Numerical Analysis 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Satoru Yamamoto
Professor Naofumi Ohnish
Associate Professor Kanjuro Makihara

Students will be taught the numerical analysis techniques which provide the basis for analysis in fluid dynamics, thermodynamics, mechanics, electromagnetics and measurement and control engineering, etc., and learn how to apply these skills. Classes will focus in particular on (1) numerical solutions for ordinary differential equations (2) the finite difference method and the finite element method for partial differential equations, and (3) linear algebra and numerical optimization methods, covering the basics of numerical analysis and their engineering applications.

Applied Analysis 2 credits

Elective Required
Associate Professor Reika Fukuizumi

Mathematical analysis is important for the understanding of random phenomenon apperaing in various fields of natural, life and social sciences, and the probabilistic approach is essential. We start with fundamental concepts in probability theory and learn basic tools for probabilistic models. In particular, for the time evolution of random phenomenon we study basic properties of random walks, Markov chains, Markov processes, and take a bird's-eye view of their wide applications.
These lectures will be in Japanese in principle and an English resume will be distributed.

Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Sawada

This course covers the basics of both incompressible and compressible fluid dynamics.
1. Conservation laws and governing equations
2. Inviscid, incompressible flows
3. Viscous, incompressible flows
4. Inviscid, compressible flows

Solid Mechanics 2 credits

Elective Required
Professor Masumi Saka
Professor Tomonaga Okabe

This class is designed to provide students with a comprehensive understanding of deformation of solids and covers the fundamentals of continuum solid mechanics. It focuses on two-dimensional elasticity in infinitesimal strain theory, the concept of strain and stress, and the introduction of general methods of solving the boundary value problems through the specific problems. Moreover, this class also covers the fundamentals of finite deformation theory, which is used for addressing the large deformations of solids.

Thermal Science and Engineering 2 credits

Elective Required
Professor Shigenao Maruyama
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Associate Professor Takashi Tokumasu

In this course, students will master the basic physics of thermal fluid science, energy conversion and energy systems and learn to link this knowledge to engineering applications. In particular, the course is designed to cover (1) microscopic approaches to thermal phenomena in molecular physics, (2) thermal phenomena involving chemical reactions such as combustion, and (3) understanding and control of the various types of heat transfer Through these classes, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

System Control Engineering 2 credits

Elective Required
Professor Kazuhiro Kosuge
Professor Kazuya Yoshida
Professor Koichi Hashimoto
Professor Yasuhisa Hirata

New mechanical systems using advanced mechanisms are being developed in a range of areas for medical care and welfare, space exploration, disaster rescue purposes and so on. This course focuses on motion control design of increasingly advanced and complex mechanical systems. Students will learn fundamentals for non-linear system analysis and control system design methods. First, phase plane analysis methods and Lyapunov methods are introduced as the main ways to analyze non-linear systems. Next, non-linear feedback control system design methods that can be used for mechanical control systems with non-linear dynamics. Finally, students look at several control system design methods.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
Professor Yuji Takakuwa
Associate Professor Yoichi Takeda

Most metals in the earth's atmosphere inevitably change into more thermodynamically stable compounds such as oxides or sulfides. To understand this principle more precisely, students will learn chemical and electro-chemical equilibrium theory, and kinetics theory in relation to corrosion and oxidation of metals. Practical examples will be used to explain the phenomena and theories of wet corrosion and high-temperature oxidation, deepening students' understanding of the chemical and electro-chemical reactions related to macro phenomena of corrosion and oxidation. This course will be offered in English with presentation and discussion style, using English-language materials. A detailed outline of the course will be presented during the first class.

Computer Hardware Fundamentals 2 credits

Elective Required
Professor Tetsu Tanaka
Associat Professor Riyusuke Egawa

Computers have become an indispensable part of modern society. In this course, both VLSI technology and computer architecture will be lectured for better understanding of modern computer systems. First, CMOS-IC Technology, memory technologies, circuit architecture, high-level synthesis and integrated design technologies that support a remarkable evolution of computer systems over the past few decades will be introduced. Then, the topics will move to computer architecture that focuses on the structure of computer systems, issues and tradeoffs involved in the design of computer system architecture, and high-performance computing. Also, research topics on state-of-the-art LSI technology and computer architecture will be also presented in the lecture.

Solid State Physics 2 credits

Elective Required
Professor Hiroo Yugami
Professor Takahito Ono
Professor Ying Chen

This course targets students from mechanical engineering, system engineering and a wide range of other specialized areas. Using Introduction to Solid State Physics (Charles Kittel, Eighth Edition) as the main text, it focuses on the fundamentals of material science. Following the chapter order in this text book, each class will cover the content associated with that chapter. The course aims to provide students from a wide range of areas with an understanding of the basics concept of solid state physics and a broad perspective on the behavior of materials in engineering systems.

Mechanics of Plasticity 2 credits

Elective Required
Professor Toshiyuki Hashida
Associate Professor Yoshiteru Aoyagi

This lecture covers the concepts and analytical methods that form the basis of plastic deformation mechanics, including material strength and fracture, deformation processing and tribology, and learn how to apply these skills. Key themes will be (1) basic concepts in plastic deformation, (2) mechanical description of plastic deformations, (3) finite element analysis and (4) using case studies to consider applications to engineering. This lecture aims to have students understand and master basic concepts in and mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Associate Professor Makoto Ohta

In all types of engineering with a connection to the human body, a thorough understanding of the structure and function of the human body and other living systems is vital, as is consideration of systems geared to the special features of these living systems. This course covers the biology knowledge in terms of the basic functions and structures of living organisms that forms the basis of bioengineering. Particular emphasis will be placed on the basic knowledge and approaches necessary for deep exploration of the anatomy and physiology of the human body from the perspective of biomechanics.

Intelligent Machine Design 2 credits

Elective Required
Various teachers

Nano/Micro Tribology 2 credits

Elective Required
Professor Koshi Adachi

Many contact interfaces exist in one machine or device, and they have strong effects on the performance of the machine or device. Performance of machines and devices are sometimes limited by such contact interfaces.
Microscopic design of contact interfaces becomes important and necessary as the size of a machine or device becomes smaller or thinner together with higher performance and accuracy.
Principal properties of surfaces and contact interfaces will be explained in this lecture for such needs, and fundamentals and applications of friction and wear will be introduced.

Micro-Nanomechanical Architectonics 2 credits

Elective Required
Professor Takahito Ono
Associate Professor Masaya Toda

Designing of mechanical system based on nanotechnology is an intellectual task combining large amount of information and wide experimental knowledge. In this class, the fundamental knowledge and designing theories of the highly developed micro machines for each process of their planning, fabrication and evaluation are presented. The processes to combine mechanics, electronics, fluidics and optical components in the design of micro mechanics, the examples of modelling, simulation and fabrication of the devices, and the evaluation and the optimization of design are lectured with several trial examples of actual designs.

Engineering of Fluid Systems 2 credits

Elective Required
Professor Yu Fukunishi
Associate Professor Seiichirou Izawa

The objective of this lecture is to explain turbulent flow phenomena, which is very important fluid systems because they may lead to large energy loss. The lecture will cover from the basics of turbulence to the methods to control turbulence.
The students will also learn about the past efforts to understand the complicated phenomena including the fundamental features of turbulence and the basic idea behind the ongoing attempts to control turbulence.

Control of Thermal Energy 2 credits

Elective Required
Professor Tetsushi Biwa

Transporting, converting and utilizing thermal energy constitute the fundamentals of engineering. It is required to understand the basics of heat transfer caused by various means, and learn the methods to enhance the heat transfer and to control it. The subject of this class focuses on the heat transfer caused by oscillatory flows like sound waves propagating in a gass-filled tube.

Energy Systems Engineering 2 credits

Elective Required
Professor Hiroo Yugami
Associate Professor Fumitada Iguchi

There are serious energy and environmental issues for the Earth and humanity. Solving the issues will demand effective usage of non-renewable energy sources and growth in the use of renewable energy generation systems. For such a purpose, new technologies for energy conversion and energy policy must be important. In this lecture, new energy conversion technologies such as fuel cells are introduced. Students also investigate energy technologies and energy policy. Based on the information, students will think current state of the energy system and the future through discussion.

Oxidation in High Temperature Environments of Structures and Materials 2 credits

Elective Required
Professor Kazuhiro Ogawa
Associate Professor Yoichi Takeda

Due to improve the operation efficiency, gas temperature of energy conversion systems, such as gas turbines and boilers, gradually increases. As a result, degradation of the structures, such as high-temperature creep, low cycle fatigue or high-temperature oxidation and corrosion, etc. may be occurred. These damages are called “aged deterioration” or “degradation”.
In this lecture in the first half, the degradation in the energy conversion systems especially high-temperature oxidation is lectured, and the mechanism of high-temperature oxidation is explained. And in this lecture in the second half, presentation and discussion concerning high-temperature oxidation behavior of structures and materials are conducted.

Environmental Heat-Transfer Control 2 credits

Elective Required
Associate Professor Atsuki Komiya

This class covers the heat transfer control and transport phenomena under extreme conditions such as a global and space environment. Especially, the emission, absorption and propagation of thermal radiation and the interaction of the light and matter will be introduced, and the issue of global warming is discussed. Also the reduction of carbon dioxide emission is studied and the efficient method of reduction is discussed at the viewpoint of heat and mass transfer.

Applied Energy Dynamics 2 credits

Elective Required
Professor Kaoru Maruta

To solve energy issues, fundamental knowledge on thermodynamics, fluid engineering, energy conversion, rate process, combustion engineering, etc. is required. This lecture discusses dynamics of various modern energy systems from not only these fundamentals but also interdisciplinary viewpoints including system dynamics and non-linear physics. Novel energy-related topics, i.e., discussion on alternative fuels, mild combustion and micro-scale combustion are also presented.

Electromagnetic Functional Flow Dynamics 2 credits

Elective Required
Professor Hideya Nishiyama
Associate Professor Hidemasa Takana

This course focuses on the thermal and non-thermal plasma flows and electromagnetic fluids such as magnetic fluid, MR fluid, ER fluid and ionic liquid, whose functionality appears under the applied electromagnetic field. The flow functionalization associated with microscopic flow structure is explained from the physicochemical points of view. Furthermore, the governing equations for the functional fluids and diagnostic methods for the evaluation of their functionality will be discussed. The advanced engineering applications of the functional fluids to the environmental purification, energy devices, plasma processing are introduced.
References:
1. Ferrohydrodynamics,R.E.Rosensweig(1985),Cambridge University Press.
2. The Structure and Rehology of Complex Fluids, R.G.Larson(1999),Oxford University Press.
3. Partially Ionized Gases, M. Mitchner and C. H. Kruger, Jr., (1973). John Wiley & Sons.
4. Thermal Plasmas, Fundamentals and Applications, M. I. Boulos, P. Fauchais and E. Phender,Vol. 1, (1994), Plenum Press
5.Plasma Chemistry, A.Fridman(2008),Cambridge University Press.

