atmosphere and introduces various atmospheric probing techniques such as radar, lidar, and earth observation satellite. It also elucidates the advantages and disadvantages of these techniques. This course is offered to the Inter-Graduate School Program for Sustainable Development and Survivable Societies (GSS) of the
Center

for the Promotion of Interdisciplinary Education and Research (C-PIER).
Required background: Radio engineering, fundamentals of light quantum theory, spectral analysis, mathematical statistics

**Remote Sensing Engineering**

This course introduces remote sensing engineering as an application of telecommunication technology. We adopt remote sensing of the Earth's atmosphere from a vast area of the studies--i.e., radar observation of the atmosphere (active remote sensing from the ground) and radiometric measurement of the atmosphere from satellites (passive remote sensing from space)--and teach their principles, equipment, signal processing, and data analysis. This class is offered to the Inter-Graduate School Program for Sustainable Development and Survivable Societies (GSS) of the Center for the Promotion of Interdisciplinary Education and Research (C-PIER).
Required background: radio-wave propagation, Fourier transform, probability and statistics

**Advanced Study in Communications and Computer Engineering 1**

This course will provide students with the necessary skills to conduct research and development in this area by understanding cutting-edge technologies in computer hardware/software as well as information and communication technology, which constitute the infrastructure of an information society.

**Advanced Study in Communications and Computer Engineering 2**

This course will provide students with the necessary skills to conduct research and development in this area by tackling new challenging research topics in computer hardware/software as well as information and communication technology, which constitute the infrastructure of an information society.

# Design courses

**Information Design**

Any valuable information or knowledge does not make sense if it is not transferred effectively among human beings and our society. We need to organize, design and present information in a way that fosters efficient and effective understanding of it. This course lectures information design, interaction design and visual design. The main topics of the course are: comprehensibility and credibility of information, language and information design, organization of information and spatial cognition, infographics, design of user interfaces and interactions, photo grammar and film grammar, storytelling, and information visualization.

**Field based Learning/Problem based Learning (FBL/PBL) 1, 2**

This course is designed to enable students to put design theories and design methods into practice and to acquire these theories and methods. In Field based Learning (FBL), students can experience the process of finding the problems to be solved from a given real-world fields as a team project. In Problem based Learning (PBL), students can experience the process of solving a given real-world problem as a team project.

# Other courses provided by the School

**Computational Science, Exercise B**

This lecture is for learning high-performance and parallel programming for scientific computing. Students will develop their own programs of a given typical scientific problem in C or Fortran according to their preference, and parallelize the program with MPI and OpenMP to run it on the supercomputer in ACCMS. The given problem, such as an explicit differential solver of diffusion equations, is not only fundamental and commonly acquainted by students, but also useful for their research of computational science because the programming and parallelization technique for it is widely applicable. The lecture is open to students from any graduate schools whose convenience to attend the lecture is regarded by offering it as a summer school seminar.

1) Introduction to supercomputers and parallel computing
2) Finite difference method for diffusion equations
3) Program coding of an explicit differential solver
4) Multi-thread parallel programming (OpenMP)
5) Multi-process parallel programming (MPI)

**Computational Science for Big Data**

Because of the recent progress in a computer or the maintenance of intelligence infrastructure technology, the increase of the quantity of the data generated from the social activity performed through the Internet such as cloud computing and the quantity of the data obtained through the computer simulation which is an important technique of computational science, is being enhanced every day. It is the purpose of this course to study the technique for analyzing and visualizing those big data. In particular, the data analysis to the large sparse matrix is exercised using the C language.

**Practice on Informatics in Business**

Information Technology (IT) is ubiquitous in society. Technological innovation, which is also called "the fourth industrial revolution," including the Internet of Things (IoT), big data, robots, and artificial intelligence, is moving forward at an unprecedented speed and magnitude. In this situation, the key to succeed in business competition requires an understanding the importance of information, which forms the basis of IT, and utilizing IT in core business operations.

In cooperation with multiple companies, this course allows students to experience how IT is used in business to capture the importance of information, which improves the competency of skills required in society. Because information and IT are also required in a variety of research areas and occupations, this course targets a wide range of students without restrictions on the field of study. By recognizing

the connection of IT to their own field, we hope this course will play a big role for the students' future success in society.

