

Special Subjects of the Department of Informatics

Field	Course Code	Subject	Credit	Content of subject	Instructor
Foundations of Informatics	20DIFa01**	Logic in Computer Science	2	Type theory gives a fundamental framework for programming languages and software specification. This course will introduce type theory and give its explain in a mathematically rigorous way.	TATSUTA Makoto
	20DIFa02**	Theory of Numerical Methods	2	We will study the basics of compressed sensing, which is a relatively recent area of research that has applications to signal/image processing and computer algorithms. We will investigate it using a variety of mathematical techniques such as graph theory, probability theory, linear algebra, and optimization. The course is based on: M. Vidyasagar, <i>An Introduction to Compressed Sensing</i> , SIAM, 2019.	
	20DIFa04**	Algorithm	2	Explain basic concepts and techniques on algorithm, which is the theory of the way of compute, by showing applications in the real world, from the view point of algorithms theory.	UNO Takeaki
	20DIFa06**	Discrete Mathematics	2	Discrete mathematics has become popular in recent decades because of its applications to computer science. Concepts and notations from discrete mathematics are useful to study or describe objects or problems in computer algorithms and programming languages.	KAWARABAYASHI Ken-ichi
	20DIFa09**	Mathematical Logic	2	An introductory–intermediate level course in mathematical logic. Topics are chosen among those related to applications of logic in computer science.	TATSUTA Makoto
	20DIFa10**	Quantum Information Systems	2	Modify to have an emphasis on quantum error correction and quantum computer architecture.	Please refer to the Web Syllabus 2022
	20DIFa11**	Quantum Computation	2	Introduction of elementary mathematical thory of quantum information. Namely, we deal with entanglement, data compression, and state estimation.	MATSUMOTO Keiji
	20DIFa14**	Computational Neuroscience	2	Computational neuroscience aims to understand how the brain transmits information and develop a computer program that has the same function of the brain. This course will introduce the methodology of computational neuroscience.	
	20DIFa15**	Sublinear Algorithms	2	“Efficient” algorithms have meant polynomial–time algorithms. As the data size is increasingly large, however, even polynomial–time algorithms could be too slow. To handle such large data, “sublinear algorithms” have been developed in the last decades, where sublinear means less than linear. This course will cover theoretical foundations of sublinear–time algorithms as well as their applications to practical problems such as the analysis of web/social graphs.	YOSHIDA Yuichi
	20DIFa19**	Control Theory and Optimization	2	This course will introduce basics of control theory and optimization. We will also discuss reinforcement learning from the perspective of control and optimization.	KISHIDA Masako
	20DIFa17**	Graph Algorithms	2	A graph is a representation of connections between objects, and various problems can be formulated on graphs. This course will introduce algorithms for graph problems from basic ones to advanced ones.	