Mechanical Systems Maintenance Engineering 2 credits

Elective Required
Professor Toshiyuki Takagi
Professor Tetsuya Uchimoto
Associate Professor Hiroyuki Miki
Specially-appointed Professor Takayuki Aoki

In large-scale, complicated artifacts such as various industrial plants and airplanes, maintenance activities play an important role to prevent loss of function of the systems due to aging degradation. Optimization of the maintenance activities in view of both system safety and economic performance is placed as a major key challenge. In this course, we outlines the disciplines composing maintenance engineering such as reliability engineering, risk evaluation, nondestructive testing, failure analysis, and discuss the optimization of the maintenance activities.

Introduction to Solid State Ionics 2 credits

Elective Required
Professor Koji Amezawa
Associate Professor Keiji Yashiro

In this lecture, ionic transport phenomena in solids will be discussed. Ions in ceramics, ionic crystals, and inorganic glasses can move in varying degrees. Particularly solids showing excellent ionic conduction are called as solid state ionic conductors, and utilized as electrolytes or electrodes of fuel cells, batteries, and electrochemical sensors. In this lecture, basics of solid state ionics, such as mechanisms of ionic conduction in solid, will be first explained, and then advanced applications of solid state ionic conductors will be introduced.

Ultraprecision Machining 2 credits

Elective Required
Professor Tunemoto Kuriyagawa
Associate Professor Masayoshi Mizutani

Focusing on description of the principles, technologies and applications achieving both the ultra-precise form accuracy and ultra-smooth surface roughness. Ultra-precision cutting, Brittle-ductile transformation of hard-brittle materials, Diamond turning, Ultra-precision grinding, Aspherical mirror grinding of opto-electric devices, Ultra-precision machine, Material removal process, Form/roughness measurement and evaluation. Includes discussion of methods and properties in micro-meso mechanical manufacturing "M4"processes.

Manufacturing Systems 2 credits

Elective Required
Professor Tunemoto Kuriyagawa
Associate Professor Masayoshi Mizutani
Adjunct Instructor Makoto Sano
Adjunct Instructor Takashi Genma

This class is included two topics. One is focusing on description of the fundamental principles and applications for intelligent CNC machining centers and industrial robots for industrial production. Machining center, Control system of CNC machine, Mechanisms and control for robot, Sensing system for robot, Software and language for robot, CAD/CAM and FMS, ultra-precision machine. The other is focusing on an optical instrument for LSI manufacturing systems. Design and manufacture of optical lenses, Mechanisms and control of AF/AE camera, Microscope and telescope, Laser interferometer measuring instrument, LSI production, Stepper.

Design of Crustal Complex Fracture Systems 2 credits

Elective Required
Professor Toshiyuki Hashida

This course provides the fundamentals for the design of subsurface energy and materials systems such as geothermal heat extraction and CO2 geological sequestration systems. The subsurface is an inner-space that includes a number of complex natural fractures. One of the key issues in the design of the subsurface systems is how to control the complex natural fractures. Hydraulic injection technologies play a crucial role in the formation of the subsurface energy and materials systems. First, a fracture mechanics model will be presented to analyze the mechanical response of a simple crack system subject to hydraulic injections. Then, a fracture network model that is based on the fractal geometry will be described to characterize the mechanical behavior and fluid/heat transfer processes in a complex fracture systems. This course then discusses an engineering methodology for designing complex fracture systems. In the latter part of the lecture, a couple of journal papers will be read in turn to study applications of the fundamentals to the design of the subsurface energy and materials systems.

Fundamentals of neuroscience 2 credits

Elective Required
Professor Tetsu Tanaka
Associate Professor Takafumi Fukushima

High-performance and highly efficient signal processing is performed in the human brain, compared with that in conventional Neumann-type computing. In this course, from the viewpoint of signal processing systems, both brain and nervous systems will be reviewed. The students will be able to:
・Understand the detail structures and functions of neurons as a basic element of nervous system.
・Learn about visual signal processing on the human brain, cochlear implants, retinal prosthesis, and brain-machine interface.
1. Introduction
2. Elements of nervous systems
3. Structures of nervous systems 1
4. Structures of nervous systems 2
5. Neuronal potential and neuronal excitation
6. Mechanism of synapse transmission 1
7. Mechanism of synapse transmission 2
8. Sensory systems 1
9. Sensory systems 2
10. Artificial sensory organ
11. Current topics including BMI
12. Special class

Bio-Plasma Fluid Engineering 2 credits

Elective Required
Professor Takehiko Sato

Plasma medicine is now becoming one of new medical treatments since a plasma flow is capable of generating various stimuli such as heat, light, pressure, chemical species, charged particles and electric fields. The fundamental and applications of fluid, plasma and biological engineering for plasma medicine are main contents in this course. This course aims to introduce transportation phenomena, plasma generation phenomena, biological reaction phenomena, with measurement methods for the fluid, the plasma, and the biological reaction and to understand interactions of each phenomenon. Also, we will consider the present situation and the future of health problems facing humanity through plasma medicine.

Physical Fluctuomatics 2 credits

Elective Required
Professor Kazuyuki Tanaka

Applications to many fields in engineering like control, signal processing etc. and in information sciences are in mind through the lecture course for the basic knowledge of statistical machine learning theory as well as stochastic processes. Brief introduction will be given to methods for applications like statistical estimation etc., and to the relationship with statistical-mechanical informatics. We first lecture probability and statistics and their fundamental properties and explain the basic frameworks of Bayesian estimation and maximum likelihood estimation. Particularly, we show EM algorithm as one of familiar computational schemes to realize the maximum likelihood estimation. As one of linear statistical models, we introduce Gaussian graphical model and show the explicit procedure for Bayesian estimation and EM algorithm from observed data. We show some useful probabilistic models which are applicable to probabilistic information processing in the stand point of Bayesian estimation. We mention that some of these models can be regarded as physical models in statistical mechanics. Fundamental structure of belief propagation methods are reviewed as powerful key algorithms to compute some important statistical quantities, for example, averages, variances and covariances. Particularly, we clarify the relationship between belief propagations and some approximate methods in statistical mechanics. As ones of application to probabilistic information processing based on Bayesian estimation and maximum likelihood estimations, we show probabilistic image processing and probabilistic reasoning. Moreover, we review also quantum-mechanical extensions of probabilistic information processing.

Environmental and Industrial Policy
2 credits

Elective Required Various teachers

Interdisciplinary Research 2 credits

Elective Required Various teachers

Project-Based Learning for Frontier of Mechanical Engineering 2 credits

Elective Required Various teachers
In this study program, students will master a whole process of a project for mechanical design and system integration through practical hands-on experience. The first part comprises some classes on system integration, project management and safety management. The second part comprises project training, in which the students are expected to generate a project proposal and a conceptual design, undertake a design review and create a prototype. At the end, students must give a presentation on their results and write a report. This program is a prerequisite for students who wish to take the course entitled “Innovation Oriented Seminar on Mechanical Engineering.”

Internship Training 1 or 2 credits

Elective Required All teachers

Practical training and research conducted at a company for around one week to one month in the first-year of masters program. Through this training, students learn how to apply the basic research at university to a real industrial technology setting. Additionally, students gain on-site experience and understand the realities of planning, surveys and research, product development, manufacturing and product management, etc., in companies. It is desirable that all students take this training. One or two credits are given to them according to the content and the period of the training.

International Scientific Internship Training 1 or 2 credits

Elective Required All teachers

When students have attended any lectures or practiced in a foreign academic organization or science program, one or two credits are given to them according to the content and the period.

Special Lecture on Mechanical Systems Engineering A

Elective Required Various teachers

A special lecture on leading-edge academic research in the major area, or on the creation and development of knowledge in relation to the major area.

Advanced Seminar on Mechanical Systems Engineering A

Elective Required Various teachers

Addressing leading-edge academic research in the major area, this course comprises seminars on a subject which students have chosen themselves as well as training in and beyond the university. Integrating these advanced specialist knowledge helps to develop students' problem-posing ability.

Seminar on Mechanical Systems 2 credits

Elective Required
Professor Koshi Adachi
Professor Tunemoto Kuriyagawa
Professor Takahito Ono
Professor Kazuhiro Ogawa
Associate Professor Takanori Takeno
Associate Professor Masayoshi Mizutani
Associate Professor Masaya Toda

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Energy Engineering 2 credits

Elective Required
Professor Hiroo Yugami
Professor Yu Fukunishi
Professor Tetsushi Biwa
Professor Shigenao Maruyama
Professor Kaoru Maruta
Professor Toshiyuki Takagi
Professor Tetsuya Uchimoto
Professor Koji Amezawa
Professor Yuka Iga
Associate Professor Fumitada Iguchi
Associate Professor Seiichirou Izawa
Associate Professor Atsuki Komiya
Associate Professor Hidemasa Takana
Associate Professor Hisashi Nakamura
Associate Professor Keiji Yashiro
Associate Professor Hiroyuki Miki

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Intelligent Mechano-Systems 2 credits

Elective Required
Professor Takehiko Sato

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Innovation Oriented Seminar on Mechanical Engineering 8 credits

Elective Required Various teachers

In this course, students engage in experiments and seminars (including research presentations, discussion and literature reviews) on particularly innovation-oriented themes in leading-edge areas of mechanical engineering. To take this seminar, students must pass Project-Based Learning for Frontier of Mechanical Engineering and satisfy the other registration prerequisites. The eight credits are considered to be the equivalent of the eight credits for Masters Course Seminar in terms of masters program completion requirements. However, students earning credits through this seminar cannot simultaneously earn credits for Masters Course Seminar.

Master Course Seminar on Mechanical Systems and Engineering 8 credits

Elective Required

Students engage in experiments and seminars, including research presentations, discussion and literature reviews. Students who have acquired credits from the Innovation Oriented Seminar on Mechanical Engineering program do not need to take this course.

Numerical Analysis 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Satoru Yamamoto
Professor Naofumi Ohnishi
Associate Professor Kanjuro Makihara

Students will be taught the numerical analysis techniques which provide the basis for analysis in fluid dynamics, thermodynamics, mechanics, electromagnetics and measurement and control engineering, etc., and learn how to apply these skills. Classes will focus in particular on (1) numerical solutions for ordinary differential equations (2) the finite difference method and the finite element method for partial differential equations, and (3) linear algebra and numerical optimization methods, covering the basics of numerical analysis and their engineering applications.

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Professor Tomonaga Okabe

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Professor Koji Amezawa
Professor Yuji Takakuwa
Associate Professor Yoichi Takeda

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Solid State Physics 2 credits

Elective Required
Professor Hiroo Yugami
Professor Takahito Ono
Professor Ying Chen

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Mechanics of Plasticity 2 credits

Elective Required
Professor Toshiyuki Hashida
Associate Professor Yoshiteru Aoyagi

This lecture covers the concepts and analytical methods that form the basis of plastic deformation mechanics, including material strength and fracture, deformation processing and tribology, and learn how to apply these skills. Key themes will be (1) basic concepts in plastic deformation, (2) mechanical description of plastic deformations, (3) finite element analysis and (4) using case studies to consider applications to engineering. This lecture aims to have students understand and master basic concepts in and mechanical descriptions of plastic deformation.

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Associate Professor Makoto Ohta

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Precision Nanometrology 2 credits

Elective Required
Professor Wei Gao
Associate Professor Yuki Shimizu

This course focuses on measurement methods and systems with nanometer resolution and accuracy for ultra-precision production, including measurement of displacement and vibrations, surface profiles, geometric forms and motions of precision machines. Fundamental theories and applications of sensor technologies, such as laser interferometer, linear encoder, laser displacement sensor, optical fiber sensor, as well as those of measuring instruments, such as scanning electron microscope, interference microscope, scanning probe microscope, mechanical stylus profiler will be learned through presentations and discussions.