**Artificial Intelligence, Advanced**

Artificial intelligence (AI) has found its way into everyday life through tools such as those used for translation and image recognition, and is expected to undergo further development. AI is also expected to play an extremely important role in providing a competitive advantage to industries that adopt AI technologies. On the other hand, humans have not yet clearly defined intelligence, and the definition of the term artificial intelligence has yet to be clarified. In this lecture series, AI will be discussed from a historical perspective, beginning with its birth and advancement to its current state, as well as a potential future state. The technological and practical considerations of AI will be discussed systematically through the lenses of system recognition, analysis, and control. The future of AI will also be discussed.

**Information Security**

Information technology and networks have advanced to the point that they have become necessary for industrial and academic activities. However, the vulnerabilities hidden in these technologies have led to new dangers to society. This lecture series will discuss knowledge such as ensuring safety, defense against attacks, data recovery, and the legal system, with respect to the use of the internet or intranet, from the perspective of the user as well as the latest technologies.

**Practice of Design Thinking**

Design thinking is one effective method for bringing about innovation in society and is a problem-solving approach that has recently garnered much attention. It is difficult to accurately grasp true intentions in a rapidly changing modern society, in addition to responding to client or user desires and requests. This lecture series will discuss design thinking and its processes from two broad perspectives: problem discovery and problem resolution. These discussions will equip students with the skills to uncover the true issues and resolve them.

**Practice of Business Requirements Definition**

The importance of clearly defining requirements such as functionality to be implemented during system and software development can be said to determine the success of a given project. Defining business requirements begins with identifying the problem that a system or software is being designed to solve. This lecture series discusses the importance of defining business requirements and common pitfalls from the perspectives and experiences of the user and system developer. These important points will be experienced through practical case studies of both a waterfall-type approach and agile approach

to defining business requirements. These case studies are designed so that students gain an understanding of the differences in development methodologies as well as the advantages/disadvantages and characteristics of each approach.

**Practice of Business Data Analysis**

Society is moving towards resolving social issues in a data-driven manner through all things connected to the internet. In such an environment, it will be extremely important to determine how best to manage the large amount of data, and to pick out the relevant resolution to social issues. In this practical lecture series, students will learn how to effectively use data analysis to resolve issues in a business setting.

**Practice of Frontier Technology Application**

The 8 focused lectures will be conducted as follows. However, the contents of these lectures may change based on the level of understanding.

1. Trends and Proof-of-Concept Methods for State-of-the-Art Technology
   (1) Trends in State-of-the-Art Technology
   (2) Understanding Proof-of-Concept Methods

2. Practical Proof-of-Concept Group Training for Effective Use of State-of-the-Art Technology
   (1) Understanding new technologies that can potentially resolve identified issues
   Group activity involving a discussion about how to apply current state-of-the-art technologies to resolve a given issue (developing a hypothesis).
   (2) Testing new technologies and giving feedback on results
   Real-world testing of current state-of-the-art technologies (such as those supported by APIs) and confirmation of whether they support the assumptions of the hypothesis. Searching for other technologies if the hypothesis is not supported.
   (3) Proof-of-concepts and trial and error
   If a state-of-the-art technology that supports the hypothesis is found, perform trials within the context of the hypothesis to see if the actual issue can be resolved.
   (4) Presentation of new services (concepts)
   Group presentation on concepts developed to resolve new issues, using current state-of-the-art technology. Non-presenting groups will be giving feedback to the presenting groups.

# Department of Intelligence Science and Technology

| Course title | Instructors | hours / week | | Number of credit | Remarks |
|---|---|---|---|---|---|
| | | 1st semester | 2nd semester | | |
| Seminar on Intelligence Science and Technology, Advanced | Kamitani, Kumada, Nishida (Shinya), Yamamoto(Akihiro), Kashima(Hisashi), Nishida（Toyoaki）, Kurohashi, Kawahara(Tatsuya), Nishino, Akutsu, Okabe, Mori(Shinsuke) | 2 | 2 | 4 | Through the academic year |
| Seminar on Brain and Cognitive Sciences, Advanced | Kamitani, Kumada, Nishida (Shinya), Hosokawa, Mizuhara | 2 | | 2 | |
| Seminar on Cognitive System, Advanced | Kashima(Hisashi), Yamamoto(Akihiro), Nishida（Toyoaki）, Yamada, Nakazawa | | 2 | 2 | |
| Seminar on Intelligence Media, Advanced | Kurohashi, Kawahara(Tatsuya), Nishino, Kawahara(Daisuke), Yoshii, Nobuhara | 2 | | 2 | |
| Seminar on Application of Multimedia, Advanced | Okabe, Mori(Shinsuke), Iiyama, Miyazaki(Shuichi) | | 2 | 2 | |
| Seminar on Bio-system Informatics, Advanced | Akutsu, Tamura | | 2 | 2 | |