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Foundations of Informatics	20DIFa18**	Algorithmic Market Design	2	Market design is a field of research that considers how to design rules of markets, such as matching and auction markets. Through game-theoretic analysis, this field aims to design market rules that yield socially desirable outcomes, while each participant acts selfishly. In this course, we learn theory and applications of market design, while laying emphasis on its algorithmic and discrete-mathematical aspects.	YOKOI Yu
	20DIFa20**	Numerical Analysis	2	This course gives an overview of numerical analysis and numerical algorithms, in particular numerical linear algebra (especially eigenvalue problems and the SVD) and approximation theory (polynomials and rational functions). While the goal is to understand the mathematical foundations, we focus on subjects that are particularly applicable in scientific computing.	
	20DIFa21**	Computational Complexity Theory	2	In this course, we learn computational complexity theory. The topics include the following: the P versus NP question, proof techniques for proving limits of algorithms, interactive proof systems, and pseudorandom generators.	HIRAHARA Shuichi
	20DIFa22**	Computational Game Theory	2	Game theory is the mathematical theory that models the strategic interactions among self-interested agents. This course covers selected theoretical topics in algorithmic game theory that aims to understand the design of the algorithms in strategic environments. The course's topics include: solution concepts in game theory, such as Nash equilibrium and correlated equilibrium, and their computation; computational social choice: procedures for fair division, such as cake cutting algorithms.	IGARASHI Ayumi
	20DIFa23**	Combinatorial Optimization for Machine Learning	2	Machine learning tasks often involve combinatorial structures. To design an efficient algorithm for these problems, techniques of combinatorial optimization are indispensable. This course will cover the theory of combinatorial optimization, such as submodular optimization and approximation algorithms, and its applications to machine learning.	FUJII Kaito
Information Infrastructure Science	20DIFb01**	Computer System Design	2	This course will focus on (1) computer architecture including high-performance microprocessors and LSI technologies, (2) system software stack, including communication mechanisms and parallel file systems, and (3) fault-tolerant system architectures and techniques for error recovery, error detection, automatic test pattern generation, and formal verification, all of which are indispensable for designing highly-reliable high-performance computer systems.	YONEDA Tomohiro GOSHIMA Masahiro ISHIKAWA Yutaka
	20DIFb02**	Information and Communication Systems	2	This course provides an introduction of the principle, algorithms, system architecture, and performance evaluation methods of information and communication systems.	JI Yusheng ABE Shunji KANEKO Megumi FUKUDA Kensuke
Software Science	20DIFc01**	Distributed Systems	2	This lecture address several recent topics in distributed algorithms and software technologies for distributed systems.	SATOH Ichiro
	20DIFc02**	Data Engineering	2	This course overviews basic theories for data analysis and processing and studies the recent progress in text mining.	TAKASU Atsuhiko
	20DIFc03**	Software Engineering	2	In this lecture course, we learn software engineering techniques for efficient development of large-scale and high-quality software systems. We overview activities and techniques in each phases of development process. We also discuss various development paradigms and the state-of-the-art topics.	ISHIKAWA Fuyuki

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Software Science	20DIFc05**	Probabilistic Models in Informatics	2	The focus of this course is probabilistic models that play important roles in informatics for the modeling of real world data. This course deals from the basics to the application of probability theory, and discuss important topics for using probabilistic models such as learning and evaluation.	KITAMOTO Asanobu
	20DIFc18**	Database Theory	2	This course overviews database theory, especially for database programming languages and surveys state of arts in this research area.	KATO Hiroyuki
	20DIFc10**	Mathematical Structures in Programming	2	This course discusses the mathematical structures in programs and explains how mathematical reasoning plays an important role in designing efficient algorithms and constructing correct programs.	
	20DIFc13**	Programming Languages and Theory	2	In this class we learn the foundation of programming languages and implement a small programming language.	TSUSHIMA Kanae
	20DIFc15**	Mathematical Structures in Formal Methods	2	Formal methods refer to a body of mathematical techniques used for guaranteeing correctness of computer systems. This course introduces the mathematical foundation of formal methods. Our technical focus will be on automata theory, especially on automata that classify infinite words.	HASUO Ichiro
	20DIFc16**	Formal Methods for Cyber-Physical Systems	2	Application of information systems is getting rapidly diversified. A notable example is cyber-physical systems (CPS), in which physical dynamics and digital control closely interact with each other. Assuring safety and quality of CPS is a research topic of social impact: CPS serve a number of safety-critical applications, while the scale and complexity of CPS is growing fast. Moreover, from the academic point of view, quality assurance of CPS poses interesting challenges on software science with their unique features such as continuous dynamics, quantitative quality measures, stochastic behaviors and uncertainties. In this course, several lecturers take turns to present some advanced techniques in CPS quality assurance. These techniques originate from formal methods, a branch of software science where mathematical and logical rigor is emphasized for the purpose of quality assurance.	HASUO Ichiro
	20DIFc17**	Software Verification	2	This course gives a lecture on technologies for software verification. In particular, it introduces techniques based on type systems, which make it possible to verify software exhaustively and rigorously.	SEKIYAMA Taro
	20DIFc19**	Embedded Real-Time Systems	2	Real-time and embedded systems pervade many aspects of modern life ranging from mobile communications, robotics, medical systems and devices, motion control systems, transportation systems, energy generation and management, to aerospace and aircraft systems. This course covers both the core concepts underlying such systems and application-level concepts. First, the course focuses on the core concepts and principles, including resource management, task scheduling, dependability and system safety. Also, the course offers the application-level discussions for Cyber-Physical Systems (CPS) and Internet-of-Things (IoT), and real-time networks.	AOKI Shunsuke