Intelligent Sensing of Materials 2 credits

Elective Required
Professor Hitoshi Soyama

As evaluations of materials characteristics are very important to guarantee reliability of systems, and conventional method cannot be used in microstructures and microcomponents such as IC packages and micro/nano machine, a novel sensing method will be required to evaluate material properties for advanced systems. Lecture will deal with sensing of materials such as inverse analysis to evaluate strain, stress and strength, especially residual stress in polycrystalline metallic materials which affects strength and lifetime of machine components and plants.

Mechanics of Materials System 2 credits

Elective Required
Associate Professor Hironori Tohmyoh

Recently, materials system which is composed of various components has become more and more complex for producing new functionality. To develop or operate safety such an advanced materials system, cross-cutting knowledge, which is related with various disciplines, is indispensable. In this lecture, nondestructive evaluation techniques for advanced materials system, e.g., techniques for detecting a crack or materials degradation, etc., are treated. Also, we discuss the evaluation techniques for small-scale materials system and advanced electronic devices.

Ultraprecision Machining 2 credits

Elective Required
Professor Tunemoto Kuriyagawa
Associate Professor Masayoshi Mizutani

Focusing on description of the principles, technologies and applications achieving both the ultra-precise form accuracy and ultra-smooth surface roughness. Ultra-precision cutting, Brittle-ductile transformation of hard-brittle materials, Diamond turning, Ultra-precision grinding, Aspherical mirror grinding of opto-electric devices, Ultra-precision machine, Material removal process, Form/roughness measurement and evaluation. Includes discussion of methods and properties in micro-meso mechanical manufacturing "M4"processes.

Nano/Micro Mechanoptics 2 credits

Elective Required
Professor Kazuhiro Hane
Associate Professor Yoshiaki Kanamori

Mechanoptics is the fusional research field of optics and mechanics. Nano/Micro mechanoptics is a research field of mechanoptics on nano/micrometer scales. Fundamental technologies and applications in the field are surveyed. The topics on micrometer scale are spatial modulators for displays, micromechanical systems for optical telecommunication, optical sensors, etc. The topics on nanometer scale are wavelength-selective optical filters using subwavelength mechanical structures, optical devices for controlling surface optical reflectance and light polarization, and structural optics smaller than the subwavelength optics. Micro/Nanometer scale fabrication technologies for micro/nano mechanoptics are also studied. The latest papers relating to the above are also presented and discussed.

Nano/Micro Tribology 2 credits

Elective Required
Professor Koshi Adachi

Many contact interfaces exist in one machine or device, and they have strong effects on the performance of the machine or device. Performance of machines and devices are sometimes limited by such contact interfaces.
Microscopic design of contact interfaces becomes important and necessary as the size of a machine or device becomes smaller or thinner together with higher performance and accuracy.
Principal properties of surfaces and contact interfaces will be explained in this lecture for such needs, and fundamentals and applications of friction and wear will be introduced.

Strength and Reliability of Advanced Materials and Devices
2 credits

Elective Required
Professor Hideo Miura

The Strain-induced changes of physical and chemical properties of various materials are discussed from the view point of the order of atom arrangenment in the strained materials. The change of the free energy of materials due to strain energy causes the variation or fluctuation of various physical and chemical properties of the strained materials. Since nanotechnology enables us to create very complicated fine structures, large local strain occurs in the structures during manufacturing and operation because of lattice mismatch between nearby materials and higher density of the concentrated fields of strain and mechanical stress. The large local strain and stress accelerate the anisotropic diffusion of component elements, and thus, cause the change of micro texture of the materilas. Therefore, deep understanding of the mechanism of the changes of variou sproperties of materials help us to evaluate the damage of the strained structures and devices and to design the optimum structures and their manufacturing methods. Some examples of fracture and/or failure mechanisms of products are also introduced based on the actual experience of the lecturer.
Hideo Miura:hmiura@rift.mech.tohoku.ac.jp

Kinetic Theory of Gases 2 credits

Elective Required
Associate Professor Shigeru Yonemura

In rarefied gas flows, or in micro/nanoscale gas flows around a nanostructured body, the frequency of intermolecular collisions is on the same order of the frequency of molecule-wall collisions, and therefore, gas molecules are in intense non-equilibrium. Such gases cannot be treated as a continuum, and hence, the governing equation of gas flows is not the Navier-Stokes equations but the Boltzmann equation. The molecular gas dynamics, i.e., the rarefied gas dynamics, which is based on the kinetic theory of gases, has been developed in the aerospace field, but recently, micro/nanoscale gas flows around a nanostructured body have also received attention due to the development of the microfabrication technology. The aim of this lecture is to discuss characteristics of gas molecules as a group and to learn about the Boltzmann equation.

Green Nanotechnology 2 credits

Elective Required
Professor Seiji Samukama
Associate Professor Tomohiro Kubota

Nanofabrication (etching, deposition, and surface modification) of advanced devices such as ULSIs, nanomachines, optical devices, and bio chips are realized by means of reactive plasmas, scanning tunneling microscope (STM) and so on, via interaction between the device material and microscopic particles such as atoms, molecules, ions, radicals, and photons. This lecture will introduce behavior and interaction of such microscopic particles in processes such as reactive plasma, beam, and atom/molecule handling which are basis of advanced technologies. Measurement methods of such interactions will be explained. Examples of advanced green nanodevices and nanoprocesses used in these devices advanced industries will be introduced.

Nanoscale Thermal and Fluid Engineering 2 credits

Elective Required
Professor Taku Ohara
Associate Professor Gota Kikugawa

Understanding of the phenomena and mechanism of nanoscale flow contributes to the establishment of basic theory for thermal and fluid flow to predict the phenomena in natural and artificial nanoscale structures. It also leads to fundamental technology that is important to control the interfacial phenomena such as wetting and friction and to explore novel machines invented by the biomimetic approach to transport phenomena in living bodies. In this class, basic theories of nanoscale thermal and fluid engineering, that span a wide range of physics and engineering from the molecular dynamics of thermofluid to the macroscopic thermophysical properties and flow characteristics determined by the molecular scale mechanism, are given in detail and comprehensibly.

Nano-Physics, Analysis and Control of Surfaces

Elective Required
Professor Yuji Takakuwa
Associate Professor Tadashi Abukawa

This lecture deals with various physical analysis methods to get atomic-scale information on the chemical composition, crystal structure, electronic states, and morphology of surfaces and thin films, which are inevitable for the Nanotechnology. The in-situ observation and control of the chemical reaction kinetics on surfaces and interfaces of solids present under a reactive gas atmosphere, which are explored by the real-time surface analysis methods, are described.

Engineering for Geo-Energy Exploitation 2 credits

Elective Required
Professor Takatoshi Ito
Associate Professor Hirokazu Moriya

This course provides an introduction to geomechanics and engineering techniques for exploitation of geo-energy, especially geothermal energy. The class will explore the status and origin of temperature and stress fields in subsurface rocks, hydraulic fracturing techniques used for creating fractures and improving hydraulic properties of rocks, microseismic imaging and event analysis used for determining geometry and characteristics of fractures, and well testing carried out for determining well and reservoir performance.

Manufacturing Systems 2 credits

Elective Required
Professor Tunemoto Kuriyagawa
Associate Professor Masayoshi Mizutani
Senior Assistant Professor Makoto Sano
Senior Assistant Professor Takashi Genma

This class is included two topics. One is focusing on description of the fundamental principles and applications for intelligent CNC machining centers and industrial robots for industrial production. Machining center, Control system of CNC machine, Mechanisms and control for robot, Sensing system for robot, Software and language for robot, CAD/CAM and FMS, ultra-precision machine. The other is focusing on an optical instrument for LSI manufacturing systems. Design and manufacture of optical lenses, Mechanisms and control of AF/AE camera, Microscope and telescope, Laser interferometer measuring instrument, LSI production, Stepper.

Intelligence and Systems Engineering 2 credits

Elective Required
Professor Kazuo Hokkirigawa
Associate Professor Takeshi Yamaguchi

This course will provide all students with the latest knowledge and concept associated with intelligent mechanical systems such as a continuously variable transmission and low noise and high precision positioning system. This course will also review recently-developed mechanical elements such as friction drive system and dry bearing system.

Design of Materials System 2 credits

Elective Required
Professor Kazuo Hokkirigawa
Associate Professor Takeshi Yamaguchi

This course will provide all students with the fundamental knowledge of material design to develop intelligent mechanical systems with high performance. This course will also review the latest knowledge and concept associated with material system design.

Biosensor Engineering 2 credits

Elective Required
Professor Matsuhiko Nishizawa
Associate Professor Hirokazu Kaji

Biological molecular systems for transduction of information and energy will be briefly lectured, followed by the lecture of the construction, mechanism, and technical trends on biosensors utilizing bioelements such as enzymes and antibodies. Biointerface engineering for integrating bioelements with the electric devices will also be lectured for educating ability for engineering innovative biosensors for advanced medicines.

Bio-Micromachine Engineering 2 credits

Elective Required
Professor Matsuhiko Nishizawa
Associate Professor Hirokazu Kaji

The progress of Biomicromachine, which is the fusion of biotechnology and micromachine technology, will be fully lectured, assuming their use for advanced medicines. The processing of biocompatible soft materials is important content of this lecture because the fusion of bioelements and the electric devices requires suitable biointerface techniques utilizing smart biomaterials.

Biofluid Mechanics 2 credits

Elective Required
Professor Takuji Ishikawa

In this lecture, we learn functions of biological flows in terms of fluid mechanics. The cardiovascular, respiratory and digestive systems in the human body are lectured. Rheology of blood, flow in a flexible tube, mass transport, and heat transport in a body are explained using basic equations of mechanical engineering. Moreover, swimming microorganisms and fish as well as flying birds are explained. Finally the effects of mechanical environment on the biological functions are discussed.

Biomechanics 2 credits

Elective Required
Professor Takuji Ishikawa
Associate Professor Makoto Ohta

This course will be opened for providing knowledge of biomechanical properties of tissues and biofluids such as blood flow. The knowledge will lead you to understand the relationship between the structures and the functions including remodeling. And the understandings are strongly related to biomedical engineering such as medical devices.

Cell Engineering 2 credits

Elective Required
Professor Yoichi Haga

Intelligent Mechanosystem Analysis 2 credits

Elective Required
Professor Toshiyuki Hayase

Intelligent mechano-systems are generally modeled as infinite dimensional nonlinear dynamical systems. As a basis of modern control theory to deal with such systems, we first study basic concepts of function spaces, dual spaces, and linear operators, and understand basic theories of optimization from intuitive geometrical point of view. Next, mathematical modeling of mechano-systems is discussed for fluid control systems focusing on the relationship between the structure of differential equations and physical phenomena. It is preferable to have basic background on fluid dynamics, control engineering, linear algebra, and analysis.