**Seminar on Intelligence Science and Technology, Advanced**

In this seminar we review and discuss, from broad perspectives, the latest topics in the field of information processing mechanisms in human and animal organic systems and the field of artificial mechanisms in advanced intelligent information processing.

**Seminar on Brain and Cognitive Sciences, Advanced**

This course provides a broad overview of biological and cognitive processing. It will discuss a number of selected issues and different views with regard to the topic.

**Seminar on Cognitive System, Advanced**

In this seminar, students learn about state-of-the-art research topics in the field of cognitive systems.

**Seminar on Intelligence Media, Advanced**

This seminar explains the constructing and controlling methods of intelligence media systems.

**Seminar on Application of Multimedia, Advanced**

In this seminar, students examine the multimedia technologies used for intelligent systems, which integrate the functions of recognizing, understanding, generating and authoring multimedia data, such as images,

videos and speech. Students also review the methodologies used for flexible human-machine interfaces and communication systems that use the above technologies.

**Seminar on Bio-system Informatics, Advanced**

Through this seminar, students learn about the latest worldwide research activities concerning various topics in the field of bioinformatics.

# Department of Social Informatics

| Course title | Instructors | hours / week | | Number of credit | Remarks |
|---|---|---|---|---|---|
| | | 1st semester | 2nd semester | | |
| Seminar on Social Informatics, Advanced | Yoshikawa(Masatoshi), Kanda, Ohte, Tajima, Moriya, Tatano, Kuroda, Yamori, Hatayama, Ogata | | | 2 | E<br>Mandatory<br>Intensive course |
| Seminar on Social Information Model, Advanced | Yoshikawa(Masatoshi), Ma, Kanda, Tajima | (2) | (2) | 4 | E<br>Through the academic year |
| Seminar on Social Information Network, Advanced | Abe, Matsubara | (2) | (2) | 4 | E<br>Through the academic year |
| Seminar on Biosphere Informatics, Advanced | Moriya, Ohte, Koyama, Mitamura | (2) | (2) | 4 | E<br>Through the academic year |
| Seminar on Regional Disaster Prevention Information Systems, Advanced | Tatano, Yamori, Hatayama | (2) | (2) | 4 | Through the academic year |
| Seminar on Medical Informatics, Advanced | Kuroda, Okamoto(Kazuya) | (2) | (2) | 4 | E<br>Through the academic year |
| Seminar on Information Education, Advanced | Ogata | (2) | (2) | 4 | Through the academic year |

**Seminar on Social Informatics, Advanced**

In this seminar, we focus on advanced topics concerning technologies used for gathering and analyzing information, which is necessary for modeling social information systems and their problems from the viewpoint of informatics. In addition, we discuss those topics from multi-disciplinary viewpoints.

**Seminar on Social Information Model, Advanced**

In this seminar, students will learn several social information systems, such as e-governments, e-commerce, digital libraries, and e-learning systems, as well as the fundamental technologies used to construct those social information systems, such as digital document processing, Web information searching, data mining, contents archiving, digital rights processing, and database management.

**Seminar on Social Information Network, Advanced**

In this seminar, we will discuss the most advanced topics related to basic theories in interdisciplinary areas (including computer science and social science) such as computational organization theory and computational economics. We will also examine the most advanced topics regarding application systems in social information networks.

**Seminar on Biosphere Informatics, Advanced**

In this seminar, we will discuss the topic of bio-resources, which includes the global environment and food. We will also discuss methods of analysis for assessing valuable information about the environment and bio-resources in the biosphere using integrated approaches.

**Seminar on Regional Disaster Prevention Information Systems, Advanced**

Taking into account human behavior and organizational features, this seminar focuses on advanced topics in disaster-prevention information systems to enhance the effective management of disaster risk and response.