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Multimedia Information Science	20DIFd02**	Fundamentals of Media Processing	2	Data structures and algorithms for handling various information media, as well as pattern recognition theory and signal processing theory as basic technologies related to media processing in general, will be outlined. These techniques are indispensable for efficiently handling large amounts of audiovisual and linguistic information, analyzing information media, extracting features, and converting them into desirable forms. If necessary, we will have time for exercises, and students will be able to deepen their understanding by actually processing visual information.	SUGIMOTO Akihiro YAMAGISHI Junichi AIZAWA Akiko KATAYAMA Norio KODAMA Kazuya GOTODA Hironobu IKEHATA Satoshi MO Hiroshi SATO Shin'ichi
	20DIFd03**	Applications of Multimedia Processing	2	As an application of media processing technologies, this course focuses on image, computer graphics, speech and text media and gives the overview of their processing, analysis, editing, visualization, and simulation algorithms. Example topics include 3D information reconstruction from images using computer vision techniques, realistic visualization of 3D information using computer graphics techniques, numerical physics calculations, and speech information processing. Advanced multimedia processing based on their combinations is also introduced. Pre-requisites: Suitable for students who took the course of Fundamentals of Media Processing and Digital media infrastructure.	YAMAGISHI Junichi SUGIMOTO Akihiro SATO Imari IKEHATA Satoshi MO Hiroshi KODAMA Kazuya
	20DIFd04**	Interactive Media	2	In this course, we will explain human interaction with information system and human interaction with human. We first explain basic fundamental concepts and techniques such as user behavior modeling, design method, evaluation method, machine learning, multimedia retrieval. We then elaborate practical applications such as cross-modal retrieval system, and reading comprehension problem.	ARAI Noriko ECHIZEN Isao GOTODA Hironobu KATAYAMA Norio YU Yi
Intelligent Systems Science	20DIFe01**	Logical Foundations for Artificial Intelligence	2	The principles of Artificial Intelligence are studied. In particular, symbolic representation of knowledge and inference are investigated in detail.	INOUE Katsumi
	20DIFe02**	Reasoning Science	2	We study theoretical foundations of advanced reasoning such as nonmonotonic reasoning and its implementation and applications.	SATO Ken
	20DIFe03**	Knowledge Sharing System	2	Firstly the concept of knowledge sharing is identified. Then key techniques are introduced; Semantic Web, Ontology and Social network analysis.	TAKEDA Hideaki
	20DIFe04**	Human-Agent Interaction	2	This course will introduce fundamental concepts, methodologies, and applications of HAI.	YAMADA Seiji
	20DIFe06**	Machine Learning	2	In this course, we will discuss theoretical and practical aspects of machine learning. We study several machine learning techniques including concept learning, Bayesian learning, ensemble learning, and deep learning.	Please refer to the Web Syllabus 2022
	20DIFe16**	Robot Informatics	2	This course introduces the basic knowledge of informatics that is required to develop intelligent robot systems. It also focuses on real-time sensor information processing and system integration method for the development of robot systems.	INAMURA Tetsunari