Physical Fluctuomatics 2 credits

Elective Required
Professor Kazuyuki Tanaka

Applications to many fields in engineering like control, signal processing etc. and in information sciences are in mind through the lecture course for the basic knowledge of statistical machine learning theory as well as stochastic processes. Brief introduction will be given to methods for applications like statistical estimation etc., and to the relationship with statistical-mechanical informatics. We first lecture probability and statistics and their fundamental properties and explain the basic frameworks of Bayesian estimation and maximum likelihood estimation. Particularly, we show EM algorithm as one of familiar computational schemes to realize the maximum likelihood estimation. As one of linear statistical models, we introduce Gaussian graphical model and show the explicit procedure for Bayesian estimation and EM algorithm from observed data. We show some useful probabilistic models which are applicable to probabilistic information processing in the stand point of Bayesian estimation. We mention that some of these models can be regarded as physical models in statistical mechanics. Fundamental structure of belief propagation methods are reviewed as powerful key algorithms to compute some important statistical quantities, for example, averages, variances and covariances. Particularly, we clarify the relationship between belief propagations and some approximate methods in statistical mechanics. As ones of application to probabilistic information processing based on Bayesian estimation and maximum likelihood estimations, we show probabilistic image processing and probabilistic reasoning. Moreover, we review also quantum-mechanical extensions of probabilistic information processing.

Discussion on Environmental and Industrial Policy
2 credits

Elective Required Various teachers

Ethics of Engineering and Life 2 credits

Elective Required
Professor Tatsuo Yoshinobu
Adjunct Instructor Seishi Kudo

We will study wide range of ethical issues including "research ethics", which are important for researchers and engineers. Not only medical science but also engineering is closely related to “life”. Applying some engineering technologies to various fields such as medicine and food productions, we undoubtedly face the matter of life and death in humans and other creatures. The intrinsic influence of engineering is huge, which requires us to acquire sophisticated knowledge and learn the ethical norm. We will invite experts engaged in various fields to give lectures. We will also arrange an e-learning program, and group discussion and presentation.*Note for foreign students: Lectures are given in Japanese. In slides and handouts, some lecturers give titles etc. both in Japanese and English, but others do not.

Interdisciplinary Research 2 credits

Elective Required Various teachers

Project-Based Learning for Frontier of Mechanical Engineering 2 credits

Elective Required Various teachers

In this study program, students will master a whole process of a project for mechanical design and system integration through practical hands-on experience. The first part comprises some classes on system integration, project management and safety management. The second part comprises project training, in which the students are expected to generate a project proposal and a conceptual design, undertake a design review and create a prototype. At the end, students must give a presentation on their results and write a report. This program is a prerequisite for students who wish to take the course entitled “Innovation Oriented Seminar on Mechanical Engineering.”

Internship Training 1 or 2 credits

Elective Required All teachers

Practical training and research conducted at a company for around one week to one month in the first-year of masters program. Through this training, students learn how to apply the basic research at university to a real industrial technology setting. Additionally, students gain on-site experience and understand the realities of planning, surveys and research, product development, manufacturing and product management, etc., in companies. It is desirable that all students take this training. One or two credits are given to them according to the content and the period of the training.

International Scientific Internship Training 1 or 2 credits

Elective Required All teachers

When students have attended any lectures or practiced in a foreign academic organization or science program, one or two credits are given to them according to the content and the period.

Special Lecture on Finemechanics A

Elective Required Various teachers

A special lecture on leading-edge academic research in the major area, or on the creation and development of knowledge in relation to the major area.

Advanced Seminar on Fainmechanics A

Elective Required Various teachers

Addressing leading-edge academic research in the major area, this course comprises seminars on a subject which students have chosen themselves as well as training in and beyond the university. Integrating these advanced specialist knowledge helps to develop students’ problem-posing ability.

Seminar on Materials and Mechanics 2 credits

Elective Required
Professor Kazuo Hokkirigawa
Professor Hitoshi Soyama
Professor Masumi Saka
Professor Hideo Miura
Associate Professor Takeshi Yamaguchi
Associate Professor Hironori Tohmyoh
Associate Professor Yoshiteru Aoyagi
Associate Professor Ken Suzuki
Associate Professor Yoichi Takeda

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Nanomechanics 2 credits
Elective Required
Professor Kazuhiro Hane
Professor Wei Gao
Professor Taku Ohara
Professor Seiji Samukawa
Professor Yuji Takakuwa
Associate Professor Yoshiaki Kanamori
Associate Professor Yuki Shimizu
Associate Professor Takanori Takeno
Associate Professor Shigeru Yonemura
Associate Professor Takashi Tokumasu
Associate Professor Tomohiro Kubota
Associate Professor Tadashi Abukawa
Senior Assistant Professor Gota Kikugawa

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Biomechanics 2 credits
Elective Required
Professor Matsuhiko Nishizawa
Professor Takuji Ishikawa
Associate Professor Hirokazu Kaji

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Intelligent Mechano-Systems 2 credits

Elective Required
Professor Toshiyuki Hayase
Associate Professor Atsushi Shirai
Associate Professor Makoto Ohta
Associate Professor Kenichi Funamoto

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Innovation Oriented Seminar on Mechanical Engineering
8 credits
Elective Required Various teachers

In this course, students engage in experiments and seminars (including research presentations, discussion and literature reviews) on particularly innovation-oriented themes in leading-edge areas of mechanical engineering. To take this seminar, students must pass Project-Based Learning for Frontier of Mechanical Engineering and satisfy the other registration prerequisites. The eight credits are considered to be the equivalent of the eight credits for Masters Course Seminar in terms of masters program completion requirements. However, students earning credits through this seminar cannot simultaneously earn credits for Masters Course Seminar.

Master Course Seminar on Finemechanics 8 credits
Elective Required
Students engage in experiments and seminars, including research presentations, discussion and literature reviews. Students who have acquired credits from the Innovation Oriented Seminar on Mechanical Engineering program do not need to take this course.

Numerical Analysis 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Satoru Yamamoto
Professor Naofumi Ohnishi
Associate Professor Kanjuro Makihara

Students will be taught the numerical analysis techniques which provide the basis for analysis in fluid dynamics, thermodynamics, mechanics, electromagnetics and measurement and control engineering, etc., and learn how to apply these skills. Classes will focus in particular on (1) numerical solutions for ordinary differential equations (2) the finite difference method and the finite element method for partial differential equations, and (3) linear algebra and numerical optimization methods, covering the basics of numerical analysis and their engineering applications.

Applied Analysis 2 credits

Elective Required
Professor Nobuaki Obata

Mathematical analysis is important for the understanding of random phenomenon apperaing in various fields of natural, life and social sciences, and the probabilistic approach is essential. We start with fundamental concepts in probability theory and learn basic tools for probabilistic models. In particular, for the time evolution of random phenomenon we study basic properties of random walks, Markov chains, Markov processes, and take a bird's-eye view of their wide applications.
These lectures will be in Japanese in principle and an English resume will be distributed.

Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Sawada

This course covers the basics of both incompressible and compressible fluid dynamics.
1. Conservation laws and governing equations
2. Inviscid, incompressible flows
3. Viscous, incompressible flows
4. Inviscid, compressible flows

Solid Mechanics 2 credits

Elective Required
Professor Masumi Saka
Professor Tomonaga Okabe

This class is designed to provide students with a comprehensive understanding of deformation of solids and covers the fundamentals of continuum solid mechanics. It focuses on two-dimensional elasticity in infinitesimal strain theory, the concept of strain and stress, and the introduction of general methods of solving the boundary value problems through the specific problems. Moreover, this class also covers the fundamentals of finite deformation theory, which is used for addressing the large deformations of solids.

Thermal Science and Engineering 2 credits

Elective Required
Professor Shigenao Maruyama
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Associate Professor Takashi Tokumasu

In this course, students will master the basic physics of thermal fluid science, energy conversion and energy systems and learn to link this knowledge to engineering applications. In particular, the course is designed to cover (1) microscopic approaches to thermal phenomena in molecular physics, (2) thermal phenomena involving chemical reactions such as combustion, and (3) understanding and control of the various types of heat transfer Through these classes, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

System Control Engineering 2 credits

Elective Required
Professor Kazuhiro Kosuge
Professor Kazuya Yoshida
Professor Koichi Hashimoto
Associate Professor Yasuhisa Hirata

New mechanical systems using advanced mechanisms are being developed in a range of areas for medical care and welfare, space exploration, disaster rescue purposes and so on. This course focuses on motion control design of increasingly advanced and complex mechanical systems. Students will learn fundamentals for non-linear system analysis and control system design methods. First, phase plane analysis methods and Lyapunov methods are introduced as the main ways to analyze non-linear systems. Next, non-linear feedback control system design methods that can be used for mechanical control systems with non-linear dynamics. Finally, students look at several control system design methods.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
Professor Yuji Takakuwa
Associate Professor Yoichi Takeda

Most metals in the earth's atmosphere inevitably change into more thermodynamically stable compounds such as oxides or sulfides. To understand this principle more precisely, students will learn chemical and electro-chemical equilibrium theory, and kinetics theory in relation to corrosion and oxidation of metals. Practical examples will be used to explain the phenomena and theories of wet corrosion and high-temperature oxidation, deepening students' understanding of the chemical and electro-chemical reactions related to macro phenomena of corrosion and oxidation. This course will be offered in English with presentation and discussion style, using English-language materials. A detailed outline of the course will be presented during the first class.

Computer Hardware Fundamentals 2 credits

Elective Required
Professor Tetsu Tanaka
Associate Professor Riyusuke Egawa

Computers have become an indispensable part of modern society. In this course, both VLSI technology and computer architecture will be lectured for better understanding of modern computer systems. First, CMOS-IC Technology, memory technologies, circuit architecture, high-level synthesis and integrated design technologies that support a remarkable evolution of computer systems over the past few decades will be introduced. Then, the topics will move to computer architecture that focuses on the structure of computer systems, issues and tradeoffs involved in the design of computer system architecture, and high-performance computing. Also, research topics on state-of-the-art LSI technology and computer architecture will be also presented in the lecture.

Solid State Physics 2 credits

Elective Required
Professor Hiroo Yugami
Professor Takahito Ono
Professor Ying Chen

This course targets students from mechanical engineering, system engineering and a wide range of other specialized areas. Using Introduction to Solid State Physics (Charles Kittel, Eighth Edition) as the main text, it focuses on the fundamentals of material science. Following the chapter order in this text book, each class will cover the content associated with that chapter. The course aims to provide students from a wide range of areas with an understanding of the basics concept of solid state physics and a broad perspective on the behavior of materials in engineering systems.

Mechanics of Plasticity 2 credits

Elective Required
Professor Toshiyuki Hashida
Associate Professor Yoshiteru Aoyagi

This lecture covers the concepts and analytical methods that form the basis of plastic deformation mechanics, including material strength and fracture, deformation processing and tribology, and learn how to apply these skills. Key themes will be (1) basic concepts in plastic deformation, (2) mechanical description of plastic deformations, (3) finite element analysis and (4) using case studies to consider applications to engineering. This lecture aims to have students understand and master basic concepts in and mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Associate Professor Makoto Ohta

In all types of engineering with a connection to the human body, a thorough understanding of the structure and function of the human body and other living systems is vital, as is consideration of systems geared to the special features of these living systems. This course covers the biology knowledge in terms of the basic functions and structures of living organisms that forms the basis of bioengineering. Particular emphasis will be placed on the basic knowledge and approaches necessary for deep exploration of the anatomy and physiology of the human body from the perspective of biomechanics.