**Seminar on Medical Informatics, Advanced**

After discussing the current situation surrounding the medical information field, students will complete an exercise on medical information. The aim of the course is to understand the field of medical informatics systematically and to obtain an ability to discuss matters in the field of medical informatics.

**Seminar on Information Education, Advanced**

Information education is a field connecting computer science, information technology, information society, educational methodologies, and the use of information and communication technologies in education. From a variety of points of view, this seminar studies both theoretical and practical topics in the area of information education.

# Department of Applied Mathematics and Physics

| Course title | Instructors | hours / week | | Number of credit | Remarks |
|---|---|---|---|---|---|
| | | 1st semester | 2nd semester | | |
| Seminar on Applied Mathematics and Physics, Advanced | Nakamura(Yoshimasa), Nagamochi, Yamashita, Ohta, Umeno, Yagasaki, Nonaka | (2) | (2) | 4 | Through the academic year |
| Seminar on Applied Mathematics, Advanced | Nakamura(Yoshimasa), Nagamochi, Tsujimoto(Satoshi) | | (2) | 2 | |
| Seminar on Applied Mathematical Systems, Advanced | Ohta, Nonaka, Yamashita, Kashima(Kenji), Takahashi, Fukuda | | (2) | 2 | |
| Seminar on Mathematical Physics, Advanced | Umeno, Yagasaki, Shibayama | (2) | | 2 | |
| Seminar on Mathematical Finance | | (2) | | 2 | Not provided for this year |

**Seminar on Applied Mathematics and Physics, Advanced**

This course discusses some of the current topics in the mathematical sciences from a broad perspective across various specialties with wide experience including internships at industrial laboratories and overseas research institutes.

**Seminar on Applied Mathematics, Advanced**

This seminar selects and surveys some of the current topics in applied mathematics.

**Seminar on Applied Mathematical Systems, Advanced**

In this seminar, students study and discuss state-of-the-art research and related literature on various subjects in applied mathematical systems.

**Seminar on Mathematical Physics, Advanced**

This seminar discusses some of the current topics in mathematical physics.

**Seminar on Mathematical Finance**

This seminar introduces important research and cutting-edge topics in the area of mathematical finance.

# Department of Systems Science

| Course title | Instructors | hours / week | | Number of credit | Remarks |
|---|---|---|---|---|---|
| | | 1st semester | 2nd semester | | |
| Seminar on Systems Science, Advanced | Kano, Ohtsuka, Tanaka(Toshiyuki), Shimodaira, Ishii, Matsuda, Nakashima | 2 | | 2 | |
| Seminar on Human Machine Symbiosis, Advanced | Kano, Ohtsuka, Nishihara, Sakurama | (2) | (2) | 4 | Through the academic year |
| Seminar on Systems Synthesis, Advanced | Tanaka(Toshiyuki), Shimodaira | (2) | (2) | 4 | Through the academic year |
| Seminar on Systems Informatics, Advanced | Ishii, Matsuda, Masuyama, Oba, Nakao | (2) | (2) | 4 | Through the academic year |
| Seminar on Applied Informatics, Advanced | Nakashima, Fukazawa | (2) | (2) | 4 | Through the academic year |

**Seminar on Systems Science, Advanced**

We will discuss advanced topics in all areas of systems science, with a wide range of view, free from area of expertise.

**Seminar on Human Machine Symbiosis, Advanced**

We will study research on the most advanced topics in human machine symbiosis in Japan and all over the world.

**Seminar on Systems Synthesis, Advanced**

We will study research on the most advanced topics in systems synthesis in Japan and all over the world.

**Seminar on Systems Informatics, Advanced**

We will study research on the most advanced topics in systems informatics in Japan and all over the world.

**Seminar on Applied Informatics, Advanced**

We will study research on the most advanced topics in applied informatics in Japan and all over the world.