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Intelligent Systems Science	20DIFe08**	Natural Language Processing	2	This course aims to introduce the fundamental techniques of natural language processing (NLP), i.e. the study of human languages from a computational and engineering perspective. Basic topics include part-of-speech tagging, lexical analysis, syntactic and discourse parsing, language modeling, and word sense disambiguation. Dialogue system and question answering are included as practical applications. We also learn about cutting-edge research and deepen understanding of current issues and future developments.	AIZAWA Akiko SUGAWARA Saku
	20DIFe12**	Communication Environments	2	We exchange various kinds of information and establish human relationships not only in face-to-face conversation but also in talk via mobile phone, internet environment, and so on. This course describes a diversity of communication studies and the methodologies to discuss about communication environments in our daily lives.	BONO Mayumi
	20DIFe15**	Data Mining	2	This course introduces data mining from theory to practice.	SUGIYAMA Mahito
	20DIFe19**	Deep Learning	2	In this course, we will study the basic techniques underlying Deep Learning and its main architectures, including Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks, and so on. We will also discuss practical examples of Artificial Intelligence and Deep Learning applied to drones.	PRENDINGER Helmut
	20DIFe18**	Computational Social Science	2	"Computational Social Science" is a new research field in which large-scale economic, social, and political data are collected, analyzed, modeled, and visualized applying information technology to quantitatively and theoretically understand human behavior and economic, social, and political phenomena. In this course, you will learn the basic concepts of social science, application methods of information technology, and social scientific interpretations of the outcomes, which are necessary for researchers in information science to tackle social science questions. ※Students who have taken the credits of "Econophysics" (until AY2020) can't take this subject.	MIZUNO Takayuki
Information Environment Science	20DIFf01**	Digital Publications	2	Students will study on digital information resources from the viewpoint of information environment through lecture and case study.	OYAMA Keizo
	20DIFf02**	Information Retrieval	2	Principles and methods of information retrieval. An examination of the central concept in Information Retrieval, methods, consideration for the relationship to user's context, retrieval purpose, task and need as well as characteristic of information objects.	KANDO Noriko
	20DIFf07**	Methodology of Scientometrics	2	This course focuses on methodology and case analysis of the scientometrics for measuring scientist's research activity, research trends and development of science. We discuss technique to extract internal factor to explain the characteristics of the empirical distribution with comparing a mathematical model in natural science.	NISHIZAWA Masaki
	20DIFf08**	ICT-enabled Business	2	This course focuses on how E-business including Electronic Commerce or Electronic Money affects the economic activity or social structure.	OKADA Hitoshi

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Information Environment Science	20DIFf11**	Introduction to Statistical Methods in Bibliometrics	2	Bibliometrics has become a standard tool of science policy and research management in the last decades. All significant compilations of science indicators heavily rely on publication and citation statistics and other, more sophisticated bibliometric techniques. This course aims to introduce the underlying statistics, together with related multivariate analysis methods.	SUN Yuan
	90DIFg01**	Research in Informatics for Ph.D. thesis I A	1	This course gives discussions and advices for writing a Ph.D. thesis.	All professors
90DIFg02**	Research in Informatics for Ph.D. thesis I B	1			
90DIFg03**	Research in Informatics for Ph.D. thesis II A	1			
90DIFg04**	Research in Informatics for Ph.D. thesis II B	1			
90DIFg05**	Research in Informatics for Ph.D. thesis III A	1			
90DIFg06**	Research in Informatics for Ph.D. thesis III B	1			
90DIFg07**	Research in Informatics for Ph.D. thesis IV A	1			
90DIFg08**	Research in Informatics for Ph.D. thesis IV B	1			
90DIFg09**	Research in Informatics for Ph.D. thesis V A	1			
90DIFg10**	Research in Informatics for Ph.D. thesis V B	1			
Common	90DIFg11**	Seminar on Basic Knowledge in Informatics I A	2	This course gives discussions and seminars in order for students to acquire basic knowledge and skills which are necessary for research in Informatics.	All professors
	90DIFg12**	Seminar on Basic Knowledge in Informatics I B	2		
	90DIFg13**	Seminar on Basic Knowledge in Informatics II A	2		
	90DIFg14**	Seminar on Basic Knowledge in Informatics II B	2		
	90DIFg15**	Research in Informatics for Master Thesis I A	1	This course gives discussions and advices for writing a master-thesis-level research paper. * "Research in Informatics for Master Thesis II B" is mandatory course for 5-year doctoral course students.	All professors
	90DIFg16**	Research in Informatics for Master Thesis I B	1		
	90DIFg17**	Research in Informatics for Master Thesis II A	2		
	90DIFg18**	Research in Informatics for Master Thesis II B	2		

A two-digit number or letter will be entered to ** according to the semester or the lecturer in charge.