Microengineering for Bio-mechanodevices 2 credits

Elective Required
Professor Shiuji Tanaka

This course deals with key components and microfabrication technology for bio-mechanodevices, which are used for human interface, advanced robotics, biomedical applications, wireless communication etc. Important key components such as sensors, actuators and packaging are overviewed together with related materials and typical applications. Microfabrication technology is explained in detail. The topics include wet/dry etching, physical/chemical vapor deposition, lithography, diffusion, oxidation, electroplating and wafer bonding. The lecture is given in practical aspects as well as fundamental aspects for who is studying microdevices and a wide range of related technology.

Cell Engineering 2 credits

Elective Required
Professor Yoichi Haga

Robot Systems Engineering 2 credits

Elective Required
Professor Kazuhiro Kosuge
Professor Yasuhisa Hirata
Professor Mitsuhiro Hayashibe
Associate Professor Shogo Aarai

The robot is an advanced system that consists of mechanical parts, actuators, sensors, and controllers. By integrating the several systems and control methods effectively, the robot could realize required tasks in the real environment. In this lecture, the fundamental and advanced motion control methods of the robot will be given, and the recent applications developed by the integration of the robot technologies will be introduced.

Biomechatronics 2 credits

Elective Required
Professor Mami Tanaka

Foundations of Molecular Robotics 2 credits

Elective Required
Professor Satoshi Murata
Associate Professor Shinichiro Nomura

Intelligent Mechanosystem Analysis 2 credits

Elective Required
Professor Toshiyuki Hayase
Associate Professor Atsushi Shirai

Intelligent mechano-systems are generally modeled as infinite dimensional nonlinear dynamical systems. As a basis of modern control theory to deal with such systems, we first study basic concepts of function spaces, dual spaces, and linear operators, and understand basic theories of optimization from intuitive geometrical point of view. Next, mathematical modeling of mechano-systems is discussed for fluid control systems focusing on the relationship between the structure of differential equations and physical phenomena. It is preferable to have basic background on fluid dynamics, control engineering, linear algebra, and analysis.

Introduction to Solid State Ionics 2 credits

Elective Required
Professor Koji Amezawa
Associate Professor Keiji Yashiro

In this lecture, ionic transport phenomena in solids will be discussed. Ions in ceramics, ionic crystals, and inorganic glasses can move in varying degrees. Particularly solids showing excellent ionic conduction are called as solid state ionic conductors, and utilized as electrolytes or electrodes of fuel cells, batteries, and electrochemical sensors. In this lecture, basics of solid state ionics, such as mechanisms of ionic conduction in solid, will be first explained, and then advanced applications of solid state ionic conductors will be introduced.

Human-Robot Informatics 2 credits

Elective Required
Professor Satoshi Tadokoro
Associate Professor Masashi Konyo

Computer Vision 2 credits

Elective Required
Professor Takayuki Okatani

This course covers methods for analyzing/recognizing images on a computer, methods for measuring physical quantities and controlling robots etc. by using visual information, and theories of recognizing and understanding three-dimensional scenes from images. Their applications to robot vision, medical image analysis, and image synthesis/computer graphics are also discussed.

Fluid Design Informatics 2 credits

Elective Required
Professor Shigeru Obyashi
Associate Professor Koji Shimoyama

This lecture introduces a new framework of knowledge discovery by the fusion of fluid engineering and information technology. More specifically, this lecture explains a new computer-aided visualization approach based on data mining techniques and a new knowledge discovery approach to tackle with design trade-offs in fluid engineering problems, for example, where ecological and economical issues trade off with each other. They result from identifying design trade-offs by multi-objective optimization and visualizing design information by cluster analysis.

Fundamental Nano-Technology 2 credits

Elective Required
Professor Hiroki Kuwano

Informative Nanosystem 2 credits

Elective Required
Professor Hiroki Kuwano

Intelligent Control Systems 2 credits

Elective Required
Professor Koichi Hashimoto
Associate Professor Shingo Kagami

The aim of this lecture is to obtain the basics knowledge and to know the latest trend for intelligent control systems. Lectures on robot kinematics, robot vision, and feedback control theory will be given. Lectures on building blocks for robot vision systems such as image sensors, image processing and visual tracking will also be given.

Physical Fluctuomatics 2 credits

Elective Required
Professor Kazuyuki Tanaka

Applications to many fields in engineering like control, signal processing etc. and in information sciences are in mind through the lecture course for the basic knowledge of statistical machine learning theory as well as stochastic processes. Brief introduction will be given to methods for applications like statistical estimation etc., and to the relationship with statistical-mechanical informatics. We first lecture probability and statistics and their fundamental properties and explain the basic frameworks of Bayesian estimation and maximum likelihood estimation. Particularly, we show EM algorithm as one of familiar computational schemes to realize the maximum likelihood estimation. As one of linear statistical models, we introduce Gaussian graphical model and show the explicit procedure for Bayesian estimation and EM algorithm from observed data. We show some useful probabilistic models which are applicable to probabilistic information processing in the stand point of Bayesian estimation. We mention that some of these models can be regarded as physical models in statistical mechanics. Fundamental structure of belief propagation methods are reviewed as powerful key algorithms to compute some important statistical quantities, for example, averages, variances and covariances. Particularly, we clarify the relationship between belief propagations and some approximate methods in statistical mechanics. As ones of application to probabilistic information processing based on Bayesian estimation and maximum likelihood estimations, we show probabilistic image processing and probabilistic reasoning. Moreover, we review also quantum-mechanical extensions of probabilistic information processing.

Bio-Plasma Fluid Engineering 2 credits

Elective Required
Professor Takehiko Sato

Plasma medicine is now becoming one of new medical treatments since a plasma flow is capable of generating various stimuli such as heat, light, pressure, chemical species, charged particles and electric fields. The fundamental and applications of fluid, plasma and biological engineering for plasma medicine are main contents in this course. This course aims to introduce transportation phenomena, plasma generation phenomena, biological reaction phenomena, with measurement methods for the fluid, the plasma, and the biological reaction and to understand interactions of each phenomenon. Also, we will consider the present situation and the future of health problems facing humanity through plasma medicine.

Discussion on Environmental and Industrial Policy

Elective Required Various teachers

Ethics of Engineeing and Life 2 credits

Elective Required
Professor Tatsuo Yoshinobu
Professor Seishi Kudo

We will study wide range of ethical issues including "research ethics", which are important for researchers and engineers. Not only medical science but also engineering is closely related to “life”. Applying some engineering technologies to various fields such as medicine and food productions, we undoubtedly face the matter of life and death in humans and other creatures. The intrinsic influence of engineering is huge, which requires us to acquire sophisticated knowledge and learn the ethical norm. We will invite experts engaged in various fields to give lectures. We will also arrange an e-learning program, and group discussion and presentation. *Note for foreign students: Lectures are given in Japanese. In slides and handouts, some lecturers give titles etc. both in Japanese and English, but others do not.

Interdisciplinary Research 2 credits

Elective Required Various teachers

Project-Based Learning for Frontier of Mechanical Engineering 2 credits

Elective Required Various teachers

In this study program, students will master a whole process of a project for mechanical design and system integration through practical hands-on experience. The first part comprises some classes on system integration, project management and safety management. The second part comprises project training, in which the students are expected to generate a project proposal and a conceptual design, undertake a design review and create a prototype. At the end, students must give a presentation on their results and write a report. This program is a prerequisite for students who wish to take the course entitled “Innovation Oriented Seminar on Mechanical Engineering.”

Internship Training 1 or 2 credits

Elective Required All teachers

Practical training and research conducted at a company for around one week to one month in the first-year of masters program. Through this training, students learn how to apply the basic research at university to a real industrial technology setting. Additionally, students gain on-site experience and understand the realities of planning, surveys and research, product development, manufacturing and product management, etc., in companies. It is desirable that all students take this training. One or two credits are given to them according to the content and the period of the training.

International Scientific Internship Training 1 or 2 credits

Elective Required All teachers

When students have attended any lectures or practiced in a foreign academic organization or science program, one or two credits are given to them according to the content and the period.

Special Lecture on Robotics A

Elective Required Various teachers

A special lecture on leading-edge academic research in the major area, or on the creation and development of knowledge in relation to the major area.

Advanced Seminar on Robotics A

Elective Required Various teachers

Addressing leading-edge academic research in the major area, this course comprises seminars on a subject which students have chosen themselves as well as training in and beyond the university. Integrating these advanced specialist knowledge helps to develop students’ problem-posing ability.

Seminar on Nano-Systems 2 credits

Elective Required
Professor Shuji Tanaka
Professor Satoshi Murata
Professor Hiroki Kuwano
Professor Yoichi Haga
Associate Professor Shinichiro Nomura
Associate Professor Motoaki Hara

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Robot-Systems 2 credits

Elective Required
Professor Kazuhiro Kosuge
Professor Mami Tanaka
Associate Professor Yasuhisa Hirata
Associate Professor Takeshi Okuyama

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Innovation Oriented Seminar on Mechanical Engineering 8 credits Elective Required Various teachers In this course, students engage in experiments and seminars (including research presentations, discussion and literature reviews) on particularly innovation-oriented themes in leading-edge areas of mechanical engineering. To take this seminar, students must pass Project-Based Learning for Frontier of Mechanical Engineering and satisfy the other registration prerequisites. The eight credits are considered to be the equivalent of the eight credits for Masters Course Seminar in terms of masters program completion requirements. However, students earning credits through this seminar cannot simultaneously earn credits for Masters Course Seminar.	**Master Course Seminar on Robotics** 8 credits Elective Required Students engage in experiments and seminars, including research presentations, discussion and literature reviews. Students who have acquired credits from the Innovation Oriented Seminar on Mechanical Engineering program do not need to take this course.

Numerical Analysis 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Satoru Yamamoto
Professor Naofumi Ohnish
Associate Professor Kanjuro Makihara

Students will be taught the numerical analysis techniques which provide the basis for analysis in fluid dynamics, thermodynamics, mechanics, electromagnetics and measurement and control engineering, etc., and learn how to apply these skills. Classes will focus in particular on (1) numerical solutions for ordinary differential equations (2) the finite difference method and the finite element method for partial differential equations, and (3) linear algebra and numerical optimization methods, covering the basics of numerical analysis and their engineering applications.

Applied Analysis 2 credits

Elective Required
Professor Nobuaki Obata

Mathematical analysis is important for the understanding of random phenomenon apperaing in various fields of natural, life and social sciences, and the probabilistic approach is essential. We start with fundamental concepts in probability theory and learn basic tools for probabilistic models. In particular, for the time evolution of random phenomenon we study basic properties of random walks, Markov chains, Markov processes, and take a bird's-eye view of their wide applications.
These lectures will be in Japanese in principle and an English resume will be distributed.

Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Sawada

This course covers the basics of both incompressible and compressible fluid dynamics.
1. Conservation laws and governing equations
2. Inviscid, incompressible flows
3. Viscous, incompressible flows
4. Inviscid, compressible flows

Solid Mechanics 2 credits

Elective Required
Professor Masumi Saka
Professor Tomonaga Okabe

This class is designed to provide students with a comprehensive understanding of deformation of solids and covers the fundamentals of continuum solid mechanics. It focuses on two-dimensional elasticity in infinitesimal strain theory, the concept of strain and stress, and the introduction of general methods of solving the boundary value problems through the specific problems. Moreover, this class also covers the fundamentals of finite deformation theory, which is used for addressing the large deformations of solids.