# Department of Communications and Computer Engineering

| Course title | Instructors | hours / week | | Number of credit | Remarks |
|---|---|---|---|---|---|
| | | 1st semester | 2nd semester | | |
| Seminar on Communications and Computer Engineering, Advanced | Minato, Takagi(Naofumi), Igarashi, Harada(Hiroshi), Morikura, Oki, Sato(Takashi), Onodera, Yamamoto(Mamoru), Hashiguchi | (1) | (1) | 2 | Through the academic year |
| Seminar on Computer Engineering, Advanced | Minato, Takagi(Naofumi), Igarashi, Kawahara, Suenaga | (2) | (2) | 4 | Through the academic year |
| Seminar on Communication Systems Engineering, Advanced | Harada(Hiroshi), Morikura, Oki, Murata, Yamamoto(Koji), Shinkuma | (2) | (2) | 4 | Through the academic year |
| Seminar on Integrated Systems Engineering, Advanced | Sato(Takashi), Onodera | (2) | (2) | 4 | Through the academic year |
| Seminar on Radio Atmospheric Science, Advanced | Yamamoto(Mamoru), Hashiguchi, Yokoyama | (2) | (2) | 4 | Through the academic year |

**Seminar on Communications and Computer Engineering, Advanced**

From a broad perspective independent of the area of expertise, this seminar will introduce and discuss the latest topics in computer hardware/software as well as information and communication technology, which constitute the infrastructure of an information society.

**Seminar on Computer Engineering, Advanced**

This seminar will introduce hot topics in computer engineering, including computer architecture that enables high-performance computation, the underlying logic circuits and algorithms, and basic software systems such as programming language systems.

**Seminar on Communication Systems Engineering, Advanced**

This seminar includes intensive discussion on the current status, issues, and future directions regarding telecommunication systems engineering such as highly reliable information transmission over severe wireless channels and architectures of various wired/wireless information networks.

**Seminar on Integrated Systems Engineering, Advanced**

This seminar includes intensive discussion on the current status, issues, and future directions regarding integrated systems engineering such as design methodologies for digital and analog LSIs, advanced signal processing, etc.

**Seminar on Radio Atmospheric Sciences, Advanced**

A variety of remote-sensing technologies based on radio waves and light are used for the study of the Earth's atmosphere. This seminar will introduce recent results from a wide area of radio atmospheric science --- i.e., advanced observation technology, recent signal processing technique, and scientific achievements from advanced observations.

## Design courses

(Enroll after passing the Qualifying Examination (QE).)

For the students of the School, credits not counted towards completing the degree.

| Course title | Instructors | hours / week | | Number of credit | Remarks |
|---|---|---|---|---|---|
| | | 1st semester | 2nd semester | | |
| Open innovation practice 1 | TBA | | | 2 | General Design Courses (Intensive course through the academic year) |
| Open innovation practice 2 | TBA | | | 2 | General Design Courses (Intensive course through the academic year) Prerequisite is Open Innovation Practice 1 |
| Field internship | TBA | | | 2 | General Design Courses (Intensive course through the academic year) |
| Research internship | TBA | | | 2 | General Design Courses (Intensive course through the academic year) |

### Open innovation practice 1

Design activities to discover and solve real social issues by consulting related specialists or stakeholders to assemble a team for open innovation, and offering a series of workshops to achieve the objectives. The role of the students in this course is not to participate as a specialist to solve or discover issues, but to assemble and manage a team for the purpose of the aforementioned open innovation. Through this activity, students' communication and management skills are developed and students gain the knowledge about the basics of design theories and methods to successfully lead design activities through practical experience.

### Open innovation practice 2

Design activities to discover and solve real social issues by consulting related specialists or stakeholders to assemble a team for open innovation, and offering a series of workshops to achieve the objectives. Students in this course develop their knowledge of design theories and methods learned in Open Innovation Practice 1 to further improve their communication and management skills, and acquire a deeper understanding of design theories and methods to successfully lead design activities through practical experience.

### Field internship

Students in this program form a group to tackle international/social challenges encompassing several fields of specialties, and apply their knowledge in the field inside or outside Japan to foster their leadership abilities through group activities. In this internship program, students are required to create a strategic solution in the field, where the situation can truly be understood for the first time. Students will do this by structuring the information obtained, defining solvable issues, and interacting seamlessly with stakeholders on the scene and members from different fields within a limited timeframe.

### Research internship

The research internship aims to cultivate students' leadership skills while staying at an overseas research laboratory. Students will form and lead a team in a new research field by conducting multidisciplinary research from the design perspective through planning and executing a research project in collaboration with local researchers. A research plan must be submitted and assessed by program professors before the internship begins.