Thermal Science and Engineering 2 credits

Elective Required
Professor Shigenao Maruyama
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Associate Professor Takashi Tokumasu

In this course, students will master the basic physics of thermal fluid science, energy conversion and energy systems and learn to link this knowledge to engineering applications. In particular, the course is designed to cover (1) microscopic approaches to thermal phenomena in molecular physics, (2) thermal phenomena involving chemical reactions such as combustion, and (3) understanding and control of the various types of heat transfer Through these classes, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

System Control Engineering 2 credits

Elective Required
Professor Kazuhiro Kosuge
Professor Kazuya Yoshida
Professor Koichi Hashimoto
Professor Yasuhisa Hirata

New mechanical systems using advanced mechanisms are being developed in a range of areas for medical care and welfare, space exploration, disaster rescue purposes and so on. This course focuses on motion control design of increasingly advanced and complex mechanical systems. Students will learn fundamentals for non-linear system analysis and control system design methods. First, phase plane analysis methods and Lyapunov methods are introduced as the main ways to analyze non-linear systems. Next, non-linear feedback control system design methods that can be used for mechanical control systems with non-linear dynamics. Finally, students look at several control system design methods.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
Professor Yuji Takakuwa
Associate Professor Yoichi Takeda

Most metals in the earth's atmosphere inevitably change into more thermodynamically stable compounds such as oxides or sulfides. To understand this principle more precisely, students will learn chemical and electro-chemical equilibrium theory, and kinetics theory in relation to corrosion and oxidation of metals. Practical examples will be used to explain the phenomena and theories of wet corrosion and high-temperature oxidation, deepening students' understanding of the chemical and electro-chemical reactions related to macro phenomena of corrosion and oxidation. This course will be offered in English with presentation and discussion style, using English-language materials. A detailed outline of the course will be presented during the first class.

Computer Hardware Fundamentals 2 credits

Elective Required
Professor Tetsu Tanaka
Associate Professor Riyusuke Egawa

Computers have become an indispensable part of modern society. In this course, both VLSI technology and computer architecture will be lectured for better understanding of modern computer systems. First, CMOS-IC Technology, memory technologies, circuit architecture, high-level synthesis and integrated design technologies that support a remarkable evolution of computer systems over the past few decades will be introduced. Then, the topics will move to computer architecture that focuses on the structure of computer systems, issues and tradeoffs involved in the design of computer system architecture, and high-performance computing. Also, research topics on state-of-the-art LSI technology and computer architecture will be also presented in the lecture.

Solid State Physics 2 credits

Elective Required
Professor Hiroo Yugami
Professor Takahito Ono
Professor Ying Chen

This course targets students from mechanical engineering, system engineering and a wide range of other specialized areas. Using Introduction to Solid State Physics (Charles Kittel, Eighth Edition) as the main text, it focuses on the fundamentals of material science. Following the chapter order in this text book, each class will cover the content associated with that chapter. The course aims to provide students from a wide range of areas with an understanding of the basics concept of solid state physics and a broad perspective on the behavior of materials in engineering systems.

Mechanics of Plasticity 2 credits

Elective Required
Professor Toshiyuki Hashida
Associate Professor Yoshiteru Aoyagi

This lecture covers the concepts and analytical methods that form the basis of plastic deformation mechanics, including material strength and fracture, deformation processing and tribology, and learn how to apply these skills. Key themes will be (1) basic concepts in plastic deformation, (2) mechanical description of plastic deformations, (3) finite element analysis and (4) using case studies to consider applications to engineering. This lecture aims to have students understand and master basic concepts in and mechanical descriptions of plastic deformation.

Structure and Function of Living System 2 credits

Elective Required
Professor Yoichi Haga
Associate Professor Makoto Ohta

In all types of engineering with a connection to the human body, a thorough understanding of the structure and function of the human body and other living systems is vital, as is consideration of systems geared to the special features of these living systems. This course covers the biology knowledge in terms of the basic functions and structures of living organisms that forms the basis of bioengineering. Particular emphasis will be placed on the basic knowledge and approaches necessary for deep exploration of the anatomy and physiology of the human body from the perspective of biomechanics.

Aerospace Systems 2 credits

Elective Required
Professor Naofumi Ohnishi
Senior Assistant Professor Koichi Yonemoto
Senior Assistant Professor Toshiyuki Kimura
Senior Assistant Professor Toshihiko Nakagawa

Aerospace Propulsion 2 credits

Elective Required Various teachers

Computational Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Sawada
Associate Professor Soshi Kawai

Lectures on computational fluid dynamics for compressible flows are given. Accuracy and errors of finite difference methods, finite volume discretization of conservation laws, upwind schemes based on nonlinear wave theory, -TVD stability theory, and recent high-order accurate numerical methods are given in the lectures.

Aerospace Structural Mechanics 2 credits

Elective Required
Associate Professor Kanjuro Makihara

This course covers the theories of mechanics and design of thin-walled structures used in aircrafts, rockets and space structures.
1. Structures and materials of aircrafts, rockets and space structures
2. Vibration analysis of aerospace structures
3. Dynamics of space structures
4. Vibration control of aerospace structures
5. Numerical analysis of structures
6. Damage modelling and simulation

Aerospase Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Asai
Associate Professor Taku Nonomura

The accurate knowledge and comprehension for thermo fluid dynamics are required to understand the extreme flow phenomena in the aerospace engineering field and to design aircraft and spacecraft. In this course, from the viewpoint of experimental aerodynamics, 1)various experimental techniques in aerospace engineering fields such as wind-tunnel experiments are lectured with introducing latest examples, and 2)flow control techniques and applications for advanced aircraft and spacecraft are discussed.

Space Robotics 2 credits

Elective Required
Professor Kazuya Yoshida
Associate Professor Toshinori Kuwahara

 Study engineering issues on space robotics.
 Fundamental knowledge on space environment and spacecraft designs are introduced, then some advanced topics are elaborated.
 Orbital mechanics, angular motion kinematics and attitude dynamics of a spacecraft are studied.
 Multi-body dynamics and control issues for space robots and manipulators are elaborated.
 Advanced topics include (1) reaction dynamics and control of a free-flying space robot, (2) vibration dynamics and its suppression control of a flexible space robot, (3) impact dynamics and post-impact control when a space robot captures a floating target, (4) teleoperation and telepresence, and (5) mechanical simulation of micro-gravity environment.
 All lectures are given in English.

Space Engineering for Robotic Exploration 2 credits

Elective Required
Professor Kazuya Yoshida
Associate Professor Keiji Nagatani

 Study engineering issues for space exploration missions.
 Fundamental knowledge on space environment and spacecraft designs are introduced, then some advanced topics are elaborated.
 History of lunar/planetary exploration missions is introduced.
 Mechanics and systems design of mobile robots for exploration missions are elaborated.
 Sensing, planning and navigation issues are also elaborated.
 Advanced topics include (1) terra-mechanics (soil-wheel interaction mechanics), (2) visual odometry, (3) SLAM (simultaneous localization and mapping), (4) various motion planning algorithms, and (5) terrestrial field application of exploration robotics.
 All lectures are given in English.

Aerospace Combustion Dynamics 2 credits

Elective Required
Professor Hideaki Kobayashi

In this course, the lecture is performed on turbulent combustion which is a fundamental process of aerospace propulsion systems. First, statistical parameters of turbulent flows are reviewed for weak and strong turbulence. The non-dimensional numbers which describe the relationship between turbulent flows and turbulent flame structures are explained, and then the scale relations predominant for determination of the turbulent combustion are demonstrated. The lecture is extended to the turbulent combustion models and elementally process highly related to the flamelet concept of turbulent combustion, as well as chemical reactions of combustion in the extreme conditions of the propulsion systems; i.e., high pressure and high temperature.

The Science of Shock Waves 2 credits

Elective Required
Associate Professor Mingyu Sun

Mathematical Modeling and Computation 2 credits

Elective Required
Professor Satoru Yamamoto

This lecture introduces typical mathematical models on some physical and social problems observed in nature and in events which are basically formulated by a system of nonlinear partial-differential equations, and also teaches the numerical methods based on the finite-difference method for solving the mathematical models. Each student is subjected to make his own mathematical model and submits the computational result as the final report.

Applied Mathematical Fluid Dynamics 2 credits

Elective Required
Professor Yuji Hatsutori

A number of ideas in applied mathematics, which include dynamical systems, differential geometry, Lie groups, and statistical mechanics, have been applied to fluid dynamics. Recent development in basic fluid dynamics is introduced and methods and ideas for attacking various problems in nonlinear dynamics are given. The lecture consists of three parts: (i) theory of hydrodynamics stability, (ii) statistical fluid dynamics, and (iii) topological fluid dynamics.

Ultra-Highspeed Information Processing Algorithms

Elective Required
Professor Hiroaki Kobayashi
Associate Professor Hideaki Goto
Associate Professor Hiroyuki Takizawa

This course reviews supercomputing systems from both aspects of hardware and software. The course talks about the importance of parallel processing, parallel system architectures, parallel algorithm design, parallel programming, and performance evaluation methodologies. The course also discusses the memory systems necessary for supercomputing. See the class web page http://www.sc.isc.tohoku.ac.jp/class/uhsipa/ for more details. (Contact instructors to have an access ID)

Fluid Design Informatics 2 credits

Elective Required
Professor Shigeru Obyashi
Associate Professor Koji Shimoyama

This lecture aims to construct the theories, learn the methodologies, and see the real-world examples of fluis engineering design, which is based on computational fluid dynemics (CFD) combined with information science. The lecture outline is organazed as 1. CFD for design, 2. design optimizatio, 3. gradient-based method, 4. evolutionaly computation, 5. multi-objective design exploration, 6. data mining, 7. surrogate model, and 8. unccertainty quantification.

Multiphase Flow Systems 2 credits

Elective Required
Professor Jun Ishimoto

This class covers the multiphase fluid mechanics. Especially, the research topics closely related to the cavitation and liquid atomization phenomena would be introduced. Furthermore, the numerical modeling, basic equations and computational simulation technique of multiphase fluid dynamics would be lectured.

1. Multiphase fluid flow pattern
2. Cavitation characteristics
3. Numerical analysis of cavitating flow
4. Computational method of dispersed multiphase flow
5. Cryogenic and magnetohydrodynamic multiphase fluid flow
6. Bubble dynamics
7. Microbubble dynamics
8. Computational method of free surface and interfacial flow
9. Atomization and spray dynamics
10. Numerical modeling of phase change and boiling phanemena

Computer Architecture 2 credits

Elective Required
Professor Hiroaki Kobayashi

The term "computer architecture" means the concept of designing computers and is also its philosophy. This course begins with the basic principles of computers, and then talks about instruction-level parallel processing, vector processing, parallel computing systems, and their control mechanisms. Supercomputing techniques such as vector systems and accelerators are also reviewed.
See the class web page
http://www.sc.isc.tohoku.ac.jp/class/architecture/ for more details.
(Contact instructors to have an access ID).

Physical Fluctuomatics 2 credits

Elective Required
Professor Kazuyuki Tanaka

Applications to many fields in engineering like control, signal processing etc. and in information sciences are in mind through the lecture course for the basic knowledge of statistical machine learning theory as well as stochastic processes. Brief introduction will be given to methods for applications like statistical estimation etc., and to the relationship with statistical-mechanical informatics. We first lecture probability and statistics and their fundamental properties and explain the basic frameworks of Bayesian estimation and maximum likelihood estimation. Particularly, we show EM algorithm as one of familiar computational schemes to realize the maximum likelihood estimation. As one of linear statistical models, we introduce Gaussian graphical model and show the explicit procedure for Bayesian estimation and EM algorithm from observed data. We show some useful probabilistic models which are applicable to probabilistic information processing in the stand point of Bayesian estimation. We mention that some of these models can be regarded as physical models in statistical mechanics. Fundamental structure of belief propagation methods are reviewed as powerful key algorithms to compute some important statistical quantities, for example, averages, variances and covariances. Particularly, we clarify the relationship between belief propagations and some approximate methods in statistical mechanics. As ones of application to probabilistic information processing based on Bayesian estimation and maximum likelihood estimations, we show probabilistic image processing and probabilistic reasoning. Moreover, we review also quantum-mechanical extensions of probabilistic information processing.

Discussion on Environmental and Industrial Policy
2 credits

Elective Required Various teachers

Interdisciplinary Research 2 credits

Elective Required Various teachers

Special Lecture in Cooperation with JAXA 2 credits

Elective Required
Visiting Professor Sadatake Tomioka
Visiting Associate Professor Toshiya Kimura

Visiting teachers from JAXA (Japan Aerospace Exploration Agency) make special lecture on future space transportation system. Major topics are liquid rocket engine with high performance and high reliability, as well as the rocket-based combined cycle engine, especially on their system and research on components.

Project-Based Learning for Frontier of Mechanical Engineering 2 credits

Elective Required Various teachers

In this study program, students will master a whole process of a project for mechanical design and system integration through practical hands-on experience. The first part comprises some classes on system integration, project management and safety management. The second part comprises project training, in which the students are expected to generate a project proposal and a conceptual design, undertake a design review and create a prototype. At the end, students must give a presentation on their results and write a report. This program is a prerequisite for students who wish to take the course entitled "Innovation Oriented Seminar on Mechanical Engineering."

Internship Training 1 or 2 credits

Elective Required All teachers

Practical training and research conducted at a company for around one week to one month in the first-year of masters program. Through this training, students learn how to apply the basic research at university to a real industrial technology setting. Additionally, students gain on-site experience and understand the realities of planning, surveys and research, product development, manufacturing and product management, etc., in companies. It is desirable that all students take this training. One or two credits are given to them according to the content and the period of the training.

International Scientific Internship Training 1 or 2 credits

Elective Required All teachers

When students have attended any lectures or practiced in a foreign academic organization or science program, one or two credits are given to them according to the content and the period.

Special Lecture on Aerospace Engineering A

Elective Required Various teachers

A special lecture on leading-edge academic research in the major area, or on the creation and development of knowledge in relation to the major area.

Advanced Seminar on Aerospace Engineering A

Elective Required Various teachers

Addressing leading-edge academic research in the major area, this course comprises seminars on a subject which students have chosen themselves as well as training in and beyond the university. Integrating these advanced specialist knowledge helps to develop students' problem-posing ability.

Seminar on Aero Systems 2 credits

Elective Required
Professor Keisuke Sawada
Professor Tomonaga Okabe
Professor Keisuke Asai
Professor Shigeru Obyashi
Associate Professor Soushi Kawai
Associate Professor Naofumi Ohishi
Associate Professor Hiroki Nagai
Associate Professor koji Shimoyama

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Space Systems 2 credits

Elective Required
Professor Kazuya Yoshida
Professor Hideaki Kobayashi
Visiting Professor Eiko Tanno
Visiting Professor Sadatake Tomioka
Associate Professor Kanjuro Makihara
Associate Professor Keiji Nagatani
Associate Professor Mingyu Sun

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Innovation Oriented Seminar on Mechanical Engineering 8 credits

Elective Required Various teachers

In this course, students engage in experiments and seminars (including research presentations, discussion and literature reviews) on particularly innovation-oriented themes in leading-edge areas of mechanical engineering. To take this seminar, students must pass Project-Based Learning for Frontier of Mechanical Engineering and satisfy the other registration prerequisites. The eight credits are considered to be the equivalent of the eight credits for Masters Course Seminar in terms of masters program completion requirements. However, students earning credits through this seminar cannot simultaneously earn credits for Masters Course Seminar.

Master Course Seminar on AeroSpace Engineering 8 credits

Elective Required

Students engage in experiments and seminars, including research presentations, discussion and literature reviews. Students who have acquired credits from the Innovation Oriented Seminar on Mechanical Engineering program do not need to take this course.

Numerical Analysis 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Satoru Yamamoto
Professor Naofumi Ohnish
Associate Professor Kanjuro Makihara

Students will be taught the numerical analysis techniques which provide the basis for analysis in fluid dynamics, thermodynamics, mechanics, electromagnetics and measurement and control engineering, etc., and learn how to apply these skills. Classes will focus in particular on (1) numerical solutions for ordinary differential equations (2) the finite difference method and the finite element method for partial differential equations, and (3) linear algebra and numerical optimization methods, covering the basics of numerical analysis and their engineering applications.

Applied Analysis 2 credits

Elective Required
Professor Nobuaki Obata

Mathematical analysis is important for the understanding of random phenomenon apperaing in various fields of natural, life and social sciences, and the probabilistic approach is essential. We start with fundamental concepts in probability theory and learn basic tools for probabilistic models. In particular, for the time evolution of random phenomenon we study basic properties of random walks, Markov chains, Markov processes, and take a bird's-eye view of their wide applications.
These lectures will be in Japanese in principle and an English resume will be distributed.

Fluid Dynamics 2 credits

Elective Required
Professor Keisuke Sawada

This course covers the basics of both incompressible and compressible fluid dynamics.
1. Conservation laws and governing equations
2. Inviscid, incompressible flows
3. Viscous, incompressible flows
4. Inviscid, compressible flows

Solid Mechanics 2 credits

Elective Required
Professor Masumi Saka
Professor Tomonaga Okabe

This class is designed to provide students with a comprehensive understanding of deformation of solids and covers the fundamentals of continuum solid mechanics. It focuses on two-dimensional elasticity in infinitesimal strain theory, the concept of strain and stress, and the introduction of general methods of solving the boundary value problems through the specific problems. Moreover, this class also covers the fundamentals of finite deformation theory, which is used for addressing the large deformations of solids.

Thermal Science and Engineering 2 credits

Elective Required
Professor Shigenao Maruyama
Professor Hideaki Kobayashi
Professor Kaoru Maruta
Associate Professor Takashi Tokumasu

In this course, students will master the basic physics of thermal fluid science, energy conversion and energy systems and learn to link this knowledge to engineering applications. In particular, the course is designed to cover (1) microscopic approaches to thermal phenomena in molecular physics, (2) thermal phenomena involving chemical reactions such as combustion, and (3) understanding and control of the various types of heat transfer Through these classes, students will further deepen their understanding of the essence of thermal phenomena and will become able to apply this to practical devices.

System Control Engineering 2 credits

Elective Required
Professor Kazuhiro Kosuge
Professor Kazuya Yoshida
Professor Koichi Hashimoto
Professor Yasuhisa Hirata

New mechanical systems using advanced mechanisms are being developed in a range of areas for medical care and welfare, space exploration, disaster rescue purposes and so on. This course focuses on motion control design of increasingly advanced and complex mechanical systems. Students will learn fundamentals for non-linear system analysis and control system design methods. First, phase plane analysis methods and Lyapunov methods are introduced as the main ways to analyze non-linear systems. Next, non-linear feedback control system design methods that can be used for mechanical control systems with non-linear dynamics. Finally, students look at several control system design methods.

Materials Chemistry 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Koji Amezawa
Professor Yuji Takakuwa
Professor Eiji Akiyama
Associate Professor Yoichi Takeda

Most metals in the earth's atmosphere inevitably change into more thermodynamically stable compounds such as oxides or sulfides. To understand this principle more precisely, students will learn chemical and electro-chemical equilibrium theory, and kinetics theory in relation to corrosion and oxidation of metals. Practical examples will be used to explain the phenomena and theories of wet corrosion and high-temperature oxidation, deepening students' understanding of the chemical and electro-chemical reactions related to macro phenomena of corrosion and oxidation. This course will be offered in English with presentation and discussion style, using English-language materials. A detailed outline of the course will be presented during the first class.

Computer Hardware Fundamentals 2 credits

Elective Required
Professor Tetsu Tanaka
Associate Professor Riyusuke Egawa

Computers have become an indispensable part of modern society. In this course, both VLSI technology and computer architecture will be lectured for better understanding of modern computer systems. First, CMOS-IC Technology, memory technologies, circuit architecture, high-level synthesis and integrated design technologies that support a remarkable evolution of computer systems over the past few decades will be introduced. Then, the topics will move to computer architecture that focuses on the structure of computer systems, issues and tradeoffs involved in the design of computer system architecture, and high-performance computing. Also, research topics on state-of-the-art LSI technology and computer architecture will be also presented in the lecture.

Solid State Physics 2 credits

Elective Required
Professor Aoki Dai
Associate Professor Honda Fuminori

This course targets students from mechanical engineering, system engineering and a wide range of other specialized areas. Using Introduction to Solid State Physics (Charles Kittel, Eighth Edition) as the main text, it focuses on the fundamentals of material science. Following the chapter order in this text book, each class will cover the content associated with that chapter. The course aims to provide students from a wide range of areas with an understanding of the basics concept of solid state physics and a broad perspective on the behavior of materials in engineering systems.

Science and Engineering of Particle Beam 2 credits

Elective Required
Professor Manabu Tashiro
Professor Atsuki Terakawa
Guest Professor Tomihiro Kamiya
Associate Professor Shigeo Matsuyama
Associate Professor Keitaro Hitomi

Quantum and Statistical Mechanics 2 credits

Elective Required
Professor Yasuyoshi Nagai
Associate Professor Koji Inoue
Associate Professor Takeshi Toyama
Associate Professor Kenta Yoshida
Associate Professor Keitaro Hitomi

Fundamentals of quantum mechanics and statistical mechanics will be lectured. The main contents are:
1. General theory of quantum mechanics
2. Potential problems
3. Approximation methods
4. Identical particles and spin
5. Fermi-Dirac and Bose-Einstein statistics
6. Quantization of electromagnetic field
7. Others

Science and Engineering of Radiations 2 credits

Elective Required
Professor Atsuki Terakawa
Professor Hiroshi Watabe
Professor Shigeo Matsuyama
Associate Professor Yohei Kikuchi
Associate Professor Keitaro Hitomi
Associate Professor Seong-Yun Kim

Fusion Reactor Materials 2 credits

Elective Required
Professor Akira Hasegawa
Associate Professor Shiyuhei Nogami
Guest Professor Takeo Muroga
Guest Associate Professor Takuya Nagasaka

Reduced-Activation System Design for Nuclear Applications 2 credits

Elective Required
Professor Akira Hasegawa

Fusion Reactor Technology and Magneto Hydrodynamics 2 credits

Elective Required
Professor Hidetoshi Hashizume
Associate Professor Shinji Ebara
Associate Professor Noritaka Yusa
Associate Professor Satoru Ito

This lecture will introduce an outline of a magnetic confinement fusion power reactor, and deal with superconducting magnet and blanket systems and so on as one of the most challenging devices in terms of engineering feasibility. In addition, physics underlying those devices and these applications are lectured as well as some key issues related to the fusion power reactor design, especially to blanket systems. Moreover, the problematique existing in the fusion blanket systems, such as thermal-magneto-hydraulic problems with structural restriction and some measures will be shown.

Environmental Perspective on the Energy Flow 2 credits

Elective Required
Professor Yuichi Niibori
Associate Professor Sonyun Kimu
Adjunct Instructor Taiji Chida

The purpose of this class is to understand quantitatively the relations of primary energies and global environment through some topics including fossil fuel, global warming, acid rain and nuclear energy. Also, this class refers to the reprocessing of spent fuel, the safety assessment of geological disposal system and so on.

Neutron Device Engineering 2 credits

Elective Required
Professor Tomohiko Iwasaki
Associate Professor Shinji Ebara

Neutron Device Engineering is the lecture on the behavior of neutron in the system and device such as fission and fusion reactor from the viewpoint of microscopic to macroscopic. The main topics of the lecture are “Transport of neutron in a medium” and “Dynamics and control of neutron in an energy system and device like nuclear reactor”.
This lecture is compulsory for the student who pursues the license for chief engineer of reactor. Besides, it is desired that student takes the lecture of “Introduction to Neutron Transport” in undergraduate course.

Fusion Plasma Diagnostics 2 credits

Elective Required
Visiting Professor Kenji Tobita
Visiting Professor Atsushi Okamoto

Plasma diagnostics is one of important bases for the development of a nuclear fusion reactor. The aim of this course is to introduce basic concepts for equilibrium and transport of plasma confined by a magnetic field e.g. tokamak and stellarator and to give a brief overview of plasma heating methods. After introductions this course provides how to diagnose the core plasma in large experimental devices giving examples of current plasma diagnostic systems.

Energy Physics and Engineering Education 2 credits

Elective Required
Professor Atsuki Terakawa

The lecture course presents and discusses the physics foundations of energy generation through nuclear fission and fusion reactions. Its aim is to provide the student with sufficient scientific knowledge to understand nuclear power generators.

Particle Beam System Engineering 2 credits

Elective Required
Professor Atsuki Terakawa
Professor Shigeo Matsuyama
Professor Shozo Furumoto
Professor Hiroshi Watabe
Associate Professor Keitaro Hitomi
Associate Professor Kim Seong

Safety Engineering of Nuclear Energy Systems
2 credits

Elective Required
Professor Makoto Takahashi
Professor Daisuke Karikawa

Basics for Plant Life Management 2 credits

Elective Required
Professor Yutaka Watanabe
Professor Tetsuya Uchiichi
Associate Professor Noritaka Yusa

Applied Nuclear Medical Engineering 2 credits

Elective Required
Professor Hiroshi Ohtsu

Quantum Energy Engineering 2 credits

Elective Required Various teachers

Engineering of Materials for Application in Irradiation Envi
2 credits

Elective Required
Associate Professor Shinji Nagata

Materials for Nuclear Energy Systems 2 credits

Elective Required
Professor Akira Hasegawa
Professor Ryuta Kasada

Nuclear Fuel Separation Engineering 2 credits

Elective Required
Professor Nobuaki Sato
Associate Professor Akira Kirishima

Nuclear Nano Materials Physics 2 credits

Elective Required
Professor Yasuyoshi Nagai
Associate Professor Koji Inoue
Associate Proffesor Takeshi Toyama
Associate Professor Kenta Yoshida

The understanding of nano-scale atomic and electronic structures is increasingly important to study nuclear materials and their irradiation effects. In this lecture, the state-of-the-art methods to analyze the atomic scale defects induced by irradiation and the solute/impurity clustering in the nuclear materials, including transmission electron microscopy, three-dimensional atom probe method and positron annihilation spectroscopy, will be reviewed.

Engineering for Actinide Materials 2 credits

Elective Required
Professor Dai Aoki
Associate Professor Fuminori Honda

Actinide science is lectured from the view points of physics and chemistry, focusing on the difference from the transition elements and the rare earth elements. The topics on nuclear fuel and radioactive waste, and the related recent studies are also presented.

Accelerator Health Physics 2 credits

Elective Required
Professor Hiroshi Watabe
Professor Tomohiko Iwasaki
Associate Professor Shigeo Matsuyama

In response to the extension of accelerator application, it is important to understand the characteristics of radioactive ray occurred from accelerator, the interaction of ray with a medium, the behavior of ray in a medium and the effect of rays to human health for the safety and effective use of accelerator.
In Accelerator Health Physics, we give a lecture on the various kinds of accelerator and its characteristics of radiation field, the transport of radioactive ray in a medium, the effect of radiation to human health and the shielding and protection from radiation through a perspective of their mathematical and statistical approach.

Experimental Nuclear System Engineering 2 credits

Elective Required
Professor Tomohiko Iwasaki
Associate Professor Ken Gaiyama

Student must participate in one practical experiment program of following #1 or #2. The recognition of credit on Experimental Nuclear System Engineering is evaluated on the basis of the contents of report in practical experiment program.

#1 Nuclear reactor experiment and Operation control work of reactor by the use of critical assembly experiment facility at Kyoto University Reactor Research Institute

#2 Experiment of actinide element and material for nuclear application at International Research Center for Nuclear Material Science, Institute for Materials Research, Tohoku University

The credit of the lecture can be approved if student participates in an experiment or practical training on nuclear engineering system held at university or research institute in the country or overseas such as Japan Atomic Energy Agency. In this case, student must submit a certification of the experiment or training issued by concerned institute and a report on the experiment or training. The recognition of credit is evaluated on the basis of the report.

Advanced Practical Nuclear Engineering 1 credits

Elective Required Various teachers

Concrete for nuclear Power Plants 2 credits

Elective Required
Professor Makoto Hisada
Associate Professor Hiroshi Minagawa

In this class, students learn the general properties of concrete, required quality of various materials for concrete production and its testing method, production method of concrete, construction method to build concrete structures. This class provides the explanations of the relationship between the properties of the concrete and the properties of the materials used as well as the production and construction method of concrete, to help students understand the fabrication of concrete suitable for the design conditions, for materials selection, mix proportion design, production, construction etc.

General Earthquake Engineering 2 credits

Elective Required
Professor Shigeki Unjoh
Associate Professor Hideki Naito

This course provides students with the basic theories on the dynamic behavior of infrastructures subjected to earthquake ground motions and the seismic design methods. The purpose of this course is to help students understand the process of seismic design of structures, including mathematical modeling, earthquake response analysis methods and the performance evaluation of structures as well as the basic knowledge for the seismic design.

Nucleal Safety Theory and egulation 2 credits

Elective Required
Professor Hidetoshi Hashizume
A specially appointed professor Seiji Abe
A specially appointed professor Eiji Hiraoka

Physical Fluctuomatics 2 credits

Elective Required
Professor Kazuyuki Tanaka

Applications to many fields in engineering like control, signal processing etc. and in information sciences are in mind through the lecture course for the basic knowledge of statistical machine learning theory as well as stochastic processes. Brief introduction will be given to methods for applications like statistical estimation etc., and to the relationship with statistical-mechanical informatics. We first lecture probability and statistics and their fundamental properties and explain the basic frameworks of Bayesian estimation and maximum likelihood estimation. Particularly, we show EM algorithm as one of familiar computational schemes to realize the maximum likelihood estimation. As one of linear statistical models, we introduce Gaussian graphical model and show the explicit procedure for Bayesian estimation and EM algorithm from observed data. We show some useful probabilistic models which are applicable to probabilistic information processing in the stand point of Bayesian estimation. We mention that some of these models can be regarded as physical models in statistical mechanics. Fundamental structure of belief propagation methods are reviewed as powerful key algorithms to compute some important statistical quantities, for example, averages, variances and covariances. Particularly, we clarify the relationship between belief propagations and some approximate methods in statistical mechanics. As ones of application to probabilistic information processing based on Bayesian estimation and maximum likelihood estimations, we show probabilistic image processing and probabilistic reasoning. Moreover, we review also quantum-mechanical extensions of probabilistic information processing.

Discussion on Environmental and Industrial Policy

Elective Required Various teachers

Interdisciplinary Research 2 credits

Elective Required Various teachers

Internship Training 1 or 2 credits

Elective Required All teachers

Practical training and research conducted at a company for around one week to one month in the first-year of masters program. Through this training, students learn how to apply the basic research at university to a real industrial technology setting. Additionally, students gain on-site experience and understand the realities of planning, surveys and research, product development,

International Scientific Internship Training 1 or 2 credits

Elective Required All teachers

When students have attended any lectures or practiced in a foreign academic organization or science program, one or two credits are given to them according to the content and the period.

Special Lecture on Quantum Energy Engineering A

Elective Required Various teachers

A special lecture on leading-edge academic research in the major area, or on the creation and development of knowledge in relation to the major area.

Advanced Seminar on Quantum Energy Engineering A

Elective Required Various teachers

Addressing leading-edge academic research in the major area, this course comprises seminars on a subject which students have chosen themselves as well as training in and beyond the university. Integrating these advanced specialist knowledge helps to develop students' problem-posing ability.

Seminar on Advanced Nuclear Energy Engineering

Elective Required
Professor Shigeo Matsuyama
Associate Professor Yohei Kikuchi

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Safety Engineering of Nuclear Energy Systems 2

Elective Required

Associate Professor Daisuke Karikawa
Hiroshi Abe
Taishi Chida

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Energy Physics Engineering 2 credits

Elective Required
Professor Hidetoshi Hashizume
Professor Tomohiko Iwasaki
Associate Professor Shinji Ehara
Associate Professor Yusa Noritaka
Associate Professor Satoru Ito

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Particle-Beam Engineering 2 credits

Elective Required
Professor Hiroshi Ohtsu
Professor Akira Hasegawa
Professor Atsuki Terakawa
Associate Professor Shiyuhei Nogami

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Energy Materials 2 credit

Elective Required
Professor Nagai Yasuyoshi
Professor Koji Inoue
Associate Professor Takeshi Toyama
Associate Professor Kenta Yoshida

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Energy Chemical Engineering 2 credits

Elective Required
Professor Nobuaki Sato
Associate Professor Akira Kirishima

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Quantum Theoretic Material Engineering 2 credits

Elective Required
Professor Dai Aoki
Associate Professor Fuminori Honda

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Seminar on Accelerator Radiation Science and Engineering 2 credits

Elective Required
Associate Professor Seong-Yun Kim
Associate Professor Keitaro Hitomi

By introducing and discussing key research papers in relation to their masters thesis, as well as the background to and interim results of their own research. Through this seminar, students will identify research trends in their particular area and the position of their own research.

Master Course Seminar on Quantum Energy Engineering 8 credits

Required

Students engage in experiments and seminars, including research presentations, discussion and literature reviews. Students who have acquired credits from the Innovation Oriented Seminar on Mechanical Engineering program do not need to take this course.